Final Report

Statewide Marine Mapping Planning Workshop

December 12 - 13, 2005
California State University, Monterey Bay
Seaside, California

March 15, 2006

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1 EXECUTIVE SUMMARY

This Report presents an overview of the objectives for and the results from the Statewide Marine Mapping Planning Workshop held at CSU Monterey Bay, December 12-13, 2005. The overall goal of the project is to create a strategic plan for completing the mapping of all seafloor habitats within California State Waters (shoreline out to 3 nm). The approach was to involve key stakeholders in a gap analysis of existing data coverage, identification and ranking of current mapping information needs, the prioritization of areas for new field data acquisition, and the definition of minimum survey and analysis specification required to support these needs. The specific objectives for the workshop were to:

- Summarize for each participating organization a description of their existing data holdings, current data needs and planned data collection efforts.
- Perform a gap analysis to identify priority areas where data are still missing.
- Create a prioritized list of areas for future mapping within state waters.
- Recommend minimum standards for survey specifications, level of data interpretation and map product creation appropriate for a comprehensive state waters mapping project.

In addition to setting state-wide mapping priorities and standards, the sponsor requested a separate ranking of mapping priorities to support an anticipated RFP for seafloor mapping confined to the state waters extending from Monterey Bay north to Bodega Bay (hereafter referred to as the Central Coast RFP Area).

The two-day workshop attracted 56 invited participants representing 38 institutions including regional, state and federal resource management agencies, universities, research institutions, NGO's and private industry. A surprising degree of overlap was discovered among the participants regarding their need for mapping data products including:

- MPA mapping in support of the MLPA process
- Environmental monitoring and change detection
- Sediment transport dynamics (erosion, deposition and beach nourishment)
- Geologic hazards (faults and landslides capable of producing tsunamis)
- Habitat maps for fisheries management, stock assessment and identification of biological hot spots
- Safe navigation in shallows, bays, harbors and estuaries
- Economical sources of sand
- Data to support wave, current, sediment transport and oil spill prediction models
- Location of shipwrecks with potential for oil leaks
- Location of derelict fishing gear
- Tsunami run-up modeling and potential tsumani generation sites

Workshop participants identified and ranked areas for future mapping through a voting process making use of the existing 10' CDFG commercial fishing block designations. In

the state-wide priority voting exercise, 6 of the top 11 blocks were in southern California (Ventura and Oceanside), 2 were at San Nicolas Island, two along the central coast (Big Creek Reserve and Cambria) and one in northern California (Trinidad Head) (Table 1, Figure 3).

In the Central Coast RFP Area voting exercise, the majority of the votes fell within blocks along the coast between Año Nuevo and just north of the Golden Gate, and around the Farallon Islands (Table 2). Other areas of high interest can be seen on the Central Coast RFP Area Priority Block Map (Figure 5).

Recommendations for data acquisition and final product standards were obtained during group and breakout sessions regarding critical elements key to the success of a statewide mapping effort. These elements included: data acquisition, level of interpretation, metadata, and dissemination.

There was consensus that the minimum universal seafloor mapping information should cover all "lands" from the shore strand line (MHHW) out to the 3 nm state water limit and include:

- Seabed geomorphology (relief via xyz digital elevation models - DEM)
- Texture (substrate type via backscatter mosaics).
- Ground truthing (via video or physical samples)
- Meet or exceed International Hydrographic Organization (IHO) Order 1 standards, and be carried out at the maximum resolution obtainable using state-of-the-industry tools.
- Best available geodetic positioning technology (vertical and horizontal)

And where appropriate and possible

- Subsurface structure, sediment thickness and stratigraphy via subbottom profiles & coring

Specific recommendations for and examples of appropriate survey specifications are provided in the report.

All participants acknowledged the ultimate need for and great value in full geologic and habitat interpretation of collected mapping data. However, it was also recognized that mapping is expensive and that the state of California currently has limited financial resources, leading to a debate about where to focus financial resources. The participants fell into three camps as to the minimum level of interpretation and classification that should be funded as part of a large regional mapping project supported with limited resources; those favoring: 1) reduced field data collection so as to fund maximum interpretation of all survey data collected, 2) maximizing field data collection coverage combined with basic cost-effective derivative products easily created using automated GIS analysis tools (shaded relief, slope, rugosity, contours, autoclassification) saving full interpretation of the data for later "matching" contributions by interested organizations, and 3) a balanced weighting of data collection and interpretation to maximize field data

while simultaneously producing certain thematic maps with high-priority resource management information.

Representatives from the US Geological Survey, who have created highly interpreted and classified map products, recommended considering map product generation as a 3 tiered process of increasing project cost, with each tier being constructed from the previous. The first tier consists of the basic survey data (xyz grids [bathymetry] and backscatter [substrate] mosaics). These first tier data sets can be efficiently converted into second tier products in GIS at little additional cost using automated numerical derivatives including autoclassification of substrates and surface models based on parameters (slope, aspect, rugosity, contours, relief, etc.). Second tier products are GIS-ready and are often of high value to management agencies because many of the patterns in which they are interested in (e.g. rocky versus soft bottom habitats, bed forms, and depth zones) are easily discernable at this intermediate level of data analysis. The third product tier (fully interpreted, classified and attributed geologic and habitat maps), enables consideration of a variety of different types of data of varying scales and so represents considerable "value added" when there are several different data sets to be considered. However, these maps require careful "manual" work of highly experienced geologists who interpret and apply complex classification schemes to the second tier products. (Examples of each of these product tiers are presented in the report.) USGS has found that the inclusion of this third level of product creation can increase project costs by approximately 50%. Under this scenario, the resulting acquisition/interpretation trade-off at a fixed level of funding would be a reduction of total area mapped by as much as one third.

Finally, all acknowledged the critical importance of having all data meet FGDC metadata standards. For archiving and dissemination, the recommendation was for a tiered system of accessible databases (ftp with links, http download sites, website images of data that link to data sources, internet GIS map servers [e.g. ArcIMS]).

Table of Contents

1 Executive Summary 2
2 Background & Purpose 7
3 Goal 7
4 Objectives & Tasks 7
4.1 Stakeholder Workshop - Overview 7
4.2 Workshop Structure 8
4.3 Pre-Workshop Assessment 9
4.3.1 Identifying Potential Invitees 9
4.3.2 Invitation & Survey Materials 9
4.3.3 Data Needs & Data Holdings Instructions & Worksheets 9
4.3.4 Defining Mapping Sites 10
4.4 Workshop Sessions 10
4.4.1 Updates on Seafloor Mapping Technology, Coverage & Analysis 10
4.4.2 Data Needs and Holdings Update 10
4.4.3 Identification of Priority Habitat Mapping Locations 10
5 Results 11
5.1 Participants 11
5.2 Data Holdings Update 11
5.3 Data Information & Needs 12
5.4 Priority Voting for Future Mapping 13
5.4.1 Statewide Priority Voting Results 13
5.4.2 Central Coast RFP Area Priority Voting Results 15
6 Recommendations 18
6.1 Data Acquisition & Basic Products 18
6.2 Survey Specifications – General Recommendations & Rationales 19
6.2.1 Variance with IHO Order 1 for habitat and geologic mapping 19
6.3 Deliverables 23
6.3.1 Raw Data Types 24
6.3.2 Coverage 24
6.3.3 Products 25
6.4 Survey Specifications – Examples for MBES & LIDAR surveys 26
6.4.1 Methodology and Technical Specifications – MULTIBEAM 26

6.4.2 Methodology and Technical Specifications – Airborne Bathymetric LIDAR 32

6.5 Production Rates 37

6.6 Interpretation and Habitat Classification 38

6.6.1 Second Tier Map Products – Algorithmically Derived GIS Products 40

6.6.2 Third Tier Map Products – Fully Interpreted Geologic and Habitat Classification Schemes 49

6.7 Metadata, Archiving, Dissemination 53

7 Appendices – A: Pre-workshop documents 54

7.1 Agenda* 54

7.2 Marine habitat data holdings worksheet 56

7.3 Marine habitat data needs worksheet 57

7.4 Data holdings coverage map – Northern California 58

7.5 Data holdings coverage map – Central California 59

7.6 Data holdings coverage map – Southern California 60

7.7 Data holdings coverage map – Central Coast RFP Area 61

7.8 Pre-Workshop Data Needs Summary Table 62

7.9 Worksheet B 63

7.10 Voting BALLOT 63

8 Appendices – B: Post-workshop documents 65

8.1 Acronyms 65

8.2 Attendees 66

8.3 State-wide priority voting results by need criteria 68

8.4 Central Coast RFP Area priority voting results by need criteria 69

8.5 Synthesis and Summary of Workshop Notes 70

9 Appendices – C: Supplemental documentation 108

9.1 Survey Specifications – Additional Resources 108

2 BACKGROUND & PURPOSE

In November 2005, California State University Monterey Bay Foundation was contracted by the California Coastal Conservancy to develop a strategic plan for statewide seafloor mapping in California state waters, in consultation with relevant stakeholders, including academic institutions, management agencies, and other mapping data consumers. This work builds on previous priority-setting exercises including the 2000 California Marine Habitat Mapping Task Force Workshop, as well as reviews of existing inventories of data and maps. A major objective of the workshop was to update and complete the inventory of existing seafloor data coverages to facilitate the gap analysis needed to identify where future mapping efforts should be focused. This review and compilation of existing data is ongoing, having benefited from attendee input before, during and after the workshop.

Here we present an overview of the project objectives and results from the Statewide Marine Mapping Planning Workshop held at CSU Monterey Bay, December 12-13, 2005.

3 GOAL

The overall goal of the project is to create a strategic plan for completing the mapping of all seafloor habitats within California State Waters (shoreline out to 3 nm). The general approach has been to involve relevant stakeholders in a gap analysis of existing data coverage, identification and ranking of current mapping information needs, and the prioritization of areas for new field data acquisition. The stakeholders were also to provide recommendations pertaining to data quality, acquisition, resolution, interpretation and classification.

In addition to setting state-wide mapping priorities, the sponsor requested a separate ranking of mapping priorities confined to the state waters extending from Monterey Bay north to Bodega Bay (hereafter referred to as the Central Coast RFP Area). The results of this more regional analysis and the stakeholder recommendations for data acquisition and interpretation are to support the framing of an RFP (request for proposals) for mapping work within the Central Coast RFP Area beginning in 2006.

4 OBJECTIVES & TASKS

4.1 STAKEHOLDER WORKSHOP - OVERVIEW

The primary effort of this project has been to design, plan and implement an inclusive 2-day workshop with stakeholders that updates the findings of the 2000 California Marine Habitat Mapping Task Force Workshop. The specific objectives for the workshop were to:

- Summarize for each participating organization a description of their:
  - Existing data holdings
  - Current data needs
  - Planned data collection efforts
- Perform a gap analysis that compares 2000 priority areas with other recent (within past 6 years) data collection efforts to identify priority areas where data are still missing.

- Create a prioritized list of areas to be mapped for all state waters and for the Central Coast Project Area
- Summarize recommendations from standardization of mapping protocols and dissemination of mapping data
- Propose strategies or opportunities for leveraging funds for data acquisition, using in-kind resources (staff, equipment, etc.) and matching funds

The workshop objectives were to be met by having the stakeholders complete the following tasks during the two-day event:

- Provide overview of state of knowledge related to marine habitat mapping
- Identify common needs for habitat maps and data coverage
- Define appropriate scales of resolution and coverage based on specific needs
- Discuss and develop guidelines for the applications of various habitat mapping technologies and methods based on specific information needs
- Develop guidelines for the application of various habitat classification schemes based on specific information needs
- Develop guidelines for the application of various methods of mapping data analysis and interpretation required to support different habitat classification schemes
- Review and adopt GIS metadata and quality control standards for mapping data
- Define procedures for processing and inclusion of existing & pending data sets
- Identify mapping data gaps
- Define criteria for prioritizing sites for mapping
- Prioritize sites to be included in future mapping efforts based on current information needs
- Specify methods for filling data gaps
- Discuss and recommend strategies for archiving and dissemination of mapping data and products

4.2 WORKSHOP STRUCTURE

In order to meet the objectives, conference organizers gathered lists of agencies' data needs and data holdings prior to the workshop to help foster a discussion of common needs and holdings at the conference. As in the 2000 Habitat Task Force Workshop, the organizers designed a data needs survey and data holdings survey using the California Department of Fish and Game statistical fishing blocks as a means of subdividing the California state waters into definable units (see Appendix A). In this way, data could be easily quantified to show gaps in data holdings as well as overlaps in areas of common interests. The invited resource agency representatives were provided with maps of the fishing blocks and were asked to identify where (in which blocks) they needed habitat information and where they already possessed existing data. This information was then summarized and provided in both tabular and map format for discussion at the meeting.

The meeting was coordinated to meet all of the objectives in the two-day timeframe (see meeting agenda Appendix A). A large group discussion was held on the need for habitat maps and the importance of seafloor mapping to obtain the habitat information. Using the information collected prior to the workshop, breakout groups identified important fishing

blocks and added them to the list of mapping needs and holdings in each region (Northern, Central, and Southern), and ranked the list to define the highest priority blocks for mapping in each region.

4.3 PRE-WORKSHOP ASSESSMENT

4.3.1 Identifying Potential Invitees

The meeting was publicized as an important event designed to extend and update the 2000 California Marine Habitat Mapping Task Force effort to create a multi-agency cooperative aimed at producing a comprehensive habitat map of the California continental shelf. The primary difference was that the focus of the 2005 workshop was exclusively on mapping within California State Waters. The meeting design included those agencies and organizations with a vested interest in mapping California marine habitats. Within those agencies, meeting organizers sought to identify the most qualified experts to represent the needs of their institutions (Appendix B). An invitation outlining the meeting scope was sent out to a limited number of agencies throughout California. The response was overwhelmingly positive. Agencies and representatives that accepted the invitation were sent follow-up materials in preparation for the workshop.

4.3.2 Invitation & Survey Materials

After accepting their invitation, the workshop participants were asked to provide a preliminary assessment of their agencies' data holdings, as well as mapping needs and selection criteria. Survey sheets and reference maps were provided to each participant, as well as a list of suggested guidelines for selecting and prioritizing mapping areas (Appendix A).

This information on regional data needs and holdings was compiled into maps and tables in advance of the workshop to show the distribution of existing or planned data sets (Appendix A). The summaries were used to perform a data gap analysis that was presented at the beginning of the meeting and used to focus the discussions on setting mapping priorities and data sharing. In this document, marine habitat mapping is defined as ‘spatial quantification of those physical parameters of greatest value in defining seafloor habitat (e.g. depth, substrate type, slope, and aspect)’.

4.3.3 Data Needs & Data Holdings Instructions & Worksheets

Data holdings were acquired from each institution in order to identify areas of potential overlap for data sharing and new data acquisition. Representatives completed one data holding worksheet for each specific area for which their institution had existing habitat, substrate, or multibeam bathymetry data, or plans for obtaining those data; describing where, why, what, how, and when the mapping was or would be done. The data holdings locations were marked on a single fishing block map for each region.

For addressing data needs, the attendees were asked to list all of the reasons that their agency would want a site or sites mapped. Examples of these reasons included: areas of use conflict, areas of multiple use (potential conflict), designated areas (special use, harvest areas, reserves, preserves, sanctuaries, etc.), areas of high political interest, high use areas, and agency-specific management priorities.

Each institution completed one data needs worksheet for each specific area in which they had habitat mapping needs. On this worksheet, representatives described in detail where they needed to map (in some cases, mapping needs were less than one fishing block, and in other cases the needs spanned many blocks), why they needed to map (including their mapping criteria), what type of data they need (bathymetry, sidescan sonar, substrate type, etc), what resolution they needed the data at, and how and when the mapping should be done.

4.3.4 Defining Mapping Sites

Discussions of mapping needs were conducted at several different regional scales. Because the sponsor's highest short-term need was related to the pending Central Coast RFP, this area (Monterey Bay to Bodega Bay) was singled out for separate discussion and voting. Additional group discussions were then held separately for California coastal waters north and south of the Central Coast RFP Area. Priority voting was conducted at two spatial scales: statewide including all state waters, and for the Central Coast RFP Area. The existing 10' CDFG statistical fishing block designations were used to define priority areas for marine habitat mapping within the larger regions.

4.4 WORKSHOP SESSIONS

During registration on the first day of the workshop each attendee was provided with a folder containing the meeting agenda, anticipated attendee list, summary sheets and maps of data holdings and needs, blank maps with designated fishing blocks and worksheets for contributing additional information on data needs and holdings.

4.4.1 Updates on Seafloor Mapping Technology, Coverage & Analysis

A primary goal of the workshop was to provide all participants with an update and overview of the capabilities, limitations and applications of current seafloor mapping technologies. This goal was accomplished through a series of invited presentations by many of the attendees, as listed in the workshop agenda (Appendix A). These presentations have been placed online at the workshop website hosted by the CSUMB Seafloor Mapping Lab and the NOAA funded CSU CICORE Program (http://seafloor.csumb.edu/StrategicMappingWorkshop.htm).

4.4.2 Data Needs and Holdings Update

Each participant was given the opportunity to discuss their institutions mapping needs and holdings and add to the needs and holdings databases developed from the pre-workshop surveys. Note takers recorded the content of these discussions, and the summarized notes are provided with the final report (Appendix B). A major finding from these discussions was not only the great breadth of reasons for mapping, but also how many of these reasons were shared by all attendees.

4.4.3 Identification of Priority Habitat Mapping Locations

A facilitated discussion was held for participants to describe their data holdings and needs for the Central Coast RFP Area, and two breakout sessions were held for the regions north and south of the Central Coast RFP Area. The three working sessions began with the facilitator reviewing wall-size tables and maps summarizing the pre-workshop

surveys and proposing guidelines & criteria for additional site selection based on the second workshop notice information.

Based on priority block identification for each separate region, participants were instructed to determine block priorities based on specific economic and environmental habitat parameters/ criteria (e.g. fishery management, parallel use conflicts, zoogeographical importance, etc) for all regions and blocks (Ballots in Appendix A). Each participant was given 10 priority "dots" (represented by stick-on dots number-coded by agency) to assign to regional blocks and criteria where they felt habitat-related data were lacking. Wall-sized data tables (Worksheet A) were used to capture "dot" assignments. Participants could assign one or more votes (dots) to any location (fishing block) for which they wished to raise the mapping priority; multiple votes could be assigned to a single block in order to place more emphasis on the need for new data in that location.. Dots were tallied after final voting to rank individual blocks. This process was carried out twice, once for the Central Coast RFP Area, and once for all State Waters.

5 RESULTS

5.1 PARTICIPANTS

Of the more than 65 invited participants, 56 attended the workshop despite the very short notice, indicating a high interest in and need for the event. The participants represented 38 individual institutions (Appendix B), including regional, state and federal resource management agencies, universities, research institutions, NGO’s and private industry, all sharing a vested interest in the development of comprehensive seafloor map products and information for the California state waters.

5.2 DATA HOLDINGS UPDATE

Prior to and during the workshop, attendees were asked to identify any additional data holdings not already represented on the pre-workshop data holding coverage maps provided to them by the organizers (see Appendices A: Pre-Workshop Documents). The Data Holdings Coverage Map for the Central Coast RFP Project Area was updated with these additions and is shown in Figure 1.

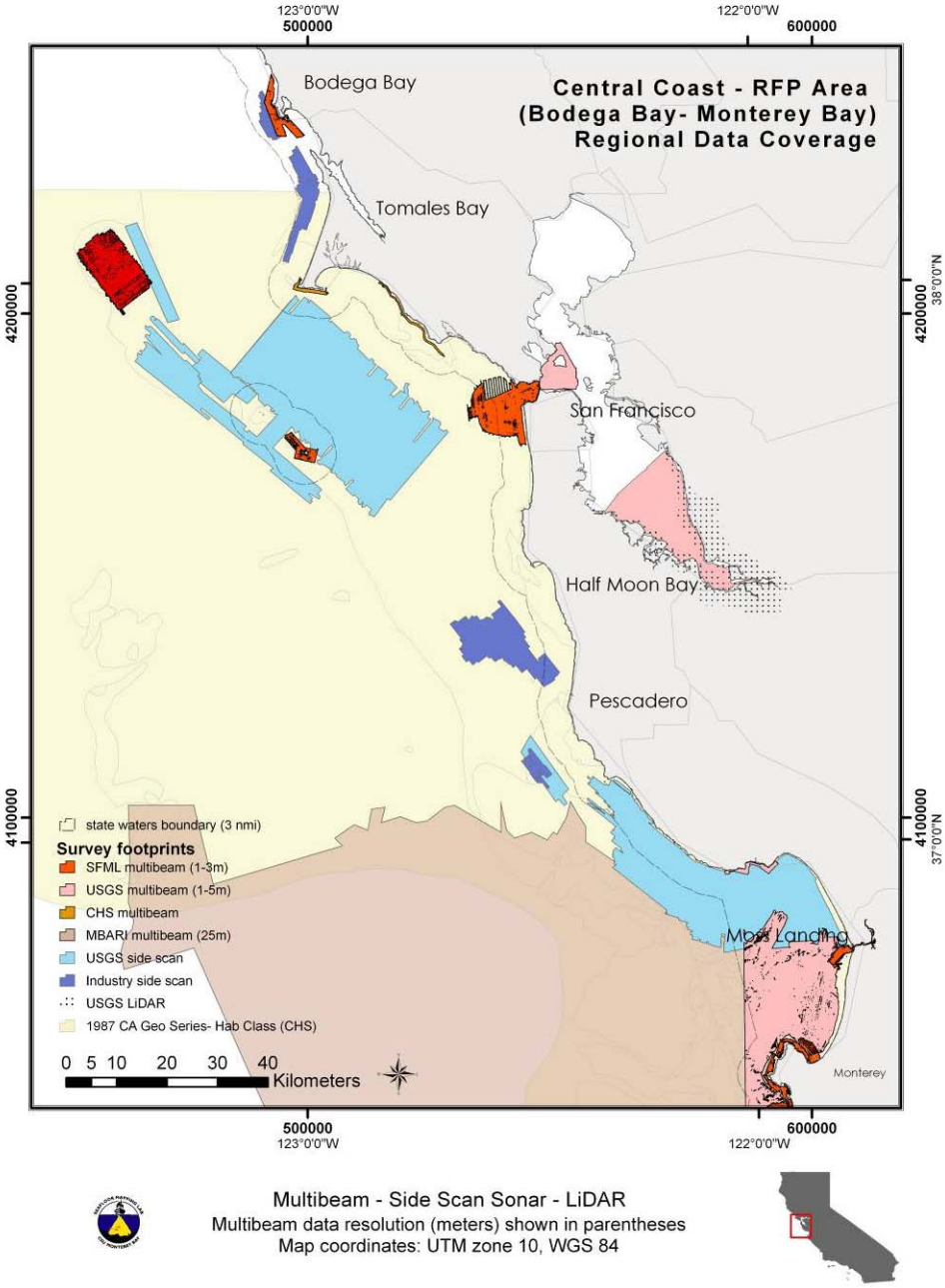


Figure 1. Updated Data Holdings Coverage Map for the Central Coast RFP Project Area showing both multibeam (warm colors) and sidescan (blues) sonar data sets. The dotted area shows LIDAR coverage. Maximum horizontal resolution of the data sets are listed in the legend. The only additions to this area within state waters (3nm) are the relatively small contributions in the immediate vicinity of Point Reyes and along the Santa Cruz shoreline (N. Monterey Bay).

5.3 DATA INFORMATION & NEEDS

The group discussion regarding the needs for and applications of mapping data by the participants demonstrated not only a pressing need for such information, but also a remarkable diversity of needs shared by many of the agencies represented (Appendix B – Data needs group discussions notes). There was a surprising and near universal consensus

expressed regarding the need for bathymetric and habitat information for the intertidal and shallow subtidal depths (+2 m to -8 m water depths) to support a wide array of applications. (It was also noted that this depth range has traditionally been the most difficult and expensive in which to obtain high resolution data, but that new technology, e.g. Light Detection and Ranging (LIDAR) [see below] may be changing this situation.) Common seafloor mapping data need themes expressed in these discussions included:

- MPA mapping in support of the MLPA process
- Environmental monitoring
- Sediment transport dynamics (erosion, deposition and beach nourishment)
- Geologic hazards (faults and landslides capable of producing tsunamis)
- Habitat maps for fisheries management & stock assessment
- Base maps for environmental change detection via repetitive mapping
- Safe navigation in shallows, bays, harbors and estuaries
- Habitat maps of existing marine protected areas
- Identification of biological hot spots (especially areas of high relief, submarine canyons and shelf break)
- Economical sources of sand
- Data to support wave, current and oil spill impact prediction models
- Location of ship wrecks with potential for oil leaks
- Location of derelict fishing gear

This diversity in the need for and application of marine mapping data is reflected in the results for the statewide and central coast RFP area priority voting (Figures 2 and 4, and Appendix B Tables 2 and 3). The highest ranking needs for statewide and central coast mapping identified by the participants were: baseline maps for monitoring and assessment (53% and 59%), identification of critical natural areas or biological hot spots (15% and 9%), fisheries management (9% and 5%), and use conflicts and impact analysis (8% and 4%).

5.4 PRIORITY VOTING FOR FUTURE MAPPING

The results from the priority voting exercise were compiled and are presented below in table and map formats. The rationale for future mapping efforts have already been discussed in the section above, and are presented in Figures 2 and 4, Appendix B Tables 2 and 3.

5.4.1 Statewide Priority Voting Results

In the state-wide voting exercise, 6 of the top 11 blocks were in southern California (Ventura and Oceanside), 2 were at San Nicolas Island, two along the central coast (Big Creek Reserve and Cambria) and one in northern California (Trinidad Head) (Table 1). Other areas of high interest can be seen in on the Statewide Priority Block Map (Figure 3). It should be noted, however, that there is reason to believe that a significant number of participants constrained their statewide voting choices to fall outside of the Central Coast RFP Area, thinking that the Central Coast RFP Area blocks had already been considered during that voting exercise. Thus, the relative weighting of blocks within the Central Coast RFP Area blocks during the statewide vote may be somewhat underrepresented.

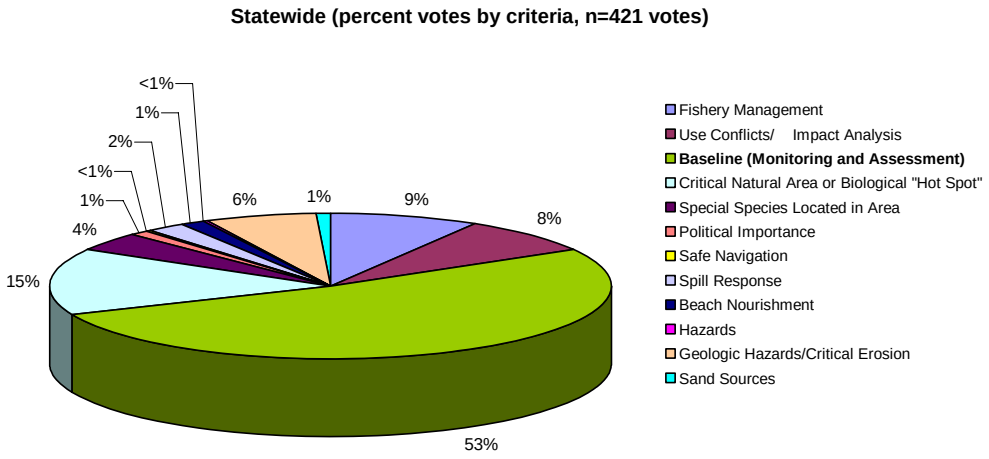


Figure 2. Distribution of statewide priority mapping votes by management/information need criteria.

Block #	General Location	Votes
664	Ventura	16
822	Oceanside	14
665	Ventura	13
683	Ventura	12
813	San Nicolas Island	12
814	San Nicolas Island	11
602	Cambria	11
132	Trinidad Head	10
547	Big Creek Reserve	10
801	Oceanside	10
821	Oceanside	10

Table 1. State-wide priority voting results: Top 11 blocks identified in state waters (0-3nm) for mapping based on state-wide priority voting exercise.

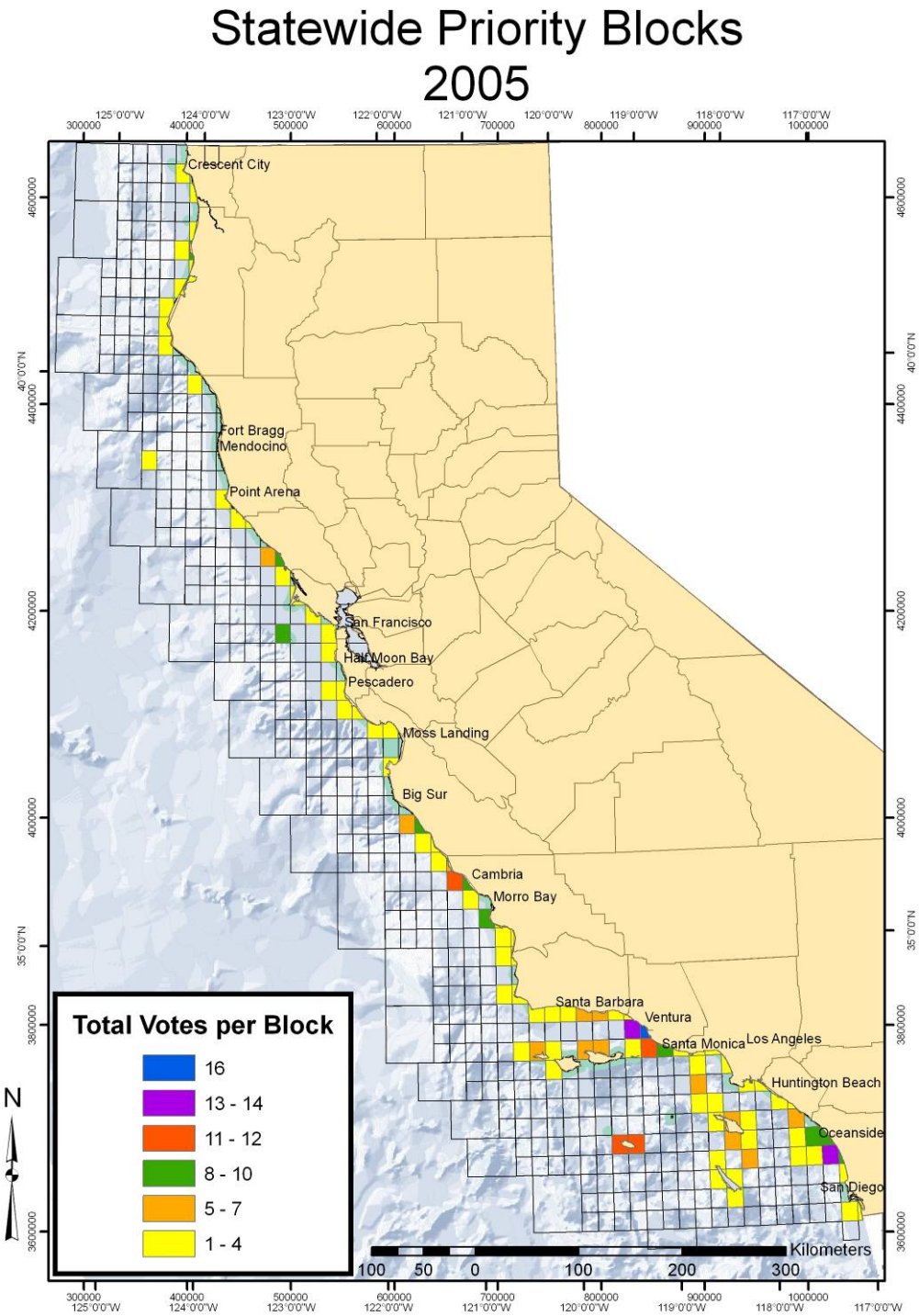


Figure 3. Spatial distribution of number of votes cast per block for state-wide priority mapping needs.

5.4.2 Central Coast RFP Area Priority Voting Results

In the Central Coast RFP Area voting exercise, the majority of the votes fell within blocks along the coast between Año Nuevo and just north of the Golden Gate, and around

the Farallon Islands (Table 2). Other areas of high interest can be seen on the Central Coast RFP Area Priority Block Map (Figure 5).

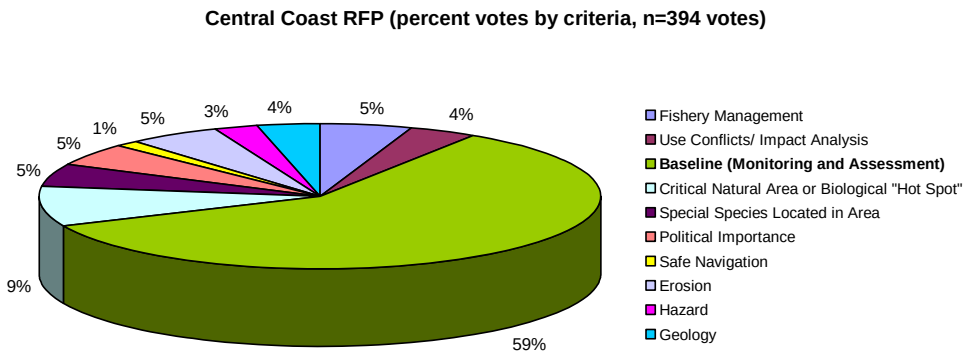


Figure 4. Distribution of Central Coast RFP Area priority mapping votes by management/ information need criteria.

Block #	General Location	Votes
464	N. of Half Moon Bay	55
446	N. of Golden Gate	35
478	Pt. Año Nuevo	34
455	S. of Golden Gate	32
502	S. of Año Nuevo	28
472	Half Moon Bay	27
458	Farallon Islands	23
422	Bodega Bay	20
438	N. Pt. Reyes	15
431	Dillon Beach	14

Table 2. Central Coast RFP Area priority voting results: Top 10 blocks identified in state waters (0-3 nm) for mapping based on Central Coast priority voting exercise.

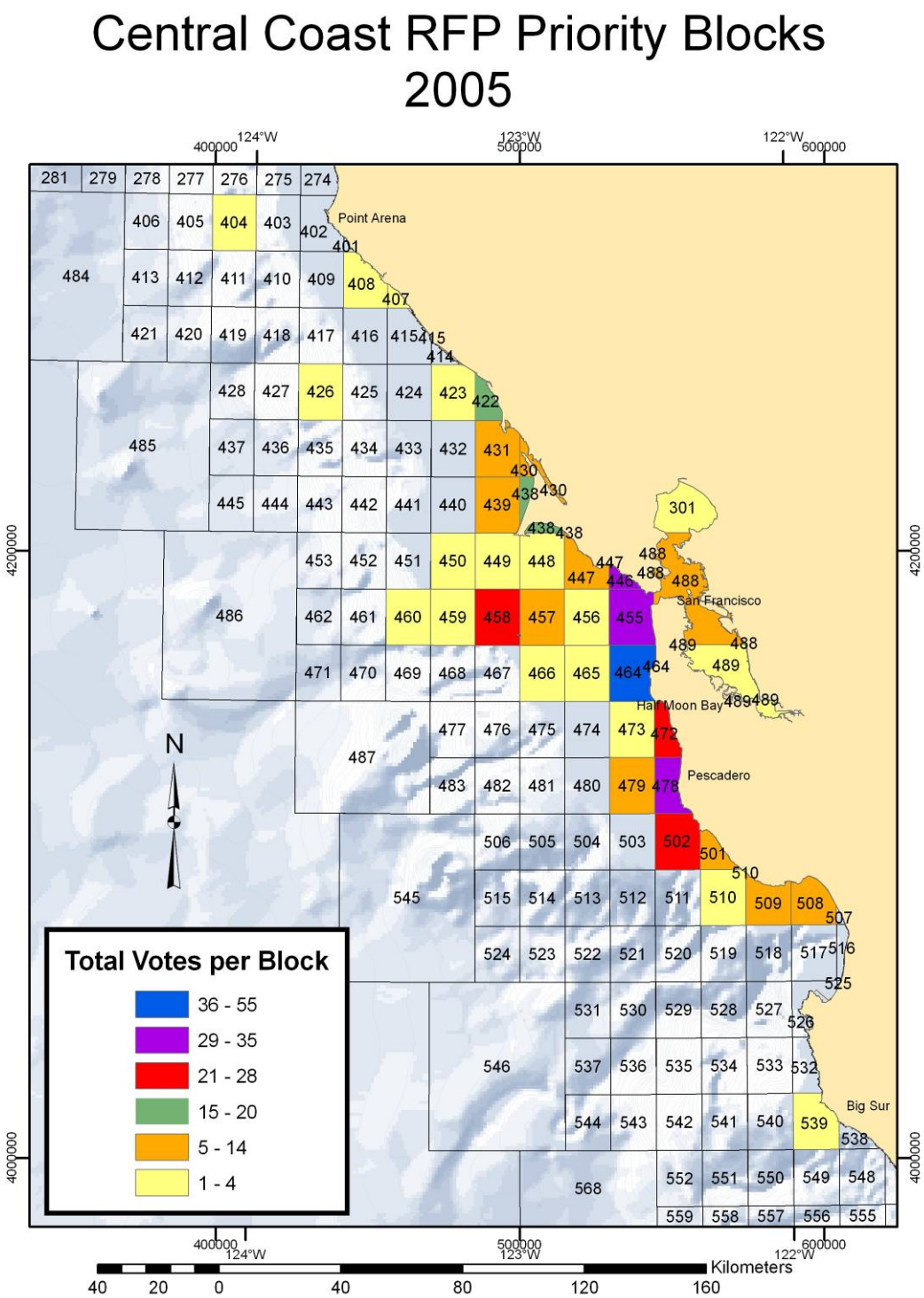


Figure 5. Spatial distribution of number of votes cast per block for the Central Coast RFP Area (Monterey Bay to Bodega Bay) priority mapping needs.

6 RECOMMENDATIONS

During the group and breakout sessions the participants considered and made specific recommendations regarding critical elements key to the success of a statewide mapping effort. These elements included: data acquisition, level of interpretation, metadata, archiving and dissemination. Notes of these discussions were recorded, summarized, and returned to the participants after the workshop for review, edits and augmentation. The final versions of the workshop notes are provided in Appendix B. Summaries of the recommendations derived from discussions, notes and subsequent contributions are presented below. These recommendations generally fell into two categories, 1) minimum necessary and 2) highly desirable, reflecting the groups' acknowledgement that resources available for comprehensive mapping of state waters are likely to be limited.

6.1 DATA ACQUISITION & BASIC PRODUCTS

Given the application and information needs described by the participants and outlined above, there was consensus that the minimum universal seafloor mapping information should include seabed geomorphology (relief via xyz digital elevation model - DEM) and texture (substrate type). These two data sets are the minimum needed to support basic habitat classification. It was also noted, that adequate ground truthing (e.g. via video or physical samples) of acoustic and optical remote sensing data used to create the DEM and surface texture data sets would be needed to verify the classifications. Where appropriate and possible, subsurface structure (sediment thickness and stratigraphy via subbottom profiles & coring) would be highly desirable.

In terms of data quality and resolution, the consensus was that all data acquisition should meet or exceed International Hydrographic Organization (IHO) Order 1 standards, and be carried out at the maximum resolution obtainable using state-of-the-industry tools. It was agreed that coverage should include all "lands" from the shore strand line (MHHW) out to the 3 nm state water limit. The participants acknowledged that obtaining this coverage will require the application of multiple acquisition sensors including acoustic (e.g. multibeam echo sounder [MBES]) and optical (e.g. LIDAR, hyperspectral, multispectral).

There was also considerable discussion devoted to geospatial accuracy and geodesy, with the recognition that the best available positioning instrumentation be used (e.g. high-precision kinematic GPS), and that a common vertical datum be agreed on and used. The consensus among the most experienced surveyors present was to do all bathymetric and topographic surveying on the ellipsoid (e.g. ITRF or WGS84), thereby facilitating more accurate tidal corrections, data fusion and conversion to other datums.

Following, we present the general recommendations from the group along with explicit examples of survey specifications for multibeam bathymetry (multibeam echo sounder [MBES]) and LIDAR surveys required to support the identified mapping information and product needs, allowing the highest quality data affordable. The mapping standards stated here should be regarded as important guidelines subject to negotiation and discussion among funding agencies and data acquisition partners.

6.2 SURVEY SPECIFICATIONS – GENERAL RECOMMENDATIONS & RATIONALES

The consensus from the survey specification and data acquisition breakout group was that the collection of hydrographic data within state waters should generally adhere to the International Hydrographic Organization (IHO) Order 1 survey specifications (IHO SP-44, 1998)(Table 3 and Appendix C). The specifications for hydrographic surveys classified as Order 1 are intended for harbors, harbor approach channels, recommended tracks, inland navigation channels, coastal areas of high commercial traffic density, and are usually in shallower areas lower than 100 meters water depth. The participants noted several advantages of selecting IHO Order 1 as the standard for all coastal seafloor mapping within state waters, even though depths in excess of 100 m commonly occur within 3 nm of the shore:

1. The IHO standards are well established and in current use by NOAA and its contractors in coastal waters (see below).
2. The IHO standards are sufficiently rigorous to ensure the accuracy and resolution of data required to support the creation of final products deemed essential to the users (i.e. positional and vertical accuracy, and feature discrimination needed to support detailed habitat and geology interpretation).
3. Although IHO standards were developed primarily to support safe navigation, and thus relax accuracy and resolution requirements at greater depths, the higher vertical and horizontal resolution specified in Order 1 are desirable in the case of habitat mapping.
4. Where necessary, Order 1 standards can be modified to meet the product requirements for individual project areas according to the needs of the sponsor contracting or otherwise supporting the work. For example, the more rigorous IHO Special Order may be deemed appropriate for some shallow areas of highly complex topography due to its potential value as habitat.

Details of IHO specifications can be found in the following document, *International Hydrographic Organization's Standards for Hydrographic Surveys, Special Publication 44, Fourth Edition, April 1998* (http://www.iho.shom.fr/publicat/free/files/S-44-eng.pdf, Appendix C).

The National Oceanographic and Atmospheric Administration (NOAA) National Ocean Service (NOS) implementation of IHO Order 1 specifications is described in the following, *HYDROGRAPHIC SURVEYS SPECIFICATIONS and DELIVERABLES (March 2003)* (http://chartmaker.ncd.noaa.gov/hsd/specs/specs.htm, Appendix C).

6.2.1 Variance with IHO Order 1 for habitat and geologic mapping

While the participants endorse general adherence to IHO Order 1 standards for state water mapping, it was noted that the standards for data acquisition and processing associated with hydrographic mapping for safe navigation are not necessarily the most appropriate for geologic and habitat mapping. For example, while lower resolution (system detection capability) is not required for navigation mapping below 40 m water depth because there are no ship keels that reach that depth, if the data are to be used for habitat and geologic mapping, it is desirable to retain as much resolution of habitat relief

and complexity as possible (Figure 6). There are also differences between the IHO published standards and NOAA's NOS implementation of them (NOAA 2003). These differences are generally due to the greater specificity of the NOS standards, but also reflect NOS's primary mission of supporting safe navigation through established national charting conventions rather than habitat or geology mapping. Because the goal here is to provide hydrographic survey specification guidance for projects aimed primarily at habitat and geology mapping, and not to supplant the excellent hydrographic mapping already being done by NOS in support of safe navigation, the following recommendations are offered that either augment or are at variance with established NOS and/or IHO practice.

Horizontal Accuracy

Recommendation: Increase horizontal accuracy from 5m + 5% of depth to 2m + 5% of depth.

Rationale: With the advent of generally available high precision differential GPS (RTK and satellite correction services) it is now possible to greatly exceed the precision and accuracy of the conventional DGPS correction. Rather than the conventional DGPS error of 2-5 m, newer generations of widely available correction technologies have reduced horizontal error to 15 cm worldwide. By requiring habitat mapping surveys to take advantage of these improvements in navigation positioning, higher horizontal accuracy than IHO Order 1 can be met and greater discrimination of seafloor features will be enabled.

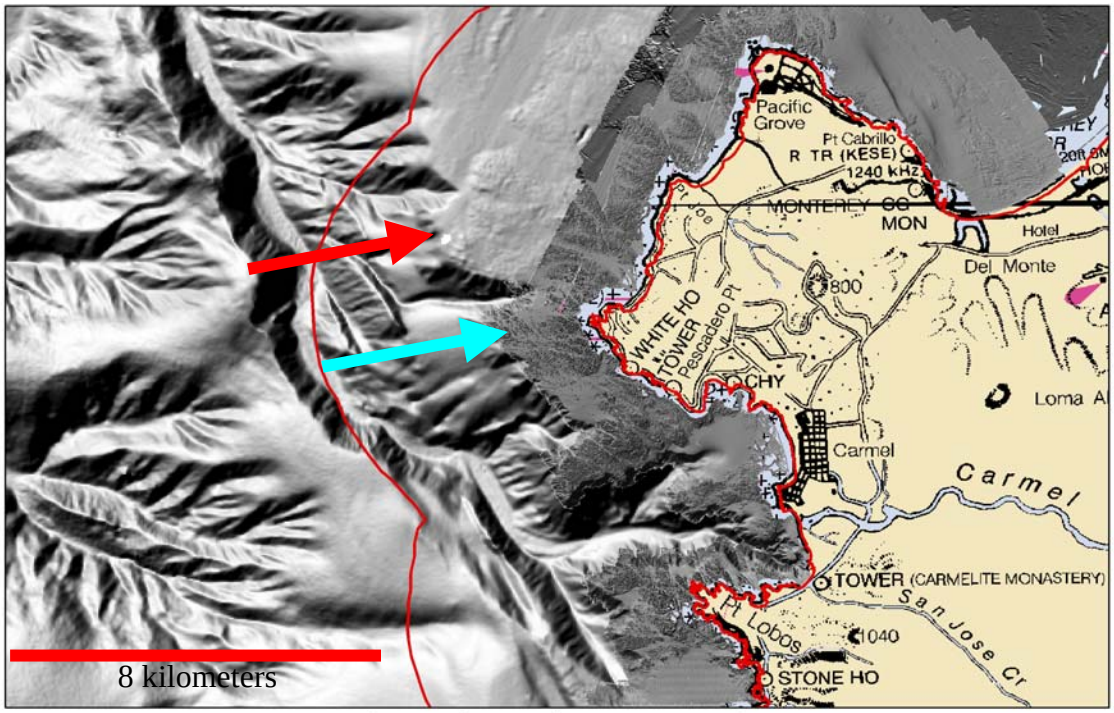


Figure 6. Composite DEM from multibeam sonar data illustrating the differences in discrimination ability between data sets collected and difference spatial resolution (red arrow points to 5m resolution offshore data, and blue arrow to 2 m resolution inshore data). (Source: MBARI and CSUMB Seafloor Mapping Lab).

Coverage

Recommendation: Full (100%) bottom coverage is compulsory for all areas.
Rationale: Because the mission is to map and identify the distribution and patch size of habitat and substrate types within state waters, 100 % coverage is necessary.

System Detection Capability

Recommendation: Increase detection of Cubic features from > 2 m in depths up to 40 m; 10% of depth beyond 40 m, to Cubic features > 2 m in depths up to 40 m; 5% of depth beyond 40 m.
Rationale: The use of the 40 m transition depth in the IHO standards was due to ship keels not reaching below that depth, and previous limits to resolution of bathymetric mapping systems. Not only is it desirable to achieve higher feature discrimination in habitat and geology surveys at greater depths, but recent advances in multibeam sonar technology (e.g. narrower beam widths) are able to support this need.

Horizontal Datum

Recommendation: All positions will be referenced to the World Geodetic System of 1984 (WGS 84). This datum must be used throughout a survey project for everything that has a geographic position or for which a position is to be determined.
Rationale: Given the expressed need for data fusion requiring the merging of multiple data sets and time series within GIS for change detection, definition of legal and jurisdictional boundaries, and policy decisions, use of a common datum will greatly reduce the likelihood and propagation of errors. The WGS 84 datum is the standard for GPS and thus the most universal. This universality has lead to the development of many highly reliable tools for translating it into other reference frames as required.

Sounding Datum

Recommendation: All sounding data will be reduced to North American Vertical Datum of 1988 (NAVD88) and local MLLW.
Rationale: The workshop participants repeatedly expressed great interest and need for merging marine and terrestrial data sets to address coastal zone patterns and processes that cross the land-sea interface. Most terrestrial terrain data and maps are commonly in datums related to geoid models (e.g. NAVD88, NGVD27). Whereas, marine bathymetry is generally reported and charted in reference to local tide datums, most often mean lower low water (MLLW). These differences in vertical datums make merging marine and terrestrial data sets more difficult and error prone, often leading to artifacts that appear as large vertical offsets in the map products or change detection analyses.

Now, with the rapid advancement of GIS and GPS technologies, it is possible to conduct hydrographic surveys “on the ellipsoid”. High-precision GPS (e.g. RTK, satellite correction services, Kinematic post-processing) enables soundings to be referenced directly to WGS84 or ITRF ellipsoids over the entire survey area. These values can then be converted to NAVD88 using current geoid models that specify the separation between the ellipsoid and geoid as it varies across the entire survey area. Once in NAVD88, it is possible to convert the soundings to a local tidal datum of choice depending on need.

As stated in IHO SP-44: "In order for the bathymetric data to be fully exploited in the future using advanced satellite observation techniques, tidal observations should be related both to a low water datum and also to a geocentric reference system, preferably the World Geodetic System 84 (WGS 84) ellipsoid."

Because the local tidal models and data are derived from a fixed location, the vertical accuracy of the sounding data declines with distance from the tidal station. This decline can be dramatic in topographically complex underwater terrain due to significant changes in tidal heights over small distances. Rather, by recording the soundings with respect to the ellipsoid and then converting to the geoid, both of which the spatial variation is tractable and known to a high level of accuracy, a much higher level of vertical accuracy and precision can be achieved across and between data sets.

Ground-Truthing

Recommendation: Some physical (e.g. grab) or visual (video) sampling should be conducted for all major substrate types identified in remotely sensed data from a given survey area. This recommendation is similar but more broadly defined than in the IHO standards. The particular seafloor characteristics of the surveyed area and the level of validation required circumscribe the frequency, density, and method(s) selected for obtaining ground-truth samples.

Rationale: Habitat differences of biological or geological significance cannot always be fully discerned from remotely sensed data.

Table 3. Summary Table of Minimum Standards for Hydrographic Surveys: IHO Orders (IHO SP-44, 4th edition, 1998) and Workshop Recommendations

Order	Special	Workshop Recommendations	1	2	3
Examples of Typical Areas	Harbors, berthing areas, and associated critical channels with minimum under keel clearances	All state waters from MHHW out to 3 nm.	Harbors, harbor approach channels, recommended tracks and some coastal areas with depths up to 100 m	Areas not described in Special Order and Order 1, or areas up to 200 m in water depth	Offshore areas not described in Special Order, and Orders 1 and 2
Horizontal Accuracy (95 % Confidence Level)	2m	2 m + 5% of depth	5 m + 5% of depth	20 m + 5% of depth	150 m + 5% of depth
Depth Accuracy for Reduced Depths (95% confidence level)[1]	a = 0.25 m b = 0.0075	a = 0.5 m b = 0.013	a = 0.5 m b = 0.013	a = 1.0 m b = 0.023	Same as Order 2
100 % Bottom Search	Compulsory	Compulsory	Required in selected areas	May be required in selected areas	Not applicable
System Detection Capability	Cubic features > 1m	Cubic features > 2 m in depths up to 40 m; 5% of depth beyond 40 m	Cubic features > 2 m in depths up to 40 m; 10% of depth beyond 40 m	Same as Order 1	Not applicable

(1) To calculate the error limits for depth accuracy the corresponding values of a and b have to be introduced into the formula $\pm\sqrt{[a^2+(b*d)^2]}$

6.3 DELIVERABLES

There was universal agreement that any hydrographic mapping done in state waters should be conducted in a manner consistent with the data requirements for producing a wide range of derivative products related to habitat and geology identification and classification, and environmental change detection. Here we summarize the recommendations for the basic raw data types, depth ranges to be covered, and the hierarchy and relative ranking of derivative products required to support these information needs.

6.3.1 Raw Data Types

Three basic data types required to support all the major seafloor habitat/geologic information needs were identified by the workshop participants: topographic relief, surface type, and the thicknesses of surface and sub-surface sediment layers. (Although others were mentioned including water column properties and currents, these three stand out as the most relevant and widely supported.) Topographic relief is derived from bathymetric sounding data, and is most commonly collected using multibeam bathymetric sonar in depths > 5 m (multibeam becomes highly inefficient and unsafe within the surf zone along exposed rocky coasts)(see below for comments and recommendations on other survey methods more appropriate for shallow depths).

Surface or substrate type can be inferred from acoustic backscatter data obtained from sidescan sonar. Most modern multibeam bathymetry systems also collect sidescan quality backscatter data, thus enabling efficient simultaneous collection of both backscatter and bathymetry data along each survey line. The backscatter and bathymetry only provide a 2 dimensional view of the seafloor surface characteristics, and do not provide any information on the thickness of surface sediment layers or the nature and thickness of subsurface sediments. Thus, what may appear as a sandy bottom in the sidescan record may in fact be only a thin layer of sand atop rock or some other sediment type. This distinction can have significant ramifications for those looking for exploitable sand and aggregate deposits or the potential for seabed erosion or disturbance. Acoustic sub-bottom profilers are capable of imaging vertical sections of the seabed along survey lines, and are often run in conjunction with, but separate from multibeam sonar surveys due to the differences in ship speed required. (Towed systems such as sub-bottom profilers, and stand-alone sidescan systems, typically must be run at a much slower survey speed than multibeam systems.)

The consensus was that surface data (substrate type and topographic relief) were the most important and should be collected throughout the state waters. Sub-bottom data, while important in some critical areas, did not need to be collected everywhere, and its collection should more appropriately follow and be directed based on the results from surface mapping surveys.

Recommendation: Backscatter and bathymetry data should be collected for all state waters, using the most appropriate survey technologies for each depth zone needed to meet the stated data specifications. Sub-bottom profiling, while valuable, should be considered a second tier effort; funded as and where needed following examination of surface mapping results.
Rationale: Surface habitat and geology maps are desirable for all state waters. The survey technologies required for surface mapping are far more efficient than sub-bottom profilers, and provide 100% bottom coverage. Sub-bottom profilers only provide data along and directly below the ship track line, and thus their results require the use of surface mapping data to help plan, and extrapolate the results from, profiling surveys.

6.3.2 Coverage

In addition to the depths that fall within the normal efficient working range of multibeam sonar systems, the technology of choice for most hydrographic surveys (> 5-8 m

depending on the nature of the survey area), keen interest was expressed in the need to cover the narrow strip shoreward of this depth up to and including the mean higher high water (MHHW). The most promising (and arguably only) technology for efficiently covering this shallow zone is airborne bathymetric LIDAR, which is capable of yielding both bathymetry and backscatter in accord with IHO Special Order and Order 1 standards, and reflected laser light imagery of the seafloor.

Recommendation: The surf zone and intertidal should be included in the scope of work for all state water mapping designed to support baseline habitat and geologic classification, and change detection. This recommendation is made despite the previous environmental and technological challenges that have resulted in this depth zone being ignored in virtually all previous 100% coverage hydrographic surveys along the California coast.

Rationale: It is now theoretically possible to conduct 100% coverage hydrographic surveys of California shallow subtidal and intertidal habitat. Although bathymetric LIDAR has not yet been fully evaluated for its efficacy along the California coast, the success of this technology elsewhere and the high need for data within this critical, narrow depth zone strongly argue for the use and continued development of LIDAR as a shallow water mapping tool. If, however, other technologies are or become available that are equally capable of meeting the survey standards specified, they too should be considered. The purpose here is not to advocate for a specific technology, but rather to encourage the use of whatever tools meet or exceed the data needs and survey specifications in a cost effective manner.

6.3.3 Products

Although the basic survey data sets and their metadata are fully specified in the IHO Order 1 and NOS standards already recommended as the basis for state water mapping specification, here we emphasize only those most critical to habitat and geologic mapping information needs. A fuller discussion and pro's and con's of the relative rankings of additional derivative mapping products is provided in the section on Interpretation and Habitat Classification.

There was general agreement that the most important initial products of greatest universal value for habitat and geologic mapping are those required for distinguishing surface type and quantifying surface topography (relief). The first order derivatives from the raw survey data that fall into these categories are backscatter mosaics (Figure 7) and sounding (xyz) data. The sounding data, in turn can efficiently and accurately be converted into digital elevation models (DEMs or grids) and used to show the topography of the seafloor in shaded relief (Figure 7), as well as slope, aspect, and contour lines. These initial finished products in georeferenced digital GIS-compatible format, along with all associated metadata and raw survey data sets, as specified by IHO, should be the minimum standard hydrographic products for all state water mapping surveys. In addition, ground truth sampling resulting in georeferenced video and/or physical samples should accompany the initial products in GIS-compatible formats.

6.4 SURVEY SPECIFICATIONS – EXAMPLES FOR MBES & LIDAR SURVEYS

6.4.1 Methodology and Technical Specifications – MULTIBEAM

The following lists specifications, techniques and certifications that are considered mandatory for the best possible data and accuracy requirements available for hydrographic, bathymetric and benthic habitat assessment studies. The details in this section are limited to the fundamental and essential elements of the specifications. Precise details on hardware and software are left to the organization charged with fulfilling the requirement. This survey specification example is based on information provided by Fugro Pelagos Inc. (FPI) based on their experience as a NOAA hydrographic survey contractor and in accordance with their role as an industry representative attendee of the December 2005 workshop. The original FPI submission has been generalized to meet the workshop recommendations on survey specifications and products.

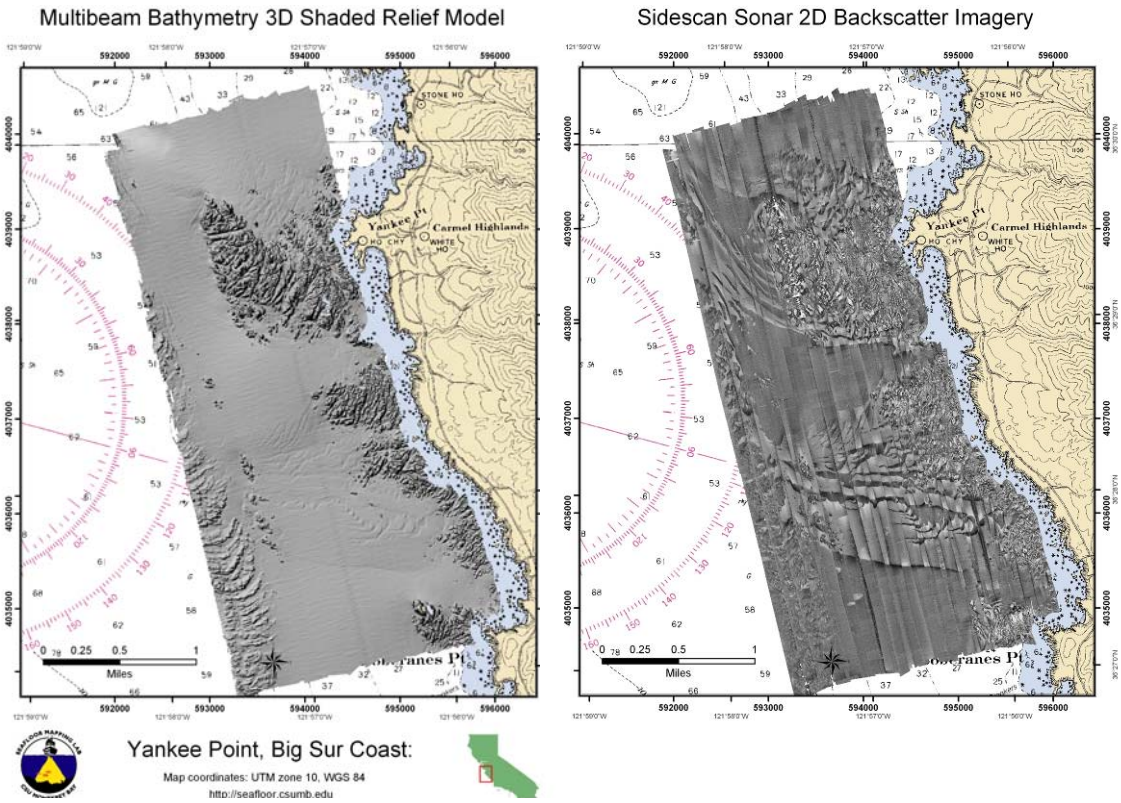


Figure 7. Multibeam sonar survey data from Yankee Point, California. The bathymetry data (xyz) are rendered in shaded relief superimposed on a NOAA nautical chart in ArcGIS, and clearly show the differences between rocky and soft-bottom habitats (left). The sidescan sonar data from the multibeam system for the same site is shown as a mosaic (right) revealing differences in the properties of the surface sediments and substrate textures. (Source: CSUMB Seafloor Mapping Lab).

6.4.1.1 Survey Plan Optimization - Survey Planning Tool

A GIS based Survey Estimator or Planning Tool should be used to plan the survey. This same tool should be provided to the operator and sponsor to aid in its evaluation of the

Survey Plan and aid in its ability to modify the Survey Plan. The Survey Planning Tool should:

- allow the operator and the sponsor to change acquisition parameters and configurations and quickly evaluate the cost or saving implications of the change
- automate various manual tasks in the process of multibeam and LIDAR survey estimation resulting in reduced time to carry out estimates and making results more consistent and less subjective

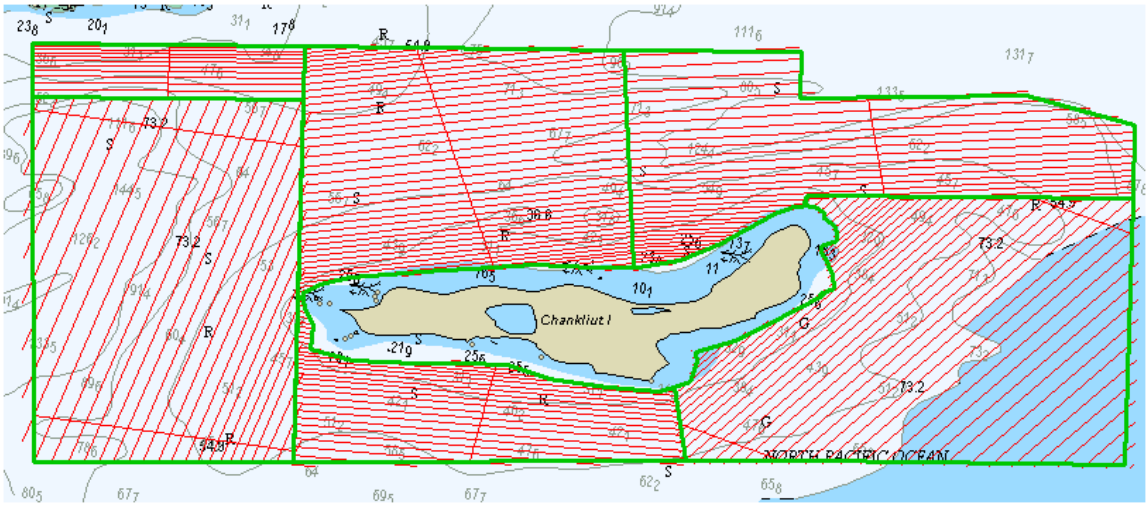


Figure 8: Survey Planning Tool example Line Plan

6.4.1.2 Equipment and Systems

Sounding Accuracy and Density Requirements

Accuracy standards for various types of hydrographic surveys are tabulated in the International Hydrographic Organization (IHO) 1998 Special Publication No. 44, 4th Edition (Table 4). For multiple use data sets, a strict adherence to IHO specifications may not be suitable. Much higher data densities are possible at little or no extra cost at almost any water depth. This additional data density at depths greater than 40 meters is of little use to hydrography for safe navigation, but may be crucial for habitat studies using metrics like rugosity to classify habitat. As shown in Table 5, the majority of the vertical error now comes from tide measurements and water column sound velocity measurements. These error sources can both be minimized well beyond the IHO requirement.

Table 4: Summary of Minimum Standards for Hydrographic Surveys

Order	Special	1	2	3
Examples of Typical Areas	Harbors, berthing areas, and associated critical channels with minimum under keel clearances	Harbors, harbor approach channels, recommended tracks and some coastal areas with depths up to 100 m	Areas not described in Special Order and Order 1, or areas up to 200m water depth	Offshore areas not described in Special Order, and Orders 1 and 2
Horizontal Accuracy (95% Confidence Level)	2m	5m + 5% of depth	20m + 5% of depth	150m + 5% of depth
Depth Accuracy for Reduced Depths (95% Confidence Level) (1)	a = 0.25m b = 0.0075	a = 0.5m b = 0.013	a = 1.0m b = 0.023	Same as Order 2
100% Bottom Search	Compulsory (2)	Required in selected areas (2)	May be required in selected areas	Not applicable
System Detection Capability	Cubic features > 1m	Cubic features > 2m in depths up to 40m; 10% of depth beyond 40m (3)	Same as Order 1	Not applicable
Maximum Line Spacing (4)	Not applicable, as 100% search compulsory	3 x average depth or 25m whichever is greater	3-4 x average depth or 200m, whichever is greater	4 x average depth

(1) To calculate the error limits for depth accuracy the corresponding values of a and b have to be introduced into the formula

$$\pm \sqrt{[a^2+(b*d)^2]}$$

with

a	constant depth error, i.e. the sum of all constant errors
b*d	depth dependent error, i.e. the sum of all depth dependent errors
b	factor of depth dependent error
d	depth

(2) For safety of navigation purposes, the use of an accurately specified mechanical sweep to guarantee a minimum safe clearance depth throughout an area may be considered sufficient for Special Order and Order 1 surveys.

(3) The value of 40m has been chosen considering the maximum expected draft of vessels.

(4) The line spacing can be expanded if procedures for ensuring an adequate sounding density are used.

The following notes apply to multibeam operations that meet or exceed IHO Order 1 specifications:

- To obtain IHO Order 1 accuracy, a local tidal program must be in place; and, sound speed in water must be measured frequently, typically every 2 hours.

- Multibeam data should be motion compensated with systems sufficient to meet the specifications listed in Table 5. (e.g. systems equivalent to an Applanix POS-MV inertial navigation system using Pelagos Precise Timing (PPT) and Applanix TrueHeave®.)

- Sound velocity casts must be carried out using a velocimeter system deployed at regular intervals dependent on rate of change of sound velocity in the survey area.

- Water level recording should be conducted during survey operations as needed to correct soundings for tidal variation.

- A patch test is necessary at a suitable location.

Multibeam Echo Sounder (MBES) data density and coverage

Any multibeam sounder system will deliver different data densities along track and across track. The along track density is controlled by the system ping rate and the vessel speed. Ping rate itself is a function of swath width or swath angle and water depth, and sonar processing time. Most sonars can process all the data they collect without impeding the ping rate. So, this leaves swath angle as the primary driver in ping rate estimations. A well-engineered multibeam should be able to collect data at swaths of 120 – 140 or more degrees.

Across track data density will vary widely between systems. The newest multibeams available have much higher beam densities than systems that are now a few years old. The Reson 7125, for example, can generate 256 equidistant beams at 200 kHz and 512 equidistant beams at 400 kHz. The survey provider should utilize a RESON 8101 or 7125, Simrad EM3000, or equivalent system for water depths up to 200 m. Deeper water systems appropriate for surveys > 200 m could be used, but will necessarily have lower spatial resolution. Depending on multiple combinations for configuration of the MBES system, the total swath of the optimal configuration of the MBES system should be $\geq$ 5.0 times water depth. This is the expected swath width for Survey Plan purposes and estimating the required effort for the overall survey.

Table 5: Achievable RMS error estimates from selected components for sounding TPE calculation. Note: Values stated exceed IHO Order 1 specifications. (Fugro Pelagos, Inc. Proposal No. 2006.006, MBES Survey Specifications)

Error Source	Value	Comment
General		
Positioning system error (m) drms	0.20	RTK GPS or system of equivalent or greater accuracy. (See Positioning below.)
Heading error (deg)	0.02	2 meter GPS antenna base line with Applanix POS/MV or equivalent
Auxiliary sensor errors		
Heave - fixed error (m)	0.05	Using Applanix TrueHeave®, post processed heave solution
Heave (% error of heave Amplitude)	5.00	
Roll (deg)	0.02	POSMV
Pitch (deg)	0.02	POSMV
Vessel-specific errors		
Draught error (m)	0.02	Estimates from RTK GPS (or equivalent) based squat settlement tests
Squat error (m)	0.02	
Loading changes (m)	0.02	
Sensor coordinate offset errors		
Positioning X (m)	0.010	Values are for a detailed vessel offset survey using total station during mobilization while the vessel is in dry dock or on blocks.
Positioning Y (m)	0.010	
Positioning Z (m)	0.010	
VRU X (m)	0.010	
VRU Y (m)	0.010	
VRU Z (m)	0.010	
Transducer X (m)	0.010	
Transducer Y (m)	0.010	
Transducer Z (m)	0.010	
Latency		
Positioning time lag (ms)	0.001	These values are based on Pelagos Precise Timing, such that latencies between position, attitude and heading are zero. A known latency at the sonar of 0.003 seconds is accounted for. The values shown here are overestimates. Variable latency has been eliminated
VRU time lag (s)	0.001	
Transducer time lag (s)	0.001	
Latency (s)	0.000	
Tide and SVP		
Water level error (m)	0.02	These are the largest and potentially most variable components of the error model. Careful planning on the tide program and the use of an MVP for sound velocity can help keep these values near the levels shown here.
Spatial tide prediction error (m)	0.1	
Sound speed sensor error (m/s)	0.5	
Surface sound speed error (m/s)	0.25	

Positioning

Positioning using DGPS with Coast Guard differential correctors is sufficient for most IHO Order 1 surveys. However, positioning using real time kinematic (RTK), satellite based correction services, or inertially aided post-processed kinematic (IAPPK) will greatly improve position accuracy and, in effect, focus the final data products. Both RTK

and IAPPK have an advantage in that they not only improve the horizontal accuracy of the data, but they also improve the vertical accuracy. In cases where tide regimes are complex or not well defined, kinematic GPS processing can allow data analysis to proceed without the errors induced by inaccurate tidal correctors.

Backscatter

The multibeam sonar used for sounding acquisition must also be capable of backscatter collection. The specific sounder needs to be factory calibrated to within 1 dB throughout the entire system (electronics and ceramics). All aspects of the system that effect backscatter amplitude must be documented. Two product types are available from multibeam backscatter: seafloor backscatter reflectivity and water column backscatter.

Seafloor backscatter from each individual beam should be precisely georeferenced and corrected for all documented sounder parameters. The resulting mosaic is an accurate depiction of acoustic seafloor reflectivity at the sonar's frequency. The mosaic resolution must be at least 5x higher than the bathymetry DTM (Digital Terrain Model) resolution. For example, if the bathymetry DTM resolution is 1 meter, the sidescan mosaic resolution must be ≥ to 0.2 meters (20 cm). Some acoustic 'smearing' is acceptable along track.

It is important to note that side scan sonar and pseudo side scan (from some MBES systems) cannot replace beam-specific MBES backscatter (sometimes referred to as snippets) in this capacity.

Sound Speed

Speed of sound in the water column is a vital parameter for accurate multibeam surveying as it affects both the position and depth of soundings. The sound velocity (SV) profile is frequently quantified by the survey crews. During the initial phases of hydrographic survey projects, field crews generally over sample sound velocities. As the project matures and velocity trends become well known, cast frequencies are adjusted to the appropriate levels. Naturally, required cast frequencies are dictated by local conditions.

Vessel Squat

Definitions of squat and settlement vary. For the purposes of discussion here, "squat" will refer to vertical movement at the Common Reference Position (CRP) of the survey vessel as a function of speed through the water. The term "settlement" refers to vertical movement anywhere away from the CRP as a function of vessel pitch changes with changing speed.

A squat test is recommended on every vessel before the start of every survey season. This allows a squat curve to be computed that allows the data sets to be corrected for changes induced in the vessel draft by changes in vessel RPM's or engine loading. Squat data is processed to render a curve of vertical displacement at the CRP as a function of vessel RPM.

Bottom Sampling

Recommended benthic sampling would employ a $0.1m^2$ grab sampler for acquiring bottom sediment samples with relatively few coarse grains. An accepted procedure is as follows, if the grab sampler, when recovered, is closed with no sample, the bottom is deemed to be rock and no additional attempt for a sample made. If it appears the device did not engage when it came in contact with the bottom, an additional attempt should be made to obtain a bottom sample. All samples would be precisely positioned with the vessel stopped in the water. Onboard analysis may comprise of photography, sediment description and classification.

Deliverables

Basic deliverables for multibeam surveys should include:

- Raw data in XTF format
- Processed data in Caris HDCS format
- X, Y, Z data set of all accepted soundings
- DTM of accepted soundings, resolution variable with depth:
  0 – 40 m 1m
  > 40 m 5 % water depth
- Interpretive surfaces from automated GIS analyses of the DTM (e.g. slope, aspect, rugosity, Topographic Position Index [TPI])
- Backscatter Mosaic, resolution varies with depth
  0 – 40 m 20 cm
  > 40 m 10 % water depth
- Metadata compliant with Federal Geographic Data Committee Standards (FGDC) provided with each dataset.
- Report:
  A digital (*.doc) file produced with the final deliverable including: summary maps of areas surveyed, dates of field survey collection, types of equipment and software used, quality control check details, base stations and monuments used for kinematic control and processing, unique circumstances and/or issues related to this survey, general approach/methodology to the survey.

6.4.2 Methodology and Technical Specifications – Airborne Bathymetric LIDAR

As in the previous section on 'Methodology and Technical Specifications – MULTIBEAM', this section summary for employing LIDAR technology (Figure 9) provides general guidelines for discerning optimal survey specifications, techniques, and certifications. Summary information and examples are based on documents provided by experienced industry representatives, Fugro Pelagos Inc (FPI). Again, this assessment is limited to the essential elements of survey requirements (as a bulleted summary) and the projected data products. As a technical guideline for planning though, it is worth pointing out that where possible it would be prudent to schedule the airborne LIDAR bathymetry (ALB) before surveying the inshore with MBES. This allows the MBES surveys lines to be planned around the maximum ALB coverage.

Sensor fusion: LIDAR with hyperspectral or multispectral for bottom type and bathymetry

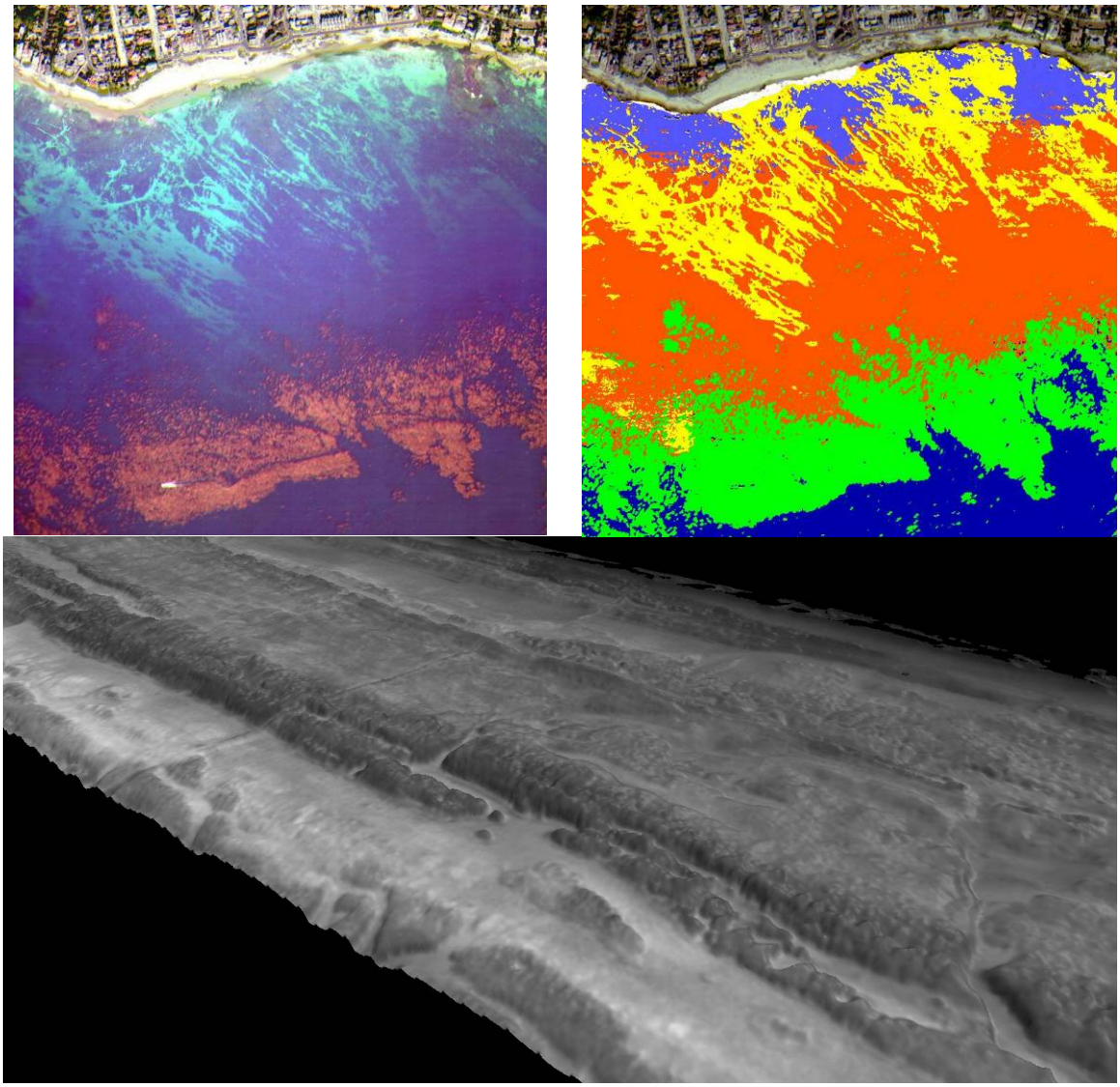


Figure 9. Airborne Bathymetric LIDAR data (bottom) can now be obtained in conjunction with hyperspectral (top left) or multispectral data (top right) for unprecedented coverage and resolution in depths too shallow for the efficient or safe use of conventional acoustic survey techniques. These new techniques provide both bathymetry data and bottom type discrimination via backscatter. (Source: Fugro Pelagos Inc.).

6.4.2.1 Overview

The purpose of this airborne bathymetric (Hydrographic) LIDAR survey specification is to obtain the existing conditions of the beach and near shore in support of the California Coastal Mapping Program.

Compliance: Surveying and Mapping shall be in strict compliance with USACE EM-1110-1-1000 for Photogrammetric Mapping, USACE EM -1110-1-1002 Survey Markers

and Monumentation, USACE EM -1110-1-1003 NAVSTAR Global Positioning System Surveying, USACE EM -1110-1-1004 Deformation Monitoring and Control Surveying, USACE EM -1110-1-1005 Topographic Surveying, USACE EM -1110-2-1003 Hydrographic Surveying, USACE EM -1110-1-2909 Geospatial Data and System, Tri-Services A/E/C CADD Standards, Tri-Services Spatial Data Standards, and Related Spatial Data Products.
Safety: Operations shall be in full compliance with appropriate Federal, State, County, and City safety rules and regulations.

6.4.2.2 Survey Requirements

Hydrographic LIDAR

- Hydrographic LIDAR data are required within the limits specified by the sponsor.
- Data are required from water's edge seaward for 1 km or to laser extinction, which ever comes first.
- Spot density should be a minimum of 2 meters by 2 meters.
- Vertical elevations must be accurate to +/- 25 cm (1 sigma)
- Horizontal positioning must be accurate to +/- 2.5m (1 sigma)
- All flight lines should have a minimum 30 meters planned sidelap with adjacent flight lines.
- At least one cross flight line is required for every 30 km of beach length.
- Maximum depth of LIDAR penetration is dependent upon water clarity; the expected maximum depth of detection is three times Secchi depth. Therefore, the survey should be flown on a day when the weather and water quality can reasonably assure the success of data collection at the survey site.
- Flight lines at or near the land water interface shall be flown within 2 hours of high tide to ensure sufficient overlap with the topographic data.
- Down looking digital camera imagery should be collected at 1Hz to aid in editing and the production of photomosiacs.

Topographic LIDAR

- Topographic LIDAR data are required along the shoreline within the limits specified by the sponsor.
- Data are required from the water's edge inland 500 meters.
- Spot density should be a minimum of 2 meters by 1 meter acquired at an altitude of about 400 meters, or less.
- Vertical elevations must be accurate to +/- 25 cm (1 sigma).
- Horizontal positioning must be accurate to +/- 2.5 m (1 sigma).
- All flight lines should have a minimum 30 meters planned sidelap with adjacent flight lines.
- All topographic data should have 200% coverage with each flight line being flown twice from opposite directions.
- Topographic data collected at or near the land water interface should be flown with 2 hours of low tide to ensure sufficient overlap with the bathymetric data.

- Down looking digital camera imagery should be collected at 1Hz to aid in editing and the production of photomosiacs.

Horizontal Control and Datum

- Any horizontal control used for this project must be referenced to an NGS published monument with a position quality of Class B or better.
- Geographic WGS84 is the recommended datum.

Vertical Control Datum

- Any vertical control used for this project must be referenced to an NGS published monument with a position quality of at least First Order, Class I.
- All data should be referenced to GPS derived ellipsoid heights and converted to NAVD88 orthometric heights using the Geoid03 geoid model. See http://www.ngs.noaa.gov/GEOID/GEOID03/ for geoid information.

6.4.2.3 Quality Control

Quality control measures for both hydrographic and topographic data must adhere to the following specifications,

- Overlapping lines and datasets must be compared to each other and the differences determined. These differences should be within these specifications as outlined in the Survey Requirements Section above.

6.4.2.4 Digital Data

Hydrographic and topographic data must conform to these requirements,

- All necessary computations to verify the accuracy of all measurements and apply the proper theory of location in accordance with the law or precedent must be performed.
- Computation and tabulation of the horizontal and vertical positions to include the application of any GPS kinematic data, tidal or water level corrections for all data collected must be performed.
- A review and edit of the data for discrepancies should be performed.

6.4.2.5 Deliverables

Recommended deliverable data include, but are not limited to the following:

ASCII XYZ Files

- 3 Files: Hydro Laser, Topo Laser Last Return, Topo Laser First Return
- Files containing point data in an ASCII space delimited format. Files containing 6 columns of information: longitude latitude elevation date utc_time and intensity for topographic points or depth confidence for hydrographic points.
- Data referenced to WGS84 and provided in decimal degree geographic coordinates.
- Elevations referred to NAVD88 in meters.

- Metadata compliant with Federal Geographic Data Committee Standards (FGDC) for each associated dataset.

DEM Files

- Digital Elevation Model (DEM) grids provided in a geo-rectified TIFF format
- Created from the ASCII Hydrographic and Topographic Last Return XYZ files.
- Pixel value as an average elevation.
- Pixel resolution at 1m.
- Coordinates should be in WGS84 geographic with elevations in meters and referred to NAVD88.
- Metadata compliant with Federal Geographic Data Committee Standards (FGDC) for each associated dataset.

Shoreline Vector

- Vector delineation of the shoreline, based on WGS84 geographic coordinates and NAVD88 'zero' elevation.
- Contour data provided in ESRI shape file format.
- Metadata compliant with Federal Geographic Data Committee Standards (FGDC) for each associated dataset.

Bare Earth DEM Files

- Digital Elevation Model (DEM) grids in a geo-rectified TIFF format that provide bare earth elevations.
- The input data for this includes first return topographic LIDAR and last return topographic LIDAR data.
- Created with WGS84 UTM coordinates and NAVD88 elevations, both in meters.
- Pixel resolution at 1m.
- Metadata compliant with Federal Geographic Data Committee Standards (FGDC) for each associated dataset.

Ortho-Mosaic Images

- Ortho-mosaic RGB images in MrSID format, created from individual 1Hz down looking images.
- Individual images should have approximately 60% overlap and a pixel resolution of about 20cm.
- Mosaic images should be in WGS84 geographic coordinates.
- Metadata compliant with Federal Geographic Data Committee Standards (FGDC) for each associated dataset.

Reflectance Images

- Georeferenced TIFF images that depict the bottom reflectance as calculated from the green LIDAR signals.
- The image produced in WGS84 UTM coordinate space with 5m pixel resolution.
- Metadata compliant with Federal Geographic Data Committee Standards (FGDC) for each associated dataset.

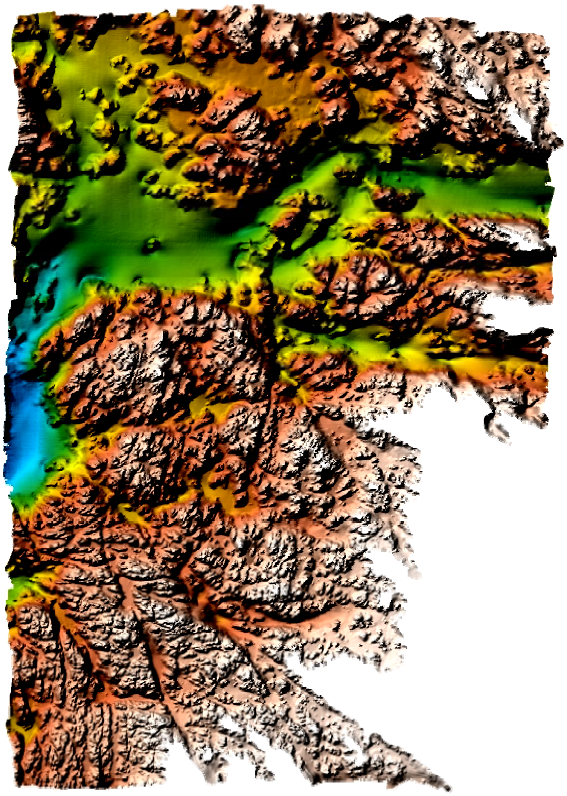
Report of Survey

- A digital (*.doc) file produced with the final deliverable.
- Information to include: summary maps of areas surveyed, dates of field survey collection, types of equipment and software used, quality control check details, base stations and monuments used for kinematic control and processing, unique

circumstances and/or issues related to this survey, general approach/methodology to this survey.

6.5 PRODUCTION RATES

Knowing how much area can be surveyed for the funding available is critical to scoping and defining the specifications for any mapping project, especially when considering all California state waters. Here we present estimates for multibeam sonar and hydrographic LIDAR survey production rates based on the extensive experience of Fugro Pelagos (Figures 10 and 11).



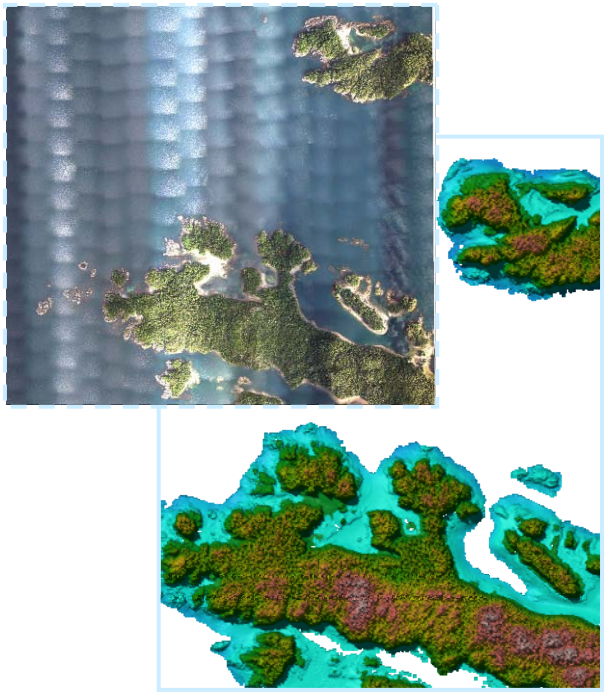
Resolution:
From sub meter to meters depending on depth

Production Rates (IH0 1)

Depth Range	Area Covered (km^2 / day)
0-10m	0.7 (0.35)
10-20m	5.0
20-50m	11.7
50-100m	25.0
100-200m	50.0

Processing days:field days
~ 2.5 - 5:1

Figure 10. Multibeam sonar survey production rates for IHO Order 1. (Source: Fugro Pelagos Inc.).



Bathymetric LIDAR
Raw Production rates
(No Turns)

Resolution (meters)	Area/hr
2x2	13.7 sq km / hr
3x3	30.5 sq km / hr
4x4	50.4 sq km / hr
5x5	76.8 sq km / hr

Real Production Rates vary widely based on:
Turns
Weather
Water Clarity

Figure 11. Bathymetric LIDAR survey production rates for IHO Order 1. (Source: Fugro Pelagos Inc.).

6.6 INTERPRETATION AND HABITAT CLASSIFICATION

Workshop participants acknowledged the ultimate need for and great value in full geologic and habitat interpretation of collected mapping data. However, it was also recognized that mapping is expensive and that the state of California currently has limited financial resources, leading to a debate about where to focus financial resources. The participants fell into three camps as to the minimum level of interpretation and classification that should be funded as part of a large regional mapping project supported with limited resources. The first camp favored reduced field data collection so as to fund maximum interpretation of all survey data collected. Their reasoning was that the data obtained from such a project would be of greatest value to the largest number of users if the results were fully and uniformly interpreted using consistent methods.

At the other end of the spectrum, the second camp recognized that if funds are limited, more interpretation means less area surveyed for a given level of funding. Their thinking was that scarce mapping funds should be allocated to maximize the acquisition of high quality, high resolution data, and the creation of those basic seafloor information layers that can be generated “automatically” and very efficiently using GIS analysis tools (e.g. gridded xyz bathymetry, DEM’s in shaded relief, contour lines, relief and slope analyses, backscatter/sidescan mosaics showing seafloor texture, etc.). Once the basic mapping data and information layers are processed, archived and made available, then the more detailed and labor intensive “manual” interpretation and attributing for specific geological or habitat needs at a specified scale could be conducted. Given the strong interest in and varied institutional needs for these levels of interpretation, the availability

of the basic high quality survey data would induce many institutions to support the additional work needed for the full interpretation of these data.

Taking the middle ground, the third camp endorsed a balanced weighting of data collection and interpretation to maximize field data while simultaneously producing certain thematic maps with high-priority resource management information. Under this scenario, full interpretation recommended by the first camp would only be performed for those areas designated as "high" need sites by the sponsors, while the suite of basic derivative mapping products recommended by the second camp would be applied everywhere else.

Representatives from the US Geological Survey, who have made extensive use of seafloor mapping data to create highly interpreted and classified map products, made the following observations and recommendations. Their approach to costing out a project is to think of mapping product generation as a three-tiered process of increasing project cost, with each tier being constructed from the previous. The first tier consists of the basic survey data (xyz grids [bathymetry] and backscatter [substrate] mosaics. GIS technicians are able to efficiently convert these first tier data sets into second tier products at little additional cost using automated numerical derivatives including autoclassification of substrates and topographic index grids associated with various parameters (slope, aspect, rugosity, contours, relief, etc.). These second tier products are GIS-ready and are often of high value to management agencies because many of the patterns they are interested in (e.g. rocky versus soft bottom habitats, bed forms, and depth zones) are easily discernable at this intermediate level of data analysis. The third product tier requires careful "manual" work of highly experienced geologists to visually interpret the second tier products in terms of detailed and complex geologic and habitat classification schemes to produce attributed GIS polygon map products. USGS has found that this third level of product creation may increase project costs by approximately 50%.

As a result, there are very significant budget and/or survey coverage implications associated with the level of interpretation and map products specified as required in the scope of work for any given project. For example, based on the USGS experience described above, including full third tier product creation in the scope of work could reduce the amount of funding available for data acquisition and thus the size of the overall survey area by as much as 50%. Given these significant implications, we present the following examples of products associated with each of the second and third tiers of map product creation listed above. Because balancing the level of data interpretation versus the size of the area that can be mapped will always be a challenge where resources are limited, our expectation is that given the information needs of the sponsor these examples will help them identify when and where each of these levels of product creation are appropriate.

In the following sections we provide examples of second and third tier data products and in some cases their application to marine management issues. Our hope is that these examples will help the sponsors and planners of future surveys select and define the

appropriate levels of mapping data analysis and interpretation for their particular project needs and applications.

6.6.1 Second Tier Map Products – Algorithmically Derived GIS Products

Second tier map products include those that can be efficiently derived through automated or semi-automated GIS processes from the raw survey data products described above (e.g. bathymetric sounding values, backscatter intensity values). Two of the most common derivatives is gridded bathymetric data (DEMs) displayed in shaded relief (Figure 12). These grids not only clearly reveal the distribution of rock versus sediment to the observer, but they can be further classified with automated GIS tools to reveal and quantify the distribution of a variety of habitat parameters at user-specified scales (Figures 13, 14 and 15). When combined in GIS with sidescan sonar backscatter mosaics that illustrate differences in surface texture (Figure 12), automated analyses of seafloor relief and bottom type can be used to create species-specific and scale independent habitat maps (Figure 15 and 16).

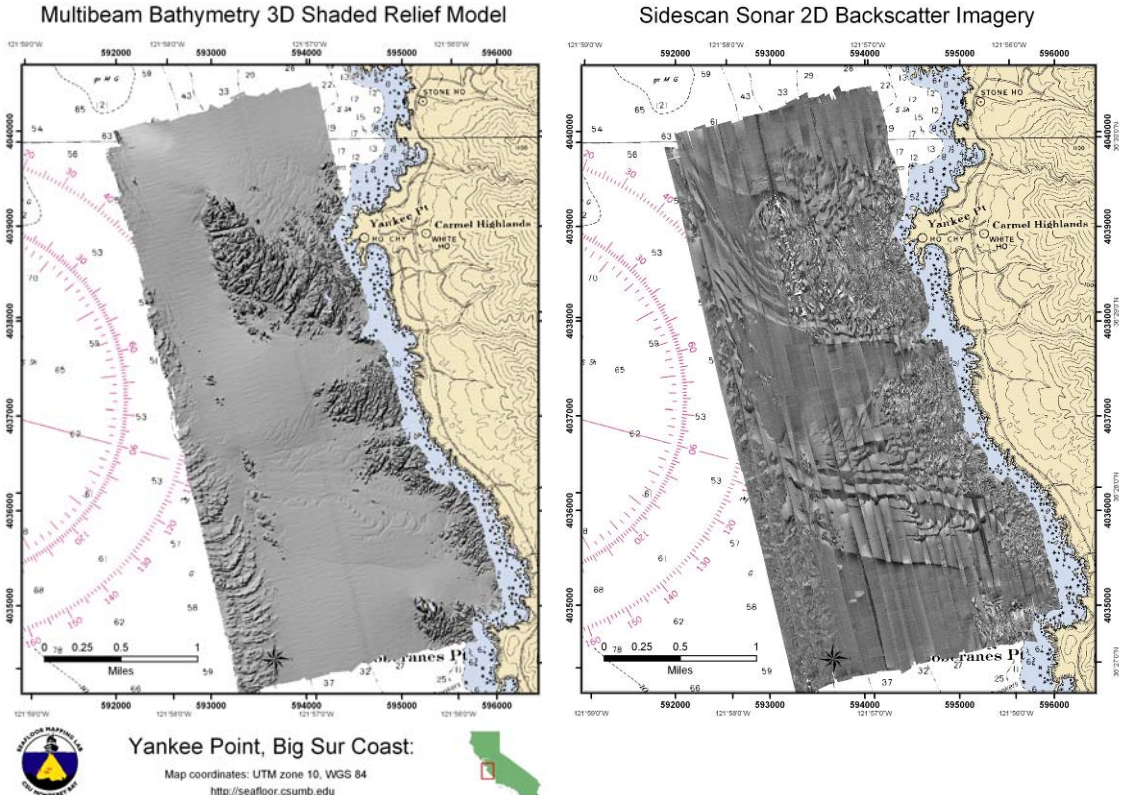


Figure 12. Second Tier map products from a multibeam sonar survey of Yankee Point, California. The bathymetry data (xyz) are rendered in shaded relief superimposed on a NOAA nautical chart in ArcGIS, and clearly show the differences between rocky and soft-bottom habitats (left). The sidescan sonar data from the multibeam system for the same site is shown as a mosaic (right) revealing differences in the properties of the surface sediments and substrate textures. (Source: CSUMB Seafloor Mapping Lab).

Additional derivative products relate to biotic mapping, habitat monitoring and change detection. Sidescan sonar backscatter has been effectively used to map the distribution and abundance of squid eggs (Figure 17) and thus squid spawning grounds and reproductive output. Multibeam bathymetry data, especially in time series, can be used to quantify seasonal and interannual seafloor habitat and geomorphic change (Figure 18), and or monitor seafloor disturbance such as bottom trawling (Figure 19), and submarine landslides (Figure 20). Combining multibeam sonar with LIDAR DEM's has enabled precise quantification of nearshore and coastal habitat change and loss including tidal scour, sediment deposition and saltmarsh erosion (Figure 21).

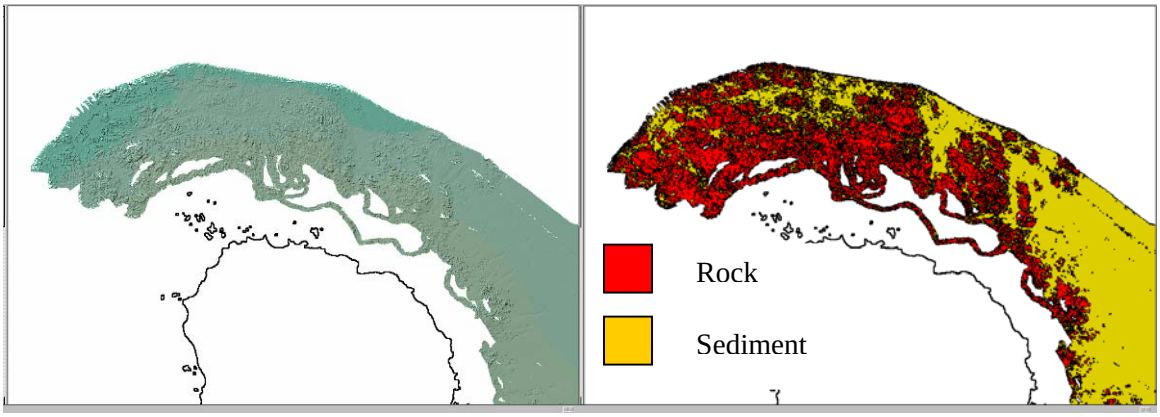


Figure 13. Second Tier map products distinguishing rocky versus softbottom habitat differences. Multibeam bathymetry data (xyz) shown in shaded relief (left) and after rugosity analysis (right) in GIS quantifying the distribution and abundance of rocky versus sediment bottom types around Point Pinos, California. (Source: CSUMB Seafloor Mapping Lab).

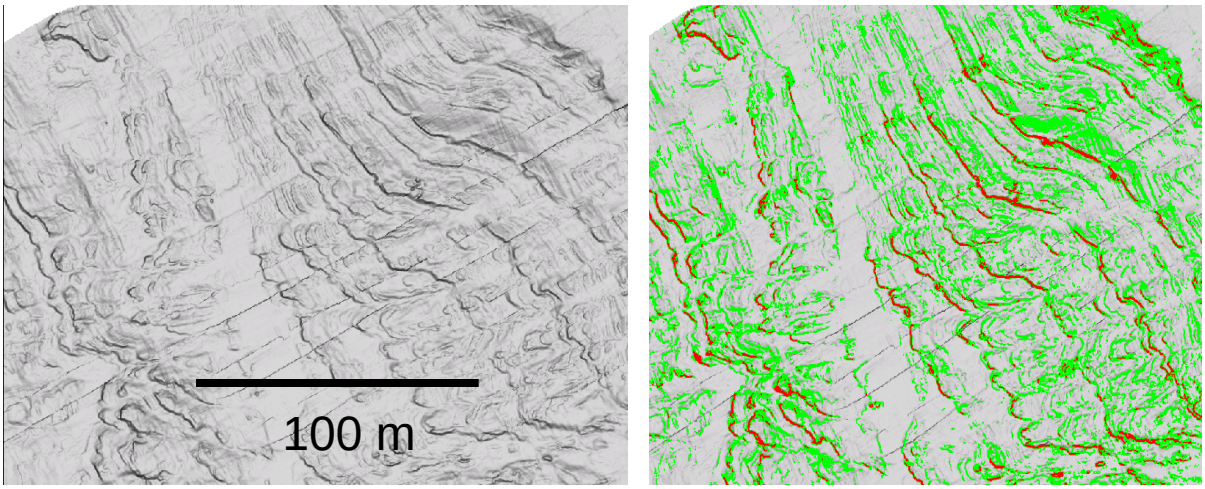


Figure 14. Second Tier map products distinguishing rock ledge types. Multibeam bathymetry data (xyz) shown in shaded relief (left) and after rugosity analysis (right) in GIS quantifying the distribution and abundance of high (red) and low (green) rocky ledges versus sediment bottom types (grey) near Delmonte Beach, Monterey, California. (Source: CSUMB Seafloor Mapping Lab).

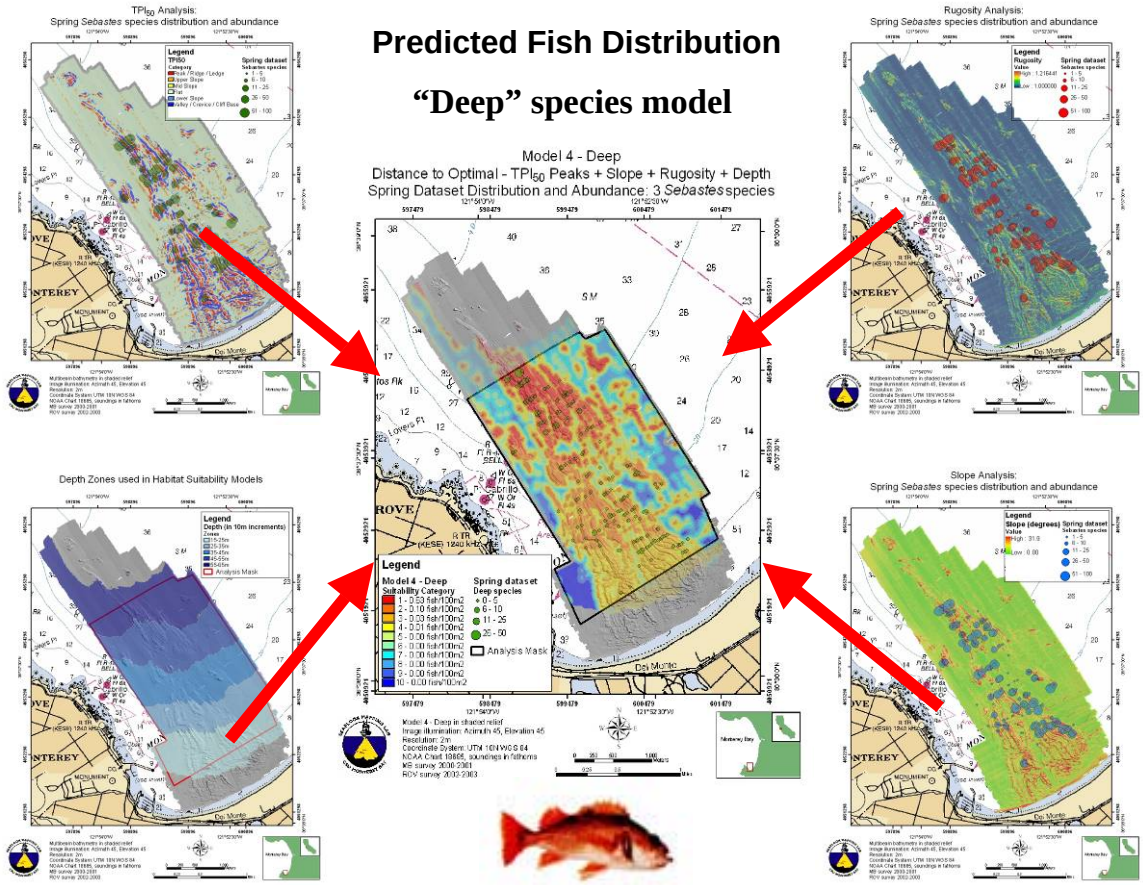


Figure 15. Second Tier map products used to predict rock fish distribution. Multibeam bathymetry data (xyz) used to quantify four separate habitat parameters: a landscape index (TPI, top left), rugosity (top right), depth range (bottom left) and slope (lower right). These four habitat models were then combined into a single predictive model based on verified species habitat preferences to accurately predict the distribution of 85% of the rock fish species observed along a rocky reef adjacent to Monterey, California. (Source: CSUMB Seafloor Mapping Lab. Iampietro PJ, Kvitek RG, Morris E (2005). Recent Advances in Automated Genus-specific Marine Habitat Mapping Enabled by High-resolution Multibeam Bathymetry. Mar Tech Soc J, vol. 39(3): 83-93).

Species-specific Habitat Maps

Bocaccio

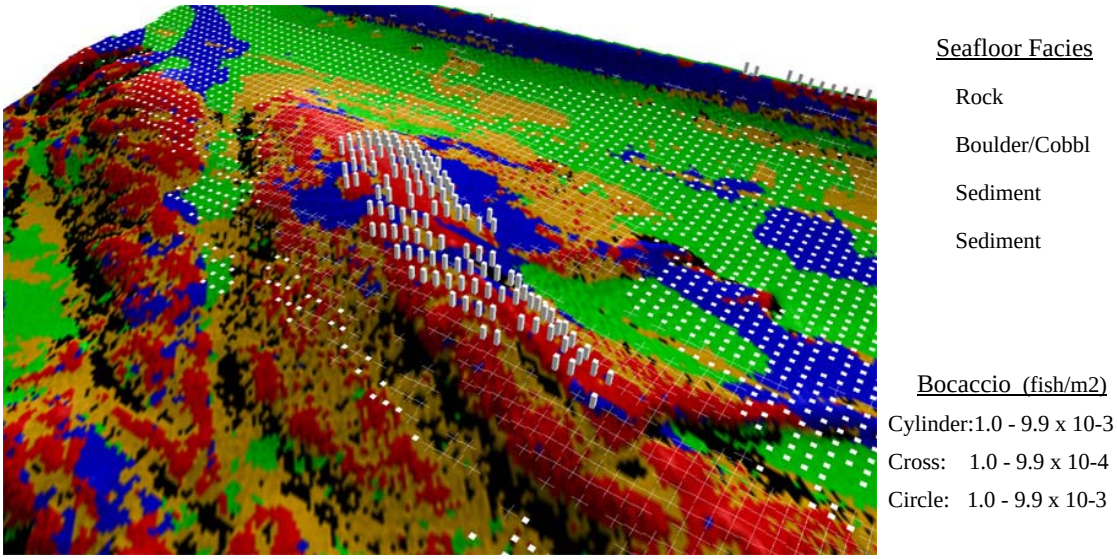


Figure 16. Second Tier auto classification habitat map products used to predict rock fish distribution. Autoclassification of multibeam bathymetry and backscatter data sets to classify habitat into simple categories (rock, boulder/cobble, and two sediment types) appropriate to the species of interest, here Bocaccio Rock Fish. (Source: Pete Dartnell, Linda Snook, Mary Yoklavich, Milton Love).

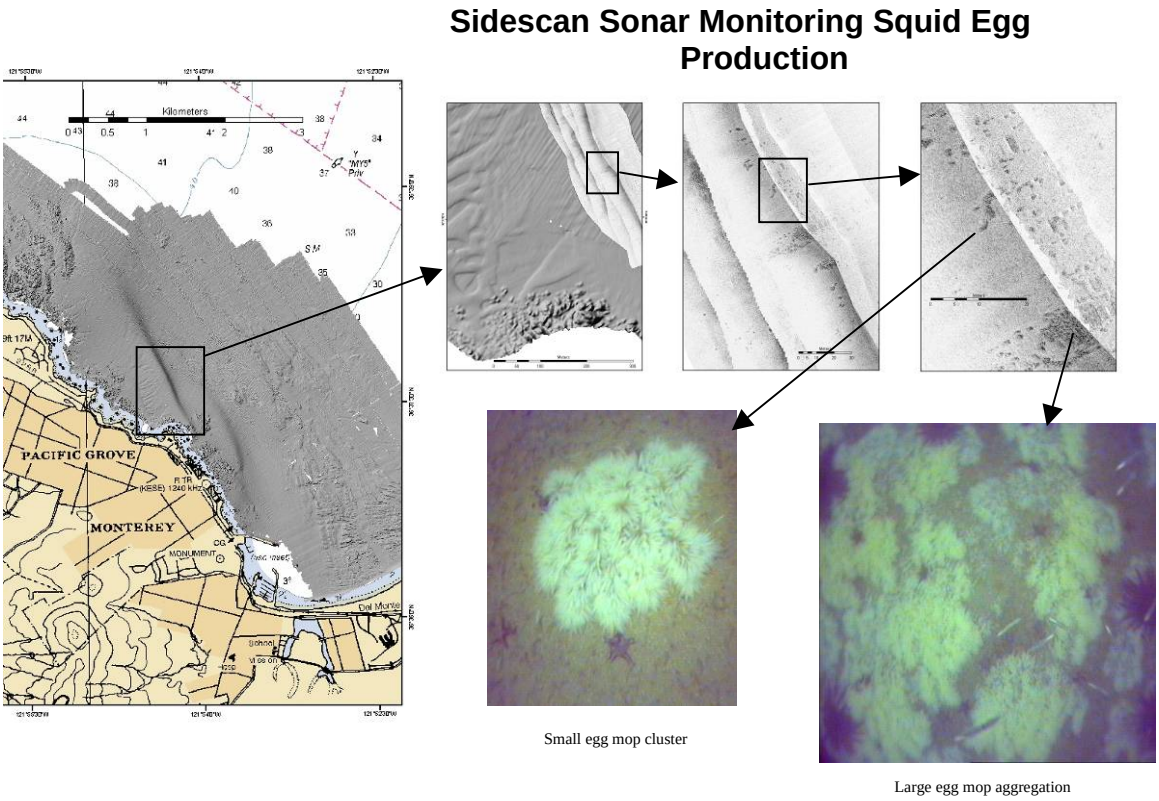


Figure 17. Second Tier map products used to identify squid egg distribution in Monterey Bay. Multibeam bathymetry data in shaded relief (left) with overlain sidescan sonar backscatter mosaics (upper right) in GIS showing squid egg mop clusters as dark patches in sidescan imagery. Video imagery (lower right) confirmed the identity of the egg clusters. (Source: CSUMB Seafloor Mapping Lab. Foote KG, Hanlon RT, Iampietro PJ, Kvitek RK (2006). Acoustic Detection and Quantification of Benthic Egg Beds of the Squid *Loligo opalescens* in Monterey Bay, California. J. Acoust. Soc. Am. 119, 844).

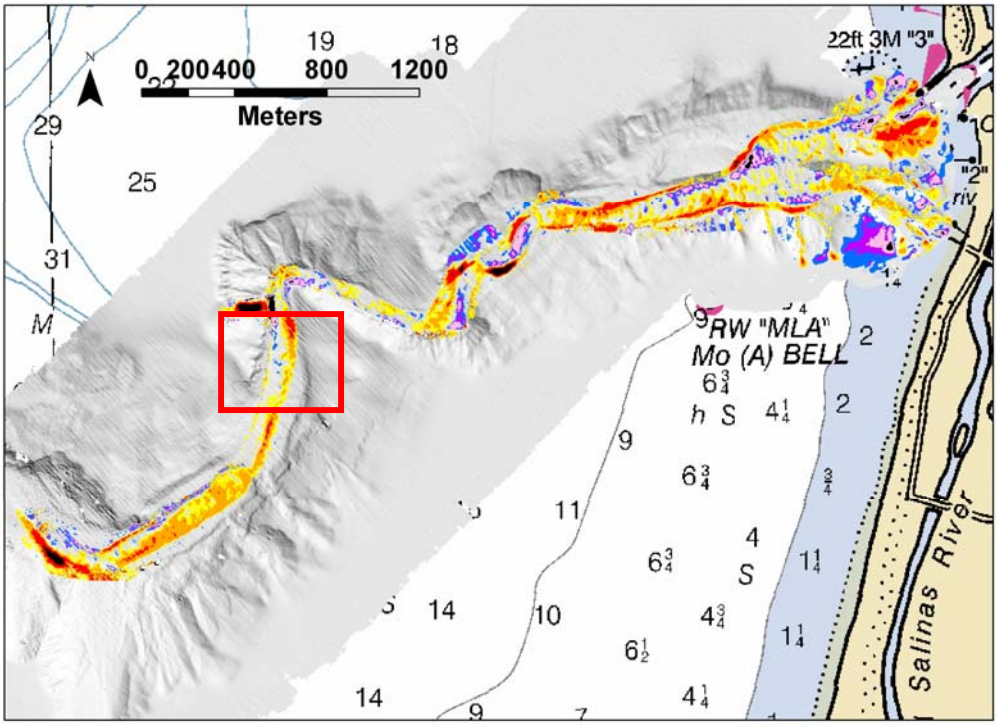
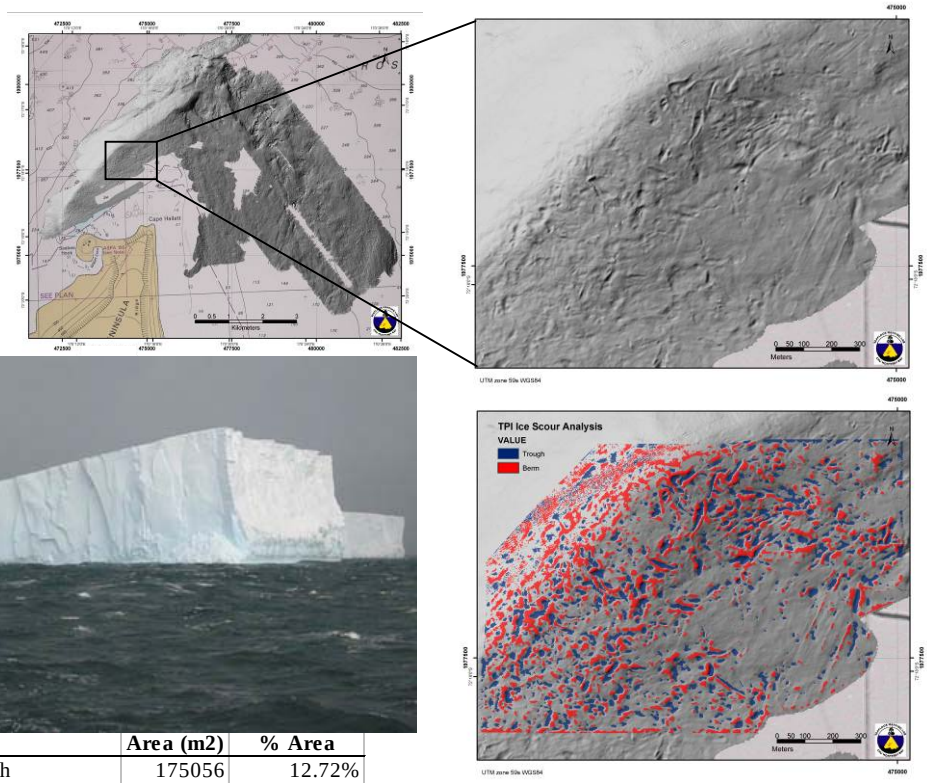


Figure 18. Second Tier map products in ArcGIS showing sediment erosion (black and warm colors) and deposition (cool colors) from multibeam bathymetry time series data along the axis of Monterey Submarine Canyon, Monterey Bay, California. Red box outlines the location of a tsunamigenic landslide and debris pile that occurred during the time series (Source: Smith DP, Kvitek RG, and Iampietro PJ (in review). Twenty-nine months of geomorphic change in upper Monterey Canyon (2002-2005). Marine Geology).

Quantifying Benthic Disturbance



	Area (m2)	% Area
Trough	175056	12.72%
Berm	223400	16.23%
Total Scour	398456	28.95%
Total Survey	1376328	

Figure 19. Second Tier map product analyses in ArcGIS used to quantify benthic disturbance, such as icebergs and bottom trawl scours. Bottom gouges (blue) and adjacent berms (red) created by ice scour are identified using TPI (topographic position index) analysis of multibeam bathymetry data at Cape Hallett, Antarctica. (Source: Kvitek RG, Iampietro PJ, Thomas K, Morris E (2004). Victoria Land Latitudinal Gradient Project: Benthic Marine Habitat Characterization. Field report to the National Science Foundation- Office of Polar Programs).
http://seafloor.csumb.edu/publications/FieldReport_VLGP.pdf

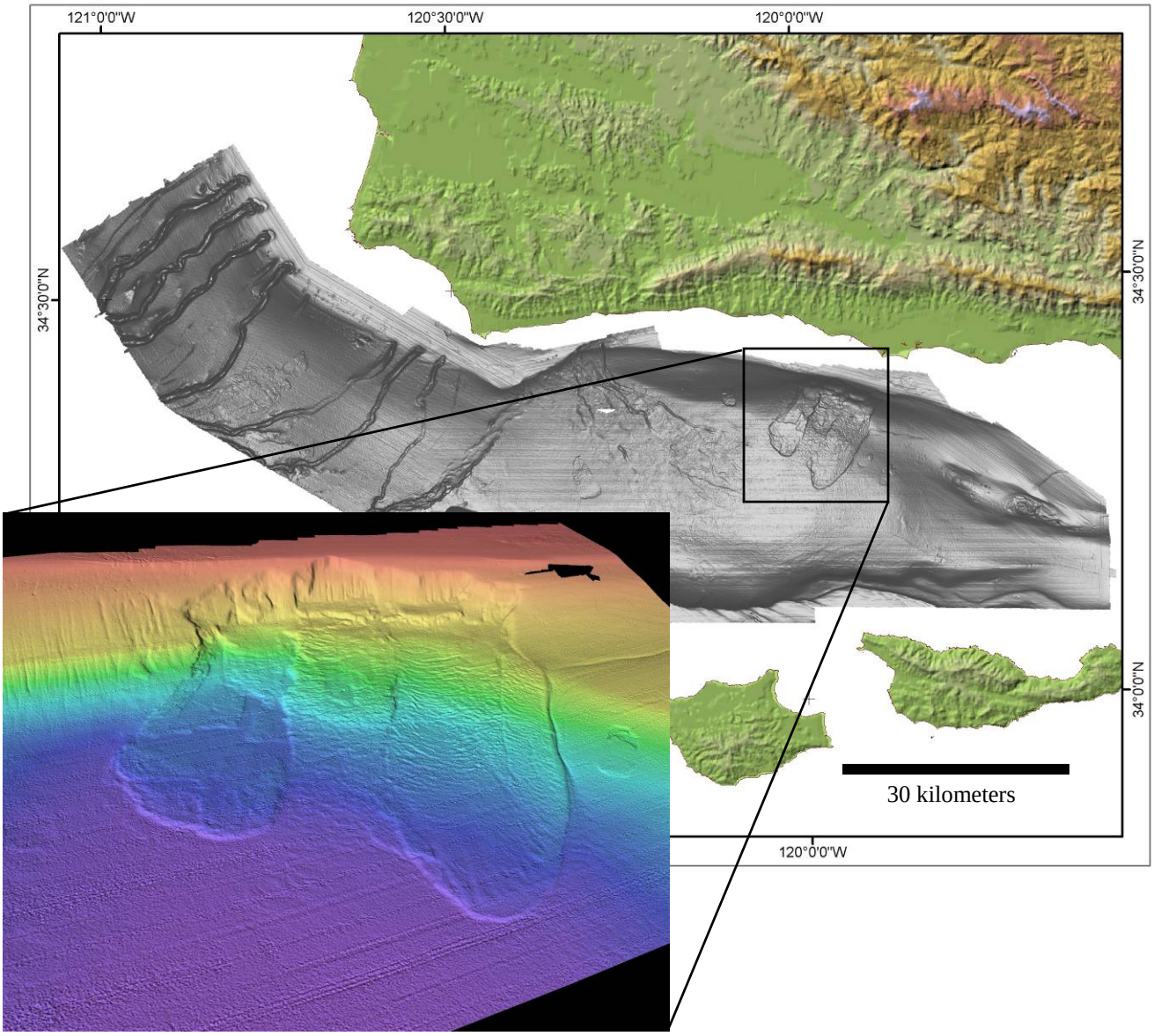


Figure 20. Second Tier map product –Massive submarine landslides identified in multibeam bathymetry data off the coast of Santa Barbara. (Source: Source: MBARI, and Center for Habitat Studies, Moss Landing Marine Labs).

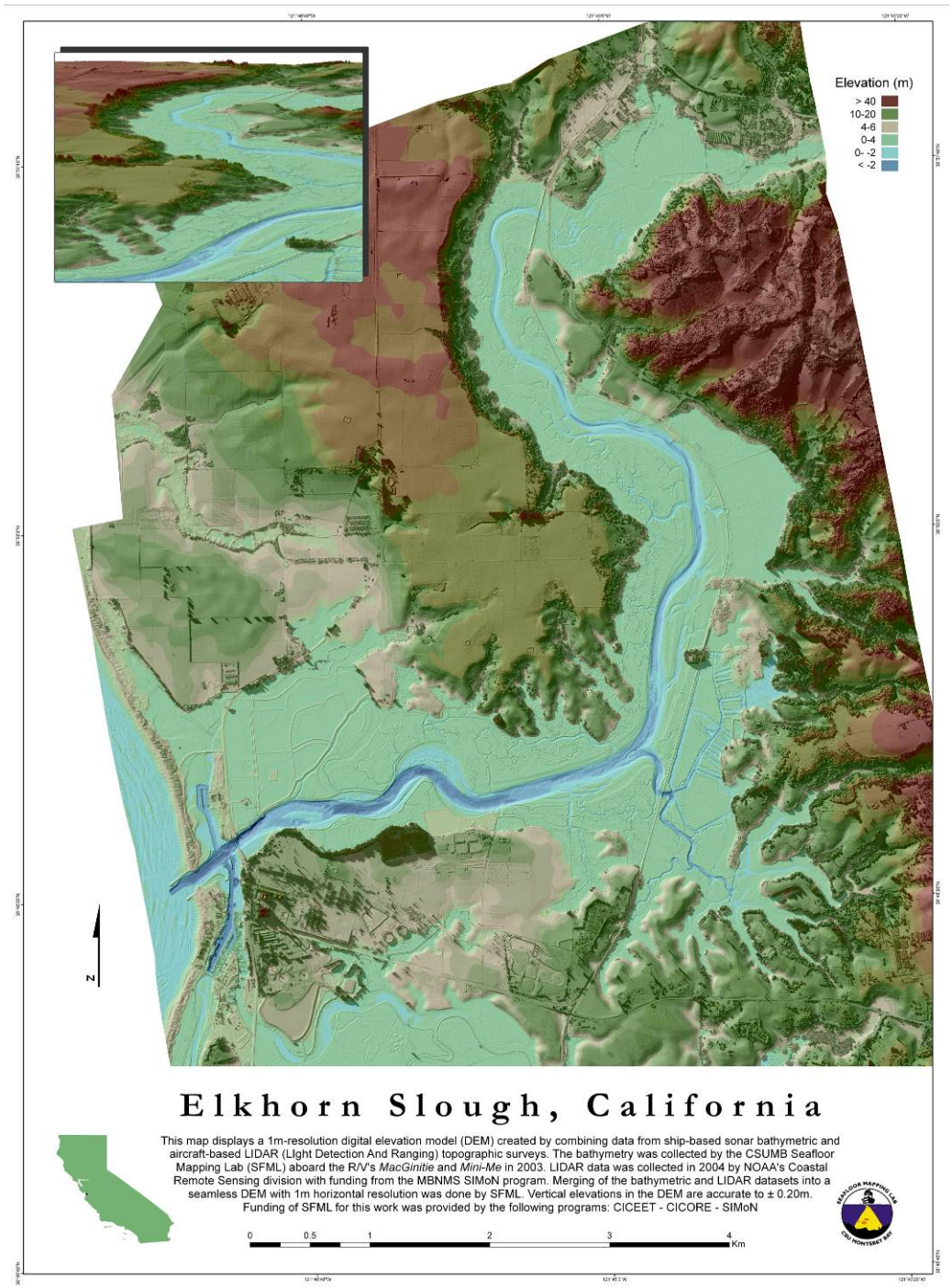


Figure 21. Second Tier map product –Digital Elevation Models (DEM) of coastal watersheds and embayments. Terrestrial LIDAR DEM and multibeam bathymetry DEM fused to create a single 3D landscape model of the Elkhorn Slough, California, colored by elevation. This product has been used to quantify rates and spatial distribution of environmental change in the ecosystem including tidal volume, habitat loss, sediment erosion and deposition. (Source: NOAA, MBNMS, CICEET and CICORE sponsored surveys).

6.6.2 Third Tier Map Products – Fully Interpreted Geologic and Habitat Classification Schemes

Third tier map products involve the manual delineation and attributing of polygons based on the application of more or less complex geologic or habitat classification schemes to several second tier map product layers (Figure 22). Second tier products for depth, substrate type and geomorphology are typical requirements for applying these third tier schemes. The resulting products are information rich, and often aesthetically pleasing (Figures 23, 24 and 25). Third tier map products commonly attempt to integrate the available bathymetry, backscatter, sample and sub-bottom profile data into a single consistent interpretation for a broad area. Integration of different data sets can be considerably more time consuming than automated attribution of a single data set, but results in more consistent and reliable interpretation. Integration of all the available data sets over a broad area allows for the geologic or habitat maps to be used in a regional context to describe the general distribution of a particular type of habitat, or rock or sediment type. The California Geological Survey presented 1:100,000 scale geologic maps at the workshop (Figure 25) that show the distribution of different materials over broad areas, such as Monterey Bay and Santa Monica Bay. Because these maps cover the entire area, they can be used to address questions regarding the regional sediment budget, distribution of different types of habitat, regional hazards, etc. The major drawback of these regional maps is that, despite the high information content, these products can be somewhat limiting because the interpreted polygon interpretation layer, once complete, is fixed both in scale and level of detail (i.e. zooming in beyond the scale at which the layer was created will reveal no additional information). In situations where multiple high resolution species-specific habitat maps are required as products from a single survey data set (Figure 16) third-tier geologic or habitat maps do not represent sufficient additional value to justify the additional expense. In situations where several data sets, of varying types and scales, all provide some data about the materials and habitats third-tier interpretive maps do represent significant additional value and are justified. The California Geological Survey has developed regional geologic maps at 1:100,000 scale that set the standard for regional offshore geologic maps. More detailed maps of smaller areas are expected to be created at 1:24,000 scale, these may be either polygon or pixel format, depending on the type of interpretation used to prepare the map and the number of data sets to be considered. The USGS, CGS, and MLML have all developed schemes for depicting geologic data at this scale, and will be expected to work together to develop consistent formats and standards for showing habitat and other data at this scale.

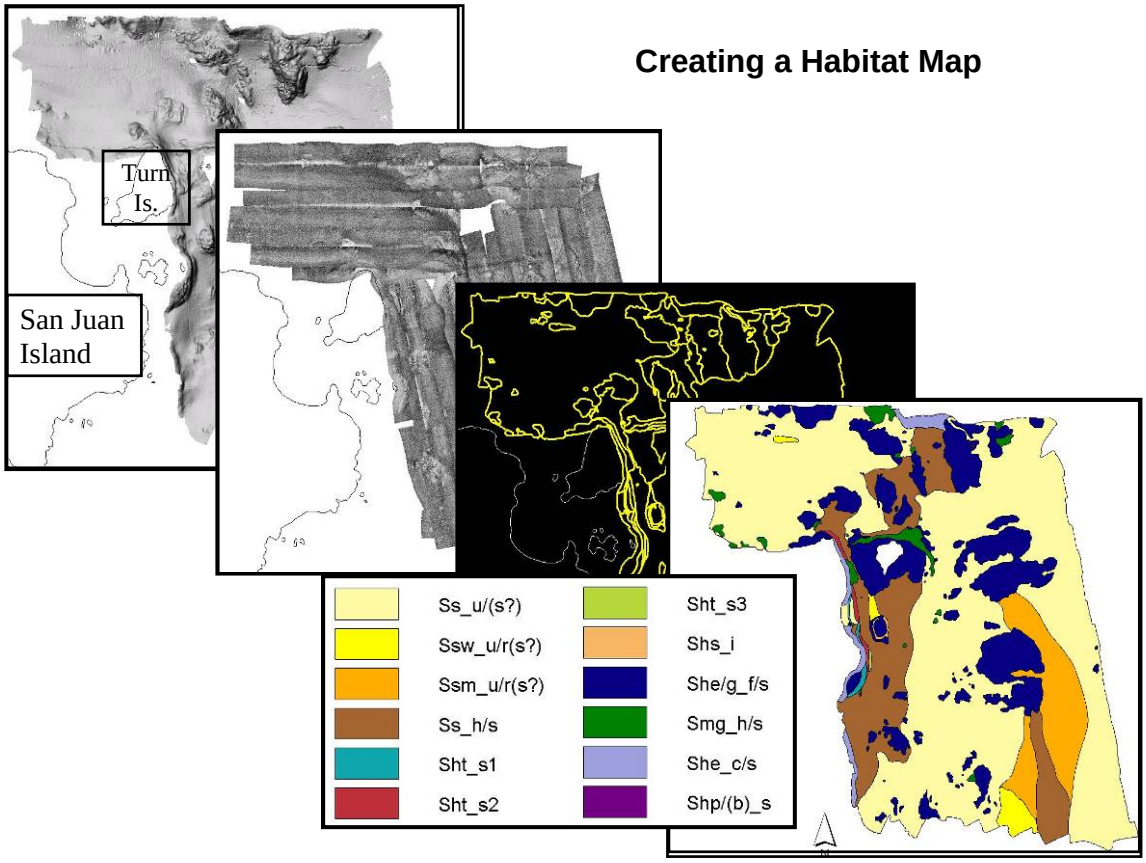


Figure 22. Steps in creating a Third Tier map product. From upper left to lower right: multibeam bathymetry in shaded relief, sidescan mosaic, hand traced polygons, and fully attributed polygons based on a detailed classification scheme. (Source: Center for Habitat Studies, Moss Landing Marine Labs).

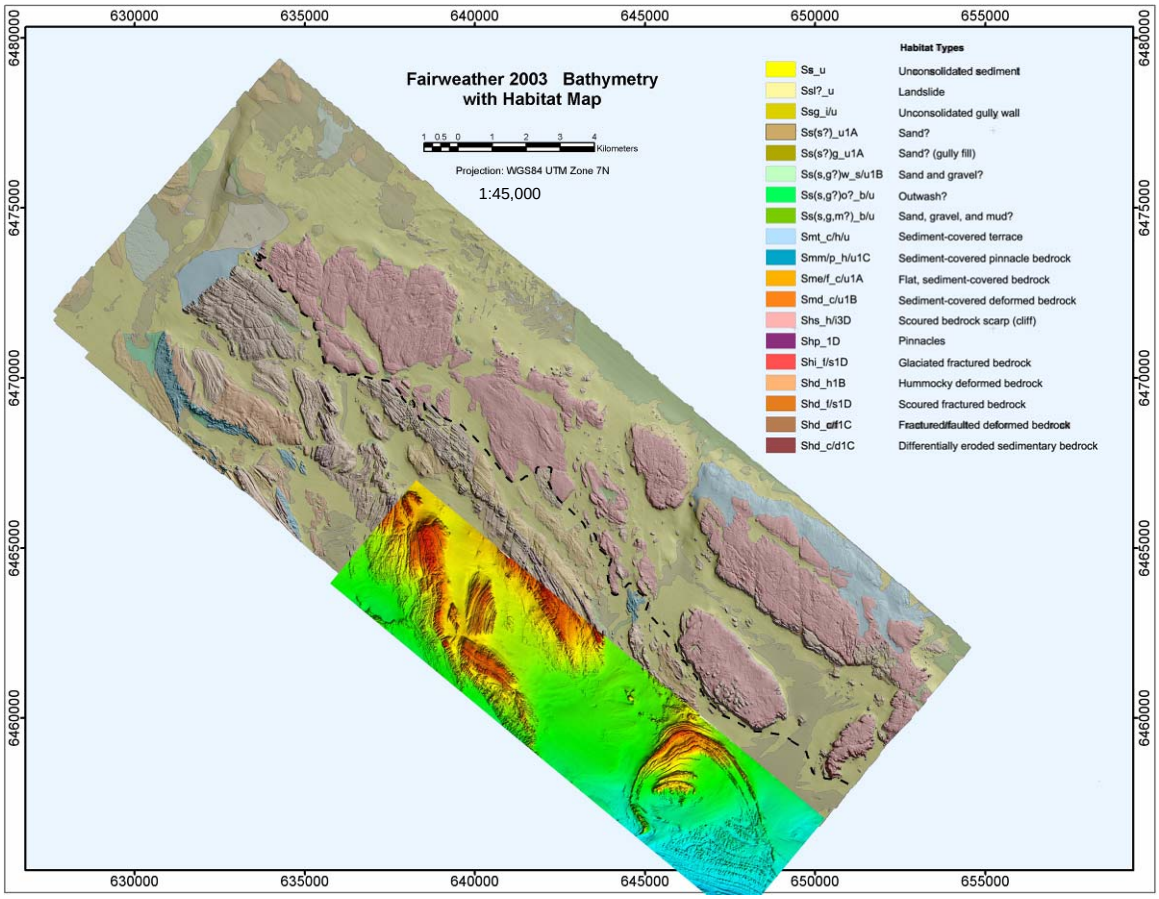


Figure 23. Third Tier map product. Fusion of all layers into a final fully interpreted seafloor habitat classification map product created for Fairweather Bank, Alaska. (Source: Center for Habitat Studies, Moss Landing Marine Labs).

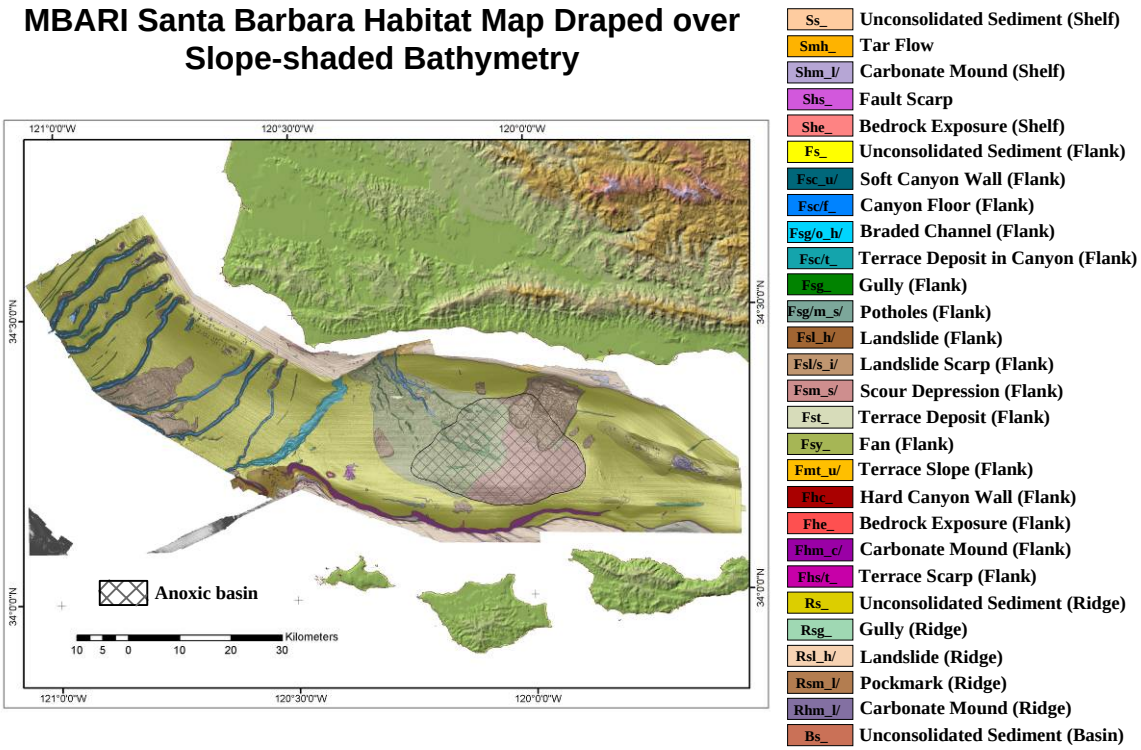


Figure 24. Third Tier map product. Habitat classified attributed polygon data draped over shaded relief bathymetry data and juxtaposed with terrestrial DEM of Point Conception. (Note nearly all the marine data falls outside the state waters 3 nm limit). (Source: Center for Habitat Studies, Moss Landing Marine Labs).

Geologic Map of Monterey

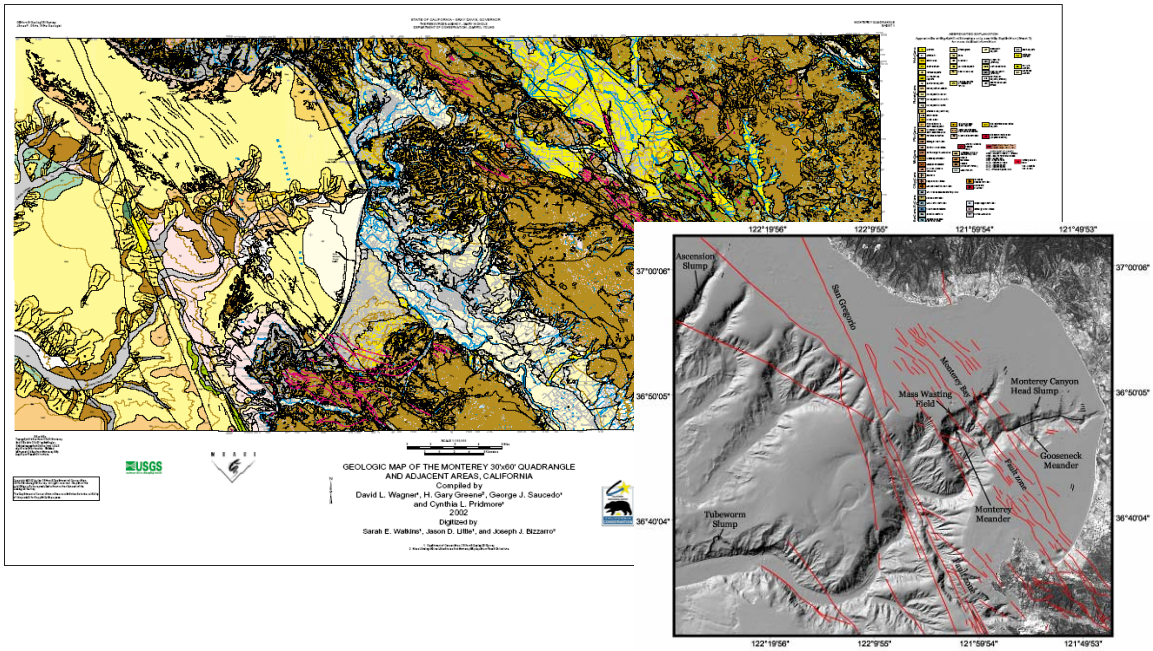


Figure 25. Third Tier map product – Fully interpreted and attributed geological map of Monterey Bay and surrounding terrestrial area. Marine and terrestrial data sets from many sources (seismic, bathymetry, backscatter, DEMs, aerial remote sensing, video, grabs, cores, etc.) were combined and utilized in this comprehensive classification of regional geology depicting geologic units, rock and sediment types, and fault lines. These are the most labor and data-intensive products to create. (Source: Center for Habitat Studies, Moss Landing Marine Labs).

6.7 METADATA, ARCHIVING, DISSEMINATION

The participants all acknowledged the critical importance of accurate and complete metadata and strongly recommended that all data must meet FGDC metadata standards. For archiving and dissemination, the recommendation was for a tiered system of accessible databases (ftp with links, http download sites, website images of data that link to data sources, internet GIS map servers [e.g. ArcIMS, CERES, Geography Network) with keyword and spatial box search capabilities. Potential data repositories (e.g. NOAA's National Oceanographic Data Center (NODC)) would need to be equipped for handling the large data volumes anticipated with statewide mapping. The workshop breakout group on Metadata, Archiving, and Dissemination of Data Products (Appendix B) suggested the implementation of a web-based data portal for locating distributed data archives as a more realistic approach than populating a centralized data warehouse.

7 APPENDICES – A: PRE-WORKSHOP DOCUMENTS

7.1 AGENDA*

Goal: Develop a strategic plan for statewide seafloor mapping in California state waters (3 nmi), in consultation with relevant stakeholders, including academic institutions, management agencies, and other mapping data consumers.

December 12, 2005 Day 1

8:00-9:00 **Registration and Continental Breakfast**

9:10-9:15 **Welcome and Overview (Plenary)-** Rikk Kvitek, CSUMB

9:15-9:30 **Overview of California Ocean Protection Council (COPC), California Ocean Protection Act (COPA), and Mapping RFP-** Neal Fishman, CA Coastal Conservancy/ Ocean Program

9:30-9:45 **Workshop goals, objectives, process** – Rikk Kvitek, CSUMB

9:45-10:00 **Update and Overview of Seafloor Mapping Techniques, Capabilities, Interpretation, and Applications** – Rikk Kvitek, CSUMB

10:00-10:15 **Habitat and Other Derivative Maps- Added Value to Seafloor Mapping**– Gary Greene, MLML

10:15-10:30 **Geologic Maps: Basic Data Required for Habitat, Resources, and Hazard Studies**- Chris Wills, California Geological Survey

10:30-10:45 **Production Rates, Spatial Coverage, Resolution and Limitations: Data Acquisition Considerations-** Doug Lockhart, Fugro

10:45-11:00 **Coffee Break**

11:00-12:00 **Focus: Regional Mapping Needs**

- Review and discuss current Statewide mapping coverage in California state waters (data type and resolution)
- Central Coast region focus: Stakeholders identify data gaps in marine habitat holdings and discuss information needs for the Central Coast region (Monterey Bay/Moss Landing to Bodega Bay)

(12:00-1:30) **LUNCH Presentations (University Center Ballroom)**

12:15-12:30 **Recent and Future Seafloor Mapping in the Area of the Santa Barbara Channel-** Guy Cochrane, USGS

12:30-12:45 **CIMPA Remotely Operated Vehicle Monitoring-** Dirk Rosen, Marine Applied Research and Exploration

12:45-1:00	**Implementation of the California Derelict Fishing Gear Removal Pilot Project**- Kirsten Gilardi, SeaDoc Society
1:00-1:15	**Mapping Mainland Shelf Benthic Habitats Offshore of San Pedro, CA-** Brian Edwards, USGS
1:15-1:30	**MBARI Mapping AUV** - Dave Caress, MBARI
1:30-1:45	Review break-out group tasks
1:45-2:45	Breakout groups for North and South region focus: Stakeholders identify data gaps in marine habitat holdings and discuss information needs for the North and South Coast regions (University Center Meeting Rooms)
2:45-3:00	**Snack Break**
3:00-4:00	Identify Priority Habitat Mapping Locations- **Conduct Voting Exercise**
4:00-	Begin discussions of mapping data acquisition versus habitat interpretation efforts
5:00-6:00	**BUFFET DINNER (University Center Ballroom)**

December 13, 2005 Day 2

8:00-9:00	**Continental Breakfast**
9:10-10:00	**Review Day 1 Results (Plenary)**
10:00-11:00	Discussion on Strategic Approach for Statewide Mapping Efforts
11:00-12:00	Discussion and Development of General Guidelines and Standards for Mapping- data acquisition, processing, interpretation, metadata, data sharing, and archiving
12:00-1:00	**LUNCH**
1:00- 2:00	Discuss RFP- led by California Ocean Protection Council/ California Coastal Conservancy- - Marina Cazorla, CA Coastal Conservancy
2:00-2:15	**Snack Break**
2:15-3:15	Develop recommendations for a Draft RFP, including priority sites, mapping methods, and level of interpretation to be funded by the sponsor
3:30	**Conclude meeting**

* The Day 2 agenda was modified from the schedule shown here.

7.2 MARINE HABITAT DATA HOLDINGS WORKSHEET

Your Name: _____
Institution Name: _____
Address: _____
_____
Data Contact: _____
Phone Number: _____
Email: _____

Fill out one worksheet for each coverage (see instructions).

Where has/will mapping be(en) done? (shade cells or draw the area on copies of the attached maps)

Site name: _____
General location:_____
Approximate size of area mapped (Sq. miles) _____
Water depth range (ft): minimum depth ___ft maximum depth _____ft
Block number(s) that cover the data set (from attached maps)_____
_____
_____

Why was/will mapping (be) done? (use more space as needed)

Species or resources of concern: _____
_____
_____
Management issues of concern:_____
_____
_____
How has/will the mapped data be(en) used?_____
_____
_____

What habitat parameters were/will be mapped?

☐ bathymetry ☐ substrate type

How are/will data (be) formatted, are/will they (be) accessible to others, and how were/will they (be) acquired?

__ Digital (Describe) File Size, GIS Format
__ Hardcopy only
__ Web Accessible
__ CD
__ Disk
__ Not available
__ Cost $_____

__ Sidescan-Single Line
__ Sidescan – Mosaic
__ Multibeam – Single Line
__ Multibeam - Mosaic
__ Seismic Reflection Profiles

7.3 MARINE HABITAT DATA NEEDS WORKSHEET

Your Name: _____
Institution Name: _____
Address: _____
_____

Data Contact: _____
Phone Number: _____
Email: _____

Fill out one worksheet for each area of interest (see instructions).

Where should mapping be done? (shade cells or draw the area on copies of the attached maps)

Site name: _____
General location:_____
Priority: θ**High** (high need to complete within 1-2 years)
θ**Medium** (complete within next 2-5 years)
θ**Low** (complete within 5-10 years)
Approximate size of area mapped (Sq. miles) _____
Water depth range (ft): minimum depth ____ft maximum depth _____ft
Block number(s) that cover the proposed area (from attached maps)_____
_____
_____

Why should mapping be done? (use back of page as needed)

Ranking criteria that apply: _____
_____
_____
Species or resources of concern: _____
_____
_____
Management issues of concern:_____
_____
_____
_____
How would the mapped data be used?_____
_____
_____
_____

What habitat parameters should be mapped?
☐ bathymetry ☐ substrate type

How finely should this site be mapped? (resolution & scale)
What is the smallest habitat "patch" size you need to identify on your map? (e.g. every rock larger than 1x1 ft, or rocky reefs greater than 500 x 500 ft)
__ 1 x 1 ft __ 10 x 10 ft __ 100 x 100 ft __ 1000 x 1000 ft __ other_____

7.4 DATA HOLDINGS COVERAGE MAP – NORTHERN CALIFORNIA

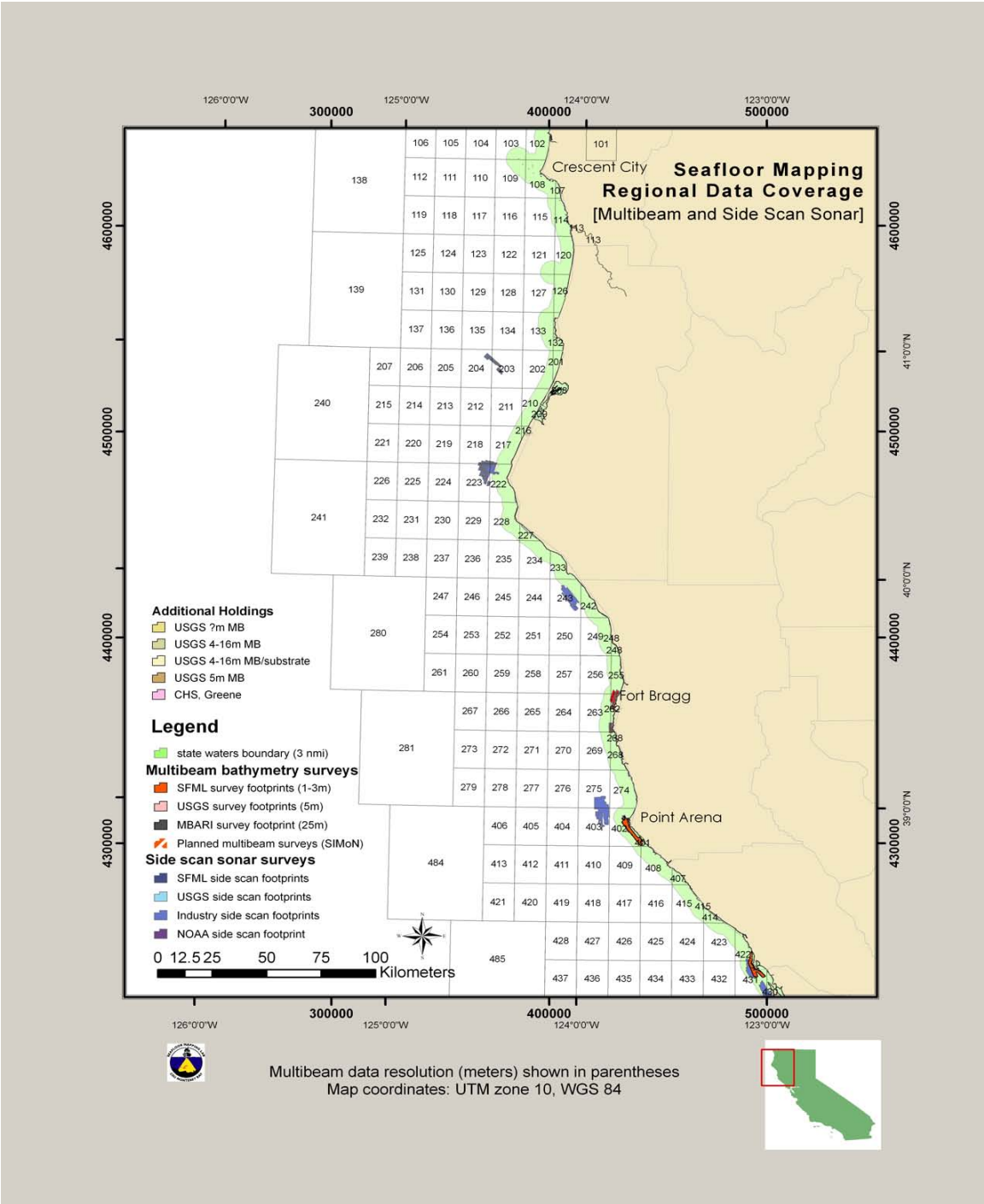


Figure A-1. Spatial distribution of current multibeam and sidescan sonar data holdings for Northern California compiled by from various sources prior to the date of the workshop.

7.5 DATA HOLDINGS COVERAGE MAP – CENTRAL CALIFORNIA

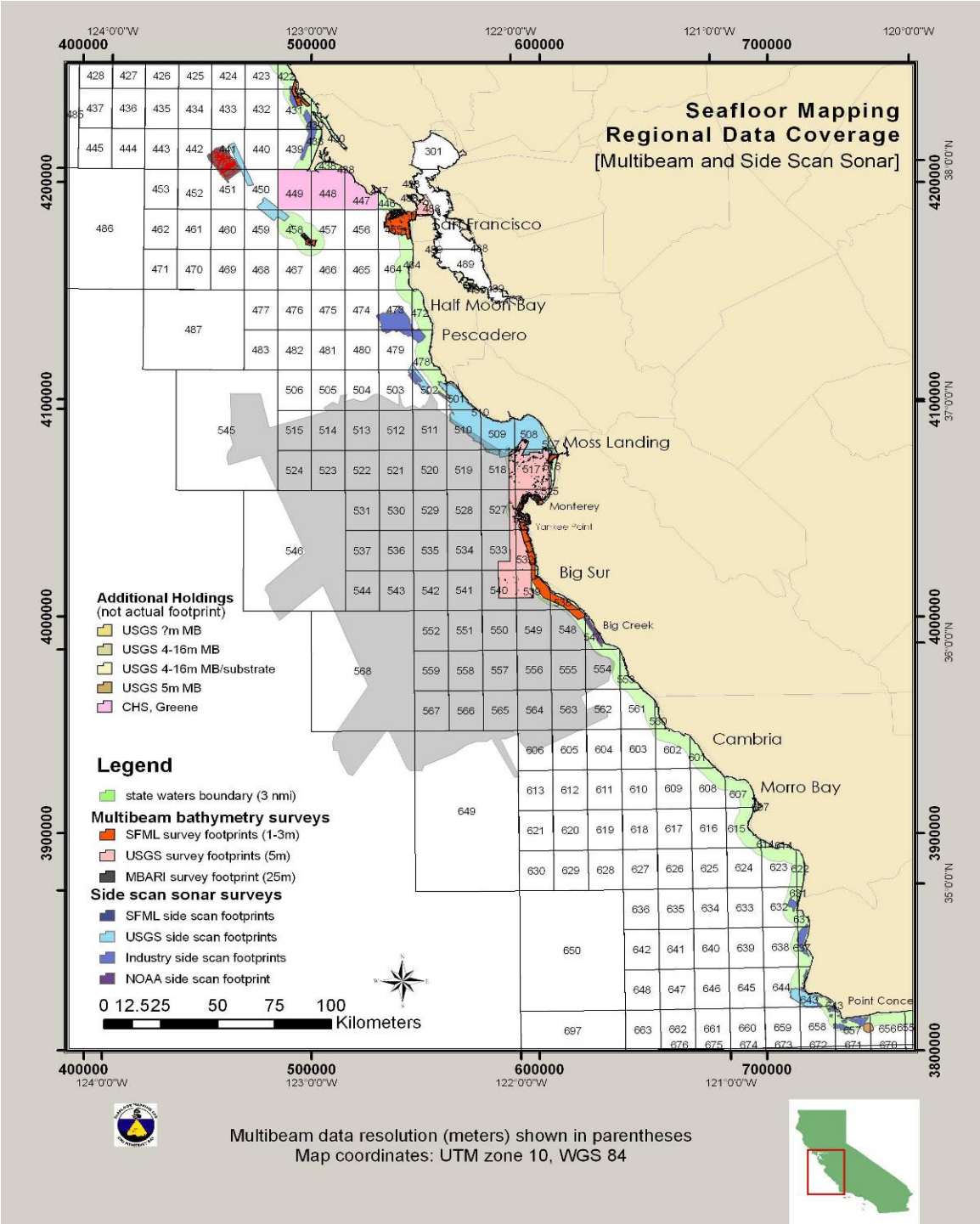


Figure A-2. Spatial distribution of current multibeam and sidescan sonar data holdings for Central California compiled by from various sources prior to the date of the workshop.

7.6 DATA HOLDINGS COVERAGE MAP – SOUTHERN CALIFORNIA

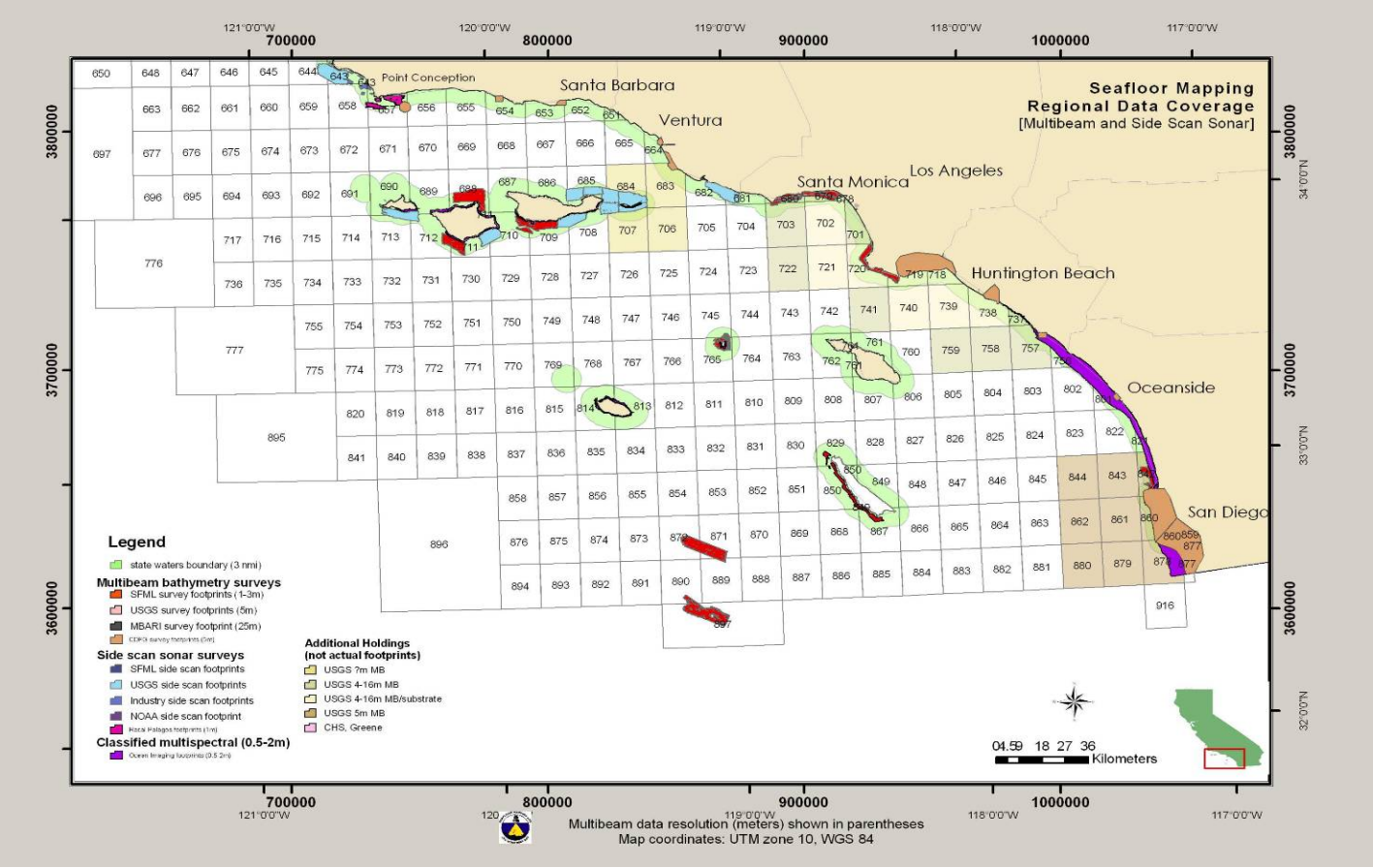


Figure A-3. Spatial distribution of current multibeam and sidescan sonar data holdings for Southern California compiled by from various sources prior to the date of the workshop.

7.7 DATA HOLDINGS COVERAGE MAP – CENTRAL COAST RFP AREA

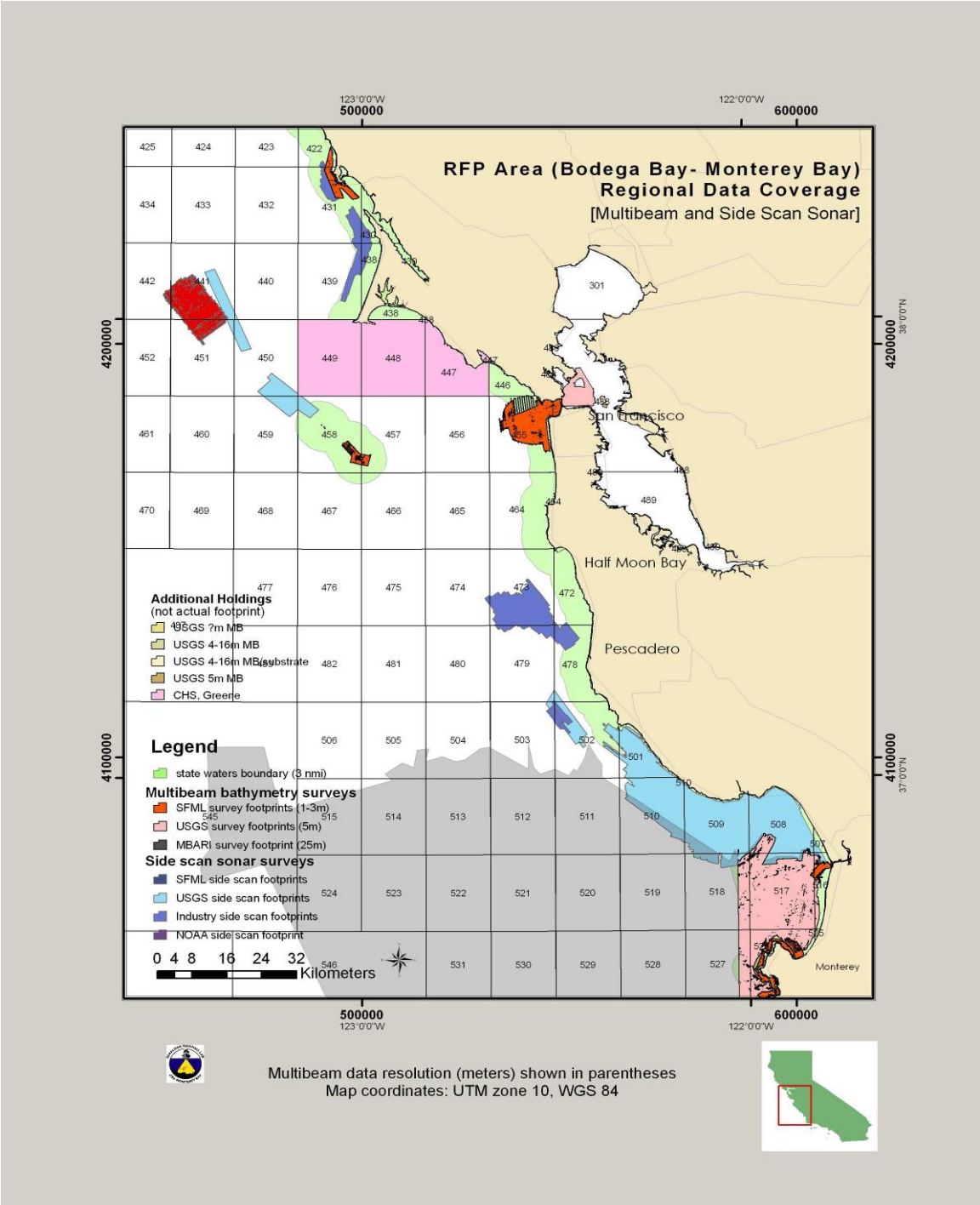


Figure A-4. Spatial distribution of current multibeam and sidescan sonar data holdings for Central Coast RFP Area compiled by from various sources prior to the date of the workshop. Additional coverages identified during the workshop will be added to the map.

7.8 PRE-WORKSHOP DATA NEEDS SUMMARY TABLE

Institutions	General Areas	Block #(s)	Priority (H,M,L)	Water depth (range in ft)	Why Data Needed						Resolution & Scale
					Ranking Criteria	Species or Resource of Concern	Management Issues of Concern	How would Mapped Data be Used?	Bathy	Subst	
National Park Service	Marin Headlands to Tomales Pt		High	0-200 m				To aid in designation of future MPAs		Y	
MMS	Offshore Ocean Beach, SF 3-5 miles offshore	465,466,467,468,474,475,476,477,480,481,482,483,487	High	35-100 ft		fish, cultural artifacts, shipwrecks, reef habitat, human dumping of munitions or waste	identify sand borrows in federal waters to dump nearshore for reinforcement of Ocean Beach. MMS would need to conduct biological, cultural, etc reviews to determine suitable areas of extraction	Used to scope out areas of high habitat value, identify areas where additional study is needed, refine scope and areal extent of additional research	Y	Y	**10x10 ft** Area is small, so fairly high resolution is needed to differential between different habitat zones, and define areas of high sand quality
MMS	Santa Barbara Channel	652,653	Medium	30-250 ft				identify potential tar seep mounds	Y		**1x1 ft** looking for "volcanos" of that diameter
MMS	Santa Maria Basin	543,648	Low			tar seep mound, hard bottom reefs, canyon heads	some has been mapped, fill gaps	to design ROV surveys, correlate groundtruth data to geophysical data	Y	Y	1x1 ft
National Marine Sanctuary Program West Coast	Big Sur, Monterey Bay NMS South, approx 350 sq miles	547,553,554,560,561,601,602,603	High	0-400 ft			characterization, marine reserves	habitat characterization	Y	Y	10x10 ft
National Marine Sanctuary Program West Coast	Pt Reyes, Farallon Islands/ Cordell Bank, approx 475 sq mi	430,431,438,439,446,447,448,449	High	0-250 ft			characterization, marine reserves	habitat characterization	Y	Y	10x10 ft
National Marine Sanctuary Program West Coast	Channel Is marine Reserves State & Proposed Federal, approx 150 sq mi	684,685,686,687,707,708,710,711,712	High	0-900 ft			characterization, marine reserves	habitat characterization, reserves monitoring, change detection	Y	Y	10x10 ft
National Marine Sanctuary Program West Coast	San Mateo Coast, Monterey Bay NMS North, approx 400 sq mi	455,464,472,473,478,502	High	0-250 ft			characterization, marine reserves	habitat characterization	Y	Y	10x10 ft
California Coastal Commission	all blocks within 3 nmi state waters		Medium (Marin to Mexico), Low (Marin to Oregon)	0-150 ft				cable and pipeline projects, habitat characterization, substrate identification	Y	Y	1x1 ft -10x10 ft
HSU/ CICORE	Trinidad/ Patrick's Pt, approx 30 sq mi	132,133,126	High	0-300 ft	fisheries manangement, stock assessment, significant natural value multiple use area	nearshore fishes, seabirds (incl murelets, puffins), habitat contains significant areas of hard substrate not impacted by sand (rare)	water quality, contains ASBS habitat	manage stocks, development of MPAs, basic info, oil spill management, shoreline erosion, tsunami prep	Y	Y	1x1 ft
HSU/ CICORE	Humboldt Bay, approx 24 sq mi (partly mapped)	208,209	High	0-60 ft	fisheries manangement, stock assessment, sediment deposition, sign natural value, aquaculture (oyster,clams,mussels), port, recreation, comm fish, migratory birds	EFH for managed fish, eelgrass, fish nursery, Pacific flyway, marine mammals	invasive species, water quality, sediment, oil spill, hazardous release	manage stocks, development of MPAs, ecosystem based management, watershed restoration	Y	Y	1x1 ft
HSU/ CICORE	Clam Beach Area (Mad River Mouth to Trinidad, approx 30 sq mi)	201	High	0-150 ft	sediment deposition, multiple use, baseline data	razor clam, snowy plover, sediment transport/deposition	multiple uses (recreation, conservation), remediation efforts	multi-agency use, habitat restoration, better understand sed transport of Mad River mouth, locate rip currents, ecosystem-based management	Y	Y	1x1 ft, 3x3 ft

7.9 WORKSHEET B

Block # / Institution	**Water Depth** (range in m)	**Why Data Needed**	**Parameters**		**Resolution & Scale** (minimum habitat patch size)
			Bathymetry	Substrate Type	

7.10 VOTING BALLOT

Name & Affiliation:											
		Vote By Criteria									**Total Votes**
	Block #	Fishery Management	Use Conflict/ Impact Analyses	Baseline (Monitoring & Assessment	Critical Natural Area or Biological Hot Spot	Special Species Located in Area	Political Importance	Safe Navigation	Other (add)	Other (add)	
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

WORKSHOP ATTENDEE FOLDER CONTENTS

The following documents are included under separate cover:

Agenda
Attendee List (invited participants and organizers)
Data Holdings form
Data Needs form (yellow)
Worksheet A- Data Needs Worksheet (yellow)
Pre-workshop Participants Data Needs table, w/ Selection Criteria list
Current Data Holdings maps (3 regions)
RFP Area (Bodega Bay- Monterey Bay) map
Map of Priority sites from California Marine Habitat Task Force Workshop 2000
Central Coast RFP Priority Blocks BALLOT (green)
Statewide Priority Blocks BALLOT (white)
Blank Reference Maps w/ Fishing Blocks (3 regions)

8 APPENDICES – B: POST-WORKSHOP DOCUMENTS

8.1 ACRONYMS

BLM	Bureau of Land Management
CBNMS	Cordell Bank National Marine Sanctuary
CDFG	California Department of Fish and Game
CenCOOS	Central and Northern California Ocean Observing System
CICORE	Center for Integrated Coastal Observation, Research and Education
COPC	California Ocean Protection Council
CSU	California State University
CSUMB	California State University, Monterey Bay
DEM	Digital Elevation Model
FGDC	Federal Geodetic Data Committee
GFNMS	Gulf of the Farallones National Marine Sanctuary
GIS	Geographic Information System
GPS	Global Positioning System
HSU	Humbolt State University
IHO	International Hydrographic Organization
IMS	Internet Map Server
ITRF	International Terrestrial Reference Frame
LIDAR	LIght Detection And Ranging
MBARI	Monterey Bay Aquarium Research Institute
MBNMS	Monterey Bay National Marine Sanctuary
MHHW	Mean Higher High Water
MLPA	Marine Life Protection Act
MMS	Mineral Management Service
MPA	Marine Protected Area
NGO	Non-Govermental Organization
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
NOAA	National Oceanographic and Atmospheric Administration
NPS	National Park Service
RFP	Request for Proposal
SFML	Seafloor Mapping Lab
SIO	Scripps Institution of Oceanography
SPAWAR	Space and Naval Warfare Systems Command
SWFSC	Southwest Fisheries Science Center
SWRCB	State Water Resources Control Board
UCSB	University of California, Santa Barbara
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WGS84	World Geodetic System 1984

8.2 ATTENDEES

Table B-1. Workshop attendees, their affiliations and email contacts.

Workshop Organizers

Name	Affiliation	Email
Rikk Kvitek	CSU Monterey Bay	rikk_kvitek@csumb.edu
Guy Cochrane	USGS Coastal and Marine Geology	gcochrane@usgs.gov
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Marina Cazorla	California Coastal Conservancy	mcazorla@scc.ca.gov
Carrie Bretz	CSU Monterey Bay	carrie_bretz@csumb.edu

Attendees

Name	Affiliation	Email
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Irina Kogan	GFNMS	irina.kogan@noaa.gov
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Dennis Long	Monterey Bay Sanctuary Foundation	lighthousegroup@earthlink.net
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Gerry Wheaton	NOAA Ocean Service	Gerry.Wheaton@noaa.gov
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Jerry Wilson	Fugro Pelagos	jwilson@fugro.com
Mary Yoklavich	NOAA/NMFS-SWFSC	mary.yoklavich@noaa.gov

8.3 STATE-WIDE PRIORITY VOTING RESULTS BY NEED CRITERIA

Statewide Priority Blocks											
Block #	**Fishery Management**	**Use Conflicts/ Impact Analysis**	**Baseline (Monitoring and Assessment)**	**Critical Natural Area or Biological "Hot Spot"**	**Special Species Located in Area**	**Political Importance**	**Safe Navigation**	**Spill Response**	**Geologic Hazards/Critical Erosion**	**Sand Sources**	**Total Votes**
664		4	11			1					16
822	5		6						2	1	14
665		3	8			1			1		13
683		4	7			1					12
813	2		3	2	5						12
602			7	3				1			11
814	2		2	2	5						11
132	1		6	3							10
547	1	1	7					1			10
801	2		6	2							10
821	4		6								10

Table B-2. Top 11 blocks in rank order that received the highest number of votes from the workshop participants for future mapping within all California State Waters (shoreline to 3nm). Rationale for mapping needs are listed across the top of the table, with the number of votes cast per block per category shown in the cells below. Total votes cast per block are shown in far right column. These results are displayed graphically on the preceding map.

8.4 CENTRAL COAST RFP AREA PRIORITY VOTING RESULTS BY NEED CRITERIA

Central Coast RFP Priority Blocks												
Block	Reference Location	Fishery Management	Use Conflicts/ Impact Analysis	Baseline (Monitoring and Assessment)	Critical Natural Area or Biological "Hot Spot"	Special Species Located in Area	Political Importance	Safe Navigation	Erosion	Hazards	Geology	RFP Total
464	N. of Half Moon Bay	4	1	25	8	3	7		7			55
446	N. of Golden Gate		3	19	5		7			1		35
478	Pt. Año Nuevo	4	2	19		5			3	1		34
455	S. of Golden Gate			16			6	3	3	1	3	32
502	S. of Año Nuevo	4		15	5	3				1		28
472	Half Moon Bay	4	2	19		2						27
458	Farallon Islands	2		14	5	1			1			23
422	Bodega Bay		2	14		2				2		20
438	N. Pt. Reyes	1		12	1					1		15
431	Dillon Beach		2	7		2			2	1		14

Table B-3. Top 10 blocks in rank order that received the highest number of votes from the workshop participants for future mapping within the Central Coast RFP Area (Monterey Bay to Bodega Bay). Rationale for mapping needs are listed across the top of the table, with the number of votes cast per block per category shown in the cells below. Total votes cast per block are shown in far right column. These results are displayed graphically on the preceding map.

8.5 SYNTHESIS AND SUMMARY OF WORKSHOP NOTES

Note takers recorded and summarized the comments of all presenters and the participants in each of the several discussion sessions. The first draft of the summary notes were redistributed to the workshop participants for them to review, edit and supplement with further comment. Post-workshop supplemental contributions are shown in brackets[ ].

DECEMBER 12, 2005

PLENARY SESSION

Overview of workshop goals and objectives, followed by a series of participant mapping presentations (See workshop archive for related Powerpoints). Session facilitated by Rikk Kvitek (CSUMB). (notes: H. Lopez).

- CA Coastal Conservancy mission
- Strategic plan: Ocean mapping
- What does Ocean Protection Council need in terms of resources to achieve goals and objectives?
- Cost, accomplishing it, proposals to legislature for future funding
- Users of ocean mapping, equipment, utilization, efficiency

Talk: Rikk Kvitek (CSUMB) – Workshop goals and objectives, Mapping technologies

- Ocean – not just big blue area, but composed of complex, diverse habitats
- Need exists for entire state of CA – management issues
- Current data coverage indicate most nearshore habitat mapped
  <40% mapped, high-resolution
- 75% – state waters, very little mapping attention
- 2000 – Task Force Meeting, Central Coast priority sites
- 2004 – Seafloor habitat data

Goal:

- Develop plan for statewide seafloor mapping (3 nm shore to offshore) with stakeholders

Objectives:

- Provide update on seafloor mapping capabilities and applications
- Identify additions to data coverage
- Identify gaps and needs
- Prioritize areas
- Recommendations for 2006 Central Coast Mapping RFP

Voting

1. Statewide – all statewide waters in CA for identifying priority blocks
2. Central Coast – Mid-Monterey Bay to Pt. Arena

- Identify location(s) you want mapped
- Mapping: broad habitats, seafloor, sub-seafloor structure
- Decide what mapping products are necessary
- Tools, habitat maps, survey techniques: multibeam bathymetry, side-scan sonar, video, grab
- High-resolution, critical habitat

- Hand digitizing methods vs. algorithmic approaches
- Identifying critical habitat, for example, white abalone
- Tools: DEM rugosity analysis, pros and cons
- Counted, measured and identify fish; classified habitat: depth, slope, rugosity, TPI
- Combined parameters, shallow/deep species
- Predicted fish distribution
- Required extensive groundtruthing
- Identify squid egg production
- Repetitive mapping
- Environmental change detection
  - Use base map as reference point to see how landscapes change, for example, Monterey Submarine Canyon
- Identify scarps, terraces, sediment waves, time series, locate changes
  - Monitoring habitat disturbance
  - Quantifying benthic disturbance
- Think about technologies required to fulfill needs
  - Side-scan, multibeam bathymetry
  - They show different things, acoustic reflectance, sediment composition, relief
  - Optical imaging safe and useful for shallow-water areas

[]Talk: Gary Greene (MLML) – Habitat mapping, added value

- A need exists for interpretive [process of] habitat maps [ping]
- A Mapping [as series of] data set[s] can be used to produce a variety of thematic maps [applicable to a variety of fields], not just maps for fisheries
- Substrate is what is best mapped today with present mapping techniques and is a necessary component in evaluating seafloor [plays a major role in] fisheries and ecology
- In Alaska [work], multibeam bathymetry, backscatter, and submersible observations were used to construct interpretive polygons of habitat types for fisheries management purposes
- In Alaska, specific geologic features such as volcanic cones were found to be ideal habitat for Yelloweye rockfish due to relief and types of rocks and boulders present and identification of such structures were useful for MPA evaluations
- Creating a habitat maps, requires multiple tasks such as collection, processing and interpretation of multibeam bathymetry, backscatter, and groundtruth data at a desired resolution or scale from which potential habitat polygons can be constructed [, dependent upon scale]
- For this workshop, participants should [we must] keep in mind scale at which habitat maps should be produced [desired scale]
- In the majority of mapping efforts what is actually produced are *Potential* habitat maps;[,] in order to define [be] *actual* habitats, groundtruthing is required and distinct associations with a species or community of organisms need to be determined

- The seafloor is a dynamic environment and often multiple surveys need to be undertaken in order to detect changes and develop time-series analyses
- Workshop participants need to think of areas of priority where dynamic conditions are important, processes that may alter habitat associations
- Habitat maps can be too complex/detailed for some users, but can often be simplified if initial interpretations are attributed in a way that they can be easily queried in a GIS; to be successful in this effort the most detailed interpretations need to be done
- Thematic and derivative maps, other than habitat maps, can be produced from a single data set and should be constructed to produce the most comprehensive map series possible in any mapping effort
- In addition, a need exists to fill in gaps along the shoreline where substrate types have been historically interpreted by extending [– continue with] onshore geology offshore, but today the use of air photos or the use of such technologies as Shoals bathymetric LIDAR can image the very shallow nearshore areas and should be considered in any State mapping effort [, for example]
- Thematic maps consist of seafloor [–] morphology, grain size distribution, geology, geohazards, non-living resources and substrate types
- For example, landslides can be easily imaged as a geohazered and also may be a critical habitat to a particular specie of fish
- Time series analyses, if done properly, can provide repeatability in the evaluation of dynamic conditions on the seafloor such as has been done offshore of Santa Cruz to determine seasonal sediment shifts
- The mapping community needs to determine a classification scheme to use in the California mapping efforts because a standard process in habitat typing is critical to comparing and contrasting habitats state-wide
- It is also critical[:] to inventory [of] existing data in order to prevent duplication of effort and to develop a baseline
- Data type and quality maps should be constructed to show area of coverage, type, quality and other information on seafloor data that exists today and can be used to evaluate marine benthic habitats

Talk: Chris Wills (California Geological Survey) – Geologic mapping along CA coast

- History of mapping
- Vintage 1960s maps
- L.A., Ventura, Orange County mapping
- New, detailed geologic maps, for example, onshore grain sizes, useful for active sedimentation, onshore geologic map, added habitat maps from Greene
- Seamless onshore/offshore geologic maps
- When performing habitat classifications, have a geologist at hand
- Incorporate wide range of disciplines
- Current maps: 24:000 scale – preferred standard
- Geologic maps provide: bedrock types, sediment types, landslides, faults

Talk: Doug Lockhart (Fugro Pelagos, Inc) – data acquisition and processing considerations

- Variety of resolution (sub-meter to meters depending on depth)
- Surveys require extensive manpower
- Clients' needs vary
- Topographic data collection (red laser)
- Hydrographic LIDAR (green laser used for bathymetry)
- Why do they collect topographic data? To detect tidal changes in beach profiles
- Small launches to big boats
- East Coast LIDAR survey
- Select a consistent, repeatable datum
- Consider datum: Tide; ellipsoid
- Error budget
- NOAA has specs for hydrographic surveys

Talk: Guy Cochrane (USGS Coastal and Marine Geology) – Recent and future seafloor mapping plans of the USGS Coastal and Marine Geology Team and The Consortium for California Coastal Geologic and Habitat Mapping

- The Seafloor mapping project of the Coastal and Marine Geology Program is presently mapping in Southern and Central California.
- One task headed by Curt Storlazzi is doing repeated surveys to identify geologic change in Northern Monterey Bay
- We use a towed sidescan which can operate in deep water, and a pole mounted interferrometric side-scan for nearshore mapping out to 75 m
- Estuarine and open ocean areas are being mapped.
- We follow up sonar mapping with video groundtruthing with a collaborating biologist who logs Epifauna, bottomfish identified
- We log primary and secondary substrate, slope, complexity, and bio-coverage along with microhabitat features, key species, and anthropogenic features.
- Deep-water multibeam is contracted out.
- California Mapping Consortium – idea was to get large group together who are mapping for various reasons and coordinate.
- Create forum for data voids, needs and availabilities
- Produce quad-based maps
- Maintain online source of maps and metadata including data sources.
- Produce GIS including topo-bathy, geologic unit, hazards and resources, surficial seafloor substrate, habitats, physical processes, and legal boundaries
- Prototype map that can be used as example is being produced now
- A variety of State and Federal organizations are involved

Talk: Dirk Rosen (Marine Applied Research and Exploration) – Baseline monitoring

- ROV work – Establishing quantitative baseline in Santa Barbara
- Cooperation between ROV pilot and captain
- Preplanning is critical
- Using Guy's and Rikk's maps in Channel Islands

- Data collection phase:
  - Select comparable sites based upon existing mapping
  - Plan ROV transects
  - Fly planned ROV transects using acoustic tracking
- Post-processing phase:
  - Determine fish quantities
- Sand, rock, cobble, boulder
- Processed ROV trackline with habitat and fish
- Depth range: 20 m – 100 m
- Compare site inside and outside MPA
- ROV surveys – 18 sites, 213 km
- To get quantitative baseline, repeated surveys are necessary
- Want to add fish size to density estimates

Talk: Kirsten Gilardi (UC Davis, SeaDoc Society) – Removing derelict fishing gear

- Lots of abandoned commercial and recreational fishing gear
- Synthetic materials
- Potential to entangle marine life, poses navigational threat, endangers divers, etc.
- Significant decline of Hawaiian monk seal
- Removal program began in 2002 in Puget Sound – NW Straits, >1,000 nets, pots and traps removed
- Is derelict fishing gear an issue in CA? If so, we need to find locations in need of removal
- Assessment of reports complaining of presence of gear
- State Coastal Conservancy funding
- Gather data showing where gear exists; gathering people to do removal work
- Pilot year: chose four study sites
- Gear locations identified by divers, side-scan sonar, reports from individuals, prioritize gear for removal
- Gear removal: GIS software to locate sites, divers, winch
- Data collected: gear type, legal/illegal, biological impacts, owner identification, status (removed)
- Gear disposal: landfill

Talk: Brian Edwards (USGS) – Mapping benthic shelf habitats

- Study area: San Pedro Shelf, 18 km wide
- Cooperative project between USGS, UCSC, LA County Sanitations Districts
- Approach: using pixel-scale classification of seafloor composition and sediment texture
- 4 m pixel data, can identify wrecks, dredge spoils, outfalls, pipelines, etc.
- Pete Dartnell looked at multibeam data
- Generated two roughness categories and integrated with backscatter density
- Created rule-based hierarchical decision tree
- Preliminary classification scheme – pixel by pixel

- Assessing accuracy – two methods – medium sized sled, 1) two digital video cameras, lasers, digital still camera, 2) grab sampler
- Still images taken every 30 seconds
- 180 samples were taken
- Video observation and data entry – recording on tape and creating log on programmable key pad
- Lat/long and time stamps recorded
- Plot observations in GIS
- Allows subsequent observations – time efficient
- New Hampshire developed video mosaic strip at pixel level resolution
- Time consuming, but very compelling
- Interfaces – very important for biological reasons
- Adding biological component
- Species-specific habitat maps
- Data products – several maps

Talk: Dave Caress (MBARI) – Mapping using an AUV

- Working with engineers and operational people at MBARI
- Motivation: map deep ocean (6,000 m)
- Developing technology that will impact the concerns of the people present at workshop
- Monterey Canyon – axis 1,400 m depth
- Components – side-scan sonar (Edgetech 110/410 kHz chirp), multibeam (Reson 7100 multibeam sonar), sub-bottom profiler, CTD, antenna, etc.
- 3 knot speed, 21" diameter, torpedo shaped with no fins, 17.2' length
- AUV can be attached to ROV *Ventana*
- Goal: keep consistent height off bottom
- Operations to date: sub-bottom profiles, repeated surveys in Monterey Canyon to monitor changes in sediment transport, upper Smooth Ridge for MARS cable route
- 100 m, 300 m, 520 m, 1000 m, and 1400 m depth range
- Ex. MARS cable route – 1 m lateral resolution
- Bedforms identified, repeated mapping efforts
- Current status : achieved operational status
- Future : scheduled for 50 days at sea

– Davidson Seamount, Axial Seamount (Juan de Fuca spreading ridge), Santa Monica Basin, Barclay Canyon (British Columbia), Monterey Canyon repeat mapping, Smooth Ridge (Monterey Bay), Offshore San Andreas Fault (proposed)

Talk: Neal Driscoll (Scripps Institute of Oceanography – Sub-bottom profiling)

- Sub-surface data importance
- Need to know third dimension
- Faults and interaction
- Left lateral faults – compression

- Right lateral faults – extension
- Habitat changes correlating with presence of faults
- Need of high-resolution maps and cores to data changing horizons
- AUV work – future for recurring surveys
- Determine future movements on seafloor
- Fiber optic cable strain sensors
- Accuracy (mm) to detect change
- Identify seafloor change

DECEMBER 12, 2005
CENTRAL COAST RFP AREA- DATA NEEDS LUNCHTIME GROUP DISCUSSION

Focal region: mid-Monterey Bay to Point Arena. Data needs identified by participants and compiled from notes taken during group discussion. Facilitated by Rikk Kvitek (CSUMB). (notes: M. Young , S. Zurita, K. Wong).

Mark Johnsson (California Coastal Commission)

- Information on habitat: indicate rugosity/relief in addition to sediment classification
- Sediment movement for management purposes
- Sufficient detailed sub-bottom bathymetry for landslide and seismic purposes
- Beach nourishment, offshore sediment resources/nourishment management especially important in Southern California

Mary Yoklavich (NOAA/NMFS-SWFSC)

- Fish stock assessment (characterizing habitat)
- Locating and monitoring MPA sites
- Deeper water, 50 – 400m (i.e.: heads of sub-canyons) along central coast
- Future MLPA sites in state waters

Tom Albo (Greeninfo)

- Data availability/access

Dirk Rosen (Marine Applied Research and Exploration)

- Habitat classification for use with fisheries and biodiversity
- Potential MPA sites

[]Gary Greene (Moss Landing Marine Labs)

- Anything that hasn't been mapped yet [is important and needs to be considered, although we cannot map everything at this time and need to prioritize]

Michael Reichle (California Geological Survey)

- Geologic, Tsunamis and Seismic Hazards (Any bathymetric and subbottom data that shows recent landslides and faultings)
- Any geologic info would be of great interest.

Arthur Shak (US Army Corps of Engineers)

Navigation
Nearshore coastal

Jerry Wilson (Fugro Pelagos, Inc)

Throughout State
Santa Monica Bay

Cliff Davenport (Coastal Sediment Management Workgroup)

- Critically eroding coastal areas
- Areas of excess sedimentation
- Nearshore over entire state
- Offshore in areas with high erosion
- Show the difference between low and high relief areas
- Potential economic sources of sand (sand traps)

Dick Seymour (Scripps Institute of Oceanography)

Directional properties of waves
Accurate Bathymetric data from 300m to shallows

Dave Caress (Monterey Bay Aquarium Research Institute)

- Physical and biological oceanography studies associated with upwelling.

Need bathy for rest of continental shelf from Moss Landing north to Santa Cruz

Larry Espinosa (California Department of Fish & Game)

Data for nearshore shallows where greatest impact of oil spills are likely to occur
Biological component
Shipwrecks that could cause oil leaks (holdings of shipwrecks available)

Paul Veisze (California Department of Fish & Game)

MPA sites
Filling data gaps in current coverages for state waters

Dan Specht (US Army Corps of Engineers)

Nearshore data
Habitat classification
Areas of erosion, scouring and deposition
Areas requiring or involved in beach nourishment
Hydrographic surveys of ship channels

Keith Jones (CalTrans)

- ASBS data
- SF Bay area to Año Nuevo (especially Año Nuevo and James Fitzgerald Marine Reserve)

Ben Becker (NPS Point Reyes National Seashore)

- Habitat Data
- MPA sites

Mary Elaine Dunway (Minerals Management Service)

Block 456 – Beach nourishment
Offshore areas for high wind and waves

Dale Roberts (NOAA, Cordell Bank NMS)

Around Marin County
Farallones

Holly Lopez (Center for Habitat Studies, MLML)
Canyons
Bedforms in San Francisco Bay

[]Irina Kogan (NOAA, Gulf of the Farallones NMS)
MLPA process
Oil Spill Response [and Damage assessment]
Sediment transport/ processes
Nearshore and deep, some federal waters
Farallones, Cordell Bank, Fitzgerald Marine Reserve
Estuaries – Tomales Bay and Bolinas Lagoon
Año Nuevo – Pescadero Point (rocky area)
Submarine canyons and Shelf/slope break to find biological hotspots
Farallones escarpment
- Pioneer canyon

Dynamic processes of canyons

John Butler (NOAA/NMFS-SWFSC)
- High resolution data of the rocky intertidal out to 10m in South California (for black abalone)

Neal Driscoll (Scripps Institute of Oceanography)
- Tectonic deformation
  - Subsurface data with high spatial density
- Areas that subside
- Deeper cores in the shallow areas

John Orcutt (Scripps Institute of Oceanography)
- Behavior of California coastline
- Coastal Bathymetry especially southern California

Chris Wills (California Geological Survey)
- Geologic processes (offshore)
- Offshore and onshore sediment tracking (relate to watersheds)
- Pt. Reyes and Point Half Moon Bay

Chuck Katz (SPAWAR Systems Center San Diego, Navy)
- Bays, estuaries, nearshore
- Cover current data gaps
- Focus on “data user areas” versus “data gatherer areas”

Brian Edwards (USGS Coastal and Marine Geology)
- Shelf Break areas

- High resolution 3D subbottom data for benthic habitat conservation

Pete Dartnell (USGS Coastal and Marine Geology)
- Computer techniques, grid products from base maps
- Southern California

[]Sam Johnson (USGS Coastal and Marine Geology)
- [Mapping along shoreline and within 3-mile limit has lots of importance for understanding] Coastal Erosion/ Sediment Transport, [needed for sediment management]
- [Sub-bottom data can be important for habitat and resource issues]
- [Mapping of] offshore faults [is important for earthquake hazard assessments]
- [Mapping of faults and potential landslide areas can aid] Tsunami hazards [assessment]

[]Heather Kerkering (CenCOOS)
- Pt. Conception to Oregon [with habitat mapping specifically needed in northern California regions]
- San Francisco Bay (for navigation and sediment transport)
- Placement of MPAs
- End user driven mapping

Sophie DeBeukelaer (Monterey Bay National Marine Sanctuary)
- MPA process – need good habitat information
- Año Nuevo
- Mapping in already designated MPAs

MLPA site designations in progress

Paulo Serpa (California Department of Fish & Game)
- MLPA mapping
- Pigeon Point to Año Nuevo- priority
- Above Pigeon Point to San Francisco
- Groundfish habitat
- Nearshore LIDAR for entire coast

Chad King (Monterey Bay National Marine Sanctuary)
- Monitoring information
- Data gaps
- Current and future reserves
- Santa Cruz and San Mateo Counties
- Shelf break in the south

Dave Lott (Monterey Bay National Marine Sanctuary)
- Support the MLPA process – mapping MPAs

Steve Watt (Sea Engineering, Inc)

- Habitat Change – repetitive mapping
- Sediment transport modeling

Greg Benoit (CA Coastal Commission)

- Habitat Classification
- Sediment transport
- Entire state waters

Rick Hanks (Bureau of Land Management)

- San Mateo Coast
- Point Reyes to Point Arena
- Offshore mapping
- Blue strip along coast (LIDAR)

Gerry Wheaton (NOAA Ocean Service)

- Updates nautical charts for:
    - Monterey
    - Moss Landing
    - Santa Cruz
    - Half Moon Bay (sediment)
    - Bodega Bay
    - Nearshore (especially near Ft. Ord), beach erosion areas
- MLLW to legal boundary

Kirsten Gilardi (UC Davis, SeaDoc Society)

- Moss Landing to Point Lobos (sidescan for derelict fishing gear)
- Areas of intensive fishing especially Dungeness fleets
- Areas accessible by divers
- Fairly shallow waters
- San Mateo County
- North of San Francisco

Mary Gleason (The Nature Conservancy)

- MLPA process
- Biodiversity hot spots
- Potential MPA sites
- Pigeon Point to Point Arena

Unidentified participant

- Near Sewage outfalls,
- Near large municipalities
- Around larger developed areas
    - Nearshore around storm runoff/outfalls
- Areas of Biological Significance

- Around Marin County

DECEMBER 12, 2005
STATEWIDE DATA NEEDS- LUNCHTIME GROUP DISCUSSION

Statewide data needs identified by participants and compiled from notes taken during group discussion. Facilitated by Rikk Kvitek (CSUMB). (notes: M. Young , S. Zurita).

(California Coastal Conservancy)

- Funded near shore mapping from Camp Pendleton, Oceanside to San Diego
- Complete maps Santa Barbara, Ventura, LA counties
- Complete map of the California Bight

Jerry Wilson (Fugro Pelagos, Inc)

- Entire southern region south of Point Conception especially Santa Monica Bay
- Decide on what is priority bathy or sss?
- Holdings: LIDAR data from Dana Point south to the Mexican border
- IHO standards for navigation safety (non-habitat mapping)

Mary Elaine Dunway (Minerals Management Services)

- Point Conception south to Ventura in the Santa Barbara Channel
- Scouring/sediment transport areas
- Are changes needed for pipelines?

[]Sam Johnson (USGS Coastal and Marine Geology)

- [Proposed LNG facilities off] Ventura
- ~~Bathy data of shoals~~ [SHOALS bathymetric lidar data]
- ~~Faults related to Northridge quake~~
- [Trace] Transverse ranges [structures into the] offshore ~~to better understand tectonics~~ [for better earthquake hazards assessments, including tracing the fault zone that generated the Northridge earthquake]

Art Shak (US Army Corps of Engineers)

- Gap in near shore around LAX
- Coastal zone habitat mapping to better understand erosion, dredging, shore protection, sedimentation

Michael Reichle (California Geological Survey)

- Complete bathy and sub-bottom data extending out to federal waters
- Areas around Morro Bay and Cambria for faulting in line scarps

Mary Yoklavich (NOAA/NMFS-SWFSC)

- Offshore banks in federal waters
- Southern California: San Nicholas Island (blocks # 813, 814 for groundfish species stock assessments)
- Inside and outside comparisons of MPA sites

Cliff Davenport (Coastal Sediment Management Workgroup)

- Bathy data of canyons and wetlands

Mark Johnsson (California Coastal Commission)

- Potential sand deposit areas
- Location of current habitats (Oceanside to San Diego, Encinitas to Solana Beach)
- Accurate bathy data off LA ports, Long Beach, and Sand Diego coast)
- Past events (landslides) repeat intervals
- Cabrillo deep water ports
- Oxnard – liquefy natural gasline (one of first major gaslines to be placed in decades)
- Characterize needs for MPA's

Kirsten Gilardi (UC Davis, SeaDoc Society)

- Morro Bay
- Fine scale mapping around Catalina Island (backside of Catalina)
- Rocky habitats off Point Loma and Palos Verdes

Dominic Gregorio (State Water Resource Control Board)

- Near shore gaps where storm water runoff occurs
- Mouth of Mugu Lagoon (possibly block # 682, not sure)
- Julia Pfeiffer Burns near shore where landslide occurred, severe sediment scour
- Orange County mouths: Laguna Beach and Crystal Cove
- San Nicholas and San Clemente Islands
- Catalina Island (2 harbors area)
- Quarry on Catalina Island
- Data gaps of Channel Islands MPA network
- Proposed MLPA sites from Big Creek to Cambria

Paulo Serpa (California Department of Fish & Game)

- Julia Pfeiffer Burns
- Multibeam and sss for Big Creek
- Data gaps of Point Sal
- Cambria very important (block 601)
- Data gaps in current Channel Island MPA's

Pete Dartnell (USGS, Coastal and Marine Geology)

- Santa Barbara Channel regions
- Fill data gaps from Dana Point to La Jolla Canyon
- Offshore: geologic habitat maps in deeper waters

Brian Edwards (USGS, Coastal and Marine Geology)

- SSS – detailed (pixel by pixel) work and extend this approach to deeper water

- Multibeam of the coastline (…to Huntington Beach) to better understand sediment pathways (material from Bolsa Chica being placed offshore)

Don Cadien (LA County Sanitation District)

- High priority habitat areas: unmapped areas of Northern Channel Islands

Dick Seymour (SIO)

- Should near shore areas be mapped more than once (blueline coast)?
- SIO taking monthly surveys of blocks: 738,802, 842 (back beach to 8m depth) using ATV's, jet skis every 100m
- Want to do seasonal shoal type investigation

John Orcutt (SIO)

- Extend map into Baja
- LIDAR data (Newport/Inglewood fault): tectonics offshore have large impact on sediment
- Deconstruction of Matilija Dam in Ventura. Large quantities of sediment released into ocean (Blocks: 662, 664, 654)

Jeff Babcock (SIO)

- Bathymetry and sub-bottom high resolution maps from Huntington Beach south to the border (Huntington Beach to San Diego especially important)
- Near shore LIDAR combined with sub-bottom
- Repetitive mapping along with bathy data
- Sediment thickness (what happens when certain events occur?)
- Relate sub-bottom to tectonics and biological habitat

Dave Caress (MBARI)

- Question: "What frequency is needed by SIO to determine near shore sediment thickness?"

Jeff Babcock (SIO)

- Answer: "…from past experiments (Neil Driscoll) the Edgetech uses a lower frequency for sediment (approx.1 to 6 khz) and a higher frequency is used for bathymetry"

John Butler (NOAA/NMFS SWFSC)

- Black abalone (0 – 10m)
- Crescent City to Punta Abreojos
- San Nicholas Island
- Catalina
- Northern Channel Islands
- Point Conception south to Point Loma (rocky habitat)
- Offshore banks located in federal waters (300 – 500m)

Dan Specht (USACE)

- Sand sources and sinks
- Question: "What would be the consequences of not getting the data needs?"

Jerry Wilson (Fugro Pelagos, Inc.)

- Discussions by federal agencies about "noise" affects on specific species in ocean

Mark Johnsson (California Coastal Commission)

- Increasing concerns about "noise"

Chuck Katz (SPAWAR Systems Center San Diego, Navy)

- List of products that will be produced from mapping

Don Cadien (LA County Sanitation District)

- Prioritizing
- Question of stability over time

Mary Gleason (The Nature Conservancy)

- Looking for biodiversity hot spots along central coast
- Potential MPA sites need better habitat maps
- Pigeon Point to Point Arena

Marina Cazorla (California Coastal Conservancy)

- Focus on Monterey Peninsula and north
- Want as much done as possible between Monterey Bay and Bodega Bay and possibly north of Point Arena

DECEMBER 12, 2005
NORTHERN CALIFORNIA – Data needs group discussion

Mapping priorities for Northern California (Monterey canyon to northern California border) discussed during breakout session. Discussion facilitated by Gary Greene (Moss Landing Marine Labs). *Asterisks indicate areas identified by the group as priority areas. (Notes: J. Sampey, K. Wong.) *Post-workshop comments ([ ]) were by G. Greene, unless otherwise noted*.

Objectives:

1) Identify areas of data needs
2) Identify important products (from end users)
3) Prioritize the above

Discussion topics: 1) target areas 2) data types

Areas of interest (what are the areas that are important and why?)

- Farallon Islands within state waters, should concentrate on the south east Farallones [because of data gaps and potential good habitats for fisheries]
- Focus on the geological features extending from the Farallon Islands out to Cordell Banks- as this is a potential biological hotspot.
- *Proposed and agreed by many individuals in the discussion, [that] the area extending from just south of the Golden Gate to [the] west of the Farallones and north to Pt. Reyes should be an area of high priority- as there is potential for MPAs in this area. Include [in any mapping effort] previously collected data ([ranging from] 30-100+m [water depth])

Gary Green- MLML: This is a large area and we have to keep in mind the time it takes to survey and the ability to survey it [given the potential funding].

After this comment by Greene, discussion ensued as to the reasons that this area is very critical and in need of priority mapping.

- While the area is large, it is an important fishery area and [contains] biological hotspot[s] that should be mapped with high[-resolution systems in as much] detail [as possible].
- This area is critical due to MPA considerations, navigation, sediment transport, tectonic activity, and contaminants/water quality [issues].
- Area from shelf to Gualala River under consideration for inclusion into [a National Marine Sanctuary] ~~sanctuary~~.
- Area north of the Golden Gate out to the shelf should be mapped due to important bird rookeries, potential oil spill and oil drilling impacts and emergency response [planning].

Areas were identified within the state waters boundary that may require different mapping technologies.

- Deep areas that are within the 3-mile state boundary. These areas best suited for multibeam [bathymetric and backscatter mapping]
- Shallow area inaccessible by boat best suited to [bathymetric] LiDAR [digital photographic mapping].
- Offshore areas should be done with backscatter [along with multibeam bathymetry collection].

Near shore areas are the most important areas to map, due to the interaction with land and sea. However, this interface is the hardest to map.

Greg Benoit- CA Coastal Commission: The data gap from 0-10 meters needs to be addressed. This is an area in which habitat greatly affects policy decisions. It is critical that a habitat map be created for this zone for all near shore California.

- Question: Would [bathymetric] LiDAR be able to be used in the surf zone?
- Answer: (*Fugro Pelagos, Inc*): LiDAR will not penetrate white water, the reflectivity is too high. For LiDAR to be utilized a low surf day would be advisable [for the data collection time].
- LiDAR being flown in the near shore area should consider [for] surveys of coastal wetlands, and possibly conducted at the same time where possible.
- The estuaries most in need of mapping are those from San Francisco to Santa Cruz.

It was realized by the group that much of the North Coast has not been mapped and some method/ criteria needed to be in place to decide priority areas.

- Question: Could we conduct a low-resolution survey for the coast to get a sense of the habitat along the north coast.
- Answer (*Gary Greene- MLML*): The nature of [most seafloor mapping] systems does not really permit a low-resolution survey to be conducted.
- *Fugro Pelagos, Inc*: Another option is to look at original NOAA data, which is presented on mylar sheets ~~in~~ [at] higher sounding densities and use ~~that~~ [these] to aid in identifying key areas.
- *Green & others*: Also could use terrestrial geologic maps and [small scale offshore geologic maps to] interpret what may be [the substrate types] in the water and [plan a mapping exercise] ~~map~~ based on those sorts of interpretations.

The discussion then focused on identifying critical areas along the coast that individuals or groups thought would be most critical

- Estuaries (Bolinas, two Esteros [Bay] lagoons) in general should be mapped due to their biological significance. Also, repetitive surveys would be desired.
- Santa Cruz and Davenport area habitat[s need to be better delineated].
- Año Nuevo and Pescadaro Points are of interest due to the[existence of rocky] ~~rock~~ habitat. There is MPA consideration within this area.
- Fitzgerald Marine Reserve would be important due to habitat, hazards, MPA, and geology.
- Devil's Slide – CalTrans plans to build a tunnel [to bypass this area], [the activity] could cause hazards to the local nearshore area

- *Cuddy Cove- geologic interest, subbottom and habitat [all appear critical to this area].
- Areas along the north coast which are hotspots for recreational abalone diving.
- Areas such as river mouths and fishing grounds [need investigating]. River mouths may be candidates for repetitive future mapping [because of sediment input and constant seafloor alterations].

[]Cliff Davenport (Coastal Sediment Management Workgroup)
[clarity on my comment regarding the need to repetitively map offshore of river mouths: Our current paradigm expects that sediment that exits a river mouth either ends up on a downcoast beach or nearshore (coarser sediment) or gets widely dispersed in the oceanic offshore environment (fine-grained sediment). Efforts are underway looking at tearing down dams that trap sediment as a means to get more coarse sediment to our eroding coastlines. However, recent studies are implying that during high volume river flows (which is when most of the coarse sediment is moving) associated with storm events, the sediment may actually be moving offshore as a turbidity flow (aka hyperpycnal). If this is in fact the case, then costly efforts to take out dams, etc. may not produce the desired result of getting all the coarse sediment to the coastline. Repetitive mapping can shed some light on this by analyzing post storm conditions to see whether significant changes in the offshore seafloor took place.]

- *Van Damme (area south of Mendocino [where dam removal is being considered]), this is a shallow habitat area. The USGS would be very interested in this site [because of future sediment input].
- *Ft. Bragg area [is another area that was considered important to map because of the existence of fisheries habitats]
- * Trinidad to Patrick's Pt. (blocks 132-133)- This area is important for several reasons, [such as:]
    - Biologically significant
    - Water quality [issues]
    - Large [commercial and sport] fisheries, especially groundfish, salmon, and crab fisheries
    - The rocky habitat is not impacted by sediment [cover, but could be in the future]
    - Shoreline erosion [is occurring].
    - Fisheries management [for the region needs good habitat maps]
    - Important habitat for marine mammals/haul outs and many marine birds [another reason for good habitat maps]

* Mad River to Trinidad.

Razor clams (Clam Beach) [an important fisheries that needs to be protected]
Shifting Mad River Mouth [is altering sediment seafloor]
The area is a multiple use area with public recreation, shipping and active fishing [that may be in conflict and good data need to be available for proper management practices to occur].
Mapping would facilitate the understanding of rip currents-which are prevalent in the area.

Many thrust faults exist in the area [and need to be mapped as they are a geological hazard].

* Rest of Humboldt Bay, outside the jetties and around the outfall (possible LiDAR usage) [because of the areas sensitive wetlands habitats].
*Crescent City- Hazards study following the tsunami [of the]1960's, sediment dispersal [in need of evaluation for growth management]
* Klamath River to Crescent City [is in need of mapping because of:]
    - Navigation [concerns]
    - Sediment Transport [concerns]
    - Fishery [concerns]
- *St George Reef [because of:]
    - Smith river mouth – potential fish habitat and seal haul out [aeras that are in need of characterization]
- *Smith River (largest undammed river in CA) [because of:]
    - Water quality, fisheries [and other concerns]

The North Coast was arbitrarily divided into 4 geographical zones

A – Santa Cruz to Ocean Beach
B – Ocean Beach to lower Mendocino Coast
C – Mendocino Coast to South of Humboldt
D – Humboldt to Oregon

Suggestion: we should have some sort of preliminary surveys, such as low-resolution swath mapping [or a desktop study], to figure out what should be prioritized. This would be beneficial in areas that have not yet been mapped.

DECEMBER 12, 2005
SOUTHERN CALIFORNIA – Data needs group discussion

Mapping priorities for Southern California (South of Pt Conception) discussed during breakout session. Discussion facilitated by Rikk Kvitek (CSUMB). (Notes: M. Young, S. Zurita)

Jerry Wilson (Fugro Pelagos, Inc)

San Juan Bay
South of Point Conception

Mary Elaine Dunway (Minerals Management Service)

- Santa Barbara Channel
- South of Point Conception
- Areas of seeps and scouring

[]Sam Johnson (USGS Coastal and Marine Geology)

- [Santa Barbara-Ventura areas has big sediment management and coastal erosion issues]
- SHOALS bathymetric [LIDAR] data [could be very important]
- Faults (continuation of faults)
    - Understanding tectonic ring
- Offshore Ventura
- [Potential Earthquake and Tsunami sources in very active Santa Barbara channel area should be documented]

Art Shak (US Army Corps of Engineers)

- Habitat Mapping in Coastal zone (shore protection, beach erosion, dredging, and disposal of dredge spoils)
- Shoal in Ventura and Santa Barbara Counties
- Littoral Zone

Michael Reichle (California Geological Survey)

- Complete Bathymetric and Sidescan
- Morro Bay to Cambria – Faulting line scarps

Mary Yoklavich (NOAA/NMFS-SWFSC)

- State waters blocks 814 and 813
    - Stock assessment of groundfish
- Point Conception to North to Vandenburg
- Julia Pfeiffer Burns
- North of Big Creek and adjacent areas

Unidentified participant (US Army Corps of Engineers)

- Critically eroding areas (still in the process of prioritizing)

- Some Federal sites
- San Clemente
- Surfside
- Offshore
- Wetlands
- Bathy and sediment deposition areas

Mark Johnsson (California Coastal Commission)

- Current habitat
- Sand deposits
- Oceanside
- San Diego
- Tsunami modeling
- Accurate bathy for the ports of LA and Long Beach
- Off the coast of San Diego

Unidentified participant

- Identify landslide risks
    - Santa Monica Bay
- Hazards
    - Cabrillo water port (off Malibu)
    - Natural gas pipeline off Oxnard
- MLPA
    - Characterize protected areas

Kirsten Gilardi (UC Davis, SeaDoc Society)

- Morro Bay
- Backside of Catalina
- Fine scale resolution around Channel Islands
- Rockier points
    - Pt. Loma
    - Palos Verdes
- Derelict fishing gear
- Fill in unmapped areas

Unidentified participant

- Nearshore – storm water runoff
- Mouth of Mugu Lagoon
    - Block 682
- Julia Pfeiffer Burns area
    - Landslides
    - Sediment scour effects
    - Filled cove
    - Time series data
- Creek mouths in Orange County

- San Nicolas and San Clemente Islands
- Catalina Island
    - 2 Harbors – marine activity
    - road sediment
    - quarry – localized impacts

Unidentified participant
- Channel Islands – unmapped areas
- Big Sur South to Cambria for MLPA

Paulo Serpa (CDFG)
- Julia Pfeiffer Burns
- Big Creek sidescan and additional multibeam (for MLPA process)
- Filling in data gaps to Pt. Sal
- Cambria (Block 601)
- Data gaps in the Channel Islands
- Pt. Loma
- La Jolla Coast
- Torrence to LA Breakwater

Pete Dartnell (USGS, Coastal and Marine Geology)
- Santa Barbara Channel
- Gap between Dana Point and La Jolla Canyon
    - Habitats and Geologic Maps
- Deeper water habitats

Brian Edwards (USGS, Coastal and Marine Geology)
- Single, multibeam, and backscatter
- Detailed backscatter maps
    - Extend to deeper water habitats off San Diego
- Coastline (sediment transport)
- LA margin (beach nourishment)
    - Point-source dispersal of sediment

Chuck Katz (SPAWAR Systems Center San Diego, Navy)
- Environmental impacts
- Baseline monitoring

Don Cadien (LA County Sanitation District)
- Complete North Channel Islands
- North of Point Conception
- Between Pt. Reyes and Pt. Sal
    - Geology

Dick Seymour (SIO)

- Blue Line Along Coast
- Blocks 738, 802, 842
    - Monthly surveys
    - Beach to 8m depth (ATVs)
    - Every 100 meters
- Conduct seasonal shoals investigations
- Map seasonal changes to find out how often to survey coast

John Orcutt (SIO)

- Understanding of environment South of Border
- High resolution data for faults
    - Change in offshore sediments
    - Coincidental data
- Matilija Dam – dumping of sediment
    - Behavior of sediment
- Blocks 654, 682, 653, 664

Jeff Babcock (SIO)

- High resolution (<1 meter) 500 meters to 100 meters water depth
- Huntington Beach to San Diego
- LIDAR data in the nearshore
- Sub bottom data collected with multibeam
    - Baseline of sediments
    - Repetitive studies
    - Decadal change
    - El Nino change
    - Thickness of sediments
    - Resources
    - Erosion – Offshore
    - Tectonics
    - Habitat areas
    - Sands versus hard substrate
    - Faulting and seismic in high accuracy

Dave Caress (MBARI)

- Frequency range of sub bottom for nearshore sand forms
- Shallow water sandy environment

John Butler (NOAA/NMFS SWFSC)

- 0-10 meters Crescent City to Punto Abrejos (abalone)
- San Nicholas Island
- Catalina
- Northern Channel Islands
- Point Conception to Point Loma – shallow rocky habitat
- Offshore banks

Dan Specht (US Army Corps of Engineers)

- Characterization of Sediments
    - Sand sources and sinks

Mary Elaine Dunway (Minerals Management Service)

- Start Broader (use tiered approach)
- Work on problem areas

Art Shak (US Army Corps of Engineers)

- Intertidal areas
    - Topo and bathy
- Morro Bay

Jerry Wilson (Fugro Pelagos, Inc)

- Bathy for navigation safety
- Optimize Bathy or backscatter
- Biological impacts of acoustical noise
    - Eco-sounders

Mark Johnsson (California Coastal Commission)

- Response to above
    - Higher frequencies cause less problems
    - Biological ramifications

Chuck Katz (SPAWAR Systems Center San Diego, Navy)

- Maps and data products

Don Cadien (LA County Sanitation District)

- Stability over time

Frequency with regard for stability

DECEMBER 13, 2005
RECOMMENDATIONS FOR MINIMUM REQUIREMENTS OF FINAL PRODUCTS

Morning roundtable of recommendations for baseline mapping effort based on current information needs for State waters. Discussion led by Rikk Kvitek (CSUMB). (Notes: M. Young, S. Zurita, K. Wong)

Dick Seymour (SIO)

- Current state of the art SHOALS (surf zone to extinction level)
- Classified database broadly available (backscatter, xyz's)
- Data interpretation

Keith Jones (CalTrans)

- Purpose for products produced, regulatory/ policy decisions
- Keep track of water quality (to what extent will multibeam help)

Cliff Davenport (Coastal Sediment Management Workgroup)

- Valuable products from substrate maps = geologic maps (identify location, volume, and depth)
- Sub-bottom profiles of substrate maps to determine where mud belts are located
- Repetitive mapping of river mouths
- Begin with backscatter data to determine critical locations (ie: erosion)
- Identify general locations w/o knowing critters
- Core for representative grain size analyses

John Butler (NOAA/NMFS SWFSC)

- Habitat maps (more backscatter)
- Better classification maps that would be more useful for MPA selection and fishery management
- Standards for different types of relief (low & high) ad substrate type (sand & rock), costs will vary greatly with resolution required, equipment varies

Dale Roberts (Cordell Bank National Marine Sanctuary)

- Resolution of habitat maps should be dependent on site, depth, and species of interest

Paul Veisze (CDFG)

- Time factor rates
- Use productivity measures to meet timelines for legislative demands, work backwards from 2011 timeline

[]Gary Greene (MLML)

- [There is a need to] Determine what data is available (~~do we need to~~ [can we] build upon that [data]?) [and the move ahead to design a survey

- [We should determine] Specific needs of management, policies, and objectives before specifications like resolution [and scale] are determined
- Reconnaissance: [surveys can be done at] low resolution, [while] Critical areas [can be surveyed at] high[er] resolution

Guy Cochrane (USGS, Coastal and Marine Geology)

- 3 tiered structure - xyz & backscatter grids --> numerical derivative such as topographic index grid --> attributed GIS polygons (may increase costs by approximately 50%)

Irina Kogan (Gulf of the Farallones National Marine Sanctuary)

- Backscatter useful in near shore, shallow, areas with habitat
- Backscatter useful for MLPA process
- Images of substrate data done first then detailed habitat maps and groundtruthing

Art Shak (USACE)

- Baseline map of current shoreline with MLLW lines
- Good basemap from shore out to navigational depths

Rikk Kvitek (CSUMB)

- Shoreline important boundary for legal purposes
- Shoreline is moving so important to have the shoreline mapped

Gerry Wheaton (NOAA Ocean Service)

- Data all uniform
- Define data acquisition

Mary Elaine Dunway (Minerals Management Service)

- Tiered approach is cost effective and has been very useful to biologists
- Multibeam and backscatter groundtruthing, use AUV's, towed cameras, manned submersibles

[]Gary Greene (MLML)

- Knowledge of geologic processes that lead to educated guesses about substrate [types is a powerful tool in habitat characterization and mapping]
- Changes in grain size [is] key [to understanding the dynamic processes of the seafloor]

Rikk Kvitek (CSUMB)

- Groundtruthing should be included as a minimum requirement

[]Guy Cochrane (USGS, Coastal and Marine Geology)

- Groundtruthing increase costs by approximately 25%

- ~~There is a biological need for groundtruthing~~ [Sonar is useful for classifying macro-habitat and bottom induration but there is a need for groundtruthing using video and sampling for micro-habitat classification]

John Butler (NOAA/NMFS SWFS)
- Groundtruthing needs to be a focus if species are dependent on area mapped (i.e.: slopes)- rockfish habitat
- 25% of data should be groundtruthed

Chris Wills (California Geological Survey)
- Habitat mapping: polygons of substrate important for policy makers
- Evaluate fault processes, sediment processes (sub-bottom profiles)
- Hazards interpretation in baseline data, slope and potential slides

Mary Elaine Dunway (Minerals Management Service)
- Need for groundtruthing to move forward

Gerry Wheaton (NOAA Ocean Service)
- RFP's have potential outcomes (What is RFP going to accomplish?)

Dick Seymour (SIO)
- Clarification on groundtruthing
- We need to be concentrating on making specifications of minimum requirements

Doug Lockhart (Fugro Pelagos, Inc.)
- Deliverables of data is easy to determine quality total propagated processes
- Total propagated error, how good data is

John Butler (NOAA/NMFS SWFS)
- Columns in voting block determine what type of data is needed

SUMMARY

Levels of Interpretation:
- 1°-Basic Data- backscatter & bathy images (rough vs smooth & texture mosaics)- require groundtruthing (e.g. towed camera)
- 2° -GIS computer analyses [such as slope analyses and complexity evaluations]
- 3°-Geologic/Habitat [maps in a] GIS
- 4°-Hazards & Faults/Slides [maps in a GIS]
- 5°-Sediment sources [types and direction of transport maps in a GIS]

[]Cliff Davenport (Coastal Sediment Management Workgroup)
[I feel that it is extremely important that the "Statewide Mapping" effort be geared towards getting as much coverage (100%?) as possible of the seafloor under State waters, even if we have to accept a lower resolution of coverage. Information obtained during this first phase would be more appropriate for regional planning anyway, so resolution

needs should be less. We don't always know going in what we'll find or where, we don't know where all the problem/opportunity areas are, and trying to obtain initial coverage with high resolution will be expensive and possibly wasteful.

The first phase can then serve as a platform to focus more site-specific studies in the future that would need a higher resolution (ie specific attributes of habitat, offshore sources of sand for beach restoration, active fault delineation for hazard analyses, etc.). These studies could be done as part of the seafloor mapping, but I also expect that the information obtained will springboard into studies funded by other organizations as well. Its important to have Sub-bottom Profiling conducted in selected (not all) areas, especially in Geologic Areas of Significance (e.g., where economically viable deposits and geologic hazards exist).

The Phase 1 studies need to be groundtruthed after the inital data has been processed (25% was recommended in the workshop). The Phase 2 assessments can be done with cameras/grab sampling, and provides a fortuitous occasion to mount the deep profiling equipment and collect additional information at the higher resolutions needed for more site-specific investigations of current need.]

Clarification of terms “hi and low resolution”.

[… should try to get complete coverage in as economical manner as possible, and that would involve "high resolution multibeam bathymetric profiling with backscatter". Subsequent studies to gather more detailed information on a specific location(s) would constitute Phase 2 assessments.]

DECEMBER 13, 2005
RECOMMENDATIONS FOR DATA ACQUISITION AND PROCESSING

Breakout discussion of general mapping guidelines and standards for data acquisition and processing. Facilitated by Rikk Kvitek (CSUMB). (Notes: M. Young, S. Zurita)

***Objective:** To create a strategic plan for California state waters by defining the minimum standards for data acquisition.

- Base map of existing datasets, a good step to work from, synthesis of existing datasets & data gaps/what type of analyses have been done for each site map
- In addition to remote sensing data (bathy & backscatter) provide other information that exists with that data, and on data collected in strategically located places
- Include sub-bottom profiling with surveys so extra vessel time is eliminated
- Survey time is doubled if it includes a towfish survey while running multibeam, unless the sub-bottom is hull mounted
- It is more efficient to run 2 vessels: Use multibeam image to guide sub-bottom instrument

Sub-bottom in state waters:

- Sand bodies hard to image (need low frequency which would reduce resolution)
- Sub-bottom and video groundtruthing should be post bathy and backscatter
- Not many devices to image sand, faults, etc.
- Tiered studies allow you to determine where and when sub-bottom and groundtruthing should occur
- Frequency versus resolution changes due to species of interest, sediment, and processes
- USGS study: Camera tows on a continuous trackline using a sled. Coverage is less than that of a ROV
- Sled with a camera gives sediment grain size
- Data acquisition tier (shoreline out to 3 mile limit)
    - Multibeam and backscatter, XYZ
    - Sub-bottom profiles and video camera: sand & tectonics (groundtruth)
    - Physical samples, cores
- Narrow strip of hard to reach areas – GeoSwath used by *Fugr*o (shore to water in flat areas)/ Need to run a tideline
- *Ocean Imaging* – multispectral dependent on cloud cover
- Specify needs first then determined instruments used
- Multispectral displays data differently than acoustic
- LIDAR better to use for 0 – 10m depths
- Running separate systems may lose capabilities for co-registration
- Datasets co-registered wherever possible
- Biological data important- need to specify level to collect
- Include water column along with Acoustic Doppler Current Profiler (ADCP) for temperature, current, salinity (what's in the water?)

- ADCP would require another person to manage and not as easy to use on smaller vessels
- Consider local sediment transport
- Collaboration- include entities
- IHO standards: possible modifications and implications
    - Does the order of 1 standard decrease data if changed?
    - IHO = 10% at 40m mainly for navigable reasons/change to 5% at 40m for habitat analyses would work better
- Must maintain manufacturers specs to meet IHO standards
- New Reson system (7000 series) has 0.5 degree beams (512 beams across 150 degree swath)
    - 6 terabytes of data collected each day
- Verify acoustic compliance with regards to marine mammal regulations
- Shallow water mapping based on IHO Order 1 standard (most cost efficient)
- Share cost of equipment
- AUV increase resolution and cost
- High resolution data using hull mounted system of 0.5 degree beams
- LIDAR best if 2x2m @ 400m altitude (IHO standard requires two flights of 2x2m data)
- Habitat surveying versus navigation surveys dependent on processing possibility
- *Fugro* surveys based on ellipsoid and calculate back to tide (found data fits better), total propagated error is reduced by RTK use

Data Acquisition Summary

- Towed sled with continuous video (if needed use ROV for more intense studies)
- IHO Order 1 standards provides appropriate resolution for habitat, deeper water IHO may change
- Exceed IHO standards (0.5 degree beam, higher resolution for habitat in deeper water)
- Additional instruments such as an ADCP would be better if collaboration with other agencies is good
- Marine mammal regulatory compliances
- Sub-bottom and other instruments power outputs are well below regulatory levels
- Use of ROV instead of towing a sled in hard to reach areas like Big Sur

DECEMBER 13, 2005
RECOMMENDATIONS FOR DATA ANALYSIS, INTERPRETATION, AND CLASSIFICATION

Breakout discussion of guidelines and standards for data analysis, interpretation, and classification. Facilitated by Gary Greene (MLML). (Notes: K. Wong). *Post-workshop comments ([ ]) were by G. Greene, unless otherwise noted*.

Gary Greene (MLML): People want [two] (2) things, raw data, and/or some analyses/interpretation such as [habitat] ~~locations~~ or substrates [types]

What types of interpretations are minimally required for the many different purposes [of mapping the seafloor]?

Dale Roberts (NOAA Cordell Bank NMS): Contour map[s],[with] bathymetric contours (isobaths) [is at least the minimum map type needed]

What [contour] intervals [are needed]?
Dependent on the use and depth of the data: [one] (1)m contours would be desired for tsunami research [and modeling].

Pat Iampietro (CSUMB): contour lines are easily generated in GIS, rather than focusing on what intervals, we should focus on other levels of interpretation.

General request for data [type, at a minimum]:

- Gridded xyz data
- Geologic/habitat polygons
- Rugosity maps, Roughness maps, Lithologic maps.

Interpret [bathymetric and backscatter data] at greatest detail possible. Habitat maps would be species-dependent or species-specific. First, make fine scale maps (high-resolution), then back ~~out~~ [off] to using to low-resolution [(simplification of data to meet objectives of mapping effort)] data where needed.

[Consider] Employing new technologies-[such as] synthetic aperture sonar

What resolution of data do we want?

- *Gary Greene (MLML):* acquire at the highest resolution possible

- *Irina Kogan (GFNMS):* We should get as much detail as possible in the interpretation. Do a good job interpreting before giving the data to regulators.

- Accuracy assessment (confidence level of data) ~~that is~~ [should be] polygon based. This will help policy makers.

- Require interpretations [to be] done without bias, done by a credible organization [or person without an agenda]

- Groundtruthing needed ([for a] portion of survey footprint) at the time [the survey] data is collected

- Need baseline or general interpretations that everyone can use for the entire site [surveyed]. These ~~would~~ [may] not be specific to the needs of everyone.

- Make use of current data sets, background information [to plan and execute new survey and if possible use in interpretation for the construction of maps]

- We should do overall [general] background interpretations first for the whole area [surveyed]- then come back later (to the data) to do more specific interpretations.

General Agreement of minimum requirements

- Contours/isobaths [maps]
- Grids at the highest resolution possible [– artificial sun-shaded images and backscatter mosaics]
- Vector and polygon maps
- Potential habitats, geology, hazards [maps]
- Confidence levels stated [in a data quality map]
- Quality assessment, such as groundtruthing [to be undertaken for a fraction of the survey area]
- Credible source[s] doing the analysis
- Background data [to be compiled prior to surveying to prevent duplication of data] ~~with no duplicate information~~
- [Survey at a] 100% coverage [when possible]

DECEMBER 13, 2005
STRATEGIES FOR METADATA, ARCHIVING AND DISSEMINATION OF DATA AND PRODUCTS

Breakout discussion of metadata, archiving, and dissemination of data and products. Facilitated by Guy Cochrane (USGS). (Notes: J. Sampey)

- Discussion started with agreement that metadata inclusion should be a requirement of the data acquisition contract
- Agreement that FGDC standards should be followed for metadata creation
- Data should be collected in one reference plane (NAVD88 etc.), any re-projection of the data should be documented.
- Suggested use of SANDDAG project (nearshore profile) as a model for the creation of metadata and its integration into data products. This project added extra information to metadata for shallow water surveys. The new information added elements addressing project specific data collection- followed FGDC standards

Archiving

Data needs to be archived for future reference and also formatted to allow useful distribution to end-users. Due to the large data volume, a suitable location capable of storing extensive data sets and allowing user downloads has to be identified.

- *Becky Pollock (CA Coastal Conservancy):* The data has to be non-proprietary and available to the public.
- Possible archiving location- NOAA's National Oceanographic Data Center (NODC). This location has "unlimited storage", however the usability of directly obtaining data from this site was in question. The user interface is limited and data searching is rudimentary. (Further information www.nodc.noaa.gov)
- Since data collected would be limited to California, a question was posed as to the suitability of CA Department of Fish and Game (CDFG) to act as the data repository. The benefits being an already in-place data retrieval system. (Further information: http://imaps.dfg.ca.gov/)
- California Spatial Information Library was another possible archival location. (Further Information: http://gis.ca.gov/)
- No matter what location is selected for data archiving, a user-friendly interface is a must. Possible solution proposed was be the creation of an IMS webpage or other data search page that would link to archiving location such as NODC or CDFG archives.
- *Greene* [Another process is to work cooperatively with the new California Seafloor Mapping Consortium to display and publish maps that could be placed on the joint California Geological Survey/USGS web site that is presently being considered for development.]

Organization

Collected data more than likely would be compiled by numerous agencies. Due to the formats required for successful data archiving, a single contact should define the appropriate organizational and archiving format. i.e. possible scenario- data collectors

provide data files to a central organizing body to populated the archive (e.g. NODC, CDFG). A common data format is required for this process.

- Separate funds would need to be appropriated to allow for a single contact for formatting and archiving all data.
- A metadata service would need to be identified
-

Cost of implementing above approach

- Creating links to the repository site would be minimal especially if existing data site such as CSUMB's Seafloor Mapping Labs IMS server and CDFG's IMAPS were used.
- Some potential software applications that could be used to access data would require license fees which would drive cost up. May be of benefit to research free open source software which will provide data access.
- Assessment of maintenance cost would be needed.

Inclusion in RFP

- If RFP does not specifically include dissemination (but it should at a limited level), then look at adding it to individual contracts (archiving subcontract?).
- What about old/existing data? Should this be considered in the RFP?
- Specifications should be in place for including metadata descriptions of "before and during" data collection, included processing steps.

Target audience

- The method of data delivery will depend on the target audience, there is a distinct difference in presentation if the audience are scientist, policy makers, or the general public.
- Data querying and manipulations on an IMS server would not be much use to the majority of scientist. More useful is a simple data display/visualization (via IMS or map gallery) and click to download.
- If data manipulation on IMS type program is desired it would take a full time staff to maintain, thus adding considerable cost to the project
- *Carrie Bretz (CSUMB)*: IMS is not capable of out-of-the-box complex data manipulation/query. Higher-level manipulation capabilities require some programming and would necessitate extensive time on the part of the administrator.

General Agreement

A tiered approach for distribution of data and derivatives might be most effective- FTP, HTTP on web site, IMS (as viewer only). Data displayed as footprints and clicking links to downloadable files would be adequate and relatively inexpensive. This method of data distribution along with keyword searches and spatial box search would be the advisable methods (e.g. CERES, Geography Network).

DECEMBER 13, 2005
SUMMARY RECOMMENDATION FOR FINAL PRODUCTS

Summary of breakout discussions (Notes: S. Zurita)

Data Minimum Requirements

XYZ and backscatter (LIDAR, hyperspectral, multibeam, multispectral)
Data available
DEM bathy contour map (resolution based on usage of map)
Bathy for IHO specs- safe navigation
Rugosity and substrate type (gridded xyz data used for geology habitat)
Vectors showing faults and other structures
Highest resolution possible within limits
Data interpreted to greatest detail at specific resolution
Confidence of interpretation indicated, total propagated error, QAQC
Gather background data in two ways:
- 100% coverage
- Existing data incorporated into interpretive process

Analysis of collected data to determine future data acquisition
Groundtruthing should be included and at least should be obtained at least once during actual data acquisition

Metadata, Archiving, Dissemination

- FGDC standards
- Basic descriptions of data processing steps
  - Navigation precision
  - Acquisition methods
  - Sonar data processing and mosaicking
  - Resolution changes and reprojections.
- Description of files (i.e. original projections, datums)
- Consider new FGDC standard developed by SANDDAG
- Dissemination of tiered system for database (FTP with links, website images of data that link to data sources, IMS)
- Register with Geographic search engines and web search engines such as CERES, Geography Network
- Video data archiving to DVD, since video tape does not last
- Existing IMSs' available, but no one has volunteered, (the RFP may need to request a contractor to oversee and maintain website and IMS)

Summary Recommendation for Final Products
Recommendations from group discussion (Saori Zurita – note taker).

Data Minimum Requirements

Xyz and backscatter (LIDAR, hyperspectral, multibeam, multispectral)
Data available
DEM bathy contour map (resolution based on usage of map)
Rugosity and substrate type (gridded xyz data used for geology habitat)
Vectors showing faults and other structures
Highest resolution possible within limits
Data interpreted to greatest detail at specific resolution
Confidence of interpretation indicated
Gather background data in two ways:
1. 100% coverage
2. existing data incorporated into interpretive process

Analysis of collected data to determine future data acquisition
Groundtruthing should be included and at least should be obtained at least once during actual data acquisition

Metadata, Archiving, Dissemination

- FGDC standards
- Basic descriptions of data processing steps
  - Navigation precision
  - Acquisition methods
  - Sonar data processing and mosaicing
  - Resolution changes and reprojections.
- Description of files (i.e. original projections,)
- Consider new FGDC standard developed by Sanddag
- Dissemination of tiered system for database (ftp with links, website images of data that link to data sources, IMS)
- Register with Geographic search engines and web search engines such as Google
- Video data archiving to DVD, since video tape does not last
- Existing IMSs' available, but no one has volunteered, (the RFP may need to request a contractor to oversee and maintain website and IMS)

9 APPENDICES – C: SUPPLEMENTAL DOCUMENTATION

9.1 SURVEY SPECIFICATIONS – ADDITIONAL RESOURCES

INTERNATIONAL HYDROGRAPHIC ORGANIZATION'S STANDARDS FOR HYDROGRAPHIC SURVEYS, Special Publication 44, Fourth Edition, April 1998

Available at: http://www.iho.shom.fr/publicat/free/files/S-44-eng.pdf

(Stand-alone file: S-44-eng.pdf)

NOAA – NOS: HYDROGRAPHIC SURVEYS SPECIFICATIONS and DELIVERABLES (March 2003)

Available at: http://chartmaker.ncd.noaa.gov/hsd/specs/specs.htm

(Stand alone file: Spec03.pdf)