usSEABED: Pacific Coast (California, Oregon, Washington) Offshore Surficial-Sediment Data Release, version 1

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For additional information, see:

http://walrus.wr.usgs.gov/usseabed
http://walrus.wr.usgs.gov/nearshorehab
http://woodshole.er.usgs.gov/project-pages/aggregates

Feedback on usSEABED is appreciated, both in usefulness and in error detection. Please use the following contact information for issues, questions and/or data to contribute to the growing usSEABED information system in the U.S. EEZ.

Contact:

Jane A. Reid for information about the National Sea-Floor Mapping and Benthic Habitats project and (or) adding Pacific Coast, Alaska or Hawaii data
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USGS, Woods Hole Science Center, 384 Woods Hole Road, Woods Hole, MA 02543-1598; jwilliams@usgs.gov

Chris J. Jenkins for information about the dbSEABED program and data around the world
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For more information about the USGS – the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environments
World Wide Web http://www.usgs.gov
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ABSTRACT

Over the past 50 years there has been an explosion in scientific interest, research effort, and information gathered on the geologic sedimentary character of the U.S. Pacific coast continental margin. Data and information from thousands of publications have greatly increased our scientific understanding of the geologic origins of the margin surface but rarely have those data been combined and integrated.

This publication is the first release of the Pacific coast data from the usSEABED database. The report contains a compilation of published and unpublished sediment texture and other geologic data about the sea floor from diverse sources. usSEABED is an innovative database system developed to unify assorted data with the data processed by the dbSEABED system. Examples of maps displaying attributes such as grain size and sediment color are included. This database contains information that is a scientific foundation for the U.S. Geological Survey (USGS) Sea floor Mapping and Benthic Habitats project and the Marine Aggregate Resources and Processes assessment project, and will be useful to the marine science community for other studies of the Pacific coast continental margin.

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INTRODUCTION

This data release provides an improved and robust integrated database (usSEABED) of seabed characteristics for the Pacific continental margin of the United States (figure 1) that fulfills a need for information about seabed characteristics for use by geologists, ecologists, biologists, resource managers, and national defense investigators. usSEABED provides a digital, integrated database of existing physical data and information from the sea floor, including textural, statistical, geochemical, geophysical, and compositional information. It uses the dbSEABED data mining and processing software to extend the coverage of information in areas where data coverage is more descriptive than quantitative. The data coverage includes the U.S. Pacific coast from Cape Flattery (including Puget Sound) to the Mexican border, including major estuaries, for example, San Francisco and Willapa Bays and beaches, and extends seaward across the Continental Shelf and Slope. More than 100 different data sources containing over 65,000 data points from more than 25,000 sites are currently contained in usSEABED for the contiguous United States along the Pacific margin.

This data-series publication is the third in a set of similar publications that covers the entire Exclusive Economic Zone of the United States (U.S. EEZ). Also available are the sister publications of usSEABED data from the Atlantic margin (Reid and others, 2005) and the Gulf of Mexico and Caribbean regions (Buczkowski and others, 2006). Another companion publication will include data from Alaska and Hawaii. Each of these publications will be updated as significant amounts of new data are included in usSEABED. Current information about publications and other issues are posted on the usSEABED website.

This publication contains information on the usSEABED data collection, dbSEABED program processing, as well as a Data Catalog where the data are included (within compressed files) as GIS layers and comma-delimited text files.

The overall usSEABED database holds data for the entire U.S. EEZ and is an ongoing task of the National Sea Floor Mapping and Benthic Habitats project and the Marine Aggregates Resources and Processes project being conducted by USGS Coastal and Marine Geology teams in Santa Cruz, CA, Woods Hole, MA, and St. Petersburg, FL, and the University of Colorado.

Future Plans, Updates, and Online Usage

It is expected that usSEABED will continue to expand by the incorporation of new data sets and by the utilization of the data in new and different ways. As significant changes are made, we expect to reissue updates of usSEABED. Data contributions and (or) additional partners are welcomed.

Published usSEABED data from this region and others are accessible online (using ESRI™ ArcIMS®) at http://coastalmap.marine.usgs.gov/regional/contusa/index.html. Data layers will also be submitted for viewing and downloading through www.geodata.gov.

Applications

The usSEABED database is a very large compilation, containing complex assortments of data and geologic information on the geology of the sea floor. Although this database was developed for use in conducting studies of offshore sedimentary character for assessing marine aggregates and characterizing benthic habitats, it has potential for greater application by the marine science community and other users. Users are encouraged to generate their own queries and extract information to meet specific needs. Some other possible applications where data and maps from usSEABED could be useful are:

- Research ocean observation and monitoring
- Coastal zone/ocean management and planning
- Homeland security, military applications
- Sea-floor engineering, planning, and design
- Ocean disposal site placement, monitoring
- Cultural resources
- Fisheries management, marine protected areas
- Determination of seabed roughness, bedform distribution, critical shear stress, and sediment transport flux
- Public education
- Determination of sea-floor bottom-friction values for calibration of modeling processes, such as the effects of storm waves on sediment mobility and transport

National Sea-Floor Mapping and Benthic Habitat Studies

The quality and protection of natural environments is a high priority for the Nation. This includes Federal lands in the coastal and marine realm, where a variety of human activities stress natural systems and resources. The USGS is a lead scientific agency conducting research on the Atlantic, Gulf of Mexico, and Pacific margins to better understand marine sea-floor environments. This research on benthic habitats is conducted under the general topic of habitat geoscience, which is defined as the study and classification of seabed habitats in the context of their geologic framework, their response to seabed processes, and their function as substrate for invertebrates and fish, is underway in all three regions. This research requires close collaboration between geologists, biologists, and oceanographers. High-resolution and detailed knowledge of bottom characteristics and sediment distribution, a goal of the usSEABED database, is fundamental to these studies.

The National Sea-Floor Mapping and Benthic Habitat Studies Project for the Pacific coast, works collaboratively with other federal, state, and local agencies, to investigate geologic controls on benthic habitats in bays, estuaries, fjords, and continental shelf environments. The project employs a multipronged approach, utilizing tools that include sidescan, backscatter imagery, and multibeam sonar, bottom video and photos, Laser In-Situ Scattering and Transmissometry (LISST), Light Detection And Ranging (LIDAR), physical sampling and underwater digital microscope imaging (for example, an eyeball camera) and usSEABED. The collocated information is integrated, leading to better maps and increased understanding of habitats on a variety of scales. An important analytical sidelight to this research is a useful understanding of the relations between the various mapping and analytical techniques that allows for better mapping and assessment abilities.

A critical issue studied by the USGS National Sea-Floor Mapping and Benthic Habitats project for the Pacific is the impact of human activities on benthic habitats. These activities range from land development issues, watershed usage and pollutant transport, sanitary outfalls and waste disposal, shipping and anchoring, and dredging and spoil dumping to glacial retreat, uplift, the relative importance of artificial reefs as habitat, and invasive species.

Endangered and threatened living resources, such as Pacific Coast rockfish (*Sebastes*) and white abalone, are of prime concern to the public and managing agencies. One approach to the restoration of these habitats is the establishment of Marine Protected Areas (MPAs). The USGS and its partners use their expertise to map and characterize benthic habitats at biologically relevant scales to assist in MPA design and other fisheries management efforts. These efforts are centered in areas managed by National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service, NOAA National Marine Sanctuaries Program, and the National Park Service. For more information about sea-floor mapping and benthic habitat research by the USGS in the Pacific, see http://walrus.wr.usgs.gov/nearshorehab/index.html.

Marine Aggregate Resources

Continental margins are products of complex geologic processes. They comprise submerged landforms that offer a variety of benthic habitats for fisheries, as well as affect navigation, homeland security, and engineering activities. Continental shelves also contain hard-mineral deposits such as, sand and gravel, which are potential aggregate resources.

Coastal erosion, resulting from a combination of natural (storms, sea-level rise, sediment starvation, land subsidence) and anthropogenic processes (dams, dredging, coastal engineering structures), is pervasive in most U.S. coastal regions. Development in the coastal zone continues to increase, and demographic projections show that the trend of people moving to the coast will likely continue, placing more people and development at increasing risk from coastal hazards. With future global climate change likely to cause changes in storm frequency and resulting accelerated global sea-level rise, coastal regions are likely to experience even greater erosion, inundation, and storm-surge flooding.

Beach nourishment, a practice of placing sand dredged from offshore area onto eroding beaches, is increasingly viewed as a cost-effective and environmentally acceptable method for mitigating coastal erosion, reducing storm and flooding risk, and restoring degraded coastal barrier-island ecosystems for developed coasts. For beach nourishment to be viable, however, it is necessary to locate high-quality sand; the sand bodies must ideally be reasonably close to beaches being considered for nourishment, and the sand volumes must be sufficient to meet recurring nourishment requirements for 50 years or longer. Sand bodies on inner Continental Shelf regions are often the most suitable sand sources for beach nourishment. Examples of marine sand bodies are shown in figure 2.

Because offshore areas are increasingly important, comprehensive, up-to-date and integrated databases that can be used as sources for modern Geographic Information Systems (GIS) are needed to produce base maps displaying thematic information, such as sea-floor geology, sediment character and texture, sea-floor roughness, and engineering properties. Digital geologic maps, based on unified national data sets and showing the sedimentary character of U.S. continental margins, are critical for scientists to better understand and interpret the geologic history and evolutionary processes of continental margins. These products are also useful to managers for protecting and managing coastal and marine environments

The USGS, in collaboration with other Federal agencies (U.S. Navy Office of Naval Research (ONR), Minerals Management Service (MMS), U.S. Army Corps of Engineers (USACE), National Oceanic and Atmospheric Administration (NOAA) and others), coastal States, and universities, is leading a nationwide effort to gather legacy marine geologic data for use in conducting assessments of offshore sand and gravel resources and for producing GIS map products of sea-floor geology that can serve many additional needs. Assessments are being conducted in offshore Louisiana, the New York Bight (New York-New Jersey), and the Gulf of Maine regions. The GIS maps and usSEABED database from this study are providing fresh scientific insights into the geologic character and development of U.S. continental margins and useful information about the quality and potential availability of offshore sand and gravel aggregates. Additional details are available at http://woodshole.er.usgs.gov/project-pages/aggregates/index.htm.

Applications of research results include fishery management, habitat disturbance and recovery studies, impacts of invasive species, studies of deep-water coral habitats, the fates of contaminants from coastal sources, location and monitoring of disposal sites, the routes of cables and pipelines on the seabed, and the location of aggregate deposits having potential for use for beach nourishment. For more information on these and other research about coastal and marine issues, see http://walrus.wr.usgs.gov/, http://marine.usgs.gov/, and http://woodshole.er.usgs.gov/.

usSEABED (DATA)

The usSEABED database differs from a traditional relational database (RDB) because the data are processed and extended to maximize density and usability, making them more comprehensive for mapping and analysis. A traditional RDB often creates simplistic and sparse data summary coverages with thinly populated and unwieldy tables. The usSEABED database not only treats the usual forms of numerical data but also contains a vast store of data about the sea floor in word-based descriptions that can be rich in information but difficult to quantify, map, plot, or use in comparative analyses or models. The usSEABED database provides numeric values for typical seabed characteristics that are based on these descriptive data as well as numeric analytical data.

The usSEABED database also differs from other marine databases in that it incorporates a wide variety of information about sea-floor sediment texture, composition, color, biota, and rocks; sea-floor characteristics such as hardness or sediment ripples, acoustic properties, and geochemical and geotechnical analyses. The usSEABED output files are produced in comma-delimited text for ease of use and are ready for inclusion into many different GIS, RDB, and other software applications.

How usSEABED is Built

The usSEABED database is built using the dbSEABED processing software created at the University of Sydney (Australia) and the University of Colorado. It has companion databases built along similar lines: auSEABED for Australia, balticSEABED, and a global database, goSEABED. Each database relies on preexisting data from a variety of sources to mine and extrapolate useful information about the seabed.

The dbSEABED program allows these source data sets to be compiled in a standardized format and integrates information across a series of data themes (table 1) and physical sampling equipment (grabs, cores, or probes) or remotely sensed sampling (descriptions from photographs and videos, geophysics, soundings). These data may be numeric lab- or instrument-based textural, acoustic, geochemical, and geophysical data and (or) verbal (linguistic) descriptions of grabs, cores, or photographs, or a combination of any of these

In the usSEABED database, most data held in these reports are mined for additional information that increases the data density over the seabed, allowing for more complete information. Few source reports contain all data reportable in usSEABED; null values are given in those fields without data.

Sources of Data

usSEABED relies on previously existing and newly collected data, both published and unpublished, from Federal, State, regional, and local agencies and consortiums, as well as research institutions. For the Pacific coast, many of the data are from the USGS, including published and unpublished data from the 1980s to 2000s.

Data gathered by NOAA National Ocean Service (NOS) during their many sounding surveys in the 1960s to 1990s are included, as archived by the Smithsonian Institution and provided by the National Geophysical Data Center (NGDC). Theses and dissertations from many universities, reports from University of California (Berkeley) Hydraulic Engineering Lab, University of Washington's data publications of the 1960s and 1970s, U.S. Army Corps of Engineers (USACE) reports, and local harbor and U.S. Navy (USN) reports are also included. A large data compilation, Deck 41, archived at NGDC is included, which is from a wide variety of data sources. A complete list of data sources for the Pacific coast is included in Appendix A.

Although efforts have been made to reduce data duplications within usSEABED, they may exist within the input Pacific data sets as data from the same cruise or site may be published in more than one report or data compilation. For example, NGDC's Deck 41 compilation contains information for several west coast sources; sites are decommissioned in our Deck 41 data set where these sources are included within usSEABED under the original sources. In other instances, data from different sources for a given site may be included if significant additional data are included. For example, one source may report only grain size for a particular site, but another source may include geophysical properties for the same sites/sample.

Data Themes and Output Files

Seabed data come in a variety of forms, which have information in different parameters. For example, textural analyses may have information for percentages of gravel, sand, and mud (silt and clay); statistical measurements such as mean, median, sorting, skewness, and kurtosis often accompany the textural information. Acoustical measurements include various velocities and derived densities. Benthic habitat studies may include a short description of the sea-floor sediment type and a numerical survey of animals and plants on the sea floor, or evidence of them.

The original seabed information in usSEABED is entered into different data themes (table 1). The thematic basis of the values found in the outputs can be found in the DataType field of the extracted (EXT), parsed (PRS), and calculated (CLC) output files. Information on the contribution of each source report is in the accompanying source metadata files.

This publication provides six usSEABED output data files for the Pacific Coast (table 2). These files are downloadable from the Data Catalog. An additional output file type, although unpublished, provides quality control for the data and was used extensively prior to publication to debug and test the data. Field parameters for the data files are listed in tables 3, 4, and 5.

Relational keys

The usSEABED data file types are linked relationally by the foreign keys: *DataSetKey* (for individual data sets), *SiteKey* (for individual sites), and the *SampleKey* (for individual analyses). The *DataSetKey* field gives the relationship of the data to the original source. The tables can be loaded into an RDB, relationships may be constructed, and the tables may be joined using the keys.

Source data (SRC)

Information about the original data are in the source (SRC) file, including links to metadata about the original data. Each of the output data files discussed below is relationally linked to the SRC file by the *DataSetKey* field. Source information is also provided in a more traditional bibliographic format in Appendix A.

Textural and other basic information (EXT, PRS, CLC)

Textural, statistical, geochemical, geophysical, dominant component, and color information are held in three separate, but similar, data files, based on the type of data: EXT, PRS, CLC. The three data file types have the same fields (table 3) and can be combined for more extensive coverage of the sea floor.

It is important for users to understand the inherent limitations of each type of file in order to choose the best data file, or combination of data files, appropriate for a particular use. Other dbSEABED programs can combine the three files in a variety of ways, by concatenation or by telescoping, before they are mapped or used for other types of analysis. For access to these files, please see the contact information at the beginning of this report.

Extracted data (EXT)

The data file with the EXT tag is the "extracted" data: those data from strictly performed, lab-based, numeric analyses. Most data in this file are listed as reported by the source data report; only minor unit changes have been performed. In some cases, assumptions may be made about the thickness of the sediment analyzed based on the sampler type. Typical data themes include textural classes and statistics (TXR: gravel, sand, silt, clay, mud, and various statistics), phi grain-size classes (GRZ), chemical composition (CMP), acoustic measurements (ACU), color (COL), and geotechnical parameters (GTC). The EXT file is based on rigorous lab-determined values and forms the most reliable data set. Limitations, however, exist due to the uncertainty of the sample tested; for example, were the analyses performed on whole samples or only on the matrix, possibly with larger particles ignored?

Parsed data (PRS)

Numeric data mined from verbal logs, core or grab descriptions, shipboard notes, and (or) photographic descriptions are held in the parsed data set (PRS). The input data are maintained using the terms employed by the original researchers and are coded using phonetically sensible terms for easier processing by dbSEABED. Longer descriptions may have the data divided by theme (table 1). The descriptions often include information on associated biota, sea-floor features, and structure. Typical data themes for the parsed data set are lithologic descriptions (LTH), biology (BIO), color (COL), and (or) sea-floor type (SFT, descriptions from photos or videos). The values in the parsed data file are calculated using the dbSEABED parser that assigns field values based on the form and content of a description. See the section on dbSEABED processing and fuzzy set theory for a more complete explanation.

The parsing process has been tested and calibrated by comparing the outputs against analytical results for the same samples. Due to the nature of visual descriptions by observers and the use of fuzzy set theory in the parser, the output data variously show the degree of representation in the sample or percent abundance values. An assumption in the process is that the output degrees of representation reflect absolute abundances to some degree of accuracy. The calibrations provide information on that accuracy. Although at first sight the descriptive results in the parsed file may seem less accurate than measured values in the extracted file, they are frequently more representative of the sample and seabed as a whole, as they include description of objects such as shells, stones, algae, and other objects (table 6) that are a textural component of the seabed and are often left out of laboratory analyses, particularly when a machine analysis is employed.

Calculated data (CLC)

For the extracted and parsed data, some values are not reported by the original source but can be calculated directly or estimated by standard derivative equations using assumptions (see Appendix C. Frequently Asked Questions) about the conditions or variables. These values are reported in the calculated (CLC) data files. Although the CLC data can be combined with the extracted and the parsed data (table 3), they are the least reliable of the three data file types and should be used with caution.

Component/feature and facies data (CMP, FAC)

Two usSEABED data files contain information about the presence of certain sea-floor features, compositional content, biota, and sediment structure. These use senior synonyms defined by the thesaurus in the dbSEABED parsing software, which clusters comparable descriptive terms together (granite represents granite, aplite, granodiorite, pegmatite, whereas laminated represents laminated, laminations, or lamina). Individual components and features (terms like feldspar, phosphorite, bivalves, seagrass, and wood, for example) are held in the CMP data file (table 4). Appropriately combined components are held in the facies (FAC) data files (table 5). As with the parsed data files, the values held within the CMP and FAC files are the results of filters based on fuzzy-set membership to chosen sets and represent a measure of truth about the attribute, not percentages or defined values. These files only indicate presence, not absence, of material; it is rare that a report might state, "no bivalves" or "no phosphorite."

The CMP file contains information about compositional content (individual minerals, rocks), genesis (terrigenous, carbonate), and certain biota. These components are internally evaluated and the value for each attribute is based solely on the relationships of attributes within the original description. The flora and fauna included in the compositional components are those that may have an effect on textural determinations in the PRS data file, such as halimeda, bivalves, or foraminifera (table 6). The values within these attribute fields range between 0 (no membership, possibly due to no information), to 100 (complete membership, shell hash = 100 to the shell debris set).

The CMP file also includes information on sea-floor features, such as bedforms, fissures, internal structure (bedding, bioturbation), and other flora and fauna. Unlike the compositional content information, which is construed as an abundance within the sample, these attributes are an intensity of development or density of occurrence relative to scales of development or density of occurrence observed elsewhere. The flora and fauna included in the feature category are soft-bodied, for example, those that do not have an input on the textural determination within the PRS data files, such as kelp, ophiuroids, or annelids. Values within the attribute fields range from 0 (no membership, possibly due to no information) up to 100 (maximum development). In contrast to the situation with component abundances, the sum of feature intensities in a sample is allowed to exceed 100.

The 100 most common components (number limited by dbSEABED processing software) in the U.S. EEZ are given in the CMP file, and those attributes with "_F" denote features. Table 4 lists the components and gives basic forms of descriptive terms that may trigger membership for each. Included in this file are 27 components that are included in the facies (FAC) file only. The dbSEABED thesaurus used for usSEABED is also used for the sister data compilations (auSEABED, BalticSEABED, goSEABED), and the list of trigger terms may include some that are not known in U.S. waters.

The second file, the facies file (FAC), is created from components only, similar to the CMP file. This file configures multiple components into appropriate groups or facies, such as igneous, metamorphic, ooze, foraminifera, and others. The dbSEABED processing software is restricted to a maximum of six components per facies. Table 5 lists the facies type and the components that comprise each facies group.

Again, these files only indicate presence, not absence, of material; it is rare that a report might state, "no bivalves" or "no phosphorite." The values within this attribute field range between 0 (no membership, possibly due to no information) to 100 (complete membership, for example, schist = 100 to the metamorphic set).

Relationship between the PRS and CMP outputs

The dbSEABED processing software recognizes that many skeletonized biota, such as halimeda, rhodoliths, shells (broken and unbroken), and others often constitute a sediment sample. Such biological terms are included in the parsing of the textural values. The selected biota with textural implications are listed in table 6. When using the parsed data, it may be important to crosscheck with the component file using the relational foreign keys (*SiteKey*, *SampleKey*) to determine if biota are to be included in the textural outputs.

Within the PRS file, the 'seabed class' and 'class membership' field indicate the dominant compositional class and the fuzzy-set membership of a sample to that class. Other components and mined information may also be listed for that sample in the CMP file, linked by the relational keys.

Quality Control

Quality control over the data is an iterative process implemented using criteria in the following steps. First, graphical plots of site locations and parameter values are used to detect outliers and edit them appropriately. Each data set is viewed in a GIS to ensure that data locations are reasonable relative to survey extents; those sites with unresolvable location issues or known incomplete analyses are deactivated and are not included in the usSEABED output files. (Note: usSEABED does contain a small number of onshore samples.) This step may be optional depending on the data set. Older sets may require more scrutiny at this step, whereas newer or well-exercised data sets require less.

Second, built-in filters in the dbSEABED processing software detect implausible values for numeric fields, unknown verbal terms, incomplete analyses (for example, Gravel-Sand-Silt Clay (mud) (GSSC(m)) greater than 105% or less than 95%), and incorrect field types (string or number). The software also detects samples that seem to belong to a core though they are described as independent samples. For the parsing of verbal descriptions, all terms must be known to the dbSEABED data processing program, with values assigned; those analyses that fail this test have null values given to all appropriate fields. Edits are made to the data at the level of the usSEABED input data files and metadata are entered explaining the changes. The edits (or deactivations) are then taken into account in the next dbSEABED program run.

Finally, output data are analyzed in a GIS to test whether the data outputs "make sense" for a given geographic area. Users of the output data should, however, note the limitations imposed by the source data sets as to navigational precision, sampler type, and analytical technique.

As issues about the data or the data processing may be discovered, errata will be posted on the usSEABED website. Corrections will be included in the next version of this publication.

See the dbSEABED section and the Frequently Asked Questions for details about the usSEABED data mining program and the application of fuzzy set theory.

Spatial and Temporal Uncertainties

Users of usSEABED data are reminded that many seafloor regions are, by their nature, dynamic environments subject to a variety of physical processes, such as erosion, winnowing, reworking, and sedimentation or accretion that vary on different spatial and temporal scales, and sea-floor samples may represent a only moment in time. Because usSEABED is comprised of samples collected, described, and analyzed by many different organizations and individuals over a span of years, metadata are provided for each source report, linked both through the bibliographic list of data sources (Appendix A) and the relational link *DataSetKey* in the output files. In cases where original metadata are not available from the data source, metadata were created based on available information accompanying the data. Of particular importance, site locations are as given in the original sources, with uncertainties due to navigational techniques and datums ignored in the usSEABED compilation. As many reports are decades old, users of usSEABED should use their own criteria to determine the appropriateness of data from each source report for their particular purpose and scale of interest.

In addition, there are uncertainties in data quality associated with both the extracted data (from lab-based analytical analyses) and parsed data (word-based descriptions). It may be that grain-size analyses are done solely on the sand fraction excluding coarser material, such as shell fragments and gravel, while word descriptions of sediment samples may emphasize the proportion of a sediment fraction over another and may disregard other important textural or biological components. Detailed information about issues such as these are noted in the source metadata files and known incomplete data are decommissioned in usSEABED.

Users are encouraged to view the entire document before downloading the data files in the Data Catalog and should refer to the provided metadata files for information about individual sources' limitations, date of collection, and other pertinent information.

dbSEABED (PROCESSING)

The dbSEABED processing system was developed by Jenkins (1997, 2002, 2003) in collaboration with the USGS and others over the past decade. Currently, there is no open-source code for the program. This explanation of the system is intended to give information and guidance about how the data are compiled, integrated, and processed in the usSEABED database. The dbSEABED system aims to produce a unified mappable database from the multitude of data sets dealing with the seabed. The primary objective of the dbSEABED system is to produce integrated data that can be mapped, analyzed, and visualized. Data sets include both legacy and modern collections, involving data from samplings and visual inspections. Filtering routines within dbSEABED unify marine geologic data that originally may be disparate in purpose, function, style, and collection or analytical techniques. It works on data files that hold the source data in their original values (except for minor unit changes and phonetically sensible word codes) and provides standardized output data. It is important that users of the PRS and CLC output files understand the parsing process, the meanings of field values, and the limitations of the usSEABED output. More information about the dbSEABED software can be found on the dbSEABED Web site or in the Frequently Asked Questions section of this publication.

Data Import Methods

Incoming data files number in the hundreds and are diverse in content and format. The process of import begins with manual reformatting that usually involves rearranging the data in columns specific to each parameter, such as color, percent sand, seabed description, or multisensor core logger acoustic velocities. These columns are arranged according to a template specific to dbSEABED. Most data are prearranged in columns, but in some cases sections of written descriptions may need to be cut into their constituent parts.

New parameters are sometimes encountered as a data set is imported. These new parameters are added to the template at the ends of the appropriate data theme, and the dbSEABED processing software is modified to take the new parameter(s) into account if possible. For future reference and to help editing, the original data are often held as commentary metadata alongside the active data. Some data that are not useful to dbSEABED are held only as commentary metadata.

After import, the data are held in a type of written log arranged according to the nested sequence: data set / site / subbottom depth / subsample. Sites are specified by each new sampling operation. The written log structure is unusual for a database, having more in common with XML-format structure than relational databases. It has distinct advantages for dealing with sea-floor sampling data sets, such as

An algorithm can perform highly useful calculations on the data for each sample, which has made it possible to meet user demands in a timely way despite the complexity and size of the data holdings;

I. Data that are human readable, especially if metadata are interspersed;
II. It conforms with data structures that are generated by core-loggers at sea and in the laboratory;
III. It is efficient to import;
IV. It is able to cope with variable data quality and incompleteness; and
V. It is low maintenance, nonproprietary, and programs that address it have low cost of entry and are highly adaptable.

The disadvantage of the written log structure is that specialized programs, such as those in dbSEABED are needed for conversion to the flat-file formats that most users require. These flat-file formats are provided in this publication.

The Numeric Data Type (extracted, EXT)

A primary function of the processing programs is to read, quality check, and then report numerical data that have been obtained from laboratory analyses of grain size, composition, color, shear strength, and other parameters. Although we describe these data as "numeric," they also include coded data such as Munsell color codes. In many cases, the numeric data can be echoed unchanged to outputs (in EXT files), for example, in percent sand, average grain sizes, carbonate, and porosities. Checks are performed, however, on whether a value is properly numeric or string and if it is within plausible ranges. Problems are reported to a diagnostics file that is a basis for quality and completeness checks, with possible corrective edits to the data file (along with explanatory metadata). Data items are often deactivated if they are suspected as incorrect.

The numeric data output to EXT files have had minimal manipulation. The data in grain-size analyses (held at their original phi intervals) are summed into gravel, sand, silt, and clay percentages; the median, average, and standard deviations are calculated. If grain density is available, bulk densities and water contents are converted to porosities, with the porosity parameter adopted by dbSEABED. Many parameters that are available in the data are not reported to the EXT files, for example, skewness and kurtosis. They may, however, be obtained from RDB renderings of the data (not available on this publication). The dbSEABED output of Central Grain size is a composite of median (preferred), moment average, and graphical averages. Currently, only the second moment (standard deviation) is directly transferred to the sorting field.

The reporting of consistent mappable values for geotechnical and acoustic parameters is not an easy task. The results of physical property tests are very dependent on experimental setup, such as strain rates, sample preparation, equipment dimensions, and detection of behavioral thresholds for the materials. The shear strength reported from dbSEABED is a composite of penetrometer, vane-shear values (undrained, unconfined) in the unremolded states (that is, for initial failure). Also included for the sake of maximizing mappability are the cohesions from shear box and low-pressure triaxial experiments. P-wave acoustic velocities are reported without regard to the frequencies of measurement. In both cases, investigators wanting more specific information on the analyses can resort to the original data and metadata. The extracted outputs based on numeric and coded data are put out separately from the parsed and calculated results of dbSEABED. It is recognized that some investigators will choose one over the other – or may wish to combine them in different ways. It must also be recognized that rarely can a sensible coverage of the seabed be obtained from the extracted data alone, as it is too sparse.

The Linguistic Data Type (parsed, PRS)

A feature of dbSEABED is its ability to parse word-based descriptive data, such as

"brown fine sand with abundant shells; seagrass and some pebbles; whiff of H_2S?".

These types of data are held using their original terms although some abbreviation and coding is necessary. Thus dbSEABED is not a natural language parser even for the noun-phrase constructions, such as the above description. The ability to handle word-based data greatly extends the power of the system to map the seabed, because as a global estimate, approximately 85 percent or more of data characterizing the seabed are word based.

Calibrations are performed to validate this process relative to analytical data on the same sediments. A simplified description of the processing functions is included in this publication. The dbSEABED program applies these concepts to geological descriptions, using:

- A parser that divides the descriptions into arithmetic equations;
- A thesaurus that attaches meanings and memberships to the quantifiers, modifiers, and Objects; and
- A linear-weighted assembly of the numerical totals.

In the dbSEABED program, word memberships can be defined across many parameters, not just grain size. Fuzzy memberships are best thought of as a measure of truth or possibility (not probability). The outputs are fuzzy memberships of parameters such as mud, grain sizes, carbonate, organic carbon, grain types, sedimentary features, rock and weed coverages, and engineering strengths. Statistical comparisons can be made between the EXT and PRS data outputs, resulting in calibrations which are an overall guide to the accuracy of the regional mappings and a highlighting of areas and issues in the data where improvements can be made.

A simplified description of dbSEABED processing

Most descriptions, such as that noted above,

"brown fine sand with abundant shells; seagrass and some pebbles; whiff of H_2S*?".*

consist of quantifiers, modifiers, and objects (qmO) and can be written as linear expressions

q1[m1]O1 + q2*[m2]O2 + q3*[m3]O3 ... = sample*

In most cases, the sediment fraction is the whole sample, but dbSEABED records explicitly where that is or is not the case in outputs. In the previous example which in dbSEABED coding is

brn fne- snd wi_ab/ shls seagrs + som/ pbls ; whif_of/ h2s /?

where "-" on modifiers points to modified object, and "/" on quantifiers points to the quantified object. The use of abbreviations helps distinguish data from metadata in the data files and makes descriptions shorter, easier to process and more human-readable. The qmO coding for texture is then

m(fne)O(snd) + q(wi_ab)O(shls) + q(som)O(pbls) = sample

where the "*brown*", "*seagrass*", and "*h2s*" are not shown because they are neutral for texture. The textural objects are each assigned a grain size that might be cast as Fuzzy Set Memberships across a range of grain sizes or may be a single-size fraction percentage (Crisp Set). The grain-size assignment is acquired from a dictionary and is usually based on published scales, such as Wentworth (1922) and Unified Soil Classification System (USCS), on analysis of a region's sediment components, or on the sedimentologic experience of one or more people. The grain size is the median of grain sizes observed for sediments that have been labeled simply as "*sand*", which is 1.5 phi. Where a modifer is applied, the grain size is adjusted. In the case of modifier "*fine*" the mean grain size of the sand becomes 2.5 phi. "*Shells*" has a textural meaning, typically at fine gravel (-2 phi) but ranging of course by species and preservation. "*Pebble*" is assigned its Wentworth scale grain size.

The quantifiers "*abundant*" and "*some*" assign weights to the "*shell*" and "*pebble*" parts and adjust the memberships of the assigned phi grain sizes. These memberships are specified in the dictionary: "abundant" 0.5, "some" 0.3. The unquantified "*sand*" is usually assigned 1.0.

After normalization to 1.0 the "*sand*", "*shell*", and "*pebble*" components have weights of 0.56, 0.28, and 0.17, respectively. (Note: the normalization depends on the syntax, whether like the rear-significant ODP syntax, with weights increasing to the right; front significant naval data; or flat-significance syntax common in ecologic studies. At data entry which of these applies is specified in dbSEABED.) For the standard textural classes, gravel ("*shell* + *pebble*") membership totals 0.4, sand 0.6, and mud 0.0. (Note: silt and clay proportions cannot be determined from visual descriptive data.)

To estimate the mean grain size for the entire sample, then

0.56*(2.5 phi) + 0.28*(-2 phi) + 0.17*(-3.5 phi)] = 0.25 phi

This is reported to the parsed outputs (PRS). The existence of shell and pebbles is also noted in the "shell" component outputs (CMP), with a relative membership of 0.28 and 0.17.

A similar process is performed successively for the other parameters, for consolidation (no information here, sediment will be assumed loose), features such as "*seagrass*", and color. "*Brown*" will cause an output of the Munsell color code of 5YR 4/4 through calibrated processes described in Jenkins (2002).

The numbers and results above are examples only, and the explanation is simplified. Iterative comparisons of hundreds of verbal descriptions with each other and with the results of lab-based analyses have established that the accuracy is about 1 standard deviation at +/- 2 phi range.

Most input linguistic data are reasonably well organized, although there are a variety of descriptive linguistic structures familiar to geologists, ecologists, biologists, U.S. Navy divers, and other sea-floor samplers. To be usable in dbSEABED, sediment descriptions and analysis data do not need to be precise or fit a particular pattern. The dbSEABED program copes with a wide set of vocabularies (for example, foreign language, USACE codes, NOS Bottom Type Codes), and a variety of linguistic structures and ways of attaching quantities. There are currently more than 5300 terms defined in the parsing dictionary.

Further, the data need not be absolutely complete. The dbSEABED program mines what data are there, giving outputs only where data are sufficiently complete to be reliable, while rejecting (and reporting for future attention) incomplete or erroneous structures.

Each description is kept close to its original form and structure but is coded in phonetically sensible terms that include links between quantifiers, modifiers, and objects. Data coders choose between a variety of data types to organize the data so the dbSEABED program can quickly parse words into values. Table 1 gives the data types used in usSEABED output files.

The dbSEABED program contains a thesaurus where various terms used to describe the seabed are given lithologic, textural, and biological classes and weightings. Modifers and quantifiers are given relative weightings, and values are assigned to other categories as needed.

Several special semantic structures are catered for, notably the joint abundance structure, such as: "snd som/ { pbl + shl + blk- nods }", wherein the pebble, shell and nodules total 0.3 in abundance ('som'). Also, a component may be as a proportion of some special fraction such as: "snd // acid_residu", in effect the non-carbonate sand proportion.

The parsing includes a number of quality control devices. If a term is not recognized in the dictionary, the process is aborted. The process is also aborted if component weightings from certain observations such as grain counts fail to total 100 percent. If a description is too complex (currently defined as greater than 32 terms) it is not parsed. Problems encountered are reported to a diagnostics file for later attention and perhaps correction. Homonym terms, such as "dense" for consolidation and abundance, are distinguished (as "dens(phy)", "dens(ab)"). Terms that are marked "meaning unknown" in the dictionary will cause parsing to fail. Terms that have a special meaning in one survey, such as "iron" in DSDP data, are also specially marked ("iron(dsdp)"). XRD data are not parsed, as they are not regarded as reliable enough in comparison to petrologic counts or visual descriptions. At present, the location of structures in a core (for example, "below yellow layer") and gradients (for example, "grading upwards to") are not parsed.

More information about the dbSEABED software is obtainable from a number of articles listed in Appendix C. Frequently Asked Questions.

Expansion of Data Coverage

A summary of the theoretical or empirical relationships that are used by dbSEABED to expand the coverages of seabed parameters (often not directly measured or calculated in individual reports) is given in the onCalculation document (Appendix D).

Calibration

dbSEABED is an information-processing system that can perform statistical and individual tests of accuracy across the range of output parameters. Issues of accuracy and reliability become apparent as soon as data are integrated. Tools for monitoring the integration process are required, with feedback to the input data, so that improvements can be made in the system.

Basic uncertainties exist in all the incoming data that cannot be reduced and integrative systems cannot proceed past that uncertainty. Parallel studies in dbSEABED have determined on the basis of replicate analyses that analytical data, such as grain size analyses (Syvitski and others, 1991), has 1-sigma uncertainties on the order of 4 percent of the total parameter range, or 0.8 phi. With good maintenance of the data, the outputs from dbSEABED approach those levels of reliability.

Statistical Tests

In the case of the thousands of samples where both analytical and descriptive data exists, a statistical comparison can be made between the EXT and PRS data outputs. The results of this calibration are an overall guide to the accuracy of the regional mappings, and a highlighting of areas and issues in the data where improvements can be made. Those improvements involve both the analytical and descriptive raw input data. For example, grain-size analyses that appear to be the whole sediment but are really only of the sand fraction or analyses where gravel and (or) shell has been omitted from an analysis.

The EXT and PRS outputs are imported into MS Access and links are created between the two files (based usually on the *SampleKey*). Entries with null values (-99) in either EXT or PRS are eliminated through a query. This query is brought into MS Excel and used to calculate the frequency distribution of deviations (+ and absolute) and plotted for inspection. Percentile statistics are calculated using the absolute deviation at the 50 (Median Absolute Deviation (MAD)), 68 and 95 percentiles (1s, 2s). Examples of the outputs are shown in the description of usSEABED. For most data sets the percentile statistics are 0.4, 0.8, and 4 phi for the 50, 68, and 95 percent levels, which may be acceptable over such a diverse set of input data sets but can be improved. An example of this analysis is shown in figure 3, for a data set that is under improvement.

A second way of statistically evaluating the results uses a cross-plot between the EXT and PRS output data shown in figure 4. This type of plot serves to highlight some of the issues that may reduce the accuracy of dbSEABED with incoming data sets.

Individual Tests

The programs of dbSEABED have been equipped to detect problematic data, whether by values falling outside plausible limits or by mismatches between EXT and PRS results. These tools normally do not prevent the problem values being output, but they do report detections to a diagnostics file that is particularly useful in the preparation and cleaning of incoming data sets. The statistical data shown in figure 3 is employed to set the filters, usually at the 68 percent (1s) level. The original data can then be revisited, checked for issues such as those shown in figure 4, and can be corrected, deactivated, or left alone as appropriate.

DATA CATALOG

The data supplied in this publication are made available with geographic coordinates to allow the data to be incorporated into a Geographic Information System (GIS). The data layers along with additional base-map layers have been compiled into an ESRI™ ArcView® project file (usSEABED_Pacific.apr, 32 MB zip file), which is located in the *Data* folder of this publication. The project file serves to provide examples of how the data can be displayed in a GIS (figure 5 a-c). It contains several views demonstrating the possibilities of the various data fields. A variety of base map layers that can be used to accompany these data can be found on the Coastal and Marine Geology Program's U.S. Pacific West Coast Map Server. Several have been included below and are used in the project file. Other examples of ways to visualize these data are also included.

For those who do not have the ESRI™ software or a compatible GIS data browser available on their computer, a free viewer, ArcExplorer®, is available from ESRI™ (http://www.esri.com/). Please note that the ArcExplorer® software is limited to the Microsoft Windows operating systems.

Clicking on the layer name under the column header "Data Layer Name & Description" in the tables below will open a new window with a graphical representation of that layer. Federal Geographic Data Committee (FGDC) metadata are included with data layers in four formats in the tables below: (HTML, FAQ, XML, and text).

A downloadable zip archive file containing the elements that comprise the ArcView shapefile for each data layer is also provided. In addition to the ArcView® shapefile, the usSEABED data layers are available in an ASCII text format as an alternate way to view and examine the data sets. The first record of the ASCII file contains the name of the data fields for that file. Each zip file includes:

- ArcView® shapefile for each layer (with associated files);
- Comma-delimited text version of the data file;
- Metadata to accompany the data file (four versions);
- Browse graphic of the data layer; and a
- A readme file.

The zip files were created using WinZip v. 9.0. Users may obtain a free version of the software from http://www.winzip.com/.

Data Files

Table 7 lists the usSEABED data layer name and description, metadata files, and zipped file names and sizes. Table 8 gives a list of base map layers available, metadata files, and zipped file names and sizes.

A comma-delimited text file (PAC_SRC) of the list of sources is included with the output files. The *DataSetKey* number within this file gives a relational link between the source data set and the data files in tables 7 and 8. Also provided is a list of the data sources in bibliographic format (Appendix A).

Legends

To map the coded information on Color and Roughness in a GIS, load the ArcView® legends "munsell.avl" or "rgh_pt.avl" which are available with the database. ArcView® legends may be imported into ArcGIS®. To make your own legends for other applications, employ a classification that uses a "unique value" process.

Color

Color of sediment is described either in terms (brown, light greenish gray) or in Munsell color codes given in values of hue (spectral content), value (lightness), and chroma (saturation). Munsell codes are explained in a publication of the Geological Society of America (Goddard, and others, 1951).The dbSEABED program converts the former into average values of Munsell codes, rounded to increments of 5 in hue, 3 in value, and 3 in chroma (Jenkins, 2003). An ESRI™ ArcView® legend is included for ease of mapping.

Roughness

This is a coded output representing the V:H of the seabed roughness element which is observed with greatest aspect ratio. That feature may be fixed roughness like a cobble, or moveable roughness like ripples. The outputs can only report observed roughness elements, so are influenced by the size scales of samplers and observations. The V and H values are the centimeter values of the height and horizontal dimensions written in integer log 2 (base 2). For example "4:6" represents 16 cm height over length scale of 64 cm. Powers <0 are set to zero (i.e., scales <1 cm are not considered). The horizontal length H is the length of expression of a feature, rather than wavelength of repetition. Where a feature is elongated, H is taken normal to elongation (i.e., equals ripple wavelength).

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Wyllie, M., Gardner, G., and Gregory, A., 1963, Studies of elastic wave attenuation in porous media: Geophysics, v. 27, p. 569-589.

*Reprints of these articles are included in this publication

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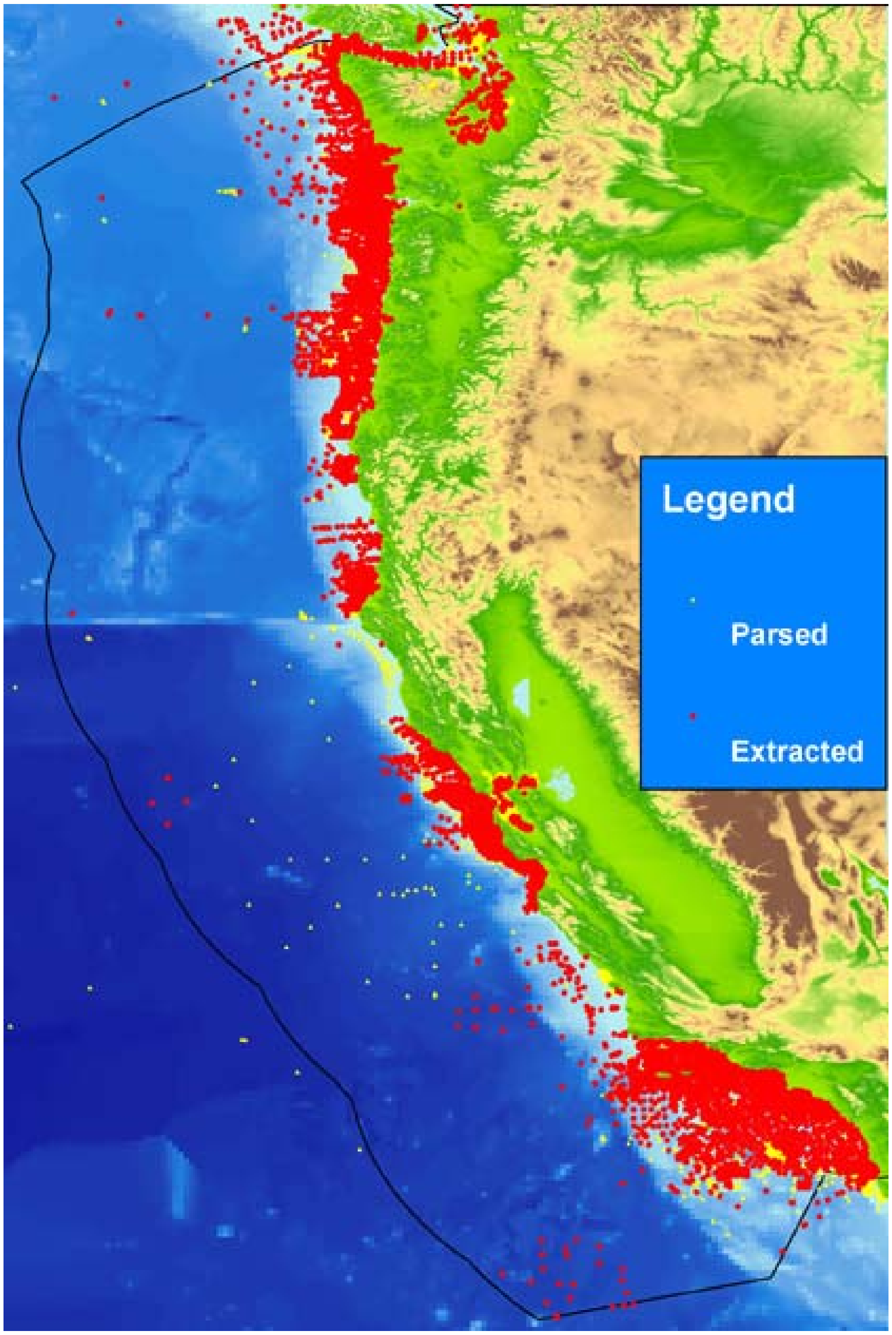

Figure 1: usSEABED data for the Pacific coast showing the locations of the extracted (EXT, in red) and parsed (PRS, in yellow) outputs. The EXT data are from numeric, lab-based analyses. The PRS data consist of numeric values parsed from text-based descriptions. Black line delineates the limit of the U.S. Exclusive Economic Zone. back

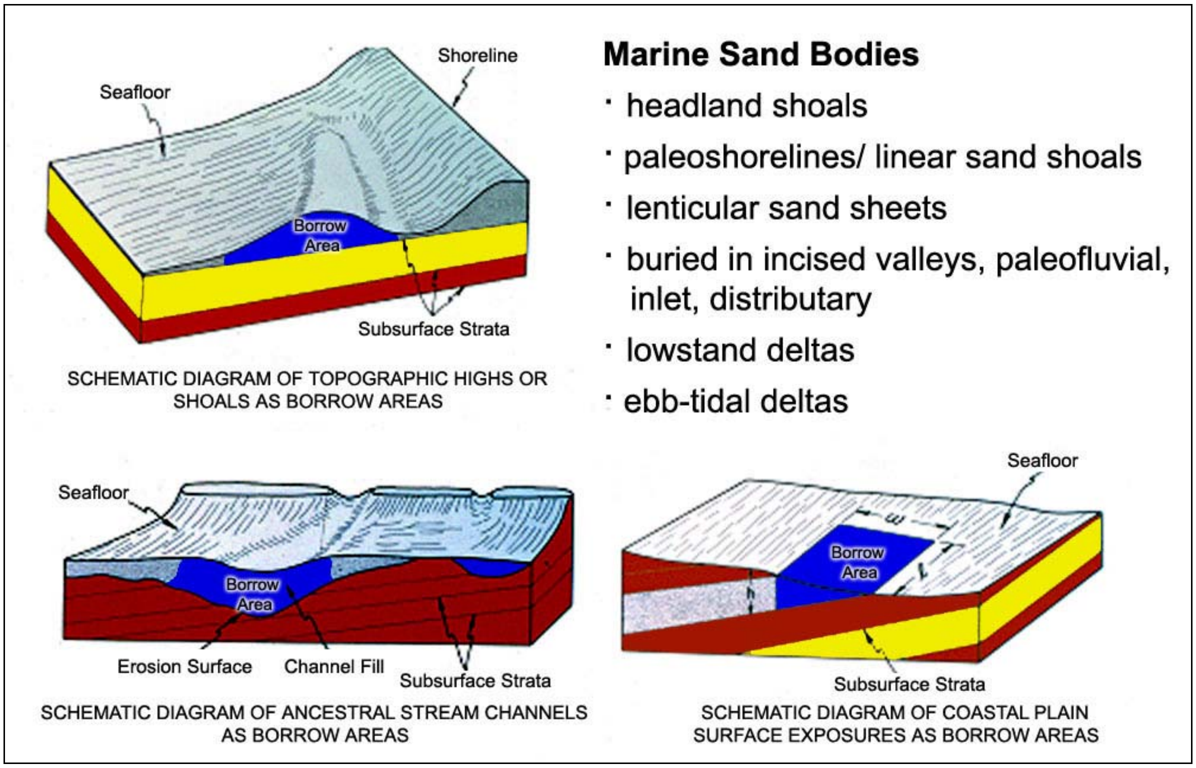

Figure 2. Marine sand bodies, having diverse origins and evolutionary histories, can be buried or exposed on continental shelves and often have been greatly modified by marine processes associated with the Holocene transgression. Nearshore marine sand bodies of the types shown above may offer the best potential sources for high quality sand for beach nourishment. (Williams and others, 2003). back

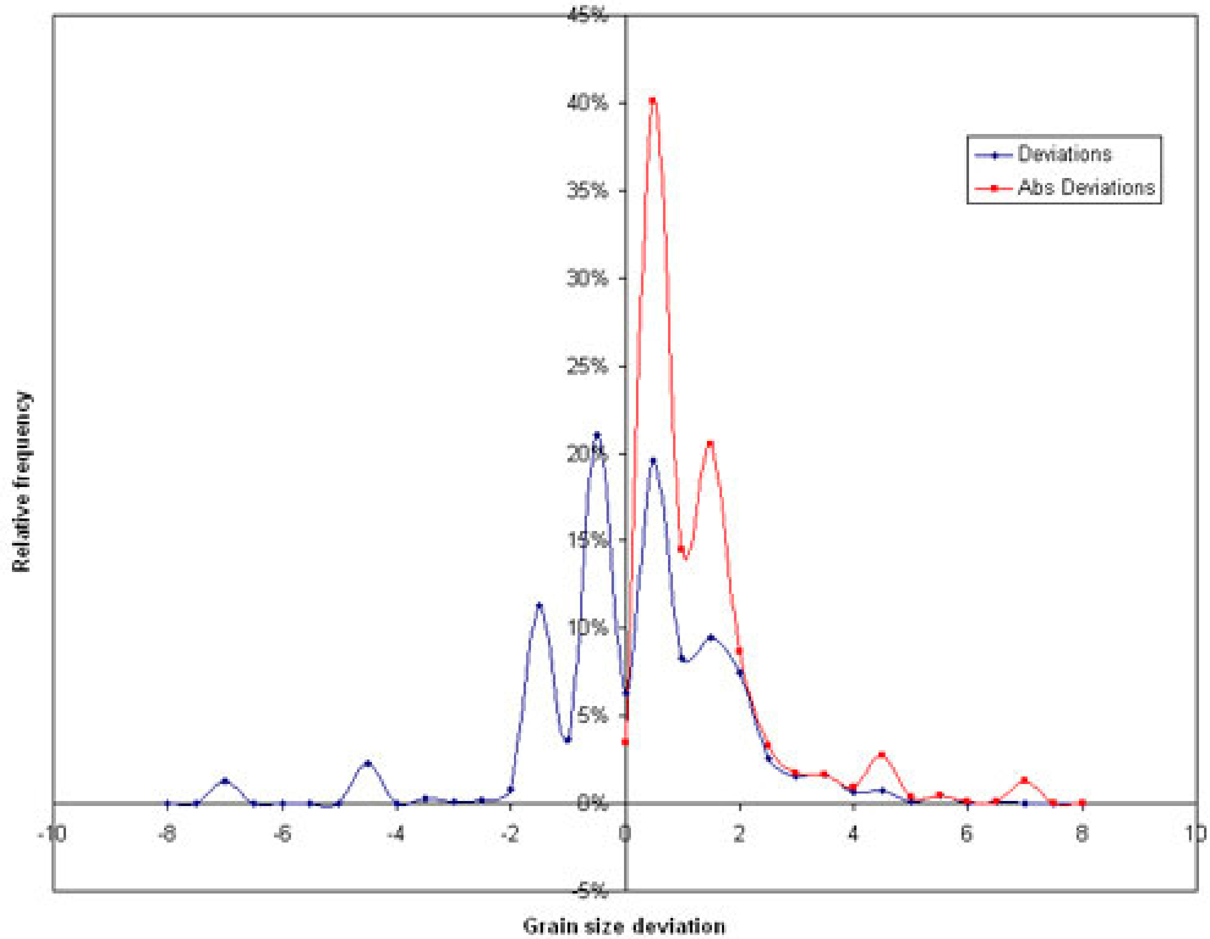

Figure 3: Statistical calibration of outputs for grain sizes, shown using a frequency plot of the deviations between PRS and EXT data, using an improving Atlantic Coast data set. Deviations are the results of inaccuracies in the EXT and PRS input data, as well as in identifiable issues in the data as highlighted below in figure 4. The 50, 68, and 95 percent confidences are 90.8, 1.3, 4.3 phi, respectively. back

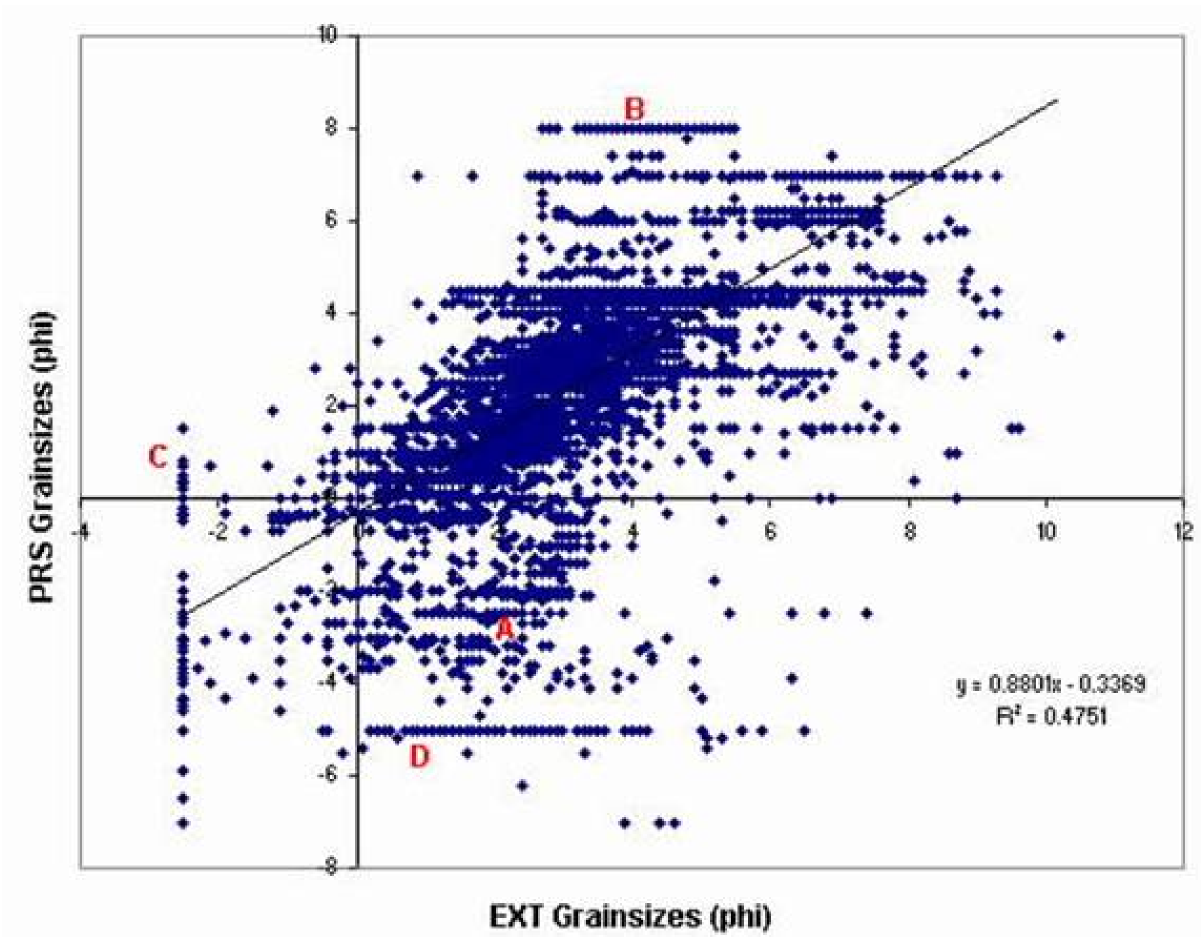

Figure 4: Crossplot of lab-based grain size values (EXT) against grain size values derived from word-based descriptions from the same samples. Areas of large differences noted by letters: A. PRS coarser than GRZ, apparently due to outsized shells / clasts being omitted from lab grain size analyses; B. Sediment described as very fine in PRS, but only the sand fraction is represented by the EXT analysis data; C. Detailed analyses of grain sizes does not go beyond coarsest class of about -2.5 phi; and D. Descriptive PRS data does not distinguish grades of sand, and is apparently dominated by reports of very large clasts, such as cobbles or shell, that were not analyzed. With the detection and fixing of these problems the accuracy of outputs is substantially improved over that shown here. Notice that overall the PRS outputs extend further in coarse grades and the EXT outputs extend further in the fine grades, reflecting their common observational biases. back

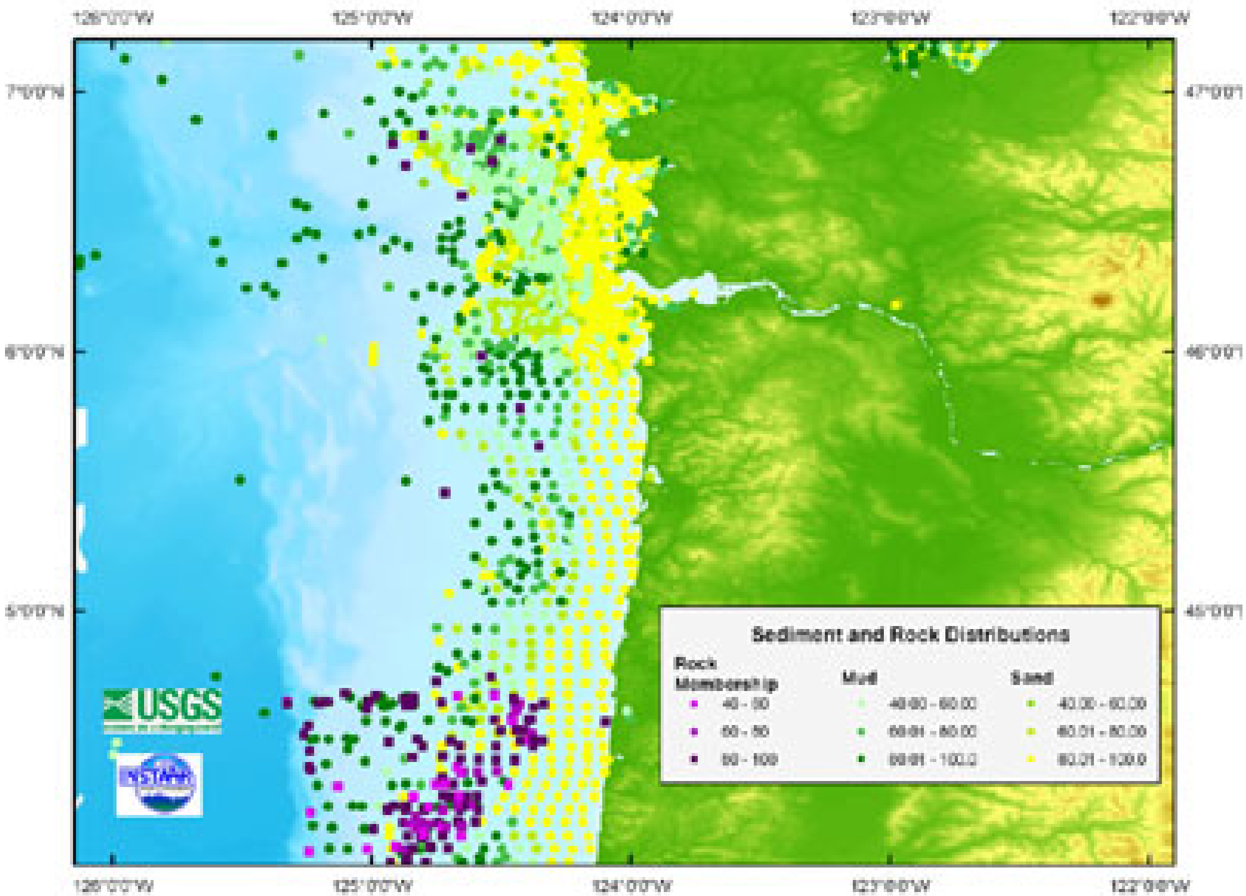

Figure 5a. Example of usSEABED data: grain-size distributions of sand (yellows) and mud (greens) with areas of hard-bottom (purples) off Oregon, using extracted (EXT) and parsed data (PRS). Image created in a GIS. back

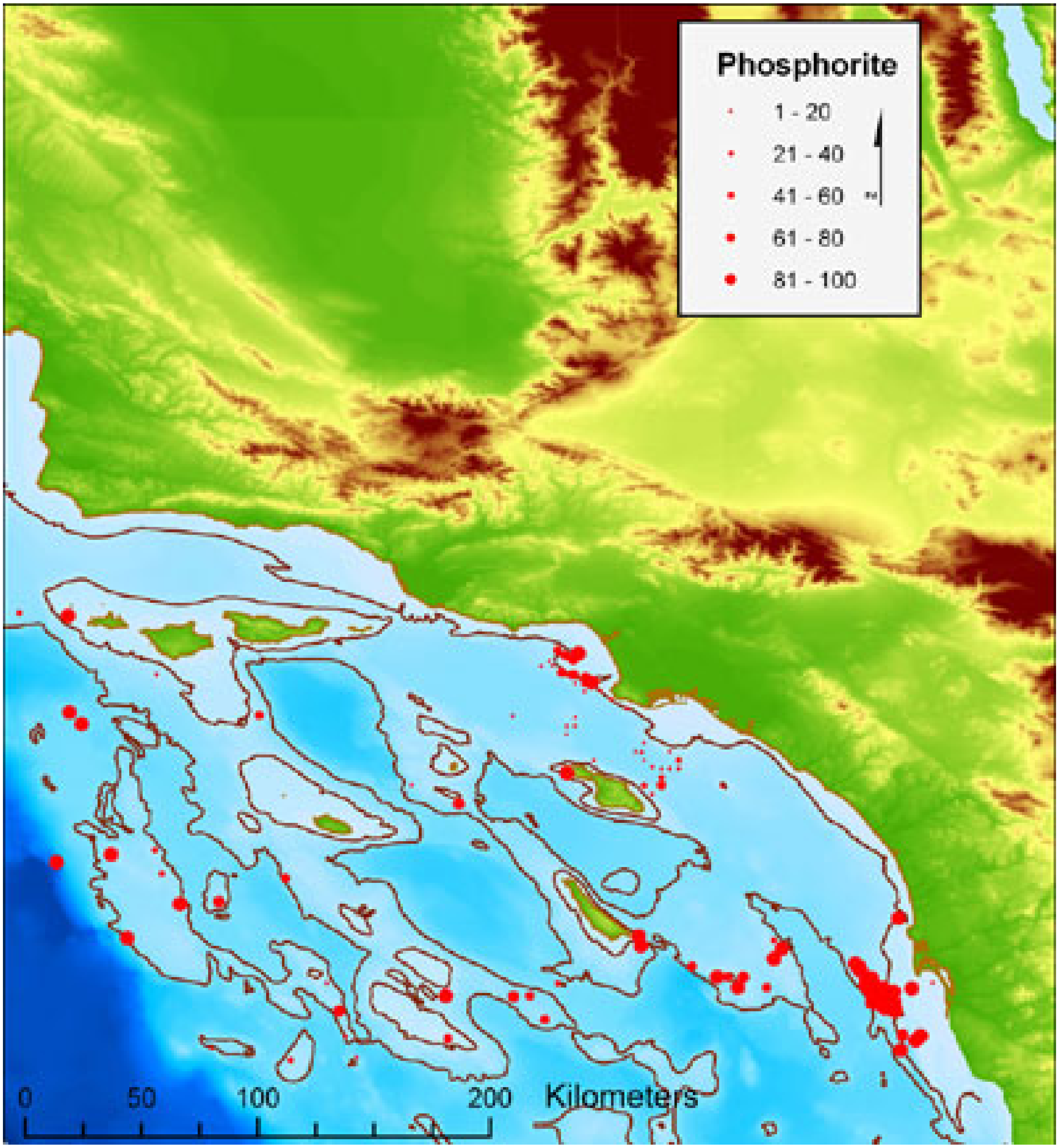

Figure 5b. Example of usSEABED data: relative presence of phosphorite in southern California using the component (CMP) data. Image created in a GIS. back

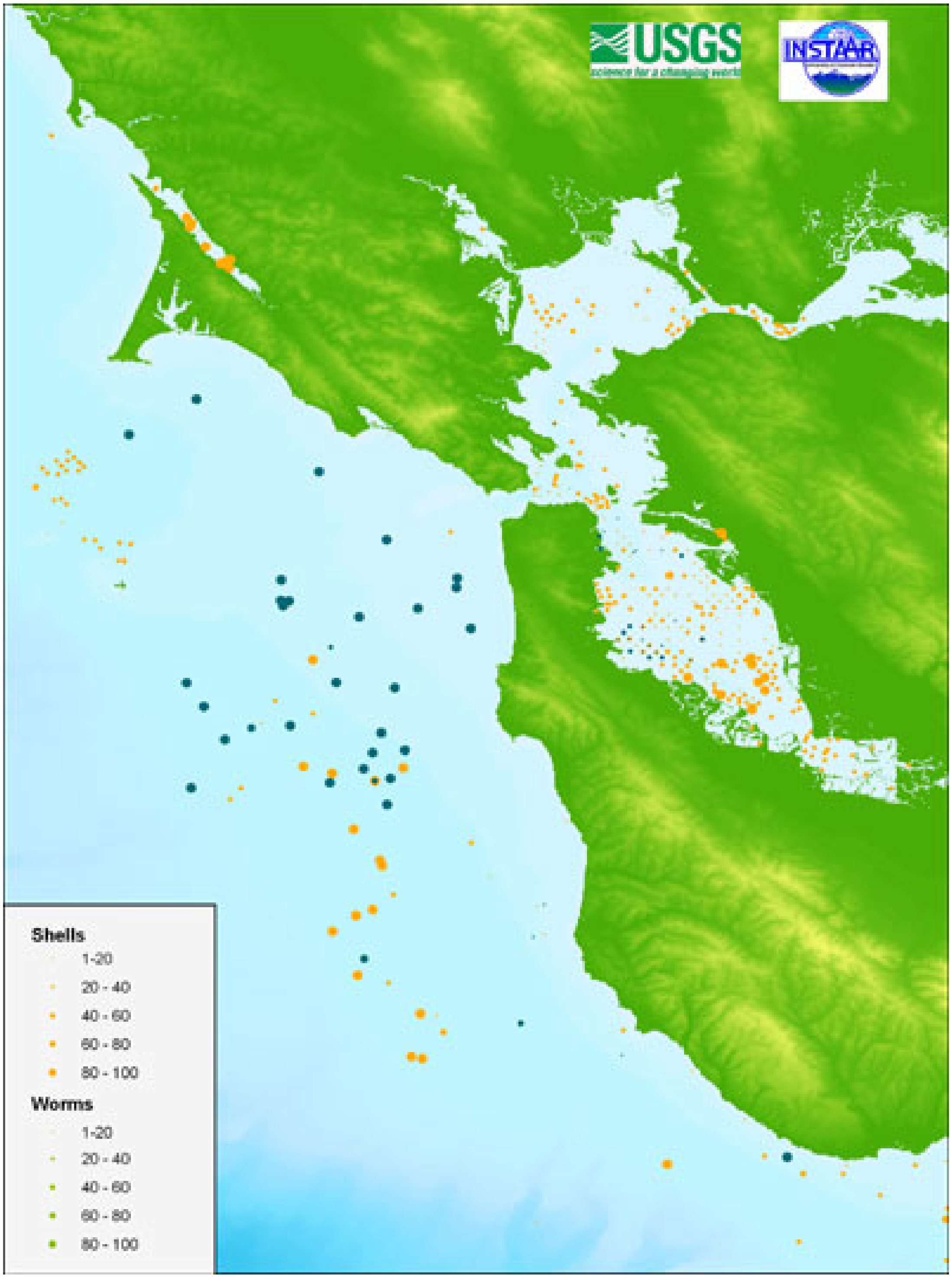

Figure 5c. Example of usSEABED data: presence of shells (orange) and worms (blues) in central California using the facies (FAC) file. Image created in a GIS. back

Table 1. Key to data themes in usSEABED output files

back

Acronym	Meaning
ACU	Acoustic properties
BIO	Biota descriptions
CMP	Sediment composition analyses
COL	Sediment color
GRZ	Grain size analyses
GTC	Geotechnical properties
LTH	Lithologic descriptions
MSL	Multisensor core-logger analyses
PET	Grain petrologic analyses
SFT	Sea-floor type descriptions
TXG	Graphical texture statistics
TXR	Texture and statistics

Table 2. usSEABED output files

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Data File	Contents
EXT	Extracted (numeric, lab-based)
PRS	Parsed (word-based)
CLC	Calculated (calculated variables)
CMP	Components (content and features)
FAC	Facies (components only)
SRC	Source information

Table 3. Field parameters, format, units, range, meaning, and comments for the extracted (EXT), parsed (PRS), and calculated (CLC) data files

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Field Name	Parameter	Data Format	Units, Range, Meaning	Comment
Latitude	Latitude	Decimal 00.00000	Decimal degrees, 90° to -90° range	World Geodetic System 1984 (WGS 84) Spheroid.
Longitude	Longitude	Decimal 000.00000	Decimal degrees, -180° to 180° range	WGS 84 Spheroid.
WaterDepth	Water depth	Integer 00000	Meters	Not always tidally correct.
SampleTop	Sample top	Decimal 000.00	Meters below seabed surface	Sample top as noted in source report.
SampleBase	Sample base	Decimal 000.00	Meters below seabed surface	Sample bottom as noted in source report.
SiteName	Site name	Character XXX: XXX	Survey or laboratory code for the sampling site	Not unique; Site name as given in report; sometimes linked to cruise name or other information to decrease sitename overlap.
DataSetKey	Dataset number key	Integer 000	For audit only	Relational key to data source (SRC) file; SRC file contains links to source metadata.
SiteKey	Site number key	Integer 0000000	For audit only	Relational key to other data files. Each site counted sequentially as total output; core data may have more than one sample per site.
SampleKey	Sample number key	Integer 0000000	For audit only	Relational key to other data files. Each site counted sequentially as total output; Multiple samples may be at each site (that is, within core).
Sampler	Sampler type	Character Xxxxxxxx....	Type of sampling device	As given in source report; recovery (“rcvy”) or penetration ("pen") length appended if given in source report. For more complete information on sampler, see source metadata.

DataType	Data types	Character XXX: XXX	For audit principally	Source data types (table 1).
Gravel	Gravel	Integer 000	Gravel grain size fraction, %	Textural class.
Sand	Sand	Integer 000	Sand grain size fraction, %	Textural class.
Mud	Mud	Integer 000	Mud grain size fraction, %	Textural class.
Clay	Clay	Integer 000	Clay grain size fraction, %	Textural class; output for EXT only, as clay value can be determined only by analysis.
Grain size	Grain size	Decimal 00.00	Phi characteristic grain size	Consensus of mean and median grain sizes.
Sorting	Sorting	Decimal 0.00	Phi grain size dispersion	Standard deviation, sorting only.
SeafloorClass	Seafloor class	Character Xxxxx...	That class (or facies) with the maximum fuzzy membership, if above 30%	Output for PRS table only.
ClassMbrshp	Class membership	Decimal 000	Fuzzy membership (%) of the class (or facies), noted above	Output for PRS table only.
Folk	Folk classification	Character xx.X...		
Shepard	Shepard classification	Character XXX…		
RockMbrshp	Rock index	Integer 000	Fuzzy membership (%)	Membership of sample to ‘rock' fuzzy set'; reported only in PRS data
WeedMbrshp	Weed index	Integer 000	Fuzzy membership (%)	Membership of sample to weed fuzzy set; reported only in PRS data
Carbonate	Carbonate	Integer 000	%; may be Fuzzy membership (PRS)	

MunsellCode	Munsell color code	Character XXXXX	Standard alphanumeric coding of color partitioned into Hue, Value, and Chroma	Ex: "5YR 6/4", See "Rock-Color Chart", (Geological Society of America, 1991).
OrganicCarbon	Organic carbon	Integer 000	%	Minimum value from descriptions (PRS tables) is 0.1%.
ShearStrength	Log shear strength	Decimal 00.0	kiloPascals, undrained, unconfined	From a variety of instrumentation.
Porosity	Porosity	Decimal 00.00	%	
P-waveVelocity	P-wave velocity	Decimal 00.0	m/sec	Usually not corrected for P/T effects.
Bottom Roughness	Roughness	Decimal 0000.00	Coded to express the height and length of the bottom feature with greatest aspect ratio	In a coding that expresses the height and length of the bottom feature with greatest aspect ratio; a coded output representing the V:H of the roughness element with greatest aspect ratio, values expressed as (rounded) integer log2.
CriticalShearStress	Log critical shear stress	Decimal 0000.00	Log10 of Tau in kPa	Log 10 of tau in kPa, being the shear stress required to initiate easily observable erosion and transport, whether by traction or suspension; taken from a compilation of published relationships ranging from large boulder to muds, through a range of grain shapes (for example. shell).

Sample phase	Where in sample the data are from	Character Xxxxx....	Where sample is from	Records whether the results are for the whole, bulk sediment, or just to some special part, for example, inside a nodule, burrow-infill, the sand fraction, porewater (chemistry), a layer in the core, a gradient observed in the core, poorly preserved specimen, a layer that is not properly located, or sample with questionable location; also may report a type of analysis or observation if that is special or potentially unrepresentative (e.g., X-ray diffraction (XRD) smear slide (XRD). Output is as a word-based description that may involve numerics. This field will need to be selected against when GIS mappings of the bulk sedient characters are being mapped. Only blank entries should be included in such a mapping.

Table 4. Components (features_F) processed within usSEABED (data file CMP)

Only the descriptive terms found in source reports are defined in the dbSEABED thesaurus. Conversely, as usSEABED uses the same thesaurus as its sister data compilations (auSEABED, goSEABED), some terms listed below may not occur within U.S. waters. Only one of possible variations is listed below; for example, laminated (laminae, lamination), and mollusc (mollusk, mollusca). back

Senior synonym	**Triggering Words (word variations not included)**
andest	andesite, augite andesite, benmoreite, trachyandesite
anmne_F	anemone, tube anemone, cerinth, cerianthid, coryanactid
annld_F	annelid, arenicola, beachworm, bloodworm, bristleworm, funnelworm, nereid worm, polychaete, polynoid
aren_frm	arenaceous foraminfera, agglutinated foramifera, ammobaculite, ammodiscus, textularid foraminfera
artif_F	artificial, soot, anchor, brass, cinder, coal, contaminated, lumber, obstruction, petroleum, oil, gas, rubber band, snag, tar, wood chip, wreck
asterd_F	asteroid, basket star, briseaster, sea star, starfish
barit	barite (-concretion -vein)
baslt	basalt, diorite, metabasalt, scoria, trap rock, trachybasalt
bioturb	bioturbation
bitumn	bitumin
biv	bivalve, arctica, astarte, cardium, chama, chione, chlmys, clam (-shell -flat material -hash -valves), cockle (anadara -shell), donax, glycymeris, katalysia, lamellibranch, macoma, mercenaria, mulinia, mussel (-bed -bank -shell), mya, mytilus, nucula, pelecypod, quahog, rangia, seep mytilid, slipper shells, surf clam, tellina, tellinid, venerid, venus clams, vesicomyid, yoldia
bluschst	blue schist, crossite-albite schist, crossite-quartz schist, glaucophane, quartz crossite schist, quartz glaucophane schist
bnth_frm	benthic foraminfera, archaias, bolivina, bulimina, coralline forams, discorbis, eponides, homotrema, hyaline, lenticulina, loxostema, miliolid, nodosirid, nonien, notosirid, peneroplis, porcellanous, rotaiid, uvigerina
borng_F	boring, bioeroded
brach	brachiopod, lingula
brncl	barnacle
bryz	bryozoa, polyzoa
burw_F	burrow, chondrite, clam siphon, crab hole, lebensspurren, Thalassinoides
c_alg	calcareous algae, purple algae, red algae

calc_ooz	calcareous ooze, nannofossil (-mud -ooze), pteropod (-mud -ooze), foraminiferal (-marl -ooze -mud), globigerina (-mud -ooze)
calcrst	calcareous crust, tufa
calct	calcite (-cement -core -filling -veinlets)
carb	allogenic grain, authigenic carbonate, biogenic, calcareous, calcilutite, calcarenite, calcirudite, calcareous biogenic, carbonate, limey, marl, skeletal micrite
chrcoal_F	charcoal, fire debris
chrt	chert, flint, porcellanite
claymin	clay mineral, bentonite, chlorite, collophane, illite, kaolinite
clypeast	clypeasteriod, sand dollar
coal	coal, lignite, bituminous
coralgl	algal coral, coralgal
crab	crab, hermit crab, sand crab, spider crab, swimming crab
crinod_F	crinoid, basket star
crl	coral, Acropora palmata, brain coral, Dendrophyllia, Madrepore, Manicina, Porite, sea twig
crl_dbr	coral debris
crlrf	coral reef, coral heads, shingle bank, reefal shoal
crnalg	coralline algae, calcareous algae, lithothamnion
crustac	crustacea, decapods, lobster, shrimp shell
defrmn_F	deformation, convolute, flame structure, flow structure, load (-cast -structure), pull apart
diat	diatom, diatomite/diatomaceous
dolmt	dolomite, ankerite, molar magnesium carbonate
echnd	echinoid, heart urchin, keyhole urchin, sea urchin, spiny urchin
echndrm_F	echinoderm
fault_F	fault
fces	feces, coprolite
ferug	ferruginous, iron fragment, iron (-cement -streak -flake -stain), iron stone, laterite, limonite
flasr_bed_F	flaser bed
fld	feldspar, albite, andesine, anorthorite, K-feldspar, labradorite, orthoclase, plagioclase
frm	calcareous foramifera, foraminifera, globigerina bit, planktonic
gas	foamy, gas

gbbro	gabbro, diabase, diorite, dolerite, meta-dolerite, monzodiorite, monzonite, quartz diorite
glacl	glacial, diamicton, erratic, moraine, till
glauc	glauconite, greensand
gniss	gneiss, diorite gneiss, granite gneiss
gradd_F	coarsening upward, fining upward, increasing grain size, normally graded, reverse graded
granit	granite, aplite, granodiorite, pegmatite
grnschst	greenschist
gstrpd	gastropod, cerithium, conch, turitella, snail, nassarius, olivella, tenebrae, turitella
h2s	hydrogen sulfide, hydrogen sulfide (-odor -smell), sulfur odor
halmda	halimeda, Peyssonnelia
holoth	holothurian, sea cucumber
hvy_min	heavy mineral, anatase, andalusite, apatite, black sand, brookite, cassiterite, clinozoisite, corundum, dumortierite, epidote, garnet, ilmenite, jadeite, kyanite, leucoxene, magnetite, monazite, ore mineral, piedmontite, rutile, sillimanite, sphene, spinel, staurolite, titanomagnetite, titanite, tourmaline, topaz, zircon, zoisite
hydrt	hydrate, gas hydrate
ign_rck	igneous rock, acidic rock, alkali basinite, augite plagioclase porphyry, augite porphyry, basic rock, dacite, felsite, olivine plagioclase clinopyroxene, olivine plagioclase phyric, plagioclase andesite porphyry, plagioclase augite porphyry, plagioclase porphyry, plutonic rock, porphyry, rhyolite, syenite, trachyte
klp_F	kelp, brown algae, ecklonia, M. vertebralis, red brown algae
lamintd_F	laminated
lenticlr_bed	lenticular bed, lenticular mass
limstn	limestone, beach rock, bioclastic (-floatstone -grainstone -limestone -rudstone), boundstone, bryozoan (-floatstone -grainstone -rudstone), calcareous (-chip -rubble -rock), coral limestone, floatstone, grainstone, packstone, rudstone, wackestone
lmp_F	lump, aggregate, ball, cast, clump, compact clot, intraclast, pellet, pisolitic, peloid
lrg_frm	large foram, foraminferal gravel, amphistegina, heterostegina, macro foraminifera, marginopora
maf	mafic, actinolite, aegirite, amphibole, augite, (brown- green- basaltic-) hornblende, bronzite, clinopyroxene, ferromagnesian, hypersthene, olivine, orthopyroxene, oxyhornblende, pyroxene, titanaugite, titaniferous, tremolite
met	metamorphic, calcsilicate, granitized, mylonite, porphyroblast, saussurite
methne	methane
metlif	metalliferous

mica	mica, biotite, chlorite, muscovite, sericite, talc
mlsc	mollusc
mn_crst	manganese crust, manganese iron oxide crust, manganese nodule, manganese pavement, manganese phosphate material
mn_nod	manganese nodule, iron manganese nodule, manganese concretion, micronodule
mnoxd	manganese oxide, iron-manganese (-coat -stain -veneer), iron-manganese oxide
motl_F	mottle, chickwire mottle
mudlmp_F	mud lump, armored mud ball, silty lump, clay (-aggregate -ball -chip -clast -gall -lump -mass -pod), mud (-aggregate -ball -chunk -clump -clot -clast -lump -pebble -pellet), claystone (-chip -gall), sandstone fragment, soft pebble, shale (-fragment -concretion)
mudstn	mudstone, calcareous (-mudstone- siltstone), clay (-rock -shale -stone), marlstone, mud (-rock -stone), pelite, shale, siliceous shale, siltstone
nan	nannofossil coccolith, nannofossil (-coccolith- ooze), silicoflagellate
nod_F	nodule, concretion
odr	odor, anoxic, fetid, foul, fishy, organic, sewage, smell
oil	oil, oil glob, oil sheen
ool	oolite, sporbo
ooz	ooze
ophiurd_F	ophiuroid, brittle star, ophiomusium
orgcbn	organic carbon, carbonaceous, organic (-streak -detritus -matter -mud -content -enriched -material -part -particle -rich -rimmed), sapropel
oyst	oyster, jingle shell
peat	peat, lignite
pelag	pelagic, hemipelagic, planktic, planktonic
phspht	phosphate, phosphorite
pit_F	pit, crater, feeding depression, hole, pockmark, mound, resting trace
planr_bed_F	planar bed
plnk_frm	planktonic foramifera, globerina, globorotalid, planktic foraminfera
plnt_F	plant, mangrove, root, vegetation, weed, root
ptr	pteropod
pumc	pumice, ash
pyrt	pyrite, marcasite

qtz	quartz, arkosic sand, calcareous quartz sand, milky vein quartz, quartz (-content -fragment -grain -granule -groundmass -mass -rich -vein -veinlet -crystal), quartzose, quartzite (-cobble -gravel -pebble), sandstone (-chunk -fragment), silica
rad	radiolaria
ripl	ripple, bedform
rlct_F	relict
root_struct	root structure, root clast, root trace
rzr_clm	razor clam, ensis, pinna, pteria, pelecypod
schst	schist, (-albite-chlorite-epidote, -albite-chlorite, -albite-mica, -albite-quartz-chlorite, -biotit -quartz, -chlorit -albite, -chlorite-quartz-albite, -chlorite, -phyllitic, -quartz-albite, -quartz-albite-chlorite, -quartz-biotite, -quartz-chlorite)
scllp	scallop, astropecten, pecten, placopecten
scour	scour, crag and tail, erosional, lag deposit
scphpd	scaphopod, dentalium
seagrs_F	seagrass, acetabularia, amphibolis, batophora, eel grass, grass, halophila, heterozostera, phyllospadix, posidonia, sargassum, strap grass, syringodium, manatee grass, thallassia, zostera
sft_alg_F	soft algae, algal (-scum -filament -mush -strand), Bossea, green algae, macrophytic, red algae
sftcrl_F	soft coral, alcynacian, ascidian, coelentrate, gorgonian, hydrozoa
shl	shell, shell (-bed -bank -carpet -fraction -content -material), shellfish, valves
shl_dbr	shell debris, shell hash, coquina, shell (-bit -conglomerate -fragments -festoon -grit -lag -mash -material -piece -particle)
shrmp_F	shrimp, amphipod, ampelisca, copepod, isopod, tanid
sidrt	siderite, siderite nodule
sil_ooz	siliceous ooze, siliceous mud
slte	slate, phyllite, quartzite, metamorphic rock
sndstn	sandstone, gritstone, graywacke, labile sandstone, sandstone reef, wacke
sol_crl	solitary coral, cup coral, disc coral, horn coral, lophelia coral
spng_F	sponge, calcareous sponge, glass sponge, hard sponge, hexactinellid sponge, porifera, Thalassodendron sponge
spoil_F	spoil, brick, coke, dumped sediment
srpul	serpulid, serpulid tube, serpulid worm tube
sulf	sulfide, chalcopyrite
trail_F	trail, trace (animal), track

trrg	terrigenous, lithic, inorganic
umafic	ultramafic, amphibolite, anorthosite, dunite, greenstone, harzburgite, lherzolite, norite, orthopyroxenite, periodotite, picrite, pyroxenite, serpentinite, troctolite, wehrlite
vol_rck	volcanic rock, volcanic -cobble -pebble
volgls	volcanic glass, obsidian, hyaloclastite, pyroclastic, quenched, vitric, subvitreous
volrck	volcanic rock, welded tuff
volsed	volcanic sediment, ash, tuff, lapilli
wood	wood, bark, twig
wrm_F	worm, chordate, echiurid, (fan- flat- glob- juicy- long- sand-) tube worm, maldanid, pogonophora, priapulida , sliverfish, siphunculid, tunicate
wrm_tbe_F	worm tube (-agglutinated -amphipod -annelid -arenicola -chitinous -diopatra -polychaete - pogonophoran, -vestimetiform)
wavy_bed_F	wavy bed

Table 5. Facies and their component makeup (data file FAC)

Facies values are determined by a combination of components and their mined values from word-based descriptions. Numeric textural, geochemical, and geophysical information held in PRS data files. Values represent memberships to fuzzy sets, given as percents. A minimum of 30 percent component presence is required to trip a given facies, and a component may trip more than one facies. See the facies (FAC) file for actual data, and table 4 for component information. Facies notes presence only, not absence.
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Field Name	Parameter	Data Format, units	Information/ triggering components
Latitude	Latitude	Decimal 00.00000	Decimal degrees, 90° to -90° range
Longitude	Longitude	Decimal 000.00000	Decimal degrees, -180° to 180° range
WaterDepth	Water depth	Integer 00000	Meters
SampleTop	Sample top	Decimal 000.00	Meters below seabed surface
SampleBase	Sample base	Decimal 000.00	Meters below seabed surface
SiteName	Site name	Character XXX: XXX	Survey or laboratory code for the sampling site
DataSetKey	Dataset number key	Integer 000	Relational key to data source (SRC) file; SRC file contains links to source metadata
SiteKey	Site number key	Integer 0000000	Relational key to other data files. Each site counted sequentially as total output; core data may have more than one sample per site.
SampleKey	Sample number key	Integer 0000000	Relational key to other data files. Each site counted sequentially as total output; Multiple samples may be at each site (i.e., in core).
Terrigenous	Terrigenous	(%)	Fld, hvy_min, maf, mica, qtz, trrg
Carbonate	Carbonate	(%)	Calcrst, calct, carb, dolmt, limstn, sidrt
Igneous	Igneous	(%)	Andest, baslt, gbbro, granit, ign_rck, umafic
Volcanic	Volcanic	(%)	Baslt, pumc, vol_rck, volgls, volrck, volsed
Metamorphic	Metamorphic	(%)	Bluschst, gniss, grnschst, met, schst, slte
Mineralized	Mineralized	(%)	Barit, metlif, phspht, pyrt, sulf
AuthFeMn	Authigenic Fe Mn	(%)	Mn_crust, mn_nod, mnoxd, ferug
Ooze	Ooze	(%)	Ooz, calc_ooz, sil_ooz
Carbon	Carbon	(%)	Coal, bitumn, orgcbn, peat

GeochemSignal	Geochemical signal	(%)	Gas, h2s, hydrt, methne, odr, oil
Forams	Forams	(%)	Aren_frm, bnth_frm, frm, lrg_frm, plnk_frm
OtherCalcPelag	Other calcareous pelagics	(%)	Nan, ptr, calc_ooz
SilcPelag	Siliceous pelagics	(%)	Diat, rad, sil_ooz
Shell	Shell	(%)	Shl, shl_dbr
Coral	Coral	(%)	Crl, crl_dbr, crlrf, sol_crl
HardPlant	Hard plants	(%)	C_alg, coralgl, crnalg, halmda

Table 6. Most frequently occurring biological components that may have textural implications (U.S. waters only)
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barnacles	coralline algae	fish debris_F	pteropods	serpulids
bivalves	corals	forams	radiolaria	shells
brachiopods	crabs	halimeda	razor clams	sponges_F
bryozoa	crustaceans	molluscs	reefs	worm tubes_F
calcareous algae	diatoms	nannofossils	scaphopods	
clypeasts	echinoids			

Table 7. usSEABED Pacific (California, Oregon, Washington) data

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Data Layer Name & Description	Metadata	Files	File Size
pac_ext usSEABED extracted data for the U.S. West Coast	HTML FAQ XML txt	pac_ext.zip	1.0 MB
pac_prs - usSEABED parsed data for the U.S. West Coast	HTML FAQ XML txt	pac_prs.zip	859 KB
pac_clc - usSEABED calculated data for the U.S. West Coast	HTML FAQ XML txt	pac_clc.zip	1.5 MB
pac_cmp - usSEABED component data for the U.S. West Coast	HTML FAQ XML txt	pac_cmp.zip	601 KB
pac_fac - usSEABED facies data for the U.S. West Coast	HTML FAQ XML txt	pac_fac.zip	380 KB

Table 8. **Base-map layers**

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Data Layer Name & Description	**Metadata**	**Files**	**File Size**
NOS80K - Medium Resolution Digital Vector Shoreline (Source: NOAA)	HTML FAQ txt	nos80k.zip	25.9 MB
U.S. EEZ Boundary - Boundaries of the Exclusive Economic Zone (EEZ) (Source: NOAA)	HTML FAQ txt	useez.zip	179 KB
State Boundaries - internal U.S. State boundaries (Source: USGS/CMGP)	HTML FAQ txt	state_bounds.zip	1.7 MB

Appendix A. Data Sources

Achstetter, Eugene V., Kelly, Eugene V., Loomis, P. Burr, McKellar, Scott M., 1970, A summary of sediment size composition and engineering properties of three cores from the eastern Pacific April 1970: U.S. Naval Oceanographic Office (NAVOCEANO) Laboratory Item 398, 16 p. National Geophysical Data Center (MGG_09695001, data set 383).

Achstetter. Eugene V., P. Burr Loomis, and Cary M. Ross, 1970, A summary of sediment size and compositions of twelve grabs, May 1970: U.S. Naval Oceanographic Office (NAVOCEANO) Laboratory Item 400, 19 p., National Geophysical Data Center (MGG_09625001, data set 375).

Anderson, Franz E., 1967, Stratigraphy of later Pleistocene and Holocene sediments from the Strait of Juan de Fuca: Seattle, University of Washington, Ph.D. dissertation, 167 p. (Anderson_PhD_1967, data set 393).

Andrews, Robert S., 1965, Modern sediments of Willapa Bay, Washington: A coastal plain estuary: Seattle, University of Washington, Department of Oceanography Technical Report no. 118, Reference M65-8, 43 p. (TechRep118, data set 390).

Ballard, Ronald L., Distribution of beach sediment near the Columbia River: Seattle, University of Washington, Department of Oceanography Technical Report no. 98, February 1964, Reference M64-16, 75 p. with appendices (TechRep98, data set 389).

Barnard, William D., 1973, Late Cenozoic sedimentation of the Washington continental slope: Seattle, University of Washington, Ph.D. dissertation, 255 p. (Barnard_PhD_1973, data set 421).

Barnes, Peter W., 1970, Marine geology and oceanography of Santa Cruz Basin off southern California: Los Angeles, University of Southern California, Ph.D. dissertation; also published as USC Report Number: USC-GEOL 70-3, 175 p. (Barnes_PhD_1970, data set 406).

Bockman, Peter, Hill, David S., and Achsetter, Eugene, 1966, A summary of sediment size, composition, and engineering properties for PMR project 121/02; September – October 1965: U.S. Naval Oceanographic Office (NAVOCEANO) Laboratory Item 277, 44 p. National Geophysical Data Center (MGG_09005011, data set 365).

Borgeld, Jeffry C., 1985, Holocene stratigraphy and sedimentation on the northern California continental shelf: Seattle, University of Washington, Ph.D. dissertation, 177 p. (J. Borgeld, additional data, written commun. 1999 to Mark Zimmermann, National Marine Fisheries Service, (Borgeld_PhD_1985, data set 385).

Bouma, Arnold and Marshall, Neil, 1964, A method for obtaining and analyzing undisturbed oceanic sediment samples: Marine Geology v. 2 no. 1/2, p. 81-99 (Bouma_&_Marshall_1964, data set 408).

Burnett, Thomas L., 1968, Bottom sediment data from the continental shelf of Washington – Grays Harbor to Cape Flattery: Seattle, University of Washington, Department of Oceanography Special Report no. 39, 1005 p. in three volumes (SpecReps57_40_39, data set 388).

Bushnell, David C., 1964, Continental shelf sediments in the vicinity of Newport, Oregon: Corvallis, Oregon State University, Masters thesis, 107 p. (Bushnell_MS_1963, data set 397).

Butcher, William S., 1951, Lithology of the offshore San Diego area and foraminifera of Coronado Bank and vicinity, California: Los Angeles, University of California, Ph.D. dissertation, 117 p. (Butcher_PhD_1951, data set 420).

Cacchione, David, and Drake, David, 1983, Variability of sea-floor roughness within the Coastal Ocean Dynamics Experiment (CODE) region: Woods Hole Oceanographic Institution, Technical Report 83-25, 44 p. (WHOI_TR_83-25, data set 298).

Carter, Lee S., 1971, Recent marine sediments of Carmel Bay California: Monterey, U.S. Naval Postgraduate School, Masters thesis, 57 p. (Carter_MS_71, data set 358).

Chambers, David M., 1968, Holocene sedimentation and potential placer deposits on the continental shelf off the Rogue River, Oregon: Corvallis, Oregon State University, Masters thesis, 103 p. (Chambers_MS_1968, data set 396).

Cherry, John A., 1962, Sand movement along a portion of northern California coast: Berkeley, University of California, Masters thesis, 125 p. (also published as U.S. Army Coastal Engineering Research Center Technical Memorandum no. 14, CERC_TM14, data set 12).

Coleman, Jess B., and Grimes, Alvin R., 1965, A summary of sediment size, composition and engineering properties for PMR project 5R-006: U.S. Naval Oceanographic Office (NAVOCEANO) Laboratory Item 242, 31 p., National Geophysical Data Center (MGG_09185006, data set 372).

Colomb, Herbert P., Jr., 1973, Recent marine sediments of the central California continental shelf between Point Lobos and Point Sur: Monterey, U.S. Naval Postgraduate School, Masters thesis, 40 p. (Colomb_MS_73, data set 359).

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Appendix B. Published Articles about dbseabed

The following published articles provide more detailed information about various aspects of dbSEABED and are included in this publication:

Jenkins, C., 1997, Building offshore soils databases: Sea Technology, v. 38, no. 12, p. 25-28. (Permission for reproduction granted by Sea Technology Magazine. For additional information contact Sea Technology.)

Jenkins, C., 2002, Automated digital mapping of geological colour descriptions: Geo-Marine Letters, v. 22, no. 4, p. 181-187. (Permission for reproduction granted by Springer. For additional information about the SpringerLink free abstract program, please see Springer Online Products.)

Jenkins, C., 2003, Data management of MARGINS geologic data, with emphasis on efficiency, quality control and data integration: MARGINS Newsletter. 10, Spring 2003, p. 8-10.*

*(Permission for reproduction granted by MARGINS. Since this article was published, a MARGINS data management system (DMS) (http://data.nsf-margins.org/) has been established within the Marine Geoscience Data Management System (http://www.marine-geo.org/). This DMS is the designated MARGINS repository for metadata relating to all data types and for digital data for which no standard repository exists. Central to the larger system are visualization and search tools that facilitate integrated access to data and metadata across diverse scales and disciplines. Ultimately, all MARGINS data and samples will be traceable through metadata maintained in the DMS.)

Appendix C. Frequently Asked Questions about dbSEABED and usSEABED

See separate sheet: DS182_FAQs.pdf

Appendix D. onCALCULATION

See separate sheet: DS182_onCalculation.pdf