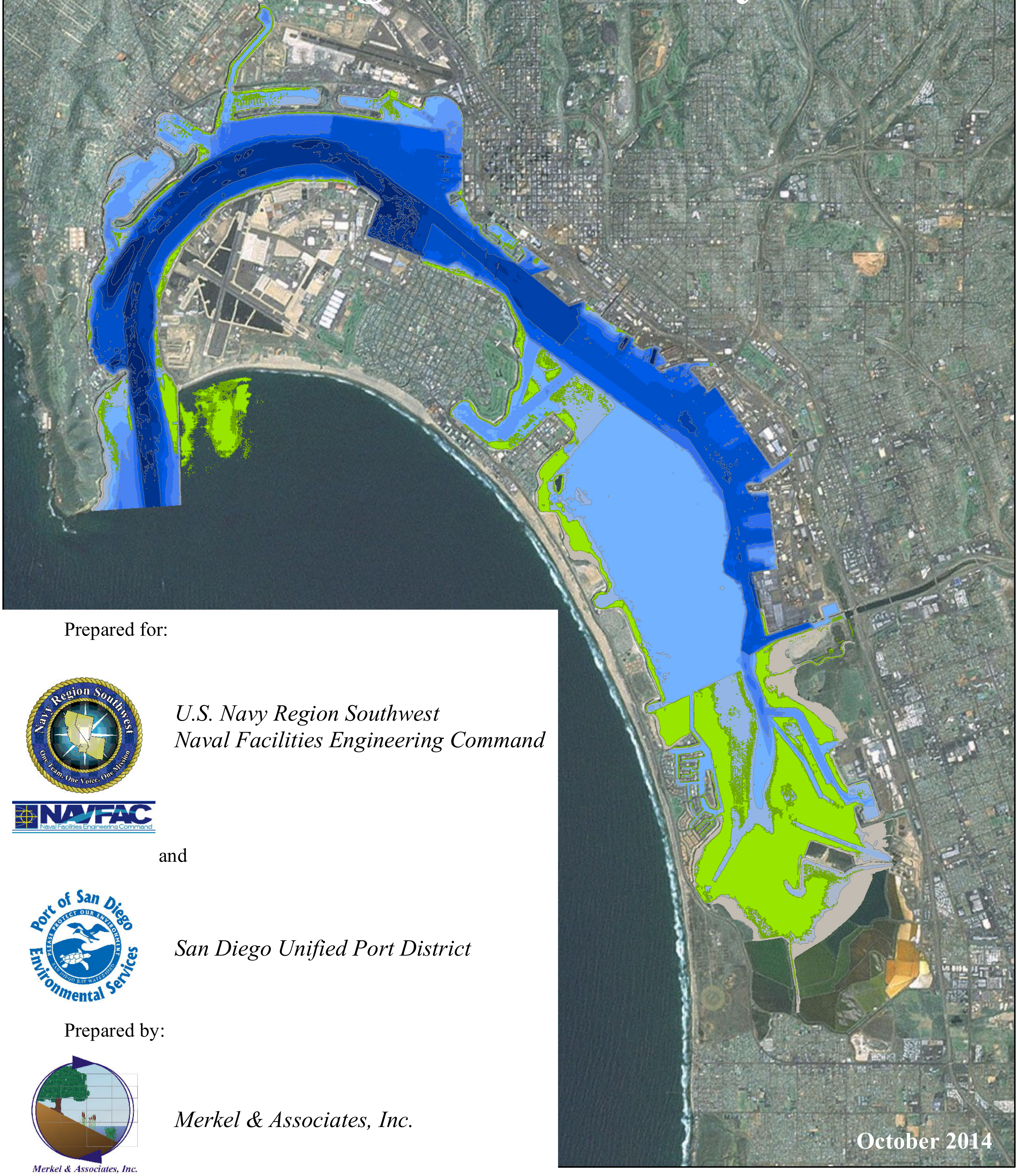
2014 San Diego Bay Eelgrass Inventory



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and

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2014 SAN DIEGO BAY
EELGRASS INVENTORY UPDATE
Merkel & Associates, Inc.
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BACKGROUND

Eelgrass

Eelgrass is a native marine plant indigenous to the soft-bottom bays and estuaries of the northern hemisphere. The species is found from middle Baja California and the Sea of Cortez to northern Alaska along the west coast of North America and is common in healthy-shallow bays and estuaries. In southern California, eelgrass is generally limited along the shoreward margin by desiccation stress at low tides and is limited along its deeper fringe by low light levels.

Eelgrass plays many roles within coastal bays and estuary ecosystems. It clarifies water through sediment trapping and stabilization and provides benefits through nutrient transformation and water oxygenation. Eelgrass serves as a primary producer in detrital based food webs and is directly fed upon by invertebrates, fish, and birds. It provides physical community structure and supports epiphytic plants and animals, which in turn are grazed upon by larval and juvenile fish, invertebrates, and birds. It is a nursery area for commercially and recreationally important finfish and shellfish species, including fishes restricted to bays and estuaries as well as oceanic species, which enter the coastal areas to breed or spawn.

In addition to the high intrinsic values of eelgrass as a habitat, it also provides significant value as a tool for examining long-term trends in water quality improvement or deterioration. It has ideal characteristics for use in monitoring system change. Eelgrass is found at the end of the watershed within coastal bays and estuaries and as such, monitoring the status of eelgrass resources helps to assess overall watershed management effectiveness. Eelgrass responds to persistent water quality stresses rather than short duration fluctuations. It is adapted to a wide range of tolerances and is capable of "averaging" exposure conditions including temperature, turbidity, seasonal light levels, sedimentation rates, etc., to result in either positive growth or a gradual decline in the resource. As a result, short-term variability such as can be seen with water quality testing is of relatively little consequence to eelgrass. A more biologically meaningful measure of long-term trends in ecosystem health can be seen in the response of eelgrass to chronic exposure to the ambient environment.

The eelgrass resources of San Diego Bay are significant not only on a local scale, but also regionally. San Diego Bay is the largest open water bay in southern California and one of only a handful of bays in California that supports sizeable eelgrass meadows. San Diego Bay ranks third behind Humboldt Bay and San Francisco Bay in total eelgrass habitat, supporting approximately 15 percent of all eelgrass habitat within the State of California. San Diego Bay supports approximately 50 percent of the total amount of eelgrass resources in southern California.

San Diego Bay

San Diego Bay is a 10,994-acre bay located between the City of San Diego to the north and east, the cities of National City, Chula Vista, and Imperial Beach to the east and south, and the City of Coronado to the south and west. The Bay represents the largest estuary in southern California. It is approximately 15.5 miles in length and contains 54 miles of shoreline. Portions of the Bay north of the Coronado Bay Bridge are narrow and deep, while most of the southern portions of the Bay are wide and shallow. Much of the northern and central Bay shoreline has been developed for commercial, industrial, and military uses.

Eelgrass is predominantly a subtidal resource and as a result it is difficult to monitor and track changes in its distribution. Moreover, comparisons between various eelgrass surveys are burdened by advancements in technology and orders of magnitude advancements in precision and accuracy of mapping capabilities. Prior to the 1990's, eelgrass surveys in San Diego Bay were performed by a variety of techniques including trawl and grab sampling, diver transects, and true color and infrared aerial imagery (Lockheed 1979a, Lockheed 1979b, SDUPD 1979, SDUPD 1990). Mapping was aided by estimation of locations based on various landmarks and, on rare occasion, some controlled survey points from which relative locations were visually approximated. Small-scale eelgrass mapping was conducted primarily through the use of grabs and divers, whereas the large-scale efforts tended to rely on aerial imagery. However, aerial imagery was not consistently capable of detecting eelgrass at depth. As a result, shallow eelgrass beds were generally well mapped, but deeper eelgrass beds were often under-reported or missed entirely.

In 1988, sidescan sonar was first used to map eelgrass within the 2000-acre Mission Bay. The boat trackline was plotted using microwave navigation and eelgrass density was determined from sonagraphic charts while diver transects were used to ground-truth the work effort (Merkel 1988). This approach was subsequently updated to make use of real-time differential GPS data to plot the centerline boat position as well as a CAD-based mapping effort (Merkel 1992). In 1993, the U.S. Navy applied this technology to San Diego Bay and provided the first comprehensive survey of eelgrass resources within the Bay (U.S. Navy 1994). The Navy and the San Diego Unified Port District followed this effort with another baywide survey in 1999 using single-beam sonar methods (U.S. Navy 2000). In 2004 and 2008, Merkel & Associates carried out both eelgrass surveys and bathymetric mapping updates that included the entire San Diego Bay (Merkel 2005, 2009). In 2011, advancements in mapping technology were made with the application of interferometric sidescan sonar to conduct the updated eelgrass mapping (Merkel 2011). The use of interferometric sidescan sonar technology substantially improved the spatial accuracy of acoustic backscatter mapping.

The present 2014 survey is a continuation of the prior eelgrass survey efforts and provides insight into long-term trends in eelgrass habitat and environmental change within the Bay. Eelgrass survey results are presented on a baywide-scale in separate maps. Depths are feet below mean lower low water (MLLW) as derived from composite bathymetric charts prepared as a product of 2008 surveys (Merkel & Associates 2009).

SURVEY AND ANALYSIS METHODS

Sonar Data

Survey equipment used for data collection included a digital interferometric sidescan sonar system with motion sensor integration and a dual antenna differential global positioning system (dGPS) was used for navigation. Data were collected over the course of 24 survey days by Merkel & Associates, Inc. to result in full baywide coverage. Within shallow environments, survey density was higher than was employed in more open deepwater environments where eelgrass would not be expected and existing high-resolution bathymetry existed. Surveys in these areas were performed as confirmatory assessments of existing data sets.

Sidescan Sonar

A hull mounted 468 kHz digital interferometric sidescan sonar system included SEA SWATHplus-H sonar, integrated with a Valeport miniSVP sound velocity sensor, and an SMC IMU-108 motion sensor to correct for speed of sound in water and roll, pitch, and heave of the survey vessel. The sidescan sonar data were collected with an across-track swath width of 31 m on both the port and starboard transducers. Tracklines were overlapped to provide for 100 percent seafloor coverage within the survey area. The difference in return time to different sensors allows for triangulation of the position of the acoustically reflective surface. The vertical and horizontal accuracy of the bathymetric data are a function of the accuracy of the vessel positioning and the accuracy of adjustments for velocity of sound and pulse angle (pitch, roll, and heave).

Navigation

The navigation system used during the surveys employed an on-board dual antenna dGPS using FM corrections provided by the U.S. Coast Guard beacon. The submeter accuracy horizontal positioning of the survey vessel was maintained with a Hemisphere VS111 providing positional accuracy within 60 centimeters, 95% of the time. The secondary antenna provided heading and yaw correction. During the survey the vessel was operated on parallel tracks with slightly overlapping sonagraphic records. The first trackline within each area was located 15 to 20 meters from the shoreline allowing full coverage of the Bay floor up to the middle intertidal zone or above. Once the initial trackline had been completed, the vessel moved offshore in approximately 25-meter increments and paralleled the primary trackline. Maintaining a line parallel to the primary trackline was accomplished by the use of a real-time position and digital trackline map. Once sufficient shoreline buffer had been developed, straight-line swaths were employed to minimize data loss occurring in turns. In high wave environments and areas with significant vessel traffic were surveyed at night to maximize the quality of acoustic record collected.

Eelgrass Mapping

Following the completion of the sonagraphic survey, the stored sidescan data were post-processed into a series of geo-rectified mosaic images covering all surveyed areas of San Diego Bay. The images were imported into geographic information systems (GIS) software to delineate eelgrass beds through on screen digitization of the acoustic signatures of eelgrass observed in the sonagraphic record.

Ground-Truthing

Diver and video spot checks, as well as low-tide surface inspections were used to ground-truth maps prepared using sonagraphic data. The distribution of ground-truthing sites was non-random and primarily focused on sites identified as having substantial discrepancies existing between the prior surveys and the present survey. Additionally, ground-truthing focused on southern portions of the Bay where warm water conditions favor the abundance of the subtropical upright bryozoan, *Zoobotryon verticillatum*. This large bryozoan returns a similar but substantially less acoustically reflective signal as eelgrass and thus sonagraphic interpretation was expected to be most questionable in these areas. The south bay region also supported limited occurrences of widgeon grass (*Ruppia maritima*), a short, densely growing, seagrass found in areas around the Chula Vista Wildlife Reserve which requires some initial signature verification based on the growth state of both eelgrass and widgeon grass at the time of mapping.

Other ground-truthing efforts were focused in areas of mixed rubble and soft bottom where *Sargassum muticum* can generate similar, but distinguishable acoustic signatures to those of eelgrass. Finally, ground-truthing efforts occurred around marinas, docks, and other areas where sonagraphic surveys were encumbered by limited open water access, and where eelgrass distribution patterns are complex and frequently sharply demarcated by density changes. Although ground-truthing efforts were focused in some regions of the Bay, all portions of the Bay were ground-truthed to the level of detail required to confirm the accuracy of the sonagraphic data analysis.

RESULTS

Information presented in this report has been prepared for use in digital format and large-scale presentation format for the Navy and Port District. Reduced versions of graphics are incorporated in this document for completeness of interpretation. Eelgrass distribution relative to bathymetry has been based on 2008 composite bathymetric charts based on a number of primary and secondary sources (Figure 1). This bathymetric chart utilizes both original data collection and composite data from other sources (Merkel & Associates 2009).

Eelgrass

The 2014 eelgrass distribution within San Diego Bay extended over a total bottom area of 1,955.7 acres (Figure 2). The distribution of eelgrass follows the general patterns of distribution noted in prior surveys. The greatest extent of eelgrass is found within the shallow southern ecoregion of the Bay with more extensive eelgrass also being found on the shallower fringes of the western Bay shorelines where more gradual soft shorelines are more prominent (Figure 1). Other smaller beds are scattered throughout the more developed regions of the Bay where shallows allow for adequate light levels to support eelgrass habitat. Fairly extensive eelgrass beds also exist at the mouth of San Diego Bay within the shallows outside of Ballast Point and along Zuniga Jetty on North Island.

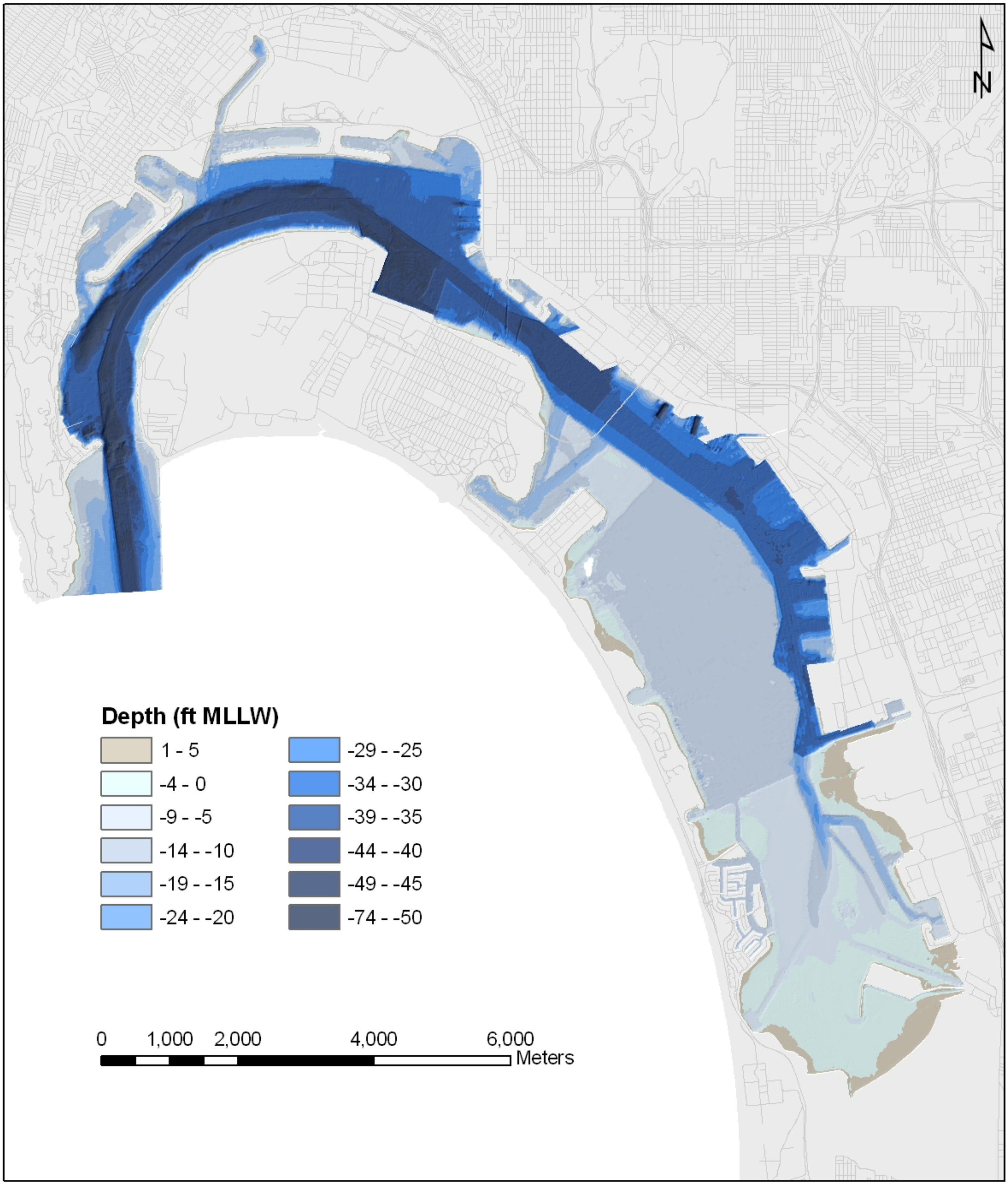

Figure 1. Composite 2008 bathymetry update of San Diego Bay

Figure 2. Eelgrass spatial distribution for San Diego Bay 2014 baywide survey

DISCUSSION

Eelgrass

San Diego Bay is a naturally shallow water embayment that has been dredged to a accommodate various navigational uses including both intermediate depth recreational boating as well as deep commercial and military harbor needs (Figure 1). The resulting bathymetric distribution within San Diego Bay exhibits a broad depth distribution curve, with natural bay depths occurring over much of the area less than –6 feet MLLW and deeper dredged harbor extending to much deeper depths (Figure 3). Eelgrass is most expansive within the southern portions of the Bay where extensive shallow flats are located. In the northern portions of the Bay, eelgrass tends to occur within fringing beds where the upper and lower limits of eelgrass growth occur close to the shoreline due to rapidly sloping bottom as developed shorelines give way to dredged/navigable waters. Notable exceptions to this trend are the eelgrass beds occurring in shallow waters north of the western terminus of the Coronado Bridge, adjacent to the Naval Amphibious Base, and on shoals near the mouth of the Bay.

Throughout the Bay, eelgrass was observed to be restricted to the shallower portions of the baywide depth range (Figure 3). Eelgrass grows most extensively in waters ranging from approximately +1 to -8 feet MLLW with the greatest percentage of available substrate being occupied between -2 and -4 feet MLLW (Figure 3). Some notable deviations from this typical range are seen in areas on higher mudflats and at the toe of riprap slopes, where wave scour, boat propeller scars, and activities of rays have creates small perched pools that can support eelgrass habitat above the +1 foot MLLW elevation that typically defines the upper elevation of eelgrass in San Diego Bay. In addition, deepwater eelgrass beds are found near the mouth of the Bay where clear water supports the broad-leaved Pacific eelgrass (*Zostera pacifica*) between Point Loma and Zuniga Jetty. At the mouth of San Diego Bay, these beds rarely extend to depths in excess of -21 feet MLLW but are common at depths in excess of -12 ft MLLW. A very small amount of eelgrass also occurs in deeper waters within the eastern portion of the central bay where clear water often occurs around the commercial piers that are exposed to flows from the deep navigation channel.

When comparing the eelgrass depth distribution observed in 2014 with that observed during the 2011 eelgrass survey, a notable increase in eelgrass can be seen to have occurred within the center of the eelgrass depth distribution range (Figure 4). The substantial loss of eelgrass between 2004 and 2008 appeared to be a biologically mediated decline given the pattern of loses occurring in expansive high-density beds rather than in isolated less dense beds and the pattern of subsequent recovery. Similar anomalous declines in the region's eelgrass beds were also observed in other systems such Mission Bay as well (Merkel & Associates 2008a). The 2011 regional survey suggested that prior declines observed in the 2008 survey were reversing with expansion of eelgrass being observed during the survey. The current 2014 survey provides evidence of continued recovery.

The current survey found 1,955.7 acres of eelgrass in the Bay. A comparison of eelgrass distribution patterns between the 1993, 1999, 2004, 2008, 2011, and the present 2014 surveys indicates an eelgrass expansion of 542 acres (50%) between 1993 and 1999, from 1,091.4 acres in 1993 to 1,633.7 acres in 1999. The expansion between 1999 and 2004 was 450.0 acres, a 27% expansion. From 2004 to 2008, eelgrass suffered a 37% decline losing 769 acres of eelgrass dropping from 2,083.7 acres to 1,315.1 acres. From 2008 to 2011, eelgrass experienced a 39% expansion from 1,315.1 acres to 1,830.4 acres. From 2011 to 2014, eelgrass experienced an expansion of almost 7% from 1,830.4 acres to 1,955.7 acres. The predominant changes in eelgrass coverage occurred within the southern ecoregion where eelgrass has expanded substantially from the prior survey periods. In all other regions of the Bay, eelgrass has shown declines from the prior 2011 extent (Figure 5). The dramatic change in eelgrass coverage observed in recent years is believed to be transitory in nature as areas that have exhibited significant die-off in the past couple of years are in a recovery phase. Over longer periods of repeated survey intervals, a more robust picture of the system norm will dilute the incidental variation between survey years. To begin to illuminate the normal patterns of eelgrass distribution within San Diego Bay, a frequency distribution map has been prepared to depict the eelgrass distribution within San Diego Bay (Figure 6). This map evaluates eelgrass persistence on a spatial scale as a frequency value derived by dividing the number of times eelgrass was present at a particular location by the total number of surveys

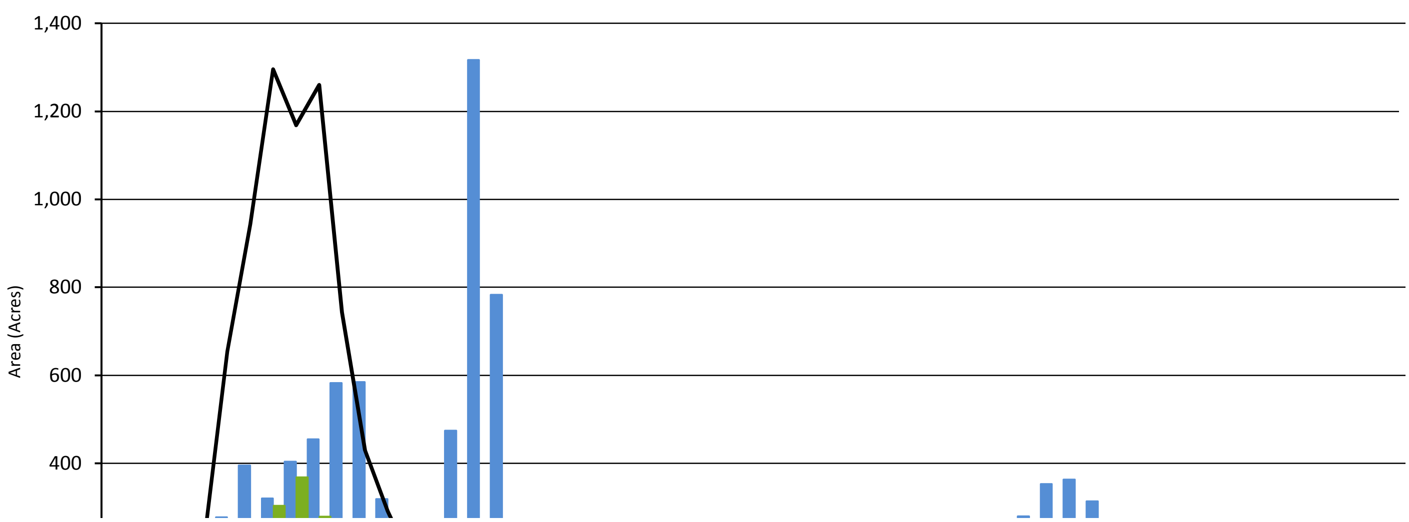

Figure 3. San Diego Bay depth distribution by percentage of total area.

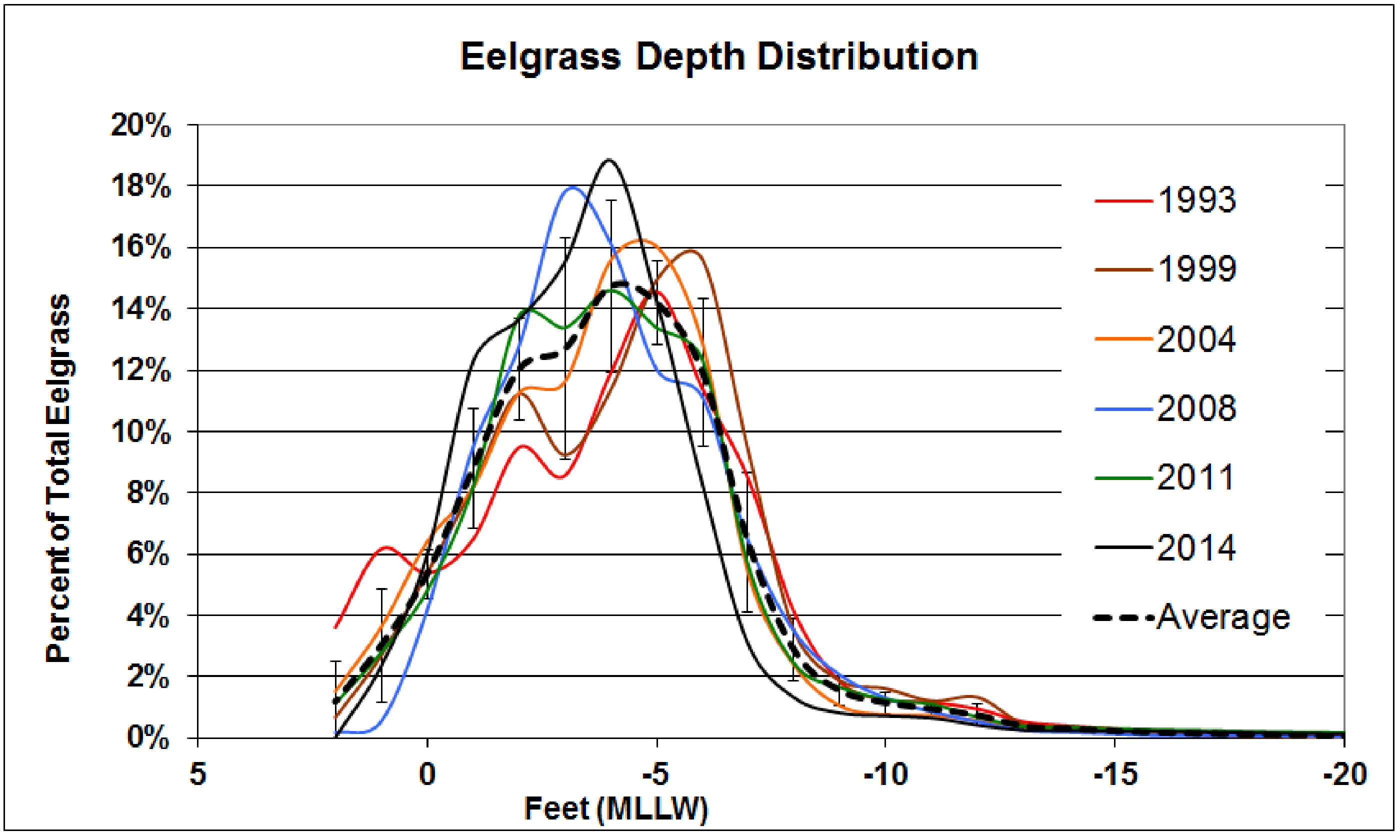

Figure 4. Eelgrass distribution by depth and year. Average ± 1 SD (1993, 1999, 2004, 2008, 2011, and 2014 survey years).

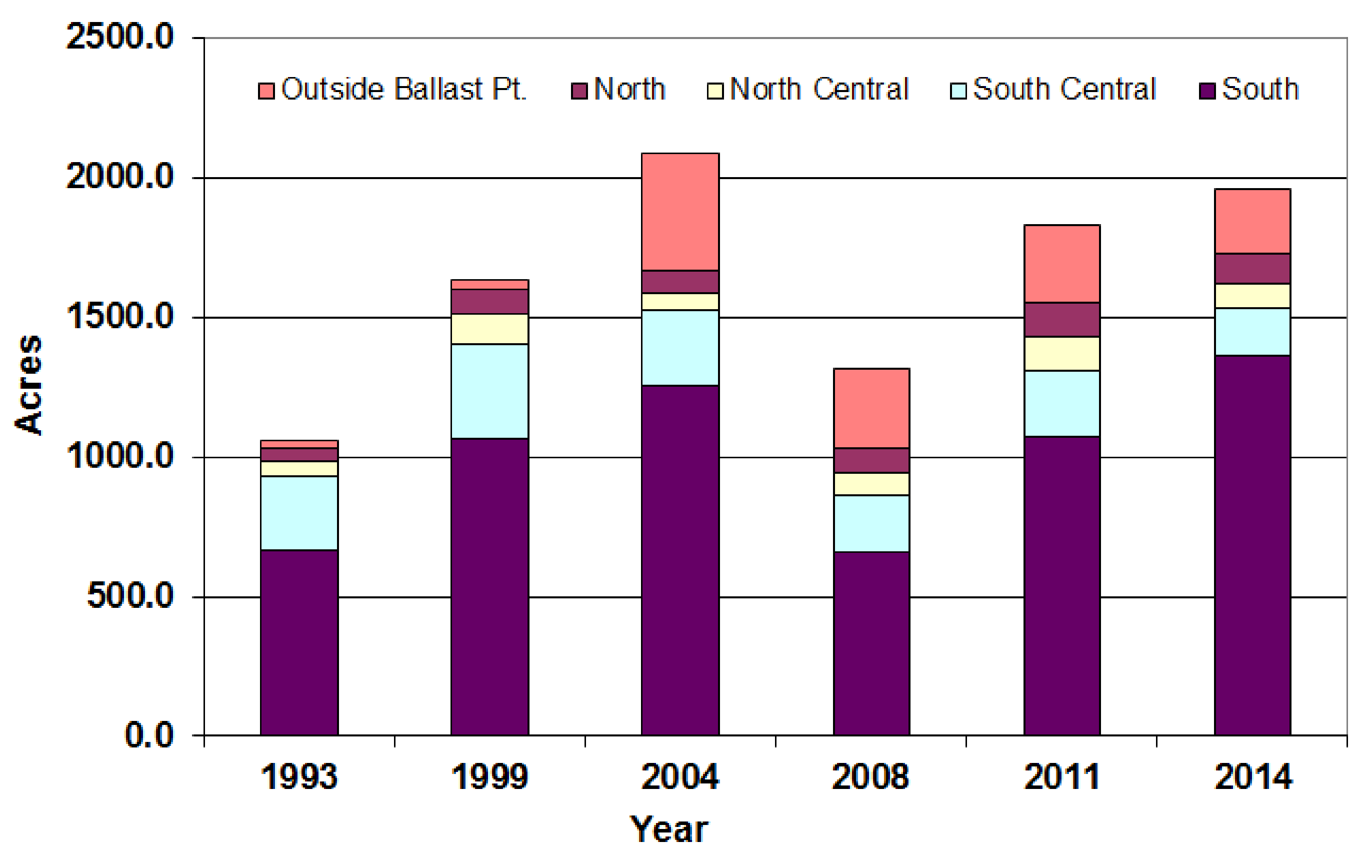

Figure 5. Eelgrass Distribution by ecoregion and year.

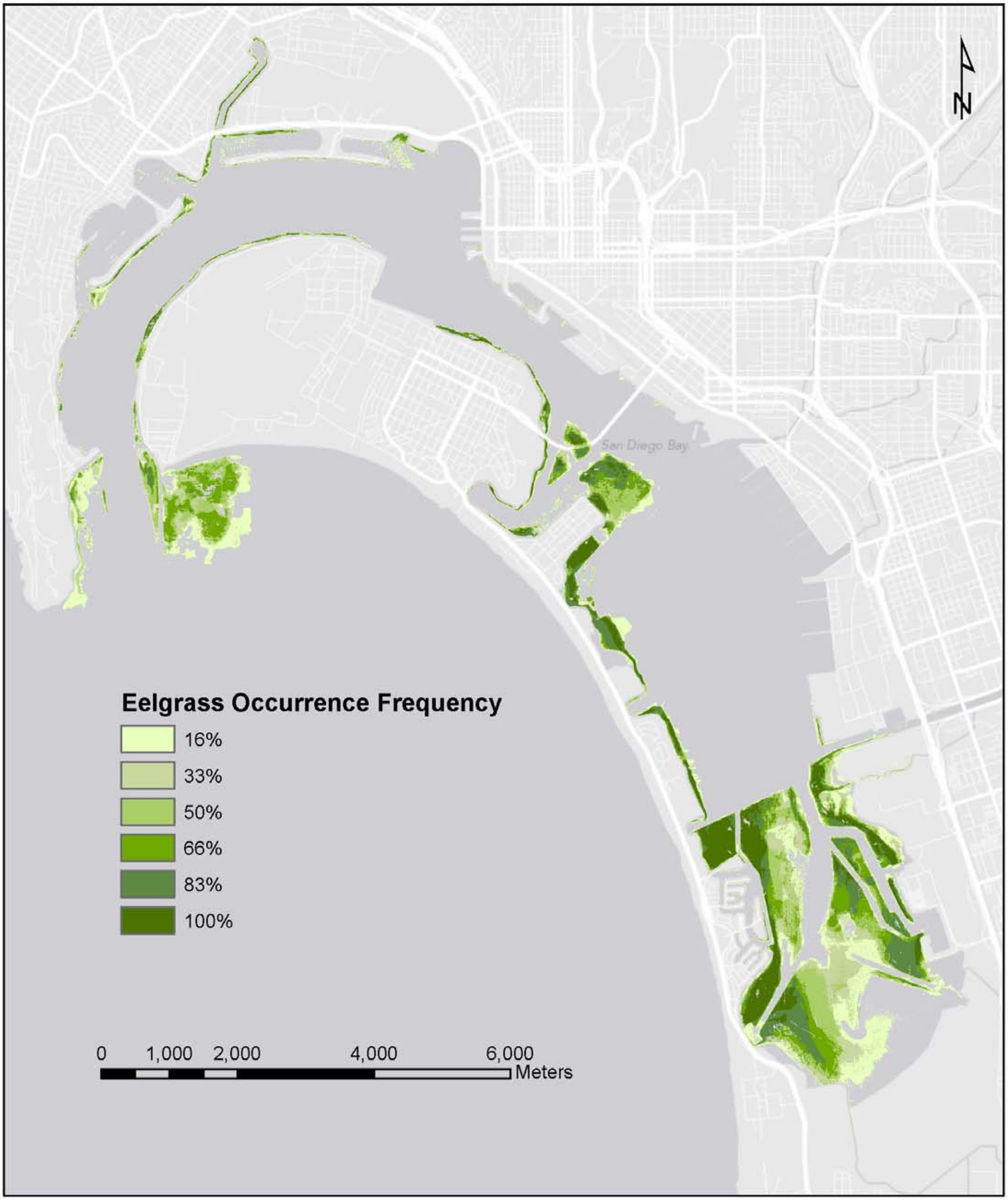

Figure 6. Eelgrass occurrence frequency for the baywide eelgrass survey years 1993, 1999, 2004, 2008, 2011, and 2014

conducted. As the number of surveys increases, the stability and variance in the map can be quantified on a per grid cell basis. In the future, it may be possible to use running averages of conditions over multiple years to truly distinguished trends within the environmental conditions from interannual variability.

Eelgrass is considered to be a habitat forming species that creates unique biological environments. As submerged aquatic beds, eelgrass is given special status under the Clean Water Act, 1972 (as amended), Section 404(b)(1), "Guidelines for Specification of Disposal Sites for Dredged or Fill Material," Subpart E, "Potential Impacts on Special Aquatic Sites." This special status has led to numerous mitigation efforts implemented under the Southern California Eelgrass Mitigation Policy (NMFS 1991). Many of these efforts have successfully established eelgrass beds within the Bay. Because of the environmental importance of eelgrass and its accompanying heightened regulatory protection status, it is important to develop a good understanding of the dynamics of eelgrass distribution on a temporal scale. While the recent baywide surveys would suggest steady and long-term gradual increasing trend in habitat area within San Diego Bay (Figure 5), this is not truly the case. A closer review reveals that increases in eelgrass are driven by the net of gains and losses within differing regions of the Bay. Eelgrass habitat is marked by seasonal and inter-annual variability such that on a fine scale, gains and losses of eelgrass habitat occur throughout the Bay and it is appropriate to consider the distribution of eelgrass in a more probabilistic sense (Merkel & Associates 2000). Thus, various portions of the Bay have a higher or lower probability of supporting eelgrass habitat at any given time. When evaluating the eelgrass frequency results (Figure 6), it is evident that some areas within the Bay had highly consistent presence of eelgrass, while other areas supported eelgrass during only one or two of the survey years.

From a resource management standpoint, it is appropriate to consider that areas that lack eelgrass during a particular survey period may support eelgrass at other times. Further, it is also reasonable to also acknowledge that not all eelgrass beds provide the same consistency in habitat values through time. As such, planning efforts should consider both spatial and temporal characteristics of the resource when evaluating benefits or detriments that may occur as a result of land-use and habitat management decisions. Substantially more complicated is the need to consider effects of actions taken away from eelgrass beds on parameters that influence eelgrass habitat development or sustainability. These may include alterations to circulation patterns, or nutrient and sediment loading of the Bay.

The ability of eelgrass to weather short-term stressful environmental conditions has been demonstrated on a number of occasions through natural and experimental restriction of resource availability. However, prolonged stresses such as consistent light limitation will result in a decline in eelgrass habitat. Within most sub-tropical and temperate environments, desiccation stresses limit the upper edge of eelgrass growth, and light requirements needed to balance respiration and fuel metabolism (photo-compensation depth) set the lower limits of eelgrass growth in soft-bottom bays. This trend holds true in San Diego Bay, and as a result a distinct topographic, but seasonably variable boundary typically defines the upper limit for eelgrass between 0.0 and +1.0 feet MLLW. A less distinct lower limit is defined by differences in depth and light penetration. The recent addition of potential biologically limiting factors on bed distributions creates a new complication to the standard model for eelgrass distribution patterns in San Diego Bay.

The differing survey methods used prior to 1993 prevent in-depth comparisons of longer-tern trends in San Diego Bay eelgrass abundance. However, on a decadal scale, eelgrass does appear to have historically expanded in its range in the Bay when compared to the best estimates that can be made from prior historic surveys and ancillary historic photographs and data. Eelgrass expansion within the Bay is likely the result of improved water quality and restoration efforts, which now account for over 57 acres of eelgrass within the Bay. Raw-sewage and industrial-waste discharges into the Bay have been significantly reduced since the 1970s (SDUPD 1990, USFWS 1998). The improved water quality has resulted in lower total particulate matter that would otherwise decrease light availability at the bottom. Additionally, stresses related to nutrient enrichment leading to plankton and macroalgal blooms have declined with reductions in waste discharges.

RECOMMENDATIONS

The long-term monitoring program for eelgrass in San Diego Bay has just begun to provide its most fruitful values in providing a view of eelgrass not as snapshots in time, but rather as a persistent, however, dynamic resource. To make full use of this monitoring program as a tool in assessing environmental trends, it is critical that it be continued into the future. It may also be highly beneficial to supplement the low-frequency full-bay surveys with a higher frequency annual or quarterly transect survey program that can be used to estimate eelgrass changes during intervening years.

Such a program may be modeled after a similar effort that has been developed and tested for two years in San Francisco Bay and which has now been applied for management purposes for the past several years (Merkel & Associates 2008b, 2011b, 2013). A similar regional monitoring developed for the Southern California Bight using the same methodology would provide an ideal structure for such a monitoring program (Bernstein et al 2011). In these programs, swath survey transects are distributed to provide a highly accurate estimate of baywide eelgrass changes using discrete repeated sampling of established transects. The results of the transect sampling are then scaled to benchmark years so that the discrete spatial distribution of eelgrass as well as the overall coverage may be analyzed through time. Given the knowledge of eelgrass distribution in San Diego Bay, implementation of such a monitoring program would be relatively straight forward and of high benefit in understanding interannual bed dynamics.

USE OF THESE EELGRASS MAPS

Because of the level of error inherent in regional mapping, these data should only be used as a general measure of the health of the system over time and as a planning tool. Eelgrass data reflect a particular period in time and are anticipated to be seasonally and stochastically dynamic. Information cannot be extrapolated for impact assessment purposes or site specific uses. While maps are generally accurate with respect to location of eelgrass, it is clear that eelgrass within San Diego Bay is dynamic. For this reason, it is essential that these maps not be over applied to situations for which they are not suited.

Eelgrass maps and bathymetric data are for planning and resource management purposes only and are not to be used for project specific analyses or navigation purposes. The authors make no representation regarding the accuracy of these maps for navigation applications.

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