Part Two

Benthic Habitat in Four Marine Reserve Locations Surrounding the Santa Barbara Basin

Benthic habitat maps have been created for four marine reserve locations surrounding the Santa Barbara Basin. A combination of: diver, ROV and submersible video transects, bathymetry data, sedimentary samples, and sonar mapping, have been combined to more fully describe the geological, biological, and oceanographic aspects of habitat. The two mainland locations, Vandenberg and Big Sycamore, are part of the Marine Ecological Reserves Research Program. The two island locations, San Miguel and Anacapa, are part of the Channel Islands National Marine Sanctuary. The USGS, in a cooperative project with Sea Grant-MERRP and investigators at NMFS, the CINMS, and NPS has collected sidescan sonar and video data for the purpose of mapping the geological component of benthic habitat. A GIS was developed that includes processed sidescan image themes, point themes for visual observations, bathymetry contours, coastlines, reserve boundaries, and a polygon theme for the benthic habitat interpretation Cochrane (in press). The habitat polygons have attributes for megahabitat, bottom induration, macrohabitat (where macrohabitat observations are available), polygon area, polygon perimeter, and water depth. The habitat GIS shows that rocky habitat suitable for rockfish (*Sebastes* sp.), abalone (*Haliotis* sp.), and other threatened benthic species is limited or lacking within the boundaries of the Vandenberg and Big Sycamore Reserves. South of San Miguel Island there is rocky habitat from shore out to the 100 m depth limit of the survey. North of Anacapa Island rocky habitat is abundant out to 80 m but is lacking in the deeper water out to 100 m.

Introduction

One of the long-term goals of establishing marine reserve networks is to provide sources of eggs and larvae that will “reseed” fished areas outside reserves. However, the effectiveness of such an approach is difficult to prove. The overall objective of this Sea Grant-MERRP study was to begin to develop methods of examining the degree to which the composition and abundances of eggs and larvae in the overlying water column reflect the benthic habitats and associated fish communities that are the presumed source of the eggs and larvae. To do this required two research efforts: 1) A detailed study of nearshore habitat and 2) A fine-scale ichthyoplankton study of the overlying waters. This report describes the physical and biological characteristics of habitat at the four study sites and the accompanying report (Watson et al. 2001) describes the ichthyoplankton portion of the study. The location of the study area was dictated by the establishment of marine ecological reserves at Vandenberg and Big Sycamore Canyon (Fig. 1). Since the types of habitat contained within these reserves and the condition of the fish communities were not fully known, two additional study sites were added. The rational was to include an island site that contained rocky habitat within the cold temperate Oregonian biogeographic province that could serve as a comparison to the Vandenberg site (San Miguel Island) and an island site that contained rocky habitat within the warm temperate San Diegan biogeographic province for comparison with the Big Sycamore site (Anacapa Island). This report presents the results of sidescan sonar mapping of the seafloor, and video and diver transect ground truthing, in the four study areas (Fig. 1).

The nearshore benthic habitat of the Santa Barbara coast and Channel Islands supports a diversity of marine life that are commercially, recreationally, and intrinsically valuable. Some of these species are threatened, endangered or locally depleted including a variety of rockfishes (*Sebastes* sp.) and the white abalone (*H. sorenseni*). State and national agencies have been mandated to preserve and enhance these resources and require detailed habitat characterization in order to do so. The data discussed in this paper was collected for use in characterizing and mapping the benthic habitat. We focus on the availability of rocky habitat in this study because it is the preferred habitat of most of the threatened species in the area.

Management strategies are being developed to protect marine resources in the Santa Barbara Channel Islands Region (Airame et al., in press). One approach under investigation is to implement no-take marine reserves (Agardy 1997, Bohnsack 1998, Roberts 1997). One small reserve presently exists north of Anacapa Island and there is a proposal now under consideration by the California Fish and Game Commission to add additional marine reserves to form a network (Calif. Dept. of Fish and Game Report 2001). Reserves may protect relatively pristine marine communities in a wild state for study and appreciation. In addition, reserves may buffer some species from over-fishing. A key feature of marine-reserve design is to protect a representation of the existing habitats in a region (Roberts 1997). Unfortunately, the distribution of habitats is not well known in this area since the underwater equivalent of soils and vegetation maps that are widely available for terrestrial systems do not yet exist. Managers need habitat maps to help determine the most appropriate boundaries for reserves in order to meet various criteria and goals (such as habitat representation, reserve size, habitat heterogeneity, reserve spacing, inclusion of sensitive habitats, etc.). Another use for habitat mapping is to better understand the distribution of those habitats that are particularly important to fished species or sensitive species. Geology along with depth, chemistry, and ocean circulation patterns, are the key elements that can be used to classify the habitat and associated biotic community occupying an area of seafloor (Greene et al. 1999).

Geologic Setting

The area of study is the Northern Channel Islands and adjacent areas of the California coast (Fig. 1). The Northern Channel Island chain runs from east to west, forming the southern margin of the Santa Barbara Channel and the southernmost range of the western Transverse Ranges. The regional structure of the Northern Channel Islands forms a broad anticlinorium, mapped eastward as a continuous structure at least 220 km long to the Santa Monica Mountains (Seeber and Sorlien 2000). Present-day folding and uplift of the Northern Channel Islands is thought to be a result of slip on the north-dipping Channel Islands Thrust, the regional thrust fault inferred to underlie the Northern Channel Islands (Shaw and Suppe 1994). The thrust faulting has uplifted and exposed volcanic and sedimentary rocks of Miocene age, and small local exposures of older rocks, on the islands and adjacent seafloor (Vedder et al. 1987). Sediment sampling studies (Scholl 1960, Reid et al. 2001), have shown that much of the nearshore seafloor around the Santa Barbara Basin is covered by sand; the seismic data collected for geologic mapping does not have sufficient resolution to show sand deposits that cover rocky habitat.

Visual Observations

Benthic habitat observations from 30 m and shallower were collected by scuba divers swimming along submerged transect lines. The transects were generally 400 m with the beginning, midpoint and ends marked by differential GPS readings. The transect lines were marked at 10 m intervals. Water depth, water temperature, bottom type, and biota were recorded on slates containing waterproof data forms. In the second year of the study digital video was also taken.

In deeper water, ROVs or submersibles were used to collect video imagery to ground truth the sidescan data. A DOE Phantom HD2+2 ROV was used in all four study areas to ground truth sidescan areas where interpretation was uncertain. The ROV was deployed with a tether attached to a dead-weighted cable deployed from the stern of the ship. The tether varied in length from 20 to 40 m. The ship could remain stationary over a site or steam ahead at slow speed, and the ship's position from GPS was used as ROV navigation. A Deepworker 2000 submersible was used in the north Anacapa MERRP area to obtain additional video. The Deepworker submersible was tracked using Trackpoint II transponders. The accuracy and precision of the submersible navigation is estimated to be 50 m.

Sonar Image Analysis

In this study we have used the Greene et al. (1999) habitat polygon classification method to classify the images. In this method the image is divided up into polygons with attributes for habitat. The first attribute is megahabitat; in this study the megahabitat is predominantly continental shelf (code symbol S). The shelf is defined as nearshore areas of low slope. In the study area, the slope becomes steeper at approximately 100 meters water depth and the megahabitat is then called canyon- or basin-flank (code symbol F). The second attribute is bottom induration, which separates the area into areas of soft, mixed, or hard bottom (code symbols s, m, and h respectively). In our study areas, soft bottom was primarily sand and muddy sand; mixed areas contained thin sand deposits and low-relief rocks; and hard bottom consisted of extensive low relief rock or higher relief rock exposures (Fig. 2).

The scuba observations and observations from video were combined in an Arc point coverage which could be viewed overlying the sonar images to aid in interpretation. The bottom observations were used to select areas of the image that were rocky for textural image analysis (discussed below). The observations were also used to identify macrohabitat, the third polygon habitat attribute. The macrohabitat classification could be improved significantly with additional diving. Macrohabitats shown in this report include rock rills (hr), rock pinnacles (hp), rock scarps (hs), rock with kelp (hk), mixed sand and rock areas with sandwaves (mw), and mixed areas forming a scarp (ms).

In sidescan sonar data, acoustic energy reflected back from the seafloor is divided into bins representing different beam angles, scaled to an 8-bit dynamic range, and displayed as a gray-scale image. In this study and many others, the use of gray level to assign a classification to a pixel has proven inadequate to classify natural images (Shokr 1991, Blondel 1996). The methods of computing gray level co-occurrence matrices, which address the average spatial relationships between pixels of a small region within the image (Haralick et al. 1973), have been used successfully for classification in various domains of remote sensing (Blondel 1996). The matrices are difficult to interpret themselves, instead they are reduced to a single statistical measure for each pixel, called a textural index (Haralick et al. 1973). In this study, we use two indices, entropy and homogeneity (as defined by Shokr 1991), which have been used successfully in several sidescan-sonar mapping studies (Blondel 1996). Entropy measures the roughness of acoustic texture, and homogeneity measures the degree of organization of the texture (Blondel and Murton 1997).

Homogeneities and entropies were computed for 10 x 10 pixel sized training regions for rocky areas identified with the visual observation point coverage (Cochrane and Lafferty, in press). These index values were then applied to the entire sidescan image to classify the pixels as either rock or not. The classified image was then converted to an Arc/Info grid and converted to an arc polygon coverage using Arc/Info. The polygon coverage was edited to remove areas where noise or other sonar data degradation produced erroneous classification Polygons were added for areas of mixed soft and hard bottom, and the remaining areas were classified as soft bottom (sand and muddy sand).

Habitat in the MERRP Study Areas

Habitat in the North Anacapa study area can be summarized as rocky from shore to approximately 80 m water depth and sandy from 80 to 100 m water depths (Fig. 3). Table 1 gives the total areas of each bottom type and areas subdivided by macrohabitat.

Habitat in the South San Miguel study area is also rocky (Fig. 4). Sidescan imaging was impeded in water depths less than 20 m by extensive kelp growth indicating large areas of rock in those water depths. Rocky area persisted out to the shelf break south of San Miguel. Extensive sand wave areas suggest strong bottom currents are common in this area. Table 2 gives the total areas of each bottom type and areas subdivided by macrohabitat.

Habitat in the Vandenberg reserve was not fully mapped with sidescan data (Fig. 5). Combining the sidescan coverage with information from diver observations suggests that the habitat within the reserve is predominantly sandy, with rock areas restricted to extensions of onshore rock into the subtidal water. Outside the reserve habitat there are some areas of rock in subtidal waters. We also observed petroleum seep related carbonate mounds (code Shm). Table 3 gives the total areas of each bottom type and areas subdivided by macrohabitat.

The Big Sycamore reserve is completely composed of sandy habitat. Expansion of the reserve seaward will not protect any rocky habitat, but expansion to the southeast a few km would. Bottom induration and macrohabitats in the area surrounding the Big Sycamore reserve have been mapped (Fig. 6).

Table 4 gives the total areas of each bottom type and areas subdivided by macrohabitat.

Figures

Figure 1. Map showing locations of the four MERRP study areas surrounding the Santa Barbara Channel; Vandenberg reserve (VA), Big Sycamore State reserve (BS), North Anacapa (NA), and South San Miguel (SM).

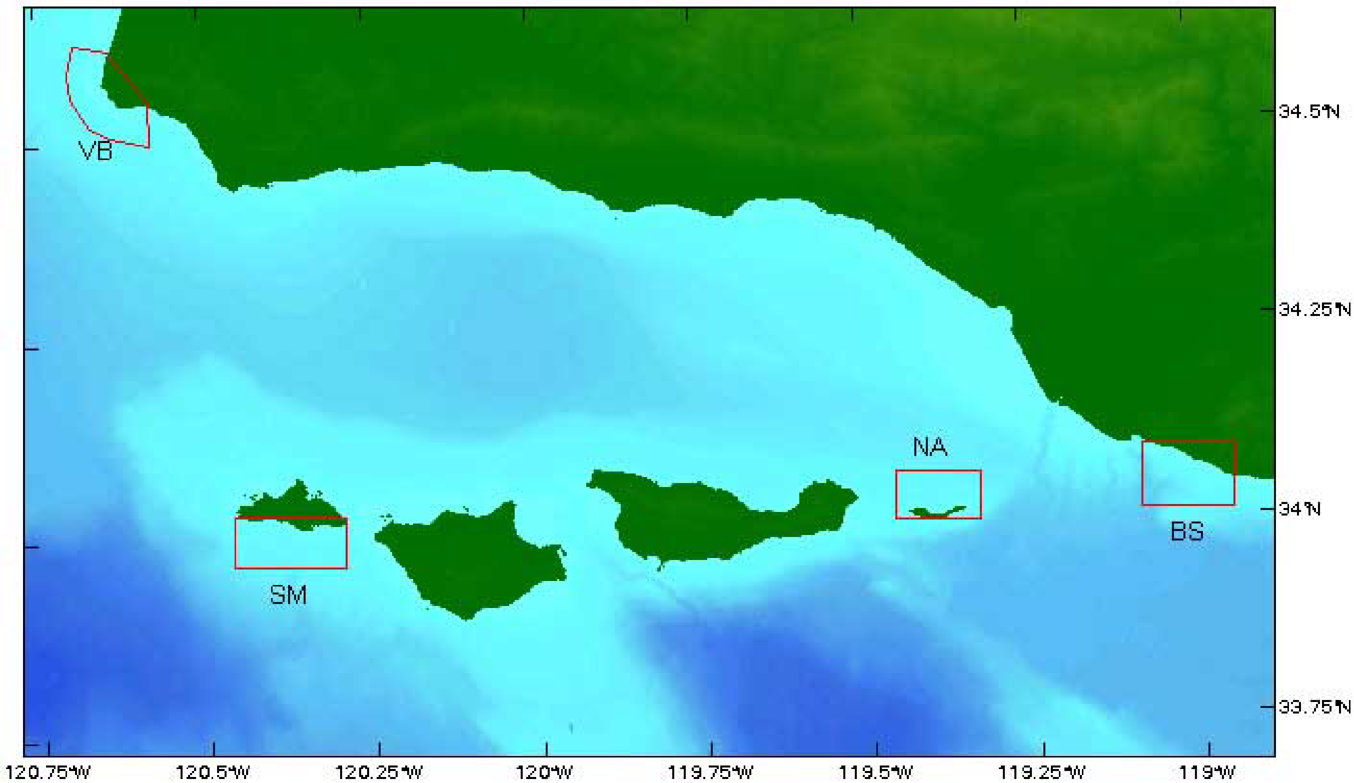


Figure 2. Submersile photos of examples of bottom type classified as soft (bottom_id = s), mixed (bottom_id = m), and hard (bottom_id = h).

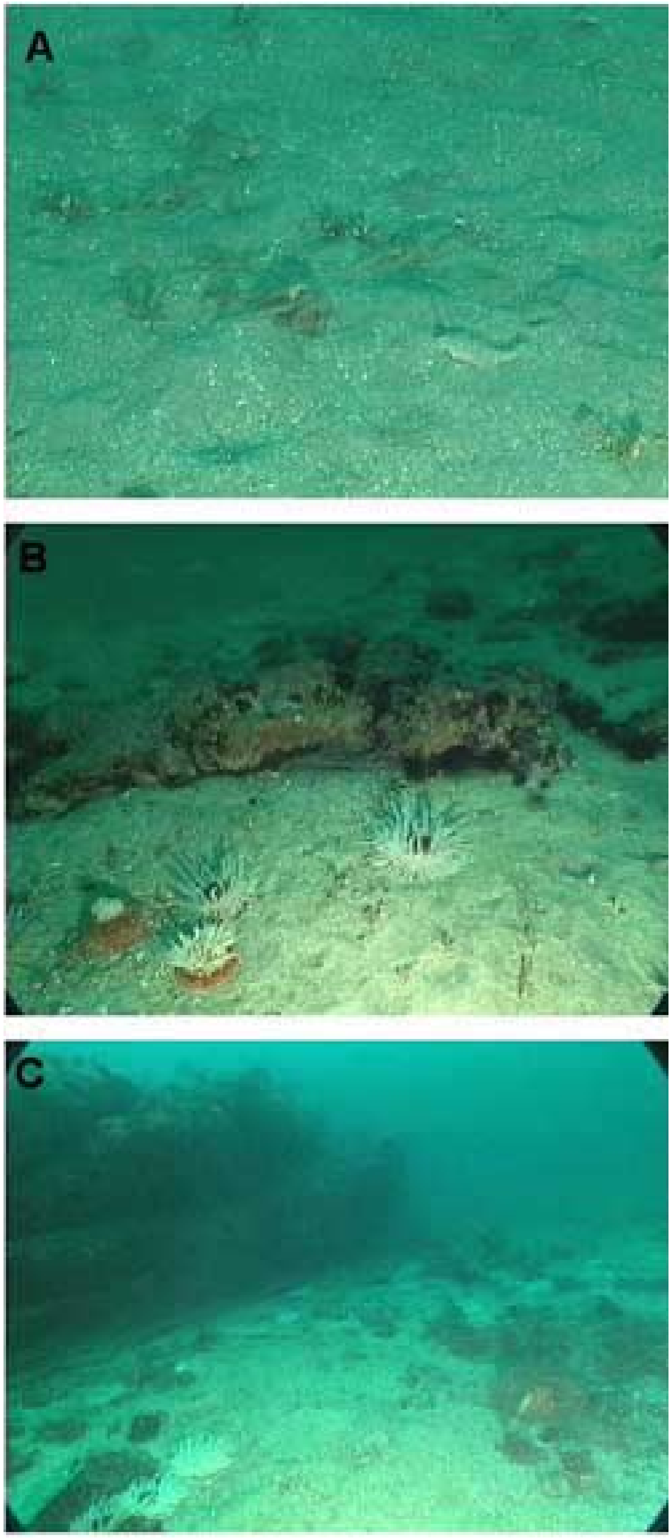


Figure 3. Map showing bottom induration and macrohabitats in the area north of Anacapa Island

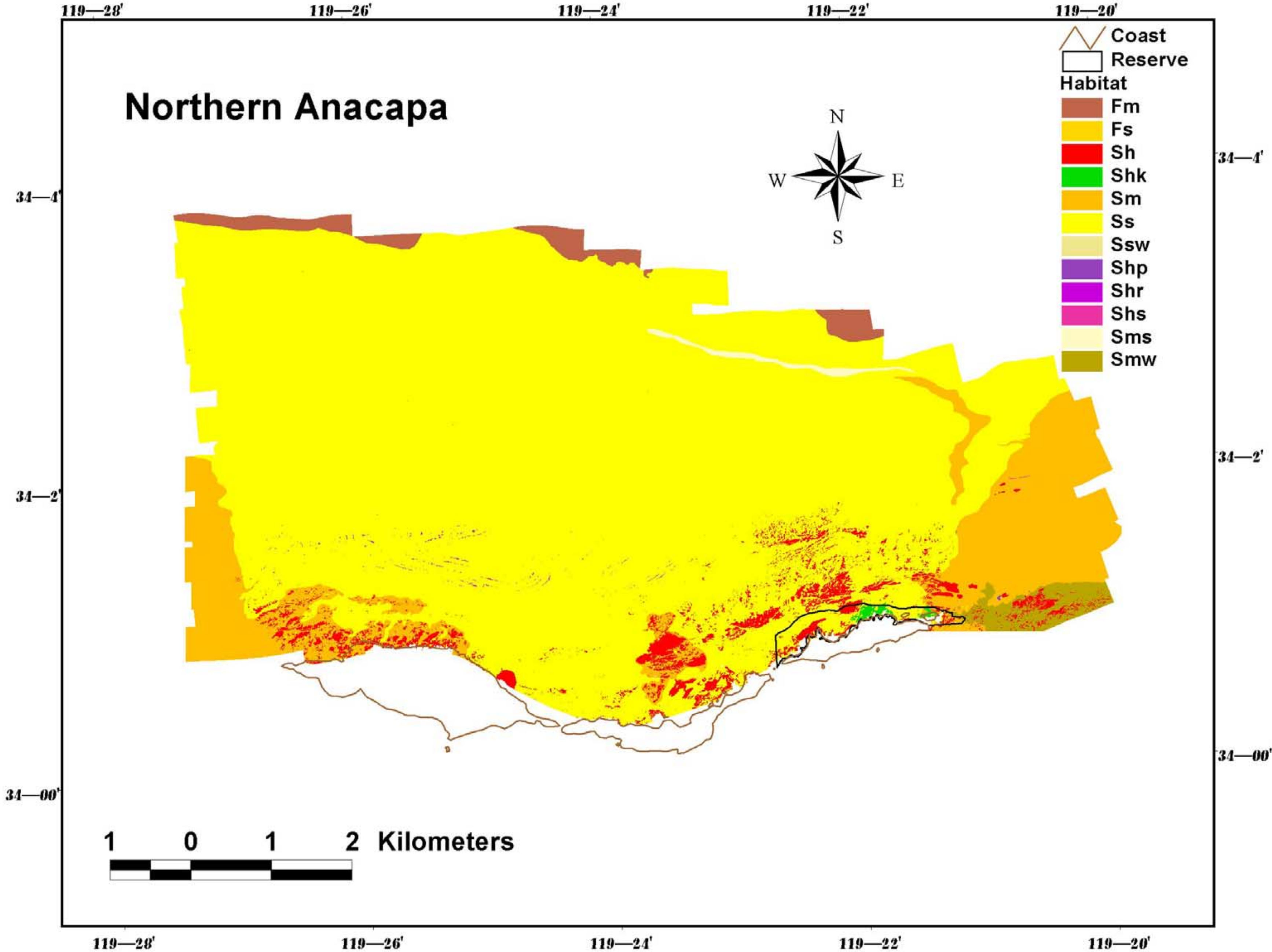


Figure 4. Map showing bottom induration and macrohabitats in the area south of Anacapa Island

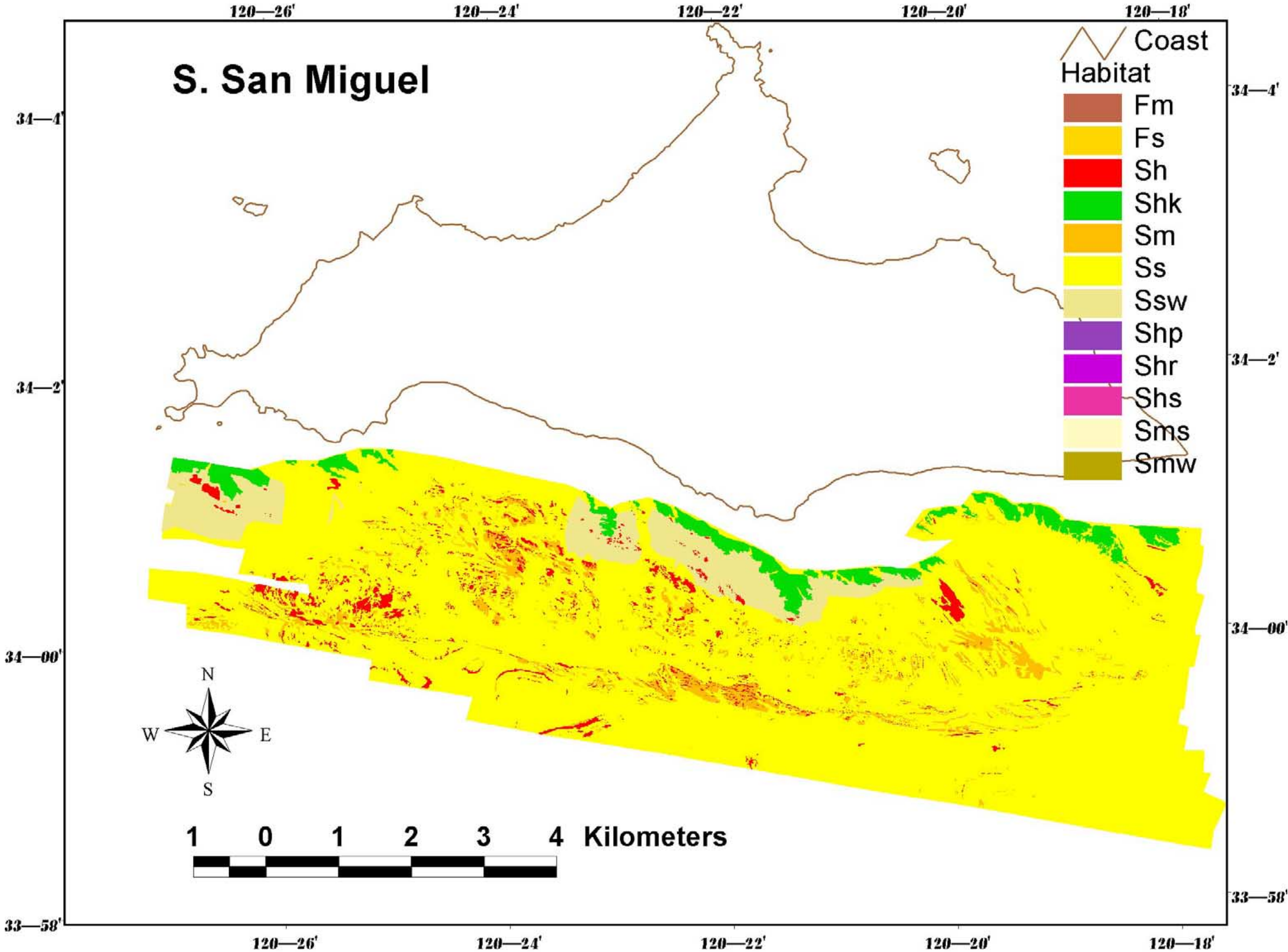


Figure 5. Map showing bottom induration and macrohabitats in the area north of the Vandenberg reserve.

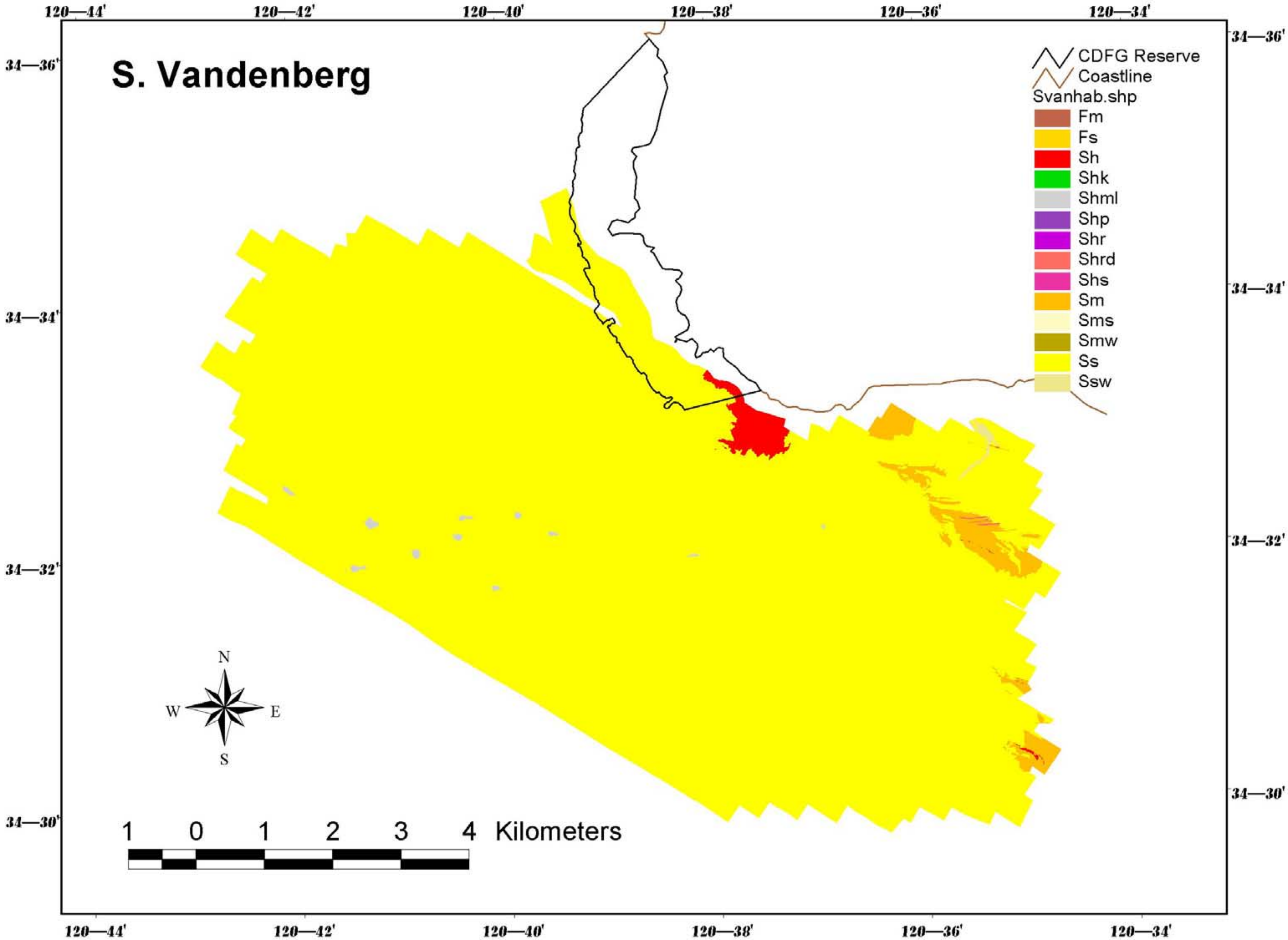
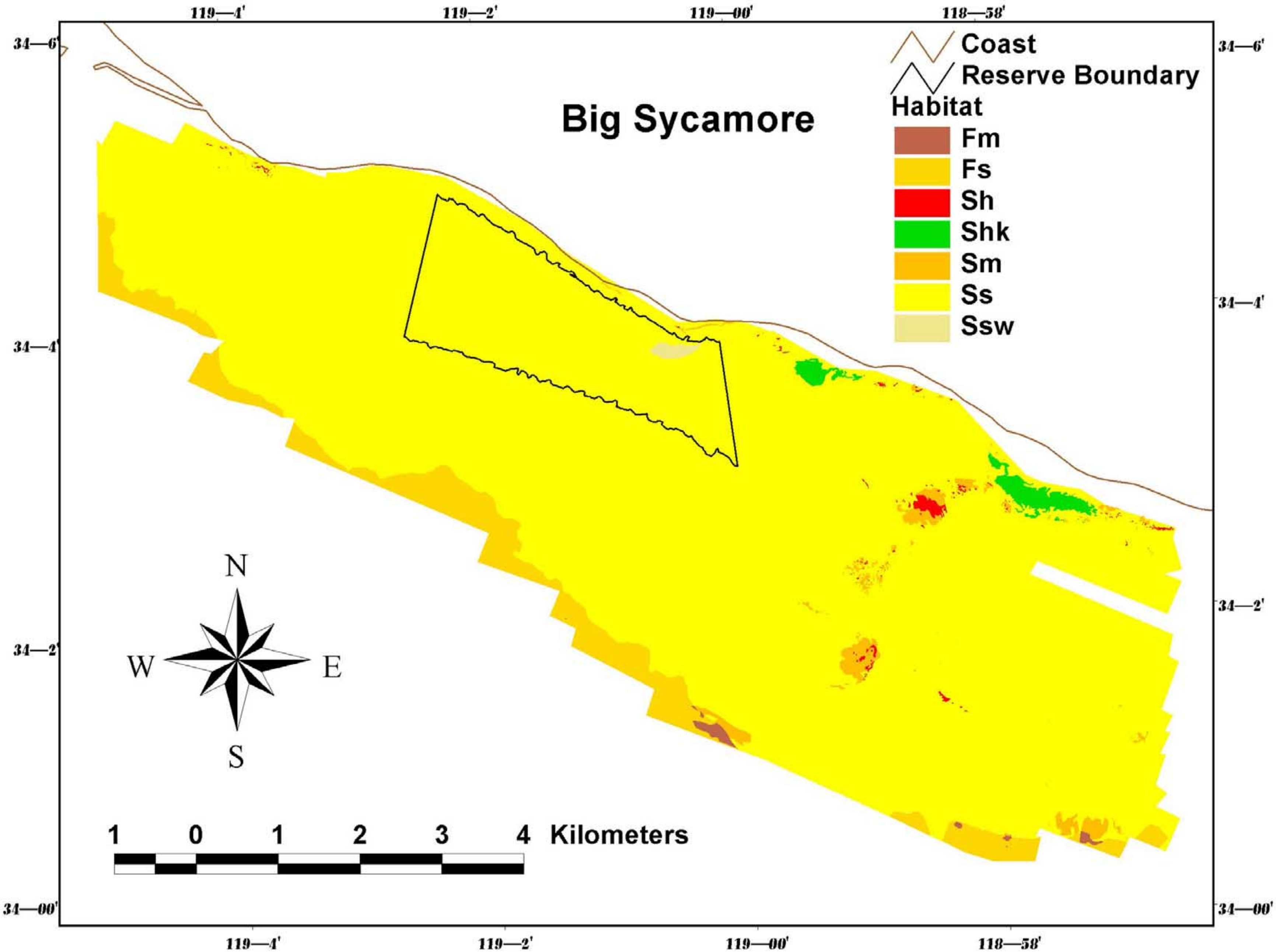


Figure 6. Map showing bottom induration and macrohabitats in the area surrounding the Big Sycamore reserve.



Tables

Table 1.	North Anacapa Habitat		
Code	m^2	km^2	%
Sh	1679169	1.679	3.131
Shr	32907	0.033	0.061
Shp	1903	0.002	0.004
Shs	1767	0.002	0.003
Shk	59167	0.059	0.110
Sm	8514794	8.515	15.878
Smw	626529	0.627	1.168
Sms	187434	0.187	0.350
Ss	43433732	43.434	80.991
Fm	991029	0.991	1.848
Total	53627699	53.628	

Table 2.	South San Miguel Habitat		
Code	m^2	km^2	%
Sh	3251039	3.251	6.843
Shk	1680022	1.680	3.536
Sm	2114957	2.115	4.452
Ss	42144196	42.144	88.706
Ssw	3259749	3.260	6.861
Total	47510192	47.510	

Table 3.	South Vandenberg Habitat		
Code	m^2	km^2	%
Sh	750748	0.751	1.079
Shm	110444	0.110	0.159
Shr	19857	0.020	0.029
Sm	1349267	1.349	1.939
Ss	67482705	67.483	96.982
Ssw	77523	0.078	0.111
Total	69582720	69.583	

Table 4. Big Sycamore Habitat

Code	m^2	km^2	%
Sh	540558	0.541	0.973
Shk	409856	0.410	0.738
Sm	635875	0.636	1.145
Ss	51042692	51.043	91.876
Ssw	80431	0.080	0.145
Fm	99546	0.100	0.179
Fs	3237359	3.237	5.827
total	55556030	55.556	

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