UNIVERSITY OF CALIFORNIA

SANTA CRUZ

GRAIN SIZE DISTRIBUTION OF BEACH AND NEARSHORE SEDIMENTS OF THE SANTA BARBARA LITTORAL CELL: IMPLICATIONS FOR BEACH NOURISHMENT

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ABSTRACT

Nourishment may be an option to widen narrow beaches of the Santa Barbara Littoral Cell if large deposits of suitable sediment can be found offshore. To determine if suitable sediment exists a digital bed sediment Eyeball© camera and spatial autocorrelation algorithms were used to rapidly collect and determine beach and nearshore sediment grain sizes from Point Conception to Point Mugu. Samples were collected approximately every kilometer alongshore across shore-normal transects.

The Beachball© camera was used to collect samples from the beach. Summer mean grain size of beach face samples ranged from 0.15 mm to 0.58 mm and averaged 0.26 mm. Seasonal samples from Goleta/Isla Vista, Carpinteria, and Ventura show that summer grain sizes are finer-grained than winter grain sizes. Summer beach grain size distributions from throughout the cell were used to determine the smallest grain size that is naturally stable on the beach. Very fine-grained sand did not remain in any significant amount anywhere throughout the cell, so the littoral cutoff diameter (the division between stable and unstable sediment) was found to be 0.125 mm. As a result, beaches should not be nourished with very fine sands; instead they should be nourished with medium or fine-grained sands depending on the specific beach.

In the offshore, ~300 samples were taken from throughout the study area at 5, 10, and 20 m water depth with the Flying Eyeball©. Mean grain size was medium or fine-grained sand for 30% of all samples. However, of these coarser samples, 78%

were located in shallow depths (at 5 m water depth), likely within the zone of active littoral transport. Of the remaining coarser sediments (which were primarily fine-grained sands), those found in deeper water were located near major headlands, such as Point Conception, near exposed bedrock, such as west of Coal Oil Point in Isla Vista and Sand Point in Carpinteria, or offshore rivers and streams, such as Gaviota Creek and Rincon Creek/Mussel Shoals. Only samples off of Gaviota and Rincon/Mussel Shoals warrant further study.

Sediments of previously identified borrow areas were also examined. This study agrees with previous findings that surface sediments offshore Goleta, Santa Barbara, Carpinteria, and Ventura/Oxnard are primarily fine to very fine-grained sands. Only a single site offshore Santa Barbara indicates possible beach compatible sediment at depth. Finally, the fact that most of surficial sediments examined are finer-grained than beach sediments, indicates that very little of the offshore sediments are suitable for beach nourishment.

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I. INTRODUCTION

In California, beaches are extremely important: they provide a large recreational area for an ever increasing tourist and coastal population. They provide protection to bluffs, cliffs and back beach development from direct wave attack, and they provide unique habitats supporting many diverse species. In addition, the beaches of California benefit not only the economy of local communities and the state, but also the entire United States (King 2002; King and Symes 2003).

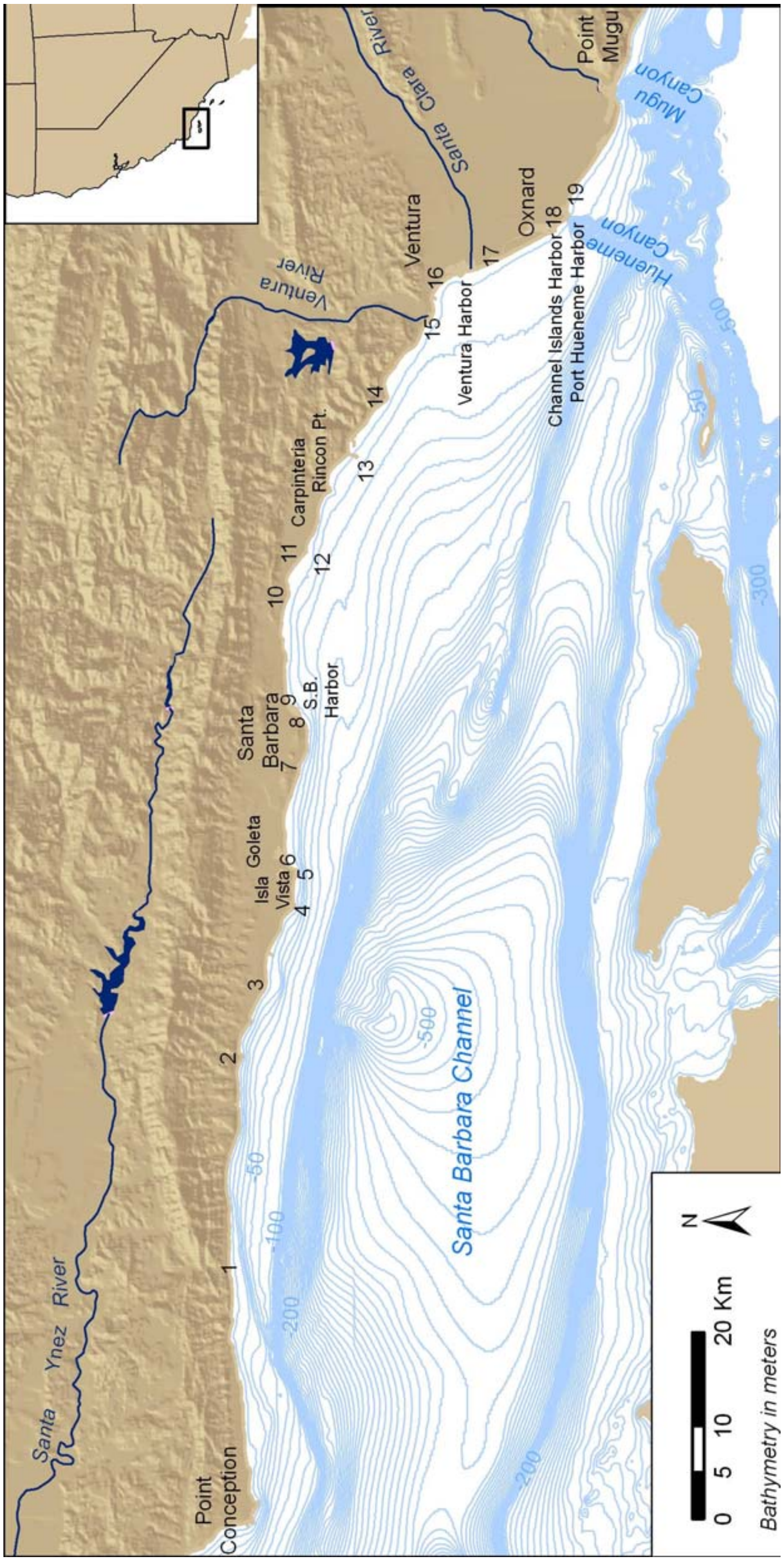
Most of the beaches of the Santa Barbara Littoral Cell (SBLC), from Point Conception to Point Mugu, are naturally narrow (Flick 1993; Wiegel 1994). In addition, studies suggest that the beaches of this cell may also be narrowing in response to human activities (Runyan and Griggs 2003; Willis and Griggs 2003; Revell and Griggs 2006). Because the beaches of California are a valuable natural resource, it is important for coastal managers to consider approaches to restore or expand existing beaches.

One possible way to restore and widen a beach is through nourishment, or adding sand to the beach. For a nourishment project to be successful, however, suitable sediment-sand with a grain size equivalent to or slightly coarser than sand found naturally on the beach-must be used (National Research Council 1995; Dean 2002; U.S. Army Corps of Engineers 2002). In this study, beaches throughout the SBLC were examined to determine both natural grain size distributions and the sediment size that is stable under natural conditions. Sediments throughout the nearshore inner shelf (i.e. out to 20 m water depth) were sampled to determine their natural grain size distributions. Finally by comparing and analyzing the two datasets it was possible to determine whether any deposits of material suitable for nourishment exist offshore.

Traditional methods of grain size analysis, including sieving or settling, require considerable time to process samples. As an alternative, a relatively new method was employed in this study, the USGS-developed digital bed sediment Eyeball© camera and autocorrelation algorithms (Rubin 2004; Rubin 2006; Barnard et al. in press). The speed and efficiency of both the collection process and the grain size determination technique has allowed for an unprecedented amount of data, almost 800 sediment samples, to be gathered quickly from the study area, thus allowing for a rapid assessment of the broad compatibility of nearshore inner shelf and onshore sediments throughout a very large area-about 149 km (~93 miles) of coastline.

Figure 1. The study area: Santa Barbara Littoral Cell beaches and nearshore inner shelf from Pt. Conception to the Mugu and Hueneme Submarine Canyons.

Location	Map No.
Carpinteria Salt Marsh	11
Coal Oil Point	4
East Beach, Santa Barbara	9
El Capitan State Beach	2
Emma Wood State Beach	15
Faria Point	14
Gaviota State Beach	1
Goleta Beach	6
Huemene Beach, Port Hueneme	19
Ledbetter Beach, Santa Barbara	8
Loon Point	10
McGrath State Beach	17
Mussel Shoals	13
Naples	3
Pierpont groin field, Ventura	16
Sand Point, Carpinteria	12
Santa Barbara Mesa	7
Silver Strand Beach, Oxnard	18
UCSB	5


Point Conception
Santa Ynez River
1
2
3
Isla Vista
4
5
6
Goleta
Santa Barbara
7
8
9
S.B. Harbor
10
11
12
Carpinteria
Rincon Pt.
13
14
15
Ventura River
Ventura Harbor
16
Ventura
17
Oxnard
18
Channel Islands Harbor
Port Hueneme Harbor
19
Santa Clara River
Point Mugu
Mugu Canyon
Hueneme Canyon
Santa Barbara Channel
-50
-100
-200
-500
-50
-500
-300
-200
0 5 10 20 Km
N
Bathymetry in meters

II. BACKGROUND

II A. Physical Setting of Study Area

The study area extends 149 km alongshore from Pt. Conception southeast to Pt. Mugu (Figure 1). In a cross-shore direction the area encompasses the subaerial (beach) and submarine portions of the SBLC and also extends outside the zone of active longshore transport onto the shallow inner shelf. The sediments composing the littoral cell and adjacent offshore depositional environment are a product of the Santa Barbara Sandshed (SBS; Figure 2). The SBS is the entire area of land that naturally produces and delivers sediment into the littoral cell, and extends from the coast inland to the headwaters of SBLC coastal watersheds (Revell et al. 2007).

The SBS exists within the Transverse Range province of Southern California and is bordered by the Santa Ynez and Topatopa Mountains to the north, the Santa Monica and Santa Susana Mountains to the south, and the San Gabriel Mountains to the east. Unlike the rest of California, where major physiographic features trend north-south, the Transverse Range province is characterized by east-west trending mountain belts, elongated basins, and other east-west structural features. Uplift and deformation within the ranges is a product of the regional transform-margin tectonic regime and associated north-south crustal shortening resulting from a restraining bend of the San Andreas Fault (Harden 2004). The SBS is composed primarily of Cenozoic sedimentary rocks except for the very eastern portions of the sandshed (i.e. the San Gabriel Mountains) where Mesozoic igneous rocks dominate the terrain (Figure 2; U.S. Geologic Survey 1966).

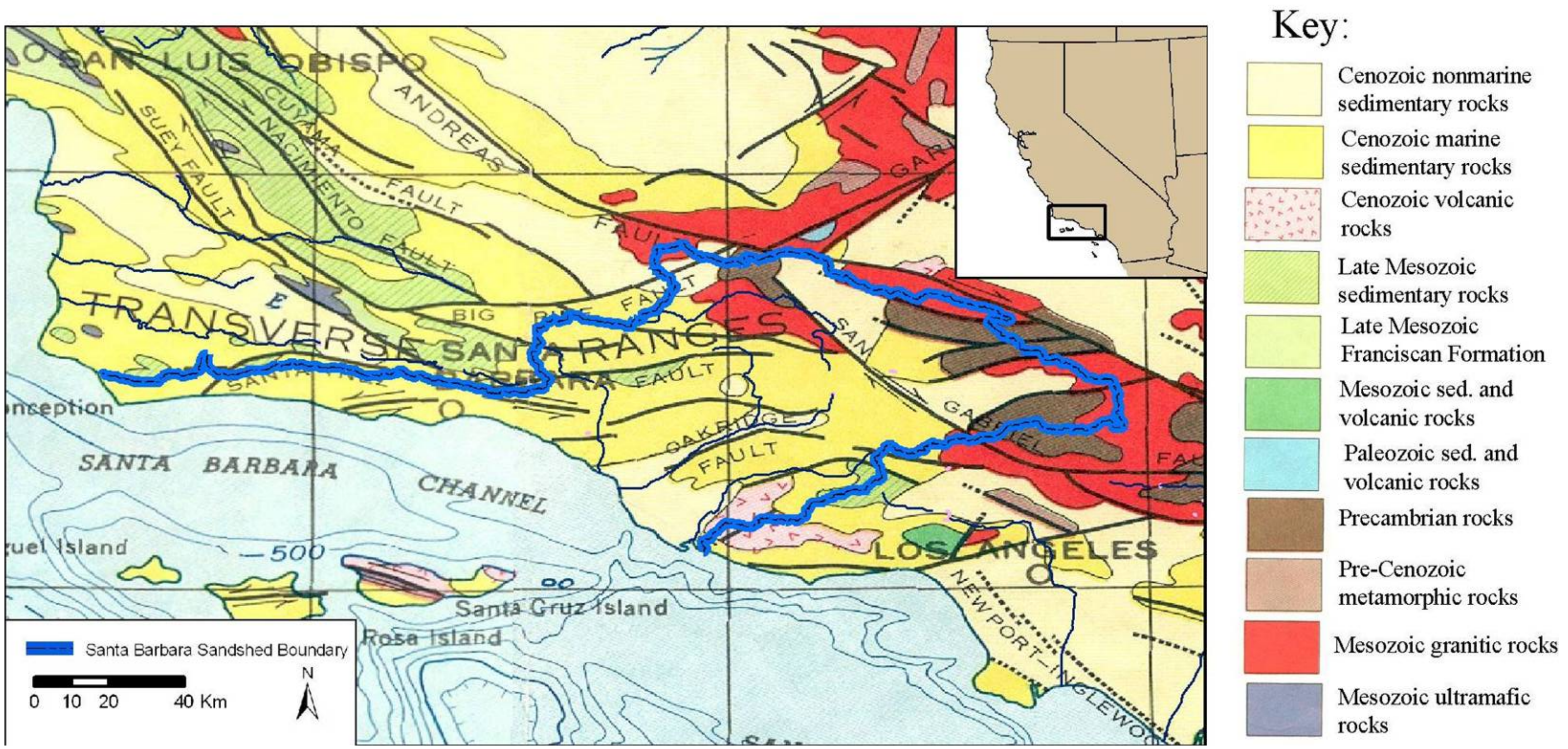


Figure 2. Geology of the Santa Barbara Sandshed (modified from U.S. Geologic Survey 1966).

In the western portion of the study area, the majority of the south-facing coastline consists of narrow, sandy beaches (~15 m wide) backed by vertical cliffs (~15+ m high), capped by sandy terrace deposits (~3 m thick; Figure 3; Norris 1968; Runyan and Griggs 2003; Norris and Patsch 2005). The cliffs, which have been cut into uplifted marine terraces by wave action and rising sea level, expose underlying terrace bedrock, most commonly shale of either the Monterey or Sisquoc Formation. Beneath the thin veneer of sandy beach, a cobble base and wave-cut platform of sedimentary bedrock extends offshore (Norris 1968; Wiegel 1994). Sediments of varying thickness cover the bedrock, but where the bedrock is exposed, a diverse habitat exists within the rocky reef (Figure 4).

Throughout the south-facing coast, the otherwise continuous cliff backed shoreline is sometimes broken by streams that drain the coastal mountains and terraces. Occasionally, these streams traverse wider, low lying coastal plains and empty into lagoons or salt marshes before reaching the ocean (e.g. the Goleta Slough and the Carpinteria Salt Marsh; Figure 5; Norris and Patsch 2005). Elsewhere throughout the cell, cobble beaches may form at the mouths of coastal streams and rivers (e.g. Naples, Rincon Point and Emma Wood Beach at Ventura Point).

South of Carpinteria, from Rincon Point to the Ventura River, mountains front the coast leaving only a very narrow strip between the mountains and ocean (Figure 6). South of the Ventura River the coast opens up into a large, alluvial plain. Relatively wide beaches front the coast here and are backed by dune fields, lagoons,

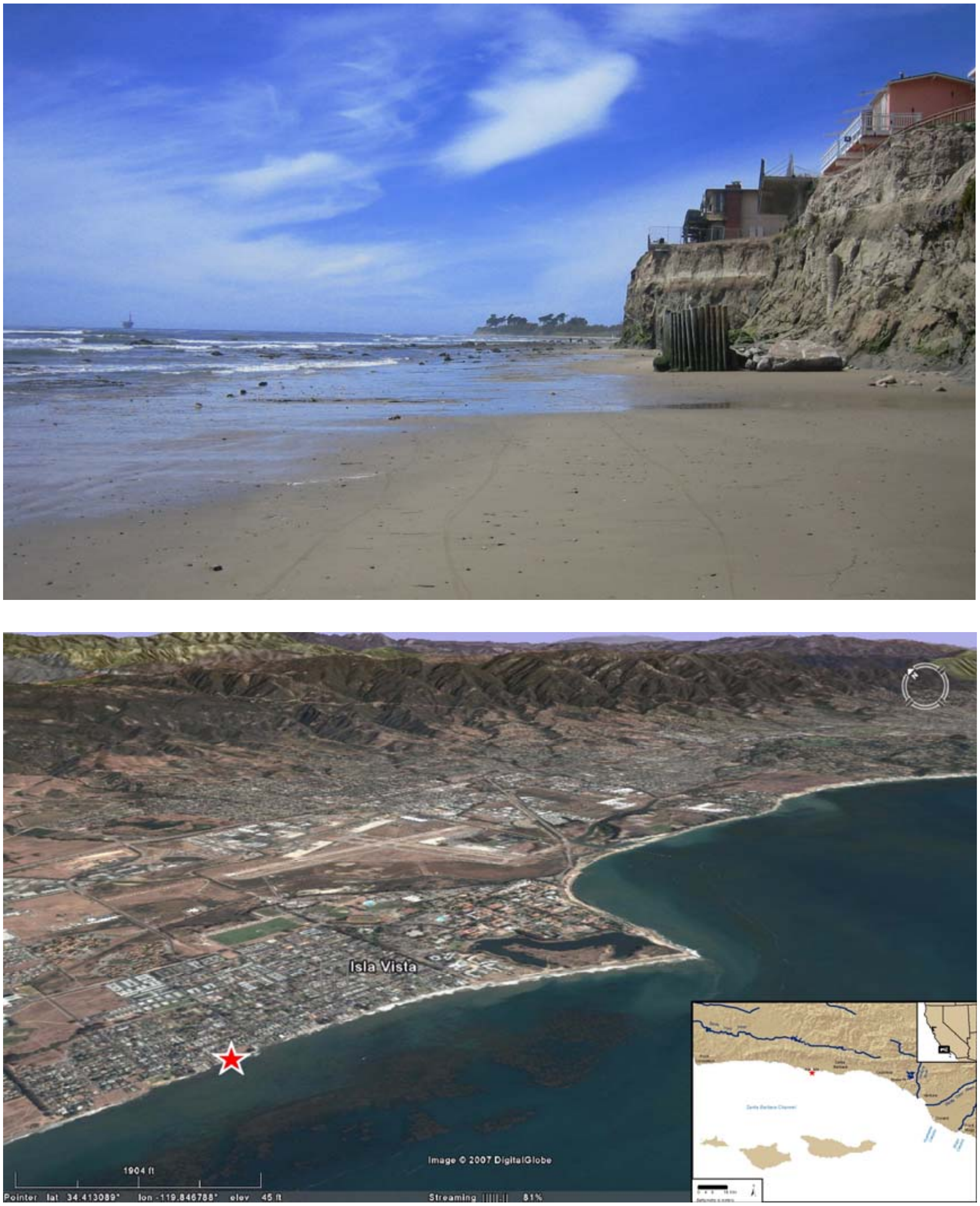


Figure 3. Top: Looking west at low tide beach and endangered cliff top development at Isla Vista. Notice wet sand to edge of cliff. Bottom: Oblique view of Isla Vista looking northeast. Star is location of where top image was taken. (Google 2007).

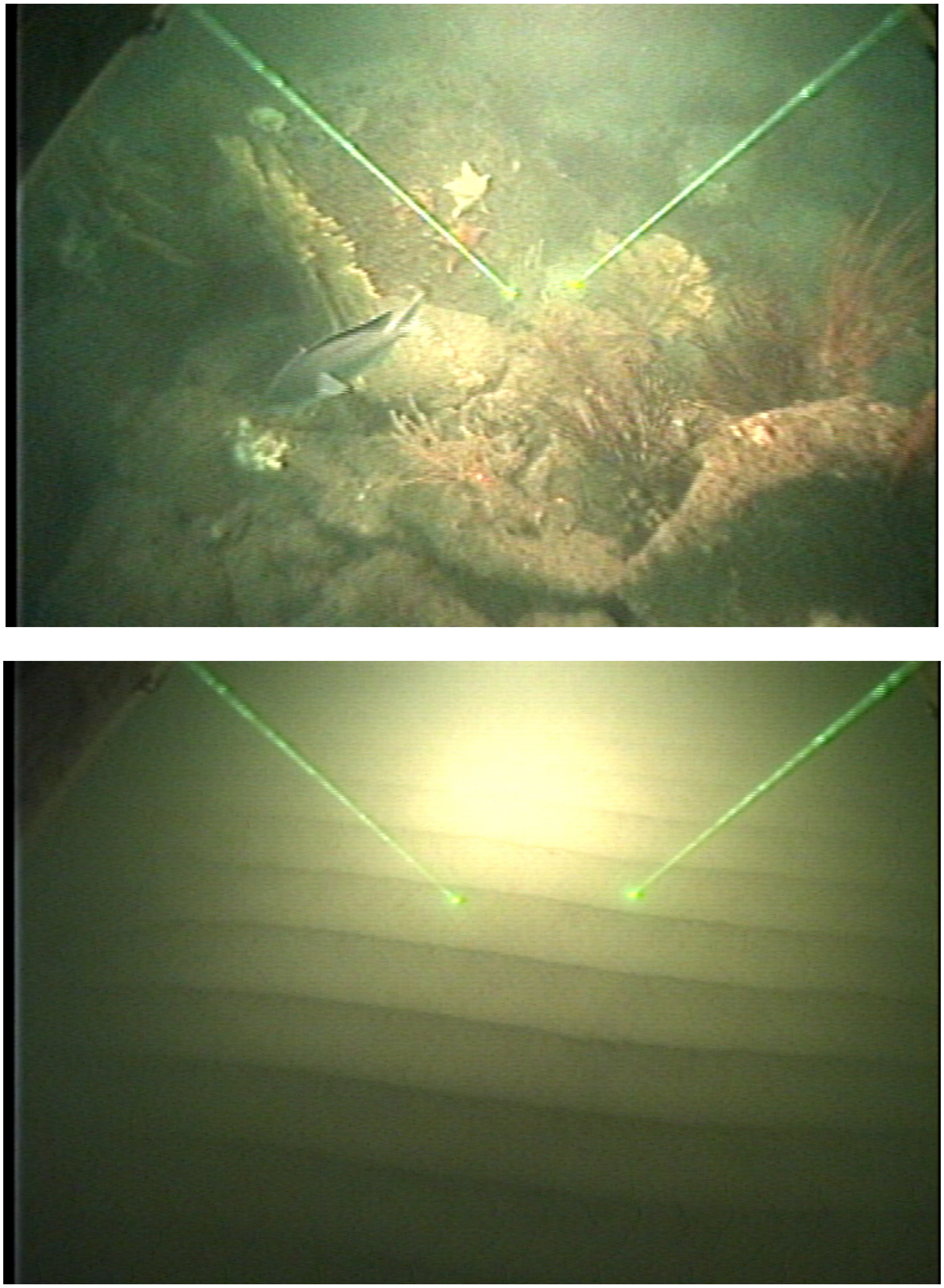


Figure 4. Top: Offshore bedrock reef habitat off of Loon Point near Carpinteria (U.S. Geologic Survey 2006). Bottom: Rippled bedforms imaged offshore at the Santa Clara River delta (U.S. Geologic Survey 2006).

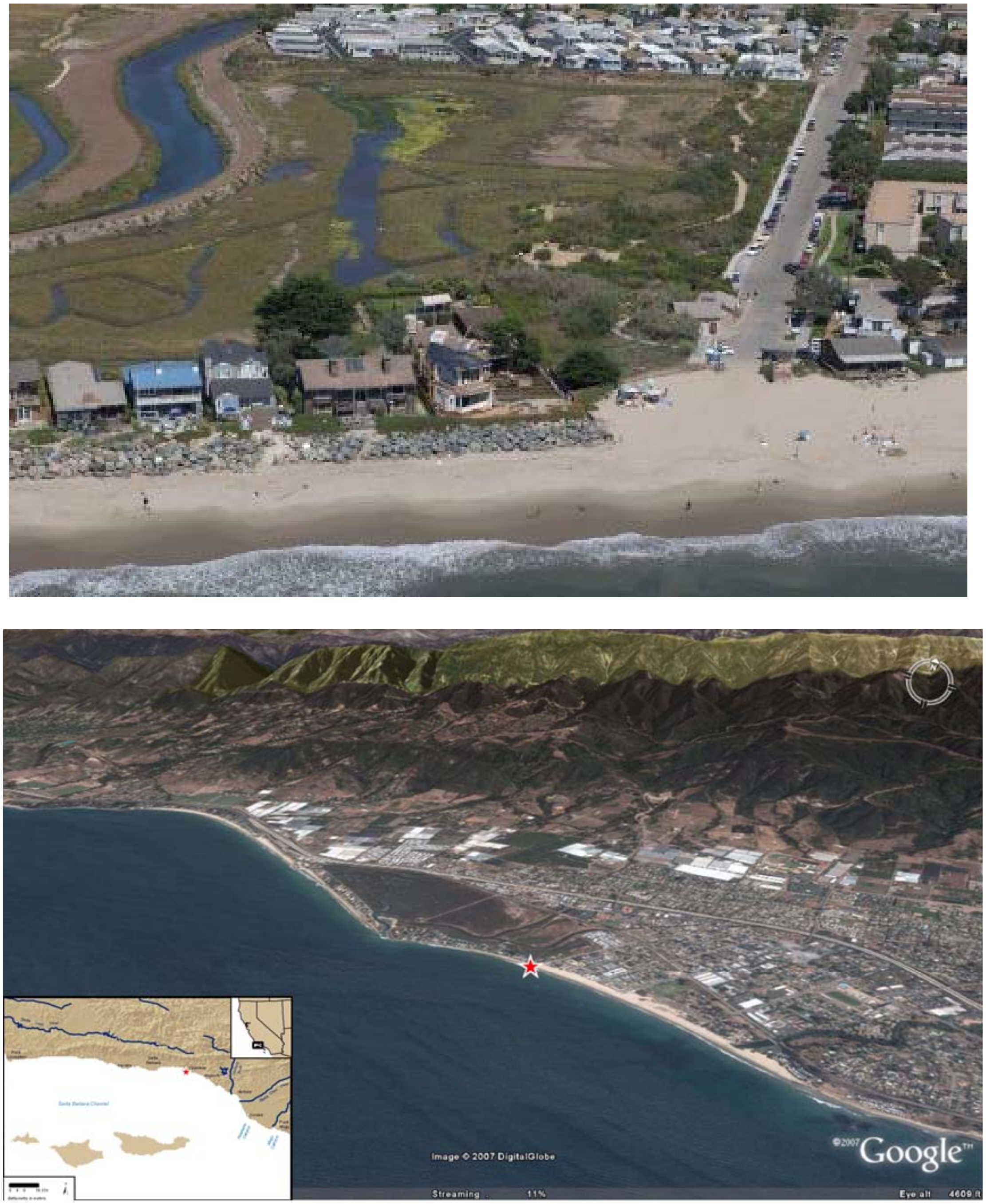


Figure 5. Top: Oblique view of narrow beach fronting Carpinteria Salt Marsh (California Coastline 2007). Bottom: Oblique view of salt marsh and suburban development of Carpinteria, looking north. Star is location of where top image was taken (Google 2007).

Figure 6. Top: Narrow coastal zone at Faria Point. Bottom: Oblique view of Rincon Point to the Ventura River. Both images look southeast; star is location of where top image was taken (Google 2007).

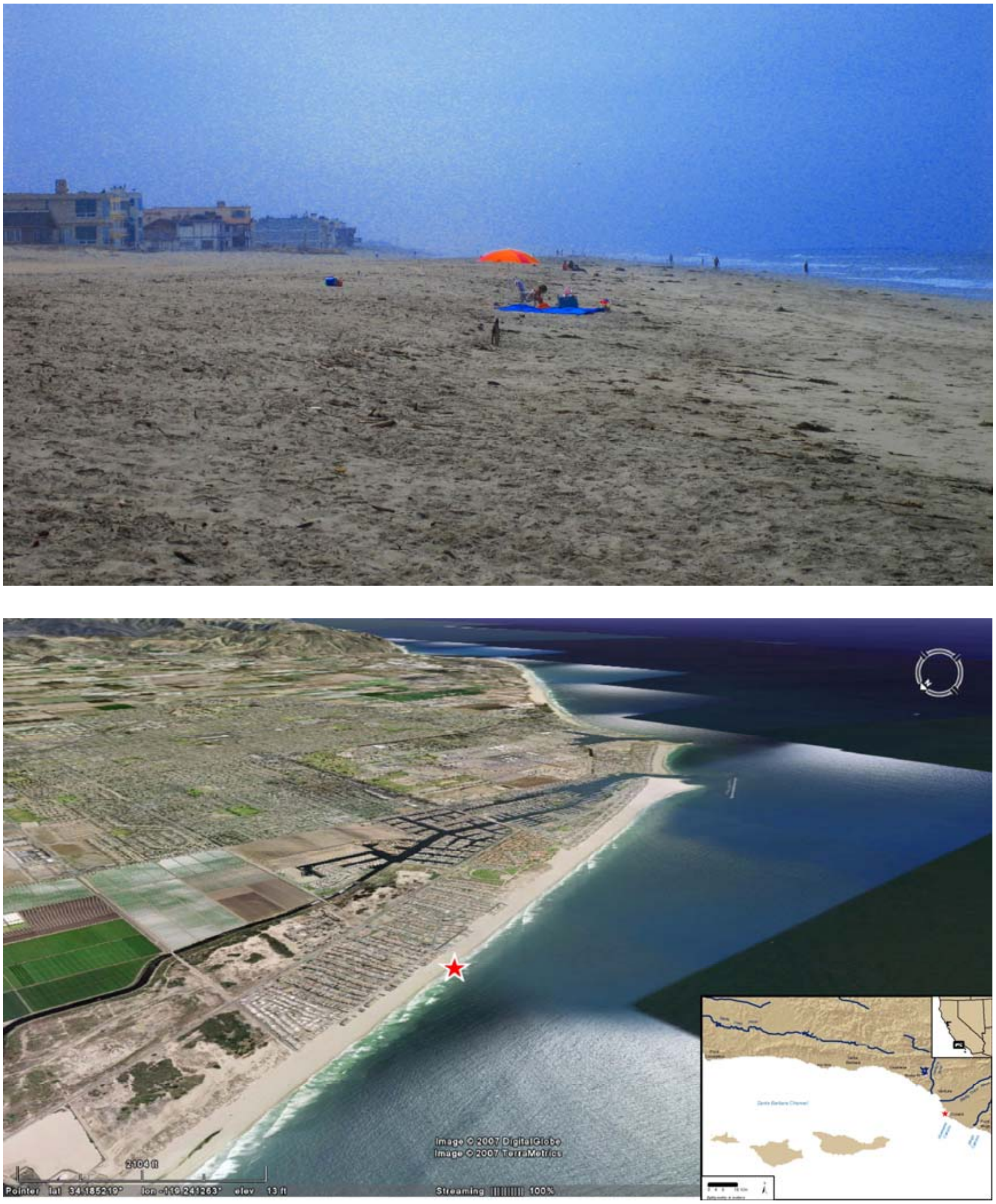


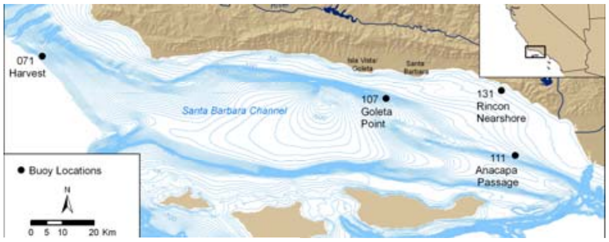
Figure 7. Top: Wider beach at Oxnard looking south. Bottom: Oblique view of Oxnard and the Channel Islands Harbor looking southeast. Star is location of where top image was taken. (Google 2007).

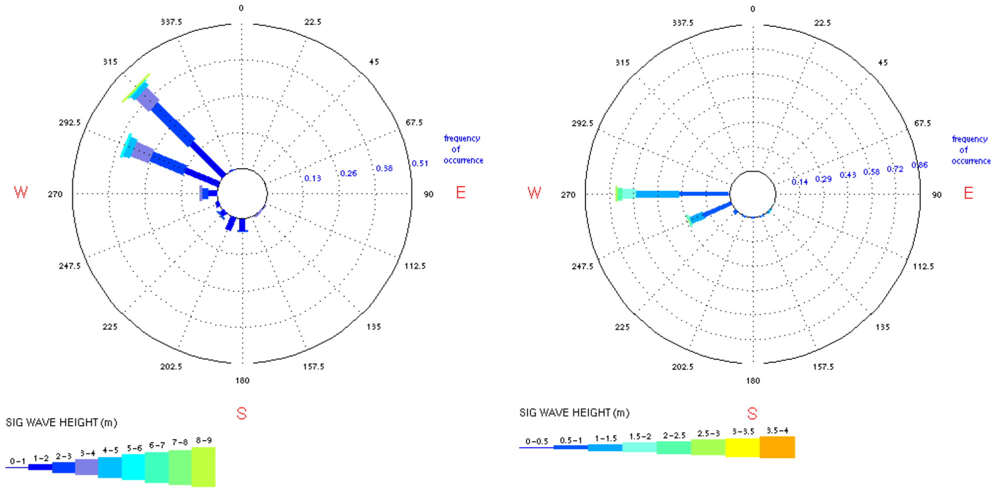
salt marshes or alluvial flats (Figure 7; Orme 2005). Deltas are present at the mouths of the Ventura and Santa Clara rivers (Figure 4).

Sediment is primarily supplied to the cell by small streams along the northern edge of the Santa Barbara Channel and large rivers along the eastern edge. The Mediterranean climate (i.e. warm, dry summers and cool, wet winters) creates episodic river flow and sediment delivery, concentrated between November and March. Longer-term climatic cycles which may last for more than a decade (e.g. PDO, ENSO) control periods of dominantly wet or dry years and affect sediment delivery to the coast by intensifying rainfall and runoff (Inman and Jenkins 1999).

Other possible sources of sediment to the cell include material eroded from seacliffs and littoral sediments transported from north of Point Conception. However, it has been shown that the fine-grained sedimentary cliffs bordering the northern edge of the Channel do not contribute significant sediment to the littoral cell (Runyan and Griggs 2003), and there is not agreement whether or not significant amounts of littoral sediments are transported from northern Santa Barbara County around Point Conception (Trask 1952; Azmon 1960; Bowen and Inman 1966; Judge 1970; Pollard 1979; Diener 2000; Patsch and Griggs 2007).

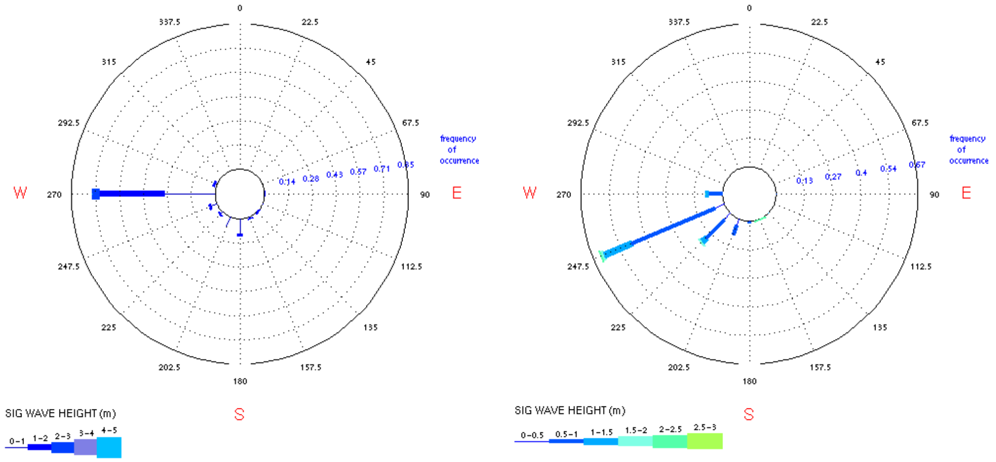
Sediment is transported through the SBLC by longshore currents, which flow dominantly from west to east due to the common oblique wave approach from the northwest into the Santa Barbara Channel (Figure 8 and 9; Scripps Institution of Oceanography 2007). Although waves drive the longshore current, the wave climate is generally mild along most of the south-facing coast. This is a result of the coastal





071 Harvest

107 Goleta Point



111 Anacapa Passage

131 Rincon Nearshore

Figure 8. Wave climate of the SBLC: annual wave height and direction. Waves enter the channel from the northwest, but approach the coast from the west, bending toward shore in the nearshore. Wave rose data reports dominant direction and significant wave height (H_s) from Jan 1 2006 to Dec 31 2006. Note that H_s scale changes on each wave rose (Scripps Institution of Oceanography 2007).

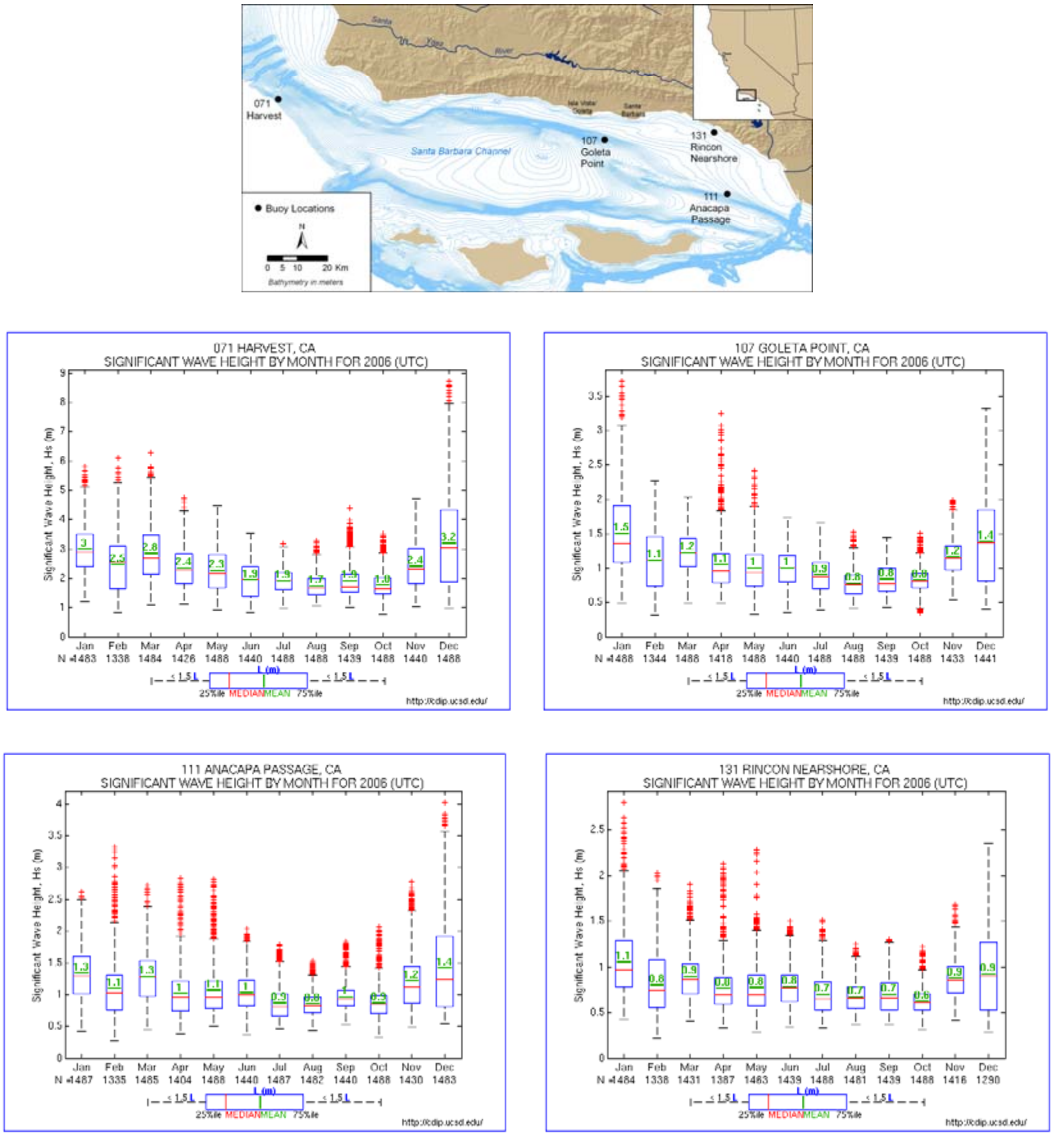


Figure 9. Wave climate of the SBLC: monthly wave height. Monthly significant wave height (H_s) measured around the Santa Barbara Channel during 2006. Note scale changes on each plot (Scripps Institution of Oceanography 2007).

orientation which limits wave exposure: waves must enter the channel directly from the west, bend around Point Conception from the north, or pass between the Channel Islands from the south. From harbor dredge records, rates of littoral drift vary throughout the cell and are estimated to average ~230,000 m^3/yr at the Santa Barbara Harbor, ~450,000 m^3/yr at the Ventura Harbor and ~750,000 m^3/yr at the Channel Islands Harbor (Patsch and Griggs 2007). Sediment is lost from the cell in the southern end of the study area into the Hueneme and Mugu submarine canyons.

II B. People and the Santa Barbara Littoral Cell

Humans have extensively developed atop coastal terraces, dunes, and have reclaimed wetland areas throughout the SBLC, but especially from Isla Vista to Oxnard. As a result of this shoreline encroachment, natural processes which once freely acted upon and shaped the coast have now become natural hazards which endanger coastal residents and developments. For example, during winter storms and high tides, large waves may surge over the beach and directly attack the backbeach. Depending on the type of backbeach present, this could result in waves directly attacking buildings, roads or other infrastructure, inundating lowlands, or eroding the base of cliffs, accelerating cliff failures and threatening cliff top development. A wide beach is the only natural defense capable of protecting the backbeach from the damaging effects of storm waves and coastal flooding. In addition, a wide beach also provides a unique habitat for many species, improved coastal access, enhanced recreational opportunities and increased revenue for coastal communities and the general public.

The coast from Isla Vista to Rincon Point is characterized by narrow beach widths (i.e. high tides and storm waves reach the cliff base at least once a year, but in some places daily) and is therefore susceptible to active coastal erosion of the bluff, cliff or dune (Norris 1968). This coastline would benefit from a wider beach and the accompanying increased storm protection. In particular, the cliff-top shoreline of Isla Vista and the sandy beaches backed by lagoons and wetlands both in Goleta and Carpinteria are areas most immediately in danger (Figure 3 and 5; Norris and Patsch 2005). In Isla Vista and Carpinteria, public beaches and private homes are threatened by coastal erosion; while in Goleta a public recreational area (County Park, public beach, and parking lot) and also a private restaurant are in danger due to shoreline erosion.

From Rincon Point to the Ventura River, mountains and sea cliffs that once fronted the coast are now cut off from direct contact with the ocean as a result of constructing the railroad, Highway 101 and an almost continuous strip of shore protection structures along the beach (Figure 6). Naturally narrow beaches are therefore constricted to an even narrower strip between these structures and the ocean. This results in very narrow or non-existent (i.e. zero dry beach width) beaches even in the summer, during the period of maximum beach widths. A wider beach, if stable, could protect public infrastructure, private properties, and enhance recreation (e.g. this stretch has a large recreation potential since Highway 101 provides easy access to the beach and various State and County beaches are located along this coast).

Although beaches from Ventura to Point Mugu are currently wider than other beaches in the SBLC (~100 m), development has encroached onto the shoreline, thereby narrowing these beaches (Figure 7). In addition, a sediment budget deficit, as a result of river sediment supply reductions, is documented along this portion of the cell (Noble Consultants 1989; Willis and Griggs 2003). Future narrowing, could therefore, threaten these beaches as well.

It is evident that many beaches of the SBLC are naturally narrow. In addition, there is concern that beaches have further narrowed in recent years and that future narrowing will continue to occur, as a result of anthropogenic activities. For example, significant beach narrowing has occurred in the SBLC as a result of constructing shore protection structures directly on the beach (i.e. beach narrowing by placement loss and passive erosion; Revell and Griggs 2006). Currently 53 km of the cell are armored by shore protection structures which cause placement loss and passive erosion, and thus beach-narrowing (Griggs 2005; Patsch and Griggs 2007). While there is no clear evidence of systematic beach narrowing as a direct result of human influenced sediment reductions, reductions in sediment supplied to the coast are well documented and future beach width reduction is therefore a likely possibility. Damming of the Ventura and Santa Clara Rivers, for example, has reduced sediment input to the southern SBLC by 53% and 27% respectively (Willis and Griggs 2003). Coastal armoring of cliffs has also reduced sediment input to the SBLC by 20%, although this impact is not as severe because cliffs naturally contribute only 0.4% of littoral sized sediments to the cell (Runyan and Griggs 2003). Overall in the entire

SBLC, there has been a 40% reduction of river and cliff sediments to the shoreline as a result of dam building and cliff armoring (Patsch and Griggs 2006).

A recent shoreline change study of the SBLC from El Capitan State Beach to Point Mugu found that 72% of this coast is eroding at an average rate of 1.2 m/yr (i.e. when examined over the short term, between the 1970s and 1990s (Hapke et al. 2006). Accordingly, to reduce or mitigate future shoreline erosion and the effects of loss of beach width (i.e. loss of storm protection, habitat, recreation opportunities, and revenue) options to resist shoreline retreat and increase beach width have been of local and regional interest throughout much of the SBLC.

II C. Nourishment as a Potential Solution for Narrow Beaches

Beach nourishment is the “soft” engineering solution to rebuild degraded beaches (i.e. either naturally degraded or by human actions). Nourishment widens a narrow beach by placing sediment directly on the beach or immediately offshore but within the zone of active littoral transport (Figure 10). Sources of sediment may be from “opportunistic” sources (e.g. from coastal dredging and excavation projects), inland sources (e.g. debris basins), or offshore sources. Beach nourishment is not a permanent solution and the added sediment will be eroded over time as nourishment does not stop the fundamental causes of erosion (e.g. rising sea level, storm waves, longshore transport and sediment supply reductions). However, if studied and planned properly, and by using sand retention structures, nourishment can widen the protective buffer and delay the effects of shoreline retreat.

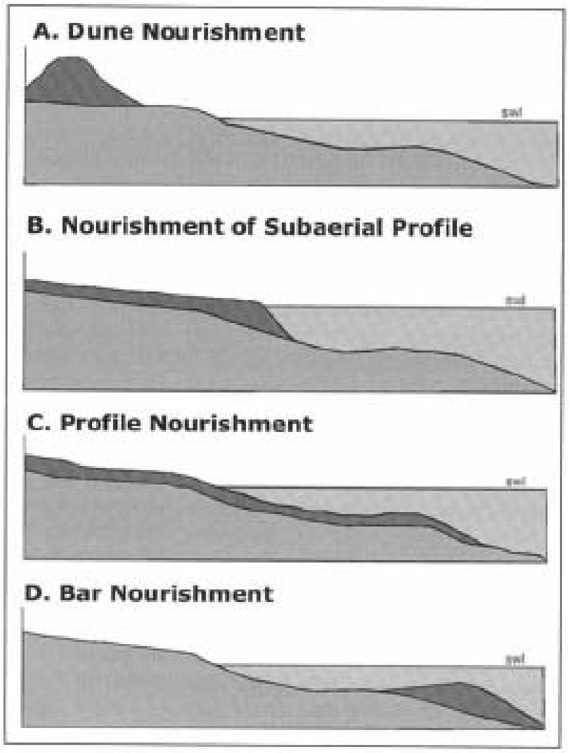


Figure 10. Methods of beach nourishment defined on the basis of where the fill materials are placed (Finkl et al. 2006).

A. Dune nourishment: sand is placed in a dune system behind the beach.

B. Nourishment of subaerial beach: sand is placed onshore to build a wider and higher berm above mean water level, with some sand entering the water at a preliminary steep angle.

C. Profile nourishment: sand is distributed across the entire beach and nearshore profile.

D. Bar or nearshore nourishment: sediments are placed offshore to form an artificial feeder bar.

Several beaches in the SBLC have been opportunistically nourished with sediment from initial harbor construction projects. For example, when the Channel Islands Harbor was excavated in 1960, ~2.8 million m^3 of sediment was placed downdrift of Port Hueneme on Hueneme Beach (Wiegel 1994). Similarly, when excavating the Ventura Marina, by 1966 ~674,000 m^3 had been placed updrift of the Ventura Harbor and trapped by the Pierpont groin field to widen the beach (Wiegel 1994). Opportunistic nourishment from harbor and marina construction has been an important sediment source to the southern SBLC; however, opportunistic nourishment is only a one-time sediment contribution. Future opportunistic nourishment projects in the SBLC are highly unlikely, due in large part to a strong Coastal Commission mandate to preserve and protect coastal wetlands and open spaces along the California coast.

Several beaches in the SBLC have been nourished with sediments that have shoaled harbor entrance channels. Dredging these sediments and placing them downdrift (i.e. sediment bypassing) is not considered "true" beach nourishment because the added sediment is not an additional sediment input into the littoral cell, but is a redistribution of littoral sediments that were temporarily trapped by a large coastal engineering structure. Beaches that have received sand from sediment bypassing include East Beach, McGrath State Beach, Silver Strand Beach and Hueneme Beach (i.e. east of the Santa Barbara Harbor and south of Ventura Harbor, Channel Islands Harbor and Port Hueneme, respectively. Sediment backpassing (i.e. which may be considered true beach nourishment for a beach, but not for the littoral cell) is similar to sediment bypassing except that sediments are placed at a beach updrift of the location where the sediments were dredged. Sediment backpassing has occurred in the SBLC. Beaches in the Ventura area, for example are occasionally nourished with sediments backpassed from the Ventura Harbor (Wiegel 1994; Higgins et al. 2004).

Recently, Goleta Beach was nourished to restore a previously wide beach and to potentially stop further erosion. In 2003, the beach was nourished with ~45,000 m^3 of backpassed sediments dredged from the Santa Barbara Harbor, transported by barge and pumped onto the beach (Moffat & Nichol 2005). In addition, ~14,000 m^3 of sand was trucked from Ledbetter Beach and ~15,000 m^3 of sand was dredged from Goleta Slough creeks (Moffat & Nichol 2005). Although post-nourishment survey data indicate that sediment moved alongshore during project monitoring, rather than offshore/onshore, one year after nourishment, the shoreline advanced at 4 of 5 monitored transects (the transect that retreated was located at the mouth of Goleta Slough; Moffat & Nichol 2005). Data also show that ~60% of the total sand volume placed on the beach was retained out to the assumed closure depth (i.e. 12m) up to one year after monitoring (Moffat & Nichol 2005). Further monitoring of Goleta Beach is currently being conducted by BEACON and the USGS.

Periodic nourishment may be a solution to the problem of narrow beaches, although many concerns with nourishment still exist (Griggs 2006). Beach nourishment is expensive and costs of the project must be balanced with benefits including aesthetics and economic value for the life expectancy of the project.

Funding (i.e. private, local, state or federal funding) must be obtained. Additional questions include whether large volumes of appropriate sand exist and how will they be recovered and delivered to the site. Environmental impacts of the project must also be considered, and the public should support the project.

In the SBLC, a very large volume of suitable sediment would be needed for any project because of the high littoral drift rates in the cell (Griggs 2006). A large volume of sediment will also increase the chance of a successful project as studies have shown that the success of nourishment projects is often dependent upon the density or volume of fill placed. Additionally, the alongshore length of the project, grain size compatibility of the fill, the use of sand retention structures with the fill, and storm activity following nourishment are also important factors affecting success (Patsch and Griggs 2006).

As a result of the large volume of sediment required for a successful nourishment project, offshore sources should be used for nourishment as they are the more economical option. Inland sources are far more costly than offshore sources due to significantly higher removal and transportation costs. For example, in the 2002 Shoreline Management Plan for Goleta Beach County Park it was estimated that it would cost $4 million to nourish Goleta beach with 160,000 yds^3 (~122,000 m^3) of sediment from upland sources, while it would cost only $1.6 million to nourish the beach with 260,000 yds^3 (~199,000 m^3) from offshore sources (this increased amount as compared to upland sources, accounts for nourishing with fine offshore sediments and is the estimated equivalent to the amount considered from upland sources;

(Moffat & Nichol 2002). Furthermore, the logistics of trucking inland sources to the beach presents difficulties for a large-scale project: a 160,000 yds^3 (~122,000 m^3) project would require approximately 16,000 dump truck loads (i.e. 10 yds^3 per load) and therefore months to deliver the sand.

When initially locating a suitable offshore sediment source, or potential borrow area, sediment characteristics, environmental impacts (both on the beach and in offshore borrow areas/habitats) and dredging feasibility must be considered. Environmental friendly methods of extraction, transportation, and placement of sediment must be considered and employed. Technical and economic aspects of dredging must be considered. Currently, economical dredging depths range from 5 to 30 m depending on the type of dredge used (U.S. Army Corps of Engineers 1983; National Research Council 1995; McLellan and Hopman 2000). However, dredging should be avoided within the zone of active littoral transport, as a sediment sink within the cell could be formed. The outer edge of the zone of active littoral transport is conceptually referred to as the depth of closure and is dependent upon offshore bathymetry and wave energy. In the case of the SBLC, this means that dredging could be undertaken from roughly 5 to 30 m water depth (but at some places not as shallow as a result of increased wave energy and thus a deeper zone of active littoral transport) if suitable sediments are found.

II D. Grain Size Considerations of Nourishment

Suitable sediment (i.e. stable fill material and what is environmentally appropriate to be placed on the beach) must be used in order for a beach nourishment project to be successful. Environmentally suitable material is sediment that is contaminant free and does not have a high percentage of fines (i.e. silts and clays). An excess of fines can result in negative biological impacts by causing a consolidated beach berm to form, and/or increasing turbidity during sediment excavation and placement (National Research Council 1995; Dean 2002). Often a maximum allowance of 10% fines can be used as a general guideline, but in practice the maximum allowance of fines should be related to the natural or seasonal turbidity in the area (U.S. Army Corps of Engineers 2002).

Stable fill material, as determined by sediment grain size, is required for a successful beach nourishment project, because the grain size distribution of the fill will affect the rate that the fill is eroded from the beach, how the beach will respond to storms, and the slope of the nourished beach (U.S. Army Corps of Engineers 2002). Stable fill material, or suitable sediment, should therefore be as coarse as, or coarser than sediment that is naturally found on the beach; finer sediment is considered unstable and is expected to be quickly winnowed out and carried offshore.

The particular grain size definition of suitable sediment will vary alongshore from beach to beach, just as the native sediment composing beaches varies alongshore. As a general guideline, the Coastal Engineering Manual (CEM) suggests that if the median grain size on the native beach is 0.2 mm or coarser, then suitable sediment should have a median diameter within +/- 0.02 mm of the native sediment. If native grain size is between 0.2 mm and 0.15 mm, then suitable sediment should have a median diameter within +/- 0.01 mm of the native; and if native grain size is finer than 0.15 mm, suitable sediment should have a median diameter at least equivalent to the native (Table 1; U.S. Army Corps of Engineers 2002). However, coarser than native sediment may still be suitable, improving resistance to storm-induced erosion while also requiring less volume (than if using native sized sediments) to attain an equivalent dry beach width. On the other hand, using coarser than native sediments may cause textural or design issues (e.g. a steeper beach face will build).

The CEM does not recommend nourishing beaches with finer than native sediments. However, it is reported that finer sediments may still be suitable, but a much larger volume of fill (then if using native sized sediments) will be required to build a beach of a given width. This will cause design and other issues (e.g. the beach will build at a flatter slope, project costs will increase as a result of the increase in sediment volume needed). In any case, the CEM highly recommends determining and comparing equilibrium beach profiles of native and potential fill sediments (i.e. because a beach forms at a slope related to its characteristic grain size, and will thus influence beach slope and dry beach width), calculating overfill ratios (i.e. determining the volume of fill material equal to one unit of native material-this is a function of grain size), and also modeling sediment transport, including the effects of waves and currents, to determine suitability of a fill (U.S. Army Corps of Engineers 2002).

But what is the characteristic grain size of the native beach? Grain size on the beach naturally varies both temporally (seasonally) and spatially (in the cross-shore,

Table 1. CEM Nourishment Recommendations (U.S. Army Corps of Engineers 2002).

Native Beach		For example:		
Median Diameter:	Ideal diameter:	for diameter:	Ideal min.	Ideal max.
> 0.20	+/- 0.02	0.20	0.18	0.22
0.15 - 0.20	+/- 0.01	0.15	0.14	0.16
< 0.15	at least same diameter	0.125	0.125	

-all grain sizes in mm.

longshore, and vertical directions (Bascom 1951; Inman 1953). A beach's natural grain size distribution is a result of composition of the sediment supplied to the beach and the coastal processes acting on the sediment (i.e. wind, waves, and currents; (Komar 1998; Stauble 2007). Several studies have documented that grain size is coarsest at the shore break plunge point, an area of high turbulence, and fines in both the offshore and onshore direction (Bascom 1951; Stauble 1992; 2007). Seasonally, grain size on beaches fines during summer beach accretion, and coarsens during winter beach erosion (Inman 1953).

As a result of natural cross-shore variation, the CEM advises to compute a composite sample from sand collected across the active part of the profile, from the berm crest to the depth of the typical storm bar to determine native grain size (U.S. Army Corps of Engineers 2002). However, after examining specific nourishment projects and associated fill variables (e.g. grain size, beach profiles, and project success) Stauble (2007) has determined that an intertidal composite (i.e. samples from the intertidal zone, between mean high tide and mean low tide) is the best indicator of the native beach. When the intertidal composite was used, it was shown to provide a more accurate measure of successful overfill ratios and in the long-term, project performance was more favorable (Stauble 2007). As a result, the intertidal composite, or representative samples from the beach face, should be used in determining the characteristic grain size of a beach.

II E. Previous Studies of Grain Size in the Nearshore

If nourishment is to be used as an engineering solution for narrow beaches in the SBLC, large offshore deposits of suitable sediment must be located within the economic dredging limit, but outside the zone of active littoral transport.

In theory, there is generally a gradation from coarser to finer sediments moving offshore and typically coarser sediments (consistent with a transgressive shoreline) in the subsurface. Processes that operate along the coast (e.g. wind, wave and current driven) control the ultimate site of modern sediment deposition. Coarse sediments are deposited in high-energy environments, while fine sediments are kept in suspension until they are transported into calmer environments further offshore where they then settle out. However, coarser-than-expected sediments may be found unpredictably. For example, relict beach or fluvial sediments, which have not yet been buried by modern sedimentation processes, may also be found on the shelf.

The Offshore Surficial Geology Map of California shows that very fine-grained sands and muds dominate the narrow shelf along the SBLC coast (Figure 11; Welday and Williams 1975). However, the map also indicates the presence of medium and coarse-grained deposits, suitable deposits for beach nourishment, throughout the shelf and close to shore within economic dredging limits. These deposits of relatively coarser sediment would be a result of either localized, present-day, high-energy environments, or relict sediments. Relict coarser sediments may be trapped within tectonically controlled structural highs or lows, or as beach or channel

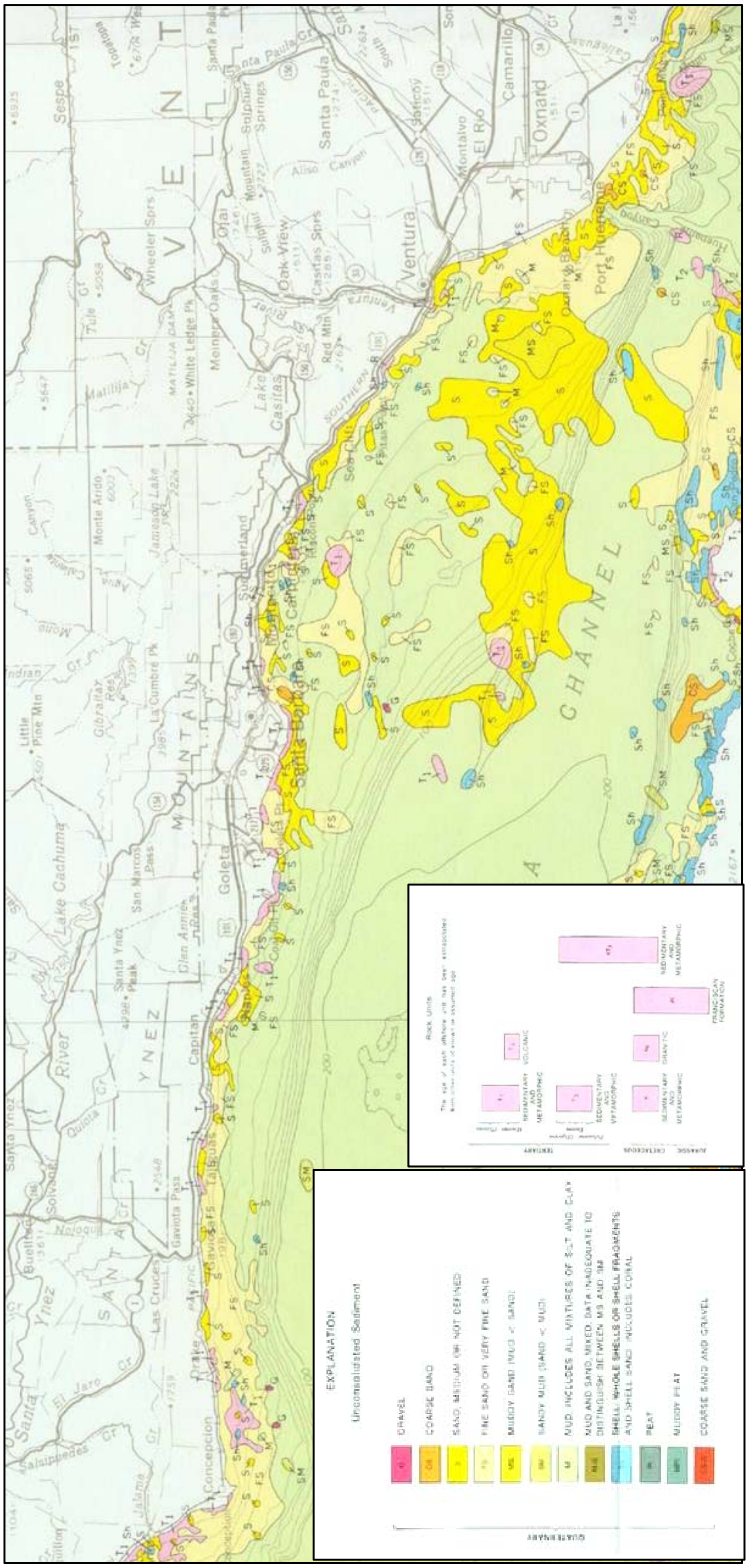


Figure 11. Offshore Surficial Geology of California, SBLC area (Welday and Williams 1975).

deposits which were deposited when sea level was lower (Welday and Williams 1975; Fischer 1983).

Recently, the USGS has compiled data on seafloor sediment characteristics, including grain size of sediments from core surfaces, into a comprehensive database, usSEABED (Reid et al. 2006). Some nearshore cores reported in usSEABED are inconsistent with the Offshore Surficial Geology Map of California: instead of coarse and medium-grained sand, cores show very fine sand or silt (Welday and Williams 1975; Reid et al. 2006). While these differences may represent natural changes within a dynamic environment, the change may alternately result from limitations of the Welday and Williams map. For example, the map was compiled from various sources which were collected between 1855 and 1975. Currently there is no detailed information about data density, data quality or the original data collection methods or classification schemes. In addition, fine sands and very fine sands were mapped together as one unit, and if the specific class of sand was undefined in the original data set, it was mapped as medium sand by Welday and Williams. This study has reconsidered existing innershelf surface sediment maps, and by extensive sampling has updated a regional map for the SBLC area, while also contributing to the usSEABED database.

Previous studies have located “suitable” deposits for nourishment within the SBLC, but the quality of these deposits is questionable because they consist mainly of fine sediments. The most recent study, which reviewed, further investigated and revised all previously considered borrow areas (e.g. those of Field 1974; Dahlen

1988) was conducted by Noble Consultants (1989). Four borrow areas offshore Goleta, Santa Barbara, Carpinteria, and from Ventura to Oxnard were identified and examined. It was estimated that together the borrow areas contained at least 240 million m^3 of sediment available for beach nourishment (Noble Consultants 1989). However, the report also indicates that most of the sediment is only marginally suitable (i.e. grain size ranging from 0.088 to 0.177 mm, as defined by 1974 Coastal Engineering Research Center criteria; Table 2). By present-day standards, the identified deposits appear to be finer than what is considered appropriate. The present study, with additional samples throughout the entire SBLC, has reexamined and further investigated offshore sediments with a primary objective of determining their suitability for beach nourishment in the Santa Barbara Littoral Cell.

Table 2. 1974 Coastal Engineering Research Center Nourishment Criteria: Criteria for Sand Grain Size Classification, (Noble Consultants 1989).

Classification	Grain Size Phi	Grain Size mm	Beach Suitability Assessment
Gravel			
------------------------	--- -1 --	----- 2 -----	Unsuitable
Very Coarse Sand		1.41	
------------------------	--- 0 ---	----- 1 -----	
Coarse Sand		0.707	Marginal
------------------------	--- 1 ---	----- 0.5 -----	
Medium Sand		0.375	Suitable
------------------------	--- 2 ---	---- 0.25 ----	
Fine Sand		0.177	
------------------------	--- 3 ---	--- 0.125 ---	Marginal
Very Fine Sand		0.088	
------------------------	--- 4 ---	--- 0.063 ---	
Silt		0.032	Unsuitable

III. METHODS

As compared to traditional sediment collection (e.g. obtaining grab samples from the beach and coring the seafloor) and traditional sediment grain size analysis (e.g. mechanical sieving or analyzing by settling velocity), this study utilizes a different approach to locate suitable sand deposits: mean surface grain size is examined and mapped over a wide area of the beach and inner shelf using the Eyeball© camera and spatial autocorrelation algorithms.

The major advantages of using the digital bed sediment camera and autocorrelation method over traditional techniques are the extensive amount of area that can be covered as a result of the speed of the collection method, the number of samples that can be processed as a result of the rapid grain size determination method, and that samples can be taken in very shallow depths-as shallow and close to shore as small coastal research vessels can safely transit. The major shortcoming of this method is that only surface grain size is captured. However, this bias can be reduced by testing Eyeball© images with grab samples that penetrate several centimeters beneath the surface.

III A. Sampling Scheme

The field survey was designed to collect samples along a cross-shore profile from the beach face and the nearshore at 5, 10 and 20 m water depth (i.e. within the economic dredging limit), with transects spaced at least every kilometer alongshore, throughout the entire SBLC (Figure 12). To compare seasonal grain size variations, winter (March 2006 and February 2007) and summer (October 2006) beach samples

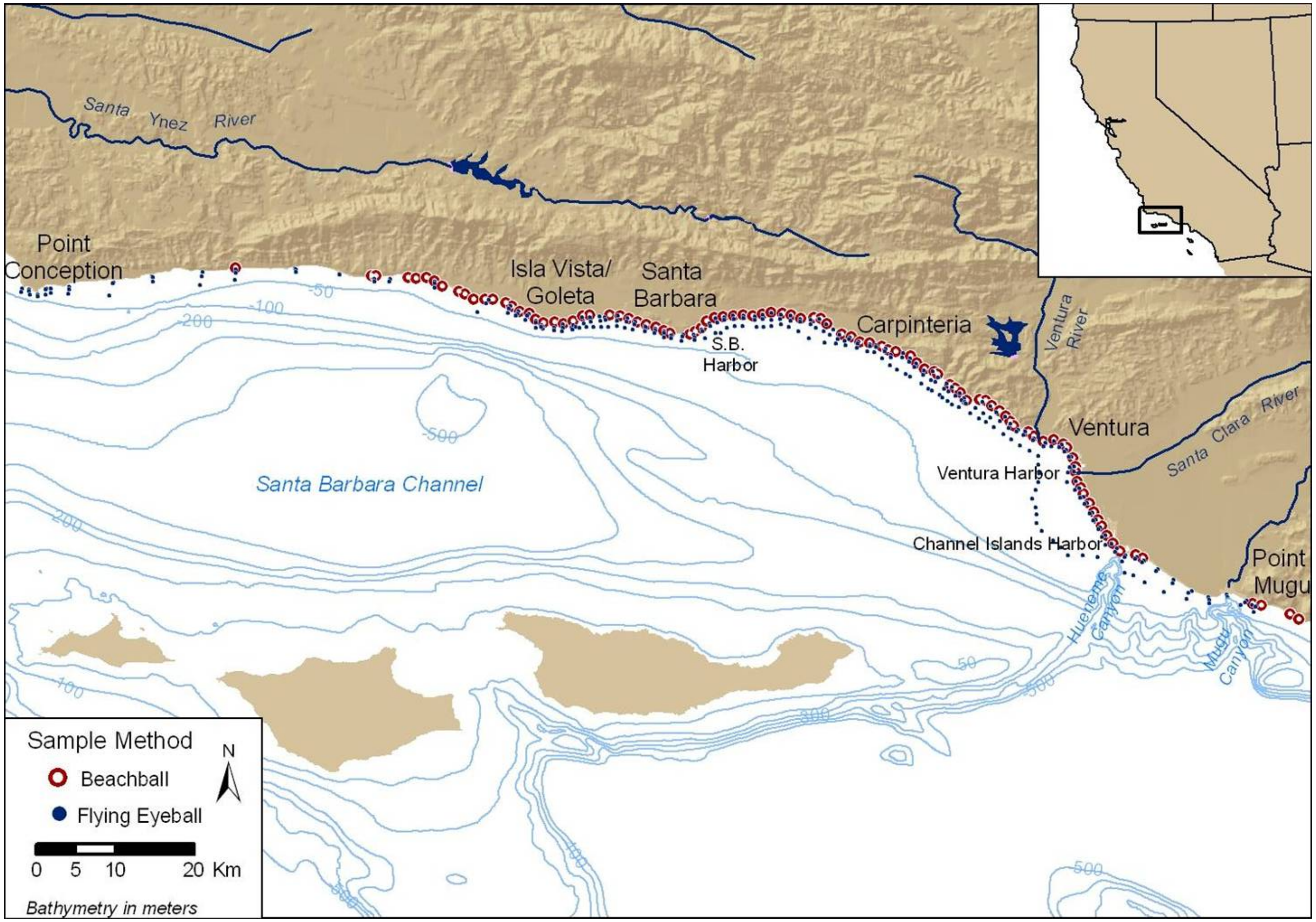


Figure 12. Locations of beach face samples collected with the Beachball© camera and nearshore samples in 5, 10, and 20 m water depth collected with the Flying Eyeball© camera .

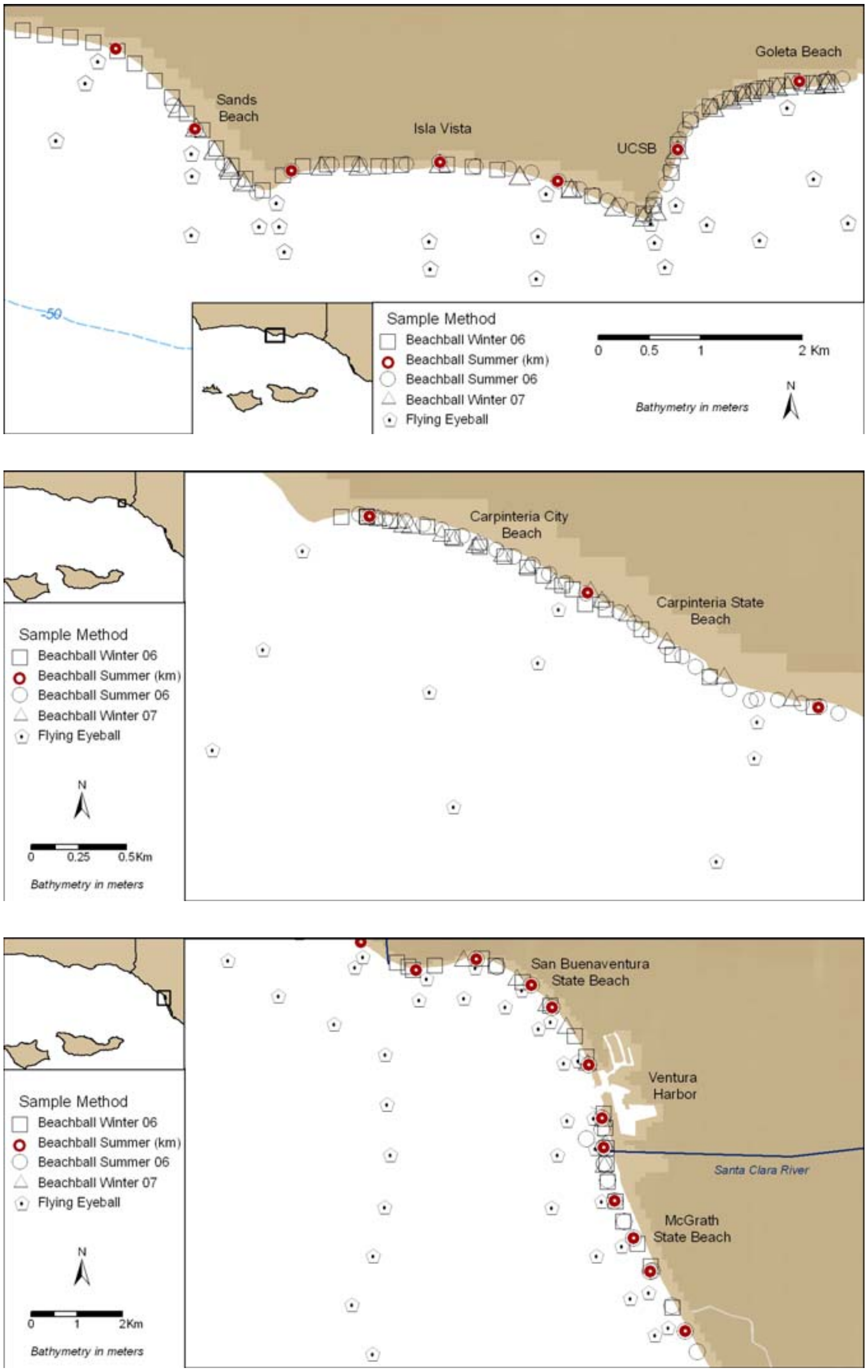


Figure 13. Locations of summer nearshore samples, summer kilometer spaced samples, and seasonal beach face samples collected at Goleta/Isla Vista (top), Carpinteria (middle), and Ventura (bottom) beaches.

were collected at a higher spatial resolution along the Isla Vista/Goleta, Carpinteria, and Ventura shorelines (Figure 13).

III B. Eyeball Methodology

Two different Eyeball© camera systems were used to collect digital samples. Beach face samples were collected with the Beachball© camera, a 5-megapixel digital camera encased in a waterproof housing (Figure 14; Rubin 2006). To sample the beach, the camera is placed flush against the sediment, which is illuminated by a ring of LED lights. Camera settings such as aperture, shutter speed, zoom, focus, and pixel resolution of the image are held constant. Nearshore samples were collected with the underwater Eyeball© version, the Flying Eyeball©, which is a video camera illuminated by LED lights encased in a wrecking ball (Figure 14; Rubin 2006). Live video is reviewed on deck while the instrument is repeatedly raised and lowered to the seafloor to collect digital video samples. The clearest frames of video are then captured as still images and processed for grain size (Figure 15). For both systems, multiple images are taken at each location and later averaged to produce a grain size result. Images that do not pass quality control checks (e.g. those that are overexposed or out of focus, or contain a coarse lag deposit, uneven sediment surface or air bubbles) are not included.

Images are processed by running a Matlab® script that uses a spatial autocorrelation algorithm developed by Rubin (2004; Barnard et al. in press; Appendix I). This algorithm determines the correlation (i.e. as measured by pixel intensities) between a pixel and subsequent pixels at increasing distances. Grain size

Figure 14. Top: Beachball© camera: digital camera encased in waterproof housing. Bottom: Flying Eyeball©: digital video camera encased in wrecking ball.

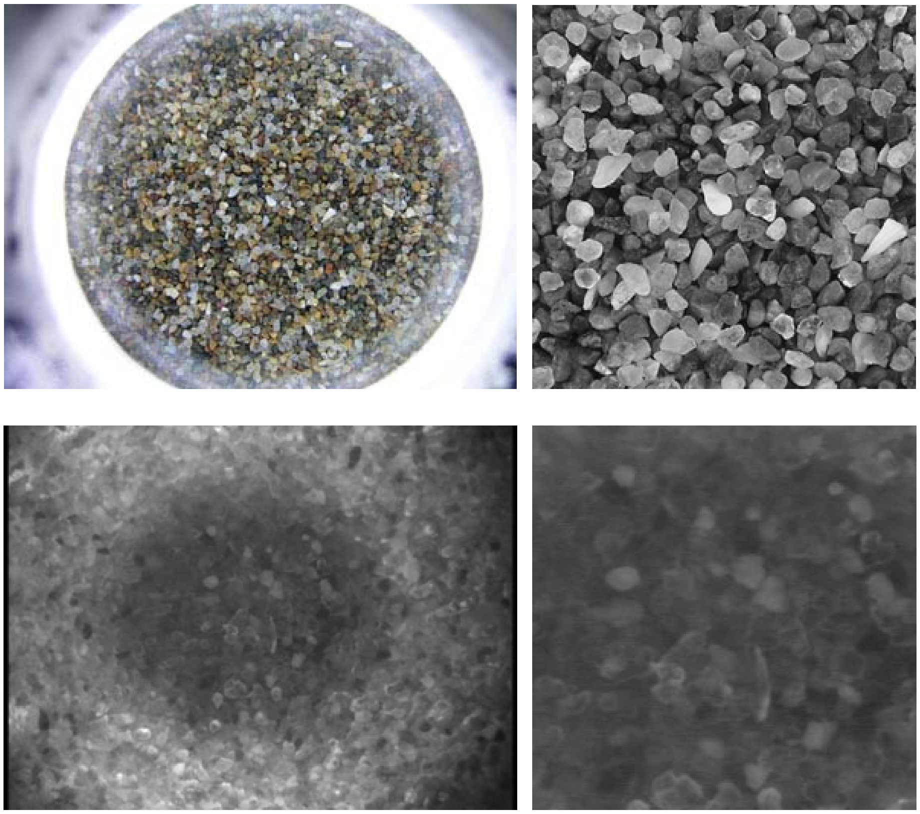
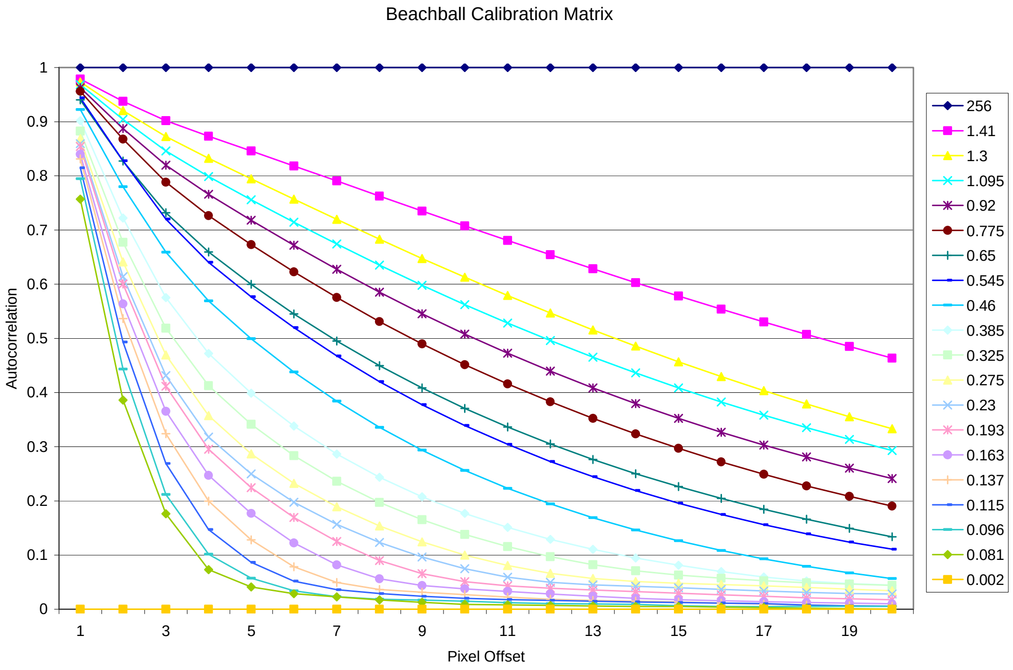


Figure 15. Top: Beachball© image and processed image in grayscale, cropped from center (images have been rescaled). Bottom: Flying Eyeball© image and processed image cropped from center (images have been rescaled).



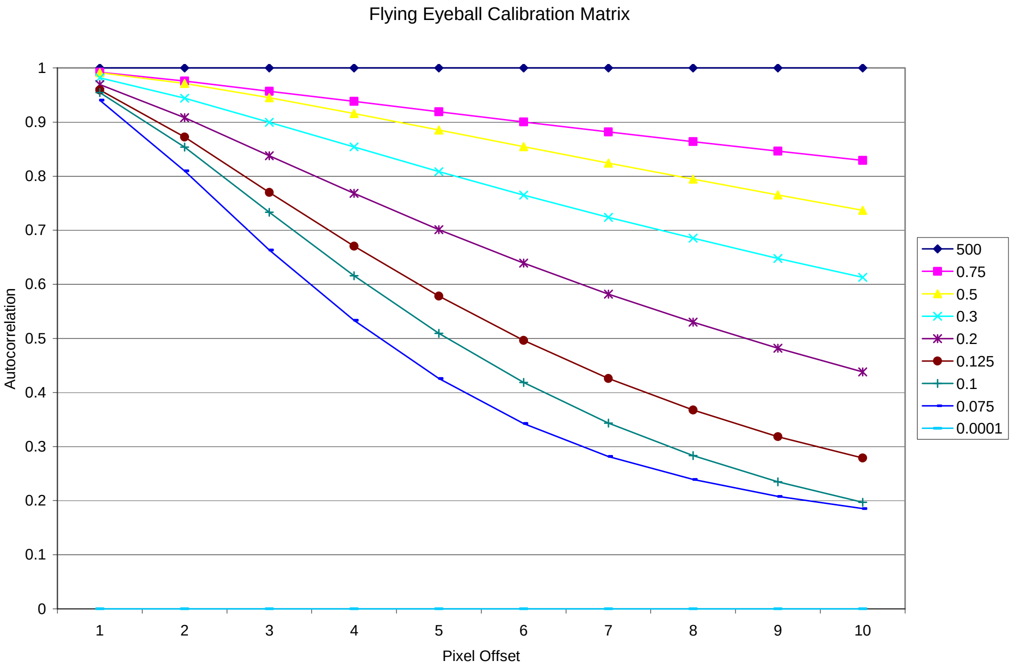


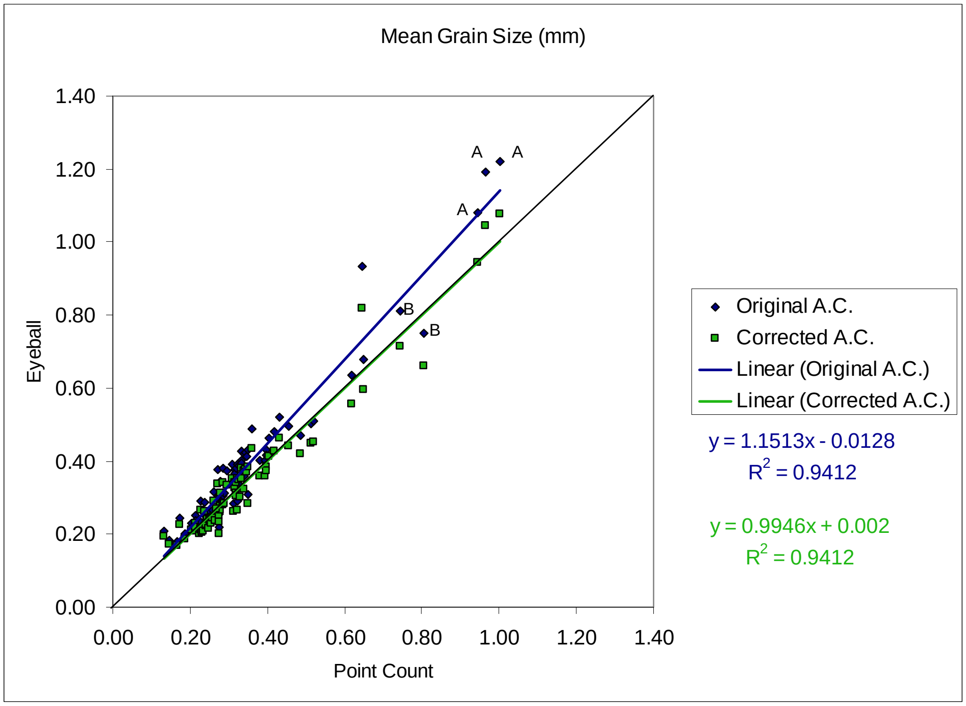
Figure 16. Beachball© (top) and Flying Eyeball© (bottom) calibration matrices, used to interpolate grain size in mm.

of an image is then interpolated by comparing the spatial autocorrelation result to a calibration matrix (Figure 16). The calibration matrix contains spatial autocorrelation results of calibrated sample images and was produced by imaging ¼ phi-interval sieved sediment collected from throughout the study area with the same equipment and camera settings as used in the field. In addition, for Flying Eyeball© samples point counted images were also used to produce the calibration matrix. Each calibration matrix created is valid only for sediment of similar size, shape and mineralogy as the sediment initially sieved and imaged.

III C. Evaluation and Discussion of Methods

To validate grain size determined from the autocorrelation method, results were compared to mean grain size determined from point counting, or calculating the mean of an image by hand-measuring the size of 100 grains in the image. A high correlation (Beachball© $r^2=0.94$ and Flying Eyeball© $r^2=0.93$) of samples is evidence that the autocorrelation method was able to successfully determine grain size of an image accurately, with only 1% error (Figure 17).

However, when using the Beachball© camera, a systematic bias was found: the autocorrelation method consistently overestimated grain size as determined from point counting. This bias could have resulted from improper sieving techniques. For example, not enough time may have been given to allow for all of the grains to settle into the proper sieve. Small grains may have been caught in larger sieves, therefore misrepresenting sediment size when images for the calibration matrix were taken. To correct for this bias, a correction (i.e. solving for the equation $y = 1.157\,x - 0.0151$)



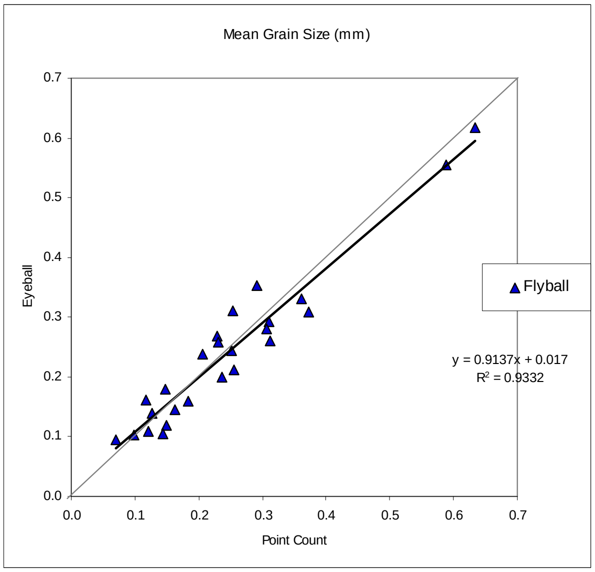


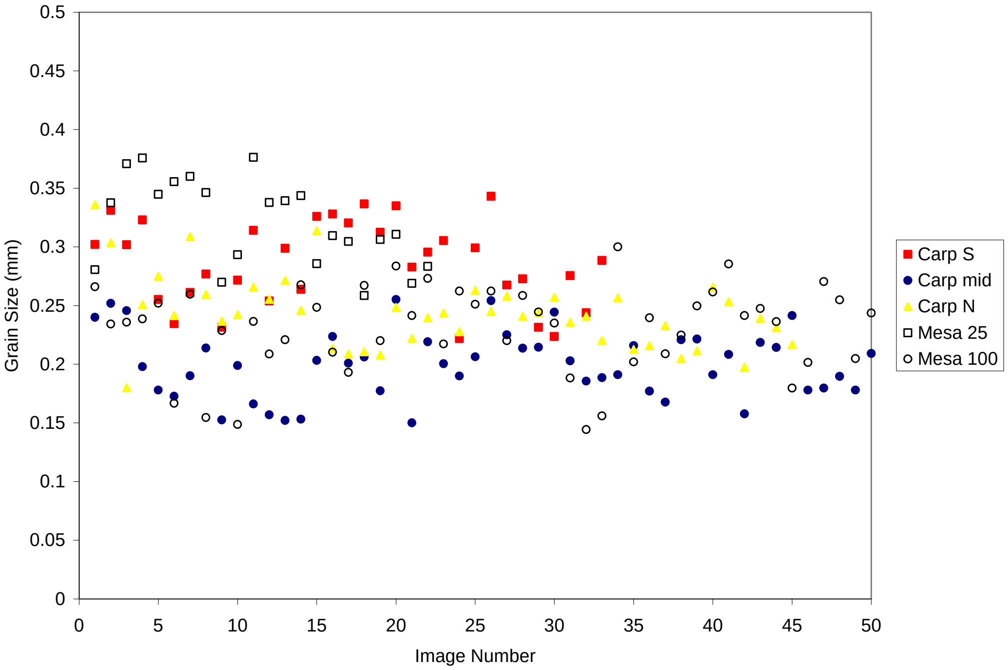
Figure 17. Top: Point counted Beachball© grain size result vs. autocorrelation result: original and corrected (for systematic sieving bias). Bottom: Flying Eyeball© point counted result vs. autocorrelation result.

was applied to Beachball© autocorrelation results (Figure 17). No correction was applied to the Flying Eyeball© results, since no systematic bias resulted (i.e. because point counted images, in addition to sieved sediments, were also used to produce the calibration matrix).

The autocorrelation method is limited by pixel resolution, especially when using the Flying Eyeball©: once grains become very small (e.g. as small as or smaller than two or three pixels) clusters or flocs of small grains begin to look (i.e. in terms of correlation) like larger grains. As a result, when nearshore grain size is less than 0.09 or 0.10 mm, the ability to accurately determine grain size by the autocorrelation method is diminished. Therefore, the finest grain sizes in the nearshore should only be regarded as an approximation.

While the autocorrelation method may not be able to resolve grain size at the finer-grained end of the scale, the autocorrelation method is definitely able to determine grain size of larger grains. In other words, large grains can be detected if they are present. Furthermore, the 0.10 mm limit in the nearshore is not a significant problem for this study because the aim of offshore sampling is to determine if beach compatible material exists, and from the following conclusions, suitable sediment for SBLC beaches is definitely coarser than 0.125 mm, making the Flying Eyeball© results adequate and this study applicable.

To analyze natural beach face variability on a small scale, 50 Beachball© images were taken within a square meter at 9 different locations throughout the cell during February 2007. Figure 18 shows that there can be considerable variation (grain



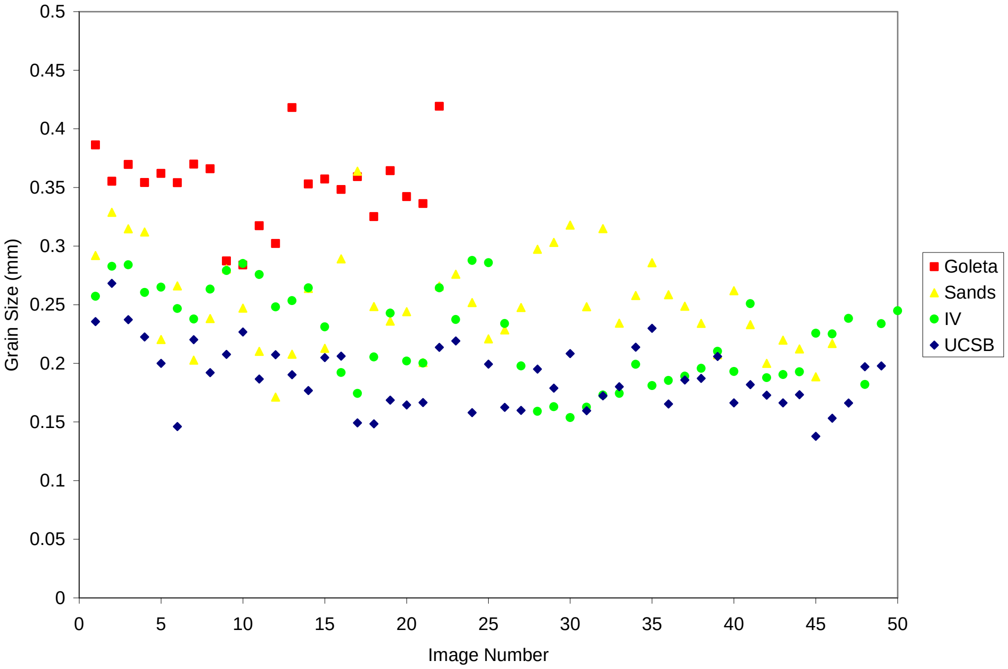


Figure 18. Mean grain size of ~50 Beachball© beach face images takes in a square meter February 2007. Top: Images from Carpinteria and the Santa Barbara Mesa. Bottom: Images from Isla Vista/Goleta.

size can vary by a factor of 2) within a small area. The results of this analysis suggest that in future work, at least 7 to 10 images should be taken at each site to converge on the ‘true’ mean.

Despite local variations, seasonal measurements from February 2007 were compared to the analysis of 50 images within a square meter, also taken February 2007, to determine how well the beach face was represented by kilometer sampling. The areas of intense sampling were either located 1 km (Carpinteria) or 2 km (Isla Vista/Goleta) apart and many seasonal measurements were in between. It was found that grain size did not vary significantly within a kilometer, at least not anymore than measurements within a square meter, unless there was a major change such as in coastal orientation (e.g. at Isla Vista). Furthermore, seasonal summer sampling shows even less variability along the beach compared to winter sampling; thus even with local variability, kilometer alongshore sampling appears to have worked well to represent summer grain size throughout the study area.

Results of the autocorrelation method were compared to grain size results from processing grab samples in a settling tube. Figure 19 demonstrates that the autocorrelation method works well, but only surface characteristics are captured. For example, grain size for some samples was determined by all three methods (i.e. autocorrelation, point counting, and settling velocity). In some cases (e.g. Sample A in Figure 19) the autocorrelation method appears to considerably overestimate grain size when compared to the grain size result as determined from settling velocity. However, after determining the same sample’s grain size from point counting (e.g.

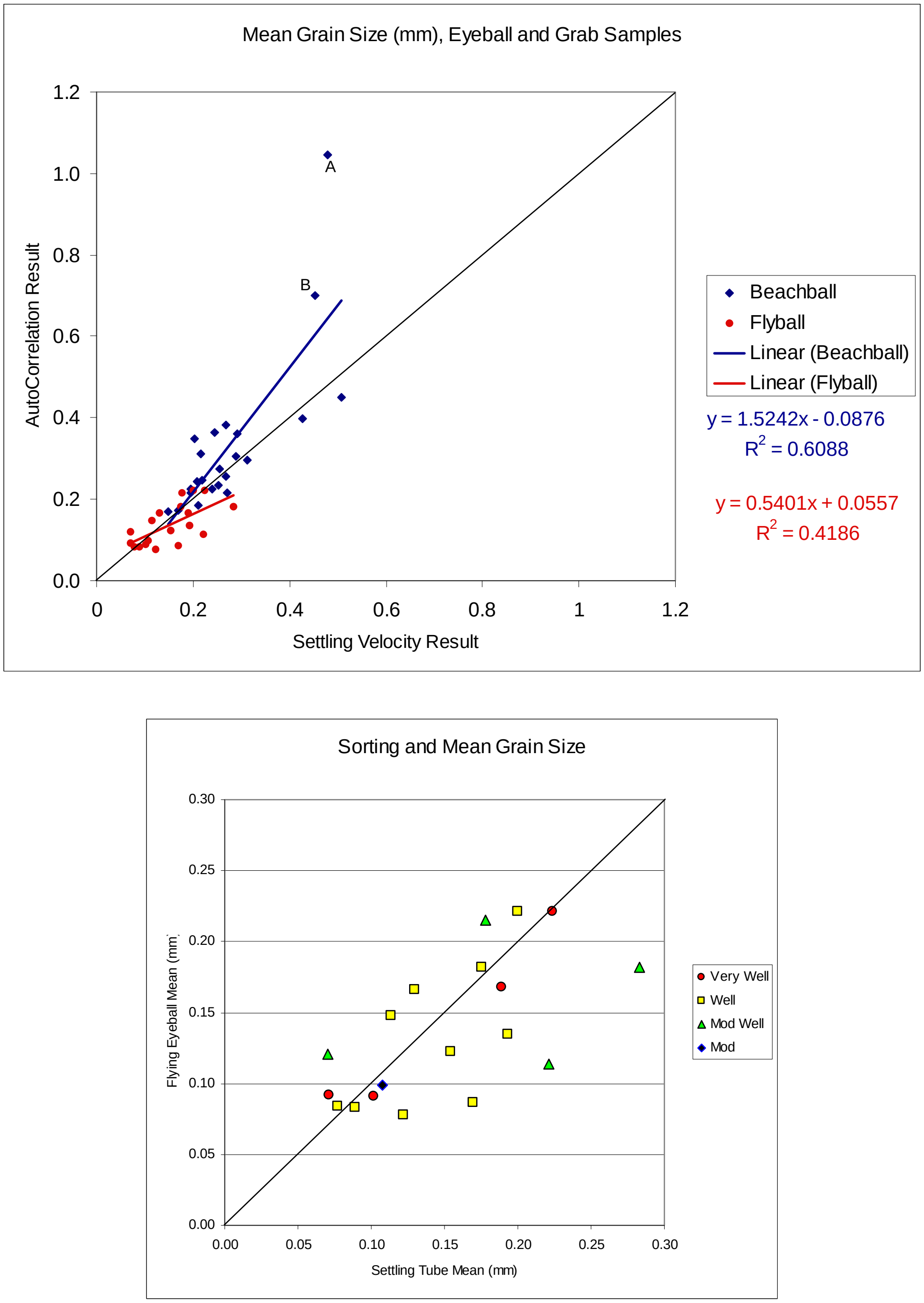


Figure 19. Top: Autocorrelation vs. settling tube results for both Beachball© and Flying Eyeball© samples. Bottom: Sorting and mean grain size: autocorrelation vs. settling tube results for Flying Eyeball© samples. Sorting was determined from settling tube results.

Sample A in Figure 17), it can be seen that the autocorrelation method did not significantly overestimate grain size. Rather the autocorrelation method only captured surface grain size. These results indicate that on the beach, there is a potential bias for sampling coarser surficial sediments. This may occur if fine sediments have been winnowed away or if a coarsening-upward sequence has developed.

In the nearshore, Figure 19 shows that more poorly sorted sediments were not as accurately portrayed by the autocorrelation method as the better sorted sediments. In addition, there seems to be a slight bias for surface sediments to be depicted finer by the Eyeball© method than the immediate subsurface layer as represented by grab samples. Consistent with rising sea level, this may be a result of recent fine sediment deposition. Alternately, fine sediments could have been winnowed or washed while bringing the grab sampler to the surface, resulting in grab samples appearing coarser than they actually were.

The Eyeball© cameras capture surface grain size well, as demonstrated by point counting, but the use of the cameras and the results of this study will be limited if sediments beneath the surface are not equivalent in size to those on the surface. However, grain size results determined from the Eyeball© cameras in this study have been compared to grab samples and cores of other studies (Noble Consultants 1989; Reid et al. 2006). From this analysis (see discussion), results indicate that surface and subsurface sediments are comparable in the offshore. In addition, future vibracoring, in cooperation with the USGS, is planned for further confirmation of these results.

IV. RESULTS

IV A. Eyeball Results

The mean grain size of 93 summer beach face samples taken from throughout the SBLC ranged from 0.15 mm to 0.42 mm (fine to medium-grained sand; Figure 20; Appendix II). The mean of one sample, just north of the Port Hueneme Harbor, was 0.58 mm, or coarse sand. The average of all (94) samples was 0.26 mm. In most cases, grab samples were very well sorted. Samples were also normally distributed, so mean and median values were essentially the same. Thus, beach samples are well represented by the mean. The finest sediment on the beach (d_{10}), varied from location to location, but followed the mean well (i.e. when the mean increased so did d_{10}). Very fine-grained sand did not remain on the beach in any significant amount (i.e. $>d_{10}$) anywhere throughout the cell (Figure 20).

Seasonal beach face samples were collected throughout the beaches of Isla Vista/Goleta, Carpinteria, and Ventura. Mean grain sizes of summer beach samples were smaller than winter beach samples throughout the high resolution study areas (Figure 21, Appendix II). Generally on average, in Goleta and Carpinteria, grain size fluctuated from medium sand to fine sand, while in Ventura grain size fluctuated from a coarser-grained medium sand to a finer-grained medium sand.

Throughout the cell, 318 nearshore locations (water depths less than 20 m) were examined, although some areas were cobble or bedrock reefs, which did not allow for grain size determination. Mean grain size was determined for about 100 samples at each water depth (5, 10, and 20 m). Grain size decreased moving from the

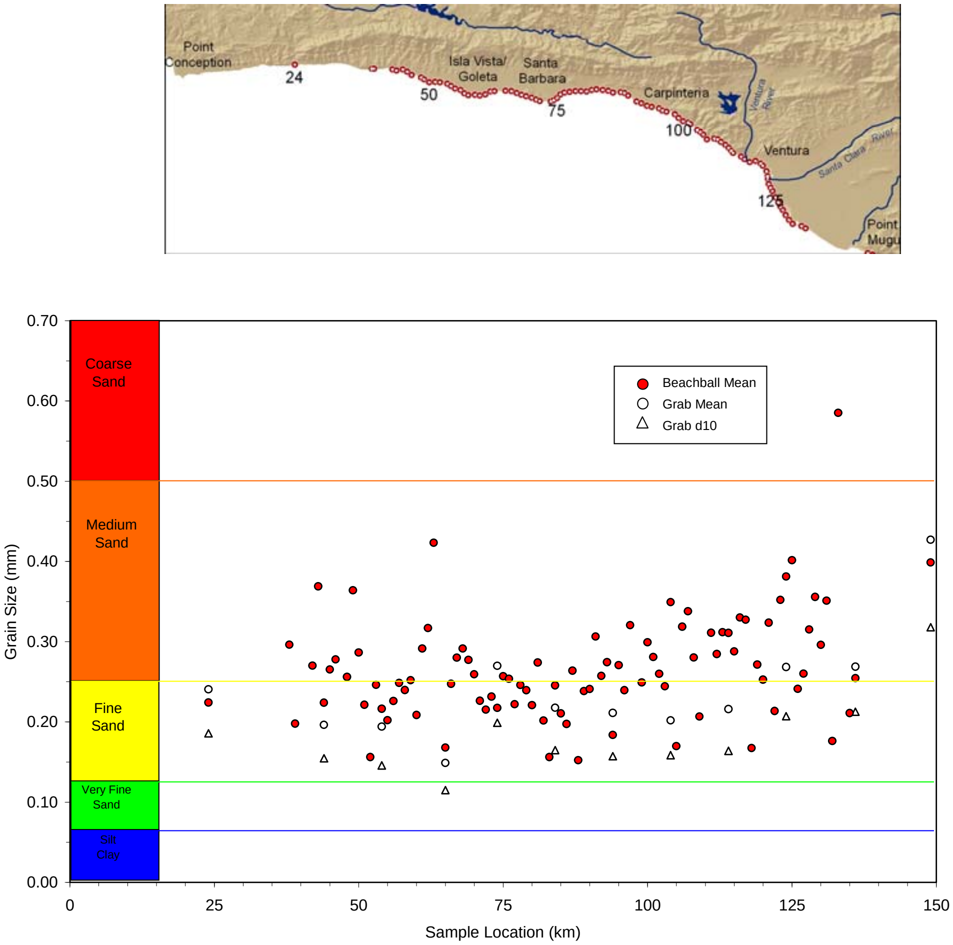


Figure 20. Top: Location of samples. Bottom: Beach face mean grain size (mm) and grab sample finest (d_{10}).

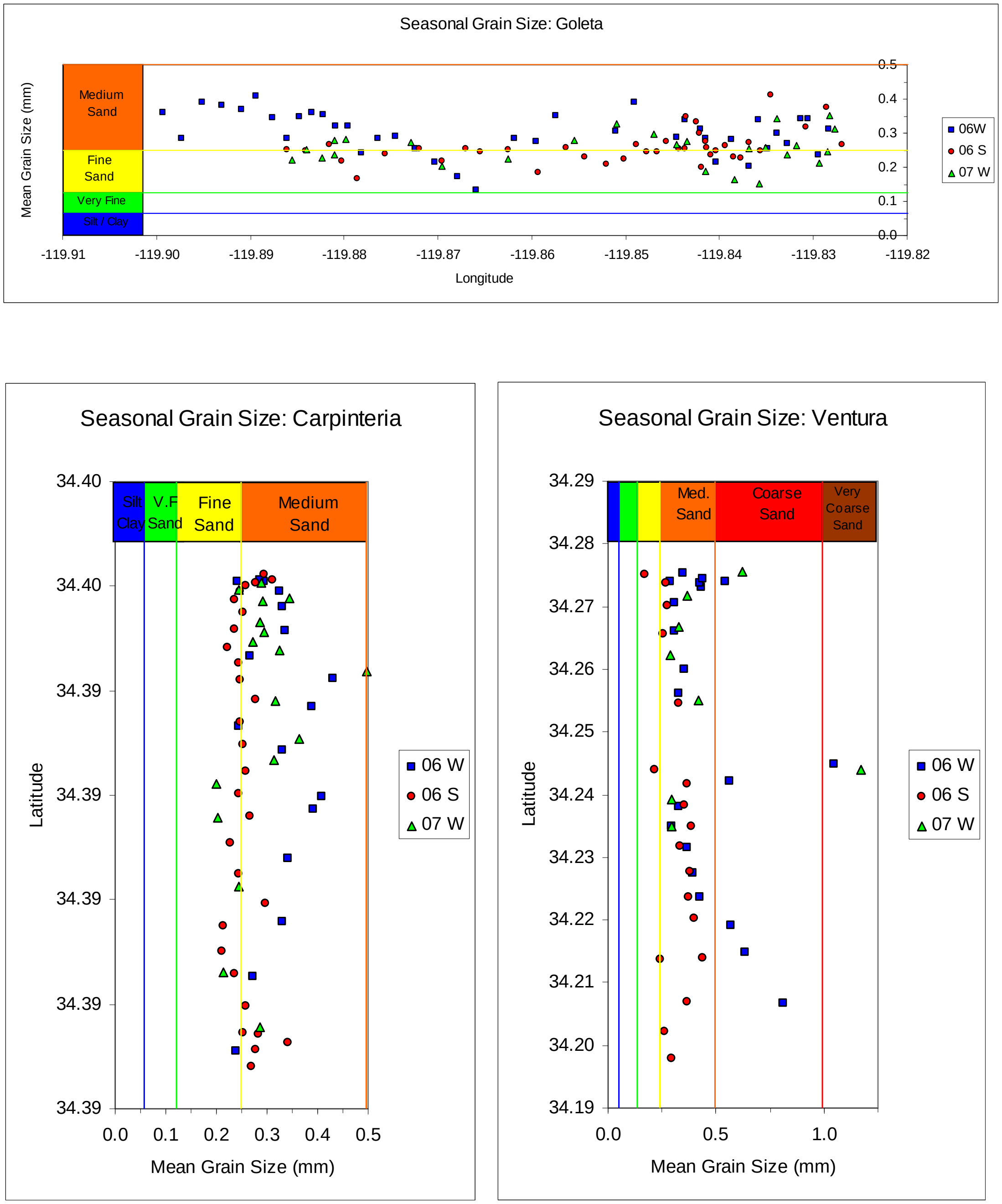


Figure 21. Seasonal beach face grain size (mm). Top: Goleta/Isla Vista. Left: Carpinteria. Right: Ventura.

beach offshore (Figure 22; Appendix II). Only 2% of all samples were medium sand, 28% were fine sand and 70% were very fine sand or smaller. The coarsest samples were found in shallow depths: 78% of all samples coarser than very fine sand were located in 5 m water depth. Only 10% of Flying Eyeball© samples in 10 or 20 m water depth (20 samples) were coarser than very fine sand. Some of these coarser, deep samples were located near major headlands, such as Point Conception and Point Mugu, near exposed reefs, such as west of Coal Oil Point in Isla Vista and Sand Point in Carpinteria, or offshore rivers and streams, such as Gaviota Creek and Rincon Creek. Samples coarser than very fine sand not located near headlands, were likely to be fine sand (92%) rather than medium or coarse sand (8%). Grab samples were mostly well sorted, but occasionally were very well sorted or moderately sorted.

Figure 23, a surficial sediment grain size map of the Santa Barbara Channel, was created with regional data from the usSEABED database (Reid 2006), beach and nearshore data from this study, and various nearshore cores collected by Noble Consultants (1989). The majority of offshore sediments are very fine-grained or smaller; relatively coarser sediments are mostly found only in the very nearshore and on the beach. A few locations, for example those along the northern edge of the channel, indicate coarser sediment-fine and medium sands-further offshore. However, these areas are represented by very few sediment samples (Figure 24), and as a result, this depiction of coarser sediment is only an artifact of the interpolation method.

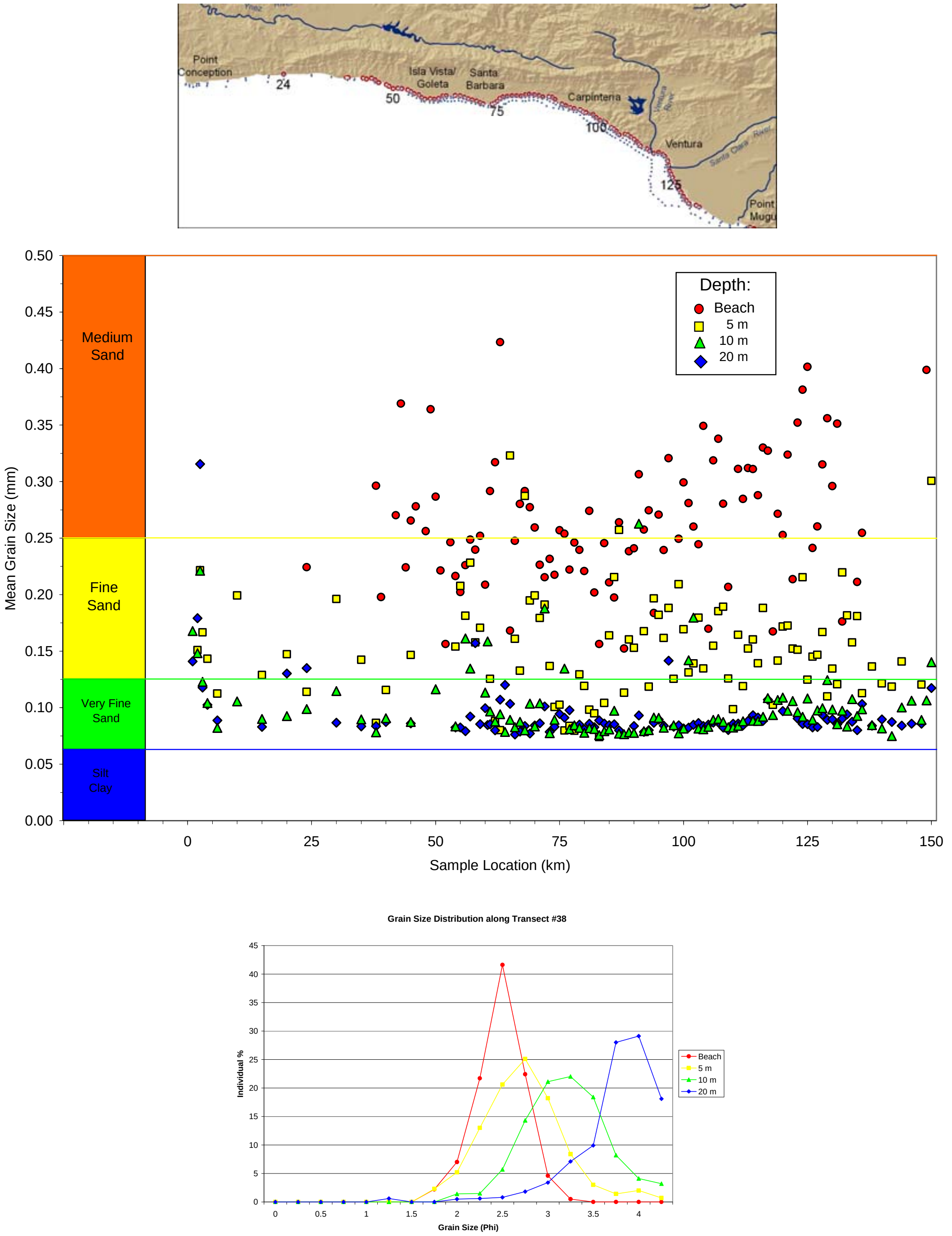


Figure 22. Top: Location of Samples. Middle: Beach face and nearshore (5, 10, and 20 m water depth) grain size (mm). Bottom: Grain size distribution (phi) along a nearshore transect (5, 10, and 20 m depth), and nearby beach. Mean of Beach = 0.20 mm; 5 m = 0.17 mm; 10m = 0.12 mm; 20 m = 0.07 mm.

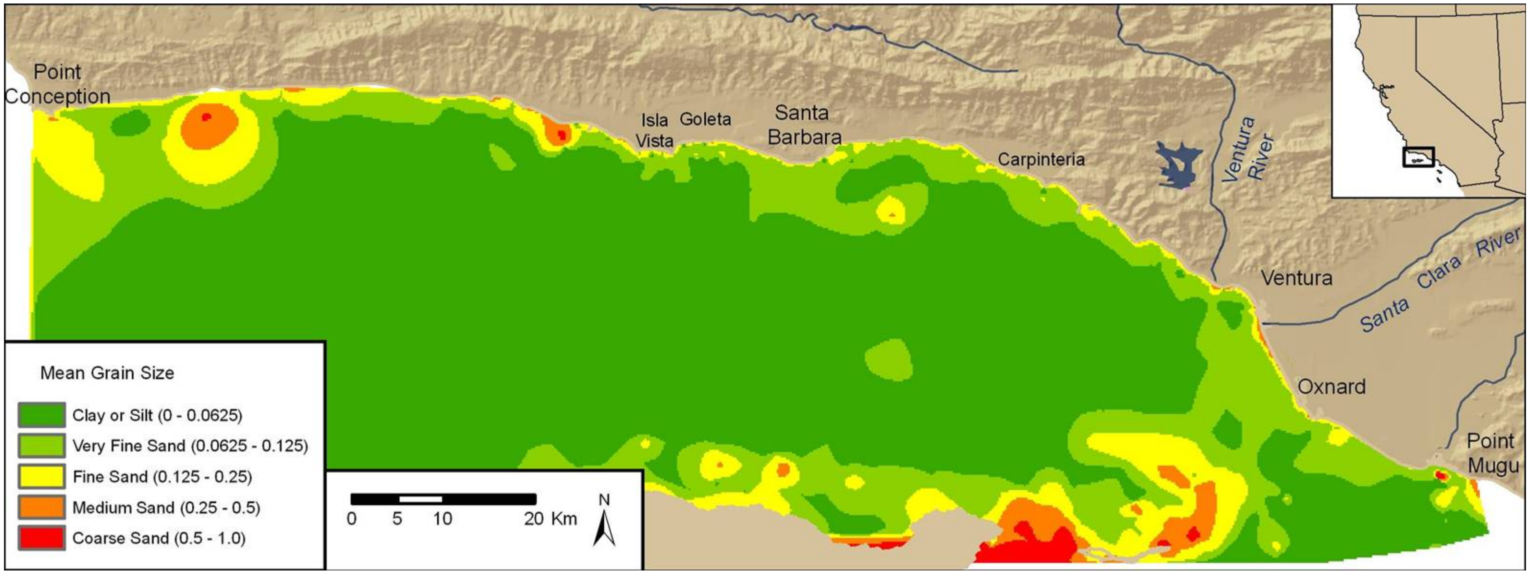


Figure 23. Surface sediment map, Santa Barbara Channel. Data from this study, usSEABED (Reid et al. 2006), and BEACON (Noble Consultants 1989).

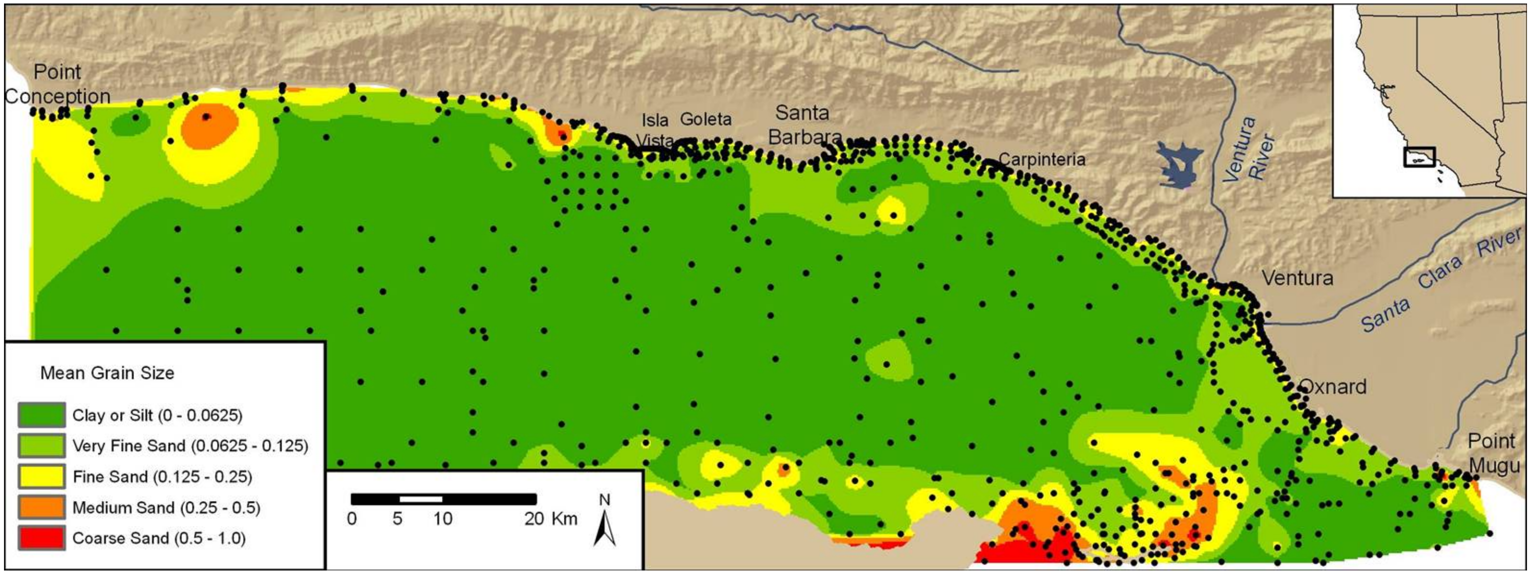


Figure 24. Surface sediment map and sample locations, Santa Barbara Channel. Data from this study, usSEABED (Reid et al. 2006), and BEACON (Noble Consultants 1989). Points are locations of samples used to interpolate map.

V. DISCUSSION

V A. Beach and Nearshore Grain Size

The majority of SBLC beach sediment (excluding cobble beaches) is fine to medium-grained sand, and as expected, the finest grained sediments, fine and very fine-grained sands, are found offshore (Figure 22, 23). Grab samples collected across a transect, further illustrate the gradual fining of sediment distributions from the beach offshore (Figure 22).

In the SBLC, sediments reach the coast and with time become sorted in the observed fashion (fining offshore) as a result of coastal processes acting on the sediment. Wind, waves and currents move sediment on, off, and along the shore. The location where a particular grain ends up is a function of its size, because its size (actually weight, which relates to size) is related to the amount of force needed to entrain and transport the grain. Coarser sediments for example, are not transported into deep waters because they are not easily entrained or kept in suspension. Instead they remain nearshore in high energy environments. Alternately, finer sediments are easily entrained, kept in suspension, and transported onshore by winds or offshore by waves until they reach calmer environments and settle out.

On the beach, grain size is a product of sediment supplied to the beach (e.g. from cliffs or streams), and the processes (e.g. including waves, wind, and currents) acting to sort, transport, and redistribute the sediment (Komar 1998). Grain size can coarsen alongshore, with increasing distance from the source, when finer sediments are preferentially eroded and winnowed offshore (Schalk 1938). Alternately, grain size can fine alongshore, with increasing distance from the source, as a result of selective sorting (i.e. as sediment is transported along a littoral cell, finer grains can be transported faster, out distancing coarser grains; Pettijohn and Ridge 1932; Best and Griggs 1991). Particle abrasion, occurring over thousands of years, can also fine sediments moving downdrift alongshore, within a littoral cell. Many factors can influence the alongshore variations in beach grain size, and in the complex coastal zone all processes likely factor to some degree. As a result, for the SBLC it is not possible to be specific and tease out whether a sediment source, differing wave energy, or selective sorting is primarily responsible for the observed grain size at a particular beach or any trends in alongshore grain size. Instead grain size variations appear to be a complicated result of all these processes.

Seasonal variation of beach grain size can be attributed to the differences in seasonal processes acting on the beach. Inman (1953) showed that in La Jolla, CA seasonal winter storms transport sediment offshore, leaving a narrower, coarse-grained winter beach. In summer, during calmer conditions, offshore sediments are transported back onto the beach, building a finer-grained beach. Wave (Figure 9) and grain size data (Figure 21) from this study indicate that seasonal differences in wave energy are also likely responsible for seasonal variations of sediment grain size in the SBLC.

V B. Suitable Sediment for the SBLC

Seasonal measurements in the high resolution areas have shown that beach sediment is finer in the summer than in the winter. Thus, summer beach grain size distributions show the finest sediment that remains on the beach. In the SBLC, an examination of the grain size distribution of summer grab samples indicates that nowhere in the cell does the sand/silt break (0.0625 mm) define what grain sizes compose the beach (Figure 20). Best and Griggs (1991) defined d_{10} (where 90% of the sediment distribution is coarser than d_{10}) as the smallest grain size that significantly remains on the beach, and termed this the littoral cutoff diameter (LCD). Runyan and Griggs (2003) previously determined that the LCD for the SBLC was about 0.125 mm. Results from this study agree; 0.125 mm appears to be a reasonable estimate for the littoral cell.

The LCD can provide an estimate of what grain sizes will remain on a beach when a beach is nourished. If a beach is at least partially nourished with sand finer than the LCD, it is expected that with time, these finer-grained sediments will be transported offshore and be lost from the beach. If the sand was not stable on the beach under natural conditions, there is no reason to believe that nourished sand of that same grain size should remain. The LCD addresses the portion of sediments that are unstable and thus are more readily transported offshore. This is important because the quantity and speed of sediment movement offshore affects the longevity of a nourishment project and thus has implications for nourishment project justifications, especially when examining costs vs. benefits.

Although a good LCD estimate for the SBLC is 0.125 mm, results from the present study indicate that a single LCD value cannot accurately define what remains on all beaches throughout the entire 149 km cell. As a result, when considering nourishment for a specific beach and using the LCD to predict the smallest grains that will remain on the beach, the appropriate cutoff diameter specific to that beach should be used. In general terms, when assessing potential offshore sand sources for the cell, the boundary between fine sand and very fine sand (i.e. 0.125 mm) can be used. This ensures that no potentially suitable offshore sediments will be overlooked.

However, using the LCD to determine what sediment a beach should be nourished with may present an overly optimistic outlook. Following CEM general guidelines, all beaches of the SBLC must be nourished with sediment having a mean diameter of at least 0.14 mm (Figure 20; Table 1). However, this again would be a very conservative estimate for most beaches: 91% of beaches sampled would be recommended by CEM standards to be nourished with sediments having a mean diameter of at least 0.18 mm, or 81% having a mean diameter of 0.20 mm. The best option, however is to nourish beaches with sediment that is at least the same, or coarser than the native mean grain size. On average, suitable sediment would therefore have a mean grain size of 0.26 mm (as this was the average grain size for the entire cell).

V C. Coarse Sediments and Potential Borrow Areas

As a result of economic and technological dredging limitations, suitable sediment must be found in water depths of at least 5 m but not more than 30 m. In some areas of the SBLC, offshore sources may need to be at water depths greater than 5 m so that sediments within the zone of active littoral transport are not dredged.

Overall, the coarsest offshore sediments exist in an extremely narrow zone close to shore (Figure 25). These fine and medium-grained sands are likely an active part of the littoral drift system and anchor the submarine beach profile. As a result these coarser, shallow sediments should only be considered sources for beach nourishment with a thorough evaluation of the coastal impact. This includes sediment within 5 m and other deeper areas affected by higher energy.

The coarsest offshore sediments in water depths greater than 5 m are found at only a few locations throughout the cell (Figure 26, 27). Coarser sediments are commonly found near major headlands, such as Point Conception and Point Mugu, as a result of the steeper nearshore slopes and/or higher energy environment. As a result of additional energy focused onto the headland and because these sediments are located close to shore (e.g. within ¾ of a km at Point Conception), these deep, coarser sediments may still be part of the active littoral drift system, within the depth of closure. However, more information is needed. If it is confirmed that these deposits are part of the active littoral system, then they should not be dredged. However, if they are not, then thickness of the deposit and the economics of dredging these areas should be evaluated-keeping in mind that these sediments are located far from populated beaches needing nourishment.

If Point Conception is not considered too far to serve as a potential borrow area, then one other site should be examined: an offshore geology map indicates a large sand deposit just offshore of Point Conception (Greene and Kennedy 1989). The sediment here could be a final sink for the Santa Maria Littoral Cell (i.e. a debated

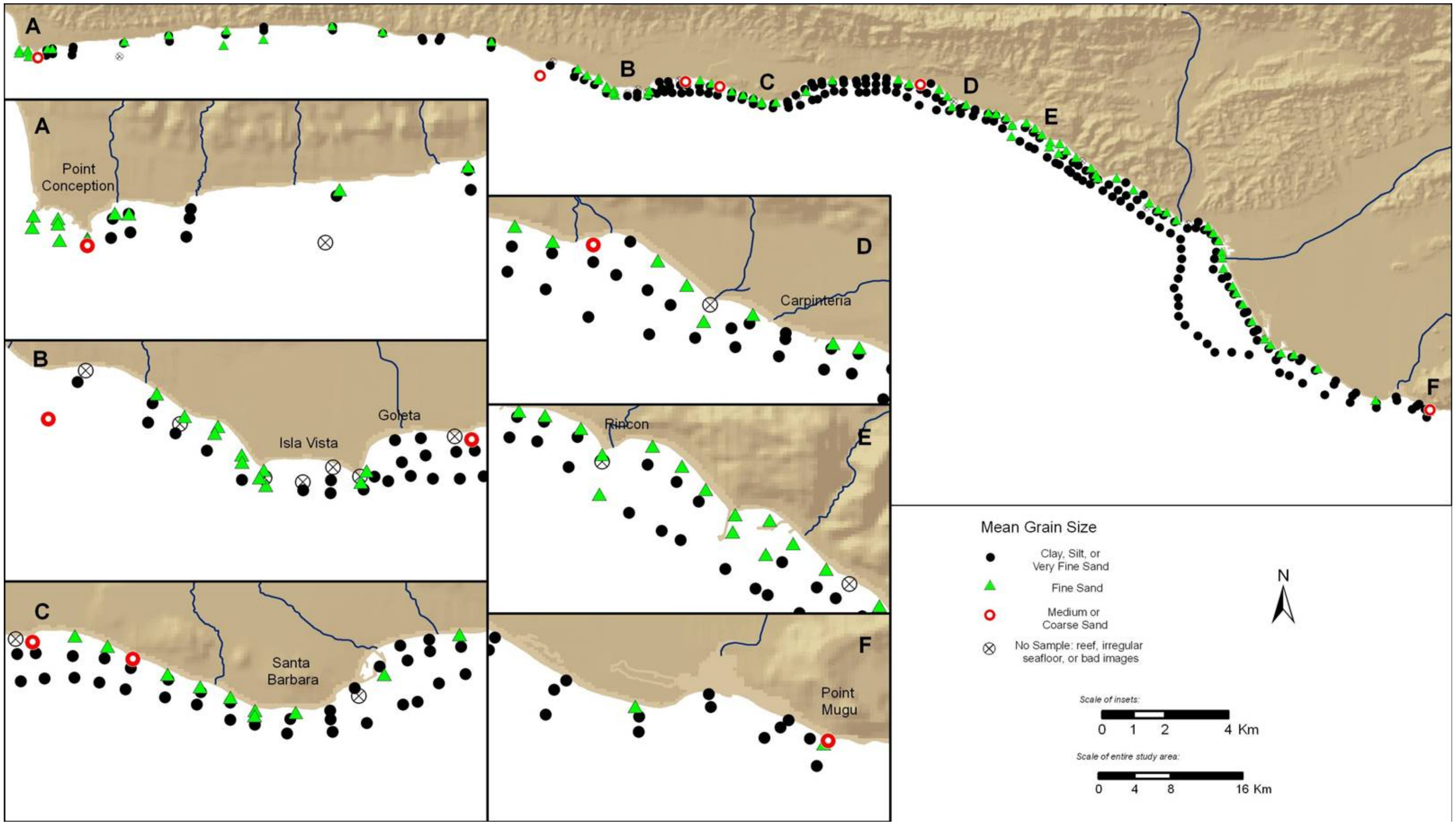


Figure 25. Mean grain size of nearshore (5, 10, 20 m depth) samples.

cell extending from the Santa Maria River to Point Conception), or if there is a single continuous cell around Point Conception, then this deposit could be a partial sink within the SBLC (Patsch and Griggs 2007). Either way, if this deposit exists, it is likely to have accumulated as a result of the longshore current deflecting sediments offshore as it encounters the headland. Further investigation of the area is recommended: the areal extent, the thickness and grain size data of the deposit should be obtained.

Samples coarser than very fine-grained sand found deeper than 5 m were examined with respect to distance from kelp beds, a proxy for exposed bedrock outcrops on the seafloor (Figure 26; Fischer 1983; California Department of Fish and Game 2006). Sediments found near rocky outcrops on the seafloor are likely to be composed of coarser broken rock fragments, which have accumulated in pockets. These deposits are presumably very thin and therefore not viable for dredging.

The samples west of Coal Oil Point and offshore of Sand Point in Carpinteria are in very close proximity to the mapped kelp beds (Figure 26). In addition it was noted in the cruise field notes that the Flying Eyeball© had to be navigated through kelp to reach the seafloor at these locations. As a result, these coarser deposits are most likely only thin deposits within bedrock pockets and are therefore not considered suitable borrow areas for beach nourishment.

For a few locations, south of Coal Oil Point, Naples, and the Santa Barbara Mesa, for example, it is not clear whether coarser samples are related to the nearby reefs (Figure 26). All three of these samples were in close proximity to kelp;

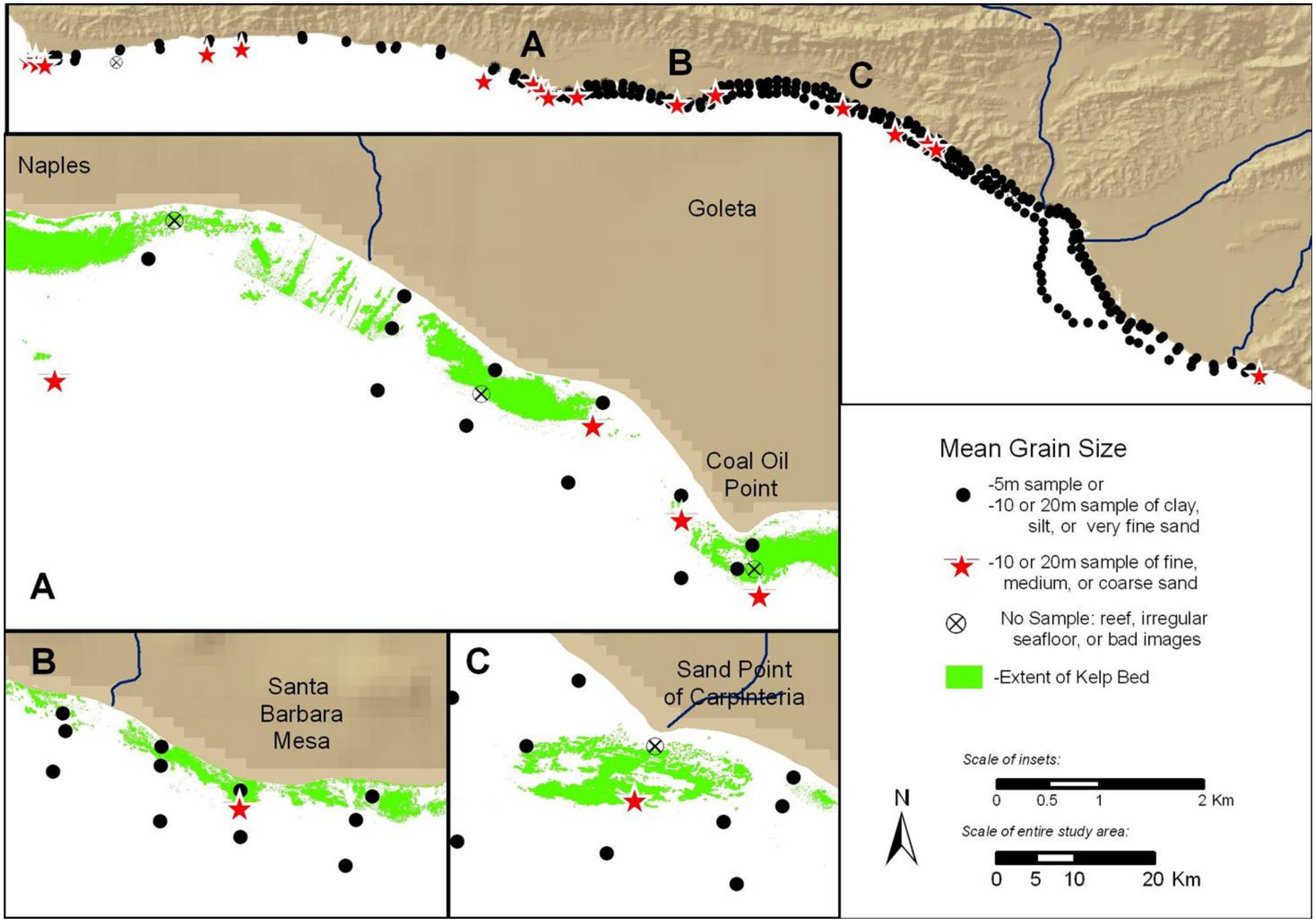


Figure 26. Flying Eyeball© samples and coarser sediments near kelp, a proxy for exposed bedrock. Sediments coarser than very fine sand found at depths deeper than 5m are starred.

however, the isopach maps of Fischer et al (1983) indicate that the unconsolidated sediment is at least 4 m thick at each of these locations.

Coarser samples deeper than 5 m are sometimes found offshore rivers and streams, such as at Gaviota, Rincon Point, and Mussel Shoals (Figure 27). If these deposits are not relict beaches, than they may be associated with the stream as either part of a paleostream deposit or as a result of a more recent hyperpycnal flow (Fischer 1983; Warrick and Milliman 2003). If the deposit is related to an old stream channel cut during a previous lower sea level, it would be expected to contain coarser sands and gravels, which may or may not be suitable for nourishment. Grain textures, such as shape and roundness, and characteristics such as sorting and layering of grain sizes within the deposit, should be thoroughly examined to determine if sediments are compatible with the beach. In addition, it should be confirmed whether sediment thickness is sufficient in these areas to provide significant volumes of sand. The isopach maps of Fischer et al (1983) indicate adequately thick unconsolidated sediments at Gaviota, Rincon Point, and Mussel Shoals. However, while these samples are not located within the present-day kelp cover, they are located within the historic kelp extent as mapped by Fischer et al. (1983).

Although coarser sediments were discussed above, these sediments may not be suitable sources for nourishment as only 4 samples are coarser than 0.20 mm (2 near Pt. Conception, 1 near Naples, and 1 near Sand Point in Carpinteria). Of the coarsest samples, there are also concerns that these sites are either within the depth of closure (at Pt. Conception) or are only part of a thin deposit, near exposed bedrock (at

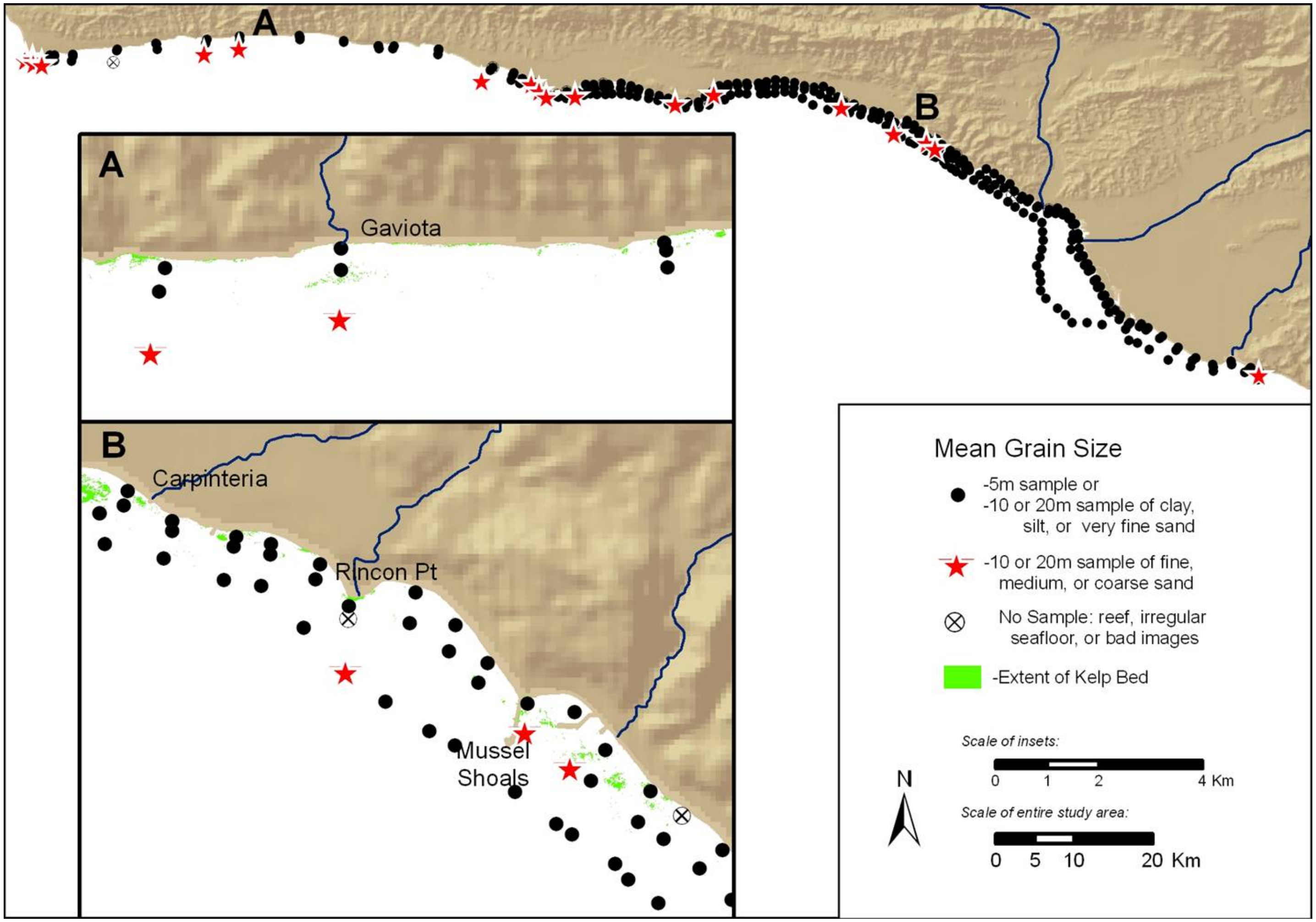


Figure 27. Flying Eyeball© samples and coarser sediments offshore streams. Sediments coarser than very fine sand found at depths deeper than 5m are starred.

Naples and Sand Point). If this is true for any sample, than that location should be considered an inappropriate location for a borrow area.

V D. Previous Potential Borrow Sites and This Study

Offshore sediments have been previously examined to determine potential borrow sites for beach nourishment. Most recently, Noble Consultants (1989) examined potential borrow areas offshore Goleta, Santa Barbara, Carpinteria, and Ventura/Oxnard.

The identified potential borrow site offshore Goleta is thought to be a relict stream channel deposit and has been estimated to contain about 18 million m^3 of sand (Noble Consultants 1989). Sediment samples taken from cores from within the deposit average 0.14 mm in mean grain size (Figure 28; Noble Consultants 1989). Flying Eyeball© samples from within the proposed borrow site ranged from 0.10 mm to 0.12 mm in mean diameter. Adjacent samples were calculated to be about 0.08 mm. UsSEABED surface samples also indicate very fine-grained sands and silts surrounding and within the deposit (Reid et al. 2006). Results from this study and reanalysis of previous grain size results indicate that the deposit is much finer than what is considered suitable for beach placement.

Flying Eyeball© surface samples offshore of the city of Santa Barbara estimate surface sediments to be about 0.08 mm in mean diameter (Figure 29). Sediment from cores indicate very fine-grained sand with silt to silty-clay at depth in a western borrow area, and fine to very fine sand with some medium sand at depth in two eastern borrow areas (Noble Consultants 1989). Together the deposits were

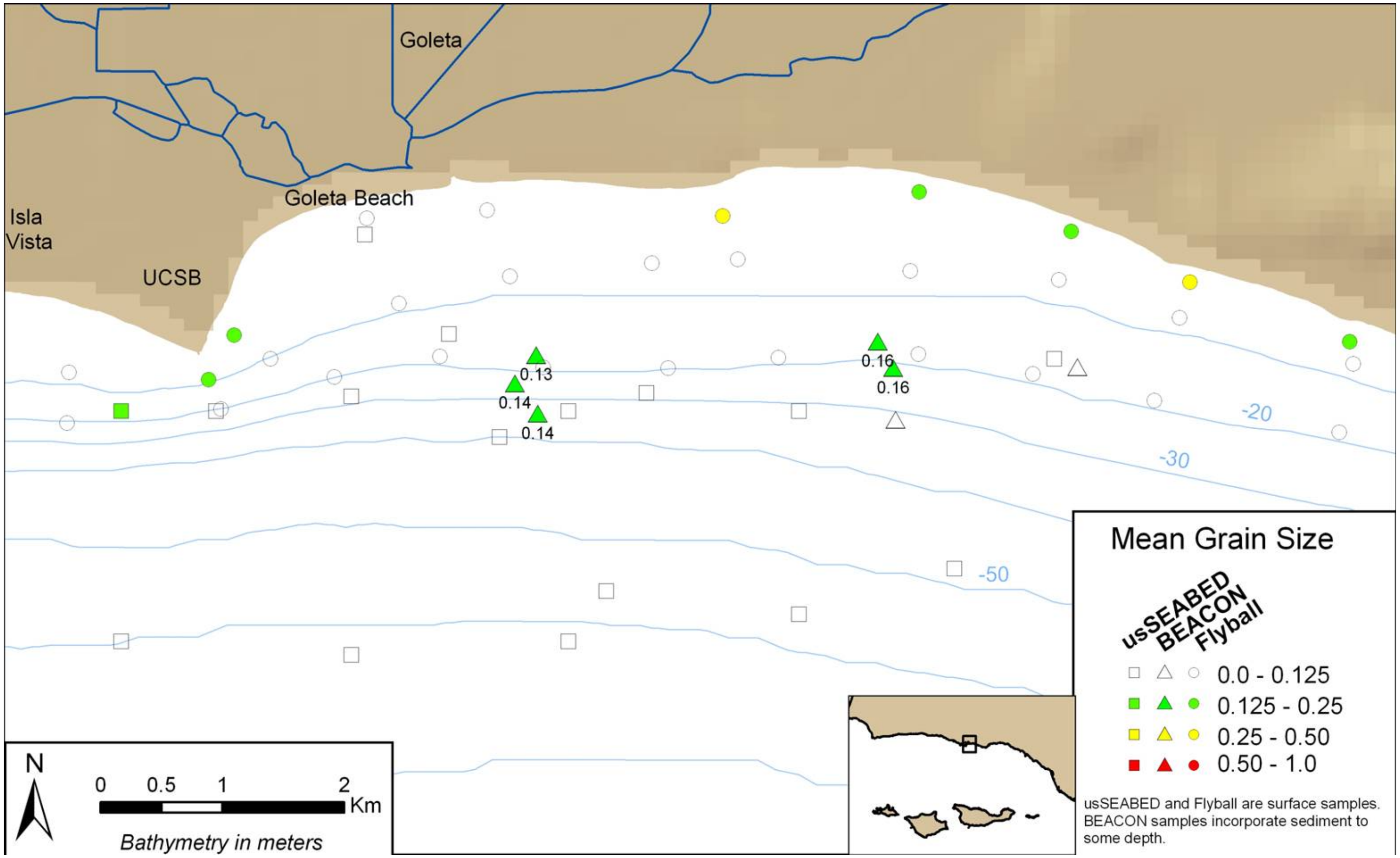


Figure 28. Samples offshore Goleta. Data from this study, usSEABED(Reid et al. 2006) and BEACON (Noble Consultants 1989).

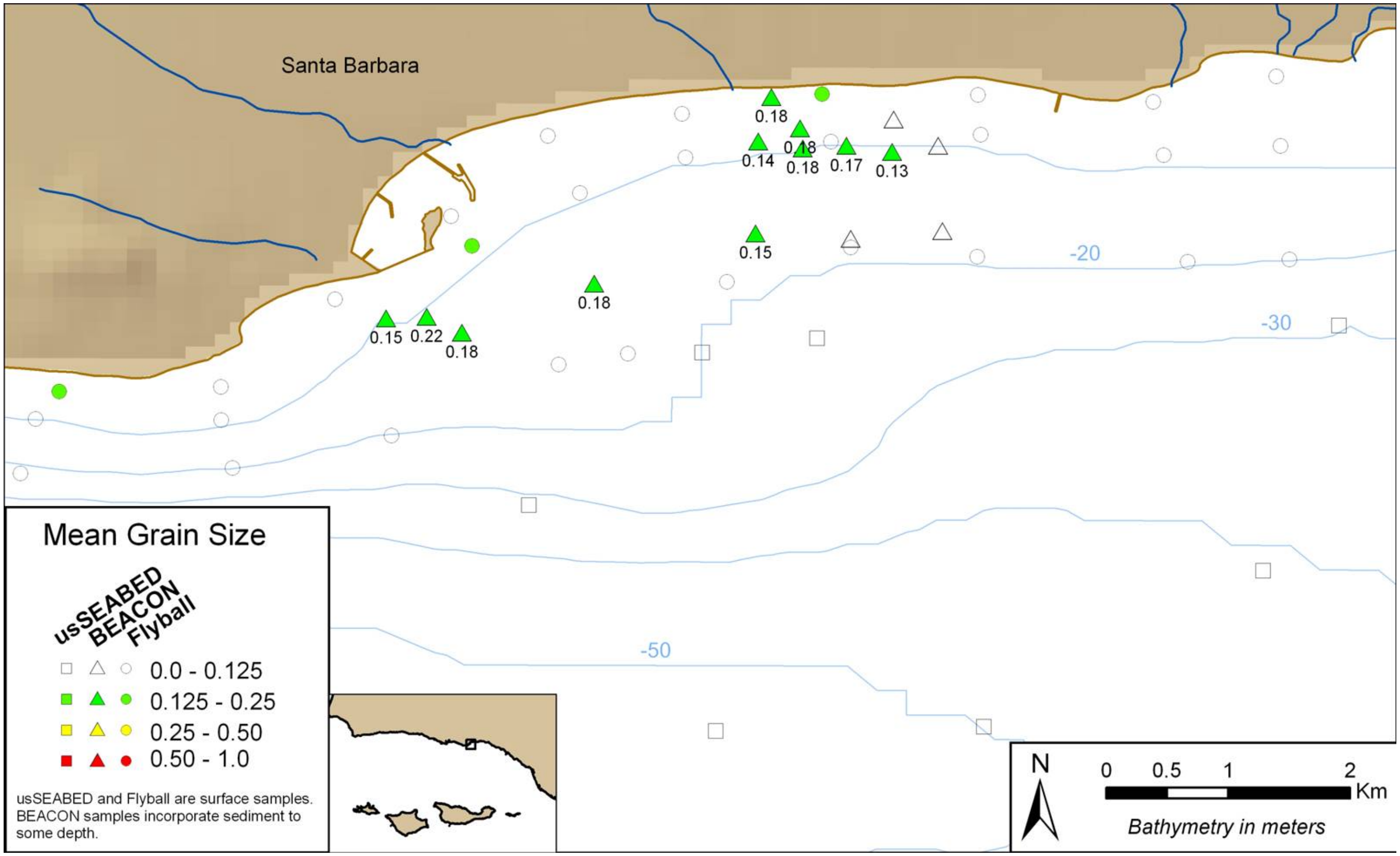


Figure 29. Samples offshore Santa Barbara. Data from this study, usSEABED(Reid et al. 2006) and BEACON (Noble Consultants 1989).

estimated to contain almost 18 million m^3 of sand (Noble Consultants 1989). Future coring should further investigate this area, as it contained some of the coarsest sediment identified in the offshore.

Potential offshore deposits in the Carpinteria area were estimated to contain about 13 million m^3 of sediment (Noble Consultants 1989). However, the same study reported that there was no strong indication of sediment with a suitable grain size; cores from the potential borrow sites contained primarily very fine sand (Figure 30; Noble Consultants 1989). Flying eyeball© surface samples agree, and in the Carpinteria area ranged from 0.07 mm to 0.09 mm. In addition one sample had a mean diameter of 0.23 mm, but is believed to be adjacent to exposed bedrock, thus implying thin sediment cover, and is therefore probably not suitable for a borrow area.

Offshore from the cities of Ventura and Oxnard, (from the Ventura River to the Hueneme Canyon), the seafloor consists of a very thick layer of unconsolidated sediments and is considered to be a very large potential borrow area containing over 191 million m^3 for nourishment (Noble Consultants 1989). However, samples from this survey, Noble Consultants (1989), and others found in the usSEABED database (2006) all identify very fine-grained sediment within the proposed borrow site (Figure 31). Mean offshore grain size ranges from 0.07 to 0.11 mm, so the quality of the deposit is highly questionable and probably unsuitable for beach nourishment.

Results indicate that offshore sediments throughout previously identified borrow areas are primarily fine to very fine-grained sands. Beach sands throughout

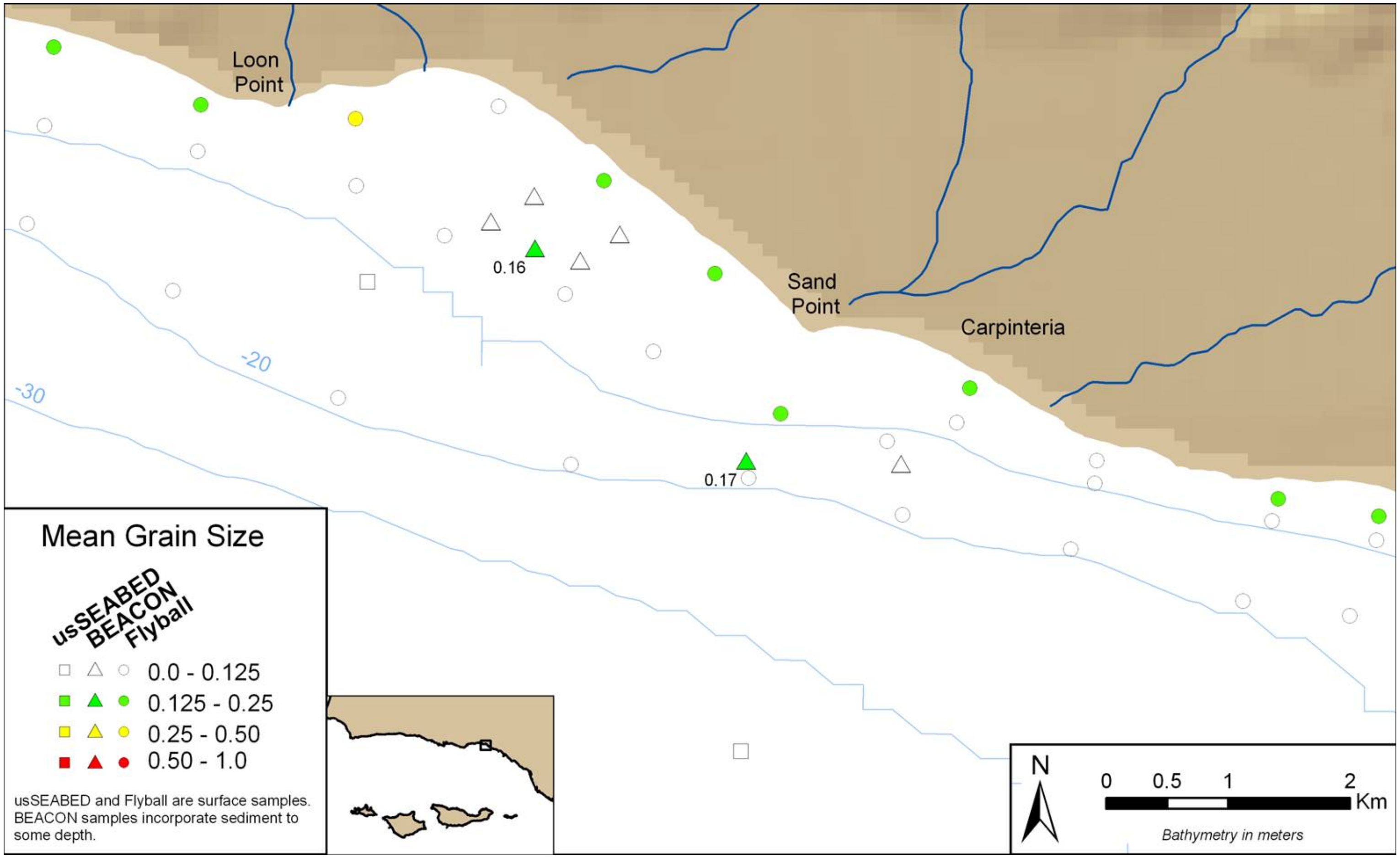


Figure 30. Samples offshore Carpinteria. Data from this study, usSEABED(Reid et al. 2006) and BEACON (Noble Consultants 1989).

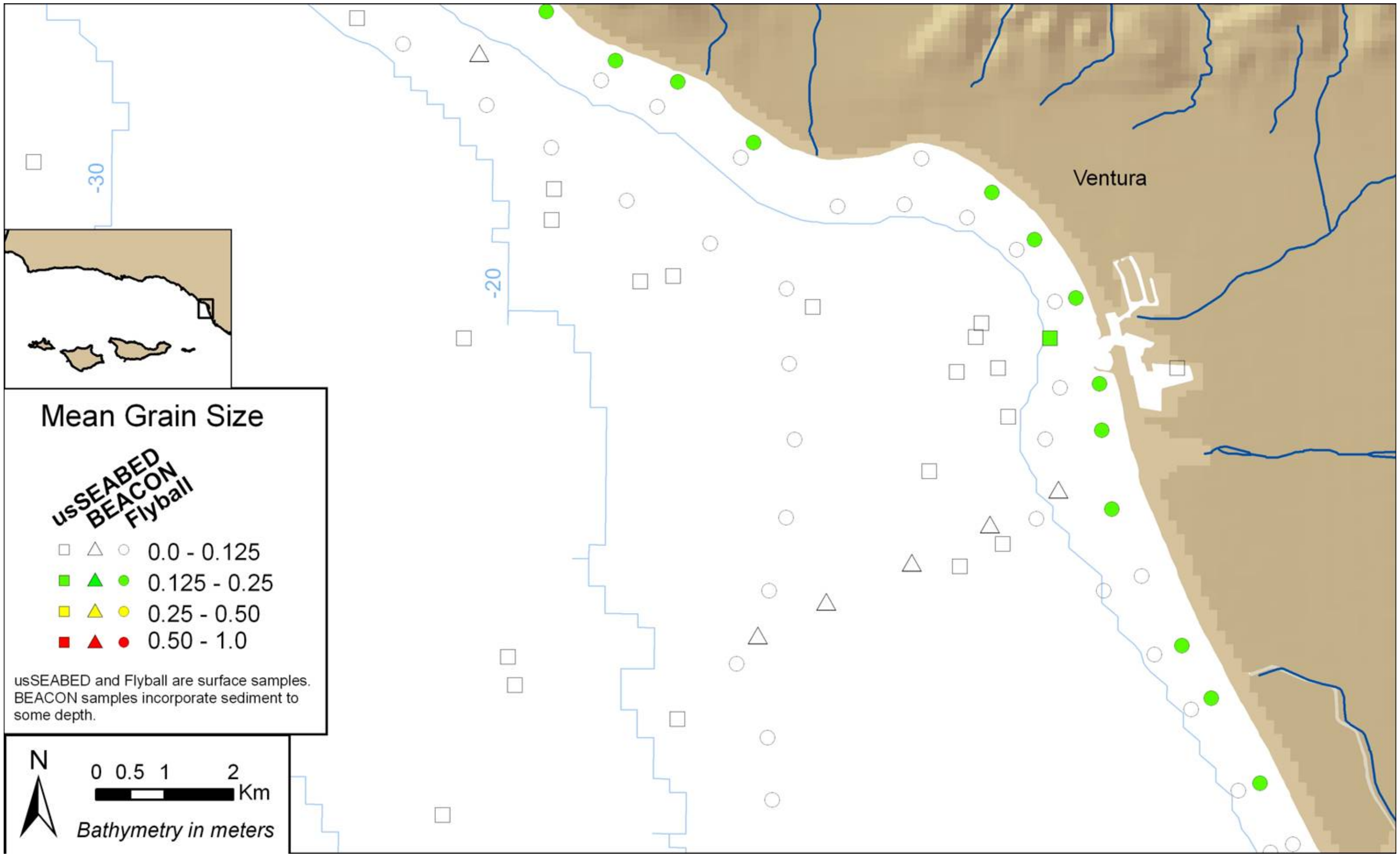


Figure 31. Samples offshore Ventura. Data from this study, usSEABED(Reid et al. 2006) and BEACON (Noble Consultants 1989).

the cell are coarser: mean grain size was generally medium sand, but sometimes fine sand (i.e. a coarser fine sand). In addition, in most cases the finest sand to remain on the beach (i.e. the LCD or d_{10}) was definitely coarser than very fine-grained sand. As a result, if these offshore sediments are used to nourish SBLC beaches, a significant portion can be expected to be easily lost offshore. In addition, to ensure a successful project, a large overfill ratio would have to be used to compensate for nourishing with finer sediments. Furthermore, biological impacts of nourishing with fine sediment will also have to be investigated and considered. So in addition to the risks involved with nourishing with finer sediments, coastal managers will have to decide whether nourishment projects, which will have a large overfill ratio and thus large costs, are even economically justifiable.

VI. CONCLUSION

The Eyeball© cameras provide a rapid way to determine the grain size of many surface sediments throughout a very large beach and offshore area. Overall, nearshore surface sediments in the SBLC are generally too fine-grained and incompatible for beach nourishment projects. The coarsest offshore sediments are found in 5 m water depth, most likely within the depth of closure or active seasonal offshore/onshore transport. Deeper offshore sediments are mostly very fine-grained sands or even finer. Some coarser deposits exist in deeper water, for example offshore Naples, Coal Oil Point, the Santa Barbara Mesa, and Carpinteria, but it is unclear whether they are part of a thick deposit of suitable nourishment material, or simply a thin, coarser deposit within bedrock pockets. Offshore Rincon Point-Mussel Shoals and Gaviota, relatively coarser sediments were found; these sites should be further investigated.

Of the previously identified potential borrow sites, only the deposit near the city of Santa Barbara indicates potential beach compatible sand. Together with previously collected cores, this current analysis confirms that coarser sediments suitable for beach nourishment do not exist in large quantities along the previously identified potential borrow areas offshore Goleta and Carpinteria, or the large deposit offshore Ventura and Oxnard.

Although it is possible that coarser sediments may exist in the subsurface, the mean grain sizes of samples from sediment cores agreed well with surficial samples and surficial Eyeball© analysis, indicating that surface and subsurface sediments are comparable. Finally, the fact that most of surficial sediments examined are finer-grained than beach sediments, indicates that very little of the offshore sediment within the SBLC are suitable for nourishment.

APPENDIX I

Matlab® scripts used to process Eyeball© images, including:
pProcessFly.m
pCalibration.m
pAutoCorr.m
pShowimage.m

Matlab® scripts used to create Calibration Matrix, including:
%cBatchCreate.m
%CreateCalibration.m

```
%pProcessFly.m
%used to batch run images.

clear all
close all

InputFileID = fopen ('filestorun.txt','rt');  %opens txt file for reading
OutputFID = fopen ('grainsizeout.txt','at');  %appends data to end of list!
OutputFID2 = fopen ('grainsizeave.txt','at'); %appends to file list
OutputFID3 = fopen ('grainsizeste.txt','at'); %appends to file list

FilesToRun=importdata('filestorun.txt');  %loads data in text file
FilesToRun=char(FilesToRun);

NumberOfFiles=length(FilesToRun(:,1));  %reads length of file list to set loop

lastsite = 's999_99_99';     %initialize fake last site
sitesize = [ 999 ] ;

pCalibrationNew;        %Read calibration data

for i=1:NumberOfFiles;                  %loop through all images

   FileName=FilesToRun(i,:);          %image to process

   ImageData=imread(FileName);         %load image data
   [M,N] = size(FileName);
   data=ImageData;
   FileName  % Write image name in command window.

   pAutoCorr; % Calculate mean grain size.

   pShowImage;

   %use image?
   UseImage=input('Enter "1" to use this image or "0" to skip:');
   %UseImage=1;

   %check to see if it is the same as the last site
   %if it is not then avg the last sites images

     if UseImage==0
       fprintf(OutputFID, FileName);
```

```
    fprintf(OutputFID, '\t  %4.4f' , GrainSizeInMM);%fprintf(OutputFID, ' mm');
   fprintf(OutputFID, '\t ERROR IMAGE NOT USED');
  GrainSizeInMM=0;
end

fprintf(OutputFID, FileName);
fprintf(OutputFID, '\t  %4.4f' , GrainSizeInMM);%fprintf(OutputFID, ' mm');
fprintf(OutputFID, '\n');

%if they are differnt sites then avg last site and print that
if strcmp(lastsite(1:7), FileName(1:7))==0

      if exist('imagesused')
       numtoavg = size(sitesize);
       total = sum(sitesize,1);
       siteavg = total / numtoavg(1);

       %output results
       %output results % print site then depth

       fprintf(OutputFID3, imagesused(1,2:4));
       fprintf(OutputFID3, '\t');
       fprintf(OutputFID3, imagesused(1,6:7));
       fprintf(OutputFID3, '\t');
       fprintf(OutputFID3, ' %4.4f' , siteavg );
       fprintf(OutputFID3, '\n');

       %output results % print site then depth
       fprintf(OutputFID2, 'Site: \t');
       fprintf(OutputFID2, imagesused(1,2:4));
       fprintf(OutputFID2, '\t \t \t');
       fprintf(OutputFID2, ' AVG = \t');
       fprintf(OutputFID2, ' %4.4f' , siteavg );
       fprintf(OutputFID2, '\n');
       fprintf(OutputFID2, 'Images Used: \n');

       %print image name then size
       for j=1:numtoavg

          fprintf(OutputFID2, imagesused(j,2:4));
          fprintf(OutputFID2, '\t');
          fprintf(OutputFID2, imagesused(j,6:7));
          fprintf(OutputFID2, '\t');
```

```
                fprintf(OutputFID2, imagesused(j,9:10));
                fprintf(OutputFID2, '\t');
                fprintf(OutputFID2, '%4.4f' ,sitesize(j) );
                fprintf(OutputFID2, '\n');
            end

            fprintf(OutputFID2, '\n');

            %start site for new site
             clear sitesize;
             clear imagesused;
         end
    end

    %if you are using image, then enter it into the matrix
     if UseImage==1;
            if exist('imagesused')
                sitesize = [ sitesize ; GrainSizeInMM ];
                imagesused = [imagesused ; FileName(1:10)];
            else
                sitesize = [GrainSizeInMM ];
                imagesused = [ FileName(1:10)];
            end
     end

   lastsite = FileName;
end
   fclose all
```

```
%pCalibration.m  Use this one for FLYING EYEBALL
%about Calibration Matrix below:
% Each row gives data for a single offset, from 1 pixel in the first row to 20 pixels in
        the last row.
% First and last column (ones and zeros) are made up, so interpolation algorithm will
        not give errors.


%Matrix: Adjusted Matrix. For Flying Eyeball
ymm = [500    0.75    0.5     0.3     0.2     0.125   0.1     0.075   0.0001
 ];

 CalibData = [
    1    0.9922 0.9912 0.9818 0.9694 0.9593 0.9546 0.9403 0
1   0.9757      0.9712 0.9441 0.908  0.8722 0.8538 0.8098 0
1   0.9569      0.945  0.8996 0.8375 0.7698 0.733  0.6633 0
1   0.9382      0.9159 0.8541 0.7683 0.6705 0.6158 0.5334 0
1   0.9192      0.8853 0.8084 0.7011 0.578  0.5094 0.4259 0
1   0.9003      0.8546 0.7649 0.6391 0.4963 0.4185 0.3427 0
1   0.8818      0.8242 0.7237 0.5819 0.4259 0.3434 0.2818 0
1   0.8638      0.7945 0.6852 0.5301 0.3676 0.2834 0.2391 0
1   0.8462      0.7652 0.648  0.4817 0.3184 0.2349 0.2079 0
1   0.8293      0.7368 0.6129 0.438  0.2789 0.1972 0.1852 0
];
```

```
% pCalibration.m  use this one for BEACHBALL
%Matrix: Adjusted Matrix. For Beachball

ymm = [0.002 0.081   0.096   0.115   0.137   0.163   0.193   0.230  0.275    0.325
             0.385   0.46    0.545   0.65    0.775   0.92    1.095   1.3      1.41
             256.000];

CalibData =[
0.0000 0.7568 0.7948 0.8148 0.8310 0.8398 0.8544 0.8593 0.8686 0.8828 0.9020
              0.9224 0.9441 0.9402 0.9562 0.9627 0.9682 0.9734 0.9788 1.0000
0.0000 0.3862 0.4432 0.4934 0.5365 0.5638 0.6004 0.6140 0.6411 0.6774 0.7223
              0.7797 0.8278 0.8274 0.8677 0.8875 0.9042 0.9203 0.9376 1.0000
0.0000 0.1764 0.2117 0.2689 0.3241 0.3654 0.4118 0.4312 0.4693 0.5190 0.5751
              0.6593 0.7203 0.7318 0.7883 0.8197 0.8459 0.8724 0.9019 1.0000
0.0000 0.0731 0.1015 0.1471 0.1995 0.2472 0.2953 0.3178 0.3574 0.4127 0.4721
              0.5690 0.6404 0.6595 0.7266 0.7661 0.7987 0.8325 0.8732 1.0000
0.0000 0.0410 0.0574 0.0867 0.1282 0.1770 0.2247 0.2497 0.2870 0.3415 0.3989
              0.4993 0.5768 0.5997 0.6729 0.7181 0.7558 0.7946 0.8458 1.0000
0.0000 0.0286 0.0340 0.0518 0.0785 0.1224 0.1695 0.1976 0.2324 0.2837 0.3380
              0.4381 0.5199 0.5453 0.6227 0.6719 0.7144 0.7570 0.8183 1.0000
0.0000 0.0228 0.0233 0.0361 0.0495 0.0819 0.1250 0.1568 0.1893 0.2365 0.2867
              0.3839 0.4676 0.4954 0.5754 0.6275 0.6742 0.7198 0.7905 1.0000
0.0000 0.0172 0.0187 0.0289 0.0364 0.0563 0.0901 0.1235 0.1537 0.1973 0.2436
              0.3357 0.4202 0.4499 0.5310 0.5852 0.6353 0.6832 0.7626 1.0000
0.0000 0.0127 0.0169 0.0240 0.0312 0.0439 0.0658 0.0965 0.1243 0.1651 0.2077
              0.2935 0.3777 0.4086 0.4898 0.5454 0.5981 0.6475 0.7349 1.0000
0.0000 0.0090 0.0149 0.0201 0.0270 0.0377 0.0509 0.0749 0.1000 0.1382 0.1771
              0.2562 0.3393 0.3709 0.4516 0.5079 0.5624 0.6128 0.7076 1.0000
0.0000 0.0080 0.0123 0.0178 0.0225 0.0331 0.0431 0.0594 0.0808 0.1156 0.1512
              0.2233 0.3044 0.3364 0.4160 0.4727 0.5284 0.5793 0.6808 1.0000
0.0000 0.0070 0.0104 0.0164 0.0187 0.0283 0.0388 0.0500 0.0665 0.0971 0.1291
              0.1944 0.2729 0.3050 0.3830 0.4396 0.4960 0.5468 0.6543 1.0000
0.0000 0.0060 0.0098 0.0150 0.0165 0.0239 0.0357 0.0453 0.0570 0.0824 0.1106
              0.1690 0.2447 0.2764 0.3523 0.4087 0.4653 0.5156 0.6284 1.0000
0.0000 0.0050 0.0090 0.0135 0.0150 0.0202 0.0327 0.0426 0.0513 0.0713 0.0949
              0.1464 0.2192 0.2503 0.3238 0.3797 0.4363 0.4857 0.6030 1.0000
0.0000 0.0050 0.0069 0.0124 0.0134 0.0176 0.0297 0.0399 0.0480 0.0632 0.0812
              0.1264 0.1960 0.2264 0.2971 0.3524 0.4087 0.4570 0.5781 1.0000
0.0000 0.0040 0.0050 0.0116 0.0115 0.0158 0.0267 0.0368 0.0455 0.0572 0.0693
              0.1087 0.1750 0.2045 0.2721 0.3268 0.3827 0.4297 0.5539 1.0000
0.0000 0.0030 0.0048 0.0106 0.0094 0.0142 0.0238 0.0336 0.0431 0.0526 0.0596
              0.0931 0.1562 0.1845 0.2490 0.3031 0.3583 0.4037 0.5303 1.0000
```

```
0.0000 0.0020 0.0053 0.0076 0.0077 0.0126 0.0213 0.0309 0.0403 0.0490 0.0524
              0.0793 0.1394 0.1661 0.2277 0.2811 0.3353 0.3790 0.5074 1.0000
0.0000 0.0010 0.0053 0.0063 0.0065 0.0113 0.0193 0.0291 0.0372 0.0464 0.0475
              0.0671 0.1242 0.1492 0.2083 0.2605 0.3136 0.3554 0.4852 1.0000
0.0000 0.0005 0.0053 0.0056 0.0058 0.0102 0.0176 0.0282 0.0342 0.0440 0.0444
              0.0566 0.1108 0.1338 0.1905 0.2414 0.2931 0.3330 0.4637 1.0000 ];
```

```
%pAutoCorr.m
ImageHeight = size(data,1);
ImageWidth = size(data,2);
MaxOffset = 10; % Leave space to shift subset of image to calculate autocorrelation. %20 was used to calculate Beachball, and 5 was used to calculate Flyball.
ImageWidthToProcess = ImageWidth-MaxOffset;
PixelStep = 1; % Define size of step (in pixels) for autocorrelation calculations.
data1 = data(:,1:ImageWidthToProcess);
MinOffset = 10;
MinAutoC = 1.0;

clear autoc1
clear mmSizeFromImage
PixelOffset = 0;
i = 0;
%while MinAutoC >= 0.2 & PixelOffset <= length(CalibData)-PixelStep ; %.3 normal Stop calculations when autocorrelation is too small.
 for PixelOffset = 0:MaxOffset-1;
    i = i+1;
   PixelOffset = (1 + (i-1)) * PixelStep; % Start at 10 px for Nikon     Write in command window, so user can track progress.
%    data2 = data(:,2+(i-1)*PixelStep:ImageWidthToProcess+1+(i-1)*PixelStep)
   data1=1:ImageHeight*ImageWidthToProcess;
   data2=1:ImageHeight*ImageWidthToProcess;
   data1(1:ImageHeight*ImageWidthToProcess)= reshape (data(1:ImageHeight,1:ImageWidthToProcess),ImageHeight*ImageWidthToProcess,1);
   data2(1:ImageHeight*ImageWidthToProcess)= reshape (data(1:ImageHeight,PixelOffset+1:ImageWidthToProcess+PixelOffset),ImageHeight*ImageWidthToProcess,1);
   correl= corrcoef(data1,data2);
   autoc1(i)=correl(1,2);  %i

%       mmSizeFromImage(i) = interp1(CalibData(1+(i-1),:), ymm, autoc1(i+1),'linear');
   mmSizeFromImage(i) = interp1(CalibData(PixelOffset,:), ymm, autoc1(i),'linear');
   MinAutoC = min(MinAutoC,autoc1(i));
end

%GrainSizeInMM = mean(mmSizeFromImage) % Write calculated grain size in command window.
```

```
   %pShowimage.m
    %plot black grid lines - 1mm squares

    figure(1);
    black = min(min(data));
    ImageData = data;
      for column = 1:60:size(data,2);
        ImageData(1:size(data,1),column) = black;
end
      for row = 1:60:size(data,1);
        ImageData(row,1:size(data,2)) = black;
end
   % %show data in grayscale
    imagesc(ImageData);
      %colorbar;
      colormap('gray');
 %   title(FileName);



   figure(2)
  % fig2 = plot(CalibData);
   %hold on
   %fig2 = plot(autoc1, 'b*-');
   %hold off
    plot(CalibData);
   hold on
   plot(autoc1, 'b*-');
   title(FileName);
   hold off
```

```
%cBatchCreate.m


%To Create Beachball Calibration Curves
%Requires  CreateCalibration.m

%Originally this file was called BatchAutoC_mac100.m.
%It was last abridged Feb 28. 2005 by  Jodi (with Patrick)
%for matlab work on Patrick's PC Desktop. Neomi then obtained
%this file in 2006 and modified it to be compatible with scripts
%obtained from Tristan (cPlotCalibration.m and CreateCalibraion.m)




clear all
close all

k=1;

if exist('FileName') == 1
   CreateCalibration;              % calculate autocorrelation curve for image using 100
         offsets



else
   FileListID = fopen ('filestorun.txt','rt');        %reads in text mode
   FileEnd = 0;
   while FileEnd == 0,

      FileName = fgetl(FileListID);
      if length(FileName) >= 0 & FileName ~= -1;

          FileName

          CreateCalibration;         % calculate autocorrelation curve

          % clear variables before processing next file.
          eval (['clear ', FileName, ';']);
          clear autoc1 correl data data1 data2 i offset;

          %Save data in an array with a column for each file
          name{k}=FileName;
          out(:,k)=SampleAutoC;
```

```
          k=k+1;

        else
           FileEnd = 1;
           end

   end
   fclose(FileListID);
end

% Write output array to ascii txt file
save Calibration_output.txt out -ascii -tabs

% Write file name and grain size distribution to txt file (appends!)
%OutputFID = fopen ('Calibration_output_OB_OL.txt','w');
%must have format statement for each file name,modify here
%fprintf(OutputFID, '%5.3ft\n' ,out(i,j));
% fprintf(OutputFID, '\t  %5.3f' , SampleAutoC);
%fprintf(OutputFID, '\t  %5.3f' , SizeInMM);
% fprintf(OutputFID, '\n');
%fclose(OutputFID);
```

```
%CreateCalibration.m
%Creates the calibration matrix.
%Mostly ran in batch mode from cBatchCreate.m
%Modified by Neomi 9/7/2006 to be compatible with cBatchCreate.m

%for TXT images
%data=FileName;
%imagesc(FileName)
%colormap gray
%data=double(FileName);

%for TIFF images
data=imread(FileName);
data = double(imread(FileName));

[ImageHeight, ImageWidth] = size(data);
MaxOffset = 50;  %set this value! This determines the number of offsets that will be
        calculated.
ImageWidthToProcess = ImageWidth-MaxOffset;

for i = 1:MaxOffset;
   data1 = data(1:ImageHeight,1:ImageWidthToProcess);
   data2 = data(1:ImageHeight,1+i:ImageWidthToProcess+i);
   correlation= corrcoef(data1,data2);
   autoc1(i)=correlation(1,2);
   offset(i) = i;
end

% report result as vector
SampleAutoC = autoc1';
SampleAutoC


% Plot autocorrelation curve
%figure(1)
%plot(offset,autoc1)
%axis([0 13 0 1])
%xlabel('offset in pixels')
%ylabel('autocorrelation')
```

APPENDIX II

Beachball© and Flying Eyeball© grain size results.

Key:

Sid	Sample ID	
Sur	Survey	K=summer kilometer N=summer nearshore S=seasonal high resolution areas
Yr	Year	
Sea	Season	W=winter S=summer
Tran	Transect#	
Lat	Latitude	
Lon	Longitude	
Dep	Depth (m)	
Ele	Elevation	BF=beach Face MB=mid Beach BB=back Beach O=offshore
Type	Sample Type	E=eyeball G=grab B=both eyeball and grab N=none
eMean	Eyeball Mean (mm)	
gMean	Grab Mean (mm)	
gMed	Grab Median (mm)	
gSort	Grab Sorting (mm)	
gSkew	Grab Skewness (mm)	
gKur	Grab Kurtosis (mm)	
gD10	Grab d10	
g%Fine	Grab Percent Fine	
Notes		

Sid	Sur	Yr	Sea	Tran	Lat	Lon	Dep	Ele	Type	eMean	gMean	gMed	gSort	gSkew	gKur	gD10	g%Fine	Notes
1	K			24	34.47088	-120.22726	0	BF	B	0.2250	0.2405	0.2360	1.1305	1.0231	0.2362	0.1858		
2	K			38	34.46264	-120.07158	0	BF	E	0.2967								
3	K			39	34.46245	-120.06668	0	BF	E	0.1988								
4	K			42	34.46083	-120.02948	0	BF	E	0.2708								
5	K			43	34.45901	-120.02120	0	BF	E	0.3691								
6	K			44	34.46079	-120.00835	0	BF	B	0.2248	0.1964	0.1931	1.1175	1.0221	0.2422	0.1548		
7	K			45	34.45653	-119.99950	0	BF	E	0.2661								
8	K			46	34.45016	-119.99054	0	BF	E	0.2785								
9	K			48	34.44465	-119.97148	0	BF	E	0.2568								
10	K			49	34.44120	-119.96503	0	BF	E	0.3641								
11	K			50	34.43529	-119.95495	0	BF	E	0.2871								
12	K			51	34.43537	-119.94251	0	BF	E	0.2221								
13	K			52	34.43531	-119.93288	0	BF	E	0.1574								
14	K			53	34.43177	-119.91840	0	BF	E	0.2470								
15	K			54	34.42761	-119.91105	0	BF	B	0.2172	0.1943	0.1872	1.1849	1.0466	0.2512	0.1459		
16	K			55	34.42189	-119.90220	0	BF	E	0.2032								
17	K			56	34.41938	-119.89113	0	BF	E	0.2269								
18	K			57	34.41225	-119.88411	0	BF	E	0.2493								
19	K			58	34.40859	-119.87558	0	BF	E	0.2405								
20	K			59	34.40936	-119.86249	0	BF	E	0.2527								
21	K			60	34.40771	-119.85208	0	BF	E	0.2096								
22	K			61	34.41047	-119.84152	0	BF	E	0.2920								
23	K			62	34.41647	-119.83084	0	BF	E	0.3174								
24	K			63	34.41712	-119.82249	0	BF	E	0.4231								
25	K			65	34.41790	-119.80000	0	BF	B	0.1692	0.1410	0.1438	1.1144	1.0285	0.2397	0.1151		
26	K			66	34.41680	-119.78800	0	BF	E	0.2483								
27	K			67	34.41350	-119.77800	0	BF	E	0.2807								
28	K			68	34.40980	-119.76800	0	BF	E	0.2921								
29	K			69	34.40620	-119.75800	0	BF	E	0.2778								
30	K			70	34.40346	-119.74721	0	BF	E	0.2600								
31	K			71	34.39999	-119.73776	0	BF	E	0.2271								
32	K			72	34.39675	-119.73046	0	BF	E	0.2162								
33	K			73	34.39584	-119.70799	0	BF	E	0.2324								
34	K			74	34.39837	-119.70231	0	BF	B	0.2183	0.2699	0.2602	1.1859	1.0457	0.2217	0.1990		
35	K			75	34.40254	-119.69552	0	BF	E	0.2575								
36	K			76	34.41016	-119.68905	0	BF	E	0.2545								
37	K			77	34.41432	-119.68025	0	BF	E	0.2229								
38	K			78	34.41595	-119.66995	0	BF	E	0.2467								
39	K			79	34.41698	-119.65844	0	BF	E	0.2403								
40	K			80	34.41726	-119.64718	0	BF	E	0.2217								
41	K			81	34.41629	-119.63595	0	BF	E	0.2746								
42	K			82	34.41887	-119.62498	0	BF	E	0.2027								
43	K			83	34.42095	-119.61541	0	BF	E	0.1575								
44	K			84	34.41963	-119.60283	0	BF	B	0.2463	0.2177	0.2142	1.1404	1.0146	0.2492	0.1648		
45	K			85	34.41758	-119.59187	0	BF	E	0.2116								
46	K			86	34.41372	-119.58161	0	BF	E	0.1983								
47	K			87	34.41490	-119.56602	0	BF	E	0.2645								
48	K			88	34.41307	-119.55904	0	BF	E	0.1535								
49	K			89	34.40795	-119.55146	0	BF	E	0.2391								
50	K			90	34.31400	-119.36300	0	BF	E	0.2417								

Sid	Sur	Yr	Sea	Tran	Lat	Lon	Dep	Ele	Type	eMean	gMean	gMed	gSort	gSkew	gKur	gD10	g%Fine	Notes
51	K			91	34.39613	-119.53439	0	BF	E	0.3068								
52	K			92	34.39247	-119.52412	0	BF	E	0.2581								
53	K			93	34.38714	-119.51315	0	BF	E	0.2750								
54	K			94	34.38518	-119.50318	0	BF	B	0.1848	0.2112	0.2075	1.1589	1.0132	0.2448	0.1574		
55	K			95	34.38183	-119.48836	0	BF	E	0.2713								
56	K			96	34.37726	-119.48154	0	BF	E	0.2402								
57	K			97	34.37527	-119.47334	0	BF	E	0.3210								
58	K			99	34.37029	-119.45634	0	BF	E	0.2500								
59	K			100	34.36263	-119.44888	0	BF	E	0.2997								
60	K			101	34.35574	-119.43960	0	BF	E	0.2814								
61	K			102	34.35312	-119.42918	0	BF	E	0.2607								
62	K			103	34.34958	-119.42507	0	BF	E	0.2452								
63	K			104	34.33748	-119.41106	0	BF	B	0.3494	0.2020	0.1993	1.1144	1.0149	0.2423	0.1586		
64	K			105	34.33392	-119.40495	0	BF	E	0.1709								
65	K			106	34.32853	-119.39887	0	BF	E	0.3191								
66	K			107	34.31951	-119.39165	0	BF	E	0.3381								
67	K			108	34.32094	-119.37670	0	BF	E	0.2808								
68	K			109	34.31950	-119.36983	0	BF	E	0.2076								
69	K			111	34.30828	-119.35439	0	BF	E	0.3116								
70	K			112	34.30207	-119.34703	0	BF	E	0.2851								
71	K			113	34.29600	-119.34201	0	BF	E	0.3122								
72	K			114	34.29134	-119.33810	0	BF	B	0.3114	0.2159	0.2119	1.1514	1.0174	0.2617	0.1639		
73	K			115	34.28409	-119.32164	0	BF	E	0.2883								
74	K			116	34.27864	-119.31549	0	BF	E	0.3304								
75	K			117	34.27312	-119.30472	0	BF	E	0.3276								
76	K			118	34.27520	-119.29280	0	BF	E	0.1684								
77	K			119	34.27010	-119.28200	0	BF	E	0.2720								
78	K			120	34.26570	-119.27790	0	BF	E	0.2534								
79	K			121	34.25450	-119.27070	0	BF	E	0.3240								
80	K			122	34.24400	-119.26810	0	BF	E	0.2145								
81	K			123	34.23820	-119.26770	0	BF	E	0.3522								
82	K			124	34.22770	-119.26560	0	BF	B	0.3812	0.2684	0.2614	1.1523	1.0336	0.2374	0.2071		
83	K			125	34.22030	-119.26190	0	BF	E	0.4015								
84	K			126	34.21380	-119.25860	0	BF	E	0.2420								
85	K			127	34.20210	-119.25170	0	BF	E	0.2609								
86	K			128	34.19209	-119.24625	0	BF	E	0.3155								
87	K			129	34.18343	-119.24166	0	BF	E	0.3560								
88	K			130	34.17620	-119.23763	0	BF	E	0.2964								
89	K			131	34.16569	-119.23147	0	BF	E	0.3513								
90	K			132	34.15640	-119.22499	0	BF	E	0.1773								
91	K			133	34.14780	-119.21720	0	BF	E	0.5842								
92	K			135	34.14337	-119.19935	0	BF	E	0.2120								
93	K			136	34.13923	-119.19108	0	BF	B	0.2552	0.2688	0.2610	1.1469	1.0410	0.2269	0.2128		
94	K			149	34.08819	-119.06486	0	BF	B	0.3986	0.4271	0.4192	1.1647	1.0146	0.2509	0.3180		
95	K			150	34.08560	-119.05510	0	BF	E	0.4206								
96	K			153	34.07560	-119.02260	0	BF	E	0.4363								
97	K			154	34.06980	-119.01270	0	BF	E	0.4760								
98	K			158	34.06070	-118.97740	0	BF	E	0.4207								
99	K			160	34.05190	-118.96070	0	BF	E	0.2923								
100	K			162	34.04570	-118.93160	0	BF	E	0.3734								

Sid	Sur	Yr	Sea	Tran	Lat	Lon	Dep	Ele	Type	eMean	gMean	gMed	gSort	gSkew	gKur	gD10	g%Fine	Notes
101	K			164	34.04250	-118.91620	0	BF	E	0.3838								
102	K			166	34.03920	-118.89310	0	BF	E	0.3171								
103	K			167	34.03800	-118.87550	0	BF	E	0.3495								
104	K			168	34.03780	-118.87420	0	BF	E	0.2673								
105	K			169	34.03510	-118.85630	0	BF	E	0.2085								
106	K			171	34.02800	-118.84090	0	BF	E	0.2369								
107	K			172	34.02190	-118.83240	0	BF	E	0.2767								
108	K			173	34.01630	-118.82470	0	BF	E	0.2719								
109	K			174	34.01250	-118.81970	0	BF	E	0.4113								
110	K			175	34.00250	-118.80980	0	BF	E	0.4802								
111	K			176	34.00120	-118.80790	0	BF	E	0.5593								
112	S	6	W		34.41658	-119.83139	0	BF	E	0.3433								
113	S	6	W		34.41644	-119.82836	0	BF	E	0.3131								
114	S	6	W		34.41636	-119.82950	0	BF	E	0.2359								
115	S	6	W		34.41636	-119.83056	0	BF	E	0.3409								
116	S	6	W		34.41614	-119.83275	0	BF	E	0.2705								
117	S	6	W		34.41592	-119.83383	0	BF	E	0.2999								
118	S	6	W		34.41567	-119.83483	0	BF	E	0.2540								
119	S	6	W		34.41539	-119.83581	0	BF	E	0.3406								
120	S	6	W		34.41500	-119.83686	0	BF	E	0.2040								
121	S	6	W		34.41428	-119.83869	0	BF	E	0.2829								
122	S	6	W		34.41311	-119.84039	0	BF	E	0.2139								
123	S	6	W		34.41094	-119.84150	0	BF	E	0.2861								
124	S	6	W		34.40847	-119.84208	0	BF	E	0.3136								
125	S	6	W		34.40558	-119.84367	0	BF	E	0.3407								
126	S	6	W		34.40481	-119.84458	0	BF	E	0.2879								
127	S	6	W		34.40639	-119.84908	0	BF	E	0.3922								
128	S	6	W		34.40697	-119.85108	0	BF	E	0.3064								
129	S	6	W		34.40872	-119.85742	0	BF	E	0.3525								
130	S	6	W		34.40897	-119.85958	0	BF	E	0.2763								
131	S	6	W		34.40919	-119.86186	0	BF	E	0.2836								
132	S	6	W		34.40792	-119.87964	0	BF	E	0.3198								
133	S	6	W		34.40906	-119.88089	0	BF	E	0.3202								
134	S	6	W		34.41058	-119.88225	0	BF	E	0.3531								
135	S	6	W		34.41219	-119.88347	0	BF	B	0.3601	0.2912	0.2895	1.1056	1.0021	0.2677			grab IV1
136	S	6	W		34.41367	-119.88481	0	BF	E	0.3491								
137	S	6	W		34.41511	-119.88614	0	BF	E	0.2835								
138	S	6	W		34.41658	-119.88767	0	BF	E	0.3445								
139	S	6	W		34.41811	-119.88944	0	BF	E	0.4101								
140	S	6	W		34.41919	-119.89094	0	BF	E	0.3683								
141	S	6	W		34.41994	-119.89306	0	BF	E	0.3824								
142	S	6	W		34.42042	-119.89508	0	BF	E	0.3896								
143	S	6	W		34.42064	-119.89733	0	BF	E	0.2853								
144	S	6	W		34.42100	-119.89933	0	BF	E	0.3609								
145	S	6	W		34.40689	-119.87814	0	BF	E	0.2434								
146	S	6	W		34.40822	-119.87636	0	BF	E	0.2858								
147	S	6	W		34.40900	-119.87458	0	BF	E	0.2912								
148	S	6	W		34.40919	-119.87244	0	BF	E	0.2543								
149	S	6	W		34.40922	-119.87031	0	BF	E	0.2142								
150	S	6	W		34.40903	-119.86792	0	BF	B	0.1732	0.1692	0.1651	1.0985	1.0417	0.2402			grab IV5

Sid	Sur	Yr	Sea	Tran	Lat	Lon	Dep	Ele	Type	eMean	gMean	gMed	gSort	gSkew	gKur	gD10	g%Fine	Notes
151	S	6	W		34.40914	-119.86594	0	BF	E	0.1344								
152	S	6	S		34.41470	-119.83771	0	BF	E	0.2274								
153	S	6	S		34.41430	-119.83855	0	BF	E	0.2311								
154	S	6	S		34.41385	-119.83935	0	BF	E	0.2642								
155	S	6	S		34.41297	-119.84037	0	BF	E	0.2482								
156	S	6	S		34.41229	-119.84089	0	BF	E	0.2359								
157	S	6	S		34.41140	-119.84135	0	BF	E	0.2573								
158	S	6	S		34.41047	-119.84152	0	BF	E	0.2749								
159	S	6	S		34.40955	-119.84190	0	BF	E	0.1988								
160	S	6	S		34.40866	-119.84217	0	BF	E	0.2990								
161	S	6	S		34.40746	-119.84252	0	BF	E	0.3338								
162	S	6	S		34.40611	-119.84355	0	BF	E	0.3478								
163	S	6	S		34.40544	-119.84373	0	BF	E	0.2538								
164	S	6	S		34.40467	-119.84438	0	BF	E	0.2552								
165	S	6	S		34.40515	-119.84562	0	BF	E	0.2768								
166	S	6	S		34.40560	-119.84663	0	BF	E	0.2443								
167	S	6	S		34.40599	-119.84772	0	BF	E	0.2463								
168	S	6	S		34.40646	-119.84887	0	BF	E	0.2655								
169	S	6	S		34.40702	-119.85019	0	BF	E	0.2234								
170	S	6	S		34.40770	-119.85207	0	BF	E	0.2096								
171	S	6	S		34.40845	-119.85441	0	BF	E	0.2295								
172	S	6	S		34.40884	-119.85639	0	BF	E	0.2564								
173	S	6	S		34.40902	-119.85933	0	BF	E	0.1846								
174	S	6	S		34.40936	-119.86251	0	BF	E	0.2527								
175	S	6	S		34.40920	-119.86549	0	BF	E	0.2447								
176	S	6	S		34.40903	-119.86707	0	BF	E	0.2556								
177	S	6	S		34.40912	-119.86957	0	BF	E	0.2189								
178	S	6	S		34.40917	-119.87205	0	BF	E	0.2544								
179	S	6	S		34.40859	-119.87559	0	BF	E	0.2405								
180	S	6	S		34.40669	-119.87862	0	BF	E	0.1671								
181	S	6	S		34.40768	-119.88029	0	BF	E	0.2181								
182	S	6	S		34.40925	-119.88161	0	BF	E	0.2681								
183	S	6	S		34.41225	-119.88408	0	BF	E	0.2493								
184	S	6	S		34.41440	-119.88605	0	BF	E	0.2520								
185	S	6	S		34.41678	-119.82696	0	BF	E	0.2677								
186	S	6	S		34.41658	-119.82857	0	BF	E	0.3750								
187	S	6	S		34.41649	-119.83083	0	BF	E	0.3174								
188	S	6	S		34.41590	-119.83452	0	BF	E	0.4126								
189	S	6	S		34.41558	-119.83569	0	BF	E	0.2472								
190	S	6	S		34.41502	-119.83689	0	BF	E	0.2721								
191	S	7	W		34.41636	-119.82775	0	BF	E	0.3069								
192	S	7	W		34.41664	-119.82827	0	BF	E	0.3452								
193	S	7	W		34.41634	-119.82844	0	BF	E	0.2455								
194	S	7	W		34.41628	-119.82941	0	BF	E	0.2128								
195	S	7	W		34.41619	-119.83180	0	BF	E	0.2631								
196	S	7	W		34.41607	-119.83274	0	BF	E	0.2375								
197	S	7	W		34.41588	-119.83388	0	BF	E	0.3378								
198	S	7	W		34.41555	-119.83508	0	BF	E	0.2554								
199	S	7	W		34.41528	-119.83580	0	BF	E	0.1581								
200	S	7	W		34.41495	-119.83682	0	BF	E	0.2552								

Sid	Sur	Yr	Sea	Tran	Lat	Lon	Dep	Ele	Type	eMean	gMean	gMed	gSort	gSkew	gKur	gD10	g%Fine	Notes
201	S	7	W		34.41425	-119.83839	0	BF	E	0.1690								
202	S	7	W		34.41048	-119.84151	0	BF	E	0.1917								
203	S	7	W		34.40505	-119.84343	0	BF	E	0.2752								
204	S	7	W		34.40456	-119.84455	0	BF	E	0.2657								
205	S	7	W		34.40548	-119.84704	0	BF	E	0.2950								
206	S	7	W		34.40704	-119.85091	0	BF	E	0.3221								
207	S	7	W		34.40823	-119.85547	0	BF	E	0.2774								
208	S	7	W		34.40929	-119.86248	0	BF	E	0.2243								
209	S	7	W		34.40909	-119.86957	0	BF	E	0.2043								
210	S	7	W		34.40905	-119.87292	0	BF	E	0.2706								
211	S	7	W		34.40767	-119.87981	0	BF	E	0.2793								
212	S	7	W		34.40874	-119.88100	0	BF	E	0.2767								
213	S	7	W		34.40897	-119.88107	0	BF	E	0.2368								
214	S	7	W		34.41043	-119.88237	0	BF	E	0.2277								
215	S	7	W		34.41248	-119.88399	0	BF	E	0.2514								
216	S	7	W		34.41421	-119.88553	0	BF	E	0.2213								
217	S	6	W		34.39608	-119.53572	0	BF	E	0.2430								
218	S	6	W		34.39608	-119.53450	0	BF	E	0.2932								
219	S	6	W		34.39611	-119.53453	0	BF	E	0.2858								
220	S	6	W		34.39589	-119.53342	0	BF	E	0.3260								
221	S	6	W		34.39561	-119.53167	0	BF	E	0.3297								
222	S	6	W		34.39514	-119.53050	0	BF	E	0.3367								
223	S	6	W		34.39467	-119.52919	0	BF	E	0.2677								
224	S	6	W		34.39422	-119.52803	0	BF	E	0.4318								
225	S	6	W		34.39369	-119.52694	0	BF	E	0.3887								
226	S	6	W		34.39333	-119.52619	0	BF	B	0.2435	0.2538	0.2499	1.2167	0.9330	0.2876			grab Carp82
227	S	6	W		34.39286	-119.52528	0	BF	E	0.3309								
228	S	6	W		34.39197	-119.52419	0	BF	E	0.4087								
229	S	6	W		34.39172	-119.52322	0	BF	E	0.3925								
230	S	6	W		34.39078	-119.52156	0	BF	E	0.3426								
231	S	6	W		34.38958	-119.52008	0	BF	E	0.3306								
232	S	6	W		34.38853	-119.51833	0	BF	E	0.2710								
233	S	6	W		34.38711	-119.51342	0	BF	E	0.2384								
234	S	6	S		34.39623	-119.53488	0	BF	E	0.2914								
235	S	6	S		34.39612	-119.53442	0	BF	E	0.3068								
236	S	6	S		34.39605	-119.53402	0	BF	E	0.2746								
237	S	6	S		34.39601	-119.53364	0	BF	E	0.2576								
238	S	6	S		34.39589	-119.53268	0	BF	E	0.2466								
239	S	6	S		34.39573	-119.53183	0	BF	E	0.2359								
240	S	6	S		34.39549	-119.53098	0	BF	E	0.2515								
241	S	6	S		34.39518	-119.53001	0	BF	E	0.2366								
242	S	6	S		34.39482	-119.52912	0	BF	E	0.2237								
243	S	6	S		34.39453	-119.52840	0	BF	E	0.2438								
244	S	6	S		34.39421	-119.52757	0	BF	E	0.2458								
245	S	6	S		34.39383	-119.52668	0	BF	E	0.2746								
246	S	6	S		34.39339	-119.52591	0	BF	E	0.2475								
247	S	6	S		34.39296	-119.52513	0	BF	E	0.2532								
248	S	6	S		34.39247	-119.52417	0	BF	E	0.2581								
249	S	6	S		34.39204	-119.52341	0	BF	E	0.2456								
250	S	6	S		34.39159	-119.52262	0	BF	E	0.2654								

Sid	Sur	Yr	Sea	Tran	Lat	Lon	Dep	Ele	Type	eMean	gMean	gMed	gSort	gSkew	gKur	gD10	g%Fine	Notes
251	S	6	S		34.39108	-119.52188	0	BF	E	0.2278								
252	S	6	S		34.39049	-119.52116	0	BF	E	0.2437								
253	S	6	S		34.38994	-119.52036	0	BF	E	0.2952								
254	S	6	S		34.38949	-119.51962	0	BF	E	0.2157								
255	S	6	S		34.38902	-119.51901	0	BF	E	0.2129								
256	S	6	S		34.38857	-119.51834	0	BF	E	0.2372								
257	S	6	S		34.38796	-119.51742	0	BF	E	0.2568								
258	S	6	S		34.38742	-119.51641	0	BF	E	0.2806								
259	S	6	S		34.38745	-119.51510	0	BF	E	0.2517								
260	S	6	S		34.38727	-119.51400	0	BF	E	0.3363								
261	S	6	S		34.38714	-119.51315	0	BF	E	0.2750								
262	S	6	S		34.38682	-119.51227	0	BF	E	0.2687								
263	S	7	W		34.39605	-119.53397	0	BF	E	0.2875								
264	S	7	W		34.39594	-119.53305	0	BF	E	0.2434								
265	S	7	W		34.39577	-119.53282	0	BF	E	0.3390								
266	S	7	W		34.39571	-119.53243	0	BF	E	0.2890								
267	S	7	W		34.39532	-119.53098	0	BF	E	0.2825								
268	S	7	W		34.39511	-119.53037	0	BF	E	0.2905								
269	S	7	W		34.39478	-119.52940	0	BF	E	0.3197								
270	S	7	W		34.39493	-119.52928	0	BF	E	0.2708								
271	S	7	W		34.39438	-119.52810	0	BF	E	0.4838								
272	S	7	W		34.39381	-119.52691	0	BF	E	0.3126								
273	S	7	W		34.39307	-119.52568	0	BF	E	0.3576								
274	S	7	W		34.39266	-119.52397	0	BF	E	0.3092								
275	S	7	W		34.39221	-119.52341	0	BF	E	0.2024								
276	S	7	W		34.39157	-119.52220	0	BF	E	0.2043								
277	S	7	W		34.39026	-119.52036	0	BF	E	0.2439								
278	S	7	W		34.38860	-119.51766	0	BF	E	0.2166								
279	S	7	W		34.38755	-119.51446	0	BF	E	0.2833								
280	S	6	W		34.24489	-119.26769	0	BF	B	1.0459	0.4796	0.4773	1.3273	0.9330	0.2754			grab V2
281	S	6	W		34.20672	-119.25422	0	BF	E	0.8116								
282	S	6	W		34.21486	-119.25853	0	BF	E	0.6368								
283	S	6	W		34.21917	-119.26108	0	BF	E	0.5703								
284	S	6	W		34.22361	-119.26389	0	BF	E	0.4259								
285	S	6	W		34.22756	-119.26536	0	BF	E	0.3927								
286	S	6	W		34.23144	-119.26692	0	BF	B	0.3685	0.2450	0.2410	1.1369	1.0174	0.2521			grab V6
287	S	6	W		34.23492	-119.26722	0	BF	E	0.2940								
288	S	6	W		34.23803	-119.26722	0	BF	E	0.3262								
289	S	6	W		34.24208	-119.26739	0	BF	E	0.5609								
290	S	6	W		34.27397	-119.28894	0	BF	E	0.2906								
291	S	6	W		34.27067	-119.28361	0	BF	B	0.3049	0.2885	0.2813	1.1314	1.0358	0.2451			grab V7
292	S	6	W		34.26611	-119.27825	0	BF	E	0.3045								
293	S	6	W		34.26006	-119.27339	0	BF	E	0.3519								
294	S	6	W		34.25603	-119.27114	0	BF	E	0.3247								
295	S	6	W		34.27394	-119.30092	0	BF	E	0.5451								
296	S	6	W		34.27308	-119.30528	0	BF	E	0.4311								
297	S	6	W		34.27372	-119.30608	0	BF	E	0.4251								
298	S	6	W		34.27453	-119.30844	0	BF	E	0.4364								
299	S	6	W		34.27536	-119.29169	0	BF	E	0.3482								
300	S	6	S		34.22030	-119.26190	0	BF	E	0.4015								

Sid	Sur	Yr	Sea	Tran	Lat	Lon	Dep	Ele	Type	eMean	gMean	gMed	gSort	gSkew	gKur	gD10	g%Fine	Notes
301	S	6	S		34.21380	-119.25860	0	BF	E	0.2420								
302	S	6	S		34.20700	-119.25430	0	BF	E	0.3663								
303	S	6	S		34.20210	-119.25170	0	BF	E	0.2609								
304	S	6	S		34.19800	-119.24930	0	BF	E	0.2977								
305	S	6	S		34.21390	-119.25810	0	BF	E	0.4415								
306	S	6	S		34.22360	-119.26370	0	BF	E	0.3734								
307	S	6	S		34.22770	-119.26560	0	BF	E	0.3812								
308	S	6	S		34.23170	-119.26700	0	BF	E	0.3340								
309	S	6	S		34.23500	-119.26760	0	BF	E	0.3845								
310	S	6	S		34.23820	-119.26770	0	BF	E	0.3522								
311	S	6	S		34.24180	-119.26810	0	BF	E	0.3661								
312	S	6	S		34.24400	-119.26810	0	BF	E	0.2145								
313	S	6	S		34.25450	-119.27070	0	BF	E	0.3240								
314	S	6	S		34.26570	-119.27790	0	BF	E	0.2534								
315	S	6	S		34.27010	-119.28200	0	BF	E	0.2720								
316	S	6	S		34.27380	-119.28880	0	BF	E	0.2669								
317	S	6	S		34.27520	-119.29280	0	BF	E	0.1684								
318	S	7	W		34.27549	-119.29528	0	BF	E	0.6235								
319	S	7	W		34.27176	-119.28482	0	BF	E	0.3687								
320	S	7	W		34.26664	-119.27896	0	BF	E	0.3295								
321	S	7	W		34.26226	-119.27512	0	BF	E	0.2870								
322	S	7	W		34.25501	-119.27096	0	BF	E	0.4210								
323	S	7	W		34.24391	-119.26775	0	BF	E	1.1742								
324	S	7	W		34.23922	-119.26743	0	BF	E	0.2939								
325	S	7	W		34.23495	-119.26765	0	BF	E	0.2915								
326	N			1	34.44705	-120.47138	10	O	B	0.1678	0.1890	0.1842	1.1497	1.0335	0.2417		1.88	
327	N			1	34.44372	-120.47179	20	O	E	0.1410								
328	N			2	34.44631	-120.46303	5	O	E	0.1509								
329	N			2	34.44480	-120.46301	10	O	B	0.1482	0.1139	0.1138	1.1519	0.9824	0.2095		2.94	
330	N			2	34.44008	-120.46232	20	O	E	0.1791								
331	N			3	34.44075	-120.45289	5	O	B	0.2217	0.2234	0.2182	1.1518	1.0279	0.2442		1.29	Transect#2.5
332	N			3	34.44020	-120.45290	10	O	B	0.2211	0.2004	0.1948	1.1729	1.0321	0.2227		0.93	Transect#2.5
333	N			3	34.43857	-120.45285	20	O	E	0.3155								Transect#2.5
334	N			3	34.44782	-120.44348	5	O	B	0.1666	0.1295	0.1256	1.1524	1.0430	0.2174		1.85	
335	N			3	34.44623	-120.44416	10	O	B	0.1228	0.1546	0.1392	1.2239	1.1832	0.2150		0.80	
336	N			3	34.44071	-120.44464	20	O	E	0.1178								
337	N			4	34.44770	-120.43867	5	O	E	0.1432								
338	N			4	34.44769	-120.43869	10	O	E	0.1042								
339	N			4	34.44239	-120.43807	20	O	E	0.1025								
340	N			6	34.44910	-120.41743	5	O	E	0.1125								
341	N			6	34.44648	-120.41780	10	O	E	0.0821								
342	N			6	34.44122	-120.41878	20	O	E	0.0886								
343	N			10	34.45490	-120.36644	5	O	E	0.1993								
344	N			10	34.45302	-120.36730	10	O	E	0.1055								
345	N			10	34.43973	-120.37117	20	O	N									REEF
346	N			15	34.46168	-120.32231	5	O	E	0.1288								
347	N			15	34.46045	-120.32213	10	O	E	0.0901								
348	N			15	34.45492	-120.32132	20	O	E	0.0830								
349	N			20	34.46599	-120.26441	5	O	E	0.1472								
350	N			20	34.46181	-120.26556	10	O	E	0.0925								

Sid	Sur	Yr	Sea	Tran	Lat	Lon	Dep	Ele	Type	eMean	gMean	gMed	gSort	gSkew	gKur	gD10	g%Fine	Notes
351	N			20	34.45119	-120.26747	20	O	E	0.1302								
352	N			24	34.46948	-120.22713	5	O	B	0.1140	0.2212	0.2129	1.2127	1.0409	0.2079		0.79	
353	N			24	34.46563	-120.22719	10	O	B	0.0988	0.1080	0.0899	1.4504	1.2610	0.2170		6.13	
354	N			24	34.45721	-120.22758	20	O	B	0.1349	0.1999	0.1934	1.1840	1.0380	0.2390		3.30	
355	N			30	34.47060	-120.15890	5	O	E	0.1961								
356	N			30	34.46922	-120.15840	10	O	E	0.1148								
357	N			30	34.46622	-120.15816	20	O	E	0.0866								
358	N			35	34.46475	-120.10824	5	O	E	0.1423								
359	N			35	34.46300	-120.10848	10	O	E	0.0896								
360	N			35	34.45829	-120.06874	20	O	E	0.0834								
361	N			38	34.45828	-120.06873	5	O	B	0.0865	0.1697	0.1653	1.2017	1.0191	0.2388		1.95	
362	N			38	34.45827	-120.06873	10	O	B	0.0782	0.1223	0.1192	1.2185	1.0134	0.2606		4.64	
363	N			38	34.45588	-120.06815	20	O	B	0.0836	0.0768	0.0748	1.1628	1.0317	0.1889		15.32	
364	N			40	34.45506	-119.99955	5	O	E	0.1156								
365	N			40	34.45873	-120.05056	10	O	E	0.0907								
366	N			40	34.45568	-120.05180	20	O	E	0.0872								
367	N			45	34.45507	-119.99954	5	O	E	0.1466								
368	N			45	34.45325	-119.99972	10	O	E	0.0872								
369	N			45	34.44883	-120.00021	20	O	E	0.0860								
370	N			50	34.43424	-119.93797	5	O	G		0.1457	0.1388	1.2199	1.0606	0.2408		1.57	
371	N			50	34.43088	-119.94074	10	O	E	0.1163								
372	N			50	34.42037	-119.95074	20	O	E	0.7083								
373	N			54	34.42762	-119.91366	5	O	E	0.1540								
374	N			54	34.42482	-119.91500	10	O	E	0.0835								
375	N			54	34.41938	-119.91654	20	O	E	0.0825								
376	N			55	34.42114	-119.90409	5	O	E	0.2076								
377	N			55	34.41904	-119.90556	10	O	N									REEF
378	N			55	34.41624	-119.90709	20	O	E	0.0825								
379	N			56	34.41827	-119.89267	5	O	E	0.1813								
380	N			56	34.41637	-119.89379	10	O	E	0.1612								
381	N			56	34.41130	-119.89636	20	O	E	0.0792								
382	N			57	34.41013	-119.88443	5	O	E	0.2282								
383	N			57	34.40814	-119.88439	10	O	E	0.1345								
384	N			57	34.40293	-119.88442	20	O	E	0.0922								
385	N			58	34.40577	-119.87690	5	O	E	0.1576								
386	N			58	34.40368	-119.87667	10	O	N									irreg. bottom
387	N			58	34.40149	-119.87621	20	O	E	0.1570								
388	N			59	34.40368	-119.87844	5	O	E	0.1707								
389	N			59	34.40239	-119.86345	10	O	N									sed, but too much kelp
390	N			59	34.39997	-119.86335	20	O	E	0.0854								
391	N			60	34.40660	-119.85310	5	O	N									debris, kelp, no good im.
392	N			60	34.40283	-119.85385	10	O	E	0.1133								
393	N			60	34.39911	-119.85398	20	O	E	0.0995								
394	N			61	34.40396	-119.84391	5	O	N									REEF
395	N			61	34.40229	-119.84354	10	O	E	0.1585								
396	N			61	34.40013	-119.84263	20	O	E	0.0847								
397	N			61	34.40558	-119.84166	5	O	E	0.1254								
398	N			61	34.40385	-119.83896	10	O	E	0.0967								
399	N			61	34.40251	-119.83426	20	O	E	0.0853								
400	N			62	34.41421	-119.83186	5	O	E	0.0884								

Sid	Sur	Yr	Sea	Tran	Lat	Lon	Dep	Ele	Type	eMean	gMean	gMed	gSort	gSkew	gKur	gD10	g%Fine	Notes
401	N			62	34.40793	-119.82951	10	O	E	0.0878								
402	N			62	34.40402	-119.82646	20	O	E	0.0800								
403	N			63	34.41479	-119.82300	5	O	E	0.0800								
404	N			63	34.40991	-119.82132	10	O	E	0.0941								
405	N			63	34.40320	-119.81884	20	O	E	0.1071								
406	N			64	34.41530	-119.81140	5	O	N									no good image
407	N			64	34.41090	-119.81084	10	O	E	0.0785								
408	N			64	34.40315	-119.80963	20	O	E	0.1201								
409	N			65	34.41438	-119.80560	5	O	E	0.3230								
410	N			65	34.41117	-119.80450	10	O	E	0.0892								
411	N			65	34.40393	-119.80150	20	O	E	0.1034								
412	N			66	34.41615	-119.79110	5	O	E	0.1609								
413	N			66	34.41032	-119.79178	10	O	E	0.0826								
414	N			66	34.40419	-119.79117	20	O	E	0.0763								
415	N			67	34.41322	-119.77990	5	O	E	0.1326								
416	N			67	34.40967	-119.78080	10	O	E	0.0874								
417	N			67	34.40272	-119.78272	20	O	E	0.0788								
418	N			68	34.40949	-119.77114	5	O	E	0.2873								
419	N			68	34.40688	-119.77190	10	O	E	0.0799								
420	N			68	34.40076	-119.77375	20	O	E	0.0838								
421	N			69	34.40509	-119.75935	5	O	E	0.1948								
422	N			69	34.40347	-119.75908	10	O	E	0.1036								
423	N			69	34.39843	-119.76010	20	O	E	0.0771								
424	N			70	34.40150	-119.74815	5	O	E	0.1992								
425	N			70	34.39997	-119.74790	10	O	E	0.0834								
426	N			70	34.39643	-119.74922	20	O	E	0.0842								
427	N			71	34.39860	-119.73775	5	O	E	0.1793								
428	N			71	34.39693	-119.73785	10	O	E	0.1038								
429	N			71	34.39208	-119.73787	20	O	E	0.0862								
430	N			72	34.39471	-119.72937	5	O	E	0.1911								
431	N			72	34.39332	-119.72954	10	O	E	0.1877								
432	N			72	34.39064	-119.72942	20	O	E	0.1010								
433	N			73	34.39419	-119.71545	5	O	E	0.1369								
434	N			73	34.39215	-119.71718	10	O	E	0.0774								
435	N			73	34.38813	-119.71830	20	O	E	0.0786								
436	N			74	34.39453	-119.70350	5	O	E	0.1006								
437	N			74	34.39208	-119.70347	10	O	E	0.0892								
438	N			74	34.38853	-119.70266	20	O	E	0.0831								
439	N			75	34.40100	-119.69508	5	O	E	0.1026								
440	N			75	34.39877	-119.69377	10	O	N									no good image
441	N			75	34.39094	-119.69092	20	O	E	0.0945								
442	N			76	34.40715	-119.68652	5	O	E	0.0798								
443	N			76	34.40494	-119.68497	10	O	E	0.1345								
444	N			76	34.39619	-119.67858	20	O	E	0.0911								
445	N			77	34.41309	-119.67938	5	O	E	0.0839								
446	N			77	34.40884	-119.67701	10	O	E	0.0810								
447	N			77	34.39698	-119.67348	20	O	E	0.0977								
448	N			78	34.41470	-119.66949	5	O	E	0.0796								
449	N			78	34.41147	-119.66923	10	O	E	0.0844								
450	N			78	34.40230	-119.66617	20	O	E	0.0837								

Sid	Sur	Yr	Sea	Tran	Lat	Lon	Dep	Ele	Type	eMean	gMean	gMed	gSort	gSkew	gKur	gD10	g%Fine	Notes
451	N			79	34.41617	-119.65914	5	O	E	0.1294								
452	N			79	34.41265	-119.65849	10	O	E	0.0820								
453	N			79	34.40484	-119.65705	20	O	E	0.0850								
454	N			80	34.41609	-119.64765	5	O	E	0.1191								
455	N			80	34.41315	-119.64745	10	O	E	0.0778								
456	N			80	34.40413	-119.64771	20	O	E	0.0808								
457	N			81	34.41560	-119.63471	5	O	E	0.0982								
458	N			81	34.41165	-119.63394	10	O	E	0.0819								
459	N			81	34.40376	-119.63219	20	O	E	0.0858								
460	N			82	34.41746	-119.62565	5	O	E	0.0950								
461	N			82	34.41233	-119.62532	10	O	E	0.0812								
462	N			82	34.40395	-119.62468	20	O	E	0.0827								
463	N			83	34.41941	-119.61497	5	O	E	0.0739								
464	N			83	34.41190	-119.61520	10	O	E	0.0758								
465	N			83	34.40506	-119.61541	20	O	E	0.0887								
466	N			84	34.41801	-119.60471	5	O	E	0.1041								
467	N			84	34.41244	-119.60489	10	O	E	0.0792								
468	N			84	34.40612	-119.60461	20	O	E	0.0859								
469	N			85	34.41687	-119.59302	5	O	E	0.1639								
470	N			85	34.41107	-119.59372	10	O	E	0.0807								
471	N			85	34.40384	-119.59501	20	O	E	0.0845								
472	N			86	34.41262	-119.58218	5	O	E	0.2155								
473	N			86	34.40918	-119.58240	10	O	E	0.0973								
474	N			86	34.39891	-119.58423	20	O	E	0.0853								
475	N			87	34.41158	-119.57075	5	O	E	0.2572								
476	N			87	34.40666	-119.57071	10	O	E	0.0770								
477	N			87	34.39101	-119.57206	20	O	E	0.0799								
478	N			88	34.41249	-119.56021	5	O	E	0.1132								
479	N			88	34.40296	-119.56419	10	O	E	0.0765								
480	N			89	34.40703	-119.55243	5	O	E	0.1603								
481	N			89	34.39866	-119.55530	10	O	E	0.0782								
482	N			90	34.40017	-119.54424	5	O	E	0.1529								
483	N			90	34.39444	-119.54879	10	O	E	0.0776								
484	N			90	34.38611	-119.55487	20	O	E	0.0838								
485	N			91	34.39448	-119.53752	5	O	N									REEF
486	N			91	34.38983	-119.53939	10	O	E	0.2369								
487	N			91	34.38509	-119.54178	20	O	E	0.0931								
488	N			92	34.39173	-119.52545	5	O	E	0.1677								
489	N			92	34.38919	-119.52642	10	O	E	0.0792								
490	N			92	34.38240	-119.53041	20	O	E	0.0785								
491	N			93	34.38640	-119.51609	5	O	E	0.1185								
492	N			93	34.38471	-119.51622	10	O	E	0.0801								
493	N			93	34.37984	-119.51799	20	O	E	0.0800								
494	N			94	34.38782	-119.53154	0	O	E	0.0921								
495	N			94	34.38356	-119.50270	5	O	E	0.1966								
496	N			94	34.38192	-119.50315	10	O	E	0.0913								
497	N			94	34.37602	-119.50529	20	O	E	0.0865								
498	N			95	34.38229	-119.49526	5	O	B	0.1821	0.1757	0.1720	1.2429	0.9958	0.2578		0.63	
499	N			95	34.38051	-119.49545	10	O	B	0.0910	0.1016	0.1019	1.0682	0.9905	0.1928		2.98	
500	N			95	34.37493	-119.49740	20	O	E	0.0894								

Sid	Sur	Yr	Sea	Tran	Lat	Lon	Dep	Ele	Type	eMean	gMean	gMed	gSort	gSkew	gKur	gD10	g%Fine	Notes
501	N			96	34.37866	-119.48504	5	O	E	0.1617								
502	N			96	34.37612	-119.48598	10	O	E	0.0822								
503	N			96	34.36760	-119.48848	20	O	E	0.0840								
504	N			97	34.37132	-119.47901	5	O	E	0.1882								
505	N			97	34.36919	-119.47908	10	O	N									REEF
506	N			97	34.35990	-119.47980	20	O	E	0.1416								
507	N			98	34.37368	-119.46481	5	O	E	0.1255								
508	N			98	34.36831	-119.46610	10	O	E	0.0843								
509	N			98	34.35455	-119.47138	20	O	E	0.0831								
510	N			99	34.36790	-119.45646	5	O	E	0.2092								
511	N			99	34.36336	-119.45790	10	O	E	0.0773								
512	N			99	34.34940	-119.46210	20	O	E	0.0843								
513	N			100	34.36129	-119.44969	5	O	E	0.1694								
514	N			100	34.35783	-119.45164	10	O	E	0.0814								
515	N			100	34.34686	-119.45681	20	O	E	0.0816								
516	N			101	34.35410	-119.44130	5	O	E	0.1312								
517	N			101	34.34921	-119.44208	10	O	E	0.1418								
518	N			101	34.33863	-119.44406	20	O	E	0.0824								
519	N			102	34.35253	-119.43149	5	O	E	0.1391								
520	N			102	34.34283	-119.43268	10	O	E	0.1796								
521	N			102	34.33299	-119.43550	20	O	E	0.0848								
522	N			103	34.34589	-119.42494	5	O	E	0.1796								
523	N			103	34.34053	-119.42804	10	O	E	0.0814								
524	N			103	34.33121	-119.43208	20	O	E	0.0864								
525	N			104	34.33865	-119.41552	5	O	E	0.1346								
526	N			104	34.33332	-119.41819	10	O	E	0.0809								
527	N			104	34.32602	-119.42303	20	O	E	0.0837								
528	N			105	34.33436	-119.40893	5	O	N									no sample
529	N			105	34.33030	-119.41280	10	O	E	0.0829								
530	N			105	34.32327	-119.42036	20	O	E	0.0849								
531	N			106	34.32825	-119.40043	5	O	E	0.1547								
532	N			106	34.32507	-119.40527	10	O	E	0.0893								
533	N			106	34.31903	-119.41405	20	O	E	0.0867								
534	N			107	34.32149	-119.39519	5	O	E	0.1853								
535	N			107	34.31957	-119.39851	10	O	E	0.0901								
536	N			107	34.31530	-119.40863	20	O	E	0.0870								
537	N			108	34.31796	-119.39364	5	O	E	0.1893								
538	N			108	34.31642	-119.39356	10	O	E	0.0872								
539	N			108	34.31145	-119.40107	20	O	E	0.0823								
540	N			109	34.31812	-119.37469	5	O	E	0.1258								
541	N			109	34.31111	-119.38220	10	O	E	0.0826								
542	N			109	34.30515	-119.38851	20	O	E	0.0802								
543	N			110	34.31313	-119.36549	5	O	E	0.0986								
544	N			110	34.30539	-119.37329	10	O	E	0.0823								
545	N			110	34.29909	-119.37867	20	O	E	0.0858								
546	N			111	34.30630	-119.35785	5	O	E	0.1644								
547	N			111	34.30048	-119.36491	10	O	E	0.0839								
548	N			111	34.29480	-119.37063	20	O	E	0.0859								
549	N			112	34.30108	-119.34783	5	O	E	0.1190								
550	N			112	34.29605	-119.35422	10	O	E	0.0879								

Sid	Sur	Yr	Sea	Tran	Lat	Lon	Dep	Ele	Type	eMean	gMean	gMed	gSort	gSkew	gKur	gD10	g%Fine	Notes
551	N			112	34.28860	-119.36095	20	O	E	0.0843								
552	N			113	34.29288	-119.34222	5	O	E	0.1523								
553	N			113	34.28835	-119.34458	10	O	N									REEF
554	N			113	34.28057	-119.35002	20	O	E	0.0884								
555	N			114	34.28642	-119.33309	5	O	E	0.1602								
556	N			114	34.28381	-119.33501	10	O	E	0.0884								
557	N			114	34.27498	-119.34156	20	O	E	0.0933								
558	N			115	34.28362	-119.32492	5	O	E	0.1392								
559	N			115	34.28039	-119.32762	10	O	E	0.0882								
560	N			115	34.26805	-119.33164	20	O	E	0.0913								
561	N			116	34.27568	-119.31502	5	O	E	0.1882								
562	N			116	34.27371	-119.31669	10	O	E	0.0918								
563	N			116	34.26243	-119.32067	20	O	E	0.0883								
564	N			117	34.27137	-119.30257	5	O	N									REEF
565	N			117	34.26727	-119.30400	10	O	E	0.1084								
566	N			117	34.25649	-119.31068	20	O	E	0.1070								
567	N			118	34.27358	-119.29296	5	O	E	0.1024								
568	N			118	34.26755	-119.29521	10	O	E	0.0934								
569	N			119	34.26910	-119.28376	5	O	E	0.1416								
570	N			119	34.26582	-119.28700	10	O	E	0.1068								
571	N			120	34.26291	-119.27815	5	O	E	0.1719								
572	N			120	34.26162	-119.28048	10	O	E	0.1089								
573	N			120	34.24662	-119.31031	20	O	E	0.0970								
574	N			121	34.25528	-119.27273	5	O	E	0.1726								
575	N			121	34.25481	-119.27548	10	O	E	0.0972								
576	N			122	34.24400	-119.26965	5	O	E	0.1522								
577	N			122	34.24350	-119.27483	10	O	E	0.1059								
578	N			123	34.23793	-119.26933	5	O	E	0.1513								
579	N			123	34.23674	-119.27674	10	O	E	0.0960								
580	N			123	34.23672	-119.30961	20	O	E	0.0904								
581	N			124	34.22757	-119.26802	5	O	B	0.2153	0.1780	0.1835	1.3714	0.8527	0.2914		2.59	
582	N			124	34.22630	-119.27790	10	O	B	0.0919	0.0714	0.0698	1.1636	1.0231	0.2220		18.43	
583	N			124	34.22643	-119.31075	20	O	E	0.0856								
584	N			125	34.21879	-119.26409	5	O	E	0.1247								
585	N			125	34.21685	-119.26908	10	O	E	0.1081								
586	N			0	34.21685	-119.31299	20	O	E	0.0854								
587	N			0	34.20727	-119.31721	20	O	E	0.0956								
588	N			126	34.20963	-119.25885	5	O	E	0.1451								
589	N			126	34.20850	-119.26245	10	O	E	0.0893								
590	N			0	34.19756	-119.31316	20	O	E	0.0825								
591	N			0	34.18941	-119.31254	20	O	E	0.0959								
592	N			127	34.20276	-119.25495	5	O	E	0.1468								
593	N			127	34.20130	-119.25761	10	O	E	0.0975								
594	N			127	34.17906	-119.31270	20	O	E	0.0828								
595	N			128	34.19159	-119.24856	5	O	E	0.1669								
596	N			128	34.19064	-119.25140	10	O	E	0.0995								
597	N			128	34.17043	-119.30620	20	O	E	0.0935								
598	N			129	34.18358	-119.24428	5	O	E	0.1100								
599	N			129	34.18251	-119.24720	10	O	E	0.1244								
600	N			129	34.15916	-119.29320	20	O	E	0.0893								

Sid	Sur	Yr	Sea	Tran	Lat	Lon	Dep	Ele	Type	eMean	gMean	gMed	gSort	gSkew	gKur	gD10	g%Fine	Notes
601	N			130	34.17406	-119.23950	5	O	E	0.1345								
602	N			130	34.17283	-119.24206	10	O	E	0.0983								
603	N			130	34.15127	-119.28405	20	O	E	0.0897								
604	N			131	34.16545	-119.23387	5	O	E	0.1207								
605	N			131	34.16328	-119.23728	10	O	E	0.0852								
606	N			131	34.14280	-119.27635	20	O	E	0.0852								
607	N			132	34.15642	-119.22696	5	O	E	0.2197								
608	N			132	34.15474	-119.23411	10	O	E	0.0972								
609	N			132	34.14279	-119.25962	20	O	E	0.0902								
610	N			133	34.15066	-119.22110	5	O	B	0.1816	0.2832	0.2810	1.3147	0.9434	0.2493		1.09	
611	N			133	34.14647	-119.22272	10	O	B	0.0833	0.0891	0.0865	1.1553	1.0409	0.2325		2.76	
612	N			133	34.14032	-119.24239	20	O	E	0.0940								
613	N			134	34.14265	-119.21033	5	O	E	0.1576								
614	N			134	34.14014	-119.21207	10	O	E	0.1076								
615	N			134	34.13533	-119.21512	20	O	E	0.0876								
616	N			135	34.14090	-119.19742	5	O	E	0.1810								
617	N			135	34.13811	-119.19972	10	O	E	0.0926								
618	N			135	34.12229	-119.21182	20	O	E	0.0801								
619	N			136	34.13673	-119.18991	5	O	E	0.1128								
620	N			136	34.13440	-119.19194	10	O	E	0.0984								
621	N			136	34.11967	-119.20190	20	O	E	0.1032								
622	N			138	34.12662	-119.17368	5	O	E	0.1363								
623	N			138	34.12486	-119.17605	10	O	E	0.0845								
624	N			138	34.11166	-119.18854	20	O	E	0.0841								
625	N			140	34.11430	-119.15566	5	O	E	0.1215								
626	N			140	34.11076	-119.15742	10	O	E	0.0816								
627	N			140	34.10024	-119.16669	20	O	E	0.0895								
628	N			142	34.10209	-119.13545	5	O	E	0.1186								
629	N			142	34.09944	-119.13888	10	O	E	0.0749								
630	N			142	34.09235	-119.14134	20	O	E	0.0873								
631	N			144	34.09478	-119.11601	5	O	E	0.1408								
632	N			144	34.09185	-119.11488	10	O	E	0.1002								
633	N			144	34.08747	-119.11489	20	O	E	0.0841								
634	N			146	34.09816	-119.09510	10	O	E	0.1061								
635	N			146	34.09458	-119.09450	20	O	E	0.0858								
636	N			148	34.09084	-119.07241	5	O	B	0.1204	0.0704	0.0677	1.1566	1.0564	0.1005		5.04	
637	N			148	34.08870	-119.07476	10	O	E	0.0891								
638	N			148	34.08572	-119.07931	20	O	E	0.0857								
639	N			149	34.08558	-119.06645	10	O	E	0.1065								
640	N			150	34.08492	-119.06128	5	O	E	0.3007								
641	N			150	34.08414	-119.06253	10	O	E	0.1402								
642	N			150	34.07773	-119.06450	20	O	E	0.1174								
643	S	6	W		34.39625	-119.53569		MB	E	0.2566								
644	S	6	W		34.39619	-119.53447		MB	E	0.2719								
645	S	6	W		34.39606	-119.53339		MB	E	0.2380								
646	S	6	W		34.39578	-119.53158		MB	E	0.2707								
647	S	6	W		34.39544	-119.53031		MB	E	0.2987								
648	S	6	W		34.39522	-119.52889		MB	E	0.2062								
649	S	6	W		34.39383	-119.52589		MB	E	0.2333								
650	S	6	W		34.39267	-119.52386		MB	E	0.3604								

Sid	Sur	Yr	Sea	Tran	Lat	Lon	Dep	Ele	Type	eMean	gMean	gMed	gSort	gSkew	gKur	gD10	g%Fine	Notes
651	S	6	W		34.38997	-119.51975		MB	E	0.3914								
652	S	6	W		34.39631	-119.53569		BB	E	0.2621								
653	S	6	W		34.39628	-119.53447		BB	E	0.2497								
654	S	6	W		34.39619	-119.53333		BB	E	0.2708								
655	S	6	W		34.39589	-119.53156		BB	E	0.2426								
656	S	6	W		34.39558	-119.53025		BB	E	0.2501								
657	S	6	W		34.39542	-119.52883		BB	E	0.1861								
658	S	6	W		34.39397	-119.52578		BB	B	0.2354	0.2513	0.2476	1.1218	1.0168	0.2411			grab Carp 76
659	S	6	W		34.39289	-119.52375		BB	E	0.2569								
660	S	6	W		34.39014	-119.51958		BB	E	0.3286								
661	S	6	W		34.41722	-119.82614		MB	E	0.1604								
662	S	6	W		34.41683	-119.82733		MB	E	0.3484								
663	S	6	W		34.41675	-119.82842		MB	E	0.1707								
664	S	6	W		34.41658	-119.83172		MB	B	0.2750	0.2546	0.2504	1.1509	1.0134	0.2589			grab G2
665	S	6	W		34.41586	-119.83494		MB	E	0.2330								
666	S	6	W		34.40800	-119.87956		MB	E	0.2654								
667	S	6	W		34.41672	-119.88753		MB	E	0.3078								
668	S	6	W		34.41931	-119.89083		MB	B	0.2735	0.3136	0.3120	1.1055	1.0001	0.2559			grab IV3
669	S	6	W		34.40708	-119.87817		MB	E	0.2148								
670	S	6	W		34.41611	-119.83503		BB	E	0.3119								
671	S	6	W		34.40808	-119.87936		BB	E	0.1925								
672	S	6	W		34.41683	-119.88736		BB	E	0.2308								
673	S	6	W		34.24492	-119.26753		MB	B	0.4496	0.5085	0.4800	1.2360	1.0733	0.2746			grab V1
674	S	6	W		34.27508	-119.30972		MB	E	0.6326								
675	S	6	W		34.27544	-119.29169		MB	E	0.4167								
676	S	6	W		34.24517	-119.26700		BB	B	0.7008	0.4537	0.4595	1.2182	0.9379	0.2598			grab V3
677	S	6	W		34.27567	-119.29158		BB	E	0.3553								
678	K			14	34.08825	-119.06479		MB	E	1.0332								coarse lag
679	K			24	34.47085	-120.22627		MB	E	0.3543								dry sand by cliff?
680	K			24	34.47107	-120.22728		MB	E	0.2936								
681	K			38	34.46280	-120.07163		MB	E	0.2572								
682	K			39	34.46254	-120.06665		MB	E	0.2994								
683	K			42	34.46091	-120.02942		MB	E	0.2802								
684	K			57	34.40806	-119.87963		MB	E	0.2274								
685	K			58	34.40932	-119.86980		MB	E	0.3888								
686	K			60	34.40758	-119.85080		MB	E	0.3989								questionable image
687	K			62	34.41597	-119.83446		MB	E	0.2208								
688	K			70	34.40368	-119.74709		MB	E	0.1738								
689	K			75	34.40271	-119.69506		MB	E	0.1656								bad exposure?
690	K			75	34.40266	-119.69557		MB	E	0.2971								
691	K			76	34.41060	-119.68976		MB	E	0.1426								
692	K			76	34.41031	-119.68925		MB	E	0.1913								
693	K			77	34.41457	-119.68030		MB	E	0.2058								
694	K			77	34.41444	-119.68027		MB	E	0.3062								
695	K			78	34.41610	-119.66998		MB	E	0.2747								
696	K			79	34.41709	-119.65842		MB	E	0.2454								
697	K			80	34.41737	-119.64716		MB	E	0.2325								
698	K			80	34.41732	-119.64719		MB	E	0.2529								
699	K			81	34.41637	-119.63601		MB	E	0.2136								
700	K			82	34.41894	-119.62495		MB	E	0.2919								

Sid	Sur	Yr	Sea	Tran	Lat	Lon	Dep	Ele	Type	eMean	gMean	gMed	gSort	gSkew	gKur	gD10	g%Fine	Notes
701	K			84	34.41979	-119.60280		MB	E	0.2275								
702	K			84	34.41972	-119.60280		MB	E	0.3763								
703	K			88	34.41313	-119.55877		MB	E	0.2433								
704	K			89	34.40808	-119.55132		MB	E	0.1700								
705	K			91	34.39532	-119.52947		MB	E	0.1817								
706	K			92	34.39292	-119.52429		MB	E	0.2515								
707	K			93	34.38753	-119.51421		MB	E	0.2075								
708	K			96	34.37732	-119.48138		MB	E	0.2742								
709	K			99	34.37043	-119.45616		MB	E	0.2523								
710	K			100	34.36274	-119.44868		MB	E	0.2534								
711	K			102	34.35328	-119.42893		MB	E	0.2261								
712	K			106	34.32861	-119.39872		MB	E	0.4040								
713	K			107	34.31955	-119.39153		MB	E	0.3650								
714	K			108	34.32114	-119.37671		MB	E	0.4250								
715	K			111	34.30840	-119.35425		MB	E	0.2417								
716	K			112	34.30221	-119.34685		MB	E	0.2388								
717	K			117	34.27330	-119.30478		MB	E	0.4241								
718	K			119	34.27318	-119.28651		MB	E	0.3259								
719	K			120	34.26368	-119.27558		MB	E	0.3847								
720	K			122	34.25497	-119.27049		MB	E	0.3588								
721	K			123	34.24519	-119.26758		MB	E	0.2215								
722	K			123	34.23994	-119.26723		MB	E	0.2822								
723	K			127	34.19831	-119.24880		MB	E	0.4163								
724	K			127	34.19818	-119.24924		MB	E	0.3136								
725	K			128	34.19233	-119.24558		MB	E	0.3439								
726	K			128	34.19217	-119.24601		MB	E	0.3767								
727	K			129	34.18349	-119.24112		MB	E	0.3026								
728	K			129	34.18351	-119.24143		MB	E	0.6065								coarse patch
729	K			129	34.18351	-119.24143		MB	E	0.3918								fine patch
730	K			130	34.17648	-119.23728		MB	E	0.2947								
731	K			130	34.17626	-119.23747		MB	E	0.3607								
732	K			131	34.16589	-119.23077		MB	E	0.3413								
733	K			131	34.16573	-119.23128		MB	E	0.3157								
734	K			132	34.15691	-119.22466		MB	E	0.2846								
735	K			132	34.15656	-119.22490		MB	E	0.2705								
736	K			133	34.14801	-119.21641		MB	E	0.3774								
737	K			133	34.14788	-119.21702		MB	E	1.1814								
738	K			149	34.08825	-119.06479		MB	E	0.4737								
739	K			153	34.07558	-119.02254		MB	E	0.4940								
740	K			154	34.06979	-119.01270		MB	E	0.3952								
741	K			154	34.06979	-119.01270		MB	E	0.7442								coarse lag
742	K			160	34.05203	-118.96063		MB	E	0.3735								
743	K			162	34.04581	-118.93156		MB	E	0.4517								
744	K			164	34.04265	-118.91623		MB	E	0.5950								
745	K			166	34.03934	-118.89300		MB	E	0.5695								
746	K			167	34.03803	-118.87546		MB	E	0.3686								
747	K			168	34.03798	-118.87412		MB	E	0.4876								
748	K			171	34.02811	-118.84082		MB	E	0.5223								
749	K			172	34.02241	-118.83201		MB	E	0.4247								
750	K			173	34.01661	-118.82449		MB	E	0.4812								

Sid	Sur	Yr	Sea	Tran	Lat	Lon	Dep	Ele	Type	eMean	gMean	gMed	gSort	gSkew	gKur	gD10	g%Fine	Notes
751	K			174	34.01279	-118.81941		MB	E	0.5002								
752	K			175	34.00265	-118.80939		MB	E	0.6576								
753	K			24	34.47122	-120.22725		BB	E	0.2370								
754	K			57	34.40816	-119.87943		BB	E	0.2635								
755	K			62	34.41624	-119.83449		BB	E	0.3271								
756	K			70	34.40375	-119.74709		BB	E	0.3101								
757	K			75	34.40312	-119.69521		BB	E	0.3470								
758	K			75	34.41359	-119.69559		BB	E	0.3568								
759	K			76	34.41095	-119.69012		BB	E	0.3860								
760	K			77	34.41480	-119.68035		BB	E	0.3428								
761	K			78	34.41671	-119.66998		BB	E	0.4423								
762	K			79	34.41718	-119.65847		BB	E	0.3105								
763	K			80	34.41745	-119.64715		BB	E	0.3548								
764	K			81	34.41645	-119.63603		BB	E	0.3423								
765	K			82	34.41910	-119.62491		BB	E	0.3329								
766	K			84	34.41996	-119.60266		BB	E	0.4570								
767	K			92	34.39309	-119.52410		BB	E	0.9926								
768	K			96	34.37740	-119.48125		BB	E	0.5550								
769	K			99	34.37063	-119.45587		BB	E	0.4051								
770	K			102	34.35342	-119.42882		BB	E	0.4353								
771	K			106	34.32863	-119.39865		BB	E	0.2328								
772	K			113	34.29609	-119.34184		BB	E	0.2294								
773	K			117	34.27352	-119.30477		BB	E	0.1616								
774	K			119	34.27330	-119.28643		BB	E	0.2319								
775	K			120	34.26381	-119.27528		BB	E	0.1547								bad exposure?
776	K			121	34.25517	-119.27030		BB	E	0.2352								
777	K			122	34.24533	-119.26720		BB	E	0.1230								
778	K			123	34.23952	-119.26615		BB	E	0.2359								
779	K			127	34.19855	-119.24815		BB	E	0.3874								
780	K			128	34.19255	-119.24495		BB	E	0.2014								
781	K			129	34.18362	-119.24032		BB	E	0.2212								
782	K			130	34.17656	-119.23686		BB	E	0.2423								
783	K			131	34.16596	-119.23025		BB	E	0.3050								
784	K			133	34.14817	-119.21560		BB	E	0.2453								
785	K			135	34.14426	-119.19884		BB	E	0.2493								
786	K			136	34.14032	-119.19058		BB	E	0.2531								
787	K			149	34.08860	-119.06422		BB	E	0.2265								
788	K			154	34.06992	-119.01259		BB	E	0.2741								
789	K			171	34.02829	-118.84056		BB	E	0.1726								

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