FISH EXPLOITATION AT SEVERAL SITES NEAR GAVIOTA, SANTA BARBARA COUNTY, CALIFORNIA: AN ALTERNATIVE ANALYTICAL METHOD

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ABSTRACT

Analysis of faunal remains recovered from several sites near Gaviota, Santa Barbara County as part of the Chevron Point Arguello Project provides insight into the exploitation of fish in an area dominated by rocky shore environs. The relative importance of fishing during several time periods is examined, including the historic as represented by the village of *Estait*. The methodology used during analysis includes standardization according to species, specific vertebral counts, and species assignment to one or more habitat zones. A maximum percentage yield per habitat zone is calculated and examined with reference to locally available offshore environs. These data are discussed according to differing patterns of exploitation over time, and compared with data from other locales in Santa Barbara County analyzed using a similar methodology.

Introduction

Efforts over the last several decades have attempted to go beyond the elementary descriptive lists of species identified in archaeological deposits. Instead, analysts have turned to quantification of these remains in an effort to reconstruct past environs and patterns of exploitation. This paper presents an analytical method applied to the analysis of fish remains, specifically vertebrae. The method is illustrated through the comparison of this method with previously established minimum number of individuals (MNI) and number of individual specimens (NISP) methods. Application of the method is then used to explicate exploitation patterns at several sites along the Santa Barbara coast (Figure 1).

The use of MNI and NISP is widely accepted as a means of deriving the relative dietary importance of a species or group of species. While these methods have merit, their applicability to the analysis of fish remains is debatable. MNI, that is, minimum number of individuals, is calculated using the most numerous discrete skeletal element of a species. While extremely applicable to mammalian species, its application to analysis of fish remains suffers in two ways: first, the paucity of discrete skeletal elements due primarily to the lack of limb bones and secondly, the differential processing of fish species by their captors, a problem also apparent in the analysis of mammalian remains.

Roughly speaking, skeletons of bony fish can be divided into 3 major groups: skull, fins, and the spine. Fins are virtually useless as analytical elements due to their poor preservation and lack of diagnostic qualities. Skull bones, especially otoliths, provide extremely useful diagnostic elements when recovered from deposits. However, previous analyses, including my own work on the Mescalitan Island collection (Glenn 1990), show clear evidence that large pelagic fish, such as Yellowtail, were decapitated off-site or, at the very least, the heads were treated in such a way as to eliminate otoliths and other skull parts of these fish from the archaeological record in the majority of cases. This practice leaves the vertebral column for analysis.

Quantification of Skeletal Elements

Vertebral elements of bony fish are often diagnostic to the species level; in other instances the analyst must make due with broader group assignments, as in the case of rockfish and perch. However, species assignment alone does not aid in the determination of relative species abundance. Calculation of MNI requires a discrete element. Only the atlas vertebrae is consistently useful in this determination. The problem with using this element has already been illustrated in the case of the missing skull. Decapitation is likely to remove one or more vertebrae, thereby eliminating the atlas from the deposit. Again, the Mescalitan collection illustrates the problem, given the disproportionate number of vertebrae relative to atlas counts. This leads us to a discussion of NISP, that is, number of individual specimens.

NISP is an easily obtainable estimate of species abundance. It simply requires the analyst to sum the number of specimens assigned to a given species. While intuitively attractive, the results of using this method in the analysis of fish remains are undesirable due to the variation in the number of vertebral elements between teleost species. Within the Mescalitan Island sample, extremes are found between jack mackerel having 24 vertebrae and giant kelpfish, which have 57. As an example, given 2 vertebral columns from each of these species, that is 48 and 104 vertebrae respectively, an analyst using the NISP method would conclude giant kelpfish was over twice as abundant as jack mackerel.

In an effort to compensate for this variability in vertebral counts, I have used a modified MNI that standardizes vertebrae

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counts by dividing the total number of vertebrae specimens of a species represented in the sample by the vertebrae count for that species. Using the previous example, the 2 jack mackerel vertebral columns totaling 48 vertebrae would be divided by the corresponding vertebrae count, 24. This formula would result in the identification of 2 individuals. The same result would conclude from analysis of the giant kelpfish example. As is invariably the case in real life, the quotient will rarely be a whole number. However, since we are interested in determining the "relative abundance" of a species, whole numbers are not necessary.

The modified MNI method thus provides an estimate of the "relative abundance" of a particular species. It does not, however, provide information regarding the "relative importance" of that species to the prehistoric occupants of a site. It is, therefore, necessary to convert relative abundance to importance. This is accomplished by multiplying the relative abundance index derived earlier by the modified MNI method by the live weight for each species; the product of which I refer to as the calculated weight. This step is in my estimation the weakest link in the methodology I am proposing. It assumes that each vertebrae corresponds to an adult fish. However, the use of average weight data available through the archaeology or marine biology communities does provide compensation.

An alternative to the NISP, MNI or modified MNI methods is the use of bone weight to determine the relative abundance and, more importantly, a bone/meat weight conversion to determine relative importance of a particular species. This bone to meat ratio is a weak link in this analytical method. Tartaglia (1976) proposes a ratio of 1 to 27.7 to convert fish bone weight to meat weight. However, data regarding the accuracy of this conversion factor relative to particular species is lacking. Once available, this data would be invaluable in the analysis of fish remains from archaeological sites.

Fish Species/Marine Habitat Correlations

Regardless of which method has been used to derive an estimation of the relative importance of each species, the focus now shifts to positing which marine habitats were utilized and to what extent. Previous studies have treated each species as if they belong exclusively to one habitat. However, studies by marine biologists discount this assumption as too simplistic. Instead, they propose that a species may occupy multiple habitats (Figure 2). We are then left with the problem of adapting our analyses to account for this phenomena. Fortunately, in southern California we are aided in this task by a study that may be familiar to a number of you. It was published by the Southern California Academy of Science in December of 1985. The paper by Larry Allen is titled *A Habitat Analysis of the Nearshore Marine Fishes from Southern California.* Allow me to quickly summarize his methods and findings by quoting a portion of the paper's abstract.

> This study synthesized the results of 38 ichthyofaunal studies from a wide range of habitats within the Southern California Bight. Quantitative clustering of sites based on species composition yielded nine distinct groups designated as bay/estuary (BE), open coast sandy beach (OC), harbor/nearshore soft bottom (H/NSB), nearshore midwater (MW), offshore soft bottom (SB), rocky intertidal (IT), shallow rock reef (SRRF), deep rocky reef (RRF), and kelp bed (KB). Clustering of the 105 species produced 19 groups of both widespread and habitat specific species (Allen 1985:133).

Salls' (1988) dissertation graphic illustrates a submarine canyon habitat zone in addition to those presented by Allen (Figure 2). I have chosen not to include this zone in my analysis.

Utilizing Allen's database, I assign each of the archaeologically identified species to one of Allen's 19 species groups (Figure 3). In cases where the species identified in the archaeological collection is not represented in Allen's database, or where the lumping of species by the archaeologist has taken place, as in the case of rockfish, it is necessary to assign a species or family to a species group based on similarities between the archaeologically represented species and those species listed by Allen. Any such assignments should be justified and documented as part of the analysis.

The next step in the analysis is to determine what percentage of the sample, as defined by the calculated weight, is represented by a given Habitat Zone. This requires the analyst to sum the calculated weight for each species group. These data are then placed into a cross-tab matrix with the X axis representing Allen's Habitat Zones and the Y axis Species Groups (Figure 4). Totals for each column represent the MAXIMUM calculated weight available from a given Habitat Zone. Habitat Zones can then be assigned rank order to assess the possible relative importance of each. Additional information is then derived by dividing Habitat Zone totals by the total for the entire sample the quotient of which represents the maximum percentage of calculated weight available from each Habitat Zone. This percentage calculation allows comparison between data sets.

These calculations can be carried out for each site, unit, or level to aid in the analysis of both spatial and temporal variability. Data can then be compared to bathymetric and marine resource maps for the coastal area adjacent to the site in order to determine which of the Habitat Zones were available to the prehistoric inhabitants. Continental Shelf Data Systems has published an excellent set of bathymetric maps (Figure 5) and the California Department of Fish and Game published a coastal resource map that includes kelp bed boundaries as of 1912 (Figure 6).

Site Descriptions

With the methodology established, let us examine Habitat Zone data from several sites. Two sites, SBA-1491 with two loci and CA-SBA-97, were excavated as part of the Chevron Point Arguello Project (see Figure 1). CA-SBA-1491 is the reported location of the historic village of *Estait.*

The Chevron Point Arguello Project covered a 30 km stretch of coastline between Point Arguello, where the offshore pipeline comes ashore, and Gaviota, where an oil processing plant was constructed. Over 25 archaeological sites were excavated to varying degrees as part of impact mitigation. Fish remains recovered from CA-SBA-1491 and CA-SBA-97 provided a sample sufficiently large to allow inference regarding exploitation patterns.

A portion of the excavations at CA-SBA-97 was funded by the California Department of Parks and Recreation. The site is cross-cut by the Southern Pacific Railroad on the west side of Cañada Gaviota near where Highway 101 turns northward away from the coast. CA-SBA-97 is found on a gently sloping uplifted terrace leading to a nearly vertical sea cliff approximately 16 m above sea level (Figure 7). A combination of chronological indicators denote a multi-component occupation during the Early Period, between 8000 and 6500 B.P. and again during the Middle Period between 3500 and 1000 B.P. Shellfish remains related to the Early Period indicate exploitation focused on the estuarine embayment. The embayment appears to have been blocked sometime prior to the Middle Period resulting in a brackish water marsh devoid of estuarine species. Due to the sparse nature of the Early Period component, the bulk of the fish remains are believed to relate to the Middle Period occupation.

The state trinomial CA-SBA-1491 delimits the north half of the historic village of *Estait*. The site was bisected by the construction of the Southern Pacific Railroad in 1900 (Figure 8). The area on the south side of the tracks has been designated CA-SBA-1492. This portion of the village was not examined as part of the Point Arguello project. The village of *Estait* is located some 15 km east of Point Conception on both sides of Cañada de Santa Anita. A variety of environs were available to the inhabitants, including sandy beaches, rocky stretches of coast and a coastal lagoon. It appears to have been occupied almost exclusive during the Late Period after A.D. 1190. Spanish records and other ethnographic data indicate the village housed 100 to 200 inhabitants. Between fifteen and thirty houses and three to five plank canoes were reportedly owned by the villagers. The village was abandoned by A.D. 1810 when the occupants moved to the La Purisima Mission.

Two additional sites, CA-SBA-1731 and CA-SBA-46, are used for comparison and, in the case of CA-SBA-1731, to further illustrate the methodology (see Figure 1). CA-SBA-1731 is exposed along the sea cliff at the mouth of Corral Canyon, south of the Southern Pacific Railroad tracks and Highway 101. The fish bone database resulted from excavations carried out by the Office of Public Archaeology at the University of California, Santa Barbara for the State Parks and Recreation Department in 1982.

CA-SBA-46 is better known as Mescalitan Island (Figure 9). The island, now land-locked, was a major Chumash village site in the Goleta Slough west of downtown Santa Barbara. Excavations at Site III on Mescalitan were conducted in 1986 by the Center for Archaeological Studies at the University of California, Santa Barbara. Both CA-SBA-1731 and CA-SBA-46, Site III are Late Period sites. CA-SBA-46 includes a Mission Period component as well.

Site Sample Comparisons

Inequities between samples due to differential screen sizes was a major consideration. Only data collected in a similar manner are compared. These inequities and attempts to compensate for them do, however, present us with the opportunity to document what we assume *a priori*. That is, the inclusion of the greater than 1/16" portion of the sample to the analysis dramatically alters our perception of the relative importance of specific species and areas of exploitation (Figure 10). In the CA-SBA-1491C example illustrated here, this variation is almost exclusively due to the addition of the large portion of sardine found in the 1/16" portion of the sample. This, of course, may differ with any given sample but is consistent with other Late Period sites within the Chumash sphere.

The CA-SBA-97 data contains 1/16" materials and is, therefore, comparable only with Unit 6 from CA-SBA-1491C for which both 1/16" and 1/8" data were collected (Figure 11). When all Habitat Zones are examined together, the visible differences appear minimal. However, when the overwhelming Midwater Habitat Zone is filtered out, the differences become more pronounced (Figure 12). These differences can be traced to the high incidence of Species Group VIII, including jack smelt, top smelt, and barracuda, in the CA-SBA-97 sample.

The CA-SBA-1731 data provides information regarding the suitability of modified MNI over the standard MNI method (Figure 13). As can be seen by the graph, the perception of Habitat Zone exploitation differs significantly between the two methods. This difference is to a large extent the result of the under-estimation of the MNI for species associated with midwater, kelp beds, and rocky reef habitats. For example, yellowtail MNI for the entire site was estimated to be 3, whereas 476 vertebrae were estimated. Given the fact that yellowtail have 51 vertebrae, a minimum of 19 individuals are represented, accounting for over 129 kilograms of live weight as opposed to less than 21 kilograms represented by the standard MNI method.

Graphic comparison between the three equitable sites, including separate analysis of the two CA-SBA-1491 loci, shows pairing within the Harbor/Nearshore Soft Bottom, Midwater and Soft Bottom-offshore Habitat Zones and, to a lesser extent, within the Kelp Bed, Open Coast Sandy Beach, and Shallow Rocky Reef Habitat Zones (Figure 14). This pairs CA-SBA-46 with CA- SBA-1731 and CA-SBA-1491B with CA-SBA-1491C. The pairing between the two loci of CA-SBA-1491 is to be expected given proximity to Habitat Zones and loci contemporaneity. The CA-SBA-46/CA-SBA-1731 pairing requires more in-depth analysis.

Explanation of Variability

From a habitat perspective, CA-SBA-1731 is more similar to CA-SBA-1491; that is, located on a narrow coastal terrace adjacent to a perennial stream. More importantly, both offshore environs are dominated by Soft Bottom-offshore, Kelp Bed, and Midwater Habitat Zones. These habitat zones were also available to the prehistoric occupants of CA-SBA-46. In addition, the remainder of Allen's Habitat Zones were also accessible to varying degrees. Given these data, it would be expected that the two loci of CA-SBA-1491 would compare more favorably with CA-SBA-1731.

It was, therefore, apparent that spatial analysis of the data could not explain the positive correlation between CA-SBA-46 and CA-SBA-1731. In addition, since all the sites examined are dominated by Late Period components, temporal differences were not responsible for the observed variation in Habitat Zone percentages.

If neither Habitat Zone availability nor period of occupation are responsible for the variation, then differential habitat exploitation might in and of itself be responsible. Detailed analysis of the Species Groups and species responsible for the variation indicates the Midwater Habitat Zone has greater amounts of sardine, yellowtail, and bonito within the CA-SBA-1731 and CA-SBA-46 samples. From this can be inferred a greater dependence on offshore resources and the concomitant use of the *Tomol*, the Chumash plank canoe, in order to exploit these environs. Data from CA-SBA-1491, on the other hand, indicate a heavier reliance on rockfish; a pattern of exploitation in which the *Tomol* would have played a lesser role.

The Crespí diary reports the village of *Helo'*, located on Mescalitan Island, had 16 canoes; the village of *Tajiguas*, located some 5 km west of CA-SBA-1731, had 15 *Tomols*. In contrast, the village of *Estait*, that is, CA-SBA-1491, had but 5 of these sea-going craft. Further inference that the prehistoric occupants of SBA-1731 had access to the *Tomol* is found in the works of D.B. Rogers. Rogers (1929) reports that his investigations at the historic village of *Kasil*, located on Refugio Bay some 2.5 km west of SBA-1731, resulted in the recovery of grooved net sinkers, Catalina Island steatite, numerous large caulking stones and lumps of asphaltum. Rogers concluded that the area represented a landing place and repair shop for the great canoes.

The presence of the *Tomol*, or at least its influence, is, however, only fully appreciated with the greater understanding of habitat exploitation inferred from the detailed analysis of fish remains and available Habitat Zones. In this paper, I have presented 5 main points: first, the use of standard MNI and NISP methods is not adequate to calculate the relative abundance of fish species; second, a modified MNI method that standardizes sample data using species specific vertebrae counts produces a more accurate estimation of relative abundance; third, the relative importance of each species must be ascertained through a form of bone to meat weight conversion; forth, estimation of habitat zone exploitation must account for species occupying multiple habitats; and lastly, an attempt must be made to account for these results through analysis of spatial, temporal, and/or functional variation within and across samples.

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Figure 1.
The Northern Channel Islands and Santa Barbara Channel Area

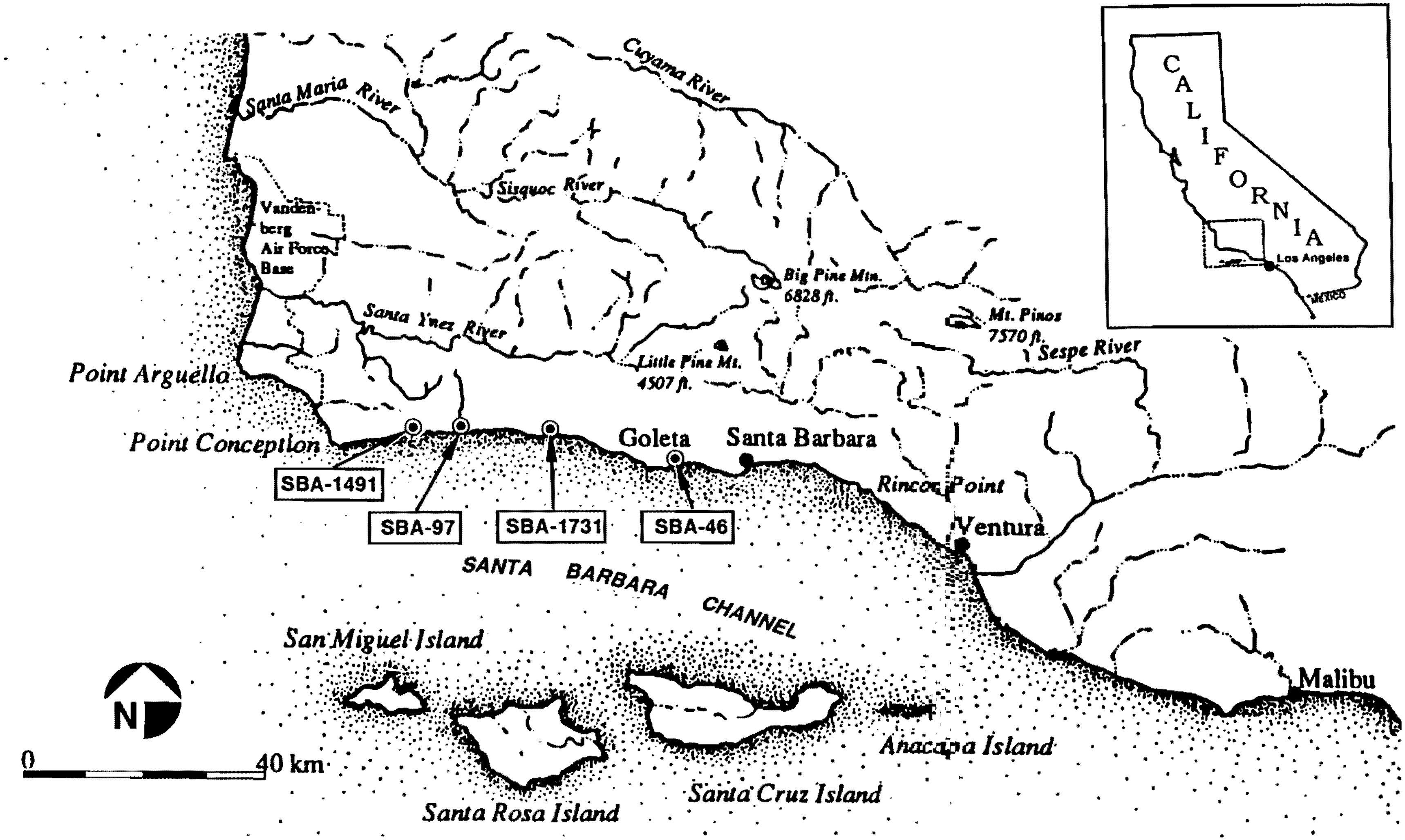
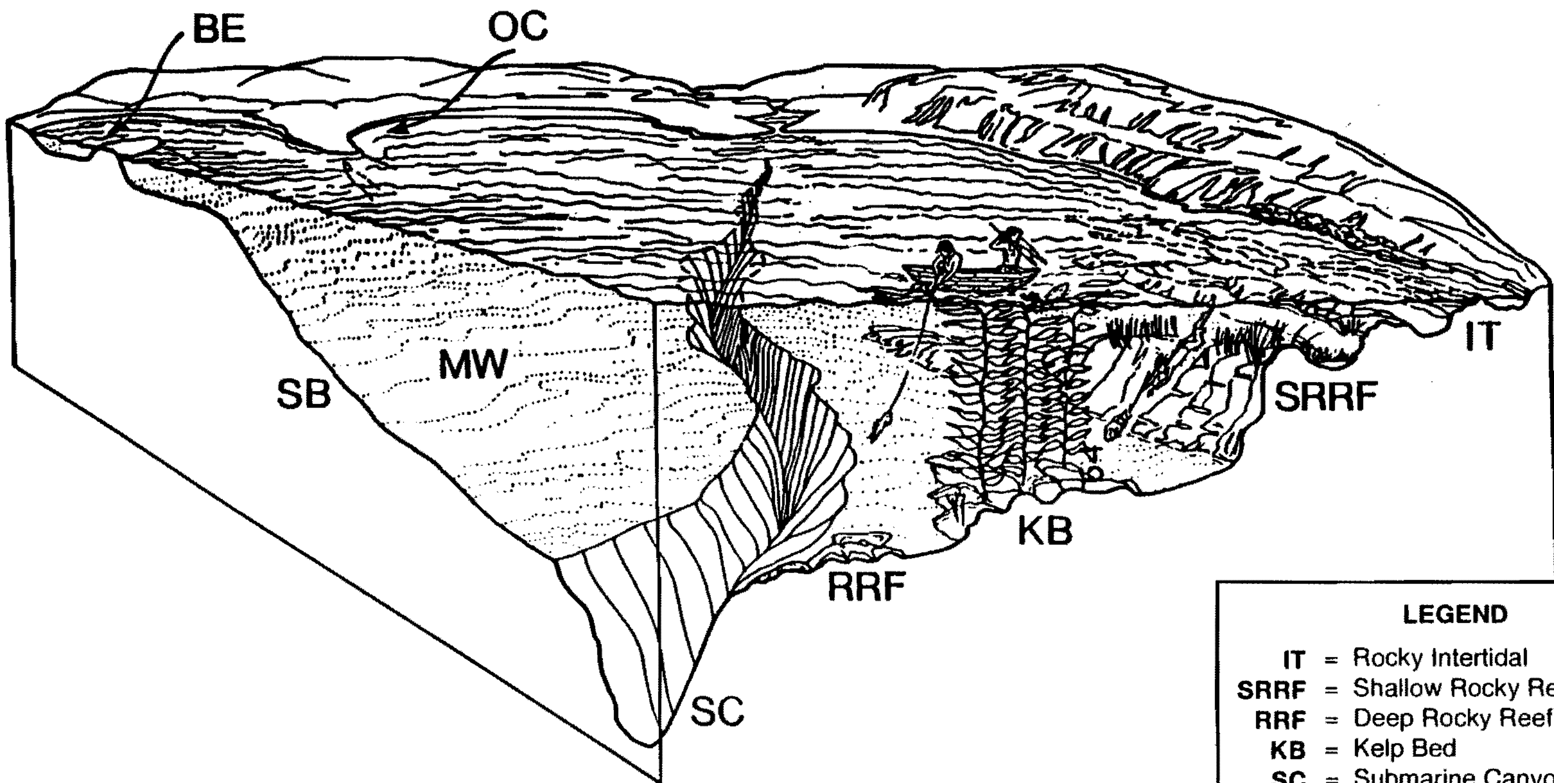


Figure 2.
Nearshore Marine Habitats of Southern California



LEGEND

IT	=	Rocky Intertidal
SRRF	=	Shallow Rocky Reef
RRF	=	Deep Rocky Reef
KB	=	Kelp Bed
SC	=	Submarine Canyon Nearshore
MW	=	Nearshore Mid-water
SB	=	Soft Bottom
BE	=	Bay and Estuary
OC	=	Open Coast Sandy Beach

REFERENCE: Salls 1988

Figure 3.
Habitat Species Matrix

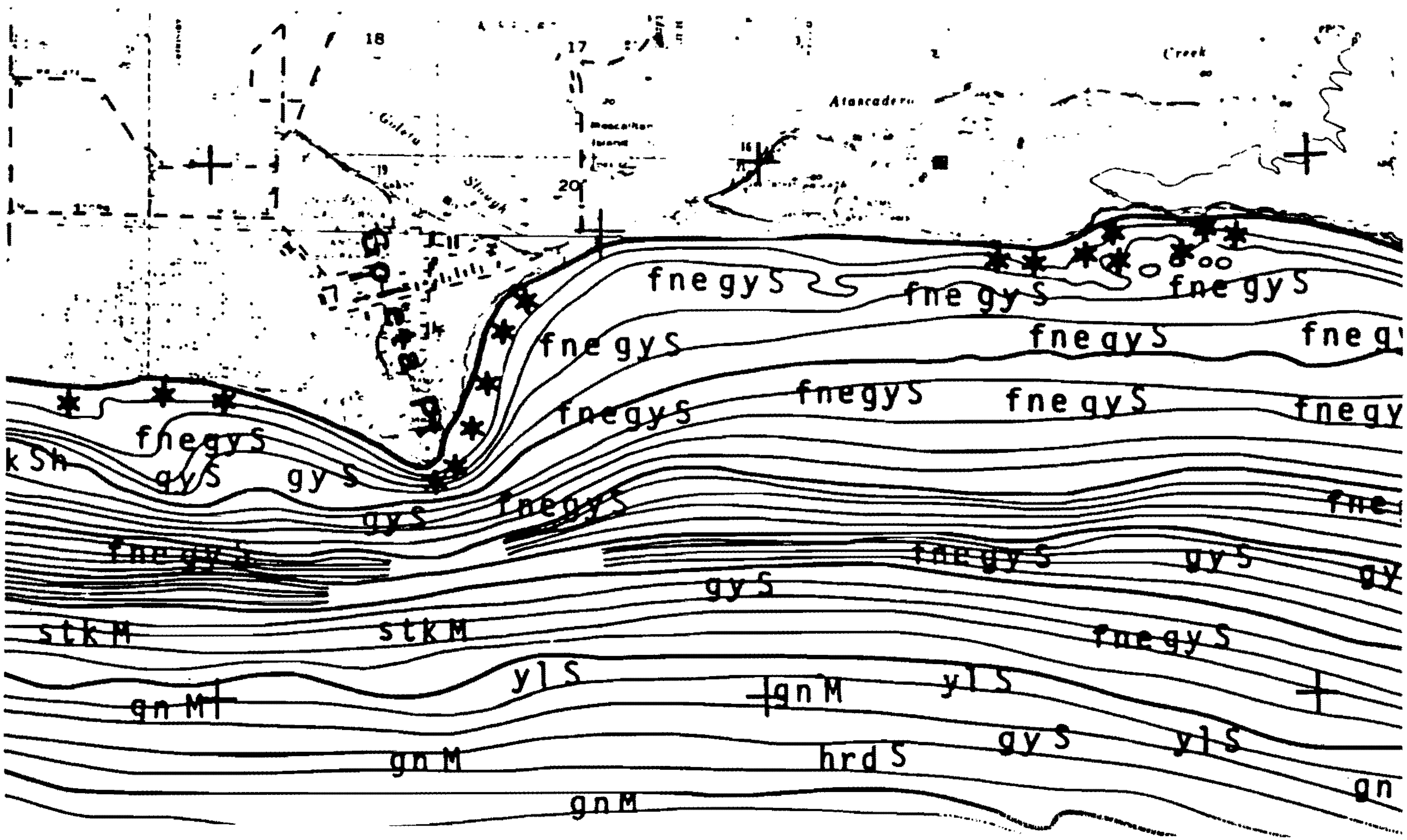
Habitat Groups

Species Groups	SB	MW	H/NSB	OC	BE	IT	RRF	SRRF	KB
I						*			
II						*	*	*	*
III								*	*
IV		*					*	*	*
V							*	*	*
VI	*	*	*	*	*		*	*	*
VII		*							*
VIII		*	*	*		*		*	*
IX	*	*	*	*	*			*	
X		*		*	*				
XI		*							
XII					*				
XIII			*		*				

Figure 4.
Habitat/Species Matrix with SBA-46 Data

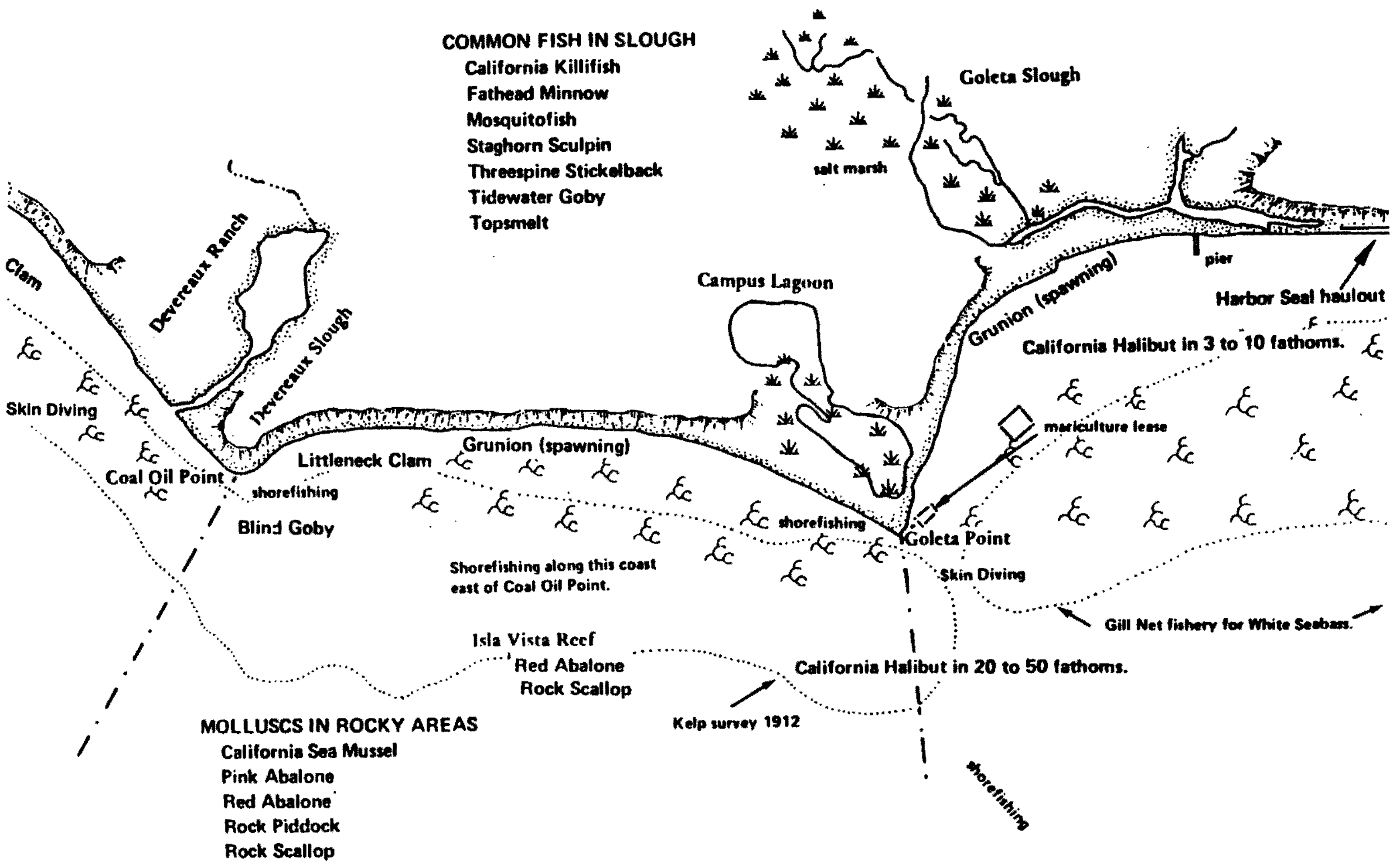
Species Groups	Habitat Groups: SB	MW	H/NSB	OC	BE	IT	RRF	SRRF	KB
I						*			
II						*	*	*	*
III								*	*
IV		0.06						0.06	0.06
V							8.51	8.51	8.51
VI	20.55	20.55	20.55	20.55	20.55		20.55	20.55	20.55
VII		75.94					75.94		75.94
VIII		9.63	9.63	9.63		9.63		9.63	9.63
IX	26.65	26.65	26.65	26.65	26.65			26.65	
X		0.60		0.60	0.60				
XI		69.57							
XII					*				
XIII			0.08		0.08				
XIV			*	*	*				
XV	2.82		2.82		2.82				
XVI	8.87		8.87				8.87		
XVII	0.15		0.15						
XIII	*		*						
XIX	*								
Total	59.04	203.00	68.75	57.43	50.70	9.63	113.87	65.40	114.69
Rank	6	1	4	7	8	9	3	5	2
Max. %	26.40	90.90	30.80	25.70	22.70	4.30	51.00	29.30	51.30

Figure 5.
Bathymetric Map of the Goleta Area, Santa Barbara County



REFERENCE: Continental Shelf Data Systems 1967

Figure 6.
Coastal Resources of the Goleta Area, Santa Barbara County



REFERENCE: California Department of Fish and Game 1976

Figure 7.
SBA - 97

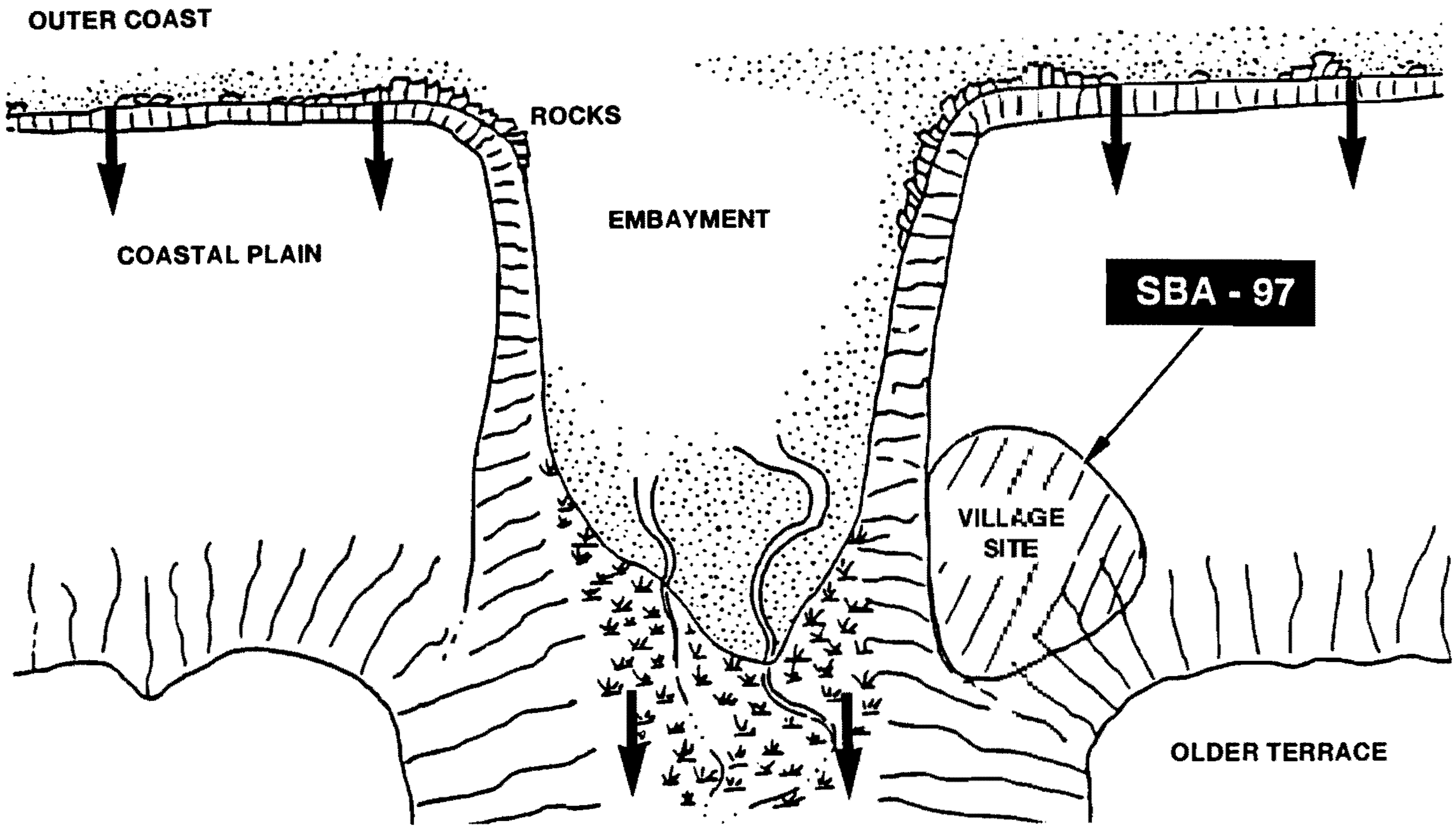
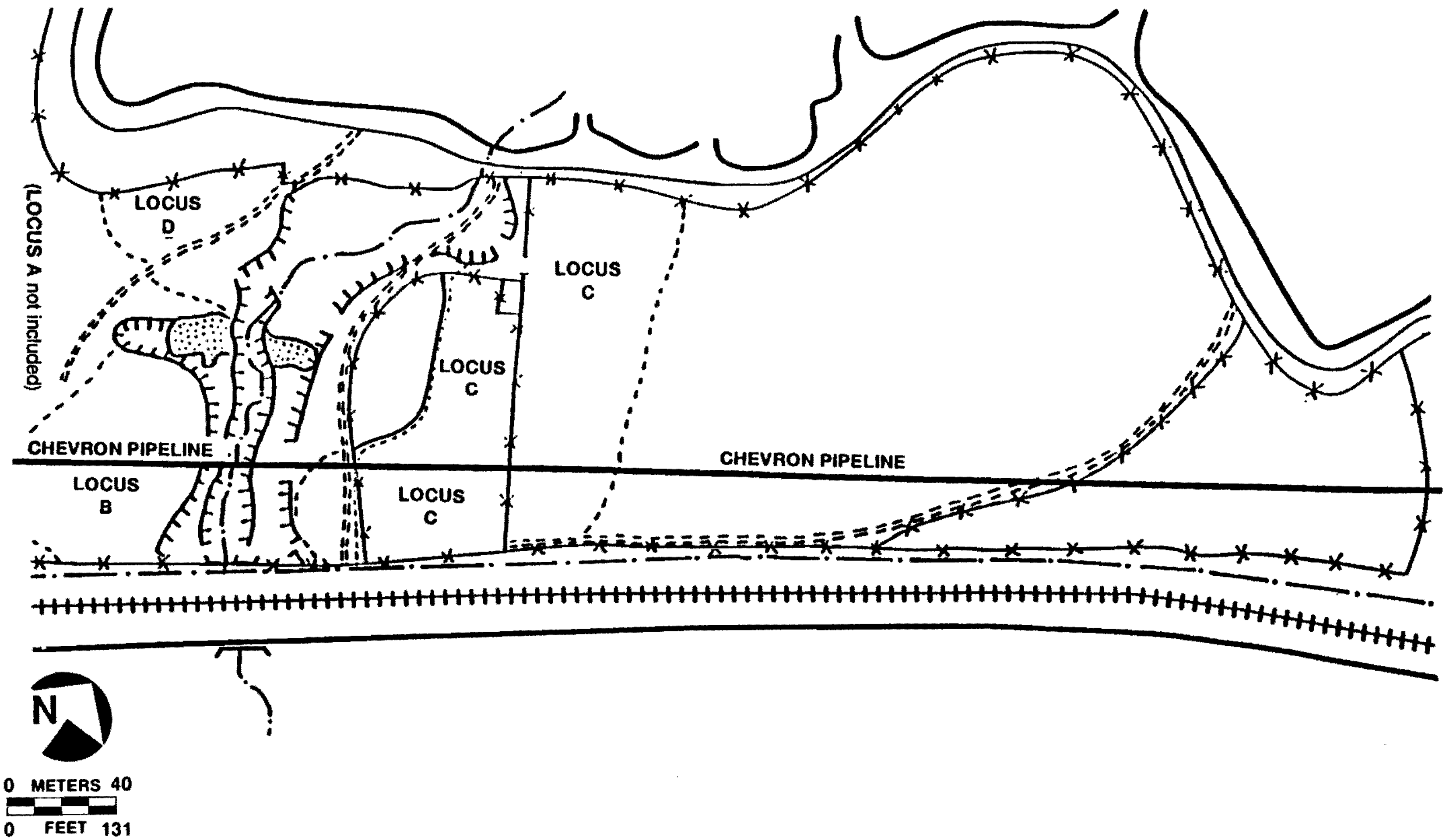
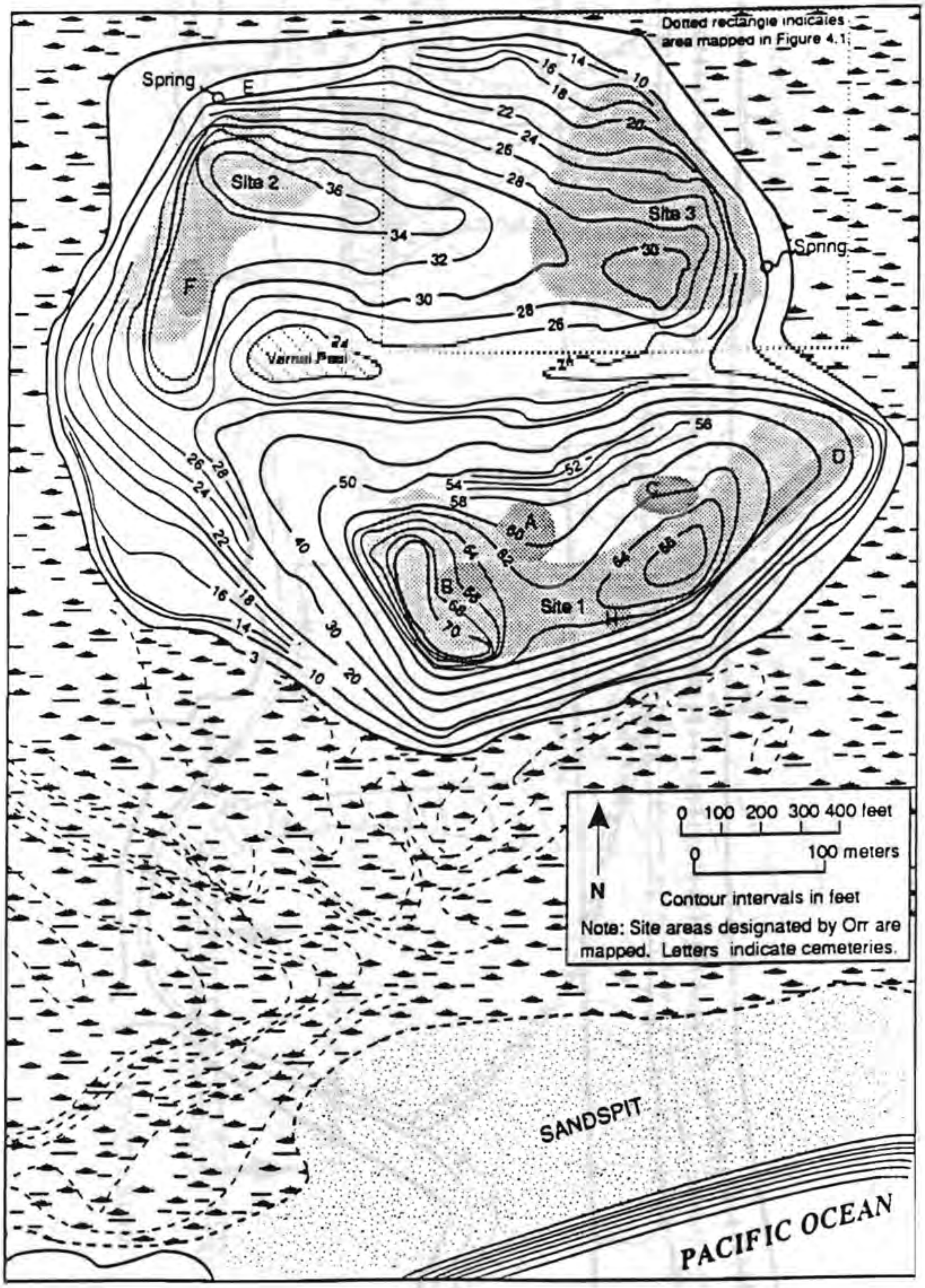


Figure 8.
SBA - 1491



REFERENCE: Erlandson et. al. 1984

Figure 9
Contour Map of Mescalitan Island Prior to Grading



REFERENCE: Gamble 1991

Figure 10.
SBA - 1491C, Unit 6 1/16" vs. 1/8"

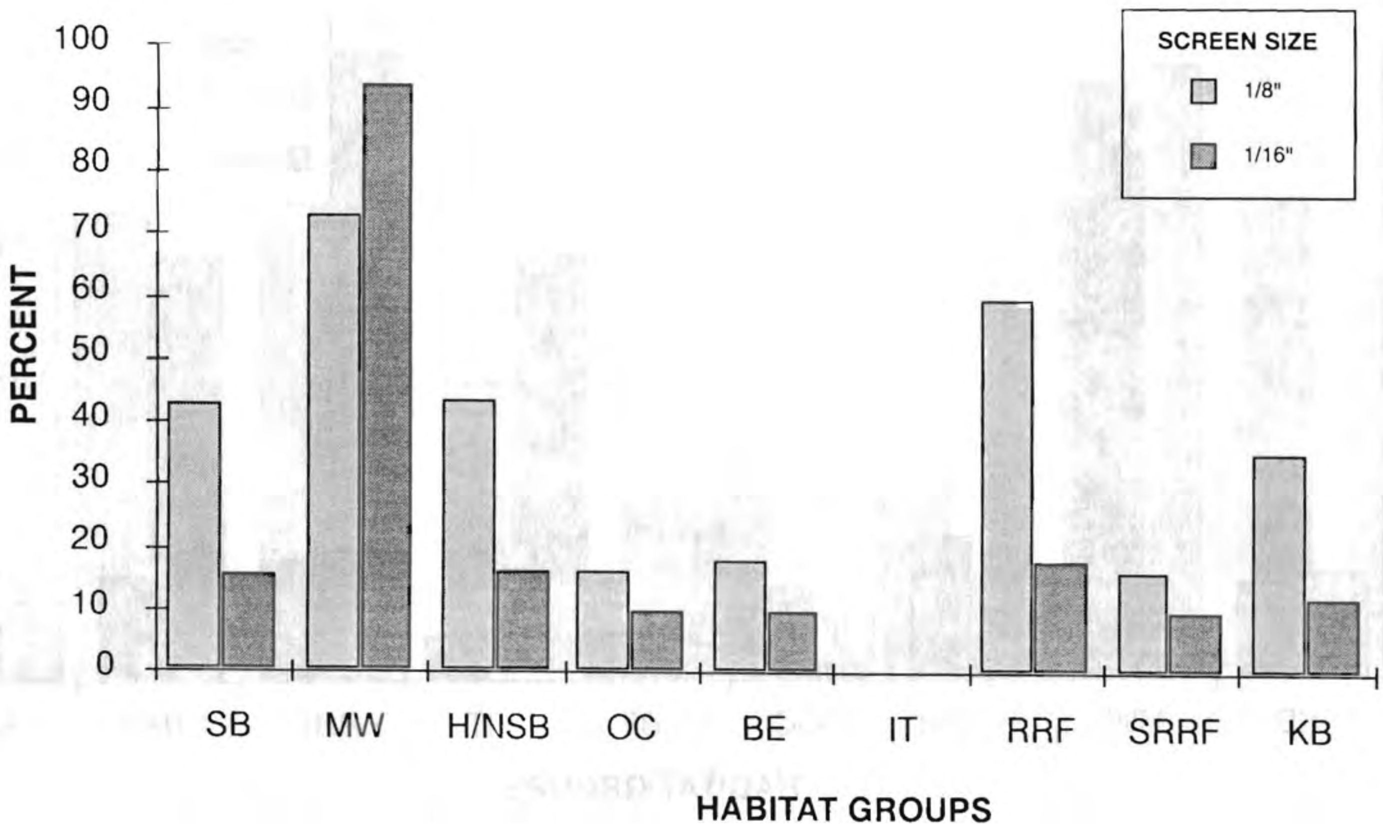


Figure 11.
SBA - 1491C, vs. SBA - 97 with Habitat

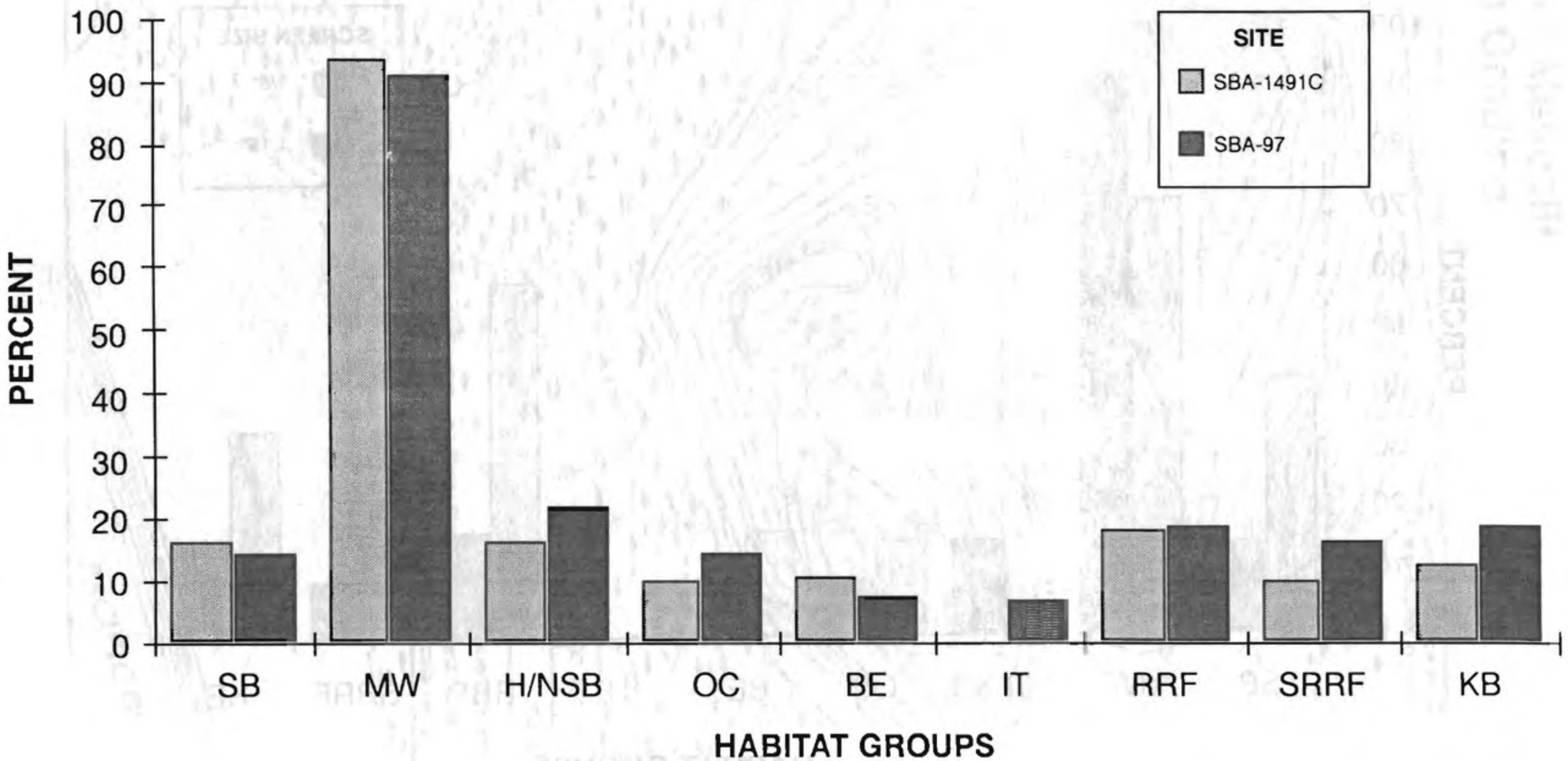


Figure 12.
SBA - 1491C, vs. SBA - 97 w/o MW Habitat

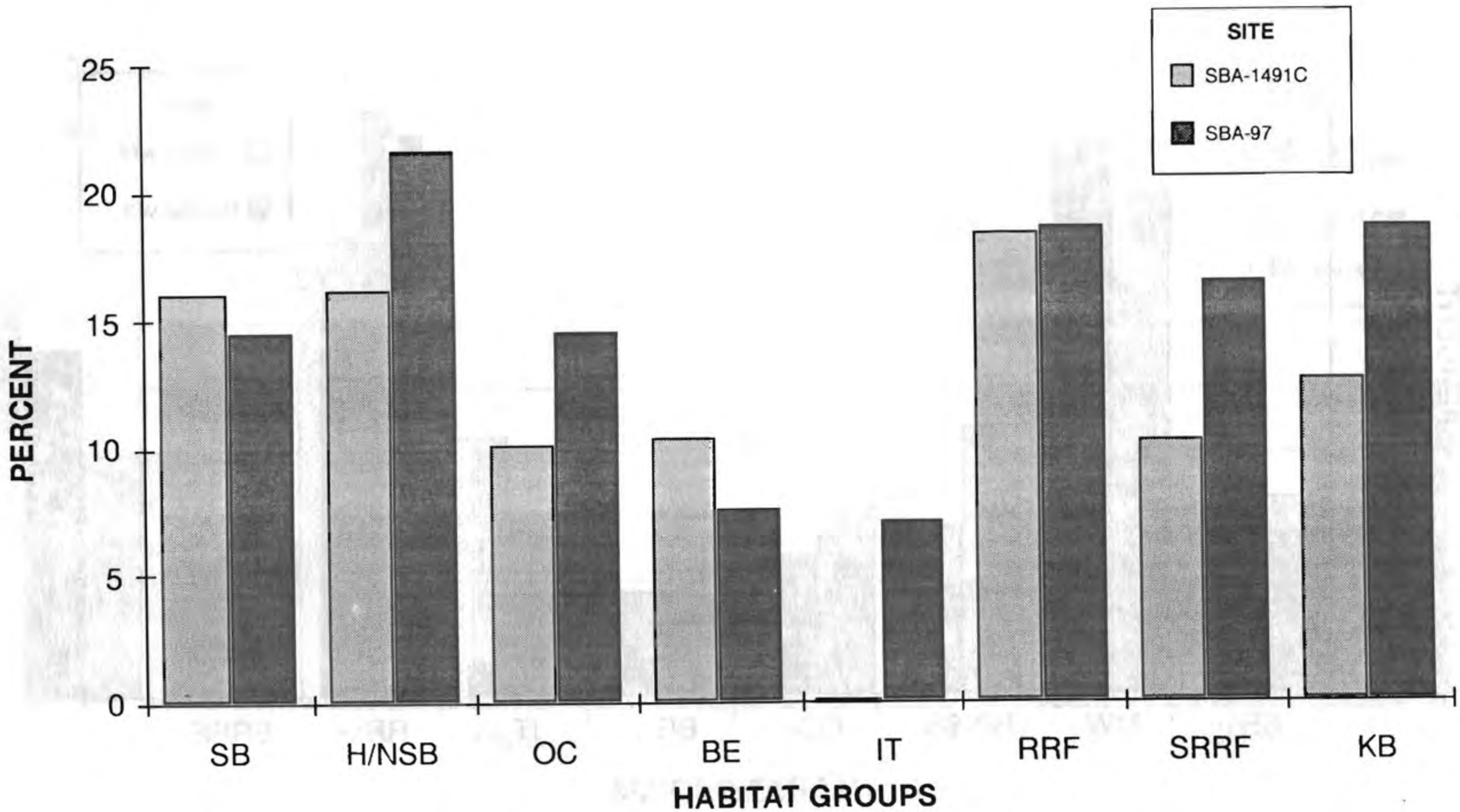


Figure 13.
SBA - 1731 Standard MNI vs. Modified MNI

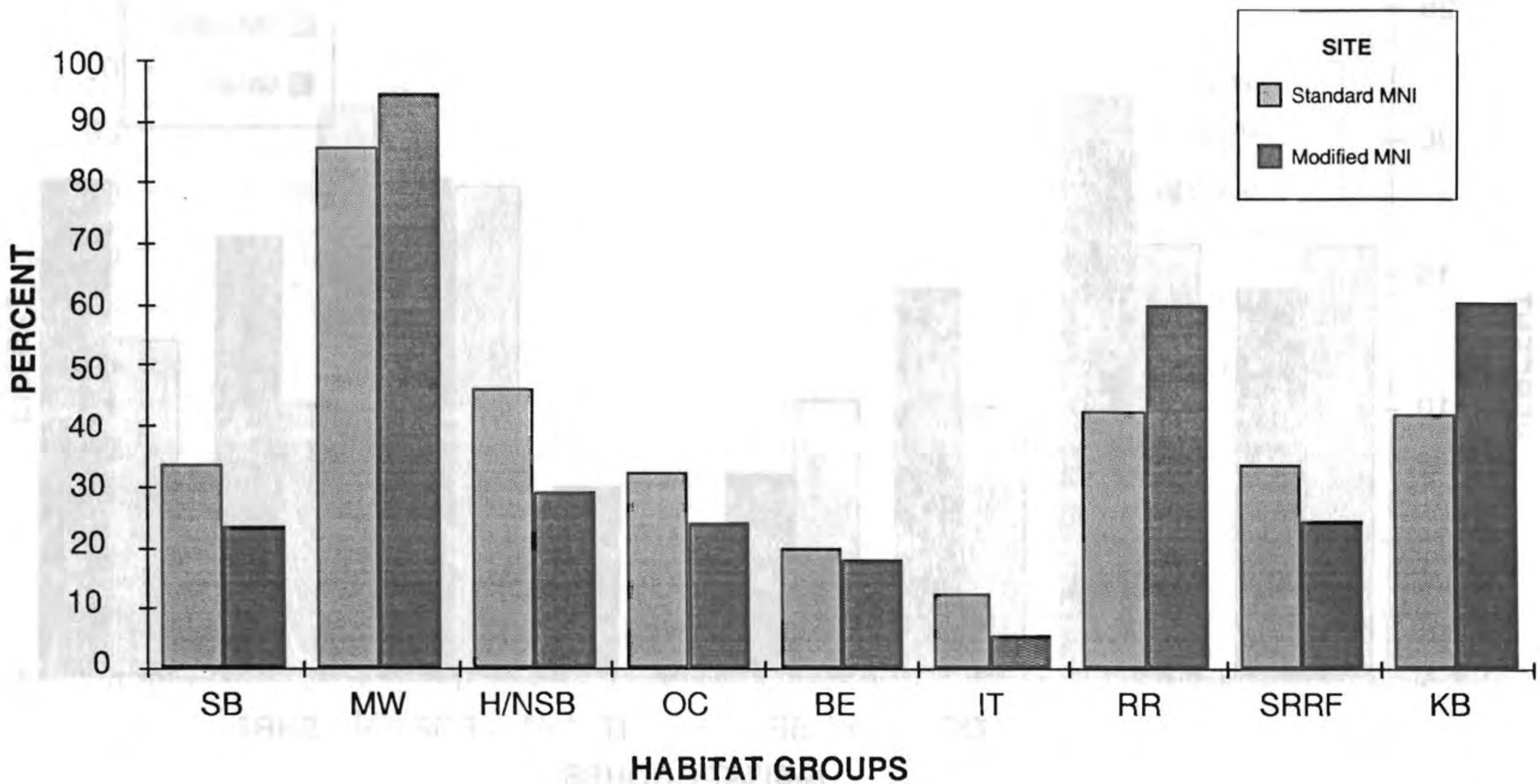


Figure 14.
Maximum Percent by Habitat for Each Site