

What Kind of Data Are in the Back Dirt? An Experiment on the Influence of Screen Size on Optimal Data Recovery

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ABSTRACT: Zooarchaeological assemblages are non-renewable resources that provide a record of human culture and the paleoenvironment. Optimal sampling of zooarchaeological remains forms a foundation from which questions about human ecology are asked and answered. It has been known for over three decades that fine-gauge screen sieving (1/16 inch = 1.58 mm) has an influence on the recovery of biological remains. However, archaeologists are not always fully aware of what types of faunal data may be lost into the back dirt, or the impact of those losses on interpreting the zooarchaeological record when fine-gauge screens are not used. As zooarchaeology has evolved to include studies of the paleoenvironment, sampling concerns have become even more important. This paper presents the analysis of the results of an experiment on the recovery of 10 zooarchaeological assemblages from coastal Alabama; Georgia; Florida; St. John, U.S. Virgin Islands; and Puerto Rico. When fine-gauge screen sampling protocol is used, large and small taxa have an equal chance of being recovered, and there is an exponential increase in the numbers of fish taxa and individuals recovered. Measurements of the lateral width of fish vertebrae in the 10 assemblages show that over 80% of the specimens are smaller than 6 mm and potentially would have been lost through coarse-gauge (1/4 inch = 6.35 mm) screen. The inclusion of remains recovered through finer meshes of screen significantly changes biomass calculations. Furthermore, descriptive statistics for sample diversity, equitability, trophic level, and similarity indices are affected. Fine-gauge screen recovers an assemblage of faunal remains that more closely resembles the midden population than do coarse-screened samples; therefore the fine-screened samples more accurately reflect the relative percentage of taxa and the size classes of the represented animals. The statistical data show that faunal assemblages recovered with different screen gauges are not directly comparable.

KEYWORDS: FAUNAL SAMPLING, ZOOARCHAEOLOGY, DIFFERENTIAL SAMPLE RECOVERY, SOUTHEASTERN UNITED STATES, CARIBBEAN

RESUMEN: Las asociaciones arqueozoológicas constituyen vestigios de recursos no renovables que documentan las culturas y los medios ambientes en el pasado. Un adecuado muestreo de estos restos genera una base a partir de la cual se pueden formular y responder cuestiones de distinta índole referidas a la ecología humana. Durante más de tres décadas hemos sabido que los tamizados con mallas finas (de 1/16 de pulgada = 1.58 mm) ha mejorado notablemente la recuperación de este tipo de restos. Aún así numerosos arqueólogos no son aún conscientes de los tipos de datos faunísticos que pueden perderse con los sedimentos desechados ni tampoco el impacto que estas pérdidas tienen sobre la interpretación del registro zooarqueológico. A medida que la zooarqueología derivó hacia los análisis paleoambientales el problema del muestreo ha adquirido una mayor importancia. Este trabajo presenta los resultados de un análisis experimental sobre la recuperación de 10 asociaciones zooarqueológicas de la costa de Alabama, Georgia, Florida, St. John en las Islas Vírgenes (EE.UU.) y de Puerto Rico. Al utilizar un protocolo de muestreo con cribas de luz pequeña los taxones de cualquier tamaño tienen igual probabilidad de ser recuperados al tiempo que se manifiesta un incremento exponencial en los números de taxones e individuos de peces que se recuperan. Las mediciones de la anchura de las vértebras de peces en estas 10 asociaciones demuestran que más del 80% de los especímenes

nes son menores de 6 mm y podrían haberse perdido potencialmente de haber usado una malla más grande en el tamiz (1/4 de pulgada = 6.35 mm). La incorporación de restos recuperados con mallas más finas cambia significativamente todos los cálculos de biomasa. Además la estadística descriptiva referida a la diversidad de la muestra, la equitabilidad, el nivel trófico y los índices de similitud se ven fuertemente afectadas. Los tamices de malla fina recuperan asociaciones de restos faunísticos que se asemejan más a las poblaciones originales de los depósitos de lo que lo hacen las muestras recuperadas con tamices gruesos. Por lo tanto, las muestras de tamiz fino reflejan de modo más preciso el porcentaje relativo de taxones y las clases de tallas de los animales representados. Los datos estadísticos demuestran, por último, que las asociaciones faunísticas recuperadas con tamices de diferente luz de malla no son directamente comparables.

PALABRAS CLAVE: KAHIKINUI, ISLAS HAWAII, ZOOARQUEOLOGÍA, EXPLOTACIÓN MARINA, ETNOARQUEOLOGÍA

INTRODUCTION

Recovery methods do matter and they need to be set forth clearly so that people can assess the strength of conclusions. Without method, theory is irrelevant. Without theory, archaeology is irrelevant. And without archaeology, life is no fun. Ian Brown, personal communication, 2003a.

The use of different gauge screens in zooarchaeological sample recovery can yield very different results. Such differences affect our interpretation of both subsistence behavior and the environment (Struever, 1968; Thomas, 1969; Casteel, 1972; Payne, 1972; Clason & Prummel, 1977; Levitan, 1982; Wing & Quitmyer, 1985; Shaffer, 1992; Gordon, 1993; Shaffer & Sanchez, 1994; James, 1997; Vale & Gargett, 2002). The goal of faunal sampling is to recover a representative assemblage that resembles what exists in the site population (Krebs, 1989). This includes the number of taxa, the relative percentage of individual animals, and the size classes of animals in the population. Sampling strategies have to afford each specimen an equal chance of being recovered in the process. By choosing the most appropriate sampling strategy, we improve our chances of making the most out of the data.

In recent years the use of fine-gauge screens (1/16 inch = 1.58 mm) in faunal recovery has gone a long way to improving the quality of zooarchaeological research (Marquardt, 1999; Reitz & Wing, 1999: 119-121). Unfortunately, fine-gauge screen sampling is perceived to be costly. Frequently the archaeologist elects not to use fine-gauge screen for optimal data

recovery in an attempt to balance the real constraints of time and money against the most accurate picture of subsistence practices that may be developed from the samples. In the field, this choice may be reinforced by the obvious presence of large animal remains, whereas very small taxa are not easily detected. The skeletal remains of smaller animals may unknowingly be lost through coarse-gauge screens (1/4 inch = 6.35 mm) without any experimental test to quantify their loss or the impact of that loss on our interpretations (Thomas, 1969). In such instances it is easy to be misled into believing that large taxa, such as mollusks, mammals, sea turtles, and large fish, were at the core of the economy.

The archaeological literature suggests that the use of fine-gauge screen in sample recovery can enhance interpretations of animal use and the environment, but we do not know to what extent the data are improved. This is especially true when using some of the newer analytic techniques in which the size classes of the individual animals are a critical part of the calculations. This paper examines faunal data from 10 sites from coastal Alabama, Georgia, Florida, U.S. Virgin Islands, and Puerto Rico (Table 1, Figure 1). These data represent a series of faunal studies over the past 25 years in which the same basic methods were used in each experiment. The faunal assemblages were recovered in a nested series of screens of progressively smaller mesh. The purpose of this paper is to describe the results of the experimental recovery of the animal remains using different sized screens, and the impact this has on the interpretation of faunal samples from a large geographic region.

METHODS

Field Recovery Strategy-The Nested-Sieve Experiment

The methods used for recovery of the faunal material in this analysis were originally designed during an experimental use of different screen meshes to recover remains from a single faunal sample (Feature 22) from a Swift Creek midden (ca. 1200-1600 BP), at Kings Bay, Georgia (Table 1; Figure 1). Wing & Quitmyer (1985) hypothesized that a considerable amount of data was being lost with the use of traditional 6.35 mm gauge screen in faunal recovery. They tested this hypothesis by water sieving Feature 22 through a nested series of screens of varying mesh size. The faunal remains from each screen fraction were methodically hand sorted and identified to the lowest possible taxonomic level using the comparative collections of the Environmental Archaeology laboratory, Florida Museum of Natural History. In so doing, Wing & Quitmyer (1985) quantified the vertebrate and invertebrate remains as if they were recovered in each of three groupings: (1) coarse-screen recovery, 6.35 mm; (2) medium-screen recovery, 6.35 mm + 3.18 mm; and (3), fine-screen recovery, 6.35 mm + 3.18 mm + 1.58 mm gauge.

The use of nested screens has the added benefit of allowing the researcher to visually and statistically evaluate the biases that may arise from the use of the three screen sizes. The Kings Bay experiment was so instructive that the nested-screen approach was then consistently used in the recovery of subsequent faunal assemblages from the southeastern United States and the Caribbean. In each case a standard suite of primary data (taxonomic identifications, specimen counts, weights, and linear measurements) and secondary data (calculations of minimum numbers of individuals, biomass, species diversity, and equitability) were collected (Reitz & Wing, 1999: 142-238).

The use of consistent recovery test methods on multiple samples has allowed me to assess the effects of screen size both on absolute sample representativeness (skeletal element size, diversity, etc) and also on newer analytical techniques that have emerged in recent years (for example, trophic level analysis) (Wing & Quit-

myer, 1985; Quitmyer, 2003; Reitz, 2004). Each of these studies represents a repeated test and validation of the original Kings Bay experiment. All the results confirmed that the use of different gauges had a significant influence on the primary and secondary faunal data.

Zooarchaeological Quantification

In this study I use various primary and secondary zooarchaeological data sets selected as examples from the 10 representative archaeological sites from the southeastern United States and the Caribbean. This is intended to document how the choice of screen mesh size in faunal sampling can affect quantification techniques and interpretation of the data. These data also show the usefulness of the nested-screen approach. I use the Kings Bay data to exemplify how the use of progressively smaller screen



FIGURE 1

A map of the southeastern USA and Caribbean showing the locations of the archaeological sites used in this paper.

Site	Sample	Cultural Period and date	Reference
Bottle Creek, AL	D100E	Mississippian - ca. 560 BP	Quitmyer 2003
	D100F	Mississippian - ca. 630 BP	Quitmyer 2003
	C100Z	Mississippian - ca. 650-750 BP	Quitmyer 2003
Mitchell River, FL	Pooled	Preceramic Archaic - ca. 5000 BP	Quitmyer 2002b
Kings Bay, GA	Feature 22	Swift Creek - ca. 1400 BP	Wing and Quitmyer 1985
Lake Monroe, FL	IQ99-1	Preceramic Archaic - ca. 5600 BP	Quitmyer 2002a
	IQ99-2	Preceramic Archaic - ca. 5600 BP	
	IQ99-3	Preceramic Archaic - ca. 5600 BP	
	IQ99-4	Preceramic Archaic - ca. 5600 BP	
	IQ99-5	Preceramic Archaic - ca. 5600 BP	
	IQ99-6	Preceramic Archaic - ca. 5600 BP	
Enclave Site, FL	Pooled	Preceramic Archaic - ca. 5600 BP	Quitmyer, O'Day, and Repass 2001
Block 107, Tampa Bay, FL	Pooled	Manasota - 1150-1550 BP	Quitmyer 2001
De Soto National Memorial, Tampa Bay, FL	FS177	ca. 1560 BP	Quitmyer 2002
	FS178	ca. 1930 BP	
	FS179	ca. 2110 BP	
	FS181	ca. 2260 BP	
Miami Circle, FL -- Matrix	Pooled	ca. 1949-1650 BP	Quitmyer and Kennedy-Thornton (2003)
Cinnamon Bay, St. John, VI	Level 2	ca. 580 BP	Quitmyer 2003
	Level 4	ca. 557 BP	
	Level 10	ca. 950 BP	
Finca Valencia , NCS-1, Puerto Rico	Pooled	Ostionoid/Chicoid - 350-1350 BP	Quitmyer and Kozch 1996

TABLE 1

Zooarchaeological assemblages from the southeastern USA and Caribbean used in this study. See Figure 1 map for site location.

gauges can significantly add new species and greater numbers of individuals (MNI) to an assemblage. A similarity index of the percent of the MNI and percent of biomass was calculated to compare the coarse- and fine-screened Kings Bay faunal assemblages. Biomass, species diversity, and equitability were also calculated for the Kings Bay fauna identified in the different screen fractions.

I use the lateral width measurements of fish vertebrae from Bottle Creek, AL; Mitchell River, FL; Kings Bay, GA; Lake Monroe, FL; Enclave Site, FL; De Soto National Memorial, FL; Block 107, FL; Miami Circle, FL; Cinnamon Bay, St. John, U.S. VI; and Finca Valencia, PR, to document the fish size distribution from across a wide geographic region (Table 1; Figure 1). These data also illustrate how the choice of screen mesh size can affect the recovery rate and biomass estimates of faunal samples.

The fauna from the Cinnamon Bay coarse and fine screens is used to calculate the mean trophic levels of the two assemblages (Quitmyer, 2003).

Tests of Sample Size: Minimum Number of Individuals (MNI). MNI was determined by the use of the concept of paired elements and individual size (Wing & Quitmyer, 1985). For example, four left frontals and five right frontals of equal size from a sea trout (*Cynoscion* spp.) represent five MNI, while four large right frontals and five small right frontals represent nine MNI (Ziegler, 1973; Reitz & Wing, 1999). MNI represents the fewest number of individuals that can be identified from the skeletal assemblage, and effectively facilitates the integration of taxa from many different phyla that have varying numbers of skeletal elements. For example, mammals (such as white-tailed deer, *Odocoileus virginianus*) have about 200 bones in their skeletons, while garfish (*Lepisosteus* spp.) has around 2,000 bones including the scales (Reitz & Wing, 1999). Clearly, the relative abundance (NISP) of a single garfish is not greater than that of a white-tailed deer.

Measures of Sample Similarity: The Percentage Similarity Index. I use the similarity index described by Krebs (1989: 305) to compare the percentage similarity of the MNI and estimated

biomass of the coarse- and fine-screened Kings Bay faunal assemblages. Sample size and species diversity has little effect on this easily calculated index (Krebs, 1989: 305).

The formula for calculating the similarity index (percentage similarity) between two samples is as follows:

$$P = \sum \text{minimum} (P_{1i}, P_{2i})$$

where:

P = percentage similarity between samples 1 and 2

P_{1i} = percentage of MNI or biomass in i in community 1

P_{2i} = percentage of MNI or biomass i in community 2

Greater sample similarity is indicated as values increase from 0 to 100.

Tests of Sample Size (MNI): Chi-square. Chi-square tests of significance were calculated for the MNI of fauna recovered in the Kings Bay coarse- and fine-gauge screens (2×2 contingency tables) (Sokal & Rohlf, 1969: 150). I test the null hypothesis H_0 : that there is no difference in the MNI of certain animal classes sampled with coarse- and fine-gauge screens. The alternative hypothesis, H_1 , is that there is a difference in the MNI of certain animal classes sampled with coarse and fine-gauge screens.

The formula for calculating the Chi-square (χ^2) distribution is as follows:

$$\chi^2 = \sum_{i=1}^r \sum_{j=1}^c \frac{(A_{ij} - E_{ij})^2}{E_{ij}}$$

where:

A_{ij} = actual frequency in the i^{th} row, j^{th} column

E_{ij} = expected frequency in the i^{th} row, j^{th} column

r = number of rows

c = number of columns

Test of Faunal Diversity and Equitability. The diversity and equitability of the fauna exploited by humans is of fundamental interest to the zooarchaeologist. Diversity and equitability of zooarchaeological taxa may differ as a

function of human choice (subsistence strategy), the natural diversity and evenness of natural resource distribution, seasonality, and the choice of an appropriate screen size for optimal faunal recovery (Reitz & Quitmyer, 1988).

The Shannon-Weaver Index is a measure of sample heterogeneity that combines the concepts of species richness (the number of taxa) and equitability (the degree to which taxa are equally distributed in the sample) (Reitz and Wing, 1999: 105).

The formula for calculating the Shannon-Weaver Diversity index is as follows (Shannon & Weaver, 1949: 14):

$$H' = -\sum_{i=1}^S (P_i)(\log_e P_i)$$

where:

H' = information content of the sample (index of species diversity)

S = number of taxonomic categories

P_i = the relative abundance of the i^{th} taxon within the sample

$\log P_i = \log_e P_i$

The Shannon-Weaver Diversity index (H') ranges from 0 to 5. Increasing values of H' indicate greater sample diversity (Shannon & Weaver, 1949: 14).

Sheldon's Equitability index (E) was used to characterize the evenness or equitability of the taxa independent of sample richness (Sheldon, 1969). The formula for calculating the Sheldon Equitability index (1969) is as follows:

$$E = H' / \log_e S$$

where:

H' = Shannon-Weaver index

S = the number of species in the community

Greater species evenness is indicated as the Sheldon statistic (E) increases from 0 to 1.

The Shannon-Weaver index (H') and the Sheldon's Equitability index (E) were applied to the Kings Bay samples and plotted in a scatter graph to show the differences in the two indices

that can occur as a result of sampling with coarse- and fine-mesh screens.

Tests of Individual Sizes Within the Population: Measured Fish Vertebrae. The relationship of screen size to faunal recovery is further characterized by measuring and plotting (by line graphs) the lateral width of the fish vertebrae identified in all 10 of the zooarchaeological assemblages (Table 1; Figure 12).

The significance of screen size to the recovery of the fish vertebrae is elucidated by calculating the mean vertebrate width (lateral) and 95% confidence interval around the mean of specimens measured from the coarse- and fine-gauge samples of Level 4, Cinnamon Bay. It is then possible to ascertain if the mean fish vertebrae sizes recovered in the coarse-gauge screen are significantly different ($P \leq 0.05$) from those recovered in the fine-gauge screen by noting whether or not their confidence intervals overlap. This technique is suitable to compare the null hypothesis H_0 : mean 1 = mean 2 for the two recovery methods. This method is straightforward, easily interpretable, and conservative in its approach.

Test of Animal Size: Biomass Estimates. Skeletal allometry was used to calculate the total body mass (biomass) of the organisms identified in this study (Table 2) (Peters, 1983). This is particularly useful with zooarchaeological collections in which skeletal elements are broken and whole skeletal elements are not present (Reitz *et al.*, 1987). Allometry reflects the structural and functional consequences of a change in size or in scale among similarly shaped animals (Peters, 1983; Reitz *et al.*, 1987; Schmidt-Nielsen, 1984). Organic growth is normally a non-linear process through ontogeny, and this allometric relationship is described by a mathematical power function:

$$y = a(X^b) \quad (\text{Schmidt-Nielsen, 1984})$$

This is transformed using the common log in order to produce a straight-line regression. The allometric formula is:

$$\text{Log } y = a + b(\text{log} X)$$

where:

b = the slope of the line

a = the y intercept

X = the independent variable, skeletal measurement (mm)

y = the dependant variable, the estimated body mass (g)

A practical limitation to this technique is that correlations between linear dimensions and body mass have not been established for every possible measurement and species. When these correlations are lacking, an estimate is made by the proportional method (Wing & Brown, 1979; Wing & Quitmyer, 1985). By this method a skeletal element is compared with a reference specimen of similar size for which the weight is known, thus the weight of the zooarchaeological animal can be extrapolated (Table 3).

The two techniques were used to estimate the amount of biomass that is represented by the fauna recovered from the coarse-, medium-, and fine-screened faunal samples from Kings Bay. Skeletal allometry was also used to calculate the biomass of fishes identified in the Cinnamon Bay faunal study. This is a critical element in determining the mean trophic level of the Cinnamon Bay fishes (see below).

Tests of Community Distribution: Analysis of Trophic Level. Food chains are formed as one organism consumes another. Solar energy in most ecosystems is fixed in the tissue of primary producers (plants and algae). Energy flows up the food chain as primary consumers [herbivores, such as mullet (*Mugil* spp.) and oysters (*Crassostrea virginica*)] are eaten by secondary consumers [primary carnivores, such as rays (Rajiformes) and whelks (*Busycon* spp.)] which in turn are eaten by tertiary consumers, such as tunas (Scombridae). Each point along the food chain is referred to as a trophic level. In each successive trophic level there is less biomass and thus less energy available to the next higher consumer (Odum, 1959).

Pauley *et al.* (1998) have recently reported that 45 years of modern fishing is affecting global fisheries. Modern fishing practices appear to be effectively reducing the availability of biomass from high trophic level species, the secondary and tertiary consumers such as

Vertebrate Taxon	N	Log a	b	r ²	*	Reference
Carcharhinidae	9	-0,13	3,48	0,98	TV	Wing and Quitmyer 1985
Rajiformes	12	1,40	2,26	0,83	TV	Wing and Quitmyer 1985
Osteichthyes	99	0,70	2,57	0,98	AT	Wing and Quitmyer 1985
Teleost	43	0,87	2,53	0,87	AT	Wing 1999
Lepisosteus spp.	9	0,91	2,57	0,96	AT	Wing and Quitmyer 1985
Siluriformes	8	0,98	1,80	0,86	AT	Wing and Quitmyer 1985
Pleuronectiformes	14	0,53	2,95	0,97	AT	Wing and Quitmyer 1985
Carangidae	17	0,68	2,83	0,98	AT	Wing and Quitmyer 1985
Sparidae	13	0,75	2,73	0,98	AT	Wing and Quitmyer 1985
Scaenidae	35	0,74	2,34	0,93	AT	Wing and Quitmyer 1985
Invertebrate Taxon						
Penaeus sp.	22	0,23	1,95	0,86	MW	Wing and Quitmyer 1985
Crassostrea virginica	100	-3,00	2,16	0,90	ASL	Wing and Quitmyer 1985
Tagelus plebeius	46	0,08	2,49	0,80	HW	Wing and Quitmyer 1985
Mercenaria mercenaria	40	-1,28	2,50	0,90	HW	Wing and Quitmyer 1985
Littorina irrorata	50	-3,87	2,77	0,97	SH	Wing and Quitmyer 1985
Polinices duplicatus	15	-1,80	2,17	0,87	AW	Wing and Quitmyer 1985
Ilyanassa obsoleta	50	-4,63	3,38	0,94	SH	Wing and Quitmyer 1985

Regression Formula:

$$Y = ax^b$$

$$\text{Transformed log } y = \log a + b(\log x)$$

Where

Y = meat weight (g)

x = skeletal measurement* (mm)

a = y intercept

b = slope

* Measurements: TV = mean width of thoracic vertebrae;
 AT = atlas vertebrae; MW = mandible width; ASL = anterior
 scar length; HW = hinge width; SH = shell height; AW =
 aperture width; SH = shell height.

TABLE 2

Allometric constants used in the regression formula $Y = ax^b$ to estimate the biomass (g) of animals identified in the zooarchaeological assemblages.

Taxon	Weight Estimate (g)	Source
Mustela vison	350,0	Ziegler 1973
Odocoileus virginianus	23595,1	FSM Collections
Anatidae	736,0	Ziegler 1973
Malaclemys terrapin	1205,4	FSM Collections
Iguanidae	2,2	FSM Collections
Plethodon glutinosus	2,3	FSM Collections
Anura	10,9	FSM Collections
Trichiurus lepturus	970,0	FSM Collections
Brachyura	83,4	FSM Collections
Geukensia demissa	3,8	FSM Collections

TABLE 3

Non regression values used to estimate the biomass of zooarchaeological remains from Kings Bay, GA.

Scientific Names	Common Name
MAMMALS	
Canidae	dog family
Mustela vison	mink
Odocoileus virginianus	white-tailed deer
BIRDS	
Anatidae	ducks
REPTILES	
Iguanidae	iguanid lizard family
Malacemmys terrapin	diamondback terrapin
AMPHIBIANS	
Amphibian	unidentified salamander
Anura	unidentified frog or toad
Plethodon glutinosus	slimy salamander
Cartilaginous Fishes	
Rajiformes	rays
Bony Fishes	
Lepisosteus spp.	gar fishes
Elops saurus	ladyfish
Brevoortia spp.	menhaden
Arius felis	hardhead catfish
Bagre marinus	gafftopsail catfish
Fundulus spp.	killifishes
Chloroscombrus chrysurus	Atlantic bumper
Archosargus probatocephalus	sheepshead
Bairdiella chrysurus	silver perch
Cynoscion spp.	sea trouts
Leiostomus xanthurus	spot
Micropogonias undulatus	Atlantic croaker
Stellifer lanceolatus	stardrum
Mugil spp.	mullet
Peprelus alepidotus	butterfish
Trichiurus lepturus	Atlantic cutlassfish
Paralichthyes spp.	flounders
Trinectes spp.	soles
CRUSTACEA	
Brachyura	marine crabs
Penaeus spp.	shrimps
Bivalves	
Geukensia demissa	Atlantic ribbed mussel
Crassostrea virginica	American oyster
Tagelus plebeius	stout tagelus
Mercenaria sp.	quahog
Gemma gemma	amethyst gem clam
Gastropods	
Orthurethra	terrestrial snail
Sigmurethra	terrestrial snail
Euglandina rosea	elongate cannibal snail
Littorina irrorata	marsh periwinkle
Polinices duplicatus	moon shell
Nassarius vibex	common eastern dog whelk
Ilyanassa obsoleta	eastern mud whelk
Olivella mutica	variable dwarf olive
Odostomia impressa	odostomia

TABLE 4

Species identified in the Swift Creek Feature 22, Kings Bay, GA.

Species Name	NISP	%	MNI	%	WT. (g)	%	Biomass (g)	%
Odocoileus	2	0,1	1	0,1	6,8	0,1	23595,1	49,8
Sub-total mammal*	6	0,2	2	0,2	7,7	0,1	23945,1	50,6
Sub-total bird*	4	0,1	1	0,1	0,6	0,0	736,0	1,6
Testudines	20	0,7	1	0,1	4,5	0,1	1205,4	2,5
Sub-total reptile*	20	0,7	1	0,1	4,5	0,1	1205,4	2,5
Sub-total amphibian*	-	-	-	-	-	-	-	-
Sub-total shark and ray*	5	0,2	1	0,1	0,1	0,0	204,7	0,4
Brevoortia	2	0,1	1	0,1	0,1	0,0	4,5	0,0
Clupeidae	-	-	-	-	-	-	-	-
Arius	50	1,8	6	0,6	12,4	0,2	1585,2	3,3
Bagre	43	1,5	6	0,6	22,8	0,3	1585,2	3,3
Ariidae	58	2,1	0	0,0	6,3	0,1	-	-
Sub-total catfish*	427	15,1	12	1,1	61,4	0,7	3170,4	6,7
Fundulus	-	-	-	-	-	-	-	-
Bairdiella	8	0,3	6	0,6	0,1	0,0	172,5	0,4
Micropogonias	48	1,7	21	2,0	5,0	0,1	1619,3	3,4
Stellifer	36	1,3	11	1,0	5,5	0,1	853,5	1,8
Sub-total drum*	126	4,5	45	4,2	13,2	0,2	3646,7	7,7
Mugil	6	0,2	1	0,1	0,2	0,0	249,7	0,5
Sub-total bony fish**	956	33,9	65	6,1	118,1	1,4	11167,1	23,6
Sub-total crab and shrimp	5	0,2	1	0,1	0,4	0,0	83,8	0,2
Geukensia	18	0,6	14	1,3	277,1	3,4	52,9	0,1
Crassostrea	575	20,4	297	28,0	5565,1	67,8	575,6	1,2
Tagelus	1135	40,2	582	54,8	1641,4	20,0	9212,5	19,5
Mercenaria	4	0,1	2	0,2	176,0	2,1	114,4	0,2
Sub-total bivalves*	1732	61,3	895	84,3	8011,9	97,7	9959,4	21,0
Littorina	2	0,1	2	0,2	0,1	0,0	0,5	0,0
Nassarius	1	0,0	1	0,1	0,5	0,0	0,2	0,0
Ilyanassa	90	3,2	90	8,5	36,7	0,4	18,5	0,0
Sub-total gastropod***	96	3,4	96	9,0	59,0	0,7	33,0	0,1
Total invertebrates	1833	64,9	992	93,4	8072,1	98,4	10076,2	21,3
Total vertebrates	991	35,1	70	6,6	131,0	1,6	37258,3	78,7
Total fauna	2824	100	1062	100	8203,10	100	47334,50	100

* Sub-totals may include minority species not otherwise listed here.

** Includes sub-totals for catfish, drum, Mugil sp., and minority species.

*** Excludes small parasitic and terrestrial forms.

TABLE 5

Fauna recovered in the Swift Creek King's Bay Feature 22, Kings Bay, GA, using coarse gauge (6.35 mm) screen recovery.

Species Name	NISP	%	MNI	%	WT. (g)	%	Biomass	
							(g)	%
Odocoileus	2	0,02	1	0,06	6,8	0,1	23595,1	34,0
Sub-total mammal*	8	0,1	2	0,13	7,8	0,1	23945,1	34,5
Sub-total bird*	6	0,1	1	0,06	0,7	0,0	736,0	1,1
Testudines	26	0,3	1	0,06	4,7	0,0	1205,4	1,7
Sub-total reptile*	26	0,3	1	0,06	4,7	0,0	1205,4	1,7
Sub-total amphibian*	2	0,02	1	0,06	0,1	0,0	2,3	0,0
Total shark and ray*	20	0,2	1	0,06	0,3	0,0	282,7	0,4
Brevoortia	21	0,3	8	0,51	0,1	0,0	36,0	0,1
Clupeidae	12	0,1	-	-	0,1	0,0	-	-
Arius	83	1,0	17	1,08	12,8	0,1	3390,7	4,9
Bagre	101	1,2	10	0,63	24,4	0,3	1994,5	2,9
Ariidae	132	1,6	7	0,44	7,3	0,1	1396,2	2,0
Sub-total catfish*	743	8,9	34	2,15	68,9	0,7	6781,4	9,8
Fundulus	5	0,1	1	0,06	0,1	0,0	2,1	0,0
Bairdiella	91	1,1	31	1,96	2,2	0,0	1269,4	1,8
Micropogonias	186	2,2	54	3,42	12,4	0,1	3272,1	4,7
Stellifer	1689	20,3	368	23,3	41,6	0,4	14127,9	20,4
Sub-total drum	2187	26,2	482	30,5	61,4	0,6	21543,0	31,0
Mugil	63	0,8	6	0,38	0,8	0,0	579,5	0,8
Sub-total bony fish**	6365	76,4	545	34,5	269,6	2,8	32926,4	47,4
Sub-total crab and shrimp	28	0,3	2	0,13	1,2	0,0	96,9	0,1
Geukensia	26	0,3	16	1,01	294,4	3,1	60,4	0,1
Crassostrea	595	7,1	316	20	5565,8	58,8	615,5	0,9
Tagelus	1153	13,8	593	37,6	1643,6	17,4	9386,6	13,5
Mercenaria	4	0,0	2	0,13	176	1,9	114,4	0,2
Total bivalves*	1778	21,3	927	58,7	9128,7	96,4	10176,9	14,7
Littorina	2	0,0	2	0,13	0,1	0,0	0,5	0,0
Nassarius	1	0,0	1	0,06	0,5	0,0	0,2	0,0
Ilyanassa	90	1,1	90	5,7	36,7	0,4	18,5	0,0
Total gastropod***	99	1,2	96	6,08	59	0,6	33,0	0,0
Sub-total invertebrate	1905	22,9	1025	64,9	9189,8	97,0	10306,8	14,9
Sub-total vertebrate	6427	77,1	551	34,9	283,2	3,0	59097,8	85,1
Total fauna	8332	100	1579	100	9473	100	69404,6	100

* Sub-totals may include minority species.

** Includes sub-totals for catfish, drum, Mugil sp., and minority species.

*** Excludes small parasitic and terrestrial forms.

TABLE 6

Fauna recovered in the Swift Creek King's Bay Feature 22, Kings Bay, GA, using medium gauge (6.35 mm + 3.18 mm) screen recovery.

groupers (Serranidae), snappers (Lutjanidae), and tunas. In other words, species from higher in the food web are now smaller and less numerous. Modern fishing practices are making up this shortfall by increasingly exploiting species from lower in the food web, the primary consumers, such as herrings (Clupeidae) and mullet (Pauley *et al.*, 1998). We can identify this trend by quantifying the amount of biomass and the trophic levels of various marine organisms on a scale of 1 to 5 based on their diets (Pauley *et al.*, 1998). For instance, primary producers, such as smooth cord grass (*Spartina alterniflora*), are assigned a value of 1, primary consumers a value of 2, and secondary consumers a value of 4.6. The time series data presented by Pauley *et al.* (1998) shows that the yearly mean trophic level of marine resources has declined during his study period; he refers to this as “fishing down the food web.”

The formula for calculating the mean trophic level (TL) is as follows (Pauley *et al.*, 1998):

$$TL_i = \sum_{ij} TL_{ij} Y_{ij} / \sum_{ij} Y_{ij}$$

where:

TL_i = the mean trophic level for year i

Y_i = landings by trophic levels of individual species groups j

The application of the trophic level formula using zooarchaeological specimens follows a three-part process (Wing, 2001):

1) The appropriate allometric formula (Tables 2 and 3) is used to calculate the average biomass for the various taxa in each sample from the measurements of their vertebrae. In the rare cases in which there are no measurable vertebrae, the mean vertebral width of teleost fish is used, with the assumption that the vertebrae come from a cross section of the identified species.

2) The estimated biomass of the catch for each species is determined by multiplying the average biomass of the individuals in each species by the minimum number of individuals (MNI).

The final step is to multiply the biomass of each of each species by the mean trophic level index (Pauley *et al.*, 1998). The trophic level

index ranges from 1 to 5. Plants are primary producers, with a trophic level (TL) of 1, while the TL value for top predators is 5. These indices are derived from the feeding behavior of the organisms (Pauley *et al.*, 1998; See <http://www.fishbase.org/trophic.t.htm>).

Wing (2001) and Quitmyer (2003) have applied the methods of Pauley *et al.* (1998) to zooarchaeological assemblages sampled with fine-gauge screen from some Caribbean islands. A decline in the mean trophic level contributed by reef resources with exposure time to humans was documented (Wing, 2001; Quitmyer, 2003). This is the result of the fewer and smaller high-trophic-level reef fish (e.g., snappers and groupers), and the greater number of reef herbivores (e.g., parrotfish) identified in the sample. Relative to the reef taxa, there is a trend toward the use of species with larger biological reservoirs, such as the herrings and tunas (Wing, 2001).

In this study I calculated the mean trophic level of aquatic vertebrates recovered by the coarse-and fine-screen-gauge methods from Cinnamon Bay, U.S. Virgin Islands (Quitmyer, 2003). This technique illustrates how the use of different screen gauges can affect the identification of changes in the mean trophic level of reef resources exploited from some pre-Columbian Caribbean Islands (Wing, 2001).

RESULTS AND DISCUSSION

The Effect of Differential Recovery Methods on Sample Size and Diversity: Kings Bay (Feature 22) Sieving Experiment

The vertebrate and invertebrate fauna that were identified in Feature 22 are presented in Table 4. These data form the basis of the screening experiment in which the faunal sample was quantified as if it were recovered in coarse- (Table 5), medium- (Table 6), and fine-gauge (Table 7) screens (Wing & Quitmyer, 1985).

In total, 33 species were identified in the coarse-sieved sample, whereas fine sieving increased this number to 44 species, a 25% increase (Table 4). The slimy salamander (*Plethodon glutinosus*), killifishes (*Fundulus* spp.), spot (*Leiostomus xanthurus*), soles (*Trinectes* spp.), shrimp (*Penaeus* spp.),

Species Name	Count	%	MNI	%	WT (g)	%	Biomass (g)	
							(g)	%
Odocoileus	2	0,01	1	0,0	6,8	0,1	23595,1	28,9
Sub-total mammal*	8	0,03	2	0,1	7,8	0,1	23945,1	29,3
Sub-total bird*	6	0,03	1	0,0	0,7	0,0	736,0	0,9
Testudines	26	0,1	1	0,0	3,6	0,0	1205,4	1,5
Sub-total reptile*	28	0,1	2	0,1	4,9	0,0	1207,6	1,5
Sub-total amphibian*	8	0,0	2	0,1	0,3	0,0	13,2	0,0
Sub-total shark and ray*	51	0,2	1	0,0	0,5	0,0	209,4	0,3
Brevoortia	43	0,2	13	0,6	0,2	0,0	1758,6	2,2
Clupeidae	415	1,8	-	-	0,9	0,0	-	-
Arius	83	0,4	17	0,8	12,8	0,1	2563,2	3,1
Bagre	109	0,5	10	0,5	24,4	0,2	1507,8	1,8
Ariidae	155	0,7	8	0,4	7,6	0,1	1206,2	1,5
Sub-total catfish*	847	3,7	35	1,7	69,5	0,7	5277,2	6,5
Fundulus	23	0,1	7	0,3	0,2	0,0	140,6	0,2
Bairdiella	132	0,6	44	2,1	2,6	0,0	2059,9	2,5
Micropogonias	198	0,9	58	2,8	12,4	0,1	3039,5	3,7
Stellifer	5055	21,8	743	35,8	69,1	0,7	24353,5	29,8
Sub-total drum*	5803	25,1	874	42,1	90,1	0,9	32326,6	39,6
Mugil	228	1,0	24	1,2	1,3	0,0	1325,8	1,6
Sub-total bony fish**	21010	90,7	993	47,8	529	5,1	44872,6	55,0
Sub-total crab and shrimp	160	0,7	40	1,9	2,4	0,0	401,4	0,5
Geukensia	26	0,1	16	0,8	294,4	2,9	60,4	0,1
Crassostrea	606	2,6	327	15,7	5566	54,1	637,6	0,8
Tagelus	1155	5,0	593	28,6	1643,7	16,0	9386,6	11,5
Mercenaria	4	0,02	2	0,1	176	1,7	114,4	0,1
Sub-total bivalves*	1792	7,7	939	45,2	9675,9	94,1	10199,0	12,5
Littorina	2	0,01	2	0,1	0,1	0,0	0,3	0,0
Nassarius	1	0,00	1	0,0	0,5	0,0	0,2	0,0
Ilyanassa	90	0,4	90	4,3	36,7	0,4	18,5	0,0
Sub-total gastropod***	100	0,4	97	4,7	60	0,6	33,0	0,0
Total invertebrates	2052	8,9	1076	51,8	9738,3	94,7	10633,4	13,0
Total vertebrates	21111	91,1	1001	48,2	543,2	5,3	70983,9	87,0
Total fauna	23163	100	2077	100	10281,5	100	81617,3	100

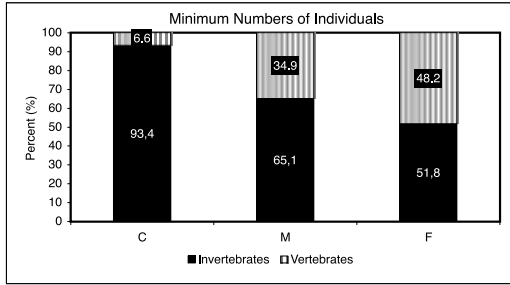
* Sub-totals may include minority species.

** Includes sub-totals for catfish, drum, Mugil sp., and minority species.

*** Excludes small parasitic and terrestrial forms.

TABLE 7

Fauna recovered in the Swift Creek King's Bay Feature 22, Kings Bay, GA, using fine gauge (6.35 mm + 3.18 mm + 1.59 mm) screen recovery.



Similarity index

	Minimum Number of Individuals		Similarity index
	Coarse %	Fine %	
Mammals	0,2	0,1	56,3
Birds	0,1	0,1	
Reptiles	0,1	0,1	
Amphibians	0,0	0,1	
Chondrichthyes	0,1	0,1	
Osteichthyes	6,1	47,8	
Crustaceans	0,1	1,9	
Bivalves	84,3	45,2	
Gastropods	9,0	4,7	

Key:

Coarse = MNI of taxa recovered in the 6.35 mm gauge screen.

Medium = MNI of taxa recovered in the 6.35 mm and 3.18 mm gauge screen.

Fine = MNI of taxa recovered in the 6.35 mm, 3.18 mm, and 1.59 mm gauge screen.

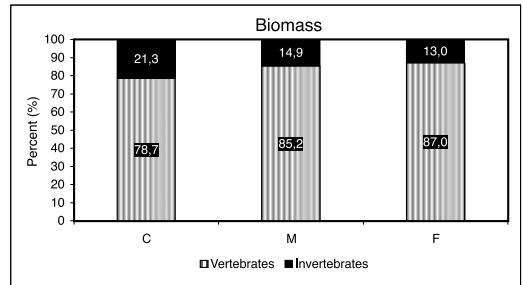
FIGURE 2

A comparison of the minimum numbers of individuals recovered in coarse, medium and fine gauge screen from the Swift Creek Feature 22, Kings Bay GA.

amethyst gem clam (*Gemma gemma*), and the variable dwarf olive (*Olivella mutica*) are among the species that were added by the use of fine-gauge screen (Table 7).

A difference in the numbers of individuals (MNI) of certain species is apparent in these data (Tables 5, 6, and 7). Fine sieving nearly doubles the MNI of vertebrates over the coarse-gauge sieved assemblage, whereas virtually no increase shows in the invertebrate component (Table 8; Figure 2). In fact, the Chi-square distribution calculated for the MNI of the vertebrates and invertebrates recovered in the coarse and fine screens is significant. Almost all the mollusk shells are recovered with 6.35 mm screen. No significant difference can be demonstrated between the bivalves and gastropods or between oysters (*Crassostrea virginica*) and stout tagelus (*Tagelus plebeius*) by any of the methods of quantification applied to the fine- and coarse-sieved samples. The Chi-square distributions in these cases are not significant (Table 8; Figure 2).

By the measure of MNI the percentage of vertebrates recovered by coarse-gauge screen increases from 6.6% to 48.2% in the fine-gauge sample (Table 2); the Chi-square distribution is



Similarity Index

	Biomass		Similarity index
	Coarse %	Fine %	
Mammals	50,6	29,3	67,5
Birds	1,6	1,5	
Reptiles	2,5	0,0	
Amphibians	0,0	0,0	
Chondrichthyes	0,4	0,3	
Osteichthyes	23,6	55,0	
Crustaceans	0,2	0,5	
Bivalves	21,0	12,5	
Gastropods	0,1	0,0	

Key:

Coarse = biomass calculated for taxa identified in the 6.35 mm gauge screen.

Medium = biomass calculated for taxa identified in the 6.35 mm and 3.18 mm gauge

Fine = biomass calculated for taxa identified in the 6.35 mm, 3.18 mm, and 1.59 mm

FIGURE 3

A comparison of the biomass contributed to faunal assemblages recovered in coarse, medium and fine gauge screen from the Swift Creek Feature 22, Kings Bay, GA.

significant (Table 8). The largest contributor to the vertebrate component of the fine-sieved sample is fish (Tables 5, 6, and 7). Fish represent 6.1% of the MNI in the coarse-sieved sample, but increase to 34.5% in the medium and 47.8% in the fine-sieved sample (Figure 2; Tables 5, 6, and 7). As might be expected, the small-sized fishes are the major contributors to the fine-sieved sample; they include menhadens (*Brevoortia* spp.), killifishes, and soles. Of these, the most important is the stardrum (*Stellifer lanceolatus*). Thirty-six skeletal fragments (NISP) recovered with 6.35 mm screen (Table 5) were identified to stardrum; there is a substantial increase in their remains with the medium (N = 1,689) and fine (N = 5,055) sampling methods (Tables 6 and 7).

When the cumulative weight of meat that stardrum could have contributed is estimated, their importance becomes even more impressive. They are estimated to have provided as much as or more meat than either deer (*Odocoileus virginianus*) or the mollusks represented in the sample (Tables 5, 6, and 7). The relative contribution of biomass from all invertebrate taxa also declines with the use of finer gauge screen recovery (Figure 3) because of the

Fauna	NISP Coarse	NISP Medium	NISP Fine	MNI Coarse	MNI Medium	MNI Fine
a						
Mammal/bird/reptile/amphibians	30	40	50	4	4	7
Fishes	961	6385	21061	66	546	994
Total	991	6425	21111	70	550	1001
b						
Catfish	427	743	847	12	34	35
Drum	126	2187	5803	45	482	874
Total	553	2930	6650	57	516	909
c						
Vertebrates	991	6427	21111	70	551	1001
Invertebrates	1833	1905	2052	992	1025	1076
Total	2824	8332	23163	1062	1576	2077
d						
Gastropods	96	99	100	96	96	97
Bivalves	1732	1778	1792	895	927	939
Total	1828	1877	1892	991	1023	1036
e						
Oyster	575	595	606	297	316	327
Stout tagelus	1135	1153	1155	582	593	593
Total	1710	1748	1761	879	909	920

Chi-square values are given for comparisons of MNI between coarse and fine screen recovery.

a $\chi^2 = 18.30$ $p \leq 0.001$ $df = 2$ distribution is significant

b $\chi^2 = 32.65$ $p \leq 0.001$ $df = 2$ distribution is significant

c $\chi^2 = 539.29$ $p \leq 0.001$ $df = 2$ distribution is significant

d $\chi^2 = 0.08$ $p \leq 1.00$ $df = 2$ distribution is not significant

e $\chi^2 = 0.61$ $p \leq 1.00$ $df = 2$ distribution is not significant

Table 8 Continued

Species	NISP % Coarse	NISP % Medium	NISP % Fine	MNI % Coarse	MNI % Medium	MNI % Fine
Mammal/bird/reptile/amphibians	3,0	0,6	0,2	5,7	0,7	0,7
Fishes	96,9	99,4	99,8	94,3	99,3	99,3
Total	99,9	100	100	100	100	100
Catfish	77,2	25,4	12,7	21,1	6,6	3,9
Drum	22,8	74,6	87,3	78,9	93,4	96,1
Total	100	100	100	100	100	100
Vertebrates	35,1	77,1	91,1	6,6	35,0	48,2
Invertebrates	64,9	22,9	8,9	93,4	65,0	51,8
Total	100	100	100	100	100	100
Gastropods	5,3	5,3	5,3	9,7	9,4	9,4
Pelecypods	94,7	94,7	94,7	90,3	90,6	90,6
Total	100	100	100	100	100	100
Oyster	33,6	34,0	34,4	33,8	34,8	35,5
Stout tagelus	66,4	66,0	65,6	66,2	65,2	64,5
Total	100	100	100	100	100	100

TABLE 8

Comparison of different screen sizes for groups of major fauna from the Swift Creek Feature 22, Kings Bay, GA.

exponential increase of so many small fishes recovered in the fine-gauge sample.

A comparison between vertebrate and invertebrate contributions shows a significant difference between the coarse and fine recovery methods (Table 8; Figures 2 and 3). The invertebrates, or at least the mollusks, were almost completely recovered with coarse sieving, while the small fishes, such as stardrum, were almost completely lost through 6.35 mm screen (Table 8; Figure 2). This is a significant loss, as it is projected that stardrum alone could have provided more than twice as much meat as all of the invertebrates combined (Table 7). The use of coarse- and fine-screen recovery also results in quite dissimilar faunal assemblages. When comparing coarse- and fine-screen sampling methods using the percent similarity index, the MNI results in a similarity value of 56.3, and the biomass similarity value is 67.5 (Figure 2 and 3). A similarity index of 100 would indicate the greatest similarity among the classes of animals identified in the coarse- and fine-sieved samples.

Differences in faunal samples recovered in coarse- and fine-mesh screens can be further shown with the Diversity (H') and Equitability (E) indices calculated for the Kings Bay assemblage. Sample diversity (H') and Equitability (E) increase with the use of finer screen gauge recovery (Figure 4). The important point here is that there is a change associated with the use of different screen gauges for faunal recovery in the two indices. It should be remembered that the diversity statistic (a measure of sample heterogeneity) can be altered in several ways depending on the composition of what might be contained in the fine-screen fraction of the sample, and that composition is usually unknown to the analyst (Tables 5, 6, 7, and 8). For example, samples with an even distribution of abundance among taxa have higher diversity than samples with the same number of taxa but a disproportionately high abundance of a few taxa.

The Effect of Differential Recovery Methods on Animal Size Distributions (Multiple Sites from Southeastern North America and the Caribbean)

Another example of bias resulting from differential sampling with coarse-, medium-, and fine-sieved samples is in the sizes of the animals

recovered. For example, in the Kings Bay sieving experiment there were 62 stardrum atlases in the medium-gauge sample, with a mean width of 2.45 mm (range 1.6-3.0 mm) and a standard deviation of 3.5 mm. In contrast, there are 89 atlases in the fine-screen sample, with a mean width of 2.01 mm (range 1.5-3.0 mm) and a standard deviation of 0.259 mm. The mean atlas sizes of the medium and fine samples are allometrically estimated to be from fish weighing 91.93 g and 60.69 g respectively (Wing & Quitmyer, 1985). Thus, fine-screen sieving not only increases the number of stardrum but also changes the size profile (biomass) of the recovered population.

I question how the losses of size class data for the fishes affect the interpretation of faunal assemblages. The fish vertebra width profile of specimens from Cinnamon Bay, St. John, U.S. Virgin Islands, shows that over 91% of the fish vertebrae from the three excavation levels are smaller than 6 mm, and the use of coarse-gauge screen methods would have resulted in major losses of data (Table 9; Figure 5). For example, measured fish vertebrae recovered by the coarse screening method of Level 4 have a mean lateral width of 7.35 mm (standard deviation = 2.36 mm), whereas the vertebrae recovered by the fine-screen technique have a mean width of 3.2 mm (standard deviation = 1.6 mm) (Table 9; Figure 6). The mean width of the fish vertebrae and the 95% confidence interval plotted around the mean of the coarse- and fine-screen samples do not overlap, indicating a significant difference between the two samples (Figure 6). These data also show that faunal assemblages recovered with different screen gauges are not statis-

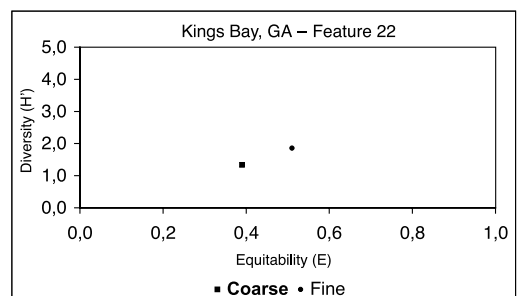


FIGURE 4

A plot of the Diversity (H') and Equitability (E) statistics of faunal assemblages recovered in coarse and fine gauge screen from the Swift Creek Feature 22, Kings Bay, GA.

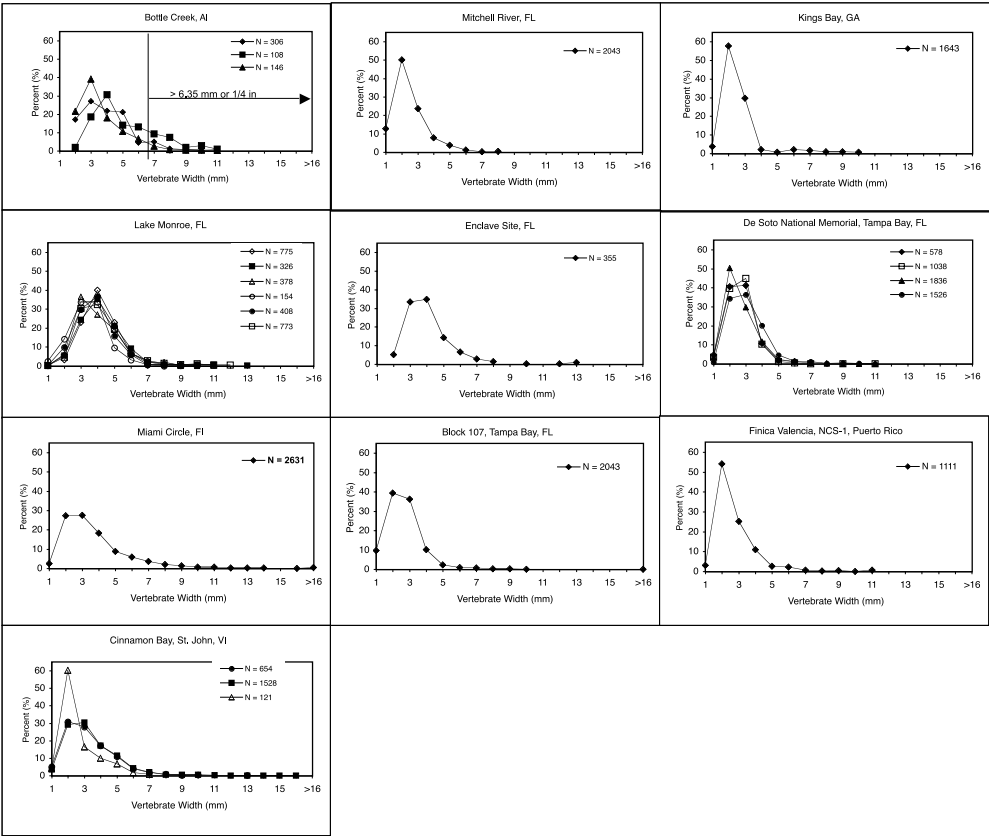


FIGURE 5

Measured fish vertebrae from 10 archaeological sites in the southeastern USA and Caribbean showing width frequency distribution.

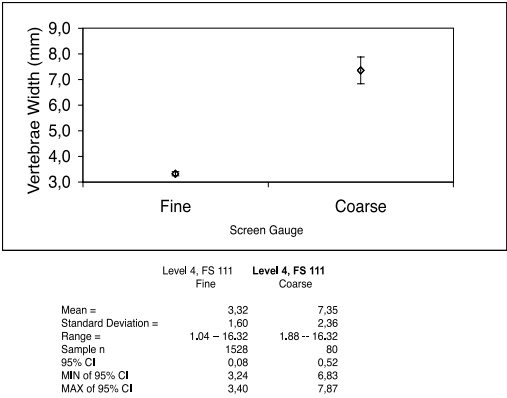


FIGURE 7

PThe mean and 95 % confidence interval plotted around the mean comparing the lateral width of fish vertebrae recovered with fine (6.35+3.18+1.59 mm) and coarse (6.35 mm) gauge screen of Unit 1, level 4, Cinnamon Bay, St. John, U.S. Virgin Islands.

tically comparable. Further, if one were to use the linear dimensions of the fish vertebrae from the coarse sample to allometrically estimate fish biomass, an overestimate would result. This would lead the analyst to conclude that only larger fishes were being exploited.

The change in the body size profile of zooarchaeological fish recovered in finer screen gauges can be further elucidated by examining the plot of the measured fish vertebrae from the 10 representative sites in the southeastern United States and the Caribbean (Table 9; Figure 5). With the exception of one sample (Bottle Creek, D100F), 85% (or more) of the fish vertebrae have a lateral width smaller than 6.0 mm (<1/4 in). In other words, most of the fish vertebrae (more than 85%) could have been lost through the coarse-gauge screen, thus providing a skewed view of the sizes of fishes that were part

Bottle Creek, AL																		Specimens (%)		
Vertebrae Width (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	>16	N	Sample	Smaller than 6 mm
%		17,0	27,0	21,9	21,2	4,6	4,9	1,3	0,7	0,3	0,7							306	D100E	87,1
%		1,9	18,5	30,6	13,9	13,0	9,3	7,4	1,9	2,8	0,9							108	D100F	64,9
%		21,7	39,1	18	10,6	6,6	2,5	0,6	0,4	0,4	0,2							146	C100Z	89,4
Mitchell River, FI																		Specimens (%)		
Vertebrae Width (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	>16	N	Sample	Smaller than 6 mm
%	12,7	50,2	23,6	7,8	3,7	1,2	0,3	0,4										2043	Pooled	98,0
Kings Bay, GA																		Specimens (%)		
Vertebrae Width (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	>16	N	Sample	Smaller than 6 mm
%	3,7	57,6	29,6	2,2	0,7	2,2	1,5	0,9	0,9	0,6								1643	Feature 22	93,8
Lake Monroe, FI																		Specimens (%)		
Vertebrae Width (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	>16	N		Smaller than 6 mm
%		3,2	23,0	40,0	23,0	6,6	2,5	0,9	0,8	0,1								775	IQ99-1	89,2
%	0,3	5,5	24,2	35,3	21,2	9,2	2,1	0,6	0,0	0,6	0,6		0,3					326	IQ99-2	86,5
%	0,0	6,3	36,5	27,2	19,0	6,6	1,6	2,1	0,3	0,0	0,3							378	IQ99-3	89,0
%	2,6	14,3	33,8	33,8	9,7	3,2	0,6	0,6	0,6	0,6								154	IQ99-4	94,2
%	0,2	9,8	29,9	36,8	15,9	5,9	0,7	0,0	0,2	0,5								408	IQ99-5	92,6
%	0,1	4,5	30,3	32,5	19,5	6,7	2,7	1,4	0,8	1,0	0,4	0,4						773	IQ99-6	86,9
Enclave Site, FI																		Specimens (%)		
Vertebrae Width (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	>16	N		Smaller than 6 mm
%		5,1	33,5	34,9	14,4	6,5	2,8	1,4		0,3		0,3	0,8					355,0	Pooled	87,9
Block 107, Tampa Bay, FL																		Specimens (%)		
Vertebrae Width (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	>16	N	Sample	Smaller than 6 mm
%	9,76	39,4	36,3	10,2	2,26	0,89	0,61	0,3	0,1	0,1						0,1		2479	Pooled	97,9
De Soto National Memorial, Tampa Bay																		Specimens (%)		
Vertebrae Width (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	>16	N	Sample	Smaller than 6 mm
%	4,5	40,5	41,2	10,7	1,9	1,2												578	FS177	98,8
%	3,4	39,6	44,8	10,4	1,2	0,4	0,1		0,1		0,1							1038	FS178	99,3
%	3,8	50,4	29,7	11,7	2,4	1,1	0,5	0,3	0,1	0,1	0,1							1836	FS179	97,9
%	0,9	34,3	36,4	20,1	4,7	1,4	1,2	0,3	0,4	0,3	0,1							1526	FS181	96,3
Miami Circle, FL -- Matrix Sample																		Specimens (%)		
Vertebrae Width (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	>16	N	Sample	Smaller than 6 mm
%	2,5	27,3	27,5	18,4	8,9	5,9	3,6	2,1	1,4	0,6	0,6	0,3	0,1	0,2		0,1	0,4	2631	Pooled	84,5
Cinnamon Bay, St. John, VI																		Specimens (%)		
Vertebrae Width (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	>16	N	Sample	Smaller than 6 mm
%	5,4	30,9	27,8	17,3	11,0	4,0	1,7	1,1	0,3	0,5			0,2					654	Level 2	92,4
%	3,4	29,2	30,4	17,3	11,5	4,3	1,9	0,5	0,6	0,5	0,2	0,1		0,1	0,0	0,1	0,1	1528	Level 4	91,8
%	4,1	60,3	16,5	9,9	6,6	1,7	0,8											121	Level 10	97,5

TABLE 9
Measured fish vertebrae from nine sites in the southeastern USA and Caribbean.

of the subsistence economy. A change in the body sizes of animals is a fundamental marker for changes in technology, the season of resource procurement, the exploitation of new habitats, and anthropogenic effects of subsistence behavior.

The Effect of Differential Recovery Methods on Trophic Level Estimations (Example from Cinnamon Bay and other Caribbean Sites)

As I indicated earlier, our ability to calculate the mean trophic level of resources contributed by fish from reef and inshore or pelagic habitats hinges on three factors: our ability to identify the taxa, to determine the MNI, and to calculate the biomass of species from each habitat. A decline in any of these key factors would result in a less accurate picture of the mean trophic level of resources from reef and inshore/pelagic habitats. Figure 7 presents the mean trophic level contributed by reef and inshore/pelagic fishes from three finely sieved samples from Cinnamon Bay, U.S. Virgin Islands. Levels 2, 4, and 10 were stratigraphically superimposed, thus the mean trophic level can be plotted as a time series in order to document changes in the mean trophic level of the fisheries resources. Wing’s (2001) data from the Caribbean islands of St. Thomas (Tu Tu), St. Martin (Hope Estate), Saba (Kelbey’s), and Nevis (Indian Castle and Hichmans) are included as supportive data (Figure 7).

The fine-screen Cinnamon Bay data show that the mean trophic level of the reef component of the sample rises in the first 390 years of

occupation (it should be noted that this rise may be a statistical artifact related to an inadequate Level 10 sample) (Figure 7). During the 100 years that separate Levels 4 and 2, the mean trophic level of the reef component of the assemblage declines. This decline results from a decrease in the body size and numbers of reef predators, while there is an increase in the presence of reef herbivores. These data confirm Wing’s (2001) study documenting a similar trend in the mean trophic level contributed by reef taxa between early and late archaeological site components from four Caribbean Islands (Figure 7). Wing (2001) interprets this decline as overfishing of reef predators (such as snappers and groupers) because they are easily affected by overfishing. Wing (2001) suggests that, at places like Hope Estate and Kelbey’s, the human residents responded to the decline in the availability of reef predators by more intensively exploiting the inshore/pelagic species (such as herring and tuna) that come from larger biological reservoirs. As at Hope Estate and

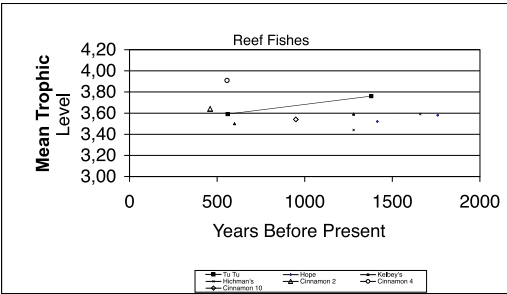


FIGURE 7

Comparison of trophic levels of reef and inshore/pelagic species of faunal samples from seven Caribbean Islands. These samples were recovered with fine gauge (6.35+3.18+1.59 mm) screen.

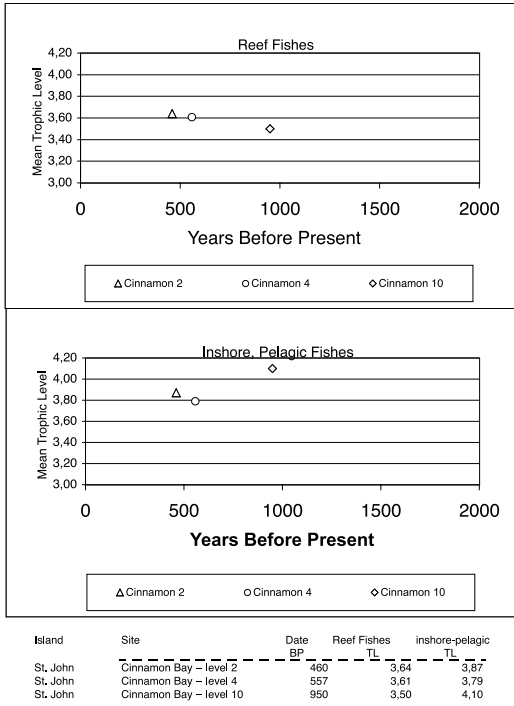


FIGURE 8

Comparison of trophic levels of reef and inshore/pelagic species of faunal samples from Cinnamon Bay, VI. These samples were recovered with coarse gauge (1.59 mm) screen.

Kelbey, in the fine-screened Cinnamon Bay assemblage, the mean trophic level of species from inshore/pelagic habitats (e.g., herring and tuna) increased over the period of occupation of the site, Level 10-Level 2 (Figure 7).

A very different picture of the influence of Cinnamon Bay human fishing pressure emerges when the mean trophic levels contributed by reef taxa from inshore/pelagic habitats are recalculated using only the skeletal elements from the 6.35 mm gauge screen (Figure 8). The reader is reminded that this would represent a sample that would have been recovered with coarse-gauge screen, and that skeletal remains of small fishes (about 91%) would have been lost (Table 9; Figure 5). Using just the coarse-screened sample data, the mean trophic level of the reef component continually increases through time; Levels 10, 4, and 2 (Figure 8). However, it must be noted that the difference in the mean trophic level between Levels 4 and 2 is only 0.03, which might have been regarded as an unimportant trend at the site. The mean trophic level of the inshore/pelagic component declines between Levels 10 and 4, and then increases between Levels 4 and 2 (Figure 8).

The coarse screen data would have supported the conclusion that the people at Cinnamon Bay were consuming greater numbers of large reef predators over the 490 years of occupation, an increase in the mean trophic level of the reef component over time. Given the sensitivity of reef carnivore populations to fishing, the evidence for greater human population density, and that island coral reef communities are regarded as small biological reservoirs, this may have been a biological improbability.

CONCLUSIONS

In Brown's (2003: 206) recently published book on the Mississippian site of Bottle Creek located in the Mobile-Tensaw Delta, Alabama, he remarks on how valuable it is to "look small." Brown (2003: 206) notes, "What a different vision of Bottle Creek subsistence we would come away with had the mesh size of our screens been larger" (Brown, 2003b: 206). As the zooarchaeological data form the basis of conclusions about the relative importance of the

various hunting, fishing, and gathering techniques used to procure animal species, the difference demonstrated in the data by using more complete recovery techniques inevitably affects any conclusions about the prehistoric use of animal resources (Wing & Quitmyer, 1995).

This study has shown significant variation in sample size and representativeness between samples recovered using different mesh screens at 10 sites through the United States and the Caribbean. Sample sizes (measured by MNI) and characters (diversity and equitability) vary widely between the various mesh sizes. As well, the individual size distributions within the various animal populations recovered are significantly different depending on the mesh size used to recover the remains. This may seem less than significant to an archaeologist faced with the costs of fine-gauge screening. However, my analyses show the dramatic effect of these sample and individual size differences on diachronic patterning in animal community trophic levels, and they highlight the danger of using less than representative zooarchaeological assemblages for such higher-order extrapolations.

What would we not have known about subsistence behavior from the sites presented in this paper had we made the choice to use coarse-gauge screens in our inquiries? We would not have known the overwhelming importance of small schooling fishes to the pre-Columbian people who were exploiting the estuarine shallows with fine-mesh nets over such a wide geographic region. We might not have found that humans regularly exploited the nursery habitats of estuaries, bays, rivers, and lakes for over 5,000 years of prehistory in the southeast. We would not have known the extent of the effect of Caribbean island society on reef resources. As Reitz & Wing (1999) have noted, when fine-mesh screen (1.58 mm) is used in faunal recovery from aquatic sites in the southeastern United States and the Caribbean, without exception small fishes form a major part of the zooarchaeological assemblage. At Kings Bay, coarsely sieved faunal samples depict an economy based on the gathering of shellfish and on fishing predominantly with hook and line, while the major part of the assemblage that might have been unknowingly discarded into the back dirt reveals a very different picture of exploiting small schooling fish with fine-mesh nets. The perspective that optimum faunal recovery gives

at Kings Bay on the importance of shellfish is particularly informative. Shell in an archaeological site is so conspicuous that the possible contribution of the vertebrates may not be fully appreciated. Samples recovered with fine screen would certainly alter that impression.

Finally, had the archaeologist not chosen to use fine-gauge screens in the recovery of the faunal samples from Cinnamon Bay and other Caribbean islands, we would probably not have been able to identify the anthropogenic effects of overfishing at those sites (Wing, 2001).

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