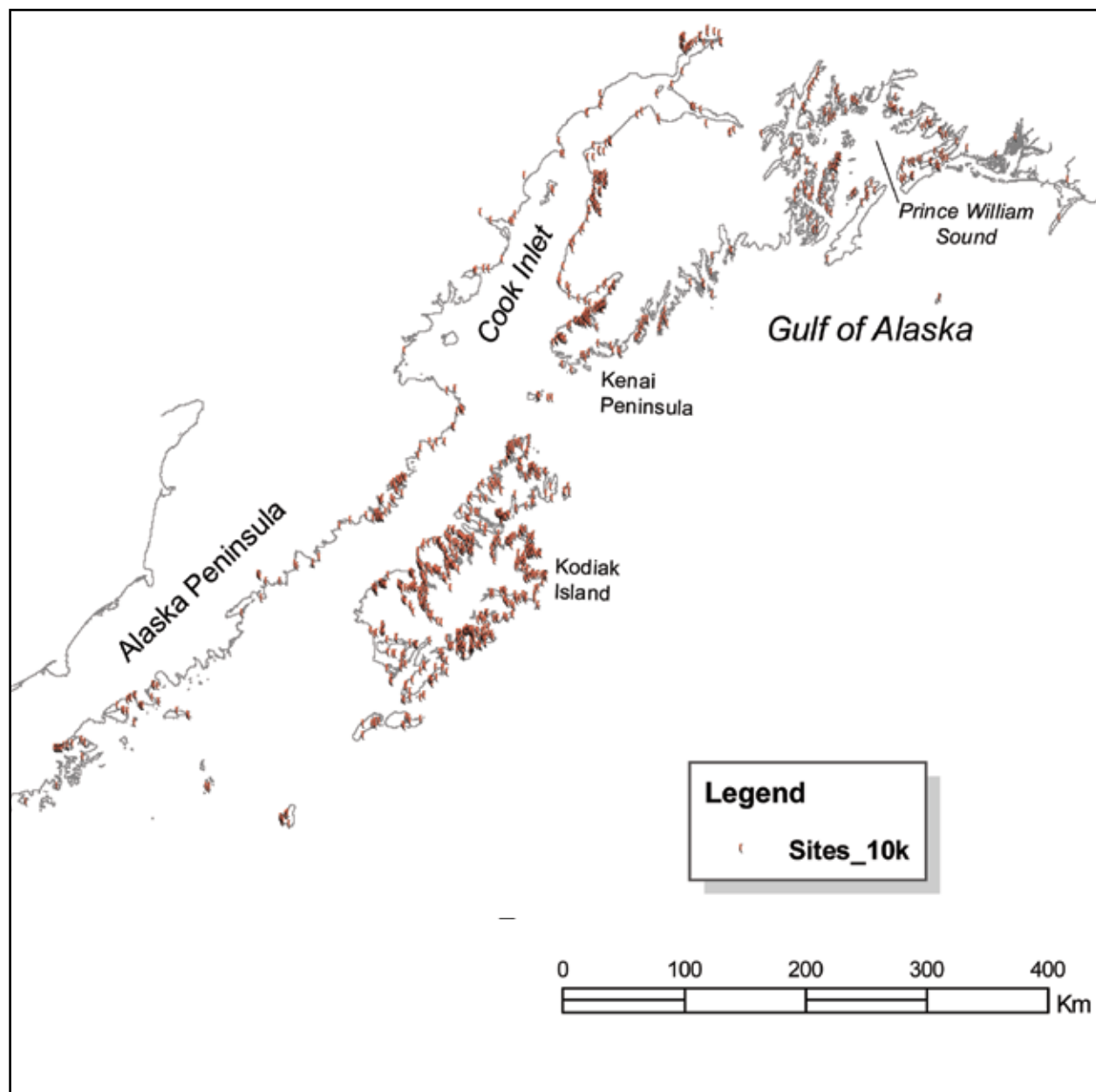




Spatial Correlation of Archaeological Sites and Subsistence Resources in the Gulf of Alaska

By Aron L. Crowell, Joseph Liddle, and Mark Matson

Abstract

A GIS-based spatial analysis of 1,959 indigenous coastal archaeological sites in the central Gulf of Alaska coast demonstrated that settlements are clustered in areas where maritime hunters and fishers had access to numerous nearby locales for harvesting subsistence species. Zones of high resource richness – primarily associated with bay mouths and complex shorelines – provided stability of food access as the availability of individual species fluctuated both seasonally and as the result of decadal and centennial climate cycles. Factor analysis revealed distinct associations between site locations and groups of species that are more or less abundant during cold and warm climate phases.

Figure 1. Locations of all reported coastal archaeological sites in the central Gulf of Alaska.

Figure 2. A 3000 year-old fishing sinker at an eroded archaeological site in Nuka Bay, Kenai Fjords National Park.

Figure 3. Test excavations in midden at an 800 year-old Sugpiaq village site in coastal forest along Nuka Passage, Kachemak Bay State Park, 2007. Left to right: Forest Kvasnikoff (Port Graham), Mark Luttrell (Seward), Ann Ghicadus (Seward), and student intern Justin Malchoff (Port Graham).

Photographs courtesy of A. Crowell

Introduction

This paper summarizes preliminary results of a regional Geographic Information System (GIS) study of the spatial relationships between coastal archaeological sites and maritime subsistence resources in the central Gulf of Alaska. Two modes of variability are relevant to the model – the uneven geographic distributions of key subsistence resources and temporal cycles in the climate and marine ecosystem (Crowell *et al.* 2003). The latter include the annual seasonal cycle, the 20 to 50 year intervals of the Pacific Decadal Oscillation (PDO), and multi-century trends including the Medieval Warm Period (~A.D. 1000-1400) and Little Ice Age (~A.D. 1400-1900). Salmon increase during warmer PDO phases, while colder phases yield increases in forage fish and shrimp that in turn support larger numbers of the seals, sea lions, and seabirds who consume these prey (Benson and Trites 2002, Finney *et al.* 2002, McGowan *et al.* 1998). We propose that indigenous hunting and fishing peoples of the Gulf of Alaska settled primarily in areas with the highest numbers and diversity of marine fish, mammal, and bird harvesting locales in order to increase harvesting efficiency and to buffer the risk of individual species declines due to climate and marine ecosystem change.

Data and Methods of Analysis

The study area spans 10,560 mi (17,000 km) of mainland and island shoreline including the Alaska

Peninsula, Cook Inlet, the Kodiak Island archipelago, Kenai Peninsula, and Prince William Sound, a region that encompasses the traditional territories of the Sugpiaq (Alutiiq) and coastal Dena'ina. The sample includes 1,959 known coastal archaeological sites: 41% are estimated from radiocarbon dates, artifacts, and features to have been occupied since A.D. 900; 10% are older than A.D. 900; and 49% are of indeterminate age (Figure 1). For each of the 6,800 shoreline segments (1.6 mi/2.5 km in length) we computed the number of archaeological sites present as well as the number of locally accessible harvest locales for each of 24 different fish, bird, and sea mammal species (Figure 4). Harvest locales for offshore subsistence species (e.g. seal concentrations, bird rookeries, and pelagic fishing areas) were counted as accessible if located within a 6.2 mi (10 km) kayak travel radius from any point on the shoreline segment. Access to anadromous fish streams was computed using a 0.6 mi (1 km) pedestrian radius, reflecting the ethnohistoric pattern of establishing fishing camps at these locations. Statistical analysis utilized simple “richness” scores – the total number of resource access locales (all species) for each segment – as well as multivariate correspondences between site occurrence and the availability of various species groups.

Results

Geographically, the highest richness scores occur in protected bays with complex shorelines (including

GIS Layer	Data Source
Archaeological Sites	AK Office of History and Archaeology
King Salmon	Alaska Dept. of Fish and Game 2006
Sockeye Salmon	Alaska Dept. of Fish and Game 2006
Coho Salmon	Alaska Dept. of Fish and Game 2006
Chum Salmon	Alaska Dept. of Fish and Game 2006
Pink Salmon	Alaska Dept. of Fish and Game 2006
Steelhead	Alaska Dept. of Fish and Game 2006
Sea Bird Colonies	U.S. Fish and Wildlife Service 2006
Harbor Seal Haulouts	National Marine Fisheries Service 2006
Sea Lion Haulouts	National Marine Fisheries Service 2006
Sea Lion Concentrations	National Ocean & Atmospheric Administration 2003
Harbor Porpoise	National Ocean & Atmospheric Administration 2003
White Whale	National Ocean & Atmospheric Administration 2003
Humpback Whale	National Ocean & Atmospheric Administration 2003
Minke Whale	National Ocean & Atmospheric Administration 2003
Fin Whale	National Ocean & Atmospheric Administration 2003
Dall's Porpoise	National Ocean & Atmospheric Administration 2003
Herring	National Ocean & Atmospheric Administration 2003
Pacific Cod	National Ocean & Atmospheric Administration 2003
Walleye Pollock	National Ocean & Atmospheric Administration 2003
Lingcod	National Ocean & Atmospheric Administration 2003
Halibut	National Ocean & Atmospheric Administration 2003
English Sole	National Ocean & Atmospheric Administration 2003
Dover Sole	National Ocean & Atmospheric Administration 2003
Arrowtooth Flounder	National Ocean & Atmospheric Administration 2003

Figure 4. GIS layers used in the study and sources of data.

bay mouth islands), while richness diminishes toward the inner reaches of bays and along straight, exposed coastlines (Figure 5). The pattern is multiscale, applying to very large features (Cook Inlet and Prince William

Sound) as well as more localized coastal involutions. The richest areas combine coastal complexity with proximity to the central Gulf of Alaska upwelling zone located at the mouth of Cook Inlet. These areas include

the northern Kodiak archipelago, Cape Elizabeth and Kachemak Bay at the tip of the Kenai Peninsula, and the Kukak Bay-Amalik Bay section of the Alaska Peninsula,

A graph of site count per segment plotted against richness score (Figure 6) suggests a threshold at approximately 10 resources, below which relatively few sites are present at most locations. Out of 856 coastal segments where sites were present, 776 (90.6%) had richness scores of 10 or greater (Figure 7), a relationship that is highly significant ($p = <0.0001$). The presence of other sites within 7.5 mi (12 km) also has a strong predictive value ($p = <0.001$), reflecting the clustering of sites within resource-rich zones (Figure 8). As a further indication of this pattern, all 1,959 regional archaeological sites were contained within only 13% of shoreline segments, while the other 87% contained no settlements. Some neighboring sites are probably villages and camps used by contemporary people during different parts of the year, while others reflect shared settlement preferences by unrelated groups at different times.

We also undertook a factor analysis of the resource matrix to determine which resources or resource groups have dominant effects on site location. The analysis showed that the 24 resource variables could be reduced to six factors. Three of these – Factor 1 (sea lions, cod, halibut, herring), Factor 4 (anadromous fish including 3 species of salmon and steelhead trout), and Factor 6 (seals and seabird colonies) were found to have highly significant influences ($p = <0.0001$) on site count. Each one unit increase in Factor 1 increased predicted site count by 33.7%; in Factor 4 by 28.7%; and in Factor 6 by 8.6%.

This result indicates the relatively equal but segregated influences of pelagic fish (along with sea lions, one of the major predators of such fish) and of salmon, reflected in Factors 1 and 4 respectively. In part, this segregation is likely to reflect seasonal rotation between fall-winter-spring villages and mid to late summer salmon camps. Factor 6 represents the association of seal haul-outs and bird colonies on offshore islands and the influence that these have on attracting human settlement to proximate coastlines.

On a longer temporal scale, Factor 1 may represent subsistence emphasis and corresponding site location choices during colder phases when salmon are reduced but sea mammals and forage fish (e.g. herring) increase. Factor 4 would represent the alternative warm phase

strategy, when coastal residents moved to major salmon rivers and relied on mass production and storage of this resource for winter consumption. Intraregional mobility of this type is documented by archaeological and ethnohistorical instances including Sugpiaq settlement

along the salmon-rich Karluk River on Kodiak Island during the Medieval Warm period and later resettlement along the sea mammal-rich coast of eastern Kodiak at the peak of the Little Ice Age in the late 1700s (Clark 1987). Dena'ina groups expanded into Cook Inlet at the start of the Medieval Warm Period around A.D. 1000 and adopted an intensive salmon fishing orientation.

Discussion

Indigenous settlement along the central Gulf of Alaska coast, as represented by a sample of almost 2,000 archaeological sites, was strongly influenced by proximity to marine subsistence resources. We have shown that distributions of fish, mammal, and bird species can be used to compute summed richness scores for individual shoreline segments, and that these scores correlate highly with the frequency of known coastal sites. In geographic terms, areas of resource richness and high site density are associated with complexly indented shorelines, in particular the protected outer portions of bays and fiords. We suggest that the concentration and diversity of resource harvest locales in such areas supported extended occupation across all time scales from seasonal to millennial by mitigating climatic and ecosystem fluctuations in the abundance of individual food species.

These regional findings extend and confirm our findings from a similar GIS study of resources and settlement patterns on the Gulf of Alaska coastline of Katmai National Park and Preserve (Crowell *et al.* 2003), as well as a previous regional study (Erlandson *et al.* 1992). This GIS predictive model has significant management implications for national parks bordering the Gulf of Alaska (Katmai, Lake Clark, Kenai Fjords, Wrangell-St. Elias, and Glacier Bay), where the most high priority regions for cultural resource documentation and protection are likely to be shorelines with associated high resource scores.

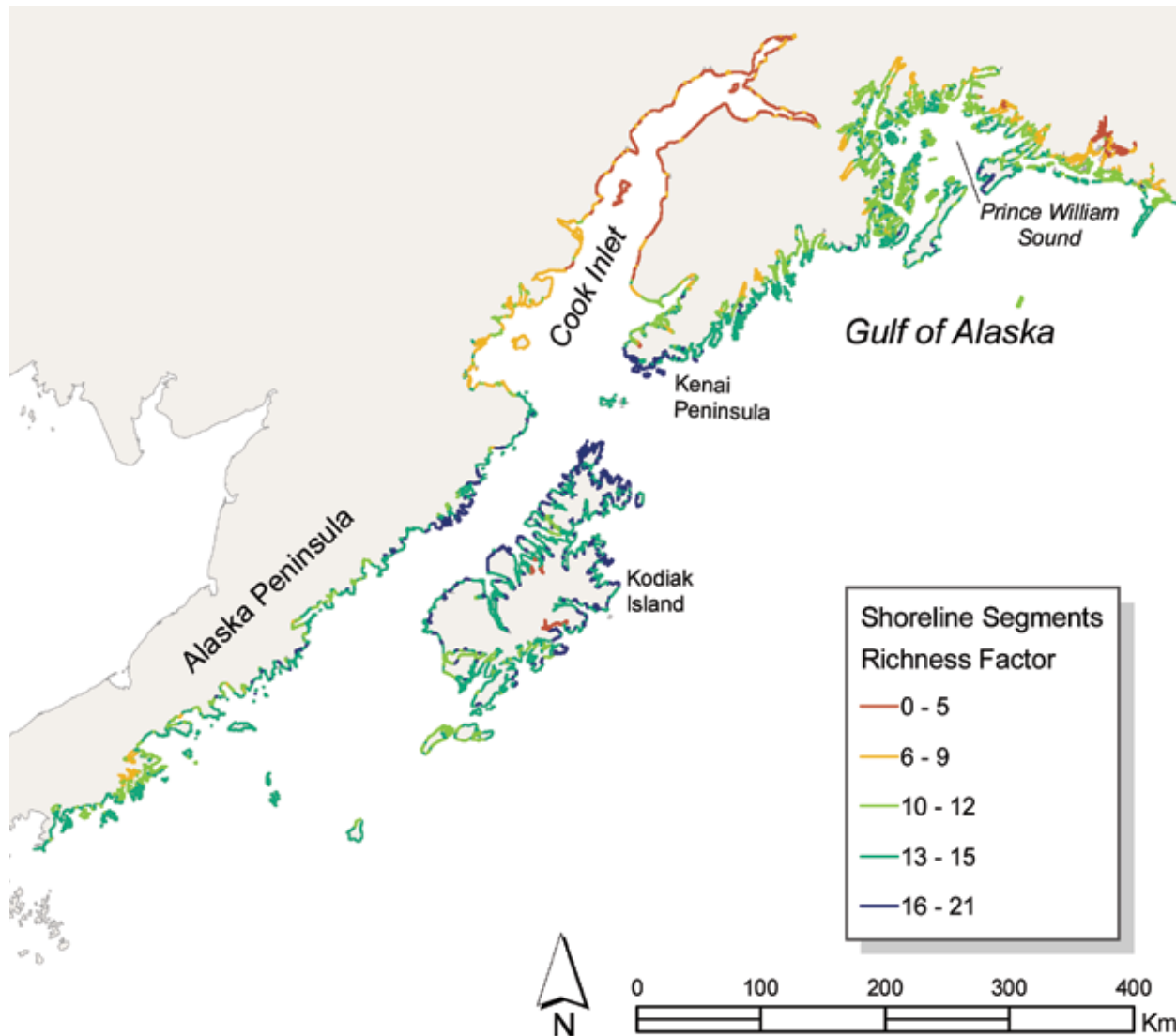


Figure 5. Computed resource richness scores for 6,800 shoreline segments (each 1.6 mi or 2.5 km long) in the central Gulf of Alaska.

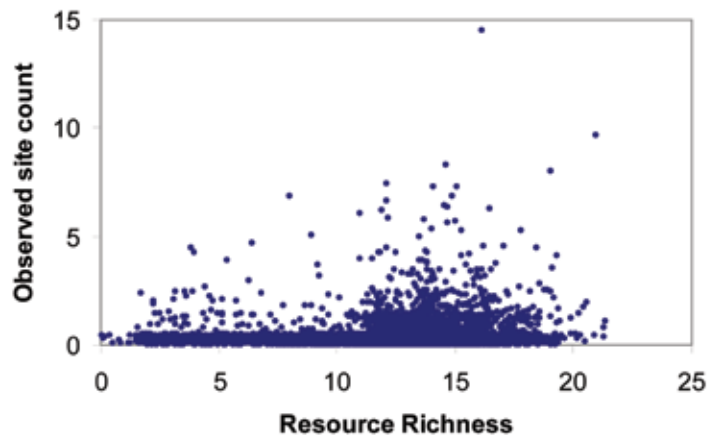


Figure 6. Scatter plot of resource richness compared to site count for 6,800 shoreline segments. The majority of sites (90.6%) occur on segments with access to 10 or more resources. Site count values are slightly "jiggled" to separate them and bring zero values up from the baseline.

	No Site	Site	Totals
Richness < 10	1072	80	1152
Richness > 10	4872	776	5648
Totals	5944	856	6800

Figure 7. Presence or absence of archaeological sites compared to richness scores of < 10 and ≥ 10 . Site presence is not independent of the criteria that resource richness ≥ 10 ($\chi^2 = 40.15$, $p < 0.0001$).

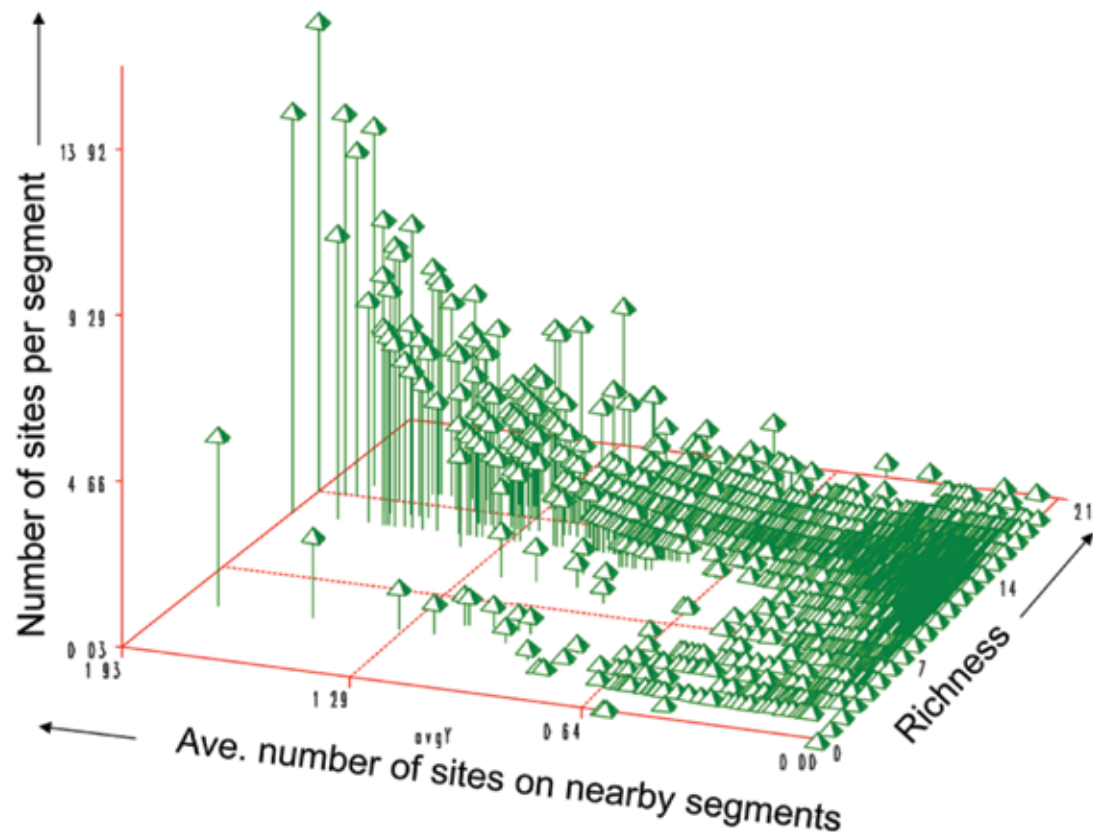


Figure 8. Predicted site counts increase as both richness and the average number of neighboring sites increase. The largest predicted site counts occur where richness is greater than 10 and the average number of neighboring sites exceeds 1.0.

Acknowledgements

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