IMPLICATIONS OF "PUNCTUATED PRODUCTIVITY" FOR COASTAL SETTLEMENT PATTERNS: A GIS STUDY OF THE KATMAI COAST, GULF OF ALASKA

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Abstract: GIS spatial analysis of 15 categories of subsistence resources (sea mammals, fish, birds, shellfish) and 90 archaeological site locations along the Pacific shoreline of Katmai National Park and Preserve indicates that sites of all time periods are concentrated within enclosed bay systems where resource diversity tends to be highest. This pattern of intensive settlement in resource-rich "hot spots" may apply to the entire Gulf of Alaska region. Ethnohistoric information on Alutiiq subsistence practices and site survey data from the study area suggest that large and ecologically diverse bays (e.g. Kukak and Amalik) may have offered sufficient resource options to buffer cyclical shifts in the productivity of salmon and other species, and to thus provide stable, self-sufficient territories for autonomous local groups. Several gaps in the Katmai occupation record are nonetheless identified (5600 – 4600 cal. yrs. B.P.; 2900 – 2000 cal yrs. B. P.) that may represent periods when even the most diverse and stable settlement areas were abandoned. The study suggests that reconstructions of maritime adaptations and social development in the Gulf of Alaska must take account of the physical and ecological heterogeneity of the coastal environment, as well as its instability over time.

Keywords: subsistence, settlement pattern, GIS, resource diversity, maritime adaptations, Gulf of Alaska, Alutiiq.

The Pacific shoreline of Katmai National Park and Preserve (Figure 1) was occupied by indigenous populations for at least 7000 years and offers an important setting for the archaeological study of Alaskan coastal adaptations. Cultural resource surveys have been conducted along virtually all sections of the topographically varied coastline between Katmai Bay and Cape Douglas, where 90 pre-contact and historic period settlements are now known. The present GIS-based study of site locations, resource distributions, and coastal geomorphology incorporates archaeological data and interpretations from University of Oregon research (G. Clark 1977; Dumond 1964, 1971, 1987; see also W. Davis 1954; Oswalt 1955), post-*Exxon Valdez* oil spill surveys and cultural ecological analysis (Dekin et al. 1993; Environment and Natural Resources Institute 1993; Erlandson et al. 1992; Haggarty et al. 1991; Mobley et al. 1990), and recent interdisciplinary studies sponsored by the National Park Service and Smithsonian Institution (Crowell and Mann 1996; Crowell and Mann n.d.; Hilton 1998, 2002; National Science Foundation 2002; Schaff 2002). It builds on Allen McCartney's observation (1988:46) that the Pacific coast of the Alaska Peninsula is a region of "punctuated productivity" where ecological hotspots correspond with areas of intensive human use.

The cultural history of the Katmai coast, where a small Alutiiq[1] population resided until the early 20th century, is unified with that of the Alutiiq region as a whole (Figure 2), with particularly close parallels to Kodiak Island and lower Cook Inlet (D. Clark 1984a; G. Clark 1977; Crowell 2000; Steffian 2001; Workman 1980). Initial settlement of the coast was almost certainly an aspect of the Paleoarctic expansion from Siberia (West 1996). Although presently known only from the Ugashik Narrows site and other inland locations on the Alaska Peninsula (Dumond 1981; Henn 1978), Paleoarctic sites dating to between 8500 and 10,000 calendar years have been documented in the eastern Aleutian Islands (Dumond and Knecht 2001; McCartney and Veltre 1996) and southeastern Alaska (Ackerman et al. 1979; S. Davis 1996; Dixon et al. 1997). Middle Holocene sites on the Katmai coast, assigned to the Takli Alder (4700 – 2700 B.C.) and Takli Birch (2700 – 1000 B.C.) phases[2], contain barbed harpoons and remains of sea otter, harbor seal, sea lion, porpoise, and a wide variety of fish and sea birds, all indicative of fully-developed maritime harvesting capabilities (Bender 1999; G. Clark 1977; Dumond 1977). Apparent population growth, the appearance of medium to large coastal villages with semi-subterranean houses and thick shell middens, and a continuing shift from chipped

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[1] The Alutiiq population (plural, Alutiit) has been referred to as "Pacific Eskimo" in earlier literature (e.g. Birket-Smith 1953; D. Clark 1984b). Crowell et al. (2001) discuss the currency of Alutiiq as a cultural designation. The spelling "Alutiiq" has been retained because of widespread usage and publication. However, in the revised orthography now used by the Alaska Native Language Center (University of Alaska Fairbanks) it would be "Alu'utíq" (Leer 2001)

[2] Date ranges are expressed in calendar years as revised from G. Clark (1977) to accommodate new sites and an expanded series of calibrated radiocarbon dates (Crowell and Mann 1996).

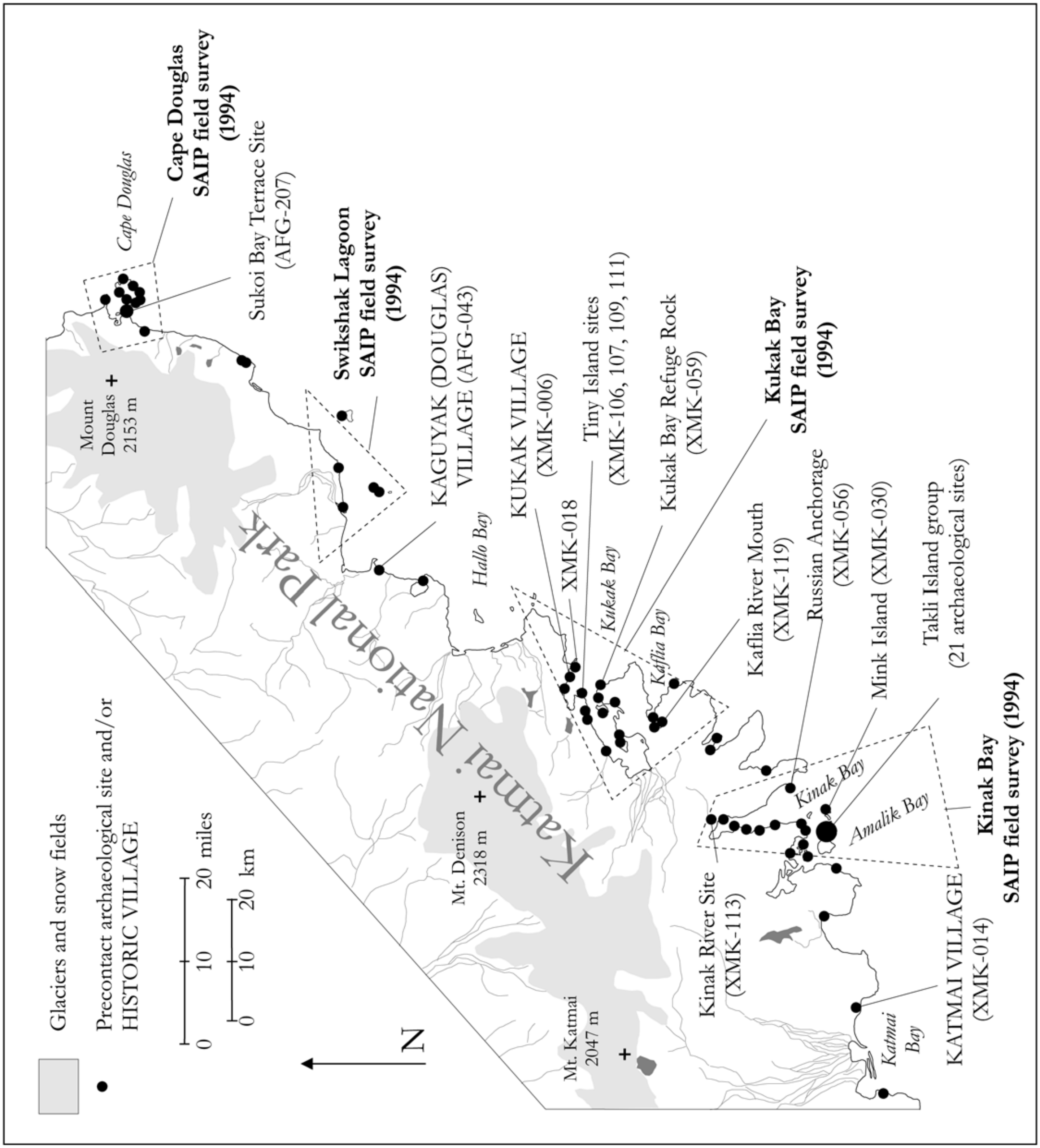

Figure 1: The Gulf of Alaska shoreline of Katmai National Park, showing 1994 survey locations, pre-contact archaeological sites, and historic villages.

to ground stone tools are among the important trends that characterize subsequent periods of occupation, known as the Cottonwood phase (A.D. 1 – 500), Beach phase (A.D. 500 – 1000), and Mound phase (A.D. 1000 – 1700). Artifact assemblages from these phases suggest strong east-west interactions with other Gulf of Alaska populations from the Aleutians to Prince William Sound, as well as intermittent connections northward to Bristol Bay and the Bering Sea (D. Clark 1984a; G. Clark 1977; Dumond 1974, 1981).

Russian fur traders who arrived in the late 18th century noted several Alutiiq villages in what is now Katmai National Park, including Katmai (Alutiiq name, *Qayihwik*) and Kukak (*Qukaq*) on the Pacific coast and Severnovskoe (*Ikak*) at Naknek Lake in the interior (Arndt n.d.; Hussey 1971; Lührmann 2000). There were scattered seasonal camps as well. All Alutiiq settlements within the study area, including newer communities at Douglas and Kaflia Bay, were deserted after the massive eruption of the Katmai/Novarupta volcano in 1912.

Native descendants of this historic population now live in villages to the west and north of the park, including Chignik, Chignik Lake, Chignik Lagoon, Perryville, Ivanof Bay, Port Heiden, Ugashik, Pilot Point, Naknek, South Naknek, and King Salmon. The Pacific coast Alutiiq villages maintain a subsistence-oriented economy that is focused on salmon, seals, caribou, moose, and a wide range of other animal foods and wild plants (Fall et al. 1995; Fall and Hutchinson-Scarbrough 1996; Morseth 1998). Oral traditions relating to life on the Katmai coast prior to 1912 are strong (Partnow 2002). This continuous relationship between people and the land is an important aspect of contemporary Alutiiq cultural identity and underlines the broader significance of archaeological studies in the Katmai area (Crowell et al. 2001).

The present paper examines the spatial distribution of indigenous habitation sites along the Pacific (Shelikof Strait) shoreline of Katmai National Park in relation to both the coastal landscape and the availability of marine subsistence resources. The focus in the latter instance is on access to key fish and game species of the coastal zone, including sea mammals, salmon, bottom fish, seabirds, and waterfowl[3]. Along the Katmai coast, most food species are concentrated in discrete patches that are seasonally specific and unevenly distributed. Examples include sea lion haul-outs and rookeries, harbor seal haul-outs and breeding areas, sea bird colonies, salmon spawning streams, shellfish beds, and spring concentrations of waterfowl. From the standpoint of the human harvester, the coastal and near-shore zones thus represent a space-time mosaic of relatively predictable hunting and fishing opportunities. The Katmai Alutiit and their ancestors chose settlement locations and adopted patterns of seasonal movement that maximized these opportunities, as documented by archaeological and historical data and as discussed in this paper[4].

A limiting but necessary assumption of the analysis is that spatial distributions of fish and game species have remained at least approximately the same over the last 7000 years. It is certainly true that the populations of some species have been reduced by historic impacts including commercial fishing and whaling. It is also to be expected that populations of all coastal fauna have fluctuated as the result of cyclical changes in climate, sea temperature, and other natural variables (Beamish and Bouillon 1993; Francis et al. 1994, 1998). We nonetheless assume that animals have utilized broadly similar feeding, breeding, and migration areas through time, despite these changes in population. Future paleoenvironmental research and studies of archaeological fauna may at least partially invalidate this assumption and lead to modification of the present model. To minimize untenable projections from present data into the past, the analysis focuses on the *generalized spatial diversity* of resources rather than on measures of absolute abundance.

One key perspective of the study is that large bays with complex coastlines are topographically and ecologically diverse and for this reason offer an exceptional variety of harvest options to human foragers (cf. Haggarty et al. 1991:225-247). The spatial concentration of resource locales within such bays probably attracted settlement for several reasons, including shorter foray distances and less need to shift residence from main villages to seasonal fishing and hunting camps. Diversity of subsistence options would also have mitigated changes in the abundance of individual food species. In addition, bays that are protected from ocean storms by reefs and islands provided a relatively sheltered environment for travel in skin-covered kayaks and larger transport craft (*angyat*). Low energy beaches are safer for landing boats, and their physical characteristics – including substrate, sediment, width, and slope – indirectly reflect the reduced risks of boat travel in the vicinity. For these reasons, the geomorphological characteristics of Katmai beaches were incorporated into the GIS analysis.

The results of the study are relevant to the ecology of human settlement and adaptation around the Gulf of

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[3] Terrestrial resources were not included in the present analysis. Brown bears and moose have generalized distributions along the Katmai coast, while caribou are sometimes locally available in the vicinities of Hallo Bay and Katmai Bay. Caribou are more abundant along the coast west of the study area and in the interior, beyond the Aleutian Range. Usable distributional data are lacking for porcupine, fox, beaver, and other smaller land animals. Limited archaeological samples suggest that terrestrial species played a relatively minor role in the diets of former coastal inhabitants of Katmai National Park (Bender 1999; Dumond 1977), although they are important today for Alutiiq villages such as Chignik.

[4] Mike Hilton (personal communication 2002) suggests that "catcher beaches" where driftwood is available in quantity were also important resource locales.

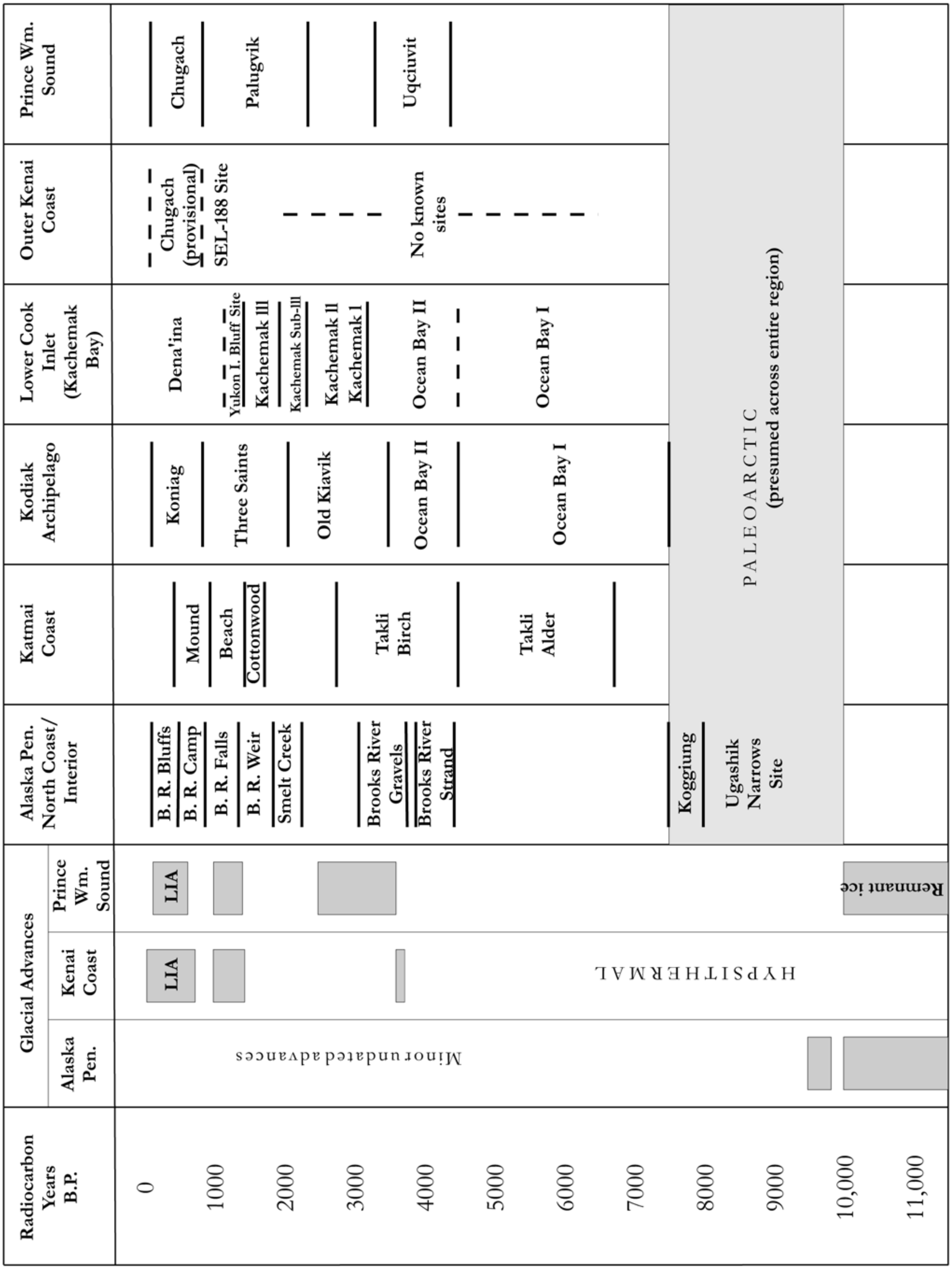

Figure 2: Cultural phases of the central Gulf of Alaska coast.

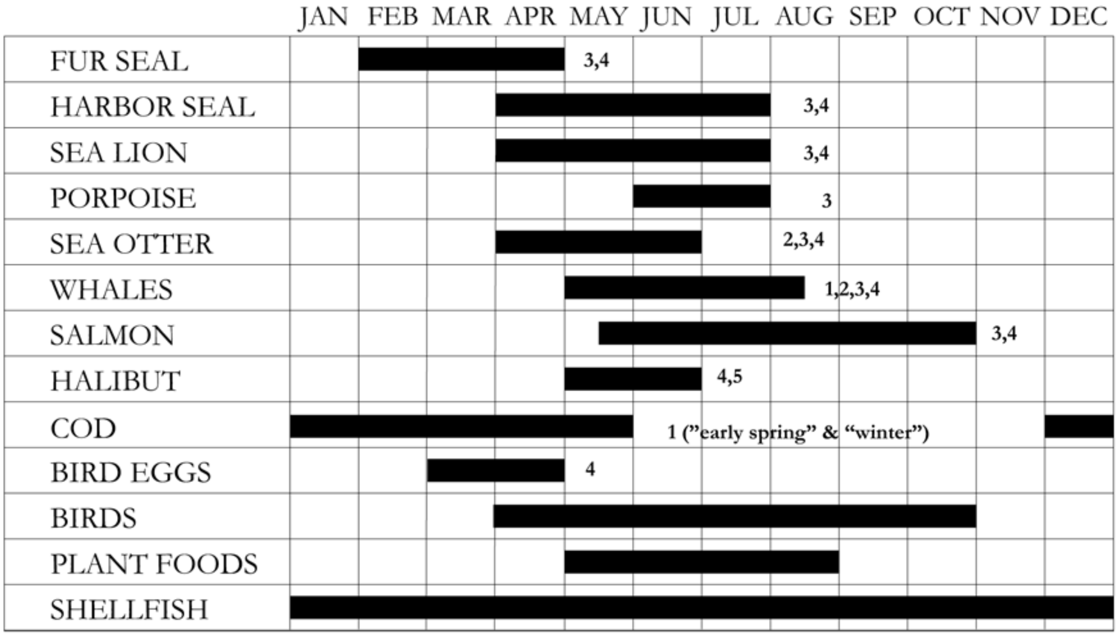

Figure 3: Ethnohistorically reconstructed Alutiiq seasonal round for Kodiak Island, circa 1790 – 1805 A.D.

1. Davydov (1977:175, 224, 232)
2. Holmberg (1985:48, 50)
3. Merck (1980:106-106)
4. Sauer (1802:178)
5. Billings (in Merck 1980:206)

Alaska, one of the world's most productive oceanic regions (*Exxon Valdez* Oil Spill Trustee Council 2002; Hood and Zimmerman 1986). Southern Alaska – along with the coasts of southern California, Florida, and Peru - was among the earliest places in the Americas where human foragers came to rely primarily on maritime food sources (Erlandson 2001; Workman and McCartney 1998; Yesner 1998). Trends of the middle and late Holocene - including increased sedentism, population growth, social inequality, and warfare - prefigure ethnographic characteristics of historic Unangan, Alutiiq, Dena'ina, Tlingit, Haida, and Tsimshian societies (Crowell et al. 1991; Lantis 1970; Townsend 1980). Environmental variation and instability – demonstrated on a local scale for the Katmai coast – are likely to underlie these cultural and demographic patterns.

SETTLEMENT PATTERN STUDIES IN THE ALUTIIQ REGION

Ethnohistoric Patterns

Ethnohistoric data for the Alutiiq area (e.g., Black 1977; Davydov 1977; Gideon 1989; Holmberg 1985; von Langsdorff 1993; Merck 1980; Sauer 1802) indicate that pre-contact settlement patterns were characteristic of a "logistical foraging mode" of hunting, fishing, and gathering (Erlandson et al. 1992). Logistical foraging systems, which incorporate movements of task groups between base settlements and temporary exploitation camps, are associated with pronounced seasonality and spatial dispersion of food resources.

A reconstruction of early historic period Alutiiq seasonal subsistence activities is presented in Figure 3, with source annotations. The figure represents Kodiak Island for the period of about 1790–1805 and is a proxy for the Katmai coast, where direct ethnohistoric information is scarce. The pattern may be distorted to a certain degree by Russian colonial control and its imposed focus on maritime fur production. During the environmentally unproductive months of October through March, coastal residents undertook relatively few subsistence activities and concentrated in large, long-established villages where they consumed a diet of dried salmon, seal oil, berries, and other stored foods. Shellfish were collected in all seasons but were especially important as a source of food in the spring when other supplies ran low. From April through September the population was more dispersed, as households divided their efforts among a wide variety of subsistence harvest opportunities as well as sea otter hunting voyages (Black 1977:85; Davydov 1977; Lisianskii 1814:195; Merck 1980:206; Sauer 1802:178). During this time, salmon, whales and dozens of other migrant species become available and many birds and sea mammals were concentrated at their breeding grounds. Individuals and family groups traveled to hunting, fishing, and collecting places and often resided there for periods of days or weeks. Accumulated stores of dried fish, whale meat, and other foods were transported back to the main villages by boat. Fleet watercraft and the close packing of ecological zones permitted many subsistence efforts to be staged entirely from the winter villages, where at least some of the population resided year-round (Clark 1987; Haggarty et al. 1991:93-98).

Ioasaf summarized this pattern from his observations on Kodiak Island in 1794-1799:

> Almost every family has its own dwelling, and many have more than one dwelling in various places. They settle on the bays and inlets, on the sea shore, and near streams, but change their locations and dwellings with the seasons. In the spring they usually stay in places where the run of fish from the sea toward the streams occurs earliest, and in winter near the shallows where they can find subsistence for themselves. (Black 1977:85).

Ethnographically-recorded factors in the selection of settlement sites included proximity to the sea, protected beaches for boat landings, open views of adjacent bays for monitoring sea mammals and the approach of enemies, and access to fresh water and food (Birket-Smith 1953; D. Clark 1984b, 1987; de Laguna 1956). It is important for archaeological interpretation to note that seasonal subsistence phases were often but not *necessarily* associated with either different locations or different types of dwellings. Impermanent shelters such as skin tents, overturned boats, and small plank sheds were used for travel and subsistence camps (Arteaga 1779:107; Merck 1980:122-123; Portlock 1789:253; Zaikov 1979:4), while winter or year-round base villages on Kodiak Island and the Alaska Peninsula consisted of semi-subterranean dwellings that could shelter as many as 15 – 20 occupants (Davydov 1977:154; Gideon 1989:39-40; von Langsdorff 1968:235; Lisianskii 1968:212-213; Merck 1980:204; Shelikhov 1981:55-56; D'Wolf 1968:66-67). However, similar houses were also built at many summer salmon fishing locations (Clark 1987; Jordan and Knecht 1988). In Prince William Sound, plank dwellings for summer and winter use were very similar in construction (although floors of the latter were more deeply excavated) and both types were sometimes built in the same locations (Birket-Smith 1953:53-55; de Laguna 1956; Walker 1982:140-141; Zaikov 1979:4).

Archaeological Models

Archaeological settlement pattern models for southern Alaska have placed varying degrees of interpretive emphasis on the physical and biological characteristics of coastal environments. "Landscape focus" models interpret site locations primarily in relation to such variables as shoreline topography, wave and weather exposure, beach substrate, and fresh water access (e.g., Dekin et al. 1992; Maschner 1999a; Maschner and Stein 1995; McCartney 1977). Biological resources are typically assumed to be sufficiently homogeneous in distribution to be equally accessible from all possible settlement locations. "Resource focus" models, on the other hand, may incorporate a variety of physical variables (such as wave energy and shoreline shape) but in particular address the spatial heterogeneity or "patchiness" of subsistence resources and the attraction that resource concentrations would have had for indigenous settlers (e.g., Corbett 1991; Crowell and Mann 1998; Dumond 1987; Environment and Natural Resources Institute 1993:71-77; Erlandson et al. 1992; Fitzhugh 1996; Haggarty et al. 1991). Erlandson et al. (1992) consider paleodemography as an additional factor, positing that early settlement and human population growth in the most productive and reliable environments would have been followed by fissioning and territorial expansion into less desirable locations.

Investigations of long-term shoreline history are essential to settlement pattern modeling on the North Pacific rim because tectonically and isostatically-induced changes in relative sea level – often rather localized in their effects - are important factors in the formation and destruction of the coastal archaeological record (Crowell and Mann 1996, 1998; Fitzhugh 1996; Johnson and Winslow 1991; Maschner 1999b). Changes in relative sea level can also have widespread effects on coastal ecology by altering the tidal regime in biologically productive lagoons and marshes (Gilpin 1995).

One result of recent coastal surveys has been recognition that human populations were in fact disproportionately concentrated in some areas of the Gulf of Alaska, and that these concentrations are almost certainly related to variations in ecological productivity and diversity. Mobley et al. (1990) found that there are two to four times more archaeological sites per km of coastline in the Kodiak archipelago than in other parts of the Alutiiq region including the Alaska Peninsula, Kenai Peninsula, and Prince William Sound. This measure is affected by differential site preservation due to sea level and glacial histories but correlates roughly with comparative estimates of Alutiiq subgroups at the time of Western contact (Crowell and Lührmann 2001:30-36)[5]. Local concentrations of sites are evident in the Morzhovoi Bay/ Cold Bay area of the lower Alaska Peninsula (Maschner 1999a, 1999b), Amalik Bay and Kukak Bay on the Katmai coast (Erlandson et al. 1992; this paper), the Karluk River/ Uyak Bay area of western Kodiak Island (Jordan and Knecht 1988), Sitkalidik Island and the entire east side of Kodiak Island (Clark 1987; Fitzhugh 1996), Kachemak Bay in lower Cook Inlet (de Laguna 1975; Workman et al. 1980), and the outer islands of Prince William Sound (de Laguna 1956).

Haggarty and co-authors (1991) suggested that precontact human populations were highest in areas where the widest variety of resources was available. They quantified proximity of archaeological sites in the central Gulf of Alaska to several types of food sources: salmon streams, sea lion rookeries and haul-outs, harbor seal concentrations, and seabird colonies. The sample included 285 sites in the Kodiak archipelago, 23 on the Pacific coast of the Alaska Peninsula, and 17 on the Kenai Peninsula[6]. The authors found that, on average, sites in the Kodiak archipelago were within 10 km of 18 different resource locales, about a third more than mean values for the Alaska Peninsula and Kenai Peninsula. Kodiak's higher site density may therefore be attributable to a richer, more diverse resource base.

A large majority (81%) of archaeological sites in this sample was located in "protected" and "semi-protected" waters of bays and fjords, while only 19% were along exposed outer coasts and 1% along rivers. Outer bays were found to support a disproportionate number of the largest sites, many with surface imprints of semi-subterranean houses and evidence of occupation over time spans of hundreds or thousands of years (Haggarty et al 1991:226-228). Such settlements fit the ethnographic profile of winter village sites. One evident advantage of outer bay placement for winter villages was minimization of travel distances to resources across a wide gradient of ecological conditions, from surf-pounded offshore rocks where sea lions and sea birds can be taken to quiet inner bays where larger streams with salmon runs are typically located. Reefs, islands, and submerged glacial moraines add to the topographical and ecological complexity of many outer bay areas, increasing the harvest potential for shellfish. In contrast, the heads of bays are often poor areas for shellfish because of silting, winter freezing, and low salinity.

These findings are corroborated by D. Clark's (1987) ethnohistorical and archaeological analysis of 32 winter settlements on Kodiak Island. Clark found that 20 (63%) of the winter villages reported by Lisianskii in 1805 were located in the middle or outer thirds of major bays or straits; eight (25%) were in outer coast locations, and only four (12%) were located in the inner reaches of bays.

Expectations for the Katmai study area derive from these previous studies and observations. Overall site densities should be highest in areas of maximum resource diversity and these should occur in the outer portions of protected bay systems. These same resource-rich zones should support the largest settlement sites – probable winter villages – characterized by semi-subterranean house depressions and thick, stratified middens. Other settlement sites will be smaller in extent, may lack house pits, and will have relatively thin middens. The latter are likely to be warm season exploitation camps and may be present in locations where fewer or perhaps only a single resource is accessible. Virtually all sites should be at locations where low or medium energy beaches allow reasonable access by skin boat. On-shore topography, including availability of level terrain for house construction, may further constrain site locations.

KATMAI COAST STUDY AREA

The study area includes the entire 250 km coastline of Katmai National Park, from Katmai Bay to north of Cape Douglas (see Figure 1). Mt. Katmai, Mount Douglas, and other glaciated volcanic peaks form the crest of the rugged Aleutian Range, which rises north of the narrow fringe of coastal land and partitions it from the lake and river country of the Alaska Peninsula interior. Passes extend through the mountains from Katmai Bay, Hallo Bay, and north of Cape Chiniak (at Douglas) into the upper Naknek drainage, and were important routes for trade and travel (Arndt n.d.; Clemens and Norris 1999; Dumond 1977).

The coast includes two distinct geomorphic sectors (Mann 2001). The shallowly scalloped shoreline from Hallo Bay northeast to Cape Douglas is a depositional environment indicative of long-term tectonic uplift. Long, surf-pounded beaches of sand and gravel are composed of sediments transported by streams from the glaciated interior. A contrasting zone of long-term subsidence extends along the southern coast, configured of drowned glacial valleys. The heads of larger fjords like Kukak Bay are filled with alluvium while their outer portions are

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[5] For regional comparison, Kroeber (1939) estimated that overall Alutiiq population density was similar to that of the Tlingit (2.8 and 2.5 persons per coastal mile, respectively) and relatively low in comparison to the eastern Unangan (4.6), Tsimshian (7.0) and Haida (8.2).

[6] The study included a tiny and unrepresentative sample of only three sites from Prince William Sound and results for that area are ignored here.

characterized by bedrock cliffs that drop steeply into deep water. Small islands and shoals create intricate, sheltered coastlines in the mouths of both Kukak and Amalik bays.

A discontinuous pre-Pleistocene marine terrace extends along many parts of the southern coast at 10–15 meters above current sea level. This terrace provided an attractive platform for pre-contact settlement and is occupied by numerous archaeological sites dating from the Alder phase to historic times. These perched sites have been fortuitously protected from erosion during minor Holocene fluctuations in relative sea level, which appear to have included a high stand (1-2 m above present level) that ended around 4000 years ago as well as one or several periods since 3000 B.P. when sea level was slightly lower than it is today. However, lower elevation sites may have been destroyed or submerged by these fluctuations. A number of sites in Amalik Bay are currently eroding as the result of a .5 m increase in sea level that occurred during the last 300 years (Crowell and Mann 1996:26; Hilton 1998).

Unlike areas further east in the Gulf of Alaska, the Katmai coast was relatively unaffected by Holocene glaciation. This has been a positive factor in preservation of the archaeological record. Repeated volcanic eruptions, including the Katmai/Novarupta event in A.D. 1912, have draped the coast in tephra deposits.

Vegetation along the Katmai coast is dominated by grass and shrub tundra, with isolated patches of recently arrived Sitka spruce and stream mouth stands of willows and cottonwoods. The weather is generally windy and highly changeable, with frequent storms from October through April. This weather pattern, combined with strong currents and a large tidal range, poses great risks to boat travel on Shelikof Strait.

The Katmai coast is located within an exceptionally rich area of summer phytoplankton production that extends from the Kenai Peninsula to Umnak Pass (Sambrotto and Lorenzen 1986). Marine food resources are correspondingly abundant and dominate strongly in archaeological midden samples (Bender 1999; G. Clark 1977; Davis 1954; Oswalt 1955). In total, the area is home to six species of marine mammals, 29 species of land mammals, 137 bird species, 24 freshwater fishes and five anadromous fishes.

ARCHAEOLOGICAL RESEARCH

Most of the Katmai coast has been archaeologically surveyed on at least a reconnaissance level, beginning with field work by the National Park Service, University of Oregon, and the University of Alaska in the 1950s (Davis 1954; Oswalt 1955) and by the University of Oregon in the following decade (G. Clark 1977; Dumond 1964, 1971). These projects included extensive excavations at Kukak Village (XMK-006) and the Takli Site in Amalik Bay (XMK-018).

Systematic coastal surveys conducted after the 1989 *Exxon Valdez* oil spill added a substantial number of new locations and radiocarbon dates (Table 1). These surveys were augmented through coordinated archaeological and geological research by the Arctic Studies Center (Smithsonian Institution) and National Park Service (NPS) in 1994 under the NPS Systemwide Archaeological Inventory Program (SAIP), resulting in documentation of 22 new sites.

The focus of the SAIP work was on four sections of the coast where existing data were inadequate. These were 1) Cape Douglas 2) Swikshak Lagoon 3) Kukak and Kaflia Bays combined, and 4) Kinak Bay and Amalik Bay combined (Crowell and Mann 1996; Crowell and Mann n.d.)[7]. The SAIP study areas, indicated in Figure 1, also represent contrasting environmental zones: the resource-poor Cape Douglas headland, the estuarine environment of Swikshak Lagoon, and the resource-rich, protected waters of several major bay systems. More recent NPS-sponsored studies include supplemental site assessments in Kukak Bay and Amalik Bay and excavations at the Mink Island site (XMK-030) in the Takli island group (Hilton 1998, 2002; Schaff 2002).

Some sections of the coast – for example, Katmai Bay - have not been intensively examined and may be under-represented in the inventory of known sites. One benefit of the GIS model presented here is its utility for identifying areas of high site potential where future investigations may be focused.

GIS ANALYSIS: DATA AND METHODS

A GIS model of the coast of Katmai National Park was developed in ArcView 3.1 (Environmental Systems Research Institute 1998) to quantify aspects of the biological and physical settings of indigenous archaeological sites. The purpose was to test expectations about coastal

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[7] Our work in Amalik Bay was geological only, complementing archaeological surveys and excavations by other investigators (G. Clark 1977; Dekin et al. 1993; Haggarty et al. 1991; Mobley et al. 1990).

Table 1: Archaeological Sites and Radiocarbon Dates on the Pacific Coast of Katmai National Park and Preserve
Calibrated radiocarbon dates from Crowell and Mann 1996; Mills 1994; and calculated from other sources using the University of Washington Quaternary Isotope Lab Radiocarbon Calibration Program Rev. 4.3

Site Number	Site Name	Culture	Site Type	Period	Radiocarbon dates	Citations
AFG-001	Cape Chiniak	Indigenous	Midden & structures	Pre-contact		Dumond 1964:37-41; Dumond 1965:14; Mobley et al. 1990; Haggarty et al. 1991; Hilton 1998:80-81
AFG-037	Ashivak	Indigenous	Midden	Historic		Petroff 1884:28; Porter 1893:72
AFG-043	Kaguyak Village Site	Both	Midden & structures	Pre-contact & historic		Davis 1954:45ff; Dumond 1965:9-13; Orth 1971:484; Mobley et al. 1990; Haggarty et al. 1991; Hilton 1998:81-82
AFG-044	Swikshak Lagoon	Indigenous	Midden	Unknown		Dumond 1965:8-9; Mobley et al. 1990; Hilton 1998:83-84
AFG-107	Cape Douglas Sod Feature	Unknown	Structures	Unknown		Mobley et al. 1990; Haggarty et al. 1991
AFG-108	Sukoi Bay Cabins	Unknown	Structures	Historic		Haggarty et al. 1991; Crowell and Mann n.d.
AFG-109	Swikshak Cannery	Euro-American	Cannery	Historic		Haggarty et al. 1991; Hilton 1998:84-86
AFG-110	Swikshak House Pits	Indigenous	Structures	Pre-contact		Mobley et al. 1990; Hilton 1998:86-87
AFG-117	Shakun Lithic Site	Indigenous	Midden	Pre-contact		Mobley et al. 1990; Hilton 1998:88
AFG-118	Shakun House Pits	Indigenous	Structures	Pre-contact		Mobley et al. 1990; Hilton 1998:89-90
AFG-134	Cape Douglas Cairn	Indigenous	Rock cairn or cache	Pre-contact		Mobley et al. 1990
AFG-165	Sukoi Cairn	Unknown	Rock cairn or cache	Historic		Mobley et al. 1990; Crowell and Mann n.d.
AFG-171	Pre-Katmai Historic Scatter	Indigenous	Midden & structures	Historic		Haggarty et al. 1991; Crowell and Mann n.d.
AFG-176	Triple Lakes Creek #1	Indigenous	Midden	Pre-contact		Haggarty et al. 1991
AFG-177	Triple Lakes Creek #2	Indigenous	Midden	Pre-contact		Haggarty et al. 1991
AFG-181	Kiupalik Island North End Depressions	Indigenous	Structures	Unknown		Hilton 1998:90-92
AFG-192	Kiukaplik Island Historic Remains	Euro-American	World War II site	Historic		Hilton 1998:92-93
AFG-194		Indigenous	Structures	Pre-contact		Dekin et al. 1993
AFG-199	Sukoi Cabin II	Unknown	Structures	Historic		Crowell and Mann n.d.
AFG-200	Cape Douglas Lithic Scatter I	Indigenous	Lithic Scatter	Pre-contact		Crowell and Mann n.d.
AFG-201	Cape Douglas Lithic Scatter II	Indigenous	Lithic Scatter	Pre-contact		Crowell and Mann n.d.
AFG-202	South Cape Douglas Camp	Indigenous	Structures	Historic		Crowell and Mann n.d.
AFG-203	Cape Douglas Lithic Scatter III	Indigenous	Lithic Scatter	Pre-contact		Crowell and Mann n.d.

Table 1: Archaeological Sites and Radiocarbon Dates on the Pacific Coast of Katmai National Park and Preserve, con't

AFG-204	Cape Douglas Cairn II	Indigenous	Rock cairn or cache	Unknown		Crowell and Mann n.d.
AFG-205	South Cape Douglas Midden	Indigenous	Midden	Pre-contact		Crowell and Mann n.d.
AFG-206	Cape Douglas Cairn II	Indigenous	Rock cairn or cache	Pre-contact		Crowell and Mann n.d.
AFG-207	Sukoi Bay Terrace Site	Indigenous	Midden & structures	Pre-contact	B.C. 190 (**B.C. 10**) A.D. 140 B.C. 2040 (**1900**) 1740	Crowell and Mann n.d.; Crowell and Mann 1996
AFG-208	Sukoi Bay Cairn II	Indigenous	Rock cairn or cache	Pre-contact		Crowell and Mann n.d.
AFG-209	Cape Douglas Cairn III	Indigenous	Rock cairn or cache	Pre-contact		Crowell and Mann n.d.
ILI-058	Shaw Island Site	Indigenous	Structures	Pre-contact		Mobley et al. 1990
KAR-127	Twin Creeks Midden	Indigenous	Midden	Pre-contact		Mobley et al. 1990
XMK-006	Kukak Village	Indigenous	Midden & structures	Pre-contact & historic	A.D. 1030 (**1261**) 1394 A.D. 1020 (**1261**) 1400 A.D. 711 (**977**) 1170 A.D. 268 (**609**) 860 A.D. 400 (**605**) 759	G. Clark 1977:12ff; Dumond 1964:31-35; 1965:14; 1971:Davis 1954; Hilton 1998:53-54
XMK-006A	Kukak Isolated Housepit	Indigenous	Midden & structures	Pre-contact	B.C. 5030 (**4724**) 4249	G. Clark 1977; Hilton 1998:54-55
XMK-007	Kaflia	Indigenous	Midden & structures	Pre-contact & historic		Oswalt 1955; Dumond 1963:36; 1964:36-37; 1965:17-19; Mobley et al. 1990; Haggarty et al. 1991
XMK-014	Katmai	Both	Midden & structures	Pre-contact & historic		Orth 1971:502; Davis 1954: Dumond 1971; Petroff 1881:33
XMK-015	Old Kukak	Indigenous	Midden & structures	Pre-contact & historic		Dumond 1964:31; Orth 1971:549; Mobley et al. 1990; Hilton 1998:55-56; Crowell and Mann n.d.
XMK-017		Indigenous	Midden	Pre-contact		Dumond 1965:19-21
XMK-018	Takli Site	Indigenous	Midden	Pre-contact	B.C. 1289 (**984, 954, 943**) 799 B.C. 1419 (**1099**) 839 B.C. 3090 (**2856, 2688, 2622**) 2204 B.C. 4779 (**4495**) 4249	G. Clark 1977:7ff; Dumond 1965:23-24, 33-43; Dekin et al. 1993:788ff; Hilton 1998:11-12
XMK-019		Indigenous	Midden	Pre-contact		Dumond 1965:24-25, 1971; Mobley et al. 1990; Dekin et al. 1993:794; Hilton 1998:14
XMK-020	Hook Point Site	Indigenous	Midden & structures	Pre-contact	A.D. 100 (**381**) 600 B.C. 2130 (**1865, 1845, 1771**) 1519	G. Clark 1977:10ff; Dumond 1971; Dekin et al. 1993:801-802; Hilton 1998:15
XMK-021		Indigenous	Midden	Pre-contact		Dumond 1971; Haggarty et al. 1991; Dekin et al. 1993:803; Hilton 1998:16-17

Table 1: Archaeological Sites and Radiocarbon Dates on the Pacific Coast of Katmai National Park and Preserve, con’t

XMK-022		Indigenous	Midden & structures	Pre-contact	B.C. 3356 (**2882**) 2458 B.C. 4356 (**3983**) 3652 B.C. 3486 (**2902**) 2470 B.C. 3501 (**3078, 3071, 3025**) 2679	Dumond 1971; Mobley et al. 1990; Hagarty et al. 1991; Dekin et al. 1993:706ff; Hilton 1998:17-18
XMK-023		Indigenous	Midden	Pre-contact		Dumond 1971; Hilton 1998:19
XMK-024		Indigenous	Midden	Pre-contact		Dumond, D.E. 1971; Dekin et al. 1993:805ff; Hilton 1998:19-20
XMK-025		Indigenous	Midden	Pre-contact		Dumond, D.E. 1971; Haggarty et al. 1991; Hilton 1998:20-21
XMK-026		Indigenous	Midden	Pre-contact		Dumond 1971; Mobley et al. 1990; Dekin et al. 1993:811ff; Hilton 1998:22
XMK-027		Indigenous	Midden	Pre-contact	B.C. 2841 (**2276, 2253, 2229, 2221, 2206**) 1774 B.C. 3941 (**3492, 3469, 3373**) 2877	Dumond 1971; Mobley et al. 1990; Dekin et al. 1993:814ff; Hilton 1998:23
XMK-028	Little Takli Island	Indigenous	Midden	Pre-contact		Dumond 1971; Mobley et al. 1990; Hilton 1998:24-25
XMK-029		Indigenous	Midden & structures	Pre-contact		Dumond 1971; Mobley et al 1990; Dekin et al. 1993:819ff; Hilton 1998:25-27
XMK-030	Mink Island Site	Indigenous	Midden & structures	Pre-contact	B.C. 4898 (**4705, 4691**) 4460 *reports 84 unpublished dates from B.C. 5650 to A.D. 1460 (calibrated)	Dumond 1971; Mobley et al 1990; Dekin et al. 1993:821ff; Hilton 1998:27-29; National Science Foundation 2002*; Schaff 2002
XMK-031		Indigenous	Midden	Pre-contact		Dumond 1971; Dekin et al. 1993:824ff; Hilton 1998:29-30
XMK-046	Devil’s Cove House Pits	Indigenous	Midden & structures	Pre-contact		Dumond 1965:15-17, 1971; Oswalt 1955:53; Hilton 1998:57; Crowell and Mann n.d.
XMK-047	Kukak Bay I	Indigenous	Midden & structures	Pre-contact	A.D. 1235 (**1310, 1365, 1375**) 1440	Dumond 1971; Hilton 1998:58-59; Crowell and Mann n.d.
XMK-049		Indigenous	Midden & structures	Pre-contact		Dumond 1971
XMK-055	Kachemak Village Site	Indigenous	Midden & structures	Pre-contact		
XMK-056	Russian Anchorage	Indigenous	Midden & structures	Pre-contact	A.D. 1240 (**1290**) 1410 B.C. 20 (**A.D. 120**) A.D. 320 B.C. 3920 (**3710**) 3640 B.C. 4020 (**3920, 3880, 3810**) 3660	Mobley et al. 1990; Crowell and Mann n.d.; Crowell and Mann 1996
XMK-057		Indigenous	Midden	Pre-contact		
XMK-058	Cape Gull Cove Site	Indigenous	Midden & structures	Pre-contact	A.D. 1284 (**1421**) 1637 A.D. 1284 (**1406**) 1482 A.D. 1301 (**1414**) 1466 A.D. 1245 (**1329, 1343, 1395**) 1482 A.D. 1028 (**1278**) 1413 A.D. 1028 (**1282**) 1431	Mobley et al. 1990; Haggarty et al. 1991

Table 1: Archaeological Sites and Radiocarbon Dates on the Pacific Coast of Katmai National Park and Preserve, con't

XMK-059	Kukak Bay Refuge Rock Site	Indigenous	Midden & structures	Pre-contact	A.D. 1435 (**1505, 1595, 1620**) 1660 B.C. 2106 (**1880, 1837, 1831**) 1686	Mobley et al. 1990; Hilton 1998:59-61; Crowell and Mann n.d.; Crowell and Mann 1996
XMK-060	Kukak Bay Cannery	Euro-American	Cannery	Historic		Mobley et al. 1990; Hilton 1998:61-62
XMK-061	Kaflia Bay Cabin	Unknown	Structures	Historic		Mobley et al. 1990
XMK-062	Point Jane Hut	Unknown	Structures	Historic		Mobley et al. 1990; Hilton 1998:63
XMK-067	Rounded House Pits	Indigenous	Midden & structures	Pre-contact		Mobley et al. 1990; Hilton 1998:33-34
XMK-068	Nate's Told You So Site	Indigenous	Structures	Pre-contact		Mobley et al. 1990
XMK-070	Thirty Meter Cutbank Site	Indigenous	Midden	Pre-contact		Haggarty et al. 1991; Dekin et al. 1993:831-832; Hilton 1998:34-35
XMK-071	Twenty Meter Cutbank Erosion Scatter	Indigenous	Midden	Pre-contact		Haggarty et al. 1991; Dekin et al. 1993:833-34; Hilton 1998:35-36
XMK-072	Intertidal Debitage Site	Indigenous	Midden	Pre-contact	B.C. 2457 (1945) 1531 B.C. 2880 (**2397, 2384, 2344**) 1830	Haggarty et al. 1991; Dekin et al. 1993:757-769; Hilton 1998:36-37
XMK-073	Takli Island Fox Farm	Unknown	Fox farm	Historic		Dekin et al. 1993:835-37; Hilton 1998:38-39
XMK-074	Takli Southwest	Indigenous	Midden	Pre-contact		Haggarty et al. 1991; Dekin et al. 1993:838-83; Hilton 1998:39-41
XMK-075	Geoduck Site	Indigenous	Midden	Pre-contact	B.C. 795 (201) A.D. 317 B.C. 345 (**B.C. 38, 30, 21, 11, 1**) A.D. 131	Haggarty et al. 1990; Dekin et al. 1993:770-787; Hilton 1998:41-42
XMK-076	Amalik Bay Inlet Flakes	Indigenous	Midden	Pre-contact		Haggarty et al. 1990; Hilton 1998:42-43
XMK-077	Fuel Cache Point	Indigenous	Isolated artifact find	Pre-contact		Haggarty et al. 1990
XMK-079		Indigenous	Midden	Pre-contact		Dekin et al. 1993:770-787; Hilton 1998:44-45
XMK-080		Indigenous	Midden	Pre-contact		Dekin et al. 1993:788-89; Hilton 1998:45-46
XMK-081		Indigenous	Midden	Pre-contact		Dekin et al. 1993:843; Hilton 1998:47-48
XMK-089		Indigenous	Midden & structures	Pre-contact		Hilton 1998:48-50
XMK-090		Indigenous	Midden	Pre-contact		Hilton 1998:50-51
XMK-091	Kukak Bay II	Indigenous	Midden	Pre-contact		Hilton 1998:64-65
XMK-106	Tiny Island Village	Indigenous	Midden & structures	Pre-contact	A.D. 390 (**550**) 660 B.C. 4580 (**4470**) 4350	Hilton 1998:65-67: Crowell and Mann n.d.
XMK-107	Tiny Island II	Indigenous	Structures	Pre-contact		Hilton 1998:67-68; Crowell and Mann n.d.; Crowell and Mann 1996
XMK-108	Kukak Bay III	Indigenous	Structures	Pre-contact		Hilton 1998:68; Crowell and Mann n.d.
XMK-109	Tiny Island Passage I	Indigenous	Midden & structures	Pre-contact		Hilton 1998:69-70; Crowell and Mann n.d.

Table 1: Archaeological Sites and Radiocarbon Dates on the Pacific Coast of Katmai National Park and Preserve, con't

XMK-110	Inner Kukak Bay Village	Indigenous	Midden & structures	Pre-contact		Hilton 1998:70-71; Crowell and Mann n.d.
XMK-111	Tiny Island Passage II	Indigenous	Midden & structures	Pre-contact	B.C. 1690 (**1520**) 1405	Hilton 1998:71-72; Crowell and Mann n.d.; Crowell and Mann 1996
XMK-112	Kinak Bay Islet	Indigenous	Midden	Pre-contact	A.D. 1475 (**1665**) 1950	Crowell and Mann n.d.: Crowell and Mann 1996
XMK-113	Kinak River Wet Site	Indigenous	Midden & structures	Pre-contact	A.D. 1530 (**1670, 1950**) 1950 A.D. 990 (**1040**) 1220	Crowell and Mann n.d.: Crowell and Mann 1996
XMK-114	Kinak Bay I	Indigenous	Midden	Pre-contact		Crowell and Mann n.d.
XMK-115	Aguchik Island Cove	Indigenous	Midden & structures	Pre-contact	B.C. 2137 (**1886**) 1688	Hilton 1998:72-73; Crowell and Mann n.d.: Crowell and Mann 1996
XMK-116	Aguchik Island Tombolo	Indigenous	Midden	Pre-contact	B.C. 1390 (**1211, 1198, 1192, 1138, 1133**) 1001	Hilton 1998:73-74; Crowell and Mann n.d.: Crowell and Mann 1996
XMK-117	Aguligik Island I	Indigenous	Midden & structures	Pre-contact		Hilton 1998:75; Crowell and Mann n.d.
XMK-118	Kukak Point Village	Indigenous	Midden & structures	Pre-contact	A.D. 1020 (**1170**) 1260	Hilton 1998:75-76; Crowell and Mann n.d.: Crowell and Mann 1996
XMK-119	Kaflia River Mouth-South Midden	Indigenous	Midden	Pre-contact	B.C. 1880 (**1630**) 1425	Crowell and Mann n.d.: Crowell and Mann 1996
XMK-120	Kaflia River Mouth-North Midden	Indigenous	Midden	Pre-contact	A.D. 1400 (**1440**) 1640	Crowell and Mann n.d.: Crowell and Mann 1996
XMK-121	Aguligik Island II	Indigenous	Midden	Pre-contact		Hilton 1998:77-78; Crowell and Mann n.d.
XMK-122	Kukak Bay IV	Indigenous	Midden	Pre-contact		Hilton 1998:78-79; Crowell and Mann n.d.

foraging and settlement strategies, as discussed above. Several layers of information were incorporated: base maps, archaeological data, resource distributions, and shoreline classification. The model was then used analytically to examine environmental variation and patterns in site location.

Base Maps

Base maps for Katmai National Park and Preserve (coastline, park boundary, streams) were derived from an ArcView extension, the GIS Theme Manager, developed by the Alaska Support Office of the National Park Service (NPS-AKSO 1997).

Archaeological Data

Primary archaeological data consisted of all indigenous coastal sites within the park boundary, a total of 90 locations that represent the Alder phase through the early 20th century (Table 1). Digital description and location data were acquired from the Alaska Heritage Resources Survey (AHRS) database, with checks and corrections based on field notes and topographic maps. The Alaska Heritage Resources Survey classifies 72 as probable pre-contact middens, of which 34 have evident surface house pits. In addition, there are eight sites with house pits that are classified as historic or of unknown age; three lithic scatters, six rock cairns or caches, and one isolated artifact find. Four historic sites were excluded from most statistics: two canneries, a fox farm, and a World War II facility.

This sample was treated as an aggregate, without attempting any breakdown by age other than pre-contact vs. historic. This choice allowed inclusion of many sites –more than half of the sample–that do not have even approximate age determinations. Many sites also have multiple components. Therefore, the selected sample reflects site location choice over a period of almost 7000 years but allows very limited interpretation of temporal trends. Radiocarbon dates and apparent gaps in the occupation record are discussed separately below.

Biological Data

We used digital species distribution data packaged with the NPS-AKSO GIS Theme Manager (see www.nps.gov/akso/gis) and which are in turn derived from two main sources: the *Kodiak Island and Shelikof Strait Environmental Sensitivity Index* (National Oceanic and Atmospheric Administration 1998) and the *Cook Inlet and Kenai Peninsula, Environmental Sensitivity Index* (National Oceanic and Atmospheric Administration 1995). These sources combine information from zoological surveys by the U. S. Fish and Wildlife Service (USFWS), the Alaska Department of Natural Resources (ADNR), and the Alaska Department of Fish and Game (ADF&G).

Several non-digital sources were converted for use in the project. The preliminary edition of the *West Coast of North America Strategic Assessment Atlas* (National Oceanic and Atmospheric Administration 1988) provided coverage of Pacific cod, Pacific halibut, and harbor porpoise. For harbor seals, we used the *Sensitive Areas Identification Project* produced by the Kodiak Island Borough Coastal Management Program (Kodiak Island Borough 1997). Further technical details are available from the authors.

Coastal Geomorphology

Schoch (1996) described shoreline geomorphology for the entire Katmai coast. This dataset, based on the Howes Physical Shore-Zone Mapping System (Howes et al. 1994), differentiates 4160 segments of shoreline into 34 classes according to four categories: substrate, sediment, width, and slope. A simplified binary classification into beaches that are favorable or unfavorable for skin boat landings was derived for purposes of the analysis. Favorable beaches (13 of the 34 Howes classes) were defined as those composed mostly of sand and/or finer sediments, with slopes of less than 5 degrees. Low beach angle is a reasonable index of low wave energy throughout the year, indicating that such beaches are sheltered from heavy surf (Carl Schoch, personal communication, 1999).

Method

The first step was to overlay the base map with distributional data for all 15 subsistence resources (see Figures 4-7 [Appendix]). These include harbor seal haul-out and high use zones, sea lion haul-outs, sea otter concentrations, and harbor porpoise areas (Figure 4); outlets of salmon spawning streams (Figures 5 and 6); spring herring spawning areas, concentrations of adult halibut during April - October, and year-round concentrations of adult Pacific cod (Figure 6); summer seabird colonies, spring and fall waterfowl concentrations, and razor clam beds (Figure 7).

Computer-generated catchment zones (buffers) were drawn around resource locales to represent reasonable or average distances that indigenous residents would have traveled to harvest them. Ethnohistoric information suggests that exploitation of salmon and shellfish was generally carried out in the immediate vicinity of settlements, including fishing camps, so we assigned one km buffers to the sources of these foods. Resources that were normally exploited by kayak, including sea mammals, bottom fish, and seabirds, were assigned 10 km buffers. Note that this method generates circular catchments around point sources (e.g., seabird colonies and mouths of salmon streams), whereas resource locales that cover definable areas (e.g., harbor seal concentrations) were enclosed by irregular catchments of the same shape as the actual distribution.

Overlays (unions) of these catchment zones were then combined. The resulting map (Figure 8 [Appendix]) shows the number of resource locales, ranging from one to 24, which is available by foot or skin boat from any point along the coast. The map demonstrates considerable variation in resource density, from broad areas where only three or four food sources are available to sections of the south coast where 20 or more sources are within range.

We took an alternative view of the same data by constructing 1 km and 10 km catchment circles (as appropriate by prey species) around archaeological site locations. By taking this site-centered view of what resources were within range, we were able to compare harvest potentials for different categories of sites by location and type (Tables 2, 3, and 4).

The next two procedures were applications of the coastal classification data. Figure 9 [Appendix] shows segments of shoreline that are favorable for skin boat landings (blue), unfavorable (red), or unknown/unspecified (green), on the basis of our index combining shoreline substrate and inferred wave energy. This figure graphically illustrates that points and headlands are exposed to the full force of the sea, and tend to have few usable beaches. Unfavorable sections of shoreline are also indicated within Kukak Bay and other protected areas. For the most part, these are places where sheer cliffs enter the water directly.

Access to “favorable” beaches was determined by generating 250 m buffers around all archaeological sites

Table 2: Average number of resource harvest locations per site catchment, by general resource category

Location	No. sites	Marine mammals	Fish	Seabirds & clams	Total
Cape Douglas	17	3.9	1.7	2.6	8.2
Amalik Bay/Kinak Bay	33	9.7	5.1	5.8	20.6
Kukak Bay/Kaflia Bay	26	4.8	5.7	7.2	17.7
Swikshak	9	5.3	2.1	2.6	10.0
All other sites	9	5.2	3.6	3.0	11.8

Table 3A: Average number of resource harvest locations per site catchment by marine mammal species

Location	No. sites	Harbor seal	Sea lion	Sea otter	Harbor porpoise	Total Marine mammals
Cape Douglas	17	1.9	0.0	1.0	1.0	3.9
Amalik Bay/ Kinak Bay	33	4.2	2.7	1.8	1.0	9.7
Kukak Bay/ Kaflia Bay	26	2.2	1.3	0.3	1.0	4.8
Swikshak	9	2.6	.7	1.0	1.0	5.3
All other sites	9	2.1	1.2	.9	1.0	5.2

Table 3B: Average number of resource harvest locations per site catchment by fish species

Location	No. sites	Pink salmon	Chum salmon	Coho salmon	Sockeye salmon	King salmon	Herring	Halibut	Cod	Total fish
Cape Douglas	17	0.7	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.7
Amalik Bay/ Kinak Bay	33	0.1	0.1	0.0	0.0	0.0	2.9	1.0	1.1	5.1
Kukak Bay/ Kaflia Bay	26	0.3	0.2	0.0	0.2	0.0	2.9	1.0	1.2	5.8
Swikshak	9	0.3	0.3	0.2	0.2	0.0	0.0	1.0	0.0	2.1
All other sites	9	0.3	0.1	0.0	0.0	0.0	1.2	1.0	.9	3.6

Table 3C: Average number of resource harvest locations per site catchment by clams and bird species

Location	No. sites	Razor clams	Seabirds	Waterfowl	Total
Cape Douglas	17	0.5	1.1	1.0	2.6
Amalik Bay/Kinak Bay	33	0.0	4.8	1.0	5.8
Kukak Bay/Kaflia Bay	26	0.1	6.1	1.0	7.2
Swikshak	9	0.6	2.0	0.0	2.6
All other sites	9	0.1	2.6	0.3	3.0

Table 4: Number of Harvest Resource Locations per Site Catchment
By Site Type

Site Type and Period	Total Sites	1-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-24
Pre-contact midden sites without structures	38	0	2	1	3	2	1	1	3	25
Pre-contact middens with structures	34	0	0	4	3	2	1	2	11	11
Historic or unknown age with structures	8	0	0	4	2	0	1	0	0	1
Lithic scatter	3	0	0	2	1	0	0	0	0	0
Rock cairn or cache	6	0	1	3	2	0	0	0	0	0
Isolated artifact find	1	0	0	0	0	0	0	0	1	0

Table 5: Access to Favorable Boat Landing Beach
By Site Type

Site Type and Period	Total Sites	Favorable Shore	Unfavorable Shore	Inland Site	Not Classified
Pre-contact midden sites without structures	38	31	6	0	1
Pre-contact middens with structures	34	22	8	2	2
Historic or unknown age with structures	8	3	5	0	0
Lithic scatter	3	3	0	0	0
Rock cairn or cache	6	2	4	0	0
Isolated artifact find	1	1	0	0	0

(Table 5). This distance represents an arbitrary but practical walking distance between shore and living area. If a "favorable" beach segment of any length occurred within this circle then access was considered to be available.

The final step was to integrate both aspects of the analysis for the purpose of identifying portions of the coast that have both good landing beaches and high resource access (greater than ten food sources within range). Segments of coastline that meet both criteria are indicated in red on Figure 10 [Appendix]. This figure also shows the locations of all archaeological sites in the sample, allowing the actual and predicted distribution of sites to be compared.

RESULTS

Exceptional resource density is indicated along the highly indented southern coastline (Figure 8). The highest values (up to 24 resources in range) are in Amalik Bay, Kinak Bay, Kuliak Bay, and Kaflia Bay. Slightly lower values pertain to most of Kukak Bay. Considerably lower values are evident in the wider bays and along the straighter coastlines north to Cape Douglas and southwest to Katmai Bay. Site-centered subsistence scores (Table 2) indicate that site catchments in the Amalik Bay/ Kinak Bay and Kukak Bay/Kaflia Bay SAIP survey areas included an average of 20.6 and 17.7 different food sources respectively, while corresponding figures for Cape Douglas, Swikshak, and elsewhere on the coast are half these values or less. The Amalik Bay/Kinak Bay area is exceptionally high in sea mammal resources.

Resource density - the number of separate resource locales within range of a site – tends to be accompanied by resource diversity. Average subsistence scores by species (Tables 3a, 3b, and 3c) include relatively few values of zero or less than one for Kukak/Kaflia Bay and Amalik/ Kinak Bay areas, whereas many zero values (meaning no access at all) are evident for Cape Douglas, Swikshak, and elsewhere. For example, Cape Douglas offers no access to sea lions or to any fish species except pink salmon and halibut, whereas residents of Kukak and Kaflia Bays had access to all subsistence species except for king salmon and coho salmon.

Results of the Katmai analysis show that high resource access correlates strongly with the locations of indigenous settlements. Villages and camps are clustered along the ecologically rich south coast where 59 sites, well over half the total for the entire park shoreline, are located in just four fjords: Kukak Bay, Kaflia Bay, Kinak Bay, and Amalik Bay (Figure 10).

For the whole park coast, 82% (59/72) of precontact settlements have catchments encompassing more than 10 resource locales (Table 4). While this result accords with the expectations of our settlement model, the data do not support the corollary proposal that sites with house depressions – a minimum but not sufficient condition for identifying winter settlements – should be associated with areas of highest resource density. In fact, the average total number of harvest locations is 18.4 for sites without house pits and only 16.4 for sites with house pits. However, this result may be skewed by a distinctive impediment to archaeological surveys on the Katmai coast – the great extent to which house depressions and other surface features have been filled in with tephra from the 1912 eruption and earlier volcanic events, making them difficult to identify. Aeolian sands are also a factor at some locations (Schaff, personal communication 2002).

Several anomalies in spatial patterning are notable. A cluster of 17 sites appears at Cape Douglas, an intensively surveyed area that is not favored by a good subsistence base. However, many of the Cape Douglas sites (9/17) are rock cairns and surface lithic scatters and most others (5/17) are post-contact cabins and house pits. This unusual combination of site types probably reflects the greater importance of the cape as a stopping-over locale for coastal kayak travelers rather than as a place to live. The cairns, most near the shore, are food caches or landing markers. Although no historic records pertaining to Alutiiq residence at Cape Douglas have been located, it is likely to have been a summer camping place for sea otter fleets dispatched by the Russian-American Company (Kodiak District). These fleets hunted each year along the Alaska Peninsula coast from Sutkhum to Kamishak Bay. Sea otter hunting continued in this area under American rule (Arndt n.d.; Clemons and Norris 1999:12-37).

Two major villages – Katmai and the post-contact fur trade settlement of Douglas (also known as Kaguyak) – appear to be located in areas of relatively poor resource diversity. However, both villages are situated near important passes through the mountains, and caribou are locally available at Katmai. Under Russian and American rule, both villages served as trading centers that dealt in furs from the interior as well as sea otters from the annual commercial hunt.

Of the sites in the total sample 69% (62/90) had access within 250 m to a "favorable" beach for landing and launching boats while 26% (23 sites) did not (Table 5). Most of the sites without good landing beaches are located at Cape Douglas, Swikshak, and other parts of the more exposed northern coast, although a few are scattered through the fjords of the southern coast. Five sites were either too far inland for access to any beach or were located along "unclassified" segments of shoreline.

DISCUSSION

The non-random distribution of human settlement along the Katmai coast arose in part from tectonic forces that shaped the coastline and produced its varied configuration from north to south. The indented and island-studded southern coast provided diverse habitats for marine species that in turn supported long-term and relatively intensive human occupation.

Local Settlement Patterns

The Katmai coast data suggest the possibility that the most ecologically productive bay systems may have offered self-sufficient territories for autonomous local groups. In this case, fjords along the south coast should each include contemporaneous sites representing all phases and activities of the annual subsistence cycle. Excavation data, faunal samples, and radiocarbon dates are presently inadequate for detailed settlement pattern analysis on the local level, although preliminary results may be mentioned.

In Kukak Bay, a series of large house pit sites of different ages is located in the mouth of the fjord. During its time, each may have been a central village where the whole population of the bay resided during winter. Smaller sites of all time periods, interpreted as probable warm weather subsistence camps, are scattered around the bay at salmon streams, islands, and other locations.

The earliest of the hypothetical central villages is Tiny Island Village (XMK-106), which has Alder and Birch phase components and a calibrated basal date of 4470 B. C. The site was resettled during the Cottonwood phase (about A. D. 200 – 500) after a long occupation hiatus that is part of a general pattern on the coast (see discussion below). Tiny Island Village was deserted again in about A.D. 500, a date which corresponds to the beginning of occupation at the very large Kukak Village site (XMK-006). Thick midden deposits and 89 surface house depressions at Kukak Village span the Beach and Mound phases, ending about A. D. 1500 (G. Clark 1977). Dumond (1977) suggests from annual growth rings on clam shells and other faunal data that Kukak Village was probably used throughout the year, which is consistent with the Alutiiq ethnographic pattern of "winter village" occupation[8].

By A. D. 1500 the local population appears to have shifted again, this time across the bay to XMK-059, a large village site that is partially perched atop a high sea stack. Defensible villages of this type are widespread across the Gulf of Alaska during the 2nd millennium A. D. (Maschner and Reedy-Maschner 1998; Moss and Erlandson 1992).

Another apparent occupation hiatus in Kukak Bay spans the last several hundred years before Western contact. By the early 19th century people were once again living at Kukak Village, as reported by George von Langsdorff and John D'Wolf in the summer of 1806 (von Langsdorff 1993; d'Wolf 1968).

Farther west along the Katmai coast, the majority of sites in Amalik Bay are small Alder and Birch phase components dating from 5650 – 1000 B. C., clustered in the Takli Island/Mink Island group. The deeply stratified Russian Anchorage site (XMK-056) at the mouth of adjoining Kinak Bay was first inhabited between about 3800 B.C. and A.D. 100 and may have been the winter home of families that spent the summer fishing for cod and halibut and hunting sea mammals, seabirds, and waterfowl on the Amalik Bay islands. Dumond's faunal analysis suggested a summer occupation at XMK-018, the Takli Site (Dumond 1977). There are later Beach and Mound phase occupations at Russian Anchorage and XMK-030 on Mink Island. A newly reported site on Mink Island (XMK-092) with 19 house depressions and storage pits may represent a central village during the late prehistoric period, although satisfactory radiocarbon dates are not yet available (J. Schaff, personal communication 2002).

Resource Stability

Another implication of demonstrated ecological diversity along the southern Katmai coast is that total subsistence output should have remained relatively stable, allowing a greater potential for uninterrupted human occupation. In other words, alternatives were locally available to human foragers when any one prey species or set of species declined in abundance.

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[8] The contemporaneous but much smaller Kukak Point Village site (XMK-118) should also be mentioned. XMK-118, located only 1 km from the main Kukak Village, has a thick midden and deep house depressions including a very large, central structure (20 x 27 m) that may have served as a winter ceremonial house (*qazgiq*). The basal midden date of this village site is A.D. 1020 (**1170**) 1260.

Significant fluctuations of major prey species must in fact have been a general problem for Gulf of Alaska foragers. Sockeye salmon, for example, increase dramatically during periods of warmer sea surface temperatures (SST) in the Gulf of Alaska, as shown by historic catch records and nitrogen isotope signatures in spawning lakes (Finney et al. 2000). Over the past 500 years there have been six phases of high temperatures and salmon abundance alternating with periods of colder SSTs and salmon minima (Finney 1998). Change in the opposite sense is indicated for sea lions and seals, which declined substantially during warmer sea temperatures from the mid-1970s through 1990s but may now be recovering (Francis et al. 1998). This decadal-scale cycling of marine regimes overlies long-term paleoclimatic trends including colder Neoglacial temperatures after 3800 B.P. and the Little Ice Age of A.D. 1400 – 1900. (Mann et al. 1998).

The wide range of food choices within bay systems of the southern coast would have buffered most impacts of ecosystem change and encouraged the long-term residential stability of local groups. Nonetheless, there are several temporal gaps in the archaeological record of the area that suggest reduction or out-migration of the Katmai coast population as a whole (Figure 11 [Appendix]). In calibrated radiocarbon years, there are no known components between 5600 - 4600 B.P. or 2900 - 2000 B.P., and only a few in the Little Ice Age interval of 100 – 500 B. P. Further study is needed to account for such gaps, which could conceivably be laid to the tectonic destruction of cultural deposits, abandonment of the coast as the result of large volcanic eruptions such as the 1912 Katmai/Novarupta event, or climate-driven ecosystem changes, as Knecht suggests for Kodiak Island at the start of the Little Ice Age (1995). In the latter instance we believe that ecologically diverse bay systems such as Kukak and Amalik would have been the last areas to be abandoned, and the first to be resettled. Verification awaits a better understanding of site structure and chronology for the coast as a whole.

CONCLUSION

Resource and landscape factors were combined to create a heuristic GIS model of coastal settlement patterns on the Katmai coast. The model is predictive as well as descriptive and suggests, for example, that under-explored areas of high site potential lie in parts of Kukak Bay, between Kinak Bay and Kaflia Bay, in Hallo Bay, and north of Cape Douglas (Figure 10). More and larger excavation samples will be needed, however, to test and refine the view of Katmai coastal settlement that we have proposed. Actual resource use at different sites, as determined from faunal remains, may in the future be compared to the harvest options suggested by our catchment analysis. Linear regression and other mathematical modeling techniques could be employed to make the model more statistically robust (e.g. Maschner and Stein 1995), although the principal conclusion - that resources and sites are non-randomly distributed and spatially correlated – is clear from inspection and basic data tabulations.

More generally, the present study suggests that reconstructions of maritime adaptations and social development in the Gulf of Alaska must take account of the physical and ecological heterogeneity of the environment, as well as its instability over time. In Katmai and elsewhere, population appears to have been concentrated in limited local areas of high resource potential that are separated by significant expanses of exposed and relatively unproductive shoreline. Effective population densities were therefore much higher than regional averages might suggest, underlining the potential for territorial circumscription, forced sedentism, intensification of resource harvests, aggressive competition between local groups, and complex political relations even at a relatively early stage of the region's demographic growth (Ames 1981, 1994; Coupland 1996; Fitzhugh 1996; Erlandson et al. 1992; Maschner 1991; Maschner and Reedy-Maschner 1998).

On the other hand, even the most favored local areas might occasionally fail biologically or become uninhabitable due to eruptions, tectonic subsidence, or glacial advances. The devastation and abandonment of villages on the Katmai coast during the 1912 Katmai/Novarupta eruption is only one example (Hussey 1971; Morseth 1998; Partnow 2002). Others include Alutiiq abandonment of the Kenai Fjords coast around 1170 A.D. as the result of sudden tectonic submergence (Crowell and Mann 1998), abandonment of Kachemak Bay around A. D. 500, possibly due to subsistence failure (de Laguna 1975; Workman and Workman 1988), and the late 18th century Tlingit migration from Icy Straits north to Yakutat when Little Ice Age glacial advances filled Glacier Bay and submerged local shorelines (de Laguna 1972; Mann and Streveler 1996). We suggest that subsequent Tlingit and Eyak pressure on eastern Prince William Sound may have forced Chugach Alutiiq migration to the outer coast of the Kenai Peninsula, as recounted in oral histories from the Cook Inlet villages of Nanwalek and Port Graham (Stanek 1999). Alutiiq populations around eastern Bristol Bay were similarly displaced by aggressive Yup'ik (Aglurmiut) expansion in the late 18th century (Harritt

1997). In the dynamic environment of southern coastal Alaska it would appear that natural disasters and human migration – sometimes requiring the seizure of new territory by force – must have periodically punctuated longer periods of stability, population growth, and cultural complexification within fixed territories.

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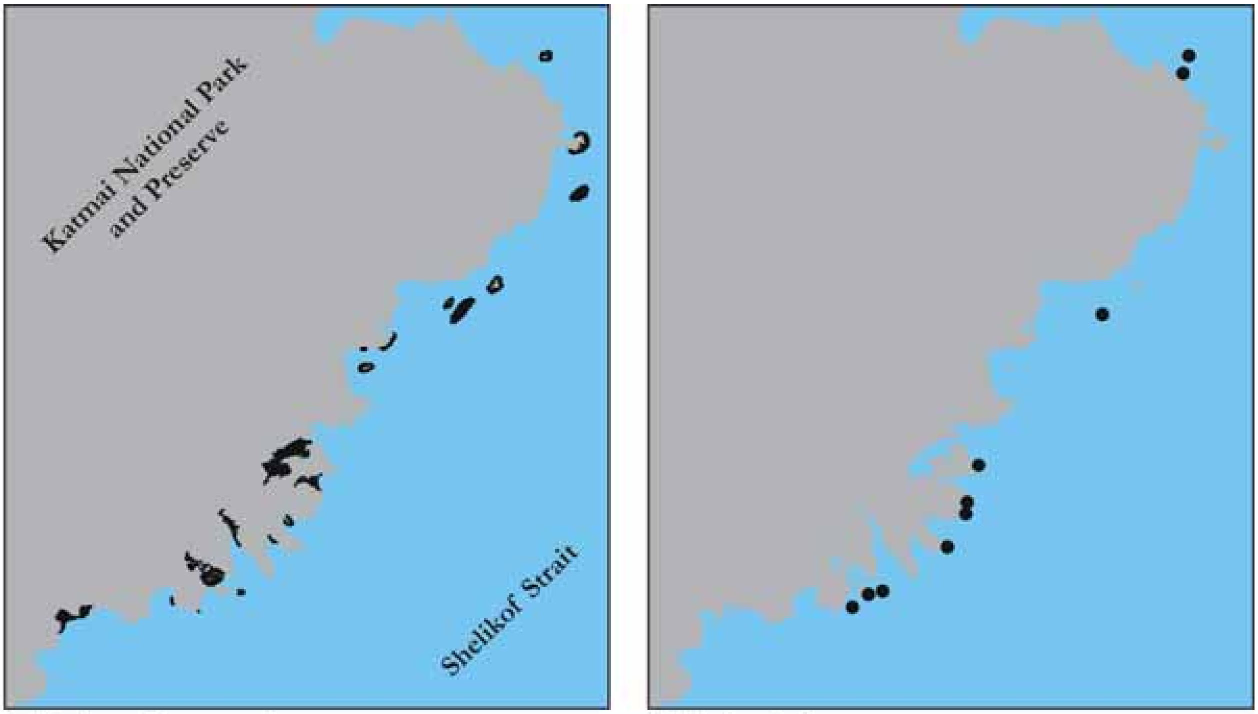
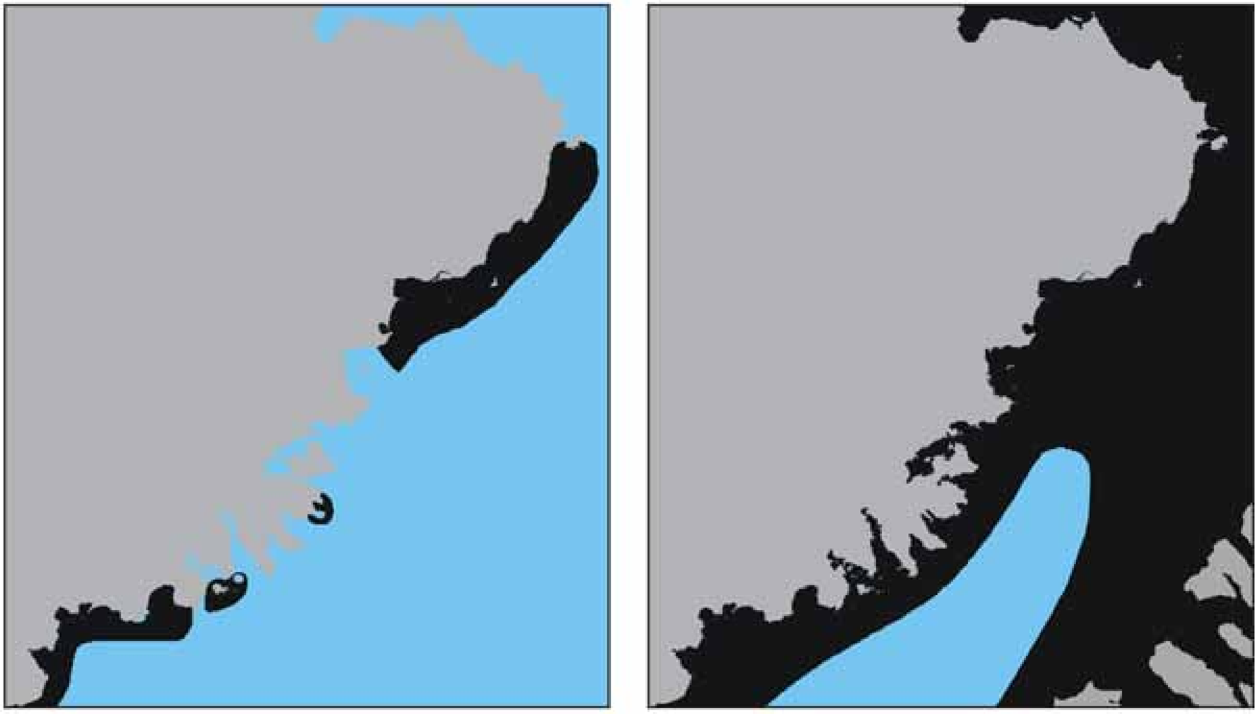
APPENDIX

Figure 4: Harbor seal, sea lion, sea otter, and harbor porpoise distributions.



A. Harbor seal concentration areas
Phoca vitulinarichardsi
Sensitive Areas Identification Project
Kodiak Island Borough 1997

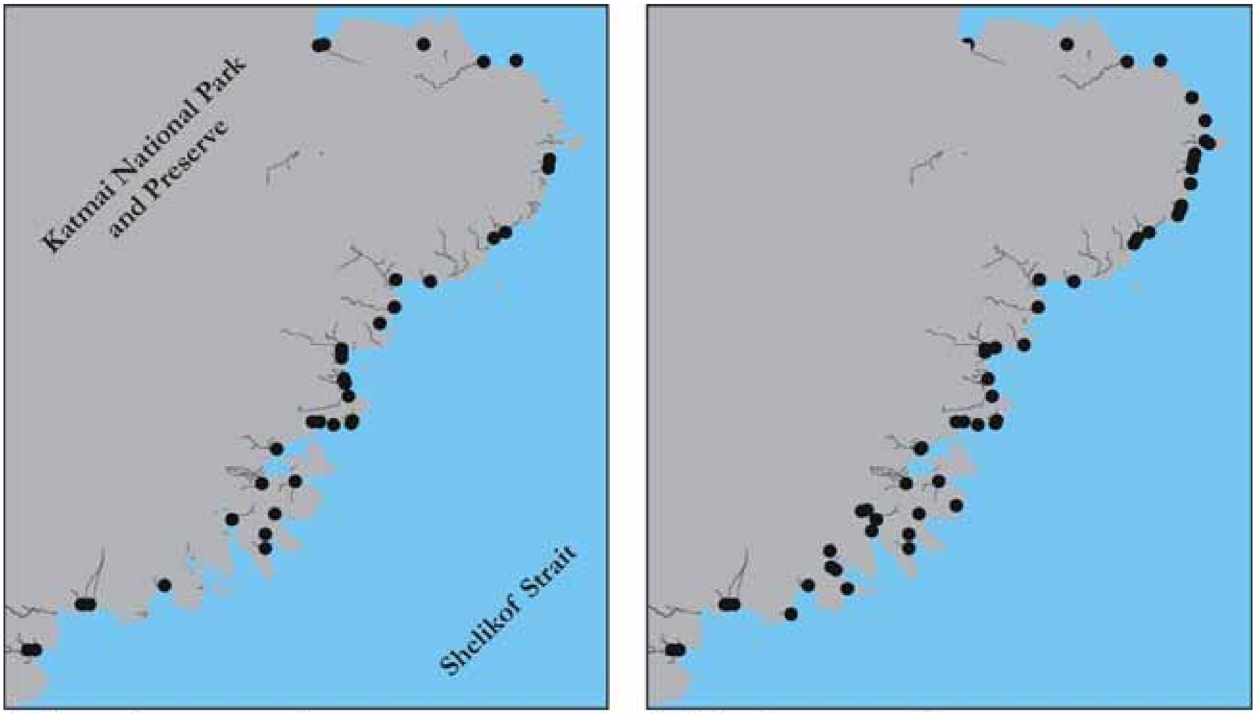
B. Sea lion haulouts
Eumetopias jubatus
Kodiak Island and Shelikof Strait Environmental Sensitivity Index
NOAA 1998



C. Sea otter concentration areas
Enhydra lutris
Kodiak Island and Shelikof Strait Environmental Sensitivity Index
NOAA 1998

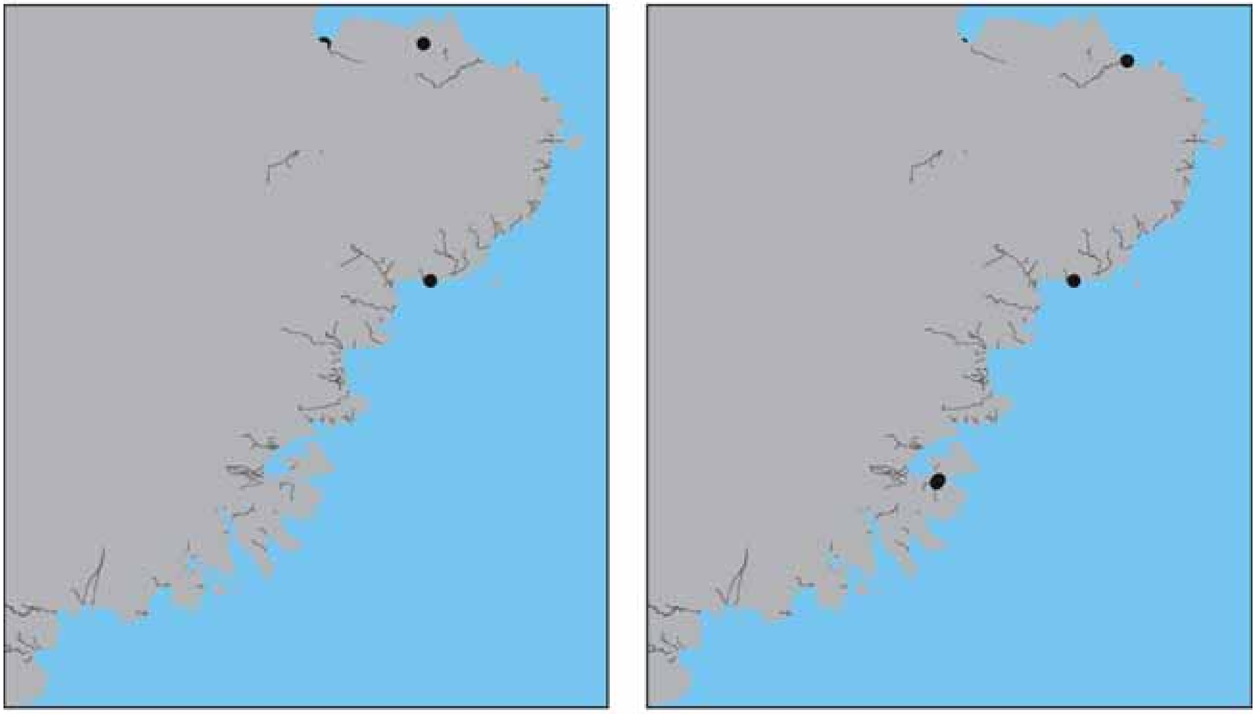
D. Harbor porpoise adult area (year round)
Phocoena phocoena
West Coast of North America Strategic Assessment Atlas
NOAA 1988

Figure 5: Salmon resources (chum, pink, coho, and sockeye).



A. Chum salmon stream outlets
Oncorhynchus keta
Kodiak Island and Shelikof Strait Environmental Sensitivity Index
(NOAA 1988)

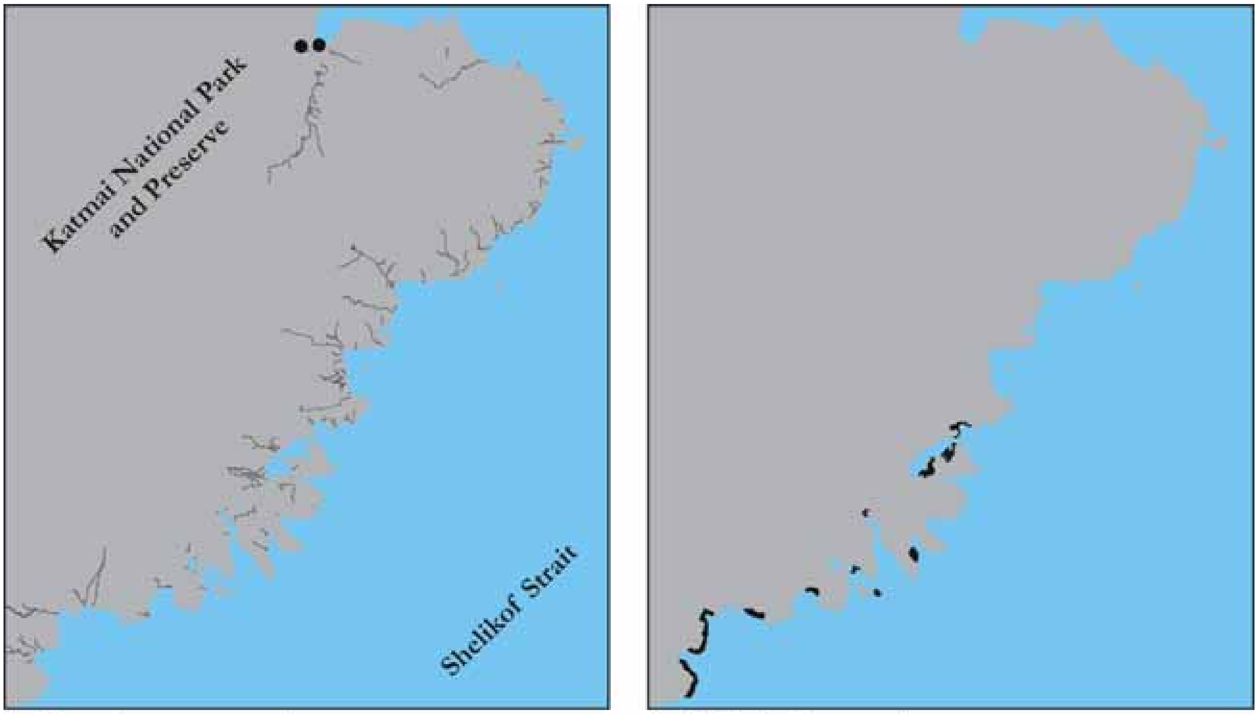
B. Pink salmon stream outlets
Oncorhynchus gorbuscha
Kodiak Island and Shelikof Strait Environmental Sensitivity Index
(NOAA 1988)



C. Coho salmon stream outlets
Oncorhynchus kisutch
Kodiak Island and Shelikof Strait Environmental Sensitivity Index
(NOAA 1988)

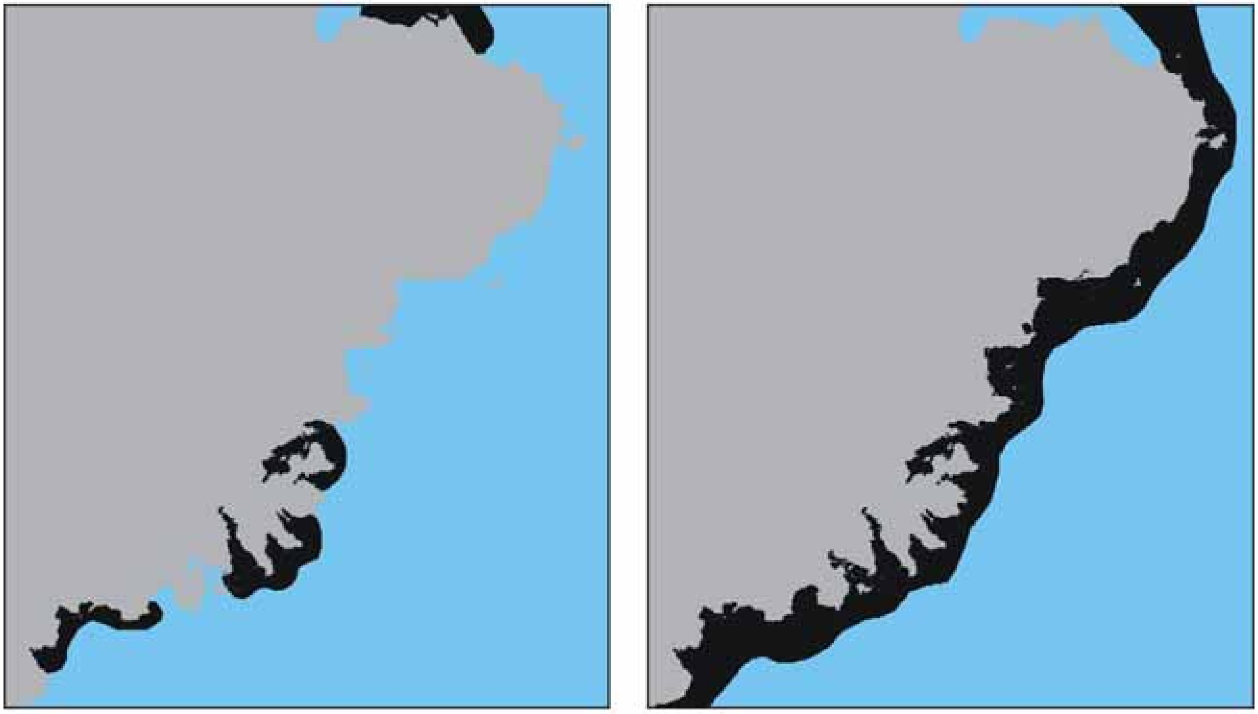
D. Sockeye salmon stream outlets
Oncorhynchus nerka
Kodiak Island and Shelikof Strait Environmental Sensitivity Index
(NOAA 1988)

Figure 6: Fish resources (king salmon, herring, cod, and halibut).



A. King salmon stream outlets
Oncorhyncus tsawytscha
Kodiak Island and Shelikof Strait Environmental Sensitivity Index
(NOAA 1988)

B. Pacific herring spawning areas
Clupea harengus pallasi
Kodiak Island and Shelikof Strait Environmental Sensitivity Index
(NOAA 1988)



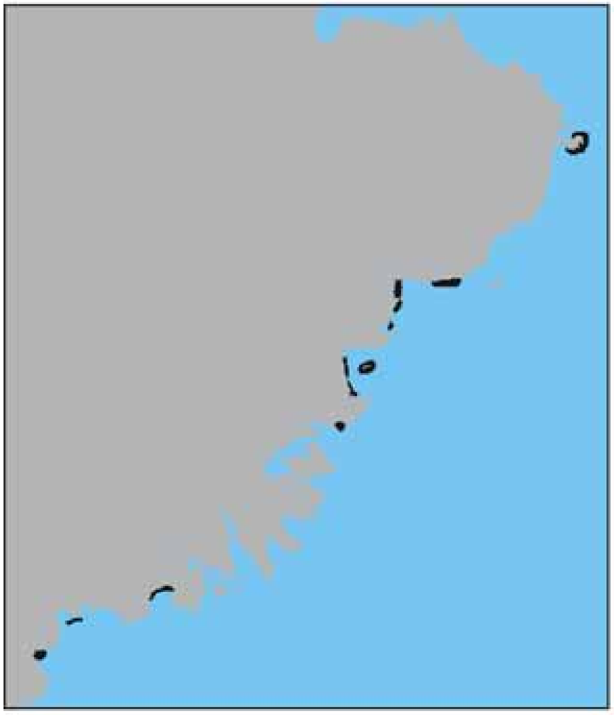
C. Pacific cod major adult concentrations
Gadus macrocephalus
West Coast of North America Strategic Assessment Atlas
(NOAA 1988)

D. Pacific halibut adult area (November - March)
Hippoglossus stenolepis
West Coast of North America Strategic Assessment Atlas
(NOAA 1988)

Figure 7: Seabird, waterfowl, and razor clam distributions.

A. Seabird colonies
Seabird species
Kodiak Island and Shelikof Strait Environmental Sensitivity Index
(NOAA 1998)

B. Waterfowl concentration areas
Family Anatidae
Kodiak Island and Shelikof Strait Environmental Sensitivity Index
(NOAA 1998)



C. Razor clam beds
Siliquapatula
Kodiak Island and Shelikof Strait Environmental Sensitivity Index
(NOAA 1998)

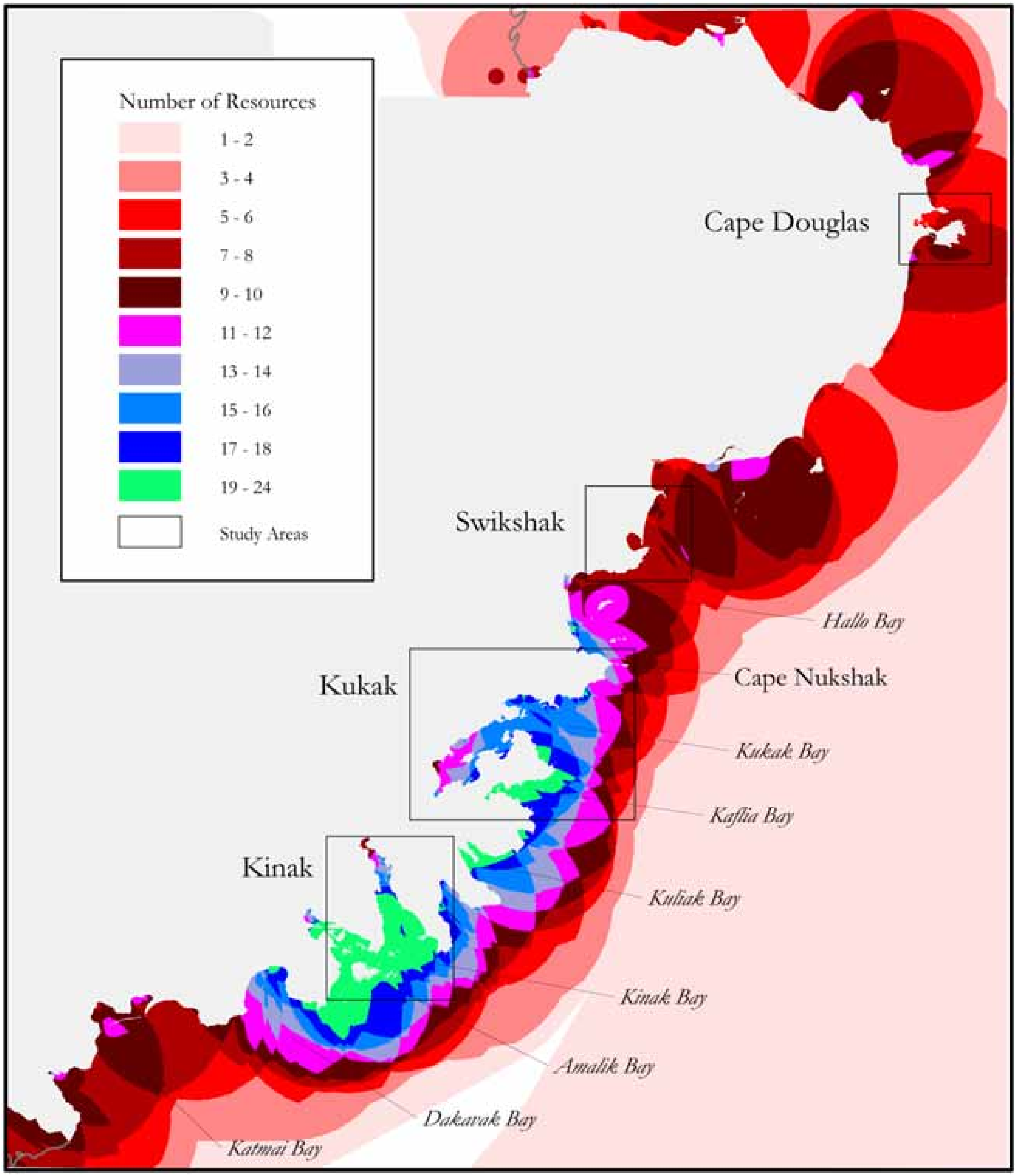


Figure 8: Variations in combined resource availability along the Katmai coast. Ten km kayak-harvest zones surround sea mammal, bottom fish, and seabird resource locales; one km foot-harvest zones center on clam beaches and the mouths of salmon streams. Color-coded overlaps indicate total numbers of accessible resource locales.

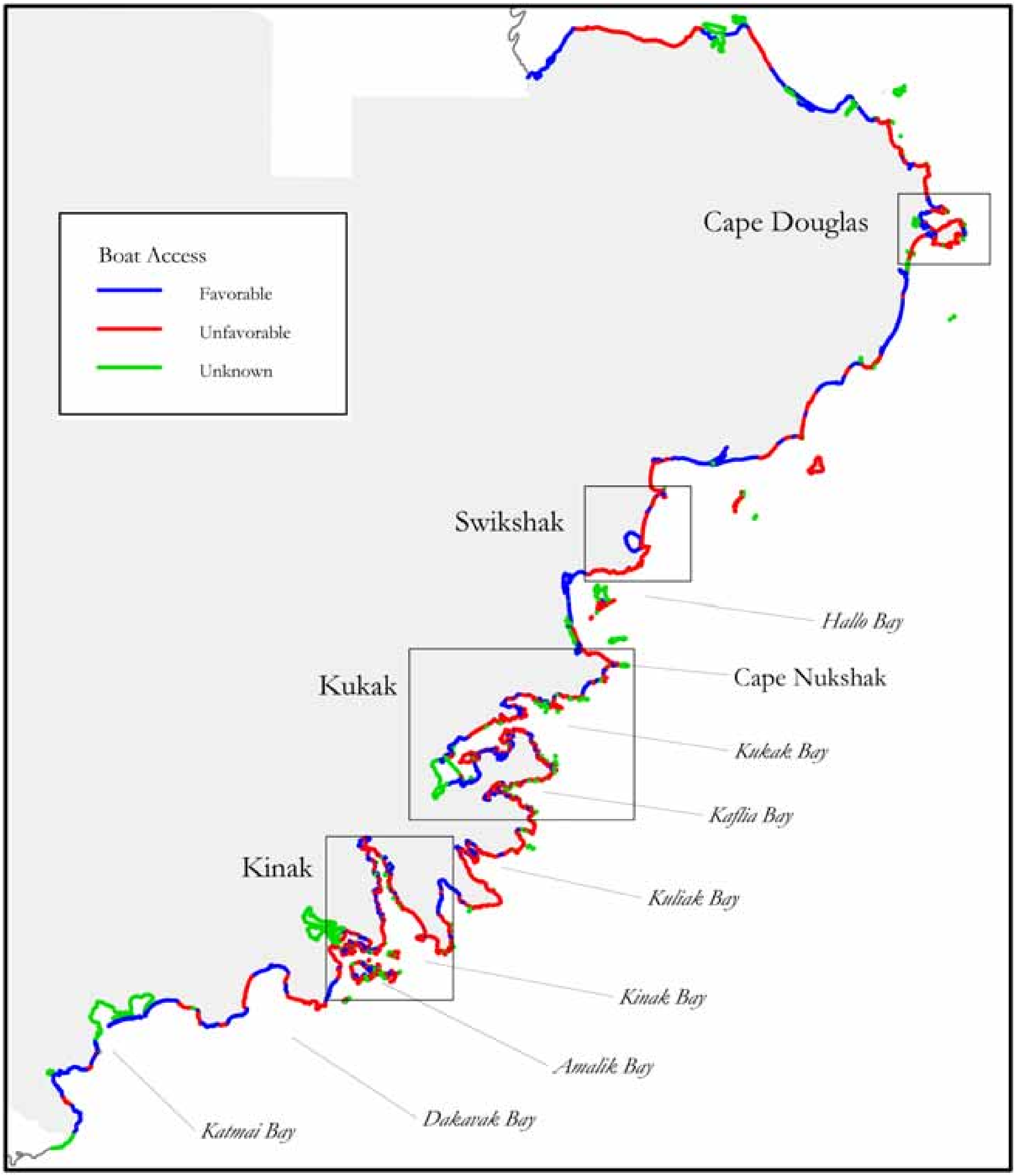


Figure 9: Suitability of shoreline for landing skin boats, based on substrate and inferred wave energy. "Favorable" beaches (green) are composed of fine sediments and have slopes of less than 5 degrees.

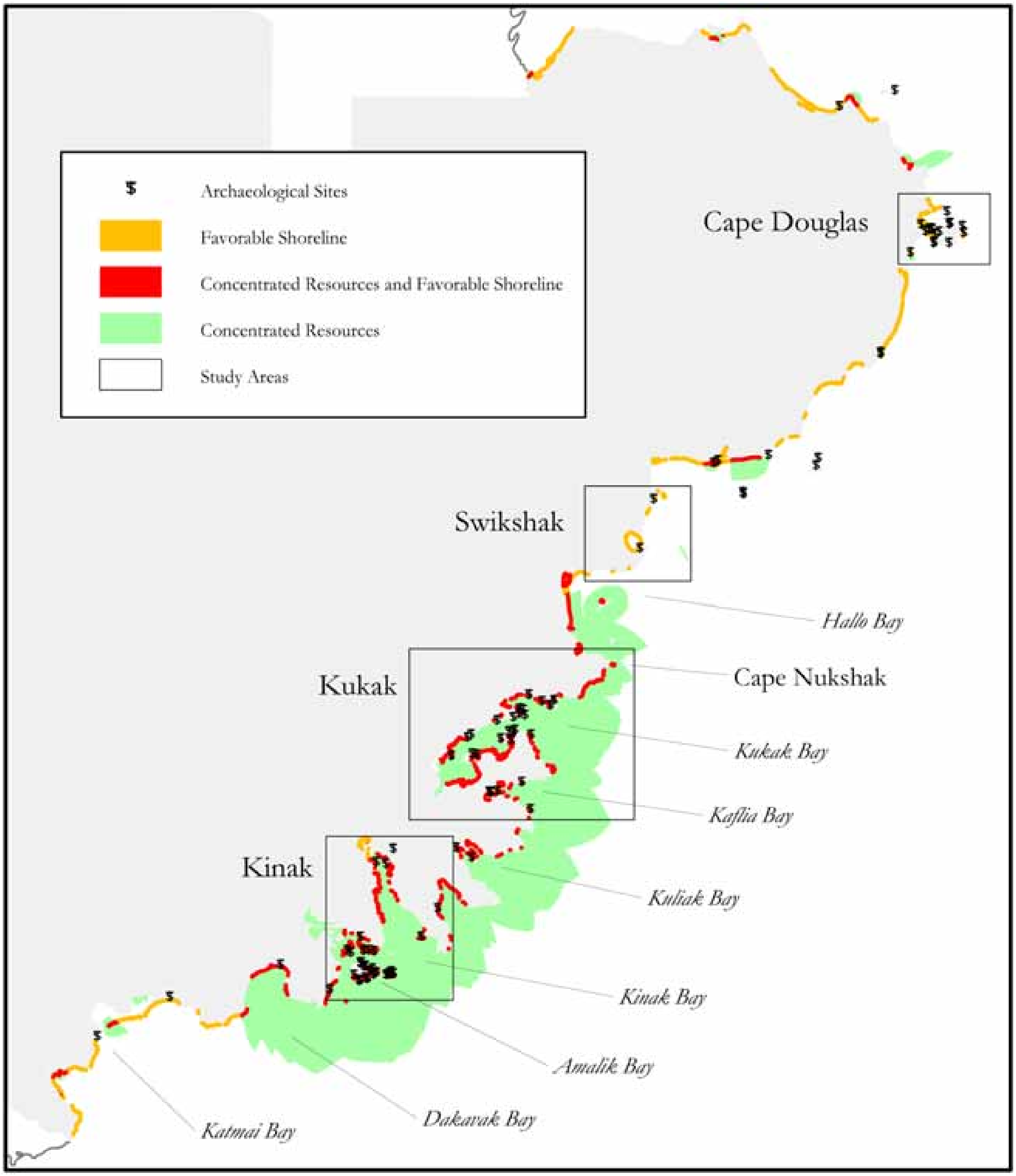
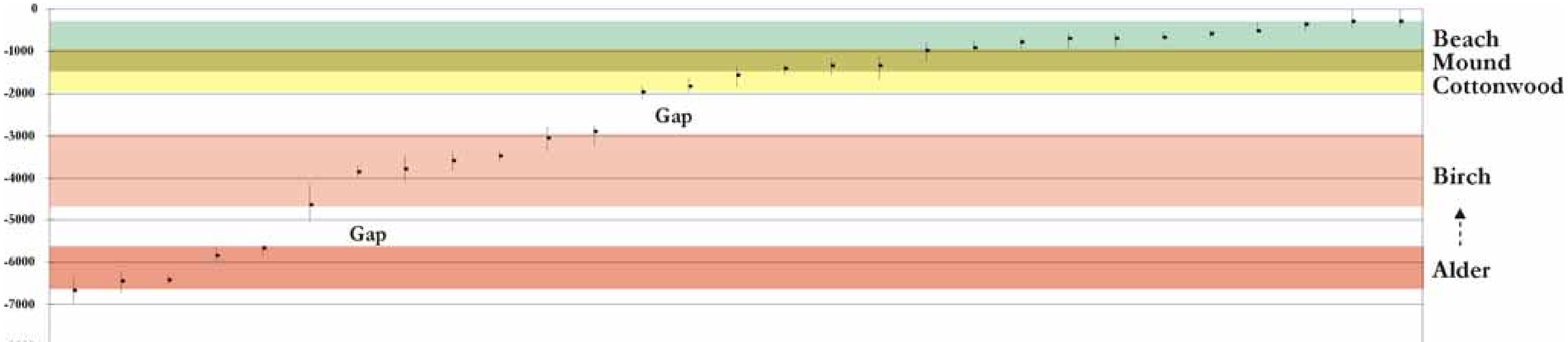


Figure 10: Spatial distribution of all archaeological sites in relation to sections of shoreline with favorable skin boat access (yellow) and favorable skin boat access combined with concentrated resource availability (red). Areas of resource concentration (green) are defined by access to 11 or more resource locales.



I-1945	I-1940	Beta 74859	Beta 74854	Beta 74855	I-1639	Beta 74850	I-1943	Beta 75320	Beta 75315	I-1941	I-3733	Beta 74849	Beta 75318	I-1942
-6356	-6199	-6300	-5610	-5590	-4154	-3690	-3469	-3375	-3355	-2789	-2749	-1810	-1630	-1350
-6980	-6729	-6530	-5970	-5870	-5040	-3990	-4080	-3830	-3640	-3369	-3239	-2140	-1970	-1850
-6674	-6445	-6420	-5830	-5660	-4638	-3850	-3795	-3580	-3470	-3049	-2904	-1960	-1830	-1569

Beta 74857	I-1944	I-1637	I-1638	Beta 74852	Beta 75319	I-1636	I-505	Beta 74853	Beta 75314	Beta 75321	Beta 74856	Beta 75316	Beta 74851
-1290	-1191	-1090	-780	-730	-690	-550	-556	-540	-510	-310	-290	0	0
-1560	-1550	-1682	-1239	-960	-930	-930	-920	-710	-715	-550	-515	-475	-420
-1400	-1345	-1341	-973	-910	-780	-689	-689	-660	-585	-510	-355	-285	-280

Figure 11: Calibrated radiocarbon dates from the coast of Katmai National Park, showing gaps between 5600 – 4600 cal B. P.and 2900 – 2000 cal B. P. Ranges represent two standard deviations. The figure excludes the extensive date series from the Mink Island Site (XMK-030), not yet published.