Alaskan Eskimo and Polynesian Island Population Skeletal Anatomy: The "Pacific Paradox" Revisited Through Surface Area to Body Mass Comparisons

Wendy Nicole Leach

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ALASKAN ESKIMO AND POLYNESIAN ISLAND POPULATION SKELETAL
ANATOMY: THE “PACIFIC PARADOX” REVISITED THROUGH SURFACE
AREA TO BODY MASS COMPARISONS

By

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B.A., Purdue University, West Lafayette, IN, USA, 2003

Thesis

Presented in partial fulfillment of the requirements
For the degree of

Master of Arts
In Anthropology

The University of Montana
Missoula, MT

Autumn 2006

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This project is an attempt to re-examine the “Pacific Paradox”, as proposed by Philip Houghton (1996), through various morphological measurements on two climatically different populations, Alaskan Eskimo and Pacific Island groups. The “Pacific Paradox” has been widely discussed, but research using direct comparisons between this Pacific population and cold climate groups has received little attention. The methods employed are those preformed by Ruff (1994), Ruff et al (1991, 2004, 2005) and Houghton (1996) to create the most accurate determination of overall body form in both populations. Eight measurements were used to construct variables to create an accurate portrayal of overall body shape. These measurements were taken on Alaskan Eskimo populations spread throughout the entire region of Alaska and on Polynesian populations from a wide variety of Pacific Islands. The overall comparisons demonstrate similarities in the two body mass estimations; the bi-iliac breadth measurement and maximum femoral head diameter, and in the overall stature to body mass ratios, except in the males, who are significantly different in every measurement apart from surface area to body mass ratios and stature to body mass ratios. Further studies on each population were conducted to determine the role of latitude or isolation factors on each population. Interestingly, the Alaskan group did not follow the stereotypical trend of cold climate adaptation based on latitude. In the female groups, the females from the lowest latitude had the lowest surface area to body mass ratios followed by the highest latitude group. The male groups followed the stereotype with the highest latitude group having the lowest surface area to body mass ratio but interestingly, the group from the lowest latitude had the next lowest ratio. Polynesian results illustrated somewhat similar body proportions throughout the region with only a few exceptions. Meanwhile, several individuals measured from the Polynesian collection could be considered part of Melanesia. Migration patterns, founder effect through disease frequencies, nutritional effects and cultural traits along with many other issues are presented when examining the similarities and differences the Polynesian population has in comparison to both the Alaskan group and the small Melanesian sample.
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CHAPTER 1: INTRODUCTION

Climatic differences in human morphology have held a certain fascination for anthropologists throughout the history of the field. How and why these differences occur in present day populations has been the subject of countless studies in many sciences. Philip Houghton (1996) is one of the many researchers who contributed to these studies. His focus, Polynesian Island populations, has shown body types not commonly seen in populations living in a tropical environment. Many Pacific groups, as addressed by Houghton, have physiques commonly associated with cold climate populations. In his research, Houghton discovered that in contrast to Bergmann’s Rule, which explains that within a warm-blooded polytypic species, those living in cold regions tend to have greater body mass than those living in warm regions, Pacific populations are some of the largest and most muscular people on earth.

The populations studied are found across a region that lies firmly within the tropics which, on the other hand, would imply warm climate adaptation, a relatively high surface area to body mass ratio. Houghton attributes this “Pacific Paradox” to the cool climate associated with the trade winds that blow steadily from the east between April and September. During this time, the sky is often overcast for several consecutive days, often creating cold, wet conditions. People at sea in small craft are often exposed to these winds and very cool climates. Early Pacific explorers and colonizers were exposed to frequent, very cold conditions during their voyages and even during their daily routines such as coastal fishing.
According to Houghton (1996), people of Remote Oceania exhibit this morphology because of their particular and uniquely cold environment. He also states that in these wet-cold Oceanic conditions, only those individuals with the Polynesian body type, large and very muscular, could maintain body heat and limb function over several hours. Individuals with a lesser build, commonly seen in tropical environments, would be uncomfortable, hypothermic, and possibly subject to death depending on the extent of the wind, wet-cold conditions. The people who possess this body type, according to Houghton (1996), have only been established in Remote Oceania for 3,500 years. His hypothesis is that these adaptations have occurred in this short period of time. He believes that the island people did not possess this body type until after their establishment on these islands. From this information, the question of how quickly such adaptations could occur arises. Is it possible for a population to adapt so quickly to their environment? Is 3,500 years a large enough time period for such adaptations to occur? Also, is there an obvious similarity in the Oceanic body morphology when compared to a cold climate population’s body morphology? If there is an obvious similarity, what would this imply?

The implications of the occurrence of similar body types would illustrate the importance of evolutionary mechanics in the study of human morphological variation. Without the understanding of a population’s migration patterns, nutrition, or culture in general, making assumptions based solely on one or two rules from previous studies could be erroneous. For instance, with these two populations, Alaskan Eskimos and Polynesian Islanders illustrating warm versus cold adaptations, it would be assumed that they would present very different morphological traits based on their environment. From
Bergmann and Allen’s rules those individuals from a warm climate, the Polynesian Islanders, would be assumed to have high surface area to body mass ratios with very long lean body types. In turn, the Alaskan Eskimo sample would be presumed to have very low surface area to body mass ratios based on these two rules. In this study, I will illustrate that evolutionary mechanics play a major factor in determining body morphology.

The objective of this project was to expand and test previous research carried out by Houghton (1996). Some questions I will address include:

1.) Is there a similarity in the surface area to body mass ratio in Pacific Islanders and Alaskan Eskimos?
2.) Is there a solid link between climate and body morphology in humans?
3.) If the body types of the two populations do, in fact, exhibit similarities, what does this imply?

The hypothesis for this project is that there will be a close similarity between Pacific Island populations and Alaskan Eskimos. The support of this hypothesis would refute the idea that climate is the main determinant when looking at variation in human morphology. Knowledge of population history, migration patterns, and cultural history are also required to gain a full understanding of human variation in human morphology.
CHAPTER 2: BACKGROUND

Population history is an important issue to examine in any anthropological study. In this chapter, I describe research on the origins of these populations and the lifestyle of individuals measured for this study.

Population History

For both groups, Alaskan and Polynesian, the issue of how, when, and by whom these areas were populated has been a topic of interest for many researchers. The first movement of groups into Alaska, for example, is an important factor in determining the point in time when the New World was originally peopled. Although an overwhelming majority of researchers believe that the New World was populated by groups crossing the Bering Strait through Alaska and throughout time and spreading throughout the New World, it must be said that the people who first moved across the Bering Strait may not be the ancestor of the modern Alaskan. The major point of issue when dealing with Polynesian populating is where did the original inhabitants come from and how did they reach these remote islands?

Alaskan Population History

The crossing of populations from the Bering Strait to the New World has been a widely accepted hypothesis in regard to the issue of populating Alaska. The time period in which this happened, however, is highly debated. Due to an archaeological find by George McJunkin, a New Mexico cowboy, there is a virtually unanimous agreement that man’s arrival in the New World was during the Ice Age. McJunkin’s find, bones of an
ancient bison that had gone extinct approximately 10,000 years ago along with man made flint bits, put the exact timing into question once again. These finds focused attention on how individuals had reached the New World. If they, as it seemed indisputable, had traveled as far south as New Mexico by the latter part of the Ice Age, they must have left Siberia a few thousand years earlier (Claiborne, 1973). If, in fact, this was the case, they would not have had to use a boat or traveled across ice pack, but could have merely walked across dry land. This dry land, a land bridge between Asia and Alaska, was created when the glaciers of the last ice age were at their peak. These glaciers removed enough precipitation that the Bering Sea was lowered more than 300 feet.

A three stage Beringia environment hypothesis was constructed to determine when these populations crossed the land bridge. This palynological data was proposed by Hoffecker, Powers, and Goebel (1993). From this data, an illustration was provided explaining when the landscape could have supported populations crossing into the New World. These environmental stages range from a relatively productive cold steppe environment to a time of bleak polar desert (Hoffecker et al, 1993). From approximately 25,000 to 14,000 years before present, the Beringia environment was considered an herb zone, dominated by grasses, sedges, willow, and sage. From 14,000 to 12,000 years before present, a significant increase in dwarf birch was noticed. Finally, from approximately 10,000 to 7,000 years before present, a transgressive zone was noted with a sharp increase in alder and some spruce (Hoffecker et al, 1993).

In Alaska, most activities that lead to archaeological finds, such as dam making, road construction, and other projects that involve massive excavating, are scarce. Due to this, the archaeological record is scarce in sparsely populated areas. Two major sources
of archaeological materials from the Pleistocene into the Holocene are in the North Central Alaska Range and the Tanana Valley areas of Alaska. Sites from 11,820 to 8,400 years before present have been found in these areas. Carbon 14 dating has been used in a majority of these sites to determine approximate dates.

In the North Central Alaska Range, sites are found in both the range itself and in the northern foothills. The sites in the Alaskan Range are mostly along the upper reaches of three major rivers flowing north into the Tanana Basin. The first site described was found along the Teklanika River. This site is further broken down into Teklanika East and Teklanika West sites. From this area, artifacts dating to the Middle Holocene age have been found. Along the Nenana River, also known as the Carlo Creek site, and the Delta River, known as the Tangle Lakes sites, Carbon 14 dating of artifacts illustrated dates ranging between 10,150 and 8,400 years before present. These artifacts are characteristic of the Denali complex, a microblade industry seen in Northeast Asia and Northwest North America in the Late Pleistocene and Early Holocene. Sites in the North Central foothills are commonly found in major valleys along the margins of terraces adjacent to tributary systems (Hoffecker et al, 1993). These sites include the Nenana Valley site; including Dry Creek, Walker Road, Pangingue Creek, and Moose Creek sites, and the Teklanika Valley site, including Owl Ridge. From these sites, artifacts have been found and dated back to 11,820 to 11,010 years before present.

From these archaeological sites, along with palynological data, the authors proposed a colonization of Beringia model. Again, as mentioned previously, while it is widely accepted that the New World was populated by individuals crossing the Bering Strait, these people may not in fact be the ancestors of modern Alaskans. First,
settlement began approximately 12,000 years before present with rapid colonization of east and west Beringia. Due to the lack of regions in the New World with firm dating before 11,200, the approximate date of 12,000 years before present for colonization was proposed. This area was colonized at the beginning of the interstadial zone with a marked reappearance of trees in river valleys and other areas. These provided fuel sources for the first time since 25,000 years before present. Their third observation was that there was no obvious source for early Beringian complex in Northeast Asia. The people who occupied Beringia after 12,000 years before present spread into the New World very quickly. Lithic assemblages in mid-latitude North America are closely related to the Nenana complex approximately 11,000 years before present. After the final Pleistocene cold from 11,000 to 10,500 years before present, the Beringian technology was replaced by a microblade technology. This reflects the spread of a new population which supports a multi-migration model into the New World (Hoffecker et al, 1993).

This multi-migration hypothesis has gained support throughout the scientific community. Researchers examined not only the artifacts found but also the remains of the people, including their teeth. These studies are vital in gaining an understanding of the first New World populations. From dental characteristics, a researcher can trace an individual’s heritage and origins. Dental characteristics can also help determine diet and even some cultural habits. This, therefore, can lead to an image of the who, what, when and where factors of these first settlers.

Dental morphology has provided valuable information when examining human population history, particularly when 5,000 to 10,000 years or more are involved (Turner, 1983). He credits four reasons as to why this is true:
This is because of (1) the substantial evolutionary stability of the numerous crown and root traits; whose (2) intergroup differences or similarities signal past degrees of relationship; (3) tooth hardness, which enhances the probability of long-term preservation; and (4) the high genetic component in trait occurrence and expression, which minimizes many environmental effects, sex dimorphism, and age influences that reduce the usefulness of osteological remains. (Turner, 1983)

According to Turner, prehistoric dental variation in the New World can be divided into three groups. The first is the arctic coast group which includes the Aleut Eskimos. The Na-Dene speakers of the Alaskan interior and Northwest coast create the second group. The rest of the native populations from North and South America, labeled Indians, comprise the third group. In the short amount of time since the Paleo-Indian arrival, little dental evolution could have occurred (Turner and Bird, 1981). The differences between the groups would therefore have to be due to differences in their old world populations.

According to univariate and multivariate analyses performed by Turner (1983), migrations into the New World appeared to be in two to three stages. The Eskimos and Na-Dene dental morphology exhibit pronounced differences leading Turner to believe these two groups moved into the New World during two different migrations. The Na-Dene speaker dental characteristics are intermediate in frequency between Eskimos and the Indians. Due to this observation, unless strong parallel selection occurred, this population could not have a common Eskimo ancestor within the New World. All three groups, however, have crown and root traits similar to North Asians. According to Turner, these traits are commonly known as Sinodonty. In the New World, incisor shoveling, double shoveling, single rooted upper first premolars, and three rooted lower first molars are the Sinodonty characteristics that can be found. Since Sinodont occurs
only in North Asia and the Americas; excluding recent Chinese, Japanese, and Mongol migrations, the Siberian origin through the Bering Strait route is evident from these patterns (Turner, 1983).

Turner further explained his three migration hypothesis in subsequent articles. In Greenberg et al (1986), four observations were listed that provided the evidence for these three migrations. The first observation stated that all New World groups resemble each other more than they do most Old World populations. This provides clear evidence that all Native American groups had an ancestral origin in one Northeast Asian population system since all are similar and possess Sinodont dental patterns rather than Sundadont or European dental characteristics (Greenberg et al, 1986). Dental variation in the New World is also greater in the north than in the south. This provides evidence that the peopling of the New World was a north to south progression since variation is greatest where populations have resided the longest. The final two observations stated that New World groups are more like Asians than Europeans, and that Aleut-Eskimos, greater Northwest Coast Indians (Na-Dene speakers), and all other Indians form three different New World dental clusters.

Also in this article, the authors discuss the timing of the peopling of the New World. They proposed that the worldwide rate of dental microevolution was about 0.01 MMD (mean measures of divergence) per 1,000 years (Greenberg, 1986). If this rate is applied to Indian samples, the first group to cross over the land bridge, the population has been separated from Northeast Asia for approximately 14,000 years. This is, again, considered substantial evidence for both the timing and migration pattern proposed by the authors.
The oldest archaeological remains in this Pacific Eskimo area were found on Kodiak Island and date approximately 5,500 years before present (Oswalt, 1967). There was continuity in the artifacts found up until 900-1500 A.D. Afterwards, an abrupt change in artifacts occurred, possibly due to the arrival of proto-Suk from the shores of Bristol Bay.

**Yearly Cultural Practices in Arctic Eskimo Alaska**

In Oswalt (1967) the different regions of Alaska and their cultural practices, including Arctic Eskimo, were described. Point Hope is included in the area considered Arctic Eskimo territory. In this study, the Tikerarmiut were the group measured from this region. These people are represented in samples taken from Point Hope and Point Barrow, and are culturally very closely related to the people at Cape Prince of Wales, East Cape, Siberia, and Gambell, St. Lawrence Island (Oswalt, 1967). The Point Hope sample used in this study was taken from Tigara, Ipiutak, and Jabbertown. The location for settlement at Point Hope was probably chosen due to the great baleen whales that swam close to shore during their yearly migrations. The wind and the sea currents also produced favorable winter seal hunting conditions and enormous herds of walrus followed the ice pack northward. Movements of pack ice were of great importance due to the yearly migrations. Hunting was the basis of this culture and what this population hunted was based upon the current season (Oswalt, 1967).

There was little hunting in the fall. During this time the people ate whale, seal, and walrus meat that was stored underground from the previous spring. In late October, winter seal hunting began. The timing was due to the solidity of the ice. Hunters could safely travel across the ice and look for seal breathing holes. In early winter, however,
the ice was still moving and wind and currents often swept hunters out to sea. From October until April the men hunted everyday from daylight until dark. Seal nets were also used before the introduction of rifles. This type of seal hunting, though, was extremely dangerous and now only a few use this technique. Arctic fish visited Point Hope in January and were harvested through holes in the ice. Old women and children were mostly responsible for this type of food hunting. In February or March, the people would move to the south side of the Point to fish for crabs through holes cut in the ice. Polar bears were hunted with bows and arrows and hand lances. Unlike the Greenland Eskimos, the people in this region did not use dogs to surround the polar bears, so this was considered a very dangerous and exciting hunting project. Famine was not uncommon during the fall and winter, but ceremonial and social activities were at a high during this period.

In late March snowbirds appear at Tigara which was the first sign that the whales would soon appear. Whale hunting was a culturally complex time of year. Crews of men, as small as five individuals, would participate in the whale hunt. They camped on the pack ice and waited for the whales to spout. When this occurred, all crews would launch their boats and if a boat was capable of catching the whale, the harpooner would stand on the bow and the paddlers would row up onto the whale’s back. The harpooner would then thrust the harpoon into the whale. All the crews would then attack the whale. If the whales failed to appear, water fowl were often killed in large numbers. The meat from the hunt was stored in underground caches where it could remain edible for more than a year. All parts of the whale were used with the exception of the skull which was
returned to the sea in ceremonial fashion. Many hunting implements and household items were produced from the bones of the whale.

Finally, late in May the ice pack began to melt and small hair seals and large bearded seals crawl out of the water to lie in the sun. These seals were the target for summer hunting. Walrus were killed during the summer after the ice had disappeared. Sea birds were also hunted using bolas and the Eskimo bird spear. Hunting mostly ceased in the summer, and most families packed up and dispersed to summer settlements. Most groups camped at no great distance from Tigara where beluga and fish could be netted for food.

It is obvious that Alaskan cultural history is very detailed and complex. The activities of the different groups to sustain a healthy lifestyle vary with the landscape. From the arctic whale hunters to the inland caribou hunters, the Alaskan prehistory is rich with different cultural traditions. As can be seen in most indigenous areas, the culture and practices changed with the introduction of more technologically advanced materials. The introduction of the rifle to these areas provided an easier form of hunting than the use of traditional weapons. It is obvious, especially in the Arctic Eskimo cultural group, that the introduction of rifles was viewed as a much safer alternative to most traditional practices due to the distance that could be maintained from dangerous wildlife. Perhaps, eventually, these technological changes could change the morphology of the people in these areas.
Classification of Modern Alaskan Groups

According to Birket-Smith (1959) there are 17 important Eskimo groups. For the purpose of this project I examined only the groups in the areas from which samples were taken. The groups researched, as taken from Birket-Smith (1959), are as follows:

I. **Aleut:** *Atka* on Andreanov, Rat, and Near Islands, *Unalaska* on the Alaska Peninsula up to Cape Stroganov on the north side and Pavlov Bay on the south side as well as on Fox and Shumagin Islands. A number of Aleuts were transported by the Russians to the north-east point of Kodiak and the opposite coast of the mainland.

II. **Pacific Eskimos:** *Qigertarmiut* on and near Kodiak and the opposite mainland coast.

III. **Bering Sea Eskimos:** *Aglemiut* and *Nushagammiut* on Bristol Bay. *Kuskokwimmiut* by the lower *Kuskokwim*, *Nunivagmiut* on *Nunivak Island* and the opposite mainland coast. *Kaialigmiut* and *Magemiut* in the delta of Kuskokwim and Yukon, *Kuigpammiut* by the lower Yukon. *Unaligmiut* by Norton Sound.


From the sample of Alaskans I was able to collect from the National Museum of Natural History and the American Museum of Natural History, there are four distinct cultural groups, according to Birket-Smith (1959). Even though cultural differences exist, the physical type of the Eskimo is somewhat similar. As soon as exact measurements were
taken, mostly cranial measurements, this uniformity became unmistakable. According to Birket-Smith (1959) only in Alaska does the extreme type fade out and on Kodiak and the Aleutians, it disappears completely.

Normally, three groups of Eskimos are used to describe regional similarities and differences. I combined the four groups mentioned above into these three categories to achieve the best view of the culture in these different areas. It is from these comparisons that we can understand the cultural complexities of Alaska. These three groups: the Pacific Eskimos, the Bering Sea Eskimos, and the Arctic Eskimos represent the major geographical and linguistic segments of Alaskan Eskimos.

Fig 2.1 Alaskan sample locations.
Eskimo Lifestyle

At the time of first contact there were 8,700 Pacific Eskimos. The area included the Kodiak Island group and Koniag, which had a very high population density at this time. The average population density of Pacific Eskimos was much higher than that of other Eskimo tribes, due to the abundance of resources in this area. Due to its location some 20 miles from the mainland, raids from neighboring tribes were uncommon, thus creating security for the inhabitants of the Kodiak Island group. These populations participated in a developed maritime economy. Salmon spawned in great numbers in the streams of these islands, and the coastline was provided sea mammals for hunting. Perhaps even more important was that this area was a crossroads of various Eskimo cultures. The people in this area absorbed cultural influences from Aleuts, Na-Dane speaking Indians, and other Eskimos (Oswalt, 1967).

The people who were considered Pacific Eskimos used blunt arrows, multipronged darts and arrows for birds. Bolas, gill nets for fish, and seal nets were also used. These artifacts show that some of the typical Bering Strait area hunting devices faded away in the south. Pacific Eskimos also developed many trait complexes that were absent among all the other Alaskan Eskimos including a well developed warfare complex included fortified and habitable positions, whaling with poisoned slate-lance blades, secret rituals for whale hunters, separate rooms for sleeping, slavery, killing slaves at the death of their owner, different burial rituals for people of different status, halibut hooks, breast tattoos on women, and cylindrical wooden quivers. Also unique to Pacific Eskimos were their kayaks. There were two varieties; the standard kayak and a two-hole variety. The two-hole kayak was the most sophisticated ocean going vessel found
anywhere at this time (Oswalt, 1967). Their whaling practices commonly link them to the southern Northwest Coast Indians.

There were approximately 9,000 Bering Sea Coast and Nunivak Eskimos present at the time of contact. This is the region of greatest Eskimo antiquity and continuity. In a sense, this was the core area in which the other populations spread north and south. These populations did not hunt whales but had a broad inventory of weapons used for open water sea-mammal hunting from kayaks. Matrilocal residence was common, and the bilateral descent system placed more stress on the male line, and Iroquois cousin terms were prevalent. Caribou hunting was common among some groups of this area and could be an indicator of the survival of the Ipiutak culture.

Finally, 6,350 Arctic Eskimos were found at the time of contact. The most stable and successful of these Eskimos were those found from Point Barrow to Sledge Island (Oswalt, 1967). Whale hunting in this area had been prominent from around 4,000 years before present. The inland region of this area, due to the environmental conditions, would be an area of very stressful conditions for human settlement. Due to this, subcultural radiations would be more unsuccessful than those to the south. Little is known about these groups of people. In an area such as this, any slight change in ecological patterning could be disastrous for the population and lead to the coalescence of people or to their extinction (Oswalt, 1967).

**Polynesian Population History**

Before examining Polynesian population history, it is important to examine the different regions in this island group. This area of islands ranging from the east shores of
Asia throughout the Pacific to the shores of the western United States has three major area distinctions. Normally these areas are designated as Melanesian, Micronesian, and Polynesian. Melanesia is the region of islands nearest to Australia moving toward the Northeast. New Guinea, Bismark and Solomon Islands, New Caledonia, Vanatu, and Fiji are the major islands in this area. Micronesia is the area north of Melanesia and includes the Marshall Islands, Kiribati, and the Caroline and Marianne groups (Dodd, 1972). Polynesia consists of the islands in a triangle with the points being at Hawaii, Easter Island, and New Zealand. These areas are broken down into two main groups, Near and Remote Oceania. Remote Oceania comprises the islands east and southeast of the Solomon chain (Fig 2.2).

As with the Alaskan population history, the questions of how, when, and by whom these islands were populated are issues addressed in Polynesian research. Scientists have been studying the people of this region for centuries. Radio-active carbon dates tell us that there were island inhabitants for over 2,500 years. The evidence for the origin of these people is overwhelming. It is commonly agreed upon that the ancestors of Polynesia originated in Southeast Asia and migrated mostly by way of Indonesia and Melanesia to the ocean islands (Lum et al, 2002). How they got there is another issue all together and has been the focus of many debates. There are many hypotheses on the previously mentioned subjects

One hypothesis, proposed by Andrew Sharp (1964), is commonly known as the “migration by chance” hypothesis. He stated that the islands were inhabited by individuals who were simply blown off course on a journey to a different location. Sharp
used numerous statistical studies to support his hypothesis. Sharp’s claim begins in the widely hypothesized, “correct place”, Southeast Asia, so it is more widely accepted than many other “by chance” hypotheses. His hypothesis is tolerable among scientists but has still been called into question by many researchers. Sharp has modified his hypothesis and now acknowledges that some of the islands may have been “purposefully” settled. Unfortunately, what this hypothesis lacks is an appreciation of Polynesian voyaging. It places all the credit with natural occurrences and leaves little room for human intent.

Lum et al (2002) presented a neutral biparental genetic perspective on Polynesian origins. Their hypothesis supported the idea that there was a rapid initial colonization of Remote Oceania from island Southeast Asia which was followed by substantial gene flow among Austronesia and Papuan-speaking populations of Melanesia. The genetic
perspective of the populating of this region illustrated a series of bottlenecks. Language
and geography were also used to enhance genetic evidence. There was a marked
correlation between both genetic and geographic distances among Near and Remote
Oceanic Melanesians. This suggests that there was gene flow among Near and Remote
Oceania populations, but most gene flow was seen among Austronesian speakers.

The language support of the genetic evidence was discussed in Lum and Cann
(1998). They hypothesized that there were two stages of Pacific Island settlement. First
the Melanesian regions of New Guinea were settled around 40,000 years before present,
the Bismark Archipelago was settled approximately 33,000 years before present, and the
Northern Solomons were populated approximately 29,000 years before present. In the
last 4,000 years Remote Oceania was beginning populated. The Lapita cultural complex
could be found in Remote Oceania. This cultural complex is noted mostly by highly
decorated red-slipped pottery found along the north coast of New Guinea and throughout
Remote Oceanic Melanesian West Polynesia. The finding of this complex illustrates a
rapid expansion into Remote Oceania. This, therefore, is evidence of a wave of
immigration from Southeast Asia and dispersal throughout Oceania with little interaction
with descendants of Pleistocene settlers in Western Melanesia (Diamond, 1988). Terrell
(1989) challenged Diamond’s hypothesis. He believed that the finding of evidence of the
Lapita culture illustrated a set of cultural innovations by indigenous Melanesians
resulting from long-term interactions with other western Pacific populations.

Lum and Cann (1998) found extensive gene flow within Micronesia. However,
they found substantial isolation among other groups of Austronesian speaking
populations. This, according to Lum and Cann, supported a rapid colonization of Remote
Oceania by a closely related group of Austronesian speaking populations from island Southeast Asia. Following settlement, extensive gene flow occurred between recent migrants and neighboring peoples (Lum and Cann, 1998). Both the language and genetic factors researched in this study support this hypothesis.

Another issue when examining Polynesian colonization is dental studies. From the knowledge of ancestry and migration patterns, an image of original morphology can be drawn. Dentition is often used in tracing population due to the evolutionary stability of numerous crown and root traits, intergroup relationships established through similarities and differences, long term preservation due to tooth hardness, and a high genetic component in trait occurrence and expression (Turner, 1983).

When examining dentition, the most important issue to remember is that human dentition is a food processing device. Dental differences should reflect differences in food processing necessities. Dietary changes are not the only issue when examining food processing. Food processing technology plays a vital role in examining dental variation. It is not so much the food itself, but what was done to it before it was eaten (Brace and Hinton, 1981). If food processing is made easier on the teeth by advanced technology, the selection for large dentition will be relaxed. The consequence of this advanced technology is tooth size reduction. From this, it can also be hypothesized that populations with smaller dentition have utilized advanced food processing technology for a long period of time. Those maintaining large dentition would have been introduced to this technology at a later point in time. For example, long term residents of the northern portions of the Old World, from Europe to China, have utilized advanced food processing techniques for a longer period of time than any other population. These groups
demonstrate the greatest degree of dento-facial reduction (Brace and Hinton, 1981).

From this information, the differences in dental size can be attributed to different cultural histories over the past 100,000 years (Brace and Hinton, 1981).

Furthermore, Brace and Hinton (1981) stated that in Asia and the western Pacific, longstanding regional differences in selective-force intensity resulted in tooth size differences between populations. Subsequent movements brought these populations into contact. They hoped to illustrate that tooth dimensions could demonstrate an index of the extent in which these groups mixed. According to this study, the tooth data demonstrated that the final peopling of Oceania was carried out by groups who had come from a part of Asia where tooth-size reduction had been occurring throughout the late Pleistocene. Due to their impressive technology, these people were able to move directly into Oceania where they met and mixed with the Melanesian people who were the descendants of earlier, large toothed settlers. In eastern Polynesia, tooth size is said to be the same as in pre-Chinese Taiwan, suggesting minimal mingling occurred during the movement into the Pacific.

The “how” hypotheses do not hold as much focus in science as the question of “when”. Radio-carbon dates for the Marquesas are as early as 124 B.C. along with Easter Island in A.D. 536 (Suggs, 1960). What makes this significant is that the Marquesas Islands are some 2,000 miles from Samoa and Easter Island is an additional 1,000 miles further. This may demonstrate that these islands were settled in stages. With the knowledge of boat designing, building, testing, and redesigning, along with a means of navigating, came high reward. Methods of provisioning had to be learned along with ways of carrying plants and animals to future settlements. These skills were learned and
perfected over short distances and then later employed on voyages spanning thousands of miles (Suggs, 1960).

Philip Houghton (1996) provided a timeline of his view on Polynesian populating. The western fringes of Polynesia showed evidence of settlement many thousands of years ago. In New Guinea, for example, evidence of human settlement (though there were no human remains) was dated to approximately 40,000 years before present (Houghton, 1996). Inland settlements in Melanesia have produced sites as old as 35,000 years old. Unfortunately, the rise in sea level over the past 16,000 years may have drowned and washed away evidence on many Polynesian Islands. These sites illustrate the movement of objects by humans.

East of these sites, there is no indication of human settlement or presence before 3,500 years before present. The antiquity of some settlements in North Bougainville, an island in Polynesia, suggests earlier sites may exist. Another archaeological date for islands used in this study in Polynesia is approximately 500 years before present on the Chatham Islands. One point of interest on Easter Island and Hawaii illustrates human settlement at around 1,200 years before present (Houghton, 1996). In the Marquesas Islands, an approximate midpoint between the two islands, a settlement existed approximately 1,700 years before present. Is it possible that the population that settled the Marquesas expanded both north and south at about the same time, in hopes of finding new land?

While Polynesian prehistory is the subject of many studies, conclusive evidence is minimal. Perhaps it is due to the ocean currents and levels throughout the last 20,000 years. It also could be due to the fact that these areas were uninhabited until only about
3,500 years ago. Remote Oceania, the area used in this study, has a brief but very exciting past. How people with minimal technology could survive on the open ocean with no land in sight for thousands of miles has been one of the more entertaining and exciting issues in the study of human migrations throughout history. The archaeology of Polynesia is constantly expanding the range of time periods and illustrating techniques used by these people to maintain an existence in both travel and settlement.
CHAPTER 3: MATERIALS AND METHODS

Materials
Metric dimensions were taken from skeletal remains of 350 individuals from various regions of Alaska and from various regions of the Polynesian Islands known as remote Oceania (Table 3.1). All measurements were obtained from original specimens by the researcher from the American Museum of Natural History in New York, New York, and the National Museum of Natural History (Smithsonian Institution) in Washington D.C.. Alaskan individuals obtained from the American Museum of Natural History were cited in the archaeological record as being from the precontact period of time for the area.

A total of 251 Alaskan individuals were collected from 15 different regions of Alaska. 138 of these individuals were male while 113 were female. From Polynesia, a total of 99 individuals were measured with 38 being male and 61 being female. After further researching this Polynesian sample, 9 individuals were removed from the overall Polynesian statistics due to conflicting ideas of whether these individuals would be considered part of Remote or Near Oceania. These individuals were from the Philippine Islands, Solomon Islands, New Britain and Sumatra. With this in mind, the total Polynesian sample used in the statistical analysis was 90 individuals with 34 being male and 56 being female.

Methods
In this project, I measured and calculated stature, body mass, surface area, surface area to body mass ratios, and stature to body mass ratios in Pacific and Alaskan samples collected from the American Museum of Natural History in New York City and the
Smithsonian National Museum of Natural History in Washington D.C. The measurements from the Pacific populations were then compared to an Alaskan Eskimo sample, also collected from the American Museum of Natural History in New York City and the Smithsonian National Museum of Natural History in Washington D.C. The Alaskan sample underwent the same analysis as the Pacific sample, using stature, body mass, surface area, surface area to body mass ratios, and stature to body mass ratios as an indicator of morphology. Methods for determining the Alaskan Eskimo stature were taken from Trotter and Gleser’s stature equations following Ruff and Auerbach (2004). Stature equations proposed by Houghton (1996) were used for the Pacific populations. Before determining the stature from long bone lengths, sex was determined to apply the measurements to the correct stature formula. Body mass for both populations was estimated using one of the two following techniques proposed by Ruff:

1.) Bi-iliac breadth (Ruff, 1991)

2.) Maximum femoral head diameter (Ruff et al, 1991)

With both stature and body mass determined, the surface area of each individual was estimated using a formula proposed by Dubois and Dubois (1916). After estimating surface area, the surface area to body mass ratio was determined for each individual. An additional measurement of stature to body mass ratios was used partially due to the use of this technique in Houghton (1996). With this information, comparisons between the two populations were observed.

Maximum femoral head breadth, maximum long bone lengths, and bi-iliac pelvic breadths, after rearticulation, were taken on each individual. Measurements were taken from both the left and right sides and averaged to reduce laterality biases. These
Measurements were taken using sliding calipers and an osteometric board provided by each museum. Measurements were taken in millimeters and later converted to fit each equation as necessary. Each measurement was taken three times and recorded. Each data sheet contained areas used to record the museum in which the individual was collected; the population, which consists of the broad group (e.g., Alaskan or Polynesian), the narrow group (e.g., the quadrant or island chain in which they were found), and the population/nationality (e.g., the specific area, island, or village in which they were found).

The sex of the individuals was also recorded. Sexing of the individuals was carried out using the method of Phenice (1969), utilizing features of the os coxae. Due to the cataloguing systems at both institutions, crania were not readily available to use as a method of sexing for individuals in which sexing from the pelvis was ambiguous or unavailable. In this instance, a method utilizing the maximum femoral head breadth from the Arkansas Archaeological Survey Research Series (1994) was used, along with museum records. These museum records, according to the staff members at the institutions, were developed many years ago. As a result, they recommended reevaluating the past research and using the records only as a last resort. Museum staff offered assistance when sex was difficult to determine. All individuals in which sexing was still ambiguous were eliminated from this project.

Maximum long bone lengths; including the femur (Fig 3.1), tibia (Fig 3.2), fibula (Fig 3.3), humerus (Fig 3.4), radius (Fig 3.5), and ulna (Fig 3.6), were recorded three
Table 3.1. Populations used in this study.

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<td>5</td>
<td>NMNH</td>
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<tr>
<td></td>
<td>Point Hope Quad</td>
<td>Point Hope - Ipiutak</td>
<td>42</td>
<td>24</td>
<td>18</td>
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</tr>
<tr>
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<td>Russian Mission Quad</td>
<td>Bogus Creek</td>
<td>10</td>
<td>4</td>
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<td></td>
<td></td>
<td>Okahamute</td>
<td>3</td>
<td>1</td>
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<tr>
<td></td>
<td></td>
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<td>1</td>
<td>0</td>
<td>1</td>
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<tr>
<td></td>
<td></td>
<td>Old Napaimiut</td>
<td>12</td>
<td>7</td>
<td>5</td>
<td>NMNH</td>
</tr>
<tr>
<td></td>
<td>St. Michael Quad</td>
<td>Pastolik</td>
<td>8</td>
<td>6</td>
<td>2</td>
<td>NMNH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kuzitrik River</td>
<td>9</td>
<td>3</td>
<td>6</td>
<td>NMNH</td>
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<tr>
<td></td>
<td>Unalaska Quad</td>
<td>Shiprock Island</td>
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<td>8</td>
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<td>NMNH</td>
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<tr>
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<td>Polynesian</td>
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</tr>
<tr>
<td></td>
<td>Marquesas Islands</td>
<td>Marquesas Islands</td>
<td>21</td>
<td>9</td>
<td>12</td>
<td>AMNH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Marquesas Islands</td>
<td>21</td>
<td>9</td>
<td>12</td>
<td>AMNH</td>
</tr>
<tr>
<td></td>
<td>Tuamotus Islands</td>
<td>Fagatau</td>
<td>3</td>
<td>3</td>
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<td></td>
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<td>Fakahina</td>
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<td></td>
<td>New Britain</td>
<td>Baining</td>
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<td>AMNH</td>
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<td>1</td>
<td>1</td>
<td>AMNH</td>
</tr>
<tr>
<td></td>
<td>Chatham Islands</td>
<td>Moriiori</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>AMNH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Luzon Island - Manila</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>NMNH</td>
</tr>
<tr>
<td></td>
<td>Philippine Islands</td>
<td>Guada Canal</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>NMNH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Malaita</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>NMNH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Savo</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>NMNH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pagai Islands</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>NMNH</td>
</tr>
<tr>
<td></td>
<td>Total</td>
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</tr>
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<td></td>
<td>Combined Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1AMNH, American Museum of Natural History, New York City, NY; NMNH, National Museum of Natural History (Smithsonian Institution), Washington D.C.
times in side specific areas, and bi-iliac breadth (Fig 3.7) and maximum femoral head
 diameters (Fig 3.8) were also recorded on the data sheets. From the data sheets, each of
the three measurements for each area were then averaged for the most accurate result.
Only individuals with fully fused epiphyses on the long bones and the pelvis were
measured to ensure that primary growth was complete. Individuals illustrating
pathologies due to age, disease, or trauma were not included in this study.

**Stature Estimation**

Maximum femoral length was used for most samples in this study, due to the
availability of a wide variety of reference samples. This measurement also has relatively
low standard errors of estimate. In some cases, when the femoral maximum length was
not available, the humerus was used as the estimator for stature due to previous research
illustrating a low standard error (Trotter and Gleser, 1958). Sex-specific formulae were
used to obtain the most accurate results. These sex-specific formulae were designed by

The study samples were matched with stature formula reference samples as
closely as possible, using population specific formulae when available (e.g., Remote
Oceania populations estimated using the Polynesian specific formulae developed by
Houghton (1996)). For Alaskan Eskimos, in previous research developed by Ruff
(1991), Trotter and Gleser’s equations for “white” male and female individuals were
used. The reasoning for this, as stated by Ruff and Auerbach (2004) deals with the very
low crural indices of the Eskimos and American Indians. These low indices overlap with
the crural indices of the sample population used by Trotter and Gleser. All stature
estimation equations are listed in Table 2.2 along with the groups to which they were applied.

**Body Mass Estimation**

Two body mass estimations, using previously researched equations, were used for each individual. All equations are listed in Table 3.2. They include a femoral head body mass estimation calculation (Ruff et al., 1991) and a stature/bi-iliac breadth body mass estimation technique (Ruff et al., 2005). The femoral head body mass estimation and the stature/bi-iliac breadth body mass estimation are both sex specific. The stature/bi-iliac

<table>
<thead>
<tr>
<th>Source</th>
<th>Equation</th>
<th>Groups Applied to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trotter and Gleser (1952)</td>
<td>S = 2.61 * Femm + 53.76 (“white” males) S = 2.48 * Femm + 56.93 (“white” females) S = 3.10 * Humm + 70.00 (“white” males) S = 3.36 * Humm + 60.47 (“white” females)</td>
<td>Alaskan</td>
</tr>
<tr>
<td>Ruff et al. (1991)</td>
<td>BM = (2.741 * FH – 54.9) * .90 (males) BM = (2.426 * FH – 35.1) * .90 (females)</td>
<td>Alaskan Polynesian Alaskan Polynesian</td>
</tr>
<tr>
<td>Ruff et al. (2005)</td>
<td>BM = 0.422 * ST + 3.126 * BIB – 92.9 (males) BM = 0.504 * ST + 1.804 * BIB – 72.6 (females)</td>
<td>Alaskan Polynesian Alaskan Polynesian</td>
</tr>
<tr>
<td>Dubois and Dubois (1916)</td>
<td>SA = 71.84 * BW^{425} * ST^{725}</td>
<td>Alaskan Polynesian</td>
</tr>
</tbody>
</table>

1S, estimated stature in cm; Femm, femoral maximum length; Humm, maximum length of humerus
2Units are in millimeters, S = stature, G = sex (10 = male, 20 = female)
3BM, body mass in kilograms; FH, maximum femoral head diameter (mm)
4BM, body mass in kilograms; ST, stature in centimeters; BIB, skeletal bi-iliac breadth
5SA, surface area; BW, body weight in kg; ST, stature in cm
breadth body mass estimation is based on the most diverse sample of any of the body mass estimation researched by Ruff. Due to this, the bi-iliac breadth equation is utilized as the more accurate of the two body mass equations. Unfortunately, bi-iliac breadth requires a fully articulated pelvis. The availability of a full pelvis was very limited. In the Alaskan sample, bi-iliac breadth was collected in approximately 50% of the individuals collected. Unfortunately, the Pacific population had a much lower availability of this measurement, approximately 10% of individuals collected. On the other hand, femoral head diameter was collected in 99% of both populations (bi-iliac breadth was available in a small number of individuals when femoral head diameter was not). This technique has been shown to be an accurate determinate of body mass in many populations, and is thus utilized extensively in this project.
Fig 3.1 Maximum length of femur. (Moore-Jansen et al, 1994)

Fig 3.2 Maximum length of tibia. (Moore-Jansen et al, 1994).
Fig 3.3 Maximum length of fibula (Moore-Jansen et al, 1994).

Fig 3.4 Maximum length of humerus (Moore-Jansen et al, 1994).
Fig 3.5 Maximum length of radius. (Moore-Jansen et al, 1994)

Fig 3.6 Maximum length of ulna. (Moore-Jansen et al, 1994)
Fig 3.7 Bi-iliac breadth (Gray, 1974)

Fig 3.8 Maximum femoral head breadth. (Moore-Jansen et al, 1994)
CHAPTER 4: RESULTS

As mentioned earlier, the hypothesis for this project was that these two groups, Alaskan Eskimos representing the cold adapted group and Polynesian Islanders representing the warm climate group, would exhibit morphological similarities in their surface area to body mass ratios. The two groups’ body types created an image of similarities in some aspects and differences in other aspects.

**Overall Comparison: Alaska vs. Remote Oceania**

The overall surface area to body mass ratios (Fig 4.1) for each narrow group are shown. With the exception of three Polynesian groups, there seemed to be a small difference between the two groups. For further study, this illustration was broken down further into the two separate groups. For the purpose of this study, I organized each group by latitude for the Alaskan sample and longitude for the Polynesian sample. These smaller groupings were designed to explain the differences seen throughout these areas by the measurement of placement on the Earth with longitude for Polynesia (Fig 4.2) and latitude for Alaska (Fig 4.3).

To achieve overall values of comparison, measurements of the maximum femoral length, bi-iliac breadth, and maximum femoral head diameter were used to equate surface area to body mass ratios, stature to body mass ratios, surface area, stature, and body mass. These numbers (Table 4.1, 4.2) are the building blocks for this project. In both sexes and overall, the maximum femoral length is larger in the Polynesian sample than in the
Fig 4.1. Overall surface area to body mass measurements for the Alaskan and the Polynesian sample. The first 15 groups were from Alaska while the following 5 were from Polynesia when reading the figure from left to right. The groups are organized by latitude in the Alaskan sample with the highest latitude being Barrow and the lowest latitude being Atka. The Polynesian sample is organized by longitude with the easternmost group being Easter Island moving west toward Asia. In this study, the Solomon Island population will be considered part of Melanesia. The Philippine Islands, New Britain, and Sumatra will be grouped in a separate group known as Southeast Asian Islands.

Alaskan sample. Also, the bi-iliac breadth is larger in the Alaskan sample than in the Polynesian sample in both sexes and overall. Finally, the maximum femoral head diameter is larger in the Polynesian sample than in the Alaskan sample in both sexes and overall.
Table 4.1. Polynesian equation measurement raw number averages.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Sex</th>
<th>Number</th>
<th>Average</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum femoral length</td>
<td>Overall</td>
<td>85</td>
<td>426.95mm</td>
<td>28.75</td>
<td>364.00mm</td>
<td>496.00mm</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>33</td>
<td>453.38mm</td>
<td>19.17</td>
<td>405.33mm</td>
<td>496.00mm</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>52</td>
<td>410.70mm</td>
<td>19.80</td>
<td>364.00mm</td>
<td>461.00mm</td>
</tr>
<tr>
<td>Bi-iliac breadth</td>
<td>Overall</td>
<td>11</td>
<td>250.25mm</td>
<td>15.93</td>
<td>232.00mm</td>
<td>283.33mm</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>4</td>
<td>256.75mm</td>
<td>8.97</td>
<td>249.33mm</td>
<td>268.33mm</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>7</td>
<td>247.00mm</td>
<td>18.11</td>
<td>232.00mm</td>
<td>283.33mm</td>
</tr>
<tr>
<td>Maximum femoral head diameter</td>
<td>Overall</td>
<td>86</td>
<td>62.11mm</td>
<td>7.73</td>
<td>49.20mm</td>
<td>86.27mm</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>34</td>
<td>68.35mm</td>
<td>7.18</td>
<td>55.85mm</td>
<td>86.27mm</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>52</td>
<td>58.03mm</td>
<td>4.83</td>
<td>49.20mm</td>
<td>76.86mm</td>
</tr>
</tbody>
</table>

Table 4.2. Alaskan equation measurement raw number averages.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Sex</th>
<th>Number</th>
<th>Average</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum femoral length</td>
<td>Overall</td>
<td>239</td>
<td>414.28mm</td>
<td>28.25</td>
<td>333.33mm</td>
<td>514.00mm</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>135</td>
<td>426.48mm</td>
<td>24.10</td>
<td>377.84mm</td>
<td>514.00mm</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>104</td>
<td>398.44mm</td>
<td>25.30</td>
<td>333.33mm</td>
<td>496.50mm</td>
</tr>
<tr>
<td>Bi-iliac breadth</td>
<td>Overall</td>
<td>137</td>
<td>266.80mm</td>
<td>15.23</td>
<td>217.00mm</td>
<td>299.67mm</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>83</td>
<td>270.51mm</td>
<td>14.56</td>
<td>240.00mm</td>
<td>285.67mm</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>54</td>
<td>261.09mm</td>
<td>14.58</td>
<td>217.00mm</td>
<td>299.67mm</td>
</tr>
<tr>
<td>Maximum femoral head diameter</td>
<td>Overall</td>
<td>238</td>
<td>43.59mm</td>
<td>3.43</td>
<td>33.17mm</td>
<td>53.67mm</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>134</td>
<td>45.61mm</td>
<td>2.75</td>
<td>37.33mm</td>
<td>45.67mm</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>104</td>
<td>41.00mm</td>
<td>2.79</td>
<td>33.17mm</td>
<td>53.67mm</td>
</tr>
</tbody>
</table>
Fig 4.2. Polynesian sample surface area to body mass ratio means. Groups are organized by longitude moving from Easter Island east to the Asian continent.

Fig 4.3. Alaskan sample surface area to body mass ratio means. Groups are ordered by descending latitude with Point Barrow having the highest latitude and Atka being located in the lowest for this group.
Comparisons by Sex: Alaska vs. Remote Oceania

Breaking the groups down into smaller groupings by sex created an even more interesting pattern. The female comparisons exhibited significant differences in the same measurements as the overall groups, namely surface area, and stature. The females also showed a significant difference in the surface area to body mass ratio. Maximum femoral head diameter measurements along with bi-iliac breadth measurements and stature to body mass ratios were shown to be not significantly different. Meanwhile, the male groupings also presented an interesting case. Males showed a significant difference in all measurements; surface area, stature, maximum femoral head diameter, and bi-iliac breadth, except surface area to body mass ratios and stature to body mass ratios.

What was most interesting about the male results was that the measurements which are not significantly different represent the measurements most commonly used to determine overall body morphology. While the females exhibited similarities in simple body breadth type of measurements, men showed an overall similarity in body type. Meanwhile, stature to body mass ratios are commonly accepted as a better illustration of body type than surface area to body mass ratios according to some researchers (Houghton, 1996). If this was the case, both groups, male and female, exhibit similarities in overall body physique. When taking this into consideration, the hypothesis of similarities in overall body type was supported. Thus, when examining the information from this study, depending on which measurement one prefers, these two populations can be considered very similar or different in overall morphology.

Similarities and differences can be witnessed through the assessment of the means of these measurements. Another examination of the means and variance for both the
Alaskan and Polynesian groups can be seen through histograms. Histograms were useful in illustrating the spread of the frequencies of each measurement, including the mean and variance. For this project, again, histograms for the overall groups were formulated along with smaller groupings by sex.

**Surface Area to Body Mass Ratio Comparisons**

First, the overall means for the two populations were examined in bar graphs, starting with mean surface area to body mass ratios (Fig. 4.4). This graph illustrated that the Polynesian population measured had a higher overall surface area to body mass ratio. For the point of this study, it is important to acknowledge exactly what higher and lower surface area to body mass ratios imply. Individuals with a higher surface area to body mass ratio are said to be more heat adapted than those with lower surface area to body mass ratios. A higher surface area to body mass ratio demonstrates a high surface area with a low body mass, thus a taller, leaner person. A low surface area to body mass ratio demonstrates a low surface area with a high body mass, thus, more short and stout. With this in mind, however, the Polynesian sample still had a lower surface area to body mass ratio than expected. To put this in perspective, the Tutsi of Sub-Saharan Africa, living at a latitude of 3 degrees, have a surface area to body mass ratio of 298.33 cm²/kg (Ruff, 1994). The Polynesian population has a surface area to body mass ratio of 277.12 cm²/kg while the Alaskan group has a surface area to body mass ratio of 273.87 cm²/kg.

Graphing the groups separately created a clearer picture of their similarities and differences. The spread of the frequency of each ratio helped to create a sense of the
Fig 4.4. Bar graph illustration of overall means of the surface area to body mass ratio of all populations.

population as a whole. Taking all measurements; surface area to body mass ratios, surface areas, bi-iliac breadth, maximum femoral head diameter, stature, and stature to body mass ratios, and producing histograms utilizing the frequencies of these measurements created a broad understanding of how the body types of both populations were similar. While some measurements were surprisingly different, I feel the trends that can be seen, especially in the males of both populations, are even more surprising.

When the groups were split and measured, the surface area to body mass ratios were obviously different when examining the histograms. The overall groups had a difference in their means of approximately 3.25 cm$^2$/kg. The Polynesian sample (Fig 4.5) had a larger overall surface area to body mass ratio than the Alaskan (Fig 4.6). The t-test illustrated these two populations were not significantly different. The Polynesian sample (Table 4.3) had a 95% confidence interval of 273.71 cm$^2$/kg to 280.02 cm$^2$/kg, while the Alaskan sample (Table 4.4) had a confidence interval of 272.24 cm$^2$/kg to 275.73 cm$^2$/kg.
Interestingly, the maximum surface area to body mass ratio was actually higher in Alaskans than in Polynesians. It is possible that this was due to the difference in the sample size of each population.

Table 4.3. Polynesian surface area to body mass measurement information.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Sex</th>
<th>Number</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>Standard Deviation</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface area to body mass</td>
<td>Overall</td>
<td>87</td>
<td>277.12</td>
<td>270.88</td>
<td>299.44</td>
<td>15.57</td>
<td>273.71</td>
<td>280.02</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>34</td>
<td>272.00</td>
<td>270.80</td>
<td>297.84</td>
<td>16.98</td>
<td>266.65</td>
<td>277.85</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>53</td>
<td>280.41</td>
<td>270.88</td>
<td>299.44</td>
<td>13.77</td>
<td>276.18</td>
<td>280.50</td>
</tr>
</tbody>
</table>

Table 4.4. Alaskan surface area to body mass measurement information.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Sex</th>
<th>Number</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>Standard Deviation</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface area to body mass</td>
<td>Overall</td>
<td>247</td>
<td>273.87</td>
<td>209.08</td>
<td>318.58</td>
<td>14.01</td>
<td>272.24</td>
<td>275.73</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>137</td>
<td>272.96</td>
<td>237.36</td>
<td>318.58</td>
<td>13.44</td>
<td>270.68</td>
<td>275.23</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>110</td>
<td>274.99</td>
<td>209.08</td>
<td>315.80</td>
<td>14.68</td>
<td>272.53</td>
<td>277.99</td>
</tr>
</tbody>
</table>

When the groups are further split, the female surface area to body mass ratios illustrated a similar trend as the overall sample. The difference in the means of the females was approximately 5.42 cm²/kg with the Polynesian sample (Fig. 4.7) having a larger surface area to body mass ratio. T-tests illustrated a significant difference in this measurement between the females. The Alaskan female sample (Fig 4.8) had a 95% confidence interval spread of 272.53 cm²/kg to 277.99 cm²/kg, while the Polynesian female sample had a spread of 276.18 cm²/kg to 283.50 cm²/kg. In the female sample, while the Polynesian minimum was much higher than the Alaskan minimum, the
Fig 4.5. Overall Polynesian surface area to body mass ratio histogram. The line illustrates the mean for this measurement.

Fig 4.6. Overall Alaskan surface area to body mass histogram. The line illustrates the mean for this measurement.
Fig 4.7. Polynesian female surface area to body mass ratio histogram. The line illustrates the mean for this measurement.

Fig 4.8. Alaskan female surface area to body mass histogram. The line illustrates the mean for this measurement.
Fig 4.9. Polynesian male surface area to body mass histogram. The line illustrates the mean for this measurement.

Fig 4.10. Alaskan male surface area to body mass histogram. The line illustrates the mean for this measurement.
maximum measurements for both groups were similar. Again, this may be due to sample size issues.

When the male surface area to body mass ratios were compared, however, the results were quite interesting. The difference in the means between the males was only 0.92 cm²/kg, with the Polynesian sample (Fig 4.9) actually having a lower surface area to body mass ratio than the Alaskan sample (Fig 4.10). T-tests illustrated that the males of these two populations were not significantly different. The Alaskan male sample had a 95% confidence interval spread of 270.68 cm²/kg to 275.23 cm²/kg while the Polynesian male sample had a spread of 266.65 cm²/kg to 277.85 cm²/kg. The Alaskan sample had a lower minimum and a higher maximum surface area to body mass ratios.

**Stature to Body Mass Ratio Comparisons**

While some researchers (Ruff, 1994) feel the surface area to body mass ratio is the best indicator of morphology, other researchers believe that the stature to body mass ratio provides a more accurate indication (Houghton, 1996). Stature to body mass ratios range from 2.6 for individuals from cold climates to values above 3.2 for warmer regions (Houghton, 1996). To put this into perspective, the Bushmen of Australia have a stature to body mass ratio of approximately 3.86, while cold adapted Remote Oceania populations have stature to body mass ratios of approximately 2.22 (Houghton, 1996). If his research was taken into consideration, these Remote Oceania populations would be the most cold adapted of any other people on earth.

Following Houghton (1996), stature to body mass ratios were calculated for this project. When the broad group stature to body mass ratios were compared, the difference
between the group means was approximately 0.02, with the Polynesian sample (Fig 4.11) having the larger mean. T-tests illustrated that these two populations were not significantly different for this measurement. The Polynesian sample (Table 4.5) had a 95% confidence interval of 2.69 cm/kg to 2.80 cm/kg. The overall Alaskan sample (Fig 4.12) had a 95% confidence interval of 2.74 cm/kg to 2.83 cm/kg. (Table 4.6)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Sex</th>
<th>Number</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>Standard Deviation</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stature to body mass</td>
<td>Overall</td>
<td>87</td>
<td>2.75</td>
<td>2.01</td>
<td>3.36</td>
<td>0.27</td>
<td>2.69</td>
<td>2.80</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>34</td>
<td>2.63</td>
<td>2.01</td>
<td>3.28</td>
<td>0.28</td>
<td>2.54</td>
<td>2.72</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>53</td>
<td>2.83</td>
<td>2.04</td>
<td>3.36</td>
<td>0.23</td>
<td>2.76</td>
<td>2.88</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Sex</th>
<th>Number</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>Standard Deviation</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stature to body mass</td>
<td>Overall</td>
<td>247</td>
<td>2.73</td>
<td>2.12</td>
<td>3.59</td>
<td>0.25</td>
<td>2.74</td>
<td>2.83</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>137</td>
<td>2.69</td>
<td>2.12</td>
<td>3.59</td>
<td>0.24</td>
<td>2.65</td>
<td>2.73</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>110</td>
<td>2.78</td>
<td>2.28</td>
<td>3.58</td>
<td>0.25</td>
<td>2.74</td>
<td>2.83</td>
</tr>
</tbody>
</table>

When the female stature to body mass ratios were compared they showed similar results. The difference in the two female stature to body mass ratio means was approximately 0.05 cm/kg, with the Polynesian sample (Fig 4.13) having the larger mean. T-tests illustrated that the females of these two populations were not significantly different. The Alaskan female sample (Fig 4.14) had a 95% confidence interval of 2.74 cm/kg to 2.83 cm/kg while the Polynesian sample had a confidence interval of 2.76 cm/kg to 2.88 cm/kg.
Fig 4.11. Polynesian group stature to body mass ratio histogram. The line illustrates the mean for this measurement.

Fig 4.12. Alaskan group stature to body mass ratio histogram. The line illustrates the mean for this measurement.
Fig. 4.13. Polynesian female stature to body mass ratio histogram. The line illustrates the mean for this measurement.

Fig 4.14. Alaskan female stature to body mass ratio histogram. The line illustrates the mean for this measurement.
Fig 4.15. Polynesian male stature to body mass histogram. The line illustrates the mean for this measurement.

Fig 4.16. Alaskan male stature to body mass ratio histogram. The line illustrates the mean for this measurement.
When the male stature to body mass ratios were compared, they were similar, resembling the female and overall samples. The difference in the two male stature to body mass ratio means was approximately 0.06 cm/kg, with the male Polynesian sample (Fig 4.15) having the smaller mean. T-tests demonstrated that the males of these two populations were not significantly different. The Alaskan male sample (Fig 4.16) had a 95% confidence interval of 2.65cm/kg to 2.73 cm/kg. The Polynesian male sample had a confidence interval of 2.54 cm/kg to 2.72 cm/kg. This, in accordance to Houghton (1996), illustrated that the male Polynesian sample was more cold adapted than the Alaskan sample when examining this measurement.

**Surface Area Comparisons**

When the surface area of the populations were examined, there was a noticeable difference once again. The overall population comparison illustrated means that were approximately 942.44 cm² different, with the Polynesian sample (Fig 4.17) having the larger surface area measurements. T-test results illustrated a significant difference between the groups for this measurement. The Polynesian sample (Table 4.7) had a 95% confidence interval of 16774.77 cm² to 17331.84 cm². The overall Alaskan sample (Fig 4.18) had 95% confidence interval of 16014.22 cm² to 16330.28 cm² (Table 4.8).

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Sex</th>
<th>Number</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Standard Deviation</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface area</td>
<td>Overall</td>
<td>87</td>
<td>17114.69</td>
<td>14214.96</td>
<td>21081.57</td>
<td>1428.99</td>
<td>16774.77</td>
<td>17331.84</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>34</td>
<td>18492.96</td>
<td>16931.75</td>
<td>21081.57</td>
<td>1068.26</td>
<td>18081.05</td>
<td>18785.14</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>53</td>
<td>16230.53</td>
<td>14214.96</td>
<td>17737.69</td>
<td>783.68</td>
<td>16028.09</td>
<td>16431.68</td>
</tr>
</tbody>
</table>
Table 4.8. Alaskan surface area measurement information.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Sex</th>
<th>Number</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Standard Deviation</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall</td>
<td>247</td>
<td>16172.25</td>
<td>12510.28</td>
<td>20416.09</td>
<td>1260.92</td>
<td>16014.22</td>
<td>16330.28</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>137</td>
<td>16789.70</td>
<td>13596.77</td>
<td>20416.09</td>
<td>1123.68</td>
<td>16599.85</td>
<td>16979.55</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>110</td>
<td>15403.25</td>
<td>12510.28</td>
<td>17497.41</td>
<td>967.92</td>
<td>15220.33</td>
<td>15586.16</td>
</tr>
</tbody>
</table>

The female surface area measurements followed the overall trend in surface area results. Between the two populations, the female surface area means were approximately 827.28 cm² apart, with the Polynesian sample (Fig 4.19) having the larger surface area mean. T-tests illustrated a significant difference between the two groups for this measurement. The female Alaskan sample (Fig 4.20) 95% confidence interval was 15220.33 cm² to 15586.16 cm². The female Polynesian sample had a 95% confidence interval of 16028.09 cm² to 16431.68 cm². Interestingly, the Alaskan females actually had a larger maximum value than the Polynesian sample.

The male surface area measurements, again, followed the overall trend in surface area results. Between the two populations, the male surface area means were approximately 1703.26 cm² different with the Polynesian sample (Fig 4.21) having the larger mean. T-tests demonstrated a significant difference between the two populations for this measurement. The male Alaskan sample (Fig 4.22) had a 95% confidence interval of 16599.85 cm² to 16979.55 cm² while the Polynesian males had a confidence interval of 18081.05 cm² to 18785.14 cm².
Fig 4.17. Overall Polynesian surface area histogram. The line illustrates the mean of this measurement.

Fig 4.18. Overall Alaskan surface area histogram. The line illustrates the mean for this measurement.
Fig 4.19. Polynesian female surface area histogram. The line illustrates the mean for this measurement.

Fig 4.20. Alaskan female surface area histogram. The line illustrates the mean for this measurement.
Fig 4.21. Polynesian male surface area histogram. The line illustrates the mean for this measurement.

![Polynesian male surface area histogram](image1)

Fig 4.22. Alaskan male surface area histogram. The line illustrates the mean for this measurement.

![Alaskan male surface area histogram](image2)
Stature Comparisons

The overall stature comparisons illustrated a similar trend with the surface area comparisons. The difference in the two populations overall mean was 8.42 cm for this measurement, with the Polynesian sample (Fig 4.23) mean being larger. T-tests showed a significant difference between the two populations. The Polynesian 95% confidence interval was from 167.20 cm to 171.14 cm (Table 4.9). The Alaskan sample’s (Fig 4.24) 95% confidence interval was 159.70 cm to 161.64 cm (Table 4.10).

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Sex</th>
<th>Number</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Standard Deviation</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stature</td>
<td>Overall</td>
<td>87</td>
<td>169.09</td>
<td>149.83</td>
<td>196.04</td>
<td>10.03</td>
<td>167.20</td>
<td>171.14</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>34</td>
<td>177.95</td>
<td>163.35</td>
<td>196.04</td>
<td>7.79</td>
<td>175.30</td>
<td>180.39</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>53</td>
<td>163.41</td>
<td>149.83</td>
<td>158.82</td>
<td>6.60</td>
<td>162.21</td>
<td>165.77</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Sex</th>
<th>Number</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Standard Deviation</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stature</td>
<td>Overall</td>
<td>247</td>
<td>160.67</td>
<td>139.60</td>
<td>187.91</td>
<td>7.80</td>
<td>159.70</td>
<td>161.64</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>137</td>
<td>165.18</td>
<td>152.38</td>
<td>187.91</td>
<td>6.26</td>
<td>164.12</td>
<td>166.24</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>110</td>
<td>155.21</td>
<td>139.60</td>
<td>168.08</td>
<td>5.72</td>
<td>154.14</td>
<td>156.27</td>
</tr>
</tbody>
</table>

The female stature comparisons were consistent with the trend in the stature measurements. The difference in the female mean measurements was 8.20 cm with the Polynesian sample (Fig 4.25) having a larger mean. T-tests demonstrated a significant difference between the females of the two populations. The Alaskan female (Fig 4.26) 95% confidence interval was 154.14 cm to 156.27 cm. The Polynesian female confidence interval was 162.21 cm to 165.77 cm.
Fig 4.23. Overall Polynesian stature histogram. The line indicates the mean for this measurement.

Fig 4.24. Overall Alaskan stature histogram. The line illustrates the mean for this measurement.
Fig 4.25. Polynesian female stature histogram. The line illustrates the mean of this measurement.

Fig 4.26. Alaskan female stature histogram. The line illustrates the mean of this measurement.
Fig 4.27. Polynesian male stature histogram. The line illustrates the mean for this measurement.

Fig 4.28. Alaskan male stature histogram. The line illustrates the mean for this measurement.
Male stature comparisons demonstrated the same tendency. The difference in the male means was the largest difference at 12.77 cm with the Polynesian sample having the larger mean (Fig 4.27). T-tests display a significant difference for the males of the two populations for this measurement. The Alaskan male 95% confidence interval (Fig 4.28) was 164.12 cm to 166.24 cm, while the Polynesian confidence interval was 175.30 cm to 180.39 cm.

**Body Mass from Bi-iliac Breadth Comparisons**

When examining the overall body mass from bi-iliac breadth measurements, an interesting result occurs. The difference in the means was 1.24 with the Polynesian population illustrating a larger mean (Fig 4.29). This indicates that the Polynesian population was broader and heavier than the Alaskan group (Fig 4.30). According to the t-test results, there was not a significant difference in this measurement between the two populations. The Polynesian confidence interval (Table 4.11) was 55.70 kg to 61.72 kg while the Alaskan confidence interval (Table 4.12) was 57.09 kg to 59.48 kg. The Alaskan maximum, interestingly, was almost 10 kg higher than the Polynesian sample. The comparison histograms provide a better illustration of the spread of the two populations.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Sex</th>
<th>Number</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Standard Deviation</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bi-iliac breadth</td>
<td></td>
<td>Overall</td>
<td>59.65</td>
<td>49.45</td>
<td>68.28</td>
<td>5.61</td>
<td>55.70</td>
<td>61.72</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>65.72</td>
<td>62.35</td>
<td>68.28</td>
<td>2.50</td>
<td>61.77</td>
<td>68.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>56.18</td>
<td>49.45</td>
<td>64.17</td>
<td>3.28</td>
<td>53.66</td>
<td>58.75</td>
</tr>
</tbody>
</table>
The female body mass estimation from bi-iliac breadth comparison illustrated the same trend as the overall sample. The difference in the population means was approximately 2.75 kg with the Polynesian sample (Fig 4.31) having the larger of the two means. These two measurements were not significantly different according to t-test results. The Alaskan female 95% confidence interval (Fig 4.32) was 52.05 kg to 54.80 kg while the Polynesian sample confidence interval was 53.66 kg to 58.75 kg. Again, the Alaskan maximum was higher than the Polynesian maximum.

The male groups demonstrated a different trend when examining this measurement. The difference in the means of the males of the two populations was 4.01 kg with the Polynesian sample (Fig 4.30) having the larger mean. T-tests illustrated a significant difference between the two male populations of these two groups. The Alaskan male sample (Fig 4.33) had a confidence interval of 60.35 kg to 63.08 kg. The Polynesian confidence interval was 61.77 kg to 68.32 kg. The Polynesian spread might have been skewed due to the small sample size of male bi-iliac breadth measurements.

**Body Mass from Maximum Femoral Head Diameter Comparisons**

Maximum femoral head measurements were easier to collect than the bi-iliac breadth measurements. Maximum femoral head diameter provided an estimate of body mass.
Fig. 4.29. Overall Polynesian bi-iliac breadth histogram. The line illustrates the mean for this measurement.

Fig 4.30. Overall Alaskan bi-iliac breadth histogram. The line illustrates the mean for this measurement.
Fig 4.31. Polynesian female bi-iliac breadth histogram. The line illustrates the mean for this measurement.

Fig 4.32. Alaskan female bi-iliac breadth histogram. The line illustrates the mean for this measurement.
Fig 4.33. Polynesian male bi-iliac breadth histogram. The line illustrates the mean for this measurement.

Fig 4.34. Alaskan male bi-iliac breadth histogram. The line illustrates the mean for this measurement.
mass for a large majority of the individuals measured. The overall comparisons illustrated an approximate difference in the mean measurements of 1.54 with the Polynesian sample (Fig 4.35) having a larger mean. These two measurements were not significantly different according to the t-test results. The Polynesian sample (Table 4.13) had a 95% confidence interval of 54.63 kg to 61.13 kg while the overall Alaskan sample (Fig 4.36) had a confidence interval of 60.19 kg to 62.34 kg (Table 4.14).

This implied that the Polynesian sample’s overall mass was greater than the Alaskan sample. When comparing the female body mass estimation from maximum femoral head diameter, the same trend occurred. The overall difference in the means was approximately 0.33 with the Polynesian sample (Fig 4.37) providing the smaller mean. T tests illustrated that there was not a significant difference between the two female groups. The female Alaskan sample’s (Fig 4.38) 95% confidence interval was 56.72 kg to 58.68 kg. The Polynesian sample had a confidence interval of 56.42 kg to 58.96 kg.

Table 4.13. Polynesian body mass by femoral head measurement information.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Sex</th>
<th>Number</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Standard Deviation</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femoral head</td>
<td>Overall</td>
<td>86</td>
<td>62.11</td>
<td>46.66</td>
<td>86.27</td>
<td>7.73</td>
<td>54.63</td>
<td>61.13</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>34</td>
<td>68.35</td>
<td>55.85</td>
<td>86.27</td>
<td>7.18</td>
<td>65.52</td>
<td>70.26</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>52</td>
<td>58.03</td>
<td>46.66</td>
<td>76.86</td>
<td>4.83</td>
<td>56.42</td>
<td>58.96</td>
</tr>
</tbody>
</table>

Table 4.14. Alaskan body mass by femoral head measurement information.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Sex</th>
<th>Number</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Standard Deviation</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femoral head</td>
<td>Overall</td>
<td>247</td>
<td>60.57</td>
<td>40.82</td>
<td>82.98</td>
<td>6.54</td>
<td>60.19</td>
<td>62.34</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>137</td>
<td>62.92</td>
<td>42.68</td>
<td>82.98</td>
<td>6.60</td>
<td>61.79</td>
<td>64.04</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>110</td>
<td>57.70</td>
<td>40.82</td>
<td>68.13</td>
<td>5.21</td>
<td>56.72</td>
<td>58.68</td>
</tr>
</tbody>
</table>
Fig 4.35. Overall Polynesian femoral head histogram. The line illustrates the mean for this measurement.

![Polynesian Femoral Head Histogram](image)

Mean = 62.10938
Std. Dev. = 7.734101
N = 89

Fig 4.36. Overall Alaskan femoral head histogram. The line indicates the mean of this measurement.

![Alaskan Femoral Head Histogram](image)

Mean = 60.57457
Std. Dev. = 6.538784
N = 245
Fig 4.37. Polynesian female femoral head histogram. The line illustrates the mean for this measurement.

Fig 4.38. Alaskan female femoral head histogram. The line illustrates the mean for this measurement.
Fig 4.39. Polynesian male femoral head histogram. The line illustrates the mean for this measurement.

Fig 4.40. Alaskan male femoral head histogram. The line illustrates the mean for this measurement.
As seen in the previous measurements, the male comparisons were the most different of the three. The overall maximum femoral head diameter difference in means was approximately 5.43 with the Polynesian sample (Fig 4.39) having the larger mean. T-tests illustrated a significant difference between the male groups for this measurement. The Alaskan 95% confidence interval (Fig 4.40) was 61.79 kg to 64.04 kg while the Polynesian confidence interval was 65.52 kg to 70.26 kg. It is easy to see, merely from the numbers, that the Polynesian males were significantly heavier than the Alaskan males.

**Outliers vs. Remote Oceania**

When examining an overall graph of the differences between each group (Fig 4.1), quadrants for Alaska and islands for Polynesia, I noticed a group of outliers in the Polynesian group that seemed to not belong in the overall group. These groups, from Sumatra, the Philippines, the Solomon Islands, and New Britain were fairly different than my other Polynesian populations. After further investigation, I found that these islands were not considered part of, or were on the very western regions of Remote Oceania. Due to this, the Polynesian results that were used in comparison to the Alaskan sample were the islands considered part of Remote Oceania which did not include these groups. When these outliers were removed, in all circumstances, the mean of the overall measurement changed (Table 4.15), but the t-test results stayed relatively the same except the overall surface area to body mass ratio. T-tests performed when these outliers were included resulted in a significant difference in surface area to body mass ratio. When these groups were removed, t-tests demonstrated these populations were not significantly
different in overall surface area to body mass ratios. When the histograms of the Polynesian group without the four groups listed above were compared with the histograms of the original group tested, only a slight change in most means was examined.

The surface area to body mass ratio mean between the original Polynesian and re-examined Polynesian groups changed by approximately 1.61 cm²/kg, with the original sample illustrating the larger of the two means. This would decrease the difference between the means, and the t-test results between the Alaskan and Polynesian samples changed as mentioned previously. When the stature to body mass ratio without the three groups was examined, there was a 0.11 cm/kg difference in the two means, with the original sample demonstrating a larger mean. This, however, does not change the results of the t-test, illustrating no significant difference.

With the surface area already illustrating such a large difference in the original samples, removing the three outlier groups had little effect on the t-test results. When compared to the original sample, the removal of these three groups only changed the mean by approximately 61.38 cm². The groups with the outliers removed demonstrated the larger of the two means. This still illustrated a significant difference when compared to the Alaskan sample through t-tests. Stature estimations also had no considerable change when these three groups were removed. When the means were compared, the Polynesian group that included the sample from the Philippine Islands, Solomon Islands, Sumatra, and New Britain was smaller by 0.08 cm. T-test results for this new mean illustrated a significant difference.
Table 4.15. Difference between overall Polynesian means when outliers are removed.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Mean measurement with outliers</th>
<th>Mean measurement without outliers</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface area to body mass ratio</td>
<td>278.73</td>
<td>277.12</td>
<td>1.61</td>
</tr>
<tr>
<td>Stature to body mass ratio</td>
<td>2.86</td>
<td>2.75</td>
<td>0.11</td>
</tr>
<tr>
<td>Surface area</td>
<td>17053.31</td>
<td>17114.69</td>
<td>61.38</td>
</tr>
<tr>
<td>Stature</td>
<td>169.17</td>
<td>169.09</td>
<td>0.08</td>
</tr>
<tr>
<td>Bi-iliac breadth</td>
<td>58.71</td>
<td>59.65</td>
<td>0.94</td>
</tr>
<tr>
<td>Femoral head</td>
<td>61.54</td>
<td>62.11</td>
<td>0.57</td>
</tr>
</tbody>
</table>

When bi-iliac breadth was re-examined, there was a difference of 0.94 kg in body mass with the group excluding the outliers having the larger mean. T-tests still illustrated that the Polynesian and Alaskan groups were not significantly different. Finally, when body breadth determined by maximum femoral head diameter was re-examined, there was a 0.57 change in the means. The group excluding the three samples had the larger of the two means. T-tests were consistent with the original groups, showing no significant difference.

**Comparisons between Southeast Asian Island, Melanesian, and Polynesian Island Populations**

When it was discovered that these groups, while being considered part of Polynesia in the institutions in which they were gathered, were not part of Remote Oceania, the idea of comparisons between these two groups to illustrate the similarities and differences was considered. The sample collected and labeled as Polynesian was, however, actually three different population groups. The Southeast Asian Island group
consists of the Philippine Islands, Sumatra, and New Britain while the Melanesian group consists of the Solomon Island population group. Polynesia, in this study, consisted of the populations from Easter Island, the Marquesas Islands, Chatham Islands and Taumotus Islands.

Interestingly, there seemed to be a significant variation in the Polynesian and Melanesian sample. With mean surface area to body mass ratios over 25 cm$^2$/kg different, these two populations were fairly different when looking at their body type. Meanwhile, the Southeast Asian Island group, while still slightly different than the Polynesian group, illustrated what was expected, a higher surface area to body mass ratio when compared to the more remote Polynesian sample (Fig 4.41).

Fig. 4.41. Polynesian Island sample compared to Melanesian sample and Southeast Asian Island sample.
When these results were broken down further into sex specific differences, the males indicated an interesting trend (Fig 4.42). The Polynesian male and Southeast Asian Island male measurements were within 5 cm²/kg of one another. This is interesting due to our overall results which illustrated that the male samples from the Alaskan and Polynesian Island populations were more similar in their surface area to body mass ratios. So the male population from Alaska, Polynesia, and the Southeast Asian Island group had similar surface area to body mass ratios (Fig 4.43). Also, in each group the male sample was more cold adapted, in accordance to their surface area to body mass ratios, than the female sample.

Fig. 4.42. Sex differences in surface area to body mass ratios in each of the three Pacific populations.
Fig. 4.43. Alaskan, Polynesian, Melanesian, and SE Asia Island male comparison.

The males in these populations illustrated, especially in the Polynesian and Alaskan comparison, surprising similarities. Between the Alaskan and Polynesian sample, there was only 0.961 cm²/kg difference with the Polynesian sample having the lower surface area to body mass ratio. When these groups were compared to the Melanesian and SE Asia Island samples, it was interesting to note that the male sample from the SE Asia Island group was more similar to, in the surface area to body mass numbers, the Alaskan sample than the Polynesian sample. The Alaskan sample had a mean of 272.96 cm²/kg while the Polynesian had a mean of 272.00 cm²/kg. The Melanesian sample, while only having one male individual measured, had a mean of 297.79 cm²/kg, which is significantly different from the Polynesian and Alaskan sample while the SE Asia Island group had a mean of 276.54 cm²/kg (Table 4.16). The confidence intervals overlap in all the male groups.
Table 4.16. Male sample raw number comparisons.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Population</th>
<th>Number</th>
<th>Mean Surface area to body mass ratios</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Standard Deviation</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Area/Body Mass</td>
<td>Alaskan Male</td>
<td>137</td>
<td>272.96</td>
<td>237.36</td>
<td>318.58</td>
<td>13.44</td>
<td>270.69</td>
<td>275.23</td>
</tr>
<tr>
<td></td>
<td>Polynesian Male</td>
<td>34</td>
<td>272.00</td>
<td>232.82</td>
<td>310.48</td>
<td>16.98</td>
<td>266.07</td>
<td>277.92</td>
</tr>
<tr>
<td></td>
<td>Melanesian Male</td>
<td>1</td>
<td>297.79</td>
<td>______</td>
<td>______</td>
<td>______</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td></td>
<td>SE Asia Island Male</td>
<td>2</td>
<td>276.54</td>
<td>273.18</td>
<td>279.89</td>
<td>4.75</td>
<td>233.90</td>
<td>319.18</td>
</tr>
</tbody>
</table>

While the males of these groups exhibited similarities, the females seemed to be quite different. As in the initial comparisons, they had higher surface area to body mass ratios when compared to the men (Fig 4.44). Also, the female comparison numbers were more variable than the male comparison numbers. The Alaskan female sample had a mean of 274.99 cm$^2$/kg while the Polynesian female sample had a mean of 279.84 cm$^2$/kg. Meanwhile, the Melanesian and Southeast Asia Island female samples had substantially larger surface area to body mass ratios. The Melanesian mean was 306.19 cm$^2$/kg and the Southeast Asia Island group had a mean of 301.84 cm$^2$/kg (Table 4.17). Confidence intervals illustrate overlapping among the Alaskan, Polynesian, and Southeast Asia Island groups while the Melanesian does not.
In all comparisons; overall, male, and female, the Melanesian sample had the largest surface area to body mass ratios. The difference between the overall Polynesian sample and the Melanesian sample was 26.97 cm²/kg. The male comparative difference was 25.80 cm²/kg and the female sample, with the largest difference, was 27.07 cm²/kg.
dissimilar. This was quite interesting when examining this situation geographically.

While this Melanesian population is located, according to some, within or on the outskirts of Polynesia, they possess significantly different body types. Remarkably, the Alaskan population, in comparison, was much more similar in this measurement. Unfortunately, due to small sample sizes, in all comparisons the Melanesian and Southeast Asia Island groups had very broad confidence intervals. Due to this small sample size, the interpretations of these comparisons may not be accurate.

**Regional Differences in Alaska by Latitude**

After re-examining the Polynesian sample, I felt it was also noteworthy to split the Alaskan group into regions based on latitude. This presented a more in depth image of morphology in the Alaskan region. Based on latitude, one could see a slight trend throughout Alaska. The northern populations would, hypothetically, be more cold adapted, having smaller surface area to body mass ratios. As one moves south, the temperature increases and it would expected to see a less cold adapted body.

Latitude throughout Alaska spans approximately 25-30 degrees. For the purpose of this project, I collected individuals from four latitude groups in Alaska (Table 4.18). I broke these four groups down, as closely as possible, into groups that would illustrate the difference in weather and climate patterns in Alaska. These groups were split into four regions, the high arctic, Group #1; the northern regions of the state, Group #2; the central to southern regions of the state, Group #3; and the southern region and southern islands, Group #4. I believe these breakdowns best exemplify the climatic areas in Alaska.

For Group #1, at approximately 75°N to 65°N, I collected 85 individuals. The
mean surface area to body mass ratio was approximately 269.56 cm²/kg (Table 4.19). This group illustrated surface area to body mass ratios considerably smaller than the Alaska group as a whole (Fig. 4.45). This was to be expected due to the severe conditions in which they lived and their subsistence activities. Their food gathering activities included whaling, seal hunting, and other actions in which they were exposed to very harsh cold elements of their area.

For Group #2, at approximately 64ºN to 60ºN, 89 individuals were measured. The mean surface area to body mass ratio (Fig 4.46) was approximately 276.74 cm²/kg. This demonstrated a very large difference between Group #1 and Group #2, with only a small distance separating them. Interestingly, of the 89 individuals measured, almost 30 of these individuals had surface area to body mass ratios between 270.00 cm²/kg to 280.00 cm²/kg which is a considerably high instance in an area as cold as this latitude. When compared to the Polynesian sample, Group #2 was merely 0.38 cm²/kg different in their overall surface area to body mass ratio.

Group #3 was consistent with the north to south gradient increase in surface area to body mass ratio. The mean surface area to body mass ratio for this group (Fig 4.47) was approximately 277.69 cm²/kg. Fifty six individuals were measured from this area between 59ºN to 55ºN. This group demonstrated an even closer mean measurement with the Polynesian group. These groups had an overall surface area to body mass ratio larger than the Polynesian sample by 0.57 cm²/kg.

The southern population of Alaska between 54ºN to 50ºN showed very interesting results. While only 18 individuals were collected from this region, it was still obvious that the area does not fit into the hypothesis of increasing surface area to body mass ratios
Table 4.18. Alaskan groupings based on latitude and the quadrants exact recorded latitude.

<table>
<thead>
<tr>
<th>Group #</th>
<th>Latitude Grouping</th>
<th>Location Quadrant</th>
<th>Exact Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>75°N – 65°N</td>
<td>Point Barrow</td>
<td>71.32°N</td>
</tr>
<tr>
<td>1</td>
<td>75°N – 65°N</td>
<td>Point Hope</td>
<td>68.35°N</td>
</tr>
<tr>
<td>1</td>
<td>75°N – 65°N</td>
<td>Teller</td>
<td>65.26°N</td>
</tr>
<tr>
<td>2</td>
<td>64°N – 60°N</td>
<td>St. Michael</td>
<td>63.478°N</td>
</tr>
<tr>
<td>2</td>
<td>64°N – 60°N</td>
<td>Holy Cross</td>
<td>62.20°N</td>
</tr>
<tr>
<td>2</td>
<td>64°N – 60°N</td>
<td>Russian Mission</td>
<td>61.79°N</td>
</tr>
<tr>
<td>2</td>
<td>64°N – 60°N</td>
<td>Sleetmute</td>
<td>61.70°N</td>
</tr>
<tr>
<td>2</td>
<td>64°N – 60°N</td>
<td>Baird Inlet</td>
<td>60.53°N</td>
</tr>
<tr>
<td>2</td>
<td>64°N – 60°N</td>
<td>Bethel</td>
<td>60.792°N</td>
</tr>
<tr>
<td>3</td>
<td>59°N – 55°N</td>
<td>Dillingham</td>
<td>59.05°N</td>
</tr>
<tr>
<td>3</td>
<td>59°N – 55°N</td>
<td>Nanek</td>
<td>58.74°N</td>
</tr>
<tr>
<td>3</td>
<td>59°N – 55°N</td>
<td>Afognak</td>
<td>58.00°N</td>
</tr>
<tr>
<td>4</td>
<td>54°N – 50°N</td>
<td>Unalaska</td>
<td>53.89°N</td>
</tr>
<tr>
<td>4</td>
<td>54°N – 50°N</td>
<td>Attu</td>
<td>53.50°N</td>
</tr>
<tr>
<td>4</td>
<td>54°N – 50°N</td>
<td>Atka</td>
<td>52.196°N</td>
</tr>
</tbody>
</table>

with decreasing latitude. The mean surface area to body mass ratio for this area (Fig 4.48) was approximately 268.15 cm$^2$/kg. The mean for this area was lower than the mean for the highest latitude group in Alaska. For the purpose of this study, these results were particularly interesting due to the similarities in the environment of the two populations, Polynesian islanders and Alaskan islanders. Both the Alaskan area and the Polynesian
area shared an island environment surrounded by cooler water conditions. This may indicate that this type of island environment, as proposed by Houghton (1996), does have a significant effect on morphology.

For further investigation of latitude changes, I broke each group down further into male and female subgroups. This was important due to the interesting results from the
overall Alaskan sample being compared with the Polynesian sample. For the purpose of this study, I only broke down surface area to body mass ratios due to its accurate portrayal of overall morphology (Ruff, 1994). These results provided further insight into the similarities and differences between the two populations.

For the latitude group between 75ºN and 65ºN, there were 35 females measured. The average mean for the females in this area (Fig 4.49) was approximately 271.51 cm²/kg. The male average mean (Fig 4.50) was approximately 268.19 cm²/kg. For this area, 50 male individuals were collected. In this case, the men would, when examining these numbers, be presumed to be more cold adapted than the females.

For Group #2, between 64ºN and 60ºN, the overall female mean was larger than the Polynesian overall mean. Forty females were measured in this area. The average mean for the females in this area (Fig 4.51) was approximately 280.15 cm²/kg. Males illustrated the same trend as the first group, possessing a smaller surface area to body mass ratio. I saw a very significant difference between the two sexes with the male mean (Fig 4.52) measuring only 273.96 cm²/kg. In this group, 49 male individuals were measured. This, as noted before, implied that the males in this area were considerably more cold adapted than the females.

Interestingly, the last two groups illustrated the opposite result. In both the southern groups, females, in accordance to the numbers, were more cold adapted. For Group #3, between 59ºN and 55ºN, 29 females were measured. The mean measurement for the females of this group (Fig 4.53) was approximately 275.28 cm²/kg. The males,
Fig 4.45. Alaskan sample surface area to body mass ratios in latitudes between 75°N and 65°N. The line illustrates the mean for this measurement.

Fig 4.46. Alaskan sample surface area to body mass ratios in latitudes between 64°N and 60°N. The line illustrates the mean for this measurement.
Fig 4.47. Alaskan sample surface area to body mass ratios in latitudes between 59ºN and 55ºN. The line illustrates the mean for this measurement.

Fig 4.48. Alaskan sample surface area to body mass ratios in latitudes between 54ºN and 50ºN. The line illustrates the mean for this measurement.
however, had a mean measurement (Fig 4.54) of approximately 280.27 cm$^2$/kg. In this region, there were 27 males measured. The females possessed a body type, when compared to the males of this group, which was more cold adapted according to the surface area to body mass ratios.

Finally, the southernmost group illustrated the largest difference between the sexes. In the female group, the approximate mean (Fig 4.55) was 261.78 cm$^2$/kg. Unfortunately, only seven females were measured from this group. However, even with such a small sample, the females of this area were definitely well adapted to a cold climate. The male group from this region also illustrated cold adapted bodies, but not nearly as obvious as the female measurement. The average mean (Fig 4.56) for the 11 males measured was approximately 272.20 cm$^2$/kg. This demonstrated a significant difference between the male and female groups of this area. The female mean implies that they were considerably more cold adapted than the men.

The trend in these male and female groups did not fit the stereotypical differences by latitude hypothesis. In the female groups, those from the lowest latitude had the lowest surface area to body mass ratios, followed by Group #1 from 75°N to 65°N, Group #3 from 59°N to 55°N, and then finally Group #2 from 64°N to 60°N with the highest surface area to body mass ratio. This result does not fit into the hypothesis of increasing surface area to body mass ratio with a decrease in latitude. The males followed the trend slightly better with Group #1 from 75°N to 65°N having the lowest surface area to body mass ratio, followed by Group #4 from 54°N to 50°N, Group #2 from 64°N to 60°N, and finally Group #3 from 59°N to 55°N with the largest surface area to body mass ratio. From these
Fig 4.49. Alaskan female sample surface area to body mass ratios in latitudes between 75°N to 65°N. The line illustrates the mean for this measurement.

Fig 4.50. Alaskan male sample surface area to body mass ratios in latitudes between 75°N to 65°N. The line illustrates the mean for this measurement.
Fig 4.51. Alaskan female sample surface area to body mass ratios in latitudes between 64°N to 60°N. The line illustrates the mean for this measurement.

Fig 4.52. Alaskan male sample surface area to body mass ratios in latitudes between 64°N to 60°N. The line illustrates the mean for this measurement.
results, it was obvious that Group #4 had the most cold adapted individuals collected in Alaska.

**T-test results**

T-tests were preformed utilizing analytical software, SPSS 13.0. Separate tests were executed for each measurement; surface area to body mass ratio, stature, bi-iliac breadth, maximum femoral head diameter, surface area, and stature to body mass ratio. For each of these measurements, an overall test was carried out and included all individuals from the samples. The groups were then divided by sex and tests were conducted for each measurement comparing the same sex group from both populations (e.g., mean surface area to body mass ratios of all females from the Alaskan sample were compared to the mean surface area to body mass ratios of all females from the Polynesian sample). The breakdown of the two populations into sex-specific groups provided an excellent view of both the variation and similarities between and within the populations.

For each t-test performed, the analytical software provided results illustrating whether the groups were significantly different or not (Table 4.20). The first step, however, utilized Levene’s Test of the Equality of Variances, and was included in the results gathered from each t-test. This test of equality was important in determining whether equal variances for each measurement should be assumed. This can be determined by examining the significance in the Levene’s Test. If this significance was larger than 0.05, equal variances should not be assumed. This was important due to a difference in the 2-tailed significance number in the overall t-test. In all tests in this project, equal variances were not assumed.
Examining the 2-tailed significance factor was the next step. When examining this number, again, if the value was less than 0.05 there was a significant difference, and if it is greater than 0.05 there was no significant difference. These differences were used to create groupings representing areas that were similar and different. From these t-tests, I created groups of similar populations, representing certain measurements. These tests illustrated that surface area to body mass ratios, body mass results, the bi-iliac breadth measurement and maximum femoral head diameter, and the overall stature to body mass ratios were not significantly different, except in the men who were significantly different in every measurement except surface area to body mass ratios and stature to body mass ratios. This illustrated similarities in body weight in the two populations while stature is different. Standards of error were also utilized in this study from t-test results.

Fig 4.53. Alaskan female sample surface area to body mass ratios in latitudes between 59ºN to 55ºN. The line illustrates the mean for this measurement.
Fig 4.54. Alaskan male sample surface area to body mass ratios in latitudes between 59°N to 55°N. The line illustrates the mean for this measurement.

Fig 4.55. Alaskan female sample surface area to body mass ratios in latitudes between 54°N to 50°N. The line illustrates the mean for this measurement.
Fig 4.56. Alaskan male sample surface area to body mass ratios in latitudes between 54ºN to 50ºN. The line illustrates the mean for this measurement.
Table 4.20. T-test results.

<table>
<thead>
<tr>
<th>Surface area/Body Mass Ratio</th>
<th>Number</th>
<th>P Value</th>
<th>Mean</th>
<th>SD</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Alaskan</td>
<td>248</td>
<td></td>
<td>273.87</td>
<td>14.01</td>
<td></td>
</tr>
<tr>
<td>Polynesian</td>
<td>87</td>
<td></td>
<td>277.12</td>
<td>15.57</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0.760</td>
<td></td>
<td></td>
<td></td>
<td>Not Significantly Different</td>
</tr>
<tr>
<td>Alaskan</td>
<td>137</td>
<td></td>
<td>272.96</td>
<td>13.44</td>
<td></td>
</tr>
<tr>
<td>Polynesian</td>
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<td></td>
<td>272.00</td>
<td>16.98</td>
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</tr>
<tr>
<td>Female</td>
<td>0.023</td>
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</tr>
<tr>
<td>Alaskan</td>
<td>111</td>
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<td>274.99</td>
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<td>53</td>
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<td>280.41</td>
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<table>
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<td>Polynesian</td>
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<td>10.03</td>
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<tr>
<td>Male</td>
<td>&lt; 0.001</td>
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<td></td>
<td></td>
<td>Significantly Different</td>
</tr>
<tr>
<td>Alaskan</td>
<td>137</td>
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<td>165.18</td>
<td>6.26</td>
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</tr>
<tr>
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<td>7.79</td>
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</tr>
<tr>
<td>Female</td>
<td>&lt; 0.001</td>
<td></td>
<td></td>
<td></td>
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</tr>
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<tr>
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<th>Overall</th>
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<td></td>
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<td>7.08</td>
<td></td>
</tr>
<tr>
<td>Polynesian</td>
<td>11</td>
<td></td>
<td>59.65</td>
<td>5.61</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0.037</td>
<td></td>
<td></td>
<td></td>
<td>Significantly Different</td>
</tr>
<tr>
<td>Alaskan</td>
<td>83</td>
<td></td>
<td>61.71</td>
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<tr>
<td>Polynesian</td>
<td>4</td>
<td></td>
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</tr>
<tr>
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<td>62.11</td>
<td>7.73</td>
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</tr>
<tr>
<td>Male</td>
<td>&lt; 0.001</td>
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<td></td>
<td></td>
<td>Significantly Different</td>
</tr>
<tr>
<td>Alaskan</td>
<td>135</td>
<td></td>
<td>62.92</td>
<td>6.60</td>
<td></td>
</tr>
<tr>
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<td></td>
<td>68.35</td>
<td>7.18</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.695</td>
<td></td>
<td></td>
<td></td>
<td>Not Significantly Different</td>
</tr>
<tr>
<td>Alaskan</td>
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<td>57.70</td>
<td>5.21</td>
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</tr>
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<td>Polynesian</td>
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<td>58.03</td>
<td>4.83</td>
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</table>

<table>
<thead>
<tr>
<th>Surface Area</th>
<th>Overall</th>
<th>&lt; 0.001</th>
<th></th>
<th></th>
<th>Significantly Different</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaskan</td>
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CHAPTER 5: DISCUSSION

The results of this study generally confirm a correlation of morphology between Remote Oceania populations, living in a warm climate, and Alaskan populations, living in cold environments. To my knowledge, my research is the first study to actually do a focused comparison of a Remote Oceania population sample and a cold climate population directly. The main discussion point is how these Polynesian populations achieved a cold adapted body type. From the results of the current study, it is easy to see that while this population does not necessarily possess cold adapted stature measurements, the body breadth of this group can be determined as cold adapted in the overall comparisons.

The results illustrate that the overall comparisons show similarities in the two body mass estimations; the bi-iliac breadth measurement and maximum femoral head diameter, and in the overall stature to body mass ratios, except in the men who are significantly different in every measurement except surface area to body mass ratios and stature to body mass ratios. These results demonstrate that the Polynesian populations studied were very heavy and had generally wide breadths. It has been said that, due to their environmental conditions with the cooler water and trade winds, that the insulation provided by body fat had a survival value in the founding of Polynesia (Houghton, 1996). However, the obesity of westernized Polynesians has led many researchers (Baker 1984, Beaven 1977), to believe that this heavier body type was not selected for until they reached Remote Oceania. Baker believed that while these voyagers would not have died from hypothermia on their voyages, the fat provided both insulation against the cold and
a store of calories used to deal with the metabolic heat production induced by the cold
climate (Baker, 1984).

An important point to note is the correlation between bi-iliac breadth and body
mass. Normally, when the issue of pelvic breadth variability is discussed, the focus is on
hominid evolution. The width of the pelvis has been noted as a point of interest in
bipedality. An increase in pelvic breadth has been researched due to its implications on
the gluteal abductors. For the purpose of my study, I utilized past research by
Christopher Ruff who examined bi-iliac breadth as an indicator of body mass.

In my project, basic surface area to body mass ratios were the main determinate of
morphology. The Polynesian group displayed a wide bi-iliac breadth which, according to
Ruff (1991), illustrates a wide body breadth. From his research, utilizing a cylindrical
model of human morphology, this wide body breadth correlates to a large body mass. Bi-
iliac breadth crosses the midline very close to a body’s center of gravity and is less
dependant on variation in limb or joint morphology than other body breadth
measurements (Ruff, 1991). The accuracy of bi-iliac breadth use in determining body
type is quite good. When surface area using stature, bi-iliac breadth and the cylindrical
model in living humans was compared to surface area calculated from Dubois and
Dubois (1916) formula, the correlation was very good with \( r = 0.89 \) and a slope close to
1.0. A similar analysis of body mass estimated as a cylinder versus true body mass gave
a correlation of 0.86 with a slope of 1.02 (Ruff, 1991).

From this, the application of the bi-iliac breadth measurement when used in body
mass estimation is quite accurate. For the purpose of this study, fat and muscle comprise
part of an individual’s overall body mass. An increase in either would present an
increase in body mass. From this idea, Ruff (1991, 1994, 2000) and Ruff et al (2004, 2005) formulated an equation from his bi-iliac breadth measurements that was highly accurate when determining body mass. While the body mass equation is slightly less correlated than the bi-iliac breadth alone, this creates a very accurate image of overall morphology.

While the overall results from this study were examined, the importance of male and female differences to this study was quickly noticed. While the females illustrated similarities to the overall group results, having similar stature to body mass ratios, bi-iliac breadth, and femoral head diameter measurements, the men’s similarities only included the stature to body mass ratio and the surface area to body mass ratio. These two measurements are usually the source of determining overall body morphology in skeletal remains. While researchers may dispute over which of these two measurements, stature to body mass ratios or surface area to body mass ratios, provide the most accurate description, it is noteworthy that the men of the two populations, when compared, were similar in these two measurements. This illustrates that, if the earlier research is accurate, these men have a body type that is not significantly different.

**Environmental Influence**

Houghton (1996) believes that for this Polynesian population, there is a secondary and indirect consequence of selection for muscle mass as an adaptation to the cold environment. He compared Polynesian and European children on sports teams in both areas. He noted that from the age of 12, the Polynesian children are ahead in stature, and predominantly in musculature. By the age of 17, the European group had matched the Polynesian average stature, but remained lacking in muscle mass. Along with this lack in
muscle mass, a smaller body breadth in European individuals has also been cited (Ruff, 1994). This difference is seen throughout the lifetime of these two populations. Houghton attributes this early development to a survival situation. He believes that this held a selective advantage in the past. Houghton also considers this early maturation an advantage in such a harsh environment. With the critical childhood period cut short, it provided survival security for these individuals.

Another issue when dealing with Polynesian morphology is muscle composition. Muscle fiber types in humans normally fall into two groups. Particular muscles have predominance for one or the other fiber type; however, muscles normally contain 50% of each type with an even distribution. Saltin and Gollnick (1983) suggest that “the large range of the percentages of ST (type I) and FT (type II) fibers observed in the population in these studies implies that for a certain percent of the population of males and females, their muscles are predominately of one or the other fiber type.” This variation appears to have a genetic basis. Muscle use in the maintenance of body temperature has been discussed readily, and according to Houghton (1996), the adaptation by people to the environment of Polynesia emphasized individuals with large muscle mass. Shivering utilizes muscle in an attempt to maintain body temperature. Type II fibers are used in shivering. Environmental influences in this region may have selected for muscle fibers accustomed to shivering, Type II. Interestingly, type II muscle fibers have been said to have a correlation with obesity. This is said to be due to the Type II muscle fiber’s inability to metabolize free fatty acids, which therefore are deposited as fat in the body (Staron et al 1984, Wade et al, 1990).
To further expand on this idea, how much fat was required to stay adequately warm in cold situations needs to be addressed. First, it is necessary to explain a common unit of measurement used in insulation studies. A Clo is a unit of insulation normally used when discussing clothing. One Clo is intended to represent the insulation required to keep a resting individual warm at an indoor temperature of 70º F. One Clo is equal to 0.155 m²K/W. Burton and Eldholm (1955) estimated that a thickness of 2.5 cm is required to provide one Clo of insulation. Another study suggested that merely one centimeter of fat would be required to provide one Clo of insulation (Rennie et al, 1962).

With this in mind, however, there is no evidence that native people active in cold environments have a tendency to accrue major quantities of subcutaneous fat. Studies performed by Elsner (1963) and Ducros and Ducros (1979) illustrate that the opposite is actually true. The Alacahuf Indians of Tierra del Fuego, Alaskan and Canadian Inuit, and Quechua and Arctic Indians demonstrate skin fold thicknesses that are actually less than modern westernized populations. If this fat was important for insulation purposes, this would not be seen. Another example of this can be seen in the Hae Ngo of Korea. These professional female divers wore only thin cotton clothing until about 20 years ago, and had a mean fat thickness considerably lower than the average Korean woman, due to exposure to cold water conditions (Rennie et al, 1962). This loss occurred only during the diving period. Once these women began wearing modern diving suits, they did not lose the fat. However, these examples indicated that a loss of fat is often seen when individuals are exposed to several weeks of cold.
Evolutionary Mechanisms

Thus far we have examined only the external factors that could have led to a cold adapted body type. While these factors are important, they are commonly debated due to the disagreement in the effects of the trade winds on these populations, along with the question of whether the time period of settlement, around 4,000 years before present, has provided sufficient time for such adaptations to occur on these remote islands. Due to this, I will discuss internal factors contributing to this body type. Various evolutionary mechanisms, including natural selection, which may or may not have been a factor due to the extended period of time in which natural selection occurs, genetic drift and especially founder effect which changes gene frequencies within a short period of time, and even dietary effects, play an important role in these adaptations.

Heritability of Traits

How much mingling occurred between the populations moving into Polynesia? This may create insight into the body types of these people due to the heritability of traits. However, the question of the heritability of body height and weight is an important first step in examining this issue. Normally, twin studies are used in heritability studies to gain the best understanding. While the environment plays a strong role in body physique, genetics plays a role also. Body height has been noted as being a classic example of a polygenic inherited trait, which is substantially influenced by the environment during fetal life, childhood, and adolescence (Sinclair, 1989). In 2003, a group of researchers carried out a twin study to examine the heritability of body height in European samples. Their results illustrated a correlation in identical twins ranging from 0.87 to 0.94 in males.
and from 0.84 to 0.94 in females. The corresponding fraternal twin correlations ranged from 0.42 to 0.60. There was substantial variation in mean body height, but there was little variation in the heritability estimates of body height (Silventoinen et al, 2003).

Body size in humans has been determined to have high heritability. Galton (1870, 1889, 1891) discussed the heritability of body traits extensively. It has been shown that height has an especially large heritability, even though it is a multifactoral trait. Not only are there many genes involved, such as genes for growth hormone, genes for the receptors on the outside of cells for growth hormone, genes for bone proportion, genes for the timing of the release of hormone and other growth factors, but there are also many interactions with the environment, including nutrition during the fetal stage and growth years, stresses, nutrition, and even exposure to chemicals such as cigarette smoke that are said to have an effect on height.

While the environment of this population was discussed in Chapter 1, the nutrition and dietary resources were not. Height and especially body mass have correlations to an individual’s diet and nutrition. In various twin studies (Stunkard et al 1986, Eveleth and Tanner 1990, Cavelaars et al 2000, Silventoinen et al 2003) the effect of good nutrition has shown positive effects on body height. Normally, these studies are based on socioeconomic status. The diet of the Polynesian population will be examined later in this study. With all of these factors, it appears that we are born with a genetic potential for height while also dealing with environmental aspects that determine our overall height.
**Gene Frequencies**

Gene frequency studies of Polynesian individuals have had a long history. After many years of these studies, a few traits became obvious. The rarity of blood group B is an example of the results from these long term studies. However, many researchers became interested in an approach that could trace the migration patterns and origins of this population. In both Cavalli-Sforza et al (1988) and Nei and Roychoudhury’s (1994) research they both constructed phylogenetic trees based on 42 polymorphic loci (Cavalli-Sforza et al, 1988) and 29 polymorphic loci (Nei and Roychoudhury, 1994). In both studies, the trees illustrated that the Polynesian populations split from a Southeast Asian cluster that includes southern Chinese, Thai, Filipino, and Indonesian areas. Their studies indicate that the entire population of this area had origins in approximately the same area.

**DNA Studies**

Deletions and base substitutions have been researched to determine the relationship between groups. Lum et al (1994) traced at least three distinct mitochondrial DNA groups in Remote Oceania. These groups demonstrate a common maternal ancestor of more than 85,000 years ago. Their analyses also recognize 10 or 11 separate maternal ancestors for Polynesia. Genetic heterozygosity in these founding populations would be required due to the short expanse of time in which we see new mutations.

Looking deeper into the DNA studies of the Polynesian people, we turn to nuclear DNA. Globin gene variants have been studied in this area over the past two decades. These studies, researchers have postulated, will help trace the relationships in the Pacific peoples. The normal hemoglobin molecule contains 2 globin types, alpha and beta. The
alpha globin is coded into four genes, two genes on each chromosome 16. Also on chromosome 16, two zeta globin genes are seen. This, Houghton (1996) describes as the embryonic alpha-like globin chain. On each chromosome 11, one beta globin gene is found on the short arm. Delta, gamma, and epsilon globins, which are produced in embryonic or early infant life, lie adjacent to the beta globins.

Identifiable segments of differing links, known as haplotypes, have been researched and about 30 of a very large number of possible haplotypes have been described. Of these 30, only seven are commonly found (Higgs et al, 1986). These are designated by numbers I-VII with differing subtypes. Haplotypes I and II are very common in most populations while III and V are rare. In Southeast Asia, haplotypes Ia, IIa and II d/e make up around 90% of the alpha globin haplotypes (Houghton, 1996). In Melanesia, however, these only make up less than 7% and haplotypes IIIa, IVa and Vc dominate.

In Polynesia, haplotypes III, IV, and V constitute 28% of the haplotypes in Tonga, 42% in Samoa, 36% in the Cook Islands, and 37% in Tahiti with the remainder being haplotypes I and II (O’Shaughnessy et al, 1990). When the alpha globin gene haplotypes are more closely examined in Polynesia, Samoans, Niueans and New Zealand Maoris illustrate limited diversity. These populations share six haplotypes in all. Hertzberg et al (1989) have commented that this is consistent with a common ancestral founding population.

From these genetic studies, there is no serious argument as to whether or not these people came from Asia. What is interesting is the question of these populations stopping in Near Oceania before moving onto Remote Oceania. Mitochondrial DNA, as well as
multiple loci gene frequency studies, has suggested a separate movement of the people who settled Australia and Highland New Guinea (Houghton, 1996). Polynesian populations share maternal lineages with some populations in coastal New Guinea and Island Melanesia, and Asia (Houghton, 1996). The 9-base pair deletion in the Americas suggests an antiquity of some 17,000 years and, assuming it to be the same, allows at least this time period to be seen in Polynesia. The nuclear DNA results illustrate clear evidence for considerable genetic mixing and presumably considerable time depth of contact between the ancestors of present Polynesian people and some of Island Melanesia (Houghton, 1996). Nuclear DNA findings suggest that the Polynesian genome had considerable ancestral residence in Island Melanesia.

**Founder Effect through Disease Frequencies**

These results are important to this study to gain an illustration of the ancestors of the Remote Oceania island populations. With Asian ancestors and the idea of ancestral residence in Island Melanesia, one can gain a general idea of the appearance of these original populations. In addition to these DNA studies, the idea of genetic drift or the founder effect, based on disease frequencies in these islands, needs to be discussed. The settlement of the Pacific must have been subject to the founder effect again and again. According to Houghton (1996), the founder effect situation would have illustrated the elimination of deleterious homozygotes; this situation favored the emergence of distinctive incidences of congenital defects, for example, cleft palate. The incidence of cleft palate is 1.87 per 1000 Maori compared with the New Zealand European incidence of 0.64 per 1000. In contrast to this, the incidence of cleft lip, with or without cleft palate, is 0.397 per 1000 in Maori compared to 1.195 per 1000 for Europeans (Chapman,
These figures illustrate that Polynesians are about three times more likely to be born with a cleft palate, but Europeans have the same tendency to have cleft lip when compared to the Polynesians.

Club foot is another example of a defect with similar patterns. The Maori figures are approximately 6.5-7 individuals per 1000 against 1-2 per 1000 births for New Zealanders of European ancestry. In Hawaii, the incidence was reported to be approximately 6.812 per 1000 births while the Europeans illustrated a 1.121 incidence and the Asian group measure illustrated a 0.567 per 1000 birth occurrence (Chung et al, 1969). Anencephalus and spina bifida, two neural tube defects, have been said to have genetic components (Elwood and Elwood, 1980). The rate of the defect spina bifida in Polynesia is significantly lower than those of other groups. In the Maori, there is an occurrence of 0.58 per 1000 births while the Europeans illustrate a 1.0 per 1000 rate. When the tropical Pacific is observed, the occurrence is remarkably lower still with a rate of 0.14 births per 1000. A similar trend is seen in the occurrence of anencephalus throughout Oceania.

A variety of the dental congenital defect, amelogenesis congenital imperfects is commonly seen in Polynesia. This is described as a distinctive patchy defect of mineralization of tooth enamel. The enamel is yellow to brown, chips frequently, and decays quickly (Houghton, 1996). This defect has been noted in the Maori, Cook Islanders, and Marquesans. Some 2% of Maori and Cook Islanders show this defect. Smillie et al (1986) claim that the pedigrees obtained are consistent with the abnormality being inherited as an autosomal dominant, the gene having abridged penetrance.
Frequencies of several tissue genetic systems in Pacific populations have been well documented. For the HLA (human leukocyte antigens) system, Hla-A1 and A3 along with HLA-B5, B8, B12, B17, and B27 are either completely absent or seen in very low frequencies in Polynesian populations. A2, A9, BW22, and B40 are more commonly seen in Polynesians. According to Houghton (1996), the processes of drift and possibly selection have shaped these distinctive patterns. Due to the use of these systems in body responses to disease, there may be clinical implications to this pattern also. Neale and Bailey (1990) suggested that Polynesians have a much higher risk than Europeans of developing chronic renal disease and it has been proposed that this vulnerability lies in the histocompatibility or immune response to gene frequencies.

Breaking these genetics studies down even further, we turn to the reading of the genome. Mitochondrial DNA has been studied to create knowledge of migration patterns and the connections between groups. Stoneking and Wilson (1989) concluded that a minimum of 16-19 mitochondrial DNA types initially colonized Australia. From Australia, a minimum of 14 females colonized highland New Guinea. For the Polynesian sample, there is a shift to a distinctive 9 base-pair deletion in the mitochondrial sequence.

The marker consists of a deletion of one of two copies of a 9-base pair sequence CCCCCTCTA in the non-coding region V of mtDNA, between the genes for cytochrome oxidase and TRNALys. In studies of DNA variation this has been named haplotype B. It has been found in an incidence of 16% in Japanese, 5% in Okinawans, 18% in East Asians (a mixed group dominated by Chinese and Filipinos), 42% in coastal New Guineans, and not at all in Highland New Guineans or Australian Aborigines. Subsequently Hertzberg et al (1989) established for this deletion an incidence of 14% in another group of coastal New Guineans, 8% in the Tolai of New Britain, 82% in Fijians and 93% through Polynesia. (Houghton, 1996)
What this occurrence implies is a distant link with contemporary Asian groups. Also, it illustrates evidence of the amplifying nature of the founder effect. This mutation has been dated as possibly prior to 21,000 years B.P and much before 10,500 B.P. This deletion has been used as a genetic marker to trace descent from peoples of East Asian origin. What this implies, if correct and representing the same mutational happening, is an antiquity in Asia for the common ancestor of both Pacific and New World groups. Also, it illustrates an extended time period for this mutation to have been in Island Melanesia.

**Nutritional Effects**

Anemia is a well documented problem in Maori and Polynesian children (Tonkin 1960, Akel et al 1963, Neave et al 1963, Cantwell 1973, Wood and Gans 1984, Moyes, O’Hagen et al 1990). Researchers have suggested that this may be a multifactorial problem. These researchers suggested that inadequate dietary iron, infections, gastrointestinal blood loss, and even growth patterns played a role in this issue. While these issues play a small role, the persistence of anemia in Polynesia has created a perplexing problem. Thalassaemia plays a vital role in the anemia issue in Polynesia. In Vanuatu, most anemias could be attributed to alpha-thalassaemia of the single-gene deficiency type, rather than to iron deficiency or parasitism (Bowden et al, 1985). When examining the alpha-thalassaemia gene, one must notice that while there is more than one type, both are very common in areas of Southeast Asia. The more common Polynesian type –α⁺, appears to have arisen in Near Oceania.

Another issue to examine when dealing with any anemia is malaria. Within Melanesia, the incidence of anemia is related to the presence of malaria. East of
Vanuatu, malaria does not occur and Fiji and New Caledonia are free of this parasite (Houghton, 1996). However, the blood polymorphisms that are said to offer a degree of resistance to the parasite are distinctive in Oceania. While these polymorphisms are commonly seen in Southeast Asia, it appears that the Pacific variants differ from those prevalent in Southeast Asia. Neither the sickle cell trait nor the absence of the Duffy blood groups, that elsewhere offer protection, are present in Oceania. Meanwhile, ovalocytosis wherein the red cell membrane appears to be rather unfavorable to the parasite is common (Houghton, 1996). So while their nutritional status and environment may play a role in the incidence of anemia in Polynesian children, there are evolutionary influences as well.

Metabolic disorders in native populations have been the subject of numerous studies in recent years. The westernized diet is often to blame for the tendency toward obesity in native peoples. Also, the westernized diet is said to be the main cause of non-insulin dependent diabetes in these populations. The evolutionary background must be studied to gain a full understanding of why this happens. As with most native populations with an exposure to a westernized diet, the major disorder in these populations is non-insulin dependant diabetes.

Non-insulin dependant diabetes is regularly looked upon as an effect of obesity. The rate of NIDDM rises with urbanization and change to the westernized diet. Some rates in Polynesian populations are as high 33.4% of Polynesian adults on some islands. When discussing the issue of NIDDM, the research performed by Neel (1962) is often mentioned. According to his research, the persistence of this tendency toward diabetes must have had an advantage at some point in time. The idea of rapid insulin production
to store calories during times of plenty was proposed. Neel (1976) revised his version determining that the primary event is insulin resistance which is partially inherited and partially acquired through a sedentary, overfed modern existence (Houghton 1996, Neel 1976). Individuals with rapid insulin responses secrete more insulin which exhausts the receptors, makes them fatter as individuals, and eventually exhausts the pancreatic cells. Hyperinsulinaemia is the innermost issue.

Along with obesity and NIDDM, abnormalities of uric acid metabolism are common in Polynesians. Having a uric acid level greater than 7mg% is referred to as hyperuricaemia. This is evident in 49% of Maori males and 42% of Maori females (Brauer and Prior, 1978). This problem can be seen throughout the South Pacific including Aamoa, the Cook Islands, the Tokelaus, and Tonga. A study of Hawaiians (Healey et al, 1966) illustrated that these levels were significantly lower in Hawaii than in the Maori, though still higher than in European groups. This disorder has also been related to an individual’s muscle mass (Brauer and Prior, 1978). An increase in lean body mass correlates with raised serum uric acid levels. Fessel and Barr (1978) concluded that with regard to raised levels of uric acid in the blood, it seemed reasonable to infer that muscle bulk played a role.

The increased effects of these diseases in Polynesia illustrate the influence of the founder effect or genetic drift. As mentioned before with Neel’s work (1962, 1976), the occurrence of these diseases may have been maintained due to compensating advantages. Unfortunately, research on Polynesian island diseases and the heterozygous and homozygous tendencies is very limited. Houghton (1996) suggests that the compensating factor in many of these diseases is a larger muscle mass, utilized to maintain body
temperature. This additional muscle mass has been related to many of the diseases in high prevalence in the Pacific.

**Cultural Practices and Sexual Differences in Physique**

External factors, including the environment in which an individual lives, and their diet, have an effect on their body type. The Polynesian environment, described in previous chapters, has had researchers, such as Houghton (1996), hypothesizing that this is the main determinant in the different body types of these islanders. This area of Remote Oceania illustrates cold trade winds that blow steadily from April until September. These winds play a vital role in Houghton’s hypothesis of this body type. What links this Polynesian population with the associated trade winds is their cultural habits. Leading a primarily maritime lifestyle, individuals in this area are constantly exposed to these winds coupled with wet conditions.

As in any island environment, fish and aquatic animals play a vital role in the Polynesian diet. In Tikopia, barracuda, Spanish mackerel, jewfish, and groupers are some of the largest fish these island people harvest and consume. These fish are usually gathered by individuals in small canoes or double canoes. A baited hook is dropped into the water at approximately 100 fathoms. To put this in perspective, 1 fathom is approximately 1.83 meters. This is an impressive feat due to the extreme size of some of these fish. The fisherman would be required to pull over 100 meters of fishing line up out of the water to catch an enormous fish normally weighing at least 100 pounds or more. For this exploit, an individual with little strength would probably have difficulty staying in the canoe. Strength would be required for such an activity.
When discussing Polynesian fishing, it is important to note that while searching for certain fish, such as bonito, a ceremony is conducted. Bonito were sizable and a prized food resource, and to catch one of these fish was a matter of pride (Firth, 1963). Bonito fishing was a competition between the men of this area due to the difficulty in catching one of these fish. The bonito is a very quick moving fish. Paddling a canoe to keep up and catch one of these fish was very difficult. For this reason, men are the only sex, by ceremony, who are allowed to attempt to catch these fish.

Women are considered taboo during a bonito ceremony and men are not allowed contact with them during that time. The night before his fishing expedition, a man is not allowed to sleep with a woman. As his canoe is being carried down to the beach, it is taboo for women to be present. This taboo also includes an exclusion of women from the fishing grounds. Traditional stories illustrate that whenever a woman was involved in this fishing ritual, there were no fish to be seen. In one of the stories, a chief of long ago did not appreciate this taboo and allowed his daughter out in his canoe. The fishing ground was quickly deserted by the fish. When the chief and his daughter returned to shore, the fish were following behind the canoe to return to the fishing grounds (Firth, 1963).

Many other stories relate sea creatures with women. An octopus is an example of how these sea creatures could victimize women. The octopus was concupiscent toward women. Various tales explained how lost girl children were taken away to be married by the octopus. Eels were also very dangerous to women. Eels, in their spirit form, were essentially concupiscent. Eels were also always conceived as males. Due to this, they were very dangerous to the women (Firth, 1963).
While sea food is very important to these populations, plant foods are the most important. It has been stated that in these islands, if fishing was impossible, the people could survive solely on their plant foods. However, if the crops fail, famine quickly occurs (Malinowski, 1935). Yams, taro, bananas, and coconut are the major agricultural resources on the islands. During a full year average, a man on the small island of Bellona is estimated to fish only 45 days for about 8 hours each day. Plant foods provide the necessary nutrition beyond fish.

Plant foods in Polynesia fall into two categories, trees and root crops. The trees are mostly natural and semi-cultivated at best while the root crops usually require extensive work. Coconut palm has been planted by the Polynesian people. This tree does not survive under 25º C, so this is a plant of the tropical strand. Not only does it provide food, but it also provides the materials commonly seen in Pacific technology. The sago palm tree, a staple in parts of its western distribution, is only used as a famine resource in the Pacific. Breadfruit, bananas and various species of pandanus provide additional dietary resources.

The root crops are even more important in this region. Taro, swamp taro, and yams form the staple of most diets. Due to the skill and technology it takes to cultivate these root crops, some researchers (Kirch, 1984) feel that for the first settlers, the sea was the major food provider. The sweet potato entered Polynesia around approximately 500 AD (Houghton, 1996). This has become a very important piece of the dietary picture for the Pacific Islanders. Few domesticated animals can be found in Polynesia, mostly pigs, chickens, and dogs, and some say the rat.
The diet of the Polynesian people has been scrutinized and studied by many researchers. Ross (1976) stated, about the Baegu of Malaita, that they were adequately nourished. He claimed their diet met or exceeded minimum daily requirements in every nutrient category. Even with their starch rich, low meat diet, the people still receive adequate protein, fat, vitamin and trace mineral intake. These people are healthy and well fed even though they have problems with chronic malaria and intestinal parasitism around 25%. Other researchers (Hornabrook 1977, Friedlaener 1987, Page et al 1987) have found similar results throughout Polynesia.

When examining dietary effects on stature, the issue of sexual dimorphism often comes into play. Some believe that male stature is more liable to reduce under poor conditions. Groups from Polynesia show a healthy dimorphism, however, which is another indicator of an adequate diet. The people of Remote Oceania illustrate a lesser sexual dimorphism than the populations of Near Oceania. The women of Remote Oceania are larger than average. This is unlikely based on the idea of malnutrition (Houghton, 1996). Houghton attributes survival to the environment and the ability to maintain this large body size in the women, due to ample food.

From examining the dietary effects on stature in Polynesia, one can see that their diet is adequate, but cannot fully attribute to their large size. While their diet may help maintain the current body size, it could not have been adequate enough to be the only factor in body morphology. The change in physique across the Pacific does not seem to rest on a transition from an inadequate to an adequate diet (Houghton, 1996). Something interesting that was acknowledged in the dietary issue, though, was the division of labor.
dictated by taboos in these Polynesian populations. This may be extremely relevant to the study results.

**Division of Labor**

The taboos in Polynesia for women are often strict and play off the idea that these women are unclean. They are not allowed in certain places during certain times, as mentioned previously. Along with the hunting taboos, women are also not allowed to walk over where food is prepared. They cannot eat food that has been beaten by a man. There is also a large range of foods that are forbidden to them. What's more is that their clothes cannot touch certain people or things within the community. These taboos invariably separate the women from the men in dealing with the meat gathering and processing. In other arenas, such as sexual aspects, there seems to be little taboo.

The division of labor when collecting dietary materials in Polynesia, with the men providing most of the very difficult to acquire foods, and the environment in which this is carried out is an important factor when comparing the two researched populations due to the fact that the Alaskan populations share in this division of labor. Men are the primary hunters and are the sex exposed to the harshest of elements. Women spend most of the time inside the house (Birket-Smith, 1959). Apart from cooking, their main work is removing the skin of the animals that are hunted and killed. With large animals such as whale or walrus, the women cure the skins and sew. Baskets and earthenware are made by women also.

Similar to the Polynesian population is the Alaskan taboo associating women and some animals or meat. While these Alaskan taboos are not nearly as harsh, they are still visible. For example, the inland tribes of northern Alaska treat the body of the brown
bear with great respect. Women and children, who are more likely to fall victim to evil, are not allowed to eat brown bear meat. Also, the caribou is very sensitive to women. As long as the summer caribou hunting lasts, they are not allowed to sew at this time.

Probably the most important taboo seen in Alaskan sexes is the taboo for childbirth and menstruation. For an entire month after childbirth, the mother is unclean. She is required to stay in her own house or tent and must refrain from eating certain foods. Also, she cannot mention animals of the chase by name. As seen with the Polynesian women, it seems as though the taboos separating women are mostly focused around the meat gathered from hunting activities, and the hunting activities themselves (Oswalt, 1967).

What exactly could this imply? If men from both populations are exposed to the harsh elements of their environment for long periods of time, they would be expected to have a more cold adapted overall body type than the women. As noted from Houghton (1996) the sea environment in which the men of Polynesia are exposed, is very harsh and very cold. While this cannot be the only factor involved in the body morphology of this population, it is interesting to note the similarities in the cultural idea between the two groups. In both, the men are the primary hunters and women are similarly not allowed a great deal of access to the meat provided. The men in both populations are sea faring and deal with the harsh environment of both the arctic temperatures and the Polynesian temperatures from the trade winds. Also, Polynesian male individuals are even more exposed to the cold elements of their environment due to the technology of their canoes. While these canoes are sturdy and reliable, they are not designed to keep an individual dry and warm. The Alaskan individuals have both technologically sound craft for their sea faring, but also clothing to keep them warm and dry.
Related to the above topic, when the Alaskan group was broken down further, the individuals from the islands of southern Alaska illustrated very low surface area to body mass ratios. Similar to the Polynesian situation, these individuals are surrounded by cooler water. With these islands having similar characteristics with the Polynesian islands, in both environment and subsistence activities, it is interesting that both populations, Alaskan and Polynesian Island people, are outliers in the Bergmann and Allen rules. Both populations utilize canoes to collect fish and have a primarily sea faring way of life. They are often exposed to ocean winds and the effects of the tides and currents. Another similarity is the population group size. In Alaska, the average population density is approximately four persons per one hundred square kilometers. Caribou hunters, arctic hunters and fishermen, and arctic whalers have an approximate population density of two per one hundred square kilometers. These small size population villages are similar to those of Remote Oceania. These similarities make the population comparisons particularly interesting.

While genetics or environment alone cannot determine a particular body type, the cultural similarities between the groups present an interesting phenomenon. The division of labor with men being the big game hunters in both groups may be a starting point in understanding the differences in morphology between the sexes. These island populations, perhaps, had these cultural complexes before they settled the islands. The men of Alaska, overall, are more cold adapted, according to the research collected, than the women, and the Polynesian sample illustrates this trend also. Future research would be required to gain a broader understanding of the exact similarities and differences between the groups and also between the sexes. I feel that the breakdown of the groups
into sex specific clusters may be the key to unlocking this phenomenon. Unfortunately, there is little research in relating the Polynesian population with other groups throughout the world. Drawing cultural illustrations and comparing them with various other regions can also be a vital key in the deciphering of the Pacific paradox.
CHAPTER 6: CONCLUSION

This project presented numerous anomalies in the basic idea of climatic differences and clinal distributions throughout the world. While the warm climate population residing in Polynesia would be expected to have warm adapted bodies, from the results of this project, one can see this is not the case.

Researching a population’s morphological variation is not merely examining their body type, but also examining their past and present lifestyle. Without the knowledge of cultural practices, background, migration patterns, and an idea of their place of origin, it is very difficult to understand some of the variation seen throughout the world. A multifactoral research project is required in this area to gain a full understanding.

Further research into the cultural practices of Polynesian females is required for the comprehension of their morphology. Most Polynesian research records provide very vivid explanations of male lifestyles, but few female accounts could be found that were as thorough. This is also an issue when dealing with the Alaskan female population. While both populations studied are commonly cited in research projects, research in these areas is few and far between, especially in Polynesia.

T-tests reveal interesting results in the measurements taken and cited. Whether one believes surface area to body mass ratios or stature to body mass ratios present a more accurate image of body type, this study demonstrates interesting results in both cases. Utilizing both these ratios along with all other measurements utilized provided a wide understanding of both populations and how they compared to one another. Future research on both the complex cultural background and measured morphology, which includes gathering a larger sample of Polynesian individuals, for Pacific populations is
necessary for further understanding of this interesting phenomenon known as the “Pacific Paradox”.
Bibliography


Dodd, Edward. 1972. *Polynesian seafaring; a disquisition on prehistoric celestial navigation and the nature of seagoing double canoes, with illustrations reproducing original field sketches, wash drawings, or prints by artists on the early voyages of exploration and occasional written reports from on-the-scene observers*. New York: Dodd, Mead & Company.


Firth, R. 1963. *We, the Tikopia*. Boston: Beacon Press.


