THE DIVERSITY OF NORTHWEST COAST SHELL MIDDENS: LATE PRE-CONTACT SETTLEMENT–SUBSISTENCE PATTERNS ON VALDES ISLAND, BRITISH COLUMBIA

by

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ABSTRACT

This study explores the nature of late pre-contact settlement-subsistence activity (1400/1000 - 200 B.P.) on Valdes Island, a large southern Gulf Island in the Gulf of Georgia region of the Northwest Coast. Settlement-subsistence patterns on Valdes Island demonstrate an economic orientation toward exploiting critical resource locations in the marine environment, specifically sandy intertidal environments and tidal streams, where populations aggregated to collect predictable, localized and abundant coastal resources, particularly shellfish and Pacific herring.

The diversity of shell middens (or shell matrix sites (cf. Claasen 1998)) on Valdes Island agree with patterns of logistical mobility indicative of a "collector strategy" (cf. Binford 1980). The majority of small-sized, shallow shell matrix sites on Valdes Island represent limited-activity sites, such as shellfish resource-processing locations and task-specific field camps, where specific, highly localized resources in the coastal environment were collected. Large, deep, highly-stratified shell matrix sites on Valdes Island - several of which are identified as ethnographic Central Coast Salish Halkomelem winter villages - represent long-term residential bases located to maximize access multiple, overlapping coastal resource zones in proximity to the tidal streams and sandy foreshore environments of the southwest coast.

This settlement study identifies an important strategy Central Coast Salish populations used to engage the highly variable, locally diverse nature of subsistence resources in the Gulf of Georgia was to strategically position settlement locations at dense, biologically-diverse marine micro-environments. This settlement strategy enabled these complex hunter-gatherer populations to generate economic surplus for subsistence, exchange and feasting, and provided the economic base for competition among elites.

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Chief Richard Thomas of the Lyackson First Nation first inspired the idea for this study during discussions with R.G. Matson in 1995 relating to the proposed *Gulf of Georgia Prehistoric Household Archaeology Project* at the Shingle Point site (DgRv 2), Valdes Island - the ancestral village of the Lyackson First Nation. I strongly thank both Chief Thomas and Herman Thomas of the Hulq'umin'um Treaty Group for their constant support and encouragement of this research - the participation and interest of the Lyackson community has provided meaning and purpose to this effort.

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CHAPTER 1 INTRODUCTION

Archaeologists have yet to systematically explore the range of past cultural behavior represented by the regional variability of shell matrix sites[1] on the Northwest Coast. Ethnographic and archaeological settlement pattern studies of shell matrix sites in several world regions have identified systemic variability in site formation processes (Barber 1983; Bird and Bird 1997; Buchanan *et al.* 1984; Claasen 1998:220-228); Lightfoot 1985; McNiven 1992; Meehan 1977; Waselkov 1987:115-117; Yesner 1977). The Northwest Coast's complex hunter-gatherer cultures have long been assumed to be the epitome of a "collector strategy" (Ames 1985; 1994; Lyman 1991; Matson and Coupland 1995:114-117), where centrally-located populations dispatch small, task-specific groups to manage conflict in the scheduling of seasonal, disparately-located subsistence resources in the environment (Binford 1980); however, settlement pattern research has yet to significantly contribute to this discussion.

In this study, I explore the nature of late pre-contact settlement and subsistence activity on Valdes Island, a large southern Gulf Island in the Gulf of Georgia region on the Northwest Coast (*Figure 1*).

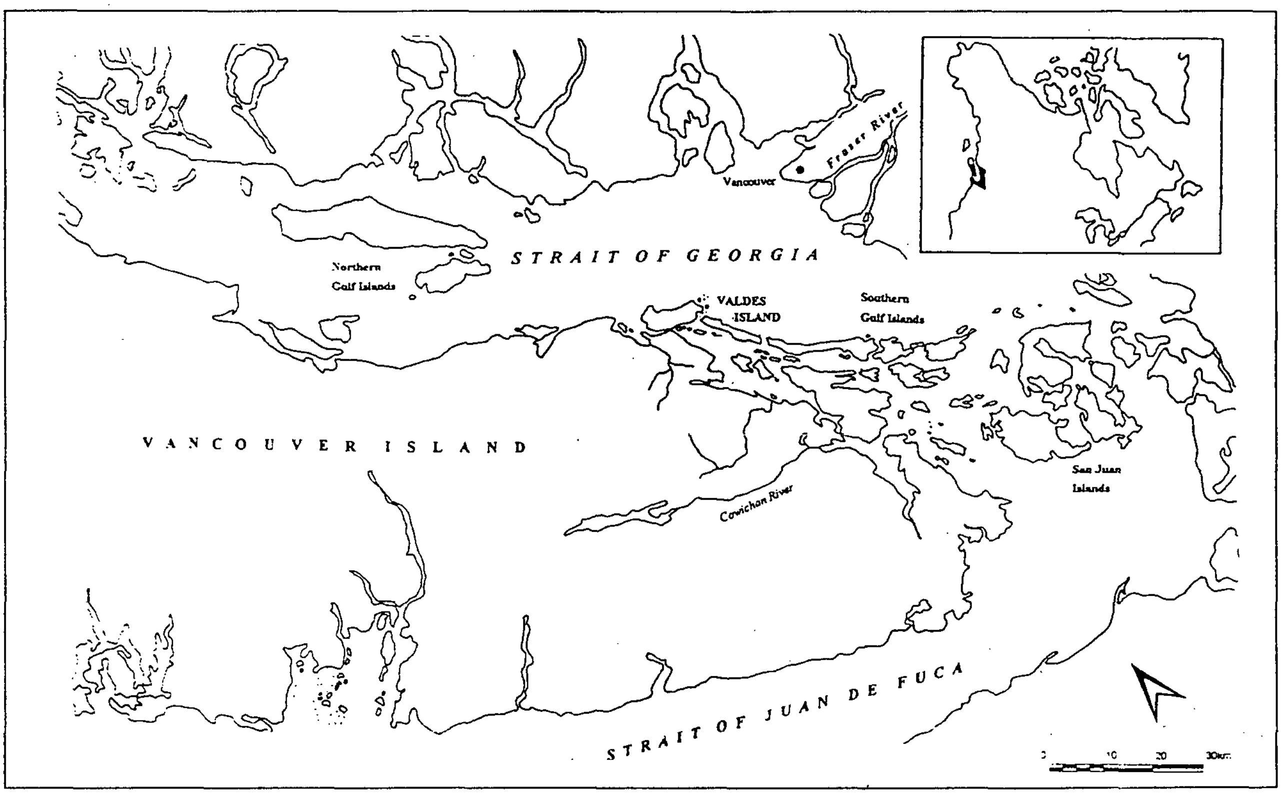

Figure 1 Valdes Island in the Gulf of Georgia Region, Northwest Coast

[1] Following Claasen (1998), I employ the neutral term *shell matrix site* to emphasize the behavioral variation inherent in the formation of archaeological shell deposits, or shell middens.

The history of archaeological research in the region has primarily been site-specific, focused toward the investigation of large, shell matrix sites to address questions of culture history (Borden 1970; Carlson 1960; Carlson and Hobler 1994; Matson 1976; Mitchell 1971a; Smith 1907). The approach of this settlement study is ecological in nature and comparative in focus, oriented toward exploring the relationship between archaeological site location and resource use across a complete southern Gulf Island landscape.

Discerning the nature of the ecological relationship between settlement locations and resource distributions in the environment involves several key issues, such as what critical subsistence resources were significant factors influencing the choice of site location, and how populations organized their regional settlement patterns to procure these resources. In this paper, I evaluate how shell matrix sites vary in relation to the distribution of critical resource locations in the marine environment. Secondly, I assess whether the nature of resource exploitation exhibited by shell matrix sites on Valdes Island is the product of a collector strategy.

I demonstrate that late pre-contact settlement patterns on Valdes Island exhibit an economic orientation toward exploiting productive coastal zones, specifically sandy intertidal environments and tidal streams, where populations concentrated upon the collection of predictable, localized and abundant marine resources, particularly shellfish and Pacific herring. Furthermore, I identify the specific, localized nature of resource use exhibited by the majority of shell matrix sites on Valdes Island to define limited-activity sites, such as resource-processing locations and task-specific field camps, which are distinguished from long-term residential bases, or ethnographic winter village sites, based on analysis of environmental location, archaeological features and faunal diversity. In essence, the nature of late pre-contact settlement-subsistence patterns on Valdes Island fits a collector strategy. This study, therefore, has important implications for understanding the nature of regional settlement-subsistence patterns in the Gulf of Georgia, discerning strategies of economic production on the Northwest Coast, and for considering ecological aspects of hunter-gatherer complexity.

ECOLOGY AND NORTHWEST COAST SETTLEMENT PATTERN RESEARCH

The Northwest Coast of North America is a diverse, physiographically-complex, maritime environment on the northeast Pacific Ocean. The complex hunter-gather cultures of the Northwest Coast are renowned in the anthropological literature for their relatively sedentary, hierarchically-organized societies, elaborate feasting and artistic institutions, based upon the economic intensification of natural resources in the environment (Ames 1994; Arnold 1996; Matson and Coupland 1995; Moss and Erlanderson 1995; Suttles 1990). Pacific salmon are understood to be the primary subsistence focus of Northwest Coast economies (Chrisholm 1986; Matson 1992); yet, the Northwest Coast environment provides a regional diversity of important subsistence resources that varied greatly in productivity and spatial and temporal distribution (Suttles 1968). How different Northwest Coast pre-contact populations structured regional settlement activity to schedule the procurement of the diverse set of critical subsistence resources across the physically-heterogeneous, seasonally-variable environment is currently not well understood.

Despite numerous large-scale archaeological survey projects, few regional settlement pattern studies presently exist on the Northwest Coast (Acheson 1998; Beattie 1995; Cranny 1975; Hobler 1983; Lepofsky 1985; Maschner 1997; Maschner and Stein 1995; Thompson 1978). A basic understanding of the nature of the relationships between archaeological site locations and the distribution of subsistence resources in the environment remains to be successfully approached by settlement pattern research.

Archaeological site location is often conceptualized as a positioning strategy to resolve problems in the physical and social environment (Binford 1980; Jochim 1976;1981). Hunter-gatherer behavior is understood to be strongly influenced by variation in subsistence resource abundance and the constraints of spatial and temporal resource distributions, including choice of selection of settlement location, as well as decisions concerning mobility, range and foraging group size (Bettinger 1991; Binford 1980; Cashdan 1992; Jochim 1976; 1981; Kelly 1995; Struever 1968; Winterhalder 1981).

Resources influencing the choice of site locations may vary within an environment; yet, it is reasoned that the lesser the economic risks and costs of exploiting a resource or resource patch in relation to the net yield, the greater the pull of the resource or resource patch for a population to settle (Jochim 1976:25). Thus, the greater the abundance and density of a resource and the lower its mobility (the lesser absolute distance traveled and the greater the spatial and temporal predictability), the greater the influence that resource/or resource patch possesses in choice of site location (Jochim 1976: 52-55). For example, many maritime hunter-gatherer cultures tend to locate settlements in proximity to highly accessible, low-risk subsistence resources which can be exploited at minimal cost, such as intertidal shellfish resources (Matson 1983;1985; Meehan 1977; Yesner 1977; 1980)

Matson (1983;1985) argues that Developed Northwest Coast societies focused settlement to control access to critical subsistence resources, specifically Pacific salmon, which were abundant, localized, and predictable in specific areas of the environment. Settlement and control over productive resource locations resulted in increasing sedentism and population densities in the region, which Matson (1983;1985) argues led to the development of social complexity on the Northwest Coast. Monks (1987) contends Northwest Coast populations focused upon the collection of a diversity of correlated, seasonal resources which could be harvested in mass from strategic locations. Monks (1987) suggests, for example, Northwest Coast populations targeted intertidal environments in late winter-early spring where an abundance of marine resources were attracted to prey upon spawning Pacific herring and its roe during seasonal resource blooms.

Recent geographic information studies of Northwest Coast sites have recognized significant associations between site locations and shoreline environments (Maschner and Stein 1995; Beattie 1995). Importantly, Maschner and Stein (1995) distinguish the majority of shell matrix sites in their region are located in association with sand/gravel beaches in contrast to rock/boulder coasts, which they interpret is a practical preference for canoe landing.

Concerns for maritime transportation, such as good beach sites for landing, were ethnographically important influences upon choice of site location on the Northwest Coast (Drucker 1951:10; Barnett 1955: 18; Suttles 1951:46). The development of advanced watercraft among maritime cultures in the region significantly reduced transportation and labour expenditures, which allowed populations to maximize subsistence efforts and increase social interaction and exchange (Arnold 1995). The efficiency of water transport is suggested to be an important factor that facilitated sedentism and encouraged a greater degree of logistical mobility among maritime hunter-gatherer cultures (Arnold 1995; Yesner 1980).

The Northwest Coast's ethnographic cultures have long been acknowledged to practice a collector strategy (Ames 1985; Lyman 1991; Matson and Coupland 1995:115-117). To resolve spatial and temporal conflicts in the scheduling of resources in the environment, Northwest Coast populations invested in storage technology, specialized fishing equipment and large-scale labour constructions, such as riverine weirs, to collect specific, critical resources that can be gathered in high quantity and stored for future consumption (Ames 1985; Matson 1992; Matson and Coupland 1995; Croes and Hackenberger 1988).

In the archaeological record, collector settlement patterns are expected to exhibit a variety of specific functional site types and high redundancy of settlement activity at centrally-located bases (Binford 1980). Site types associated with a collector strategy include long-term residential bases (the centre of habitation, processing and maintenance activities), and limited-activity sites, such as *locations* (specialized resource-processing sites), *field camps* (task-specific, short-term residential bases), *stations* (resource monitoring sites), and *caches* (Binford 1980). Limited-activity or task-specific sites, such as resource-processing locations and field camps, are predicted to be efficiently located in direct relation to specific resources, while more permanent residential bases are expected to be centrally located relative to a diverse set of resources to maximize subsistence returns (Plog and Hill 1971).

In contrast, a "forager" strategy is affiliated with small, highly mobile hunter-gatherers who utilize a "residential mobility" pattern, a positioning strategy which moves populations in direct proximity to opportunistically encountered food resources, which are gathered in limited, unstored quantities using expedient technology. Sites types associated with forager strategies include *short-term residential bases* and *locations* (Binford 1980). Archaeologically, forager's settlement patterns are expected to exhibit a generalized pattern of residential bases and locations and low redundancy of settlement across a landscape.

Lightfoot (1985) has profitably explored corresponding systemic differences in the regional diversity of shell matrix sites in eastern North America. Based on analysis of shellfish frequencies, artifact diversity and archaeological features. Lightfoot (1985) interprets different hunter-gatherer systems exploiting the same region, distinguishing collector settlement types (long-term residential bases and special-purpose sites) from forager settlements (short-term residential bases). Settlement-subsistence research integrating a comparative range of archaeological data from shell matrix sites, therefore, has the ability to greatly contribute to discussion of this key issue on the Northwest Coast.

Thompson's (1978) settlement pattern study of the Gulf of Georgia region tentatively suggests settlement activity became increasing specialized in late prehistory during the variously named *Late, Gulf of Georgia* or *Developed Coast Salish Phase* (1400/1000-200 B.P.)[2]. The introduction of limited-activity sites during this time period, as suggested by Thompson's (1978) artifact-based data, may reflect the development of logistical mobility and a collector strategy in late prehistory. The investment in large-scale house architecture during at least the Marpole Phase (2400-1400/1000 B.P.), however, indicates a high redundancy and continuity of settlement occupation existed earlier in the Gulf of Georgia (Grier 1998a; Matson and Coupland 1995: 208). Based on Frederick's interpretation of a "forager" strategy during the Charles Culture (4500 - 3300 B.P.), Matson and Coupland (1995:114-115) argue that a collector pattern of economic organization initiated earlier with the emergence of a salmon-based storage economy in the region during the Locarno Beach Phase (3300 - 2400 B.P.).

COASTAL RESOURCE ZONES AND NORTHWEST COAST SITE LOCATIONS

The nature and structure of the marine resource base has important implications for modeling hunter-gatherer behavior on the Northwest Coast. Regional marine diversity on the Northwest Coast is deeply enhanced by the local variability of its coastal habitats, which range from exposed outer coasts to protected, shallow-water coastal embayments, fjords, straits and estuaries (Tunnicliffe 1993). The rugged, physical nature of the coastal environment is further augmented by the highly seasonal, unpredictable nature of many marine resources (Suttles 1960). The locally diverse, variable nature of resource distributions within the Northwest Coast maritime environment create dense, spatially and temporally-disparate coastal resource zones, or micro-environments.

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[2] Uncalibrated dates. Late Phase chronology follows Matson and Coupland (1995) and Thom (1995)

Of these coastal micro-environments, the ecotone between the land and sea is one of Earth's most affluent biological zones (Ricketts *et al.* 1985:ix). The dynamics of intertidal and tidal environments create a great biodiversity of species where life must adapt to highly variable, demanding physical conditions to withstand submergence by tides, currents, wave action and exposure to rapid changes in temperature, oxygen, sunlight, moisture and salinity (Carefoot 1977:65-73). A diversity of marine invertebrates, marine fish and algae resources flourish in the fertile, shallow marine environment of the intertidal zone.

In a highly variable maritime environment, intertidal shellfish represent a stable, expedient subsistence resource (Croes and Hackenberger 1988; Perlman 1980:286; Yesner 1980). Shellfish resources are common in the diet of most ethnographic maritime-oriented hunter-gatherer cultures, as shellfish can withstand a relatively high culling rate and with proper management can form a productive, annual food supplement (Yesner 1980). The very low risk and level of labour investment is argued to make shellfish a critical subsistence resource (Perlman 1980; Yesner 1980).

Ecological and seasonal constraints exists, however, in both the spatial distribution and temporal availability of shellfish resources. Shellfish species vary spatially, both along the shoreline between different types of intertidal environments, and across the shore between different intertidal zones. Temporal variation exists in the availability of resources dependent upon the annual, monthly and daily tidal cycles in the region, which present highly predictable but confined windows of access for populations. Paralytic shellfish poisoning hazards during summer and fall months may have further constrained temporal access to shellfish. Shellfish resources, therefore, represent restricted, yet productive, spatially and temporally clumped resources, whose predictability and localized nature present an ideal focus for subsistence and settlement in a variable environment.

Yesner (1980) demonstrates many maritime-oriented ethnographic cultures located their settlements in close proximity to shellfish beds. Several ethnographic studies of modern shellfish foragers indicate that the low energy costs of shellfish gathering opposed to the high costs of transporting shellfish to a central locale strongly influenced the location of hunter-gatherer sites (Bird and Bird 1997; Meehan 1977). Meehan's (1977) research among the Gidjingali of northern Australia indicates that certain settlement types, such as temporary, "dinner-time" camps and processing sites were often located immediately adjacent to shellfish beds. Several archaeological studies of shell matrix sites have similarly noted the close correspondence between the shellfish content of archaeological sites and the modern locale's available shellfish resources (cited in Waselkov 1987:167-168). Therefore, the assertion that Northwest Coast populations located settlements in respect to the distribution of shellfish resources in the environment has many ethnographic and archaeological parallels from maritime cultures around the world.

Of equal distinction, marine tidal passages or tidal streams represent some of the most dynamic and biotically-diverse marine micro-environments on the Northwest Coast (Breen-Needham and Lash 1993). Due to the Pacific's tidal forcing through the intricate network of inner islands and channels, tidal streams illustrate high-density coastal resource zones, where the powerful ebb and flow of the plankton-rich tidal currents condense the regional diversity of the marine environment. The current-swept, nutrient-laden tidal streams support dense, perennial populations of marine life and, resembling riverine environments, channel seasonally migrating fish populations (Cranny 1975; Thompson 1978). Tidal streams and intertidal environments, therefore, represent primary production zones within regional marine ecosystems which possess immense potential for settlement and subsistence on the Northwest Coast.

ORGANIZATION OF CHAPTERS

In Chapter 2, I introduce the cultural and ecological context of the study area and describe the research design of the settlement pattern study on Valdes Island. In Chapter 3, I present the results of the environmental resource survey, and in Chapter 4 empirically evaluate the relationships between the location, size and content of shell matrix sites and the distribution of coastal resources and resource zones. I present two models to examine the respective roles of intertidal environments and tidal passes as foci for settlement location on Valdes Island. In Chapter 5, I assess the nature of shell matrix site diversity to explore the relationship between settlement activity and resource use. In the final chapter, I summarize and discuss the relationship between coastal resources and Central Coast Salish settlement patterns on Valdes Island, and suggest future directions of settlement pattern research.

CHAPTER 2 VALDES ISLAND ARCHAEOLOGICAL SURVEY

Valdes Island is a narrow, outer island of the southern Gulf Island archipelago in the Gulf of Georgia region, located 40km southwest of Vancouver, British Columbia (*Figure 2*). It is the fourth largest of the 77 greater and lesser southern Gulf Islands, measuring 15km in length, 1.5 to 4 km in width and totaling 2488 ha in size (Green *et al.* 1989:5). In this chapter, I introduce the environmental and cultural context of the study area and present the research design of the settlement pattern study on Valdes Island.

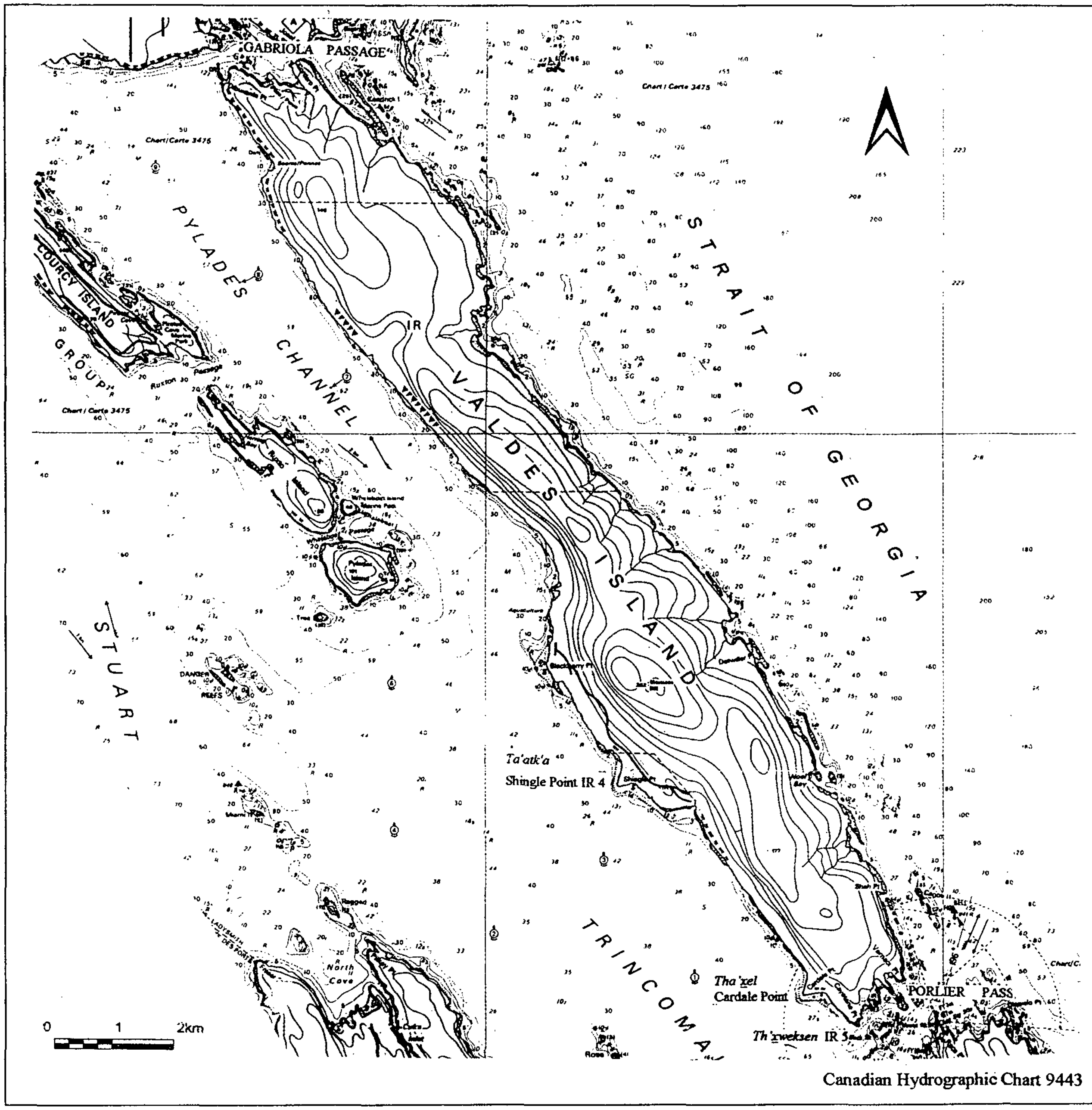

Figure 2 Valdes Island in the southern Gulf Island archipelago, British Columbia

ENVIRONMENT

Valdes Island is illustrative of the surficial geology of the late Upper Cretaceous Nanaimo Group, a succession of uplifted, folded, and glaciated sedimentary formations deposited between 96-66 Mya, which create a steep, rugged island landscape (Mustard 1994). The inner, west coast of Valdes Island is dominated by eroding sandstone cliffs underlain on the southwest coast by extensive sandy foreshores; in contrast, the outer, east coast is characterized by low, sloping rocky foreshores and shallow reefs exposed to the Strait of Georgia. The vigorous, narrow tidal passes of Porlier and Gabriola Passage frame the polar ends of Valdes Island where geologic breaks divide the island from, respectively, Galiano and Gabriola Islands.

In the rainshadow of the Vancouver Island Ranges, Valdes Island is situated within the unique climate of the Coastal Douglas-fir Zone, a warm, relatively arid environment host to many plant communities rare to the Northwest Coast (Nusdorfer *et al.* 1991). Important plant resources include fern roots, berry plants and several species of the lily family, notably camas (*Camassia spp.*) (Turner and Bell 1971). Terrestrial mammal populations, however, are sparse, aside from Coast blacktail deer (*Odocoileus hemionus*) and formerly Roosevelt Elk (*Cervus elaphus*) (Nusdorfer *et al.* 1991).

Immersed in the inner, coastal environment of the Gulf of Georgia region, however, Valdes Island is set in the centre of one of the most productive marine ecosystems on the Northwest Coast (Canada. Department of Fisheries and Oceans 1994; UBC Fisheries Centre 1998). Powered by the large estuarine inflow from the Fraser River watershed and by the Pacific's tidal, wind and oceanic forcing through the inlet (Thompson 1994:38), the sheltered Pacific waters of the Strait of Georgia and Puget Sound are the source of one of the largest anadromous fish populations in the world and harbor over 200 species of marine fish and 24 reported species of marine mammal (Calambokis and Baird 1994; Schmitt *et al.* 1994; UBC Fisheries Centre 1998). Pacific salmon (*Oncorhyncus spp*), in particular, engage in large-scale, seasonal migrations in late spring to late fall through the Gulf of Georgia into the Fraser River system and the region's smaller watersheds. These salmon migrations largely bypass Valdes Island, although some runs may occasionally border the east of the island to circuit the sediment plume of the Fraser River estuary (Canada. Department of Fisheries 1914:7).

In addition, the Gulf of Georgia region is one of the primary sources for the spawning of Pacific herring (*Clupea harengus pallasi*), a non-anadromous, marine fish considered one of the most important prey species in the ecosystems of the northeast Pacific (Haegele and Schweigert 1985; Schmitt *et al.* 1994:233). The southern Gulf Islands once formed critical spawning habitat for herring in the Gulf of Georgia, including Valdes Island's southwest coast and the kelp beds of Porlier and Gabriola Passages (Hay *et al.* 1989; Howes *et al.* 1993; Romaine 1981).

In respect to implications for regional settlement patterns, therefore, the terrestrial environment of Valdes Island presents few prolific or concentrated subsistence resources for populations to aggregate, while the marine environment exhibits a variety of dense, abundant resources to attract human settlement.

CENTRAL COAST SALISH ETHNOGRAPHY

The Central Coast Salish occupy the core of the Gulf of Georgia region - one of the early centres of social complexity on the Northwest Coast (Mitchell 1990; Suttles 1990). The Central Coast Salish Halkomelem[1], who maintained a broad sphere of cultural interaction from southeastern Vancouver Island to the Lower Fraser River watershed, are traditionally perceived as riverine-oriented cultures principally settled in the region's major watersheds to exploit anadromous Pacific salmon (Mitchell 1971a). General ethnographic descriptions of Halkomelem settlement-subsistence activities in the southern Gulf Islands describe highly seasonally mobile patterns of land and resource use. In early spring, households fissioned from winter villages on Vancouver Island's river valleys to resettle at owned, seasonal resource locations within the southern Gulf Islands. Small family groups constructed temporary camps built of light, bullrush mat shelters along the shoreline to collect a diversity of resources for household subsistence, including shellfish, herring, camas, deer and marine mammals (Barnett 1955; Curtis 1907; Drucker 1955; Grant 1857; Hill-Tout 1907; Jenness 1934-1935).

In contrast to this seasonal model of land-use, Valdes Island is the ancestral territory of the Lyackson First Nation - a small, Central Coast Salish Halkomelem group who resided at three permanent winter

[1] *Hul'qumin'um*, or Island Halkomelem, is the regional dialect of the Central Coast Salish Halkomelem language spoken on Vancouver Island. Halkomelem also incorporates *Halq'emeylem*, an upriver dialect, and *Hunq'uminum*, a downriver dialect.

villages of *T'a'at'ka7*, *Th'a'xel* and *Th'xweksen*, on Valdes Island (respectively, at Shingle Point, Cardale Point and Porlier Pass) (Rozen 1978; 1985; Sproat 1877; Suttles 1952). The Lyackson and neighbouring Penelakut villages on Galiano and Kuper Island were renowned among the Coast Salish for their tradition of marine mammal hunting, particularly for sea lion, and, more opportunistically whales (Lane 1953; Rozen 1978; 1985; Suttles 1952). Settlement-subsistence patterns on Valdes Island, therefore, may document alternative models of regional land use, which contrast the permanent settlement patterns of the Lyackson community with the highly seasonal settlement activity of household groups from neighbouring Vancouver Island.

The antiquity of Central Coast Salish ethnographic settlement patterns, however, demands definitive research. Although the Late Phase (1400/1000-200 B.P.) is believed to represent a continuum of the ethnographic pattern in the Gulf of Georgia, which terminates in the late 18th Century A.D. with the arrival of European explorers on the Northwest Coast (Matson and Coupland 1995; Mitchell 1971a;1990; Thom 1995), the early, large-scale effects of European contact on First Nation settlement patterns are well-documented for major areas of the Northwest Coast (Acheson 1998; Boyd 1990; Galois 1994). As argued by Harris (1997), the effects of pre-contact smallpox epidemic among Coast Salish cultures in the Gulf of Georgia resulted in massive depopulation, large-scale population movements, social and political disruption and inter-regional conflict. Important questions exist, therefore, about the nature of pre-contact land use and socio-economic organization in the Gulf of Georgia region. To advance this discussion, regional archaeological settlement pattern research can contribute to answering how pre-contact populations the utilized the regional landscape and resources through time in the Gulf of Georgia.

RESEARCH DESIGN

In cooperation with the Lyackson First Nation and in conjunction with the University of British Columbia's household archaeological investigations at the Shingle Point site (DgRv 2) (Matson 1998; Matson *et al.* 1999), I designed an archaeological survey (with the assistance of R.G. Matson and David Pokotylo) to investigate the nature of late pre-contact settlement-subsistence patterns on Valdes Island.

HYPOTHESES

Settlement-subsistence patterns on Valdes Island are argued to be strongly influenced by two main factors: 1) ecological variance in the distribution of critical resources and resource patches in the marine environment; and 2) systemic differences in the logistical organization of resource-processing, transport and settlement activities. Archaeological expectations include aspects of the location, size and content of shell matrix sites.

To evaluate whether the distribution of critical resources in the marine environment are significant foci for site location on Valdes Island, it is expected that: a) shell matrix sites will located in direct proximity to productive coastal zones; b) the size of shell matrix sites will increase in proximity to productive coastal zones; and c) the content of shell matrix sites will correspond to the types and relative proportions of available resources in the local coastal environment. Expectations will be tested using models of intertidal environments and tidal passes on Valdes Island.

Secondly, to assess whether the nature of resource exploitation on Valdes Island is consistent with a collector strategy, limited-activity sites, such as resource-processing locations and field camps, are expected to be: a) located directly in relation to specific, critical subsistence resources (Plog and Hill 1971); and b) demonstrate highly specific types of resources associated with a low richness and low evenness of resource diversity. In contrast, it is expected that long-term residential bases will be: a) located relative to a greater variety of critical resources (Plog and Hill 1971); and b) demonstrate both a generalized high richness and high evenness of resource diversity relative to limited-activity sites.

ARCHAEOLOGICAL INVENTORY

To evaluate the nature of past settlement-subsistence activity on Valdes Island, an archaeological survey was designed to inventory a representative sample of archaeological sites and collect archaeological and modern environmental resource data. Valdes Island is one of the few, large southern Gulf Islands unscathed by suburban development and offers a relatively intact set of archaeological sites preserved within their natural environment. To collect a representative sample of shell matrix sites on Valdes Island, the island landscape was divided into coastal and interior strata, assuming that past populations would utilize these distinct environmental zones according to different priorities. I directed a complete shoreline survey of the 50m-wide coastal strata, and the interior strata was systematically sampled using eleven 50m-wide transects to cross-cut the island landscape. As a second stage of sampling, systematic and judgmentally-located shovel tests and soil probes were employed along transects to detect and assess the boundaries of subsurface archaeological deposits.

In total, I defined 56 pre-contact archaeological sites on Valdes Island, which illustrate a range of cultural features, including house depressions, shell deposits, rockshelter habitations, burial remains, cultural depressions, isolated finds, and a defensive earthwork[2]. Shell matrix sites clearly dominate the types of archaeological sites located on Valdes Island - 45 sites (80% of archaeological sites) exhibit shellfish deposits. The geographic locations of these shell matrix sites are very homogeneous: all shell-bearing sites are in the coastal strata, situated at low elevations within 5m of the high tide line, on relatively flat ground, and within close distance to fresh-water streams [3].

Evidence of settlement activity within the interior of Valdes Island, in contrast, is very limited. Transect survey discovered only one archaeological site - a remote, small, inland rock shelter burial site. Two further interior sites - an isolated lithic find and another rock shelter burial - are recorded outside of the transect units. While the coastal strata represent the location of 95% (n=53) of all recorded sites and demonstrate a broad, diversified range of settlement activity, sites in the interior of Valdes Island appear relatively rare, highly dispersed in distribution and of very limited-activity in nature[4]. In nature and spatial distribution, settlement patterns on Valdes Island appear distinctly coastal in orientation.

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[2] For purposes of data resource management, these 56 sites are grouped into 44 Borden designations: multiple sites within these groups retain alphabetic subdivision (ex. DgRv 4c).

[3] Two exceptions to this general pattern derive from shell deposits within larger cultural features - a defensive earthwork (DgRv-1c) and rock shelter habitation (DgRw-64b) - which are located within 20m of the coast at slightly higher elevations on sloping ground.

[4] Due to repeated past timbering harvesting and forest fires, no pre-contact culturally modified trees (CMTs) were observed on Valdes Island which are useful for documenting interior land-use activity.

ENVIRONMENTAL INVENTORY

To obtain modern and archaeological environmental data, I directed two phases of research, which included: a) a coastal resource survey of Valdes Island of intertidal environments and marine tidal passes (Chapter 3); and b) an inventory of archaeological shellfish and faunal material.

The inventory of archaeological faunal material from shell matrix sites on Valdes Island involved the: a) surface survey of all 45 shell matrix sites to observe the presence/ absence of shellfish types (*Appendix 1*); and 2) small-scale test excavations at select sites to collect *in situ* samples of archaeological shellfish and faunal material for fine-grained analysis. In total, nine shell matrix sites on Valdes Island (n=20%) were sampled to collect archaeological faunal material[5] (*Appendix 3, 4*). Test excavation procedures utilized 50cm x 50cm units within intact shoreline archaeological deposits, excavated in natural layers cross-cut by arbitrary 10cm levels. Unscreened 9L matrix samples were collected from the topmost natural layers for laboratory shellfish analysis at UBC, which calculated both shellfish weights and minimum number of individuals (MNI) (*Appendix 3*). Rebecca Wigen and Susan Crockford of Pacific Identifications Ltd., Victoria, identified and conducted an analysis of all vertebrate remains (*Appendix 4*). In the absence of radiocarbon dates, I must assume all sites contain a recent component dating to the Late Phase (1400/1000-200 BP), and limit our data recovery and analysis to material collected from only the topmost identified prehistoric layers.

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[5] For a comparable faunal sample from Shingle Point (DgRv-2), I used a 9L matrix sample from Layer CO - Unit 108N/16E - a unit located on the shoreline berm immediately outside of excavated house depressions (Matson and McLay 1996; Matson *et al.* 1999)

CHAPTER 3 COASTAL RESOURCE SURVEY

1. INTERTIDAL ENVIRONMENTS

I directed the intertidal environmental resource survey of Valdes Island at annually extreme low spring tidal periods in the summer of 1996 and 1997 in order to generate expectations of archaeological sites' exploitation of their local environment. The present distribution of native shellfish types on Valdes Island are assumed to reflect the general distribution of shellfish resources in late pre-contact times; however, as the abundance of many native shellfish have been affected by commercial harvesting, marine pollution and competitive, introduced shellfish (Bourne and Chew 1994; Jamieson and Francis 1986), intertidal survey was limited to observing presence/absence data on the distribution of native shellfish types and identify physical shoreline types as representative intertidal habitats for distinctive types of shellfish resources. Data on the physical shoreline of Valdes Island is based upon the BC Ministry of Environment's *Coastal Resource Folio -Eastern Vancouver Island - Zone 7* (Romaine 1981) which provides detailed information on the coastal morphology of the southern Gulf Islands using the British Columbia Physical Shore Zone Mapping System (Howes *et al.*1994).

INTERTIDAL SHELLFISH RESOURCES

The systematic inventory of intertidal shellfish resources is limited to native species of archaeological relevance in the region (Hanson 1991: Table 9.1.1). These shellfish resources were inventoried within shoreline units (natural areas of homogenous shoreline character (Howes *et al.*1994)) in the immediate environment of shell bearing sites. This method is most practical for evaluating the nature of shellfish adapted to inhabit characteristic types of intertidal habitats. For purposes of analysis, 20 shellfish species are classified into 11 shellfish types (*Table 1*). These shellfish types are generalized into two basic categories which differentiate species of infauna, adapted to burrowing into shoreline sediments, and species of epifauna, which live on the surface of rocky shores (Carefoot 1977; Ricketts *et al.* 1985). I further differentiate four general types of shellfish species based on their behavior within these environments which have implications for patterns of shellfish procurement: 1) shallow-burrowing infauna; 2) deep-burrowing infauna; 3) sedentary epifauna; and 4) mobile epifauna.

Table 1 INTERTIDAL SHELLFISH RESOURCES INVENTORIED ON VALDES ISLAND

BEHAVIORAL CLASS	SCIENTIFIC NAME [1]	TYPE [2]	COMMON NAME
	SANDY INTERTIDAL ENVIRONMENTS		
SHALLOW-BURROWING INFAUNA			
Phylum Mollusca*			
Class Bivalvia			
Order Veneroida			
Family Veneridae	*Saxidomus gigantea* (Deshayes, 1855)	SAXIDOMUS	Butter Clam
	Protothaca staminae (Conrad, 1837)	PROTOTHACA	Pacific Littleneck
Family Cardiidae	*Clinocardium nuttallii* (Conrad, 1837)	CLINOCARDIUM	Basket Cockle
Family Tellinidae	*Macoma secta* (Conrad, 1837)	MACOMA	White Sand Macoma
	Macoma nasuta (Conrad, 1837)		Bent-nose Macoma
DEEP-BURROWING INFAUNA			
Family Mactidae	*Tresus capax* (Gould, 1850)	TRESUS	Horse Clam
	Tresus nuttallii (Conrad, 1837)		Pacific Gaper
	ROCKY INTERTIDAL ENVIRONMENTS		
SESSILE EPIFAUNA			
Order Mytiloidae			
Family Mytilidae	*Mytilus trossulus* (Gould, 1850) [3]	MYTILUS	Pacific Blue Mussel
Phylum Arthropoda			(formerly *Mytilus edulis*)
Class Cirripedia			
Order Thoracica			
Family Archaeobalanidae			
	Semibalanus cariosis (Pallas, 1788)	ARCHAEOBALANIDAE	Acorn Barnacle
	Balanus nubilus (Darwin, 1854)		Acorn Barnacle
MOBILE EPIFAUNA			
Phylum Mollusca			
Class Gastropoda			
Order Patellogastropoda			
Family Lottiidae	*Tectura scutum* (Rathke, 1833)	LOTTIIDAE	Plate Limpet
	Tectura persona (Rathke, 1833)		Mask Limpet
	Lottia pelta (Rathke, 1833)		Shield Limpet
	Lottia digitalis (Rathke, 1833)		Ribbed Limpet
Order Neogastropoda			
Family Nucellidae	*Nucella lamellosa* (Gmelin, 1791)	NUCELLA	Frilled Dogwinkle
	Nucella emarginata (Deshayes, 1839)		Ribbed Dogwinkle
Phylum Echinodermata			
Class Echinoidea			
Order Echinoida			
Family Stronglyocentroidae	*S. droebachiensis* (Mueller, 1776)	STRONGLYOCENTROTUS	Green Sea Urchin
	S. purpuratus (Stimpson, 1857)		Purple Sea Urchin
	S. franciscanus (Agassiz, 1863)		Red Sea Urchin
Phylum Mollusca			
Class Polyplacophora			
Order Neoloricata			
Family Mopaliidae	*Katharina tunicata* (Wood, 1815)	KATARINA	Black Katy Chiton

Notes:

1 Scientific and common names reference Coan et al. (1997), Harbo (1997) and Morris (1996)

2 Names of shellfish types follow Wessen (1994) using the lowest common taxonomic level

3 DNA studies of Pacific blue mussel populations identify the presence of three *Mytilus* species (*M.trossulus, M.edulis, M.galloprovincalis*). *M.trossulus* is concluded to be the native Pacific blue mussel species, in contrast to *Mytilus edulis* and *Mytilus galloprovincialis* which are both recent, introduced species (Koehn 1991; Koehn and MacDonald 1988)

* Several intertidal shellfish species of potential archaeological importance, such as geoduck (*Panopea generosa*), native oyster (*Ostrea conchophilla*) and Giant Pacific chiton (*Cryptochiton stelleri*), are not frequent in the environment on Valdes Island and were not observed in any archaeological sites. Further, I did not systematically examine species of crab (*Cancer spp*.) or octopus (*Octopus spp.*) due to the difficulty of systematically observing these species in the intertidal environment and their rare occurrence in archaeological sites.

TYPES OF INTERTIDAL ENVIRONMENT

Intertidal ecosystems are strongly influenced by three primary environmental factors: type of substrate, degree of wave shock, and the degree of tidal exposure (Ricketts *et al.*1985: 447-456). Of these three factors, type of substrate is the strongest influence determining the distribution of intertidal shellfish species, which are adapted to inhabit specific types of substrates (Ricketts *et al.* 1985: 450-453). Two basic types of intertidal environment are recognized in intertidal ecology, which contrast sandy and rocky foreshores (Carefoot 1977; Ricketts *et al.*1985). I further classify Valdes Island intertidal environments into six shoreline types based on the texture and form of shoreline unit's intertidal substrate provided by Romaine(1981), following definitions by Howes *et al.* (1994).

SANDY INTERTIDAL ENVIRONMENTS

Sandy foreshores (or sediment foreshores) on Valdes Island are dynamic, low to high energy shoreline environments composed of unconsolidated sediments deposited along protected bays or shoreline spits, which represent 11% of Valdes Island's coastline. Due to their generally low physical stress, these environments sustain a high diversity of highly competitive, prolific invertebrate species (Ricketts et al. 1985: 317). Shellfish which have adapted to inhabit sandy intertidal environments are generally species of infauna, such as clams with mobile, burrowing behavior and high reproductive rates. In the Gulf of Georgia, the major types of sandy intertidal shellfish resources of archaeological relevance include Butter Clam (*Saxidomus gigantea*). Pacific Littleneck (*Protothaca staminae*), Horse Clams (*Tresus capax; T. nuttallii*), Basket Cockle (*Clinocardium nuttallii*), and Sand Clams (*Macoma secta; M. nasuta*) (Hanson 1991).

SAND FLATS

Sand flats represent highly productive resource zones for intertidal shellfish resources, such as the shallow-burrowing clam genera, *Saxidomus. Protothaca. Clinocardium*, and *Macoma*, and in the lower intertidal zone deep-burrowing clams. such as *Tresus* and *Panopea*, and frequently Dungeness crab (*Cancer magister*). Eelgrass (*Zoster marina*). a perennial species of marine plant, often form thick beds on sand flats, providing a stable, meadow-like substrate which attracts a diverse community of marine invertebrates (particularly *Clinocardium*) and spawning marine fish, such as Pacific herring, species of gunnel (family *Pholidae*) and prickleback (family *Stichaeidae*). Other seasonally spawning marine fish at sand flats include the prey species Pacific sand lance (*Ammodytes Hexapterus*), surf smelt (*Hypomesus pretiosus pretiosus*) and capelin (*Mallotus villosus*).

SAND / GRAVEL FLATS

The sand/gravel flats on Valdes Island are productive habitats for shallow-burrowing clams, particularly *Protothaca* and *Saxidomus*. Boulder fields at sand/gravel flats create micro-environments for many rocky intertidal shellfish species (including octopus dens) and spawning habitat for species of marine fish, such as Plainfin midshipman (*Porichthys notatus*). Sand/gravel flats, therefore, represent a blend of sandy and rocky foreshore environments, which presents a broad diversity of intertidal resources, yet of lesser abundance than sand beaches and flats.

ROCKY INTERTIDAL ENVIRONMENTS

High to moderate energy, rocky intertidal environments represent 89% of Valdes Island's coastline. These rocky coasts sustain a wealth of intertidal biological diversity, and support sedentary, epifaunal shellfish communities, such as mussel (*Mytilus trossulus*) and acorn barnacle (family *Archaeobalanidae*), and alternatively a variety of more dispersed, mobile shellfish taxa, including limpets (family *Lottiidae*), whelk or dogwinkle (*Nucella spp.*), sea urchin (*Stronglyocentrotus spp.*), and black katy chiton (*Katerina tunicata*). Tide pools, boulders, and other surface irregularities similarly represent micro-habitats for diverse, unique assemblages of marine life, including a variety of shellfish, other invertebrates, small marine fish and a variety of important species of marine algae.

ROCK CLIFFS

Intertidal shellfish resources inhabiting rock cliff environments on Valdes Island are generally restricted to limited populations of the rocky intertidal shellfish, *Mytilus* and *Archaeobalanidae*, and on lesser inclines, *Nucella* and *Lottiidae*. The current-swept rock cliff environments at the tidal passes, however, represent productive resource zones for large populations of *Mytilus* and *Strongylocentrotus*.

ROCK RAMPS

Shellfish resources associated with rock ramps are similar to those in rock cliff environments, but are more accessible. This habitat is characteristic of rocky intertidal shellfish such as *Mytilus,Archaeobalanidae, Nucella*, and *Lottiidae*. These shellfish resources are generally found in the high to middle intertidal zone, especially within numerous fractures and crevices in the bedrock.

ROCK PLATFORMS

Intertidal rock platforms environments on the eastern coast of Valdes Island represent wide, horizontal low-tide terraces, which often have many surface irregularities - pitted with tide pools, crevices and surficial veneers of boulder and gravel. Rock platforms represent an important resource zone for a diversity of rocky intertidal shellfish, including large communities of *Mytilus* and *Archaeobalanidae*, and dispersed *Lottiidae, Nucella*, and *Katarina*. Tide pools and veneers of boulders and very shallow sediments atop rock platforms serve as protective habitat for species of invertebrates and marine fish. Rock platforms are identified as the most accessible and productive type of rocky intertidal environment on Valdes Island.

GRAVEL FLATS

While technically a type of sediment foreshore, gravel beaches are generally barren of intertidal shellfish resources due to severe wave shock and the turbulent nature of the substrate (Ricketts *et al.* 1985: 450). For this reason, the gravel beaches on Valdes Island are considered associated with the surrounding rocky intertidal environment.

2. TIDAL STREAM ENVIRONMENTS

Tidal forcing through the complex topography of islands and shallow sills in the Gulf of Georgia produces some of the strongest tidal currents in the world (Huggett 1988; Thompson 1994). Framing Valdes Island, Porlier Pass and Gabriola Passage are narrow, powerful tidal channels characterized by strong tidal currents which can reach maximum speeds, respectively, of 9.5 and 8.3 knots (Canada. Hydrographic Survey 1997: 78-85). The turbulent, upwelling cold Pacific tidal waters and warm, nutrient-rich inflow from the Fraser River watershed collide in these tidal passes to create primary production zones for plankton which stimulate a diversity of marine life. The rocky foreshores of the tidal passes strongly resemble more productive, wave-exposed, outer Pacific coasts as exhibited by their extensive kelp forests, and dense, abundant rocky intertidal shellfish populations of Pacific blue mussel (*Mytilus),* green, purple and red sea urchin (*Stronglyocentrotus* ssp.), and large acorn barnacles (*Archaeolbalanidae).*

Tidal streams illustrate rich, fishing locations for a diverse, perennial abundance of marine fish populations, particularly reef-dwelling groundfish, such as rockfish, greenling and sculpin (Breen-Needham and Lash 1993). Unlike island passes further south in the Gulf of Georgia, seasonal migratory runs of Pacific salmon enroute to the Fraser River system and lesser watersheds bypass Porlier or Gabriola Passages; nonetheless, these locations are recognized as important rearing areas for juvenile salmon (Canada. Department of Fisheries 1914; Howes *et al.* 1994a; Romaine 1981). The affluence of these marine environments – particularly during the late winter-early spring Pacific herring spawn – seasonally attracts large predatory marine mammals to the tidal streams, including Stellar sea lions (*Eumetopias jubatus*), seals, porpoise, and, less commonly, species of toothed whale. Several marine mammal haul out sites located adjacent to Porlier Pass are currently designated as marine protected areas (Romaine 1981).

SUMMARY

Intertidal environments are classified into two major types - sandy intertidal and rocky intertidal environments that contrast infaunal shellfish which burrow into sediments, and epifaunal shellfish which attach themselves to rocky substrates. Twenty shellfish species of archaeological relevance are inventoried on Valdes Island, which are generalized into 11 shellfish types and four behavioral classes. Sandy intertidal environments are identified as the most productive coastal resource zones, presenting highly-accessible, prolific, and concentrated intertidal shellfish and marine fish resources, particularly Pacific herring. The majority of Valdes Island's intertidal zone, however, represents rocky intertidal environments, that represent coastal resource zones of increasing lesser abundance, higher dispersion, and lesser accessibility relative to the steepness of their gradient. Yet, the rock cliff environments of Porlier and Gabriola Passages exhibit dense, productive rocky intertidal environments adjacent to flourishing kelp forests and plankton-rich, strong tidal currents. These tidal streams bordering Valdes Island represent biologically-diverse coastal resource zones which embody prime environments to target the regional diversity of marine life.

CHAPTER 4 ECOLOGICAL VARIABILITY

In this chapter, I evaluate whether shell matrix site locations on Valdes Island vary in relation to the distribution of critical coastal resources and resource locations in the marine environment. I examine whether shell matrix sites correspond to the distribution of: 1) shellfish and spawning fish resources at productive intertidal environments; 2) marine fish and marine mammal resources at tidal stream environments. To assess these hypotheses, I explore variability in the location, size and content of shell matrix sites on Valdes Island.

1. INTERTIDAL ENVIRONMENTS

LOCATION

If shell matrix sites are located to exploit productive intertidal resource locations, specifically sandy intertidal environments, it is expected that sites will be directly located at sandy intertidal environments in greater density than the relative length of these foreshores on Valdes Island. If shell matrix sites are not located in relation to productive intertidal environments, it is expected shell matrix sites will be located in frequencies equal to sandy and rocky foreshore environments' relative length of shoreline.

Figure 3 compares the frequency of shell matrix site locations (N=45) to the relative lengths of sandy and rocky intertidal environments on Valdes Island. Although sandy foreshores represent only 11% of the coastline, sandy intertidal environments are associated with the location of 58% (n=26) of all sites.

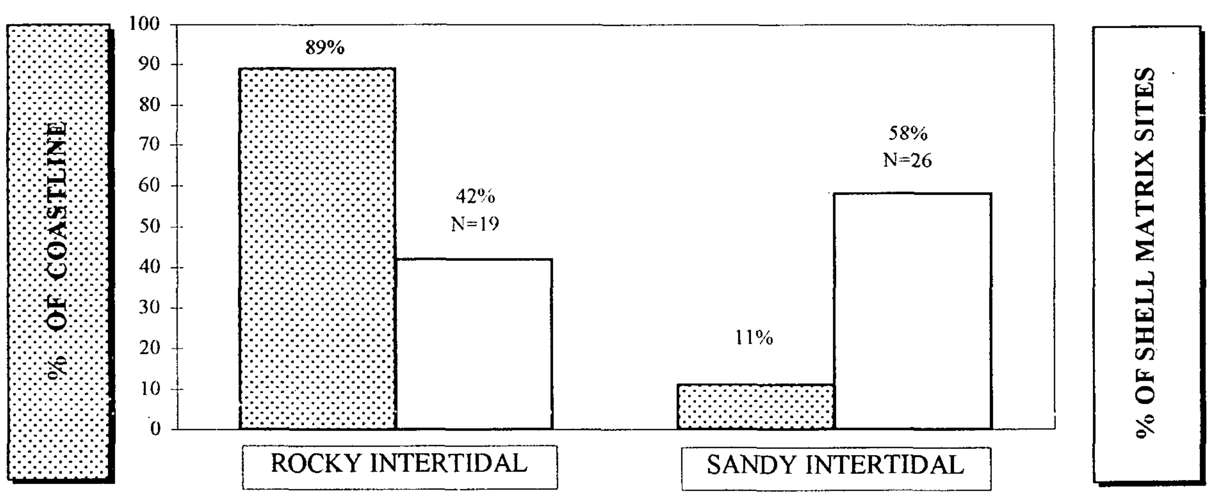

Figure 3 Shell Matrix Site Locations vs. Primary Intertidal Environments

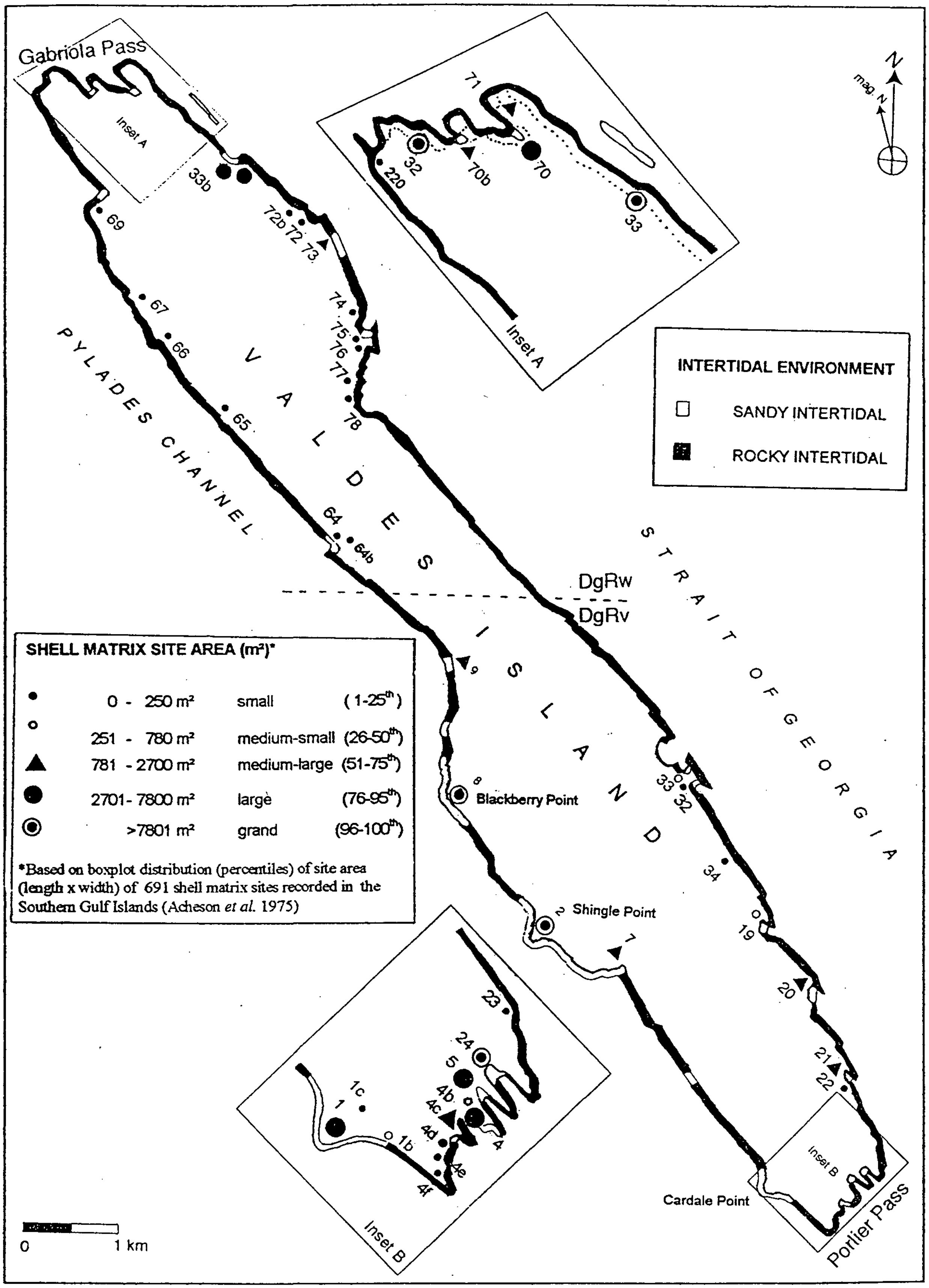

Figure 4 Shell Matrix Site Location and Size, Valdes Island

Susan Matson 1998

In contrast, while rocky foreshores account for 89% of Valdes Island's coastline, rocky intertidal environments are associated with only 42% (n=19) of all shell matrix sites. The site density of sandy intertidal environments (6.8 sites/km) is ten times the site density of rocky intertidal environments (0.6 sites/km). The difference between the observed and expected frequency of sites by the relative length of shoreline is highly significant at a 0.001 level of probability (x^2= 99.2, df=1, p=0.000). Shell matrix site locations on Valdes Island demonstrate very strong association with sandy intertidal environments.

To compare the distribution of sites across the six shoreline types, *Figure 5* illustrates the highest frequency of sites are located on sand flats (44%), which account for only 6% of Valdes Island's coastline. Similarly other productive intertidal environments, such as sand/gravel beaches and rock platforms, represent a minor 16% of the shoreline, yet contribute a further 25% of all site location. The difference between observed and expected frequencies of site location at productive intertidal environments (sand flats, sand/gravel flats, and rock platforms) and less productive intertidal environments (rock cliffs, rock ramps and gravel flats) compared to the grouped relative length of these foreshores are highly significant at a 0.001 level of probability (x^2= 56.7, df=1, p=0.000). The majority of shell matrix sites on Valdes Island, therefore, are located on a very small percentage of the coast in direct association with productive intertidal environments.

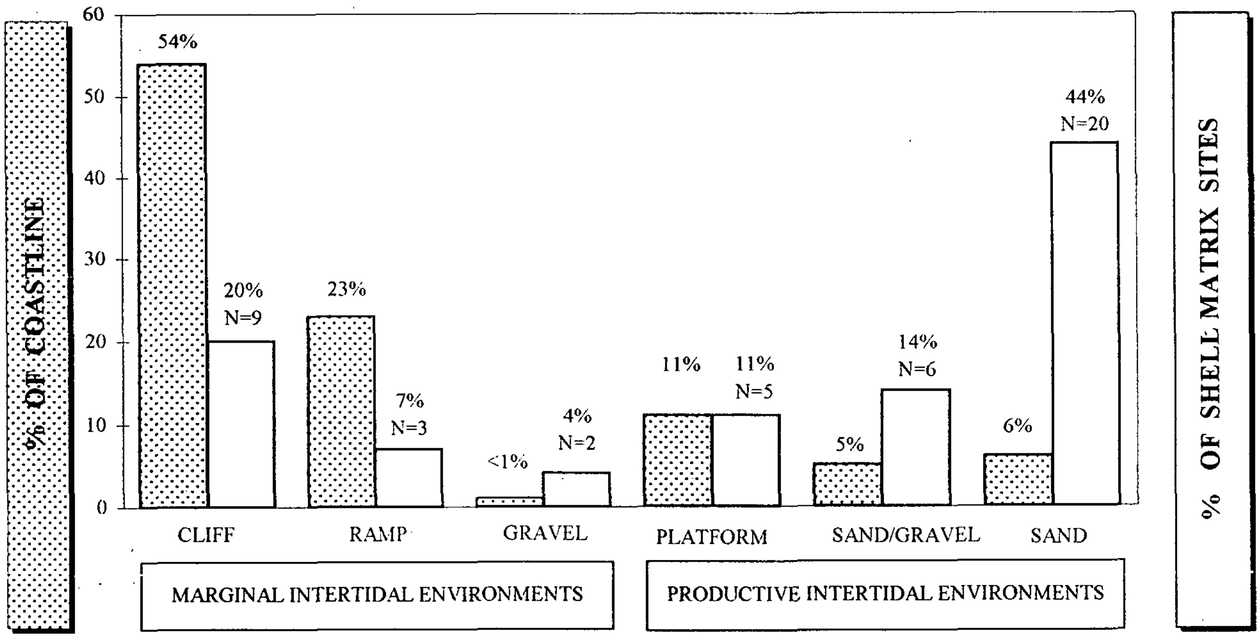

Figure 5 Shell Matrix Site Locations vs. Secondary Intertidal Environments

SIZE

To evaluate if the size of shell matrix sites are related to the intensity of intertidal resource use, I examine whether site area (m^2), as an approximate measure of site occupational intensity, increases in proximity to productive sandy intertidal environments. In general, shell matrix sites on Valdes Island (n=45) are small and illustrate a median size of only $500m^2$ with a low interquartile range of between $52m^2$ to $2675m^2$ (*Figure 6; Appendix 2*). Comparison of this distribution with resource management survey data from the southern Gulf Islands (Acheson *et al.* 1975) demonstrates this distribution is representative of the general size of sites in the region. Shell matrix sites recorded in the southern Gulf Islands (n=691) present a similar small median size of $780m^2$ and a low interquartile range of between $240m^2$ to $2700m^2$. The difference between these two distributions is not significant at a 0.05 level of criteria using a Mann-Whitney test statistic (U=13326.5, p=0.111). Although other settlement pattern studies on the Northwest Coast have arbitrarily classified shell matrix sites larger than $1000m^2$ as villages and lesser as more temporary settlements (Acheson 1998; Maschner 1997), I focus here upon examining the variability of size in relation to use of the environment.

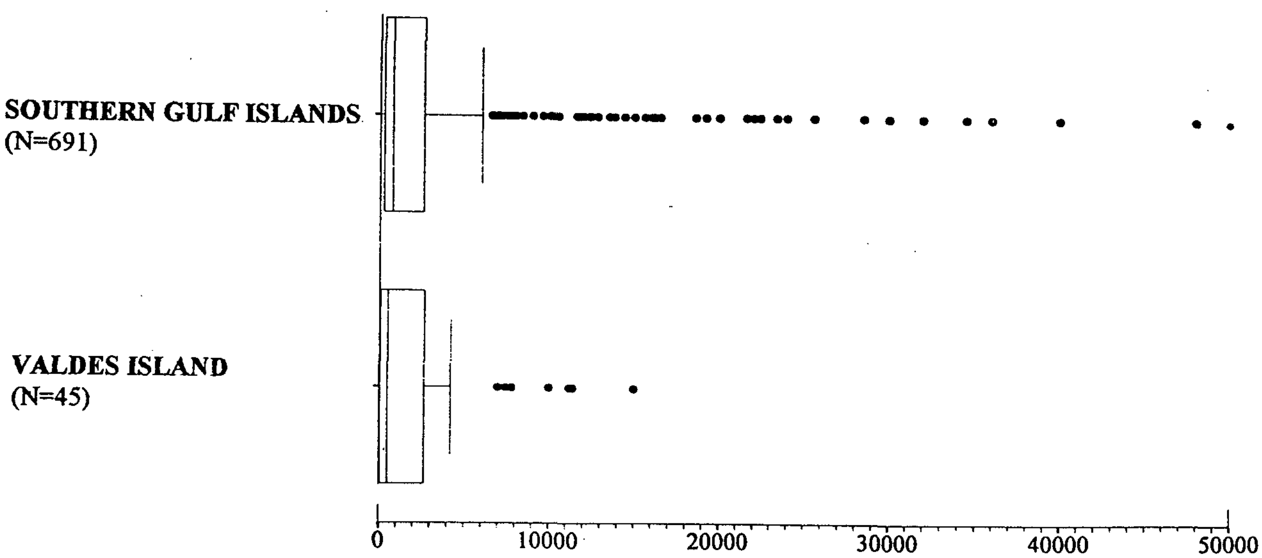

Figure 6 Shell Matrix Site Areas (m^2): southern Gulf Islands vs. Valdes Island

If populations concentrated upon the exploitation of intertidal resources associated with sandy intertidal environments, it is expected that shell matrix sites located at sandy foreshores will demonstrate significantly higher median size and range than sites associated with rocky foreshore environments.

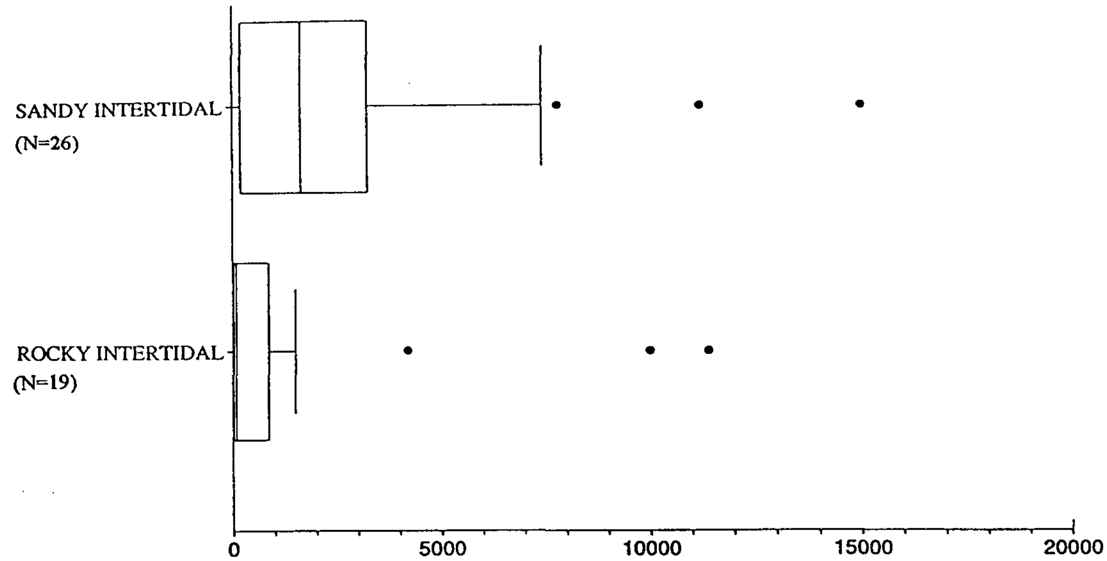

Figure 7 Shell Matrix Site Area (m^2) vs. Primary Intertidal Environment

Figure 7 compares the site area (m^2) of sites (n=45) to their distribution at sandy and rocky intertidal environments. Sites associated with sandy intertidal environments demonstrate a very high median size of 1637.5m^2 and larger interquartile range of between 185m^2 and 3367m^2, compared to sites associated with rocky intertidal environments, which possess a very low median size of 90m^2 and narrow interquartile range of between 25m^2 and 760m^2. The differences in size between these two samples are significant at at a 0.05 level of probability using a Mann-Whitney U-test statistic (U=150.0, p=0.026). The significant difference in size between shell matrix sites relative to their type of intertidal environment strongly supports the assertion that settlement-subsistence activity on Valdes Island is directly related to the productivity of intertidal environments.

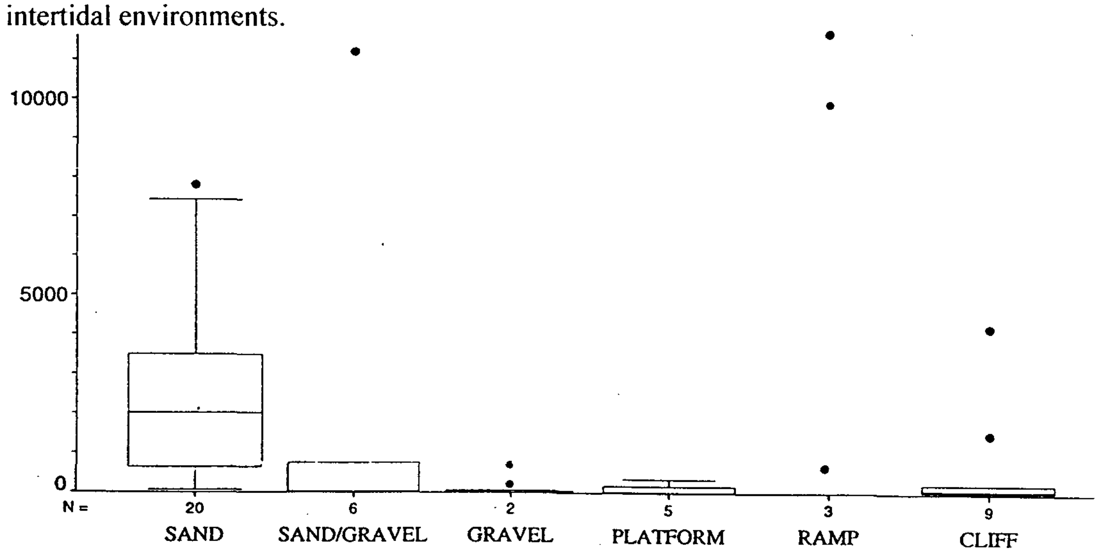

Figure 8 Shell Matrix Site Area (m^2) vs. Secondary Intertidal Environments

Figure 8 compares the size of shell matrix sites relative to the six types of intertidal environments. Although low sample sizes limit interpretation, the most frequent intertidal environment, sand flats (n=20), presents a relatively symmetrical distribution with a high median size of 2012m² and large interquartile range. In comparison, the second most frequent intertidal environment, rock cliffs (n=9) a highly right-tailed distribution and low median size of 90m². Sand/gravel flats (n=6) and rock platforms (n=5), exhibit more symmetrical, if slightly right-tailed distributions, and demonstrate even lower median sizes of 26m² and 24m², respectively. Rock ramp environments (n=3), in contrast, demonstrate the highest median size and second highest range, yet interpretation is constrained by very low sample size. In general, however, shell matrix sites on Valdes Island demonstrate important differences in size relative to their productivity of their intertidal environments, where sandy intertidal environments exhibit significantly higher intensity of site use in contrast to the very low redundancy of rocky intertidal environments. The evidence strongly supports the hypothesis that pre-contact populations concentrated settlement activity on Valdes Island to exploit critical resources distributed at sandy intertidal environments.

CONTENT

If sites were located to exploit local intertidal resources, the faunal content of shell matrix sites should correspond with the types and proportions of resources available in the local intertidal environment. To explore the content of sites in relation to intertidal environments, I examine: a) presence/absence of archaeological shellfish from 45 sites; b) MNI shellfish and NISP fish samples from nine shell matrix sites.

SHELLFISH DATA - PRESENCE/ABSENCE

The correspondence between the presence-absence of shellfish resources in archaeological sites and the environment is used to address two related questions: a) what types of intertidal environments were selected for shellfish procurement: and b) what types of shellfish were critical resources in respect to settlement patterns. *Appendix 1* lists the presence-absence of shellfish types observed at 45 shell matrix sites on Valdes Island to the distribution of shellfish resources available in the local environment. If sites are located to exploit local shellfish resources, it is expected that the types of shellfish resources available in the local intertidal environment will correspond to the types of shellfish material observed in archaeological sites. Conversely, if shellfish types in the environment do not correspond to archaeological shellfish material in sites, this evidence indicates that sites may not be strongly influenced by the distribution of local intertidal shellfish resources.

The proportion of archaeological shellfish types that correspond with available resources in the environment are calculated for each site - measured by dividing the number of shellfish types in sites which co-occur with available shellfish types in the environment by the total number of observed shellfish types at each site (*Appendix 1*). Examining shellfish types which co-occur relative to their primary type of intertidal environment, the median of sandy intertidal sites contains 100% co-occurrence with shellfish types in the environment, while the median of rocky intertidal sites maintains a median of only 66%. Although the archaeological shellfish content of sandy intertidal sites closely correspond with local shellfish resources, rocky intertidal sites generally contain an equal or greater proportion of sandy intertidal shellfish types which do not co-occur in the environment. The difference between these two distributions is highly significant at a 0.001 level of probability using a Mann-Whitney test statistic ($U=49.5$, $p=0.000$). This evidence implies rocky intertidal site locations were not as strongly influenced by the distribution of shellfish resources in the local environment as sites located at sandy intertidal environments.

To examine what shellfish resources influence site location, I focus upon the distribution of shellfish types. Cross-tabulating each shellfish types' presence-absence in the environment and in sites (column analysis) are used to examine the types of associations (*Table 2*). The two strongest types of association which are expected to occur are the mutual presence (A) and mutual absence (D) of shellfish types in sites and the environment, in contrast to shellfish types which are found in greater frequency in archaeological sites but not the environment (B). Shellfish types that are found more frequently in the environment than in sites (C) does not directly contradict expectations, but indicates that populations were selective of the types of shellfish procured.

TABLE 2 Shellfish Distributions - Sites vs. Environment

	TYPES OF ASSOCIATION							
	A		B		C		D	
SITES ENVIRONMENT	Presence Presence		Presence Absence		Absence Presence		Absence Absence	
	(+/+)		(+/-)		(-/+)		(-/-)	
	(N)	%	(N)	%	(N)	%	(N)	%
SAXIDOMUS	22	49	17	38	0	0	6	13
PROTOTHACA	27	60	17	38	0	0	1	2
MYTILUS	35	77	0	0	9	20	2	4
ARCHAEOBALANIDAE	34	75	0	0	11	24	0	0
CLINOCARDIUM	14	31	6	13	2	4	23	51
TRESUS	8	17	6	13	0	0	31	69
MACOMA	2	4	1	2	5	11	37	82
STRONGLYOCENTROTUS	9	20	4	9	1	2	31	69
LOTTIIDAE	16	35	0	0	20	44	9	20
NUCELLA	11	24	5	11	15	33	14	31
KATARINA	2	4	0	0	9	20	34	75

Examining *Table 2*, the direction of association for all shellfish types generally correspond to expectations exhibiting higher frequencies of mutual presence (A) and /or mutual absence (D) in the environment and archaeological sites, as opposed to their presence in sites but not the environment (B). Critical types of shellfish resources most frequently exploited on Valdes Island are the sedentary epifauna, Pacific blue mussel *(Mytilus)* and acorn barnacle *(Archaeobalanidae)*, and the shallow-burrowing infauna, butter clam *(Saxidomus)* and Pacific littleneck *(Protothaca)*. Each of these shellfish types are characteristically prolific, highly-accessible, robust resources broadly available in the environment, which demonstrates the greatest mutual presence (A) in sites and the environment on Valdes Island. However, *Saxidomus* and *Protothaca* are also observed to occur in high frequency in archaeological sites when not present in the local environment (B) (particularly at rocky intertidal sites). While this contradicts expectations of local site exploitation, the evidence asserts the importance of these shellfish resources in the subsistence economy.

The shallow-burrowing infauna, basket cockle (*Clinocardium)* and sand clam (*Macoma*), the deep-burrowing infauna, horse clam *(Tresus)*, and the mobile epifauna, sea urchin *Stronglyocentrotus*, are less common shellfish types on Valdes Island, and exhibit greater mutually absence (D) than mutual presence (A) on Valdes Island. The low frequency of these shellfish types in archaeological sites when not present in the environment (C), suggest their lesser importance in the subsistence economy, or alternatively more restrictive access to their procurement sites. These shellfish types are characteristically sensitive to specific environmental conditions and are correspondingly limited in spatial distribution: *Clinocardium, Tresus*, and *Macoma* are generally restricted to the lower intertidal zone of extensive sand flats and eelgrass beds, whereas *Stronglyocentrotus* concentrates near kelp forests in the lower intertidal and subtidal zones of rocky foreshores, particularly the current-swept rock cliff environments of the tidal streams.

Less concentrated, mobile epifauna shellfish types common to rocky intertidal environments, such as *Lottiidae, Nucella,* and *Katarina,* generally demonstrate greater presence in the environment than in archaeological sites (C). The broad availability of these shellfish types in the environment but low frequency in sites indicate highly selective patterns of resource procurement. The low abundance and dispersed distribution of these shellfish types combined with the selective nature of procurement indicates the lesser economic importance of these rocky intertidal shellfish resources in the subsistence economy, and a corresponding limited influence upon site location.

However, these preliminary interpretations are tentative due to methodological considerations. The nominal-scale nature of the survey data masks the relative proportions of shellfish present in archaeological sites, which potentially overemphasizes the importance of rare shellfish types. Conversely, the low frequency of certain shellfish types in shell matrix sites on Valdes Island, particularly *Tresus* , *Macoma, Lottiidae*, and *Katarina*, may be underestimated due to problems of field identification. For these reasons, I collected ratio-scale shellfish data from the test excavation of nine shell-bearing sites on Valdes Island to further explore the nature of the relationship between shellfish resources and settlement patterns.

SHELLFISH DATA - MINIMUM NUMBER OF INDIVIDUALS (MNI)

To specify variability in the content of shell matrix sites relative to their intertidal environments, nine sites were sampled to collect unscreened 9L shellfish matrix samples for fine-grained laboratory analysis, which calculated both shellfish weights and minimum number of individuals (MNI) (*Appendix 3*). As the relative proportions of shellfish weights and MNI values strongly substantiate each another, I limit discussion to the analysis of MNI data for clarity of argument. MNI analysis has the advantages of not being biased by differential shell weight or general classes of unidentified shellfish fragments, which renders precise estimates of shellfish species representation. MNI analysis employs 100% of subsampled shellfish material from 12.2mm (1/2"), 6.3mm (1/4") and 3.2mm (1/8") screens (used for weight analysis) and totals the count of elements for each shellfish type. MNI values are calculated for shellfish following the basic methodology of Wessen (1994). Specific descriptive elements of shellfish species are used to calculate the minimum number of individuals that represent the sample population. For univalves (gastropods) such as *Lottiidae* and *Nucella*, MNI values are calculated using the count of their apices. For bivalve species, such as *Saxidomus*, *Protothaca*, *Clinocardium*, *Tresus*, *Macoma*, and *Mytilus*, the highest frequency of either the left or right hinges (umbos and cardinal teeth) are used to determine the minimum number of individuals. *Katarina* are determined as the highest frequency of either head or tail plates, or by the count of body plates divided by six. MNI values for *Archaeobalanidae* differ from Wessen's (1994) technique and count wall plates from only the 12.2mm screen (smaller specimens are assumed to be incidental and, furthermore, highly skew relative proportions) divided by six. *Stronglyocentrotus* uses the highest frequency of either the right or left half of the lantern teeth divided by five (five lantern teeth in total, each made of two opposite pieces) or by the higher count of lantern teeth hinges, divided by five (anal plates may also be used as an MNI indicator, see Green 1999). For comparative analysis, the absolute frequency of each shellfish type is divided by the total number of shellfish MNI to create relative percentages for each shellfish type.

If coastal sites are located to exploit local shellfish resources, the types and relative proportions of shellfish remains in sites are expected to correspond to the types and proportions of shellfish resources available in the local intertidal environment. The relative proportion of non-local shellfish types in shell-matrix sites are expected to be minimal.

Figure 9 and *10* compares the relative proportion of MNI values of shellfish types associated with sandy and rocky intertidal environments across the nine sites. All nine shell matrix sites demonstrate strong patterning in their shellfish content. Importantly, six of the nine shell matrix sites demonstrate shellfish content strongly corresponding to expectations based on the classification of their local environment.

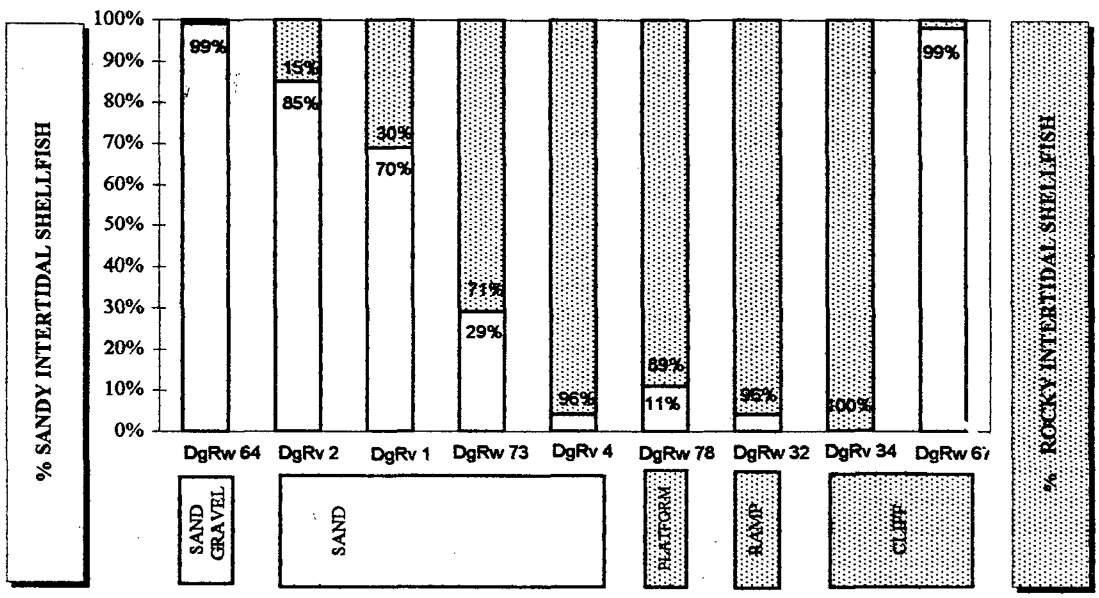

Figure 9 Shellfish Content (MNI Analysis) vs. Intertidal Environments

Three of the five sites associated with sandy intertidal environments (DgRv 1, DgRv 2, DgRw 64) contain very high relative proportions of shellfish types associated with sandy intertidal environments. *Saxidomus* and *Protothaca* are the most frequent shellfish types exploited from these intertidal environments, with *Clinocardium*, *Tresus*, and *Macoma* generally demonstrating lesser relative proportions in shellfish content. The proportion of rocky intertidal shellfish types are 30% or less of the total shellfish content. Similarly, three of the four sites located at rocky intertidal environments (DgRw 78, DgRw 32,

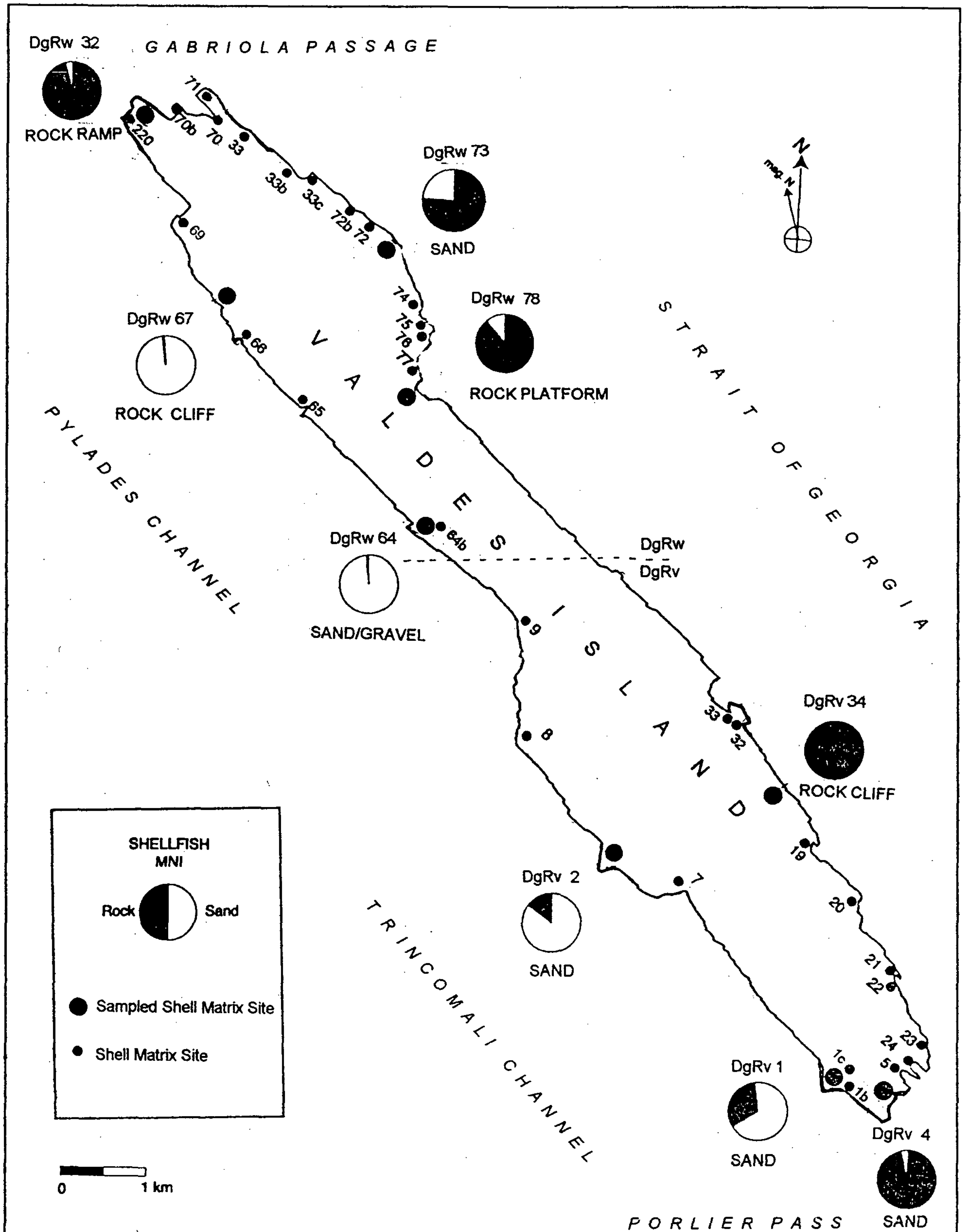

Figure 10 MNI Shellfish Content of Sampled Shell Matrix Sites, Valdes Island

DgRv 34) contain very high relative proportions of shellfish types associated with rocky intertidal environments, particularly *Mytilus*. Of exceptional note, the occurrence of uncommon types of rocky intertidal shellfish found in archaeological sites, such as *Lottiidae*, *Nucella*, *Stronglyocentrotus*, and *Katarina* take prominence in the shellfish content of several of these rocky intertidal sites (DgRw 32, DgRw 78), which substantiate very localized patterns of resource exploitation. Although a variety of non-local shellfish types are present in rocky intertidal sites, notably *Saxidomus*, *Protothaca* and *Clinocardium*, they represent less than 11% of the total content. These six shell matrix sites demonstrate highly localized patterns of shellfish exploitation, which directly correspond to available shellfish resources in the environment.

Three sites do not match expectations. The shellfish contents of the sandy intertidal sites, DgRw-73 and DgRv 4, demonstrate greater relative proportions of shellfish types associated with rocky intertidal environments, particularly *Mytilus* and *Stronglyocentrotus*. Conversely, the shellfish content of the rock cliff site, DgRw 67, is dominated by sandy intertidal shellfish and clearly lacks any relationship to the local intertidal environment. Based on presence-absence data, DgRw 67 is not atypical of rocky intertidal sites which contain a high proportion of transported shellfish. Therefore, while the majority of sites demonstrate strong association between the types and proportion of exploited shellfish and available resources in local environments, it is apparent that not all sites on Valdes Island are positioned to exploit local shellfish resources. To clarify these exceptions to the site location model based on intertidal shellfish resources, I examine the influence of Pacific herring and intertidal marine fish resources upon site location.

INTERTIDAL MARINE FISH RESOURCES

A total of eighteen fish taxa are classified among 3500 identified fish elements sampled on Valdes Island (*Appendix 4*). Identified fish are classified into two categories: anadromous salmon and marine fish (Schmitt *et al.* 1994). I divide the marine fish category into two types of groundfish: a) species who seasonally inhabit and spawn at shallow, soft-bottom environments, such as Plainfin midshipman (*Porichthys notatus*), flounder and sole (family *Bothidae* and *Pleuronectidae*, respectively); and b) species that generally inhabit and spawn at near-shore rocky shores, such as rockfish (*Sebastes* spp.), sculpin (family *Cottidae*), and surf perch (family *Embiotocidae*). Within the marine fish category, I further distinguish Pacific herring (*Clupea harengus pallasii*) and spiny dogfish (*Squalus acanthus*).

If sites are located to exploit local fish resources from the foreshore, it is expected that the archaeological fish content of shell matrix sites will correspond to the general types of fish resources available in the local marine environment. Sandy intertidal sites should demonstrate high proportions of Pacific herring and other sandy foreshore marine fish, in contrast to rocky intertidal sites which are expected to exhibit high proportions of rocky shore reef-fish. From a regional perspective, marine fish should dominate the types of fish exploited on Valdes Island in contrast to anadromous Pacific salmon.

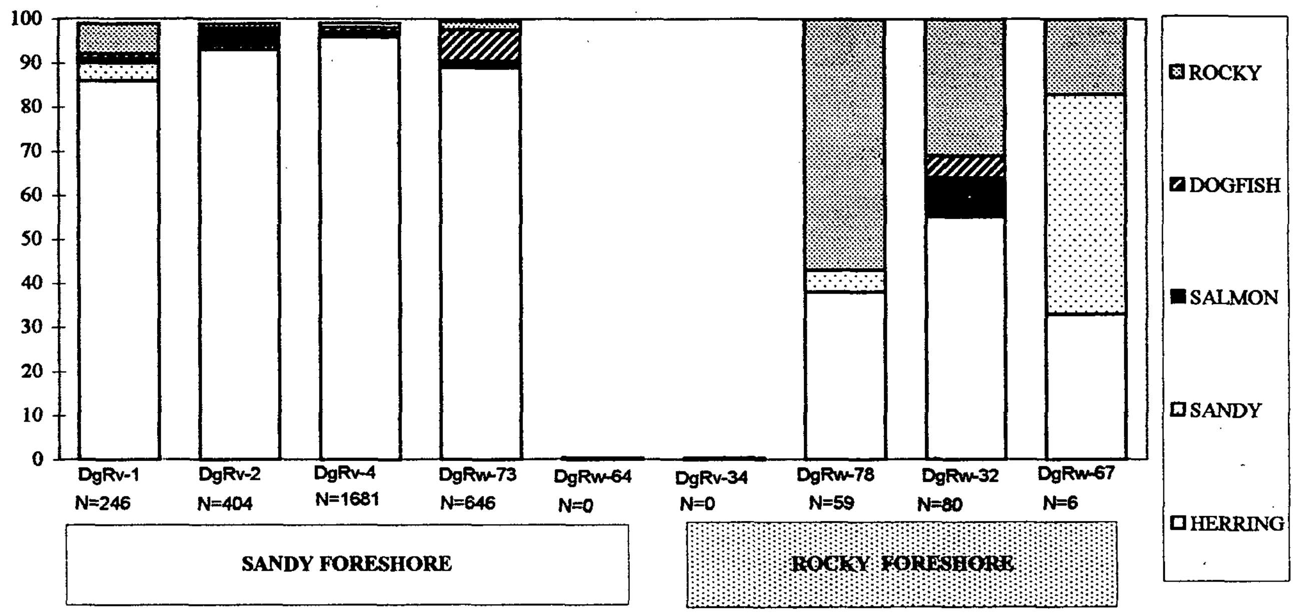

Figure 11 Archaeological Fish Content (NISP %) vs. Intertidal Environment

Figure 11 compares the number of identified specimens (NISP %) of archaeological fish elements from the nine sites to their foreshore environmental location. As expected, anadromous Pacific salmon is not a major constituent of the faunal content of shell matrix sites on Valdes Island. Instead, Pacific herring overwhelmingly dominates the archaeological fish remains at sandy foreshores on Valdes Island. The sandy intertidal sites, DgRw 73 and DgRv 4, which do not fit expectations based on shellfish resources, exhibit the highest percentages of Pacific herring. These sites correspond to Monks (1987) and Ham's (1982) models of primary herring fishing sites, where Northwest Coast populations mass-harvested spawning Pacific herring in late winter/early spring at near-shore eelgrass and kelp beds, and reaped seasonally-correlated marine resources which prey upon spawning herring and their roe, such as dogfish, salmon, and marine mammals. Sandy intertidal sites on Valdes Island further exhibit relatively higher presence of other sandy foreshore marine fish resources, such as Plainfin midshipman, sand lance, starry flounder and other flatfish.

In contrast, rocky intertidal sites exhibit only minor proportions of Pacific herring and sandy foreshore fish resources. but yield high relative proportions of rocky shore reef-fish, particularly rockfish, surfperch and, to lesser extents, greenling and sculpin. Only the rock cliff site, DgRw 67, does not correspond to expectations. The small sample of identified fish remains from DgRw 67 (n=6) exhibit mainly Pacific herring and plainfin midshipman, which supports shellfish data indicating the off-site exploitation of an sandy intertidal environment. Several shell matrix sites, however, contain no fish remains; for example, DgRv 34 and DgRw 64, comprise only shellfish material.

In general, the strong correspondence of archaeological fish remains with locally available intertidal and near-shore marine resources substantiates the highly localized nature of resource exploitation patterns on Valdes Island. Pacific herring, in particular, demonstrates a critical role for explaining the frequency and intensity of site location at sandy intertidal environments. The high degree of variability in the quantity of fish remains between sites, however, both acknowledges the influence of critical resource locations for marine fish in the environment, and is prescient of identifying systemic functional differences between shell-bearing sites on Valdes Island (*Chapter 5*).

2. TIDAL STREAM ENVIRONMENTS

To explore whether tidal stream environments influence settlement-subsistence patterns on Valdes Island, I group all shell matrix sites within a one kilometre radius of Gabriola and Porlier Pass, and differentiate the major coasts of the island as distinct marine environments - contrasting the active, rocky tidal passes to the west coast's sheltered, soft-bottom environment and the east coast's exposed, reef-stricken, rocky marine substrate (Romaine 1981). If productivity of marine resources at the tidal streams strongly influences site location on Valdes Island, tidal stream environments are expected to demonstrate greater frequency in location and size, and exhibit a greater abundance and diversity of marine resources.

LOCATION

Figure 12 compares the frequency of shell matrix sites to the proportionate lengths of coastlines on Valdes Island. Tidal stream environments represent the location of 45% (n=20) of all shell matrix sites on Valdes Island, although accounting for a minor 20% length of the coastline. In contrast, the west and east coast exhibit 55% of site locations (n=10 and 15 sites, respectively), although totaling 80% of the coastline. The site density at the tidal streams (2.8 sites/km) is two to three times the density of sites located on either the east coast (1.2 sites/km) or west coast (0.7 sites/km). The differences in the observed and expected frequencies of sites relative to their length of shoreline are significant at a 0.001 probability level (x^2=18.5, df=2, p=0.000). The spatial distribution of site locations on Valdes Island, therefore, significantly converge upon the marine environments of the tidal streams.

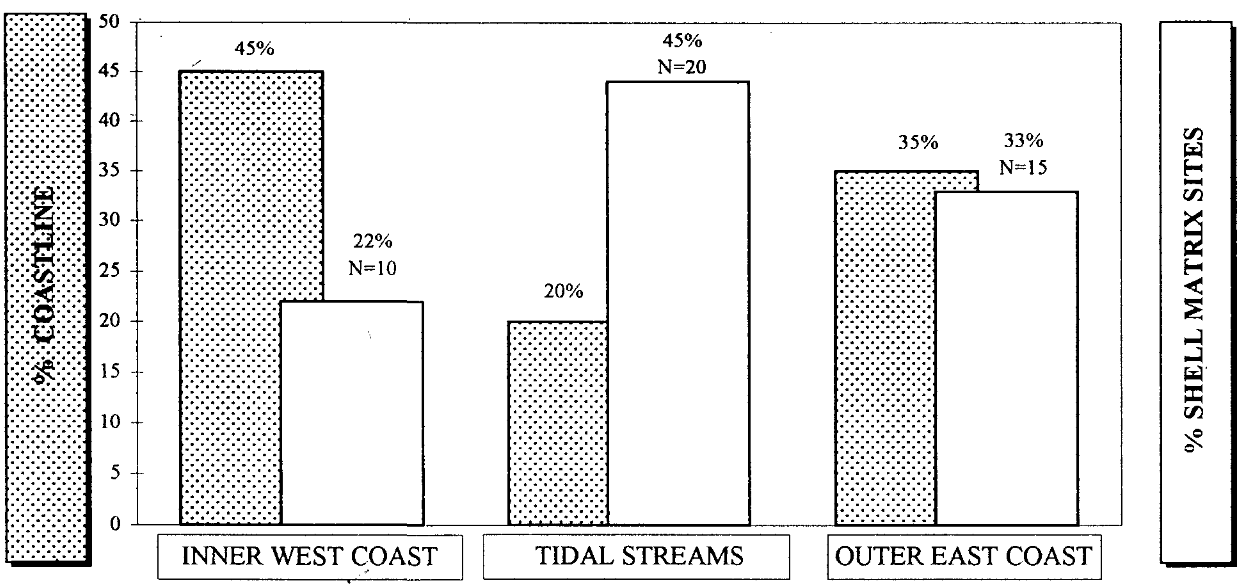

Figure 12 Shell Matrix Site Locations vs. Marine Environments

SIZE

The majority of the largest sites on Valdes Island (>2701m^2) are observed to be directly located on Gabriola and Porlier Pass (*Figure 4*). *Figure 13* illustrates that the site area (m^2) of shell matrix sites at the tidal streams has a high median of 1600m^2 and symmetrical distribution, while sites on the west and east coast exhibit very low median sizes of 105m^2 and 140m^2, respectively. The differences in size between these three samples are significant at a 0.05 level of criteria using a Kruskal-Wallis test statistic (KW=

7.016, p= 0.034). Settlement activity on Valdes Island, therefore, distinctly concentrate upon the productive marine environments of the tidal streams.

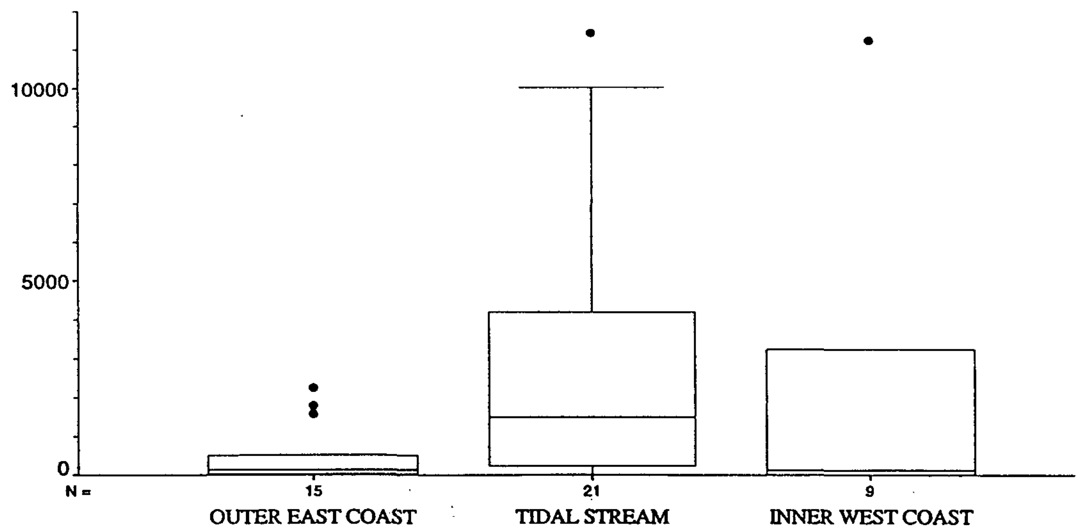

Figure 13 Shell Matrix Site Area (m^2) vs. Marine Environments

CONTENT

The defining quality of the tidal streams is the productivity of their marine environments - their localized abundance and biological diversity of marine resources, particularly rocky intertidal shellfish, fish and marine mammals. This is clearly evident in the high abundance and localized patterning of shellfish exploitation at the tidal stream sites, DgRv 4 and DgRw 32, where 96% of the shellfish content is dominated by rocky intertidal resources, particularly Pacific blue mussel, *Mytilus,* and to a lesser extent, green and purple sea urchin, *Stronglyocentrotus* (*Figure 9* and *10; Appendix 3*). The faunal content of archaeological sites at the tidal streams, therefore, are expected to exhibit greater richness (number of taxa) and abundance (sample size) of marine resources compared to other marine environments.

Figure 14 compares the abundance of archaeological fish elements (NISP) to the richness of fish elements in relation to the marine environment. Sample size effects on diversity scores (Kintigh 1989; Thomas 1989) are minimal - the richness of fish remains are not significantly correlated to the size of the samples (removing the DgRv 4 outlier) (r^2= 0.152, p= 0.387). As the sampling methodology is consistent, observed variability in the content of shell matrix sites is interpreted as behavioral differences reflected by the sample populations, rather than simply the result of sampling error.

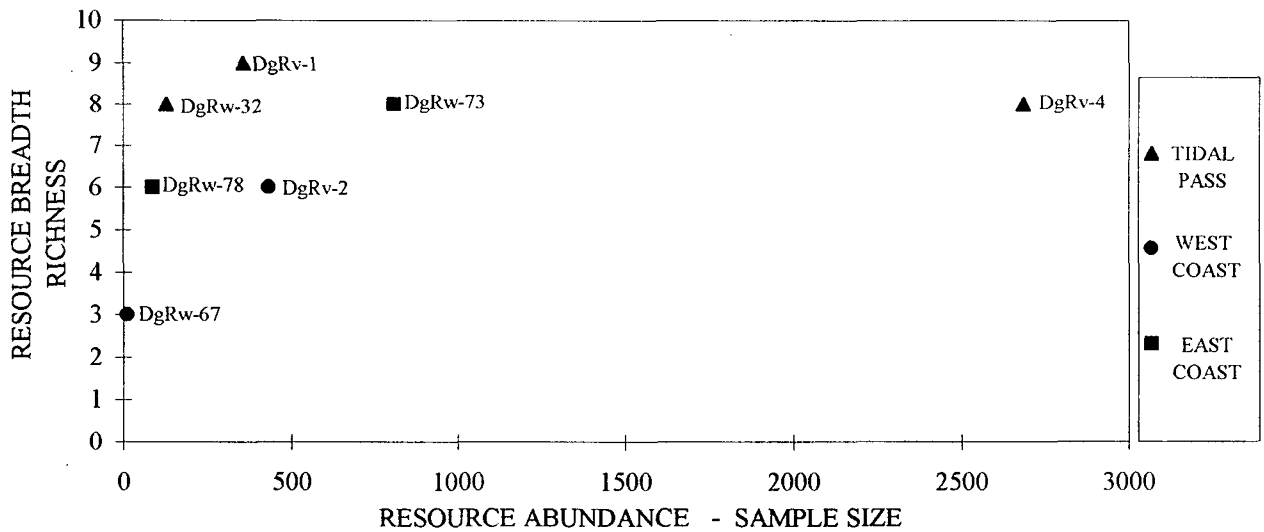

Figure 14 Marine Fish (NISP) - Richness vs. Abundance (NISP)

In accord with expectations, the tidal stream site, DgRv 4, clearly demonstrates the greatest abundance of identified fish elements (over 2500) and a high diversity of fish taxa (n=9), although strongly focused upon Pacific herring (96%) (*Figure 11*). The tidal stream sites, DgRv 1 and DgRw 32, illustrate a similar high diversity of fish taxa in comparison to other shell-bearing sites (n=10 and 9, respectively), yet exhibit much much lower abundance of fish elements compared to DgRv 4 (n=246 and 80, respectively). The outer east coast site DgRw 73 similar presents a relatively high richness (n=9) and abundance of fish elements compared to DgRv-4 (n=646); again, dominated again by Pacific herring (89%) (*Figure 11*). Therefore, although the tidal stream site, DgRv 4, strongly supports the hypothesis of greater abundance and diversity of fishing activity at the marine tidal passes, the evidence from the other tidal stream sites provide less conclusive results. Further, variability in the abundance of fish among sites appears strongly associated with sites' resource intensity upon Pacific herring.

Tidal stream sites are also expected to exhibit relatively higher frequencies of marine mammal elements in contrast to other marine environments (*Appendix 4*). The sampling bias against large mammals due to the small size of the excavations are evident, but the tentative results are surprising. Of distinction, the Cardale Point site (DgRv 1) near Porlier Pass exhibits six skeletal elements of Northern sea lion (*Eumatopias jubatus*) and a scapula fragment of a small toothed whale identified as a False Killer Whale (*Pseudorca crassidens*) - the first such toothed whale specimen excavated from a site in the Gulf of Georgia region (Crockford, pers.comm.1997; see Hanson 1991:235). The tidal stream sites, DgRv 4 and DgRw 32, however, exhibit no marine mammal remains. One harbour seal element (*Phoca vitulina*) is recovered from the Shingle Point site (DgRv 2) and two porpoise elements (possibly Pacific white-sided porpoise (*Lagenrhynchus obliquidens*)) are excavated from the small, east coast site of DgRw-78. The small number of terrestrial mammal elements identified on Valdes Island include deer (*Odocoileus heminous*) and dog (*Canis familiaris*). Although a small sample, it is suggested that marine mammals performed an important role in pre-contact subsistence patterns on Valdes Island. Further, the Cardale Point site (DgRv 1) contains the highest frequency of marine mammals on Valdes Island which tentatively supports the hypothesis that site locations in proximity to tidal streams were strongly influenced by the concentration of marine mammals in the rich, marine micro-environment.

In summary, environmental variance in the distribution of critical resource locations - specified as productive coastal resource zones - explains a great amount of observed variability between shell matrix sites on Valdes Island. In the next chapter, I explore the nature of resource exploitation exhibited among shell matrix sites on Valdes Island to study systemic variability in settlement-subsistence patterns.

CHAPTER 5 SYSTEMIC VARIABILITY

Ethnographic studies of shell matrix site formation processes observe a high level of systemic variability existing within hunter-gatherer's patterns of resource procurement, processing, transport and settlement activity (Bigalke 1973; Bird and Bird 1997; Meehan 1977). An integral dimension of inter-site variability on Valdes Island, therefore, relates not to how resources are distributed in the environment, but how populations structured settlement activity and labour organization to procure critical resources.

The Cardale Point site (DgRv 1) and Shingle Point site (DgRv 2) exhibit house depression features and deep, highly-stratified shellfish deposits that indicate long-term, diversified settlement activity on Valdes Island (Matson 1998; Matson *et al.* 1999). This archaeological evidence substantiates ethnographic accounts that document a greater permanence of settlement activity to exist on Valdes Island than general ethnographic texts describe for the southern Gulf Islands (Rozen 1978; 1985; Sproat 1877; Suttles 1952).

The majority of shell matrix sites on Valdes Island, in contrast, represent small-sized, shallow, unstratified limited-activity sites that demonstrate direct relationships with the distribution of specific, critical resources in the local marine environment. This perspective parallels generalized ethnographic descriptions of Central Coast Salish settlement-subsistence patterns in the southern Gulf Islands that indicate highly seasonal patterns of land use and resource procurement at spring and summer temporary camps (Barnett 1955; Jenness 1934-1935; Suttles 1951). Whether or not these settlement patterns represent alternative ethnographic models of land use, the nature of settlement patterns and resource exploitation demonstrated on Valdes Island is congruent with the collector model of logistic mobility, where centralized populations dispatch task-specific labour groups to collect disparate resources to manage conflict in resource scheduling (Binford 1980).

Using the hypothesis that limited-activity sites are located in relation to specific resources, while residential bases are generally located in relation to a greater variety of distributed resources (Plog and Hill 1971), I examine whether the relative diversity of archaeological fauna from the sampled shell matrix sites on Valdes Island differentiate long-term residential bases from limited-activity sites. A collector pattern is expected to demonstrate high variability in the faunal diversity of shell matrix sites. On a scale of relative diversity, limited-activity sites, such as resource-processing locations and field camps, should demonstrate very fine-grained patterning and exhibit low levels of species richness or resource breadth (number of taxa) and low evenness or resource intensity (distribution across the number of taxa). Long-term residential bases or village sites, such as DgRv 1, DgRv 2, and possibly DgRv 4 are expected to illustrate a more generalized relationship between resource use and the environment distinguished by a greater richness and evenness of faunal content. A forager strategy, in contrast, should demonstrate relatively homogeneous patterns of settlement activity, which involve resource-processing locations and short-term residential bases (Binford 1980). Foragers' short-term residential bases, in contrast to collectors' field camps and long-term residential bases, are expected to exhibit high evenness and generally low richness of faunal diversity (Kintigh 1985; Lightfoot 1985; Thomas 1985).

A total of 44 faunal taxa are classified on Valdes Island (*Appendix 5*). *Figure 15* compares the richness or resource breadth of sites to a measure of evenness or resource intensity based on absolute NISP values (J= H/Hmax)[1] (see Kintigh 1989).

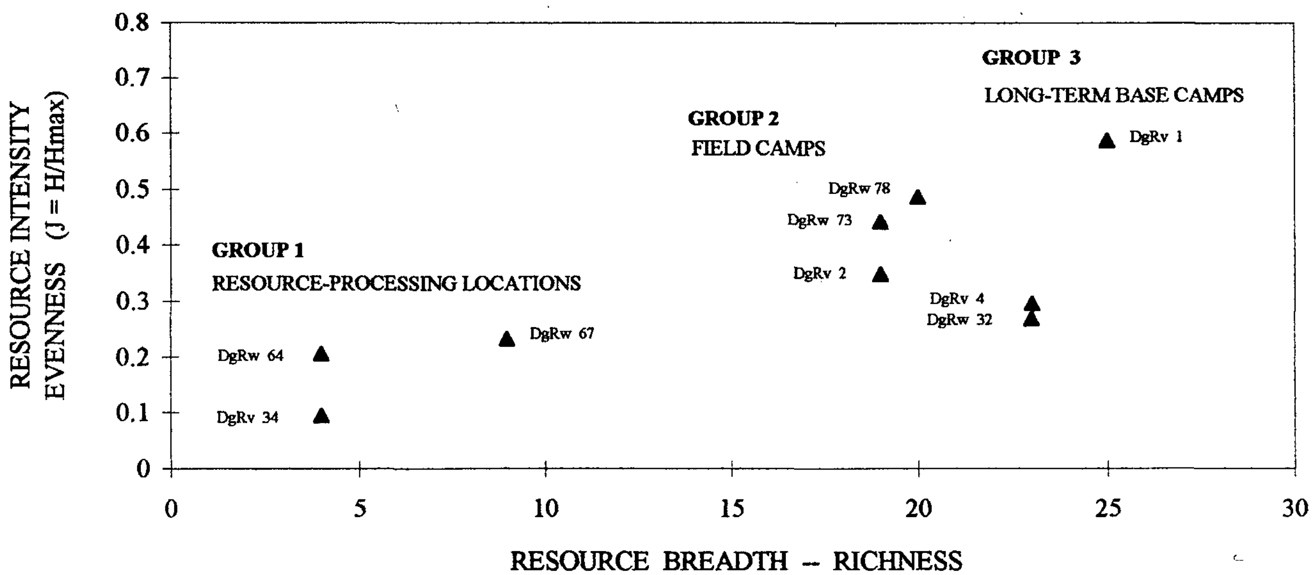

Figure 15. Shell Matrix Diversity on Valdes Island

[1] J= H/Hmax (where H = n (log 10n) - Σ fi (log 10fi) /n and Hmax= log K) n=sample size, K= number of faunal taxa, and fi= frequency of observations for each faunal taxa. Evenness is measured as a relative scale of between 0 and 1, where 1 is the highest proportionate evenness of distribution across the total number of categories.

Regression analysis of richness vs. sample size indicates sample size effects explains only 39% of variability, and are not a significant factor affecting diversity scores at a 0.05 level of probability ($r^2=0.389$, $p=0.072$). Again, as sampling methodology is consistent, observed variability is interpreted as behavioral differences between sample populations rather than sampling error. Due to low sample sizes, however, this analysis should be considered exploratory and subject to further research.

If the relative diversity of these sites are indicative of a linear scale of settlement mobility, I identify by inspection three major groups of shell matrix sites which I interpret distinguish limited-activity sites, including 1a) resource-processing sites (DgRw 64 and DgRv 34) and 1b) task-specific field camps (DgRv 2, DgRv 4, DgRw 67, DgRw 32, DgRw 73, DgRw 78), from 2) long-term residential bases (DgRv 1).

The small, unstratified sand/gravel site DgRw 64 ($10m^2$) and rock cliff site DgRv 34 ($90m^2$) exhibit very low diversity and evenness and clearly indicate shellfish resource-processing locations, oriented to the procurement of specific shellfish types corresponding to resources found in the local environment (*Saxidomus* and *Mytilus*, respectively). The second cluster of shell matrix sites are small to large-sized, stratified, generally featureless sites with higher richness values but moderate evenness, which are indicative of field camps oriented toward the procurement of specific, localized, abundant seasonal resources, such as Pacific herring and *Mytilus*, which could be collected and stored in large quantity. The DgRw 73 site, for example, is typical of this group representing a medium to large-sized ($2650m^2$), shallow shell matrix site located on the outer east coast upon an extensive sand flat, eelgrass beds and adjacent rock platform environment, positioned primarily to exploit Pacific herring, yet harvesting the diversity of seasonally-correlated local sandy and rocky intertidal shellfish resources, particularly *Mytilus, Stronglyocentrotus* and *Clinocardium* as well a variety of marine fish, including dogfish, salmon and rocky shore reef fish.

The small, rock cliff site DgRw 67 ($8m^2$), however, is intermediate between these limited-activity groups, containing only a slightly greater diversity of faunal remains than shellfish resource-processing sites (with the inclusion of fish remains). Due to the non-correspondence of the faunal content of DgRw-67 site with the local environment (*Figure 10* and *12*), I interpret the DgRw-67 site is more consistent with a diurnal field camp (or Meehan's (1977) "dinner-time camp") than a resource-processing site, where a small, task-specific or family group were temporarily based during a transitory movement to exploit specific, off-site resources.

In contrast to the pattern of limited-activity sites, both Cardale Point and Shingle Point exhibit house depressions and archaeological deposits consistent with long-term, diversified settlement activity. However, only the Cardale Point site (DgRv 1) exhibits distinctly greater richness and evenness of fauna corresponding to expectations of a long-term residential base or permanent winter village. Although both Cardale and Shingle Point are positioned to exploit the variety of resources available from the most extensive sandy intertidal environments on Valdes Island, Cardale Point is situated to further directly access the diverse, marine resources of Porlier Pass. The strategic, permanent nature of settlement at Cardale Point is attested to by the construction of a large, defensive earthwork atop the bluff overlooking the site (DgRv-1c). The relatively moderate diversity of the Shingle Point site, DgRv 2, in contrast, probably relates to the seasonal nature of the shellfish deposit sampled from the shoreline ridge outside the house depressions interpreted as resulting from the local exploitation of sandy intertidal shellfish and Pacific herring (Matson and McLay 1996; Matson *et al.* 1999).

In summary, the nature of resource exploitation and shell matrix diversity on Valdes Island corresponds to the expectations of logistic mobility, where the majority of sites represent limited-activity sites oriented to exploit specific, seasonal subsistence resources, in contrast to long-term residential bases, which are positioned to exploit several critical resource locations in the environment. In the final chapter, I summarize and discuss the implications of this settlement study upon Central Coast Salish settlement-subsistence patterns and ecological aspects of Northwest Coast hunter-gatherer complexity.

CHAPTER 6 SUMMARY AND DISCUSSION

Suttles (1951:46) defines the shoreline between the land and sea as the "midline" of Coast Salish existence - a daily medium to engage the natural and social world. In this study, I have demonstrated that late pre-contact settlement-subsistence patterns on Valdes Island illustrate an intrinsic relationship with the maritime environment. Settlement-subsistence patterns on Valdes Island characterize an economic orientation toward exploiting critical resource locations in the marine environment, where populations aggregated to procure localized, abundant and predictable coastal resources, particularly shellfish and Pacific herring. Shell matrix sites positioned in productive coastal resource zones, such as sandy intertidal environments and tidal streams, exhibit significantly higher site densities and size than sites located at rocky intertidal environments, which generally exhibit small-size, highly dispersed distribution and low redundancy of settlement activity. A strong correspondence exists between exploited archaeological fauna and local intertidal shellfish and marine fish resources, which substantiates that the distribution of critical resources in the marine environment strongly influenced past decision-making processes concerning site location. Ecological variance in the productivity of critical resource locations in the marine environment, therefore, explain a significant amount of observed variability among shell matrix sites on Valdes Island.

Shellfish resources are long understood to have affected a critical role in Northwest Coast economies (Croes and Hackenberger 1988; Ham 1982; Hanson 1991; Matson 1992; Moss 1989; Wessen 1988). This study demonstrates shellfish resources strongly influenced the location of shell matrix sites. More broadly, this study establishes the ecological role of intertidal and tidal environments as foci for settlement-subsistence on the Northwest Coast.

Critical shellfish resources exploited on Valdes Island are identified as highly accessible, prolific species, particularly the shallowing-burrowing sandy intertidal shellfish, butter clam (*Saxidomus)* and Pacific littleneck (*Protothaca)*, and sedentary rocky intertidal communities of Pacific blue mussel (*Mytilus)*. More environmentally-sensitive sandy intertidal shellfish types, such as basket cockle (*Clinocardium)*, sand clams (*Macoma)*, and horse clam *(Tresus)* and rocky intertidal sea urchin (S*tronglyocentrotus)*, appear restricted in distribution to their local availability in the environment, which indicates either their lesser importance in subsistence patterns or the greater social control over access to these shellfish resource locations. Dispersed, less productive rocky intertidal shellfish types, such as *Lottiidae*, *Nucella* and *Katarina*, exhibit greater frequency in the environment than presence in archaeological sites, and (except for several sites on the east coast) do not appear to exhibit a stong influence on site location on Valdes Island.

Pacific herring is identified as a primary resource for site location at sandy intertidal environments on Valdes Island. The resource pulse created by spawning Pacific herring in late winter/early spring was an important event in the Central Coast Salish economy (Monks 1987). At a time when winter stores were nearly deplete, household groups organized their collective labour to harvest the abundance of Pacific herring in mass using specialized fishing rakes and cedar branches to procure their roe (Jenness 1934-35; Grant 1857; Suttles 1951). Similar to salmon resources, however, strong variability exists in the spatial and temporal distribution of Pacific herring spawn (Haegele and Schweigert 1985). Access to productive Pacific herring spawning beds, therefore, exhibit important influence for site location.

Other spawning intertidal marine fish observed in shell-bearing sites on Valdes Island include plainfin midshipman, sand lance and prickleback, which may be procured by hand during intertidal foraging at sandy intertidal environments. Common, rocky shore reef-fish on Valdes Island, particularly rockfish, perch, sculpin, and dogfish are recognized as the next most important exploited marine fish resources, and were readily accessible from local foreshore environments using hook and line, spears or nets. Pacific salmon, in contrast, is not a major resource exploited on Valdes Island.

The tidal streams of Porlier and Gabriola Passages parallel critical foci for settlement activity. The tidal stream site, DgRv 4, contain the greatest abundance and diversity of fish remains on Valdes Island and the Cardale Point site (DgRv 1) exhibit a surprisingly high frequency of large, marine mammal elements, notably sea lion and toothed whale. This archaeological evidence substantiates oral traditions of the Lyackson village of *Th'a x̱el* at Cardale Point renowned for their tradition of their sea lion hunt and, opportunistically, whales (Lane 1953; Rozen 1978; 1985; Suttles 1952). Marine mammals are indicated to play a greater role in pre-contact subsistence patterns on Valdes Island compared to other Late Phase sites excavated in the Gulf of Georgia region (Hanson 1991).

Although settlement-subsistence activity converged at productive coastal resource zones on Valdes Island, a large number of small, shell-bearing sites located at relatively less productive marine environments, such as the rocky, eastern coast, may relate to the scheduling of more labour-intensive shellfish resources during seasonal tidal fluctuations. Although general ethnographic accounts describe shellfish as a constantly available resource, shellfish are a diverse behavioral set of invertebrate species uniquely adapted to inhabit specific ecological conditions, which correspondingly vary in spatial and temporal availability. Suttles (1964), for example, suggests Central Coast Salish populations scheduled the collection of sandy intertidal shellfish during the peak extreme low tides of the year around the summer solstice, to maximize the efficient collection and management of shellfish resources.

Rocky intertidal shellfish types, however, are generally accessible most times of the year in the high to middle intertidal zone. Rocky intertidal shellfish, therefore, may act as a constant reserve for populations to schedule the procurement of supplementary resources during fluctuations in tidal cycles when high tides restricted access to more productive, sandy intertidal resource locations at less abundant seasons of the year (Croes and Hackenberger 1988). For example, the rocky intertidal shellfish, Pacific blue mussel (*Mytilus)* and green sea urchin (*Stronglyocentrotus droebachiensis*) (which is ideally procured prior to its spawn in late winter-early spring (Matson *et al.* 1999)), co-occurs in high proportions with Pacific herring at several sandy intertidal sites (DgRv 1, DgRv 4 and DgRw 73) – a strong seasonal indicator for a late winter-early spring exploitation for these shellfish deposits. The high proportion of generally infrequently exploited rocky intertidal shellfish, including limpet (*Lottiidae*), dogwinkle (*Nucella*) and chiton (*Katarina*), observed at several east coast sites (ex. DgRw 73 and DgRw 78), in contrast, may indicate the scheduling of subsidiary rocky intertidal resources outside of peak resource blooms, such as during the autumn season. An alternative explanation offered by Wessen (1988) and Maschner (1997) suggests the greater exploitation of less productive shellfish types in late prehistory relates to the increasing overexploitation of intertidal environments, rather than seasonality and resource scheduling concerns. Croes and Hackenberger's (1988) economic modeling and Thompson's (1978) settlement pattern research comparably suggest populations in late prehistory in the Gulf of Georgia began exploiting a variety of new ecological niches and resources in the environment due to increasing population pressure.

Variance in the function of sites equally explains a great amount of shell matrix diversity on Valdes Island. The highly localized nature of resource exploitation on Valdes Island agrees with patterns of logistic mobility, where populations utilized task-specific groups to exploit local resources in the environment. The majority of shell matrix sites on Valdes Island are small to medium-sized, shallow, featureless sites less than $2700m^2$, interpreted to represent limited-activity sites, such as resource-processing locations and/or task-specific field camps, located in direct relation to specific, local resources.

A greater permanence of settlement activity, however, is documented on Valdes Island than the seasonal pattern of land use described by general ethnographic texts. Ten large-sized ($2700m^2$ - $15000m^2$), deeply-stratified shell matrix sites exist on Valdes Island, which include the ethnographic winter village sites of the Lyackson First Nation at Cardale Point (DgRv 1), Shingle Point (DgRv 2) and Porlier Pass (DgRv 4, 5, 24). These sites are directly positioned to access the variety of resources available at the extensive sandy intertidal environments on the southwest coast and the tidal stream environments at Porlier and Gabriola Passages. Only the Cardale Point site, however, corresponds to expectations of a long-term residential base camp based on measurements of faunal diversity. The Cardale Point site represents one of the most strategic location on Valdes Island to access the broadest variety of concentrated resources from the marine environment, encompassing both sandy intertidal and tidal stream environments. As an example of a packed ecological niche (Yesner 1980), DgRv 1 is positioned to overlap multiple coastal resource zones and, therefore, maximize resource access from the marine environment.

In summary, settlement-subsistence patterns on Valdes Island demonstrate a distinct maritime orientation, strongly influenced by the productivity of coastal resource distributions in the environment and the logistic organization required to procure seasonal, dense, spatially-disparate marine resources.

THE CENTRAL COAST SALISH AND THE ECOLOGY OF THE GULF OF GEORGIA

The Central Coast Salish of the Gulf of Georgia region are distinguished in Northwest Coast literature as semi-sedentary complex hunter-gatherer cultures renowned for the unique flexibility of their hierarchical social organization and the magnitude of their large-scale, long-distance residential population movements during the annual round (Grier 1998b; Mitchell 1971a; Mitchell 1988; Suttles 1991;1998). Suttles (1960) interprets the ethnographic pattern of the Coast Salish as a cultural adaptation to an environment distinguished by " a variety of types of resources, local diversity and seasonal variation in their occurrence, and year to year fluctuation in their abundance".

This settlement study extends both Matson's (1983; 1985) and Monks (1987) arguments that Northwest Coast populations concentrated upon exploiting the productivity of resources in the marine ecosystem from strategic locations – specified here as biotically-diverse, coastal resource zones or micro-environments. The settlement focus at these coastal resource zones is argued to be an important strategy that Central Coast Salish populations used to engage the highly variable, locally diverse nature of subsistence resources in the Gulf of Georgia. In particular, sandy intertidal environments concentrate a variety of shellfish and spawning fish resources which are strongly localized, seasonally abundant, and predictable in the environment. Situated along major coastal transportation routes between Vancouver Island and the Mainland, the riverine nature of tidal stream environments in the southern Gulf Islands further represent ecological niches the Central Coast Salish Halkomelem were well-adapted to exploit, and demonstrate the resource capacity to sustain permanent settlement (Mitchell 1971b; Grier 1998a). From such critical resource locations in the maritime environment, populations aggregated to monitor regional resource distributions, exchange information, and coordinate household labour to maximize the creation of economic surplus for subsistence, storage, exchange, and feasting. The generation of surplus arising from settlement location and access to these critical resource locations in the marine environment is suggestive to have provided the economic base for competition among elites.

The Central Coast Salish's settlement organization of permanent winter villages and semi-sedentary mobility, described as "the intensive use of specific places in specific times of the year" (Suttles 1951), can be considered an extreme form of a collector strategy model, where large-scale, task-specific groups organized their collective labour to procure, process and transport in bulk, specific, disparately-located resources in the environment. This regional settlement system represents a complex, logistical strategy designed to maximize the resource diversity and abundance of regional micro-environments in the Gulf of Georgia.

In conclusion, this study has applied an ecological model to understand the nature of late pre-contact settlement-subsistence patterns on Valdes Island. There presently exist few settlement pattern studies on the Northwest Coast to compare this research. This study, however, has illustrated the broad spatial variability and systemic diversity which exists among shell matrix sites, and has demonstrated these sites can no longer be normatively assumed to represent evidence of past "habitation" on the Northwest Coast (Acheson 1998; Maschner and Stein 1995; Maschner 1997). Further, this study establishes that the distribution of resources in the environment possess greater significance for site location than geographic variables (Maschner and Stein 1995), and that a basic understanding of the ecological relationships between settlement patterns and the environment on the Northwest Coast must precede discussions invoking political dynamics or population pressure to explain regional variability in site locations through time (Maschner 1997; Thompson 1978).

Settlement pattern research presents strong relevance for modern politics of land in British Columbia. In this study, a greater permanence of settlement activity is indicated to exist in the Gulf Islands than general ethnographic accounts describe - the likely product of regional depopulation and settlement reorganization in the Gulf of Georgia as a consequence of pre-contact smallpox (Harris 1997). Secondly, this study indicates the highly localized nature of pre-contact resource use within the coastal environment. This settlement pattern research, therefore, strengthens the Lyackson First Nation's claims for aboriginal title on Valdes Island and supports aboriginal rights relating to greater voice in resource management in British Columbia.

Thus, as archaeologists on the Northwest Coast address new questions of cultural process, the study of regional settlement patterns across the spectrum of the environment and time can develop not only a much more dynamic understanding of Northwest Coast prehistory, but make significant contributions to issues debated in the anthropological world literature of hunter-gatherer complexity and ecology. In addition, settlement pattern research can help to address modern issues of regional land and resource management.

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APPENDIX 1 SHELLFISH DISTRIBUTIONS ON VALDES ISLAND

	INTERTIDAL ENVIRONMENT											SHELL MATRIX SITE CONTENT											
	Sandy Intertidal					Rock Intertidal						Sandy Intertidal					Rock Intertidal						
LOCATION	Saxidomus	Protothaca	Clinocardium	Tresus	Macoma	Strongylocentrotus	Katarina	Nucella	Lottiidae	Mytilus	Archaeobalanidae	Saxidomus	Protothaca	Clinocardium	Tresus	Macoma	Strongylocentrotus	Katarina	Nucella	Lottiidae	Mytilus	Archaeobalanidae	LOCAL (%)
SAND																							
DgRv 1	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	91
DgRv 1b	X	X	X	X	X		X	X	X	X	X	X	X	X	X						X	X	100
DgRv 1c	X	X	X	X	X		X	X	X	X	X	X	X	X	X								100
DgRv 2	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	90
DgRv 7	X	X	X	X	X		X	X	X	X	X	X	X	X	X						X	X	100
DgRv 24	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X				X	X	100
DgRw 73	X	X	X				X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	78
DgRv 5	X	X	X	X	X	X		X	X	X	X	X	X	X	X		X				X	X	100
DgRv 4	X	X	X			X		X	X	X	X	X	X	X	X	X	X		X	X	X	X	100
DgRv 4c	X	X	X			X		X	X	X	X	X	X				X				X	X	100
DgRv 33	X	X	X					X	X	X	X	X	X	X					X	X	X	X	100
DgRw 33b	X	X	X					X	X	X	X	X	X	X					X	X	X	X	100
DgRw 70a	X	X	X					X	X	X	X	X	X	X	X				X	X	X	X	88
DgRv 9	X	X	X						X	X	X	X	X	X	X								75
DgRw 70b	X	X						X	X	X	X	X	X								X	X	100
DgRw 75	X	X						X	X	X	X	X	X	X							X	X	80
DgRv 19		X						X	X	X	X	X	X								X	X	75
DgRv 20		X						X	X	X	X	X	X	X					X	X	X	X	72
DgRv 21		X							X	X	X	X	X	X							X	X	60
DgRv 22	X	X								X	X	X	X										100
SAND/GRAVEL																							
DgRv 8	X	X	X	X	X		X	X	X	X	X	X	X	X	X						X	X	100
DgRv 4d	X	X	X			X		X	X	X	X	X	X				X				X	X	100
DgRw 64	X	X							X	X	X	X	X										100
DgRw 64b	X	X							X	X	X	X	X	X	X						X		60
DgRw 69	X	X							X	X	X	X	X										100
DgRv 32		X							X	X	X		X								X	X	100
																					Median		100
GRAVEL																							
DgRv 4b						X		X	X	X	X	X	X				X				X	X	66
DgRw 77							X	X	X	X	X		X						X	X	X	X	80
PLATFORM																							
DgRw 78							X	X	X	X	X	X	X					X	X	X	X	X	72
DgRw 74							X	X	X	X	X	X	X							X	X	X	60
DgRw 72a								X	X	X	X	X	X						X	X	X	X	66
DgRw 72b								X	X	X	X	X	X										0
DgRw 76								X	X	X	X		X						X	X	X	X	80
RAMP																							
DgRw 32		X				X		X	X	X	X		X				X		X	X	X	X	100
DgRw 33						X		X	X	X	X	X	X				X		X	X	X	X	66
DgRv 23										X	X	X	X								X	X	50
CLIFF																							
DgRw 71						X		X	X	X	X		X				X		X	X	X	X	84
DgRv 34								X	X	X	X										X	X	100
DgRv 4f						X		X	X	X	X	X	X				X		X		X	X	66
DgRv 4e						X				X	X	X	X										0
DgRw 33c										X	X	X	X								X	X	50
DgRw 65										X	X	X	X	X							X	X	20
DgRw 220										X	X	X	X										0
DgRw 66											X	X	X										0
DgRw 67											X	X	X	X	X								0
																					Median		66

APPENDIX 2 ARCHAEOLOGICAL LOCATION AND SIZE

LOCATION	Site Area (m2)	Size Class* small (1-25th) 1-240m2	medium-small (26-50th) 241-780m2	medium-large (51-75th) 781-2700m2	large (76-95th) 2701-7800m2	grand (96-100th) >7800m2
SAND						
DgRv 1	7425				x	
DgRv 1b	1120			x		
DgRv 1c	200	x				
DgRv 2	15000					x
DgRv 4	2650			x		
DgRv 4c	1360		x			
DgRv 5	2700			x		
DgRv 7	2225			x		
DgRv 9	3240				x	
DgRv 19	500		x			
DgRv 20	2250			x		
DgRv 21	1800			x		
DgRv 22	72	x				
DgRv 24	7800				x	
DgRv 33	540		x			
DgRw 33b	7000				x	
DgRw 70a	3750				x	
DgRw 70b	1700			x		
DgRw 73	1575			x		
DgRw 75	140	x				
SAND/GRAVEL						
DgRv 4d	220		x			
DgRv 8	11200					x
DgRv 32	36	x				
DgRw 64	11	x				
DgRw 69	16	x				
DgRw 64b	2	x				
GRAVEL						
DgRv 4b	760			x		
DgRw 77	52	x				
PLATFORM						
DgRw 72a	360		x			
DgRw 72b	4	x				
DgRw 74	12	x				
DgRw 76	24	x				
DgRw 78	187	x				
RAMP						
DgRv 23	32	x				
DgRw 32	11400					x
DgRw 33	10000					x
CLIFF						
DgRv 4e	50	x				
DgRv 4f	240	x				
DgRv 34	90	x				
DgRw 71	1500			x		
DgRw 33c	4200				x	
DgRw 65	80	x				
DgRw 66	130	x				
DgRw 67	8	x				
DgRw 220	25	x				

*Based on boxplot distributions (percentiles) of site areas (length x width) of 691 shell matrix sites recorded in the Southern Gulf Islands (Acheson *et al.* 1975)

APPENDIX 3 SHELLFISH DATA- MINIMUM NUMBER OF INDIVIDUALS (MNI)

	DgRv-1		DgRv-2		DgRv-4		DgRv-34		DgRw-32		DgRw-64		DgRw-67		DgRw-73		DgRw-78	
	MNI	%	MNI	%	MNI	%	MNI	%	MNI	%	MNI	%	MNI	%	MNI	%	MNI	%
SANDY FORESHORE																		
SAXIDOMUS																		
Saxidomus gigantea	38	0.2	48	0.48	3	0.007			5	0.01	48	0.58	86	0.73	17	0.05	11	0.03
PROTOTHACA																		
Protothaca staminae	24	0.13	17	0.17	12	0.03			14	0.03	31	0.38	20	0.17	39	0.11	31	0.08
CLINOCARDIUM																		
Clinocardium nuttallii	46	0.25	6	0.06	1	0			1	0	2	0.03	1	0.008	47	0.13	2	0
TRESUS																		
Tresus capax	17	0.09	12	0.12	4	0.01							9	0.07	1	0		
Tresus nuttallii																		
MACOMA																		
Macoma secta																		
Macoma nasuta	4	0	1	0	2	0												
ROCKY FORESHORE																		
MYTILUS																		
Mytilus trossulus	47	0.25	9	0.09	379	0.84	23	0.88	415	0.81	1	0.01	1	0.008	187	0.52	132	0.34
ARCHAEOBALANIDAE	1	0	1	0.01	9	0.02	1	0.04	11	0.02			1	0.008	2	0	2	0
STRONGLYOCENTROTUS																		
S. droebachiensis	4	0.02	1	0.01	10	0.02			1	0					59	0.16	1	0
S. purpuratus	1	0	1	0.01	3	0.007			1	0								
LOTTIIDAE					19	0.04												
Tectura scutum					2	0			38	0.07					2	0	144	0.38
Tectura persona							1	0.04	1	0								
Lottia pelta			1		2	0									1	0	55	0.15
Lottia digitalis					1	0											2	0
NUCELLA																		
Nucella lamellosa	2	0.01	2	0.02	3	0.007	1	0.04	18	0.03							2	0
Nucella emarginata									1	0								
KATARINA																		
Katharina tunicata															1	0	1	0
CANCER	1	0	1	0.01														
SANDY INTERTIDAL	125	**0.7**	84	**0.85**	22	**0.04**	0	**0**	20	**0.04**	81	**0.99**	116	**0.99**	104	**0.29**	44	**0.11**
ROCKY INTERTIDAL	56	**0.3**	15	**0.15**	428	**0.96**	26	**1**	486	**0.96**	1	**0.01**	2	**0.01**	252	**0.71**	339	**0.89**
TOTAL SHELLFISH	**181**	**1**	**99**	**1**	**450**	**1**	**26**	**1**	**506**	**1**	**82**	**1**	**118**	**1**	**356**	**1**	**383**	**1**

APPENDIX 3 SHELLFISH DATA- WEIGHT ANALYSIS

	DgRv-1	DgRv-2	DgRv-4	DgRv-34	DgRw-32	DgRw-64	DgRw-67	DgRw-73	DgRw-78
	%	%	%	%	%	%	%	%	%
SANDY FORESHORE									
SAXIDOMUS									
Saxidomus gigantea	0.18	0.09	0.04		0.03	0.26	0.12	0.04	0.02
PROTOTHACA									
Protothaca staminae	0.05	0.08	0.07	0.06	0.1	0.16	0.11	0.15	0.27
CLINOCARDIUM									
Clinocardium nuttallii	0.37	0.05	0.03		0.01	0.16	0.05	0.23	0.05
TRESUS									
Tresus capax		0.04	0.02				0	0	
Tresus nuttallii									
MACOMA									
Macoma secta	0								
Macoma nasuta		0							
VENEROIDA	0.14	0.54	0.09	0.09	0.07	0.2	0.45	0.03	0.13
ROCKY FORESHORE									
MYTILUS									
Mytilus trossulus	0.1	0.01	0.46	0.47	0.55	0.008	0.01	0.2	0.16
ARCHAEOBALANIDAE	0.05	0.15	0.2	0.32	0.12	0.008	0.01	0.04	0.06
STRONGLYOCENTROTUS									
S. droebachiensis	0.01	0	0.02				0	0.29	0
S. purpuratus	0	0	0.04		0.01				
LOTTIIDAE									0.04
Tectura scutum			0.01	0.02	0				0.07
Tectura persona									
Lottia pelta					0			0	0.01
Lottia digitalis									0
NUCELLA									
Nucella lamellosa	0	0	0	0.04	0.08				0
Nucella emarginata					0				
KATARINA									
Katharina tunicata								0.001	0
CANCER	0	0			0				
SANDY FORESHORE	0.78	0.8	0.25	0.15	0.21	0.79	0.74	0.46	0.46
ROCKY FORESHORE	0.17	0.16	0.74	0.85	0.76	0.01	0.02	0.54	0.35
PELECYPODA	0.05	0.04	0.01	0	0.03	0.2	0.24	0	0.19
TOTAL SHELLFISH	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

APPENDIX 4 FAUNAL DATA

	DgRv-1				DgRv-2				DgRv-4				DgRw-67				DgRw-32				DgRw-73				DgRw-78			
	NISP	%	MNI	%	NISP	%	MNI	%	NISP	%	MNI	%	NISP	%	MNI	%	NISP	%	MNI	%	NISP	%	MNI	%	NISP	%	MNI	%
FISH																												
ANADROMOUS																												
Pacific salmon	4	2	1	8	17	4	0		23	1	1				0		7	9	1	10	6	0.9	1				0	
MARINE																												
Pacific herring	211	86	4	31	377	93	15	78	1617	96	58	87	2	33	1	33	44	55	1	10	578	89	24	75	23	38	1	14
Dogfish	1	0	1	8			0		17	1	1	1.5			0		4	5	1	10	43	7	1	3.1			0	
Soft-bottom																												
Plainfin	2	1	1	8	3	1	1	5			0		3	50	1	33			0				0				0	
Starry flounder	1	0	1	8			0				0				0				0				0		3	5	0	
Flatfish	3	1	1	8			0				0				0				0		4	0.6	1	3.1			1	14
Staghorn sculpin	5	2	1	8	1	0	1	5	3	0	1	1.5			0				0				0				0	
Prickleback			0				0		1	0	1	1.5			0				0				0				0	
Sand lance			0				0				0				0		1		0				1	3.1			0	
Rocky shore																												
Rockfish					1	0	1	5	11	1	2	3	1	17	1	33	8	10	2	20	5	0.7	1	3	15	25	2	29
Greenling							0		3	0	1	1.5			0		1	1	1	10	1	0.1	1	3			0	
Red Irish lord	1	0	1	8			0		4	0	1	1.5			0		1	1	1	10			0				0	
Lingcod			0				0				0				0				0		9	1.3	2	6.3			0	
Cabezon			0				0				0				0				0				0		2	3	1	14
Pile perch	13	5	1	8			1	5			0				0		7	9	3	30			0				0	
Sea perch			0				0				0				0				0				0		1	2	1	14
Perch	5	2	1	8	5	1	0		2	0	1	1.5			0		7	9	0				0		15	25	1	14
TOTAL	**246**		**13**		**404**		**19**		**1681**		**67**		**6**		**3**		**80**		**10**		**646**		**32**		**59**		**7**	
MAMMAL	NISP	%	MNI	%	NISP	%	MNI	%	NISP	%	MNI	%	NISP	%	MNI	%	NISP	%	MNI	%	NISP	%	MNI	%	NISP	%	MNI	%
Dog	8	47	1	25													1	33	1	50								
Ungulate	2	12	1	25																					2	33	1	50
Land Mammal																	2	66	1	50	1	100	1	100	2	33		
Rodent					2	66	1	50																				
Northern Sea lion	6	35	1	25																								
Harbour Seal					1	33	1	50																				
Porpoise																									2	33	1	50
False Killer Whale	1	6	1	25																								
TOTAL	**17**		**4**		**3**		**2**										**3**		**2**		**1**				**6**		**2**	

Vertebrate analysis directed by Rebecca Wigen and Susan Crockford, Pacific Identifications Ltd., Victoria

APPENDIX 5 FAUNAL DIVERSITY (NISP)

TAXA	DgRv 1	DgRv 2	DgRv 4	DgRv 34	DgRw 32	DgRw 64	DgRw 67	DgRw 73	DgRw 78
Oncorhyncus spp.	4	17	23	0	7	0	0	6	0
Clupea harengus	211	377	1617	0	44	0	2	578	23
Squalus acanthias	1	0	17	0	4	0	0	43	0
Porichthys notatus	2	3	0	0	0	0	3	0	0
Platichthys stellatus	1	0	0	0	0	0	0	0	3
Pleuronectiformes	3	0	0	0	0	0	0	0	0
Leptocottus armatus	5	1	0	0	0	0	0	4	0
Stichaeidae	0	0	1	0	0	0	0	0	0
Ammodytes hexapterus	0	0	0	0	1	0	0	0	0
Sebastes spp.	0	1	11	0	8	0	1	5	15
Hexagrammos spp.	0	0	3	0	1	0	0	1	0
Hemilepidotus hemileptidotus	1	0	4	0	1	0	0	0	0
Ophiodon elongatus	0	0	0	0	0	0	0	9	0
Scorpaenichthys marmoratus	0	0	0	0	0	0	0	0	2
Damalichthys vacca	13	0	0	0	7	0	0	0	0
Embiotica lateralis	0	0	0	0	0	0	0	0	1
Embiotocidae	5	5	2	0	7	0	0	9	15
Canis familiaris	8	0	0	0	1	0	0	0	0
Odocoileus heminous	2	0	0	0	2	0	0	0	2
Mammalia	0	0	0	0	0	0	0	1	2
rodent	0	2	0	0	0	0	0	0	0
Eumatopias jubatus	6	0	0	0	0	0	0	0	0
Phoca vitulina	0	1	0	0	0	0	0	0	0
Delphinidae	0	0	0	0	0	0	0	0	2
Pseudorca crassidens	1	0	0	0	0	0	0	0	0
Saxidomus	73	96	6	0	6	92	164	31	19
Protothaca	43	25	20	0	22	52	37	76	61
Clinocardium	87	11	1	0	0	3	1	91	4
Tresus	27	21	5	0	0	0	12	1	0
Macoma secta	7	2	3	0	0	0	0	0	0
Macoma nasuta	0	0	0	0	0	0	0	0	0
Mytilus	80	17	720	36	792	1	1	373	254
Archaeobalanidae	4	1	36	1	42	0	1	8	12
S.droebachiensis	31	1	95	0	1	0	0	567	1
S.purpuratus	6	0	20	0	1	0	0	0	0
Lottiidae	0	1	19	0	38	0	0	0	144
Tectura scutum	0	0	2	0	1	0	0	2	55
Tectura persona	0	0	0	0	0	0	0	0	2
Lottia pelta	0	0	2	0	0	0	0	1	0
Lottia digitalis	0	0	1	1	1	0	0	0	2
Nucella lamellosa	2	2	3	1	18	0	0	0	0
Nucella emarginata	0	0	0	0	1	0	0	0	0
Katarina tunicata	0	0	0	0	0	0	0	8	1
Cancer	2	1	0	0	0	0	0	0	0
Abundance	625	585	2611	39	1006	148	222	1814	620
Richness	25	19	23	4	23	4	9	19	20
Evenness	0.586	0.348	0.295	0.094	0.268	0.205	0.232	0.441	0.486