Seasonal Implications of Rockfish Exploitation in the Toquaht Area, B.C.

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SEASONAL IMPLICATIONS OF ROCKFISH EXPLOITATION IN THE TOQUAHT AREA, B.C.

BY

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Table of Contents

Tables

Figures

Figures – cont.

Appendices

Abstract

The following research was undertaken in order to evaluate opposing models of subsistence and settlement among the Nuu-chah-nulth – the indigenous inhabitants of the west coast of Vancouver Island. One model assumes that pre-contact patterns of subsistence and settlement mirror those from the ethnographic period. The other model interprets the ethnographic pattern as a product of relatively recent historical forces and assumes a different pattern for the pre-contact period. The seasonal timing of rockfish (*Sebastes* spp.) exploitation at several archaeological sites within Barkley Sound is examined in order to address this question.

The season of rockfish capture was determined by examining growth increments on their vertebrae. An annual growth model for rockfish vertebrae was developed using modern specimens captured within the study area at known times of year. Archaeological specimens were then compared to this model to determine season of capture in the past.

The results of the present research suggest that the ethnographic pattern of seasonally scheduled subsistence and site use was not typical of Barkley Sound sites during the pre-contact period. The ethnographic pattern is, therefore, rejected as a model of pre-contact Nuu-chah-nulth subsistence behaviour.

Chapter 1 - Introduction

1.0 Preface

The Northwest Coast of North America has long been a region of particular anthropological interest. Much of this focus has been due to the remarkable level of cultural sophistication achieved by the indigenous inhabitants of the Northwest Coast; particularly given that this sophistication was achieved by a people whose sole means of subsistence was hunting and gathering. The attributes usually ascribed to hunter-gatherer societies include low population density, simple portable technology base, egalitarian social structure, and highly mobile settlement systems. None of these attributes are fully applicable to the cultures of the Northwest Coast.

Two factors are usually cited in order to account for the apparently anomalous development of Northwest Coast societies. The first is that salmon (the primary food resource associated with most of these groups) is a storable resource. This would have allowed the accumulation of wealth, the development of a more sedentary life, and the associated development of social mechanisms for dealing with surplus and redistribution, factors usually associated food producing societies. The second is that the Northwest Coast is a uniquely rich environment, a veritable Garden of Eden, where the sheer abundance of food would have freed individuals to develop more advanced artistic and cultural traditions. This point of view is well expressed by Ruth Underhill (1944, in Suttles 1987a: 26).

> *"In this sense the Northwest Coast had everything. There were fish in the streams; game in the forests; berries and roots in open places. There were trees large enough to a build banquet hall yet, splitting like matchwood. There was a climate so moist that plants grew as if in the tropics, yet so mild few clothes were necessary.*
>
> *People who lived in such a climate did not need to plant. They had more berries and roots than they could use, simply by going to places where nature had spread them. Most of them did not even hunt, unless they felt like a change of diet. Every year, they had only to wait until the salmon came swarming up the streams, "so thick," say the old settlers, "that you could walk across on their backs." In three or four months, a family could get food enough to last a year. The rest of the time they could give to art, to war, to ceremonies and feasting. And so they did."*

This over-idealised conception of the Northwest coast environment is now largely rejected. Researchers such as Suttles (1987a, 1987b) suggest that, while the Northwest coast environment was extremely productive, this alone cannot account for the development of Northwest Coast societies. Researchers now widely acknowledge that many cultural and technological adaptations were required in order to take full advantage of the region's resources (e.g. Carlson 1990; Fladmark 1986; Matson and Coupland 1995).

The general Northwest Coast adaptation of seasonally variable subsistence and settlement patterns has been the focus of recent study and debate (e.g. Ford 1989). This can be seen in the different approaches taken by researchers working in the Nuu-chah-nulth region on the west coast of Vancouver Island. Some researchers (e.g. Dewhirst 1980: 15; Suttles 1990) argue that a pattern of seasonal mobility similar to that described in ethnohistoric accounts was a necessary adaptation to spatially and temporally patchy West Coast resources. Other researchers (e.g. McMillan 1999: 196) argue that the pattern of seasonal mobility described in ethnohistoric accounts (e.g. Drucker 1951: 33-36) was the product of relatively recent historical events – specifically, the massive disruption of indigenous societies resulting from contact with Europeans – and that a different seasonal pattern (year-round occupation of a central location) prevailed prior to contact.

The following research examines evidence of the seasonal exploitation of an important food resource - rockfish (*Sebastes* Spp.) - at several sites within Barkley Sound on the west coast of Vancouver Island. The sites are within the traditional territory of the Toquaht, a Nuu-chah-nulth sub-group. The purpose of this research is twofold. First, it is hoped that this research will shed new light onto the seasonal scheduling rockfish exploitation, and thus, improve our knowledge regarding local subsistence activities. Secondly, this research will examine the implications of (possible) seasonal rockfish exploitation on the seasonality of Toquaht site occupation thereby evaluating the two opposing views of Nuu-chah-nulth seasonal mobility discussed above.

1.1 Species of Interest

The research presented here focuses on the seasonal timing of rockfish capture by the Toquaht, the indigenous inhabitants of the north shore of Barkley Sound. Rockfish were selected for analysis because certain aspects of their ecology and traditional use within the Nuu-chah-nulth region permit inferences relating the season of rockfish capture to the season of site occupation in Barkley Sound. The non-seasonal nature of rockfish availability (except on those occasions when poor winter weather prevented fishing) is particularly important in this regard. The acquisition of rockfish can be interpreted as a function of scheduling decisions about a) where to live at what time of year, and b) what resources were assigned priority for acquisition when the site was occupied.

Additionally, rockfish were selected because of the probable economic importance of these species to the Toquaht. The importance of rockfish to Nuu-chah-nulth economies is suggested by the relative abundance of their remains in archaeological collections from other sites within the study region such as Hesquiat Harbour (Calvert 1980). Despite its numerical abundance, the economic importance of rockfish has been generally under-emphasized or overlooked, possibly due to the perceived superior economic importance of salmon and whales.

1.2 Seasonality Studies

The general methodology for this research takes the form of a seasonality study. Seasonality studies in archaeology are aimed at identifying the time of year that sites were occupied, or the timing of specific activities that took place there. Such studies may take several forms. Most seasonality studies, however, involve the examination or quantification of faunal or botanical remains. Rockfish remains are examined in the present research in order to determine their season of capture and, by association, the season of occupation of the sites from which they were recovered.

A number of techniques have been developed for determining the age and season-of-death of fish from their skeletal remains, many of which involve the analysis of incremental growth structures. Several kinds of mineralized structure are known to grow incrementally and have been used to estimate age and season of death of fish. The most commonly used structures are otoliths, scales, fin-rays, dorsal spines, and vertebrae. The present research focuses on rockfish vertebrae because of the relative durability, abundance, and reliability of vertebral remains.

1.3 Methodology for Seasonal Determinations

The estimation of season of death from growth increments involves two important stages. First it is necessary to view and accurately measure incremental growth. A number of techniques have been developed for viewing growth structures in fish vertebrae. These are discussed and evaluated (in terms of time, cost and effectiveness) in section 4.2.2. The examination of growth increments on thecentrum surface of whole vertebrae under a low-power (16X magnification) stereomicroscope using reflected light is deemed the most appropriate technique for use in this research.

The second important stage in the estimation of seasonality from growth increments involves establishing a model for the rate of growth and timing for the deposition of structurally different increments. A theoretical or empirical model of expected seasonal growth is required in order estimate the season-of-death associated with specific growth readings (Monks 1981: 193). The accuracy of the estimation is dependent upon the strength of the model. The growth model used in this research is developed from empirical observations of rockfish vertebrae collected within the study area over a one-year period and basic theoretical concepts regarding the seasonal growth of fishes.

1.4 Archaeological Sample

The archaeological sample for this research originates from three sites in Barkley Sound on the west coast of Vancouver Island. These sites come from two important environmental settings within the study area: the outer Pacific coast; and the shore of Barkley Sound. Collectively, materials from these sites reflect the last 4000 years of human occupation in Barkley Sound.

The sample used comprises all of the intact rockfish thoracic vertebrae from these sites that could dated by radiocarbon estimates, type-artifacts, or relative stratigraphy. Rockfish thoracic vertebrae are defined, following Cannon (1987: 21), as the first five vertebrae (counting from head to tail and excluding the atlas) in the spinal column. Rockfish thoracic vertebrae are distinguished from caudal and pre-caudal vertebrae primarily by the absence of haemal spines and by the presence of facets associated with rib attachments (Cannon 1987: 91).

1.5 Theoretical Approach

The approach taken in the following research is grounded in the "cultural ecology" theoretical perspective. This perspective focuses on the dynamic relationship between environment and culture (Trigger 1989: 281). Julian Steward (1959) provided the first explicit formulation of cultural ecology (Trigger 1989: 281); he defined it as "the study of the processes by which a society adapts to its environment (Steward 1968: 337)". According to Steward (1968), cultures should be analyzed as environmental adaptations; where the "environment" encompasses a broad range of variables, including such aspects as terrain, surrounding materials, and other social groups.

Steward proposes that the interpretation of cultures and culture change should begin by focusing on that part of culture ("culture core") which is most closely connected to the physical world (i.e. subsistence or productive strategies) (1955: 209). The cultural core, in turn, is seen as shaping (and shaped by) other culture features (e.g. social organization).

The following research examines the exploitation of a single resource, rockfish, as part of an overall subsistence strategy of which seasonal mobility may, or may not, have been a necessary component. According to cultural ecological theory, subsistence and settlement strategies (as "core" features) are fundamental to the interpretation of cultures.

The exploitation of a single resource, rockfish, is examined as part of an overall subsistence strategy of which seasonal mobility may, or may not, have been a necessary component. Two models which attempt to explain the pattern of seasonal mobility observed among ethnographic Nuu-chah-nulth groups are considered: one regards ethnohistorically documented patterns of mobile settlement and subsistence as a required and longstanding adaptation to the natural environment (e.g. Dewhirst 1980: 15; Suttles 1987a, 1987b); the other regards the ethnographic pattern of seasonal mobility as an adaptation to reduced population size and to relatively recent changes in the socio-culturally defined natural environment (i.e. the expansion of the number and variety of resource areas to which groups held rights) (e.g. McMillan 1999: 196). Differences in the seasonal patterning of rockfish remains from the study area, with respect to site-setting and depositional time-period, are interpreted in relation to the archaeological implications of these two ecologically grounded views.

1.6 Summary

The question of when (at what time of year) rockfish were exploited at several sites within the traditional Toquaht territory is addressed here. The examination of rockfish utilization provides insight into a little-studied component of Nuu-chah-nulth subsistence. The seasonal timing of rockfish exploitation in two different environmental settings has implications for the seasonal scheduling of exploitation of other food resources, and it provides a means of testing two models of Nuu-chah-nulth subsistence and settlement strategies.

Incremental growth mark analysis is used to assess the season-of-death of rockfish recovered from three village sites within the Toquaht study area and thereby reveal associated patterns of seasonal rockfish exploitation. The selected technique involves the analysis of growth rings on the centrum surface of vertebrae. In order to estimate season-of-death from these readings, a common model of rockfish growth is developed here for the first time.

Chapter 2 – Background to the Research

2.0 The Northwest Coast Culture Area

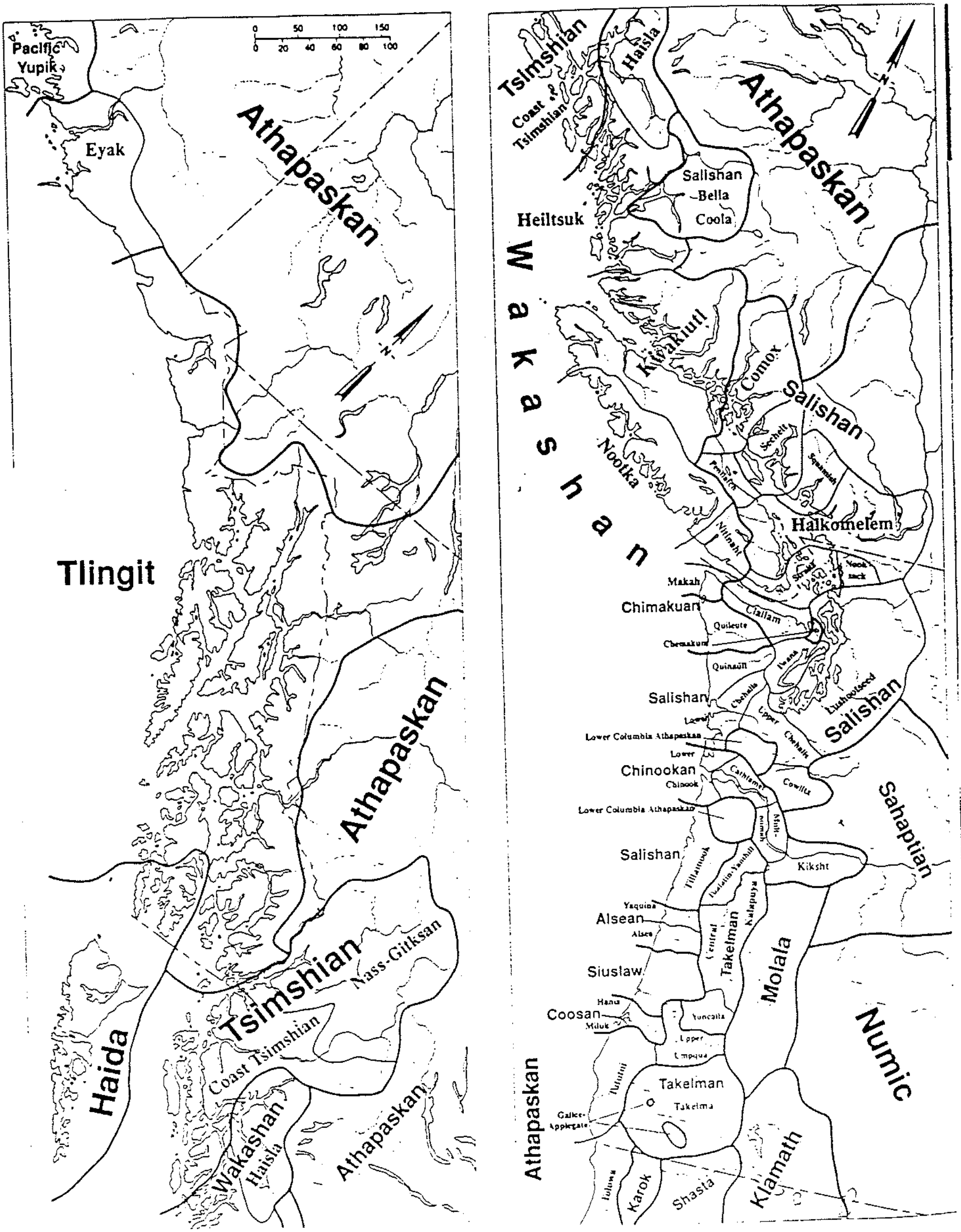
Exact definitions vary, but the Northwest Coast culture area (Figure 2.0.1) is generally thought to extend from the northern California Coast to Yakutat Bay at the northern end of the Alaska Panhandle (Matson and Coupland 1995; Ames 1999; Suttles 1990). Though there are significant environmental and cultural differences within this broad region, it is possible to describe the culture area in general terms (below).

The climate of the Northwest Coast is moderate, with warm summers and cool wet winters. The region's climate is probably most often characterized by the amount of precipitation it receives. Annual precipitation here typically exceeds 1000 mm, even at the southern or "dry" end of the Northwest Coast (Matson and Coupland 1995). Vegetation in the region is dominated by rain-adapted coniferous forest. A Sitka spruce-Western hemlock forest is found along the coast from the California border to Yakutat Bay (Suttles 1990: 2). Other firs, spruces, cedars, and redwoods are found in different areas along the coast. The area is also characterized by the richness of its marine environment. The abundance and economic importance of Pacific salmon (genus *Oncorhynchus*) is one of the best-known characteristics of the Northwest Coast culture area. However, a variety of other marine and intertidal resources are available along the coast. Important marine fish include halibut and other flatfish, Pacific cod, Pacific herring, rockfish (*Sebastes* Spp.), and eulachon (Matson and Coupland 1995; Suttles 1990: 12).

The indigenous peoples of North America's Northwest coast share many cultural characteristics. All of the peoples included within this culture area relied on hunting and gathering for subsistence with an emphasis on fishing. Due to the limited seasonal availability of many marine resources, particularly salmon, most Northwest Coast groups

(Figure 2.0.1) Location of Northwest Coast Culture Area adopted mass harvesting along with preservation and storage technologies (Matson and Coupland 1995). The traditional material culture of Northwest Coast peoples was typified by an emphasis on bone and antler working, woodworking, and pecked and ground stone technology. Indeed, Northwest Coast carvers and craftsmen still produce one of the world's most famous art styles (Ames 1999). By contrast, the flaked stone industry was poorly developed and ceramics were unknown (Matson and Coupland 1995). A settlement pattern involving the amalgamation of large groups (commonly over 100 people) in semi-permanent winter villages was also typical for the entire Northwest Coast culture area (Matson and Coupland 1995; Suttles 1990: 4). Hereditary social inequality is another defining characteristic of Northwest Coast societies. Three distinct social groups existed - a titled upper class, an untitled class of commoners, and slaves (Matson and Coupland 1995; Suttles 1990: 4). Class inclusion was based on principals of residential kinship and descent (generally bilateral, though matrilineal among some northern groups) (Suttles 1990: 4). Elites maintained and validated their claims to status through their wealth. Closely associated with these concepts of rank and status was a notion of private property that gave nobles unique rights to resources and resource locations.

Although cultural similarities exist within the Northwest Coast culture area, it is by no means culturally homogeneous. At the time of European contact, the Northwest Coast was the second most diverse linguistic area in North America (following California) (Thomson and Kinkade 1990: 31). It encompassed up to 45 languages (Fig. 2.0.2) belonging to at least seven language families including Na-Dene, Haida, Tsimshian, Wakashan, Chimakuan, Salishan, and Penutian (Suttles 1990; Matson and Coupland 1995). The Northwest Coast volume of the Smithsonian Institute's "Handbook of North American Indians" (Sturtevant 1990) identifies 29 distinct socio-linguistic groups inhabiting the culture-area. These socio-linguistic groups do not describe single political



(Fig. 2.0.2) Northwest Coast Language Areas (from Thompson and Kinkade 1990: p.32) entities or single societies (i.e. individual local groups, tribes, or confederacies); rather, they represent populations that share a common language or language family and that are closely linked culturally and socially (Ames 1999). Differences between separate socio-linguistic groups may be evident in their residence patterns, artistic traditions, material cultures, and subsistence economies. However, interaction within greater regional systems of trade, intermarriage, and ritual (e.g. potlatches) frequently crosscut socio-linguistic and cultural divisions (Suttles 1990: 16). Therefore, socio-linguisitic groups can not be regarded as entirely independent systems, operating outside of a broader Northwest Coast regional context.

2.1 Northwest Coast Pre-History

The time of the initial peopling of the Northwest Coast is uncertain. It likely occurred as part of the major population expansion throughout North America that followed the end of the last glaciation about 13,000 years ago (Fladmark 1986). The earliest archaeological remains from the Northwest Coast consist mostly of stone tools (Carlson 1990: 60). Fladmark (1986) defines this early period in the region's past as the "Lithic Stage", dating from about 12,000 to 5000 years ago. This period is identified by at least four technological traditions: the Fluted Point and the Stemmed Point traditions in the south, the more widespread Pebble Tool tradition, and the predominantly northern Microblade Tradition. The typological distinctiveness and geographical patterning of these traditions is generally taken to indicate that they represent distinct cultural traditions and possibly separate populations (Carlson 1990; Fladmark 1986; Matson and Coupland 1995). The Fluted Point and Stemmed point Traditions are the oldest and likely spread to the Northwest Coast from the interior of North America via the Columbia River between 11,000 and 10,000 years ago (Carlson 1990: 61). The two other traditions are likely more recent, emerging between about 10,000 and 9000 years ago, and appear to be of coastal origin (Carlson 1990: 61).

Fladmark (1986) uses the term "Early Developmental Stage" to describe the period between about 5500 and 3500 years ago. Many general Northwest Coast cultural characteristics seem to have first appeared during this period. The Early Developmental Stage is best known archaeologically by the Charles and Mayne phases of the cultural sequence from British Columbia's southern coast (Mitchell 1990: 297). Throughout the Northwest Coast, this period is associated with an increase in both the number and size of archaeological sites. Many of the sites associated with this period are large shell-middens - suggesting the development of more intensive patterns of site occupation, including the establishment of semi-permanent winter-villages (Fladmark 1986). Art objects, status symbols and human burials associated with this period further suggest the development of increasingly complex societies and belief systems.

Most of the main features associated with Northwest Coast cultures seem to have been attained by the period between about 3500 and 1500 years ago (Fladmark 1986). Fladmark (1986) terms this period the "Middle Developmental Stage". This period is best known by the Locarno Beach and Marpole phases of the archaeological sequence from the southern mainland coast of British Columbia (Mitchell 1990: 297). The development of storage technology at this time is thought to have played an important role in the emergence of characteristic Northwest Coast ways of life (McMillan 1998: 5; Coupland 1998: 44). A storage-based economy is thought to have allowed higher population levels and it is generally agreed that social stratification fully emerged only after salmon specialization and storage techniques were in place (McMillan 1999: 123). Throughout the Northwest Coast, archaeological sites from this period are generally larger and show signs of greater permanence than those from preceding periods (Fladmark 1986). Among other developments, the Middle Developmental Stage provides the first clear archaeological evidence of large plank houses characteristic of historic Northwest Coast villages (Fladmark 1986). Regional differences persisted throughout this period and are evidenced by differences in lithic technology; particularly by the presence and abundance of flaked-stone, ground-stone, and microblade tools.

Archaeological remains from the last 1500 years of Northwest Coast's past - Fladmark's (1986) "Late Developmental Stage" - are generally assumed to represent the prehistory of populations living in those locations at the time of European contact. Therefore, the archaeological study of this period is generally divided into the specific pre-histories of separate socio-linguistic or tribal groups in existence today.

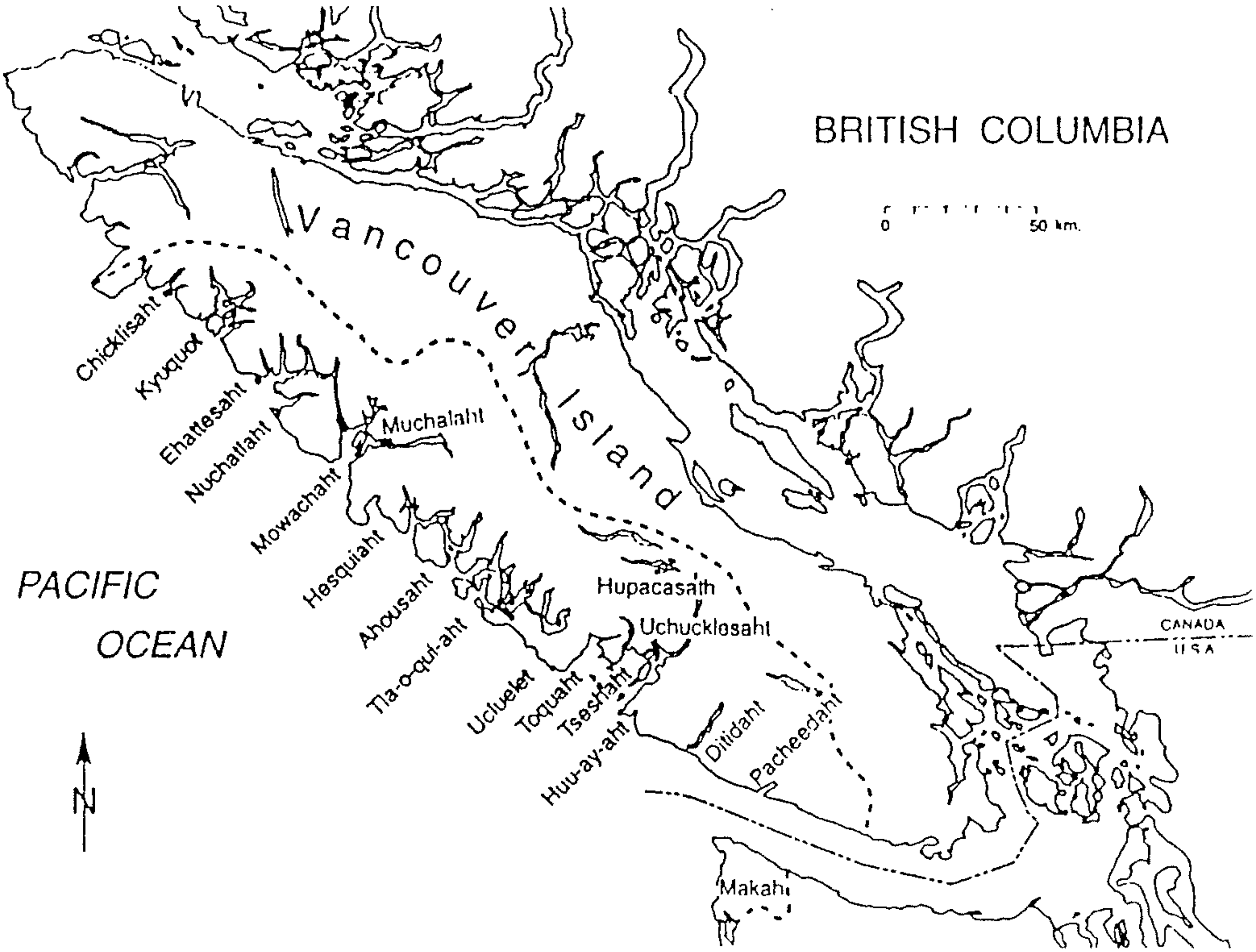
2.2 The Nuu-chah-nulth

The study area is situated within the geographical distribution of the Nuu-chah-nulth socio-linguistic group, part of the broader distribution of "Nootkan" languages within the Wakashan language family. The Wakashan language family includes six languages and is divided into a northern and a southern branch. Three languages are represented the northern branch: Kwakwala (spoken by the Kwakwaka'wakw people - formerly called the Southern Kwakiutl – located on the north coast of Vancouver Island and the adjacent mainland coast), Heiltsuk (spoken by people at Bella Bella), and Haisla (spoken at Kitimaat) (McMillan 1999: 13). The southern branch contains the three "Nootkan" languages: 1) Nuu-chah-nulth (formerly "Nootka"), spoken by people from Barkley Sound to Cape Cook an the west coast of Vancouver Island, 2) Ditidaht (formerly Nitinat), spoken by Vancouver Island groups south of Barkley Sound, and 3) Makah, spoken on the north-western tip of the Olympic Peninsula in Washington State (McMillan 1999: 13). Although most linguists identify these as separate languages because they are not mutually intelligible, the aboriginal peoples of the area have a strong sense of shared culture and consider Nuu-chah-nulth, Ditidaht, and Makah to be a single language (McMillan 1999: 14). Anthropological researchers either group Nootkan speakers into a single socio-linguistic group or recognize the Nuu-chah-nulth, Ditdaht, and Makah as distinct. Further confusing the issue, the term "Nootka" has been variously used to refer to: the autonomous political group occupying Nootka Sound; the Nuu-chah-nulth socio-linguistic group; or as a collective term for all three Nootkan socio-linguistic groups. The term "Nootka" is used here only when collectively describing the Nuu-chah-nulth, Ditidaht, and Makah, in order to avoid such confusion.

The "Nootka" were organized into 20 named, politically autonomous, local groups (Figure 2.1.2) (Matson and Coupland 1995). These correspond, more or less, to the sixteen legally recognized bands of Nuu-chah-nulth, Ditidaht, and Makah that exist today - although some groups have disappeared or have amalgamated into larger political units (McMillan 1999: 14). The local group - centering on a family of chiefs who owned territorial rights, houses, and various other privileges - was the basic social and economic unit in the Nuu-chah-nulth political system (Drucker 1951: 33). These groups usually shared a winter village and took their name from their 'place' (a site at their fishing ground where they 'belonged'), or from a chief. They also firmly believed they descended from a common ancestor (McMillan 1999: 13). Local groups had clearly defined territorial boundaries, and access to resources within those boundaries was strictly controlled. The local group was the basic political unit in Nuu-chah-nulth society; it was also divided into varying numbers of subgroups, called "septs" by Boas (1891). These represent different lines of descent from the common ancestor associated with each local group (McMillan 1999: 13).

2.3 Environmental Setting - The West Coast of Vancouver Island

The traditional territory of the Nuu-chah-nulth is a stretch of roughly 300 km of rugged coastline on the west coast of Vancouver Island (Figure 2.1.2). It is dominated



(Figure 2.1.2.) Nootkan Sub-Groups (from McMillan 1999: 14) on one side by the steep Island Mountains and on the other by the North Pacific Ocean. The region is characterized by two major geographical settings: an "outside" outer coast/fjord mouth environment, and an "inside" inner fjord/river mouth environment. These two geographical settings were recognized by the Nuu-chah-nulth and referred to as "kla'a" and "hilsts" respectively (Dewhirst 1980: 9).

The outer coast is typically rugged, rocky, relatively unbroken and totally exposed to the open ocean. An undersea shelf extends a short distance offshore: the 20-fathom line extends offshore about 5 kilometers; the 50-fathom line extends from 6 to 14 kilometers (Dewhirst 1980: 10). Offshore banks, reefs and rocks belonging to this shelf support considerable tidal, pelagic and demersal food resources. A riparian lowland (less than 200 meters above sea level) extends inland for up to about 5 kilometers along the outer coast (Dewhirst 1980: 10). The lowland contains an occasional lake near the shore and generally few streams of consequence.

The "inside" setting is made up of inlets that vary in length from a few kilometers to 60 kilometers in the Alberni Inlet. Relief increases with distance inland where hills and mountains rise to as much as 1400 meters above the sea (Dewhirst 1980: 10). Major rivers at inlet heads and lesser streams along their sides break up the typically steep and rocky shores. Marine resources in the inlets are generally poorer than those of the "outside". However, the "inside" setting contains many other rich, though seasonally fluctuating, resources (Dewhirst 1980: 10). Many of the larger inside streams support good-sized salmon runs, though these are generally less productive than those of the mainland. Land mammals and edible plants are also plentiful on the inside.

The coastal western hemlock biogeoclimatic zone characterizes the terrestrial environment of both settings. This environment is supported by a wet, rainy climate with an annual precipitation of 165 to 665 cm. Precipitation increases with proximity to the Island Mountains (Dewhirst 1980: 10). Winters are mild (January mean monthly temperatures fluctuate between -4° and 5° C) and wet, accounting for from 30 to 40 percent of total annual precipitation. Summers are cool (July mean monthly, 13° to 18° C) and comparatively dry, receiving 7 to 15 percent of annual precipitation (Dewhirst 1980: 10). The coastal western hemlock zone supports a predominantly coniferous rainforest characterized by Douglas fir, western hemlock, western red cedar, pacific silver fir, Sitka spruce, lodgepole pine, western white pine and yellow cypress (Dewhirst 1980: 10).

It is reasonable to assume that the environmental conditions on the coast, as described here, have remained relatively stable for the last 5000 years (Coupland 1998: 37). The major process that impacted the early Holocene environment of this region was sea level change following the end of the Pleistocene. Deglaciation and subsequent tectonic uplift led to the establishment of present sea levels by about 5000 BP (Coupland 1998: 37).

2.4 Nuu-chah-nulth Culture History

No archaeological sites have yet been found in the Nuu-chah-nulth area that predate c.5500 BP - corresponding to Fladmark's (1986) "Lithic Stage" of Northwest Coast prehistory (McMillan 1999: 104). The earliest evidence of human occupation on Vancouver Island comes from the Bear Cove site and from similar finds made at Quatsino Sound - located, respectively, on the northeast and northwest coasts of the island. Assemblages from both locations contain Pebble Tool Tradition type artifacts and date to between about 9000 and 8000 BP (McMillan 1999: 104). Faunal material from Bear Cove suggests a more maritime orientation than is commonly associated with Pebble tool tradition sites (Carlson 1990: 63).

Major excavations have been undertaken within the Nuu-chah-nulth area at Yuquot in Nootka Sound (Dewhirst 1980), Shoemaker Bay at the head of Alberni Inlet

(McMillan and St.Claire 1982), and at several sites in the vicinity of Hesquiat Harbour (Calvert 1980; Haggarty 1982) and Barkley Sound (McMillan and St.Claire 1996).

Yuquot, with a date of about 4200 BP - corresponding to Fladmark's (1986) "Middle Developmental Stage" - is the oldest site in Nuu-chah-nulth territory (Mitchell 1990: 357). Evidence of much earlier occupation in surrounding regions (i.e. northern Vancouver Island and the adjacent mainland coast), however, suggest that archaeological evidence of this region's earliest inhabitants has yet to be discovered (Coupland 1998: 39). Yuquot's principal investigator, Dewhirst (1980) stresses cultural continuity through to the historic period and suggests that, even for this early period, many characteristic Nuu-chah-nulth traits were already in place at Yuquot.

Mitchell (1990: 357) also stresses continuity in his proposed "West Coast" culture type which he applies to the entire west coast of Vancouver Island for the period from about 5000 BP to European contact. The culture type is identified primarily by the dominance of small bone points and bipoints and by the absence flaked stone tools. Like Dewhirst, Mitchell considers the early West Coast materials to be so like historic Nuu-chah-nulth technology that he characterizes the entire area as one "of relatively little change in subsistence and other aspects of technology (1990: 357)". Mitchell's classification is based principally on the examination of excavated materials from Yuquot (Dewhirst 1980), Hesquiat Harbour (Calvert 1980; Haggarty 1982), and to a lesser extent Shoemaker Bay (McMillan and St.Claire 1982).

While Dewhirst and Mitchell stress cultural continuity and stability, more recent excavations of several sites in Barkley Sound suggest a slightly different picture - at least for this portion of the coast (McMillan 1998). Carbon dates from Ch'uumat'aa indicate that this site was occupied as early as 4000 BP. Materials from the site predating 2000 BP share many characteristics (particularly chipped stone tools) with the adjacent mainland Gulf of Georgia Locarno Beach stage and are distinct from those found during the contemporary period at Yuquot. This is taken by McMillan (1998) to suggest a long period of occupation prior to Nuu-chah-nulth arrival.

The first known contact between Europeans and Nuu-chah-nulth peoples occurred in 1774, when Juan Pérez, captain of the Spanish frigate *Santiago,* exchanged gifts with local inhabitants in the vicinity of Hesquiat Peninsula (McMillan 1999). In 1778 James Cook visited Nootka Sound where he stayed for nearly a month and traded iron and other metals for sea otter pelts. These pelts were sold in China for great profits and shortly thereafter an international maritime fur trade was established on the Northwest Coast (Amira and Dewhirst 1990). The intensive trade in otter pelts only lasted until the early 19^{th} century, but it's impact on Nuu-chah-nulth societies was severe. Nuu-chah-nulth populations plummeted during the 19^{th} century as a result of introduced diseases and endemic warfare over the control of resources (McMillan 1999).

2.5 Nuu-chah-nulth Subsistence - the Seasonal Round

Nuu-chah-nulth subsistence during the early-contact period was characterized by a pattern of seasonal mobility between semi-permanent villages and resource procurement sites. This pattern has been described as a "seasonal round" (Dewhirst 1980: 11-12; Amira 1983; Mitchell 1983, 1990). Drucker (1951: 33-36) was the first to describe a general model of the Nuu-chah-nulth seasonal round: 1) in late fall local groups move from their fishing camps situated at or near stream mouths (commonly at "inside" settings) to more protected, "inside", tribal winter villages. Here they subsist mostly on stored salmon; 2) as stores begin to run out, local groups move to spring herring spawning sites in order to harvest fish and eggs; 3) by summer people are encamped in their "outside" sites in order to exploit maritime resources (halibut fishing and whaling were considered to be particularly important); 4) in late summer/early fall local groups would return to their fishing camps in order to take advantage of the fall salmon run.

The antiquity of the ethnographically documented Nuu-chah-nulth system of subsistence and settlement has become a subject of debate (e.g. Calvert 1980; Dewhirst 1980; McMillian 1999; Suttles 1962). One hypothesis is that successful adaptation to the West Coast environment required a pattern of seasonal mobility (i.e. while resources on the coast were abundant, they were too spatially and temporally patchy to be successfully exploited without some form residential mobility [Suttles 1962]). If this hypothesis holds, one would expect to find evidence for the considerable antiquity of the ethnographic pattern of seasonal movement in the archaeological record. Dewhirst's (1980) archaeological examination of the Yuquot site in Nootka Sound seemingly supports this hypothesis. He interprets his findings as evidence that the historic pattern of movement between inner and outer locations was long established (Dewhirst 1980: 15). He extends this argument to propose that successful adaptation to the coast required that groups have access to both inside and outside settings.

The opposing hypothesis asserts that the pattern of seasonal mobility observed in the ethnographic record is a product of relatively recent historical forces. Researchers such as McMillan (1999), Calvert (1980), and St.Claire (1991) trace the ubiquity of the ethnographic pattern throughout the Nuu-chah-nulth region to fundamental changes in social organization and settlement pattern that occurred very early in the post-contact period. These changes are seen as resulting from drastically reduced populations due to introduced diseases and intensified warfare - a result of destabilized economies and differential access to European goods, especially firearms.

According to McMillan (1999: 196), prior to European contact Nuu-chah-nulth territory was occupied by many autonomous political groups exploiting relatively small territories from central locations that were occupied more or less year-round. As populations dropped in size, amalgamations of political groups were required. This resulted in each political group holding much more territory, which could only be effectively exploited through a seasonal pattern of movement. This then, was the origin of the "universal" Nuu-chah-nulth practice as recorded in the ethnographic sources (e.g. Drucker 1951: 33-36). If the seasonal round is an artifact of early historic forces then archaeological evidence for changing patterns of seasonal site use will be visible. According to McMillan's hypothesis, large sites (such as T'ukw'aa) should show evidence of year-round occupation in the pre-Contact period.

This second hypothesis is supported by archaeological investigations at several locations on the Northwest Coast. Calvert's (1980) faunal analysis of three sites in Hesquiat Harbour documents year-round occupation in the pre-contact period and indicates that access to different local habitats accounts for most of the assemblage variation between sites. On the Olympic Peninsula in Washington State (the traditional homeland of the Makah who share a close cultural affinity with the Nuu-chah-nulth) faunal analyses by Huelsbeck and Wessen (1995) indicate that what were initially described as seasonal winter villages were actually occupied for much or all of the year. Farther north, in the Coastal Tsimshian area, a similar picture emerges from Stewart and Stewart's (1996) faunal analysis of the Boardwalk and Grassy Bay sites near Prince Rupert. The historically observed subsistence pattern in this area involved amalgamation in large winter villages with smaller fishing sites being occupied at other times of year (Stewart and Stewart 1996:40). Their research suggests that prehistoric Boardwalk was occupied year-round (Stewart and Stewart 1996:57).

Therefore, there are two distinct models for seasonal site occupation on thewest coast of Vancouver Island during the pre-contact period. One model (Dewhirst 1980: 11-12, 15) predicts that sites were occupied on a seasonal basis according to their proximity to seasonally available resources, weather, quantities of winter provisions, ownership of resource properties, and threat of warfare. Inside sites are expected to be associated with winter occupation while outside sites are expected to be associated with summer occupation. The other model (McMillan 1999: 128-129,196) predicts year-round occupation for all village sites regardless of setting until the beginning of the contact period, during which the ethnographic model (Drucker 1951) emerges. These two models are evaluated below in terms of their predictions for site seasonality using rockfish seasonality data from several sites within Barkley sound.

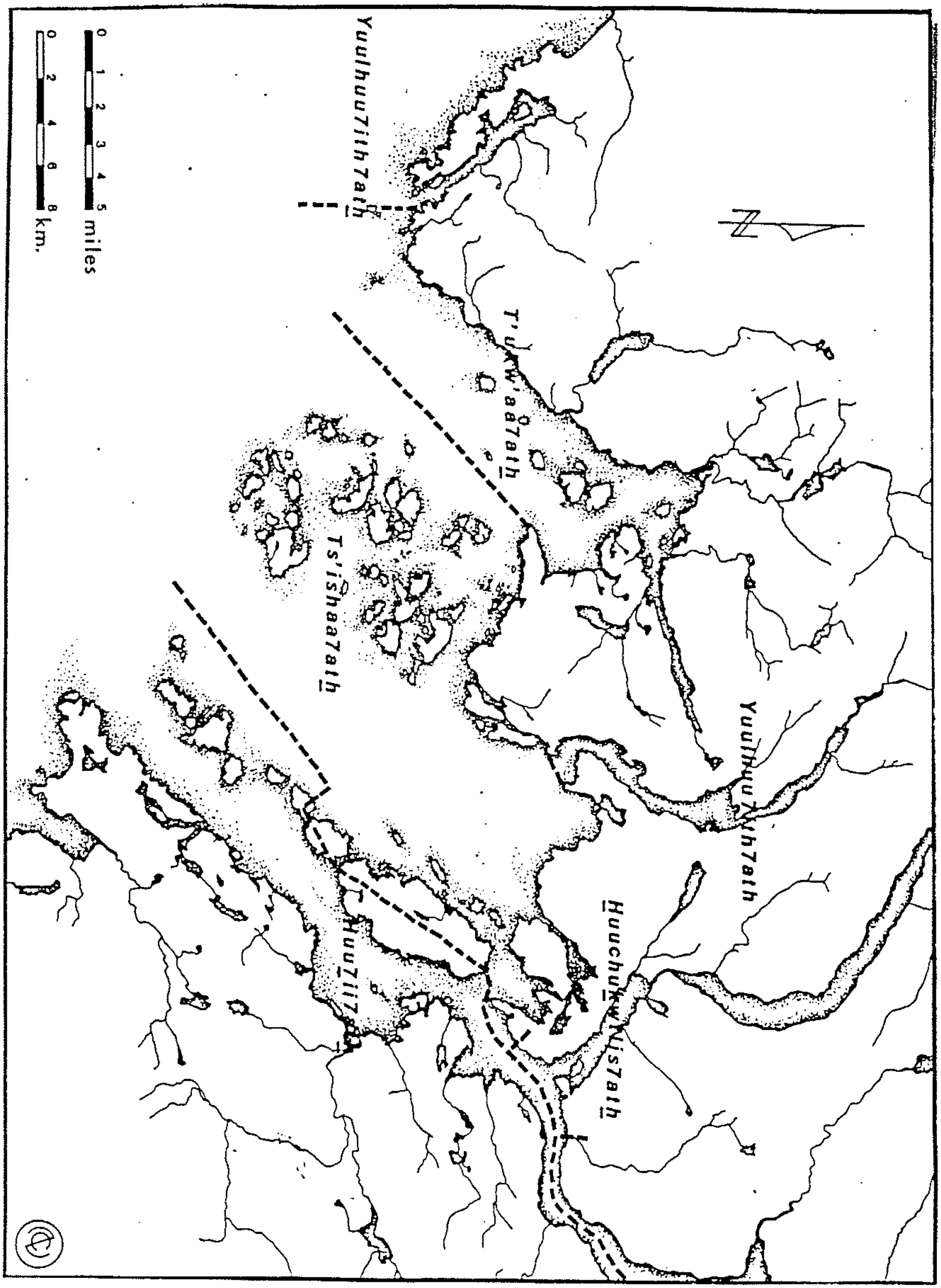
2.6 Study Area

2.6.0 The Toquaht and Barkley Sound

The study area consists of the traditional territory held by the Toquaht in the 19th century (Figure 2.6.1). Today the Toquaht are a small Nuu-chah-nulth band living near Ucluelet on the west coast of Vancouver Island (McMillan and St.Claire 1996: 1). Their traditional territories include many of the islands and most of the western shoreline of Barkley Sound (Amira *et al.* 1991). This region has been the focus of an ongoing archaeological research program aimed at documenting Toquaht heritage resources and investigating Toquaht culture history (McMillan and St. Claire 1991, 1992, 1994, 1996).

Barkley Sound is a roughly rectangular bay about 24 km wide, which is broken into three channels by two major island groups (the Broken Group and the Deer Group) (McMillan & St. Claire 1982). Many islands, bays, and inlets provide the sound with a diversity of habitats and a wide range of marine, littoral, and terrestrial resources.

In pre-contact times the Toquaht local group held a dominant political and territorial position in Barkley Sound (Amira *et al.* 1991: 54). In a statement to Denis St.Claire (Amira *et al.* 1991) Bert Mack, the present hereditary chief of the Toquaht, recalled his father telling him that, "the [Toquaht] were the original Barkley Sound group, from which all others directly or indirectly originated (Amira *et al.* 1991: 54)". Similarly,



(Fig. 2.6.1) Traditional Territories of Barkley Sound Groups in the 19th Century (from McMillan and St.Claire 1991: 2) T'ukw'aa7athh: Toquaht in the text

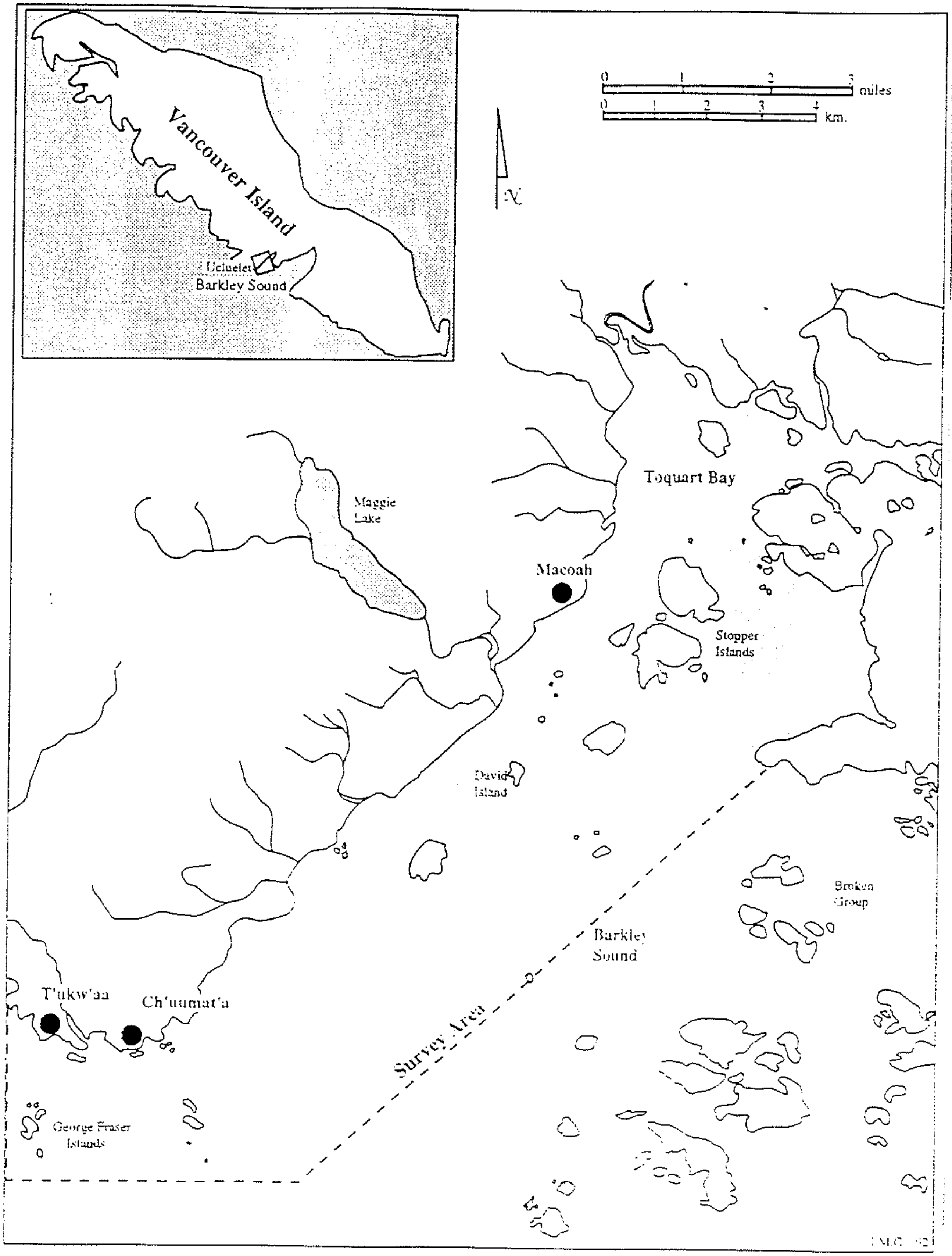
G.M. Sproat's (1868) description of indigenous peoples living in the vicinity of Alberni states, "that the Toquaht in Barkley Sound were generally considered by their neighbours to be the [local group] from which the others originated (1868: 19)". War and disease took a heavy toll on the Toquaht during the post-contact period. In his report to the Indian Commissioner, Blenkinsop (1874) describes the Toquaht as "...dwindling away from a once powerful tribe to scarcely a tenth of what they were fifty years since... continual wars with their more powerful neighbours and disease have reduced them to their present weak state (Blenkinsop 1874: 32-33)".

2.6.1 the Toquaht Annual Round

In many cases, ethnographic and historic accounts of seasonal occupation in the region give conflicting information. All accounts do agree, however, that some form of seasonal movement between the sites was in practice. For example, there is some disagreement between early historic and later ethnographic accounts regarding site seasonality at T'ukw'aa (Figure 2.6.2) on the outer coast. When O'Reilly laid out the site as a reserve in 1882, he described it as "a fishing station used only during the sealing season [i.e. spring/summer]" (O'Reilly 1883). However, less than a decade earlier, Blenkinsop (1874) described T'ukw'aa as a winter village.

By contrast, all of McMillan and St. Claire's (1991: 88) modern informants confirmed that the most extensive use of the site was during the spring and summer when halibut, cod, seals, and whales were abundant in the area. In the fall, when salmon began to spawn, most of the Toquaht reportedly moved to Ma'acoah and other sites at the top of Barkley Sound.

Ethnographically, the inside site of Ma'acoah (Figure 2.6.2) was the major winter village of the Toquaht (McMillan and St. Claire 1991: 71). However, historical accounts referring to site seasonality are again conflicting. O'Reilly (1883) describes Ma'acoah as



(Figure 2.6.2) Sites Excavated as Part of the Toquaht Archaeological Project (from McMillan and St.Claire 1996: 6) a winter village and fishing station for taking advantage of the fall salmon runs;Blekinsop (1874) refers to the site as the Toquaht summer residence - reversing the seasonality of both Ma'acoah and T'ukw'aa from most other accounts. Further complicating the issue, modern informant Jim McKay reports that some people lived at Ma'acoah year-round (Amira *et al.* 1991: 163), using it as a sort of headquarters for the exploitation of all the surrounding creeks.

In "The Nootka: Scenes and Studies of Savage Life", G.M. Sproat (1868) describes the Nuu-chah-nulth annual round in general terms. As a result, some of his accounts are vague, and it is difficult to relate them specifically to theToquaht or to sites within Barkley Sound. His observations were, however, based on peoples living in and around Alberni Inlet (including the Toquaht) in the 1860's and provide some insight into their seasonal movements;

> "Following the salmon as they swim up the rivers and inlets, the natives place their summer encampments at some distance from the seaboard, towards which they return for the winter season about the end of October, with a stock of dried salmon – their principal food at all times. By this arrangement, being near the seashore, they can get shellfish, if their stock of salmon runs short, and can also catch the first fish that approach the shore in the early spring. Every tribe, however, does not thus regularly follow the salmon; some of the tribes devote this season to whale-fishing, or to the capture of dog-fish [traded with the British for use in saw mills], and supply themselves with salmon by barter with other tribes. If the natives did not thus often move their quarters, their health would suffer from the putrid fish and other nastiness that surrounded the camps, which the elements and the birds clear away during the time of non-occupation (Sproat 1868 p.30)."

and;

> "In fine seasons, the Aht [Nootka], following the salmon up the inlets and streams, have been known not to return to their winter quarters till the end of November. A month sooner, however, is about usual time (Sproat 1868 p.39)."

This description is interesting in several respects. First, the pattern of moving *away* from the sea during the summer and back to the coast during the winter is a complete reversal of the general *ethnographic* pattern described by Drucker (1951: 33-36), and reported for the Toquaht by O'Reilly (1883) and by McMillan and St.Claire's modern informants (1991: 71). The pattern described by Sproat may reflect a particular adaptation to the long Alberni Inlet or it may be evidence of change brought about through increased European contact. Such change may be more clearly evidenced by the inclusion of commercial activities such as dogfish oil procurement in seasonally scheduled activities.

Much of the confusion between accounts of Toquaht site seasonality likely arises from the fact that late prehistoric cultural, political, and economic systems were markedly disrupted during the post-contact period. Disease and warfare during early European contact clearly had a profound and negative effect on the Toquaht (Amira *et al.* 1991; Blenkinsop 1874).

2.6.2 Archaeological Sample

The sites of interest to this research are those found in the Toquaht area that are thought to represent remnants of villages or camps. Eleven sites were identified in the initial survey of the region (McMillan & St. Claire 1992: 10). Classification of these as village/camp sites was based on the identification of shell midden deposits and/or accumulations of fire-cracked rocks and charcoal (McMillan & St. Claire 1992: 8). Three village sites (T'ukw'aa, Ma'acoah, and Ch'uumat'a) were deemed to have significant archaeological potential and were excavated as part of the Toquaht archaeological project (McMillan & St. Claire 1991, 1992, 1994, 1996). These three sites comprise the target group for this research (Figure 2.6.2). The location of the sites on both inner and outer-coastal shorelines enables testing of predictions of the two opposing hypotheses discussed above regarding the seasonal occupation of these settings.

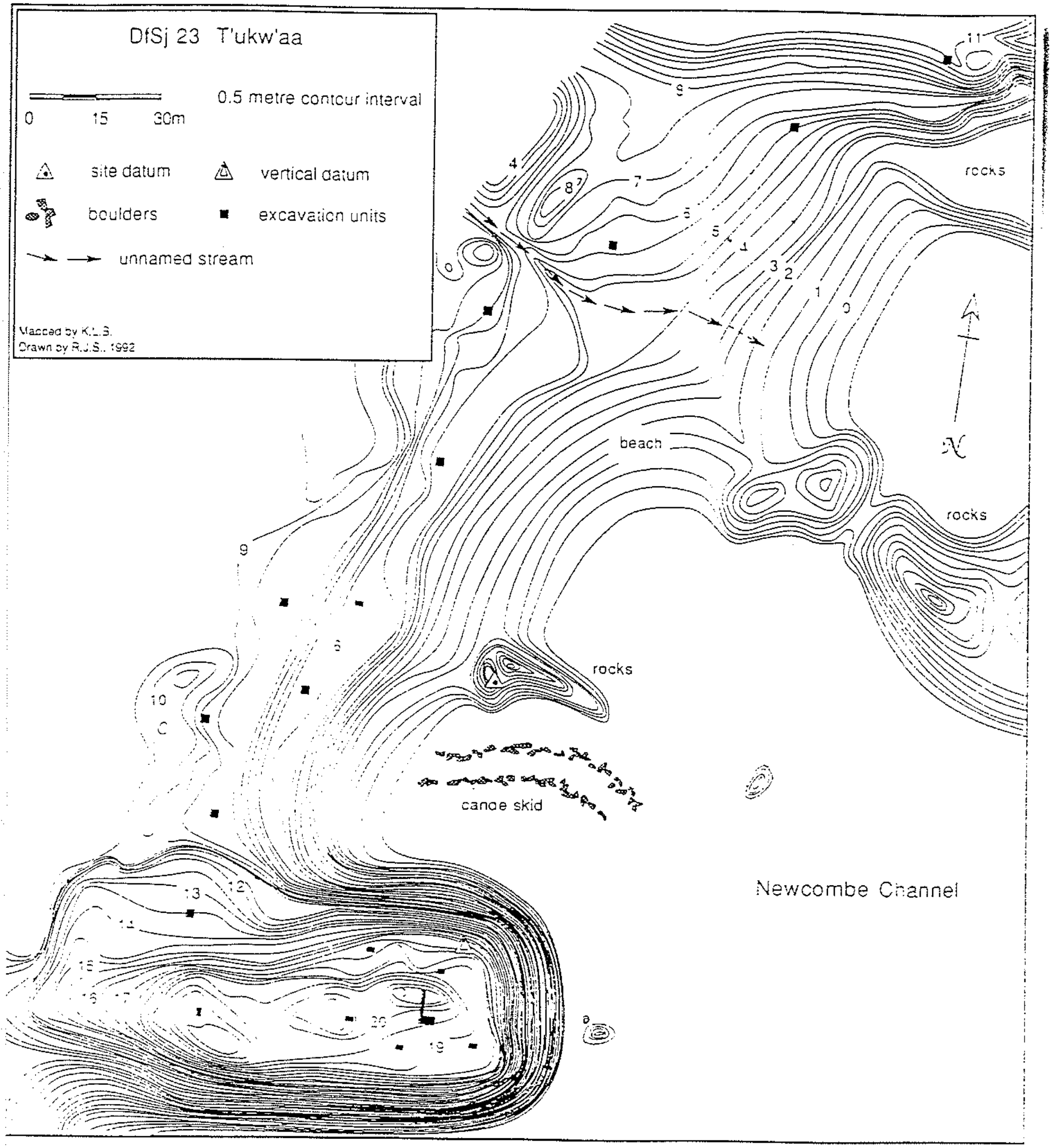
2.6.2a T'ukw 'aa (DfSj -23)

Site Description:

T'ukw'aa is a large village site located near the western edge of Barkley Sound, controlling the entrance to Ucluelet Inlet. It is located within the territory that is today Toquaht Indian Reserve No. 5. Radiocarbon dates and artifactual evidence suggest that the site was occupied from at least 990 AD up until the early 20th century (McMillan and St.Claire 1992: 25, 36). Cultural deposits stretch for about 250 metres along the current beach (McMillan & St. Claire 1991: 22). This provides strong evidence that at one time T'ukw'aa was a large and important village. Other evidence for the importance of the site comes from its name, the Toquaht are literally the "people of T'ukw'aa" (McMillan & St. Claire 1991: 22). The name itself translates as "narrow beach" (Amira *et al.* 1991). According to ethnographic accounts by Boas (1891), the "sept" (subgroup) most closely associated with this village were the most highly ranked of the eleven that made up the Toquaht.

As noted above (Section 2.6.1), historic and ethnographic accounts of the season of occupation at this site are conflicting. Blenkinsop (1874) describes the site as a winter village while O'Reilly (1883) describes the site as a seasonal (spring/summer) fishing station. T'ukw'aa's position on the outer coast and its proximity to outlying reefs and small islands (Figure 2.6.2) made it a good location for the exploitation of ground fish (including halibut and cod) and marine mammals (including seals, sea-lions, and whales) (Amira *et al.* 1991: 155). These activities are generally associated with spring/summer occupation and modern informants attest to the site's former use as the main Toquaht summer village (Amira *et al.* 1991: 155).

The T'ukw'aa site is divided into two sections (Figure 2.6.3). Most of the site is located in the historically known village of the same name. The portion of the site lying in the historical village of T'ukw'aa contains clearly visible evidence of house outlines and a large canoe run in the intertidal zone (McMillan and St. Claire 1991: 22). The other portion of the site is located atop a rocky bluff and has been classified by the archaeologists as a defensive or refuge area. On the top of the promontory are an extensive shell midden and several flat areas that suggest house locations (McMillan and St. Claire 1991: 22).



(Figure 2.6.3) T'ukw'aa Site Map (from McMillan and St.Claire 1992:24)

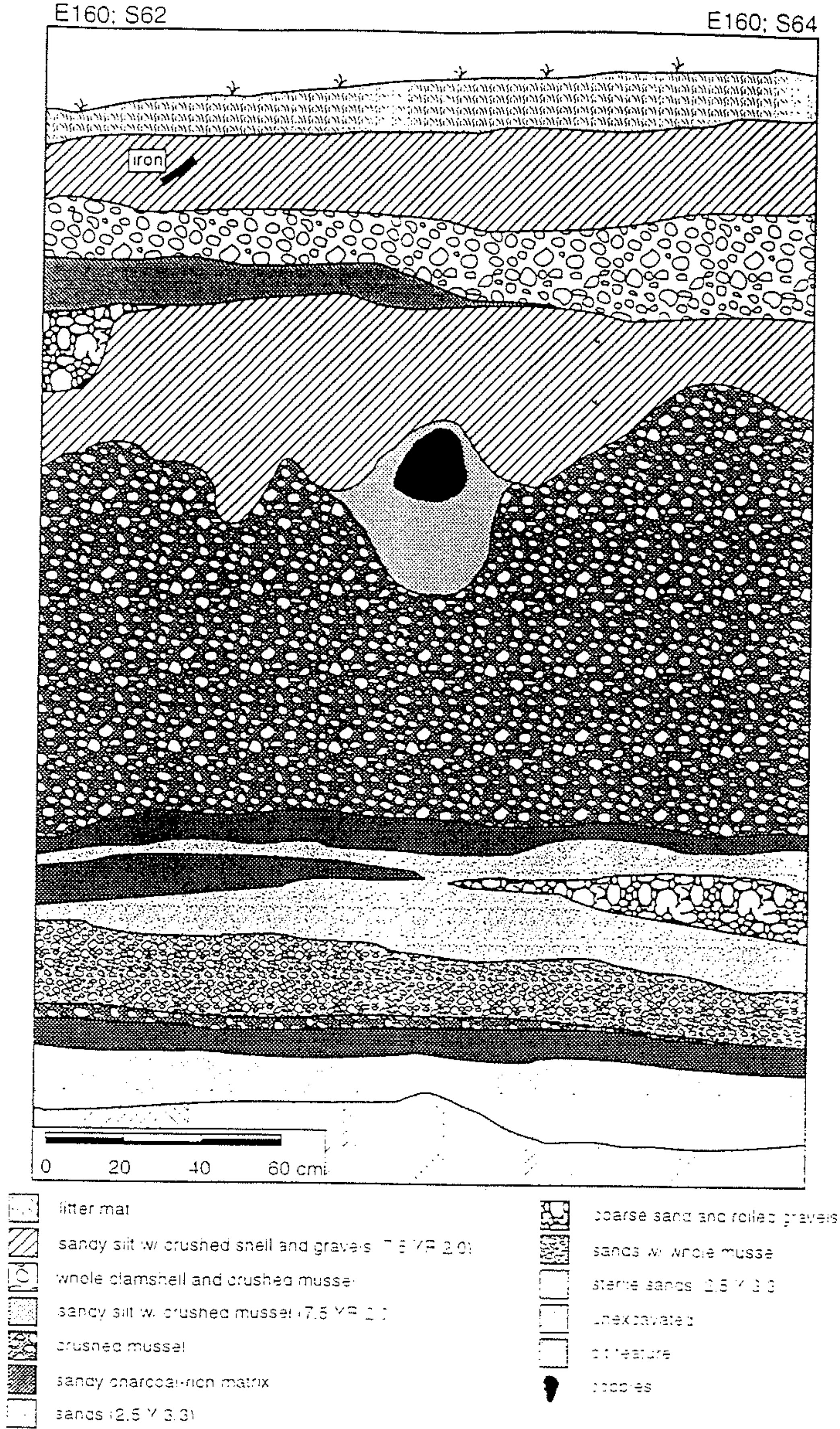
Excavated Material:

Excavations began at the T'ukw'aa site in 1991 and continued in 1992 (McMillan and St. Claire 1991, 1992). Excavations in the village part of the site revealed cultural deposits including at least four distinct strata averaging (in total) between about 0.85 and 1.40 metres in depth (McMillan & St. Claire 1992: 32). Three radiocarbon dates which range between 760-990 AD and 1260-1310 AD cal. have been obtained for this section of the site (Appendix 1).

Nine 2 x 2 metre and one 1 x 2 metre units were opened up in the village area over two excavation seasons. Units were spaced more-or-less evenly across the surface of the site (Figure 2.5.2.1). In total, 82.9 cubic metres ofmidden were excavated from the village portion of the site (McMillan andSt.Claire 1992: 32). Radiocarbon dates come from two units at the north and south ends of the village portion of the site, including unit E158-160 S62-64 (Figure 2.6.4).

Thirteen 1 x 2 metre units were excavated on the defensive portion site during the 1991 and 1992 field seasons. Seven units were joined to form an open L-shaped area, which cut through a high ridge on the top of the site. In addition, a 2 x 2 metre unit was excavated on the lower slope of the defensive area. Excavation continued to bedrock. The average depth of deposit ranged from about 0.85 to metres to 1.4 metres. Approximately 23.3 cubic metres of material was removed from the defensive area of the site (McMillan and St.Claire 1992: 32). Three radiocarbon dates, ranging from 1175-1280 A.D. to 1660-1880 A.D. cal., were taken from three units near the eastern edge of this portion of the site.

Historic artifacts (i.e. those of non-aboriginal raw materials) were recovered from both the village and defensive portions of the site. Late-19th and early 20th century objects (e.g. glass bottles, imported ceramics) are restricted to the central and northern village portions of the site while early-historic or proto-contact objects (e.g. rolled copper,



(Figure 2.6.4) Stratigraphic Profile – east wall of unit E158-60 S62-64 (from McMillan and St.Claire 1992: 38).

glass beads) are abundant in the southern-village and defensive portions of the site - suggesting a less intensive use of the defensive and southern portions in the late-historic period (McMillan and St.Claire 1992: 40).

2.6.2b Ma'acoah (DfSi -5)

Site Description:

The Ma'acoah site is located within Toquaht Indian Reserve No.1, about 13 kilometres up Barkley Sound from T'ukw'aa (see Figure 2.6.2). This formerly important village was abandoned some time around the 1920's when the Toquaht resettled near Ucluelet (McMillan and St.Claire 1991: 71). Radiocarbon evidence suggests that the site was initially occupied some time before 1355 AD. The name Ma'acoah translates as "house on the point". This likely refers to a rocky point on the north end of the modern reserve (McMillan & St. Claire 1991: 73). The location of several known salmon spawning streams near the village site suggests its importance for salmon fishing (McMillan and St. Claire 1991: 71). The area in front of the site, Ma'acoah passage, is known to be an important herring spawning area (Amira *et al.* 1991).

The sept associated with Ma'acoah was, according to Boas, the second highest ranking of the eleven Toquaht component groups (Boas 1891: 584). According to a modern informant, "the [Toquaht] head chief came from [the Ma'acoaht], the [sept] whose name was derived from this site (Amira *et al.* 1991: 163)".

Again, historical evidence relating to the season of occupation at this site is conflicting. Blenkinsop (1874) refers to the site as the Toquaht summer residence while O'Reilly (1883) describes Ma'acoah as a winter village. The relatively protected, "inside", location of the site fits with the general pattern proposed for winter villages by Drucker (1951: 33-36) and Dewhirst (1980: 11-12, 15). This seasonal pattern of site occupation is supported by the accounts of modern Toquaht informants (Amira *et al.*

1991).

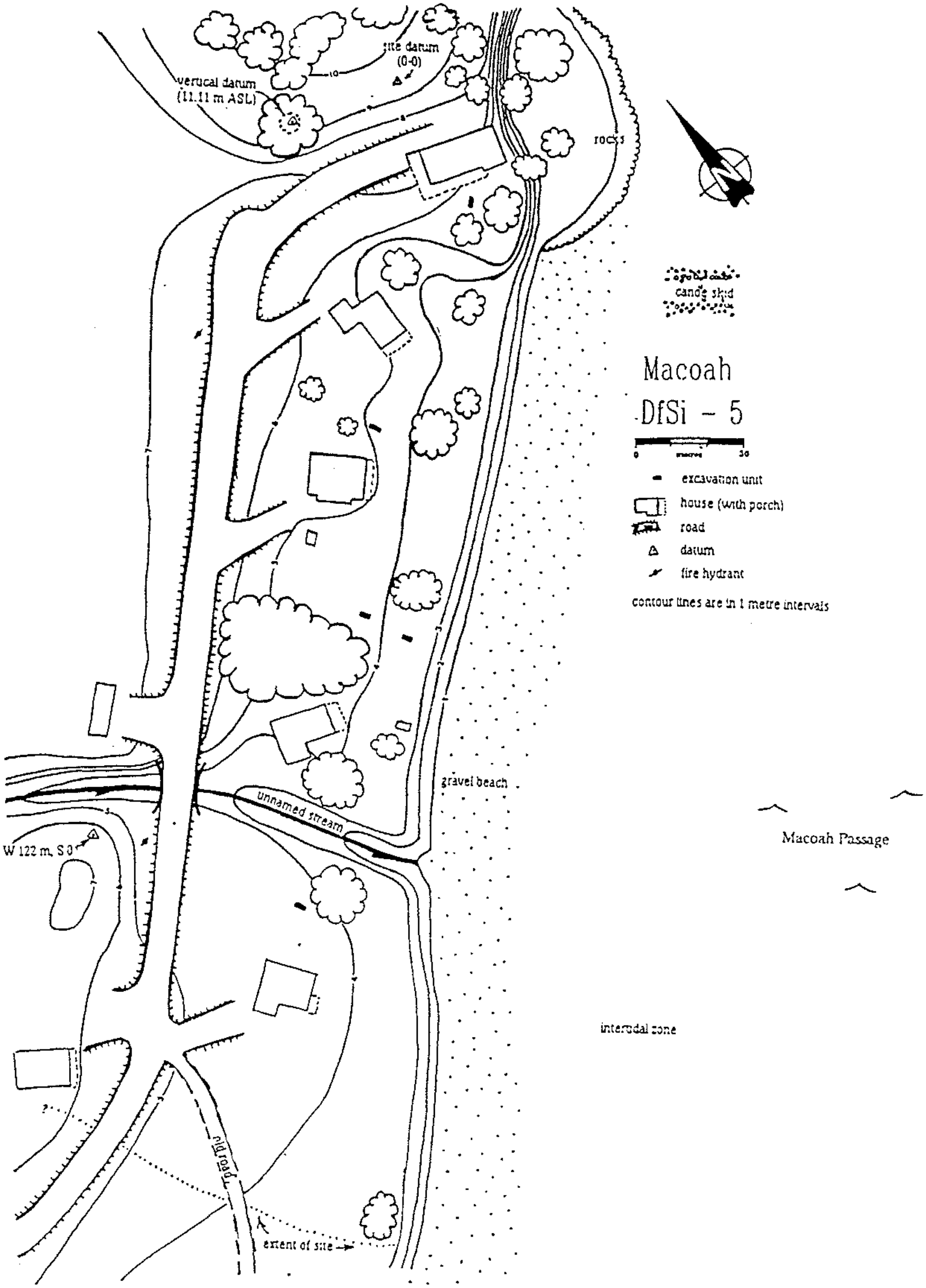
The construction of houses and logging activities carried out in the 1950's resulted in the disturbance of much of the archaeological material from Ma'acoah. However, shell midden deposits and the remains of a canoe skid are still clearly visible at the site (McMillan and St.Claire 1991: 73).

Excavated Material:

Excavation of the Ma'acoah site was conducted during the 1991 field season of the Toquaht project (McMillan and St. Claire 1991). Excavation of the site revealed cultural deposits about 1.5 metres deep comprised of three distinct strata, the earliest of which has been carbon dated to about 1310-1355 AD cal. (McMillan and St. Claire 1991: 80).

Five 2 x 1 metre excavation units were opened at the site (Figure 2.6.5). The three central units reached the old beach (sterile) at depths of about 1.6 metres. The southernmost unit was about 1.9 metres in depth. The deepest unit, on the rise of the point at the north end of the site, reached 2.4 metres. In total, approximately 18.2 cubic metres of archaeological deposit were excavated (McMillan and St.Claire 1991: 79).

One radiocarbon date of roughly 1310-1355 A.D. cal. has been obtained so far for this site (Appendix 1). It was based on wood charcoal, collected from the base of the site at a depth of 1.5 metres (McMillan and St.Claire 1991: 80). Historic artifacts from the late post-contact period (e.g. glass, nails) were recorded to a depth of about 60 cm in the dated unit, after which they are absent. The presence of these artifacts confirms the relatively recent abandonment of Ma'acoah.



(Figure 2.6.5) Ma'acoah Site Map (from McMillan and St.Claire 1991: 74)

2.6.2c Ch'uumat'a (DfSi-4)

Site Description:

This large shell midden is located in a small cove about 2 km east of T'ukw'aa at the extreme southwestern edge of Barkley Sound in a location consistent with Drucker (1951: 33-36) and Dewhirst's (1980: 11-12, 15) "outside" sites (Figure 2.6.2). The midden spreads about 120 metres along the beach and about 70 metres inland (McMillan and St.Clare 1996: 8). Parallel rows of large rocks on the beach, removed to create a canoe skid, clearly indicate the presence of a site in this location. The site takes its name from the large mountain behind the village (Amira *et al.* 1991).

Historically, Ch'uumat'a was the major village of the Ch'uumat'ath, a Toquaht subgroup (Amira *et al.* 1991). Boas (1891: 584) records the Ch'uumat'ath as the lowest ranking of all eleven Toquaht septs. One of Sapir's informants recounted that "the [Ch'uumat'ath] were originally a separate tribe with their main village at [Ch'uumat'a] (Sapir 1910-1914: xvii: 4)". The tribe's relatively recent inclusion within the Toquaht may account for their low rank.

By the beginning of the 20th century the village had fallen into disuse and it is not currently held as Toquaht reserve (McMillan and St.Claire 1994). Radiocarbon evidence suggests that the initial occupation of the site probably occurred some time before 2310 BC (McMillan and St.Claire 1996: 17).

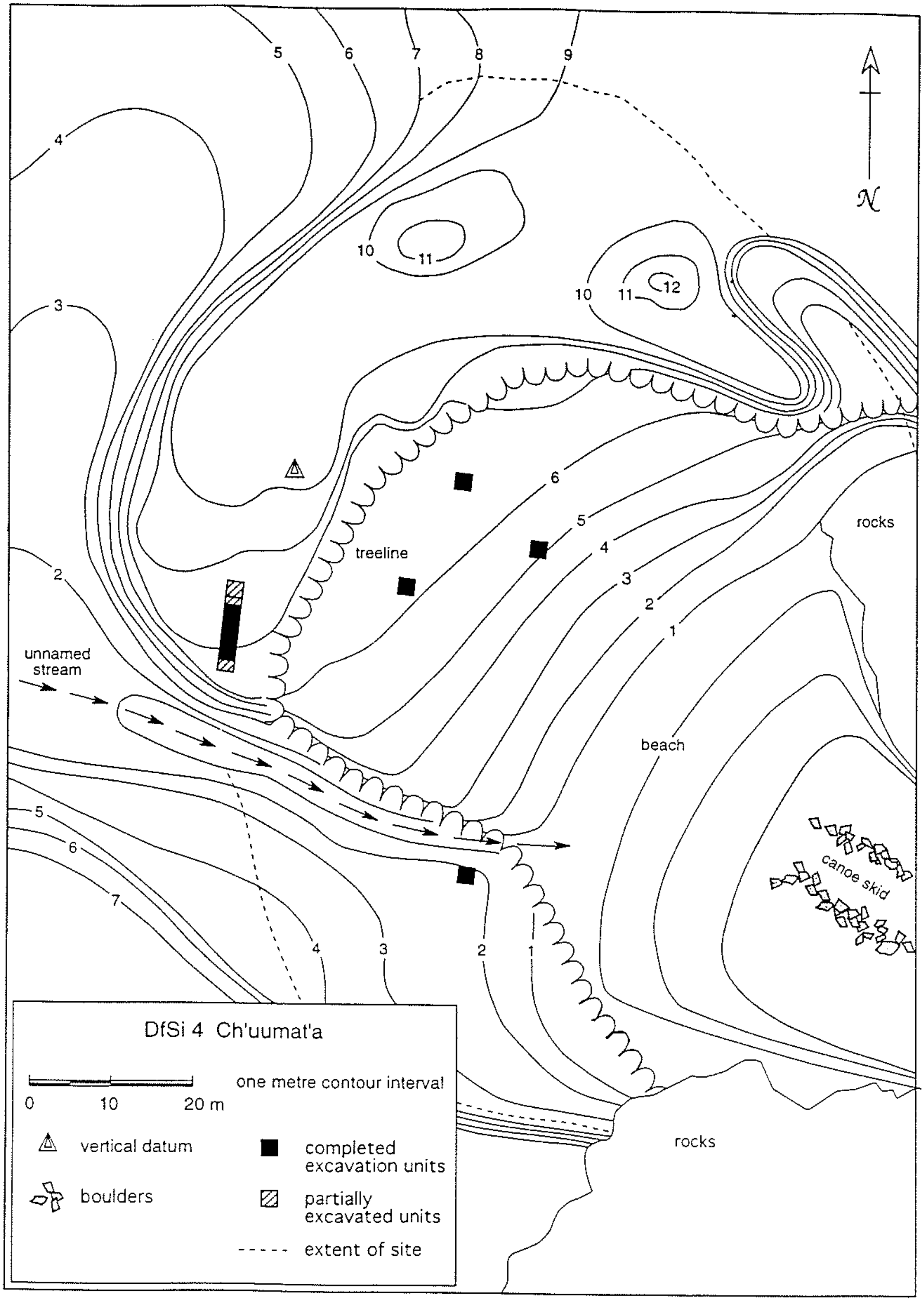
No ethnographic or historical data describe the seasonal timing or economic function of this site. All of the "outside" resources available at T'ukw'aa would also have been easily accessible here. The general models of site seasonality proposed by Drucker (1951: 33-36) and Dewhirst (1980: 11-12, 15) predict summer occupation based on location.

Excavated Material:

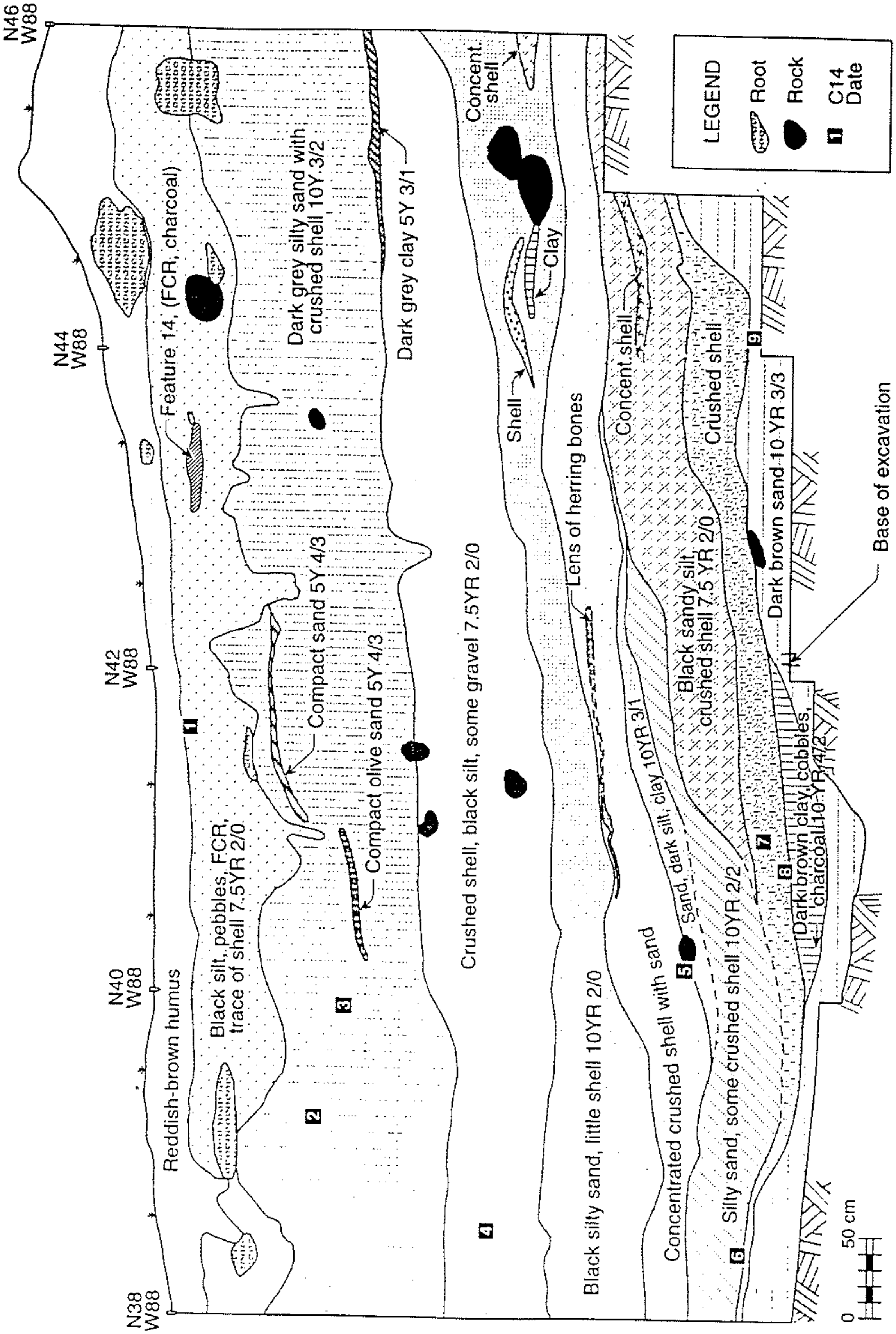
Excavation of the Ch'uumat'a site was begun in earnest in 1994 and continued during the 1996 field season (McMillan and St. Claire 1994, 1996). The main focus of excavation was a 7 x 2 metre trench (Figure 2.6.6) containing over 4 metres of cultural deposits, represented by at least nine stratigraphic levels (Figure 2.6.7). About 68.3 cubic metres of matrix were removed from this trench. Four other 2 x 2 metre units were also excavated. In total, about 115.7 cubic metres of deposit were excavated at Ch'uumat'a.

A total of sixteen radiocarbon dates for the site were taken from each of the excavated units. Nine radiocarbon dates were obtained from various levels within the main trench. These range from 2855-2310 BC cal. in the basal deposit, to 1270-1300 BC cal. at a depth of about 3 cm (see Appendix 1- Toquaht radiocarbon dates). No historic artifacts were recovered from the main trench. Only three non-aboriginal artifacts were recovered from Ch'uumat'a - all from the upper levels of units in the front (seaward) portion of the site (McMillan and St.Claire 1996: 23). These include a piece of rolled copper, a ceramic sherd, and a glass bead. These items are associated with the early historic or proto-contact period and are, therefore, consistent with ethnographic accounts of the village's abandonment prior to the early 20th century (McMillan and St.Claire 1994: 8). Several artifacts with apparent Gulf of Georgia characteristics (i.e. flaked or incised stone) were also recovered from the main trench (McMillan and St.Claire 1996: 25-26). These were all recovered from layers that pre-date 2000 BP.

The considerable antiquity of this site gives it a relatively unique place in the archaeology of the west coast of Vancouver Island. Indeed only one other site in the Nuu-chah-nulth region, Yuquot (in Nootka Sound), also has cultural deposits spanning the last 4000 years (McMillan and St. Claire 1996: 8). Analysis of cultural material from Ch'uumat'a has already lead to significant revisions of earlier thinking about Nuu-chah-nulth prehistory and the peopling of the west coast of Vancouver Island (Section 2.6).



(Figure 2.6.6) Ch'uumat'a Site Map (from McMillan and St.Claire 1996:11)



(Figure 2.6.7) Stratigraphic Profile – west wall of excavation trench N38-46 W86-88 (from McMillan and St.Claire 1996:11)

Chapter 3 – Seasonality Studies

3.0 Seasonality Studies

Seasonality studies in archaeology are aimed at identifying the time of year that sites were occupied or when specific activities took place there (Monks 1981). These studies are particularly relevant in the examination of hunter-gatherers, for whom mobility and seasonal resource scheduling are widely considered defining characteristics (Bindford 1980; Kelly 1992; Lee and DeVore 1968; Steward 1938). When, how, and why hunter-gatherers move about their environment at different times of year is often considered to affect their economic base (e.g. Bettinger 1991; Winterhandler and Smith 1981), social/political structure (e.g. Mitchell 1983), and even their moral and religious beliefs (Mauss 1906).

Many natural phenomena, specifically those linked to the growth of organisms are cyclical events with annual or sub-annual seasonal timing. Most archaeological seasonality studies rely on identifying evidence of these natural phenomena in the archaeological record. Studies generally take one of two forms: 1) general - a broad examination of faunal and/or floral remains from archaeological contexts in order to identify seasonal abundance of taxa; or 2) specific - the determination of season-of-death for individual organisms from morphological markers such as antlers or through the analysis of incremental growth structures. Both types of studyare dependant upon a number of assumptions regarding past environmental conditions, the growth of organisms, and human activities. The two approaches do not necessarily share the same set of underlying assumptions. As a result, one technique may be used to provide separate support for (or call into question) results obtained using the other.

3.1 Incremental Growth Structures

Incremental growth structures are defined as "distinctive, self-contained additions to the previous growth of an organism" (Monks 1981: 193). These structures are the product of differential deposition of tissue throughout the year and the annual occurrence of a period of growth arrest.

Incremental growth structures have been observed in a number of different organisms and tissues. Archaeological seasonality studies involving growth increment analysis have utilized: the bones and teeth of terrestrial mammals (e.g. Burke 1995; Grue and Jensen 1967; Klevezal 1999; Leberman and Meadow 1992; Pike-Tay 1991); fish otoliths, scales, fin-rays, and bones (e.g. Noe-Nygaard 1983; Le Cren 1947); mollusc shells (e.g. Classen 1993; Ham and Irvine 1975); and wood (e.g. Bannister 1963).

There is a wide range of confusing and often conflicting terminology used to describe incremental structures in mineralized tissues(Gordon 1993). This research will use the following definitions adapted from Burke (1995: 6):

- zone: a relatively wide band of deposition corresponding to a period of rapid growth. In temperate climates these are often associated with summer growth.
- annulus (plural : annuli): a relatively narrow band of deposition corresponding to a period of slowed growth. In temperate climates these often correspond to winter growth.
- line of arrested growth (LAG): a narrow, visually dramatic, break in deposition corresponding to cessation of growth, often falling within annuli.
- growth layer group (GLG): the collective term for structures comprising a full annual growth cycle.

Estimations of season of death from growth structures in mineralised tissues are either derived by observing the nature of the final increment (i.e. does growth terminate in a partial or complete zone, annulus, or LAG?) or by measuring the amount of growth in the final GLG. In order to derive date of death estimates from final GLG growth measurements, the amount of tissue deposited in the final GLG is compared with a model of expected annual deposition (e.g. a growth curve). Where absolute growth between specimens is variable, measurements must be standardised. Standardised growth measurements are generally expressed as a proportion (ratio) of expected growth for a complete growth period (Monks and Johnston 1993). The expected annual growth for a specimen may be estimated by measuring the penultimate growth increment or by averaging several preceding growth increments (Monks 1981; Gordon 1993). Because growth rate generally slows with age, estimating expected growth from preceding increments is not always straightforward.

The accurate estimation of season of death requires referral to a reference collection (i.e. specimens of the species being examined with known date of death). Examination of a reference collection is needed to establish the periodicity of the growth increments being examined (some growth structures have sub-annual cycles, others are not cyclical) and to assess the amount of variability within and between individuals (Burke and Castanet 1995).

The reference collection should consist of the same species that are examined archaeologically. The reference specimens should also ideally come from the same environmental and ecological setting as that expected for the archaeological specimens (Burke 1995: 15-16). This is particularly the case when studying fish given the highly plastic nature of fish growth (Weatherley and Gill 1987: 4). Different populations of the same species of fish under different ecological or climatic conditions can exhibit very different growth rates. Other important considerations when assembling a reference collection include: adequate representation of age and sex classes; sufficient annual coverage; and statistically representative sample sizes.

3.2 Recording Structures in Fish

The mineralised tissues of many fish species, particularly those found in temperate environments, are well suited for this kind of analysis. Fish are generally poikilotherms (i.e. they do not internally regulate their body temperatures), and their rate of growth is highly sensitive to seasonal changes in external temperature (Ricker 1979). Fish grow relatively rapidly in months associated with warm water temperatures and more slowly in months associated with cooler water. The highly seasonal nature of fish growth is often evidenced in their mineralized tissues.

Several kinds of calcified structure are known to exhibit incremental growth and have been used to estimate age and season of death of fish. The most commonly used structures are otoliths, scales, fin-rays, dorsal spines, and vertebrae. Among fisheries researchers, otoliths are generally the preferred structure because of their demonstrated annual growth pattern and, consequently, their detailed and accurate recording of fish growth (Casselman 1983; Chilton and Beamish 1982). Unfortunately, otoliths are rarely recovered during archaeological excavations. This is likely due to the unstable nature of their mineral composition (aragonite) compared to the hydroxyapatite of bone (Colley 1984). It may also be that in many cases otoliths are simply overlooked due to their relatively small size and non-descript form (Van Neer *et al.* 1999). Nootoliths have been recovered from the Toquaht material (Monks, pers. comm. 2000).

Scales were the first structure to be used for aging and seasonal estimates of the time of death of fish (see review by Casselman, 1974). They are excellent recorders of growth, however, they are very fragile and preservation is an issue (Colley 1984: 220). Further, a single fish may be represented in an archaeological collection by thousands of scales; as a result, it is particularly difficult to establish sample independence or to quantify remains using measures such as MNI (minimum number of individuals). No scales have been recovered from the Toquaht material (Monks, pers. comm. 2000).

Given the problems associated with otoliths and scales, most archaeological seasonality studies using fish remains have relied upon spines (e.g. Morey 1983) or, more commonly, vertebrae (e.g. Noe-Nygaard 1983; Van Neer *et al.* 1999; LeGall 1981, 1994; Casteel 1972, 1974; Cannon 1988; Rojo 1987). Fish vertebrae are relatively robust and comprise one of the most commonly found fish remains in archaeological investigations (Colley 1984: 220; Casteel 1976). The research presented here employs a technique of seasonal estimation based upon the analysis of vertebral centra.

3.3 Seasonal Dating from Fish Vertebrae

The deposition of layers of calcium carbonate ($CaCO_3$) and the protein ostein during the embryogenesis and development of fish vertebrae follows a cyclic pattern (Rojo 1987: 209). This pattern is characterized by an alternation of zones (wide bands corresponding to rapid growth during periods of food abundance and warm temperatures) and annuli (narrow bands, formed during the colder period of the year). These bands are visible as concentric rings on the concave facets of the vertebral centra (Figure 3.3). A wide (zone) and a narrow band (annulus) together form a growth layer group (GLG), which corresponds to one year's growth. The width of the first GLG, also called the core, depends on the time elapsed between hatching of the embryo and the first winter (Rojo 1987: 209). The second GLG is much wider than the first and from then on the width of consecutive GLG's decreases with age. Lines of arrested growth do not appear to be a characteristic feature of incremental growth in fish vertebrae, viewed either whole or thin-sectioned (Price *et al.* 1985).

The physical, chemical, and physiological mechanisms that produce incremental growth in fish vertebrae are poorly understood (Casselman 1983: 4; Chilton and

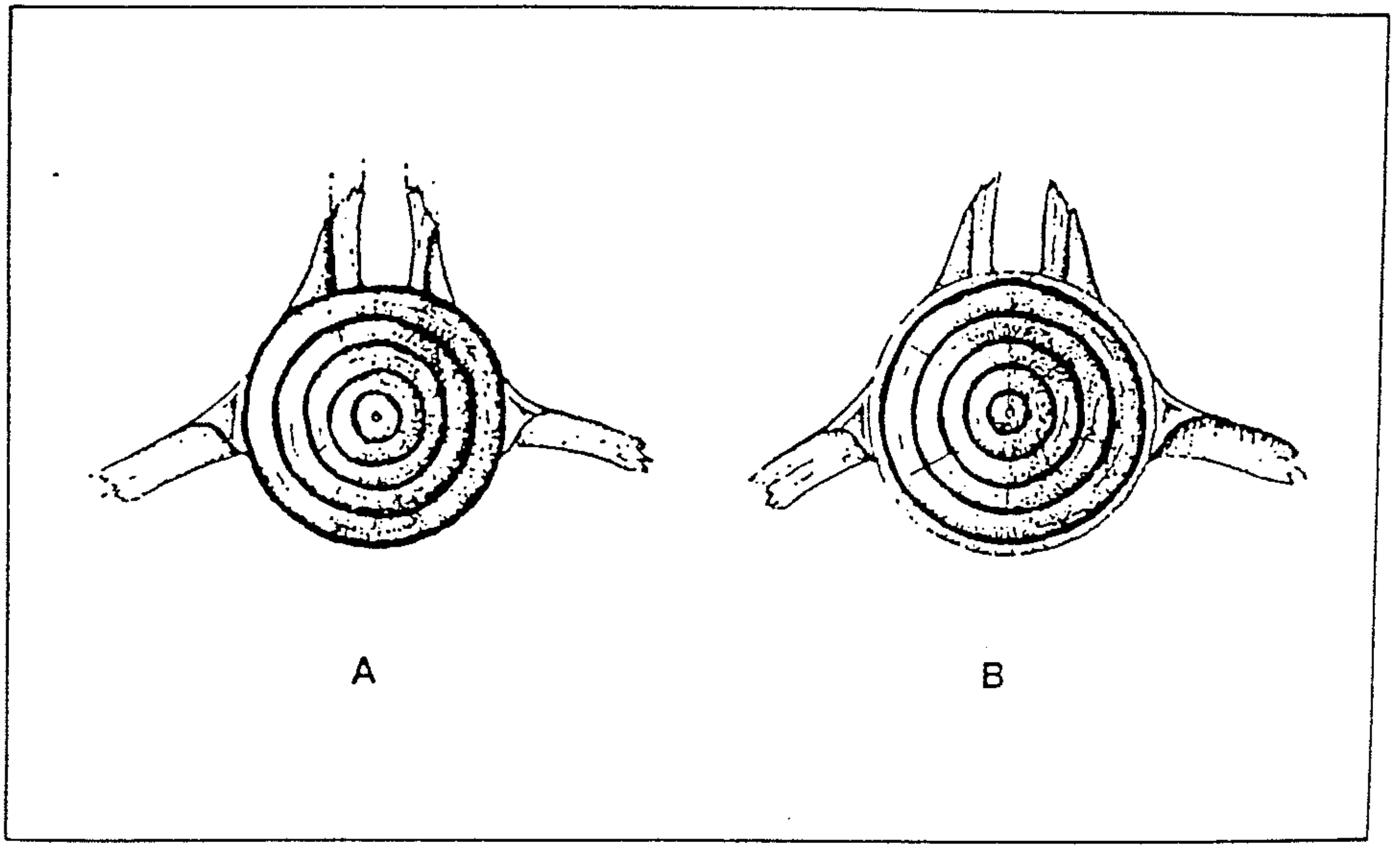
Beamish 1982). However, external temperature is generally regarded as the most important factor influencing the rate, nature, and timing of growth (Cassleman 1983: 4; Weatherly and Gill 1987: 215). Other major factors likely include feeding rate and reproductive cycle. Less is known about the influence of these factors because they are relatively difficult to measure and require detailed laboratory study (Casselman 1983: 4). In a study of widow rockfish (*Sebastes entomelas*) from the Pacific coast of the United States, Pearson (1996) concluded that the seasonal timing of annulus (hyaline-zone) formation in otoliths is much more dependant upon latitude and temperature than on spawning pressures. If annulus formation in vertebrae is the product of the same physiological process that results in otolith annuli, then it may be assumed that temperature and latitude will again be the primary determinants of growth rate and annulus formation in vertebrae.

Vertebrae are not widely used for age or season of death estimation outside of archaeology because of the difficulty and time involved in extracting and preparing them for analysis (Casselman 1983: 4). Biological studies of this sort are mostly limited to sharks and rays because the usual means of age determination in bony fishes, using otoliths or scales, are not applicable to cartilaginous fishes (elasmobranchs) (Cailliet *et al.* 1982b). Vertebrae have also been used, to a lesser extent, for the age assessment of several species of tuna (e.g. Price *et al.* 1985; Lee *et al.* 1983).

Casteel was the first archaeologist to propose and apply the use of fish vertebrae for seasonal dating (Casteel 1972). Other archaeologists who have attempted season of death estimation from fish vertebrae have had mixed results. The major shortcoming of many of these studies is that researchers have failed to pay sufficient attention to the need for a suitable reference collection. Brinkhuizen (1997) is particularly critical of such studies,

"Some of these investigators first studied growth rings in recent material and relevant literature on the species involved before studying growth rings in excavated material (e.g. Noe Nygaard 1983). Others, however, had the impression, after reading Casteel's publications, that the method is a priori applicable to vertebrae of any species (e.g. Torke 1981; Le Gall 1981; 1984; Ijzereef 1981; Desse 1983)."

While some of these researchers (e.g. Casteel 1972; Le Gall 1981; Rojo 1987) may have obtained results that appear convincing, it is difficult to assess the validity of their conclusions because they failed to either adequately discuss or display their reference data. Other researchers (e.g. Noe-Nygaard 1983; Van Neer *et al.* 1999) have been more diligent in their use of reference data and demonstrate the applicability of this method (for the species they consider).



A. Vertebrae of a five-year-old fish with the outer rim representing the last winter growth. B. Vertebrae of a five+-year-old fish with the outer rim representing the growth-of-the-year in which it was caught.

(Figure 3.3) Vertebra Growth Rings (From Rojo 1987)

Chapter 4 – Choice of Species – Rockfish (*Sebastes* Spp.)

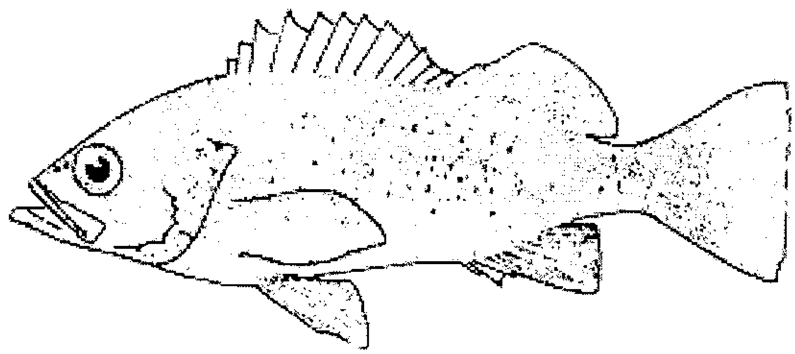


Figure (4.0) *Sebastes flavidus* from (Marine Sportfish Identification Guide. www.DFG.gov. April 2002.)

4.0 Introduction

The research presented here focuses on the seasonal timing of rockfish capture by the indigenous inhabitants of Barkley Sound. Rockfish were selected for analysis because of their likely importance to Toquaht subsistence and because certain aspects of their ecology and traditional use within the Nuu-chah-nulth region (both discussed below) permit inferences to be made relating the season of rockfish capture to the season of site occupation in Barkley Sound.

4.1 General Description

Rockfish (also called rock-cod, snappers, canaries, greenies, or rock salmon) is a common name for the genus *Sebastes*. In the Northern Pacific Ocean, rockfish species are distributed from southern California to Kyushu Island (Japan). At least 35 separate species of rockfish are known to inhabit the coastal waters off British Columbia, and at least 16 of these species have been recorded for the west coast of Vancouver Island (Hart 1973: 388-350; Archibald *et al.* 1981).

Rockfish are bony fish, related closely to scorpionfish (genus *Sebastolobus*) and to sculpins (order Cottidae) (Hart 1973: 388). They are bass-like in appearance and are distinguished by a stout, heavy build, large broad heads, usually bearing spines and a bony connection under the cheek (suborbital stay), and heavily-spined fins (Figure 4.0) (Hart 1973: 388). The colour patterns vary from black and drab green to brilliant orange and crimson; some are accented by the presence of wide red or black vertical stripes. Species range in maximum size from about 15 to 91 cm (Hart 1973: 388-450). The average size of most commercially important rockfish species is from 35 to 50 cm (Fisheries and Oceans Canada - Pacific Region 2000).

4.2 Habitat and Diet

Rockfish mainly inhabit the continental shelf and the upper slope (pelagic-littoral) regions. In most places on the west coast of Vancouver Island this extends to about 20 kilometres offshore (Calvert 1980: 9). Little is known about the migratory patterns of rockfish though they generally are considered to be non-migratory with only localized movement (Fisheries and Oceans Canada - Pacific Region 2000). Therefore, rockfish could potentially be caught at any time of year. Rockfish are primarily a bottom living fish, though some species undergo seasonal depth migrations (Hart 1973: 388-350). They prefer rocky-bottomed areas and are most commonly found in and around kelp beds and reefs to depths of about 300 m. These habitats are easily accessed almost everywhere within Barkley Sound. As a result, rockfish would have been available not only at any time of year, but also, at almost any location.

Rockfish are considered to be opportunistic feeders that will take whatever food is available at the time (Fisheries and Oceans Canada - Pacific Region website). They are predatory fish, and their diet is known to include herring, eulachon, sand lance, crabs, shrimp, squid, euphasids and even other rockfish (Hart 1973). Seals and sea otters are the main natural predators of rockfish.

4.3 Life History

Rockfish are ovoviviparous (i.e. they produce eggs that hatch within the female's body without obtaining nourishment from it) and fertilization is internal (Hart 1973: 388). Parturition occurs about one month after fertilization (Pearson 1996: 190). Therefore, males expend energy on reproduction at a different time than females. "Spawning season" for rockfish denotes the period when developed eggs are shed (Phillips 1964: 17). This occurs between January and June for most British Columbia species (Hart 1973: 388-450).

Growth rates vary between species, sexes, and regions, but most rockfish reach their maximum size at about 25 years of age (Archebald *et al.* 1981: 7). Estimates of maximum age vary depending on species and age-assessment technique. Age estimates based on scale and whole otolith readings tend to give lower age estimates while age estimates based on counts of annual growth rings on thin-sectioned and broken and burned otoliths suggest much older ages (Cailliet *et al.* 1996). Based on otolith sections, Chilton and Beamish (1982: 56) suggested a maximum age of 140 years for rougheye rockfish (*Sebastes aleutinus*). This is one of the oldest recorded ages for any fish species. Sectioned otoliths are generally considered to give the most accurate rockfish age estimates (Archebald *et al.* 1981; Bennett *et al.* 1982; Chilton and Beamish 1982; Cailliet *et al.* 1996). Table 4.0 below gives the maximum size and age estimates for species known to exist within the study area (estimates cited from Archebald *et al.* [1981] and Chilton and Beamish [1982] are based on sectioned ototliths; estimates cited from Phillips [1964] are based on scales).

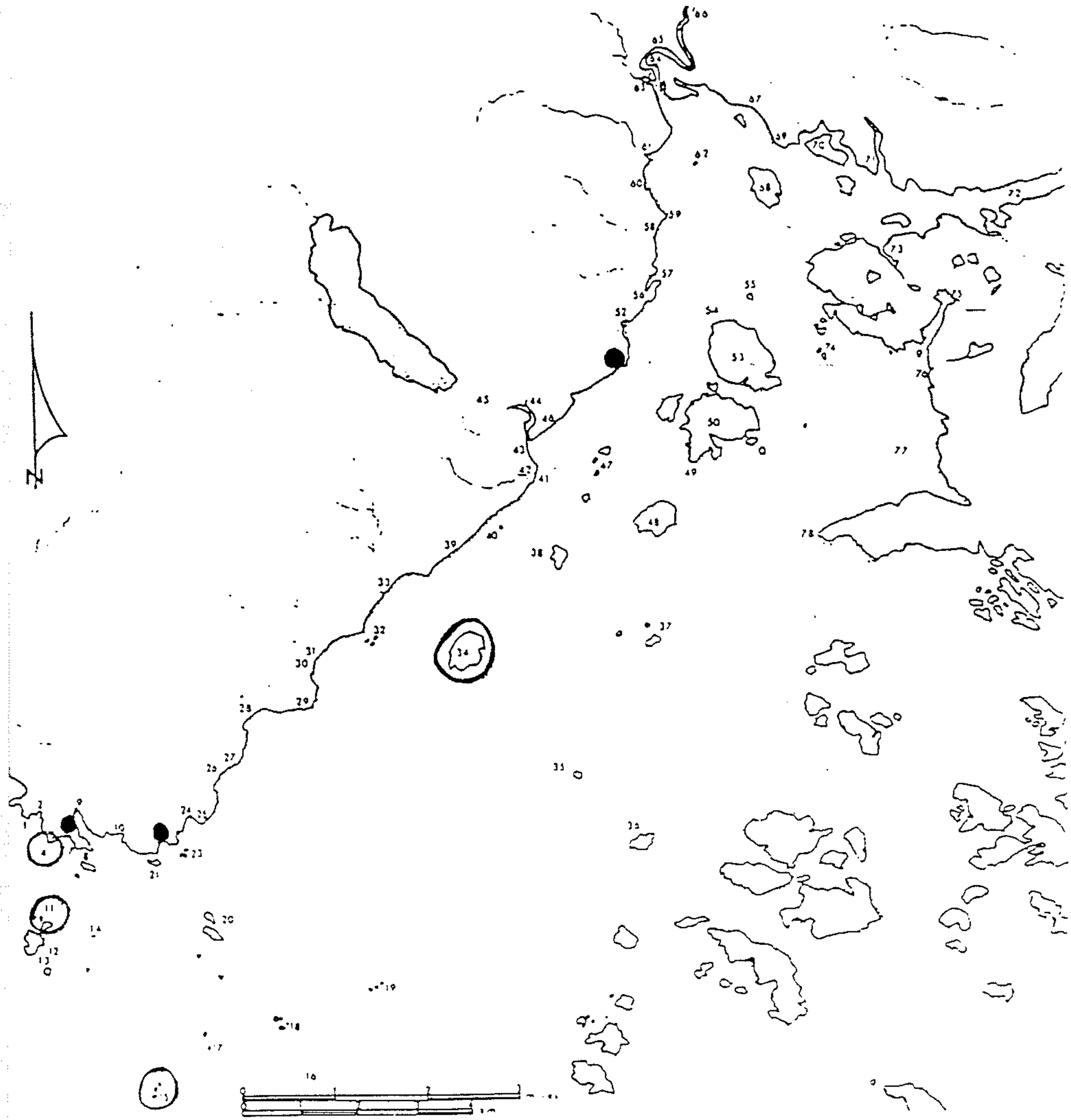
(Table 4.0) Study Area Rockfish Species

Known Rockfish Species for the West Coast of Vancouver Island

Scientific Name	Common Name	Average Depth (M)	Spawning* Season	Maximum Size (cm)	Maximum Age	Source
Sebastes babcocki	Redbanded Rockfish	50-240	April	64		Hart 1973
Sebastes borealis	Shortraker Rockfish			91	120	Chilton and Beamish 1982
Sebastes brevispinis	Silvergrey Rockfish	0-200	June	71	80	Archebald *et al.* 1981
					80	Chilton and Beamish 1982
Sebastes caurinus	Copper Rockfish	Shallow	April	55		Hart 1973
Sebastes entomelas	Widdow Rockfish	50-200	Jan/Feb	53	59	Archebald *et al.* 1981
					58	Chilton and Beamish 1982
					16	Phillips 1964
Sebastes flavidus	Yellowtail Rockfish	0-300	March	66	52	Archebald *et al.* 1981
					64	Chilton and Beamish 1982
					24	Phillips 1964
Sebastes helvomaculatus	Rosethorn Rockfish	50-300		33		Hart 1973
Sebastes jordani	Shortbelly Rockfish	0-150		30.5	10	Phillips 1964
Sebastes maliger	Quillback Rockfish	0-275		61		Hart 1973
Sebastes miniatus	Vermillion Rockfish	100-150		91	22	Phillips 1964
Sebastes melanops	Black Rockfish	0-366	April	59		Hart 1973
Sebastes paucispinus	Bocaccio	90-300	March	91	30	Phillips 1964
					36	Chilton and Beamish 1982
Sebastes pinniger	Canary Rockfish	50-100		73	75	Archebald *et al.* 1981
					75	Chilton and Beamish 1982
					22	Phillips 1964
Sebastes proroger	Redstripe Rockfish	50-200	January	51	32	Archebald *et al.* 1981
					41	Chilton and Beamish 1982
Sebastes reedi	Yellowmouth Rockfish	77-200	April	54	71	Chilton and Beamish 1982
Sebastes ruberrimus	Yelloweye Rockfish or "Red Snapper"	46-550	June	91		Hart 1973

4.4 Traditional Use

Rockfish are known ethnographically to have played an important part in the diet of Nuu-chah-nulth peoples (Drucker 1951:36-61). Calvert's (1980) faunal analysis of the DiSo-1 site in Hesquiat Harbour (to the north of Barkley Sound) provides archaeological evidence for the economic importance of rockfish in the Nuu-chah-nulth region. Rockfish remains are the most numerous category of fish remains for all five components (the oldest of which has been dated to 700 AD) identified at DiSo-1

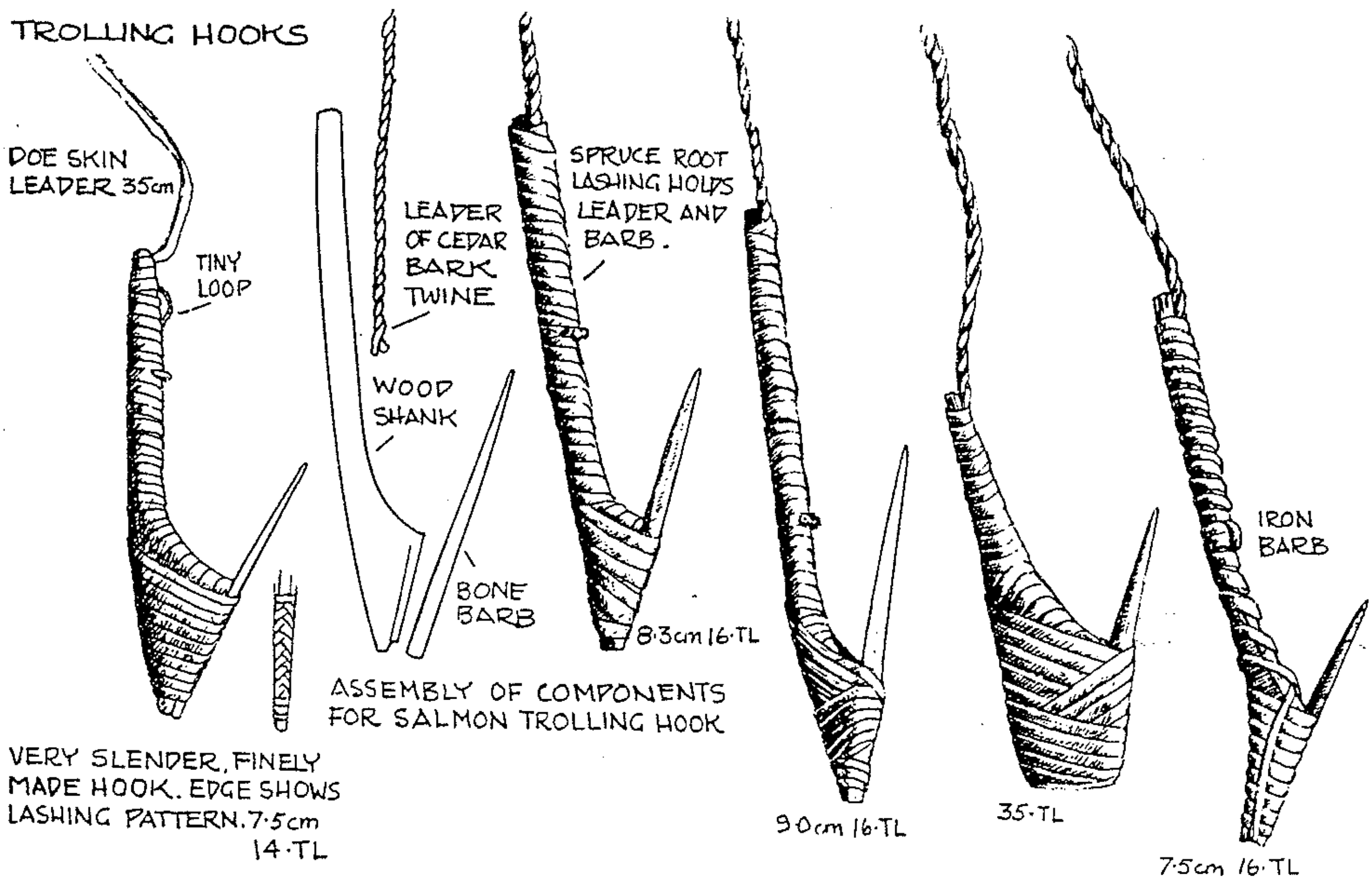


(Figure 4.1) Important "cod" fishing locations in Barkley Sound (fromAmira 1991)

– making up 64% of all recovered fish remains for component IV. The territory of the site's traditional inhabitants (the Haimai?isath) was entirely within the outer-coast zone and provided only limited access to salmon streams and herring spawning sites which may explain the abundance of rockfish. According to Calvert (1980: 96), the Hesquiat people are known to have distinguished at least five different kinds of rockfish. Particularly, they made a distinction between the smaller species that were more generally distributed and the large species (such as "red snapper") that were only found in deeper offshore waters.

As stated above, rockfish are non-migratory. As a result, they could have potentially been caught at any time of year in Barkley Sound. Drucker (1951: 39) describes "snapper" and "cod" fishing as activities associated with the (inside) winter village setting; intended to add variety to the steady diet of dried salmon and herring. Drucker does not list rockfish among the species that were caught in outer-coast contexts, although they were certainly available. The DiSo-1 faunal data indicate that rockfish were indeed an important "outside" resource (Calvert 1980: 175). Ethnographic accounts from the Barkley Sound area describe the islands and reefs adjacent to the outer-coast sites of Ch'uumat'a and T'ukw'aa as important "cod" fishing sites (Amira 1991) (see Figure 4.1). The term "cod" is used for a variety of fishes that are not always distinguished in the ethnographic literature. The term may refer to true Pacific cod (*Gadus macrocephalus)*, rockfish (*Sebastes* Spp., commonly called rock-cod), sablefish (*Anoplopoma fimbria*, commonly called black-cod), kelp greenling (*Hexagrammos decagrammus,* known as tommycod), or lingcod (*Ophidon elongatus*) (Suttles 1990).

Drucker (1951: 38) describes "cod" being caught by a number of ways, the most common method being angling, using hand lines armed with straight wood or stone shanks and bone barbs (see Figure 4.2). According to this description, a cod fisherman



(Figure 4.2) Strait-shanked Fish Hooks (from Stewart 1977: 42) didn't anchor but drifted along over the kelp bed or bar he was fishing. "Red snappers" (probably *Sebastes ruberrimus* or other larger rockfish species) are described as being caught in the same way.

Unlike some other fish species (e.g. salmon, herring), rockfish were almost exclusively taken for immediate use by the Nuu-chah-nulth (i.e. were not preserved), although some may have been dried in the summer (Drucker 1951: 38). If this behaviour is assumed for the pre-contact period, it has important implications for the interpretation of seasonal data from rockfish remains. It allows season of death (capture) estimates for rockfish remains to be directly related to season of site occupation.

4.5 Summary

The research presented here focuses on rockfish because they are an economically important and understudied component of the traditional Nuu-chah-nulth maritime subsistence economy. It is hoped that a better understanding of how this resource was exploited, and how it fit into seasonal subsistence patterns, will be achieved by examining the relationship between site location and season of rockfish exploitation. Further, the diachronic perspective afforded by archaeology allows for possible changes in rockfish exploitation over time to be examined.

The examination of rockfish remains also has implications for broader questions regarding the pattern of seasonal mobility and/or sedentism that was followed by Barkley Sound's indigenous population. It allows testing of the predictions made by two different hypotheses of the occupation of archaeological sites within Barkley Sound proposed by Dewhirst (1980) and McMillan (1999).

Chapter 5 - Techniques for Examining Incremental Growth Structures

5.0 Introduction

There is no single accepted investigative technique for the observation of growth structures in fish vertebrae. Simple examination of surficial growth increments using a low-power stereomicroscope seems to be adequate in some instances (Lee *et al.* 1982). In other cases (specifically those involving long-lived individuals) it may be necessary to examine thin-sectioned vertebrae microscopically, under transmitted light to identify internal zonations (Prince *et al.* 1985).

Different techniques seem to work better for different species, and each has its own strengths and weaknesses. The most widely used techniques are reviewed below and are evaluated with respect to their relative strengths and limitations prior to selection of a suitable method to apply to rockfish.

5.1 Overview of Techniques

5.1.1 Reflected Light – Whole Vertebrae

Growth increments (GLG's) on the anterior and posterior surfaces of many fish vertebrae are visible to the naked eye. Examining them with a low-power (16X magnification) Zeiss stereomicroscope using reflected light enhances viewing and measuring of these increments. Increments appear as alternating bony ridges and valleys under these conditions (Prince *et al.* 1985). This is the simplest means of examining incremental growth in fish vertebrae. Only limited preparation of the sample is required before viewing; as a result, this technique is non-destructive, relatively quick, and inexpensive. Accordingly, this is the technique that has been used most widely by archaeologists examining growth in fish vertebrae for seasonality studies (Voorhies 1969; Casteel 1972; Noe-Nygaard 1983; Le Gall 1981, 1994). Lee *et al.* (1983) compared this technique with otolith readings as a method for aging Atlantic bluefin tuna

(*Thunnus thynnus*) in a capture/recapture study. Vertebral counts were found to give comparable estimates of age to otolith counts. However, vertebra counts tended to underestimate age (likely resulting from increment crowding on the outercentrum margin [Price *et al.* 1984]) while otolith counts tended to over-estimate age (likely due to the presence and miss-identification of sub-annual increments).

There are some important considerations when using vertebra counts under reflected light, particularly when using them to establish season of death. The centrum surface of a fish vertebra may not be perfectly straight (from focus to margin), but rather slightly convex. This means that measurements of the linear distance between increments and of the final growth region may be distorted if the vertebra is not oriented correctly. It may be difficult to orient samples consistently. The observed distance between increments is a function of the angle at which they are viewed; as a result absolute measurements of growth between samples cannot be compared. Similarly, different orientations of the reflected light source on the sample may produce different optical effects (e.g. darkening or extending shadows behind ridges). Because vertebral surfaces are conical, it can also be difficult to orient the viewing area such that a whole record of growth (from focus to margin) is visible and none of it is obscured by the opposite portion of the cone (Cailliet *et al.* 1983: 159).

Another problem with this technique occurs when dealing with long-lived species such as tuna and certain species of rockfish (section 3.5.4). As an individual gets older, the deposition of new material on a vertebra takes place over a larger area. Thus, even if an individual grows the same amount in every year of its life, depositing the same amount of tissue, later growth increments will appear thinner because they occupy a greater circumference. This may result in crowded banding on the centrum margin and can obscure reading (Lee *et al.* 1983: 61).

5.1.2 Reflected Light – Thick Sectioned Vertebrae

Removing part of the vertebra can help to lessen some of the problems associated with orientation of the sample. Sectioning along the longitudinal plane is particularly useful for vertebrae with deep cones where opposing halves may obscure the viewing surface and prevent even lighting of the sample (Cailliet *et al.* 1983: 159). This is a fairly standard procedure among fisheries researchers examining growth increments on vertebral cone surfaces (e.g. Johnson 1983, Cailliet *et al.* 1983, Gruber and Stout 1983). Cross-sections of vertebrae are made by either polishing away the unwanted portion (e.g. Cailliet 1983, Gruber and Stout 1983) or by cutting the vertebra in half (e.g. Johnson 1983, Gruber and Stout 1983). This technique is obviously more time-consuming than viewing whole vertebrae though it involves little, if any, additional cost in terms of materials. Sectioning requires removal of at least a portion of the specimen and is therefore destructive.

5.1.3 Staining

Several staining procedures are used by researchers to enhance the visibility of growth increments on modern fish vertebrae. Different staining procedures are better suited for different species. The two most commonly used staining mediums are alizarin red and silver nitrate (see below). Other stains, such as crystal violet (Schwartz 1982), are also used, but less frequently. Staining samples obviously involves a greater investment in both time and materials by the researcher. Staining is also somewhat destructive (in that it may permanently alter the chemical and optical properties of the sample). This may be of concern if one wishes conduct further analyses using other techniques.

alizarin red -

Alizarin red may be used for specimens viewed under reflected ordinary light (Cailliet 1982a; Gruber and Stout 1982; Johnson 1982; Schwartz 1982). This substance selectively stains calcifying zones of the collagen matrix in growing bones (Kevezal 1996). Although the exact process involved is unclear, alizarin red appears to bind to calcium ions in mineralizing tissues (Klevezal 1996: 27). Growth marks on fish vertebrae stained with alizarin red show up as coloured ridges on the centrum surface (Johnson 1982). Lee *et al.* (1982) used alizarin red to stain Atlantic bluefin tuna (*Thunnus thynnus*) vertebrae for age determination and report reliable results. Similarly, Johnson (1982) found that this procedure was useful for enhancing growth marks on the vertebrae of little tunny (*Euthynnuus alletteratus,* another species of tuna). Attempts at using this procedure to enhance growth marks on shark vertebrae have produced mixed results. In a comparison of staining procedures for lemon shark (*Negaprion brevirostris* Poey) vertebrae, Gruber and Stout (1982) report that, "the clearest differentiation [of growth bands] was obtained with the use of alizarin red (1982:200)". However, in describing the use of alizarin red to stain longnose skate (*Raja rhina*) vertebrae, Cailliet *et al.* (1982a) state that, "success in enhancing growth bands was variable and contrast was moderate (1982a:161)". Experiments at staining scalloped hammerhead (*Sphyrna lewini*) and Dusky (*Carcharhinus obscurus*) shark vertebrae by Schwartz (1982) found alizarin red to be of little value in enhancing growth rings. The discrepancy in the apparent utility of alizarin red between tuna and shark species may be related to differences between the form of calcium deposition in elasmobranch vertebrae (which are composed of cartilage) and teleost vertebrae (which are composed of bone).

silver nitrate –

Silver nitrate staining replaces calcium salts in the centrum with silver, providing distinct silver impregnated bands that appear dark under ultra-violet illumination (Cailliet 1982a). Researchers working with shark vertebrae have had success using silver nitrate to stain samples (Cailliet 1982a, 1982b, Schwartz 1982). Cailliet *et al.* (1982a) report that, "using the ... silver nitrate staining technique, bands were clearly discernible in 10 of the 14 [shark] species tested (1982a:161)". They do caution, however, that, "(t)his technique did not produce repeatable band counts in species that had centra with a poorly differentiated calcification pattern, poor calcification, or narrow and tightly spaced bands (1982a:161)." Given the physiological differences between bony and cartilaginous fishes, it is unclear as to whether or not silver nitrate staining would work as well for teleosts.

5.1.4 Oil-Clearing

Some researchers have attempted to enhance the visibility of growth increments by applying oil to the surface of vertebrae (Cailliet 1982a, Schwartz 1982). Oil-clearing is intended to increase the clarity of bands by eliminating superficial irregularities. Cailliet *et al.* (1982a: 160) found that preparing samples by scraping the centrum face with a scalpel and applying cedarwood oil produced good results when viewed under a dissecting microscope using a fiber optics light transmitted both vertically and horizontally over a dark background. When samples are prepared and viewed this way, "bands that are composed of more tightly spaced rings (narrow bands) appear darker than those with less tightly spaced rings (broad bands) (Cailliet 1982a:160). According to the authors, this technique worked well for all seven tested elasmobranch species. Schwartz (1982) attempted a similar procedure using anise oil but found that this was not effective for enhancing growth increments.

5.1.5 Transmitted Light – Thin-Sectioned Vertebrae

Generally, thin-sectioning involves embedding the sample in epoxy resin, sectioning the sample using a low-speed saw, and further cutting/polishing until the desired thickness is achieved. This is normally around 0.5 mm for fish vertebrae (Campbell and Babaluk 1979: 22). Samples are viewed under a microscope using transmitted ordinary light. Slow-growth bands (annuli) are optically less dense and appear as lighter areas when viewed this way (Campbell and Babaluk 1979: 2).

Thin sectioning can be a laborious, time-consuming, and relatively expensive procedure when compared with other techniques used to examine growth increments in fish vertebrae and, as a result, is not commonly used. The technique has been applied, with mixed results, to produce age estimates of walleye (*Stizostedion vitreum vitreum*) and quillback (*Carpiodes cyprinus*) by researchers at the Department of Fisheries and Oceans (Campbell and Babaluk 1979, Praker and Fanzin 1994). Thin-sectioning has also been used by Prince *et al.* (1985) to age Atlantic bluefin tuna (*Thunnus thynnus*). They argue that when dealing with long-lived species, traditional methods of examining vertebrae tend to underestimate age as a result of crowded increments on the outer margin of the centrum surface. When thin-sections of tuna vertebrae are viewed under transmitted light, the authors state that internal zonations are visible in the solid area corresponding to the outer margin of the vertebral cone surface. They also observed that the portion of the vertebra nearer the focus tends to be spongy and lacking in internal zonations. From these observations, the authors propose a new method of age determination for Atlantic bluefin tuna involving the examination of external bands (those visible under reflected light on the vertebrae surface) near the focus and internal bands (visible in thin-sections viewed under transmitted light) near the outer surface. Age determinations using this combined viewing technique were found to be more accurate for older individuals when compared to whole-vertebra readings. However, results of this technique for juvenile and younger fishes were inconsistent (Prince *et al.* 1985: 495).

5.1.6 X-Ray Radiography

X-ray radiography may be useful for viewing incremental growth in the vertebrae of some fish species. Slow (winter) growth tends to be more densely mineralized than more rapid (summer) growth (Cannon 1988: 104). Because radiopacity is related to density, X-ray radiographs of vertebrae may exhibit a series narrow, light (radiopaque) and wider, dark (radiolucent) bands corresponding visible growth increments (Cannon 1988: 104). A major advantage of this technique is that it allows for the rapid processing of many vertebrae (Cannon 1988, Cailliet *et al.* 1982a, 1982b).

X-ray radiography has been successfully used to age several elasmobranch species (Cailliet *et al.* 1982a, 1982b) and by Aubrey Cannon (1988) to age Pacific salmon (*Oncorhynchus* spp.) recovered from the archaeological site of Namu. This technique has not been used to make seasonal determinations. An attempt by Cannon (1988) to use x-radiography with different Pacific teleost fish families (Gadidae, Hexagramidae, and Pleuronectidae) "failed to reveal any radiographically-visible concentric rings that could be interpreted as growth annuli (1988:104)". Cannon notes that, "(t)he fact that salmon bone is generally less dense than that of most other fish may have allowed easier passage of x-rays through summer-growth bands, in marked contrast to the radiopacity of the denser winter-growth bands. In other species of fish, the entire surface of the vertebrae was generally much more radiopaque, making it impossible to distinguish alternating growth bands (1988:104)." It is, therefore, unlikely that the technique could be applied to rockfish.

5.2 Reference collection - The Modern Sample

The reference sample for this research consists of sixteen Yellowtail Rockfish (*Sebastes flavidus*). The sample was obtained through the Marine Biological Research Station of the D.F.O. at Nanaimo. Specimens were collected from the commercial catches of several marine management districts on the west coast of Vancouver Island in 2000. The months of May, July, August, and October are each represented by four individuals. Samples from the remaining months were unavailable at the time of this study. Growth from the missing months was inferred using a mathematical growth model (section 6.1).

(Table 5.0) Reference Collection Body Metrics

Specimen ID #	Month	Weight (g.)	Standard Length (cm)	Age-at- Length Estimate	Wt(g.)/L(cm)
00-05-01	May	1048.0	38.7	8	27.1
00-05-02	May	1569.5	42.1	10	37.3
00-05-03	May	1568.0	43.5	12	36.0
00-05-04	May	1526.4	39.0	8	39.1
Average	***May***	***1428.0***	***40.8***	***10***	***34.9***
00-07-01	July	1600.0	41.5	10	38.6
00-07-02	July	1515.0	41.0	10	37.0
00-07-03	July	1294.0	39.0	8	33.2
00-07-04	July	1211.0	40.0	9	30.3
Average	***July***	***1405.0***	***40.4***	***9***	***34.7***
00-08-01	August	1292.0	38.5	8	33.6
00-08-02	August	1142.0	39.0	8	29.3
00-08-03	August	1209.0	38.5	8	31.4
00-08-04	August	985.8	35.0	6	28.2
Average	***August***	***1157.2***	***37.8***	***8***	***30.6***
00-10-01	October	1147.5	39.0	8	29.4
00-10-02	October	1222.0	39.5	9	30.9
00-10-03	October	1451.4	40.0	9	36.3
00-10-04	October	1162.0	38.5	8	30.2
Average	***October***	***1245.7***	***39.3***	***9***	***31.7***
Average	**Total**	**1309.0**	**39.6**	**9**	**33.0**

Standard measurements of body size and weight were taken for each individual. There is little variation either within or between months in the size or weight of individuals in the collection. All specimens in the collection are likely at or close to sexual maturity (c. 41-45 cm.), but none approach the maximum length for the species (about 66 cm) (Williams 1989).

Measurements of standard length provide a rough means of age-at-death estimation for the reference specimens. Researchers at the Pacific Biological Research Station have compiled an age-at-length growth curve for yellowtail rockfish based on the examination of otoliths from 979 fish collected off the central coast of B.C. and off the Olympic peninsula in Washington state (Archibald, *et al.* 1981). This curve was used to predict the ages of the specimens in the reference collection on the basis of their standard lengths (Table 5.0). Age estimates generated this way ranged from about 8 to about 10 years old. Only two individuals fell outside of this range (specimen 0804 at 6 yr. and 0504 at 12 yr.). While there is clearly an association between length and age of fish in general, there may be considerable variation in size between individuals of the same age. As a result, age-at-length curves are usually generated for descriptive rather than predictive purposes (Archibald *et al.* 1981: 103). Age-at-length estimates are used here to provide a rough, independent estimate to which age estimates derived from vertebral growth increments can be compared.

5.2.1 Preparation of the Reference Sample

In order to remove vertebrae from the fish for further analysis, basic maceration procedures were followed. First, each fish was filleted in order to remove most of the flesh. The filleted fish were then placed in water at 60°C for about 10 min. This helped to soften and remove most of the remaining flesh and cartilage. The vertebral column was then removed from each fish and submerged in a light (<50%) peroxide mixture for about 1 hr. in order to loosen remaining connective tissue. The vertebrae were then removed from the column and cleaned by gentle brushing. Care was taken not to damage the "reading" surface of vertebrae, especially the edges.

5.3 Comparison of Techniques as Applied to Modern Rockfish Vertebrae

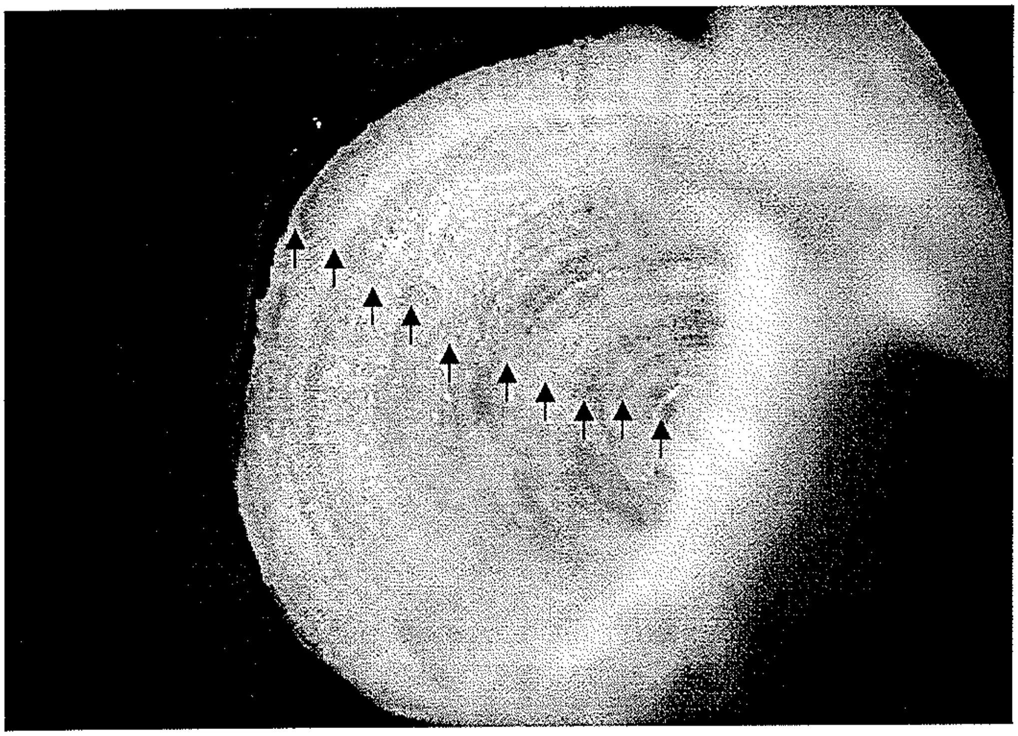
Several techniques were tested using material from the reference collection to establish which method would work best for examining growth increments on rockfish vertebrae for the purpose of seasonal determination. The techniques tested include:

- whole and cross-sectioned vertebrae viewed under reflected, unfiltered light
- thin-sectioned vertebrae viewed under transmitted, polarized light
- thick-sectioned vertebrae viewed under transmitted, polarized light

No attempt was made at using any of the staining procedures or radiography because the required materials were either unavailable or prohibitively expensive.

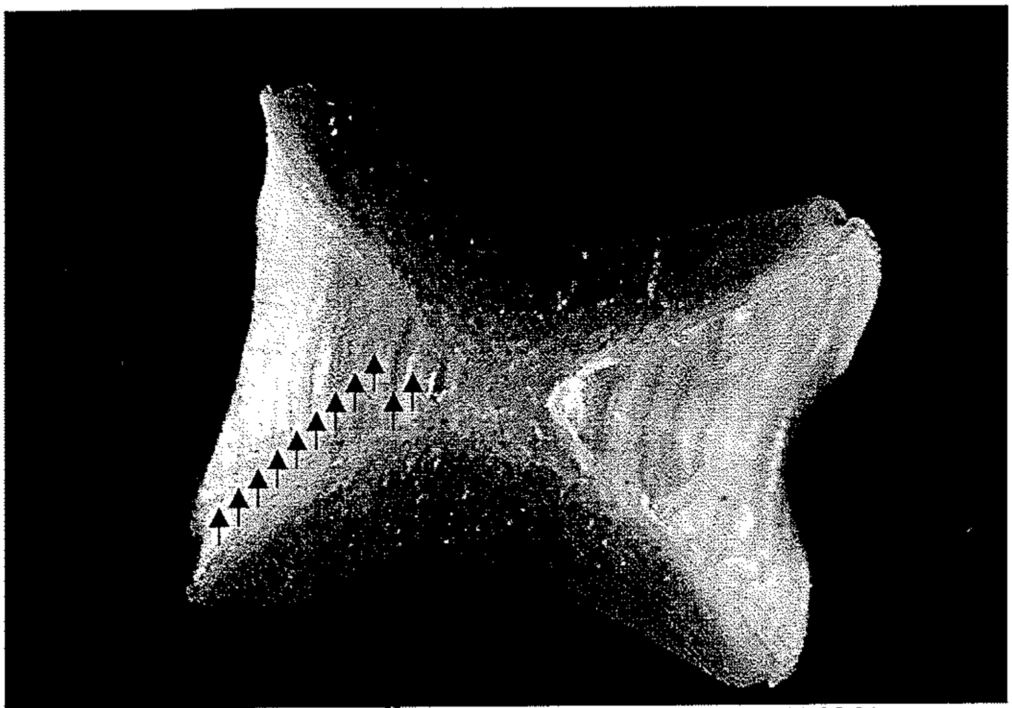
5.3.1 Results – Comparison of Techniques

5.3.1a Reflected Light – Whole/Cross-sectioned Vertebrae



(Figure 5.3.1). whole 1st pre-caudal vertebra from individual 00-05-02 viewed under reflected light at 16X magnification

One whole and one cross-sectioned vertebra were examined under reflected light. These include the 1st pre-caudal vertebra from individual number 00-05-02 and the 2nd pre-caudal vertebra from individual number 00-05-01 respectively. Both specimens were examined using a double fiber-optic external light source under a low power stereomicroscope at 16X magnification. The whole vertebra from specimen 00-05-02 (Figure 5.3.1) was oriented and fixed on the microscope stand using a small plasticine block so that a portion of the vertebra cone surface was perpendicular to the line of view. Alternating dark and light bands are clearly visible on the vertebra surface. These likely correspond to winter slow growth annuli (dark) and summer rapid growth zones (light)



(Figure 5.3.2). cross-sectioned 2nd pre-caudal vertebra from individual 00-05-01

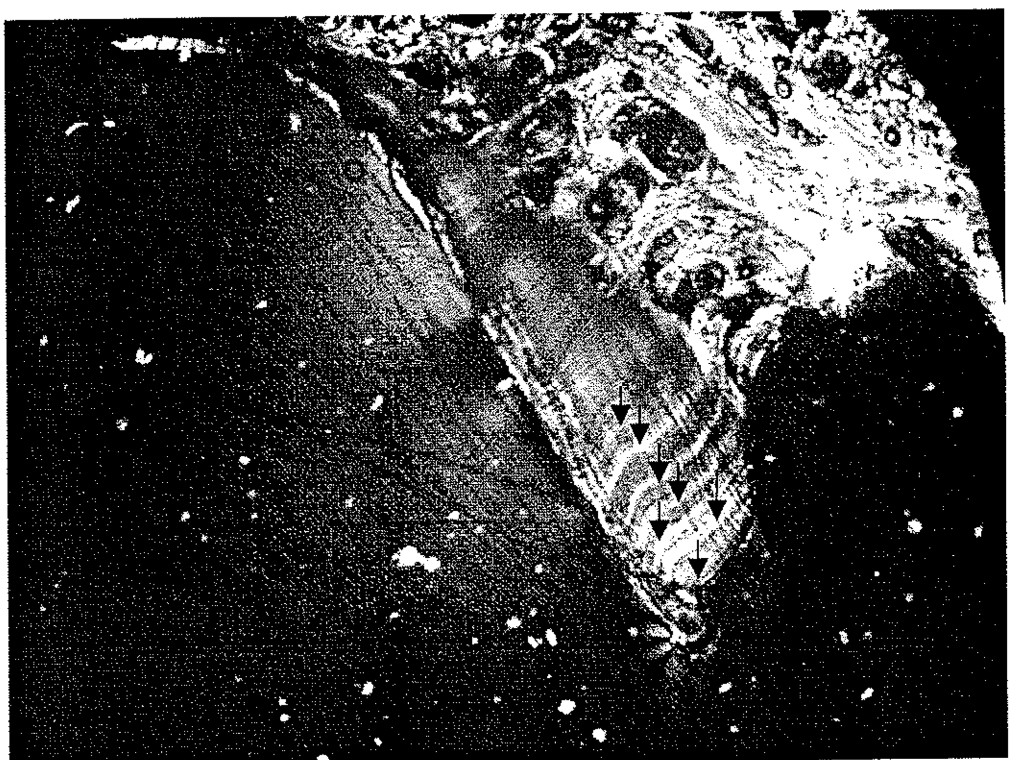
as described by Rojo (1987). If this assumption is correct, then this vertebra suggests an age of about 10 years. The predicted age-at-death for this individual based on its total body length was 10 years. The summer growth on the outer margin (from the distal margin of the final annulus to the vertebra edge) appears to be minimal, suggesting a spring/early summer season of death for this individual.

The vertebra from specimen 00-05-01 (Figure 5.3.2) was sectioned along the sagittal plane (i.e. anterio-posterior and through the centrum). Again, growth increments appear as alternating thin dark annuli and wider light zones. Counting these GLG's suggests an age-at-death of about 11 years. The predicted age based on body length for this individual was 8 years. Again, minimal growth is evident on the centrum margin.

5.3.1b Thin-Sections

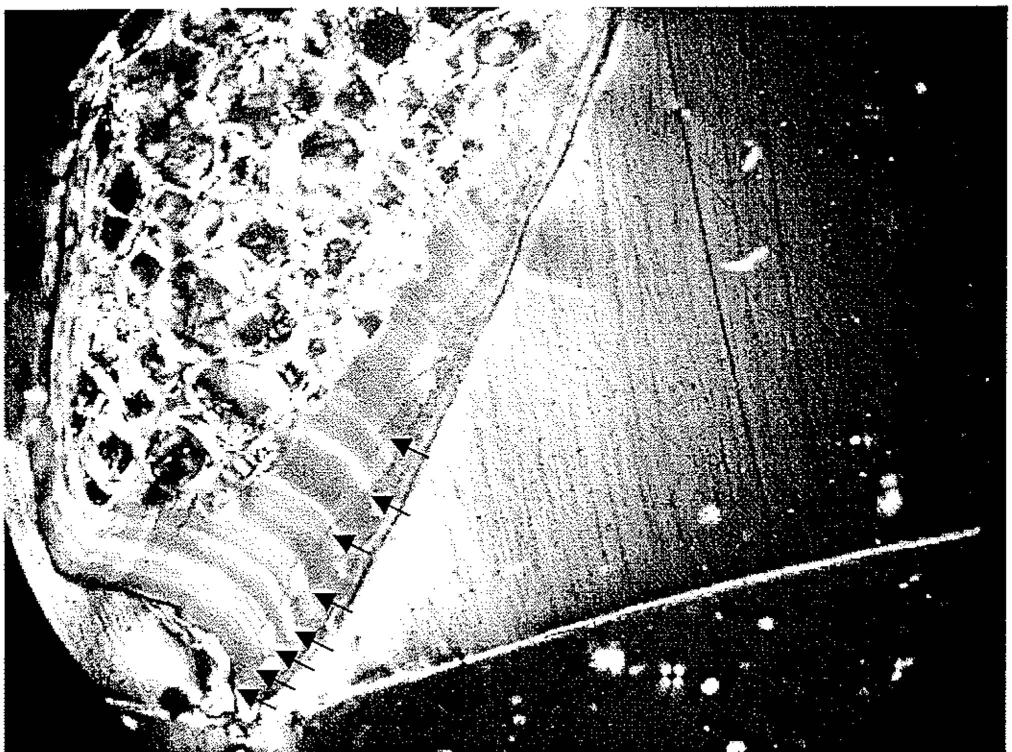
Thin-sections were produced from the 2nd and 3rd thoracic vertebra of specimen 00-05-01. Slides were prepared according the standard procedure for making histological thin-sections used by the University of Manitoba, Department of Anthropology, Thin-Section Laboratory. Samples were included in epoxide resin and sectioned along the sagittal plane using a low-speed diamond saw. Each sectioned half was then polished and glued to slides using epoxide resin, and thin-sectioned using an Isomet thin-sectioning machine. Further thinning and removal of abrasion artifacts was achieved by hand polishing with progressively finer (320, 400, and 600-grit) paper. Prepared samples were viewed under the microscope at 40X magnification using transmitted polarized light and transmitted ordinary (unfiltered) light.

In each case, increment banding (alternating light and dark increments) was visible on the centrum margin under polarized light. However, as Prince (1985) observed, increments become less clear near the centrum focus (Figures 5.3.3 and 5.3.4). Light, narrow increments likely correspond to slow, winter growth (i.e. annuli), as observed by Campbell and Babaluk (1979: 2). Under transmitted ordinary light banding was too faint to be clearly visible.



(Figure 5.3.3) thin-sectioned 2nd thoracic vertebra from individual 00-05-01 viewed under transmitted light at 40X magnification

The thin-sectioned 2nd thoracic vertebra of specimen 00-05-01 (Figure 5.3.3) exhibits about six distinct light bands (annuli) near the centrum margin. Nearer the focus, increments become less clear. Growth terminates in a narrow light increment (annulus) on the centrum margin, suggesting death prior to the resumption of summer growth.

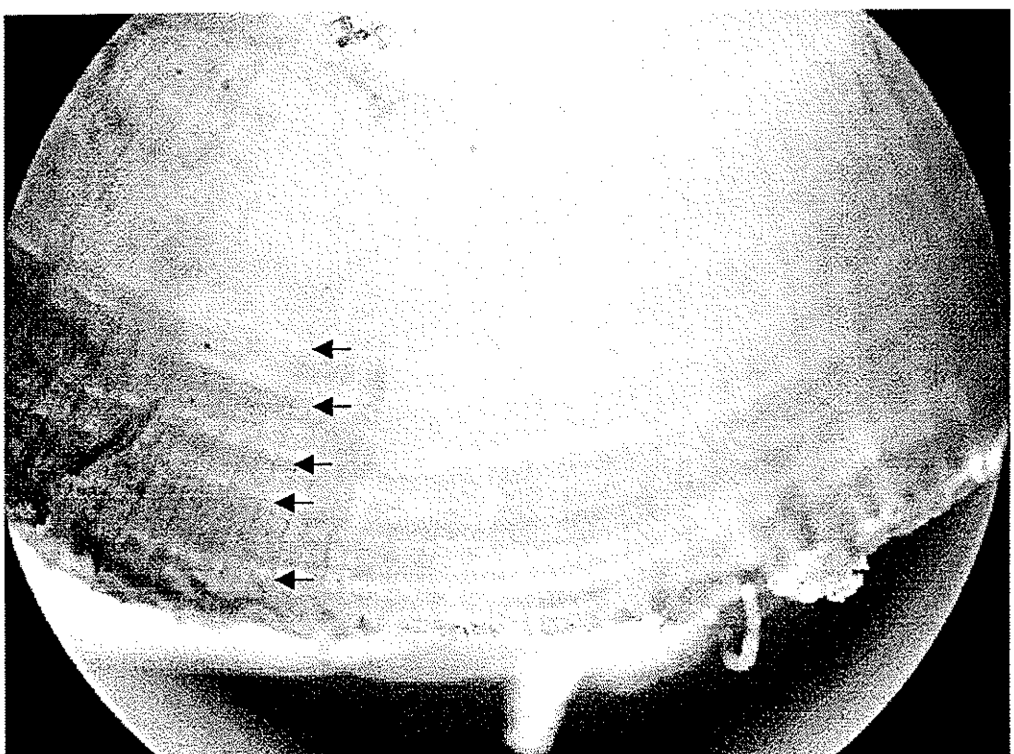


(Figure 5.3.4) thin-sectioned 3rd thoracic vertebra from individual 00-05-01 viewed under transmitted light at 40X magnification

The thin-sectioned 3rd thoracic vertebra of specimen 00-05-01 (Figure 4.3.1.4) exhibits about eight major light-dark increment groups (possibly annual GLS's) on the centrum margin. Again there appears to be a very narrow light increment on the outer centrum margin.

It is unclear how to interpret the internal zonations in these vertebrae. If each major light-dark increment group represents an annual event (GLG) and this density of increment deposition can also be assumed for the portion of the vertebra towards the focus where increments are not visible, these slides would suggest a much older age for this individual than indicated by whole vertebrae counts (11 years) or age-at-length data (8 years). Both thin-sections also exhibit finer bands within each major light-dark increment group. Further study is needed to determine the timing and periodicity of internal increment formation in rockfish vertebrae, but it appears that sub-annual banding may make it be difficult to distinguish annual increments (using this technique). Sub-annual banding may result from cyclical annual phenomena such as reproduction or from non-cyclical environmental phenomena such as extreme water temperature and food shortage.

5.3.1c Thick-Sections Transmitted light



(Figure 5.3.5) thick-sectioned 1st thoracic vertebra from individual 00-05-01 viewed under transmitted light at 40X magnification

A third technique, partial thinning of vertebrae and viewing under ordinary transmitted light, was also tested. The whole 1st thoracic vertebrae of specimen 00-05-

01 was polished using 320 grit sanding paper until it allowed the passage of enough transmitted light for increments to be visible on the vertebra cone surface. This required removing about half of the vertebra. The prepared sample was then placed directly on a microscope slide and viewed under the microscope at 40X magnification using transmitted light. The vertebra was sectioned to bisect the two relatively flat cone surfaces, and viewed on the anterior surface.

This specimen exhibited fairly clear, though faint, banding (Figure 5.3.5). At least 5 major light-dark increment groups are visible near the centrum margin. As with thin-sections, broad dark bands seem to be comprised of groupings of narrower dark bands. The major "breaks" between such zones appear as relatively narrow light bands. Increments are less visible toward the focus of the vertebra. Again, it is unclear what these increments represent, but sub-annual banding may occur, and more study is needed to establish the timing and periodicity of their formation.

5.3.2 Discussion and Conclusions

(Table 5.1) Comparison of three tested techniques for enhancing and viewing growth structures

Technique	**Preparation Time**	**Cost**	**Effectiveness**	**Notes**
Reflected light	Minimal (cleaning)	Minimal	Good	Cross-sectioning improved visibility and lighting
Thin-section - Transmitted light	c. 2 hrs (labour) c. 2 days (total)	High	Good (only outer increments)	Increments were clear and distinct but may not reflect annual growth
Thick-section – Transmitted light	c. 5 min	Minimal	Inconclusive	Same as above

The techniques tested here all show some success at revealing increments in, and on the surface of, rockfish vertebrae. Examination of whole or cross-sectioned vertebrae under reflected light and thin-sections under transmitted light seems to produce the most consistent results. The third technique (thick-sectioned vertebrae viewed transmitted light) seemed to work reasonably well. However, there may be serious problems with this technique relating to orientation of the sample.

Thin-sectioned vertebrae exhibit clear and distinct banding. However, these were only visible on the outer margin of the vertebrae. The absence of visible increments near the centrum focus precludes using this technique for age determination, although it may still be of use when examining the final growth increment for season-of-death estimates. An additional limitation of this technique is the time and cost involved in preparing samples. This makes the technique very unattractive when (as in the case of this study) large samples need to be examined.

Vertebrae viewed whole under reflected light allow adequate examination of growth marks. Although increments did appear less distinct than those visible in thin-sections it was easier to distinguish annual banding (GLGs). There are several major advantages to this technique. Minimal preparation of samples is required, and this allows for quick and inexpensive analysis. Further, specimens examined this way can be analyzed over a larger surface area (i.e. not just a across transect as in thin-sections). This helps in identifying false annuli or checks that are discontinuous over the entire centrum surface. Because this technique allows for the counting of all growth increments (from focus to margin) it can also be used in the estimation of age at death. Finally, it is non-destructive; as a result of all of the above this technique was chosen for the following research.

Chapter 6 – Establishing a Common Model

6.0 Reading the reference collection and growth curve

The first step in this part of the analysis was to accurately identify annual growth marks on the modern rockfish vertebrae. Identification was not straightforward as the vertebrae exhibit both major (distinct) and minor (faint) growth bands. In order to assess which (if any) of these bands corresponded to annual growth, age estimates based on vertebrae readings were compared against those derived from age-at-length data.

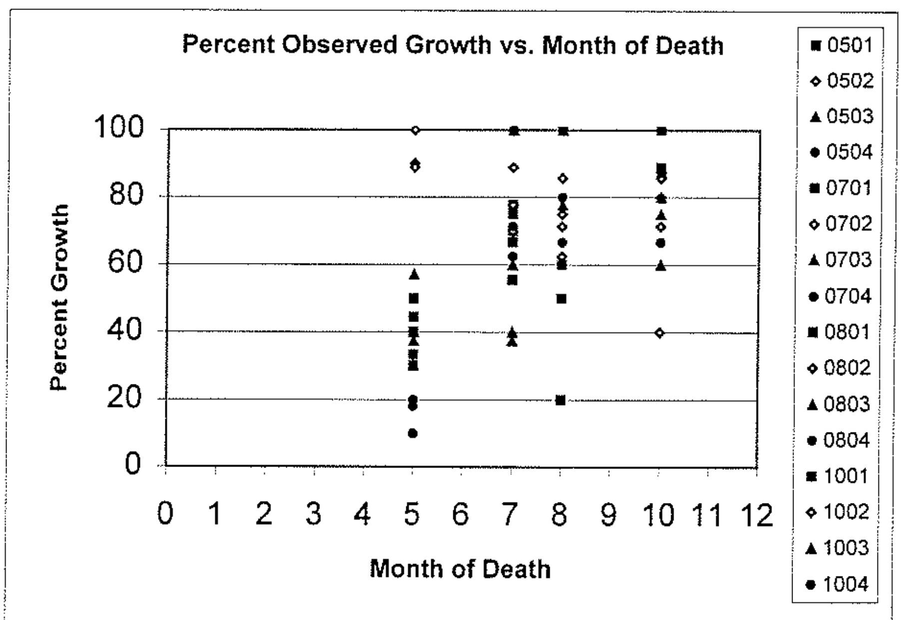
Estimates based on the major increments gave ages roughly consistent with the age-at-length data. Estimates based on all (major and minor) increments (bands) suggest that the major increments represent annual growth but that the minor increments likely represent sub-annual, possibly even aperiodic, growth. Therefore, subsequent readings were based only on major increments.

(Table 6.0) Comparison of Age Estimates

Specimen ID	Standard Length (cm)	Age-at-Length Estimate	Vertebra Age Estimate			
			Major Inc.	Difference	Minor Inc.	Difference
00-05-01	38.7	8	10	2	23	15
00-05-02	42.1	10	10	0	17	7
00-05-03	43.5	12	10	-2	19	7
00-05-04	39.0	8	9	1	22	14
00-07-01	41.5	10	10	0	31	21
00-07-02	41.0	10	9	-1	24	14
00-07-03	39.0	8	12	4	22	14
00-07-04	40.0	9	12	3	24	15
00-08-01	38.5	8	12	4	21	13
00-08-02	39.0	8	11	3	18	10
00-08-03	38.5	8	11	3	19	11
00-08-04	35.0	6	9	3	22	16
00-10-01	39.0	8	9	1	27	19
00-10-02	39.5	9	13	4	24	15
00-10-03	40.0	9	10	1	25	16
00-10-04	38.5	8	12	4	16	8
			Average	2.25	average	13.4375

This research focuses on thoracic vertebrae because of issues involving the archaeological sample (section 6.5.2). A common model for thoracic vertebrae is derived from 2nd thoracic vertebrae for this research. Second thoracics were selected because their overall morphology is typical of thoracic vertebrae.

Specimens from the reference collection were examined in the manner outlined in Section 4.3.1a. Whole 2nd thoracic vertebrae were viewed under reflected light using a Zeiss stereomicroscope. Each vertebra was mounted in plasticine and oriented such that the greatest portion of the posterior centrum surface (from focus to margin) was in focus. This procedure was consistently used in order to facilitate comparison between specimens and because this orientation provided optimal viewing of growth increments.



(Figure 6.0.1) Percent Observed Growth vs. Month of Death
*note on figures 6.0.1, 6.0.2 the first 2 digits of specimen ID correspond to month of death

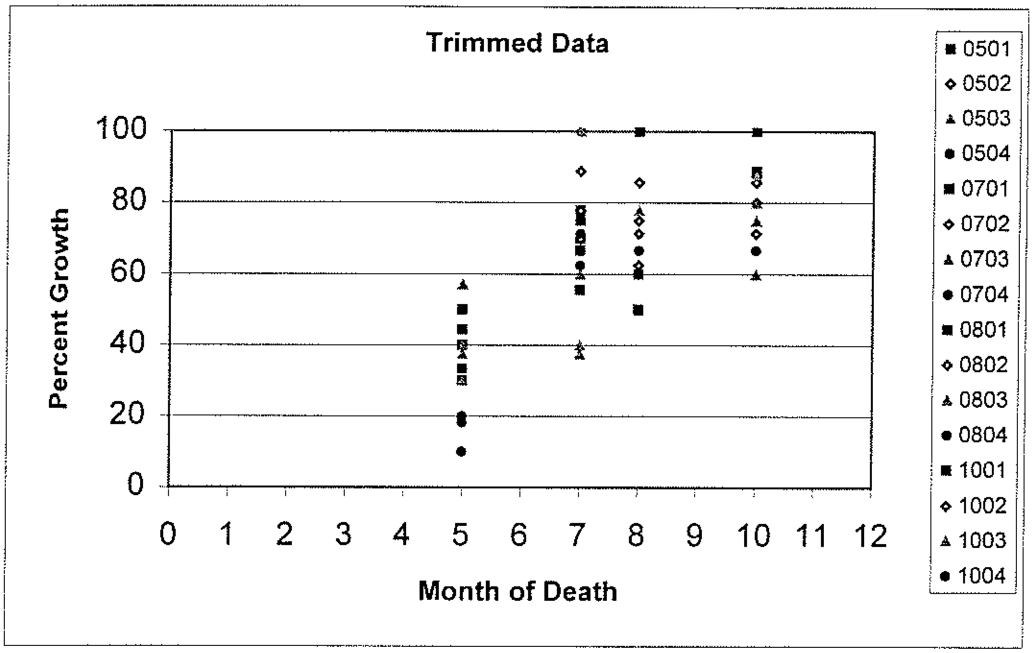
Measurements of the final (or marginal) and penultimate growth increments were taken at 16x magnification using an ocular graticule with a scale of 1/16th (.063) mm. Growth in the final increment was then expressed as a percentage of growth in the preceding increment or "growth ratio". Five blind readings were taken for each vertebra in the sample (i.e. each specimen was "read" by the same investigator on five separate occasions). The order of specimens was mixed prior to each set of readings in order to conceal specimen identities further.

Figure 6.0.1 (above) shows the growth ratio (relative to the penultimate increment) recorded for five successive readings of the sixteen specimens in the reference collection. Specimens are sorted on the x-axis by actual month of death. A clear trend of increasing growth relative to season of death is evident. There are, however, some readings that do not appear to correspond to this overall trend.

These outliers are interpreted as resulting from three main sources of variability. These include: 1) observer error (i.e. the degree to which measurements of the same structures on the same specimens vary between readings); 2) intra-individual variability in the percent of tissue deposited at any one point on the circumference of vertebra (deposition is not perfectly symmetrical); and 3) inter-individual variability in growth rates resulting from factors such as specimen habitat, age, and sex, as well as possible inter-population variability (specimens were collected from several marine management districts).

The purpose of this stage of the analysis is to propose a common model of growth for rockfish in the study region. Extreme outliers carry significant weight because of the limited sample size and have a strong influence on the proposed typical growth pattern. It is therefore necessary to deal with this variability before proceeding to the growth model.

For the most part, variability of the first and second types (observer error and intra-individual variability) can be dealt with by averaging repeated measurements (the assumption being that repeated measurements will be normally distributed about the "true" value). However, some extreme measurements are likely not the product of normal variability. Because of the weight such cases carry in a small sample it is necessary to identify and exclude anomalous measurements from further measures of central tendency. The third source of variability (inter-individual variability) is to be expected in any biological population, but significant deviations from the overall seasonal growth trend should be examined closely for other possible sources of error.

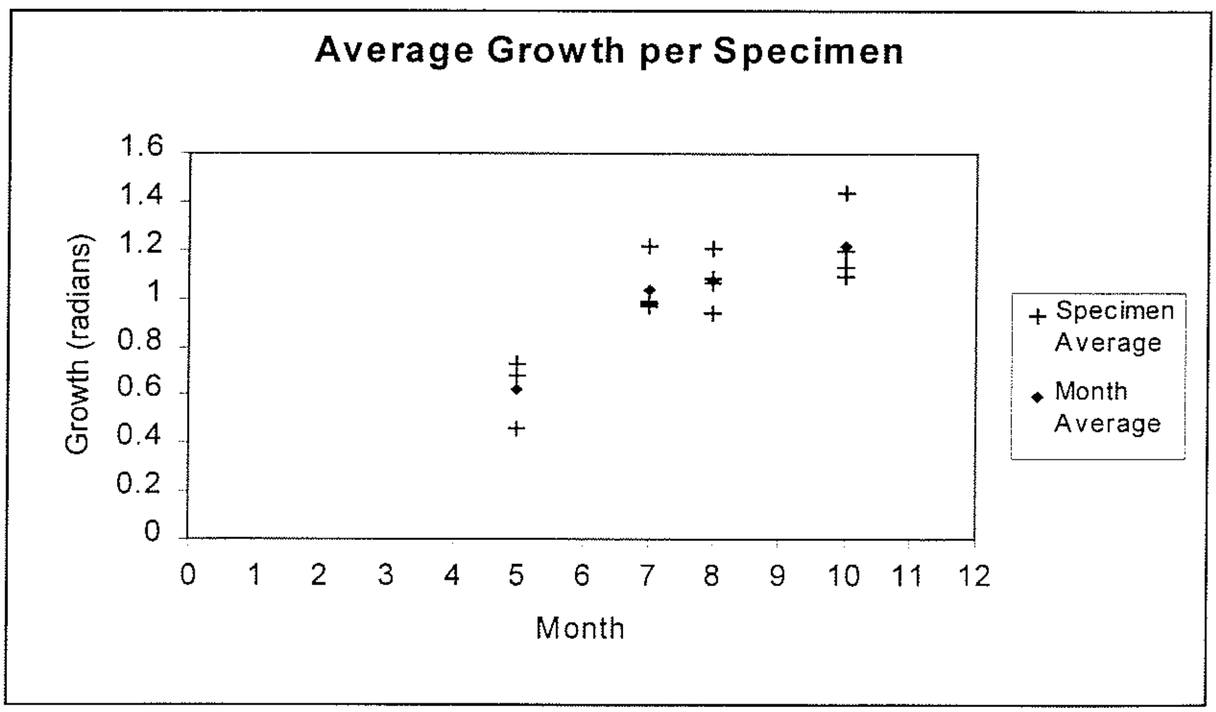


(Figure 6.0.2) Trimmed Data

Two statistical measures were applied in order to identify and confirm outlying values in the series of measurements associated with each specimen: Maximum Normed Residual (MNR); and Dixon's Criteria for testing extreme observations in single sample (Snedecor and Cochran 1980: 280). Each test was calculated to the 5% level (i.e. outliers were defined as values that should occur less than 5% of the time under normal conditions). Five readings were identified as outliers and excluded (Figure 6.02).

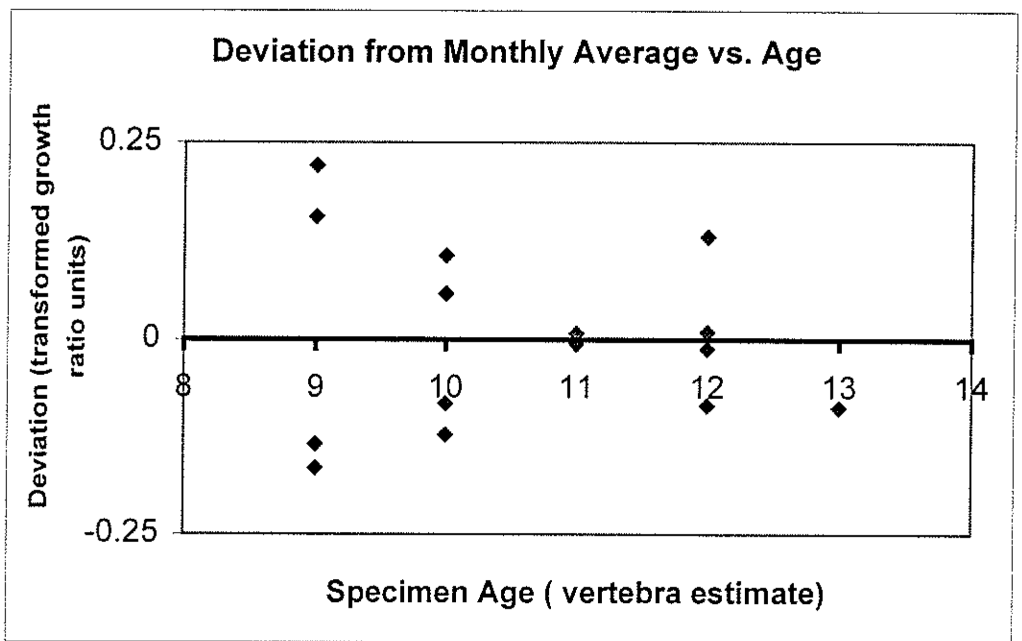
One specimen (0502) was excluded because of pronounced variability of the third type (inter-individual). All five blind readings for this specimen gave consistent results (~100%), but suggest an amount of growth atypical for specimens caught in May and inconsistent with the trend suggested by recorded growth for specimens from other months. Further examination of this specimen revealed that growth on the edge of the vertebra appeared "clouded" (i.e. growth increments were non-distinct). Inception of growth in the final year may be masked, resulting in both penultimate and final increments being read in error.

Figure 6.0.2 (above) shows the "trimmed" data after application of MNR, Dixon's Criteria, and removal of specimen 0502. The remaining variability between readings is assumed to be the product of normal variation. However, because growth is measured here as a ratio (percentage), the data may be forced into a skew below about 30% and above about 70% (Snedecor and Cochran 1980: 290). An angular transformation (arcsine$\sqrt{x}$) was applied in order to better approximate normal variation. The resulting values are expressed as transformed growth ratio units. The average growth measurement for each specimen was calculated on the basis of this transformed and trimmed data. The results of this are plotted (Figure 6.0.3) along with average recorded growth for each month. These data were used to produce the common model for rockfish thoracic vertebra growth.



(Figure 6.0.3) Average Growth per Specimen

Specimen age was examined as a potential source of the remaining inter-individual variability. Individuals tend to have progressively thinner annual bands as they age (section 3.2). Therefore, it may be expected that older individuals also exhibit proportionally less growth than younger individuals caught in the same month. In order to compare growth between specimens of different ages in the collection, it was necessary to factor out differences in growth between specimens that resulted from different months of capture. Inter-month variability was accounted for by recording the extent to which specimens deviated from the average growth ratio associated with each month of capture. The relationship between specimen age and growth (in units of deviation from monthly average) is shown in Figure 6.0.4. No consistent relationship between estimated age (vertebra growth increment count) and growth is visible.



(Figure 6.0.4) Deviation from Monthly Average vs. Age

This result may be due to the relatively narrow estimated-age range of the reference collection. Alternatively, it suggests that the use of a proportional measure of increment growth is sufficient to account for differences in absolute growth between specimens of different ages. Further examination of the relationship between age and vertebra growth may help to resolve these issues.

6.1 Selection of Growth Model

A mathematically derived growth curve was fitted to the reference data in order to describe the observed distribution and to provide a model of expected growth against which archaeological data could be interpreted. Many mathematical models of growth exist, and it was necessary to select a form that theoretically and empirically best suited the data. A sigmoid (S-curve) was selected for this purpose. This type of curve has broad applicability. The organismic growth of animals and plants in controlled laboratory conditions, where environment and nutrient supply can be maintained, often approximates the sigmoidal form (Weatherly and Gill 1987: 10). This growth pattern has also been shown to be common for fish in natural localities subject to orderly seasonal change such as can be found in many temperate environments (Weatherly and Gill 1987: 10). Consequently, sigmoid curves are generally considered to be the most appropriate form for describing the seasonal course of growth in fishes (Ricker 1979: 719).

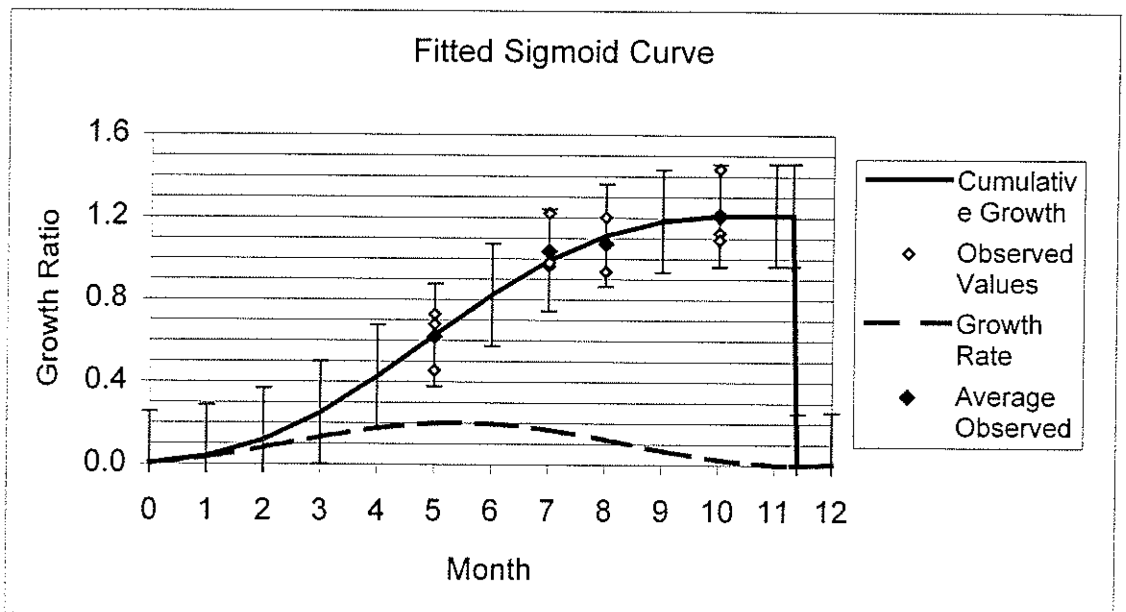
A number of S-shaped curve equations have been used to model growth including such forms as the logistic, Gompertz, and Putter No.1 and No.2 curves (Ricker 1979: 719). S-curve equations differ slightly in the parameters they are able to model and where they place points of inflection. Because it is not the intention of this research to estimate specific parameters that may influence growth, the simplest curve (i.e. the one requiring estimation of the fewest parameters) was selected.

The selected curve form was derived by progressively summing growth increments (per unit time) from a sine curve, beginning where growth (y) = ~0. The basic sine curve equation has four parameters. These control the amplitude, period, and vertical and horizontal position of the curve. The period of the curve may be assumed to equal 12 months (i.e. a full annual growth cycle). The vertical shift can be assumed to be equal to the amplitude (i.e. at no point does the curve go below the x-axis and by definition it must originate at 0). That leaves only amplitude and horizontal shift as parameters that need fitting.

6.2 The Fitted Growth Curve

The sigmoid curve was fitted by the least-squares method. Figure 6.2.1 shows the fitted sigmoid curve and the sin curve from which it is derived. The fitted sine curve has the equation:

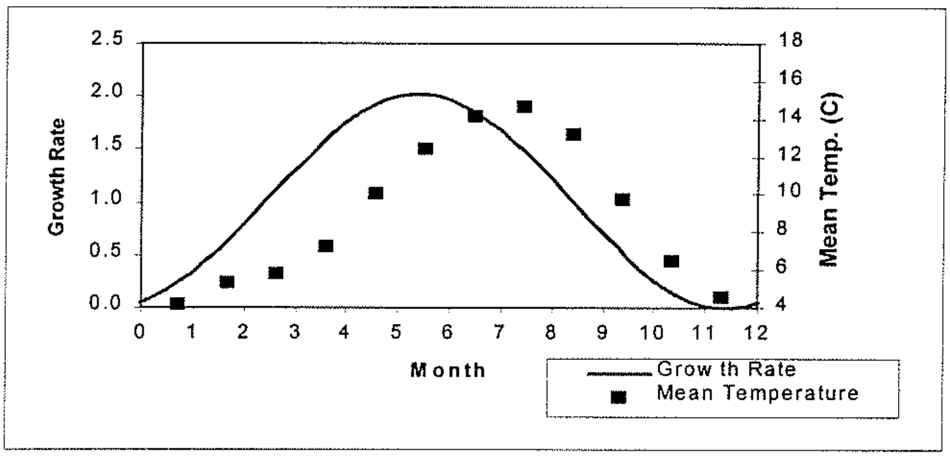
$$Y = a*\sin[(2\pi/12)*(x-b)]+c$$



(Figure 6.2.1) Fitted Sigmoid Curve

where a and c (amplitude and vertical shift) = .102 (transformed growth ratio units) and b (horizontal shift) = 2.54 (months). The sine curve represents growth rate and the sigmoid curve represents expected growth ratio. The fitted sine curve has a value of ~0 (i.e. growth rate equals ~0) in mid-December. This suggests a possible timing for growth cessation and annulus formation and is taken as the starting/finishing point of the growth curve.

Another reason for selecting a sine curve as the underlying growth model is that average monthly temperature (likely the major factor affecting growth rate) follows a similar sinusoidal pattern. Figure 6.2.2 shows the fitted sine curve and the average monthly air temperature for Tofino on the west coast of Vancouver Island (Environment



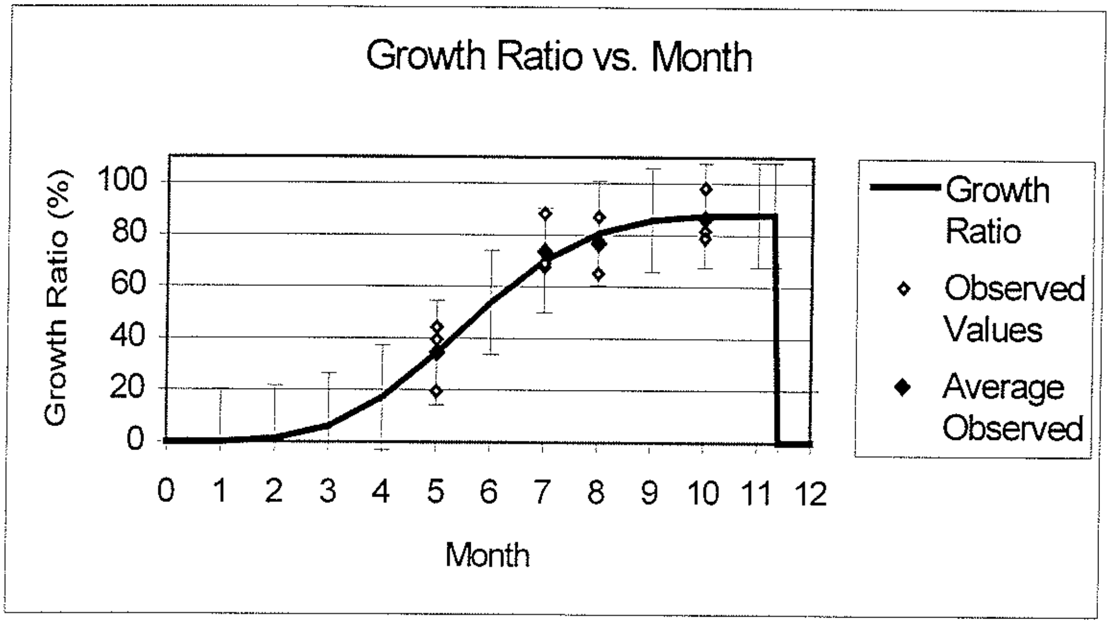
(Figure 6.2.2) Growth Rate vs. Mean Temperature

Canada 1998). The estimated growth rate appears to conform quite closely to the mean temperature curve. However, maximum growth seems to occur about two months (June) before maximum temperature (August).

The sigmoid curve has a standard error of estimate of 0.138 radians. This is given by the equation (Leother and McTavish 1993: 236):

$$S_{y.x} = \sqrt{}\Sigma(Y_i - \hat{Y}_i)^2 / n\text{-df}$$

where Y_i = an observed value of Y at a given value x, $\hat{Y}_i$ = the corresponding value of Y predicted by the curve, n = number of observations, and df = degrees of freedom (number of fitted parameters). If the reference collection is treated as a random and representative sample of the rockfish population as a whole, this value may be used as an estimate of the population standard error of estimate. The error bars about the curve (Figure 6.2.1) show +/- 1.96 standard errors of estimate (0.27 transformed growth ratio units) or approximately 95% confidence.



(Figure 6.2.3) Growth Ratio vs. Month

The curve was converted back into percentage growth units (Figure 6.2.3) in order to simplify its use in subsequent analysis. The standard error of estimate was re-calculated with reference to the percentage growth ratio data giving a new value of 10.3%. The error bars on Figure 6.2.3 again represent 95% confidence or +/-1.96 std. errors.

6.3 Application of the Growth Model

The model indicates that there is a high degree of inter-individual variability for each month. Therefore, a given individual's date of death can only be reliably estimated within a range of several months. As a result, the model is used to estimate season rather than month of death. Three broad seasons were defined (Figure 6.4) to minimise overlap in ranges of expected growth. The selected season-of-death model lacks the implied precision associated with month-of-death point-estimates but provides much greater (expected) accuracy. Given a larger and more complete reference collection it may be possible to reduce the expected variability in growth ratio associated with specimen month of death. This reduction in inter-individual variability would allow more precise (less broad) season-of-death estimation without sacrificing accuracy.

Monks and Johnston (1993) discuss the use of a quantitative procedure that may improve the accuracy associated with multiple specimen date-of-death estimates. This technique involves averaging the growth ratios of multiple specimens associated with the same event and comparing this averaged value to a growth model (e.g. regression line) to estimate date of death (event seasonality). Due to the relatively small archaeological sample involved with this research and the likelihood that these specimens represent multiple events, their approach was not practical.

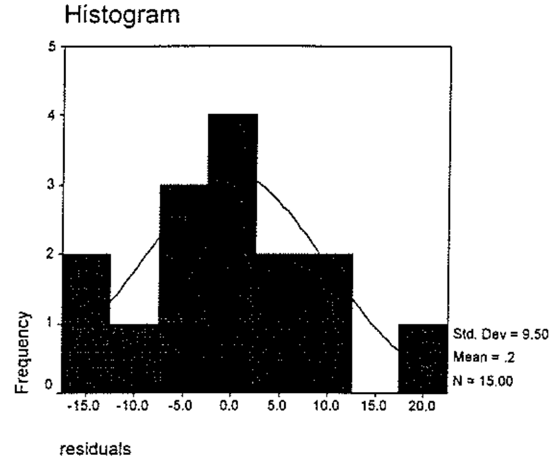
In order to define appropriate "seasons", it was necessary to more precisely determine the extent and location of expected overlap. Overlap was examined by re-plotting the growth model as a probability matrix. The resulting matrix (Table 6.3.1) shows the probability (proportion of specimens) expected to be associated with each percent range for each month. Probabilities were calculated using the curve's standard error as an estimate of inter-individual variability.

The apparently discontinuous distribution of values in the upper-left and lower-right portions of the matrix is a product of this calculation. Negative growth or growth exceeding 100% is rejected because there is no evidence for it in the reference collection. While such growth (or resorption) may occur, it is impossible to model given the data available. The upper and lower boundaries for possible growth ratios are, therefore, assumed to be 100% and 0%. The resumption and termination of a complete annual growth cycle are equivalent. Therefore values predicted by the growth model to be above 100% are expressed here as above 0% (lower right) while values predicted to be below 0% are expressed as below 100% (upper left).

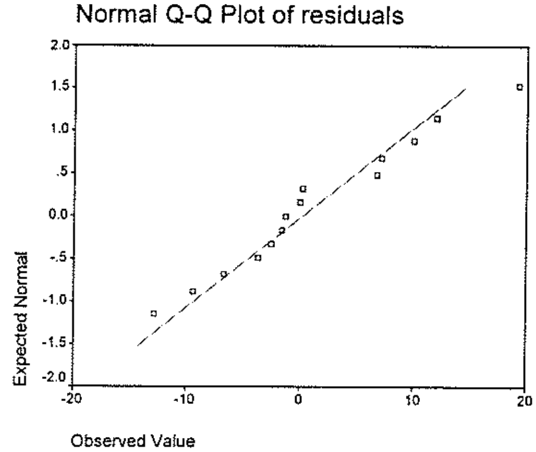
(Table 6.3.1) Growth Model Probability Matrix

Percent Range	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
90-100	0.34	0.32	0.24	0.06	0	0	0.02	0.16	0.26	0.31	0.29	0.32
80-89.9	0.14	0.12	0.06	0.01	0	0	0.11	0.32	0.38	0.37	0.37	0.33
70-79.9	0.02	0.02	0.01	0	0	0.03	0.32	0.34	0.22	0.18	0.18	0.18
60-69.9	0	0	0	0	0	0.18	0.36	0.14	0.05	0.03	0.03	0.03
50-59.9	0	0	0	0	0.04	0.37	0.16	0.02	0	0	0	0
40-49.9	0	0	0	0.01	0.17	0.31	0.03	0	0	0	0	0
30-39.9	0	0	0.01	0.07	0.37	0.1	0	0	0	0	0	0
20-29.9	0.03	0.03	0.07	0.26	0.31	0.02	0	0	0	0	0	0
10-19.9	0.13	0.15	0.23	0.35	0.1	0	0	0	0.02	0.02	0.02	0.02
0-9.9	0.34	0.36	0.38	0.24	0.01	0	0	0.03	0.07	0.1	0.12	0.12

The calculation of matrix probabilities using the growth model's standard error as an estimate of inter-individual variability involves the assumption that variability about the growth model is normally distributed. This assumption was tested by examining the distribution of residuals (observed-expected values) for the growth model (Figures 6.3.1 and 6.3.2). The null-hypothesis that the residuals are normally distributed was tested by calculating Kolmogorov-Smirnov and Shapiro-Wilk statistics. Neither test was able to refute the null-hypothesis (values of 0.164 sig 0.200, and 0.976 sig 0.913 respectively). Therefore the assumption of normality is not invalid for this data.



(Figure 6.3.1) Residuals Histogram



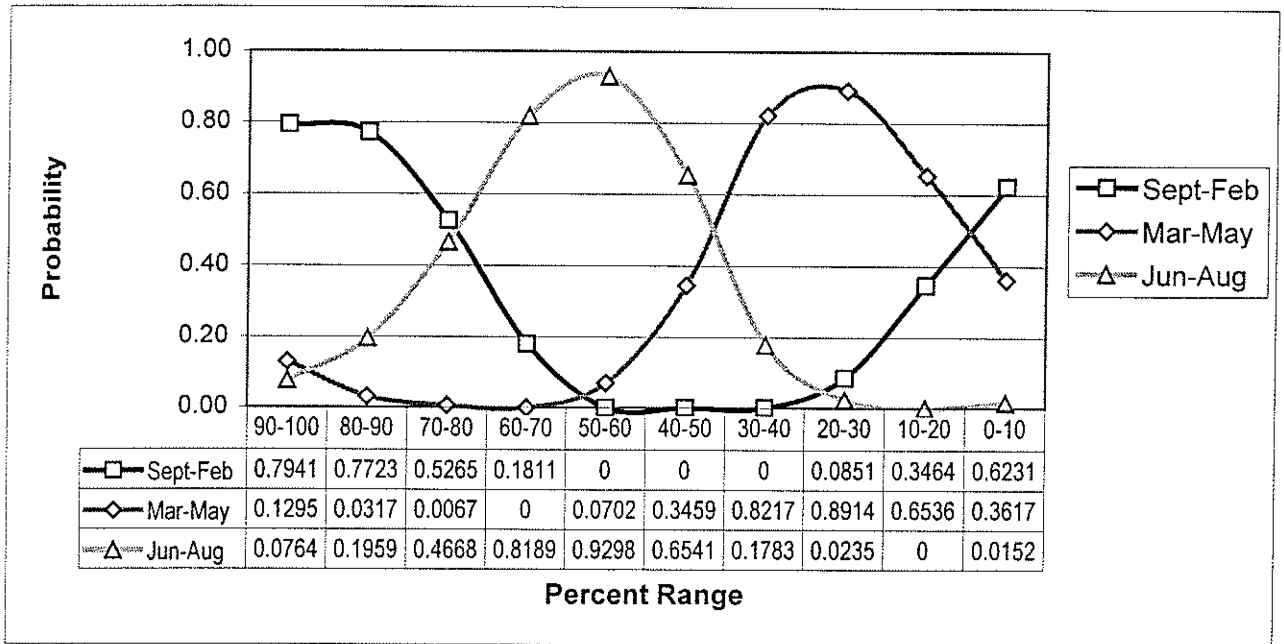
(Figure 6.3.2) Normal Q-Q Plot of Residuals

In order to calculate the probability associated with each month for each percentage range the matrix in Table 6.3.1 was normed by row (i.e. cell values were divided by row totals) (see Table 6.3.2).

(Table 6.3.2) Growth Model Probability Matrix – Normed by Row

Percent Range	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
90-100	0.15	0.14	0.1	0.03	0	0	0.01	0.07	0.11	0.13	0.12	0.14
80-89.9	0.06	0.05	0.03	0	0	0	0.05	0.14	0.17	0.17	0.17	0.15
70-79.9	0.01	0.01	0.01	0	0	0.02	0.22	0.23	0.15	0.12	0.12	0.12
60-69.9	0	0	0	0	0	0.22	0.44	0.17	0.06	0.04	0.04	0.04
50-59.9	0	0	0	0	0.07	0.63	0.27	0.04	0	0	0	0
40-49.9	0	0	0	0.02	0.33	0.6	0.05	0	0	0	0	0
30-39.9	0	0	0.01	0.13	0.67	0.18	0	0	0	0	0	0
20-29.9	0.04	0.05	0.1	0.37	0.42	0.02	0	0	0	0	0	0
10-19.9	0.13	0.14	0.22	0.34	0.1	0	0	0	0.02	0.02	0.02	0.02
0-9.9	0.19	0.2	0.22	0.14	0.01	0	0	0.02	0.04	0.06	0.07	0.07

The data from this table were used to compare the probabilities associated with each possible three-part (four-month) annual division. The optimal arrangement contained the highest "peak" probabilities and minimized overlap. The arrangement that best satisfies these conditions group: Feb-May, June-Sept, and Oct-Jan. The arrangement was then modified by expanding the Oct-Jan group to include September and February. This was necessary in order to encompass the wide range of months associated with the relatively flat upper and lower portions of the growth curve. This September-February "season" includes all months likely associated with annulus formation and, therefore, the termination and resumption of annual growth. Figure 6.3.3 shows the probability of each derived "season" associated with each percent range.



	90-100	80-90	70-80	60-70	50-60	40-50	30-40	20-30	10-20	0-10
Sept-Feb	0.7941	0.7723	0.5265	0.1811	0	0	0	0.0851	0.3464	0.6231
Mar-May	0.1295	0.0317	0.0067	0	0.0702	0.3459	0.8217	0.8914	0.6536	0.3617
Jun-Aug	0.0764	0.1959	0.4668	0.8189	0.9298	0.6541	0.1783	0.0235	0	0.0152

(Figure 6.3.3) Season Probabilities

These seasonal groupings not only provide a good fit to the empirically derived rockfish data; they also closely reflect the ethnographic Nuu-chah-nulth "economic seasons" (Jochim 1976) as described by Drucker (1951: 33-36). September-February encompasses the "late-summer/fall" and "winter" portions of the year. Both of these seasons are associated with "inside" settlements and activities (Dewhirst 1980: 11-12, 15; Drucker 1951: 33-36). During the late-summer/fall most groups are described as moving to sites near river mouths (usually located near the heads of inlets) where spawning salmon could be exploited (Drucker 1951: 33-36). By the winter, groups amalgamated in protected "inside" winter villages (Dewhirst 1980: 11-12, 15; Drucker

1951: 33-36). March-May corresponds to "spring" when most groups moved from their winter villages to sites where herring could be exploited (Drucker 1951: 33-36). June-August corresponds to the "summer" months when most groups occupied "outside" sites where pelagic resources (particularly halibut, whales, and seals) could be exploited (Dewhirst 1980: 11-12,15; Drucker 1951: 33-36).

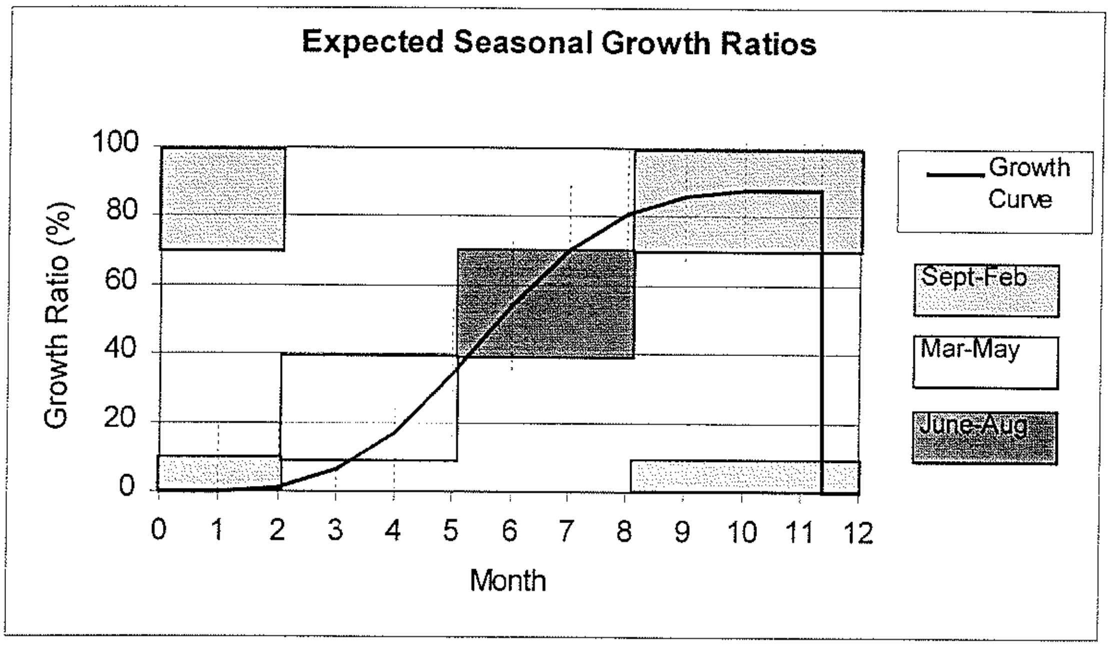
Table 6.3.3 shows the seasons associated with each growth ratio (percentage) range and their relative probabilities. Broad percent ranges were determined by combining the 10% ranges that were most strongly associated with each season (see Figure 4.4.12). This table allows growth ratio readings to be converted into season-of-death estimates and provides a measure of the probable accuracy (and error) resulting from inter-individual variability associated with such estimates.

(Table 6.3.3) Season Probabilities

Growth Ratio (%)	Sept-Feb	Mar-May	Jun-Aug
70-100 and 0-9.9	**0.68**	0.13	0.19
40-69.9	0.06	0.14	**0.80**
10-39.9	0.14	**0.79**	0.07

6.4 Summary

The method of season-of-death determination utilised in this research involves a three-part annual division (i.e. it allows estimates of season of death falling within three broadly defined "seasons", roughly corresponding to summer, fall/winter, and late-winter/spring). This grouping was done in order to minimise the expected error in estimation resulting from inter-individual variability. The proposed "seasons" are derived from the empirically observed reference collection data and correspond to ethnohistoricaly observed Nuu-chah-nulth economic seasons. The expected range of growth ratios associated with each season has been calculated along with a measure of expected error resulting from inter-individual variability. Figure 6.4 provides a graphic illustration of the proposed seasons and their expected growth-ratio ranges. The season-of-death for archaeological specimens in this research is determined by comparing their observed growth ratios with the expected range associated with each season (e.g. specimens showing 0-10% or 70-100% growth are estimated to fall within the September-February range).



(Figure 6.4) Expected Seasonal Growth Ratios

6.5 The Zooarchaeological Sample

6.5.1 Faunal Material

More than 3/4 of a metric ton of faunal material was recovered from the three village sites by the Toquaht team in 1992 alone (Monks 1992: 76). All remains were provenienced to site, unit, arbitrary level, and stratum. All faunal remains were initially classified according to a relatively gross recording scheme: e.g., land mammal, sea mammal, bird, fish, bivalve or gastropod. The current lack of a full taxonomic study prohibits the application of presence/absence seasonal determination techniques based upon the seasonal patterns of behaviour of specific species. Once identification of faunal remains from Toquaht is complete, seasonal determination on the basis of species presence/absence may well be feasible.

An interim faunal report provides preliminary observations regarding the material received in 1991 and 1992 (Monks 1992). This initial examination clearly demonstrates the relative importance of marine resources, especially fish, at each of the village sites examined here. Indeed, about half of all the recovered faunal material (in terms of N.I.S.P.) was identified as fish (Monks 1992: 79).

6.5.2 Identification of Rockfish Remains

The first step in this analysis was to sort and identify all of the rockfish vertebrae in the sample. Salmon (*Oncorhynchus* Spp.) vertebrae were also sorted in order to provide an estimate of the relative importance of the salmon and rockfish fisheries. Identifications were made by comparing the external morphology of the archaeological vertebrae with those from several species known to occur in the region. The reference material used to make these determinations included two species of rockfish (Pacific Ocean perch *Sebastes alutus* and yellowtail rockfish *Sebastes flavidus*), cabezon

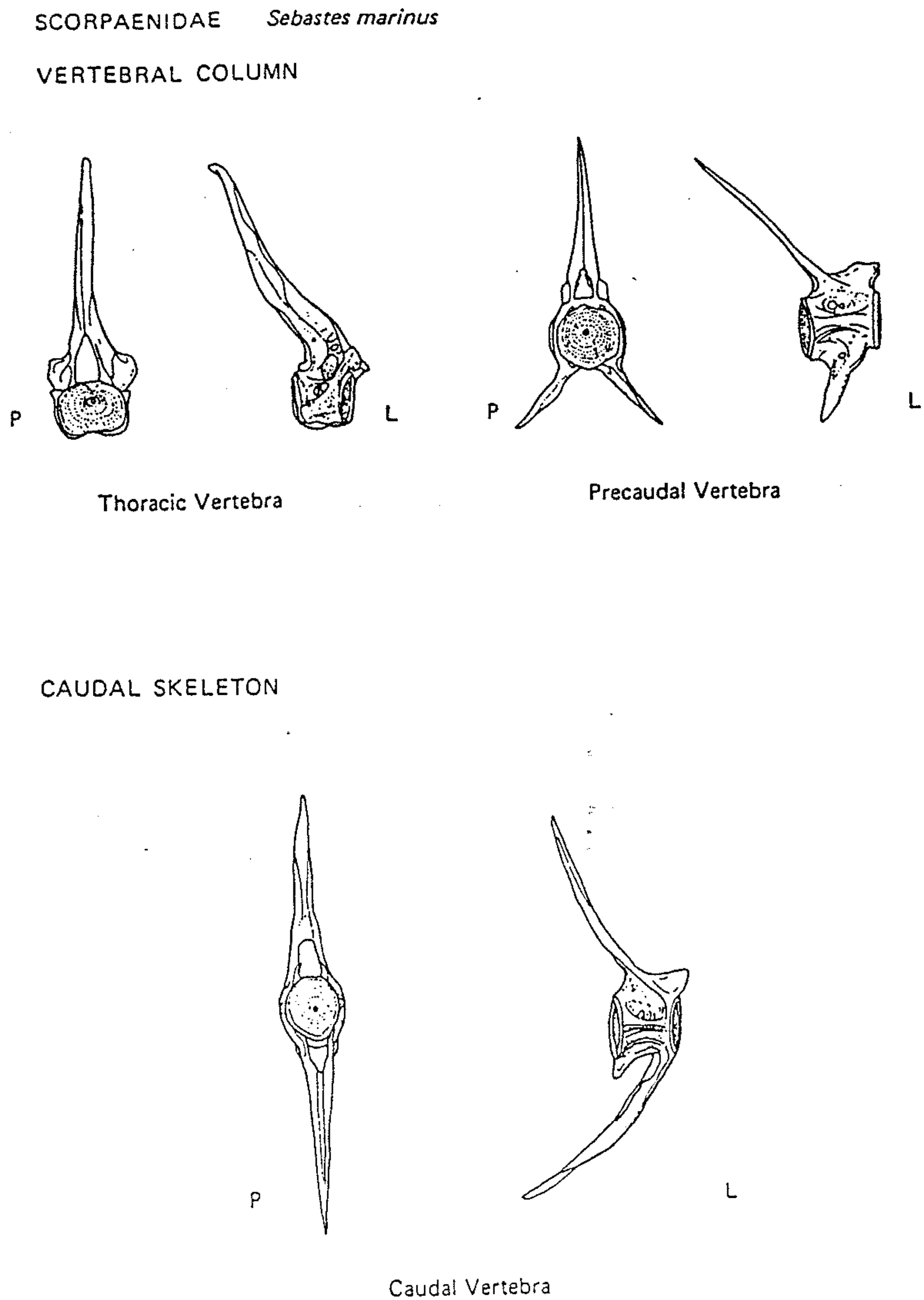
Scorpaenichthys marmoratus, lingcod *Ophiodon elongates*, pacific cod *Gadus macrocephalus*, and starry flounder *Platichthys stellatus*.

Identifications were made on the basis of several key features. For caudal vertebrae this included the presence, location, and form of the lateral process (Figure 6.5.1). It was difficult to positively identify all caudal vertebrae to taxon on this basis. The caudal vertebrae of rockfish share many characteristics with those of cabezon. As a result, some of the archaeological vertebrae could only be identified as *probably* rockfish (recorded as "unsure") and were not used.

Rockfish thoracic vertebrae are much more distinctive in form (Figure 6.5.1) and are easily distinguished from the vertebrae of other species. Because of the possible confusion associated with caudal vertebrae, only thoracic vertebrae were considered for growth increment analysis. Thoracic vertebrae were further identified to element number (e.g. 1^{st} thoracic, 2^{nd} thoracic, etc.). Some of the recovered remains could be identified as rockfish vertebrae but were too damaged or fragmentary for use in further analysis. These remains were recorded as "broken" and were not used.

6.5.3 Archaeological Sample

The archaeological sample for the research presented here consists of all of the rockfish vertebrae recovered from dated contexts at the three village sites excavated as part of Toquaht project (McMillan and St.Claire 1991, 1992, 1994, 1996). In total, nine excavation units with associated radiocarbon dates were sampled. This included five units from Tu'kw'aa, three units from Ch'uumat'a, and one unit from Ma'acoah. Only material from dated contexts was considered in order enable comparison of seasonality data between sites and over different time periods.



(Figure 6.5.1) Rockfish Vertebral Elements – *Sebastes marinus* (from Cannon 1987: 91)

In total, the sampled units contained 1258 remains classified as rockfish vertebrae (see Appendix 2). Of these, 166 vertebrae were classified as broken, and 281 were recorded only tentatively as rockfish. Most of the tentatively identified specimens were atlas, caudal, and pre-caudal vertebrae. Of the remaining 977 specimens, 301 were identified as intact thoracic vertebrae. These 301 vertebrae make up the archaeological sample for growth increment analysis presented here.

6.6 Archaeological readings

6.6.1 Preparation

Archaeological specimens required some preparation before analysis, in order to enhance the visibility of growth increments. The viewed (posterior) surface of each vertebra was cleaned of soil and debris by gently brushing with a soft toothbrush in cool water. In some cases, dried remnants of soft tissue adhered to the vertebra surface. This material was flaked off using the dull edge of a scalpel. Special care was taken not to mark or damage the outer edge of the vertebra surface during preparation.

6.6.2 Analysis of Archaeological Specimens

The size and condition of each vertebra was recorded prior to microscopic analysis. Size was recorded as vertebra diameter (posterior surface) and measured in millimeters. The quality and over-all readability of each specimen was recorded. Each specimen was recorded as poor, fair, good, or excellent (Table 6.6.1 below).

(Table 6.6.1) Condition Description

Condition	Description
Poor	Surface severely eroded, increments obscured, and/or no portion of final increment intact
Fair	Increments only visible or distinct on a limited portion of the vertebra surface
Good	Increments distinct and visible across most of vertebra surface
Excellent	Vertebra in like-modern condition and increments distinct and clearly visible across whole vertebra

Archaeological specimens were examined microscopically following the procedure used for the reference collection (Section 5.3.2). Prepared specimens were mounted in plasticine and oriented so that one side of the posterior surface was in focus. Vertebrae were viewed using a Zeiss Stereomicroscope at 16X magnification under reflected ordinary light from an external light source.

The total number of visible growth increments and width of the final and penultimate growth increments were measured and recorded for each specimen. The number of visible increments was used to provide an estimate of specimen age-at-death. Growth in the final increment was divided by growth in the penultimate increment and expressed as a percentage. This value was compared against the table of expected growth ratios vs. season (Table 6.3.3 and Fig. 6.4) and attributed to the season with the highest associated probability, thus providing a season-of-death estimate.

Chapter 7 – Results of Archaeological Analysis

7.0 Introduction

The principal focus of this research is the determination of season-of-death of rockfish caught as prey, from vertebrae recovered from three archaeological sites within the study area. The relative proportions of salmon and rockfish vertebrae within the sampled levels are also summarized as they indicate the relative importance of rockfish fisheries to the Toquaht. The significance of these results is discussed with reference to the main research questions raised above (sections 1.6 and 2.5). The opposing models of Nuu-chah-nulth seasonal site occupation proposed by Dewhirst (1980: 11-12, 15) and McMillan (1999: 128-129: 196) are evaluated in light of this research.

Several important time-periods have been identified for archaeological sites within the Toquaht region (Sections 2.1 and 2.4; Appendix 4). Results are organized by time-period where possible. The following chronological divisions are used:

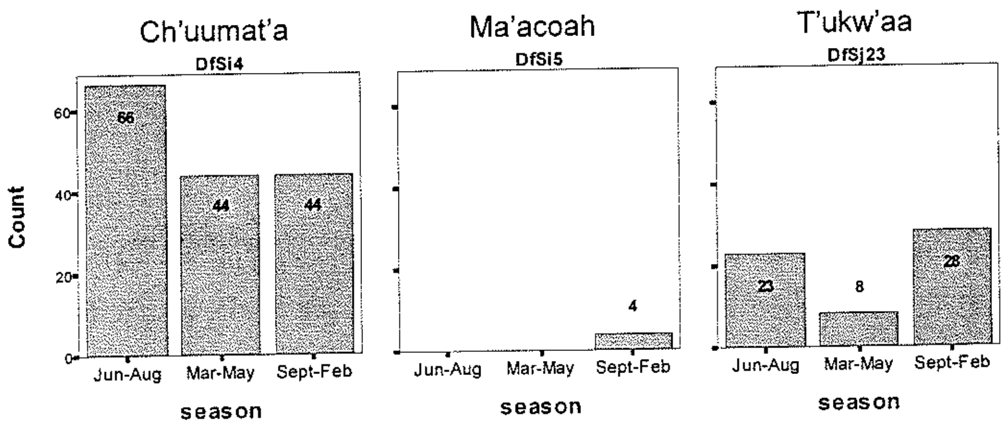
Gulf of Georgia *(2000-4000 BP)*:	Period associated with Gulf of Georgia type artefacts.
Nuu-chah-nulth *(200-2000 BP)*:	Period associated with pre-contact Nuu-chah-nulth (West Coast Culture) type artefacts.
Post-Contact *(0-200 BP)*:	Period associated with artefacts of non-indigenous origin.

Within each excavation unit, natural stratigraphic layers were assigned relative dates based on stratigraphic association with radiocarbon dates or type-artifacts. Rockfish and salmon samples were dated by stratigraphic layer. Some sample specimens could not be precisely dated according to the chronological divisions outlined above. Where it was not possible to assign a specimen to a single time-period, all probable time-periods are listed (e.g Nuu-chah-nulth/Post-contact).

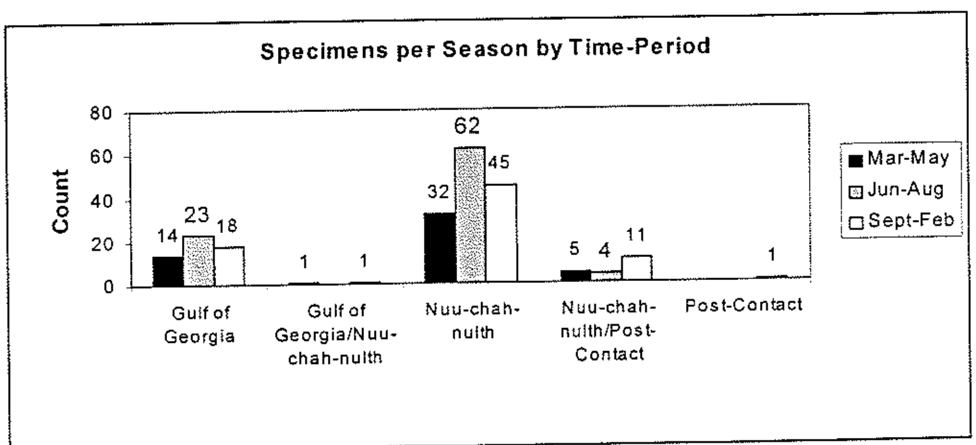
7.1 Season of Death Estimates

Results of the season-of-death determination for each vertebrae examined in this research are listed in Appendix 3. These results are summarized and discussed below. Season-of-death determinations are used to reconstruct the seasonal timing of rockfish exploitation at each site within the study area. Evidence of rockfish exploitation is taken to indicate concurrent site occupation and, thereby, probable season(s) of site occupation are proposed (below).

Figure 7.1.0 shows the total number of rockfish vertebrae attributed to each season for each site. The total number of rockfish specimens attributed to each season for each time-period is given by Figure 7.1.1.



(Figure 7.1.0) Rockfish Vertebrae by Season and Site

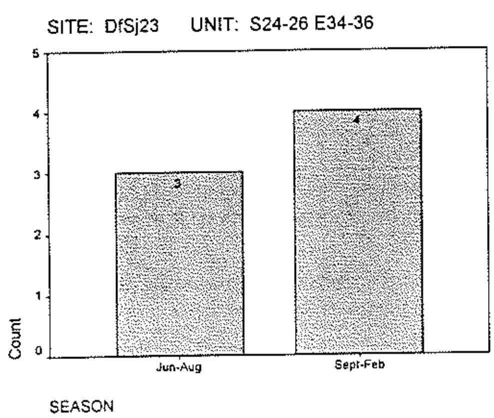


(Figure 7.1.1) Rockfish Vertebrae by Season and Time Period

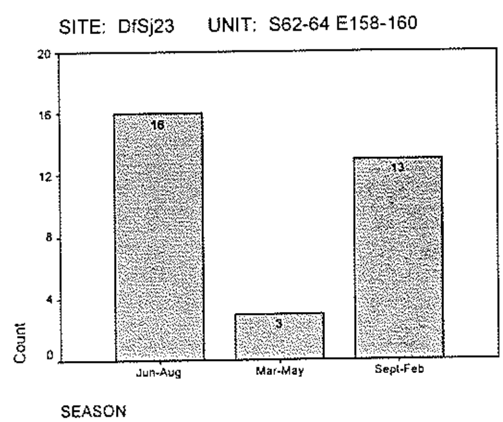
7.1.1 Tu'kw'aa (DfSj-23)

A total of 59 rockfish thoracic vertebra specimens were recovered from this site. Figures 7.1.2 to 7.1.5 show the number of specimens associated with each season by excavation unit. Figure 7.1.6 shows the total number of specimens, from all units, which are associated with each time-period. Out of the total of 59 specimens, 38 were dated to the "Nuu-chah-nulth" (2000-200 BP) period and one specimen was dated to the "Post-Contact" (200 BP to present) period. Twenty specimens could not be specifically assigned to either period. Eighteen of these came from the upper levels (layer A) of units in the defensive portion of the site - above layers radiocarbon dated to between c.500 and c.900 BP. The remaining two specimens were recovered from the upper levels of an un-dated pit-feature of unit S62-64 E158-160 in the village portion of the site. Adjacent levels, outside the pit-feature, are radiocarbon dated to 690±70 BP cal. All 20 of these remains, therefore, were likely deposited some time either late within the Nuu-chah-nulth period or within the Post-Contact period.

-DfSj 23a (Village Area)

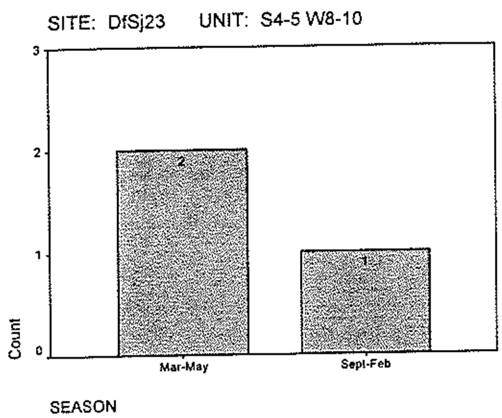


(Figure 7.1.2) DfSj-23 UnitS24-26 E34-36

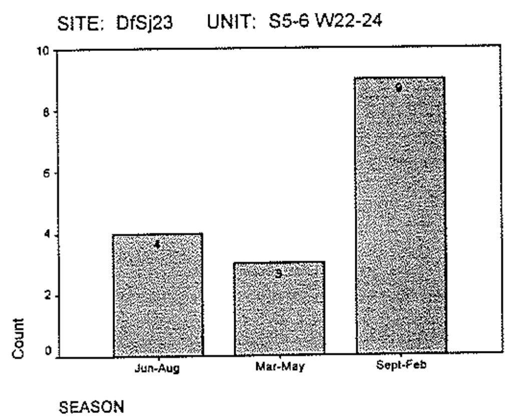


(Figure 7.1.3) DfSj-23 UnitS62-64 E158-160

- *DfSj 23b (Defensive Area)*

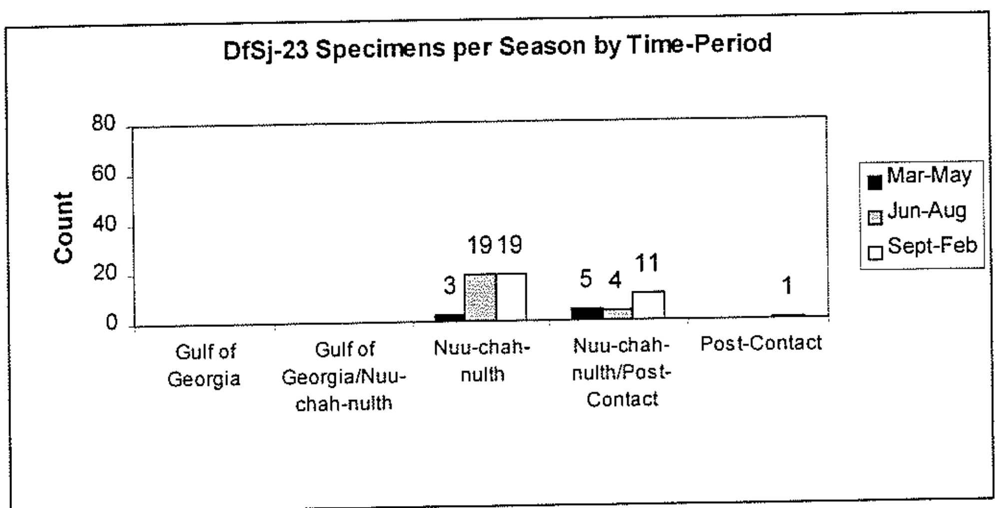


(Figure 7.1.4) DfSj-23 Unit S4-5 W8-10



(Figure 7.1.5) DfSj-23 Unit S4-5 W22-24

The unit S14-15 W28-30 was also sampled from this portion (Defensive Area) of T'ukw'aa. It contained one vertebra attributed to the season "March-May".



(Figure 7.1.6) DfSj-23 Specimens per Season by Time Period

The examined vertebrae associated with the Nuu-chah-nulth period from this site indicate that rockfish were caught/consumed here during the June-August and September-February seasons (Figure 7.1.6). Three of the 41 specimens from this period indicate a March-May season of death. Given the relatively small number of specimens associated with this season and the likelihood of overlap between this and the following season resulting from inter-individual variability in growth (Table 6.3.3), these specimens may only be regarded as possible evidence of rockfish capture during March-May.

These data indicate that T'ukw'aa was occupied during the summer (June-August) and fall/winter (September-February) seasons, and possibly year-round, in the Nuu-chah-nulth period. The hypothesis proposed by Dewhirst (1980: 11-12, 15) predicts occupation restricted to the spring and summer seasons for this site and is, therefore, not well supported. The opposing hypothesis (McMillan 1999: 128-129, 196) predicts year round site-occupation and is, therefore, less unsupported. The lower vertebrae frequencies associated with winter and early-spring (Mach-May) may result from poor weather conditions during this time of year that made ocean-going dangerous and fishing difficult.

The one specimen from T'ukw'aa associated with the Post-Contact period has an estimated season of death of September-February. This suggests that the site was occupied during the fall/winter season (though not necessarily exclusively) in the Post-Contact period. Again, Dewhirst's (1980: 11-12, 15) settlement model predicts occupation restricted to the summer and, possibly, spring seasons. This specimen, therefore, fails to confirm Dewhirst's model.

The 20 thoracic vertebrae from the upper levels of T'ukw'aa that could not be assigned to a specific period (but which all came from upper layers – post-dating 1000 BP) include specimens representing all three seasons. If these specimens are assumed to have been deposited during the Nuu-chah-nulth period, March-May site occupation (and therefore year-round site occupation) is less problematic. Alternately, if these specimens are assumed to have been deposited during the Post-Contact period, they suggest year-round site occupation and, therefore, conflict with both Dewhirst's (1980) hypothesis and ethnohistoric data (section 2.6.2a) for the site.

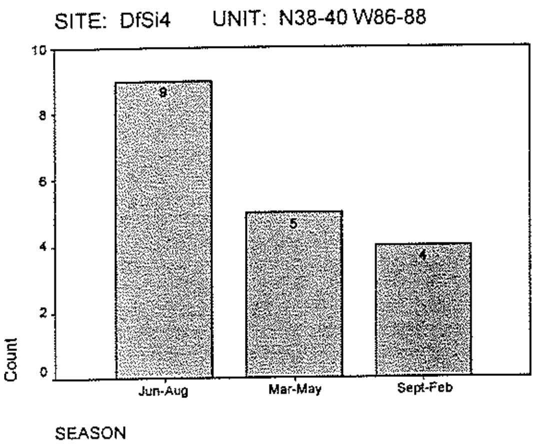
7.1.2 Ma'acoah (DfSi-5)

One unit (S46-48 W110-111) was sampled from Ma'acoah. It contained four vertebrae that were examined in order to determine season-of-death. All of these specimens date to the "Nuu-chah-nulth" (2000-200 BP) period and indicate a season of death of September-February. This suggests that, within the Nuu-chah-nulth period, occupation at Ma'acoah included the fall/winter season. Dewhirst's (1980: 11-12, 15) hypothesis predicts that occupation at Ma'acoah (an "inside" site) should be restricted to fall and/or winter. The rockfish season-of-death data for this site, therefore, does not invalidate this hypothesis. The opposing hypothesis (McMillan 1999: 128-129, 196) predicts year-round site occupation. There is no evidence for site occupation in seasons other than fall/winter in the available rockfish data. Of course, absence of evidence is not evidence of absence, particularly given the small sample size associated with this site, and McMillan's hypothesis is not invalidated by these results.

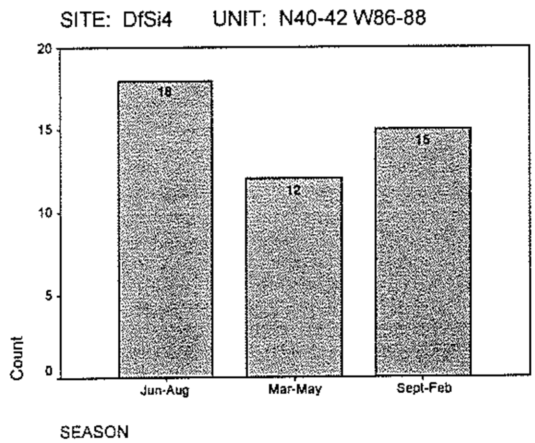
7.1.3 Ch'uumat'a (DfSi-4)

A total of 154 rockfish thoracic vertebrae were recovered from this site and examined in order to determine season-of-death. Figures 7.1.7 to 7.1.9 show the number of specimens associated with each season by excavation unit. Figure 7.1.10 shows the total number of specimens, from all units, which are associated with each time-period. Out of the total of 154 vertebrae, 55 specimens were dated to the "Gulf of Georgia" (4000-2000 BP) period, and 97 were dated to the "Nuu-chah-nulth" (2000-200 BP) period. Two specimens could not be specifically dated according to this scheme.

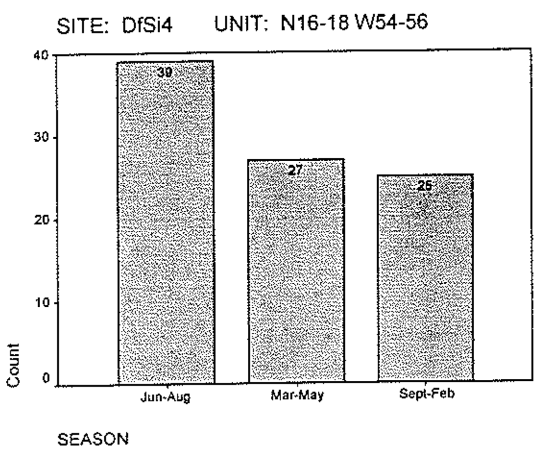
Their position in unit N40-42 W86-88's stratigraphy indicates that they were likely deposited some time around 2000 BP.



(Figure 7.1.7) DfSi-4 Unit N38-40 W86-88



(Figure 7.1.8) DfSi-4 Unit N40-42 W86-88



(Figure 7.1.9) DfSi-4 Unit N16-18 W54-56

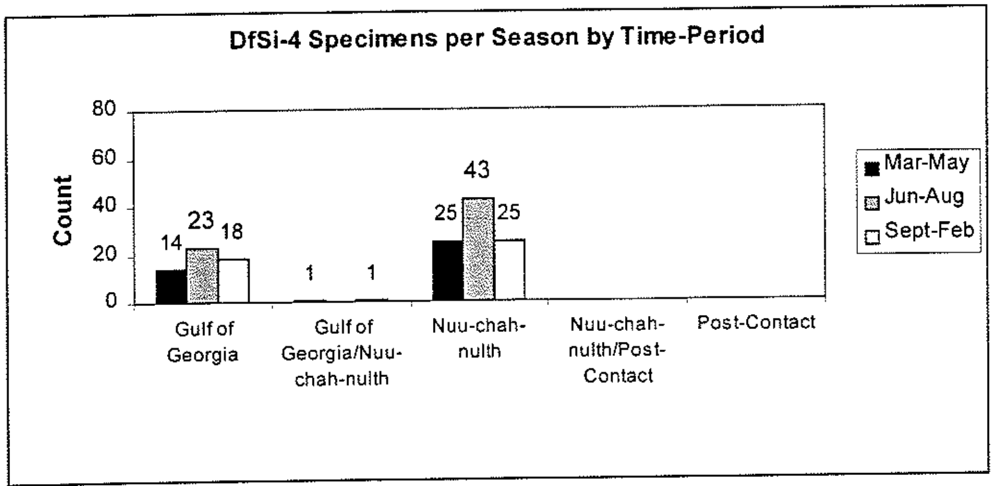


Figure 7.1.10) **DfSi-4** Specimens per Season by Time Period

Rockfish exploitation in all three seasons is indicated by the season-of-death estimates for vertebrae from the Gulf of Georgia period. This suggests that occupation of the site during this period included parts of all three seasons. Dewhirst's (1980: 11-12, 15) hypothesis predicts occupation restricted to summer and, perhaps, spring. These data, therefore, invalidate his hypotheses. Alternately, McMillan's (1999: 128-129, 196) hypothesis (year-round site occupation) cannot be rejected.

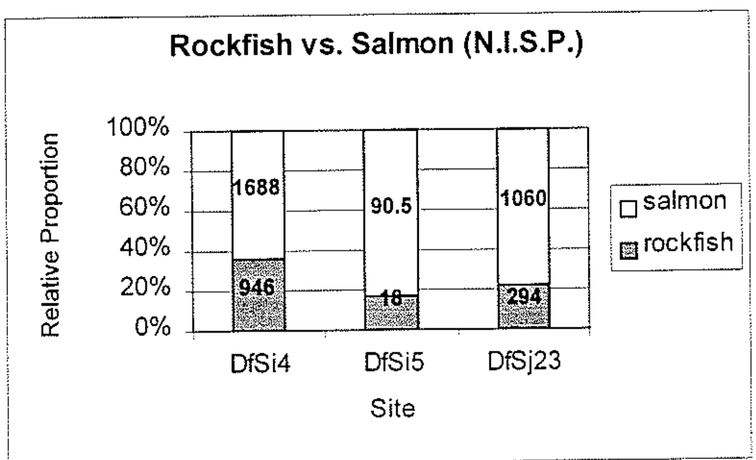
A similar pattern of seasonal rockfish exploitation at Ch'uumat'a is suggested by the data for the Nuu-chah-nulth period. Again, all three seasons are represented in the rockfish vertebrae season-of-death data. This suggests that the site continued to be occupied during at-least parts of all three seasons during the Nuu-chah-nulth period. Accordingly, Dewhirst's hypothesis (seasonally restricted site occupation) is rejected. The opposing hypothesis, again, appears to be supported.

The two vertebrae for which specific dating was not possible are estimated to have died (been caught) in the March-May and September-February seasons. Again, the presence of specimens that suggest site occupation in seasons other than summer tends to refute Dewhirst's hypothesis.

7.2 Relative Proportion of Rockfish vs. Salmon Vertebrae

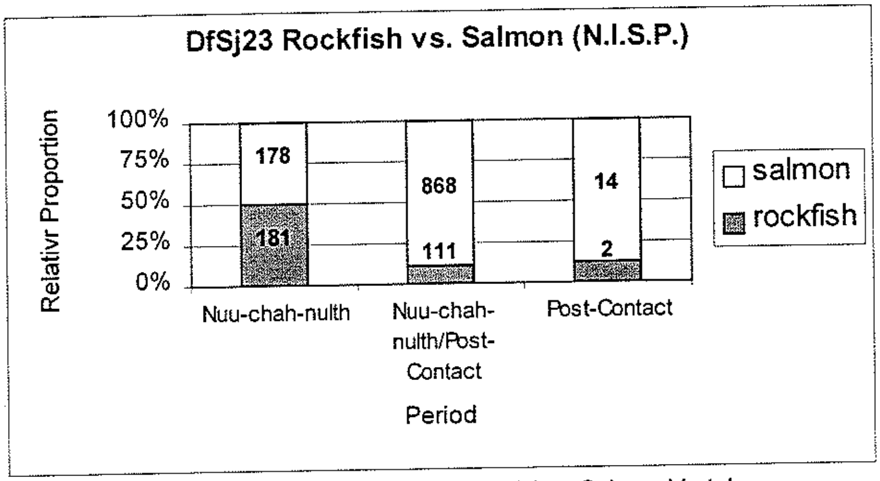
Salmon and rockfish vertebrae were counted with each excavation unit. The number of vertebrae of each species is listed by site, unit, and layer in Appendix 2 and these results are summarized below. The relative proportion of rockfish and salmon vertebrae recovered from each site provides an indication of the relative importance of these species. Salmon are generally regarded as one of the most important food resources for Northwest Coast peoples (e.g. Ames 1999). The abundance of salmon remains, therefore, provides a useful benchmark against which the abundance of rockfish remains may be interpreted.

Figure 7.2.1 shows the number (value listed inside bars) and relative proportion of salmon and rockfish vertebrae for each site. Results are expressed as N.I.S.P. (number of identified specimens) and thus include both complete and fragmentary remains. Rockfish remains recorded as "unsure" (probably rockfish) are included in the rockfish totals.

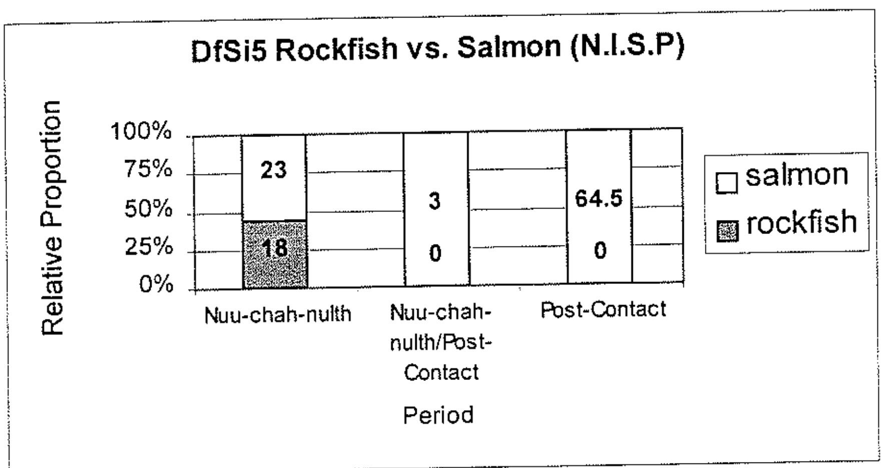


(Figure 7.2.1) Proportion of Rockfish to Salmon Vertebrae per Site

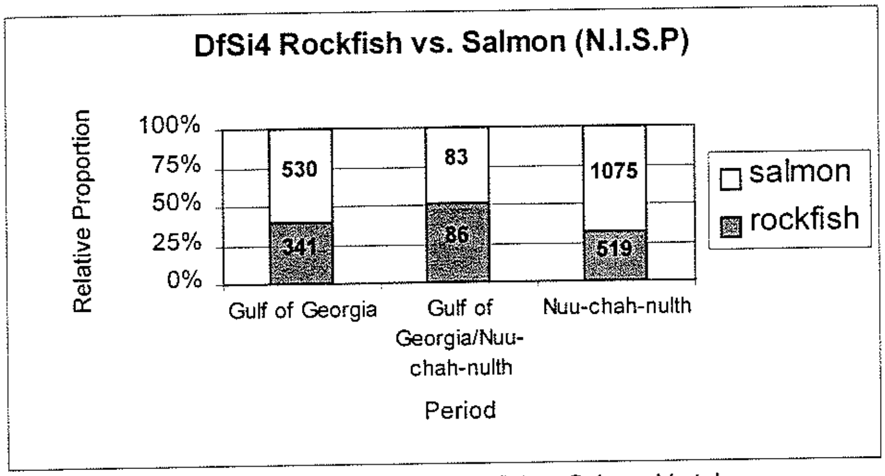
Figures 7.2.2 to 7.2.4 show the number and proportion of salmon and rockfish vertebrae sorted by site and time-period as discussed in section 7.0.



(Figure 7.2.2) DfSj-23 Proportion of Rockfish to Salmon Vertebrae



(Figure 7.2.3) DfSi-5 Proportion of Rockfish to Salmon Vertebrae



(Figures 7.2.4) DfSi-4 Proportion of Rockfish to Salmon Vertebrae

The results of this comparison suggest that rockfish was of equal importance to salmon prior to European contact, at least numerically. Site location and time-period do not appear to have much influence on these relative proportions prior to contact. At all sites, during the Gulf of Georgia and Nuu-chah-nulth time periods, the relative proportion of rockfish to salmon vertebrae is between about 25% and 50%. The proportion of rockfish is noticeably less, however, among remains associated with the Post-Contact period. In fact, no rockfish vertebrae associated with the Post-Contact period were recovered from Ma'acoah (DfSi 5).

These results may reflect a shift from a generalized subsistence strategy, associated with year-round site occupation, in pre-contact times (as predicted by McMillan 1999: 128-129, 196) to the ethnographic pattern of specialized site use, associated with residential mobility, observed during the Post-Contact period (e.g. Drucker 1951: 33-36). These results may also indicate the inadequacy of general models of Northwest Coast social complexity that focus on intensive salmon exploitation.

7.3 Conclusions

The results of the present research do not support the ("inside"-winter / "outside"-summer) annual round model of Nuu-chah-nulth site settlement proposed by Dewhirst (1980: 11-12, 15). This is particularly evident at the two outer-coast sites ofCh'uumat'a (DfSi 4) and T'ukw'aa (DfSj 23) during the Nuu-chah-nulth (2000-200 BP) period. At both sites, the evidence suggests occupation including fall/winter months. The opposing hypothesis of year-round occupation at these sites is supported by these results. The results from the "inside" site of Ma'acoah during the Nuu-chah-nulth period do conform to Dewhirst's model (i.e. they do not invalidate this hypothesis). Neither, however, do they invalidate the year-round site occupation hypothesis, particularly given the small sample associated with this site.

The results of this research provide little evidence regarding rockfish exploitation and site occupation in the Post-Contact period. As mentioned above (Section 6.2), the scarcity of rockfish data for this period may, in part, be explained by a decline in the importance of rockfish fisheries following the introduction of European economic patterns. Only one specimen within the study could be confidently associated with the Post-Contact period. This specimen came from the upper layer of a unit in the defensive portion of T'ukw'aa (DfSj 23), radiocarbon dated to 150±50 BP cal., and is associated with a fall/winter season of death. The model proposed by McMillan (1999: 128-129, 196) predicts the establishment of the ethnohistoric pattern of seasonal mobility at some (likely early) point within this period. The model proposed by Dewhirst (1980: 11-12, 15) predicts continuity of the ethnohistoric pattern throughout this (and all other) periods, i.e. occupation limited to spring/summer for this site. The limited data from this site appears to contradict Dewhirst's hypothesis, while providing no clear support for year-round site occupation. Other remains of possible Post-Contact origin from this site suggest year-round occupancy, but this evidence can only be regarded as conjectural.

Ch'uumat'a is the only site in this study with a known Gulf of Georgia (4000-2000 BP) component. The seasonality and relative rockfish abundance results from this period are interesting in that they appear quite similar to those from the following Nuu-chah-nulth period. Again, the seasonality results invalidate Dewhirst's hypothesis that "outside" sites were occupied only in spring and summer months and suggest possible year-round site occupation. Archaeological evidence from Ch'uumat'a indicates that a change in material culture (and possibly ethnic composition) occurred between the Gulf of Georgia and Nuu-chah-nulth time periods (McMillan 1998). Neither the inferred pattern of seasonal rockfish exploitation (and by association site occupation), nor the relative abundance of rockfish remains, reflect such change.

Chapter 8 – Discussion and Conclusion

8.0 Discussion

The question of when (at what time of year) rockfish were exploited at several sites within the traditional Toquaht territory has been addressed here. It has been argued (sections 4.4 and 7.2) that rockfish were an important food resource for Nuu-chah-nulth people in general and (specifically) for the indigenous inhabitants of Barkley Sound in particular. The examination of rockfish utilization presented here, therefore, provides insight into an important component of Nuu-chah-nulth subsistence. It is observed that rockfish were exploited on a year-round basis, regardless of site setting, in pre-contact times (section 7.1). This observation has implications for the seasonal scheduling of exploitation of other food resources, and overall pre-contact subsistence strategies. It also implies a settlement system organized along the lines proposed by McMillan (1999: 128-129, 196).

The term "salmonopia" has been used to describe the inability of many Northwest Coast researcher's to see beyond the importance of salmon as a food resource and examine the full, and often complex, range of subsistence strategies employed by Northwest Coast peoples (Monks 1989). On the west coast of Vancouver Island, the term "whaleopia" may also be applicable, as the focus on this unique (among sub-arctic North American hunter-gatherers) and fascinating adaptation has tended to obscure the significance of other, less dramatic, subsistence activities and resources. The research presented above reflects an attempt to broaden this focus and gain a better understanding of overall Nuu-chah-nulth adaptation.

The examination of whole vertebrae under magnification, utilizing reflected ordinary light, was determined to be the most practical and least destructive method of incremental growth mark analysis to assess the season-of-death associated with rockfish remains. The selected technique involves the analysis of growth rings on the centrum surface of thoracic vertebrae. The thoracic vertebrae of rockfish were selected because they are more easily distinguished from other taxa than are pre-caudal or caudal vertebrae and are numerous in the collection sampled. The width of growth in the final increment (year of life) was measured as a proportion of that for the preceding increment (year) in order to provide a comparable measure of annual growth for each archaeological specimen.

In order to estimate season-of-death from these readings, a model of expected annual growth for rockfish thoracic vertebrae was established. A sample of modern Yellowtail Rockfish (*Sebastes flavidus*) collected from the west coast of Vancouver Island at known dates throughout the year 2000 was examined in order to study the relationship between month of death and growth in the final increment. A simple mathematical (sigmoid) model of growth was fitted to the distribution of growth/month-of-death readings in order to describe the observed general trend, and associated variability.

Several further steps were required in order to apply this basic growth model to the interpretation of archaeological rockfish vertebrae. The observed degree of inter-individual variability in growth associated with each month prohibited the use of this model to produce precise specimen month-of-death point-estimates. The approach used in this research opted to sacrifice precision in monthly estimates for the sake of improved robustness. Instead of precise month-of-death estimates, only broad "season"-of-death estimates were attempted. The derived "seasons" maximize associated season-of-death estimate probabilities and coincide with ethnographic Nuu-chah-nulth economic seasons. Combining months into seasons, therefore, improves the expected accuracy associated with point-estimates and still enables the principal research questions to be addressed.

The significance of this research extends beyond the question of how rockfish exploitation was seasonally scheduled among the Toquaht. Specifically, because rockfish are (potentially) available year-round and were likely only caught for immediate consumption, rockfish season-of-death data has implications regarding the season of site occupation. The principal question addressed by this research is – is the ethnohistoric Nuu-chah-nulth pattern of seasonal mobility typical for the Toquaht in pre-contact times? Two models that assume different patterns of site settlement are tested in order to address this question. These models are articulated as opposing hypotheses with distinct archaeological implications. One hypothesis (Dewhirst 1980: 11-12, 15) predicts that inside sites are associated with winter occupation, while outside (coastal) sites are associated with summer occupation. The opposing hypothesis (McMillan 1999: 128-129, 196) predicts more-or-less year-round occupation for all village sites regardless of setting.

The rockfish season-of-death data presented in this research indicates that the ("inside"-winter / "outside"-summer) annual round model of Nuu-chah-nulth site settlement proposed by Dewhirst (1980: 11-12, 15) is inappropriate for Barkley Sound. The opposing hypothesis, of year-round site occupation proposed by McMillan (1999: 128-129, 196), provides a better model with which to interpret the Toquaht data.

These two models represent fundamentally different views of the pre-history of the west coast of Vancouver Island. The model proposed by Dewhirst (1980: 11-12, 18) reflects the relatively static view of Nuu-chah-nulth culture suggested by Mitchell's (1990) "West Coast" culture type. This perspective stresses continuity in culture and technology throughout the last 4000 years. The Nuu-chah-nulth pattern of seasonal mobility observed ethnographically (e.g. Drucker 1951: 33-36) is therefore assumed to be characteristic for this entire period. The validity of this assumption has been challenged, for the Northwest Coast in general by Ford (1989), and on the west coast of

Vancouver Island by McMillan (1998, 1999). Both researchers point to the massive disruption of traditional life-ways that resulted from contact with Europeans. Ford (1989) and McMillan (1999), therefore, view ethnohistoric accounts (specifically those describing "traditional" patterns of seasonal mobility) skeptically and are cautious in using these accounts to provide models of behavior in the pre-contact period. Further, McMillan's examination of artifact data from the Ch'uumat'a site in Barkley Sound directly challenges the notion of cultural continuity on the west coast of Vancouver Island in the pre-contact period.

The rockfish and salmon data appear to reflect continuity throughout the pre-contact period, and in this sense, support Mitchell's (1990) position. This continuity (from at least 3500 BP) in subsistence activities is also suggested by whale data for the Toquaht sites (Monks *et al.* 2001). However, the continuity proposed by Mitchell breaks down for the post-contact (ethnographic present) period, at least as far as the rockfish seasonality and relative abundance data are concerned.

The results of this research also have implications regarding the relationship between subsistence and cultural adaptation and development within the Northwest Coast environment. The decline in rockfish (relative to the salmon) fishery following European contact, as well as evidence for new commercial opportunities for native fishers (such as the sale of dogfish oil [Sproat 1886: 30]), suggests that native fisheries were undergoing substantial changes during the post-Contact period. Supporting McMillan's (1999) and Ford's (1989) critique of the application of ethnohistoric data to the past. The research presented here challenges the idea that a subsistence strategy involving seasonal mobility was a necessary adaptation to the Northwest Coast environment (e.g. Suttles 1987a, 1987b). Year-round site occupancy (and therefore a subsistence strategy involving limited mobility) was characteristic of Barkley Sound's inhabitants during the pre-contact period at least in coastal sites. If Suttles (1987a) and

Dewhirst (1980: 15) are correct in asserting that a subsistence strategy that includes seasonal mobility is a preferable adaptation to patchy Northwest Coast food resources, it may indicate that constraints on their socio-culturally defined environment (e.g. limited territorial or resource rights) required Barkley Sound's occupants to adopt alternate strategies.

8.1 Problems Encountered in this Research

Several difficulties were encountered in the course of this research. These include: 1) problems associated with development of the rockfish growth model; 2) problems associated with the archaeological sample; and 3) limitations of the hypotheses being tested.

The common model of rockfish growth proposed and applied here is far from perfect. This can be largely attributed to size limitations of the reference collection. The growth model presented here is derived from observations of a population sample (reference collection) and is intended to describe the population whole (i.e. all rockfish). For this assumption to be truly valid, the population sample must be unbiased and representative. In fact, the sample population is clearly biased in that it includes only specimens of one species of rockfish (and is intended to describe at least 16 species), only specimens of a limited size/age range (between about 35 and 40 cm in length), and only specimens from one year (2000). The amount of variability associated with different species, size/age-classes, and years is therefore unknown. Further, given the limited sample size (16 individuals of which only 15 could be used), it is questionable whether this sample is representative. A statistical rule of thumb holds that when estimating population parameters, a minimum sample of about 30 cases is required (assuming normal variability within the sampled population). A second problem associated with the reference collection and derived growth model also arises from the limited sample size. Particularly, the lack of full annual coverage in the reference collection required growth in months with no associated specimens to be inferred. Further, the timing of important annual events, such as growth cessation and resumption, were not directly reflected in the reference collection.

The common model would be strengthened if the reference data upon which it is based included statistically significant numbers of specimens of all possible species, sizes, and years. Practical limitations of time and cost precluded collection of enough data at this time. This model can, nevertheless, be considered broadly applicable and provides a general model for estimating the season-of-death of rockfish from incremental growth marks on thoracic vertebrae. The essentially empirical base of this research represents a vast improvement over previous archaeological attempts at season-of-death determination from fish vertebrae which rely solely upon assumptions and generalizations regarding the annual growth of fish vertebrae (e.g. Casteel 1974).

The major limitations associated with the archaeological data centre upon problems of sampling. These problems first arise at the level of excavation. Excavation units at all the sites considered in this research were selected subjectively (i.e. not randomly). The recovered archaeological materials, therefore, do not represent an unbiased sample of cultural deposition at these sites. This potential bias poses an impediment to the quantitative analysis of the resulting archaeological data. Another problem associated with the archaeological sample results from the limited number of securely dated contexts, either by radiocarbon or by diagnostic artifacts. In order to produce meaningful results that could be compared between sites, only material from dated contexts was considered. This greatly reduced the number of vertebrae included in this study. Even though all thoracic rockfish vertebrae from dated contexts were included, the resulting overall sample was relatively small (particularly forMa'acoah and for the Post-Contact period at T'ukw'aa).

The third problem area encountered in this research arises from limitations in the hypotheses being tested. In order to pose hypotheses that were testable, the basic positions of Dewhirst (1980: 11-12, 15) and McMillan (1999: 128-129, 196) were simplified. The general models of site settlement proposed by these researchers are intended to be descriptive rather than predictive. For example, it is doubtful whether Dewhirst truly expects all Nuu-chah-nulth groups, through all of antiquity, to have practiced a strict "inside"-winter/"outside"-summer settlement strategy. Further, neither model accounts for social divisions within Nuu-chah-nulth groups that may have had different patterns of seasonal site occupation. Ethnohistorically, the basic social unit among Nuu-chah-nulth peoples was the family or local group, and not the village (Drucker 1951: 33). The models tested here, however, predict that either groups move seasonally en-masse between different village sites, or whole groups reside year-round in one village location. The pattern of mobility recorded in ethnohistoric accounts was, in fact, characterized by the seasonal dispersal and amalgamation of local groups (Drucker 1951: 33-36). Thus, some local groups associated with a village may have moved to different site locations in the course of a year, while others may have remained in the same village year round. Indeed, such a pattern has been described for Ma'acoah (informant Jim McKay quoted in Amira *et al.* 1991: 163). In order to observe this sort of behavior archaeologically it would be necessary to examine the seasonal *intensity* of site occupation. This was not possible here given the limitations of the sample discussed above.

8.2 Directions for Future Research

This research has advanced our knowledge of two general fields of study: the methodology of seasonality studies involving fish remains and Nuu-chah-nulth culture history. It provides a basis for new research in Barkley Sound.

The seasonality technique used here to examine seasonal rockfish exploitation, and thereby site occupation, is ideally intended to provide independent support for other lines of evidence. This could be achieved by a similar study involving another fish species or through the analysis of incremental growth data from mollusk shells (e.g. Classen 1993). Such evidence may also be derived from a "general" seasonality technique involving the broad examination of faunal remains (Section 3.1). The complete examination and quantification of all faunal remains from all Toquaht sites would, therefore, be beneficial. This would also provide a better context in which to interpret the quantity and relevance of rockfish remains at each site.

The validity of the growth model used in this research is weakened by the small size of the reference sample. Future research should be directed towards refining this model. This could be most easily achieved by enlarging the sample of modern rockfish growth/month-of-death data to include full annual coverage. The degree of inter-species, inter-annual, and inter-age-class variability also needs to be evaluated.

Further research should also be directed towards the general question of Toquaht site seasonality. Particularly, changes that may have occurred in settlement patterns between the pre- and post-contact periods need to be examined. The research presented here provides little information regarding settlement in the post-contact period, though it suggests that significant changes in the native fishery had occurred. The impact of European contact on traditional settlement patterns could not be fully evaluated, however, due to small sample sizes (particularly at Ma'acoah). More refined dating of Toquaht archaeological materials is required in order to pursue such research.

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Appendix - 1

Toquaht Radiocarbon Dates

Site	N/S Unit	E/W Unit	Level	C14 age	Calibrated Age
Ch'uumat'a					
DfSi 4	N38-46	W86-88	35	4000±140	BC 2855-2310
DfSi 4	N38-46	W86-88	37	3900±60	BC 2470-2230
DfSi 4	N38-46	W86-88	41	3810±90	BC 2400-2040
DfSi 4	N38-46	W86-88	40	3760±80	BC 2290-2030
DfSi 4	N38-46	W86-88	33	3480±80	BC 1880-1640
DfSi 4	N38-46	W86-88	21	3010±70	BC 1380-1130
DfSi 4	N38-46	W86-88	11	2560±70	BC 795-515
DfSi 4	N38-46	W86-88	11	2510±110	BC 800-410
DfSi 4	N38-46	W86-88	3	720±50	AD 1270-1300
DfSi 4	N67-69	W60-62	40	2290±80	BC 400-210
DfSi 4	N67-69	W60-62	23	2010±60	BC 50-AD 60
DfSi 4	N48-50	W62-64	38	2450±60	BC 765-405
DfSi 4	N48-50	W62-64	22	2280±60	BC 395-215
DfSi 4	N48-50	W62-64	3	970±60	AD 1000-1160
DfSi 4	N16-18	W54-56	19	1990±70	BC 45-AD 90
DfSi 4	N55-57	W50-52	30	1140±50	AD 875-980
T'ukw'aa					
DfSj 23A	S62-64	E158-160	26	1150±90	AD 760-990
DfSj 23A	S24-26	E34-36	21	870±50	AD 1040-1220
DfSj 23A	S24-26	E34-36	13	690±70	AD 1260-1310
DfSj 23B	S5-6	W22-24	10	780±90	AD 1175-1280
DfSj 23B	S4-5	W8-10	6	560±50	AD 1310-1355
DfSj 23B	N14-15	W28-30	4	150±50	AD 1660-1800
Macaoh					
DfSi 5	S46-48	W110-111	17	580±60	not available

Rockfish and Salmon Vertebrae by Site/Unit/Layer

Ch'uumat'a

N:16-18 W:54-56

Layer	Rockfish comp.	Rockfish broken	Rockfish unsure	Salmon comp.	Salmon broken
A	30	3	17	150	74
B	115	11	48	504	286
C	37	10	17	12	10
D	90	16	34	14	10
E	10	2	0	0	0
F	7	2	2	1	0
G	27	11	15	8	0
H	1	0	0	0	0

N:38-46 W:86-88
(N:38-40)

Layer	Rockfish comp.	Rockfish broken	Rockfish unsure	Salmon comp.	Salmon broken
A					
B					
C	10	2	2	1	5
D	29	20	13	7	14
E	6	4	2	7	5
F	41	9	13	76	36
G	4	0	0		
H					
I					
J					
K	2	0	0		
5	1	0	0		
n/a (and ?)	7	3	6	1	3

Rockfish and Salmon Vertebrae by Site/Unit/Layer

N:38-46 W:86-88
(N:40-42)

Layer	Rockfish comp.	Rockfish broken	Rockfish unsure	Salmon comp.	Salmon broken
A					
B	11	5	1	12	11
B/C	6	3	3	42	45
C					
C/D	13	1	13	3	2
D	15	5	3		
D/E	5	3	2		
E	14	1	7		
F	5	0	3		
G					
H	3	3	1	17	8
I					
J	6	0	2	15	19
K	9	4	2	77	18
L					
L/M	4	1	0	1	0
M					
M/N	17	2	3	25	10
N	16	2	0	6	70
N/P	0	2	1	4	0
O	0	1	0		
P					
n/a (and ?)	29	19	15	54	25
pitfill feature 2	2	0	0		
blackey shell	1	0	1		
clayey shell	2	0	0		

N:48-50 W:62-64

Layer	Rockfish comp.	Rockfish broken	Rockfish unsure	Salmon comp.	Salmon broken
A	0	0	0	2	0
B	47	6	49	60	39
C	33	4	27	1	0
D	12	0	0	1	0
E	31	3	14	1	0
F	10	0	3	1	0
G	0	0	0	0	0
H	32	3	2	2	0
I	17	6	15	11	1
J	51	4	29	8	2

Appendix - 2

Rockfish and Salmon Vertebrae by Site/Unit/Layer

N:55-57 W:50-52

	Rockfish			Salmon	
Layer	comp.	broken	unsure	comp.	broken
A	0	0	0	0	0
B	12	2	12	29	9
C	25	7	13	63	42
D	64	20	54	17	3
E	29	2	20	2	5
F	84	10	75	50	13
G	20	4	20	6	0
H	15	2	7	0	6
I	0	0	0	1	0
n/a	6	0	3	0	0

N:67-69 W:60-62

	Rockfish			Salmon	
Layer	comp.	broken	unsure	comp.	broken
A	28	5	53	76	30
B	88	29	66	31	3
C	12	1	19	10	1
D	69	18	75	91	5
E	15	0	16	9	0
E/F	3	1	5	1	0
F	7	1	0	14	2
F/G	13	2	11	15	1
G	5	0	0	17	2
H	2	0	4	0	0
L	11	0	33	3	0
Matrix 6	8	2	20	0	2

T'ukw'aa

- Village

S:24-26 E:34-36

	Rockfish			Salmon	
Layer	comp.	broken	unsure	comp.	broken
A	0	0	0	0	0
B	18	2	0	29	30

S:62-64 E:158-160

	Rockfish			Salmon	
Layer	comp.	broken	unsure	comp.	broken
A	2	1	0	68	66
B	0	0	0	0	0
C	0	0	0	0	0
D	0	0	0	30	10
E	0	0	0	52	15
F	0	0	0	0	0
G	0	0	0	0	0
H	7	0	0	9	5
I	102	8	25	19	27
J	11	1	3	0	0
feature #28	0	0	0	17	12

- Defense

S:4-5 W:8-10

	Rockfish			Salmon	
Layer	comp.	broken	unsure	comp.	broken
A	9	2	3	38	24
B	2	0	0	30	24
?	1	1	5	31	26

S:5-6 W:22-24

	Rockfish			Salmon	
Layer	comp.	broken	unsure	comp.	broken
A	58	3	15	259	183
B	2	0	0	4	1

N:14-15 W:28-30

	Rockfish			Salmon	
Layer	comp.	broken	unsure	comp.	broken
A	2	0	0	8	6
?	4	3	4	19	18

Macaoh

S:46-48 W:110-111

	Rockfish			Salmon	
Layer	comp.	broken	unsure	comp.	broken
1	0	0	0	0	0
2	0	0	0	11.5	0
3	0	0	0	10	0
4	0	0	0	8	0
5	0	0	0	24	0
D	0	0	0	11	0
E	0	0	0	0	0
F	0	0	0	3	0
G	18	0	0	23	0

Appendix - 3

Rockfish Season of Death Estimates

site	unit	Period	level	layer	vert	age	quality	diameter	final growth	penult. growth	% growth	season
DfSi4	N16-18 W54-56	Nuu-chah-nulth	2	A	th2/3	8	excellent	10	20	25	80.0	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	4	A		7	fair	6	11	19	57.9	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	2	A	th1	7	fair	7	15	24	62.5	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	2	A	th3	6	fair	8	19	28	67.9	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	2	A	th2	9	fair	11	8	10	80.0	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	5	A	th4	8	fair	7	10	10	100.0	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	5	A	th3	6	good	6	3	10	30.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	2	A	th1	8	good	10	18	25	72.0	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	8	B	th2	11	excellent	7.5	5	13	38.5	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	5	B	th2	7+	fair	8	2	10	20.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	5	B	th3/4	7	fair	7	3	8	37.5	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	4	B	th2	6	good	6	3	9	33.3	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	4	B	th1	7	good	5	4	10	40.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	5	B	th2/3	8	good	7	6	10	60.0	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	8	B	th1	7	good	8	6	10	60.0	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	4	B	th1	8	good	7	5	8	62.5	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	4	B	th1	9	good	6	5	8	62.5	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	5	B	th2	7	fair	5.5	3	8	37.5	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	3	B	th1	8	fair	8	10	25	40.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	3	B	th4	6	fair	6	10	25	40.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	5	B	th1/2	9+	fair	11.5	5	12	41.7	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	3	B	th2	10	fair	7	11	26	42.3	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	3	B	th2/3	6	fair	7.5	12	24	50.0	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	5	B	th2	16+	fair	11	4	8	50.0	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	5	B	th2	9+	fair	10.5	5	10	50.0	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	5	B	th2	5+	fair	5	5	10	50.0	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	6	B	th2	7	fair	7	5	10	50.0	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	4	B	th1	8	fair	7	5	9	55.6	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	6	B	th2/3	8	fair	8	5	9	55.6	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	4	B	th2	8+	fair	9	7	11	63.6	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	4	B	th1/2	9+	fair	6.5	5	7	71.4	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	4	B	th2	10+	fair	9.5	8	10	80.0	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	4	B	th3	9	fair	8.5	7	8	87.5	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	4	B	th3/4	9	fair	10	11	11	100.0	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	4	B	th1	10	fair	8	10	10	100.0	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	4	B	th3	7	fair	8	10	10	100.0	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	7	C	th1/2	8+	excellent	7.5	3	9	33.3	Mar-May

Appendix - 3

Rockfish Season of Death Estimates

site	unit	Period	level	layer	vert	age	quality	diameter	final growth	penult. growth	% growth	season
DfSi4	N16-18 W54-56	Nuu-chah-nulth	7	C	th3/4	5+	good	5	3	8	37.5	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	6	C	th2	12	good	9	9	12	75.0	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	8	C	th2/3	11+	fair	11.5	2	9	22.2	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	8	C	th3/4	9	fair	8	4	10	40.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	9	C	th1	8	fair	8	4	10	40.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	6	C	th2	7	fair	7	4	8	50.0	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	8	C	th3	8	fair	8	5	9	55.6	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	6	C	th2	5	fair	6	8	10	80.0	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	9	C	th3	9	fair	6	8	9	88.9	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	11	D	th2	8+	excellent	5	1	5	20.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	15	D	th3/4	6+	excellent	6	7	10	70.0	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	8	D	th1	8	good	6	4	10	40.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	12	D	th2	8	good	8	4	10	40.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	8	D	th1	7	good	6	4	8	50.0	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	14	D	th4	12+	good	11	7	13	53.8	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	8	D	th2/3	7	good	7	4	7	57.1	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	13	D	th2	5	good	4	7	7	100.0	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	10	D	th2/3	9+	fair	8	2	10	20.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	10	D	th1	8	fair	8	2	10	20.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	16	D	th2/3	7	fair	7	3	10	30.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	13	D	th3	12	fair	6	2	6	33.3	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	7	D	th3/4	7+	fair	6	4	10	40.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	10	D	th2	3+	fair	4.5	4	10	40.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	16	D	th3	9+	fair	11	4	10	40.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	11	D	th2	6	fair	5	5	10	50.0	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	11	D	th3/4	11	fair	10	5	9	55.6	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	16	D	th1	8+	fair	7	5	8	62.5	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	16	D	th2	9	fair	7	5	8	62.5	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	7	D	th1	6	fair	7	6	9	66.7	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	14	D	th2	12+	fair	13	8	12	66.7	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	16	D	th1	6+	fair	6	6	9	66.7	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	8	D	th1	7	fair	6	7	10	70.0	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	13	D	th1	7+	fair	8	7	9	77.8	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	15	D	th1	7+	fair	11	9	10	90.0	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	6	D	th3/4	5+	fair	7	10	11	90.9	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	13	D	th2	8+	fair	7	10	10	100.0	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	14	D	th2	4+	fair	5	8	8	100.0	Sept-Feb

Appendix - 3

Rockfish Season of Death Estimates

site	unit	Period	level	layer	vert	age	quality	diameter	final growth	penult. growth	% growth	season
DfSi4	N16-18 W54-56	Nuu-chah-nulth	18	D	th2	7+	fair	8	6	6	100.0	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	12	E	th2	7+	good	8	5	10	50.0	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	12	E	th2	8+	fair	7	4	7	57.1	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	11	E	th2	9+	fair	8.5	7	10	70.0	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	11	E	th2	13+	fair	10	5	7	71.4	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	12	E	th4	9+	fair	10	10	10	100.0	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	12	F	th1	5+	fair	6	5	9	55.6	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	15	F	th1	7	fair	7	5	8	62.5	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	18	G	th1	10+	good	10	2	10	20.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	17	G	th4	9	good	7	7	7	100.0	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	18	G	th2	11	fair	8.5	3	10	30.0	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	18	G	th4	9+	fair	7	3	8	37.5	Mar-May
DfSi4	N16-18 W54-56	Nuu-chah-nulth	17	G	th4	8+	fair	6	3	7	42.9	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	17	G	th2	6	fair	6	5	10	50.0	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	20	G	th1	9+	fair	8	5	9	55.6	Jun-Aug
DfSi4	N16-18 W54-56	Nuu-chah-nulth	17	G	th2	5	fair	4	5	6	83.3	Sept-Feb
DfSi4	N16-18 W54-56	Nuu-chah-nulth	17	G	th2	7+	fair	7	9	9	100.0	Sept-Feb
DfSi4	N38-40 W86-88	Nuu-chah-nulth	4	C	th1	13+	fair	10	4	8	50.0	Jun-Aug
DfSi4	N38-40 W86-88	Nuu-chah-nulth	6	C?	th4/5	5++	fair	15	5	10	50.0	Jun-Aug
DfSi4	N38-40 W86-88	Nuu-chah-nulth	5	C?	th2/3	6+	fair	6	5	8	62.5	Jun-Aug
DfSi4	N38-40 W86-88	Gulf of Georgia	15	D	th3/4	8+	excellent	8	7	10	70.0	Jun-Aug
DfSi4	N38-40 W86-88	Gulf of Georgia	11	D	th3	5+	excellent	4.5	7	7	100.0	Sept-Feb
DfSi4	N38-40 W86-88	Gulf of Georgia	15	D	th2/3	7	good	5	2	6	33.3	Mar-May
DfSi4	N38-40 W86-88	Gulf of Georgia	16	D	th3	6+	good	5	7	9	77.8	Sept-Feb
DfSi4	N38-40 W86-88	Gulf of Georgia	14	D	th1	14+	fair	17	3	10	30.0	Mar-May
DfSi4	N38-40 W86-88	Gulf of Georgia	17	D	th1/2	7+	fair	7	6	9	66.7	Jun-Aug
DfSi4	N38-40 W86-88	Gulf of Georgia	17	D	th2/3	6+	fair	7	7	10	70.0	Jun-Aug
DfSi4	N38-40 W86-88	Gulf of Georgia	21	E	th4/5	7+	good	7	7	9	77.8	Sept-Feb
DfSi4	N38-40 W86-88	Gulf of Georgia	22	F	th4/5	6+	good	5	3	8	37.5	Mar-May
DfSi4	N38-40 W86-88	Gulf of Georgia	24	F	th5	8+	good	8	7	10	70.0	Jun-Aug
DfSi4	N38-40 W86-88	Gulf of Georgia	24	F	th3/4	10+	good	8	5	7	71.4	Sept-Feb
DfSi4	N38-40 W86-88	Gulf of Georgia	30	F	th3	8+	fair	6	2	6	33.3	Mar-May
DfSi4	N38-40 W86-88	Gulf of Georgia	22	F	th2	6+	fair	8	4	9	44.4	Jun-Aug
DfSi4	N38-40 W86-88	Gulf of Georgia	27	F	th1/2	8+	fair	10	7	10	70.0	Jun-Aug
DfSi4	N38-40 W86-88	Gulf of Georgia	38	K	th2/3	9+	fair	8	3	8	37.5	Mar-May
DfSi4	N40-42 W86-88	Nuu-chah-nulth	2	?	th3	6	good	5	3	9	33.3	Mar-May
DfSi4	N40-42 W86-88		8	?	th3	10	good	10	3	8	37.5	Mar-May

Appendix - 3

Rockfish Season of Death Estimates

site	unit	Period	level	layer	vert	age	quality	diameter	final growth	penult. growth	% growth	season
DfSi4	N40-42 W86-88	Nuu-chah-nulth	2	?	th3	5	good	5	4	10	40.0	Mar-May
DfSi4	N40-42 W86-88	Gulf of Georgia	11	?	th1	9	good	10	5	7	71.4	Sept-Feb
DfSi4	N40-42 W86-88	Gulf of Georgia	23	?	th1	10+	fair	8	3	11	27.3	Mar-May
DfSi4	N40-42 W86-88	Gulf of Georgia	14	?	th2/3	9+	fair	7	4	8	50.0	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	13	?	th2/3	9+	fair	8	5	9	55.6	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	25	?	th1/2	8+	fair	7	6	9	66.7	Jun-Aug
DfSi4	N40-42 W86-88	Nuu-chah-nulth	4	?	th1	11+	fair	14	7	10	70.0	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	24	?	th5	5	fair	4	7	9	77.8	Sept-Feb
DfSi4	N40-42 W86-88	Gulf of Georgia	16	?	th2/3	10+	fair	8	8	10	80.0	Sept-Feb
DfSi4	N40-42 W86-88		7	?	th2/3	9+	fair	7	7	8	87.5	Sept-Feb
DfSi4	N40-42 W86-88	Gulf of Georgia	12	?	th1	8+	fair	7	7	7	100.0	Sept-Feb
DfSi4	N40-42 W86-88	Gulf of Georgia	12	?	th2/3	10+	fair	7	7	7	100.0	Sept-Feb
DfSi4	N40-42 W86-88	Gulf of Georgia	11	B	th1	12	good	11	7	10	70.0	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	11	B	th2/3	9	fair	8	5	9	55.6	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	6	B	th3/4	6+	fair	8	5	8	62.5	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	7	B	th4/5	14+	fair	16	7	10	70.0	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	9	B	th4/5	11+	fair	12	7	10	70.0	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	7	B	th4/5	10	fair	12	8	10	80.0	Sept-Feb
DfSi4	N40-42 W86-88	Gulf of Georgia	7	B	th4/5	7+	fair	8	8	9	88.9	Sept-Feb
DfSi4	N40-42 W86-88	Gulf of Georgia	17	B/C	th3/4	9	fair	7	6	9	66.7	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	20	C/D	th4/5	11+	fair	10	5	10	50.0	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	20	C/D	th4/5	6+	fair	5	5	7	71.4	Sept-Feb
DfSi4	N40-42 W86-88	Gulf of Georgia	21	D	th5	5	fair	5	3	8	37.5	Mar-May
DfSi4	N40-42 W86-88	Gulf of Georgia	21	D	th2	5	fair	4	3	8	37.5	Mar-May
DfSi4	N40-42 W86-88	Gulf of Georgia	21	D	th1	5	fair	6	3	8	37.5	Mar-May
DfSi4	N40-42 W86-88	Gulf of Georgia	21	D	th1/2	6++	fair	7	6	10	60.0	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	22	D/E	th3	9	fair	7	7	7	100.0	Sept-Feb
DfSi4	N40-42 W86-88	Gulf of Georgia	15	E	th2/3	8	good	7	7	10	70.0	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	15	E	th1/2	9+	fair	8	2	10	20.0	Mar-May
DfSi4	N40-42 W86-88	Gulf of Georgia	15	E	th2/3	8	fair	7	7	10	70.0	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	29	J	th2/3	7	fair	7	10	10	100.0	Sept-Feb
DfSi4	N40-42 W86-88	Gulf of Georgia	32	K	th3	8	good	7	4	12	33.3	Mar-May
DfSi4	N40-42 W86-88	Gulf of Georgia	32	K	th1	18	fair	18	3	7	42.9	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	32	K	th1/2	20+	fair	17	7	7	100.0	Sept-Feb
DfSi4	N40-42 W86-88	Gulf of Georgia	34	L/M	th1/2	15	fair	13	5	10	50.0	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	33	L/M	th3/4	10+	fair	12	10	10	100.0	Sept-Feb
DfSi4	N40-42 W86-88	Gulf of Georgia	35	M/N	th1	13+	fair	13	3	8	37.5	Mar-May

Appendix - 3

Rockfish Season of Death Estimates

site	unit	Period	level	layer	vert	age	quality	diameter	final growth	penult. growth	% growth	season
DfSi4	N40-42 W86-88	Gulf of Georgia	35	M/N	th2	11	fair	10	5	9	55.6	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	35	M/N	th2	12+	fair	12	6	10	60.0	Jun-Aug
DfSi4	N40-42 W86-88	Gulf of Georgia	35	M/N	th1	9	fair	10	7	9	77.8	Sept-Feb
DfSi4	N40-42 W86-88	Gulf of Georgia	35	M/N	th3	16	fair	14	7	9	77.8	Sept-Feb
DfSi4	N40-42 W86-88	Gulf of Georgia	39	N	th5	7	good	7	2	9	22.2	Mar-May
DfSi4	N40-42 W86-88	Gulf of Georgia	39	N	th1	8	fair	9	4	10	40.0	Mar-May
DfSi5	S46-48 W110-111	Nuu-chah-nulth	7	D	?	14	fair	14	7	7	100.0	Sept-Feb
DfSi5	S46-48 W110-111	Nuu-chah-nulth	17	G	th1	7	fair	8.5	7	9	77.8	Sept-Feb
DfSi5	S46-48 W110-111	Nuu-chah-nulth	17	G	th2	6	fair	7	9	10	90.0	Sept-Feb
DfSi5	S46-48 W110-111	Nuu-chah-nulth	17	G	th3	8	fair	7.5	9	10	90.0	Sept-Feb
DfSj23a	S24-26 E34-36	Nuu-chah-nulth	13	B	?	9	good	10	5	12	41.7	Jun-Aug
DfSj23a	S24-26 E34-36	Nuu-chah-nulth	13	B	th1	7	good	10	8	10	80.0	Sept-Feb
DfSj23a	S24-26 E34-36	Nuu-chah-nulth	15	B	?	6	good	6.5	5	6	83.3	Sept-Feb
DfSj23a	S24-26 E34-36	Nuu-chah-nulth	8	B	?	11	fair	11	5	10	50.0	Jun-Aug
DfSj23a	S24-26 E34-36	Nuu-chah-nulth	13	B	th1	8	fair	8	4	7	57.1	Jun-Aug
DfSj23a	S24-26 E34-36	Nuu-chah-nulth	11	B	?	7	fair	8	8	10	80.0	Sept-Feb
DfSj23a	S24-26 E34-36	Nuu-chah-nulth	11	B	?	9	fair	7	8	8	100.0	Sept-Feb
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	12	H	?	9	good	?	5	9	55.6	Jun-Aug
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	12	H	?	10	good	8	10	10	100.0	Sept-Feb
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	14	I	?	6	excellent	7	5	8	62.5	Jun-Aug
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	14	I	?	5	excellent	8	10	10	100.0	Sept-Feb
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	14	I	?	13	good	11	4	10	40.0	Mar-May
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	14	I	?	9	good	8.5	5	10	50.0	Jun-Aug
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	19	I	th1/2	13	good	10	4	8	50.0	Jun-Aug
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	15	I	th3/4	14	good	13	7	13	53.8	Jun-Aug
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	18	I	th1	10	good	8	5	9	55.6	Jun-Aug
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	19	I	th2	10	good	7	5	9	55.6	Jun-Aug
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	19	I	th1	10	good	7	6	9	66.7	Jun-Aug
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	14	I	th1	9	good	11.5	7	10	70.0	Jun-Aug
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	15	I	th3/4	12	good	10	6	7	85.7	Sept-Feb
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	14	I	?	9	good	9	9	10	90.0	Sept-Feb
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	16	I	th1/2	25	good	20	12	12	100.0	Sept-Feb
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	19	I	th1	11	good	6	11	11	100.0	Sept-Feb
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	14	I	?	9	fair	8.5	5	9	55.6	Jun-Aug
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	15	I	th1	13	fair	10	4	7	57.1	Jun-Aug
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	14	I	?	9	fair	7	6	10	60.0	Jun-Aug
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	20	I	th1/2	10	fair	10	6	10	60.0	Jun-Aug

Appendix - 3

Rockfish Season of Death Estimates

site	unit	Period	level	layer	vert	age	quality	diameter	final growth	penult. growth	% growth	season
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	20	I	th2	20	fair	18	7	11	63.6	Jun-Aug
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	18	I	th1	20	fair	21	8	12	66.7	Jun-Aug
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	20	I	th1	20	fair	20	6	9	66.7	Jun-Aug
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	18	I	th2	10	fair	8	5	7	71.4	Sept-Feb
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	14	I	?	7	fair	8.5	5	6	83.3	Sept-Feb
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	12	I	?	10	fair	12	9	10	90.0	Sept-Feb
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	14	I	?	7	fair	8	9	10	90.0	Sept-Feb
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	23	J	th1	5	fair	5	3	10	30.0	Mar-May
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	23	J	th2	5	fair	4	4	10	40.0	Mar-May
DfSj23a	S62-64 E158-160	Nuu-chah-nulth	23	J	th2	8	fair	8	10	10	100.0	Sept-Feb
DfSj23a	S62-64 E158-160		8	Pit #28?		11	excellent	8	4	5	80.0	Sept-Feb
DfSj23a	S62-64 E158-160		8	Pit #28?		9	good	7	6	6	100.0	Sept-Feb
DfSj23b	N14-15 W28-30	Post-Contact	1	A?	th2	7	good	8	10	10	100.0	Sept-Feb
DfSj23b	S4-5 W8-10		2	A	th2	10	excellent	8.5	1	8	12.5	Mar-May
DfSj23b	S4-5 W8-10		2	A	th1	10	good	10	2	7	28.6	Mar-May
DfSj23b	S4-5 W8-10	Nuu-chah-nulth	4	B	th2	6	excellent	4.5	6	7	85.7	Sept-Feb
DfSj23b	S5-6 W22-24		3	A	th1	7	good	5.5	2	6	33.3	Mar-May
DfSj23b	S5-6 W22-24		3	A	th2/3	7	good	5	2	5	40.0	Mar-May
DfSj23b	S5-6 W22-24		1	A	th3/4	11	good	10	7	9	77.8	Sept-Feb
DfSj23b	S5-6 W22-24		3	A	th2	7	good	5	5	5	100.0	Sept-Feb
DfSj23b	S5-6 W22-24		2	A	th2	10	fair	8	1	5	20.0	Mar-May
DfSj23b	S5-6 W22-24		2	A	th1	7	fair	6	5	10	50.0	Jun-Aug
DfSj23b	S5-6 W22-24		2	A	th2	10	fair	7	3	6	50.0	Jun-Aug
DfSj23b	S5-6 W22-24		1	A	th2	10	fair	8.5	6	10	60.0	Jun-Aug
DfSj23b	S5-6 W22-24		6	A	th3/4	7	fair	5	5	8	62.5	Jun-Aug
DfSj23b	S5-6 W22-24		3	A	th2	10	fair	6	5	7	71.4	Sept-Feb
DfSj23b	S5-6 W22-24		1	A	th3/4	10	fair	8	7	9	77.8	Sept-Feb
DfSj23b	S5-6 W22-24		3	A	th3/4	9	fair	6	8	10	80.0	Sept-Feb
DfSj23b	S5-6 W22-24		3	A	th2	7	fair	6	5	6	83.3	Sept-Feb
DfSj23b	S5-6 W22-24		6	A	th2	6	fair	6	8	9	88.9	Sept-Feb
DfSj23b	S5-6 W22-24		6	A	th3/4	7	fair	5.5	8	8	100.0	Sept-Feb
DfSj23b	S5-6 W22-24		8	A	th1	7	fair	6	8	8	100.0	Sept-Feb

Toquaht Site Chronology

Years BP	Chuumata	Tukwaa	Macoah	
0				
100	(abandoned end 19th C	160±50	1920's	
200				Post-Contact
300				(c. 200 BP)
400				
500		*560±50	580±60	
600		690±70		
700	720±50	*780±90		
800		870±50		
900				
1000				
1100		1150±90		
1200				
1300				
1400				
1500				
1600				
1700				
1800				
1900	1990±70			Nuu-chah-nulth
2000				(c. 2000 BP)
2100				
2200				
2300				
2400				
2500	2560±70 and 2510±110			
2600				
2700				
2800				
2900				
3000	3010±70			
3100				
3200				
3300				
3400	3480±80			
3500				
3600				
3700	3760±80			
3800	3810±90			
3900	3900±60			Gulf of Georgia
4000	4000±140			(c. 4000 BP)