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Land Use and Organizational Complexity among Foragers of Northwestern North America

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This paper proposes that the separation in space and time between resource procurement and consumption offers a useful measure of organizational complexity among foragers. To examine what the determinants of complexity might be, land use systems are considered with respect to resource distributional structure for a series of aboriginal peoples who are well known for their complex organization — the Northwest Coast Indians. In a discussion of the Northwest Coast environment, it is observed that latitudinal gradients in temperature and precipitation combine to produce a northward decline in terrestrial productivity. The marine environment, on the other hand, shows no associated northward decline. Marine resources are probably more abundant along the more dissected coastline of the northern portion of the coast. The cumulative effect of these two major gradients is that more of the energy exploitable by humans is present in the form of marine resources along a gradient of declining terrestrial production. As a result, human foragers were more dependent on marine resources along this gradient and these resources are clumped in their spatial and temporal distribution. Ethnographic evidence is marshalled in support of the argument that home range size, logistic mobility, and group size all tend to increase in direct proportion to resource clumping. The consequence of increasing marine dependence, it is suggested, is the necessity to manage and manipulate more complicated resource-consumer relationships that derive from clumped resource structuring. It is concluded that organizational complexity bears no simple relationship to population density or food abundance. [Northwest Coast Indians, Cultural Complexity, Land Use Systems, Home Range, Subsistence]

INTRODUCTION

Anthropologists seldom fail to mention the aboriginal societies of the Northwest Coast of North America in any discussion of “affluence” or cultural complexity among foragers. These people have been described as “the most affluent of the world’s recent hunter-gatherers” [LEE 1976: 96]. Societies of the Northwest Coast are well-known for having high population densities, large residential groups, semi-sedentism, social stratification, and material wealth [SUTTLES 1968]. Exploitation

of marine resources, in general, is commonly associated with demographic, technological, and social organizational patterns that depart from those usually found among foragers subsisting exclusively from the land. These characteristics are the basis for frequent comparisons of maritime-oriented adaptations to agriculturalists. Murdock [1968: 15], for instance, suggests that the abundance and stability of marine resources permitted a more sedentary form of adaptation and "a considerable degree of cultural complexity otherwise achievable only with intensive agriculture." He further observes that Northwest Coast Indians "fall well beyond the range of cultural variation of any known hunting and gathering people" [1968: 15]. It should be clear that "affluence" in this context is equated with similarity to agricultural forms of adaptation. There is, however, another way of viewing "affluence" that differs fundamentally from this view.

The idea that agriculture was neither a revolutionary discovery nor a necessarily welcome improvement to foraging economics has only recently gained wide acceptance by anthropologists. Indeed, it has been only during the past two decades that much insight has been gained into *why* knowledgeable and rational humans might not willingly choose to practice agriculture even though fully aware of its potentials. This is so despite a long history of resistance to attempts by colonial nations to introduce cultivation among foragers in various parts of the world. Accumulating empirical evidence has eroded the notion that agriculture offers a less arduous subsistence with greater security, nutrition, and appeal. Numerous studies of living hunting and gathering peoples have demonstrated the contrary and have emphasized that their work effort may be considerably lower than that typically associated with cultivation [McCARTHY and McARTHUR 1960; LEE 1968; TANAKA 1976; HITCHCOCK and EBERT n. d.]. It is, therefore, appropriate that the foraging lifeway has been referred to as the "original affluent society" [SAHLINS 1968: 85].

There appear to be some fundamental disagreements about what is meant by "affluence," and as Sasaki points out (this volume), it is not obvious how measures of this concept might be operationalized. This measurement problem might be overcome with a concept that does not depend so heavily on the cultural values of the analyst. Organizational complexity, it might be argued, offers a more useful way of viewing variation in foraging adaptations and one that may lend itself to more effective measurement. For this reason, it seems appropriate to propose a way of measuring complexity and then to examine how it might be applied to some ethnographic cases.

MEASURING ORGANIZATIONAL COMPLEXITY

Organizational complexity of human adaptations could be measured in any number of defensible ways, especially if it is accepted that complexity is a multi-dimensional concept. Anthropologists have employed a variety of measures of various dimensions of complexity, and it is not possible to discuss these here except to illustrate this diversity. Service [1968: 21-22] advocated the number of non-residential, special-purpose groups (sodalities) as a measure of societal complexity. Population

or community size has also been suggested as a useful indicator of societal complexity (see discussion in THOMAS, this volume). For the purposes of this paper, I would like to consider a measure of organizational complexity that focuses on the character of energy flow from locations of energy production to points of energy consumption.

In discussing levels of organization in ecosystems, Margalef proposes that

...a measure of the organization of the ecosystem may be found in the average distance between the place of energy input and the energy sink. The distance can probably be measured either in terms of space or of time... [1968: 15].

Although this measure bears many implications as an index of ecosystem complexity or maturity as conceived by ecologists [cf. ODUM 1971: 252], its relevance to human adaptations may not be obvious. What I am suggesting is that ecosystems and human adaptations are both thermodynamic systems and that similar energetic measures of organizational complexity may be appropriate for both. In the case of cultural systems, organizational complexity might be evaluated with respect to the way resource procurement is related to resource consumption in spatio-temporal terms.

Any economic system could be ranked along a scale of increasing distance in space-time between energy capture and consumption; organizational complexity might be said to increase as this distance increases. Lee [1969: 202] makes essentially this same point:

...one of the important dimensions along which economic evolution can be traced is the increasing separation between the production of food and its allocation to consumers.

In this sense, the simplest imaginable foraging system would be one in which resource consumption takes place at the precise time and location of resource procurement. In such a hypothetical system, there would be no delayed consumption (food storage) and no transporting of resources. Food-sharing and the division of labor in subsistence would be minimal. The resource exploitation systems of non-human primates, closely approximate such a system but no known human group does; the prolonged period of infant dependency and the apparent universality of at least a minimal division of labor among all known hunter-gatherers [WATANABE 1968: 75-77] suggest that this imaginary system of minimal complexity falls considerably short of even the simplest systems.

At the other end of the proposed spectrum of organizational complexity would be those modern industrial systems in which resources are typically transported over great distances and delayed consumption is the norm. The hallmark of industrial production-consumption systems is that they are characterized by such vast separations between where and when resources are produced and consumed.

While it should be clear that all hunting and gathering adaptations are inter-

mediate to these two extremes, it should also be evident that they are enormously differentiated with respect to these criteria. Food storage obviously is a characteristic that varies from non-existent to substantial. The degree to which resources are transported spatially from where they naturally occur to the points of their ultimate consumption is also, needless to say, highly variable. In the remainder of this paper, I will focus primarily on variability in the spatial relationships between resource production and consumption among aboriginal peoples of the northwestern coast of North America.

A land use system might be conceived to be the spatial organization of a subsistence system. I would like first to discuss the distributional properties of resources in space and time along the Northwest Coast, and then move to a discussion of how resource distributions condition various dimensions of a land use system. Home range size, mobility strategies, and grouping behavior constitute three major dimensions of a land use system and each is related to resource distributional structure. This discussion will allow some conclusions to be made about the environmental determinants of variations in organizational complexity as it has been conceptualized above.

THE MAJOR STRUCTURAL CHARACTERISTICS OF RESOURCES ALONG THE NORTHWEST COAST

If the area from northern California to southeast Alaska is considered as within the Northwest Coast [following KROEBER 1939; DRUCKER 1955], then it must be recognized that there are substantial latitudinal gradients in both the terrestrial and marine environments. Variations in climate within the terrestrial environment may be directly linked to differences in the availability of plants and animal resources. Temperature on the land declines northward so that while Eureka, California, has a growing season of 328 days, Yakutat, Alaska, has one of only 152 days. This in itself would produce a reduction in both plant and animal resources available for human consumption; if precipitation and forest fire are also considered, the trend is further exaggerated.

Although subject to many local effects of topography, mean annual precipitation tends to increase northward. Thus, while vast areas of western British Columbia and southeast Alaska receive in excess of 2500 mm of precipitation a year, much of northwestern California and western Oregon and Washington receive less than 1000 mm a year. Besides this northward increase in total precipitation, the summer-dry pattern of seasonality in precipitation also tends to diminish northward. The consequence of these climatic gradients for human foragers is that more open forest types are increasingly frequent southward from Puget Sound; northward from there, the dense coniferous forest is rarely interrupted. The availability of consumable plants and animals in the terrestrial ecosystem appears to be a direct function of the extent to which such interruptions do occur [SUTTLES 1962: 98; ROSTLAND 1954], for the mature coniferous forest is an extremely food-scarce environment for humans.

One of the principal factors involved in pushing back the successional state of the forest is fire, and the frequency and magnitude of natural burns diminishes northward. Douglas fir (*Pseudotsuga menziesii*) forest seems to be a fire-maintained climax and its northern limit in the vicinity of Knight Inlet, British Columbia, marks a boundary beyond which forest fire is apparently not an important ecosystemic factor. The obvious result of the northward decrease in importance of forest fire is that terrestrial plant and animal production would be progressively depressed. From the viewpoint of humans in a high primary biomass mature coniferous forest, burning significantly boosts the abundance of exploitable plant and animal resources. It encourages ground level plant growth which would be either directly available for human consumption or as forage for the large game animals (deer, elk, and bear) that are extremely scarce in the closed forest.

The marine environment, unlike the terrestrial, shows no tendency to decline in its productivity along the south to north gradient of this coast. If anything, primary production along the marine gradient runs counter to that of the land. The major physiographic break that enters upon the Strait of Juan de Fuca separates the relatively straight coastline to the south, which is uninterrupted by substantial bays, sounds, or islands, from the coastline to the north, which is highly reticulate and dissected. The northern area would certainly have supported far more habitats for shellfish and sea mammals and provided more points of access to these resources. Other marine resources too, such as halibut and salmon, show no decrease northward paralleling the terrestrial environment, if the catches of the recent commercial fisheries for these fish have any significance. The picture that emerges regarding the latitudinal variation in marine and terrestrial environments of the Northwest Coast is that the two are probably inversely related.

The predictable result of these parallel but contrastive gradients is that, *ceteris paribus*, a larger proportion of the energy for human exploitation in a local environment would exist in the form of marine resources where the density of plant and animal resources in the terrestrial ecosystem is lower. Dependence on marine resources by foragers should vary inversely with terrestrial productivity. To anyone familiar with the ethnographic literature of this area, it is well-known that the relative contribution of hunting and gathering decreases northward and that fishing increases concomitantly.¹⁾ What I would emphasize is that the reason for this pattern is due more to the *deficiencies* of the terrestrial environment than to the magnetism of the marine environment.

One other critical point regarding the coastal gradient is that, in general, greater dependence on marine resources may be equated with an increase in the clumping or spatial aggregation of resources. It seems clear that, as a class of resources, marine

1) Murdock [1967] gives percentage estimates of relative dependence on hunting, fishing, and gathering for many of the societies of this area. Unfortunately, these estimates are so subjective that they can be used to identify only the broadest trends, such as the general decline of gathering northward along the coast. Beyond this, his estimates seem quite misleading.

resources are generally more concentrated in their spatial distribution and are located more discretely than are terrestrial resources. This contrast derives from the difficulties of access to an aqueous environment for a basically terrestrial predator. But more important is that nearly all the major marine species exploited in aboriginal subsistence systems of the North Pacific are migratory resources. They tend to have life cycles that involve the concentration in space (and time) of animal biomass that is the product of primary production occurring over vast areas of the North Pacific Ocean. These major resources include all of the salmonids, several other species of anadromous fish, including the eulachon (*Thaleichthys pacificus*) and the sturgeon (*Acipenser transmontanus*) and various sea-run trout. The herring (*Clupea harengus pallasi*), the fur seal (*Callorhinus ursinus*), and most of the whales are also creatures whose movements effectively concentrate biomass that would otherwise be so widely dispersed as to be virtually unexploitable by human foragers. Even the halibut (*Hippoglossus stenolepis*) and other deep-water species of fish follow a similar pattern of concentration insofar as they move onshore and offshore through a yearly cycle. Although all these resources are energetically the product of vast oceanic "pastures," they are generally only available for human exploitation at relatively few locations, owing to physiographic factors which restrict and direct migration. It is this concentration by migration, rather than the intrinsic productivity of marine ecosystems, that is responsible for locally abundant marine resources in the temperate and higher latitudes. Besides being some of the most spatially clumped human resources that occur in nature, they are also some of the most seasonal because they are only subject to human interception during a portion of their life cycle.

Having discussed some of the major distributional characteristics of food resources for the Northwest Coast, I would now like to consider how these characteristics condition various components of a land use system. Home range, mobility, and group size will be examined in order.

HOME RANGE SIZE AND STRUCTURE OF RESOURCE DISTRIBUTION

A number of ethnographic studies among hunter-gatherers have demonstrated that home range size responds elastically to resource density. Range size, that is, tends to vary inversely with resource density. Ethnographic evidence from arid environments such as Australia [TINDALE 1940: 150], the Great Basin of North America [STEWART 1938: 48], and the Kalahari [TANAKA 1976: 115], where resource density is regulated by precipitation, have shown inverse relationships between precipitation and home range size of foragers. Similarly, food density in the eastern Boreal Forest of Canada seems to be inversely related to temperature, and along a west to east gradient of decreasing temperature there was an increase in home range size among aboriginal groups [HALLOWELL 1949: ROGERS 1969: 45].

Another major factor that may also influence the food density for hunter-gatherers is their trophic position. Because only 10-20 percent of the energy at one trophic level is available to the next higher level in a food chain [PIANKA 1974: 225],

areal requirements for resource procurement decrease as dependence on primary biomass (plants) increases. Since toward the higher latitudes more of the energy available to humans exists in the form of animal resources, it may be expected that accordingly, home range size would tend to increase northward.

The second major determinant of range size is the degree of resource clumping. It is expected that greater clumping of resources in space will generally necessitate exploitation of a larger area to secure the required quantity of each resource. Home range size should vary proportionately with resource clumping [WIENS 1976: 97;

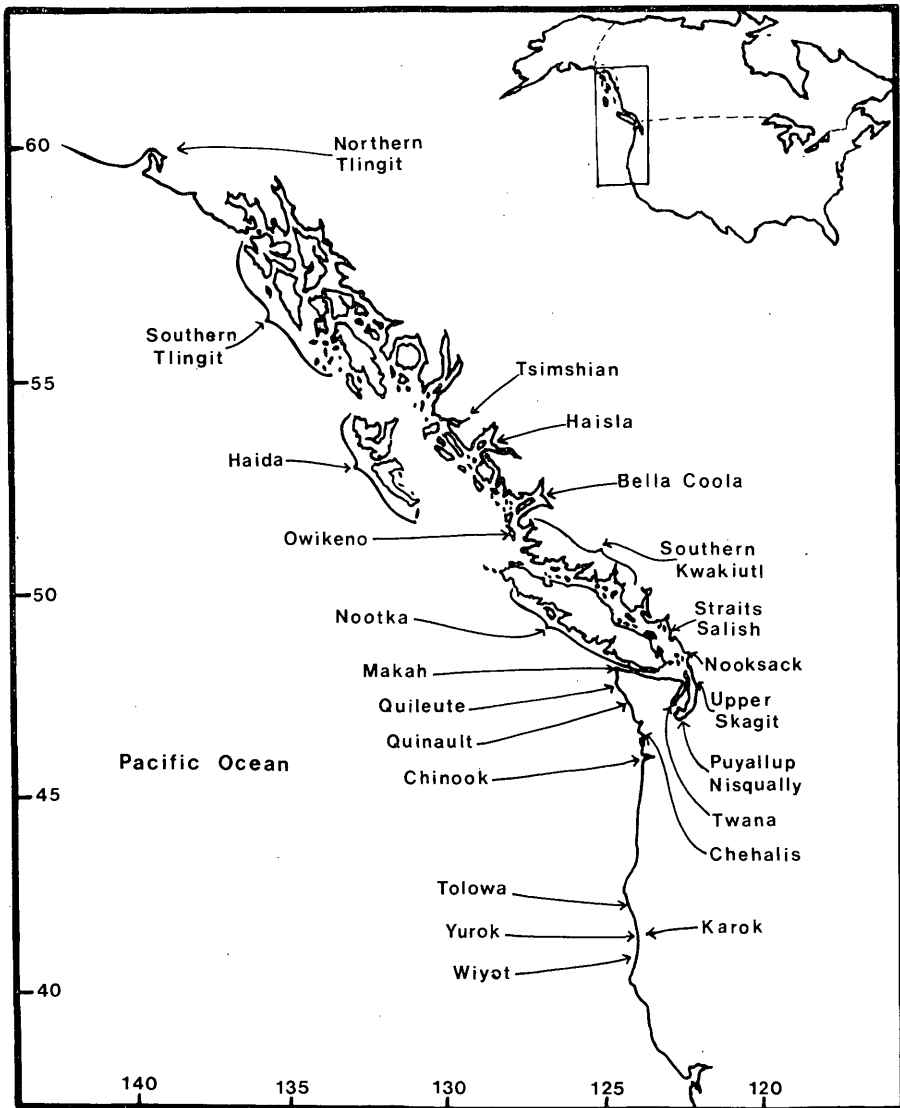


Fig. 1. Locations of various Northwest Coast aboriginal groups.

EMLÉN 1973: 191]; where resource clumping is high, home range size would be large, and *vice versa*.

It has already been suggested that terrestrial resource abundance tends to decline northward owing to patterns in the occurrence of precipitation, temperature, and forest fire. Given these environmental gradients it is possible to anticipate trends in aboriginal home range size along the Northwest Coast. It is expected that there would be a general northward increase in home range size, or a correlation between some measure of growing season and home range size, in this ecosystem.

To examine the proposed relationship, I collected data on 22 aboriginal groups or "tribes"²⁾ located along the coast from northern California to southeast Alaska [SCHALK 1978]. Approximate locations of these groups are shown in Figure 1. Specifically, two kinds of information are pertinent, the area occupied by a particular group, and the number of winter villages reported for that group at contact or shortly

Table 1. Numbers of winter villages, areal estimates, and the computed area per winter village for various Northwest Coast groups.

Group	Area (100 km ²)	Villages (No.)	Area per Village (km ²)	Source
Wiyot	13	41	31.7	Loud [1918]
Yurok	19	54	35.2	Kroeber [1925, 1939]
Karok	32	108	29.6	Kroeber [1936]
Tolowa	21	23	91.3	Waterman [1925]
Chinook	31.9	27	118.2	Ray [1938]
Quinault	21.9	20	109.5	Olson [1967]
Puyallup-Nisqually	64.8	34	190.7	Smith [1940]
Makah	9.5	5	190.1	Swan [1870]
Quileute	11.9	6	185	Curtis [1913]
Twana	29.6	14	211.7	Elmendorf [1960]
Upper Skagit	73	36	202.9	Collins [1974]
Nooksack	32	9	355.8	Smith [1950]
Straits Salish	31.9	55	58	Suttles [1974]
Gulf Salish	340.8	54	631.1	Barnett [1955]
S. Kwakiutl	211	29	727.6	Boas [1966]; Dawson [1887]
Owikeno Kwakiutl	44.7	7	639	Olson [1954]
Nootka	85.5	24	356.4	Drucker [1951]
Bella Coola	150	24	625	McIlwraith [1948]
Haisla	80	2	4000	Olson [1940]
Haida	103	17	926.9	Swanton [1909]
S. Tlingit	742	38	1952.6	Swanton [1908]
N. Tlingit	250	10	2500	Olson [1967]; Laguna [1972]

2) These groupings are distinguished by ethnographers primarily on the basis of linguistic similarity. Each group or "tribe" included multiple local groups, each of which was relatively autonomous in an economic sense.

thereafter. Areas were drawn either from Kroeber's [1939] *Cultural and Natural Areas of Native North America* or were calculated with a planimeter from maps in the ethnographic sources. By dividing the total area claimed by a particular group by the number of winter villages of that group, an estimate of area per winter village was calculated for each case (Table 1).³⁾

As an empirical indicator of terrestrial productivity (both primary and secondary), growing season was identified as a good surrogate. The rationale is that the abundance of precipitation in the entire area is such that temperature emerges as the primary ecosystem-regulating variable. Though it was not possible to obtain long-term, average growing season estimates for most of the meteorological stations within the various tribal areas, average January temperature was available for the period of existing records, and it was reasoned that this measure is highly correlated with growing season. Average January temperature (Appendix A) was then used as an empirical indicator of terrestrial productivity along the coastal gradient.

A linear regression of area per winter village on average January temperature

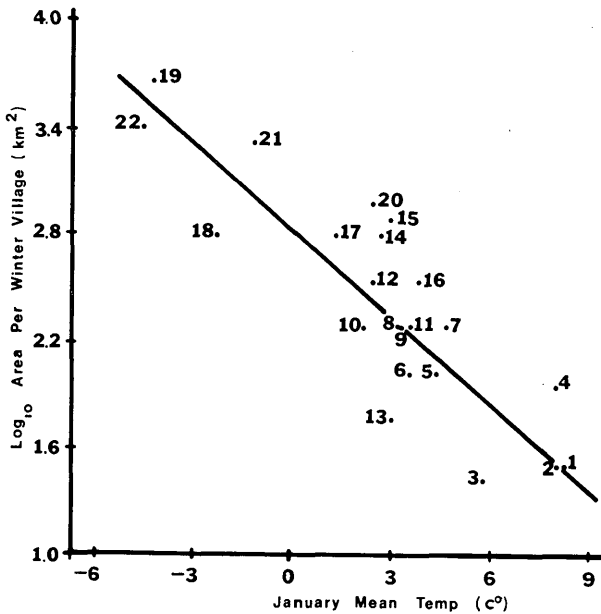


Fig. 2. Common log of area per winter village plotted against January mean temperature for 22 Northwest Coast groups. 1. Wiyot; 2. Yurok; 3. Karok; 4. Tolowa; 5. Lower Chinook; 6. Quinault; 7. Puyallup-Nisqually; 8. Makah; 9. Quileute; 10. Twana; 11. Upper Skagit; 12. Nooksack; 13. Straits Salish; 14. Gulf Salish; 15. Southern Kwakiutl; 16. Northern and Central Nootka; 17. Owikeno; 18. Bella Coola; 19. Haisla; 20. Haida; 21. Southern Tlingit; 22. Northern Tlingit.

3) This relationship could also be illustrated using the same data by computing a winter village density figure.

resulted in a negative relationship with a correlation coefficient $r = -0.867$ (Fig. 2), which may support the suggestion that there is an increase in the spatial requirement for subsistence associated with decreasing terrestrial dependence and increasing marine dependence.⁴⁾ It should be emphasized that this is not to say that average January temperature causes this variation, but this measure was merely defended as an index of the gradients in resource clumping and density that have been discussed.

MOBILITY AND RESOURCE STRUCTURE

Variations in the way food resources are distributed in space and time in different environments require different methods of movement by a species that exploits resources as they occur naturally in an ecosystem. Much of the diversity in land use systems among foragers can be directly related to the particular strategies they employ over their ranges to procure food resources. In distinguishing alternative patterns of movement among hunters and gatherers, Binford [1978] refers to two basic forms of mobility: residential and logistic. Residential mobility is defined as the movement of both producers and dependents, as in the case of re-establishment of a camp at a new location. Logistic mobility is conceptualized as the movement of producers who depart from and return to a central location or habitation site during procurement activities. The relative importance of these two forms of mobility appears to be related primarily to the degree to which resources are clumped in space and time. In general, residential mobility is expected to be the major form of movement where resources are rather homogeneously distributed in space and where seasonality in their availability is not marked. As the degree of resource clumping increases, either spatially or in a temporal sense, a greater degree of logistic mobility may be expected.

Logistical strategies...solve the problem of an incongruous distribution among critical resources (i.e. the lack of a reliable supply of a critical resource within the foraging radius of a residential base camp presumably located with regard to an equally critical resource). Under conditions of spatial incongruity it must be appreciated that a residential move will not solve the problem. A move toward one location reduces the access to the other. It is under this condition that a logistical strategy is favored. Hunter-gatherers move near one resource (generally the one with the greatest bulk demand) and procure the other resource(s) by means of special work groups who move the resource to consumers [BINFORD 1980: 15].

In view of these economic reasons for a more logistically oriented mode of procurement where resources are clumped [see also HAMILTON and WATT 1970], the relatively

4) This is not to say that the entire area would have been used with equal intensity. Where marine dependence was greatest, it is likely that large inland areas would have been minimally exploited.

low degree of residential mobility throughout the Northwest Coast is understandable.

Villages and resource procurement sites along this coast were very permanent in the sense that they were habitually occupied at the same seasons each year but they were rarely occupied throughout the year. The more southerly groups, such as the Yurok, Karok, and Wiyot, however, seem to have most closely approximated sedentism and particular local groups may well have been fully sedentary [LOUD 1918; WATERMAN 1920; KROEBER 1925; BAUMHOFF, pers. comm.]. The rather balanced contribution of fishing, hunting, and gathering to the subsistence of these groups [c.f. KROEBER 1960: 56], in combination with the small home ranges discussed above, must have been conditions conducive to minimal movement of residence. It would seem that marine dependence was less important in producing a degree of sedentism than was the balanced mix of both terrestrial and marine resources. Progressing northward along the coast, the general pattern of rising dependence on spatially concentrated but discretely located marine resources seems to mitigate the likelihood that all necessary resources would be located within a day's round trip of any single location.

Along the entire coast, most groups seem to have shifted residence between two and five times during the year and there was probably as much variability within specific districts as there was between even widely separated regions. Exploitation of larger home ranges, rather than requiring more frequent shifts of residence, was probably accomplished in two ways. On the one hand, the average distance per residential move probably increased in proportion to home range size. The little data I have been able to locate regarding mean distances of residential moves lend support to this possibility [SCHALK 1978: 128]. On the other hand, it is likely that the gradient of increasingly clumped resources would be associated with a general shift toward more logistically organized or centripetal modes of resource procurement. Since logistic procurement would be facilitated by devices such as watercraft that can increase travel speed and weight of transport capacity the protected marine waters of the northern Northwest Coast would have been especially favorable settings for quite extensive transport of resources.

Although logistic mobility is difficult to evaluate directly from much of the ethnographic material, household organization is an indirect form of information on the character of this type of procurement. Since the products of subsistence activities conducted at separate locations in space must be transported logistically for subsequent food-sharing among various producer specialists (and their dependents), it is evident that logistic mobility, division of labor, and the size of the food-sharing group are all strongly associated [SCHALK 1978: 131-138]. As logistic mobility increases in importance, a more complex division of labor and a larger food-sharing group should result. A more complex division of labor implies greater interdependence between the various producers, which in turn, should favor a more inclusive food-sharing unit. The ethnographic literature conveys the distinct impression that producer specialists were more common in the northern areas of the Northwest Coast. Perhaps even more revealing, however, is that there is a significant northward increase

in the mean household size of the ethnic group. The Yurok, Wiyot, and Karok rather uniformly lived in single, extended family dwellings that averaged between 7 and 8 persons [KROEBER 1925]. Further north, in western Oregon and Washington, estimates of average number of persons per house range from 12 to 20 [SCHALK 1978: 135]. Those groups located in British Columbia and Southeast Alaska conservatively averaged at least 20 persons per house, and figures for specific groups would probably be more in the range of 30 to 40 persons. To the extent that households were food-sharing units, this pattern of northward increase in the average size of households can be interpreted as evidence for the increasing importance of logistic mobility and its concomitants.

GROUP SIZE AND RESOURCE STRUCTURE

That group size among Northwest Coast aboriginal groups and maritime foragers tends not only to be large but also enormously variable, is, perhaps, responsible for the belief that there are less rigorous environmental constraints involved [BIRDSELL 1968: 235]. I would suggest that such constraints are indeed present but of a somewhat different nature than is characteristic of more mobile peoples.

Among more mobile hunters, group size is arguably a compromise to two opposing forces, the costs of moving residence and the demand for cooperative labor. Since the frequency of residential movement may be expected to increase with group size, larger groups would have to suffer the costs of moving more frequently [ROGERS 1963: 78; BINFORD n.d.]. Counteracting this is the demand for cooperative labor. The need to meet minimal labor requirements for cooperative food procurement techniques would exert a lower limit on effective group sizes [MARTIN 1973]. That so many hunter-gatherers live during some seasons of the year in groups of 25-50 persons [LEE 1968: 11] could be interpreted as evidence that some strong forces are involved in the regulation of group size within narrow limits among mobile foragers.

Where considerably larger groups occur, spatially and temporally clumped resources are nearly always involved. When resources such as salmon or other seasonally available migratory animals are exploited, increased group size is not always a disadvantage in terms of necessitating more frequent group movements. Because these resources are "renewable", there may not be immediate negative feedbacks on group size. It will be suggested below that the upper limit to group size in such cases is, nevertheless, established by the degree of resource concentration, but first I will examine how group size varies along a gradient of increased resource clumping.

Since larger group sizes might be expected where resources are more clumped, we would anticipate a general trend of increase in group size northward along the Northwest Coast. Data on sizes of specific local groups are scarce, but by dividing population estimates for the pre-contact period by the number of winter villages of a particular group, a *mean winter village size* can be calculated (Table 2).

If mean January temperature is used as a crude index of terrestrial production

Table 2. Mean winter village sizes as estimated from village numbers and pre-contact population estimates.*

Group	Villages (No.)	Population	Mean Size
Wiyot	30	1,000	33
Yurok	54	2,500	46
Tolowa	23	1,000	43
Lower Chinook	27	1,350	50
Chehalis	7	770	110
Puyallup-Nisqually	34	1,200	35
Quinault	38	1,500	36
Makah	5	2,000	164
Southern Kwakiutl	29	14,500	420
Bella Coola	24	1,400	58
Haisla	2	1,300	650
Tsimshian	9	3,500	389
Haida	17	9,800	577
Southern Tlingit	38	7,500	197

* Population estimates are from Kroeber [1939] with the exception of the Lower Chinook, Chehalis, Makah, and Southern Kwakiutl. Mooney [1928] was used for the Lower Chinook since Kroeber's estimate is based on a more inclusive ethnic grouping than Ray's [1938] village data. Data for the Chehalis are based on the observations of John Work, who traveled through that area in the winter of 1824 [TAYLOR 1963: 164]. For the Makah, Mooney's estimate [1928] was employed because Kroeber lumps this group with others in his estimates. Actual census data were employed for the Makah and the Southern Kwakiutl.

(and conversely dependence on clumped marine resources), and mean winter village size is regressed on it, a moderate correlation coefficient is obtained ($r = -0.538$) (Figure 3). The two cases which conform most poorly are located in areas of anomalously high terrestrial production owing to low amounts of precipitation. If these two cases are omitted the correlation coefficient is increased considerably, to $r = -0.7966$.

Despite the scarcity of precise information, there are two noteworthy patterns with respect to groupings during the growing season. The first is that there is a dichotomy between relatively small groupings associated with the warmer, drier districts within the study area, and relatively large groups of the cooler, wetter areas. This is almost certainly related to a general shift from plant dependence to marine dependence during the warm season. Second, in the cooler and wetter districts, exploitation of some productive season marine resources (sea mammals, halibut, and eulachen) is associated with groups that are larger than winter village groupings in the same areas. The Tsimshian eulachen fishing camps, for example, occupied in the spring, were apparently the largest annual groups [GARFIELD 1951]. By contrast, the largest annual groupings in the warmer, drier districts were almost invariably the winter villages.

Beyond suggesting that there are predictable regularities in mean group sizes

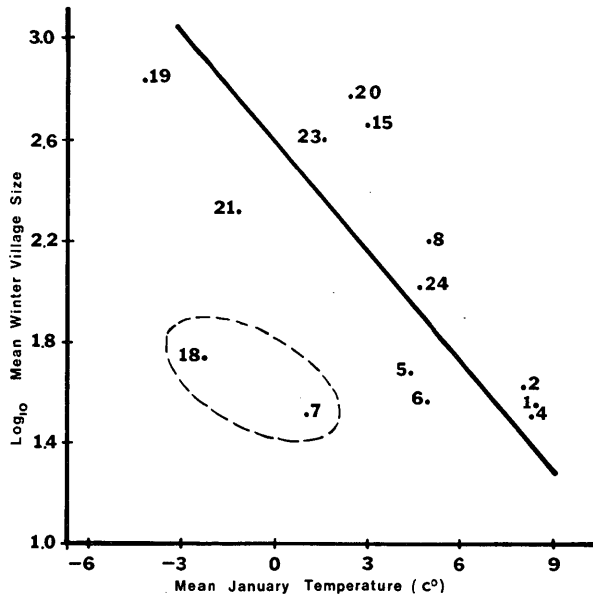


Fig. 3. Common log of mean winter village size plotted against mean January temperatures for 13 Northwest aboriginal groups. 1. Wiyot; 2. Yurok; 4. Tolowa; 5. Lower Chinook; 6. Quinault; 7. Puyallup-Nisqually; 8. Makah; 15. Southern Kwakiutl; 18. Bella Coola; 19. Haisla; 20. Haida; 21. Southern Tlingit; 23. Tsimshian; 24. Chehalis.

associated with environmental variables, I would also argue that the tremendous variance in local group size within particular districts is also understandable. The numbers of persons that may be supported at a particular location while exploiting a highly clumped resource would depend on the interception potential of various locations along a migration path. Since physiographic factors are usually the principal determinants of interception potential, local group size during seasons of migration might be expected to vary with critical aspects of landform. In a study of local group rank among the Southern Kwakiutl, by Donald and Mitchell [1975], just such a relationship was demonstrated. Using census data from the 1830's for 16 different local groups, and median salmon escapement estimates (from 1950-1967) for the salmon streams held by each group, they were able to demonstrate that 72 percent of the variance in group size could be accounted for with their salmon run-size index. The important point to be made here is that although the sizes of specific local groups ranged between 100 and 1,300, this tremendous variation could be accounted for largely by differences in the quantity of salmon potentially intercepted in their respective areas.

DISCUSSION AND CONCLUSION

In the Northwest Coast environment, latitudinal gradients in temperature and precipitation combine to produce a northward decline in terrestrial productivity. Strictly from the viewpoint of terrestrial resources, the areas north of the Strait of Juan de Fuca are probably some of the most food-scarce environments confronted by foragers anywhere in the world. The temperate zone coniferous rainforest is a "food desert" for foragers. Marine resources show no associated northward decline and, if anything, are more abundant along the more dissected coastline of the northern half of this area. The cumulative effect of these two major gradients is that more of the energy exploitable by humans is present in the form of marine resources where terrestrial production is lower. Greater dependence on marine resources is the expectable adaptive response to such a gradient and marine resources are characteristically clumped in their spatio-temporal distribution, especially in the temperate and higher latitudes. Along this northward gradient of increasingly clumped food resources, aboriginal range size increased, mobility was more logistically oriented, and group size tended to increase during the season of consumption from stores (and probably during other seasons as well). Whatever the inadequacies of the ethnographic data or the coarse-grained way they have been employed here, there can be little doubt that there are broad and discernible geographic trends in land use along this coast.

At this juncture, I would like to reconsider the suggestion that organizational complexity increases as the distance in space or the time over which food resources are conveyed increases. Food storage and logistic mobility are the temporal and spatial "pipelines" along which energy flows through a foraging system. Storage was practiced extensively by all the societies of the Northwest Coast that have been documented ethnographically. The importance of food storage under conditions of marked seasonal variations has been emphasized as placing severe demands on labor and social organization as well as on technology [SCHALK 1977]. Ideally, it would be useful to be able to compare quantitatively the relative importance of food storage for various groups along this environmental gradient. Such a measure would involve estimates of the quantity of food regularly processed during a yearly cycle for delayed consumption, or it might involve the length of time during which consumption from stores was the primary source of food. I have had difficulty in designing such a measure with the data as it exists in most ethnographies, but it is my impression that the importance of storage increased northward owing to a general decline in the length of the productive season. Anadromous fish runs, for example, tend to be more compressed temporally towards the higher latitudes [SCHALK 1977], and other resources almost certainly respond to similar climatic determinants. Other things being equal, food storage would be expected to serve a more critical role in subsistence in the more seasonal environments. Beyond recognizing this probable variation in the importance of storage within the area, it may be suggested that adaptations of the Northwest Coast Indians would *all* fall toward the upper end of a storage scale when

compared to the documented foragers of the world. By this measure they would be classified as relatively complex.

In terms of logistic mobility, evidence was presented to support the conclusion that this dimension of complexity also tended to increase northward. Logistic mobility was identified as one indicator of the extent to which food is transported in space, and there are at least three reasons for suggesting a gradient in the degree of reliance on this form of mobility. It was initially shown that range size increased substantially along a south-to-north transect of the Northwest Coast. Looked at in another way, the density of winter villages declined northward. Since there was no associated increase in the frequency of residential moves per year, logistic procurement must have played a greater role in the exploitation of the larger ranges. Given rather exclusive dependence on marine resources that were highly concentrated in their spatial occurrence and often simultaneously available in widely separated locations in the more northerly areas, this conclusion seems inescapable.

Second, because greater reliance on food storage would be expected to inhibit movement of residence, increased dependence on food storage would necessitate increased procurement of resources by logistic means. It has already been suggested that food storage probably was more important quantitatively toward the more seasonal northern environments.

Finally, it has been argued that logistic mobility is reflected in the division of labor and the size of the food-sharing unit. Evidence was presented in support of the conclusion that household size (the food sharing group) increased northward along the Northwest Coast in response to more logistically organized resource procurement.

I have argued for the equation of logistic mobility with the degree to which food resources are transported from their places of procurement to locations of consumption. This dimension of organizational complexity, then, exhibits a similar geographic pattern to that which was suggested for storage. Both measures accord well with the conclusions of ethnographers concerning variations in these same societies. Kroeber [1939: 31], for example, concluded that:

...the more northerly subareas usually have the more intensive culture. Also, except in the most southerly area, the center of intensity within each area seems to lie in its northern portions. The degree of development of such luxury aspects as art and society rituals is in agreement with this environmental-historical view.

Similarly, Suttles [1968: 64-65] suggests a northward gradient of increasing social complexity:

In social organization, there seems to have been a rough sort of south-to-north gradient of increasing tightness of structure and size of social unit. The highest development of formal organization with permanent discrete social units was that found among the northern peoples. The Tsimshian, Tlingit,

Haida, together with the Haisla (the northernmost Kwakiutl), had a system of matrilineages, sibs, and phratries or moieties.

These observations made by individuals using somewhat different criteria for evaluating organizational complexity lend credence to the possibility that the measure employed here may be a useful one. Before concluding, however, it is necessary to point out that there are some recurrent arguments in the anthropological literature which are not supported in this analysis.

The relationships that have been proposed in this paper regarding environmental structure and organizational complexity are in basic disagreement with two assumptions that are very much a part of the conventional wisdom of anthropology. One assumption is that complexity varies positively with population density. The other is that complexity among foraging adaptations is the product of a food abundant environment.

Population densities were undeniably high throughout the Northwest Coast as a whole when compared to densities of other non-agricultural peoples. The density variations *within* the area, however, do not conform to the view that the abundance of marine resources was the underlying determinant of high population density. Along a south-to-north transect of the coastline, aboriginal population densities actually tended to decrease [KROEBER 1939: 156]. Since the more northerly groups were more dependent on marine resources, it seems clear that the abundance of these resources does not account well for variations in population density. The southern portion of the Northwest Coast exhibits the highest average population density; yet the tribes in this area were less dependent on fishing than their northern counterparts. The character of variations in the terrestrial environment seems to correspond more with the population density variations.⁵⁾ The picture which emerges is that aboriginal population density along the Northwest Coast varied *inversely* with organizational complexity and the degree of dependence on marine resources. In this light, the association of these variables in other areas might be considered a non-causal correlation rather than a law-like regularity.

Regarding the belief that complexity is the product of a food abundant environment, it must be admitted that organizational complexity within the Northwest Coast indeed seems to be correlated with degree of dependence on marine resources. What is at issue is whether abundance (productivity) is actually the relevant variable.

5) Were it possible to convert the population densities of aboriginal Northwest Coast groups into a measure of the numbers of people supported per unit area of the earth's biosphere exploited, and not just the land area, these adjusted population densities would probably be quite unimpressive, and over much of the northern part of this area, they might well be the lowest for any foragers on earth. The Tlingit, for example, were estimated to have had a density of 1 person/10 km² [KROEBER 1939: 235], which in itself is not particularly high, but if we were dealing with a ratio of persons to area from which sustenance is derived, their density would probably drop even below the low levels recorded for the subarctic boreal forest hunters.

I would assert that it is not. It is important, in this context, to recall that I have used measures of the *terrestrial* productivity (a growing season index) to account for variation in land use among peoples who relied significantly on *marine* resources. That this was possible indicates something important about the use of the sea by foragers. It suggests that dependence on marine resources will be as great as the terrestrial ecosystem is poor; i.e., marine exploitation is a means for compensating for the inadequacies of a terrestrial environment. The abundance of marine resources and supposed advantages associated with their exploitation may be questioned on other grounds as well.

There are energy relationships inherent in marine ecosystems which tend to make them far less productive of usable biomass than comparable areas of most terrestrial ecosystems [see especially OSBORN 1977a, 1977b]. The primary producers in the ocean are predominantly plankton which, because of their size, are virtually unexploitable by humans. Thus marine food chains are necessarily long, and man usually fits into a marine ecosystem as a high level carnivore. In this position he is denied the energy lost at each trophic level. Further, those oceanic areas capable of substantial levels of primary production are limited mainly to the continental shelves and areas of upwelling. Lastly, as has been emphasized throughout this paper, most of the principal marine resource species available to foragers of the temperate and higher latitudes are highly clumped in their spatial and temporal distribution. If there is a single characteristic of marine resources that accounts for the organizational complexity of foragers who exploit them it is this property of their distributional structure in the environment, rather than their abundance. This viewpoint of marine resource use may help in resolving a current problem concerning the origin of maritime adaptation. Many archaeologists, working in different parts of the world, have been confronted with the paradoxical question of why marine resources thought to be so rich and plentiful were not more extensively exploited for such long periods of the archaeological record. Systematic and intensive use of marine resources seems to be a late- or post-Pleistocene occurrence throughout much of the world [BINFORD 1968]. In many areas of North America, and certainly over much of the Northwest Coast, prehistoric adaptations seem to have been more terrestrial-based until the past 3-5,000 years at most. Operating under the assumption that humans would necessarily take full advantage of the bountiful seas, innumerable arguments have been set forth to account for this paradox; most of these invoke some form of environmental change, especially related to effects of changes in sea level. These arguments seem to share the principal defect that they are based on negative evidence. On the other hand there are more economically oriented arguments that can better account for the evidence *as it exists* both in the archaeological and ethnographic records. The alternative picture of the origin of maritime adaptations is simply that increasing use of marine resources may best be viewed as a process of subsistence intensification quite similar to agricultural intensification [OSBORN 1977b; HARRIS 1977]. According to this argument, demographic factors played a far more critical

role than post-Pleistocene environmental changes in shifting human subsistence systems in the direction of increased use of marine resources.

Appendix A. Climatic indices

Group	Average January Temperature (°C)	Average Annual Precipitation (mm)	Stations* Averaged
Wiyot	8.5	1016	Eureka
Yurok	8.1	1118	Klamath
Karok	5.8	1401	Orleans, Happy Camp
Tolowa	8.2	1803	Crescent City
Lower Chinook	4.7	2261	Grays River, Naselle, Astoria
Chehalis	4.8	1499	Hoquiam, Centralia
Puyallup, Nisqually	4.9	973	Puyallup, Tacoma
Twana	2.4	1394	Quilcene
Quileute, Quinault	3.7	2667	Quillayute
Makah	3.6	2522	Neah Bay, Clallam Bay
Upper Skagit	3.4	747	Coupeville, Arlington
Nooksack	2.6	940	Bellingham
Straits Salish	3.2	803	Victoria, Olga
Gulf of Georgia Salish	3.0	1176	Powell River, Nanaimo, Duncan, Saanichton, Ladner, Squamish, Vancouver
Nootka (Northern, Central)	3.9	2845	Bamfield, Estevan Point, Gold River, Port Alberni, Quatsino, Tofino
Southern Kwakiutl	3.1	1859	Port Alice, Bull Harbour, Port Hardy, Alert Bay, Campbell River
Owikeno Kwakiutl	1.4	3086	Ocean Falls, Port Hardy
Bella Coola	-2.2	1549	Bella Coola
Haisla	-4.2	2131	Kitimat, Kemano
Haida	2.5	1367	Langara, Masset, Sandspit, Tleil
Tsimshian (proper)	1.7	2388	Prince Rupert
Southern Tlingit	-1.0	2294	Haines, Juneau, Sitka, Angoon, Petersberg, Wrangell, Cape Pole, Ketchikan
Northern Tlingit	-4.3	3353	Yakutat

* Weather stations selected within each tribal area, and where possible, several stations were averaged. Data from U.S. Department of Commerce [1976] and Province of British Columbia [1964].

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