NORTHWEST COAST TRADITIONAL SALMON FISHERIES

SYSTEMS OF RESOURCE UTILIZATION

by

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Abstract

The exploitation of salmon resources was once central to the economic life of the Northwest Coast. The organization of technological skills and information brought to the problems of salmon utilization by Northwest Coast fishermen was directed to obtaining sufficient calories to meet the requirements of staple storage foods and fresh consumption. This study reconstructs selective elements of the traditional salmon fishery drawing on data from the ethnographic record, journals, and published observations of the period prior to intensive white settlement. To serve the objective of an ecological perspective, technical references to the habitat and distribution of Pacific salmon (Oncorhynchus sp.) are included. The aim of the work is to assess the relationship of salmon technology complexes to ecological conditions at fishery sites. It is an examination of the operating principles in traditional systems of salmon production.

A model of the fishery is suggested: during migration anadromous salmon pass through a number of time and space segments where they can be intercepted by fishermen. A coincidence of appropriate elements will define a fishery site, i.e., the characteristics of the prey, accessibility to resource locations, natural features of the environment, and the enterprise of fishermen. The interaction of these and their constituent variables provides a range of selective strategies to be used, analyzed in this study with reference to specific Northwest Coast ethnic divisions and geographic locations.

Twenty-four ethnic or areal divisions within the Northwest Coast culture area were studied. The results of the research are presented in Part One supported by distribution maps and illustrative materials. Lists of reference tables for each of twelve systems of salmon production are contained in an Appendix. Part Two includes technical information about Oncorhynchus sp. and its habitat. Part Three is an analysis of social, ecological, and technological elements in several stages of inter-relation, including an interregional comparison in the final section. An Index of Salmon Abundance and a comparison of selected resource areas provide statistical evidence (Appendix II and III).

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INTRODUCTION

The pre-colonial societies that occupied the coastal region of northwestern North America were economically dependent on the Pacific inshore and riverine fisheries. Despite a diversity of languages and cultures, the unifying principle throughout the entire Northwest Coast was an adaptation to marine resources that centred on the availability and utilization of the anadromous Pacific salmon, Oncorhynchus sp. As the evidence of this thesis will demonstrate, traditional systems of salmon production were generally coincident with seasonal migrations of adult salmon returning from marine environments to fresh water spawning grounds. This characteristic movement of salmon biomass through successive time and space segments is the critical component in an appraisal of maritime adaptations on the Northwest Coast.

In each distinctive Northwest Coast cultural system, fishermen generated strategies of resource utilization that optimized the kinds of locations where salmon could be taken. From Yakutat Bay, Alaska, to the Eel River drainage in Northwestern California, there are significant shared features in the natural environment: a temperate climate, moderate to heavy precipitation, extensive tree cover, little arable soil, and innumerable rivers and streams. It was these fresh water resources that supported large salmon populations, providing the primary food source for coastal peoples. The local resource user-groups in each society had access to several fishery sites, defined by specific micro-ecological factors: currents, tides, turbidity, thermal conditions; these are generally described in geophysical terms as: riffles, bays, bars, river mouth areas (estuaries), inshore channels, fjords and inlets, small coastal streams, large rivers, waterfalls and rapids in the canyon. Every fishery location offered a combination of variable water features to challenge the fisherman's technical expertise; but the most important ecological variable was the presence of salmon.

Five species of Pacific salmon enter the waters of the Northwest Coast: chinook (*Oncorhynchus tschawytscha*), sockeye (*O. nerka*), pink (*O. gorbuscha*), coho (*O. kisutch*), and chum (*O. keta*). Characteristic differences between species are demonstrated in the timing of runs and behaviour during migration, which under some circumstances affect resource utilization. Spawning populations within each species comprise a genetic stock referred to as a 'run'. Maturing salmon in each spawning population return to the spawning ground from which they originally emerged as fry. The run itself is a discrete event in time that follows a regular and recurring pattern for each stream population or stock. The period during which any given run is accessible to human predation is limited. A river system that supports several spawning grounds and that has runs of more than one or two species of salmon is likely to have a longer season than one which has fewer runs. However, the size of the run may be an even more significant factor. Where abundant runs pass through a fishery site not only is the duration for which salmon are accessible extended, but fishing opportunities are statistically improved, and yields increased.

The seasonality of each Pacific salmon species is predictable, occurring with as much regularity as the ripening of food crops like rice and wheat. Nevertheless, as with agricultural resources, salmon is subject to fortuitous events and conditions in the ecosystem which, for humans, have an impact upon potential food production. Fluctuations in abundance that may seriously deplete the size of runs available locally to a resource utilization group commonly occur for any of a number of reasons. To extend the analogy, a plant food producer has a direct role in relation to crop growth; he or she prepares the fields, sows the seeds or plants the seedlings, and contends with weeds and pests during the growing season. The Northwest Coast fisherman had no input control to correspond with this in the empirical sense although he would, through appropriate respect behaviour, try to ensure that a compatible environment existed to attract the returning spirit of Salmon. Otherwise, all his production energies must be directed to the harvest, the salmon run, since that was his only opportunity to effect the objective. It is essential then that strategies of production increase his chances of making the catch. Pertinent information about the characteristics of local salmon stocks and the features of accessible water resources was transmitted to members of the user-group, a lineage association, through the social organization of knowledge, as essential in fishing societies as in agricultural communities. Intimate and detailed knowledge of the resource is the foundation on which technical systems of salmon production were organized.

Non-agricultural societies are generally categorized as simple social systems. The Northwest Coast is an anomoly: it was non-agricultural but it had a complex social structure, rigidly hierarchical with ranked social groups, a relatively dense population concentrated especially at river confluences and outlets, living in permanent winter villages from which user-groups emerged on seasonal excursions of resource exploitation. Like other western North American societies, the people of the Northwest Coast had an acephalous political organization, each community independent and self-sufficient (1).

According to early anthropological classifications, the Northwest Coast was in an equivocal hunter-gatherer category, despite a complexity of social organization and material culture that belies this characterization. The products of hunting and gathering provided supplemental nutrients to Northwest Coast diets but cannot be considered primary. To extend the meaning of the terms 'hunting' and 'gathering' to include the integrative modes of salmon production and resource utilization practised by fishermen on the Northwest Coast does the system of typologies an injustice. More importantly, it is likely that distinctions will be overlooked that may help to explain the nature of resource exploitation in a maritime environment, and how these differ from strategies of land-use. A closer examination of the maritime strategies utilized by Northwest Coast people obviously would be useful in rethinking systems of classification based on the ecology and traditional economics of non-industrialized societies.

Not only is the Northwest Coast miscast as a hunter-gatherer group, it has been unrecognized as the signal example of a maritime adaptation. This thesis begins with the assumption that the Northwest Coast is essentially a fishing society. Yet the conditions of its economic base are exceptional among known fishing societies in other parts of the world (2). Typically, people who are economically dependent principally on maritime resources either practice some form of agriculture or exist in symbiotic relation to plant food-producers. But on the Northwest Coast there was no significant incipient plant production and no neighbouring agriculturists. Whereas in fishing communities elsewhere people obtained wheat or rice and other staple grains through systems of exchange, utilizing their catch not only as a protein source but as a commodity, on the Northwest Coast preserved fish products were the staple storage foods. In addition to salmon, the major species utilized, where available, were: cod, halibut, sturgeon, trout, herring, eulachon in the north, eel or lamprey in the south, and other species locally obtainable, for example, the sablefish (black cod) in the waters off the Queen Charlottes. Other marine products included many species of intertidal shellfish and marine mammals. From one society to another a variable proportion of these products was preserved either as dried fish or as stored oil and roe by-products. But the chief staple food, the principal component in the annually stored provisions of each family group, was salmon. It was the availability and utilization of salmon that made a singular case of this culture area in relation to other fishing societies. Permanent villages and communities in the Northwest Coast supported sizeable populations with a fishing economy that was self-sustaining, one with no symbiotic relation to other production or economic systems.

Occasionally in the past suggestions have been made to explain the level of food production on the Northwest Coast (as well as the quality of art and architecture) by reference to a bounteous nature. It is not enough to say the environment was richly endowed, even though in many places this was certainly true. 'The waters abound with salmon', some sources say; yes, but salmon must be caught, they must be accessible to exploiting groups. 'Salmon runs fill the streams yearly', others will say; yes, but the duration of each run is limited, the resource must be exploited within the constraints of time and place, and the characteristics of individual salmon species. The size of local salmon populations varies from one stream system to another. Abundance varies from year to year. Stocks are subject to disease and to predation by non-humans that affects the number of returning spawners. The criterion by which to judge the achievement of Northwest Coast systems of marine and riverine adaptation is not the potential size of the spawning population in the entire Pacific drainage system, but the size of the catch.

A notable feature of the traditional Northwest Coast fishery was the development of multiform techniques of salmon resource production. This study contains an assembly and comparison of data on salmon ecosystems and traditional resource use. The production techniques and processes used in the native fishery were based on a complex of systems that operated within ecological and social parameters. Twelve salmon technology complexes are identified, each suited to a different set of conditions in the natural and social environment. A distributional analysis of resource use patterns is included. The standard ethnographic accounts of twenty-four linguistic or ethnic groups provides the primary data source, together with supplementary observations by early visitors to the Northwest Coast. In addition, selected technical references in the reports of fisheries researchers and biologists, geographers and hydrographers, were consulted for useful scientific material to aid in the reconstruction of the ecological context of the fishery.

LITERATURE REVIEW

Previous Studies of the Northwest Coast Traditional Fisheries

1. Hewes (1947 unpublished dissertation); Rostlund (1952); Kroeber & Barrett (1960)

It is remarkable that so little work has been done to synthesize the available Northwest Coast materials. The three references cited above are the only comprehensive studies to include traditional fishing methods used by Northwest Coast peoples. Hewes' work is an extensive survey of northwestern North America's aboriginal fisheries including most of the marine species utilized, together with intertidal species, marine mammals, anadromous species and freshwater fish. His data for the Northwest Coast region is particularly strong for California groups among whom he did original field research in 1940. Hewes describes specific geographical features at many coastal sites along the California, Oregon and Washington seaboard, and further north; and he itemizes the fishing methods used at each of these locations.

Rostlund's compendium is a standard reference for North American freshwater fish and traditional fishing methods. Essentially it is an inventory of ethnographic and historical references to the subject, complete with topical summaries of the distribution and characteristics of fishing methods. Rostlund's perspective is comparative geography but, like Hewes, he was obviously impressed by the diversity of fishing methods utilized by native North Americans and sought to bring order to the wide-ranging materials on the subject.

Kroeber and Barrett's monograph is the only anthropological analysis of fishing technology to focus exclusively on a sub-area of the Northwest Coast. It is an exhaustive accounting of all reported fishing methods used by contiguous Northwestern California language groups who occupied the Klamath River basin and several adjacent river systems. In a review of this work H.E. Driver has said that it surpasses anything else published about fishing methods in an area of comparable size in North America (1962:1078). While Kroeber introduces his work by saying that "no comprehensive accounts of fishing in the area have been published" in reference to Northwestern California, he might well have extended that observation to the wider Northwest Coast culture area (1960:1).

In the present work excerpts and data are drawn from Kroeber and Barrett's study. However, the other two selections, which relied on standard ethnographic references for their data, were not consulted because I have preferred to go directly to original sources. In the case of Kroeber and Barrett, much of the material was drawn from unpublished works or sources not easily accessible. Hewes' field notes, e.g. are more extensively treated in the California study than was feasible in his dissertation.

2. <u>Suttles (1960, 1962, 1968); Vayda (1961, 1967)</u>

It is Suttles and Vayda who are generally credited with being the first to refute theories of boundless plenty in respect of Northwest Coast resource availability. These scholars studied the implications of resource variability in social and economic features of Northwest Coast societies, and raised pertinent questions about differential access to productive resource areas. Although some questions remain unresolved, the former unexamined attitudes toward abundance and surplus have been successfully challenged.

In these studies, Suttles and Vayda applied an ecological perspective to the problems associated with systems of distribution, whereas I use a similar ecological model in the present work to examine systems of production.

3. <u>Donald and Mitchell (1975); Schalk (1977)</u>

Other scholars have more recently examined resource variability with special emphasis on salmon fisheries. Donald and Mitchell's paper, "Some Correlates of Local Group Rank Among the Southern Kwakiutl", is now a classic statement of the correlation between salmon resource availability and human population size. Donald and Mitchell demonstrated a subsequent correlation to the system of local group rank among the referenced population, that is, the "relative richness of annual salmon resources" produced in territories held by local groups of resource users correlates to their relative social rank as established by precedent during 'potlatches'.

Schalk's paper, on the other hand, focusses on the nature of the salmon and other anadromous fish as an exploitable resource (3). His is a comprehensive account of "the structure" of the resource, including variations in spawning populations and the timing of runs which are similar to the kinds of data presented in Part Two of this thesis. Schalk takes exception to earlier works in anthropology, including that of Suttles and Vayda (and Harris' analysis of that work (4)), which purport to represent ecological models of resource availability without a sufficient data base to specify more exactly what is meant by variation.

Maritime Anthropology - Canada

1. Andersen and Wadel

The series of research articles to come out of Newfoundland in the late sixties - early seventies was the first integrated attempt to examine maritime adaptations in a Canadian context. The Atlantic fisheries represented in these papers are different in most respects from the Pacific salmon pre-colonial fisheries. Nevertheless, the perspective and research approach that was used informed my initial interpretation of a method by which to study the west coast production system.

RESEARCH DESIGN

Methodology

Second and third-generation cultural ecologists have expanded on the original concepts of Julian Steward (1936, 1955) to produce more flexible definitions of the interaction between environment, cultural artifacts, and exploitative strategies; nevertheless, it was he who first suggested that it was sound methodological practice to isolate the significant ecological-culture relation in any given group, rather than consider all elements of equal value (cf Cox:1973;Geertz:1963; Harris:1968;Helm:1962).

In the past cultural ecology models have placed too much emphasis on 'adaptation', a concept that became a catch-all for uncritical analysis. Like all over-used words, it lost its original meaning and has recently fallen from favour. As Jorgensen has commented, at any moment in time every cultural system is 'adapted' to its environment (n.d.). Perhaps the main disappointment with theories of cultural ecology and such other approaches as interactional analysis (cf Barth: 1959,1968) is that they seemed to promise a means of analyzing processes, rather than an explication of static models.

The method I selected for the purposes of this study was one that would help me to define and analyze the traditional fishery as a system. I wanted to know how the fishery operated; what was the interrelation of selected and significant variables, the nature of the resource, the social organization of labour, the accessibility of resource-use sites, the technology of salmon production. Notions from both cultural ecology and general systems theory (GST) were useful in the formulation of a paradigm for the fishery (cf Bertalanffy: 1973;Watt:1968).

I do not represent my simple paradigm to be a genuine model of process. Such models, where they exist, are dependent on formal mathematical analyses, computer-enhanced, and are only recently being developed to serve specific objectives in archaeology, physical anthropology, linguistics, and population-ecology studies. Usually, a statistical base is prerequisite, or some means of quantifying the value of things that stand in relation to one another. I anticipate that as 'mainstream' anthropologists become more familiar with the modelling capabilities of certain computer languages they will experiment with processual models and qualitative analyses of social and environmental relations. For the present, I use the concepts of systems theory as an instrument: first, to isolate and define selected elements and, secondly, as a tool of analysis to help explain the interrelation of variables in the system studied. Watt (1968:7) has suggested that survey and qualitative analysis of previously unassembled materials is necessary before more rigorous methods can be usefully applied and interpreted.

Qualitative Analysis:

Each salmon technology complex (STC) is defined as a set of elements standing in interrelation. The elements are thus to be analyzed on the basis of their constitutive characteristics, to borrow a term from Bertalanffy (1973:54-55), that is, not on the basis of the sum of elements, but of their relations one to the other. Bertalanffy regards such a formulation of systems principles to be "intuitively accessible" (ibid). The argument in Part Three is a non-formal methodological approach, developed to utilize intuitive categories and inductive reasoning in the analysis of sets of ecological, social, and technological variables.

Scope and Limitations

a) This study is not concerned with ideological relations in Northwest Coast fishing; only a few brief references are included in the text. The most widely distributed ritual complex, the First Salmon Ceremony, has been analyzed by Erna Gunther (1926,1928). The ritualist's role in the Straits Salish reef net fishery has been described by both Stern (1934) and Suttles (1951). In Waterman and Kroeber's comprehensive study, The Kepel Fish Dam (1938), both the technology and ritual that attended the annual installation of an important weir are treated. With these notable exceptions, it appears there was less ritual associated with fishing than with land and sea mammal hunting. The whale complex on the west coast of Vancouver Island and at Cape Flattery was highly elaborated, but practices did not extend to fishing. Several informants reported that no magic was needed for fishing (cf de Laguna:1974; Elmendorf:1960). Profane beliefs were common: charms, lucky hats, and other such universal phenomena. In many Northwest Coast societies, women of child-bearing age observed special restrictions in relation to salmon fishing gear and sites. Any future study of social constraints on women in this context must use a broader sample than the Northwest Coast because the occurrence is wide-spread.

b) The entire geographic continuum which forms the Northwest Coast culture area is subject to this investigation; that is, Yakutat Bay, Alaska, where the northern-most Tlingit group lives, to the Wiyot at the mouth of the Eel River in Northwestern California. The features of the culture area have been described by many writers, notably Kroeber (1939), Driver and Massey (1957), and most recently, Jorgensen (1980). Twenty-four ethnic groups are included (see Table I). Omitted are the Nooksak, Chemakum, Chehalis, Cowlitz, and Nitinat for whom there was insufficient data. The names used follow Suttles' (1978) map. It is intended that the scope of the study be broad rather than intensive, so that patterns of resource use over the whole region could be demonstrated. In addition, I believe that a wide geographical basis on which to construct conclusions is more sound methodologically. However, the advantages of a close examination of the salmon fishery within each ethnic or linguistic division is necessarily sacrificed.

c) This is a synchronic, not an historical study. It represents the fishery as it existed in the past prior to colonization and white settlement; on most parts of the coast 1850 is a rough threshold date. The maritime fur trade had declined by this time, but new trading posts were being built for the land-based trade. Introduced diseases had already effected a population decline, changes in exploitative and residency patterns were well advanced, and the breakdown of coastal village communities had begun.

By 'traditional' I mean those techniques considered by successive generations to be appropriate resource use strategies in the Northwest Coast ecological context. These are fishing techniques handed down from one generation to the other. The subject of origin is not considered. Without reference to other types of models, the use of diffusion theory is inadequate to explain the occurrence at

TABLE I

ETHNIC DIVISIONS

Region	Division - Language Group		Sub-division (cited)	Language Family
Northern	1	Tlingit		Tlingit
	2	Haida	Skidegate, Massett	Haida
	3	Tsimshian		Tsimshian
		Gitksan-Nass		
		Coast Tsimshian		
Wakashan	4	Northern Kwakiutl		Wakashan
		Haisla		
		Heiltsuk		
	5	Bella Coola		Salishan
	6	Southern Kwakiutl		Wakashan
		Kwakiutl		
	7	West Coast-Nootka	Clayoquot, Ahousat, Hesquiat, Moachat	Wakashan
	8	Makah		Wakashan
Salishan	9	North Gulf Salish		Salishan
		Comox		
		Sechelt		
		Squamish		
	10	Halkomelem	Stalo (Musqueam, Katzie, Tait), Nanaimo, Cowichan	Salishan
	11	Straits	Lummi, Klallam, Saanich, Songish	Salishan
	12	Lushootseed	Puyallup-Nisqually, Skagit, Muckleshoot	Salishan
	13	Twana		Salishan
Columbian	14	Quileute		Chemakuan
	15	Quinault		Salishan
	16	Lower Chinook	Chinook	Chinookan
	17	Upper Chinook	Wishram	Chinookan
	18	Tillamook		Salishan
	19	Oregon Coast		
		Coos		Coosan
		Alsea, Siuslaw		Yakonan
		Coquille, Umpqua, Chasta Costa		Athapascan
Southern	20	Tolowa		Athapascan
	21	Yurok		Algonkian
	22	Karok		Hokan (isolate)
	23	Hupa		Athapascan
	24	Wiyot		Algonkian

various places on the coast of diversities or similarities in the technology of salmon production. Eventually, archaeological evidence will give us a time-depth perspective. For the present, whether fishing techniques and devices used by Northwest Coast peoples were the result of retentions from a protohistorical period brought to the coast by immigration, or to innovations subsequently made, is beyond the scope of this study to suggest.

Introdution Footnotes

1 Jorgensen (1980) has recently suggested this correspondence between Northwest Coast and other western North American societies.

2 Sundstom (1972) describes the more common symbiotic relation between fishing and agricultural societies in his study of Niger fishermen.

3 I am grateful to David Pokotylo for bringing to my attention the paper by Schalk, published in an archaeological journal.

4 Harris (1968) regards the work of Suttles and Vayda as a praiseworthy contribution to Northwest Coast studies.

PART ONE -- SALMON TECHNOLOGY COMPLEXES: the ethnographic record

INTRODUCTION

Who the first peoples were to settle on the Northwest Coast at a river mouth or sheltered cove, no one knows. Perhaps they came downriver from the interior, or had made their way gradually along the coast looking for new food resources. Every nation had its own story about the First People, and how they came to live by the sea. The fabulous gift of "Salmon-Bringer" is a feature of the mythology. As centuries passed, many diverse people migrated to riverine and coastal locations, each bringing with them a 'cultural kit' filled with different sorts of knowledge, tools, and skills. In time the region was inhabited by more than twenty language groups, some of whom left linguistic antecedants in other parts of the continent, but others who spoke languages known only on the Northwest Coast. Whatever their origins, each society adapted to the new conditions of a maritime environment, selectively utilizing its resources and developing new forms of expertise.

The use of salmon products gave the region relative economic security because of two complementary systems: salmon resource exploitation, through the appropriate use of technology and skills; and preservation techniques that made possible long-term storage of salmon food products. While only the first of these two systems is examined in this study, I wish to acknowledge that both the male-dominated activities to procure salmon and the female-dominated sphere of salmon preservation and storage were essential to Northwest Coast societies.

In this initial chapter, Northwest Coast salmon production strategies are presented within the context of reciprocal relations. Ecological, social, and technological variables pertinent to the success of resource utilization are considered. Twelve salmon technology complexes are introduced. These can be described as independent operating systems each of which had potential capabilities to extract the salmon resource at one or another of the time-space segments occupied by the migrating runs. I suggest that resource users selected the technical system that best suited the conditions of the fishery site. That is, for any given combination of ecological features at a site there was one salmon technology complex that was more efficient than any other. A commentary on the distribution of salmon fishing methods is included in context, supported by maps indicating which ethnic divisions are reported to have used the complex. (Note: a listing of the references cited to obtain these data for each type of fishing system is contained in the Appendix.)

SALMON TECHNOLOGY COMPLEX 1 - TROLLING

1. Contextual Description

The inshore trolling fishery operated in coastal waters around Vancouver Island and its adjacent straits and sounds. To troll is to fish for salmon with a baited hook drawn behind a moving canoe; it was the only salmon technology complex to use a lure. Long trolling lines of kelp, whale sinew, or nettle fibre drew a composite hook which had a bone point and wooden shank lashed together to make an acute angle. Midway between the canoe and the hook, a small sinker would be joined to the line.

Only two species -- coho and chinook -- commonly rise to bait in these waters. A herring was secured on the hook by a method that made it appear to be, with each stroke of the fisherman's paddle, alive and still swimming. Jewitt (1967[1815]) gives an early first-hand account of trolling among the Nootka (c.1803-1805):

> One person seats himself in a small canoe, and baiting his hook with a sprat, which they are always careful to procure as fresh as possible, fastens his line to the handle of the paddle; this, as he plies it in the water, keeps the fish in constant motion, so as to give it the appearance of life, which the salmon seeing, leaps at it and is instantly hooked, and by a sudden and desterous (sic) motion of the paddle, drawn on board.
>
> (p.68)

The presence of live herring in the waters to be trolled was an important consideration. Swan (1870:24) notes that the Makah would not go out after salmon "even though the waters be alive with them" unless herring were present.

2. Types and Materials

The gear consisted of a composite acute-angle hook, a leader, sinker, and long trolling line. The usual type is that described by Boas (1909:fig.155, 485-6) consisting of a hook with a wooden shank and a bone barb lashed together. A second type, an ironwood steam-bent hook, (Smith:1940:254) was less common. The fine line used for the leader is not adequately described. The sinker, where it was used, was attached with cedar withes or cherry bark. Drucker (1951:41) says, however, the weight of the bait was sufficient for trolling in Nootkan waters since the hook was not deeply submerged.

The preparation and manufacture of fibre trolling lines was labour-intensive. Boas says lines were 16 to 18 metres long, made of kelp line or nettle fiber. Whale sinew trolling lines were used by Nootka fishermen, kelp lines by the Makah, and kelp, nettle, or willow-bark twine by Straits Salish. Swan (1870:24) gives a very detailed description of the preparation of kelp lines.

Trolling was usually done with a single hook. The Makah were the only group reported to have attached multiple trolling hooks to their lines; they used gangs of up to thirty hooks.

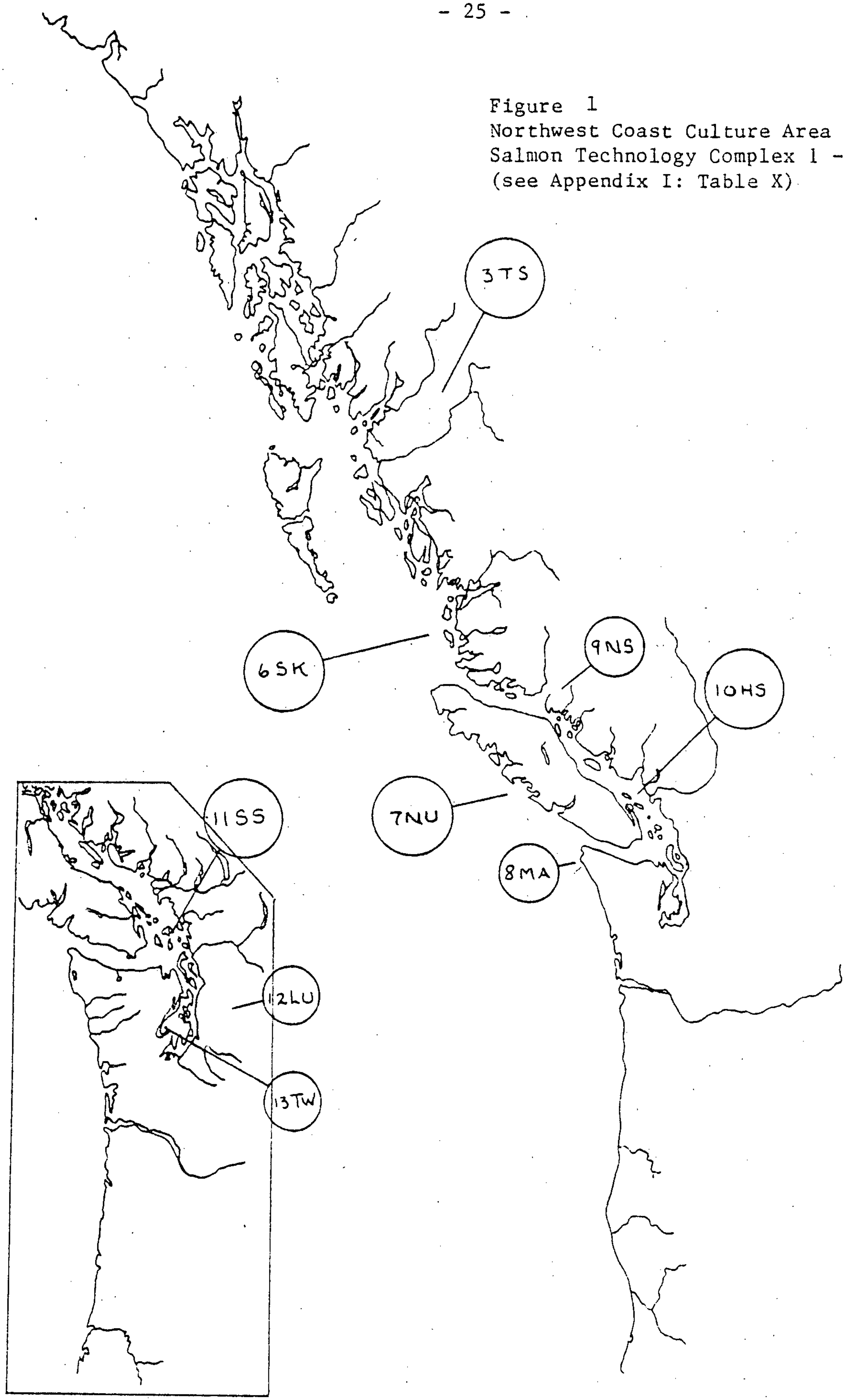
3. Distribution

Trolling complex is centred in Wakashan and Salishan territories. There is archaeological evidence to suggest that the Coast Tsimshian also used trolling methods. Salish people extended salmon resource availability by trolling prior to seasonal spawning runs in the channels of Rosario and Haro Straits, offshore near present-day Victoria, and around the Gulf Islands. The Nootka secured large supplies of salmon by trolling the inlets, coves, and lee side channels of their off-coast islands. Although Drucker said that most of the trolling catch was consumed as fresh food, Sapir and Swadesh (1955:30,41,45) were told in 1910 that Nootkan resource user-groups preserved the early autumn coho caught by trollers. What proportion of the total catch this represented is not estimated.

The centre of importance in the trolling fishery was the entrance to the Straits of Juan de Fuca. Here Makah fishermen exploited the Fraser-bound runs of chinook and coho. Trolling was the dominant mode of salmon production for the Makah, accounting for almost all their winter provisions of dried salmon, in addition to fresh consumption in the summer months. No other Northwest Coast people had such an intensive trolling fishery.

Few firm estimates of productivity are available. Jewitt (ibid) reported twenty to thirty canoes trolling in the cove which returned after a morning's fishing with eight to ten large salmon each.

Figure 1
Northwest Coast Culture Area
Salmon Technology Complex 1 - Trolling
(see Appendix I: Table X)



4. Social Variables

In the straits and sounds of the central Northwest Coast trolling was unrestricted by rights of access. The rich reserves of salmon at the entrance to Juan de Fuca were open to the Makah fishermen in common. But the Nootka data (Drucker:1951:251) suggests that since all territorial prerogatives resided in the chief no one could go trolling until he had formally opened the season.

A fisherman usually trolled alone in his canoe but fished in the same general area as others. There is no indication that the means of production (trolling lines and hooks) was other than individual and private. Much labour went into the manufacture of the long lines required.

5. Ecological Variables

The waters at the approach and entrance of the Straits of Juan de Fuca, as well as offshore fisheries on the West Coast of Vancouver Island, once significant resource areas for traditional trollers, are now the most productive commercial trolling locations (INPSF:IX:BULL.16 pp.1-73). Chinook salmon enter these waters early in spring (ibid:70); coho arrive later, beginning in July and continuing through the summer months (ibid:14). Many local run variations affect the timing. On the west coast of Vancouver Island, for example, coho run in the streams in October (INPSF:IV:23:p.311). In the Gulf of Georgia both coho and chinook are resident throughout the late spring and early summer feeding on herring and other small prey; a few stocks remain in the Gulf permanently.

Unlike other salmon technology complexes, trolling is defined by specific reference to salmon characteristics rather than by hydrological features. Water speed and turbidity play a minor role in the operation of the trolling hook. The main requirement is the presence of a species of salmon that will take the lure. Secondly, as the Makah data reports, the trolling site must have in appreciable numbers a natural prey for salmon to feed upon. The question raised is why the coincidence of these ecological features was not exploited beyond the coastal waters of Wakashan and Salishan peoples?

SALMON TECHNOLOGY COMPLEX 2 - SEINING

1. Contextual Description

The principle of the seine is to encircle and impound many salmon at one play of the net. The gear used on the Northwest Coast consisted of a flat net, long and narrow in shape, hung vertically in the water, and equipped with floats, sinkers, and guide lines. Traditionally operated as a beach seine, as in the lower reaches of the Columbia River, it was played out in an arc in the currents near shore on an ebbing tide. A beach free of obstruction was needed to land the net.

Seine nets are among the oldest of fishing devices known to man and were widely distributed. Driver (1939) described the Northwest Coast beach seine as a 'true seine'. Both salmon and non-salmon species can be captured on the principle of 'surround-and-enclose'. Yet within traditional Northwest Coast systems the seine had a limited economic importance to all but a single group, the Chinook people living at the mouth of the Columbia. The seine fishery was the primary producer of salmon for the Chinook.

In the first decade or two of the nineteenth century several non-native observers recorded their impressions of the intensive seining fishery on the Columbia (1). It was operated in late spring and early summer for chinook salmon. Great quantities of salmon were caught and processed; many for use in the far-reaching trading network of which the Chinook and Wishram peoples were an integral part.

The following account, reported by Swan (1857), who was on the lower Columbia when the impact of population decline had already reduced the effectiveness of traditional production systems, is nevertheless most useful. Swan notes small but significant details in his description of how the seine was operated.

> Three persons are required to work a net, except the very large ones, which require more help to land them. The time the fishing is commenced is at the top of the highwater, just as the tide begins to ebb. A short distance from the shore the current is very swift, and with its aid these nets are hauled. Two persons get into the canoe, on the stern of which is coiled the net on a frame made for the purpose, resting on the canoe's gunwale. She is then paddled up the stream, close in to the beach, where the current is not so strong. A tow-line, with a wooden float attached to it, is then thrown to the third person, who remains on the beach, and immediately the two in the canoe paddle her into the rapid stream as quickly as they can, throwing out the net all the time. When this is all out, they paddle ashore, having the end of the other tow-line made fast to the canoe. Before all this is accomplished, the net is carried down the stream, by the force of the ebb, about the eighth of a mile, the man on shore walking along slowly, holding on to the line till the others are ready, when all haul in together.
>
> (p.106)

It is apparent that a knowledge of the tides and currents, as well as other local site features, was essential.

Seining nets could be operated at sites in salt, brackish, or fresh water. Open bays and channels in a sound would provide suitable landing beaches in some locations, as would estuaries and upstream reaches of a river.

2. Types and Materials

Seine nets are readily distinguishable from other netting devices by their characteristic size and shape; they are large, ranging from 100' to 600' in length, relatively narrow, and flat. Table II is a comparison of reported seine nets for the Northwest Coast area. The variation in dimensions is explained by Spier and Sapir (1930:176): each seine was made to suit the conditions of water depths at the site in order to minimize the escapement of salmon.

Great lengths of cordage materials were required to make the large seine nets. Materials used by the Chinook people were imported nettle, Indian hemp, or spruce root fibers. Upriver on the Columbia, the Wishram fiber was woven with a 3 to 4" mesh for chinook salmon. Straits Salish people used willow-bark twine for their seine nets.

Wooden floats and stone sinkers of various sizes and shapes are reported. For example, Ray (1938) says the Chinook used one pound sinkers, grooved and attached with cedar withes, while Spier and Sapir say the Wishram tied three pound sinkers ten feet apart, directly below each float.

Adding to the labour-intensive aspect of seine fishing was the need for stout ropes, 1" thick, fastened along the top and bottom margins of the nets.

TABLE II

COMPARATIVE DIMENSIONS OF SEINE NETS

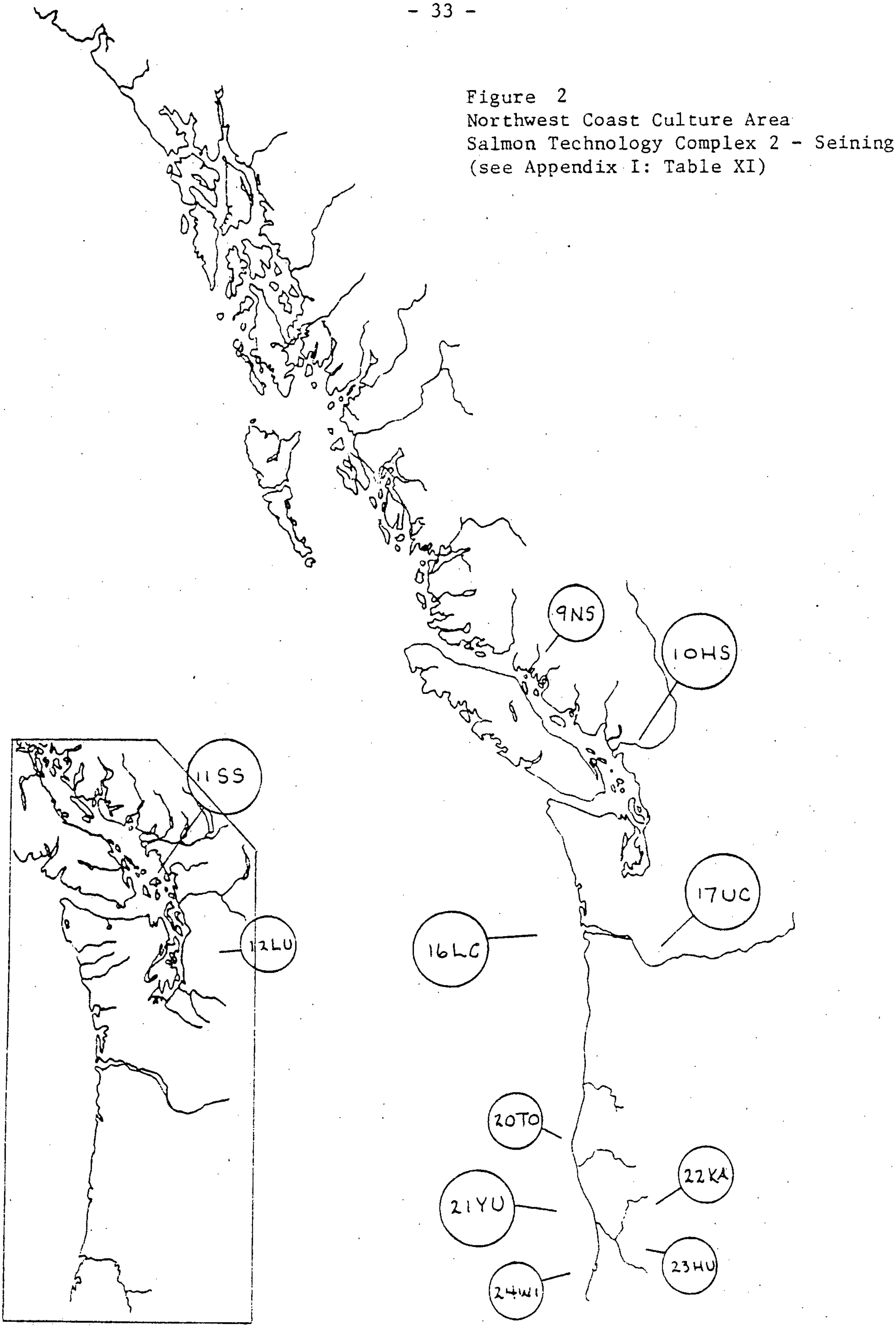
Source	Ethnic Division	Extent	Depth
Swan (1857), Ray (1938)	Lower Chinook	100 ft to 600 ft	7 ft to 16 ft
Spier and Sapir (1930)	Wishram	100 ft	12 ft
Smith (1940)	Puyallup-Nisqually	200 ft	6 ft to 7 ft
Suttles (1951)	Samish Straits	200 ft to 300 ft	- -

3. Distribution

Seine nets were operated in Salishan, Columbian, and Northwestern California regions, but not in the Northern and Wakashan territories. Local resource user-groups among the Comox, Squamish, Nanaimo and Cowichan, Samish and East Saanich communities reportedly used the beach seine but no indication is given of its relative importance as a salmon fishing technique. Suttles (1951:139-40) reports the Samish people used the seine at the mouth of the Samish River in late summer, after returning from the reef net fishery. A little further south, in Puget Sound, the Puyallup-Nisqually (Lushootseed) used the seine net in salt water, among the bays and channels of the Sound (Smith:1940:263; Haeberlin & Gunther:1930:28). A neighbouring group, the Twana, however, specifically denied the use of seines.

There is no doubt that the centre of importance for the seining complex was in the region of the Columbia. Seining was the dominant mode of salmon production used by Chinook people to exploit the important chinook runs on the lower Columbia. Ray (1938:107) refers to it as the most productive method of salmon fishing. An upriver adaptation reported for the Wishram by Spier and Sapir indicates the versatility of the seine, used in this case many miles upstream from the productive lower river fishery. Exact geographical locations are specified both for the Wishram and for the Lower Chinook so that it would be possible to research the site conditions where Columbia River seines once operated.

Figure 2
Northwest Coast Culture Area
Salmon Technology Complex 2 - Seining
(see Appendix I: Table XI)



The productivity of seine nets on the Columbia is estimated by Swan (1857:107) and Ray (1938:107) to have averaged forty salmon per set. Swan noted that a set of the net may yield nothing one time and plenty another:

> Sometimes the net is hauled repeatedly without success; but in seasons of plenty, great hauls are often made, and frequently a hundred fine fish of various sizes are taken at one cast of the seine.
>
> (ibid)

Considering chinook salmon are the largest of the five species, forty fish would yield more than 1,000 pounds of salmon.

In Northwestern California the seine complex is reported as a generalized but not significant fishery. Kroeber and Barrett (1960) point out that most rivers in the area are too fast for the use of seines, although at some places in the lower courses currents are sufficiently slack. They also cite bays, estuaries, and lagoons at river mouths as suitable places to use the seine net.

4. Social Variables

Right of access to seining beaches in the Columbia and Salishan regions is not specified in the literature. In Northwestern California sections of riverfront access were de jure property but ownership of seining beaches per se is unclear. Kroeber and Barrett infer that less important fisheries were open to anyone; they include those operated by gill nets and trawls in this category (1960:4).

At the same time, they suggest that seining beaches were limited in number which may indicate use rights were privately held.

Only wealthy user-groups could afford the seine, according to Smith (1940:263) in reference to the Puyallup-Nisqually. The organization of labour effort required to manufacture and maintain large seine nets put the technology beyond the means of people with limited resource capabilities.

It took a collective effort to operate the beach seine. The minimum number needed to work a small net (100') was three men; a seine 600' would require many more, perhaps six to eight men. There are few clues in the literature to explain how labour was organized, and no information about the catch division.

5. Ecological Variables

The seining complex shows a correlation to chinook salmon production on the Columbia, both at the brackish bays of the Chinook people and at upstream Wishram sites. Gibbs (1877:194) noted in 1855 that inland groups traded dried chinook supplies downriver to coastal groups; springs caught further upstream were less oily, and better preserved. Throughout the nineteenth century and for preceding millenia the Columbia River watershed was the centre of chinook salmon abundance on the Pacific coast. Gibbs (ibid) in his survey of the territory wrote what may be the earliest report on chinook characteristics.

> ...(springs) do not seek either the small rivers of the coast or the lower tributaries near its mouth for the purpose of spawning, but push directly up the principal branches, such as the Willamette, the Snake, etc., to the colder waters of the mountains. In this they are assisted by the simultaneous occurrence of the freshets which enable them to overcome the obstructions with greater ease.

Since chinook linger in the lower reaches before making their ascent to high water Chinook fishermen had an extended seasonal access to the runs. There were suitable beach sites where the seine could be landed. Swan mentioned in particular the fine sweep of beaches in Baker's Bay where the river widens, protected from the sea by the famous bar of the Columbia.

All the other salmon species were also fished with the seine, notably coho salmon which were specified both for the Columbia fishery and as the species caught at the mouth of the Samish River by Straits Salish fishermen.

SALMON TECHNOLOGY COMPLEX 3 - HARPOONS

1. Contextual Description

Northwest Coast composite toggling salmon harpoons were efficient missiles used to impale and retrieve the prey. In the ethnographies the terms 'harpoon', 'spear', and 'spearing', in relation to salmon fishing, refer to one essential form: the toggling head salmon harpoon. Fixed spears and leisters, useful implements to retrieve salmon from an enclosed space, could not be employed to capture a fish so strong and full of fight as salmon. As Kroeber and Barrett (1960) stated:

> For use on land the spear was in most regions preferred to the harpoon, probably because retention of game by a line was difficult or impracticable on land, whereas the harpoon thrust or thrown from shore or boat into fish...rarely fouls its line in water and enables the hunter to retrieve his prey.
>
> In (Northwestern California) the true spear is so little used in fishing that it becomes quite secondary to the harpoon. In fact, about the only spears employed are the sharpened pole used for the flat fishes on tide-water flats (i.e., not salmon)...The harpoon, with its toggle head or heads, was used for larger fishes.
>
> (1960:74)

Similarly, Oswalt concludes in his extensive study of hunting and fishing technology that spears were not used to capture salmon.

> Without belittling the importance of leisters, we can note that they probably were not an important means for obtaining fish except under certain circumstances. When fish were plentiful, in shallow water, and restricted in their movement as by a tidal pool or weir, the harvest with leisters could be great. However, since a leister usually was designed to impale one fish at a time, the form was a rather inefficient means for taking most fish on a large-scale basis. Facilities such as nets and traps were far more effective and more often employed.
>
> (1976:94)

Common usage of the words 'spear' and 'spearing' in the literature has led to some confusion on this point. Nevertheless, the implement described, typically, is a toggling harpoon. It is apparent that over time steady spears and leisters were superseded by the improved technology of composite toggling salmon harpoons as a primary mode of fishing.

A wide range of locations were suitable for daylight fishing with a harpoon providing the water was clear enough to see the fish. Men used the harpoon from canoes in the estuaries where salmon congregate, or at river bars, confluences, and in clear shallow streams. Night fishing was also common. The flicker of torchlight brings curious salmon to the surface of the water within range of the harpoon. Halkomelem people fishing at night set up a blind on the canoe so their shadows would not fall on the river and frighten fish away (Duff:1952: 67). Massett Haida fishermen had a similar night shade on their canoes, and the Skidegate Haida and Bella Bella Kwakiutl used the harpoon at night without torches when the sea was phosphorescent (Drucker:1950:240). On the West Coast, the Nootka fished at night off the mouths of rivers; Sproat (1868:221-222) saw thirty canoes at a time, each with one man steering and the other standing in the bow with his harpoon.

The proper use of the harpoon is a highly skilled activity. Stern (1934) watching Lummi fishermen at low tide along the river channels of the estuary, reported:

> ...a good spearsman usually strikes the spinal cord of the fish and kills it at once.
>
> (ibid:51)

When Jewitt accompanied Maquinna on a fishing expedition he made this observation:

> I also went with him several times in a canoe, to strike the salmon, which I have attempted to do myself, but could never succeed, it requiring a degree of adroitness that I did not possess.
>
> (1967:[1803-1805]:88)

Typically, the harpoon was thrust, not thrown, into the fish.

2. Types and Materials

Northwest Coast harpoons were finely-made complex pieces of equipment. The three-part composite harpoon head consisted of two flaring bone hafts and a point inserted between them made of bone or antler. The head was wrapped and covered with pitch; it was attached to the foreshaft by a line. Single-head harpoons were the principal type used in the North, and double-head harpoons with two divergent foreshafts were common from the Wakashan region south. Both types were constructed on the same model.

(a) head: a plain bone point inserted between two bone hafts which have been carved to fit or softened by boiling; this then lashed with sinew, cherry bark, or other binding material, and pitch-coated.

size - 2½ to 4" long

(b) foreshafts: divergent foreshafts of equal or unequal length were made of hardwood or ironwood, 2 to 3 feet long, and fitted to a socket at the base point of the head.

(c) shaft: made of fir or pine.

size range from 8 to 18 feet in length.

(d) lines: made either of stout cordage materials (cedar bark) or, as a 'leader' (lanyard), of elk or deer hide.

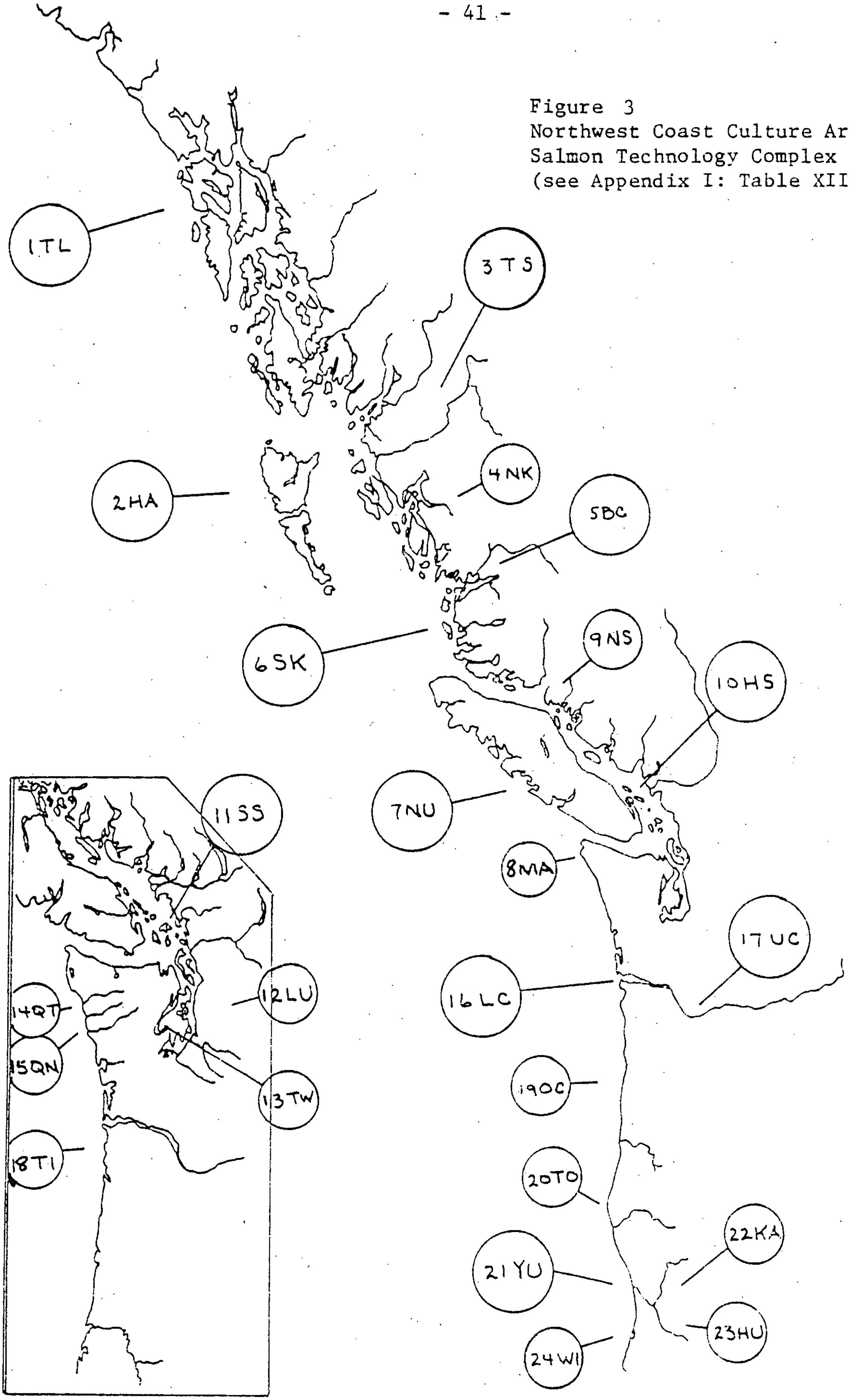
Elmendorf provides a functional description:

> A line ran from the lashing midway of each head and was attached to the shaft back of the foreshafts. The lines from the heads were slack when the heads were attached. When a fish was struck the head detached, and the line attachment to the middle of the head acted as a toggle, pulling the barbs sideways in the flesh. The struck fish was played and landed with the shaft.
>
> (1960:78)

Binder lines were tied in different ways; Boas (1909:489 Fig. 156) illustrates the line running the full length of the shaft back to the fisherman's hand.

Fixed spears and leisters, as mentioned previously, were mainly used to remove salmon at traps and weirs, or occasionally to catch them in creeks and streams. The leister, which had a wide distribution in the north, is a particularly good retrieval implement. Its two

Figure 3
Northwest Coast Culture Area
Salmon Technology Complex 3 - Harpoons
(see Appendix I: Table XII)



outer prongs recurve inward toward an interior central prong. Archaeological evidence indicates spears were used on the Northwest Coast for thousands of years. An early form was the fixed spear with barbed one-piece head of carved bone or antler. Its use continued into the historic period.

3. Distribution

All Northwest Coast ethnic groups exploited salmon with the harpoon. Because of the diversity in salmon fishery locations where the harpoon could be employed, every local resource user-group had suitable sites. What is not clear in the literature is the relative economic importance of harpoon technology. One source estimated that for the Nootka harpoons ranked second only to traps (Sproat:1868:221-2). In other production estimates, the harpoon ranked second to weir technology (Tlingit, Haida, Twana); and third to nets and weirs (Chinook, Wishram, Quileute).

The productivity of harpoon fisheries is seldom reported. Sproat (ibid) witnessed "a favourable catch" of forty salmon caught in a morning's work by one harpooner.

4. Social Variables

The Wishram in the upper Columbia and the Tsimshian on the Skeena built spearing stations in the narrow channels and eddies of the rivers. On the Columbia each station had an overseer, and six to ten men who claimed use rights to the site. Any one of them "might pre-empt the best spot temporarily" (Spier and Sapir:1939:175-6). Columbia River spearing stations were highly valued properties. Ownership of the site was held by a lineage group and other people were not permitted to fish there. A harpoon was the private property of the individual; it was said, "each man fished with his own spear" (ibid).

In other regions, ownership rights that affected resource user groups when they fished with the harpoon were vested in salmon streams. Among the Haida, Tlingit, and Tsimshian, for example, island streams and the tributaries of mainland streams were owned in their entirety by lineage resource holders.

5. Ecological Variables

Water clarity is the essential variable for daylight fishing with a harpoon; but other factors that may affect the movements of salmon -- currents, salinity, and thermal conditions -- had to be considered by the harpooner. Salmon swim at depths of three to five feet and deeper (cf Duff:1952 re Fraser River stocks). Individual stocks of salmon display characteristic delays off the mouth of a river that could be exploited by local resource users.

On the Fraser and its tributaries, the harpoon is associated with early spring when the water is low and clear, before the freshet. Later the river is too silty for spearing. Chinook were taken with the harpoon in spring; in late fall Halkomelem people fished for coho on the Fraser with the aid of torchlight.

Spearing stations in the canyons of the Columbia were made to suit the autumn water levels of the river. They were constructed separately from dip net stations to correspond to seasonal variations of the flood stage. Whereas dip netting was a summer technique, harpoons were used on the Columbia in the fall. Late runs of chinook would be available then, as well as coho, chum, and some late running sockeye stocks.

Fishing at the mouths of streams and rivers, or in smaller island rivers, the Haida, Tlingit and Tsimshian used the harpoon to take all species of salmon. de Laguna (1972:384-385) recorded a spearing fishery for chinook salmon swimming three feet below the surface at the mouths of rivers; fishermen thrust the harpoon from a canoe into the clear water. Dawson (1880:109-110) also reported Haida fishermen with harpoons in the estuaries of streams.

SALMON TECHNOLOGY COMPLEX 4 - TRAWLING

1. Contextual Description

The traditional trawl net intercepted salmon ascending the stream by the use of a large net towed between two canoes. The canoes, manned by two to four men each, were paddled downstream at a rate that slightly exceeded the speed of the current so that the bunt of the net billowed out. A wide-mouthed conical net was the common type used. It was equipped with a towing rig of poles and ropes to support the mouth of the net, holding it open. When the catch was made the canoes closed in together to take up the net.

Alexander Mackenzie witnessed the use of a trawl net in the lower reaches of the Bella Coola River, July 19, 1793.

> The men were fishing on the river with dragnets between two canoes. These nets are forced by poles to the bottom, the current driving them before it; by which means the salmon coming up the river are intercepted, and give notice of their being taken by the struggles they make in the bag or sleeve of the net.
>
> (p.371)

Another early reference to trawling was recorded in the journals of Simon Fraser (July 7, 1808) when he was in the vicinity of Upper Stalo (Halkomelem) villages on the Fraser.

> In the evening we observed the Indians fishing; their nets, which resembled purses, were fixed to the end of long poles and dragged between two canoes.

Trawls work best in turbid waters where the stirred up sediment helps to obscure the net; silt-laden rivers like the Fraser and streams swollen after a freshet reduce the visibility for salmon. Trawls were also operated at night, or at the half-light of dusk or dawn. The critical water features were moderate, steady currents and a level streambed with depths of at least six to seven feet.

Trawling was reported at locations in the estuaries and lower reaches of important salmon rivers. Suitable locations in the Fraser also were found some distance upstream from the river mouth. Here the size of the river made it impossible to construct dams or weirs but feasible to operate a trawling fishery.

2. Types and Materials

The different styles of nets and rigs used to trawl led to a confusion in terms in the ethnographic accounts. Trawls are frequently called dragnets or bag nets and, less frequently, bag seines, river seines, drift nets, drifting bag nets, pocket nets, and single drifting bag seines. Following Drucker (1950) and Suttles (1951) I use the term 'trawl' to describe the process, reserving the use of more specific words for types within the category.

The main division in types of nets is between flat and conical shapes.

a) Most common is the conical net drawn on poles with a rig of ropes, floats, and corner sinkers. The Quileute trawl is an example:

> The dragnet was bag- or pocket-shaped, coming to a point at the closed end. It was suspended between canoes and operated as they floated downstream. The mouth of the net was held open under water by means of a line from each canoe tied to the upper edge of the mouth and a pole from each canoe pushing down the lower edge of the mouth. Light lines were passed across the mouth of the submerged net and held in the hand of the fishermen as feelers. When these lines vibrated, it was known that a fish had entered and the poles were pulled up, thus closing the net.
>
> (Pettitt:1950:7)

Olson describes the trawl used by the neighbouring Quinault as very similar to this; his explanation is that the poles were tied to bottom sinkers, while the cord was tied to the upper corners (1936:29-30).

In Northwestern California the conical net was set on an A-frame and trawled with special rigs. The net was the self-same object used as a lifting net (dip net) on other occasions (Kroeber and Barrett: 1960:53). There are reports that two of the large A-frame nets were attached to rigging and towed together, forming a double conical trawl net, unique to the Yurok and Hupa. In the same region, the Klamath River, the more common conical net was also employed.

b) The drifting bag seine was a flat net used as a trawl. Among some groups it was mounted on poles, but it was also rigged with rope and trawled in the same manner as the conical net, so that it billowed out to form a bunt. Floats, sinkers, and bone rings were used on the flat net (Table III shows the main divisions of trawl net types throughout the Northwest Coast).

Landing the trawl net required a fine sense of timing and careful manipulation of the gear. When the net was ready to be taken up the two canoes moved in together, at the same time increasing their

TABLE III

TYPES OF TRAWL NETS

Source	Ethnic Division[a]	Trawl Net Type	Rigging Gear
Niblack (1890)	Haida	flat	poles
Mackenzie (1793)	Bella Coola	conical	poles
Duff (1952)	Halkomelem - Tait	1 conical 2 conical	poles ropes
Suttles (1955)	Halkomelem - Katzie	flat	ropes
Smith (1940)	Lushootseed	flat	poles
Haeberlin & Gunther (1930)	Lushootseed	conical	poles
Pettitt (1950)	Quileute	conical	poles
Olson (1936)	Quinault	conical	poles
Driver (1939)	Tolowa	conical	---
Kroeber & Barrett (1960)	Yurok	1 conical 2 double conical 3 flat	poles trapezoidal frame or poles rope
Driver (1939)	Karok	conical	---

[a]selective listing of examples

speed sufficiently to keep the catch in the net; then they raised and twisted the poles to lift the heavy net into one of the canoes. From there the catch was discharged into the other canoe (cf Duff:1952:69).

Materials used for the nets included nettle fiber, Indian hemp (Apocynum cannabium) and, in Northwestern California, the leaf of Iris macrosiphon. Cedar bark ropes were common in many areas. Netting mesh size was unstated. Table IV compares the dimensions reported. The conical net opening was either rectangular or (in Northwestern California) trapezoidal; the width was typically 2-3 times the height.

3. Distribution

Some ethnic groups in every region of the coast used the trawl. The distribution of the complex is correlated to major river systems and other important salmon rivers. Rivers specified as trawling locations are: Atnarko-Bella Coola; the lower Fraser and its tributaries (the Pitt, Alouette, Harrison and Chehalis); Squamish; Columbia; Quileute and Quinault; and the Klamath River. Two major rivers not specifically identified in the literature are the Skeena and Nass Rivers. The characteristic use of trawls at river mouth locations and in the lower courses of large streams was reported for all groups living at the estuaries of the rivers just itemized, and for the Haida. A smaller upriver adaptation of the trawl was used on the Skagit and Nisqually Rivers in Puget Sound.

TABLE IV

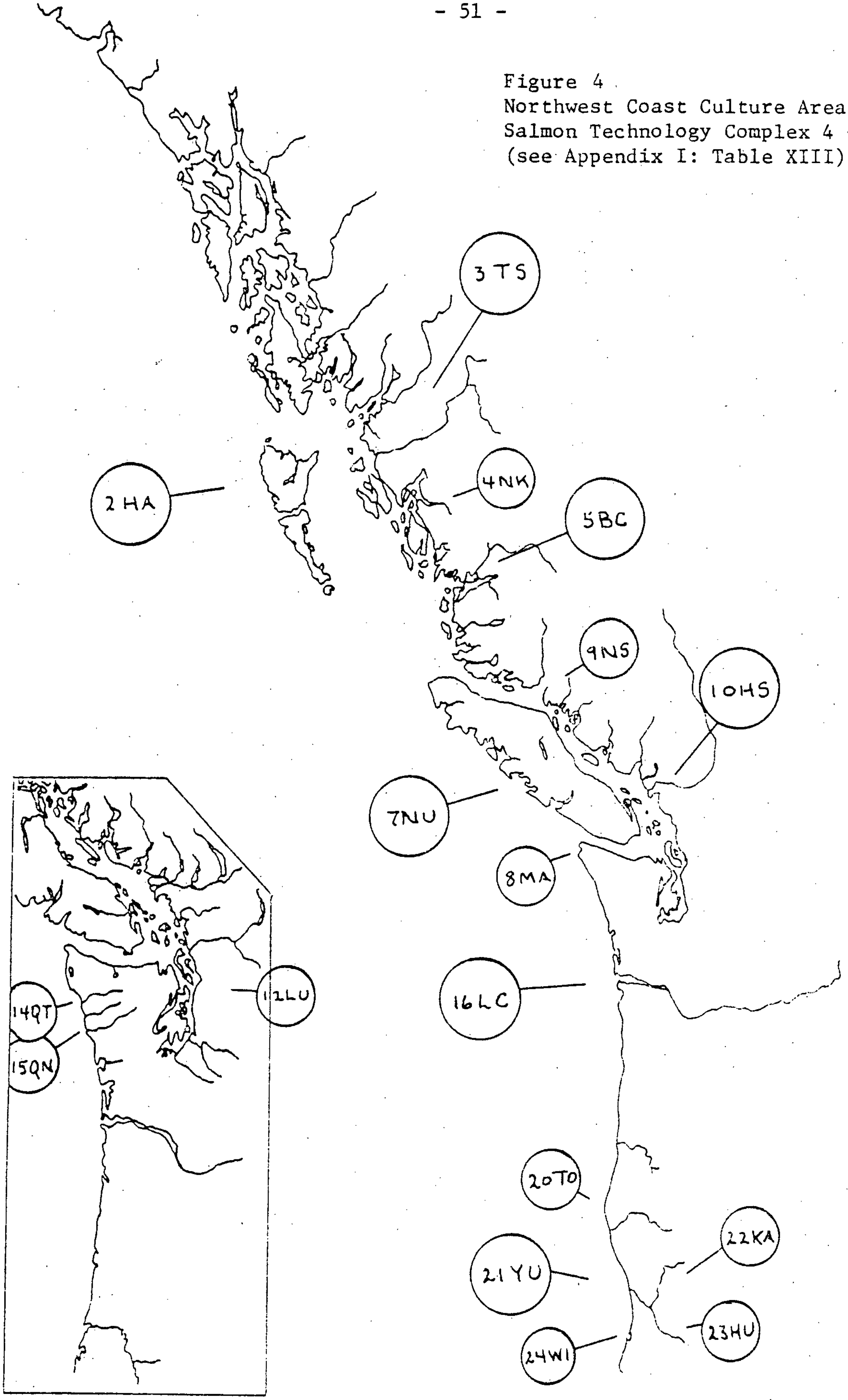
COMPARATIVE DIMENSIONS OF TRAWL NETS

Source	Ethnic Division	Width at opening	Height at opening	Depth of net
Drucker (1950)	All Northern and Wakashan groups	12 ft[a] to 24 ft	6 ft to 12 ft	18 ft to 24 ft
Duff (1952)	Upper Stalo Halkomelem	12 ft	3 ft	'several ft '
Smith (1940)	Nisqually	12 ft	6 ft	flat net
Olson (1936)	Quinault	10 ft	4 ft	10 ft
Kroeber and Barrett (1960)	Northwest California groups	4.5 ft[b] 6.5 ft	1.5 ft	8 ft

[a] Converted to ft from fathoms.

[b] Trapezoidal opening. Converted from metric.

Figure 4
Northwest Coast Culture Area
Salmon Technology Complex 4 - Trawling
(see Appendix I: Table XIII)



Frequency indications are not available. The productive potential of the salmon trawl suggests that it should be ranked as an important mode of production for local resource groups exploiting estuarial sites. The Stalo (Halkomelem) on the Fraser could exploit an appreciable abundance of salmon in the lower course of the river by trawling. Potentially high yields were possible during the main runs. On the Atnarko-Bella Coola system when Alexander Mackenzie was exploring the waterway he encountered a chief, whom he had previously met, trawling with a crew of men. In his journal, July 24, 1793, he noted: "He was seining between two canoes and had taken a considerable quantity of salmon" (1970: 1793 :385).

4. <u>Social Variables</u>

An intensive labour investment was required to produce the netting and cordage for large trawl nets. Suttles (1955:22) speaking of the Katzie (Halkomelem) reports that the trawl net was "too valuable for every man to own, being made of quantities of material that was obtained through trade with the Interior". Even where local materials were used, a trawl net represented many hours of labour to produce. Data collected by Suttles verifies that as a means of production, trawl nets were 'capital goods' owned by Salish men of rank. However, use rights to resource areas where the trawl could be operated was apparently unrestricted, and open to local resource groups.

5. Ecological Variables

Any species of salmon could be caught with trawling gear but it was operated in most areas during the runs of chinook and sockeye. Chinook salmon enter the streams in late spring-early summer in most northern and central rivers. In the south, the rivers in Northwestern California have important fall runs of chinook. Kroeber and Barrett (1960:41) report that the Klamath was best for trawling in the autumn when water volumes and velocity had decreased.

Typically sockeye run in late summer and were taken in trawls on the Atnarko-Bella Coola in July, and on the Fraser in August and September. An early run of sockeye enters the Quinault River in May when the stream is stirred up by freshets and suitable trawling conditions exist. Turbid waters were preferred to obscure the net.

In the river deltas where bars and shoals restrict the vertical subsurface dimension through which salmon runs must pass, the trawling net had an advantage. Hill-Tout (1907:90) recorded fishermen trawling off the mouths of the Fraser River on the tidal flats. Changes in tidal currents would no doubt effect the speed and manipulation of trawl nets. In tidal waters the net would have to be dragged against the current on an incoming tide.

To summarize the main ecological variables: the trawl was suitable in rivers with large salmon runs, moderate currents, turbid waters and appropriate water depths for the net.

SALMON TECHNOLOGY COMPLEX 5 - GAFFING

1. Contextual Description

People on the Northwest Coast fished with the gaff in roily or turbid streams, impaling the salmon by the action of a sudden upward thrust of the shaft. Differing techniques were used depending on the fishery location. One was to gaff from the bow of a canoe. The fisherman allowed his gaff to ply the depths of a stream, hook facing downriver, while his partner gently paddled or allowed the current to carry the canoe along. We have two early accounts that describe this process; the first was written by Harrington who visited Tlingit territories early in the 19th century.

> Especially cohoes are to be obtained in riled water such as comes from glaciers. The Indians row up a muddy river and as they float down hook cohoes from the muddy water at various places. The cohoes are swimming up and the gaffers are drifting down.
>
> (Harrington: in de Laguna:1972:386)

In the second, Swan describes gaffing at night on the Palux River, a salmon stream that flows into Shoalwater Bay in Chinook territory.

> As the boat drifts down with the tide, the pole, with the hook attached to it, comes in contact with the salmon, who...are generally quiet as soon as the tide begins to ebb. As soon as the Indian feels the fish, he jerks up the pole, and rarely fails to fasten the hook into the salmon, who is then pulled on board...The whole

> operation requires a great deal of dexterity and practice...for the salmon is a very powerful fish, and a large one makes a great commotion when hauled to the surface... splashing and thrashing about in a fearful manner.
>
> (1857[1853]:137)

A stout binder line from the hook to the shaft ensured that the struggles of the fish would not cause the shaft to snap in two. To be efficient as a salmon fishing implement the line was important. The evolutionary step that occured with the addition of a detachable hook, to take the strain of a large fighting salmon, moved the gaff from its former function as an accessory to a primary production method. The detachable hook and binder line were a technological advance that produced an incremental improvement in its use for salmon fishing.

Gaffing may be considered complementary to spearing technology. The requirements at harpoon fisheries are clear water and good visibility; gaffing sites were just the opposite, roily, stirred up waters or poor light conditions. Silty rivers after a run off, or riffles and rapids in the stream, provided suitable gaffing places. Night fishing was common. The complex is associated with fall fishing for coho and chum salmon particularly in small rivers and streams.

2. Types and Materials

There were two main types of gaff hooks: (a) the steamed and fire-hardened bent wood hook made from a hardwood; and (b) a long bone barb fastened at an acute angle to the foreshaft to make a v-shaped hook. When iron and steel hooks became available, they replaced the steam-bent wooden hooks. Files and rasps were hammered into shape by the Chinook (Swan:1857:38), for example, in the early post-contact period.

Shafts of fir or spruce 18' - 20' were reported as the usual length. Smith, however, reports 8' long shafts of hazel or fir. The lashings of cherry bark or other binding materials were covered with pitch. Lines are referred to as 'stout cords' (cedar bark rope?) about three feet in length.

Swan (1857) collected details of the construction:

> ...(the hook) is in size as large as a shark-hook, having a socket at one end formed of wood...The socket is made from the wild raspberry bush (Rubus spectablis), which, having a pith in its centre, is easily worked, and is very strong. This socket is formed of two parts, which are firmly secured to the hook by means of twine, and the whole covered with a coat of pitch. Attached to this hook is a strong cord about three feet long. A staff or pole from eighteen to twenty feet long, made of fir, is used, one end of which is fitted to the socket in the hook, into which it is thrust, and the cord firmly tied to the pole.
>
> (p.38)

The steam-bent wooden hook, and later the iron hook, were more common than the v-shaped hook, and possibly more efficient. But both Stern (Lummi:Straits Salish) and Barnett (other Salish groups) refer to a detachable bone hook used as a gaff, "fastened to a socket which fits into the end of a long pole" (Stern:1934:49). However, Suttles (1951:142-3) speaking of the same group (Straits) reports a steam-bent wooden gaff hook.

3. Distribution

Ethnic groups in each of the regions of the Northwest Coast used the gaff to some extent but its importance decreased south of the Columbia. Most emphasis is given for Tlingit (the island tribes, plus the riverine Chilkat, and the Yakutat), Southern Kwakiutl (Nimpkish), the Straits, and the Shoalwater Chinook; the gaff was commonly used by these groups. Among other Northwest Coast tribes apparently it was less important although local resource users with access to fall runs of chum and coho in riled streams employed the gaff.

4. Social Variables

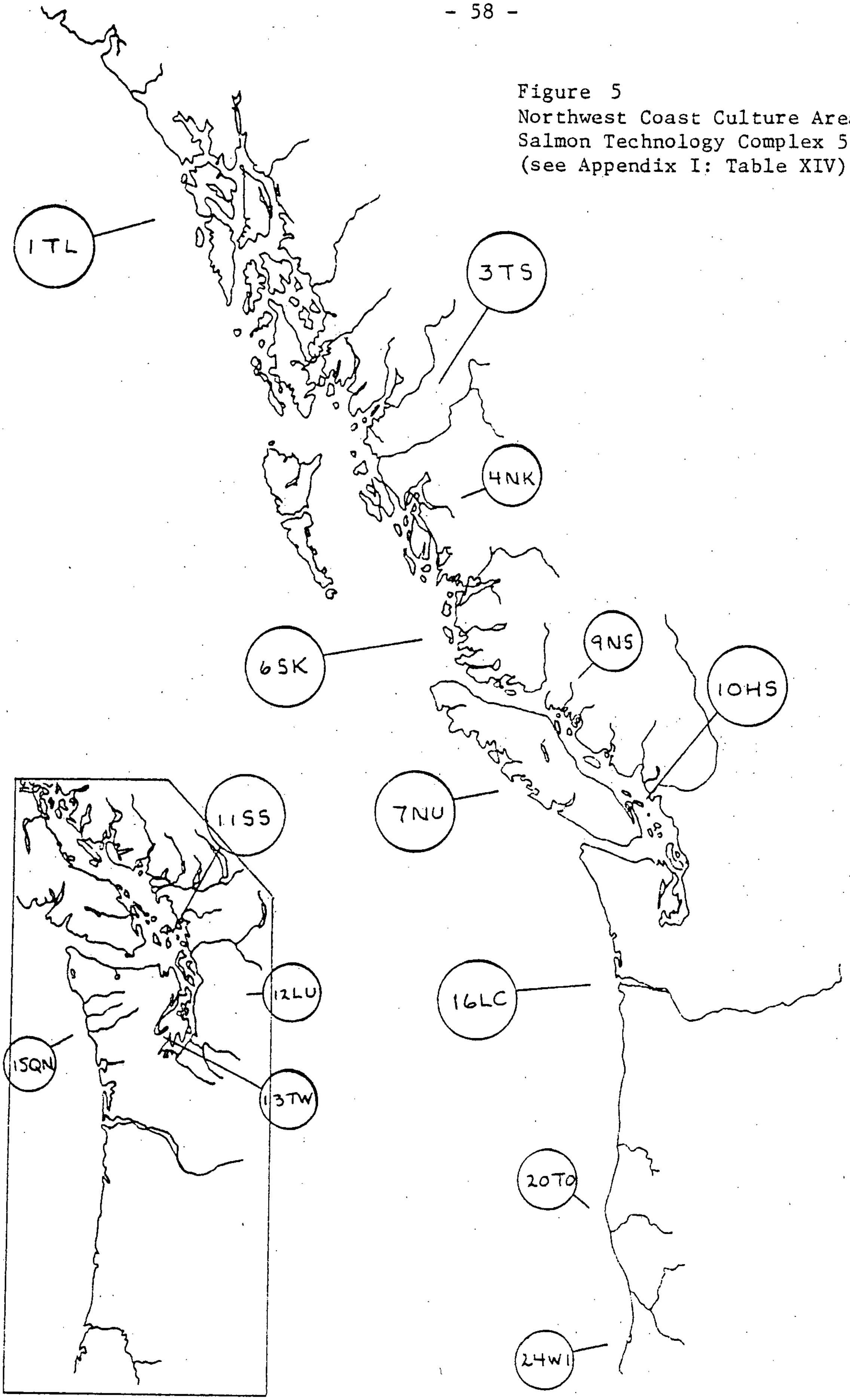
Notions of ownership of places where the gaff was used are not specifically mentioned. The overriding social rules of the ownership of local resource use areas, rivers, streams, and bays, would prevail.

Since the materials and labour needed to make a gaff are relatively easy to obtain there were no constraints on access to the implement; like the spear, it would be the private property of the man who made it.

5. Ecological Variables

Gaffing is suited to conditions of fast roily waters, muddy streams, or night fishing. Most references link it to fall fishing in

Figure 5
Northwest Coast Culture Area
Salmon Technology Complex 5 - Gaffing
(see Appendix I: Table XIV)



streams for chum and coho species; while its importance as a production system is unassessed it is feasible that to local resource groups gaffing provided significant food for winter storage.

In addition to the stream fishing from a canoe that has been described, people gaffed from the riverbanks when the runs were heavy. In the canyons of the Skeena fishermen used gaffs in the heavy rapids and torrents, standing on precarious footholds in the rockface, or on stagings built out over the currents.

SALMON TECHNOLOGY COMPLEX 6 - GILL NETS

1. Contextual Description

Gill nets set near a river bank or along the shore in sheltered coves ensnared by the gills a salmon as it tried to pass through the mesh opening. Once caught, the fish can neither retreat nor proceed. Different net mesh sizes were used for each species. The head of the fish passed through the net but the gills became entangled. Several tactics were employed to make nets less visible to the salmon. They were camouflaged with dyes; or set in streams obscured with silt. They were set at night, in which case the fishing party remained nearby with a small fire for warmth, listening for the signal of a crab shell rattle. They were set at locations where the runs were heavy, or where salmon came inshore to feed on herring and other small prey.

2. Types and Materials

The gill net was 20 to 25 meshes wide hung vertically with the aid of floats and sinker stones. Typically, one end was staked on shore. It was a long, flat net, made to suit the dimensions of the site where it would be set, varying from 15 to 50 fathoms in extent. Anchors at each lower corner held the net in position. Fishermen would leave the net untended for a period of time, returning at intervals to retrieve the gilled salmon, dispatch them with a blow, and fill their canoes.

Netting materials used in Northwestern California, iris fiber (Iris macrosiphon), were the same as for other nets. People in the Klamath drainage traded iris fibers to their neighbours the Tolowa who had no sources of their own. Kroeber and Barrett noted:

> The restriction of range, the thinness of the fiber, and its high tensile strength account for the value placed on it.
>
> (1960:57)

In other regions, the Straits Salish used nettle fiber or imported grass; Suttles was told that nettle fiber nets would last two or three years if dried after use. Halkomelem fishermen traded with the Interior Salish for Indian hemp (Apocynum cannabium) to make netting cordage. Nettle fiber was also used for gill nets on the Nass River.

Bone and antler net gauges used to ensure an even mesh size range from 92.5 mm to 116 mm (approx. 3½ to 4½ inches) in a collection from the Klamath area (Kroeber & Barrett:1960:Plate 15, and p.172). Kroeber (1925:85:quoted ibid) reports a Yurok salmon net with a "scant 3 inch" mesh; Hewes (Field Notes:1940:quoted ibid) reports 3 to 4 inches. Hewes had a Tolowa informant refer to 7½ inch mesh used to gillnet chinook salmon in the Smith River estuary. Kroeber believed this was inaccurate but admitted that 50 to 60 lb chinook are known in the Smith system. Further north, Harrington reported net gauge sizes of modern gill nets used by Tlingit fishermen in the early twentieth century as follows: chinook - 8"; coho - 6"; pinks, sockeye and chum - 5½".

These are the only mesh sizes reported; there is a lacuna in the sources.

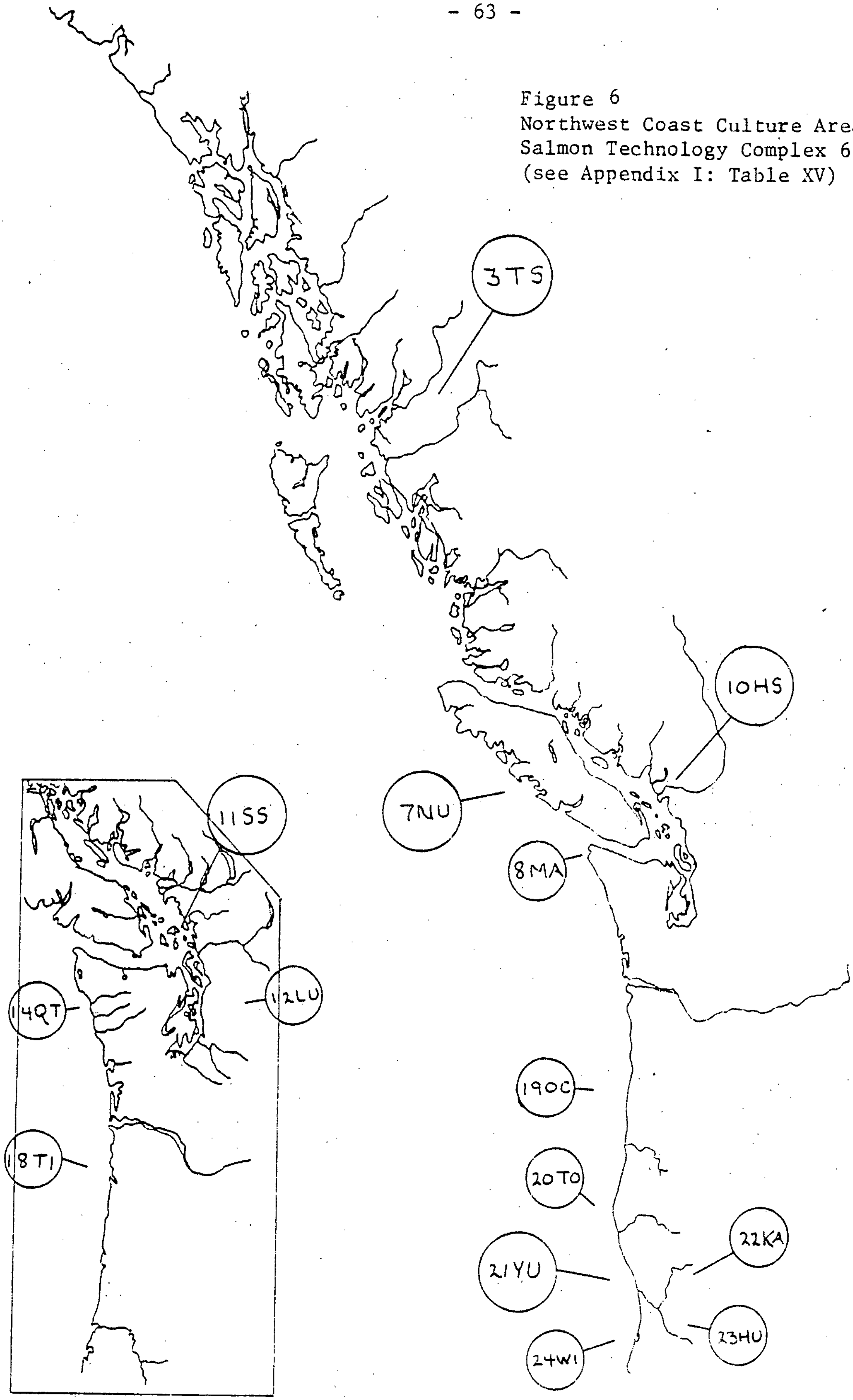
3. Distribution

Salish and Northwestern California groups reported gill net technology with more frequency than people living in other regions. Straits Salish set gill nets in salt water along the mainland shore or out in the islands. The Klallam took chinook with gill nets off the Dungeness Spit and in Washington Harbour during the herring season; the Saanich did the same in Ganges Harbour on Saltspring Island. In addition they took coho, pinks, and chum salmon in season. In Northwestern California the gill net was used at riverine sites; it was set in the deep estuarial waters of the Smith River and at places in the Klamath where the current was not too fast.

In the North the Tsimshian were principal group reported; gill nets were set at locations in both the Skeena and the Nass. The evidence is less clear for other Northern groups. Drucker's Massett informant said the Haida received their nets ready-made from the people of the Nass (1950:239).

There is archaeological evidence that the gill net was used by the Makah for chum salmon in the Hoko River over a very long period, perhaps several millenia (2). Sapir and Swadesh collected information on gill nets from Nootka informants despite Sproat's claim (1868:221) that no nets were used for salmon (3). However, there were social constraints on the use of gill nets among Nootka resource groups, and

Figure 6
Northwest Coast Culture Area
Salmon Technology Complex 6 - Gill Nets
(see Appendix I: Table XV)



there is no evidence that they were ever considered a common fishing method. Indeed, during this period, the gill net was not an intensive fishery anywhere on the coast.

4. Social Variables

Use rights to gill net locations are not distinguished in the sources from general references to site ownership. Kroeber and Barrett (1960:3,4) state as the rule for the Klamath basin private ownership of riverbank fishing sites. While they do not exclude gill net locations, neither do they specify them. The same case holds for Haida, Tsimshian, and Nootka sources.

Sapir and Swadesh's Nootka informant [c.1910] suggested the gill net was not widely available to most people.

> Not many had nets. I recall ten had them when I was a boy. It was the old men who owned nets.
>
> (1955:30)

In the Katzie (Halkomelem) data, Suttles (1955:22) makes a similar comment in reference to both gill nets and trawl nets. Nets were valuable, particularly in areas that used imported cordage materials. Suttles was told that a "set-net might be 200 feet long, but if a man were 'not siɛ'm enough' [that is a man with high social status] it might be shorter". Only important individuals or resource holders had sufficient wealth to own gill nets (4).

A single fisherman could set and operate the gill net but usually another person accompanied him to handle the canoe and give assistance. Communal fish drives are reported among the Hupa (Goddard: 1903:24), canoe-loads of men noisily directing salmon towards the net. (Perhaps they had to do this to compensate for the clarity of the stream; it seems not to have been the general usage.)

5. Ecological Variables

As a passive netting method, it was necessary for the gill net to be set where visibility was obscured by turbid water conditions or by darkness. Where salmon were densely concentrated, as when feeding on herring in the bays, or prior to entering the river mouth, a gill net was less conspicuous. Gill nets could be set at sites where it was not possible to place a weir or trap, in deep waters at the edge of a bay or large river.

Seasonality of the fishery varied with species and location. The Nootka took chinook in spring when pilchards entered their inshore waters. The Straits Salish also caught chinooks in a salt water fishery, especially during the herring runs. Gunther (1927:198) reports that the Klallam took chum in late July and coho in the autumn. Their neighbours, the Makah, set nets for fall runs of chum salmon in the Hoko River which flows into the Strait of Juan de Fuca.

Halkomelem used set nets for sockeye as well as chinook in the Fraser River in the early and late summer months. While on the Smith River in California the Tolowa took the late fall runs of chinook. As a flexible technique, the timing of salmon inshore and riverine migrations could be accommodated to suit variations in local resource conditions.

SALMON TECHNOLOGY COMPLEX 7 - TIDAL TRAPS

1. Contextual Description

At places along the shore in the intertidal zone where migrating salmon congregate in large numbers stone tidal trap structures were maintained. Stocks of salmon that habitually delay before ascending the rivers to spawn will drift into the intertidal reach on an incoming tide. Where this characteristic coincided with favourable sea currents and tidal action, a wall or obstruction was constructed as a trap. Stone walls were set out from shore in crescentic wings, individually or in series, creating artificial tidal pools to impound the salmon. When the tide receded, salmon were stranded behind the barrier of the trap.

Natural sites in shallow coves and tidelands could be improved with the addition of boulders or stakes, and made to serve as regular resource locations. Apparently, stone tidal traps were the most common kind but other materials were sometimes used: split cedar stakes and fencing materials. Whatever the configuration, the principle was the same: the incoming tide carried salmon over the obstruction, and the ebbing tide left them aground.

2. Types and Materials

The Kwakiutl built stone tidal traps in the estuaries of salmon streams, described by Boas (1909:465) as simple wing-dams extending 60 to 70 fathoms from shore. At some tidal trap sites, wing-dams were constructed in series with three, four, or more, along each side of the river mouth (Fig. 7). Stone tidal traps consisted of large boulders set in formation to create a stout wall. The remains of stone tidal traps can still be seen at many places along the coast, recognizable by the characteristic size and line configuration as man-made. This is the basic type of stone tidal trap that was utilized by Northwest Coast fishermen.

Barnett (1955:82-83) describes two other kinds of tidal traps used by Northern Gulf Salish. The first (Comox) is simply an enclosure of rocks and stakes built on the tidal flats. The second (Sechelt, Homalco, Klahuse, Squamish) is a weir framework with a lattice-work gate hinged along the bottom.

> At low water it lay flat and exposed. Rock weights were set upon it and to its top were fastened lines leading to shore. When the tide was full, the lines were used to bring the latticework fence in an upward position, and the outward flow held it against the framework.
>
> (ibid)

This trapping device was built at the narrow neck of a cove or across the mouth of the river.

de Laguna (1960:116,69) reports that the Tlingit (Angoon) had sharpened stakes set into the tidal trap to impale the salmon as the tide went out. McIlwraith (1948:221) describes the Bella Coola "ocean fish trap" as a pen made of a series of stakes, entered by the salmon at high tide, and "then closed". With the opening obstructed, salmon were impounded with the falling tide.

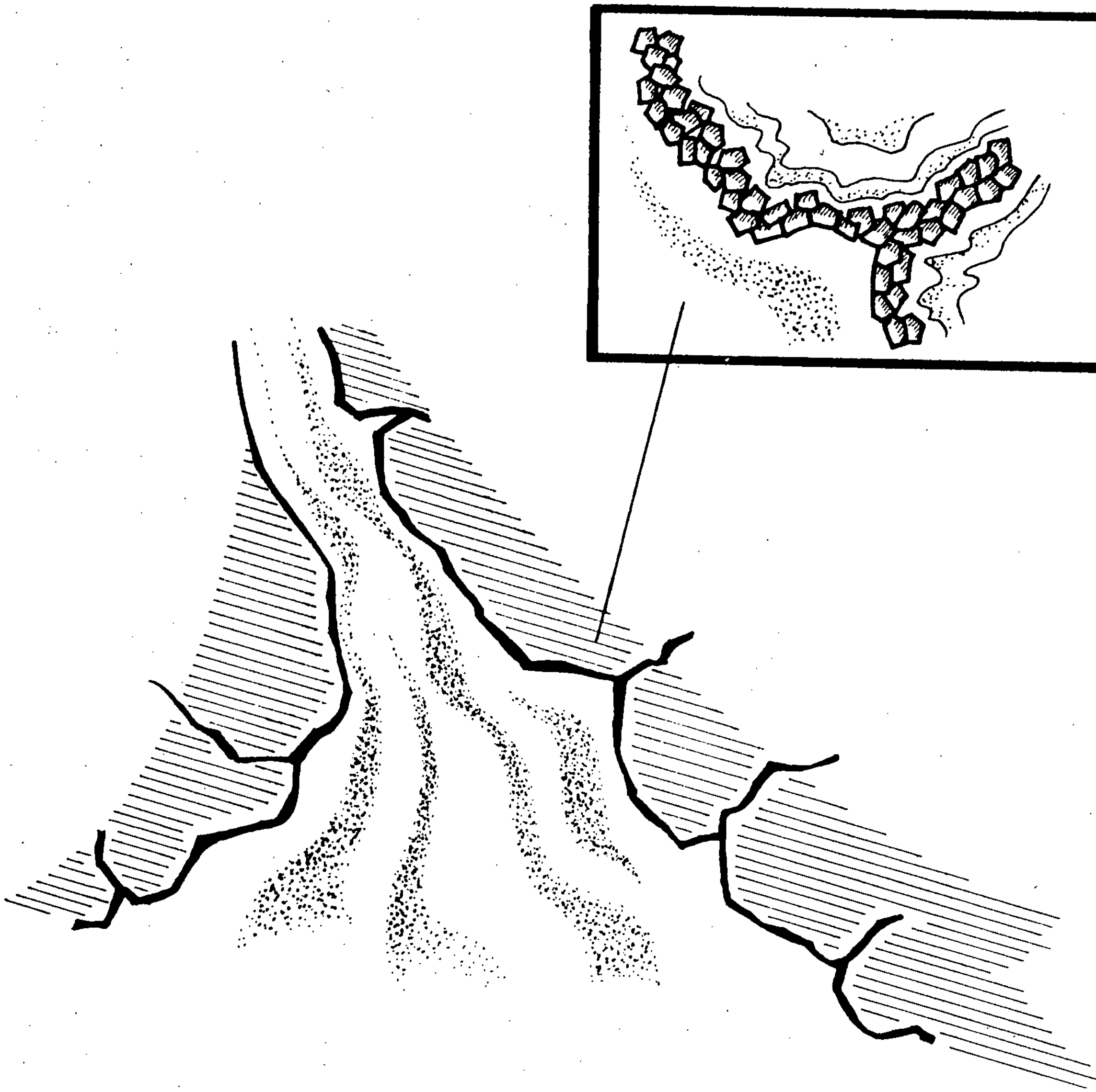


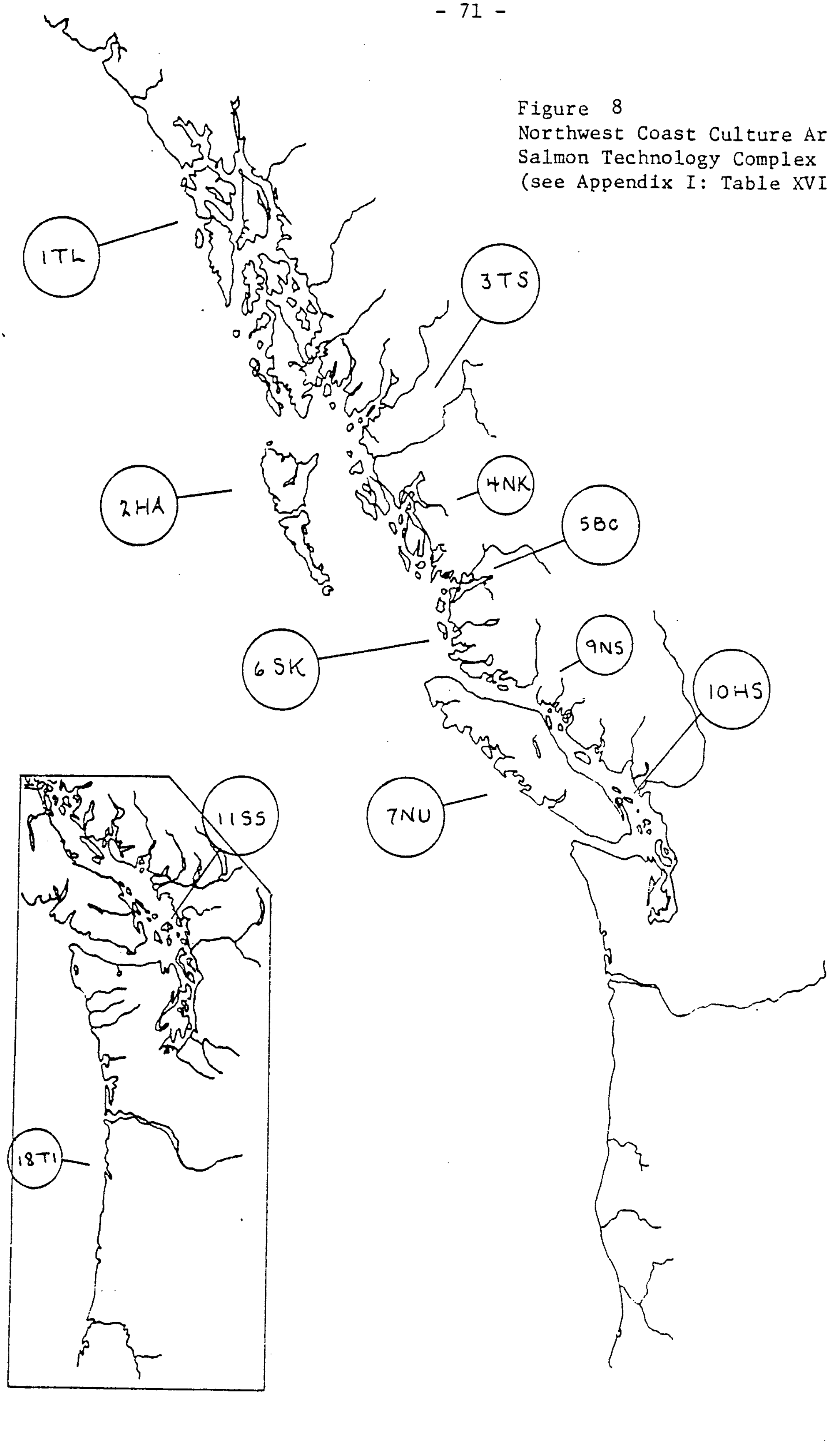
Figure 7. Stone tidal traps, in series. Shaded area represents high tide. Inset: detail of construction.

3. Distribution

Tidal trap distribution is confined to the northern half of the culture area. The dividing line seems to be at the 49° parallel, corresponding to the marked contrast between north and south coastal land features. The north coast, with its thousands of fjords, inlets, and channels, offered many suitable locations for natural and man-made tidal traps. The great straight sweep of the continent's edge on the south coast, by contrast, had few. At Tillamook Bay south of the Columbia a long coastal spit shields lagoons and tidal flats where tidal traps were built. Other estuarial bays along the Oregon Coast may have offered tidal trap sites but the data is not available. Even in the north where it is apparent that tidal traps were maintained and used, the complex is not well covered in ethnographic accounts. Tidal traps are the most under-reported fishing method.

No estimates of the relative economic importance of tidal traps are possible. The Tlingit, Haida, and Tsimshian all had tidal traps but, except for de Laguna, there is scant coverage in the standard ethnographies. Recent evidence suggests that the Haida relied on tidal traps to a greater extent than the Tlingit (pers.comm. S.Langdon:1980)(Langdon:1979). The subject is treated more fully in the Wakashan literature. Northern and Southern Kwakiutl, Bella Coola (a Salish-speaking group), and Nootka tidal traps are confirmed. Drucker (1951:16,17,259) says a Nootka "tidewater salmon trap", not made of stone, was named and owned privately; and that it was the first trap set each season. But other Nootka sources describe salmon fisheries in some detail without mentioning tidal traps.

Figure 8
Northwest Coast Culture Area
Salmon Technology Complex 7 - Tidal Traps
(see Appendix I: Table XVI)



Note that references in the literature do not always make clear the distinction between tidal traps for salmon production and for other species like benthic fishes and marine mammals. The distribution given here is based on explicit references to salmon traps, i.e., tidal traps built at locations where salmon could be exploited.

4. Social Variables

The collective effort of many people would be required for the initial construction of a large stone tidal trap. Large boulders were moved to the site and set in position, an arduous undertaking. But, once completed, little maintenance would be needed to keep it functional. Traps built at good productive locations were probably used for many years.

References to the ownership of tidal traps are incomplete. Among the Haida where established rights of access existed to all resource locations, including stretches of the coast, and river mouths, it is apparent that tidal traps were owned by lineage user-groups. By inference from the evidence of other salmon technology complexes, societies that emphasized the ownership of fishing sites, particularly the Northern and Wakashan groups, may have included tidal traps. On the other hand, perhaps tidal traps were a common resource for people living in near-by villages.

5. Ecological Variables

Within each species of salmon there are certain stocks that will delay at the mouth of a river before ascending. The reason for the delay is not completely understood, but fisheries biologists think it correlates to water temperatures in the estuary. Also some fish populations take longer to make the transition from a salt water habitat to fresh. Tidal traps built in locations where many salmon share these characteristics could exploit the resource, providing the currents are right.

The action of the tide is the primary agent that makes the trap work. In the swells of an incoming tide salmon are swept along and swim over the barrier. Favourable currents acting in conjunction with the tide may bring the salmon close to shore.

SALMON TECHNOLOGY COMPLEX 8 - WEIRS

1. <u>Contextual Description</u>

The principle of a weir is to interrupt the natural course of a salmon run. The superstructure was built shore-to-shore across a river or stream. Weirs were usually constructed as fence-like obstructions with a foundation of heavy posts overlaid with horizontal cross pieces to which panels of wattles or lattice frame sections were attached. The posts were embedded deeply in the riverbed to support the superstructure against the current of the river. Sections of screening permitted the flow of water downstream but effectively blocked the salmon. Unable to pass the obstruction salmon soon congregated in large numbers on the downstream side; confused and distracted they were easy prey and could be taken with leisters, spears, dipping nets, or gaff hooks. The screening panels were removed when the fishery was not operating to allow the fish to continue upstream.

As a mode of salmon production the weir complex was distributed throughout the Northwest Coast at hundreds of sites. The basic structure could be installed in stream sites wherever the current was not too swift. Large communal weirs were constructed on the Cowichan, Nanaimo, Skokomish, Puyallup, Nisqually, Skokomish, Quileute, Quinault, Nehalam (5), Smith, Klamath, and Trinity Rivers. Each village along the river built one or more weirs at suitable locations. A series of weirs on an important salmon river formed a system that served as focal point to the riverine settlements in the valley.

Plate I. Weir on the Cowichan River

The obligation of downstream people to those living upstream is not clearly stated; presumably the length of time the weir fishery operated was subject to negotiation and compromise, and, of course, tempered by the demands on labour and time for processing.

2. Types and Materials

(a) Weirs in streams -- Few precise descriptions of simple weirs are recorded; we know by inference that the basic principles of construction are the same for weirs built on smaller streams as for those on large rivers, the differences being a function of lesser stream velocity and volume. The supporting posts, for example, would not need to be as heavy, and rather than tripod or two-post supports, a single post with a downstream brace might be sufficient to uphold the stringers and panel sections. With this type of weir men would fish from their canoes (on the downriver side). In some weirs a canoe gate was fitted to facilitate passage. The double weir is a simple weir built twice across the river, usually in shallow water; the salmon salmon leaps the first but cannot manoeuver to leap the second, and is taken by the spearman.

(b) Communal weirs - the Twana model -- Substantial weirs with dip net platforms are similarly described for the Quileute, Quinault, Lushootseed, and the Twana. The Twana weir is characteristic of the type. Quotations in the text are from Elmendorf (1960:64-72).

The Twana weir was supported on a series of tripods that extended across the river in a straight line. These posts were imbedded deeply with the two upstream members in line with the length of the weir, while the third member projected out downstream, thus stabilizing the structure against the current. Horizontal cross pieces were lashed to the "upstream face of the tripods on the outside of the tripod members". There were three rows of horizontal cross pieces (stringers); the top one, having a flattened surface to serve as a catwalk, was four feet above the surface of the water.

Sections of screening were made by lashing together young-growth fir poles (6), about six feet long, with withes. Each panel was approximately 6 ft in height by 10 to 12 ft wide (2 m by 4 m). The lower ends of the poles were pointed and driven into the riverbed;

> ...their upper ends projected some three to four feet above water level with the poles slanting back in a downstream direction against the support stringers, to which they were lashed at intervals.
>
> (ibid)

Platforms projected on the downstream side of the weir between the tripod foundations. Each station extended 9 to 10 ft along the top stringer and was 6 ft wide (3 m by 2 m). A support stake for the dip net was driven into the streambed and attached to the platform frame at an angle parallel to the slope of the weir. The dip net "was a circular, bowl-shaped net attached to a hoop frame some five to six feet in diameter", to which were attached two ten-foot long handling poles of fir (7). At the other end, the poles met and crossed over at the mid-way point above the net; from here trigger lines of cattail fiber ran to the bag as signalling devices. When the dipping net was lowered through the scaffold opening U-shaped prongs at the juncture of the hoop "engaged the dip-net support stake" and rode the net down to the underface of the weir (8).

An alternative to this type of dipping net scaffold was used by the Cowichan who had instead narrow impounding pens connected to the upstream side of the weir. The salmon seeking a way through the barricade discovers an open gateway that leads to the spearing corral and is struck from above by the spearman.

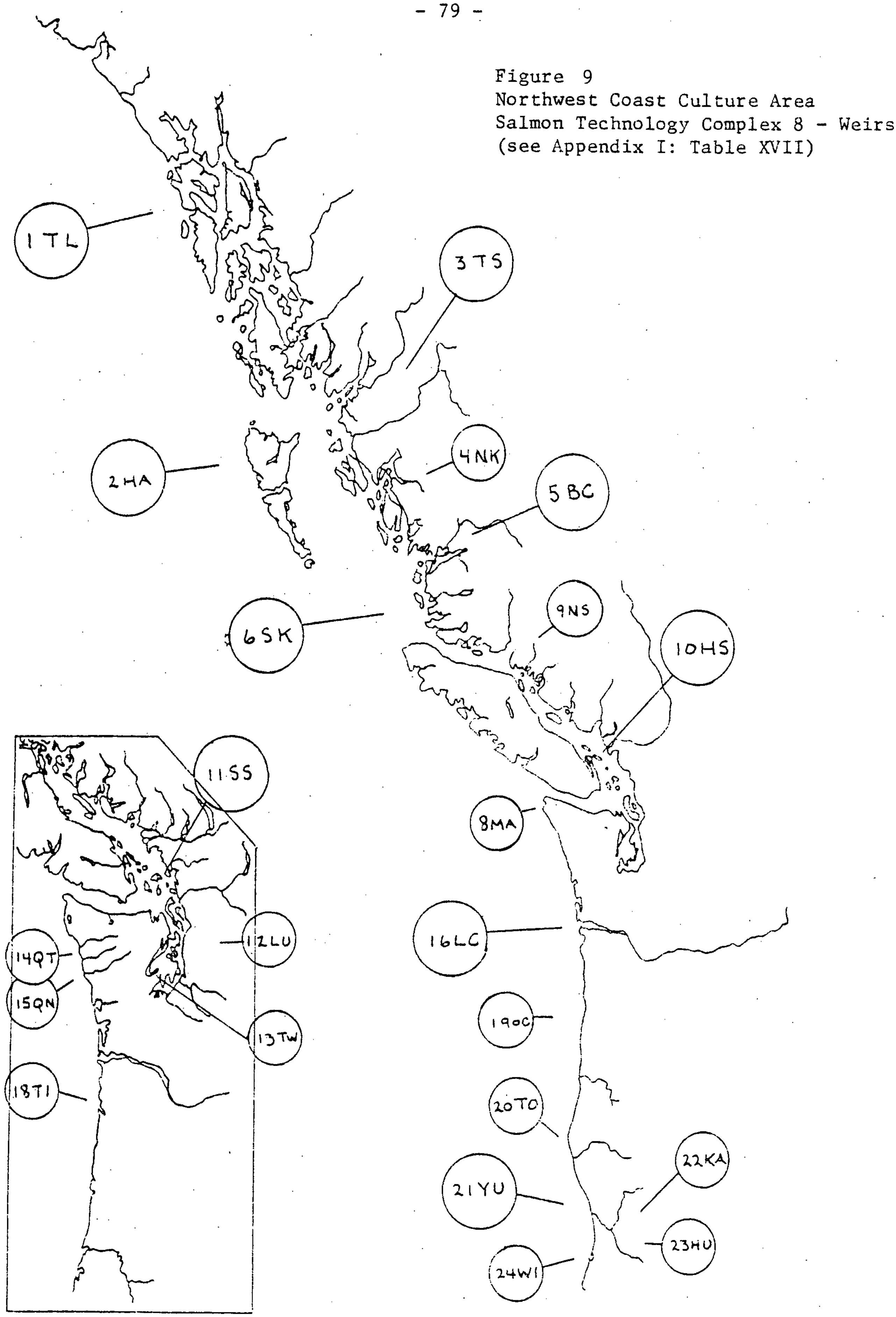
(c) The Kepel Dam -- Waterman (1973:63) and Kroeber (in Elmendorf:1960) considered the Kepel Dam to be analogous to the Twana weir even though it was a highly elaborated complex. The Klamath system, larger than the Skokomish, presented site difficulties that will be described in a following reference. Building the Kepel Dam was a labourious undertaking; heavy tripod posts were driven into the streambed to support 18 to 20 ft stringers. Additional braces shored up the supports, and hundreds of small stakes were driven in to form the body of the weir. Laurel limbs were tied underwater to the stakes. Then ten large 'salmon houses', privately owned impounding pens, would be constructed. The annual installation of the Kepel Dam was attended by restrictions on how the weir was to be constructed, and how tasks were to be performed each day. According to some informants, the weir was allowed to operate for only ten days and then it was dismantled (Kroeber and Barrett:1960).

3. Distribution

The weir complex had a wide distribution in the traditional fishery. It appears that all societies utilized the technology, building weirs at innumerable river and stream locations throughout the Northwest Coast. The communal weirs built by the Cowichan, Nanaimo, Twana, Puyallup-Nisqually, Quileute, Quinault, Tillamook, and Tolowa are among the most productive salmon technology complexes known. Riverine communities on the Skeena, Fraser, and Columbia, where weirs could not be built, installed weirs on tributaries and small streams. The Stalo (Halkomelem), for example, had weirs on the Chilliwack and Alouette Rivers, tributaries of the Fraser, and on other smaller branches. Up the coast in every inlet weirs were placed on the streams that poured forth from the coastal mountains. Island rivers, short but productive salmon producing streams that belonged to one or another resource holding group, had weirs to exploit the runs.

The Haida depended on weirs for the bulk of their winter provisions. They, like the Coast Tsimshian and Tlingit resource holders who had island streams, moved to their fishing sites for the season. Other Northern groups and the Wakashan maintained traps as well as weirs to suit the features of diverse types of water resources. For the Nootka and Southern Kwakiutl there is virtually no reference to weirs in the ethnographies; traps are described in detail but the significance of weirs appears minimal. The Northern Kwakiutl and Bella Coola built weirs in their tributary streams but these were less productive (presumably) than the large river traps of the area.

Figure 9
Northwest Coast Culture Area
Salmon Technology Complex 8 - Weirs
(see Appendix I: Table XVII)



In the Salishan, Columbian, and Californian regions the weir complex clearly was a major salmon production system. The Kepel Dam and the other Yurok and Karok weirs took many salmon in a short period; they were equal to lifting net complexes in production capability (9). The Hupa and the Oregon people (Alsea, Coos, Siuslaw) probably relied on weirs more than other methods, exploiting the runs on their short coastal rivers. Communal weirs built on important salmon rivers were a primary centre from which village communities developed and in which they were localized.

4. Social Variables

In the North each worthwhile salmon stream was owned by a lineage division of local resource holders. Weirs were the exclusive property of the corporate group and could only be used by others if permission was first obtained. Dawson (1880:109-110) describes the general dispersement of Haida from the winter villages:

> The various 'rivers' are the property of the several families or sub-division of the tribes, and at the salmon fishing season the inhabitants are scattered from the main villages; each little party camped or living in temporary houses in the vicinity of the streams they own.

In contrast, the communal weirs of the Salishan and Columbian regions were built close to riverine village at sites that were community-owned. The fishermen of the community co-operated to construct weirs; platforms on the weir, presumably the most productive fishing sites, were owned privately. Use-rights were heritable properties within the resource holding group, but the claim included an expectation and requirement to provide construction labour to build the weir (10). Thus the locus of ownership shifts from the salmon stream site to specified stations at the communal weir.

In Northern California, where the concept of individual ownership extends to all productive fishery sites, the archetypical Kepel Dam was nevertheless a communal enterprise. The use-rights to its stations were not clearly specified; but each 'salmon house' was named:

> The weir was an elaborate structure built in ten named sections by ten groups of men, all working under the actual, as well as the ceremonial, direction of one formulist. Each section was built with an enclosure provided with a gate which could be closed when the fish entered. The fish were then easily removed with dip nets. Vast numbers of fish were taken during the ten days that the dam was allowed to stand. After that it was deliberately torn down.....
>
> (Kroeber & Barrett:1960:12)

The Kepel Dam was built each year anew at a site thirty miles from the mouth of the Klamath. Hewes collected the names of ten Yurok villages downstream from Kepel which contributed work crews (field notes:1940: <u>in</u> K & B:1960:12). The building of the weir at Kepel was attended by the "most elaborate public ritual complex in the region" (Kroeber & Barrett:1960:11). Waterman, who with Kroeber co-authored a study of the Kepel Dam complex (pub.1938, cf.,1920), had also done field research in Puget Sound and reported (1973:64) that no "religious rites or taboos" appeared to be associated with the Twana weir complex.

Other large structures in the Klamath basin were the Hupa weirs built with some formality but no ceremony on the Trinity, an important tributary system. Hewes field notes (1940:ibid) contain useful detail not generally available about the social organization of production.

> On the fifth day all the men who were to participate in building the dam (there might be as many as a hundred) assembled and brought poles and other materials...
>
> The platform in the center was the most important and advantageous. Not only did the fish tend, on account of the angular form of the weir, to work toward this apex, but the fishermen who occupied this platform had available to them a bay on either side of the platform. This <u>central platform was definitely reserved for certain families</u> who had legendary right to it.
>
> All the other platforms on the weir were open to anyone who had participated in its construction, and to those whom they might invite to fish there.
>
> (p.19; emphasis mine)

5. <u>Ecological Variables</u>

In most parts of the coast the weir complex was associated with summer and fall salmon runs. Summer runs of chinook salmon were taken at weirs in the Quinault, Nanaimo, Squamish, and tributaries of the Columbia and Fraser Rivers. Fall chinook ran in the Cowichan, Skokomish, Quileute, and Klamath systems. Communal weirs were not generally constructed on sockeye streams; for example, neither the

Cowichan, Skokomish nor Klamath systems have sockeye runs. A notable exception is the Quinault River; communal weirs were built specifically to exploit the abundant sockeye runs that enter that river in early spring and peak in May. In innumerable mainland and island streams where simple weirs were built the fall runs of chum, pinks, and coho were taken.

Dawson reported for the Haida that many small rivers had weirs for fall fishing; he did not name the species he refers to but it would be chum salmon which enter the streams in large numbers beginning in mid-August, lasting through until December.

> They ascend even very small streams when these are in flood with the autumn rains, and being easily caught and large, they constitute the great salmon harvest of the Haidas.
>
> (1880:109-110)

Few sockeye runs occur in the Queen Charlottes but they enter several streams as summer runs. Chum salmon were also the most important species taken in the Skokomish, comprising the bulk of the annual Twana catch (Elmendorf:1960:61). In summary, except for the Quinault sockeye runs, the species commonly taken at weirs were chinook, chum, and to a lesser extent, coho.

Sites selected for weir placement had to meet specified requirements. The Kepel site is described as having a level streambed of fine gravel with a strong but steady current evenly across the breadth of the stream; the weir was built in late summer when the river levels had subsided, in optimal depths of five to six feet.

Because of the heavy water volume in the Klamath, the weir was V-shaped rather than straight across from one bank to the other. The point of the V-faced upriver into the current.

> In a stream of smaller volume, the shape might not matter much. The larger the flow, the greater the resistance which a two-way diagonal weir would possess, presumably, and experience may have shown the Indians that this gain in strength more than compensated for the additional length.
>
> (Kroeber & Barrett:1960:13)

The river at this point is 250 feet wide, much wider than at other weir sites on the Northwest Coast.

Deep water sites would be impracticable because of the difficulty in driving posts into the streambed. Nor could weirs be built in estuaries where channeling and shifting streambeds create problems, as would the pressure of tides. Detritus and general debris would be a nuisance because screen panels would need frequent clearing; a 'clean' river would be preferred. In summary, limitations on weir sites may be characterized by these sets of variables in the available water resources: (1) stream features including velocity, volume, and depths of water; (2) the width of the stream; and (3) features of the streambed. Weir structures could not withstand swift currents or heavy water volumes.

SALMON TECHNOLOGY COMPLEX 9 - TRAPS I

1. Contextual Description

The principle of entrapment is represented in the traditional fishery by a variety of forms designed to impound or strand fish. Since salmon do not feed upon prey during fresh water migration, traps were never baited. Instead salmon were led into a trap entrance by their characteristic behaviour in streams during the run, particularly by their capacity to surmount impediments and obstacles en route. Salmon were taken in grid traps, cylindrical basketry traps, box traps, shallow basin traps, tumble-back traps at falls, trough-shaped traps, and double weir traps with tubular baskets. A classification of types is given in the next subsection; for the present, one of the more common forms, the cylindrical basketry trap, is described in context.

Cylindrical basketry traps had a wide distribution and were very productive. Placed either singly or in multiples of three or four, cylindrical traps were set in a dam or wall, or at the apex of converging lead-in wings. Sproat reported in the early 1860s that Nootka salmon traps of this kind were set in all coastal streams.

> On each side of the trap, in some instances extending as far as the bank, a wall, or fence of stones or small stakes, slants down the stream, so as to lead the fish, in swimming up, towards (the) entrance to the trap.
>
> (1868:222)

Three and sometimes four "long circular baskets of uniform diameter, made of cedar splinters tied neatly together" were placed in position length-wise in the stream. Each trap had a funnel entry "shaped like a candle extinguisher"; the salmon having once passed through this tapering corridor could not make its way out again. The baskets, says Sproat, were "very neatly constructed, and catch a great many fish" (ibid).

Nootkan ethnographies contain many references to the use of cylindrical basketry traps. Captain Cook in 1778 noted "large fishing wears", as he called them, "...composed of pieces of wicker work made of small rods" (1784:281). Koppert (1930:72) observed that the Clayoquot used two kinds of basketry traps, the cylindrical and the box-like trap, both with funnel entry, and both frequently placed in multiples on stone walls that crossed the entire stream. The water was shallow at such sites, and the wall about two feet high. Box-like traps, for example, would be set in the wall at intervals every few feet, the total number depending on the width of the stream. Wooden stakes were driven across to provide a barrier in front of the stone wall; consequently, the salmon coming upstream, unable to surmount the obstacle, entered the trap mouth.

In addition to traps set with leads of fencing or secured to dams, cylindrical traps were used alone, staked in the streambed at rapids and natural obstructions. An early description, c.1803, was recorded by John Jewitt who accompanied Chief Maquinna's salmon fishing expedition to the Tahsis River. The fishery was pursued chiefly in "pots or wears", as Jewitt explains: (11)

> A pot of twenty feet in length, and from four to five feet diameter at the mouth, is formed of a great number of pine splinters which are strongly secured, an inch and a half from each other, by means of hoops made of flexible twigs, and placed about eight inches apart. At the end it tapers almost to a point, near which is a small wicker door for the purpose of taking out the fish. This pot or wear is placed at the foot of a fall or rapid, where the water is not very deep, and the fish driven from above with long poles, are intercepted and caught in the wear, from whence they are taken into the canoes.

Jewitt saw more than 700 salmon captured in a quarter of an hour by this means (1967:87).

Early observers in the north reported a similar dependence upon cylindrical trap technology among the Tlingit. Krause in the field in 1881-82, considered basket traps set in weir-like fences to be the most common salmon technology complex among the Chilkat (1956: 121. Plate II). Earlier, in 1799, La Perouse visited a salmon fishery at a small river, the Huagin, near Lituya Bay (Yakutat-Tlingit). Here, salmon encounter the staked stream:

> ...in the angles of the dike are placed very narrow wicker baskets, closed at one end, into which they enter, and being unable to turn in them, they are thus caught. This fishery is so abundant, that the crews of both vessels had plenty of salmon during our stay, and each ship salted two casks.
>
> (1799:Vol.I, p.389;quoted in de Laguna 1972:387)

This method of trapping salmon obviously ranked high as a productive technique for use in small to medium-range rivers and streams. It could be adapted to swift waters and variations in stream bed features, particularly in shallow rivers.

A characteristic of this and the many other types of salmon traps is the facility with which the configurations of traps could be modified to suit the variables of local site conditions.

2. Types and Materials

Salmon traps are highly individualized and difficult to categorize schematically without injustice to the data. I have collected dozens of distinctive descriptions, detailing the many ways Northwest Coast fishermen caught salmon in traps. Boas (1909) provides the classic account of a trapping repertoire - in the salmon fishery of the Southern Kwakiutl. Using native categories to distinguish the principal trapping devices, Boas describes each of them in technological terms. This is useful as a basis for a division of types. Boas' Southern Kwakiutl data with no additional interpretation is exhibited in Table V.

The classification of types that follows is ordered on functional and operating principles. For cross-reference purposes, and as a guide to distinguishing differences in types, names are included given by Boas' informants to describe similar devices.

(a) Tumble-back traps (also called 'pothangers')

The function of this trap is to catch salmon as they fail to surmount a natural obstacle, as a falls or rapids. Plate II illustrates

TABLE V

SOUTHERN KWAKIUTL TRAPS

Native term	Boas' description of traps[1]
1. lē'xsid	cylindrical basketry trap with conical entrance (used in rivers with strong current).
2. xō'lōs, lē'xsid (+ mā'lis)	xō'lōs trap with cylindrical basket-trap attached called lē'xsid. Converging frames force salmon to enter a 'box' which exits into cylindrical traps on each side. Trap door to remove fish. May be used in combination with an additional trap (mā'lis), a circular stone dam with flaring entrance which forms a shallow basin. Salmon which do not enter 'box' are guided into basin, and cannot escape. (used where current very strong).
3. dEgwī's	salmon enter a large closed basket with converging entrance from which they are turned into a long fish basket kept in place with stakes and anchored with heavy stones (for use in narrow rivers).
4. mE'wa	a trap similar to xō'lōs with a box-like framework but frames are attached to bottom which is anchored on the rocky ground of the river. 12 fathoms long, 6 fathoms wide; salmon speared (used on the mainland near inlets).
5. mā'lis	a) stone dam with flaring entrance; deep pool formed under cascade, shallow rapids below (built under small cascades). b) log dam variation of dam and basin, built in shallow water with rapid current. Salmon speared or caught in xō'lōs built under the dam.
6. Lā'wayu	Nimpkish River. On lower (downstream) side a stone dam is built which reaches to the surface of the water. Just above this a box eight fathoms wide and two deep is built, consisting of frames tied to stakes. The salmon jump into the trap across the stone dam. White clam shells cover the stream bed in the trap so that salmon may be speared more easily by fishermen in canoes alongside.

[1]After Boas:1909. (Minor restatement of Boas' text.)

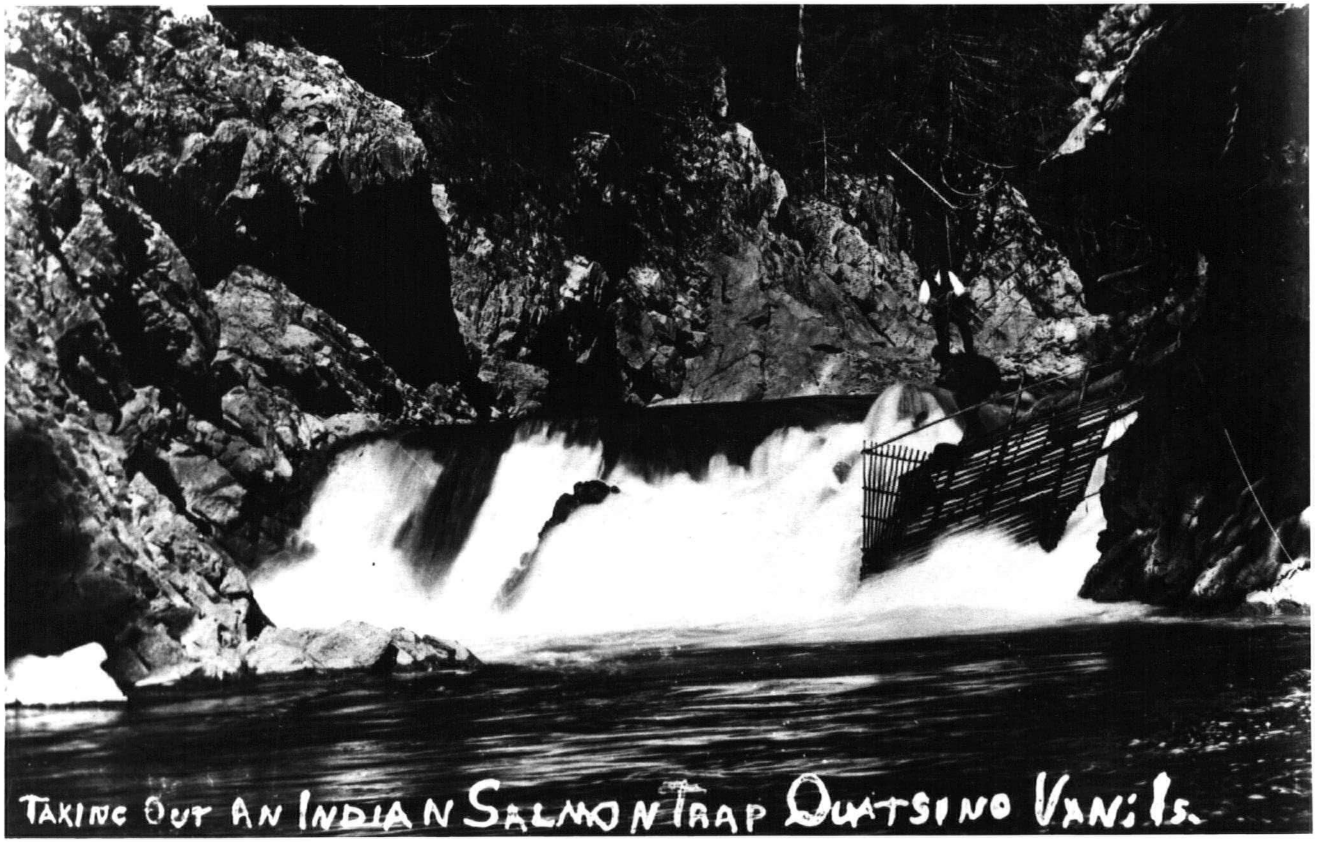


Plate II: Tumbleback Trap

a tumble back trap of this kind. Few adequate descriptions exist although the technique was known throughout the area. Varieties include: (a) an open framework box suspended by ropes from nearby rock faces with ropes (Boas:1909:465). There is no indication how the ropes were secured, or the catch removed; (b) two grid panels joined to form a wide V that held the fallen salmon; (c) a flexible grid suspended like netting.

(b) Large box-like traps and free enclosures (xo'los, degwi's, me'wa)

Units of basketry or wattle-work were constructed in various ways to enclose a portion of the stream; the entrance could be simply two converging panels (see diagram). A salmon would find its way in easily enough but be discouraged from exiting by the same route because of inward protruding points, and by the salmon's reluctance to swim in the 'wrong' direction with the current. Another entrance commonly used was the funnel or invaginated entry (see diagram, degwi's). Once inside the enclosure the salmon would find its progress blocked by the upstream member of the trap, and turn into the only available outlet, the cylindrical trap. A number of variations were possible but the basic elements consisted of (i) a one-way entry, (ii) an enclosure in the river, and (iii) egress into a confining chamber.

(c) Cylindrical basketry traps (dena'x'dax)

Long narrow cylindrical traps were generally made of cedar slats or splinters lashed to hardwood hoops with split root twining.

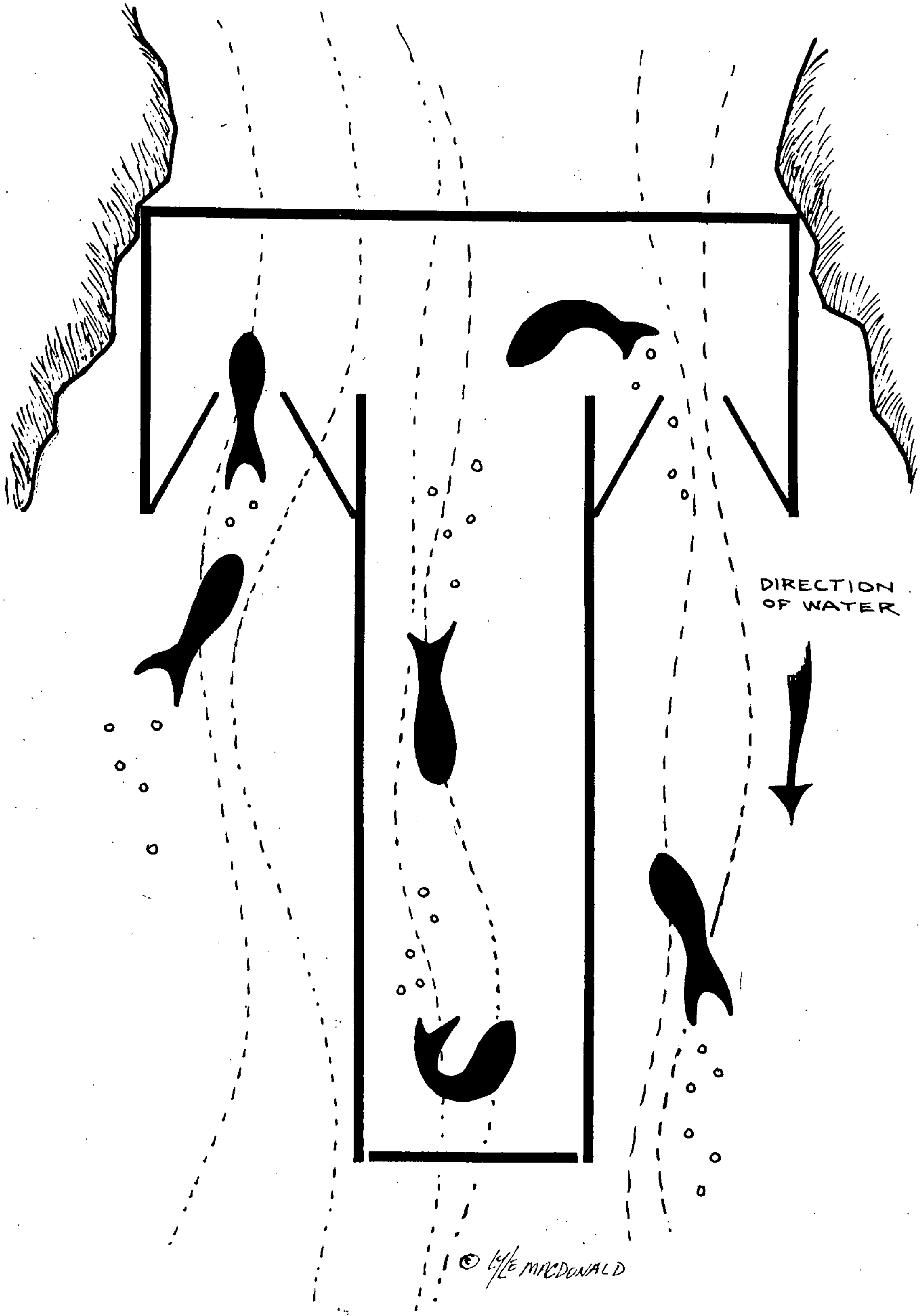


Figure 10. Scheme of degwi's trap.

In the north, Emmons (1903:242) reported baskets made of spruce slats and split spruce root twinings. Baskets were equipped with a funnel-entry insert at the mouth or, alternatively, constructed to be too narrow for the salmon to turn around. Dimensions given by Sproat (1868:222) indicate the diameters were three to five feet, and lengths ranged from ten to twenty feet. Some traps tapered to a point, but others were symmetrical.

Several of the ways in which cylindrical traps were used have already been described. In addition to providing a facility for the direct capture of salmon, they were appendages to large river enclosures —box-like traps, double weirs, closed baskets with converging entrances —as a means to concentrate the salmon for easy removal.

(d) Grids and trough-shaped traps

Grid panels were used to strand salmon following an encounter with a river obstruction, natural or man-made. They were often used in connection with free enclosures or at the threshold of artificial 'basins'. The grid itself was set on an inclined plane with the upper end either above water or in the shallows. Since the force of the river's current was utilized to sweep the fish up on the grid, the entry faced upstream. For salmon (i.e., not trout), the trap required a barrier upstream of the grid panel. Unable to progress, the fish is swept back and stranded on the grating. In the absence of a barrier, the salmon could be frightened into retreat by beating on the water (Barnett:1955:82).

A Northern Gulf Salish trap described by Barnett (ibid) (see diagram) consisted of a horseshoe-shaped enclosure with a narrow entry of converging sticks. Once inside, the salmon were confronted by the upstream member of the trap; they "would play in an eddy or relax their efforts against the barrier and in a moment be swept on to the uptilted grids of the trap enclosures" (ibid).

In Northern California, stranding devices were shaped like scoops, the sides upraised. These open-top trough traps were made of long split spruce or hazel poles set a few inches apart and tied with withes. They were often placed at the apex of two converging wings that served to guide the stalled salmon to the underwater lip of the trap, and subsequently up on the grid.

(e) Dams and basins (ma'lis, ama'la, la'wayu)

While dams and basins are essentially different kinds of structures they both alter water levels at the site. A dam built on a small river, as Boas has illustrated (1909:Fig. 139), creates the conditions of rapids and shallow water that favour spearing. If used in connection with a flaring stone basin, or the Kwakiutl combination of basin and trap (xo'los, le'xsid, and ma'lis), the stream is effectively converted into a multiple system of trapping devices, designed to take large catches.

Boas' description of the basin (ma'lis) is given:

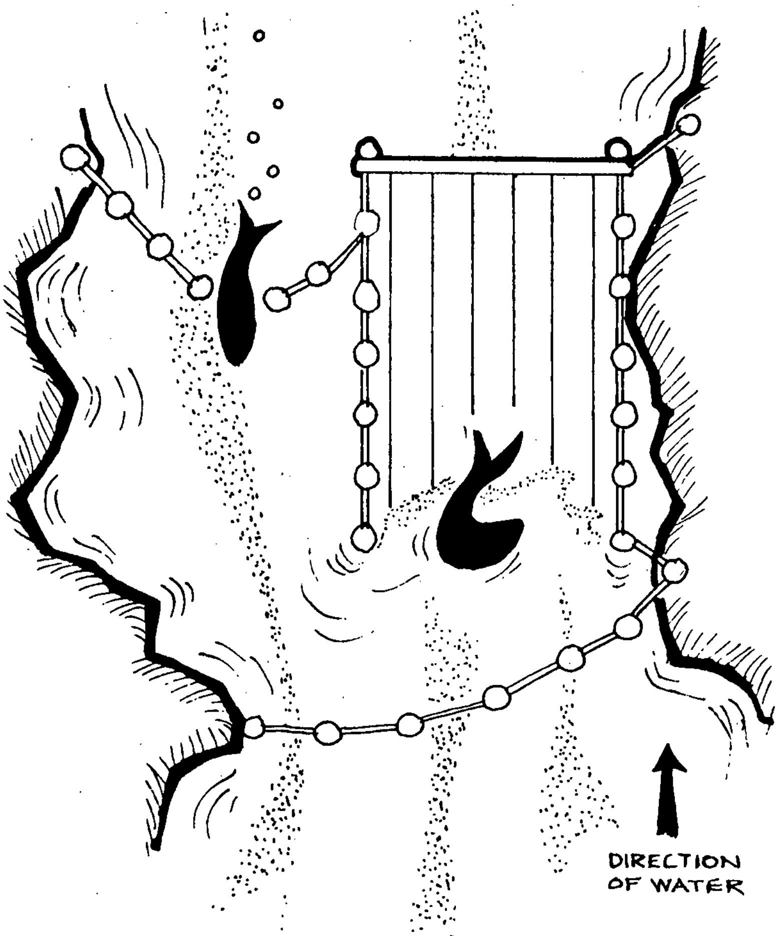


Figure 11. Scheme of grid trap.

> It consists of a circular stone dam with flaring entrance, which forms a shallow basin. In the narrow entrance to the basin a platform of slender, smooth poles is placed about 7 cm. under water at the end turned towards the basin, while the upper end is considerably deeper.
>
> (ibid:462)

This combination of grid entry and floundering basin may have been much more widely used than the ethnographies indicate. There are few references to the specifics of stream dams and basins.

Boas also described a wooden basin:

> This is fenced in with stakes and poles or frames, while the bottom is entirely filled with long poles, so that the fish have not enough water in which to move.

A similar basin-trap is described by de Laguna (1960) for the Angoon Tlingit who, she reports, did not use cylindrical traps like the Chilkat and Yakutat people did. Instead they constructed open top boxes of sticks or split wood, and set them "either across a waterfall or placed in the opening of a fence across the stream". De Laguna collected names for the various parts of the trap: the 'arms-of-trap', the posts to which a trap and fence was attached, and a "tongue-shaped ramp" called 'salmon director' that led the salmon into the trap. Presumably this was a grid-type entry. Finally, it is noteworthy that de Laguna's informants indicated that these traps took many forms but had one underlying principle:

> ...they were all made so that the water in the floor of the trap was too shallow to permit the fish to swim or jump out.
>
> (ibid:115)

It is evident that one of the ways salmon were effectively trapped was to alter the conditions of the stream flow and water depths.

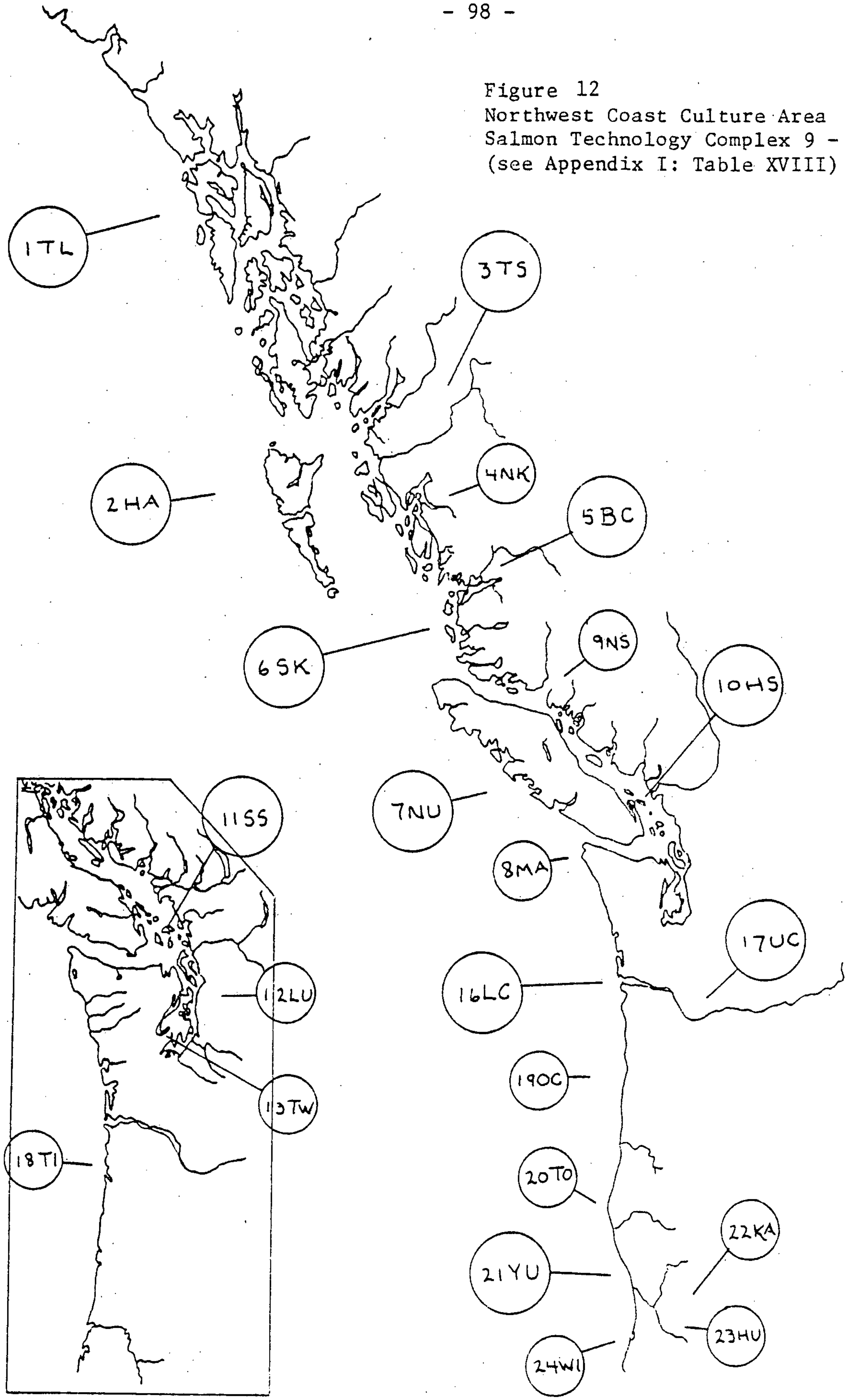
3. Distribution

The Northern and Wakashan regions produced much of their annual salmon requirements by using the trap complex. This is stated explicitly for the Tlingit and Nootka, and by inference in Boas' (1909) account of the Southern Kwakiutl. According to Krause (1956:121) and other sources, the salmon trap was the most important technology used by Tlingit groups. Both the Yakutat and Chilkat, the principal mainland groups for whom we have data, set basketry traps in weir-like fences. On the West Coast Nootka groups used cylindrical basketry traps set in walls and dams in every stream; traps were the main fresh water mode of salmon production. And the Southern Kwakiutl inventory of traps was extensive and obviously significant in terms of production capacity.

4. Social Variables

Salmon traps and the sites of salmon traps were in general terms attended by notions of ownership by lineage resource holders. Deviations from this basic premise would tend to follow the basic patterns of resource ownership peculiar to each ethnic group, and it would probably serve no useful purpose to summarize them. Instead the example of one group for whom the trap complex was significant will be given.

Figure 12
Northwest Coast Culture Area
Salmon Technology Complex 9 - Traps I
(see Appendix I: Table XVIII)



On the West Coast, the Nootka chiefs exercised territorial prerogatives over all the important resource locations.

> Salmon streams constituted the most important economic properties of the Nootka chiefs. Though they gave right to set salmon traps in certain places to kin and henchmen, the chiefs exercised their rights to claim the entire first catch of the traps made in their individual rivers.
>
> (Drucker:1951:250)

Jewitt reported that an estimated 2,500 salmon were brought on one occasion into Chief Maquinna's house (1967:88). The common rule of rights of access for people with no claim to the trap site is highlighted in this remark about the appropriate behaviour of a stranger among the Clayoquot:

> if...he passes a creek with a trap-box set for fish, he may not fish in that stream; if the trap is not set, he is at liberty to fish by hook or spear.
>
> (Koppert:1930:78)

5. Ecological Variables

Koppert also noted a conservationist rule in effect to protect salmon.

> As to fish, when the rains make the rivers rise, the trap-boxes are not allowed to be visited except once a day, so as not to hinder fish on their way to the spawning grounds. A strict Indian law forbids violating this ruling.
>
> (ibid:79)

As the creek swells salmon can pass on both sides of the barriers that contain the cylindrical traps or fish-boxes.

The variety of stream conditions at sites where traps could be constructed indicates the versatility of this mode of salmon production; traps were designed to meet the specifications of fast water, shallow water, riffles, falls, narrow places, uneven streambeds with rocks and boulders, or heavily channeled streams, among others. 'Dams' and basins altered stream levels, diverting the movements of the salmon. Leaping barriers, searching for a way past these artificial impediments, and exploring an opening in the trap, the salmon is captured.

SALMON TECHNOLOGY COMPLEX 10 - TRAPS II

1. Contextual Description

In the preceding section (STC 9) five generalized types of trapping devices were described. The same principle of entrapment was extended to several other, more specialized forms by Northwest Coast people -- traps designed to meet the conditions of large rivers. Three types will be described: the Skeena canyon trap, the Bella Coola dam, and Northern large river traps. These are each distinctive models with differing functions and ancillary parts.

2. Types and Materials

(a) Skeena canyon trap

The large Skeena river trap is a special example of an adaptation to the features of canyon fishing in a large and very productive salmon river. Little has been published about these traps. Barbeau described them briefly in an article written for the Canadian Geographic Journal, June 1930. He also obtained photographs which are held in the British Columbia Provincial Museum archival collection (Plates III and IV:Appendix). Plates from this same set accompany Barbeau's article; one of the captions reads:

Plate III. Skeena Canyon Trap (first view)

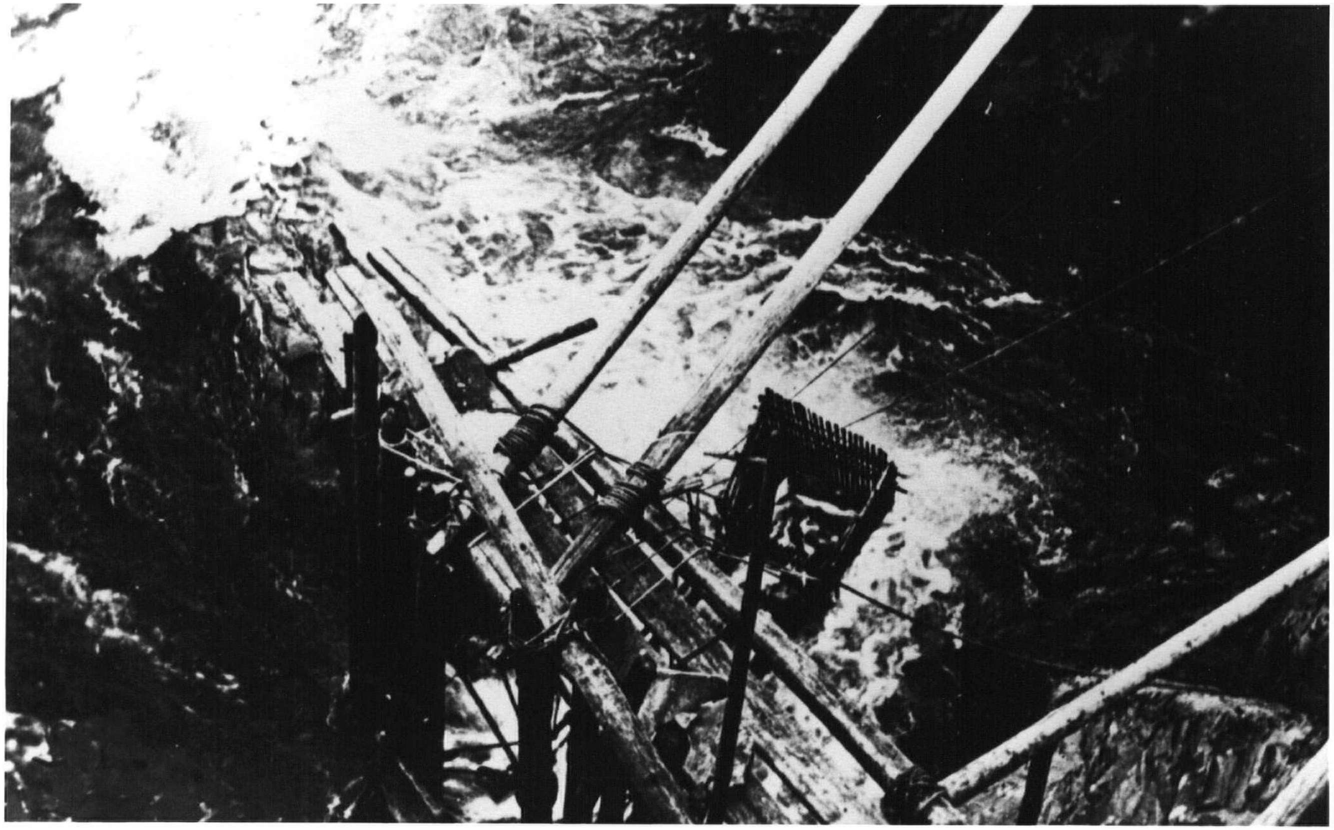


Plate IV. Skeena Canyon Trap (second view, from above)

> These traps are quite complicated and consist of three parts, the vertical barrier which is set between posts, the long "chute", and the fish basket at the rear. Nowhere else but on the upper Skeena are fish traps like these made. The efficiency of these depends upon the ability of the makers who are guided by set measurements and a long experience.
>
> (1930:144)

Barbeau identifies this special form of basket trap as Gitksan, built and operated by Gitksan user-groups on the west side of the Hagwilget canyon. On the east side of the canyon, Carrier (Plateau) people had obtained rights to fish, and used a very similar trap. Barbeau comments that the right to resource locations in the canyon had been an "object of dispute for a hundred years past" (ibid). The principal fishery he mentions is the sockeye run.

Other information about the Skeena canyon trap is not easily available (12). From an examination of the Plates, one can appreciate the complexity and size of the undertaking. The long chute or trough is supported by ropes from the superstructure of the trap and it appears the chute was raised or lowered into the river by this means. How it operated is not clear but it may be that the nether end of the chute was submerged in the roily waters of the canyon. At the height of the salmon runs, when the gorge is crowded with sockeye ascending the rapids, many fish would swim along the banks of the stream where the velocity is less extreme. It is possible that under these circumstances sockeye could not easily avoid the submerged arm of the trap. If the chute were quickly raised to a perpendicular angle (the nether end high) it would act as a flume to conduct fish into the basket at the rear where they would be enclosed. I do not know if this is how the trap actually worked; whatever the method of operation it is obvious that the Skeena canyon trap was an elaborate salmon fishing complex.

(b) Bella Coola dam

The series of 'weirs' and dams built at communities along the Bella Coola River included some of the largest structures built on northern rivers. In 1793 Alexander Mackenzie recorded as much detail about these "fishing machines" as possible, and these descriptions stand as classic accounts in the literature, even although the people of Bella Coola would not permit Mackenzie to investigate the structure as closely as he wished. The principal dam Mackenzie describes was built at 'Friendly Village' on the main arm of the Bella Coola about thirty miles from the mouth of the river. At this location an affluent from the north enters the Bella Coola, which unlike most tributaries to this stream does not debouche from a steep gorge (13). One may assume perhaps that the current of the river at this point is strong but regular.

I will quote Mackenzie at length:

> The weir is a work of great labour and contrived with considerable ingenuity. It was near four feet above the level of the water, at the time I saw it, and nearly the height of the bank on which I stood to examine it. The stream is stopped nearly two-thirds by it. It is constructed by fixing small trees in the bed of the river in a slanting position (which could be practicable only when the water is much lower than when I saw it), with the thick part downwards; over these is laid a bed of gravel, on which is

> placed a range of lesser trees, and so on alternatively, till the work is brought to its proper height. Beneath it the machines* are placed, into which the salmon fall when they attempt to leap over. On either side there is a large frame of timber-work six feet above the level of the upper water, in which passages are left for the salmon leading directly into the machines* which are taken up at pleasure. At the foot of the fall dipping nets are also successfully employed.
>
> (from Lamb's edition 1970:358)

The facility described by Mackenzie is a dam, not a weir in the sense defined in this study (STC 8); that is, the river does not flow freely through the structure as it does with a weir. By building a barrier to obstruct the flow of water, Bella Coola resource users created a multi-purpose fishing facility where salmon could be taken with at least two different trapping strategies and by other means suitable at a 'falls', dip netting in particular.

Further information collected by McIlwraith indicates that the number of traps at the dam was limited, each was privately owned, and named. As Mackenzie observed:

> Salmon is so abundant in this river, that these people have a constant and plentiful supply of that excellent fish. ...To take them with more facility, they had, with great labour, formed an embankment or weir across the river for the purpose of placing their fishing machines, which they disposed both above and below it.
>
> (ibid)

---

* Mackenzie is referring to traps. McIlwraith collected a Bella Coola word for a movable box-like container which can be raised at the salmon 'weir' (1948:610) which may be one of the types of traps Mackenzie called machines.

Mackenzie probably means both on the upstream and downstream side of the dam. The position of some traps at the facility would be more valuable than others. The dam described by Mackenzie was built where the Bella Coola was fifty yards in breadth, and about ten feet deep on the 'foot of the fall', the downriver side. This means that it must have been about fourteen or fifteen feet deep on the upriver side. At another dam further downstream, Mackenzie saw the local men in their canoes shoot over the falls, a ten foot drop at that site (14).

In summary, the Bella Coola dams were extraordinary structures, built with great labour by local resource holding groups near permanent villages. There is little doubt that they were among the more productive salmon technology complexes on the Northwest Coast.

(c) Northern large river traps

Seven ethnic or dialect groups in the north with large rivers to exploit used an open-top river trap set in a frame of posts. The type is included in the Culture Element Distributions List (15), contributed by Drucker (1950). While the type seems to share several characteristics of the Skeena canyon trap, its use was denied by Drucker's Gitksan informant. Evidently, it was not a canyon trap. There is no indication that it was used at sites where the waters were roily, but this may indeed have been the case. It was stated by several informants to have been designed to meet the conditions of large rivers; in fact, its absence among the Bella Bella and Heiltsuk "was said to be due to the smallness of the rivers in their territories" (1950:237).

Drucker provides a description:

> This trap was quite large, shaped something like half a barrel, with its ends lashed to vertical posts which supported plank scaffolds on which men stood. When enough fish were caught, men loosened the withes binding it to the posts and hauled it up till the catch was within easy reach. The posts acted as guides.
>
> (ibid)

Additional notes say that the trap had a V-entry and, at least among some user-groups, a guiding fence was used to direct fish into the mouth of the trap. These few sketchy details do not explain the operation and specific site conditions adequately, but when considered in the context of the preceding Skeena and Bella Coola traps they describe a pattern for large northern streams.

3. <u>Distribution</u>

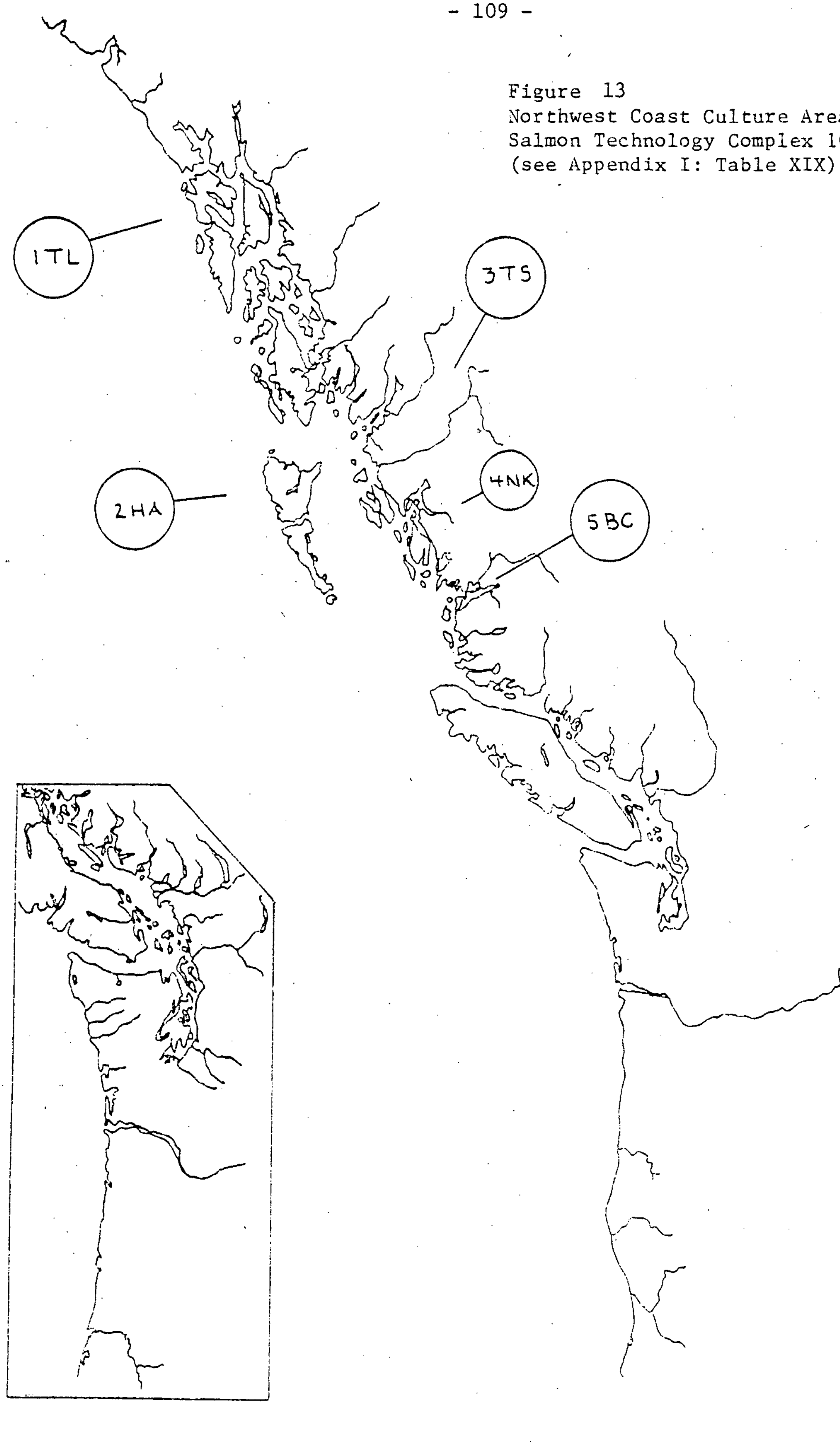
Distribution of this complex is specifically referenced:

(a) Skeena canyon trap: Gitksan Tsimshian people, particularly those with resource holding rights of access at Hagwilget canyon at or near the Skeena-Bulkley confluence.

(b) Bella Coola dam: Bella Coola people living at communities along the river and its principal tributary.

(c) Northern large river trap: (after Drucker) Northern Kwakiutl at Owikeno in River's Inlet; Bella Coola (16); Xaisla (Northern Kwakiutl) at Kitamat; Tsimshian at Hartley Bay, specifically the Kitqata; Masset Haida people; Skedans Haida; Kaian Tlingit living at Cape Fox, the southernmost group of Tlingit.

Figure 13
Northwest Coast Culture Area
Salmon Technology Complex 10 - Traps II
(see Appendix I: Table XIX)



No indication is given of productivity.

4. Social Variables

McIlwraith collected several references to notions of ownership (17) and user rights at Bella Coola dams and weirs. Limitations are imposed on the "number of salmon traps at any one weir" according to interpretations of the mythical origins of the trap/dam at a certain location. For example, ten traps may be considered the maximum number appropriate in accordance with the history of the site. "Those who have the right to the weir are members of the ancestral family with names of those first users". Inheritance of fishing rights to certain sections are thus transmitted with a name which must be validated publicly. McIlwraith added that conflicting claims and disputes were common. But that only members of the ancestral family could obtain rights.

Owners of a trap or section of the weir could lease fishing rights for a specific time period, perhaps a single night or two nights, in return for material consideration.

Information about ownership rights at the Skeena canyon trap and large river traps could be deduced from the general rules for the transmission of property rights that pertain to each northern society; specific reference to rights at the trap are not included in the accounts cited.

5. Ecological Variables

The Bella Coola and most rivers at the heads of inlets are very turbid because the glacier-fed streams that feed into them carry silt down through the system. This is consistent with description of the Bella Coola dam as partly composed of naturally-occuring materials, logs, and accumulated silt and gravel, features that essentially create obstacles in the river, diverting the movements of salmon. It would appear that these natural features were enhanced by Bella Coola fishermen to create large semi-permanent dams. Spring freshets would annually wash out parts of the dam and it would require constant maintenance throughout the season. But perhaps the foundation would remain more or less intact, especially in larger dam sites like the one described by Mackenzie.

The Bella Coola - Atnarko is a productive river system with large runs of all five species (see pp.182- for abundance and seasonality). At the time Mackenzie visited the area (July 1793), Bella Coola fishermen were probably catching chinook and sockeye salmon at the dam.

The Skeena River system is an even more productive river, ranking second after the Fraser for sockeye production in rivers of the Northwest Coast culture area. The largest runs of sockeye in the Skeena watershed spawn in the vicinity of Babine Lake; the runs must pass through the Hagwilget canyon en route to the Babine, an important tributary (18). Consequently, the canyon fishing sites would be among the most productive resource areas on the coast.

SALMON TECHNOLOGY COMPLEX 11 - DIP NET STATIONS

1. Contextual Description

At canyons and the upstream narrows of important salmon rivers a turbulent flow of water pours through the constricted rockface in swift rapids and waterfalls. At such places, the running salmon seek respite in the slower currents at the river's edge. Canyon fishermen built their dip net stagings to overhang the eddies and backwaters where salmon would linger awhile, or they worked from a natural foothold on a rocky shelf. The fishermen would wield large bag-shaped dip nets attached to the end of long shafts; the open end of the net faced in the downstream direction while counter-currents served to hold open the bunt end. One of two principles applied to operate the net depending on the style of the dip net and the species sought. Larger nets were steadied in position, braced and ready for the prey to enter; smaller, lighter nets were actively moved through the eddy in a plunging or sweeping motion to make fortuitous catches. The common feature of dip netting sites was the presence of swirling backcurrents at the edge of rapids and falls.

The earliest visitors to the Northwest Coast recorded the practice of dip netting at the canyons of principal rivers. Lewis and Clark arriving at the Dalles on the Columbia River in 1805 reported an intensive fishery operated there to produce large quantities of salmon, dried and systematically bundled for transport or for trade (19). In the Fraser canyon near Yale, as Simon Fraser noted in his journal

Plate V. Fraser River Dip Net Station (braced net in place) entry for June 29, 1808, salmon fishermen were dip netting in the canyon using implements with shafts 20 feet in length. The published accounts of explorers support the view that canyon dip net sites were highly productive resource locations where salmon runs could be efficiently exploited.

The following excerpts are from two unpublished first-hand accounts of Fraser canyon dip netting (c.1852-1867)(20). The first was written by Fred Dally, a professional photographer whose glass-negative shots of fishermen using the dip net, and of Cowichan weirs, have survived (21). After viewing the dip net stations in the twenty mile stretch above Yale, Dally reported:

> ...they build a light platform of poles jutting out of the clefts of the rocks overhanging the river with two or three short planks to stand upon ...they certainly are very light and picturesque to look at but for anyone but the most skilled to stand upon most dangerous.
>
> (B.C. Provincial archives)

Dally also collected this account written in the early 1850s by two English travellers, Milton and Cheadle:

> ...we passed many Indians engaged in salmon fishing...they select some point in the fierce rapids where a quiet eddy forms under the lee of a projecting rock. Over the rock they sling a little platform of poles, within a convenient distance of the surface of the water, and from this position grope untiringly in the eddy with a kind of oval landing-net.

The characteristic behaviour of salmon during the spawning runs through the canyon did not go unnoticed by Milton and Cheadle:

Plate VI. Fraser River Dip Net (pursed)

> The salmon, wearied by their exertions in overcoming the torrent, rest for a time in the little eddy before making the next attempt to mount the rapid, and are taken in hundreds by these clever fishermen.
>
> (B.C. Provincial archives)

Summer weather in the canyon is usually ideal for drying salmon - hot and dry, with a steady wind; both smoke-dried and air-dried stores were produced.

In the Klamath River, in Northwestern California, dip net sites were equally as significant as on the Fraser and Columbia Rivers, perhaps more so. The Yurok, Karok, and Hupa people used large A-frame lifting nets braced against stagings built out over the eddies. At the rapids they used the plunge net, an adaptation of the dip net used with an overhead motion (see Figure 14). Kroeber and Barrett (1960) provide the following commentary on the platforms associated with dip netting:

> The scaffold or staging is essentially a combination gangplank and operating platform built out over the river...On this narrow platform the lone fisherman walks out to near the end, perpendicularly lowers his triangular net frame to the bottom, (and) seats himself on a wooden block stool while holding the closure line to the bag of his net...(it) can of course not be built in any regular or preconceived shape because it has to be fitted into idiosyncracies of shore and river bottom...The number, direction, angles, and joining of the poles and planks must conform to the given terrain...
>
> (ibid:33)

Since the number of suitable locations at eddies along the river were limited, the ownership and control of dip netting stations was highly

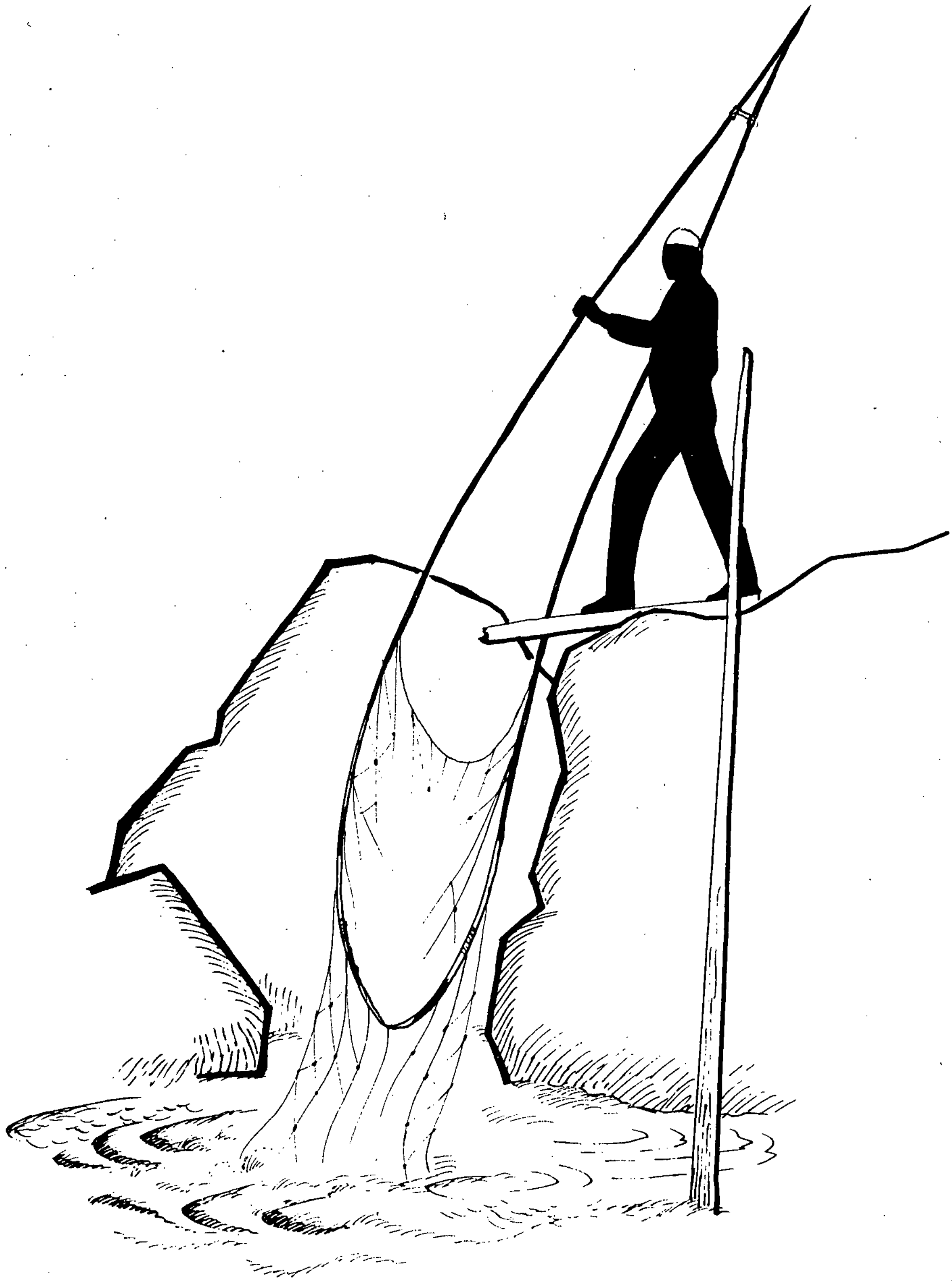


Figure 14. Northwestern California plunge net for salmon.
(Based on a photograph in Kroeber & Barrett:1960).

valued. The evidence for the Klamath, Columbia and Fraser dip net complex is clear on this point; fishing places at eddies where stations could be built were always owned.

2. Types and Materials

As a generic term dip nets denotes a range of devices including the secondary implements needed to land salmon at weirs and traps. As a primary production system, however, the dip net complex refers to the strategies used at canyon sites and rapids, described above. Distinctions in two operative styles are given here: the net used in a braced position or actively plunged or swept through riffles and eddies. 'Lifting net' is the term favoured by Kroeber and Barrett to describe the characteristic Northwestern California A-frame braced net. They call the smaller active net a 'plunge net'. Elsewhere the common English word given to all styles is simply 'dip net', but in each native language a distinction was made between the two principal types (cf Duff:1952:63). In Halkomelem not only the two net styles but the distinctions in how each was operated had a separate name.

A special downriver adaptation of the dip net is reported which makes reference to channels dug at the edge of the river; this and one or two other variations will be briefly described.

(a) Large braced dip nets

Although different in appearance, trapezoidal and elliptical dip nets were similar in function. The Yurok model with its complicated signalling devices, conical net shape, and wide trapezoidal frame was set vertically in the water using the backcurrent of the eddy to hold the mouth open. The Fraser-Columbia model had a bag-shaped net attached by bone rings to an elliptical hoop of vine maple; a line through the rings held the net mouth open until it was released by the fisherman when a salmon was netted. It too was set vertically, the long shaft braced against the fishing platform.

The advantage of the braced net was that it could be set deep in the water. Duff (1952:63) says that in the Fraser chinook salmon run at depths of below five feet. The large dip net "was braced against the pull of the current of the eddy either by holding it against a pole tied in position or by tying a line between the handle of the net and the shore". Kroeber and Barrett's data indicates that the supporting pole built into the staging platform was attached to a loop on the A-frame; a guy line held the other side:

> These two devices, the loop and the guy line, hold the large A-frame firmly in its vertical position at the staging. Otherwise the current, at times quite swift, might sweep the net, frame and all, completely out of the hands of the fisherman.
>
> (1960:34)

The similarity is apparent; the Klamath, however, is not as deep as the Fraser and stagings were constructed so that the A-frame rested on the streambed. Dip net stations at all canyon sites were, as has been said, idiosyncratic, designed to fit the natural features of the riverbank above favourable eddies. At some stations few if any improvements were needed to provide a foothold but fishermen often tied themselves to shore for safety.

Details of the manufacture of the nets, materials, sizes, lengths of shafts, and how the nets were triggered to close or 'purse', are summarized in Tables VI and VII. A comparison of all available data of significance is included in these tables but there is insufficient space to treat properly the variations in triggering devices. All large dip nets had a system of signal lines (Fig.15 shows the pursed dip net used in the Fraser Canyon).

(b) Active dip nets

Two variations in style represent nets moved actively through the water in either a sweeping or plunging motion (see Fig.14). The Fraser-Columbia model was a smaller version of the braced dip net; a bag-shaped net on an elliptical hoop. But it was lighter, easier to manipulate, and had a smaller frame. Klamath 'plunge nets' were mounted on a frame consisting of a pair of side poles which met at the top and were reinforced with a cross-piece, called the head bar. The fisherman stood over the surging waters near a falls and manipulated the net with a forward thrust. He could stand between the side poles or behind them, his arms upraised; often he would be struck by the head bar, and wore a basketry cap for protection.

TABLE VI

TYPES OF DIP NETS

Location	Type and Materials: Net	Frame	Shaft
Fraser	a) braced dip net Indian hemp pursed on bone rings signal line to close	elliptical vine maple	fir or cedar
	b) swept dip net similar to above but smaller pursed or non-pursed(?)		
Columbia	a) common dip net[1] willow or flax fibre fastened tightly to hoop	elliptical maple sapling bent into hoop	--- oxhorn segment to hold hoop ends
	b) pursed dip net similar to above but with slip-knot pursing line to close		
Klamath	a) A-frame lifting net iris fibres conical net attached by headlines to frame signal & triggering lines to close mouth of net	trapezoidal	two handles con- verge from frame to make A-shape
	b) plunge net iris fibres conical net attached firmly by its loops	semi-circular	two handles con- verge from hoop to make snowshoe shape

[1] Columbia dip nets data does not specify whether braced or swept in the eddy.

TABLE VII

COMPARATIVE DIMENSIONS OF DIP NETS

Location	Type	Net	Frame	Shaft
Fraser	a) braced dip net	4 to 5 ft deep	6 ft by 3 to 4 ft diameter	16 ft and longer
	b) swept dip net	---	4 ft by 3 ft diameter	'long'
Columbia	conical net	4 ft deep	2 ft diameter	'long'
Klamath	a) A-frame lifting net	5 to 6 meters deep	2 meters wide	'long'
	specimen[1] measured	540 cm deep	trapezoidal: 105 cm top margin 210 cm bottom 166 cm both sides	---
	b) plunge net	conical	1 meter diameter	4 meters

[1] Kroeber & Barrett:1960:35

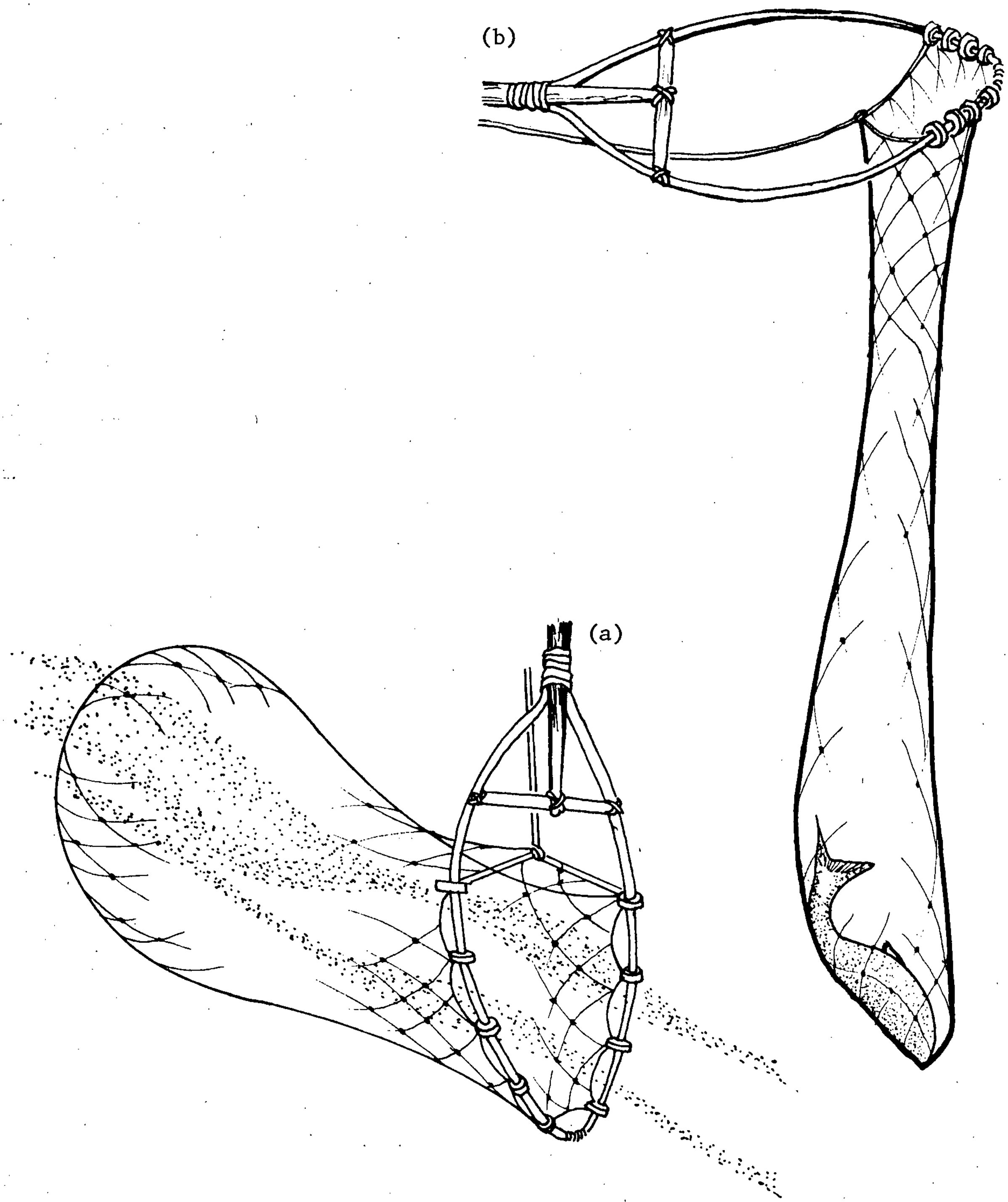


Figure 15. Fraser River dip net. Bone rings on elliptical hoop (a). Net pursed when line released (b).

Dip nets made on the Fraser-Columbia pattern were swept through roily backcurrents where salmon would linger below the rapids. Fraser sockeye, for example, swim near the surface and, with luck, could be swept up in the dip net. Both dip nets and plunge nets were repeatedly immersed. In the Klamath which has no sockeye runs, the plunge net would take coho and chinook.

(c) <u>River mouth (downriver) adaptation-dip net</u>

A special adaptation reported for the Quinault and lower Columbia groups was used at sites near a river mouth. Channels were excavated and platforms built from which a dip net similar to (b) (Columbia model) was manipulated. The shaft was 12-15 feet long. Ray (1938:109) reports for the Chinook that it was a spring fishery, probably for chinook and sockeye which run together in May-July, operated before the level of the Columbia rose.

> ...channels were dug near the shore...of proper width and depth to accommodate a dip net. A staging was then erected and made variable in height so that it might be adjusted to changes in water level. The edge of the staging was aligned with the inner edge of the channel...

The fisherman moved along the staging, keeping his dip net in the channel.

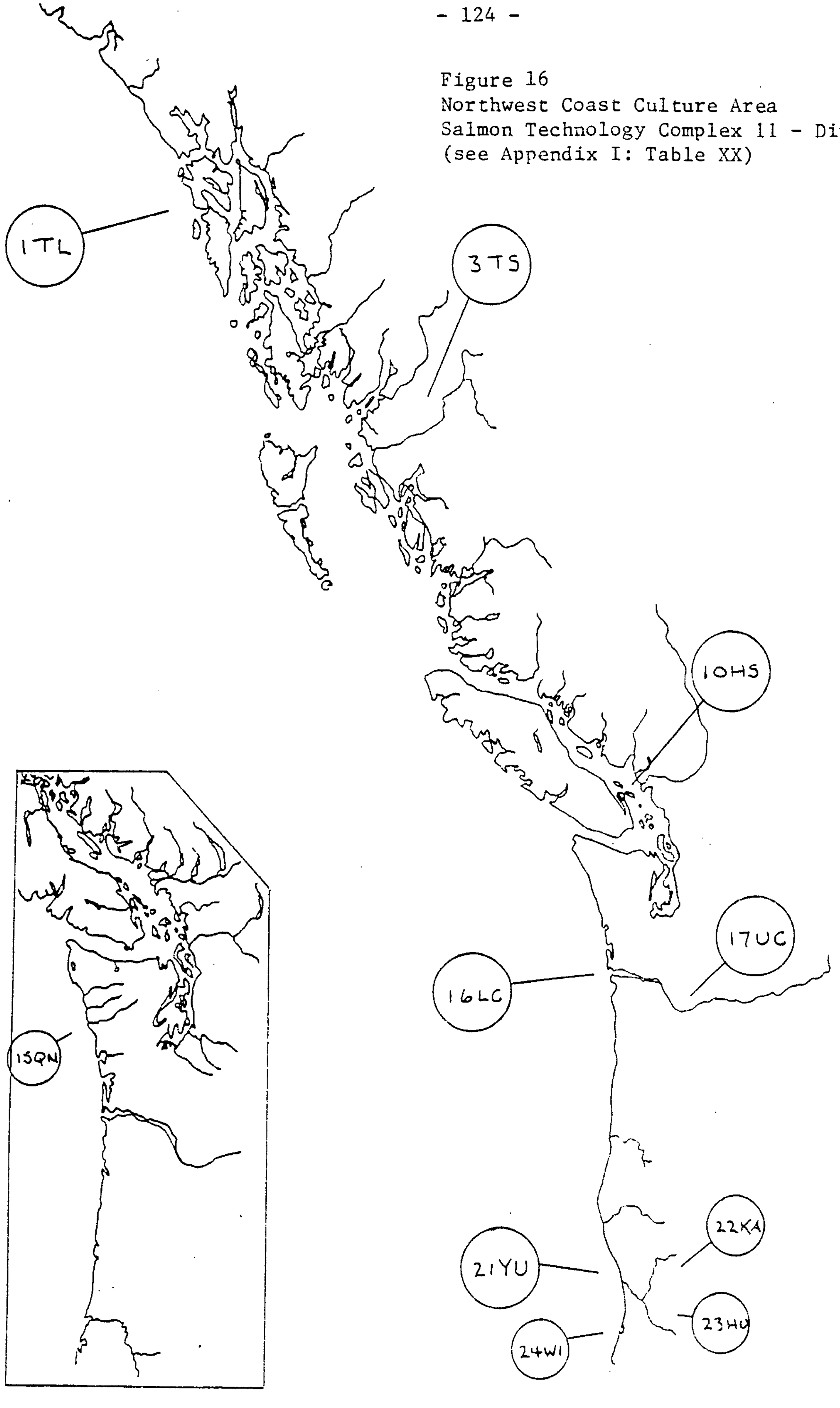
Olson (1936:31-33) reports the same adaptation for the Quinault which was used at low tide because there were "no ownership restrictions below the high tide mark".

3. Distribution

As a highly productive salmon technology complex, the dip net was used at canyon sites in rivers with major salmon populations. While the Fraser, Columbia and Klamath are best documented, other evidence is also available. The Chilkat (Tlingit) used dip nets twenty-six miles upstream from the mouth of the river; Hartley Bay and Gitksan (Tsimshian) built scaffolds out over the eddies for dip netting salmon; but there is no reference in this literature to Nass River resource holding groups. Oregon Coast groups and the Tillamook built scaffolds for 'lifting nets' (Barnett:1937:164:195), however, the site locations are not indicated. The Tolowa used the A-frame lifting net but, according to Kroeber and Barrett (1960:154) had no platforms; apparently it was not a significant fishing method on the Smith River. A similar statement is made for the littoral Wiyot who did not have access to the Klamath River.

The Skeena data show divergence from the pattern of canyon dip net stations in principal rivers. No details are provided in the regular ethnographic sources to describe a complex similar to Fraser and Columbia river canyon sites. There is confirmation that dip nets were used by the Gitksan and the Hartley Bay Coast Tsimshian, but there is no indication of the relative importance it had. One can only conclude that while local resource holders may have found appropriate conditions for the use of dip net technology in smaller systems, only on the Columbia, Fraser, and Klamath Rivers can the complex be regarded as significant.

Figure 16
Northwest Coast Culture Area
Salmon Technology Complex 11 - Dip Net Stations
(see Appendix I: Table XX)



4. Social Variables

Fishing stations in the canyons where dip netting technology was used were regarded as valuable resource holdings. Sites were owned by lineage groups who had recognized rights of access to the fishery. Each such location was known by name (22). Speaking for the Northwestern California region, Hewes records in his field notes (1940) [quoted in Kroeber and Barrett:1960] that fishing places at eddies where A-frame lifting nets and stations were operated were "always owned privately". Kroeber (1925) had found that not only were the sites owned but sometimes they were considered corporate property with several people having 'shares' in the fishing rights at the site. The shares were paid out on the basis of apportioning the length of time a co-owner could fish; the time units were usually on a twelve hour basis, thus an individual might have the right to fish at the station one day a week, or two and a half, or any divisable number. Ownership notions in the area, particularly among Yurok and Karok, are highly individualistic.

Spier and Sapir (1930) were told that fishing stations in the canyon

> ...passed by inheritance into the possession of a group of relatives in each generation. ...No one else was allowed to fish at a particular station without permission of its owners... Each station had its overseer who was usually a chief or head man.
>
> (p.175)

As many as six to ten men might claim property rights, any one of whom could "preempt the best place at the station temporarily" (ibid). Whether all the co-owners were of one corporate lineage group is unclear, but they shared kinship ties.

Fraser canyon sites were named and owned by an association defined by Jorgensen (1969) as 'patrideme and sons'. Upper Stalo people, particularly the Tait who occupied villages in the canyon from Hope to five miles upstream of Yale, were the principal owners of dip netting stations. But flexible associations of kin-based membership in resource holding groups and bilateral inheritance rules among the Halkomelem may have provided fishing opportunities for some downriver people who could support a claim.

Although ownership of stations was sometimes collective and always specific, the ownership of the dip net itself was individualistic. The materials needed to make a dip net were readily available, and its manufacture could be accomplished without difficulty. As Spier and Sapir's informants related:

> While the station and the staging erected there was common property to the group of owners, each man fished with his own...net.
>
> (p.175)

The salmon caught was carried by family members up to the processing areas above the site. The occupation of fishing at the dip net station was a solitary endeavour. No doubt at the height of the season men would spell one another off, taking turns at the arduous work.

5. Ecological Variables

The two principal styles of dip nets were, at least to some extent, related to differences in salmon species. The larger braced net was designed to take chinook salmon which run early in the season when the river is high. The combination of heavier currents and more sizeable species was met by a sturdier version of the dip net and a technology capable of withstanding the greater demands placed on it. Braced nets were set lower in the stream, according to Halkomelem informants, because chinook swim at depths slightly below sockeye. The lighter, more flexible dip net used with a sweeping or plunging action was suitable for smaller species, sockeye, coho (and steelhead trout). Smaller chinook were also taken by this means. In the Skeena, Fraser, and Columbia there is some overlap of chinook and sockeye runs; the dip net season was July and August in the Fraser; May, June and early July in the Columbia (Spier & Sapir:1930:174). On the Klamath the most important runs of chinook appear as early as July although they are considered to be part of the fall run.

There is a correlation between important chinook salmon producing rivers and the use of dip net technology. Although they are the largest and often stated to be the most favoured, chinook are not the most abundant species and their distribution is limited to a few rivers. The Columbia was the centre for chinook abundance on the Pacific coast. I do not have an estimate of the pre-colonial chinook population supported in the Columbia watershed but it was significantly greater than the Fraser population which, in a reconstruction of salmon stocks beginning with the cycle year 1801, has been estimated at 300,000 (23). Other relative estimates can be made on the basis of escapement figures which indicate the support capability of a river system. The present Fraser escapement averages (in thousands) 40-80, the Columbia exceeds 100, the Skeena 30-60, and the Klamath is broadly estimated at 50+ (INPFC:Bull23).

Differences in species alone does not account for the two dip netting methods; in fact, the Northwestern California data suggests that differences in site features were more pertinent to the selection of one method over the other. To operate either braced or plunged nets the countercurrent of an eddy must be accessible to the fishermen. Where a swift current is channeled through a narrow pass in the river the water is roily and turbid in the mainstream, the force converted at spots along the shore into strong eddies. The A-frame required a strong, steady counter current to hold open the net, whereas the plunge net could be employed in swirly unstable eddies. The fishermen also counted on water turbidity to prevent the salmon from seeing the net, and in summer a considerable amount of silt is carried downriver in large Northwest Coast systems. In summary, the specific river features that existed at dip net locations naturally limited the number of appropriate sites.

SALMON TECHNOLOGY COMPLEX 12 - REEF NETS

1. Contextual Description

The reef net was a distinctive salmon technology complex designed to intercept the Fraser-bound runs of sockeye and pinks at salt water shallows in the Straits. A large net was anchored in position facing into the current which brought salmon. The direction of the tide and current was the same at most reef net locations: the current accompanied an incoming tide, and when the tide ebbed the current reversed. The opening to the net was set in the direction of the current and could not be changed when the tide changed. Setting the anchors and lines of the reef net was a major undertaking; once set, the net remained in position for the season. Indeed, each location was suited only to one or the other tides; a flood tide was the preferred. Limitations of time and tide did not prevent the reef net from being a highly productive system. A single operation was capable of capturing hundreds of pounds of fish.

The reef net fishery operated at locations in the salt water channels of Haro and Rosario Straits, off headlands on the San Juan Islands, Lummi Island, and Point Roberts peninsula. It is here that the waters of the Strait of Georgia and Juan de Fuca Strait meet. Fraser River sockeye runs typically approach the mouth of the river by a southerly route, through Juan de Fuca. The runs usually appear in July and August but in one year of four when the cycle of quadrennial dominance effects the composition of sockeye stocks the runs appear in August and September. Several millions of sockeye run to the Fraser; in a dominant year the estimate is as high as 8 million or more. Low cycle years bring runs of 2-3 million sockeye. As the run neared the mouth of the Fraser it became more densely concentrated; reef net sites at Point Roberts had the best access to abundant stocks of salmon.

The value of permanent reef net locations to Straits Salish resource holding groups cannot be underestimated. As a littoral society with no direct access to the Fraser River, and no sockeye streams in its own territory, Straits fishermen nevertheless exploited the resources of the major sockeye producing river on the Pacific coast. Reef net technology made it possible to catch salmon in large numbers before the runs left salt water. Locations were named and owned. A crew operating from two anchored canoes aside the net worked for the owner of the site on a co-adventure basis (24), each man receiving his allotted share of the catch. Since locations were limited by natural conditions, those who owned and controlled reef net sites had a distinct economic advantage.

2. Types and Materials

Only one type of reef net was operated, a large rectangular net with a wide mouth entrance; the nether end formed a bunt in which a small hole (the 'vulva') was left. The net comprised many sections of net pieces, joined together by a ritualist. Each section was owned by a member of the crew. The owner of the site decided how many people would have shares in the enterprise, and this in turn determined the size of the net. The usual range was between 30 to 40 ft in length, and 20 to 30 ft in width. Nets were made of willow bast twine in a small mesh and often dyed a darker shade to make them less noticeable. Reef net lines were made of cedar withe ropes 1½ to 2 inches thick.

Four huge boulder anchors were laid at distances 200 ft apart, squarely. Each anchor comprised several hundredweight beach boulders which had been looped with cedar withe rope and lowered one by one to the seabed. Two main forward anchors were set ahead of the leading edge of the reef net. From each forward anchor (a) a lead line attached to a buoy led to the canoe, and (b) a head anchor line led to the lower corner of the net mouth. There were sinkers at the lower net mouth. The breast anchors were laid to the outside rear position of each canoe to stabilize and counterbalance the weight of the net. The lengthwise margin of the reef net was suspended by side lines from each canoe. The principal lines of tension were from forward anchor to net mouth, from breast anchor to canoe, and from canoe to net side lines. The stability of the net was secured by stress displacement on these main lines.

The space anterior to the net mouth was cleared to provide a pathway for the salmon to enter. Typically the area was defined by the use of floor and side lines as an entrance to the net. Beginning 100 ft or more in advance of the net as many as thirty lines might be used. Side or wall lines were attached at the top to the reef net lead line, and at the bottom to the head anchor line. Floor lines ran from one head anchor line to the other. Seaweed was sometimes tied to them to give fish the illusion of a natural pathway through undersea vegetation. For the same reason, if kelp were present on the reef, the space in front of the net would be cleared of growth.

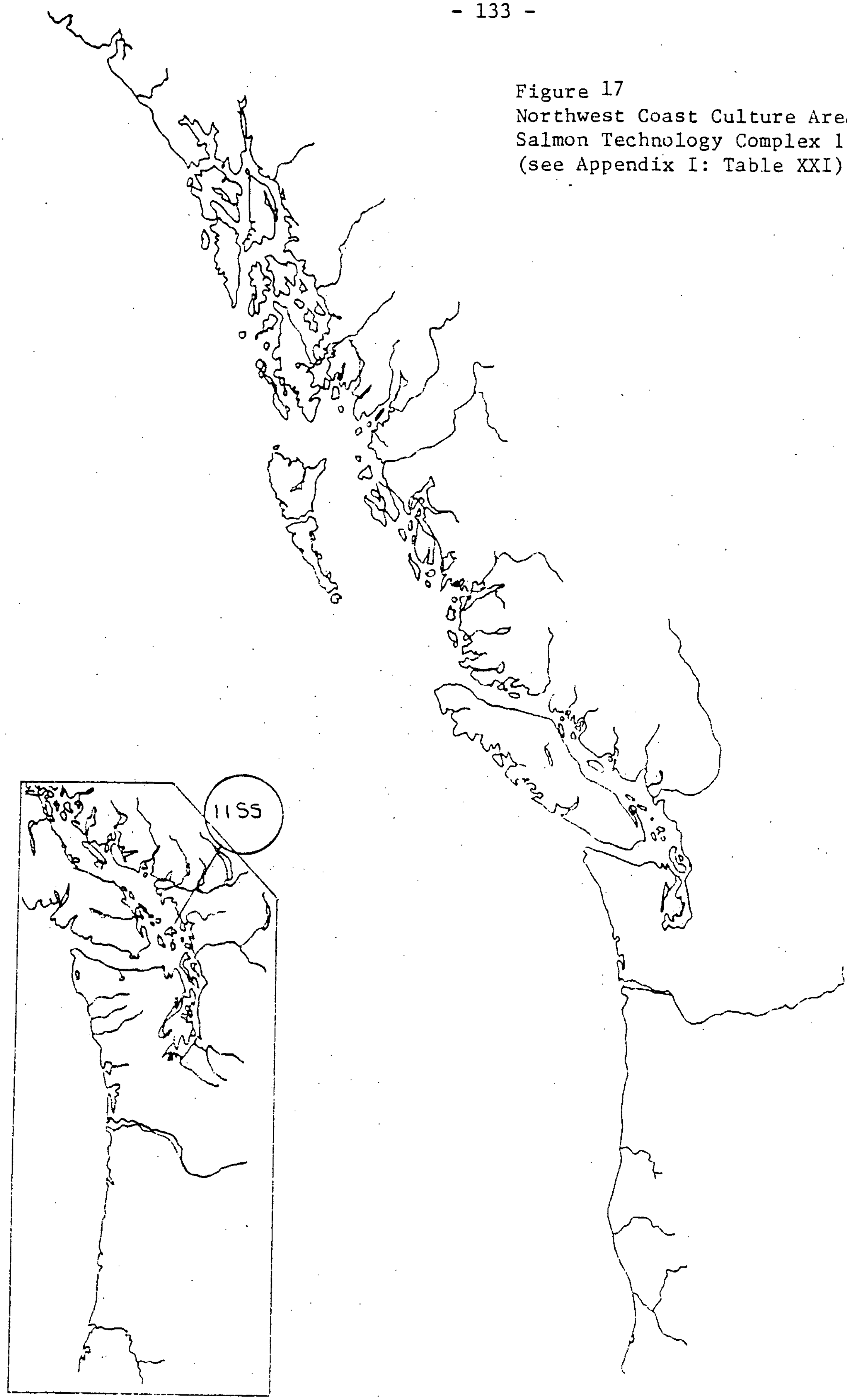
An organization of anchors, sinkers, buoys, and lines held the net in position, suspended between two large canoes of a special design. A crew of 10 to 14 men was common. The captain stood in the offshore canoe ready to give the signal when it was time to close the net. Lines to the breast anchors held the canoes athwart, parallel to the reef net. A pin on the gunwale of each canoe took up the slack, holding the breast lines taut until released. As soon as the salmon entered the net the captain gave the word to lift it.

> All pulled at the net side lines or at lines attached to the net weight. At the command... "Release it!" the men at the breast lines pulled the pins and allowed the two canoes to come together. The fishermen pulled the net into the inshore canoe and took the fish into the offshore canoe. As they lifted the net they "saluted" the fish...
>
> (Suttles:1951:171)

3. Distribution

The Straits Salish were the only Northwest Coast people to employ the reef net(25). Suttles (1951) has mapped 34 locations in the straits and 15 locations at Point Roberts that were owned by Lummi, Semiahmoo, Songish, Saanich and other Straits resource holders. Suttles has collected many references to the histories of the locations and names of past owners.

Figure 17
Northwest Coast Culture Area
Salmon Technology Complex 12 - Reef Nets
(see Appendix I: Table XXI)



The reef net was exceptionally productive.

> With fishing at its best a single net may secure as many as 2,000 salmon in a day, but to do this the fishing canoes must continue at their posts, the catch being transferred to shore by other boats.
>
> (Rathbun:1900:314 quoted in Suttles)

The productive capability of the reef net given optimal conditions could be even further extended.

> There is a small but productive reef inside of Iceberg Point, at the southern end of Lopez Island, on which a few nets are used, and where daily catches of 3,000 to 4,000 salmon are sometimes made.
>
> (ibid:315; in Suttles:220)

4. Social Variables

(a) Crew recruitment -- Owners of reef net locations recruited men to work on the net in a co-adventure relationship. The obligation of a crew member was to contribute a section of the net. The materials for net making were collected by women in his family and made into cordage from which each fisherman wove his net section. For this investment the fisherman received in return a share of the season's catch, duly apportioned according to an established distribution procedure. The catch was counted out first in groups of twenties (by tens doubled:see Suttles:1951:179-180), the crew members receiving first shares. If the catch was large, the captain repeated the count until all the salmon were distributed.

> The owner divided, or had his captain divide, the fish among the crew in this way after each day's fishing until they had received enough. Thereafter the fish were his. The wives of the crew members, who until this time had been drying their own fish, now helped dry the owner's fish.
>
> (ibid)

During the season the owner of the location was also responsible for feeding the crew members after a day's work.

The labour-intensive nature of the reef net complex is underscored by the relation between the site owner and the crew. While the owner had (exclusive) access to a resource-rich location he could exploit it only through the use of a technology that required considerable expenditure of labour investment, particularly in cordage manufacture. Not only did crew members and their families supply the netting materials but in addition the whole crew co-operated to make the heavy cedar withe lines needed for the reef net. Suttles noted that when native materials were no longer used the size of the crew decreased to as few as six men (ibid:220). Apparently the main capital investment made by the owner (other than his commitment to feed the crew members) was in anchor stones, considered to be his property. The value of the labour provided by crew members was important to the success of the traditional reef net. On the other hand, by becoming a member of a crew an individual gained access to productive resource areas.

(b) Site ownership -- Natural limitations on the number of possible reef net locations increased the value of site ownership. Those who claimed hereditary rights of access to the site were sometimes opposed. "Often there was more than one claimant to a location", as Suttles observed (ibid:215). Demographic changes that occured in the late nineteenth century affected previous patterns of transferring inherited rights.

Rights of ownership to reef net locations were inherited, apparently by an individual, or transferred through marriage. Suttles' informants emphasized the names of individuals as owners rather than families. Boas (1890) had understood that each Songish winter village had a corresponding reef net location. But it is not possible now to find evidence to support this, either for the Songish or any other Straits group, in Suttles opinion. There is no apparent correlation of winter village to location, nor of village leader to location owner. Suttles' conclusion is:

> I believe ownership can best be treated as if it were individual, recognizing that the owner may have felt obligations toward kinsmen who might be co-heirs but not co-owners.
>
> (1951:222)

What we do know is that each location was named and owned by a specified resource holder who had full rights of access to the site, and who could recruit and maintain a crew for the season. The owner if he wished could appoint someone else to be 'captain', the person who gave the signal to close the net and generally conducted the operation. A ritualist was also required to put the sections of net together according to the proper procedure. The origin was credited to supernatural helpers who taught people how to use the reef net (ibid:172). That the reef net was not a recent development seems to be supported by such evidence as the special observances that attended joining the net pieces and speaking the commands.

5. Ecological Variables

The reef net operated during the summer runs of pinks and sockeye salmon when the waters of the Straits were relatively calm, and the weather clear. These conditions were required to successfully operate the reef net. Heavy tides and strong currents would put too much stress on the net lines and anchors. Moreover, since the net was operated without signalling devices, the captain needed good visibility. Oceanographic features also played a part. As previously mentioned, appropriate tides and currents were essential for net operation. At some locations at Point Roberts the current stayed the same despite changes in tidal direction, and thus the net could be operated for longer periods of time each working day. In other locations, a floodtide was best. Seabed features on the shoals required water depths sufficient to allow the top of the net to be submerged a few feet below the surface of the sea, and the bottom of the net to be suspended several feet above the ocean floor to prevent snagging.

The quadrennial dominance of Fraser River sockeye had its high cycle year in 1801, and each subsequent fourth year, until the Hell's Gate disasters, in 1913-14, almost destroyed the Adam's Lake run and other significant spawning populations. A slow recovery of stocks occurred during the 1920s and 1930s; the Adam's Lake run eventually reconstituted itself in a new quadrennial cycle with the dominant year equivalent to 1922 and every fourth year following.

Reconstructions of nineteenth century Fraser River salmon abundance (Kew:1976; Berringer:1976) demonstrate that the quadrennial dominance of sockeye establishes for all species a ratio of 14:2:1:1. The presence of biennial odd-year pink salmon changes this ratio to 6:1:2:1. (These figures are based on the estimated average abundance of all salmon stocks as they enter the mouth of the Fraser River.) As a result, the Fraser runs of odd-year pinks serve to even out abundance fluctuations.

Characteristically, the largest proportion of Fraser-bound sockeye and pink salmon enter the estuary via the Straits of Juan de Fuca. However, at irregular intervals of time, for reasons unknown but possibly associated with marine temperatures in the offshore approaches, salmon will come from the northern route instead; that is, through Johnstone Strait. Thus, the runs would not enter the area south of the Fraser estuary, where Straits Salish people had resource locations. Consequently, when that occurred in the past, the reef net fishery would fail.

PART ONE Footnotes

1 Early accounts of this period on the lower Columbia are included in Lewis and Clark (Thwaites edn. 1905), Cox:1957 (orig. pub. 1831), Franchere:1854 (orig. pub. 1820), and Ross:1849.

2 Croes, ed. (1976, 1980) reports the excavation of water saturated sites on the Hoko River revealed a 2,500 year old fishing camp.

3 See ff Appendix I Table XV, p.4.

4 Gill nets were mainly used as a sturgeon fishing method by the Katzie, and it is within this context that Suttles provides these observations on ownership restrictions (1955:22).

5 Nehalam River is not specifically identified in the ethnographic literature but of the several rivers which empty into Tillamook Bay it has the largest salmon runs (INPFC:BULL.23).

6 Haeberlin and Gunther (1930:27) reported alder was used for pilings or posts; willow for staves, i.e., the poles of the panels.

7 A circular, bowl-shaped net of the same type was used at weirs by the Lushootseed, Quileute, and Quinault. Olson 1936:29 reports that nettle fibre was used for the cordage materials, and elk sinew, "fine as grocer's twine" for signal devices.

8 Elmendorf:1960:69-70 provides the most detailed accounting of the technical aspects associated with dipping nets at communal weirs.

> "The operator pulled apart on the upper, crossed ends of the side poles as he drove the lower ends, with prong attachments, into the stream bed. This expanded the hoop in a direction parallel to the current and drove the prongs in beyond the support stake. The latter, engaging the prongs in the river bottom, prevented the current from tearing the prongs out and carrying the net downstream, and allowed the net to remain fixed on the bottom of the stream.

> With the net in this lowered position, the loop on the trigger string was slightly below the level of the platform floor...held taut...When he felt movement of a fish against the string the fisherman leaped to his feet and pulled up on the dip-net side poles, raised the hoop frame above water level, rotated the net 90 degrees horizontally, and hooked the prongs on either side of the net frame over the outside pole of the platform scaffold and the inside pole of the platform floor. The net frame was now suspended about four feet above the water, and any fish in the net could be removed and clubbed."

9 This estimation is based principally on the emphasis given these two technologies in the Kroeber & Barrett study. No direct evidence is available.

10 cf Smith:1940; Elmendorf:1960; and Olson:1936.

11 18th and 19th century useage of the words 'pots' and 'wears' to describe basketry traps is verified by the Oxford English Dictionary, 1933 edn. 'Weir' and 'wear' are used interchangeably. One definition of weir/wear is the river obstruction device referred to in this study as weir. A second definition is given that refers to basketry traps, called wears, pots, or weels. The OED cites published examples of useage, as follows: 'sets his weir' (1834), 'a weir is a basket loose and open at one end, and smaller at the other, into which the fish were driven' (1845), and a weel was 'made of osier-twigs which are supported by Circles or Hoops that go round, and are ever-diminishing; its Mouth is somewhat Broad; but the other end terminates in a Point' (1725). In addition, a definition for 'pot' is given as "A wicker basket used as a trap for fish...".

12 I have not examined early Department of Fisheries, Government of Canada, reports for the period; these and other historical sources may contain a more adequate description.

13 These details are from McIlwraith's (1948) geographical listing of villages: Village #23, Appendix.

14 Mackenzie was very impressed with their canoe skills both on this occasion and others; the Bella Coola fishermen accomplished this feat just cited "without taking in a drop of water".

15 Culture Elements numbered 15 to 19 inclusive (1950:166-167).

16 Whether this trap was on the Bella Coola River or one of the other five or six large rivers that empty into Dean Channel, Bentick Arm or Burke Channel within Bella Coola territory, is not reported.

17 McIlwraith mentions that such information was extremely difficult to obtain (1948:286). All other quotes from pp. 135-36.

18 INPFC:1967:275 reports that 89% of the total Skeena escapement of sockeye is composed of stocks that enter the Babine and neighbouring lake systems.

19 A full description of the method used to dry, pulverize, and press the salmon supplies into transport baskets is given by Lewis & Clark (quoted extensively in Spier and Sapir:1930:178-79). Each tightly packed basket contained 90-100 lbs of dried salmon, wrapped in protective materials made of dried fish skins. Twelve baskets, seven on the bottom and five on top, formed a stack which was wrapped in mats and tied, awaiting transport. "...the fish thus preserved are kept sound and sweet for several years... At the Dalles, 'the stock of fish dried and pounded was so abundant that he (Clark) counted one hundred and seven of them (bundles), making more than ten thousand pounds of that provision'".

20 These documents are kept in Frederick Dally's file in the B.C. Provincial Archives.

21 One of Dally's Cowichan weir photographs is included in this study (see Plate I).

22 Duff:1952:63.

23 Kew:1976; Berringer:1976.

24 cf Andersen & Wadel:1972.

25 cf Suttles:1951:155 ff. for discussion of Barnett:1939 incorrect listing of reef net for Halkomelem and Northern Gulf groups.

PART TWO -- SALMON BIOLOGY AND HABITAT: the ecological record

1. Introduction

The anadromous Pacific salmon (*Oncorhynchus* sp.) is one of the planet's great migratory tribes. Sweeping through sea lanes in the subarctic zone of the Pacific, salmon spend most of their lives unobserved by humans. As with other migratory animals, salmon resolve the problems associated with feeding a mass population by extending the space they occupy at various life stages. Through the mechanism of migration, salmon, caribou, Canada geese, the gray whale, the humpback whale, and northern fur seals secure relatively safe breeding grounds to rear their young in one type of location, and sufficient food supplies for adult members in another. Necessarily, migratory animals are highly adapted to a range of ecological conditions. Anadromous salmon, for example, reared in fresh water, emigrate downstream as young fry and make an adaptation to salt water conditions at the estuary. During the adult phase, salmon are marine predators, living on small fish, fish larvae, squid, and crustaceans including euphasiids, amphipods, and copepods. At maturity they return to the natal stream to spawn and die. To human interceptors, migrating salmon stocks become a useable resource only as they near the end of their life cycle, and move from the open marine environment to the waters near land.

Pacific salmon are distributed widely in the north Pacific, entering coastal streams in Asia and North America to spawn. There are six species: chinook, coho, pink, sockeye, chum, and masu (*Oncorhynchus* masou), but only the first five enter fresh water in North America. The masu inhabits waters off eastern Asia to the estuary of the Amur River, and in the Sea of Japan, where its centre of abundance is Hokkaido. Masu salmon closely resemble coho, the only Oncorhynchus sp. that does not run in Asian streams. The geographical distribution of the two species is totally separate (INPFC:16:76). The range of salmon distribution within the Northwest Coast culture area is as follows: all five species occur in Alaska to the northern limit of our area and beyond to Bristol Bay and the Bering Strait; but only chinook and coho occur in Northwestern California, the southern limit. Beyond this, chinook and coho extend their range about 3° latitude south to 37°. Chinook run in the Sacramento River and into the San Joaquin system, where their southernmost range is the Merced River. Coho enter coastal streams near Monterey but do not spawn in the Sacramento watershed; the San Lorenzo River is the most southerly coho spawning grounds. Chum salmon run in most Oregon coastal streams as far south as the Coquille River where an Athapascan group, the Coquille, once lived. Sockeye run in the Columbia watershed system, reaching their southern extent at Redfish Lake, Idaho, in the Snake River tributary, outside the limits of Northwest Coast culture (1). Pink salmon may at one time have occurred in the Columbia system too (2), but the Puyallup River in Puget Sound is now the limit of their southerly range (INPFC:23:Part 4: Fig.5,6,8,13,21, and Table 2).

A comparison of Pacific salmon to other fish of the same family, Salmonidae, is useful. Steelhead trout (Salmo gairdneri), Atlantic salmon (Salmo salar), and the coastal Cutthroat trout (Salmo *clarki clarki*) are related and similar in general appearance to Pacific salmon species. Atlantic salmon occupy much the same macro-region of the Atlantic as Pacific salmon do of the Pacific. Both are adapted to cool temperatures both in ocean currents and spawning streams. Atlantic salmon run in rivers in Scandinavia, Greenland, Iceland, Ireland, Great Britain, Canada, and as far south as Connecticut in the west, and northern Spain in the east. An historical reconstruction of Atlantic salmon fisheries in the Kemijoki River in Finland, a major salmon producing area, indicates the antiquity of weirs and large river traps in northern Europe (Vilkuna:1975).

Atlantic salmon is distinguished from Pacific salmon not only by geography and genetic separation, but by life history differences. The composition and timing of runs does not exhibit the same intensity and regularity among *Salmo* sp. as is characteristic of *Oncorhynchus* sp. Migrations back to fresh water are more widely dispersed in time both for Atlantic salmon and the *Salmo* sp. that run in the Pacific streams, steelhead and rainbow trout. Many *Salmo* sp. individuals return to spawn more than once, although it has been noted that temperature and latitude may affect this capability. The rainbow trout survival to spawn again decreases from south to north (Hart:1973:129).

Steelhead occur co-terminously with runs of salmon spawners in many streams, particularly in Puget Sound and in the Columbia River area, centres of steelhead abundance on the coast. Elmendorf cites a Twana informant who said the steelhead were a 'tribe' of salmon. Yet, distinctions in native languages were made for steelhead and for each species of salmon, both in the literature and in ethnoichthyology glosses (3). Characteristic differences in *Salmo* sp. behaviour during migration affected resource utilization. Steelhead trout will feed while in fresh water, and thus can be taken on a lure, unlike Oncorhynchus sp. which do not feed nor readily accept a lure. Trout were sometimes caught with salmon at weirs, in dip nets or lifting nets, and with the harpoon. While anadromous steelhead do not occur in streams in Tlingit territory (Hart:1973:130), they are otherwise widely dispersed throughout the Northwest Coast.

The distribution of individual species of Pacific salmon, the centres of salmon abundance, and characteristics of rivers and streams within the area will be examined later in this chapter. These macro-environmental factors bear on the subject of salmon resource availability in a more obvious way than do the small details of biological variance. Yet, the year-to-year fluctuations in salmon population, variations in survival rates, and the effects of stream gouging in spawning areas were also elements that ultimately determined the efficiency of resource utilization. Before analyzing the patterns of species abundance and geographical distribution in Northwest Coast ethnographic areas, I will summarize details about the biological nature of the salmon resource.

2. Model of Interacting Variables

The range of potential technological applications described in Part One indicates a salmon fishery on the Northwest Coast that was diversified and complex. Unlike the maritime cod and halibut fishery where baited hook-and-line techniques constituted the main means of production, traditional salmon fishing exhibited a wide latitude of potential strategies, selected to meet variations in resource locations and species of salmon. An objective of Part Two is to consider the ecological relations within the system of resource utilization in greater detail. What variables in the nature of salmon resources affect the selection of extractive techniques and procedures?

The aspects that most directly concerned resource user-groups were: -- where to catch salmon -- how to catch sufficient quantities -- how to organize production requirements -- when to expect peak runs to occur, and for what duration? Ecological variables included the following:

(i) hydrological specifications: turbidity, clarity, velocity of the current, depths, breadths, riverbed features, temperatures, salinity, tides, eddies, etc.; and

(ii) salmon characteristics: biological variability, timing of runs, duration of peak periods, abundance, and the distribution of stocks.

In the interaction of these and other variables a salmon fishery site is definable. The sets of ecological variables are independent, they are entities that exist in the world beyond human control or manipulation. The a priori conditions revealed by the natural environment, therefore, are the <u>independent variables</u> in the "fisherman's dilemma" (4). <u>Dependent variables</u> are those elements in the superstructure of the traditional fishery which are social or technological. The labour effort of co-operative groups or individuals, differential control of productive resource locations and the means of production, the use and application of technology are dependent variables. A model of the Northwest Coast fishery includes the interrelation of both sets of variables. Thus in this study the process of traditional salmon resource utilization is to be treated as a constitutive system.

3. Characteristics of Pacific Salmon

a) Life history:

The spawning populations in each salmon species must meet the criteria of a different set of ecological conditions, yet despite variations in detail they followed essentially the same life pattern, presented here in its general outline.

(i) early development

: newly hatched alevins live for a few weeks on the reserves of the sac to which they are attached

: salmon emerge from gravel redds to remain in a fresh water environment as free-swimming fry, feeding on tiny life forms and insects. Sockeye in this phase move into an adjacent lake system where they remain for up to a year.

: fingerlings or fry emigrate downstream and emerge in estuarial waters where they typically linger 5-6 weeks and feed upon plankton and zooplankton (pink, for example, remain in the estuary 40 days growing from 3.5 cm to 8.4 cm).

(ii) adult salmon

: developmental maritime phase continues for several years as salmon gain maturity

: sexually mature salmon migrate back to their native watersheds, moving as a collective gene pool unit once they gain fresh water

: at the spawning grounds female salmon prepare the redds, mate, and deposit their eggs; they then die.

Salmon start life as newly hatched alevins living on the reserves of the sac attached to them. They emerge from the redds as free-swimming fry feeding on tiny freshwater life forms and insects. Lacustrine sockeye salmon at this stage will migrate either upstream or downstream to the nearby lake system where they spend their first year. When it is time to leave the fresh water environment, young salmon head downstream to the sea. The length of time of the emigration is a factor of speed and distance. Little fry swim with the currents and have been observed occasionally to swim faster in a slack flow. When they reach the estuary they linger for some time feeding on new life forms, and adapting to salt water conditions. Growth in the estuaries is rapid.

A comparative study of temperature variation and its relation to the growth of zooplankton in the Strait of Georgia (Vernon:1958) has demonstrated the dependance of young salmon on the availability of sufficient food resources when they first enter estuarial waters. Vernon's data indicate an inverse correlation exists between summer salt water temperatures in Georgia Strait and the subsequent abundance in Fraser River stocks of pink salmon returning to spawn in the next cycle.

Entering the marine phase, young salmon move out into the straits and channels to the sea. This life-stage is least accessible to researchers but it is known that salmon migrate great distances from the river mouth; for example, coho salmon are recorded at 1600 km offshore (Hart:1973:116). The length of time they remain in this phase is particular to each species (Table VIII), as is the food they

TABLE VIII

PACIFIC SALMON

Species	Age at maturity	Average weight[a] (lbs)
Chinook	varies between 3 to 7 years	12.8
Coho	3 years	7.
Pink	2 years, invariable	5.4
Sockeye	4 years	6.
Chum	3 and 4 year-olds	11.7

[a]Source:Berringer (1976) based on average weights by species of Fraser River stocks. Figures derived from IPSFC annual reports of catch statistics.

select. Chinook will feed upon such fish as herring, pilchards, or sand lance, and various kinds of invertebrates. Rapid weight gain occurs early in the marine phase, however, growth continues even during the inshore migration.

Mature sea-run salmon migrate back to their native watershed systems, feeding during the coastward run to build up stores of energy. All feeding ceases in fresh water or as the river mouth is approached. Sexual dimorphism occurs as the upstream migration begins, and changes in the appearance of salmon are evident. In natal spawning locations, they prepare the redds, mate and deposit their eggs in the streambed. This function performed, soon afterwards they die.

An adequate number of adults must return to the spawning grounds in each generation to ensure the continued success of salmon populations. In modern fisheries management this group is called the escapement. Salmon stocks are susceptible to mortality from many sources. They are most vulnerable during the earliest phases in fresh water and when they have first entered estuarial waters from their rearing grounds, outward bound to the sea. The marine phase reduces the population through natural attrition; the rate of survival is dependent on the availability of food for salmon to feed upon. It is assumed that most losses during the marine phase are the result of predation. Later in the life cycle, when mature salmon begin their homeward run, they must survive continual predation in coastal waters both from larger animals (fish and marine mammals), and human fisheries.

b) <u>variability:</u>

Salmon are highly susceptible to changes in their environment, particularly in fresh water habitats where incubation occurs and alevins develop into fry. One indication of salmon well-being is year-to-year average weight ratios within a single species or, where the data is available, within a single stock. The growth of micro-organisms in the critical estuarial feeding grounds of newly arrived young salmon can be influenced by temperature changes, creating a noticeable occurrence throughout the coast of fluctuations in average weight and population size (Neave:1966). Environmental factors also have an impact on salmon growth during the marine phase when changes in temperature affect the food resources on which salmon depend. Long and short term considerations affect the abundance of salmon that return to spawn in any given location. The relation between ecological variability, the genetic integrity of spawning stocks, and predator impact have implications for the survival of salmon populations.

Long term changes in abundance are usually related to the depletion of salmon stocks due to (a) the destruction of spawning grounds, (b) over-fishing a particular stock, or (c) river and stream impediments that make it impossible for spawning salmon to reach the natal stream. In recent years humans have altered the environment to the detriment of salmon stocks, especially through hydro-electric projects and intensive over-fishing. Other factors include the removal of forest cover, and subsequent destruction of spawning beds; mining operations; railway construction in the valleys of important salmon rivers. Prior to industrial intervention of this type, natural disasters could wipe out a spawning stream, or prevent returning salmon from reaching their destination. Throughout all the centuries, mud slides, flooding and scouring of gravel redds, and hydrological and temperature changes generated natural variations in the abundance and geographical distribution of salmon stocks.

Nevertheless, the threat to the salmon environment has been accelerated in the past one hundred years. Human predation during the intensive fisheries that operated at the mouths of the Skeena, Nass, Fraser, and Columbia between 1880 and the beginning of World War I reduced salmon stocks considerably. Early observers noted that within a few short years from the commencement of industrial fishing on the Northwest Coast millions of pounds of salmon had been shipped from canneries to markets outside the area. The effects of over-fishing were dramatic. Some major stocks never fully recovered (5). Today the conflicts of interest between fisheries management officials, commercial fishermen, and the industry packers have not been resolved, but perhaps a new awareness exists of the sensitive nature of salmon ecology.

The impact of the traditional fishery on salmon stocks is unlikely ever to have been severe. Canadian and American fishery officials in the late nineteenth and early twentieth century mounted a campaign to destroy weirs and traps used by native people, on the assumption that such devices did not permit salmon escapement. However, recent scientific investigations of salmon stocks indicate that spawners return to their natal streams, the pattern repeated to an accuracy rate of over 99% in populations studied (6). If, as it appears, each species of salmon is native to specific spawning locations, then the fallacy of earlier beliefs on which white people acted is demonstrated. Because, had traditional methods of salmon fishing prevented escapement, it would not have been possible for Northwest Coast people to remain on one river year after year, to build their communities there, and to utilize the returning salmon. Traditional Northwest Coast fishermen were highly aware of the need to permit escapement in order to assure continuing stocks of salmon for the future.

In contrast to the interests and expectations of traditional fishermen, commercial salmon fishermen operate within a set of strategy rules based on other criteria. Present-day fishermen must exploit a 'common resource' in competition with all the other fishermen in the area (Andersen & Wadel:1972). Since they fish in salt water where many salmon stocks are intermingled, naturally they do not relate to salmon resources as being of a certain stock or groups of stocks, or belonging to a particular river. It may be argued that since traditional Northwest Coast fishermen had a proprietory interest in specific salmon stocks that they would have been good conservationists. The social control of important resource use sites and fishery locations that was a feature of Northwest Coast societies underscores this view.

4. Hydrological Features

a) Characteristics of Riverine Hydrology

The Northwest Coast culture area contains most of the major watershed systems of the Pacific coast of North America, excluding only the Sacramento River in California, and the Yukon River in the north. In terms of drainage basin area, the Stikine, Nass, Skeena, Fraser and Columbia rivers are the most extensive. The Fraser River drainage basin, for example, occupies 230,000 km^2; its length is 1,370 km. The Columbia River (1,955 km) and its principal tributary, the Snake River (1,670 km), together comprise the greatest streamflow discharge. In addition to the Snake, significant tributary systems include the Thompson River of the Fraser watershed, and the Bulkley River which joins the Skeena near Hagwilget canyon. These large affluents discharge water from basin areas east of the Northwest Coast frontier. They provide important upstream spawning locations for Pacific salmon which must pass through the lower concourse of the watershed system. Northwest Coast people at fisheries in the lower river had first access to the salmon resource as it ascended the stream. The Bella Coola-Atnarko, Chilkat, and Klamath-Trinity systems, though smaller, each represented sizeable drainage basin areas.

Many independent mainland rivers flow directly into the sea. Such streams as these characteristically have their origin in mountain ranges that rise near the coast. Some are short rivers, just a few miles from source to salt water. Others, perhaps longer, debouche from a narrow valley at the head of a fjord. Coastal streams frequently support several major spawning locations for Pacific salmon stocks.

Basic structural aspects of river systems can be characterized independent of considerations of size. For example, the streamflow measurement at any given point along the stream is a function of the extent of the drainage basin area above, and of the climatic conditions of the surrounding land and sea surfaces. Water volumes discharged from the drainage area, together with topographical features of the streambed, define the formation of riverbank features and, ultimately, the structure of the river itself.

Warm-to-moderate ocean currents describe a wide arc up the outer coast, modifying the cool waters of the North Pacific and contributing to high levels of precipitation, most of which falls as rain in lower altitudes and snow at higher levels. In the mountain ranges of the coast this moisture is stored in glacier packs and released by warming temperatures each spring, causing an increase in streamflow volume in glacier-fed rivers. Spring freshets do not affect rain-fed rivers. In the southern part of the Northwest Coast culture area, and in streams on the large offshore islands -- Vancouver Island, the Gulf Islands, the Queen Charlottes, and the Alaskan archipelego -- higher water levels occur during the rainy winter months with a reduction in streamflow volume during spring and summer.

A comparison of the discharge profiles of the Cowichan River on Vancouver Island and the Fraser River illustrates this point (Farley: 1979:39). The Cowichan data indicate highest discharge levels occur in

December and January with a streamflow measurement of 100 m^3/sec. In July and August, water volumes are extremely low, registering approximately 10% of winter average flow. The Fraser River shows the opposite seasonal pattern. Peak streamflow occurs in late June - early July with average flow readings of 100,000 m^3/sec (7). In the winter months the streamflow of the Fraser River measures only 20% of the early summer high.

Variability in the seasonal patterns of different river systems has implications for the distribution of salmon technology complexes. From the point of view of human exploitative strategies, the significant hydrological features are water volumes and velocity. The force of streamflow discharge is a factor in determining how to extract the salmon resource. Where the streambed is level and the banks are wide, surface currents in the river may be moderate and steady throughout much of the year. However, seasonal variation in the hydrological cycle can create changes that may coincide with the timing of important salmon runs. In the case of the Fraser, the heaviest streamflow occurs during the chinook salmon run early in the season.

At the confluence of a tributary and the main stem of a river, hydrological dynamics exert powerful forces as two large streamflows meet and commingle. Typically the conditions at a confluence present good fishery site potential because salmon will seek out the shelter of counter-currents near shore close to the mouth of the tributary. In addition, people who fish below the confluence have access to both those stocks that continue to ascend the mainstream, and those that enter the affluent.

b) Natural Stream Features at Spawning Sites

Salmon typically choose spawning sites in shallow streams with loose gravel cover of a size that can be manipulated by the female salmon when she prepares the redd to deposit her eggs. Chum salmon spawn in streams a short distance from the estuary. They select spawning places with more variable stream conditions than other species. The bottom may consist of coarse gravel, large stones, or boulders. Chum females will occasionally deposit eggs on the streambed, in crevices among the boulders. More commonly, however, a depression is excavated in fine gravel as much as 40 cm below the streambed, and the eggs deposited (Neave:1966a).

Water temperatures and currents are significant factors: the range of tolerable temperature varies with different spawning populations; 3^{o} to 7^{o}C is cited as suitable for stocks of sockeye in the Fraser system (Ricker:1966). A relatively slow steady current is essential to ensure sufficient oxygenation of eggs during incubation. Sudden or extreme changes in water levels cause streambed disturbances that can damage the spawning location. Egg survival is dependent on the proper water conditions --particularly cool temperatures-- and on the appropriate depths and currents to areate but not disturb the redds.

After egg deposition, any major disturbance to the redds can result in high egg mortality. Fall and winter flooding may disrupt the streamflow. High precipitation is only one of many causes of stream flooding; others include the loss of forest cover through fire and disease (and, in this century, because of commercial logging operations). Land slides, mud slides, and streambank deterioration can result from a sudden release of high water volumes that strains the carrying capacity of spawning streams.

Stream obstructions also pose problems. Fallen logs and detritus, forest attrition, and morphological changes in streambed features, were noted in the pre-logging forests of the Queen Charlottes, surveyed in 1878 by George Dawson (1880) and later by Ells (1906). Log jams were numerous in the natural forest and occasionally contributed to flooding and streambed gouging. Nevertheless, moderate log jams retard streambed gouging and protect against damage.

In summary, variables in the hydrological cycle of precipitation and streamflow combine with geophysical properties in the coastal landforms of the area to create innumerable rivers and streams, providing anadromous salmon with abundant fresh water spawning locations. Both seasonal changes in the volume of discharge, and structural features of stream sites, were factors to be considered by the users of traditional technology.

5. Seasonality and the Nature of Runs

Salmon spawning migrations occur throughout the Northwest Coast as highly predictable events of limited duration. Phenologists define seasonality as:

> the occurrence of certain obvious biotic and abiotic events or groups of events within a definite limited period or periods of the astronomic year.
>
> (Leith:Quoted in Nolan:1977)

The timing of the arrival of spawners at any given location does not vary significantly from one year to the next; each run displays a characteristic configuration with regular and recurring dates for first arrival, peaks, and end of run (8).

Each race or stock of spawners forms a run, a discrete event occurring in time. Spawning runs consist of the age-class of a genetic stock. During migration, sexual dimorphism occurs, and becomes accelerated when the fresh water system is entered. The distance from adult feeding grounds in the ocean to the mouth of the river is thousands of kilometers. All salmon species cease feeding entirely in fresh water; the metabolic rate of each spawning population is 'programmed' to provide the migrating salmon with sufficient food reserves to enable it to swim the distance from estuary to natal stream. Stocks of sockeye and chinook, for example, spawn in streams more than 1,000 km from the mouth of the Fraser River. The amount of calories burned during the fresh water portion of the migration is determined by the difficulties encountered -- waterfalls, rapids, heavy currents -- as well as the factor of distance.

In large watersheds with many spawning locations, a series of runs composed of distinct salmon stocks will overlap. Not only do runs of the same species commingle, but different species may run concurrently, as when, for example, the major pink and sockeye salmon runs ascend the Fraser River together in late-August/early-September. Salmon of the same species are more likely than not to return to the spawning grounds of any given watershed system within the same general time frame. Coincident runs of large stocks provide resource user groups with increased resource accessibility; the salmon are present in greater numbers for a longer period.

Once the watershed system has been entered, migrating salmon must make the right 'decision' at each confluence along the way. How the salmon finds its way back to its natal stream is still not fully understood, yet each genetic stock remains distinct from neighbouring gene pools. Scale analysis of breeding populations identifies related stocks, that is, salmon of a single stock, analogous to the way fingerprints identify humans. Most research to-date has been directed to studies of sockeye and pink salmon, partly because the International Pacific Salmon Fisheries Commission is charged with the responsibility to protect stocks of Fraser River pinks and sockeye as part of their mandate. For these species, the evidence is clear: each gene pool is discrete; each age-set returns to the natal stream.

> The very strong tendency of individuals of all species of Pacific salmon to return to the spawning grounds where they originated is accepted as a basic premise by present-day investigators and administrators.
>
> (Neave:1966:74)

6. Pacific Salmon Abundance

a) Depensatory and compensatory effects

Long-term stability of abundance is related, among other things, to the mortality factors associated with population densities in salmon stocks. In his studies of freshwater and marine survival rates, Neave (1958, 1966a, 1966b) has demonstrated that both depensatory and compensatory mortality factors operate to achieve a balance in population size over time. Compensatory factors are those that have less impact on small populations than on large ones. The effects can be demonstrated by differences in the ratios of adult-to-fry survival. Lower ratios occur in salmon populations that are too large for the spawning location. Increased competition and crowded conditions at the redds result in higher egg and alevin mortality. As a result, when too many spawners return in any given stock there is a tendency for fewer eggs to survive per adult spawner. As Neave explains, the opposite occurs when smaller numbers return to spawn.

> Presumably the parent fish belonging to small populations can select the most favourable sites and are subjected to less mutual interference. There will also be less competition between eggs or alevins for available supplies of oxygen.
>
> (1966a:77)

Whereas large populations suffer higher mortality during the period from spawning to fry emergence, small populations sustain higher losses during the critical phase when they leave their natal streams or lake system to head for the sea. Natural mortality by predation hits hardest at small stocks of salmon. As Neave demonstrates, depensatory mortality tends to prevent small stocks from increasing in size by perpetuating a condition in which fewer young salmon survive to return in the next generation. Thus a balance is struck between depensatory and compensatory factors.

> ...an important feature of the mortality which occurs during fry migration...is that this effect is reversed, the percent loss being greater when the fry populations are smaller (depensatory mortality), due to the tendency of the predators to take a fixed number of fry during the short period of their migration.
>
> (ibid:after on Neave:1953)

The assumption is that predators extract a given quantity of salmon biomass as it passes through their feeding areas. If this is the case, then we may assert that depensatory and compensatory mortality acts to restrain the growth of populations. Depensatory factors mitigate against the capacity of small stocks to significantly increase their numbers; compensatory factors, through egg and alevin mortality, limit the extent to which large populations can expand.

b) Index of salmon abundance

Relative values of salmon biomass available to peoples in each region or territory are provided in Appendix tables (Tables XXIII and XXVI). An explanation of the method used to obtain these figures is included. The base data is derived from estimates published under the aegis of the International North Pacific Fisheries Commission in their series Salmon of the North Pacific Ocean, Bulletin Number 23 (1967). The two articles which chiefly contributed to the data base were "Pacific Salmon in the United States", by C.E. Atkinson, J.H. Rose, and T.O. Duncan, and "Pacific Salmon in Canada", by K. V. Aro and M.P. Shepard. In the first, all the Pacific salmon spawning streams within the territory of the United States are included in detailed sub-area maps for each species. However, estimates for spawning populations are not given for salmon streams with less than 50,000 escapement. In the latter article, the authors have compiled and tabulated the estimates of spawning populations accumulated in a twelve-year study from 1951 to 1963 for each 'major' salmon stream, by species. I prepared a frequency distribution that tabled the number of British Columbia streams, a classification of the range of spawning populations, and species of salmon. From this data linear regression techniques were used to obtain average escapement values by species for 'major' salmon streams in the United States.

PART TWO Footnotes

1 Chinook salmon also run into the Snake River basin, in far greater abundance than sockeye.

2 Ethnographic evidence (Ray:1938:107) suggests pink salmon was not abundant in the Columbia.

3 Bouchard and Kennedy & other members of the British Columbia Indian Language Project have collected native terms for fish resources in many languages.

4 cf Andersen & Wadel (1972).

5 cf International Pacific Salmon Fishery Commission: Annual Reports 1961:21, 1972:3, and Ricker:1966:67. Ricker:1966:67, Aro & Shepard:1967:239.

6 INPFC:Bulletin 16; Bulletin 23; NEAVE:1966.

7 At the hydrological measurement station at Mission.

8 Killack:1955, Ward:1959.

9 Neave:1966, and Ricker:1966 have studied characteristics of salmon runs.

PART THREE -- SALMON RESOURCE UTILIZATION: a multi-factor analysis

A. The Interrelation Of Ecology And Technology Variables

The concept of a salmon technology complex has been used in this study as a means of assessing traditional systems of salmon production within an ecological context. As a model for the salmon migration, I have in mind the image of a linear progression through time and space; the salmon begins at point a (at the threshold of the inshore waters), and proceeds in a continuous line to point b, the ultimate destination (i.e., the spawning grounds). Between a and b the line is divisible by a variable number of segments, each representing a type of fishery site where, given the application of appropriate technology, salmon are accessible to human interception. The number of segments through which any given run of salmon must pass is a function of (i) the set of ecological variables that exists en route and (ii) the technology utilized by local resource groups. Salmon are thus extracted at each segment in time and space by strategies of human exploitation. We may assume that the greater the number of available fishery site types (segments), the greater the advantage to resource users. But before developing this argument further, let us review and analyze the conditions that prevailed at fishery locations. In what follows, a non-formal methodological approach is used to generate intuitive categories and inductive reasoning; the sets of ecological and technological elements in salmon resource exploitation will be analyzed.

1. Maritime strategies during salmon migration

The best places to catch salmon were well known to local user-groups in each territory. A knowledge of ecological variables and the fishery potential at particular resource locations was regarded as a precious part of one's inheritance, to be passed down to the next generation. The number and kinds of 'best places' depended on what the natural environment offered. The ecological variable that denoted good resource accessibility was the presence of salmon in sufficient quantity to repay the effort expended to catch it.

Assuming this, then the significant ecological factors from the point of view of the resource user are variables in local water resources, and species variations that influence salmon behaviour during migration. Beginning with the inshore fishery segment of the run, we will consider the relation of ecological variables to the technology of salmon production.

Fishing sites in salt water present the greatest number of unknown factors: the expanse of water is large; the random probability of locating the prey is low. The fisherman must rely on criteria other than his powers of direct observation -- the seasonal availability of a food source for salmon to feed upon (as when herring runs attract the salmon); or tides and currents that may affect the movements of salmon, temporarily bringing them closer to shore; or light and temperature changes to which, under certain conditions, salmon are responsive. But mainly the fisherman depends on his knowledge of salmon movements and behaviour. He must know the usual course that runs follow in his area, on which side of an island they are most likely to appear, the channels and narrows they frequent, and their seasonal occurrence.

In addition to this, like all fishermen everywhere who must contend with an invisible prey in open waters, the Northwest Coast fisherman would use a classic criterion: his observations of the success or lack of success of fellow fishermen (cf Andersen & Wadel: 1972). Where live herring filled the waters, Northwest Coast fishermen trolled for chinook and coho salmon with a hook and line. Because these two species will take a lure in salt water, the problematics of a spatial dimension are secondary to other ecological variables, notably to prey characteristics. For groups with marine access, the trolling complex enabled specified salmon species to be intercepted before the homing migration had begun, or in its earliest stages.

Once salmon enter coastal waters the area they occupy is reduced, and their movements become more visible as they near shore. Typically mixed stocks of salmon species make the inshore migration in considerable numbers before dispersing to the littoral areas near their home streams. From the point of view of salt water strategies, one of two things can happen. Either people wait for this general dispersement, and exploit salmon in the estuaries and shoreline coves where the runs delay, or they develop an extractive technology that intercepts the migration further from shore before dispersement. Let us review the conditions of the fishery: the spatial dimension is again significant, since only by trolling could salmon be caught with a lure; salmon accessibility near shore is attended by the circumstances of tides and currents, as previously outlined. The behaviour of salmon along an inshore current, or at a slack in the estuary, for example, is known to resource users. The period when salmon will be present can be predicted. These and other variables operated to provide fishery site potential.

The technology of salmon production in salt water fisheries depended on multiple conditions and distinguishable features that affect salmon behaviour. Since the problem is one of extracting the resource from an unrestricted area, these subtle interactions gain added significance. The first fishery encountered by salmon once past trolling areas is the reef net complex. (This is true at least as far as the model is concerned. In reality it applied only to Fraser River populations of pink and sockeye.)(1). Extremely large nets were anchored on shoals directly in the known path of regular and recurring summer salmon runs. The presence of shoals or reefs served to shorten the subsurface vertical dimension through which salmon passed. Appropriate tidal and current actions were critical to the efficiency of reef net operations, and light and wind conditions played a part. Clearing undersea vegetation from the space in advance of the net mouth, laying up lines to create the illusion of a channel through the kelp beds, even disguising the anchor lines with beach rye grasses, all served to help direct the salmon into the net. But the significant ecological variable that made the reef net a viable production system was the sheer magnitude of numbers when scores of major sockeye and pink salmon runs, as part of their principal migratory route, passed through the fishery. Thus by developing an extractive technology to intercept the inshore migration before the general disbursement, the source of greatest abundance was tapped.

On a smaller scale, the trawl net drawn between two canoes was used in a way analogous to the reef net to intercept abundant runs in salt water channels on the northern and central coast. (Mackenzie saw the Bella Coola fish for salmon this way in early summer.) In channels and inlets the movements of salmon are controlled in some respects by natural geographic features and by the way tides and currents behave in narrow waterways.

As salmon approach the littoral region the significance of tides is increased. Trawl nets were also used on the tidal flats in estuaries. In locations where the tides are right, salmon come near enough to shore to be taken in seines or gill nets. Presumably these were riverine methods adapted, where feasible, to maritime conditions. It seems unlikely that seines and gill nets were especially productive in the sea, always with local exceptions. Gill nets were used by the Klallam at a spit of land where chinook and coho followed herring runs close in to shore, and similarly by a Straits group on Saltspring Island. The Straits used a salt water seine net in the estuary of the Samish River. It may be that the occurrence of marine adaptations is less rare than ethnographic accounts would indicate.

The most direct relation of tide to technology was the tidal trap. Constructed at suitable locations where the combined effects of tidal currents and species characteristics acted to bring salmon in near shore, large boulders or other building materials were designed to form a barrier against the receding tidewaters, leaving the stranded salmon behind to flounder. In the tidal trap salmon were caught without direct human intervention. Together with the reef net complex and trolling, the tidal trap was the only device exclusively of a maritime nature. At this stage in the migration, salmon are soon to enter fresh water. In some species, salmon stocks will delay for a period of time before leaving the littoral areas. It is these in many cases that were swept up on a tidal current and carried over the wall of the tidal trap.

Finally, we will consider maritime locations where the harpoon was used to take salmon. In the pursuit of prey, the toggling harpoon complex was a flexible system that could be adapted to varying conditions. Particularly in the more shallow regions of a bay, salmon could be caught with the harpoon if water conditions were clear, and the sea calm enough to take aim. At places where salmon congregate in large numbers the toggling harpoon would be an efficient means of capture. Night fishing with a harpoon on a phosphorescent sea is reported in the ethnographies. The fisherman depended on good visibility conditions to fish with the harpoon, and probably only used it in the sea when a considerable number of salmon were present.

To summarize, during the inshore migration the spatial bounds within which salmon move are chiefly unrestrained, and the resource is difficult to exploit. Since with the exceptions noted salmon will not take a lure, the hook-and-line methods typically used for maritime species like cod and halibut were not applicable. Fishermen depended instead on their knowledge of local tides and currents, and their knowledge of species timing and behaviour, to devise systems functionally related to variables in the ecosystem.

A note on STC Distribution -- Most data about the inshore fishery derive from Wakashan and Salishan sources. Northern inshore salmon fishing is not well described. The Makah appear to be the most southerly peoples oriented to a maritime fishery. Societies in the Columbian and Southern regions did not practise salt water salmon fishing.

2. Weir vs Trap: Tributary streams and secondary rivers

Leaving the maritime environment, salmon runs enter estuarine waters to begin the ascent of the river. The spatial dimensions salmon occupy are immediately altered. They are now bounded not only by the riverbanks on each side of the stream but by their own genetic inheritance which impels them forward, swimming upstream against the river's current. Salmon accessibility from the viewpoint of the resource user is improved immeasurably. (In relative terms, differences between large and small river systems are noteworthy, therefore each is treated independently. It is the latter that concern us here.)

While yet in brackish waters and in the lower course of the river, the salmon runs pass through various kinds of resource use sites before entering the principal riverine fisheries, weirs and traps, further upstream. Briefly, lower river fisheries included: the toggling harpoon, seine nets, gill nets and, if the river was large enough, the trawl. In places where the waters were too roily and turbid for harpoons, gaffs were employed (2). A typical harpoon fishery took chinook salmon at river mouth locations early in the season. Gaffs, on the other hand, are more often mentioned in connection with fall fishing for chum salmon. But the complementary nature of gaff and harpoon complexes is mainly concerned with the differences in water features required for the use of each, referred to previously in this study.

The most important salmon technology complexes in small- to medium-sized rivers were undoubtedly traps (3) and weirs. In the literature, traps and weirs are inferentially linked and there is confusion about the distinctions between them. The model of interacting variables is useful in sorting out the differences between the two systems; indeed, the ecological variables required for the one are quite distinct from the other. Attributes of these variables will be compared. Although ecological differences were the central criteria for classifying weirs and traps separately, in terms of technological principles each system operated under a different set of rules for salmon procurement.

The principle of the weir is to obstruct the stream, and to artificially create a barrier in the river beyond which salmon cannot proceed. The obstruction was temporary, the weir sections were left in place only long enough to pursue the fishery. Unable to continue upstream, salmon amass at the wall of the weir and are easily caught. Secondary techniques were required: dipping nets, harpoons, leisters, spears, gaffs. Where more complex developments of weir structures were built with catwalks, dip netting platforms, and spearing and impounding corrals, the weir takes on some characteristics of a trap. Double weirs in which the salmon leaps the first obstruction but cannot leap the second, is an example of an ambiguous modification. However, a typical weir fulfills the primary function of impeding the run for a period of time so that resource users have an improved fishing opportunity.

On the other hand, the principle of the trap is to entrap. Traps were devised to direct and divert the movements of salmon into a confined area from which it cannot escape. Thus, the environment of the salmon is manipulated, playing on a characteristic impulse of the fish to find its way through an obstacle. All the different trapping devices were designed to accomplish this objective; essentially each was intended to confine the salmon (4).

There are marked differences in the site conditions at weirs and traps. Traps are frequently placed where they can take advantage of natural stream conditions that impede the progress of salmon -- falls, narrows, riffles, shallow bars, and streambed channels. Weirs and traps each contain many varieties of form. It was generally the case that streambed facilities suitable for the construction of a weir were not suitable places to put a trap, and vice versa. Traps are versatile: they were better adapted to fast water sites than weirs, and could be placed even in small creeks or shallow streams; they could be set in rock-strewn streams, and at places where the salmon found its way through little rapids and eddies. The common basket trap was secured to guiding wings and set in many ways to incorporate the natural features of a stream. Consequently, stream hydrology and the natural instinct of salmon to seek a way past obstacles, were features exploited by trap emplacement.

Weirs were less versatile. The necessary streambed features at weir sites, together with factors of velocity and water volume, were more rigidly specified (5). Weirs depended less on subtle distinctions of stream flow, and more on the primary fact of the salmon migration itself. Because salmon stocks take a direct course to the spawning grounds, fight obstructions, and persist in continuing an upstream ascent, they cannot escape the fishery below the weir (6). It is this characteristic that weirs directly exploit: the run of salmon is obstructed; the compulsion to progress is checked. While salmon assemble in confusion they are easy prey (cf APPENDIX III).

3. Exploiting major salmon producing areas

The principal salmon rivers on the Northwest Coast were high production resource areas with the capacity to support human populations of a significant size. Coincident runs of salmon stocks in a large watershed system ensured a reliable source of food over an extended annual season, as one species overlapped with another, and runs of various spawning populations occured serially. The periodic failure of salmon stocks in a tributary stream or spawning ground would not be noticed in the lower course of a large river. Fluctuations in abundance would be mediated by various compensatory factors that are natural to salmon species. From year to year the catch would remain relatively stable, presuming the effort expended on salmon production was unchanged.

Riverine societies on the Nass, Skeena, Bella Coola-Atnarko, Fraser, Columbia, and Klamath all shared the advantage of abundant salmon supplies, and similar problems in resource extraction. The accessibility of salmon runs in a large river presented particular difficulties. High water volumes and strong river currents meant that ordinary weir and trap structures were impracticable. The technical and organizational skills of Northwest Coast fishermen were used to develop other solutions. The salmon technology complexes that were adapted to riverine and estuarial conditions where large runs of salmon occur include the Kepel Dam, the Bella Coola dams, the Skeena canyon trap, dip nets, the seine, and the reef net. The relations between ecological and technical variables in these complexes will be featured in this section.

a) estuaries and river approaches: In the approaches to important salmon rivers the runs are dispersed widely within a large expanse of water which near the river mouth becomes brackish where the stream outflow meets the sea. Salmon are not easily accessible in large areas, their movements are unrestricted and generally hidden from the eye of the fisherman. Nevertheless, they do follow a fairly regular course to reach the river mouth, swimming in response to favourable currents, and in some locations following in close to shore on a tidal stream.

Sheltered from the Pacific by Vancouver Island, the Fraser estuary debouches in a protected marine environment. The river has an extensive delta several miles long, and its estuarial outflow stretches into the Straits for yet more miles. Tides and currents in the protected waters are relatively predictable and steady. Near the headlands off an island or peninsula in the straits where tidal actions and shoals combine to produce the right conditions the reef net was used to intercept Fraser-bound runs of sockeye and pink salmon. The complex took advantage of the relatively consistent patterns of sockeye migration through the straits en route to the river. The natural environmental features of the Fraser approaches were unique on the Northwest Coast, as was the technological response developed by Straits Salish fishermen.

The southern approach to the Fraser River through the Straits of Juan de Fuca, which is the normal route of sockeye and pink salmon, is approximately 200 kilometers long. In direct contrast is the Columbia River estuary. The mouth of the Columbia is separated from the Pacific only by its redoubtable bar, a millenial accumulation of silt and gravel, surmounted with great difficulty by seamen. The tortuous passages at the bar are described in the early journals of explorers and fur-traders (7). Behind the bar, the Columbia estuary is broad, beach-strewn, filled with many little bays and harbours where Chinook fishermen could employ the seine, landing the catch on shore. Columbia chinook salmon stocks, many now destroyed by hydroelectric dams, must have lingered for several days or weeks in these brackish waters before beginning the ascent of the Columbia.

> Historically, the Columbia River has been the major producer of chinook salmon, and it is especially noted for the high commercial quality of its spring run.
>
> (INPFC:1967:23:p.46)

The superiority of Columbia chinook had been proclaimed long before Lewis and Clark arrived at the mouth of the river in 1805. Swan (1857) later reported:

> The Chinook salmon commences to enter the river the last of May, and is most plentiful about the 20th of June. It is, without doubt, the finest salmon in the world, and, being taken so near the ocean, has its fine flavor in perfection. The salmon, when entering a river to spawn, do not at once proceed to the headwaters, but linger round the mouth for several weeks before they are prepared to go farther up. It has been supposed that they cannot go immediately from the ocean to the cold fresh water, but remain for a time where the water is brackish before they venture on so great a change.
>
> (p.103)

In both the Columbia and Fraser systems, those who controlled the approaches to the river could intercept an important segment of the run before it began its ascent.

b) <u>the lower river course</u>: Salmon become more accessible as they enter the main course of a river. The timing and movements of the run can be perceived by watchful fishermen. But the usual traps and weirs could not be built in river channels that were deep and broad; it was necessary to generate other alternatives to meet the hydrological conditions of large rivers. Two examples show how different solutions to this problem were met by Northwest Coast fishermen.

On the Klamath and its tributary, the Trinity River, special short-term 'dams' were built anew each year to take advantage of late running chinook stocks. Of this series, the Kepel Dam was the largest structure built. Its form was based on the model of a communal weir, complete with owned platforms called 'salmon houses'. It crossed the entire width of the Klamath River, a distance estimated at the site location, thirty miles upstream from the mouth, to be 250 feet from shore to shore. The depths of the river in late August - early September were generally six feet (2 meters). To withstand the heavy flow of the current, the Kepel Dam was constructed in an upriver V-shape, rather than straight across. According to Kroeber (1925; Kroeber and Barrett:1960), the Kepel Dam built by the Yurok was probably the largest structure raised in Northwest Coast rivers before the colonial period.

Writers have long been fascinated with the institutional context of the Kepel Dam (Waterman & Kroeber:1938; Kroeber & Gifford: 1949; Kroeber:1925; and others). It is the best documented weir complex in the literature. Part of its significance as a major river technique is that it was constructed with a considerable expenditure of labour to be used for only a ten-day period. The procedure was ritually specified to show careful attention to detail. Kroeber and Barrett interpret it this way,

> The Kepel Dam cycle of ceremonies was basically of the world-renewal order, with emphasis on abundance of salmon...genetically, rather than specifically on the first salmon... The whole cycle was designed to insure collective and individual health, prosperity, and abundance...
>
> (1960:12)

Perhaps, too, the Yurok wanted to express their power and ability to 'tame' the river, at least for a few days. Whatever its symbolic importance, the Kepel Dam was the signal example of a communal weir structure in a large river and, consequently, was a highly productive mechanism to extract salmon resources. This was a short but very intensive fishery.

Bella Coola-Atnarko river dams are further examples of the ways in which technological innovations were developed by Northwest Coast fishermen to fit the specific ecological conditions of large rivers. The series of dams on the Bella Coola was described by Alexander Mackenzie, the first European to reach tidewater by an overland route. He reported that they were large semi-permanent or permanent multi-purpose installations built into the river at which several kinds of fishing methods were carried on simultaneously. The type is best classified as a facility, but Mackenzie called it a 'machine', no doubt an accurate evaluation. Whereas the Kepel Dam was built to meet a short-term objective at the height of the chinook run, the Bella Coola river dam complex was operated and maintained throughout the entire salmon season to exploit serial and overlapping runs of all five species.

It is obvious that great expenditures of labour were invested in the construction of Bella Coola river dams. The heavy flow of the river must have made it necessary to keep dams continuously under repair during the extended season in which they functioned. River dam complexes were owned and maintained by people living in adjacent village communities. Atypically, the Bella Coola practised village endogamy, raising the question of a possible relation between 'marrying in' to ensure that young men remain in the home village, and family ownership rights to fishing locations at the village river dam. The extensive upkeep and periodic restoration work required to keep these complexes functioning would best be served by a social organization of labour that was supported by a sedentary village population.

The river basins of the Bella Coola and the Klamath display significant natural differences as well as technological ones. The glacier-fed Bella Coola and Atnarko rivers are turbid and experience severe flooding throughout the early part of the year. The Klamath and Trinity swell with the winter rains but are less subject to spring freshets, or heavy sedimentation. The number and duration of salmon runs supported by each system is also different, as reported above. Large salmon populations of all five species enter the Bella Coola, but the Klamath has only chinook and coho, although the size and number of chinook salmon in the Klamath is noteworthy.

The Kepel Dam was built for a short term purpose, largely ceremonial in its obvious aspect. Yet there is no doubt it was a complex capable of taking great quantities of salmon in the ten days it operated on the Klamath. On the Bella Coola, a series of dam-trap complexes, each highly productive, served as a focus for the riverine society throughout the salmon season. Although the two rivers are comparable in size, the response of Yurok and Bella Coola peoples to apparently similar ecological conditions in the main course of a river was different.

c) principal canyon sites: The accessibility of salmon, at least theoretically, is markedly improved when the runs enter the narrow confines of the river canyon. Not only has the spatial dimension been reduced by the physical features of the canyon walls, but water features in the narrow channels produce conditions that directly effect the behaviour of salmon. In the whirlpools and eddies of the rapid current, salmon seek respite near shore. On the Fraser, Columbia, and Klamath Rivers fishermen at dip net stations in the canyons exploited the main salmon runs as they ascended the rapids.

Chinook and sockeye were the most important species taken in the summer dip net fishery on the Fraser and Columbia Rivers. The highly productive canyon fishery on the Columbia was reknowned throughout the Northwest Coast and the Plateau. Like the eulachon fishery on the Nass, Columbian-produced supplies of dried salmon were traded over great distances through a network that extended for hundreds of miles in all directions. The Dalles on the Columbia was the centre of salmon production and distribution. Chinook salmon caught upstream in the canyons had expended their excess oils in the effort to ascend the rapids. When dried and preserved, the quality of the product was superior to chinook caught elsewhere. Lewis and Clark were the first to record the Dalles fishery; by 1855 Gibbs reported that changes had occurred.

> The Dalles was formerly a great depot for this commerce. ...The quantity put up at some of the principal fishing grounds was formerly immense, and even now is very considerable.
>
> (1877:195)

The Fraser canyon dip net stations attracted Halkomelem Salish from distant villages on the lower river to fish alongside their Upper Stalo compatriots. Although ownership of canyon sites appears to have been predominantly in the hands of Upper Stalo resource holders, the Katzie, Musqueam, and people "even further afield" had inherited rights to fish in the canyon (cf Duff:1952:11,30,40,62). For those who travelled 100 km or more to reach their stations, the main economic purpose was to participate in an intensive salmon fishery where favourable wind and temperature conditions hastened the drying process. People who otherwise had limited access to sockeye or to chinook salmon in peak condition would be drawn to the canyon fishery. Dip netting techniques, both the braced net and the lighter active dip nets, were very efficient methods for taking salmon in the Fraser canyon.

On the Klamath and its tributaries both plunge nets and the large A-frame lifting nets were effectively employed from riverbank sites that were distinguished by differences in water volumes, velocity, and clarity. Some plunge net stations were merely rocky promontories where the fisherman had a foothold at the level of the river. Nevertheless, they were privately owned. In turbid rapids where back eddies formed, the net was plunged forward to fortuitously sweep up any salmon present. At other sites along the river A-frame scaffolds were built out over the water, the braced net set in the backcurrent waiting for a salmon to enter. In their study, Kroeber and Barrett observe:

> ...it is said that a man may take, in a very short time (a matter of days) at the height of the salmon run, "a winter's supply" of fish.
>
> (1960:36)

There are two significant runs of chinook salmon annually on the Klamath, a spring run, and a 'fall' run that begins in mid-summer. The dip net complex on the Klamath River was a highly productive fishery for those who had rights of access to favourable sites.

Annual runs of chinook and sockeye were also exploited at the Skeena River canyons during the summer season. The Skeena canyon trap almost rivalled the Kepel Dam in size and specifications; considerable labour was invested to construct these large traps. Built on the banks of the river, out of the heavy streamflow, they were complex structure with moveable parts, including an extended chute that was lowered by ropes into the rapids and eddies below to make the catch. Unlike other principal Northwest Coast rivers, the broad Skeena has few narrow gorges where dip nets could be employed from natural promitories. The Hagwilget canyon extends only a little way. Competition for fishing sites at this productive resource location was critical. Salmon are particularly accessible in the canyon and valuable runs of sockeye must pass through Hagwilget to reach their upstream spawning grounds in the Babines. Presumably the specialized canyon traps on the Skeena replaced former dip net stations similar to those in other Northwest Coast rivers. It is reasonable to suggest, despite the lack of published information about the Skeena canyon trap, that it was a very productive system of salmon procurement.

In conclusion, peoples who occupied major river system necessarily had the main advantage in salmon resource exploitation.

Not only did they have access to individual stocks of spawning salmon elsewhere in smaller streams within their local resource area, but they also could intercept stocks bound for upriver spawning locations. In statistical terms it was impossible for their 'runs' to fail. By extracting concurrent stocks with very large population bases, any variations in abundance were generally assimilated.

PART THREE -- SALMON RESOURCE UTILIZATION: a multi-factor analysis

B. Interrelation of Social and Ecological Variables

The social structure of the Northwest Coast was characterized by unequal access to material wealth, privilege, and status. High ranking lineage groups expressed dominance through mechanisms of status validation that included the distribution and redistribution of surplus storage and fresh foods. Socially sanctioned systems of exchange are generally assembled in the literature under the rubric 'potlatch' to describe a core institution that had important legal and economic implications. Influential, prestigious lineage groups tended to be those who had established rights of access over the most productive resource locations. With varying emphasis in each society, this applied as well to resources other than salmon. But salmon resources were a fundamental source of wealth in the Northwest Coast economy.

My present purpose is to consider how notions of resource ownership and control of the means of production related to variables in the nature of the salmon resource. Necessarily this will be a limited discussion of some aspects of the relation between social and ecological variables in the system of salmon technology complexes. The focus is on social accessibility of the salmon resource.

To generalize about Northwest Coast societies is a hazardous undertaking. Each of the twenty-four language groups included in this study were separate distinguishable units -- coherent, inclusive societies. To extract bits of evidence here and there and pull them together can be misleading. Each society had its own internal rules and procedures, much of it never recorded. Nor would any one of these language groups have considered themselves to be a unified nation or tribe. Even within each society there were important divisions based on dialect and territorial occupation. The surface details offer a semblance of similarity: the use of plank houses, permanent village sites, a recognition of social rank and material wealth, and a dependance on maritime and riverine resources, especially the anadromous salmon. Such aspects can be cross-culturally compared. But beyond the outer manifestations existed a subtle interplay of social groups, shared values, and concepts of identity that must be studied in its natural context.

For the most part I have avoided the difficulty by restricting the analysis to questions that can be elicited from the data: how did people catch salmon? what kinds of methods did they use? where were fishery sites located? These are relatively safe subjects but when I introduce social variables the water gets murky: what is the nature of resource control and ownership? who 'owns' the capital goods needed for resource extraction? how was labour organized? Rather than overgeneralize about these relations with the attendant risk of making it seem that what is true for one group can be extended to others, I take a step backward in abstraction, removing the individual differences between societies, and concentrating on a fact established in the literature that notions of ownership are a characteristic of Northwest Coast societies. The question then becomes focused on the relation between salmon technology complexes and differential constraints on access to resources.

1. Salmon resource limitations

Before beginning we need to review what has been said above about the nature of the salmon resource. The characteristics of salmon runs that particularly affect resource use strategies include the following parameters: (1) runs are of limited duration, and (2) in each spawning area stocks are limited in number and, to a lesser extent, size. These limits are imposed by the nature of the resource; they present the conditions that each user-group must work within.

While the failure of salmon supplies is not a conscious part of the fisherman's everyday strategy, it is nevertheless consistent with his larger world view. The possibility that the salmon may never return is a theme that recurs in mythology and ritual; the First Salmon ceremony in which after a ritual meal the bones of the salmon are treated with respect underscores an ecological awareness of the interdependence of all living things, and of the fragile hold man has on what occurs in nature.

A sense of uncertainty is a characteristic common to fishing societies everywhere (Andersen & Wadel:1972). It is readily understandable in the context of the pursuit of an invisible prey; fish exist in a three-dimensional world that is quite hidden from human view. On the Northwest Coast the Pacific salmon resource is subject to great fluctuations in abundance as we have noted previously.

Sproat (1868:215) reports that Nootka fishermen frequently expressed the uncertainty about how many salmon would come: from canoe to canoe the common inquiry heard, he says, was "Are there many salmon?"

Spiritual, psychological, and practical attitudes that relate to a fisherman's dependence on salmon migrations over which he has no control can be expressed as the fisherman's dilemma. Several models have been used in the literature of maritime anthropology with reference to species other than salmon (Andersen & Wadel:1972; Davenport:1960). The fisherman's dilemma refers to the interrelation of specific problematics: an invisible prey, a commonly accessible resource, and the competition of other fishermen and predators. For the situation faced by Northwest Coast fishermen I will restate it this way: the fisherman has no control over whether the salmon come or do not come into his waters; however, based on past experience, he can assume salmon will probably appear and he can predict (almost to the day) when the season will begin. He can also depend on his knowledge of local stocks to assess the potential abundance of salmon that may occur in any given run. With this information he plans his exploitative strategy. He decides which technological application best meets the criteria of his local water resources, readies his equipment, assembles labour, and so on. His production efforts must be organized to exploit the resource under the limitations of time (nature of salmon resource) within which he is operating. The reader recalls that the peak of a run may last only a few days; overlapping runs of many stocks may extend the season to several weeks. Thus, each spawning population is a discrete unit of salmon biomass, accessible at any given point in its migration for a limited time.

In many respects the salmon fisherman's dilemma parallels that of offshore cod and halibut fishermen, or fishermen anywhere. Despite the abundance of a potential prey species, the situation is viewed by the predator within a limited set of parameters. Fishing societies in general have few technological options. Their decision strategies relate to where and when to place the gear, in an on-going quest for elusive fish. The traditional Northwest Coast fishery, on the other hand, had developed diverse means of exploiting the resource at distinguishable ecological sites, thus extending the range of potential sites.

The analytic construct that expresses the idea of restrictive conditions should not obscure the empirical reality that most Northwest Coast user-groups had access to very abundant salmon resources. At highly productive sites it is probable that the only upper limit on how many salmon a fisherman would take was his access to adequate labour to process the catch, particularly since salmon must be processed within hours of being caught. Where major runs were exploited the problem was not whether there would be sufficient numbers of salmon in the run, but how to capture as many as it was feasible to process and transport <u>during the period they were available at the site</u>. Thus we return to our model of salmon resource as an entity of biomass moving through segments of space and time that presented <u>opportunities</u> to fishermen. What counted was the success ratio of control over these opportunities to extract the salmon resource.

2. Access to fishery locations

In order to maintain an ascendant control over salmon resources dominant user-groups employed constraints on access to highly productive fishery sites. We have seen many examples in the evidence presented in Part One of the association between resource ownership and produtive salmon technology complexes. Usually this has taken one of two forms: either use rights pertain to particular fishery locations, as is the case with dip net stations, weir platforms, reef net locations, and special trap facilities; or else the general resource area where a salmon fishery operates is delimited by recognized rights of access. In the latter, a resource holding group would own an entire salmon stream and be free to place weirs or traps on it at any suitable place. In general terms, the more productive the fishery site or the salmon technology capability, the greater the correlation to notions of ownership.

But the efficiency of traditional systems of resource exploitation is not measured only in its capabilities to produce winter storage foods. The diversity of salmon technology complexes made it possible to have a flexible program of food-gathering throughout an extended season. Many fisheries operated to provide fresh salmon, particularly in spring and summer. Trolling, seining, trawling, spearing, and gaffing for example, all were means of obtaining fresh foods at various times of the year. In addition, as mentioned above, traditional systems extended the range of possible resource locations by increasing the number of site types where salmon could be obtained.

While some places were socially defined as seasonal resource areas where people dried and preserved their winter supplies, others were unrestricted common reserves. The distinctions are not always clearly identified in ethnographic accounts. There are, however, enough specific references to allow us to make a preliminary analysis.

Sources agree that salt water salmon fishing grounds were usually in the public domain (Elmendorf:1960; Oberg:1973; Olson:1967; Suttles:1951). The people who lived on the adjacent coast shared the resources of their inshore fisheries. It is of course improbable that anyone from another society outside the immediate vicinity would attempt to use the 'open access' areas since he would be perceived as an intruder. Straits and inlets where fishermen trolled or trawled were apparently unrestricted, as were the sheltered bays and coves where the harpoon was used.

The principal salmon rivers on the Northwest Coast were not owned in the sense that smaller rivers and streams frequently were. The abundance of available salmon and the magnitude of the river made ownership claims either unnecessary or inequitable, and impossible to sustain. Kew (1976) states that the lower course of the Fraser River was available to any Halkomelem fishing party, and that the productive trawling fishery in the river was open access. In the north, the Tlingit shared access to important rivers:

> In places where a number of clans live together, the allocation of resources correlates very closely with the principle of scarcity. When a number of clans settled on the banks of large rivers, like the Stikine, Taku, and Chilcat, the question of rights to salmon fishing did not arise. There was plenty for everyone in the large rivers. But on the islands the rivers were smaller and the important ones far apart. It was thus necessary to apportion the resources in some manner.
>
> (Oberg:1975:56)

While the other references cited are less specific about ownership notions on the Skeena, Columbia, and Klamath, for example, it seems likely that in their lower courses such rivers were unrestricted.

Water resources most clearly identified with user-rights include small island or tributary streams with good salmon stocks, suitable for the construction of weirs and traps (cf Donald & Mitchell:1975). Oberg continues his analysis with these remarks:

> The local clan units were of a size to subsist on the supply of these smaller rivers. In fact, there is a very close correlation between the size of the local clan units and their resources. Large clans often held a good-sized stream while the tributaries were taken over by smaller clan divisions.
>
> (ibid)

In reference to the same general area Olson (1967) placed less emphasis on the ownership of individual streams but distinguished between species of salmon stocks as the main criteria.

> Sockeye (red) salmon spawn only in streams where there is an accessible fresh water lake and such streams were considered of special worth. Dog salmon and humpback salmon spawn in almost every stream and such places were regarded as hardly worth the trouble of claiming ownership.
>
> (p.12)

The clans who owned sockeye streams would also consider the bay into which the stream debouched as part of their owned place (1967:55). Olson lists many bays and inlets by name, along with their corresponding streams and rivers, as locations owned by resource holding groups. Similarly, on the Queen Charlotte Islands, the Haida people allocated all the important salmon streams to specific resource holding groups. Apparently everything was owned, coastline beaches, coves, and entire rivers.

> ...the coast line, and especially the various rivers and streams are divided among the different families. These tracts are considered as strictly personal property, and are hereditary rights or possessions, descending from one generation to another according to the rule of succession...the larger salmon streams are often the property jointly of a number of families; and at these autumn fishing grounds temporary houses...are generally found.
>
> (Dawson:1880:117-18)

Dawson notes that payment for privileges to fish in the territory of a group to whom one has no claim would be "exacted from a stranger" (p.136).

Aside from claims to broad geographic areas, ownership notions are clearly associated in the literature with specific resource sites. Access to places where productive salmon technology complexes could be employed were usually controlled by certain groups of resource holders.

Included in this category are A-frame lifting net sites on the Klamath and Trinity Rivers, the dip net sites at canyons on the Fraser, Skeena, and Columbia, special river mouth dip net adaptations on the lower Quinault and on Columbia tributaries (cf. Ray:1938; Olson:1936). Since water features at dip net sites are very specific they are necessarily limited by natural conditions. On the Klamath River sanctions on fishing below the riverbank site owned by an individual were strictly enforced. Yurok people could sue if anyone tried to interfere with the salmon runs below their dip netting locations (Kroeber:1925). For Straits Salish people it was reef net locations that were considered the most valuable resource property; the potential productive capacity of a reef net site where Fraser-bound runs of sockeye and pink salmon could be intercepted was extremely high.

Communal weirs were built on the Cowichan, Nanaimo, Chilliwack, Quinault, Quileute, Skokomish, Smith (Tolowa), Klamath and Trinity Rivers, among others. The ethnographies vary in their treatment of associated notions of ownership to community weirs; the evidence is unclear for some groups. In general terms such weirs were constructed by members of the village community and those who helped in its construction had the right to fish at the weir. Special rights resided in the ownership of fishing platforms constructed as part of communal weirs. These were claimed by hereditary right, and maintained as family property. The evidence suggests that fishing from platforms on weirs was more efficient than spearing, gaffing, and dip netting from canoes on the downriver side of the weir obstruction. Besides its increased efficiency, user rights to the platforms asserted the claim of the owning household group to status within the community.

3. Summary discussion

In a social system that emphasized the importance of wealth and status, productive resource locations were privately held by corporate user-groups, usually a household based lineage association. As Suttles has said:

> The ownership of fishing locations, root beds, and clam beds gives real material advantage. These sites are limited in number, and usually the most productive ones for whatever product is obtained there. While everyone can make a living in exploiting public domain, the real surpluses are produced at the owned locations and the owners thus have considerable advantage over the other members of the group.
>
> (1951:56)

So while others still had plenty of salmon available to them in open access areas, they did not have the advantage of controlling the most productive resource areas. Economically dependant on biomass from a migrating species, dominant groups insured themselves against possible low-yield seasons. They controlled special resource sites where high production and fishing efficiency was more assured. The disparity between elites and commoners resides less in nutritional terms than in the capacity for status validation and consolidation.

Through constraints on access to productive resource locations, dominant social groups maintained their ascendancy. Thus we can see that ecological and social variables provided for a mutually re-enforcing relation: if the resource is viewed as a 'limited good' which must be exploited within the natural constraints of the timing, duration, and number of runs, then those groups that control the best production sites are likely to have the greatest surplus of storage foods. Surplus can be converted within Northwest Coast exchange systems into slaves and capital goods, and advantageous marriage alliances -- all means of further economic power. Moreover, enhanced status positions reinforce the dominant lineage groups as 'those who have much to give'. And, in Northwest Coast terms, that is the criteria of status confirmation.

PART THREE -- SALMON RESOURCE UTILIZATION: a multi-factor analysis

C. Summary Analysis

An assumption made early in this study was that salmon fishing in pre-colonial Northwest Coast societies could be viewed as a system of interrelated variables. When data on salmon fishing techniques are treated independently of other fishing and sea mammal hunting methods, a pattern emerges that can be used as a basis of comparison for all ethnic divisions on the coast. The nature of the salmon resource is characterized by regular and recurring spawning migrations into fresh water areas within the territory of each coastal society. Systems of salmon production correlate with specific features of the water resources available to any given resource holding group or user-group. If each fishery site type is examined in detail the significance of micro-ecological variation becomes evident.

The repertoire of salmon technology complexes on the Northwest Coast was extensive. Methods of resource utilization were developed in coastal societies to fit the specifications of available water resources and characteristics of salmon species. The economic advantages made possible by high-yield salmon resources were fully exploited by Northwest Coast peoples. Their complex social forms and material well-being were contingent on relatively predictable sources of salmon abundance, and on the potential for surplus. Because of the extent and diversity of salmon technology complexes, efficient resource utilization was feasible.

In this final section, I seek to examine the significance of multiform modes of salmon production holistically. Consideration is directed to patterns of similarity and divergence in the distribution of salmon technology complexes and to interregional comparisons. The broad geographic continuum of the Northwest Coast culture area with its diversity of social forms and languages had a shared economic dependency on Pacific salmon resources. At fishery locations in inlets, bays, estuaries, rivers and streams throughout the Northwest Coast it is apparent that a knowledge of technical principles on which were based systems of resource utilization was general. For this reason it is possible to compare and evaluate salmon fisheries in the region as a whole.

The notion of salmon technology complexes was generated by the evidence of my comparative research, and by the conceptual framework that informed it. By formulating a model of interacting variables to describe the processes of resource utilization, it was possible to define the criteria of each productive type, despite ethnic variability.

Within the territorial boundaries of each ethnic division there were a range of available water resources -- places where salmon fisheries occurred. For some groups the range was limited, perhaps only two or three productive location types. Others had broader choices; their decisions about how to allocate their time and labour effort had reference to a wider set of variables. To examine differences in resource utilization we must first distinguish variations within an ethnic division from variations between divisions.

Within each ethnic division, here treated as a single unit, there was considerable diversity. The resources available to any specified user-group within the society were dependent on factors of geographic location, kinship affiliation, access to named or owned resource locations, availability of labour, and seasonality of salmon runs. A proper assessment of the deployment of production energies for specified user-groups would need to account for all these factors, and more. To do close study of a particular territory, or sub-area within a territory, one would include an inventory of all the available water resources and important salmon runs and then evaluate known strategies of resource production, or predict the selection of salmon technology complexes.

The scope of the present study makes it necessary to treat all the speakers of a language as a unit, and to look at the inventory of salmon fishing methods not of the single corporate group, or clan, but of the whole society, even while recognizing that it is unlikely any user-group had access to all potential resource location types. As a result, to compare Tlingit and Halkomelem, or the Quinault and Yurok, we must infer a generalized ideal.

1. <u>Interregional comparisons</u>

All Northwest Coast ethnic groups had access to fresh water resources of some kind. It is unlikely that any local user-groups were exempt. Even low ranking social groups who may or may not have been excluded from the more productive salmon fisheries close to their winter villages, would have had streams to which they travelled in season. Only two groups were reported to depend more on marine resources for salmon production, than on fresh water streams. The Makah took most of their salmon supplies by trolling the inshore fishery in the Straits of Juan de Fuca. This, at least, is the assessment made by Swan, and it is probably accurate for the early nineteenth century. It may be that at an earlier period when greater numbers of Makah lived at Ozette village, on the Pacific coast, the resources of Ozette River (and Ozette Lake) were more fully exploited. Four species run in this stream, including sockeye (but not pink salmon). The Hoko River which runs into the Straits has been a traditional salmon producing stream for the Makah for many centuries (Croes:1980). Thus while the Makah had very limited freshwater resources compared to other language groups, they were not dependent entirely on the sea. It should also be noted here that the Makah are the only Northwest Coast society that depended more on maritime species, cod and halibut, than on salmon resources.

The Straits Salish are the other maritime-dependent group; most of Straits salmon production derived from the reef net fisheries that operated at various locations throughout the area contingent to the chief migratory path of Fraser-bound sockeye and pink salmon. By tapping the resources of this abundant supply of salmon, Straits people were less dependent on their territorial freshwater resources; nevertheless, a diversified salt and fresh water salmon fishery extended the seasonal availability of the resource, and made chinook, coho, and chum accessible.

All other Northwest Coast societies were dependent more upon riverine salmon production for their primary storage foods than upon maritime supplies (8). The present study has demonstrated the diversity of types of fresh water locations and the variability of salmon abundance from one river system to another. A division of types concerning only the broadest considerations is given here to facilitate interregional comparisons. There are major ranking rivers, the Nass, Skeena, Fraser and Columbia systems; second ranking rivers which include among others the Bella Coola and Klamath basins; and two additional categories. The first of these are rivers that produce unusually large runs of salmon despite their relative size; the Quinault is an example. Finally, there is the category of independent streams -- often short coastal rivers, island rivers, etc. -- that produce salmon resources which come within average ranges for 'major' stocks, according to INPFC estimates. Every Northwest Coast society would have relied on one, and occasionally more, of these categories for its primary production of salmon resources.

a) <u>major rivers</u>: The advantages that obtained to riverine communities with access to the most productive Northwest Coast resource areas have already been elaborated. People who lived in the lower courses of major rivers could intercept runs bound for streams at higher levels, thereby tapping the abundance of the entire watershed system. The occurrence of coincident runs of various species and stocks provided lower river people with an extended period of time to exploit the resource; from June to November serial and concurrent runs of salmon migrated through their fisheries. In the Nass and

Skeena Rivers the season ends in late September - early October. Because of the nature of salmon populations, including the depensatory and compensatory characteristics that affect the size of spawning stocks, major river systems in their lower concourse are less susceptible to resource variation (9). In addition to the abundant salmon resources available in the main part of the river, user-groups also had access to the resources in tributary streams and rivers. There is a correlation between high resource availability and the number of salmon technology complexes used: thus, Halkomelem people - 10; Tsimshian people - 11; and the Chinook, who had no access to a maritime fishery in the open Pacific, used 6 out of a possible 9. The Chinook unlike the Halkomelem and Tsimshian, relied on one salmon technology complex as a primary production system: the seine (10). Salmon abundance on the Fraser and Skeena, and possibly on the Nass, as well, was exploited in a broader range of resource locations.

b) secondary rivers: Watershed areas next in rank supported large resident populations oriented to riverine systems of production. The Chilkat, Bella Coola-Atnarko, and Klamath-Trinity are representative examples in the literature. All three areas had important salmon runs. The Chilkat was a major producer of sockeye salmon. All five species were present in the Bella Coola River in numbers far superior to most parts of the coast; of special interest is the fact that the Bella Coola was the centre of abundance for chinook salmon in central British Columbia. Similarly, chinook salmon was the principal resource in the Klamath system. Two major 'races' entered the river each year, an early and a late run. It is difficult now to reconstruct the size of past runs in the Klamath. At present there is an escapement in excess of 50,000 (extraordinarily high for this species), although dams and hydroelectric projects have been constructed in the upper reaches of the system.

Three language groups, the Yurok, Karok, and Hupa, shared the salmon resources of the Klamath (11). The season for chinook and coho extended over a six-month period from late April - early May to late October, but apparently there were few, if any, runs in early summer. This is somewhat longer than the Bella Coola River which had an intensive four-month fishery with all five species present in a combination of serial and overlapping runs. Farther north, in the Chilkat River, sockeye and chum salmon ran mainly in July and August. Both Chilkat and Bella Coola fishermen also had access to a salt water salmon fishery and to other nearby streams, indicating a greater diversity of resource potential than the people of the Klamath basin.

c) coastal rivers as centres of species abundance: Many smaller rivers carry an exceptionally large spawning population of a particular species while supporting only average size runs of other species. Where these centres of abundance occur it appears that one of two things tended to happen: either people settled in the river valley and its adjacent areas and regularly exploited the local runs to obtain their staple foods, in which case the population of the language group probably stabilized and remained relatively small; or else people moved to a productive resource area seasonally to exploit the large runs, and then moved on to other resource areas, in which case a diffused settlement pattern and an expanded human population could occur for a specified language group.

In the southern half of the Northwest Coast culture area the option to expand and diversify was considerably more limited than in the northern half. There was no possibility of a maritime fishery, either for salmon or non-salmon species. There were no off-shore islands to settle on; and no inland expansion was possible because the little coastal rivers took their source from mountain ranges near shore. Clustered around every important salmon river was an independent language group utilizing weir technology. In an article entitled "Historic Perspectives in Indian Languages of Oregon and Washington", Jacobs (1937) remarks there were 24 or 25 mutually unintelligible languages west of the Cascades. Raising the question, what processes were operative? Jacobs states:

> The Oregon-Washington beachline seems interpretable as one thin and long region of fairly fixed coastal language enclaves which have survived from earlier times in economically well-supplied localities.
>
> (1937:55)

On the Oregon coast three rivers supported coho runs that exceeded 50,000 escapement (mult.reg. 0.71): they are the Nehalam River (Tillamook), Drift Creek and the Alsea River (Alsean), and a resource area called Ten Mile Lakes at mid-point between the Umpqua and Coos Rivers (Siuslaw and Coosan?). Whether the latter centre of abundance served the needs of people both to the north and south, or only one or the other language group, is information that because of the nature of Oregon Coast ethnography is not available (12).

Weir technology on the Quinault and Quileute Rivers has previously been mentioned. The run of sockeye salmon in the Quinault River is exceptional not only because of its abundance (over 50,000 escapement: $\bar{x}$ 7.88) but its timing (and, Swan would have added, the superiority of its flavour). On most parts of the coast, sockeye runs appear in late summer; but in the Quinault the "bluebacks" come in spring between April and June when it is possible to operate weirs before the freshets swell the river. It is the only place reported in the ethnographies where large communal weirs were constructed especially to take sockeye salmon. The Quileute does not have sockeye runs but weirs were used for fall runs of chinook and other species.

Sockeye populations in the north are supported mainly by the Nass, Skeena, and Fraser systems, and by a large run in the Bella Coola, as has been mentioned. Next in importance is the River's Inlet sockeye producing area (13), a system of ten rivers in the vicinity of Owikeno Lake each supporting large runs. This large lake is just a few short miles from the sea, a situation unique on the coast. Most lakes near coastal areas are nutrient-poor, unable to support sockeye populations; but Owikeno is the exception; it is sufficiently nutrient-rich to sustain food resources for millions of young fry. The territory was exploited by Heiltsuk people (N. Kwakiutl) who lived in coastal villages on the islands and shores of the inlets.

The Southern Kwakiutl had a sockeye river that exceeded the 50-100 range (14), the Nimpkish River in Johnstone Strait. They also had two, Smokehouse Creek and Canoe River, in the 20-50 range. There were only three other rivers of this size in British Columbia:

Copper Creek in the Queen Charlottes (Haida: Skidegate); Kitlope River (N. Kwakiutl); and Somass River system on the west coast of Vancouver Island (Nootka). In Alaska, in addition to the large sockeye run already mentioned in the Chilkat River, the Taku River and two other streams in Behm Canal had sockeye runs in excess of 50,000.

Similarly, chinook producing streams with extraordinary abundance are quite limited in number. Again the Nimpkish system appears as a leading salmon river with an escapement value of 10-20 (mult.reg. 0.96), along with two other streams: the Klinaklini (S. Kwakiutl) and the Squamish (N. Gulf Salish). A tributary of the Fraser, the Harrison, is in the same rank. Accurate estimates for chinook rivers in the south are not included in the INPFC 1967 report.

There are natural limitations on the number of potential resource areas with excessive abundance, once the five or six major salmon producing river systems are disregarded. Therefore, the advantages enjoyed by those who occupied the lower concourse of each major Northwest Coast river were not widely shared. Other language groups with large populations were dispersed generally over a larger territory, exploiting diversified salmon fisheries. Whether or not they had access to one of the richer resource areas, they were less oriented to a riverine economy. Exceptions are the southern groups along the Washington and Oregon coasts each of whom occupied river systems of a comparable size and resource potential. The few Oregon groups who had larger runs, those mentioned in this section, may have had a more intensive fishery at fewer sites than those who exploited less productive rivers and streams.

d) <u>independent streams</u>: Finally, we will consider the broad category of island rivers and independent mainland streams where 'major' spawning populations occur within the normal range for each species (15). For the British Columbia part of the Northwest Coast the number of rivers in this category has been calculated (see Table IX). In addition to these moderate size runs there would be numerous smaller spawning populations that might be exploited.

The salmon resources from independent streams were especially important to island populations and coastal communities at inlets on the north coast. Mainly affected were the Haida, most Tlingit divisions, and the people of the west coast of Vancouver Island (Nootka). The Northern Kwakiutl, Southern Kwakiutl, and Northern Gulf Salish also utilized the resources of independent streams; however, they had greater access to centres of species abundance in other locations and appear to have had a more diversified fishery. Coast Tsimshian people living on the offshore islands would also be included in this category. Island people like the Haida, Tlingit, and Nootka obtained the bulk of their salmon supplies, apparently, through the use of similar strategies. In each society small resource holding groups dispersed to the streams they owned to exploit the salmon runs. Their familiarity with the characteristics of the salmon stocks supported by these streams would enable them to schedule their labour efforts to correspond to the peak period of each run. Groups may have been able to exploit several adjacent streams in this way, depending how close together the timing of runs occurred.

TABLE IX

INDEPENDENT STREAMS

The number of salmon streams in British Columbia to support spawning populations that fall within normal ranges for 'major' stocks, by species.

Sockeye	Pink		Chum	Coho	Chinook
	odd	even			
45	56	56	81	154	82

Figures obtained by disregarding the upper values indicated in frequency distribution table (berringer) for rivers :: spawning population ranges (cf Appendix II).

In the Queen Charlottes, Haida people relied principally on fall runs of chum salmon to provide storage foods. The Tlingit also utilized chum extensively; most runs in the archipelago occurring in late summer, together with large runs of pink salmon. On the west coast of Vancouver Island, streams that support chum salmon are very common; the occurrence of runs is usually in autumn. Chum salmon populations typically select spawning grounds no more than a few miles from the sea. The runs are widely dispersed in hundreds of coastal streams. In the Queen Charlottes and the west coast of Vancouver Island, the other species that occurs late in the season, with runs in numerous rivers, is coho. Runs of coho salmon could be exploited by some user-groups in the same seasonal period as chum. Weirs, traps, harpoons, and gaffs were the principal salmon technology complexes used in independent streams.

The Northern Kwakiutl, Southern Kwakiutl, and Northern Gulf Salish groups had rivers running into inlets and channels along the roughly irregular shoreline; typically, short mainland rivers coming out of the mountains. Numerous streams support runs of chum, coho, and pink stocks (16). The control of these resource areas would afford local user-groups a degree of flexibility when planning fishing activities.

A comparison of salmon technology complexes for the six ethnic divisions mentioned in this section indicates that they all may be characterized as diversified fishermen. It is the latter three who are more commonly referred to in this way in general Northwest Coast accounts, perhaps because their orientation to the sea is more obvious. However, the three island divisions also utilized a wide range of technological applications in the salmon fishery. The number of salmon technology complexes used is as follows: Haida - 8; Tlingit - 7; Northern Kwakiutl - 7; Nootka - 7; Southern Kwakiutl - 6; Northern Gulf Salish - 9. These Northern and Wakashan groups, and the various Salish language speakers living at the northern end of the Gulf of Georgia, utilized systems of exploitation that extended over a range of potential salmon fishery sites.

The ownership of individual rivers and streams with moderately large salmon populations established a close relation between the fisherman and the resource he exploited. Variations in runs would be quickly discerned. A resource owner familiar with the nature of the salmon stocks he utilized would recognize a below-average yield as it occurred, and be able to plan alternate strategies such as moving to another resource area. As always with Northwest Coast fishermen, it was important to be at the right place at the right time to exploit the peak of a salmon run. Dispersed user-groups with access to salmon resources in several streams would be less vulnerable to run failures and natural occurrences that disrupt salmon populations. As a result, where there is a dependency on one biotic element, in this case, the anadromous salmon, those who control a diversified resource base have an obvious advantage.

2. Aggregate of Complementary Systems

In the preceding section, the reciprocal relations of the variables that have been discussed were recast to afford an inter-regional comparison of Northwest Coast traditional salmon production strategies. Attention focussed on the particulars of several sets of variables in order to assess and evaluate the total complement of technical systems. Since no single ethnic division had resource areas so diverse that all twelve salmon technology complexes could be utilized, the significance of these distinct features at fishery sites was highlighted.

The evidence denoted a qualitative difference in the types of resource locations available to people who occupied dissimilar areas, for example, the Masset Haida and the Halkomelem Salish. Because their rivers were smaller, islanders exploited the salmon resource at dispersed locations, whereas coastal mainlanders, with access to large salmon runs in the major rivers, concentrated their fishing activities at fewer sites. Differences in the length of the salmon season were also significant. Island streams with several spawning populations of salmon must be fished within the time constraints of peak migrations. On the other hand, major drainage basin systems in which serial and overlapping runs occured throughout an extended season, allowed user groups greater flexibility to tap into the resource as it suited them. Many examples of the variable nature of Northwest Coast salmon accessibility have been given in the course of this study.

The peoples of the Pacific coast inhabited an environment rich in water resources. Factors of climate and geography combined to produce conditions perhaps unparalleled elsewhere in an area of comparable size. Rivers and streams flowed copiously in the territories of each language group, seldom if ever running dry even in the warmest months of the year. Many people had maritime access or occupied areas contiguous to brackish waters; the biotic reserves of marine, estuarine, and riverine ecological niches each offered a separate set of resource opportunities.

Salmon and other anadromous species were seasonally available in all these zones, the annual variability of abundance notwithstanding. Whereas in other parts of the world humans sought out fertile land areas in which to settle, Northwest Coast peoples discovered the teeming waters of the coastal rim. It is notable that water resources were not centralized in a few valleys, but widely distributed throughout the region. As a result, accessibility to resource areas was decentralized and dispersed among productive salmon streams and inshore fishery sites in every part of the coast.

The economic significance of salmon exceeded its obvious nutritional importance as a staple food. In the prestige system of Northwest Coast societies, salmon had a 'constant value'. It was not a commodity, subject to fluctuations in price and competition, as is the case with fish in market economies. Rather it was a fundamental source of wealth. As previously indicated, surplus salmon could be converted through complex social and ceremonial systems of exchange into any of a number of things that denoted conspicuous wealth and status. Those who could assemble sufficient quantities of salmon to host the ceremonial feasts and provide gifts for many guests, typically held higher ranking positions in the society. In the exchange system of feasts, they received status confirmation and the validation of claims to non-corporeal and corporeal property. Therefore, salmon in the social system of the Northwest Coast had an intrinsic value since access was the key, ultimately, to power and prestige.

I have suggested that the dominant variables in the fishery model were those related to the nature of the prey. The annual or biennial migration back to the spawning stream of origin, a significant characteristic of the anadromous salmon, occurs as a regular event, each genetic stock in its own season. The fishermen of the Northwest Coast planned their resource use strategies to coincide with recurring salmon runs. Members of each local user-group knew the resource potential of salmon fishing sites in their territory. They knew when the important runs of each species would occur, and approximately how long the peak of a run would last. Through the use of selective systems of production, defined in this study as salmon technology complexes, and by organizing the necessary labour both to produce and preserve the catch, fishermen intercepted the runs of certain stocks en route to natal streams. As I demonstrated in the analysis, salmon are thus extracted at each time and space segment of the run through which they pass. The greater the number of available fishery sites, the greater the advantage to resource users.

In conclusion, the ethnographic record contains many examples of how Northwest Coast fishermen used as many parts of the biosphere as possible to procure salmon. An objective of this study has been to assemble these data and examine them in the context of specified ecological, social, and technological components. The model transformed some common aspects of the fishery into abstract categories but displayed a capability to return when required to the empirical case. Thus it was possible to analyze the nature of the traditional fishery and describe the interrelation of variables within several paradigmatic arrangements. As a result, ethnographic examples of diversity have provided evidence for my conclusion that the traditional fishery was a rationalized system in which production efforts were organized and integrated to exploit the salmon resource efficiently.

The concept of salmon technology complexes was formulated for this study to provide a model of interacting variables that would clarify the criteria of each salmon production system. I shall conclude with the proposition that my comparative analysis of the fundamental principles in salmon resource ecology and technology in traditional societies of the Northwest Coast establishes a base line on which to construct future economic studies.

PART THREE Footnotes

1 See p.154 for an analysis of the reef net complex using other comparative criteria.

2 Both harpoons and gaffs were also used further upstream.

3 In this section, 'traps' refers only to Traps I (pp.85..), not to the more specialized Traps II which are treated in the next section.

4 Five fundamental designs are described in Traps I.

5 Refer to Weirs (pp.75..) for fuller detail.

6 Weir panels were removed to permit escapement when people were not actively fishing.

7 cf Cox:1957 (1831); Franchere:1854; Ross:1849; Howay:1941.

8 Dawson (1880) and Murdock (1936) suggest that maritime species, particularly halibut, ranked equally with salmon in importance to the Haida. If this is the case, then the Haida and Makah both are anomalous; all other societies depended principally on salmon supplies.

9 Kew (1976) was first to observe the interrelation of all these factors in a paper on salmon resource availability in the Fraser watershed.

10 Had Lower Chinook data not been treated separately from Wishram, the results would be different. Dip net production at the Columbia River canyons probably rivalled or exceeded seine net production in the estuary.

11 Kroeber and Barrett (1960) include distribution maps for each aspect of fishing technology both for these and neighbouring language groups.

12 The area is very close to a tributary of the Coos River, possibly within Coosan territory.

13 This area is more properly referred to as Owikeno and Long Lakes, tributaries to Rivers Inlet and Smith Inlet respectively. The two races of sockeye intermingle in inshore waters (INPFC:1967:232).

14 (in thousands) Averages over twelve years for the Nimpkish: 5 years greater than 100; 7 years 50-100 range (7.88 x).

15 For the sake of brevity, and because of unique biotic and geophysical characteristics of the Puget Sound lowlands, I have not counted rivers of that area in this reckoning (cf Mitchell:1971).

16 Abundant runs of even-year pink salmon run in the streams of the Queen Charlottes.

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APPENDICES I - III

APPENDIX I

TABLES X - XXII

Introduction

A list of the references cited in the distribution analysis of Salmon Technology Complexes is tabled in this Appendix. Each STC has been tabled individually. Additional notes are included. Table XXII explains the codes used to identify ethnic divisions on the maps.

A few words of explanation about the reference lists is given here:

1 All affirmative (aff) references to salmon fishing methods in the literature consulted are indicated in the Tables. The distribution maps are based on these data.

2 Not all negative (neg) references are included in the Tables. Of those sources listed negatively the reference may mean one of the following: (a) there is an absence of information about the fishing method in question, (b) there is insufficient information to make a clear identification of the method, (c) there is a specific negative reference, i.e., the source indicates that this method was not used by the ethnic group (when this occurs, a note is generally added to the reference on the Table).

3 The Bibliography contains the listings of all sources researched; these Tables merely indicate where positive information is to be found.

APPENDIX I: TABLE X

List of References for Salmon Technology Complex 1 - Trolling

Ethnic Division	Source	Reference	Notes
Tlingit	Krause:1956(1885)	neg	(Chilkat)
	deLaguna:1972:391	neg	denies aboriginal (Yakutat)
	deLaguna:1960	neg	(Angoon)
	Drucker:1950	neg	
	Oberg:1973	neg	
	Olson:1967	neg	
	Niblack:1890	neg	
Haida	Dawson:1880	neg	
	Drucker:1950	neg	
	Murdock:1934	neg	
	Niblack:1890	neg	
Tsimshian	Boas:1916	neg	
	Drucker:1950	neg	
	Duff:1959	neg	
	Garfield:1939,1966	neg	
	MacDonald:1976:46,51	aff	(archeol.evidence: sinkers):"along the coast in spring and fall people trolled for salmon."
	MacDonald:1980	aff	(pers.comm.):trolling lines of kelp
	Sapir:1915	neg	
Northern Kwakiutl	Drucker:1950	neg	
	Olson:1940,1954,1955	neg	
Bella Coola	Drucker:1950	neg	
	Mackenzie:1970:391(1793)	aff (?)	obtuse angle hook made of two pieces of wood or bone mentioned following ref. to cordage quality *

APPENDIX I: TABLE X Cont.

Ethnic Division	Source	Reference	Notes	Trolling 2
Southern Kwakiutl	Boas:1909:485-6	aff	fig.155; details manufacturing; methods; coho salmon "trolling for salmon was practiced."	
	Boas:1921:237	aff	sockeye (?) caught by trolling, also coho **	
	Drucker:1950	aff	(Koskimo,Kwexa,Wikeno)	
Nootka	Cook:1785:328	aff		
	Drucker:1950:168	aff	(Tsishaat, Clayoquot)	
	Drucker:1951:40	aff	troll for chinook during herring runs; fresh consumpt.	
	Koppert:1930:72	aff	(Clayoquot) baited acute angle hooks on kelp lines, troll in mornings	
	Sapir & Swadesh:1955:30,45	aff	autumn:cohos:salt water (in the passage)	
	Sproat:1868:220	aff		
Makah	Gibbs:1877:167,175,195	aff	"what salmon are taken are chiefly got by trolling."	
	Gunther:1927:215	aff		
	Niblack:1890:291	aff	Plate XXX:trolling hook collected by Swan	
	Singh:1966:40,70	aff	most imp.method; Swiftsure Banks,June; single & mult.***	
	Swan:1870:23,24	aff	fresh & dried; Makah will not troll unless herring are present; very important method.	
N.Gulf Salish	Barnett:1939:230	aff	hooks, sharp angle	
	Barnett:1955:85-86	aff	Fig.26	
Halkomelem	Barnett:1939	aff	(Nanaimo - possibly; Cowichan - yes)	
	Barnett:1955:85-86	aff	Fig.26 Cowichan	
	Duff:1952	0	Upper Stalo had no salt water sites	
	Jenness:1955:7,9	0	Katzie had no salt water sites	
	Suttles:1955:23	0	Katzie (as above)	
	Hill-Tout:1907:90	aff	in the off-season	
Straits	Barnett:1939:230	aff	(East and West Saanich)	
	Barnett:1955:85-86	aff	Fig.26	
	Gunther:1927:198,201	aff	trolled inside the spit for coho	
	Stern:1934	neg		

APPENDIX I: TABLE X Contd.

Ethnic Division	Source	Reference	Notes Trolling p.3
Straits - contd.	Suttles:1951:134-136	aff	chinook in winter, spring & summer; coho in summer.
Lushootseed	Collins:1969:294	aff	trolling off Skagit Head for chinook
	Haeberlin & Gunther 1930:27	aff	salt water trolling when salmon first begin to run
	Smith:1940:254-5	aff	bent ironwood hook, herring bait (Puyallup-Nisqually)
	Waterman:1973:66	aff	'occasional'
Twana	Elmendorf:1960:57,60, 80-81,Fig.4	aff	salt water "but this method furnished relatively small proportion of the catch." Fig.4 - curved hook
Quileute	Pettit:1950	neg	
	Singh:1966	neg	
Quinault	Olson:1936	neg	
	Singh:1966:40	neg	
	Swan:1857:264	neg	never by baited hook
Lower Chinook	Cox:1957 (1831)	neg	
	Gibbs:1877	neg	
	Ray:1938	neg	
	Ray:1942:110	neg	denied
	Swan:1857:264	neg	never by baited hook
Upper Chinook		0	no salt water fishery
Tillamook	Barnett:1937	neg	
	Sauter & Johnson:1974	neg	
Oregon Coast	Barnett:1937	neg	
	Drucker:1939	neg	Alsea did not fish offshore (p.83)
Tolowa	Drucker:1937:271	neg	
	Kroeber & Barrett:1960:134	neg	

APPENDIX I: TABLE X Contd.

Ethnic Division	Source	Reference	Notes	Trolling p.4
Hupa	Kroeber & Barrett: 1960:134	neg		
Wiyot	Kroeber & Barrett 1960:134	neg		
Yurok	Kroeber & Barrett 1960:134	neg		
Karok		0	no salt water fishery	

*Bella Coola data not clearly identified as trolling hook but Berringer assumes probability high.

**Boas may have erred in identifying sockeye; they do not typically take a lure.

***Makah: Hewes' thesis reported the use of both single trolling hooks and hooks used in gangs of up to 30 on a single line. Ref. is to long-line trolls; his source: Rounsefell & Kelez. (Hewes quoted in Singh:1966:40).

APPENDIX I: TABLE XI

List of References for Salmon Technology Complex 2 - Seining

Ethnic Division	Source	Reference	Notes
Tlingit	Krause:1956:120(1885)	neg	
	deLaguna:1960	neg	nets 30-40 fathoms long; no information given
	Drucker:1950:234	neg	denied
	Oberg:1973:9	neg	nets mentioned but no information given
Haida	Dawson:1880	neg	
	Drucker:1950	neg	denied
	Harrison:1925	neg	
	Murdock:1934,1936	neg	
	Niblack:1890:293	(?)	Massett "seine" net, 52 ft x 64 inches (prob.trawl)*
	Swanton:1905	neg	
Tsimshian	Boas:1916:397	(?)	nettle fibre nets for salmon, 20 fathoms long x 20 meshes wide. Cedar bark line 46 fathoms long;floats.
	Drucker:1950	neg	denied
	Garfield:1939	neg	
	MacDonald & Inglis:1976	(?)	possible use of nets for seining
Northern Kwakiutl	Drucker:1950:234	neg	denied
	Olson:1940,1954,1955	neg	
Bella Coola	Drucker:1950:234	neg	denied
	Mackenzie:1970	neg	
	McIlwraith:1948	neg	
Southern Kwakiutl	Boas:1909:465	neg	nets for eulachon chiefly
	Boas:1921	neg	
	Drucker:1950:234	neg	denied
Nootka	Drucker:1950:234	neg	denied
	Koppert:1930:68	neg	

APPENDIX I: TABLE XI Contd.

Ethnic Division	Source	Reference	Notes Seining p.2
Nootka - contd.	Sapir & Swadesh:1955	neg	
	Sproat:1868:221	neg	
Makah	Colson:1953	neg	
	Singh:1966	neg	
	Swan:1870	neg	
N.Gulf Salish	Barnett:1939:230	aff	(Comox, Squamish)(but may have meant gill net only.*)
	Barnett:1955:86	neg	drift seine known but not resorted to very often.
Halkomelem	Barnett:1939:230	aff	(Nanaimo, Cowichan)
	Duff:1952	neg	
	Hill-Tout:1907	neg	
	Jenness:1955	neg	
	Suttles:1955	neg	
Straits	Barnett:1939:230	aff	(E.Saanich)**
	Gunther:1927:198-201	neg	
	Suttles:1951:139-140	aff	(Samish) "drag seine" used at mouth of Samish River upon returning from the summer's reef-netting. Coho.
Lushootseed	Collins:1974:46	neg	
	Haeberlin & Gunther: 1930:28	aff	seine net described but not method. Salt water.
	Smith:1940:263	aff	wealthy people only. Salt water.
Twana	Elmendorf:1960	neg	
Quileute	Pettitt:1950	neg	
	Singh:1966	neg	
Quinault	Olson:1936	neg	
	Singh:1966	neg	
	Swan:1857	neg	

Ethnic Division	Source	Reference	Notes Seining p.3
Lower Chinook	Cox:1957:177(1831)	aff	
	Ross:1849	aff	Lewis & Clark quoted in Ross
	Gibbs:1877:194,195	aff	
	Lyman:1903:66	aff	
	Swan:1857:103-108	aff	
Wishram	Spier & Sapir:1930:176	aff	
Tillamook	Barnett:1937	neg	
Oregon Coast	Barnett:1937	neg	
Tolowa	Barnett:1937	neg	
	Drucker:1937	neg	
	Driver:1939:312,378	aff	"this is dragged or circled, the true seine."
	Kroeber & Barrett: 1960	aff	Map 19
Yurok	Kroeber & Barrett: 1960:49,133,146	aff	Map 19
Karok	Kroeber & Barrett: 1960:49,146,155	aff	Map 19
	Kroeber:1925:85	aff	Map 19
Hupa	Kroeber & Barrett: 1960:40,146,155	aff	Map 19
Wiyot	Kroeber & Barrett: 1960:49,146,155	aff	Map 19

APPENDIX I: TABLE XII

List of References for Salmon Technology Complex 3 - Harpoons

Ethnic Division	Source	Reference	Notes
Tlingit	Krause:1956:120-121	aff	(Chilkat)
	deLaguna:1960:116	aff	(Angoon)
	deLaguna:1972:384-5	aff	(Yakutat)
	Drucker:1950	aff	
	Oberg:1973:9,60-62	aff	(Chilkat) important
	Olson:1967:vi	aff	
	Niblack:1890:288	aff	
	Knapp & Childe:1896:90	aff	
Haida	Dawson:1880:109,144	aff	
	Drucker:1950:170,240	aff	
	Murdock:1936:224	aff	
	Niblack:1890:288	aff	Fig.137
	Swanton:1905	neg	(no mention)
Tsimshian	Barbeau:1930:147	aff	
	Boas:1916	aff	
	Drucker:1950	aff	
	Large:1957	aff	
	MacDonald & Inglis:1976	aff	in the river, use the harpoon from platforms
Northern Kwakiutl	Drucker:1950:167	aff	
Bella Coola	Drucker:1950	aff	
	Mackenzie:1970:391(1793)	aff	toggled harpoon
Southern Kwakiutl	Boas:1909:488-495	aff	Fig.156, unequal foreshafts
	Boas:1921:223,302,238	aff	chum salmon at river mouths, sockeye in upper rivers
	Drucker:1950:167	aff	
	Niblack:1890:	aff	Plate XXX; Fig.150 Nimpkish old style spear

APPENDIX I: TABLE XII Contd.

Harpoons -2

Ethnic Division	Source	Reference	Notes
Nootka	Cook:1785:328	aff	(April 1778)
	Drucker:1951:19-20	aff	
	Drucker:1950:167	aff	
	Koppert:1930:78	aff	(Clayoquot)
	Jewitt:1967:47	aff	
	Sapir & Swadesh:1955:41	aff	
	Sproat:1868:221	aff	
Makah	Croes:1980:311	aff	Hoko R. archeol. evidence, detachable harpoon points
	Gibbs:1877:175	aff	
	Gunther:1927:215	neg	
	Singh:1966:39	aff	
	Swan:1870	neg	
N.Gulf Salish	Barnett:1939:229	aff	
	Barnett:1955:83	aff	
Halkomelem	Barnett:1939	aff	
	Barnett:1955:83	aff	
	Dally:n.d.	aff	Doc.#39 (B.C.Prov.Archives)'used for salmon on the lower Fraser':photo.
	Duff:1952:62-67	aff	(Stalo) coho in winter by firelight; chinook in spring when the water was low and clear
	Fraser:1960:101(1808)	aff	
	Hill-Tout:1907:131-32	aff	
	Jenness:1955:8	aff	(Katzie)
	Suttles:1955:22-23	aff	(Katzie) fall fishing at shallow bars
Straits	Barnett:1939	aff	
	Barnett:1955:83-84	aff	Fig.21
	Gunther:1927:198-201	aff	(Clallam) coho, pinks, chum; usually at night.
	Stern:1934:51	aff	chinook; river channels
	Suttles:1951:140-143	aff	

APPENDIX I: TABLE XII Contd.

Ethnic Division	Source	Reference	Notes Harpoons -3
Lushootseed	Collins:1974:50,58	aff	
	Haeberlin & Gunther:1930:27	aff	
	Smith:1940:264-267	aff	Smith notes differences in techniques salt water/ inland people
	Waterman:1973:55-60	aff	
Twana	Elmendorf:1960:57,76-80	aff	Fig.4., in streams from canoe; important method
	Waterman:1973:56	aff	
Quileute	Pettitt:1950:7	aff	
	Singh:1966:39	aff	not as productive as weirs, traps, and nets.
Quinault	Olson:1936:33-34	aff	shallow water
	Singh:1966:39	aff	not as productive as weirs, traps, and nets.
Lower Chinook	Cox:1957:177(1831)	neg	no information
	Gibbs:1877:195	neg	no information
	Lyman:1903:66	aff	
	Ray:1938:108-109	aff	from canoes; 3rd most important fishing method
	Swan:1857:38-40	aff	Fig.
Wishram	Gibbs:1877:195	neg	
	Lyman:1903:66	aff	speared salmon at the Cascades, the Dalles.
	Spier & Sapir:1930:175-6, 178	aff	fall fishing; owned stations over the River; second only to dip netting.
Tillamook	Barnett:1937:164	aff	
	Sauter & Johnson:1974	aff	
Oregon Coast	Barnett:1937:164	aff	
	Boas:1923	aff	
	Drucker:1939:82-83	aff	(Alsea)
	Leatherman & Kreiger: 1940:19	aff	(Coos) archeol.evidence harpoon

Ethnic Division	Source	Reference	Notes	Harpoons -4
Tolowa	Drucker:1937:233,237	aff		
	Kroeber & Barrett:1960: 74-80	aff		
Yurok	Kroeber in Elmendorf:1960 80	aff	footnotes: comparing Yurok and Twana harpoons	
	Kroeber & Barrett:1960: 73-80	aff	re access (p.76)	
Karok	Kroeber & Barrett:1960:77	aff	chinook salmon; cf Gifford footnote	
Hupa	Kroeber & Barrett:1960:74-75	aff		
	Goddard:1903:25	aff		
Wiyot	Kroeber & Barrett:1960:75	aff	quote Curtis re spearing at riffles, in moonlight; quote Hewes fieldnotes: "...salmon ran in such numbers that a spear thrust anywhere would bring up a fish."	

APPENDIX I: TABLE XIII

List of References for Salmon Technology Complex 4 - Trawling

Ethnic Division	Source	Reference	Notes
Tlingit	Krause:1956:120	neg	
	deLaguna:1960	neg	
	deLaguna:1972	neg	
	Drucker:1950	neg	
	Oberg:1973	neg	
	Olson:1967	neg	
Haida	Dawson:1880	neg	
	Drucker:1950	neg	
	Murdock:1934,1936:224	aff	at the mouths of streams with dragnets
	Niblack:1890:293	aff	between two canoes; drag nets secured to poles
	Swanton:1905	neg	
Tsimshian	Drucker:1950	aff	(Kitqata at Hartley Bay)
	Garfield:1939	neg	
Northern Kwakiutl	Drucker:1950	aff	Xaisla
	Olson:1940,1954,1955	neg	
Bella Coola	Drucker:1950	aff	
	Mackenzie:1970:371(1793)	aff	large trawl between two canoes in river channels near the mouth
	McIlwraith:1948:610	aff	
Southern Kwakiutl	Boas:1909:465	neg	
	Drucker:1950	neg	
Nootka	Drucker:1950	aff	(Tsishaat)
	Jewitt:1967(1815)	neg	
	Koppert:1930	neg	
	Sproat:1868	neg	

APPENDIX I: TABLE XIII Contd.

Ethnic Division	Source	Reference	Notes	Trawling -2
Makah	Gibbs:1877	neg		
	Singh:1966:38	aff	sockeye in Ozette Lake	
	Swan:1870	neg		
N.Gulf Salish	Barnett:1938:122	aff	Squamish River; two canoes, pocket net	
	Suttles:1951:155	aff	Squamish; (special) used between 2 poles from a single canoe	
Halkomelem	Boas:1894:460	aff		
	Barnett:1955:87	aff		
	Duff:1952:131,144-145	aff	bag netting: 2 kinds, on ropes, on poles. used more for sturgeon fishing but also to take salmon:Fraser R. Harrison R., Chehalis R. for chinooks.	
	Fraser:1960:114(1808)	aff	net dragged between 2 canoes on Fraser R.	
	Hill-Tout:1907:90	aff	Island tribes at mouth of Fraser, over shoals	
	Kew:1976	aff	important salmon fishing method lower Fraser	
	Suttles:1951:155	aff	(Cowichan & Nanaimo)	
	Suttles:1955:22	aff	(Katzie) in Fraser for sockeye	
Straits	Gunther:1927:201	(aff)	(Clallam)(special) native term for this river net same as Suttles 'trawl' but Clallam net not used between 2 canoes.	
	Suttles:1951:144-5	(aff)	Lummi in Nooksak R. but not very important method	
Lushootseed	Collins:1974:46	aff	native term similar to above	
	Haeberlin & Gunther:1930:28	aff	between two canoes	
	Smith:1940:264	aff	native term similar to above	
	Suttles:1951:145	aff	used by up-river peoples	
Twana	Elmendorf:1960	neg		
Quileute	Pettitt:1950:7	aff	between two canoes	
	Singh:1966:38	aff	mainly in estuary and few miles upstream; also Ozette L.	

APPENDIX I: TABLE XIII Contd.

Ethnic Division	Source	Reference	Notes Trawling -3
Quinault	Olson:1936:30	aff	
	Singh:1966:38		
Lower Chinook	Ray:1938:108	aff	between two canoes, conical bag net (also commonly used for sturgeon fishing)
	Ray:1942:108-109	aff	
Wishram	Spier & Sapir:1930	neg	
Tillamook	Barnett:1937	neg	
Oregone Coast	Barnett:1937	neg	
Tolowa	Barnett:1937:164	neg	
	Driver:1939:312	aff	conical drag net
	Drucker:1937	neg	
Yurok	Driver:1939:312	aff	
	Kroeber & Barrett:1960	aff	(a) drifting bag seine for salmon rigged on ropes(p.40-1) (b) conical drifting bag net for salmon on poles (ibid) (c) double drifting bag net (pp53-54): on Klamath R.
Karok	Driver:1939:312	aff	conical drag net
	Gifford:fieldnotes (1939)	aff	quoted <u>in</u> Kroeber & Barrett
	Hewes:fieldnotes (1940)	aff	as above
	Kroeber & Barrett:1960:54	aff	
Hupa	Driver:1939:312	aff	
	Kroeber & Barrett:1960:40	aff	double drifting bag net on A-frame
Wiyot	Driver:1939:312	aff	
	Kroeber & Barrett:1960:54	aff	(single) drifting bag seine

APPENDIX I: TABLE XIV

List of References for Salmon Technology Complex 5 - Gaffing

Ethnic Division	Source	Reference	Notes
Tlingit	Krause:1956:121	aff	(Chilkat)
	deLaguna:1960:116	aff	(Angoon) steam bent hardwood
	deLaguna:1972:386	aff	(Yakutat) coho salmon; from canoes in riled water
	Drucker:1950	(aff)	(Cape Fox) but Drucker believed it to be recent
	Jones:1914:103	aff	pinks and chum salmon
	Niblack:1890:289	aff	
	Oberg:1973	aff	coho
Haida	Dawson:1880	neg	
	Drucker:1950	(aff)	but Drucker believed it to be recent, not aboriginal
	Murdock:1934,1936	neg	
	Niblack:1890	(?)	unclear reference
	Swanton:1905	neg	
Tsimshian	Barbeau:1930:139	aff	(Gitksan) at Hagwilget Canyon stations, family-owned property; chinook salmon June & July; (photo)
	Drucker:1950:238	(aff)	(Kitqata at Hartley Bay) but Drucker believed not aboriginal; (Tsimshian-Gilutsa) recent acquisition*
Northern Kwakiutl	Drucker:1950:168	aff	(Xaihais-Heiltsuk) trait list entry marked positive; (Bella Bella) Drucker believed recent acquisition*
Bella Coola	Drucker:1950	neg	
	Mackenzie:1970	neg	
	McIlwraith:1948	neg	
Southern Kwakiutl	Boas:1909	neg	
	Boas:1921:223-4	aff	chum salmon, Nimpkish R.
	Drucker:1950	aff	(Koskimo, Nimpkish R.)*
	Niblack:1890:Plate XXX	(aff)	Nimpkish jig or snag for hauling out salmon:Fig.145; detachable hook with binder line.

APPENDIX I: TABLE XIV Contd.

Ethnic Divisions	Source	Reference	Notes	Gaffing -2
Nootka	Cook:1785:328	(?)	'gigs'; no description	
	Drucker:1950	neg		
	Koppert:1930:78	aff	(Clayoquot) stream fishing for salmon - hook	
	Sapir & Swadesh:1955	neg		
	Sproat:1868	neg		
Makah	Gibbs:1877	neg		
	Singh:1966	neg		
	Swan:1870	neg		
N.Gulf Salish	Barnett:1938:121	aff		
	Barnett:1939:230	aff	toggled salmon gaff**	
	Barnett:1955:84	aff		
Halkomelem	Barnett:1939:230	aff	(Cowichan)	
	Barnett:1955:84	aff		
	Suttles:1955:23	aff	(Katzie) barbless bent wooden hook of yew; binder line	
Straits	Barnett:1939:230	aff	(E. & W. Saanich)	
	Barnett:1955:84	aff		
	Gunther:1927:200-01	aff		
	Stern:1934:49	aff	fall fishing, muddy water	
	Suttles:1951:142-43	aff	exclusively in streams for fall fishing; only device used by all Straits groups; 'toggled' steam bent hook	
Lushootseed	Collins:1974	neg		
	Gunther & Haeberlin:1930	neg		
	Smith:1940:255	aff	fall fishing	
	Waterman:1973	neg		
Twana	Elmendorf:1960:80	aff	Fig.4; one piece barbless slip hook of ironwood, steamed and bent, attached by line to shaft***	

APPENDIX I: TABLE XIV Contd.

Ethnic Division	Source	Reference	Notes	Gaffing -3
Quileute	Pettitt:1950	neg		
	Singh:1966	neg		
Quinault	Olson:1936:26,34	aff		
	Singh:1966	neg		
	Swan:1857:264	aff	gaff hooks in Quinault R.	
Lower Chinook	Cox:1957:177(1831)	aff	'gig'	
	Gibbs:1877:195	aff	'gig' attached by thong; rapids & small streams	
	Ray:1938	neg		
	Ray:1942	neg		
	Swan:1857:135-38; 38-40, 287	aff	important fall fishing method used by Shoalwater Chinook	
Wishram	Spier & Sapir:1930	neg		
Tillamook	Barnett:1937	neg	category not included in trait list	
	Sauter & Johnson:1974	neg		
Oregon Coast	Barnett:1937	neg	as stated above	
Tolowa	Kroeber & Barrett:1960 81-82	aff	quote from Hewes field notes: gaff for salmon was regularly used from the canoe; bone point***	
Yurok	Kroeber & Barrett:1960 80-82	neg	no detachable ironwood or curved hooks of any kind used for salmon fishing	
Karok	Kroeber & Barrett:1960	neg		

APPENDIX I: TABLE XIV Contd.

Ethnic Division	Source	Reference	Notes	Gaffing -4
Hupa	Kroeber & Barrett:1960	neg		
Wiyot	Kroeber & Barrett:1960:81	aff	quote from Driver (see next entry)	
	Driver:1939:313,379	aff	salmon gaff	

*Drucker stated in his Ethnographic Notes that he did not believe the gaff to be aboriginal; the entries in the trait list are marked either positive or recently acquired. This Table indicates Aff for a minimum positive entry of one group within the Ethnic Divsion, and (Aff) for an entry marked 'recent' by Drucker. Nevertheless, Drucker appears to have been mistaken about the antiquity of the gaff.

**Barnett and other writers use the term 'toggled' to refer to the action of the binder line by which the gaff hook is attached to the shaft.

*** Kroeber wrote extensive footnotes in Elmendorf:1960 comparing fishing methods. He seemed to find it very difficult to believe that a detachable gaff hook was an efficient device for taking salmon, and expressed his surprise at Elmendorf's careful description of the gaff used by the Twana. Again in Kroeber & Barrett:1960:82 he questions the practicality of gaffing, this time with reference to the Tolowa data collected by Hewes: "we have no idea how the alleged Tolowa salmon gaff could have been used from a canoe."

APPENDIX I: TABLE XV

List of References for Salmon Technology Complex 6 - Gill Nets

Ethnic Division	Source	Reference	Notes
Tlingit	Krause:1956	neg	
	deLaguna:1960, 1972	neg	
	Drucker:1950	neg	
	Niblack:1890	neg	
	Oberg:1973	neg	
Haida	Dawson:1880	neg	
	Drucker:1950	neg	Massett people obtained nets from Nass in recent times
	Murdock:1934, 1936	neg	
	Swanton:1905	neg	
Tsimshian	Boas:1916:397	aff	
	Drucker:1950:169,239	aff	(Kitqata at Hartley Bay, Tsimshian-Gilutsa; Nishga)*
	MacDonald & Inglis:1976: 46,51	aff	
Northern Kwakiutl	Drucker:1950:169,239	neg	
Bella Coola	Drucker:1950:169	neg	
	McIlwraith:1948	neg	
	Mackenzie:1970	neg	
Southern Kwakiutl	Boas:1909	neg	
	Drucker:1950:169	neg	
Nootka	Drucker:1950:169,239	aff	(Hupachisat,Tsishaat, Clayoquot)*
	Drucker:1951:23	neg	
	Koppert:1930:68	neg	
	Sproat:1868:221	neg	no nets were used for salmon fishing
	Sapir & Swadesh:1955:30	aff	net set vertically

APPENDIX I: TABLE XV Contd.

Gill Nets -2

Ethnic Division	Source	Reference	Notes
Makah	Colson:1953:37,43	aff	in autumn many gather set nets for salmon Hoko R.
	Croes:1980:311	aff	archaeol. evidence: Hoko R. (chum salmon)
	Gibbs:1877	neg	
	Gunther:1927:215	neg	Makah depended wholly on trolling, no streams of any size
	Singh:1966:38-39	aff	Makah caught more salmon with hooks than nets
	Swan:1870	neg	
N.Gulf Salish	Barnett:1939:230	neg	
	Barnett:1955:86	neg	not aboriginal
Halkomelem	Barnett:1939:230	aff	(Cowichan). (Nanaimo-neg.)
	Dally n.d.	neg	
	Duff:1952:63	aff	Fraser R.
	Hill-Tout:1907	neg	
	Suttles:1951:138	aff	Fraser R.
	Suttles:1955:22	aff	(Katzie) for salmon but mainly a sturgeon fishing method; only wealthy person could obtain valuable nets
Straits	Barnett:1939:230	aff	(E.Saanich). (W.Saanich-neg.)
	Gunther:1927:198-201	aff	(Clallam) used where salmon follow the herring in near shore; chinook, chum, coho.
	Suttles:1951:136-139	aff	linguistic evidence; used in salt water by Straits
Lushootseed	Collins:1974:46	neg	(special) set net with a closed bunt end, shallows
	Haeberlin & Gunther:1930	neg	
	Smith:1940:263-64	aff	
	Waterman:1973	neg	
Twana	Elmendorf:1960:81	neg	denied
Quileute	Pettitt:1950:7	aff	before whites, made of nettle fibre
	Singh:1966	aff	not as important as dip nets or trawl nets

APPENDIX I: TABLE XV Contd.

Ethnic Division	Source	Reference	Notes Gill Nets -3
Quinault	Olson:1936	neg	denied
	Singh:1966	neg	
Lower Chinook	Cox:1831	neg	
	Franchere:1854	neg	
	Ray:1938, 1942	neg	
	Swan:1857	neg	
Wishram	Spier & Sapir:1930	neg	
Tillamook	Barnett:1937	aff	
	Sauter & Johnson:1974:57	aff	gill nets aboriginal, widely used in narrow rivers of Tillamook Bay.
Oregon Coast	Barnett:1937	neg	
	Drucker:1939	aff	(Alsea)
Tolowa	Barnett:1937	aff	
	Drucker:1937:233	aff	
	Driver:1939:312	aff	
	Hewes:1947:88	aff	1940 field notes: aff
Yurok	Driver:1939:312	aff	
	Kroeber & Barrett:1960: 50-52	aff	both coastal and riverine groups; Hewes 1940 field notes also quoted: aff
	Kroeber:1925:84-85	aff	
	Elmendorf:1960:81	aff	Kroeber footnotes in Elmendorf: Yurok aff
Karok	Kroeber & Barrett:1960: 50-52,155	aff	

APPENDIX I: TABLE XV Contd.

Ethnic Division	Source	Reference	Notes	Gill Nets -4
Hupa	Driver:1939:312	aff		
	Goddard:1903:24	aff		
	Kroeber & Barrett:1960: 50-52, 155	aff		
Wiyot	Driver:1939:312	aff		
	Kroeber & Barrett:1960: 50-52, 155	aff		

*Gill nets were used by Nishga to fish through the ice; Haida and Hartley Bay-Tsimshian (Kitqata) stated they obtained gill nets ready-made from the people of the Nass. (Drucker:1950:239). In addition, Drucker assumed his Nootka informants had erred or were referring to recent useages because of Sproat's widely circulated comment that nets were not used in the area for salmon fishing. (ibid). It is probable that Sproat intended simply to emphasize the significance of traps, trolling, and harpoons, the three principal technologies.

APPENDIX I: TABLE XVI

List of References for Salmon Technology Complex 7 - Tidal Traps

Ethnic Division	Source	Reference	Notes
Tlingit	Krause:1956(1885)	neg	
	deLaguna:1960:69,116	aff	(Angoon) stone weirs, salmon trapped falling tide
	deLaguna:1972:387	aff	(Yakutat)
	Drucker:1950:166	aff	(Cape Fox)
	Oberg:1973	neg	
Haida	Dawson:1880	neg	
	Drucker:1950:166	aff	
	Langdon:1980	aff	(pers.comm.)
	Murdock:1936	neg	
	Swanton:1905	neg	
Tsimshian	Boas:1916:400	(aff)	from the myths, evidence tidal traps for seals(?)
	Drucker:1950:166	aff	(Hartley Bay-Kitqata; Gilutsa-Tsimshian)
	Sapir:1915	neg	"people of the traps" name of group near the mouth of the Nass R.
Northern Kwakiutl	Drucker:1950:166	aff	
	Olson:1955:320-22	aff	Bella Bella stone fish weirs(incl.one built by women)
	Pomeroy:1976	aff	
Bella Coola	Drucker:1950:166	aff	
	Mackenzie:1970(1793)	neg	
	McIlwraith:1948:13,118, 221,226	aff	
Southern Kwakiutl	Boas:1909:465	aff	single and multiple wings illustrated
	Drucker:1950:166	aff	(Koskimo; Kwexa, Nimkish R.(sic))
Nootka	Cook:1784	neg	
	Drucker:1950:166,236	aff	
	Drucker:1951:16,17,259	aff	

APPENDIX I: TABLE XVI Contd.

Tidal Traps -2

Ethnic Division	Source	Reference	Notes
Nootka contd.	Jewitt:1967:1815	neg	
	Sapir & Swadesh:1955	neg	
	Sproat:1868	neg	
Makah	Colson:1953	neg	
	Singh:1966	neg	
	Swan:1857	neg	
N.Gulf Salish	Barnett:1939:229	aff	
	Barnett:1955	aff	incl.tidal fence trap
Halkomelem	Barnett:1939:229	aff	(Cowichan)(Nanaimo-neg.)
	Hill-Tout:1907	neg	
	Suttles:1962	neg	
Straits	Barnett:1939:229	aff	(W.Saanich)
	Gunther:1927	neg	
	Suttles:1951	neg	
Lushootseed	Collins:1969	neg	
	Haeberlin & Gunther:1930	neg	
	Smith:1940	neg	
	Waterman:1973	neg	
Twana	Elmendorf:1960:57,76	neg	occasional use for seals but obviously not important salmon technology (cf p.57,63); also used for herring and other salt water fish.
Quileute	Pettitt:1950	neg	
	Singh:1966	neg	
Quinault	Olson:1936	neg	
	Singh:1966	neg	

APPENDIX I: TABLE XVI Contd.

Ethnic Division	Source	Reference	Notes Tidal Traps -3
Lower Chinook	Ray:1938	neg	
	Ray:1942:114	neg	denied
	Swan:1857	neg	
Upper Chinook		0	
Tillamook	Barnett:1937	neg	
	Sauter & Johnson:1974	aff	archeol. evid.
Oregon Coast	Barnett:1937	neg	
	Drucker:1939	neg	
	Leatherman & Kreiger:1940	neg	
Tolowa	Barnett:1937	neg	
	Drucker:1937	neg	
Yurok	Kroeber & Barrett:1960	neg	
Karok		0	
Hupa		0	
Wiyot	Kroeber & Barrett:1960:22	(aff)	(special) quote from Hewes field notes; trap set in 7 to 8 ft deep stream or tidal slough for chinook which were carried down along with ebbing tide; net at opening in fence-like obstruction. (i.e., does not strand the fish.)

APPENDIX I: TABLE XVII

List of References for Salmon Technology Complex 8 - Weirs

Ethnic Division	Source	Reference	Notes
Tlingit	Krause:1956(1885)	neg	reports traps
	deLaguna:1972:384	aff	small streams blocked
	Drucker:1950:167	aff	(Cape Fox; Chilkat), both vertical & oblique stakes
	Knapp & Childe:1896:90	aff	double weir + dip net, harpoon
	Oberg:1973:9,62	aff	sporadically built
Haida	Dawson:1880:109-110	aff	small streams
	Drucker:1950:30	aff	simple row of vertical stakes lashed to horizontal poles tied to bank
	Murdock:1936:224	aff	(source:Niblack); shallow,double weir + spear,dip net
	Niblack:1888:294	aff	(source:Swan);upstream weirs + spear, dip net
Tsimshian	Boas:1916	aff	
	Barbeau:1930:147	aff	salmon 'fences'
	Drucker:1950:167	aff	(Hartley Bay;Gilutsa -oblique)(Gitksan -vertical)
	MacDonald & Inglis:1976	aff	
Northern Kwakiutl	Drucker:1950:167	aff	(Bella Bella, Heiltsuk)
Bella Coola	Drucker:1950:167	aff	
	Mackenzie:1970:361-64, 371-72	(aff)	affirmed by inference that not all people had the large Bella Coola River Dam
	McIlwraith:1948:9,118,135, 226,610	aff	
Southern Kwakiutl	Boas:1909	neg	
	Boas:1921:238	aff	sockeye caught in salmon weirs (no description)
	Boas:1966	(aff)	Codere's summary reference appears to be general for the central Northwest Coast
	Drucker:1950	aff	vertical stakes (Koskimo; Kwexa, Nimkish R.(sic))

APPENDIX I: TABLE XVII Contd.

Ethnic Division	Source	Reference	Notes Weirs -2
Nootka	Cook:1784	neg	
	Drucker:1950:167	neg	(did not collect the information)
	Drucker:1951:250	(aff)	inherited rights to put a weir in a certain place
	Koppert:1930	neg	
	Jewitt:1967(1815)	neg	
	Sapir & Swadesh:1955	neg	
	Sproat:1868	neg	
Makah	Colson:1953:33	neg	
	Croes:1980	aff	archaeol.evidence: Hoko R. lattice work recovered
	Gibbs:1877	neg	fall salmon fishing not important
	Singh:1966:37-38	aff	Ozette R. had 3 - 4 weirs for sockeye May-June
	Swan:1870	neg	
N.Gulf Salish	Barnett:1939:229	aff	(Sechelt,Squamish,Homalco,Slaiamún)
	Barnett:1955:79-81	aff	
Halkomelem	Barnett:1939:229	aff	(Cowichan,Nanaimo) Cowichan also trap door,square enclosure,upright stakes,removable lattice,scaffold.
	Barnett:1955:22,79-81	aff	Nanaimo R. had one weir; Cowichan R. had series
	Dally:n.d.	aff	(photos) widely reproduced photos Cowichan weirs
	Duff:1952:140	aff	Chilliwack R.
	Hill-Tout:1907:90	aff	
	Jenness:1955	neg	
	Suttles:1955:23	aff	(Katzie)fall fishing;built by head men on family streams, eg. Aloutte R.
Straits	Barnett:1939:229	aff	(W.Saanich)
	Barnett:1955:22-23,79-83	aff	
	Gunther:1927:199-200	aff	(Clallam)most important method; weir,platform,pen or'pocket' + gaff,spear;also double weir (p.201)
	Suttles:1951:142,145-151	aff	fall fishing; weir,platform,pen. Not used by Straits people living on Vancouver Island.
Twana	Elmendorf:1960:63-73	aff	communal weir, platforms, dipping net(good descr'n)
	Waterman:1973:63	aff	compares this to Kepel Dam type

APPENDIX I: TABLE XVII Contd.

Weirs -3

Ethnic Division	Source	Reference	Notes
Lushootseed	Collins:1974:47	aff	on tributaries but not on Skagit R.
	Haeberlin & Gunther:1930:27	aff	Fig.II'Salmon Trap' is weir; tripod construction, platforms + dipping net. Native terms.
	Smith:1940:258-262	aff	fish'trap' is weir;(good description);native terms
	Waterman:1973:64-65	aff	type in Puget Sound analogous to Kepel Dam
Quileute	Pettitt:1950:7	aff	most productive technology; platforms,dipping net
	Singh:1966:37-38	aff	
Quinault	Olson:1936:26-29	aff	platforms,dipping net; spring run of sockeye;(good description).
	Singh:1966:37-38	aff	
	Swan:1857:264	aff	obtain their salmon principally by means of weirs which they build with a great deal of skill
Lower Chinook	Gibbs:1877:195	aff	"On some of the rivers where the depth permits, weirs are built to stop their ascent."(chinook)
	Ray:1942:104;1938:108-09	aff	dams and weirs + dip net and spears
	Swan:1857	neg	
Wishram	Spier & Sapir:1930:177	neg	use the term'weir'to describe small stream trap
Tillamook	Barnett:1937:163,193	aff	communal salmon weir
	Sauter & Johnson:1974	aff	description based on pioneer diary by Vaughn
Oregon Coast	Barnett:1937:163	aff	(Alsea, Coos, Siuslaw) weirs with scaffolds for spearing and netting
	Drucker:1939:82-83	aff	(Alsea) on the main river or side streams
Tolowa	Barnett:1937:163,193	aff	communal salmon weir
	Drucker:1937:232	aff	weirs at small streams, fall fishing
	Kroeber & Barrett:1960 151-52	aff	Map 4; Map 9 - weirs with platforms

APPENDIX I: TABLE XVII Contd.

Ethnic Division	Source	Reference	Notes	Weirs -4
Yurok	Kroeber & Barrett:1960 11-18	aff	Kepel Dam most elaborate	
	Waterman & Kroeber:1938	aff		
Karok	Kroeber & Barrett:1960 20-21	aff	on Klamath R. or Salmon R. 6 locations identified: 4 weirs on Klamath, 2 on Salmon.	
Hupa	Goddard:1903:24	aff	built at 1 of 2 locations in alternate years (good description)	
	Hewes:(field notes:1940)	aff	quoted in Kroeber & Barrett	
	Kroeber & Barrett:1960 18-20	aff	photographs incl. in Appendix	
Wiyot	Hewes:1947	aff	Wiyot weirs simpler in construction (than other Northwestern Calif.); depths of 4 ft; dip net	
	Kroeber & Barrett:1960 22-23	aff		

APPENDIX I: TABLE XVIII

List of References for Salmon Technology Complex 9 - Traps I

Ethnic Division	Source	Reference	Notes
Tlingit	Krause:1956:121	aff	"most common is the salmon trap";fence with basketry traps
	deLaguna:1960:43,115-16	aff	(Angoon) tumble-back; sockeye,coho; grid trap; (funnel trap, i.e.,cylindrical basketry;Chilkat)
	deLaguna:1972:387	aff	(Yakutat) cylindrical and V-shaped
	LaPerouse:1799:Vol.I	aff	quoted <u>in</u> deLaguna:1972:387 re Yakutat:...by staking the rivers across for salmon; fence + basket traps
	Emmons:1903:242	aff	
	Drucker:1950:166,236	aff	
	Oberg:1973:9	aff	
Haida	Curtis:1916:187(Vol.11)	aff	dam at falls + tumble-back trap
	Dawson:1880:145	aff	cylindrical; tumble-back
	Drucker:1950:166-67	aff	for coho (Massett)
	Murdock:1936	aff	
	Niblack:1890:294	aff	
Tsimshian	Barbeau:1930:147	aff	trap salmon in fish fences and baskets
	Boas:1916:400	aff	
	Drucker:1950	aff	
	MacDonald & Inglis:1976	aff	basket traps
	MacDonald,J.(n.d.)	aff	field notes: very large traps used at night during month of half-moon upside down (Kitsumkalum)
	Sapir:1915	(aff)	"people of the (fish) traps", a named group
Northern Kwakiutl	Drucker:1950:166-67	aff	
	Olson:1940:199	aff	conical basketry traps for chinook, coho(Haisla)
	Olson:1954	neg	

APPENDIX I: TABLE XVIII Contd.

Ethnic Division	Source	Reference	Notes	Traps I -2
Bella Coola	Drucker:1950:166,236	aff	cylindrical river trap, funnel entry	
	Mackenzie:1970:371-72	neg		
	McIlwraith:1948:603	neg		
Southern Kwakiutl	Barnett:1939:230	neg	no information obtained	
	Boas:1909:461-465	aff	extensive description; several illustrations	
	Drucker:1950:166-67,236	aff	cylindrical river trap for chum salmon; others	
Nootka	Cook:1778 (pub.1784)	aff	"wears"=traps made of basketry (cf Oxford English Dictionary 1933 edn.) Cook:20 ft x 12" wickerwork	
	Drucker:1951:16-18	aff		
	Jewitt:1967:46-47,87	aff	"pots or wears"=traps 20 ft long cylindrical basket	
	Koppert:1930:72,78-79	aff	(Clayoquot)(good description)	
	Sapir & Swadesh:1955:42	aff		
	Sproat:1868:222-23	aff	series of cylindrical baskets set on stone wall (good description)	
Makah	Colson:1953	neg		
	Croes:1980:311	aff	Hoko R. archaeol. evidence for traps	
	Singh:1966	neg		
	Swan:1857	neg		
N.Gulf Salish	Barnett:1939:230	aff		
	Barnett:1955:81-82	aff	diagram: grid trap	
Halkomelem	Barnett:1939:230	aff	(Nanaimo -fall-back trap;Cowichan -cylindrical trap)	
	Duff:1952:67	aff		
	Hill-Tout:1907:91	aff	in tributary streams	
	Jenness:1955	neg		
	Suttles:1955	neg		

APPENDIX I: TABLE XVIII Contd.

Ethnic Division	Source	Reference	Notes Traps I -3
Straits	Barnett:1939:230	aff	(E.Saanich) basketry trap
	Gunther:1927:198-201	aff	every creek has at least one trap; chum salmon
	Suttles:1951:151	aff	(Samish) fall fishing; basketry trap
Lushootseed	Collins:1974:317	aff	basketry trap at Nookachamps Creek (L.Skagit)
	Smith:1940:257-58	aff	basketry traps ("weirs") narrow streams,anchored; grid trap, large; falls trap.
	Suttles:1951:151	aff	(Upper Skagit) conical basket trap, funnel mouth
	Waterman:1973:65	aff	
Twana	Elmendorf:1960:75	aff	basketry traps
Quileute	Pettitt:1950	neg	(uses term 'trap' for weir)
Quinault	Olson:1936	neg	
	Singh:1966	neg	
Lower Chinook	Ray:1938:108	neg	
	Ray:1942:104-05,231	aff	
	Swan:1857	neg	
Wishram	Spier & Sapir:1930:177	aff	cylindrical basket, funnel mouth; grid below riffles
Tillamook	Barnett:1937:164,195	aff	
	Sauter & Johnson:1974	aff	
Oregon Coast	Barnett:1937:164	aff	(Siuslaw, Alsea)
	Drucker:1939:82-83	aff	(Alsea)
	Frachtenberg:1920:233	aff	(Alsea) traps:small rivers best;"...builds a fish trap" (salmon).

APPENDIX I: TABLE XVIII Contd.

Ethnic Division	Source	Reference	Notes	Traps I -4
Tolowa	Kroeber & Barrett:1960 67,157	aff	cylindrical basketry traps; trough-like traps	
Yurok	Kroeber & Barrett:1960 23,67,157	aff	(Coastal Yurok) corral built on Little R.estuary to meet special conditions; co-operative labour; Fig.26 trough trap,(general.) No cylindrical traps.	
Karok	Kroeber & Barrett:1960 67,157	aff	box-like trap quoted from Hewes:1947; trough trap; No cylindrical basketry traps.	
Hupa	Goddard:1903:25	aff	grid trap	
	Kroeber & Barrett:1960 67,157	aff	box-like trap quoted from Hewes:1947; trough trap to strand fish; No cylindrical traps.	
Wiyot	Kroeber & Barrett:1960 67,157	aff	trough trap; No cylindrical traps.	

APPENDIX I: TABLE XIX

List of References for Salmon Technology Complex 10 - Traps II

Ethnic Division	Source	Reference	Notes
Tlingit	deLaguna:1972:386	aff	large box trap 25 ft x 75 ft, catwalk
	Drucker:1950:166=67,236-7	aff	(Northern large river trap) trait list #15-19 (Cape Fox)
Haida	Dawson:1880	neg	
	Curtis:1916	neg	
	Murdock:1934,1936	neg	
	Drucker:1950:166-67,236-7	aff	(Large river trap) (Haida Massett; Haida Skidegate)
Tsimshian	Barbeau:1930:144	aff	Hagwilget canyon trap (photos), description(Gitksan)
	Drucker:1950:166-67,236-7	aff	(Northern large river trap)(Hartley Bay)
Northern Kwakiutl	Drucker:1950:166-67,236-7	aff	(Northern large river trap)(Haisla, Kitamat; Wikeno, Rivers Inlet)
	Olson:1954:213-14	(aff)	Wannock R.,4 miles long,drains Owikeno L.into Rivers Inlet;very large sockeye runs early fall;tides in lower river;Olson:"Only the upper river suitable for the salmon traps."
Bella Coola	Drucker:1950:166-67,236-7	aff	(Northern large river trap)(Bella Coola)River Dam).
	Mackenzie:1970:361-64,371	aff	Bella Coola River Dam - full description
	McIlwraith:1948:135,603, 610	aff	Bella Coola River Dam
ALL OTHER NORTHWEST COAST DIVISIONS		neg	

APPENDIX I: TABLE XX

List of References for Salmon Technology Complex 11 - Dip Net Stations

Ethnic Division	Source	Reference	Notes
Tlingit	Krause:1956(1885)	neg	
	deLaguna:1960, 1972	neg	
	Drucker:1950:169,239	aff	(Chilkat) dip net on Y-frame, handle 2 -3 fathoms, net can be closed; used by Klukwan (26 miles upstream on Chilkat R.)
	other sources:	neg	no mention
Haida	all sources:	neg	no mention
Tsimshian	Boas:1916:400	(aff)	from the myths
	Drucker:1950:169,239	aff	(Hartley Bay; Gitksan) dip nets used for salmon from scaffold built over eddy;(Gilutsa -no scaffold).
	other sources:	neg	no mention
Northern Kwakiutl	Drucker:1950	neg	not enough information
	others	neg	no information
Bella Coola	Drucker:1950	neg	not enough information
	Mackenzie:1970(1793)	neg	mentioned only in connection with Bella Coola Dam
	McIlwraith:1948	neg	
Nootka	all sources	neg	
Makah	all sources	neg	
N.Gulf Salish	Barnett:1939:229-30,280	(neg)	traits (Squamish data could be interpreted as affirmative but insufficient information)
Southern Kwakiutl	all sources	neg	

APPENDIX I: TABLE XX Contd.

Ethnic Division	Source	Reference	Notes Dip Net Stations -2
Halkomelem	Boas:1894	neg	
	Dally,F. (n.d.)	aff	(photos) B.C.Provincial Archives letters c.1852-1867
	Duff:1952:62-63	aff	(Upper Stalo Tait)Fraser canyon dip net stations (good description)
	Fraser:1960:101(1808)	aff	observed fishermen dipnetting from stagings in Fraser canyon above Hope, June 29, 1808; 20 ft shafts on nets
	Hill-Tout:1907:91	aff	(Upper Halkomelem) stagings over muddy water in canyon, salmon 'hug the bank'to get out of downward rush of the current.
Straits	all sources	neg	
Lushootseed	all sources	neg	
Twana	all sources	neg	
Quileute	all sources	neg	
Quinault	Olson:1936:31-33	aff	(Lower River:special adaptation) Fig.5
Lower Chinook	Gibbs:1877:195	aff	at the rapids for chinooks (may mean Upper Chinook)
	Ray:1938:109	aff	(Lower River:special adaptation)channels dug near shore
Wishram	Gibbs:1877:195	aff	chinook salmon at the Dalles
	Lewis & Clark:1905(1805)	aff	Oct.1805 and April 1806 at Celio Falls, the Dalles*
	Spier & Sapir:1930:175	aff	stagings built in the Columbia canyon for dip nets (good description)
Tillamook	Barnett:1937:164,195	(neg)	insufficient information
Oregon Coast	Barnett:1937:164,195	(neg)	insufficient information

APPENDIX I: TABLE XX Contd.

Ethnic Division	Source	Reference	Notes	Dip Net Stations -3
Tolowa	Barnett:1937:164	neg		
	Drucker:1937	neg		
	Kroeber & Barrett:1960:154	aff	A-frame lifting net used without platforms/stagings	
Yurok	Kroeber & Barrett:1960: 153-54	aff	A-frame lifting net stations on Klamath; Plunge nets; (Coastal Yurok, no platforms). (Good description)	
Karok	Kroeber & Barrett:1960:	aff	A-frame lifting net stations; Plunge nets. (photos): 1902 photograph Little Ike with Plunge net at Ishi Pishi Falls.	
Hupa	Kroeber & Barrett:1960: 153-54	aff	A-frame lifting net stations; Plunge nets	
	Goddard:1903:23	aff		
	Curtis:1924 (vol.13)	aff	quoted in Kroeber & Barrett:1960	
Wiyot	Kroeber & Barrett:1960	aff	A-frame lifting net	

*Lewis & Clark reported in detail the method of drying salmon and preparing bundles to be transported.

APPENDIX I: TABLE XXI

List of References for Salmon Technology Complex 12 - Reef Nets

Ethnic Division	Source	Reference	Notes
Straits	Barnett:1939:230	aff	
	Boas:1890:568-69	aff	Fig.9 Seasonal village plan for Reef Net fishery
	Gunther:1927:199-201	neg	(Clallam)*
	Hill-Tout:1907:90	aff	Island tribes
	Stern:1934:43-46	aff	(Lummi) crews of ten men (good description)
	Suttles:1951:152-222 (inclusive)	aff	Suttles extensive investigation indicated only Straits people had Reef Net locations (good description).
ALL OTHER NORTHWEST COAST GROUPS		neg	

*Clallam people who settled at Sooke owned locations; those who remained on the southern side of the Juan de Fuca Strait did not, according to Suttles:1951:192.

Appendix I: TABLE XXII
Reference Codes - Distribution Maps

Ethnic Divisions	Reference Indicator
1 Tlingit	1TL
2 Haida	2HA
3 Tsimshian	3TS
4 Northern Kwakiutl	4NK
5 Bella Coola	5BC
6 Southern Kwakiutl	6SK
7 West Coast-Nootka	7NU
8 Makah	8MA
9 North Gulf Salish	9NS
10 Halkomelem Salish	10HS
11 Straits Salish	11SS
12 Lushootseed	12LU
13 Twana	13TW
14 Quileute	14QT
15 Quinault	15QN
16 Lower Chinook	16LC
17 Upper Chinook	17UC
18 Tillamook	18TI
19 Oregon Coast	19OC
20 Tolowa	20TO
21 Yurok	21YU
22 Karok	22KA
23 Hupa	23HU
24 Wiyot	24WI

APPENDIX II

Index of Salmon Abundance

Introduction

Pacific salmon populations supported by the water resources in each of five sub-regions of the Northwest Coast culture area are indicated in an Index of Salmon Abundance (Table XXVI). The base data is derived from estimates of spawning populations obtained by the International North Pacific Fisheries Commission (Bulletin 23:1967). In the study, Aro and Shepard (Appendix A:pp 273-325) estimate spawning populations in British Columbia streams, by species, for a twelve year period (1951-1963). From this data I prepared a frequency distribution (Table XXIII). Linear regression techniques were used to determine average escapement values for each salmon species (cf Tables XXIV and XXV). The statistical results were then applied to data on United States spawning streams reported in Atkinson, Rose, and Duncan (ibid: Maps, Figures 2-53;pp 77-128). Differences in species characteristics were considered in order to determine what percentage of United States streams supported spawning populations of 'major' stocks (Aro & Shepard: pp 273-74 define average escapement categories used by fieldworkers). Spawning populations in United States streams are reported in Atkinson, et.al, only where escapement exceeds 50,000 spawners. The Index of Salmon Abundance in this present study is a preliminary indication and comparison of potential salmon resources available in the Northwest Coast culture area.

APPENDIX II: TABLE XXIII

Frequency distribution for spawning populations of salmon species in British Columbia streams which support 'major' stocks.

Escapement (000)	Sockeye	Pink odd	Pink even	Chum	Coho	Chinook
1	0	0	2	0	4	43
1-2	1	4	0	0	41	23
2-5	18	9	1	14	84	16
5-10	15	6	2	38	25	7
10-20	11	9	18	29	7	6
20-50	10	20	33	26	7	0
50-100	7	5	9	1	0	0
100	1	9	4	1	0	0

Table entries are the number of streams.

Statistical evidence[1]

Table XXIII reports the frequency distribution for salmon species in British Columbia streams. It appears likely that an exponential distribution would describe the relationship between salmon and the magnitude of escapement. But first it must be known if there are differences between species.

TABLE XXIV

Statistical differences between species

Moments	Sockeye	Pink odd	Pink even	Chum	Coho	Chinook
Mean ($\bar{x}$)	7.88	8.75	8.63	13.63	21.00	11.88
Standard Deviation	6.81	4.95	11.49	15.46	29.15	15.08
Coefficient of Variation	0.87	0.57	1.33	1.14	1.39	1.27

Chi-square

The table has 35 degrees of freedom. The Pearson chi-square is 518.67; the liklihood ratio chi-square is 510.06. The variables 'species' and 'escapement' are not independent.

[1] I am grateful to Dr. Braxton Alfred for doing the statistical analysis of my data.

Exponential curve fitting

The functional form is assumed to be

$$y = k * e^{-(beta)(x)}$$

where 'y' is the table entry and 'x' the escapement. The transformation

$$\ln y = K - (beta)(x)$$

allows linear regression techniques to be used. In order to avoid taking log of 0, the constant 0.5 was added to all cells.

TABLE XXV

Results of Linear Regression Analysis

Species	F regression	R
Sockeye	0.59 (NS)	0.30
Pink - odd	0.53 (NS)	0.28
Pink - even	4.12 (0.09)	0.64
Chum	0.33 (NS)	0.23
Coho	5.99 (0.05)	0.71
Chinook	61.75 (0.0)	0.96

Note: The regression constant for Coho is 4.41 (0.01) and the regression coefficient is -0.55(0.05). For Chinook, the regression constant is 4.72 (0.0) and the coefficient -0.73(0.0).

Conclusions

Note that this functional form fits the observations on Coho and Chinook only. Untransformed linear regressions were done with the same qualitative result.

APPENDIX II: TABLE XXVI

Index of Salmon Abundance - Northwest Coast Culture Area

Regional Division	Sockeye	Pink		Chum	Coho	Chinook
		Odds	Evens			
Northern	1111 - 1212	3349 - 3481	836	1576 - 1756	189 - 324	41 - 63
Wakashan	390 - 881	565 - 1083	1178 - 2556	504 - 1099	271 - 610	64 - 131
Salishan	634 - 2278	1898 - 2161	92 - 205	703 - 1200	326 - 548	90 - 173
Columbian	297	---	---	303	232	326
Southern	nil	nil	nil	nil	6	56

Table entries indicate spawning populations in thousands.

Explanatory notes to accompany Table XXVI

1 Spawning populations for Canadian streams are derived from Aro & Shepard:1967. Named streams in each ethnic division were identified and counted. The range of average escapement for each salmon species accounts for the upper and lower values indicated in the recap totals.

2 Spawning populations for United States streams are derived by calculating the number of spawning streams for each species reported in Atkinson, et al, (1967) that correlate to Northwest Coast ethnographic locations. No range of average escapement has been introduced into the results.

3 Atkinson, et al, indicate abundance in salmon streams supporting over 50,000 spawners. Unreported estimates for smaller spawning populations have been compensated by the following procedure: statistical averages for escapement values by species were applied to a percentage of the spawning streams identified in maps of U.S. streams.

4 Characteristics of spawning populations are reported (INPFC:1967) as follows:

Chum and Coho	widely distributed production spread over moderate sized systems
Pinks	widely distributed relatively few areas support most runs (i.e., production concentrated)
Chinook	spawn in few streams production concentrated small spawning populations
Sockeye	spawn in few streams (i.e., enter few river systems) production concentrated very large spawning populations

5 Percentages used to calculate number of spawning locations that support 'major' stocks of each species: chum and coho - 35%; pinks - 20%; chinook - 50%; sockeye - 40%. While these may be high in some areas (eg. Alaskan archipelago) lower percentages would have skewed the results in the Columbian and Southern areas.

6 The quadrennial dominance of sockeye salmon in the Fraser system is not shown. Lower and upper values indicated represent years of least and greatest abundance respectively. For reconstruction of Fraser stocks available to native populations in this period (early to mid-nineteenth century) Kew (1976) and Berringer (1976) is more accurate.

APPENDIX III

Comparison of Resource Areas

To test the proposition that weirs would have been constructed on rivers that could yield high returns (given: that appropriate water features were present), whereas, traps would be the main salmon technology complex in areas with smaller runs, I compared statistical evidence from ethnographic groups known to have relied principally on weir technology with those known to use traps. Our best ethnographic example of societies with communal weirs includes the Halkomelem (Cowichan), the Twana, and the Quinault, peoples whose language family is Salishan. The best evidence of trap use is the Wakashan material, specifically Nootka. Informants claim that traps were used in every stream on the west coast of Vancouver Island; no large weirs are reported there.

Using figures obtained by INPFC:1967 and the calculations previously described in Appendix II, the following results were achieved. Tables XXVII and XXVIII indicate the Index of Abundance values for salmon run- (by species) in each of the Cowichan, Skokomish and Quinault Rivers. Table XXVIII shows that the total salmon resource in these rivers is considerably above average for one or more species. The Cowichan has three species of salmon, each of which exceeds the mean average by a significant proportion. The Skokomish and Quinault Rivers indicate similar values. An "escapement value" of over 50,000 chum salmon enter the Skokomish (Hood Canal) area; chinook and coho are not estimated by INPFC. In the Quinault River the abundant sockeye runs produce escapement figures in excess of 50,000, considerably above the 7.88 $\bar{x}$.

In contrast, the west coast of Vancouver Island streams have more runs of average size. Table XXIX indicates how diffused the resource is throughout the area. For example, chum salmon run in 183 west coast streams, only 15 in considerable numbers. An examination of these fifteen streams shows that they all are within average ranges for escapement values of chum salmon for the whole British Columbia region. Table XXX: Clayoquot Sound salmon streams, is given as an example of the other five sub-areas. The spawning populations of each 'major' stream are indicated.

While these are only preliminary tests, they appear to support the proposition that where the resource is widely distributed within an area, given that stream conditions permit, traps will be more efficient salmon technology complexes than weirs. The opposite is equally true: where the resource is concentrated, as in an important salmon stream with runs that far exceed 'average', then, the construction of weirs, the necessary organization of labour effort, and the intensive fishery at the weir during the run, are repaid by high production yields.

APPENDIX III: TABLE XXVII

Spawning populations in the Cowichan, Skokomish, and Quinault Rivers

Species	Cowichan	Quinault	Skokomish
Sockeye	nil	> 50,000	nil
Pink - odd	nil	nil	nil
- even	nil	nil	nil
Chum	occasional: > 100,000 average: 20,000-50,000	yes (no estimate)[1]	> 50,000
Coho	20,000-50,000	yes (no estimate)	yes (no estimate)
Chinook	5,000-10,000	yes (no estimate)	yes (no estimate)

[1] Atkinson, et al:1967

APPENDIX III: TABLE XXVIII

Index of Abundance values for Cowichan, Quinault, and Skokomish River.

Species	Spawning Stream	Spawning Population (000)	Statistical Average
Sockeye	Quinault	> 50	7.88 $\bar{x}$
Chum	Cowichan	>100 (occasional)	
		20 - 50	13.63 $\bar{x}$
Chum	Skokomish	> 50	13.63 $\bar{x}$
Coho	Cowichan	20 - 50	0.71 mult-R
Chinook	Cowichan	5 - 10	0.96 mult-R

APPENDIX III: TABLE XXIX

Spawning populations in West Coast Rivers of Vancouver Island

Species	Barkley Sound	Clayoquot Sound	Nootka Sound	Kyuquot Sound	Quatsino Sound
Sockeye	nil	22 - 45 (4)[a]	nil	nil	2 - 5 (1)
Pink-even	insignif.	few	few	few	30-70 (2)
-odd	nil	nil	nil	nil	nil
Chum	65 - 160 (4)	20 - 40 (3)	25 - 50 (4)	15 - 30 (3)	nil
Coho	29 - 70 (4)	10 - 24 (6)	4 - 9 (3)	6 - 13 (5)	17 - 37 (10)
Chinook	6.8-13.5 (4)	3.3-6.5 (6)	2.8-5.5 (4)	3.8-8.5 (4)	2 - 5 (1)

[a] number of streams to support 'major' stocks is shown in brackets.

Table entries indicate spawning population in thousands.

APPENDIX III: TABLE XXX

Index of Abundance values for
West Coast Rivers - Vancouver Island:
Clayoquot Sound Streams

Species	Distribution of Spawning Population (000)	Statistical Average
Sockeye	2 - 5	7.88 $\bar{x}$
	5 - 10	
	10 - 20	
	5 - 10	
	(tot. 22 - 45)	
Chum	5 - 10	13.63 $\bar{x}$
	5 - 10	
	10 - 20	
	(tot. 20 - 40)	
Coho	2 - 5	.71 mult-R
	1 - 2	
	1 - 2	
	2 - 5	
	2 - 5	
	2 - 5	
	(tot. 10 - 24)	
Chinook	.5 - 1.	.96 mult-R
	.3 - .5	
	.5 - 1.	
	1. - 2.	
	.5 - 1.	
	.5 - 1.	
	(tot.3.3 - 6.5)	