A COMPARISON OF SEA-LEVELS AND PREHISTORIC CULTURAL DEVELOPMENTS ON THE EAST AND WEST COASTS OF CANADA

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The history of past relative sea-level positions must be considered critically important in any effort to understand the evolution of coastal ecosystems and cultures, because a changing sea-level is the only significant environmental variable able to simultaneously, immediately and often drastically affect the nature of both marine and terrestrial ecozones. This paper is a first attempt to compare generalized sea-level sequences and culture histories of the eastern and western seaboards of Canada, to test the role of sea-level induced environmental change in the development of coastal cultures.

Sea-level positions and the velocity and sign of relative elevation changes will have differing effects on coastal biota, both marine and terrestrial, depending on specific details of local physiography, environment and adaptive tolerances of the various species. To precisely determine the productivity and diversity of a coastal ecosystem for any particular sea-level condition one would require at least the following data: Exact values for coastal relief and gradient; exposure; tidal amplitude; water exchange rates; salinity; temperature; nature of the substrate; precise rate of sea-level change; prior sea-level history; pre-existing biota and their ecological relationships, environmental tolerances, reproductive rates and rates of colonization; and many other individual factors. While some of this information exists for contemporary coastlines, virtually none is available for pre-modern

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sea-level positions anywhere. In short, present data simply do not permit detailed or quantified statements of paleo-shoreline ecological conditions for either the east or west coasts of Canada. Indeed, it may be argued that local variability was sufficient to overshadow any possible generalized trend in space or time. Nevertheless, we do know that there have been substantial fluctuations in sea-levels on both coasts since man has been present, which almost certainly had some effects on existing ecosystems and cultures. How can we begin to understand these effects in the absence of data required for detailed paleo-environmental reconstructions? One possible tactic is to model the theoretical gross environmental implications of major changes in sea-level "condition," on coastlines of broadly different type.

At least two major environmental factors are directly influenced by sea-level conditions. These are (1) amount of low-gradient slope or terrain on each side of the tidal line and, (2) degree of equilibrium of littoral and coastal-riverine geomorphic systems. That is, the elevation of the tidal limit at any moment in time absolutely controls the amount and quality of low-lying coastal plain suitable as terrestrial habitat, and the amount and quality of low gradient intertidal zone and shelf suitable as littoral and near-shore habitat, with obvious implications for the nature and productivity of associated biota. Sea-level fluctuation around a newly attained base will affect beach erosion and deposition, as well as aggradation or down-cutting of coastal drainages. The magnitude of these effects will depend on local coastal physiography, and rate of sea-level oscillation.

It is possible to characterize certain coastlines as physiographically "complacent" and others "sensitive" to changing sea-levels. Complacent coastlines would include those with relatively steep, regular slopes, uninterrupted by major changes of gradient within the maximum elevation range of sea-level rise and fall (Figure 1A). On complacent coasts a changing sea-level would cause only regular and directly proportionate shifts in horizontal shore position, and a physiographic transect through the tidal zone at the top of the range of sea-levels would be basically the same as a transect observed at the bottom of the range. Sensitive coastlines on the other hand are those with major changes of topographic slope within the range of possible sea-level elevations (Figure 1B,C). Here, even minor oscillations in marine limits could cause disproportionately large alteration in amount and quality of near-shore and fore-shore habitats as critical threshold levels are passed (Figure 1D) and coastal environments at maximum and minimum sea-level positions might be profoundly different.

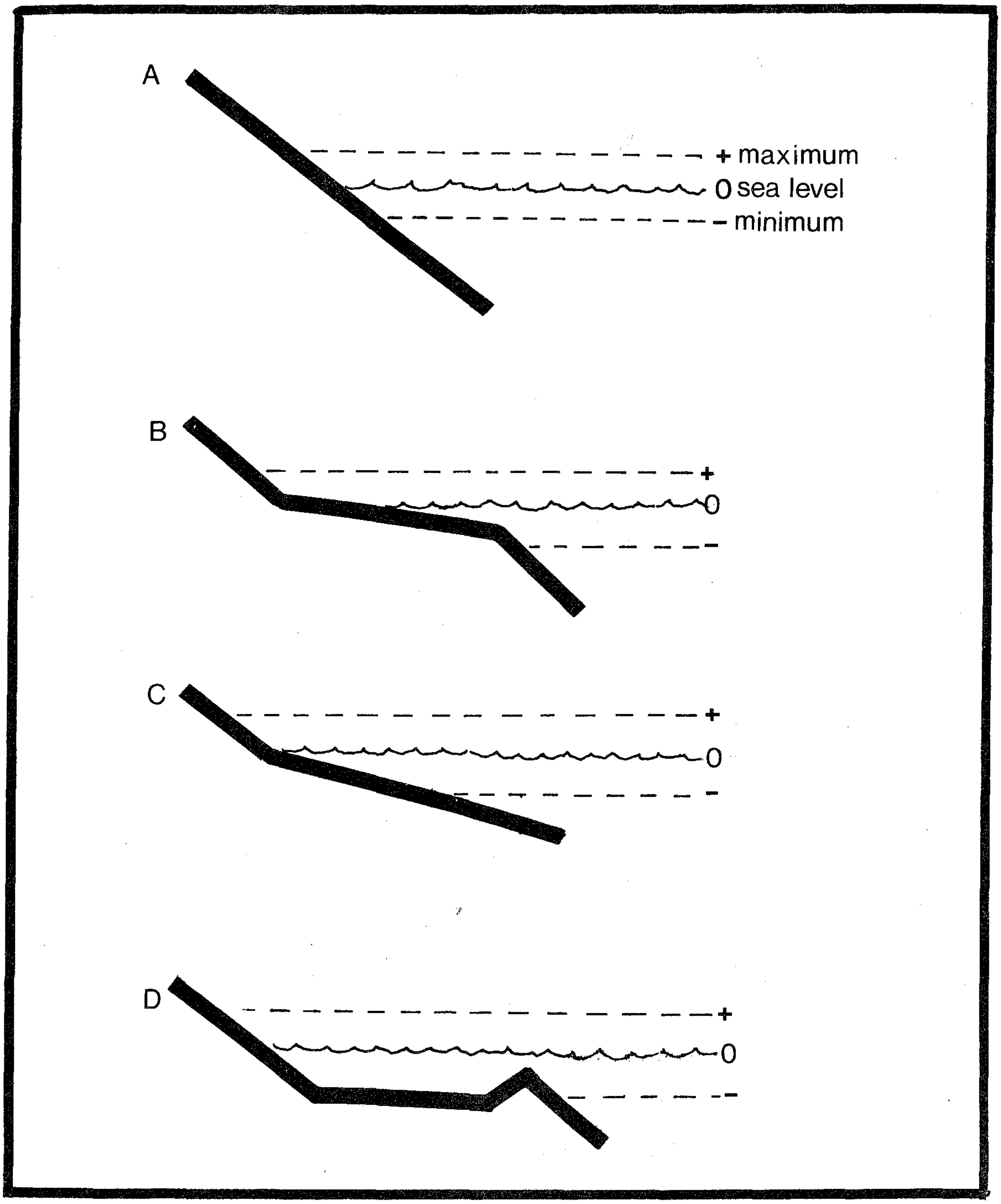

Figure 1. Generalized coastline types: A. Complacent, regular coastal gradient; B. Sensitive, variable coastal gradient; C. Sensitive, low coastal plain, steepening inland; D. Sensitive coastal basin and threshold.

In addition to physiographic considerations, rate of sea-level variation is also important in controlling equilibrium of coastal geomorphic and ecological systems. After attainment of a new sea-level position some length of time must pass before coastal sediment erosion and redeposition reaches equilibrium, particularly on shorelines formed of unconsolidated materials. Coastal drainage systems must also incise or aggrade their channels to attain gradient equilibria with new marine base-levels. When sea-level change continues at a rate beyond the capacity of coastal geomorphic processes to maintain equilibrium, the littoral system will be reduced to an unstable condition. It is easy to envision a situation in which a geomorphically immature shoreline, with scoured or aggrading intertidal zones and uplifting or turbid estuaries would have significantly reduced biotic productivity. At the other extreme it is logical that a coastline which has maintained a quasi-stable state sufficiently long to develop mature, equilibrium shoreline and riverine systems, would be, generally speaking, the most likely context in which to expect a rich climax coastal ecosystem. Of course there has never been a completely stable relative sea-level anywhere in the world, only degrees of instability. For the purposes of this paper I propose to define a quasi-stable sea-level as "prolonged oscillation within ± 2 m of a mean value." Variation of about 2 m may represent the range of small-scale eustatic modulation at any time, and certainly a spread of *at least* 2 m is encompassed within sources of error in relative sea-level curves. Employing this definition, it is possible to divide any given sea-level sequence into "quasi-stable" and "unstable" portions, with the cut-off formed by any short-term variation exceeding ± 2 m.

Classification of coastline physiography as "complacent" or "sensitive," and rates of sea-level change as either "quasi-stable" or "unstable," creates a taxonomy of four gross sea-level related environmental modes or "conditions." These in turn may be used to infer generalized ecological attributes, particularly relative productivity and ecosystem stability.

1. *Complacent/Quasi-stable:* A complacent coastline with quasi-stable sea-levels should have geomorphic equilibrium and optimum possibilities for stable ecosystems. Biotic productivity ought to be relatively high compared to other environmental modes, and all other factors being equal, this sea-level condition possesses most potential for attainment of stable, specialized coastal cultural orientations, as a response to stable optimized coastal ecosystems.

2. *Complacent/Unstable:* A regularly sloping coastline experiencing rapid but unvarying rates of relative sea-level change may also be geomorphically and biotically stable in the sense that it will not experience any marked discontinuity in topography, sedimentation patterns, and biotic habitat through time. On the other hand it is unlikely that biological productivity would be as high as during a state of quasi-stable sea-levels.

3. *Sensitive/Quasi-stable:* Geomorphic stability and biotic productivity in this sea-level condition would be highly dependent on mean shoreline elevation and type of terrain intersected. Thus a quasi-stable coast fronting extensive gently shelving foreshore would be much more productive of intertidal resources for instance, than a quasi-stable shoreline high along a steep coastal escarpment. Likewise, even ± 2 m of sea-level fluctuation around a mean located at a break in slope might produce short-term geomorphic and ecological instability far in excess of the normal quasi-stable condition.

4. *Sensitive/Unstable:* This coastline condition is least likely to attain geomorphic equilibrium and associated ecosystems would probably be sustained well below theoretical climax levels for the area. All other factors being equal, this shoreline type possesses least potential for stable, optimized coastal adaptations.

These four sea-level conditions, crude and generalized as they are, may represent a potentially useful set of predictive models applicable to the prehistory of any coast. Given data on topography and sea-level history, it should be possible to characterize any coastal segment by one of the four shoreline types, and thereby develop tentative inferences about its generalized ecological stability and productivity through time, even though data are not adequate to precisely reconstruct the history of individual species. These inferences could, in turn, be extrapolated to cultural elements of coastal ecosystems, allowing formulation of predictions concerning their stability, specialization and complexity. Where sufficient archaeological data exist, it may also be possible to test such predictions against the actual paleocultural record. In the following section this procedure will be attempted for the east and west coasts of Canada.

Ignoring localized variability, it is possible to describe much of the northern portion of the Atlantic region as a generally "complacent" coastline. This includes the north coasts of

Newfoundland and Labrador where, within the limits of late Quaternary sea-levels, coastal relief is relatively steep and gradients generally relatively regular and continuous. In contrast, the southern Maritime region, including the south-east coasts of Newfoundland and Nova Scotia, must be characterized as physiographically "sensitive." Here, uplands often reach to the present shoreline forming abrupt breaks-in-slope with extensive gently sloping continental shelves and off-shore banks. Even minor changes in relative sea-level elevation in this region could have exaggerated effects on availability of low-lying coastal terrain and its quality as a human habitat. During the early post-glacial transgression, lateral displacement of shorelines and degradation of aquatic and terrestrial habitats must have occurred very rapidly on the outer shelf (e.g., Fairbanks 1977). Later in the Holocene, drastic changes in marine environment could have resulted from the episodic attainment of "threshold" sea-levels, such as that needed to produce vigorous tidal exchange between the open ocean and previous sheltered near-shore basins (e.g., Sanger 1975).

In contrast, a generalized physiographic description of the Pacific coast must acknowledge greater homogeneity, with most of the region falling into the "complacent" shoreline type. Exceptions include scattered outer coastal zones, such as the west coast of Vancouver island and the east cost of the Queen Charlotte Islands, where broad areas of low-lying continental shelf may have been exposed by late glacial minimum sea-levels. However, even here there is no quantitative parallel to the huge emergent shelf and bank areas of the southern Maritimes. Certainly, within the known dated time frame for human presence on the Northwest Coast (i.e., 9-10,000 years) the vast proportion of the shoreline can be described as tolerant or complacent.

Late Quaternary sea-level sequences of the Atlantic seaboard have been described by Grant (1977 a,b, and 1980) and are illustrated in Figure 2. Northwest Pacific sea-level sequences have been summarized by Mathews, Fyles and Nasmith (1970); Fladmark (1975); and Clague (1975) (Figure 3).

Northeastern sea-level curves include those located close to centers of former glacial loading, such as northern Newfoundland, in which sea-level trends are dominated throughout by rapid isostatic rebound. Average rates of uplift fall clearly in the "unstable" category of sea-level fluctuation. According to Grant (1977b, 1980) northern Newfoundland sea-levels attained quasi-stability ($\pm$ 2 m of the present position) about 2800-3000 B.P., although the relative sea-level continued to fall to nearly -2 m by about 1000-2000 B.P. In contrast, curves located far from glacial centers, such as on the

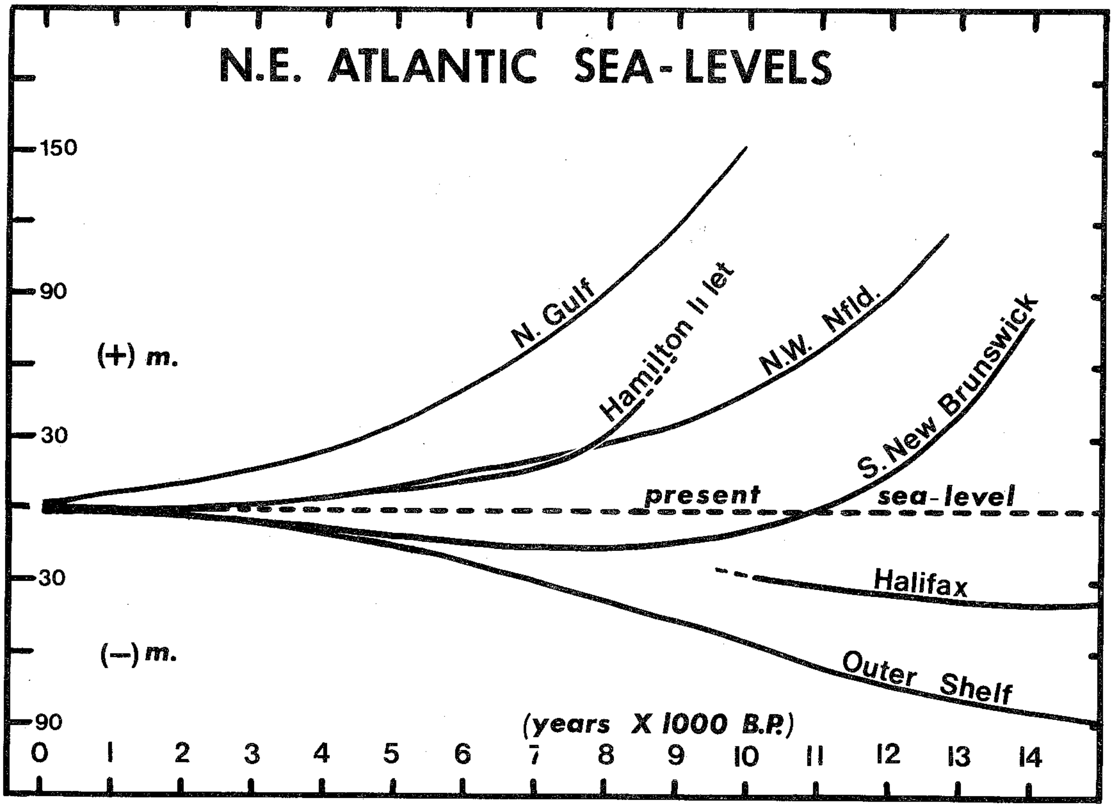

Figure 2. Northeast Atlantic Sea-Levels. (After Grant 1980 and Fitzhugh 1975a).

southern outer continental shelf (Figure 2, Grant 1977b, 1980) are dominated by continuous eustatic transgression following late glacial maximum emergence. Again, rate of sea-level change is clearly within the "unstable" category until the -2 m mark is passed about 1300 B.P.

According to the coastal taxonomy discussed previously, the pre 2-3000 B.P. period of northern Newfoundland must be classed as a Complacent/Unstable shoreline condition, followed after ca. 2000 B.P. by a Complacent/Quasi-stable situation; on the same basis southern outer shelf coastal conditions have always been Sensitive/Unstable, possibly developing quasi-stability after about 1000 B.P. Since the rate of sea-level change in the pre 2-3000 B.P. northern curve does not vary greatly it can be argued that coastal ecosystems remained relatively stable, but probably with sub-climax communities and lower productivity throughout the entire interval. After ca. 2-3000 B.P. increasingly stable sea-levels would have led ultimately to coastal geomorphic equilibrium and climax ecosystems. If coastal cultures paralleled this pattern we would expect: (a) a relatively stable and long-lasting but generalized coastal adaptation pre-dating 2-3000 B.P.: (b) some evidence of culture change or adjustment beginning ca 2-3000 B.P., with (c) after ca.

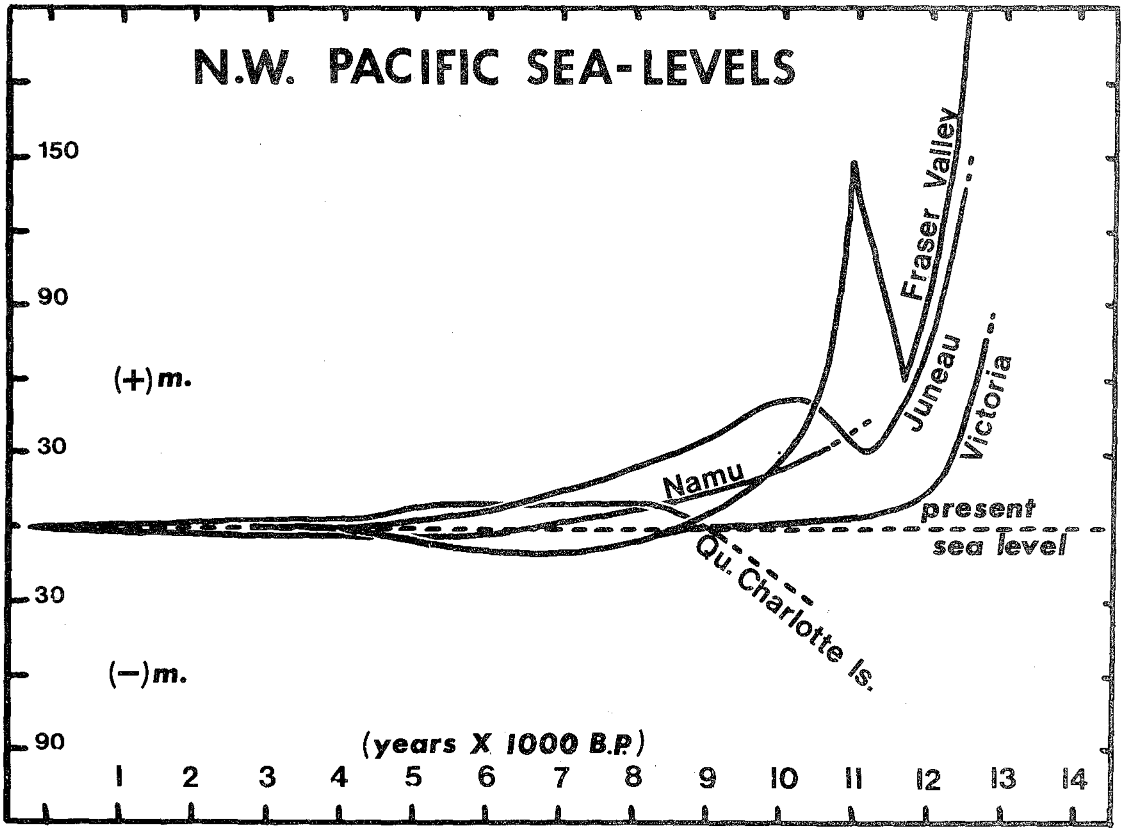

Figure 3. Northwest Pacific Sea-Levels. (After Clague 1975, Fladmark 1975, Andrews and Retherford 1978).

2000 B.P. a developing trend towards increased cultural specialization and complexity as man participated in the optimizing relationships of a maturing ecosystem. These predictions, based on the general model discussed earlier, bear a reasonable similarity at least in part, to the archaeological record of northern Newfoundland and Labrador including: (a) a "Maritime Archaic" tradition dated approximately 7500-3000 B.P. (Tuck 1976a), which exploited various marine and terrestrial resources; (b) its replacement after ca. 3000 B.P. (earlier on the central Labrador coast) by "paleo-Eskimo" or later Indian groups and; (c) the probability that the Dorset, at least, possessed a more specialized (maritime) orientation than the Maritime Archaic.

In the outer shelf region of the southern Maritimes Sensitive/ Unstable sea-level conditions are predicted to have maintained coastal ecosystems at a low level of stability, productivity and carrying capacity. It seems improbable that this would have been a good area for coastal cultural adaptations due to the high rate of lateral shoreline displacement and degradation of terrestrial habitats in a low-lying landscape, but firm archaeological data to verify this prediction are unavailable. For the southern coast of

New Brunswick, Grant (1980) illustrates a quasi-stable sea-level between about 5000 and 9000 B.P., with a mean position of approximately -14 m (Figure 2). A Sensitive/Quasi-stable shoreline condition could be at least as productive an environment as the Complacent/Unstable situation of the northern Gulf of St. Lawrence, but its actual carrying capacity as a human habitat would depend on specific details of shoreline location (etc.) which are not currently available. Between about 4000 and 1300 B.P. the New Brunswick curve exhibits a less stable rate of sea-level rise, paralleling the pattern of the outer shelf. While after ca. 1300 B.P. all southern Maritimes curves stay within ± 2 m of the present position, their slope is little changed from that of the preceeding ca. 3000 years. Gross cultural inferences based on the southern New Brunswick sea-level sequence would suggest: (a) a potentially stable and productive coastal adaptation ca. 9-5000 B.P., situated well seaward of the present shore; (b) a period of relatively increased culture change, adjustment and instability between about 5000 and 1000 B.P., accompanied by a landward displacement of people as a result of lateral shoreline translocations, and: (c) possibly followed by a trend towards renewed cultural stablity after ca. 1000 B.P. Although there are many gaps in the archaeological record, at least some of the existing information tends to generally agree with these predictive inferences. Thus while there are very few data pertaining to the 5-10,000 B.P. period, between about 5000 and 3500 B.P. there are strong manifestations of a coastally orientated Archaic culture similar to the Maritime Archaic of northern Newfoundland (Tuck 1975c; but see Sanger 1975). The brief appearance of this way of life in inland areas distant from the contemporary shoreline, ending about 3500 B.P., may reflect the final state in the landward dislocation of originally coastal peoples hypothesized above. Cultural changes after ca. 3500 B.P., rather than reflecting solely population replacement (e.g., Sanger 1975), may also be cultural responses to rapidly shifting coastal ecosystems between ca. 5000 and at least 1000 B.P.

Pacific coast sea-level sequences (Figure 3) also reflect the varied interplay of isostatic, eustatic and tectonic factors. Most areas close to the main Coast Range and centers of regional glaciation exhibit extremely high relative sea-levels before about 10,000 B.P., accompanied by rates of up-life in some cases so rapid that significant vertical changes in sea-level would have been readily apparent to any human observers in just a few years. By about 9000 B.P. the curves begin to level out, in some areas staying above the present relative level, and in others dipping slightly (ca. -10 m) below the present "0" elevation. By 4000-5000 B.P. virtually all Northwest Coast sea-levels attained quasi-stability, close to the present elevation. On outer islands distant from major glacial accumulations, isostatic effects are apparently overshadowed by general eustatic influences, although really only the Queen Charlotte Islands possess sufficient data points to verify this. The Charlottes sequence includes rapidly rising relative sea-levels before 8-9,000 B.P., followed by a period of relatively stable higher conditions until about 4000 B.P., when it declined to a quasi-stable position around the modern level. As noted earlier, excluding some coastal lowlands, off-shore shelves and other localized exceptions, the majority of the Northwest Coast can be generally described as relatively "complacent" in terms of predicted environmental tolerance to sea-level shifts. Thus, for the type of coarse-grained generalized modelling of coastal environmental trends being attempted here, it is sufficient to simply determine episodes of relative stability vs. instability in rates of sea-level change. However, in future studies it would be of interest to take into account the considerable localized variability of Northwest Coast shoreline physiography, and apply the model proposed in this paper to specific inter-locality comparisons.

As indicated in a previous study (Fladmark 1975) most Northwest Coast sea-level sequences reach quasi-stability at or near the present base about 4-5000 years ago, without any later significant fluctuation. Thus, the generalized overall pattern of sea-level change on the west coast of Canada is a pre-4/5000 B.P. period of relative instability, followed by a post-4/5000 B.P. period of quasi-stability. It should be noted that rates of sea-level change are much more rapid early in the Holocene than by 5-6000 B.P., although at least one sequence (Charlottes) suggests an early period of sea-level stability ca. 10-15 m higher than present, between about 8/9000 and 5000 years ago. The local significance of this latter event is not clear, but it may help explain some aspects of the prehistory of the Queen Charlotte Islands which seem out of phase with developments elsewhere on the Northwest Coast. However, in general a shift from unstable to quasi-stable sea-level conditions about 4-5000 B.P. characterizes most of the Pacific region of Canada.

According to the model developed in this paper, 5-10,000 year old ecosystems of the Northwest Coast, existing in complacent/unstable sea-level conditions, were, themselves, possibly relatively stable, but maintained below climax levels of productivity. This was probably particularly true for salmon, which have a spawning success rate easily degraded by fluctuations in stream run-off and sedimentation characteristics. After 4-5000 B.P., attainment of quasi-stable base-levels would have permitted development of equilibrium in coastal shoreline and riverine systems and provided the physical environmental basis for highly productive biotic communities. Therefore pre-5000 B.P. inhabitants of the Northwest

Coast possibly possessed relatively generalized cultural adaptations. These shifted around 4-5000, in response to increased ecological productivity, towards specialized exploitation of certain coastal-riverine resources (salmon), which in turn permitted the development of semi-sedentary settlement patterns, complex social organization, ceremony and other well-known energetically expensive aspects of the ethnographic Northwest Coast. The archaeological validity of this model is still indicated by the profound change in the nature of archaeological sites and their contents about 4-5000 B.P. everywhere on the Pacific coast. All major shell midden accumulations, themselves direct and undeniable evidence of at least seasonally sedentary settlements, post-date the transition between unstable and quasi-stable shorelines, while all older sites are apprently only small lithic dominated encampments, in all aspects (except for some esoteric factors of lithic artifact typology) indistinguishable from non-coastal hunter-and-gatherer sites.

Thus a brief review of sea-level and culture sequences of the east and west coasts of Canada tends to grossly confirm the generalized predictive model generated earlier, relating coastline "tolerance" and rate of sea-level fluctuation to stability of coastal ecosystems and the stability and general nature of associated cultures. In the absence of much needed direct information about the Quaternary history of coastal biotic communities, a brief perusal of a relative sea-level curve may provide a simple and useful initial indicator of the direction and chronology of major cultural-ecological events.

Additionally, direct comparison of east and west sea-level sequences may indicate some general clues to causes of parallel or non-parallel cultural developments in the two regions. While a virtually infinite range of specific environmental parameters might be involved at any given time and place in shaping synchronous cultures of the Atlantic and Pacific shores, sea-level sequences may provide a summary statement of the general state and comparability of whole complex coastal systems in the absence of any more detailed information. From this perspective, at least one marked difference is evident between east and west. Eastern sea-levels exhibit overall a much greater vertical range and rate of relative change over the last ca. 10,000 years than do Pacific examples. This is particularly true in the last 5000 years, when virtually all western ocean relative levels stay close to the modern position, while most Atlantic curves still display wide variation and rapid rates of change. It seems possible, therefore, that unstable shoreline positions may have preressed attainment of climax coastal ecosystems and complex maritime adapted cultures over the last 4-5000 years in the Atlantic area, while on the Northwest Coast contemporary stable sea-levels encouraged development of more complex societies.