TIDAL BOUNDARY DELIMITATION

SUSAN E. NICHOLS

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PREFACE

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TIDAL BOUNDARY DELIMITATION

Susan E. Nichols

Department of Geodesy and Geomatics Engineering
University of New Brunswick
P.O. Box 4400
Fredericton, N.B.
Canada
E3B 5A3

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ABSTRACT

Experience in North America has shown that the precise delimitation of tidal boundaries is often a prerequisite in resolving coastal land tenure and jurisdictional conflicts. Although tidal boundaries have not yet been a major concern in the Maritime Provinces, the ambiguity and confusion surrounding the definition of these boundaries and the lack of precise survey methods warrant an examination of the delimitation process. Recent court cases in New Brunswick and Prince Edward Island demonstrate the need to clarify the legal terminology and survey procedures.

Three broad issues are reviewed in this report: legal boundary definitions, current Canadian and American methods of surveying tidal boundaries, and the availability of tidal information to support these surveys. To recommend or implement changes that are appropriate for the Maritimes, these issues cannot be considered in isolation. Some of the relationships between law, science, and surveying are therefore reviewed. The purpose of this report is not to provide definitive answers or solutions but to give direction to future research efforts by identifying some of the issues that should be addressed and by initiating an interdisciplinary approach to tidal boundary delimitation in the Maritimes.

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No research is ever the product of a single individual, but far too many people participated in the preparation of this report, directly or indirectly, to be mentioned in this short space. To those not explicitly included here, I extend my gratitude.

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Without the insight gained from interviews with surveyors in the Maritimes, this report may have taken a different direction. I therefore offer my thanks to all those who took the time to share their experience. Aside from the interviews reported in Appendix I, information was provided by a number of individuals in the Atlantic Regional Surveyor's Office, the Nova Scotia Department of Lands and Forests, the Bay of Fundy Tidal Power Corporation, and the Tides and Currents Division of the Canadian Hydrographic Service, Atlantic Branch.

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Special thanks goes to my supervisor, John McLaughlin, for suggesting a topic that gave me an opportunity to meet surveyors throughout North America and to deal with a wide range of cadastral issues. His guidance, support, and encouragement since my arrival at U.N.B. and his patience during the last revisions of this report will always be remembered.

For the time taken in proof reading my drafts and keeping my spirits up during the last year, I am indebted to my fellow graduate student and friend, Jennifer Brown. To my parents, I extend a simple thank you, since words could not do justice to the support they have provided. Most of all they gave me the desire to learn, the courage to try, and the determination to overcome the obstacles.

CHAPTER 1

INTRODUCTION

> The artist may be well advised to keep his work to himself till it is completed, because no one can readily help him or advise him with it...but the scientist is wiser not to withhold a single finding or a single conjecture from publicity.
>
> Johann Wolfgang von Goethe

The mark left by the receding tide is a familiar sight along nearly any beach. Noting the line of seaweed and debris, the casual observer is perhaps reminded of the infinite pulse of the oceans and the periodic influx of the tides over the shore. However, the significance of the tide mark to the upland proprietor, the lawyer, and the surveyor is much greater because the marks, real or invisible, left by specific tides delimit property rights and jurisdictions along coastal waters. The tide mark is, in fact, one of the oldest natural boundaries.

Yet except in isolated cases, the precise delimitation of tidal boundaries has not been an issue addressed by either the legal or surveying professions until recently. Perhaps the most obvious reason for this quietude is the historic nature of both coastal land tenure and the boundaries themselves.

The land seaward of the high water mark is primae facie held by the sovereign in common law jurisdictions. Navigation and fisheries being the traditional coastal concerns of the state, few occasions appeared in which the location of the landward boundary was required. Lacking adverse claims to the shore by an adjacent proprietor, the upland owner was rarely concerned with the exact location of his seaward boundary. Furthermore, the extension of most land uses beyond this boundary was precluded by the very nature of the land-water interface.

The character of the tidal boundary also contributed to the lack of interest in its precise location. As it is a visible line, there is little question of its general location. It is also well recognized that water boundaries are ambulatory, shifting over time due to the transport of sediments along the coast or variations in mean sea level. Any delimitation of the boundary, therefore, would only be an indication of its location at the time of the survey.

Over the last several decades, the increasing intensity of coastal activities and the concomitant rise in the value of coastal resources have created more land use and land ownership conflicts. In their emerging roles in the management of coastal and offshore resources, governments at nearly all levels have become active in and occasionally the instigators of these conflicts. The delimitation of coastal boundaries is often a priority concern in resolving land tenure and jurisdictional problems. With rights in large areas of valuable resources at stake, the location of the tide mark has taken on a new significance.

Two major issues have been raised: the definition of the common law boundaries and the appropriate methods of surveying these tidal boundaries. Although most of the debate on these issues within the legal and surveying professions has until now been confined to the United States, similar problems have been encountered in several cases in Atlantic Canada. The ambiguity and inconsistency apparent in these cases warrant an examination of Canadian law and survey practice in light of the American experience. The purpose of this report, therefore, is to review the delimitation of tidal boundaries, with the particular objective of identifying the issues that should now or may in the future be addressed in the Maritime Provinces.

The delimitation of tidal boundaries is a multidisciplinary subject that encompasses such diverse topics as oceanography, geography, biology, geomorphology, and history, as well as the various fields of law and surveying. A comprehensive review of all of these aspects in their relation to coastal boundaries would require several large volumes and is beyond the scope of this report, which at best could investigate only one of the many issues in depth. In the absence of such a reference text for Canada, however, an interdisciplinary approach has been retained for this report, if only to place the issues in the broader context and to identify the points of beginning for future research. The myths and confusion regarding the tide mark deserve that research, but the present study will proceed on the premise that awareness is the first step to knowledge.

1.1 Definitions

Inherent in any multidisciplinary subject is the problem of terminology. The delimitation of tidal boundaries is no exception. The first difficulties are encountered in the title of this report: in the scope of the word 'delimitation' and in the implications of the term 'tidal'. To provide background for the sections that follow, some of the terminology associated with the title will first be defined.

1.1.1 Delimitation, demarcation, and delineation

McEwen has made the distinction between delimitation and demarcation in the context of international boundary law. Under the former term he refers to the legal-political process of arbitration, agreement, and definition of the boundary. The latter term includes the physical marking of the boundary,[1] which is generally the province of the cadastral surveyor. McEwen goes on to state that

> by their very nature, delimitation and demarcation are operations of completely different character, though the latter complements and stabilizes the former.[2]

One problem with this distinction in relation to water boundaries is that, although these ambulatory boundaries are surveyed, they are rarely monumented. On this point McEwen has noted that witness marks, from which measurements to the boundary are made, are a form of demarcation.[3]

In applying the term demarcation to tidal boundaries, O'Hargan states that to "demarcate a boundary is to locate that boundary on the ground by land surveying methods."[4] McEwen also comments that "demarcation is a field operation; its purpose is to mark the boundary on the ground for all to see."[5] Ambiguities arise, however, when water boundaries are surveyed by means of remote sensing, where remote sensing encompasses aerial photography in this report. It may be the case in these surveys that no physical marking or establishment of the boundary on the ground occurs. Whereas monumentation, the placing of witness and reference marks, or the establishment of a visible tide mark all provide physical awareness of the boundary on the ground, it would be stretching the definition of demarcation to include sophisticated vegetation or geomorphological analyses, particularly when not conducted by a commissioned land surveyor.

Although McEwen has excluded demarcation from the delimitation process, Black's Law Dictionary provides the following definition of delimitation:

> the act of fixing, marking off, or describing the limits or boundary lines of a territory, country, authority, right, statuatory exception or the like.[6]

McLaughlin makes an additional separation within this broader meaning of delimitation. He distinguishes delineation as the legal description and demarcation as the establishment of the boundary on the ground, the latter process providing physical awareness of the boundary.[7]

Against this background of terminology, the following definitions will be used in this report and are depicted in Figure 1.1:

a. boundary: any separation, natural or artificial, that defines and marks the extent of parcels or jurisdictions;[8]

b. demarcation: the legal-technical process of establishing boundaries on the earth's surface by a commisssioned land surveyor, where either survey monumentation or the nature of the boundary itself provide physical awareness of its location;

c. delineation: the process of describing the location of a boundary, with respect to some reference framework, in words or by depicting the boundary graphically on a plan, map, chart, or other visual display;

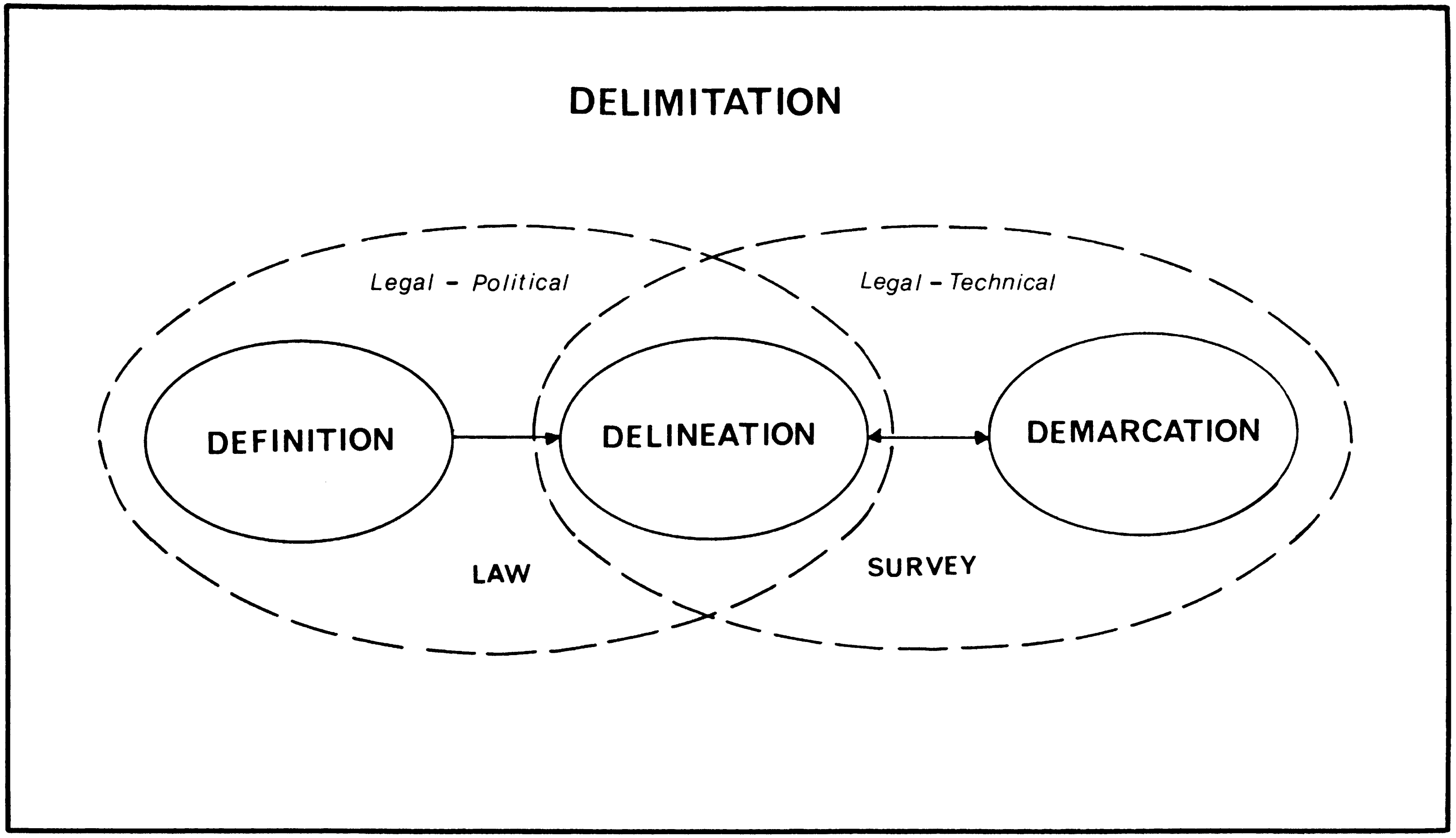

Figure 1.1: The Components of Delimitation

d. delimitation: the process of establishing boundaries through declaration, agreement, judicial settlement, or the application of recognized legal principles, in which establishment refers to the definition of the locus of the boundary, its delineation and, in most cases, its demarcation;

e. cadastral survey: a survey, conducted by a commissioned land surveyor, that includes the demarcation and the delineation of boundaries through the application of recognized legal principles and survey methods, and in which evidence of the boundary location is recorded on a plan of survey.

1.1.2 Tides, tide marks, and tidal datum

Tides are the rise and fall of the ocean surface in response to the gravitational forces of the sun and moon on a rotating earth. Astronomical tides are the ficticious periodic oscillations which the oceans would undergo, if they were to respond perfectly to these changing gravitational forces. The observed tides at any location along the coast differ greatly from these ficticious tides. Coastal configuration, ocean circulation, and meteorological processes that cause both spatial and temporal variations in the observed sea levels are critical factors in tidal boundary surveys.

The loci of tidal boundaries are generally defined by law as either the tide mark left on the shore by the receding waters of a particular stage of tide or as a line marking the intersection of a specific tidal datum with the shore. In the former case, the cadastral surveyor is concerned with gathering physical evidence of the observed local tides. In the latter situation, the surveyor must 'find' the horizontal component of the tidal datum, where the horizontal component is the intersection of the tidal datum with the shore, as shown in Figure 1.2. This may also involve the establishment of the vertical component, or height, of the particular tidal datum.[9]

A vertical datum is a reference surface from which heights or depths are measured. Tidal datums are special vertical datums corresponding to the heights of specific sea levels that are, in turn, defined by the periodic rise and fall of the local tides. Since tidal datums also vary with time and location, the assumption that tidal datums are fixed planes or level surfaces with respect to the geoid has led to some of the problems in tidal boundary surveys.

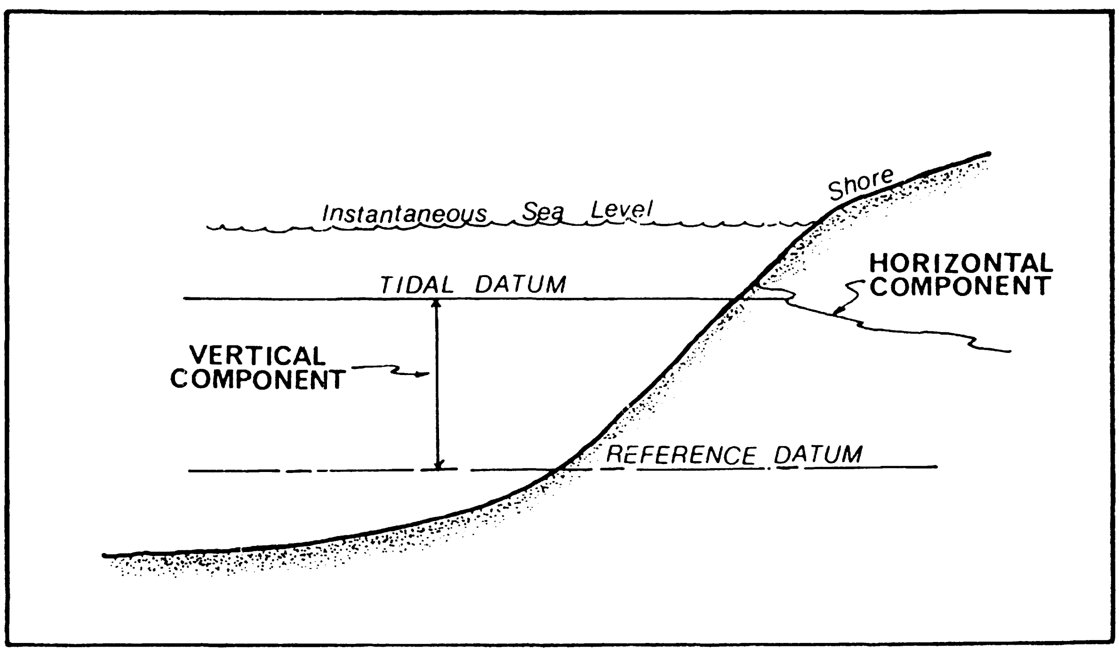

Figure 1.2 : Horizontal and Vertical Components of Tidal Datums

1.2 The Tidal Boundary Problem

The majority of issues regarding the delimitation of tidal boundaries fall within two broad catagories: the legal definition of tidal boundaries that mark the limits of coastal land tenure and the survey of these boundaries, including the role that science should play in legal surveys. To date these have not been major issues in the Maritime Provinces. Coastal land tenure problems and legislation are minimal and the courts have made few tidal boundary decisions. As indicated in interviews with a small sample of Maritime surveyors (see Appendix I), the surveying profession has generally relied on traditional survey methods.

The impact of coastal tenure changes, American legal terminology, and new survey methods have been recorded in at least two Maritime legal cases that are reviewed in Appendix II. The delimitation of the private-state boundary has also been debated in a series of articles by Doig[10] and MacDonald,[11] and the complexity of water law in the Atlantic Provinces has been comprehensively reviewed by La Forest et al. (herein referred to as La Forest).[12] Although these references indicate the significance of tidal boundaries in the Maritimes, no major attempt has been made to view tidal boundary problems in the broader context of the relationships among law, surveying, and science.

Whether coastal land tenure and jurisdictional problems in the Maritime Provinces warrant modifications in the definition and survey of tidal boundaries is a matter to be determined by the legal and surveying professions. Adopting changes at random from American law and research without assessing the consequences may actually create rather than solve problems. Before changes are advocated, the current status of tidal boundary delimitation and the interdependent roles of surveying, law, and science should be examined. This report, therefore, will provide a preliminary framework for such an assessment and identify some of the problem areas.

1.2.1 The legal problems

The primary role of law in tidal boundary delimitation is to define these boundaries, although the law pervades the entire delimitation process. Within the context of law, three problems should be considered: the legal definitions of tidal boundaries, the nature of coastal land tenure, and the degree to which the legal definitions reflect the tenure requirements.

In common law countries the definition of the private-state boundary has its genesis in a seventeenth century treatise, De Jure Maris, by Sir Matthew Hale. While justifying the claim of the English Crown to lands beneath tidal waters, Hale defined the sovereign lands as those covered by the ordinary high tides.[13] As these tides marked the natural limit of upland cultivation, the common law definition was founded on practical considerations, as well as the value of coastal resources to the state.

From this treatise the term ordinary high water mark (OHWM) came into existence, but unfortunately Hale's unscientific description of ordinary tides produced a legacy of inconsistency in succeeding court interpretations of this boundary. To resolve this ambiguity, the American judgement Borax Consolidated Limited v. Los Angeles[14] (hereafter referred to as the Borax case) defined the private-state boundary as the line of mean high tide, a mathematical average of all the high tides over an 18.6 year period. By taking judicial notice of the scientific definition of the mean high water (MHW) datum, the court added a new dimension in tidal boundary delimitation. Both the terms OHWM and mean high water line (MHWL) appear in Canadian law, but lack of consistency and precision still surround their useage.

A second problem regarding the legal definition concerns the nature of coastal land tenure, in particular, the property rights and jurisdictions delimited by tidal boundaries. Coastal land tenure also includes special property rights, known as riparian or littoral rights, which may affect the delimitation of boundaries. In some cases private property rights may also extend below the OHWM by grant or through prescription. Furthermore, variations exist in the definitions of limits for different jurisdictions, as for example federal, harbour, or coastal zone management jurisdictions.

The precision of the legal definition is a third concern. Changing patterns of land tenure and property values often require more precise boundary delimitations. This fact has been recognized in the Maritime Accuracy Study in which horizontal tolerances of 5, 10, and 50 centimeters are proposed for urban, urban/suburban, and rural areas, respectively.[15] These specifications may not be appropriate for delimiting coastal land tenure, but the legal definitions of tidal boundaries should permit their consistent establishment within suitable tolerances.

1.2.2 Surveying problems

The cadastral surveyor is concerned with the establishment of the tidal boundary on the ground and its delineation on a plan of survey. The role of cadastral surveying and other survey disciplines in tidal boundary delimitation is actually much broader, but emphasis will be placed here on three principal considerations: the survey methods employed, the evaluation of these methods, and the assessment of possible improvements.

Three generations of tidal boundary survey methods have been distinguished by O'Hargan in the United States. Under first generation methods an 'educated guess' is made, in which the tide mark is delineated as the change in vegetation or other physical characteristics reflecting tidal action. In the second generation, the elevation of the MHW datum is surveyed as a contour along the shore. Third generation methods recognize the spatial and temporal variations in tidal datums and boundaries are established from simultaneous tidal observations at the survey site and a primary tidal station. Remote sensing imagery may also be used to delineate the boundary between points established by tidal datum elevations.[16]

No such review has yet been made of Maritime survey practices, but the current survey methods should be examined to determine whether they are at variance with the legal definitions of tidal boundaries and the land tenure requirements. A determination of the former includes a review of relevant case law and legislation. Appropriate accuracy standards must be postulated in the latter case for comparison with accuracies presently achieved.

If the current survey methods are found to be either inappropriate or unacceptable, then improvements may be considered. Before changes are recommended or implemented, however, the costs and benefits of these improvements should be assessed. One particular problem in moving to third generation methods, for example, would be the availability of tidal information. In making any future assessment the Maritime surveying profession has the advantage of learning from American experience and advances in tidal boundary research.

1.2.3 Scientific problems

Until recently the role of science in the delimitation of tidal boundaries has been obscure and many of the contributions considered 'scientific' have actually been made from within the surveying community in the fields of hydrography, geodetic surveying, and photogrammetry. However, two problems should be addressed that may be placed under the heading 'science', these being the provision of information concerning coastal processes, particularly the tidal phenomena, and the legal status of new scientific methods for determining present and former high water lines.

Tidal information, or the lack of information, has had a direct influence on tidal boundary delimitation. Two examples of this dependence are Hale's ambiguous definition of the OHWM and the Borax decision, in which the MHW datum was defined as the average of all the high tides over a specific astronomically significant period. Scientific research on tidal variations has also affected the survey of coastal boundaries in the United States. Only with such knowledge of the tidal phenomena and other coastal processes can the definition and survey methods be evaluated and improved.

The second problem concerns the legal status of new methods, such as biological analysis and geomorphological studies, for locating present and former tidal boundaries. This issue has been debated in American courts and has appeared, but not been tested, in at least one Maritime case.[17] Even if these surveys are not conducted by professional surveyors, the information gathered may prove useful in delimitation. However, the weight given this evidence in boundary delimitation should be carefully evaluated against the legal definition and accepted survey methods.

Regarding the contribution of science, as well as law and surveying in coastal boundary problems, Porro and Weidener have made the following summary:

> The world of the lawyer, surveyor, and scientist have much to lend each other. The aim should be reasonable technically and scientifically based standards for establishing a tidal boundary, with the necessary legal stability that is required by the courts....In the process of establishing this [tidal] boundary, the world of science, and its current experimentation, can greatly contribute. On the other hand, the world of jurisprudence must strive to establish legal guidelines and principles which are technically rooted. Only with such a combination can the necessary legal stablility that is required for title ownership, be achieved.[18]

1.3 The Need for an Interdisciplinary Approach

The roles of science, law, and surveying have generally been considered in isolation, but the problems briefly outlined in the previous sections indicate the interdependence of these disciplines. These relationships in tidal boundary delimitation are illustrated in Figure 1.3. With its broad range of expertise, the surveying profession is in a unique position of providing a linkage between the scientific

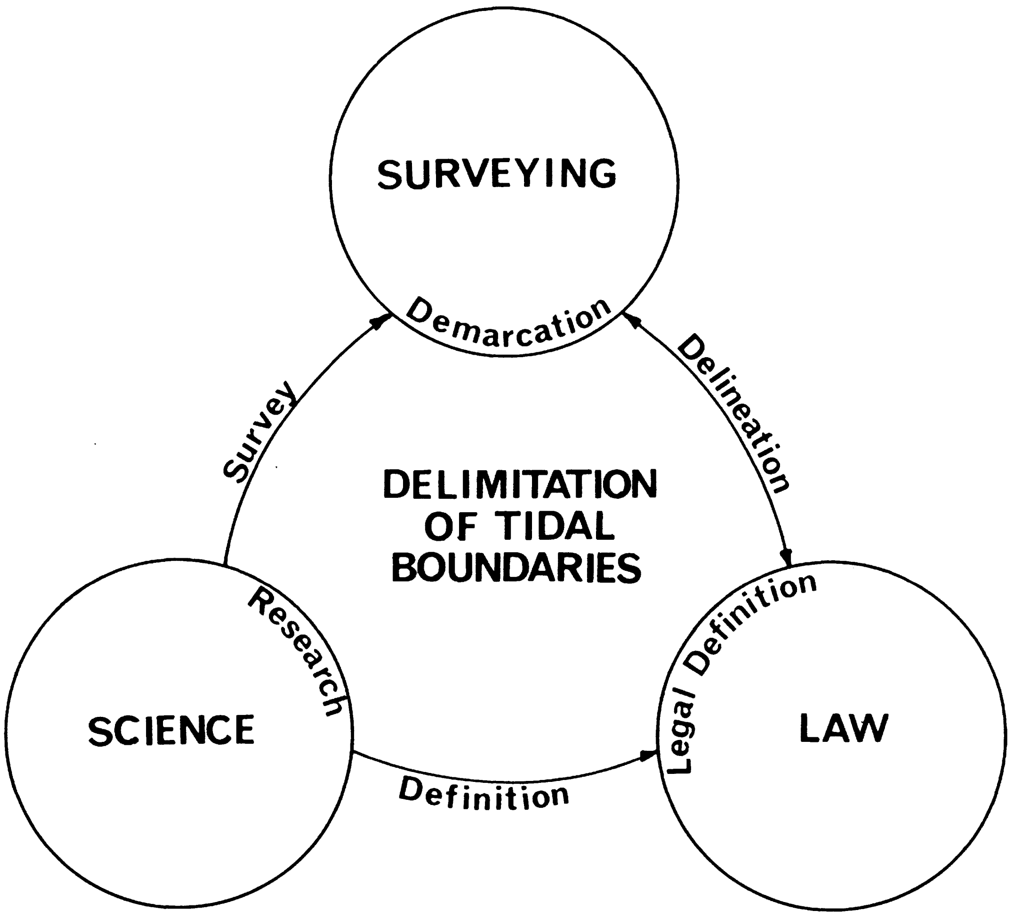

Figure 1.3: The Roles and Contributions of Surveying, Law, and Science

study of the tidal phenomena and the law.

In a series of articles outlining current American coastal law, Graber has reviewed the legal background for a comprehensive approach to tidal boundary issues in the United States. He concludes his introductory article with the following statement:

> Coastal zone administrators, oceanographers, coastal engineers, surveyors and other professionals cannot deal with the land/sea interface in a legal vacuum. They should be aware of the basic relevant rules of law. Only through such an interdisciplinary approach can the coastal zone's problems be resolved and its potential realized.[19]

From their experience in the field and in the courtroom, Porro and Weidener further comment that

> law, technology, and science have been competing to reduce the chaos of the marsh where the land and the water meet. All three disciplines have developed their own arsenal of information and rules over the centuries. Today, the challenge of the intersection of water and land in the estuarine, marshland and coastal zone, demonstrates clearly the need for communication between the three fields of advocation: law, technology and science.[20]

To assess the current status of tidal boundary law and survey practice and to determine whether changes should be recommended in the Maritimes, this communication should be fostered. This report may be viewed as one point of beginning. In-depth reviews of many of the issues that will be discussed may be found in the references at the end of each chapter and in the annotated bibliography which accompanies this report.[21] One objective of the following text will be to place these selections in the broader context of tidal boundary delimitation.

To this end, the order of the previous discussion has been altered in the text. Without an appreciation of the tidal phenomena, other variations in sea level, and the provision of tidal information reviewed in Chapter 2, the assessments of the legal framework and survey practices could not be made. The following chapters review the actual delimitation process.

Chapter 3 provides an overview of the historical and current coastal land tenure issues that form part of the criteria by which the delimitation of tidal boundaries can be evaluated. Since a more thorough review of the legislation and coastal land economy would be necessary to derive specific land tenure requirements in the Maritimes, emphasis is placed here on identifying some of the potential problem areas. The legal definitions in common law jurisdictions are also considered against the background of Maritime case law and survey practice.

In Chapter 4 the current survey procedures for tidal boundaries in the Maritimes are examined by drawing on interviews conducted with a limited sample of surveyors in private practice, summarized in Appendix I, and the case reviews found in Appendix II. The third generation methods advocated by members of the American surveying profession are presented, together with a short review of the American Coastal Mapping Program. A preliminary evaluation of the suitability of a similar program in the Maritimes is made.

The assessments and reviews in each chapter are not intended to be complete, as this task would require a much larger text and considerably more research. Instead, the goal of this report is to provide a platform for further discussion and communication among the surveying, legal, and scientific communities by identifying some of the issues and giving direction to future research efforts. Only through a mutual understanding of the problems can the challenge of the tide mark be met.

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13. supra, reference 9, pp. 90-91.

14. Borax Consolidated, Ltd. v. Los Angeles (1935) 296 U.S. 10; as reported in Shalowitz, supra, reference 9, p. 97.

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CHAPTER 2

TIDES AND TIDAL DATUMS

> So the Sun sits as upon a royal throne ruling his children the planets which circle round him. The Earth has the Moon at her service...We thus rather follow Nature, who producing nothing vain or superfluous often prefers to endow one cause with many effects.
>
> Nicholas Copernicus

The characteristic feature of tidal boundaries is their essential relation to the tidal phenomena and physical processes along the coast. Yet this relationship, the scientific foundation of tidal boundary delimitation, has often been ignored or misinterpreted within the legal and surveying professions. Hence, legal definitions have led to ambiguity and demarcation has often been approximate. Although this lack of precision may be tolerable with regard to coastal boundaries in the Maritimes, and in some respects beneficial, precise terminology and an appreciation of sea level variations are prerequisites for an evaluation of the delimitation process.

The following overview of tides and other sea level variations is descriptive in nature but analytical developments of the topics discussed may be found in the references. Emphasis is placed here on the causes of sea level variations, the significance of these variations in defining tidal datums, and the scientific information available for establishing tidal datums.

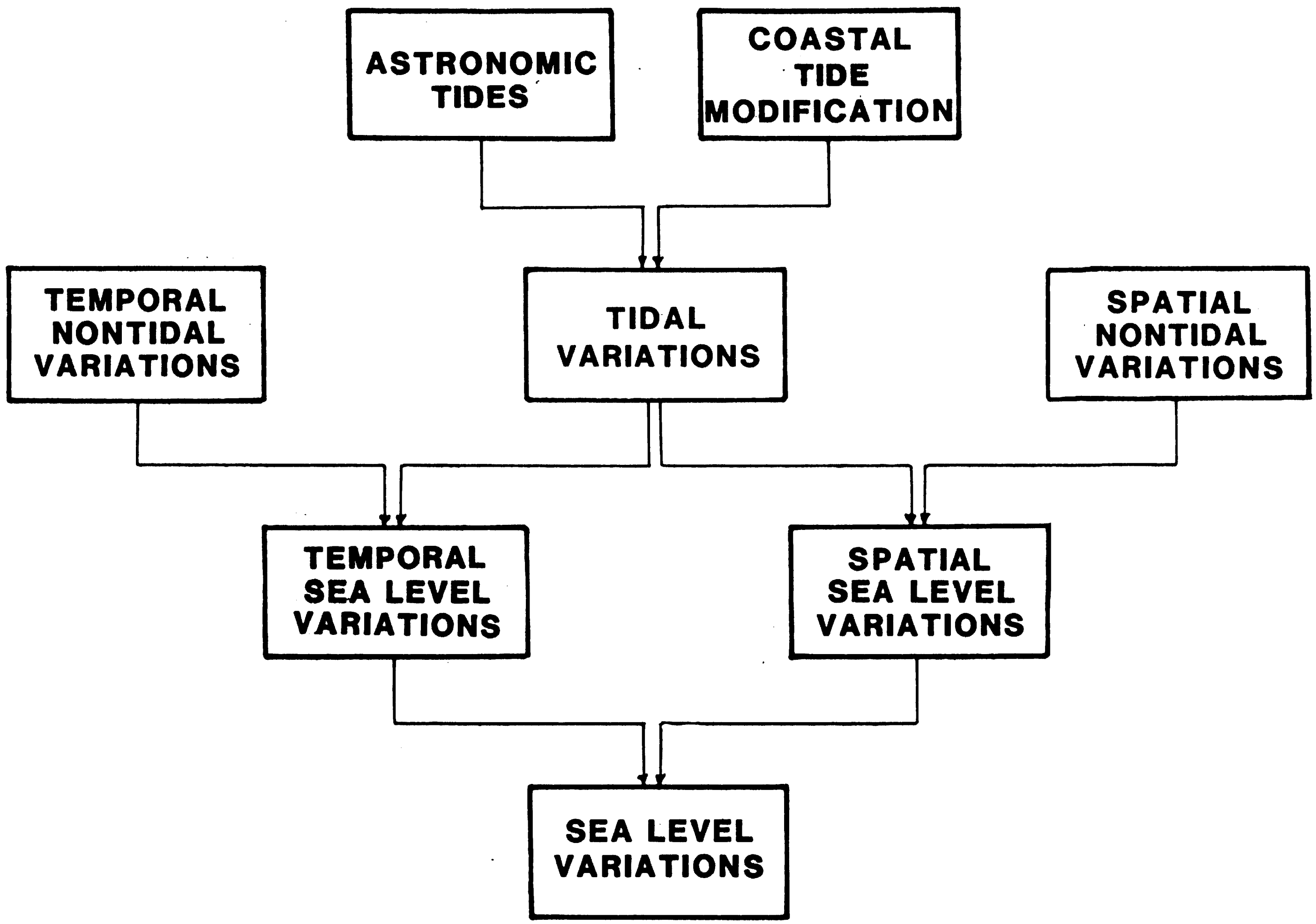

Figure 2.1: Model of Sea Level Variations

In coastal regions the variations in sea level are manifold. Despite the fact that they are derived from relatively few causes, the complexity of sea level variations presents a formidable obstacle in any short review. Figure 2.1 represents the model chosen for the present study, in which sea level variations are classified as tidal or nontidal, as well as temporal or spatial. Since tidal datums are often misunderstood to be fixed level planes rather than time dependent undulating surfaces, some of the variations that should be considered in determining datums for boundary delimitation are identified.

In establishing local tidal datums for boundary surveys, information regarding the tides and other sea level variations is essential. The observation, analysis, and prediction of the tides and methods of establishing tidal datums are reviewed only briefly to provide a preliminary assessment of the tidal information available to cadastral surveyors for boundary delimitation. Methods of recovering and transferring datums are developed in more detail in Chapter 4, but a consideration of tidal information, or the lack of information, is critical for an appreciation of current survey practices in the Maritimes.

2.1 Temporal Variations in the Astronomic Tides: Equilibrium Tides

The major temporal variations in the astronomic tides can be derived from the equilibrium tide, the response of the oceans to forces produced by the relative positions and motions of the earth, moon, and sun. Although the total range of temporal variations would span centuries, the fundamental characteristics of the tides are defined, for practical purposes, in much shorter periods of time. The significant temporal variations occur semi-diurnally, diurnally, fortnightly, monthly, and annually and are discussed below as the diurnal, phase, and parallax inequalities. Also of particular interest in tidal boundary delimitation is the 18.6 year period considered in the Borax decision.[1] These temporal variations in the tides are described in detail by Defant[2], Wood[3], and Hatfield[4] among others.

2.1.1 The equilibrium theory: semi-diurnal tides

The equilibrium theory of the tides was first proposed by Newton and provides a simplified explanation of the tide generating forces. Although many factors, such as the effects of landmasses, friction, and inertia, are ignored in this theory, it does illustrate the fundamental temporal variations that make up the astronomical tides.

The equilibrium tide is generated by two external forces acting on the water masses of the earth: the gravitational attractions of the moon and sun on the earth and the centrifugal forces on the earth produced by the revolution of these bodies around their common centres of gravity. While the centrifugal force is constant for any position on earth, both the magnitude and direction of the gravitational force varies with time and location. At the common centres of gravity, the forces are in equilibrium.[5]

By Newton's Universal Law of Gravity, the gravitational force exerted by one body on another is directly proportional to the mass of the attracting body and inversely proportional to the square of the distance between the two bodies. Since the distances from locations on the surface of the earth to the sun and moon vary, the tide generating force is inversely proportional to the cube of the distance from these locations to the moon or sun. Whereas the mass of the moon is much smaller than that of the sun, the proximity of the moon to the earth thus gives it a greater influence on the tides. The lunar gravitational attraction is approximately 2.2 times that of the sun.[6]

In Figure 2.2 only the effects of the moon, with 0^{o} declination, on a water-covered earth are considered. The resultant of the gravitational and the centrifugal forces causes a vertical displacement of the oceans towards the moon near the zenith. At the nadir the net force is directed away from the moon and a similar displacement is produced.

The resultant forces consist of components that are horizontal and vertical to the earth's surface. These vertical components must act in opposition to the earth's gravity field and are insufficient to raise the surface waters. Therefore, the movement of the water masses by the horizontal components, or tractive forces, produces the accumulations of water in the equatorial regions of the zenith and nadir meridians. In the vicinity of the poles and along the meridians 90^{o} west and east of the zenith, a corresponding decrease in water level occurs.

As the earth rotates on its axis, approximately once every 24 hours and 49 minutes with respect to the moon, these variations appear to circle the earth as a tidal wave. Two nearly equal high water levels and two nearly equal low waters are observed each lunar day along any one meridian. Since these tides have a period of approximately 12 hours, they are called semi-diurnal.

If the attraction of the sun is superimposed on that of the moon, the combined amplitude of the semi-diurnal tidal wave would

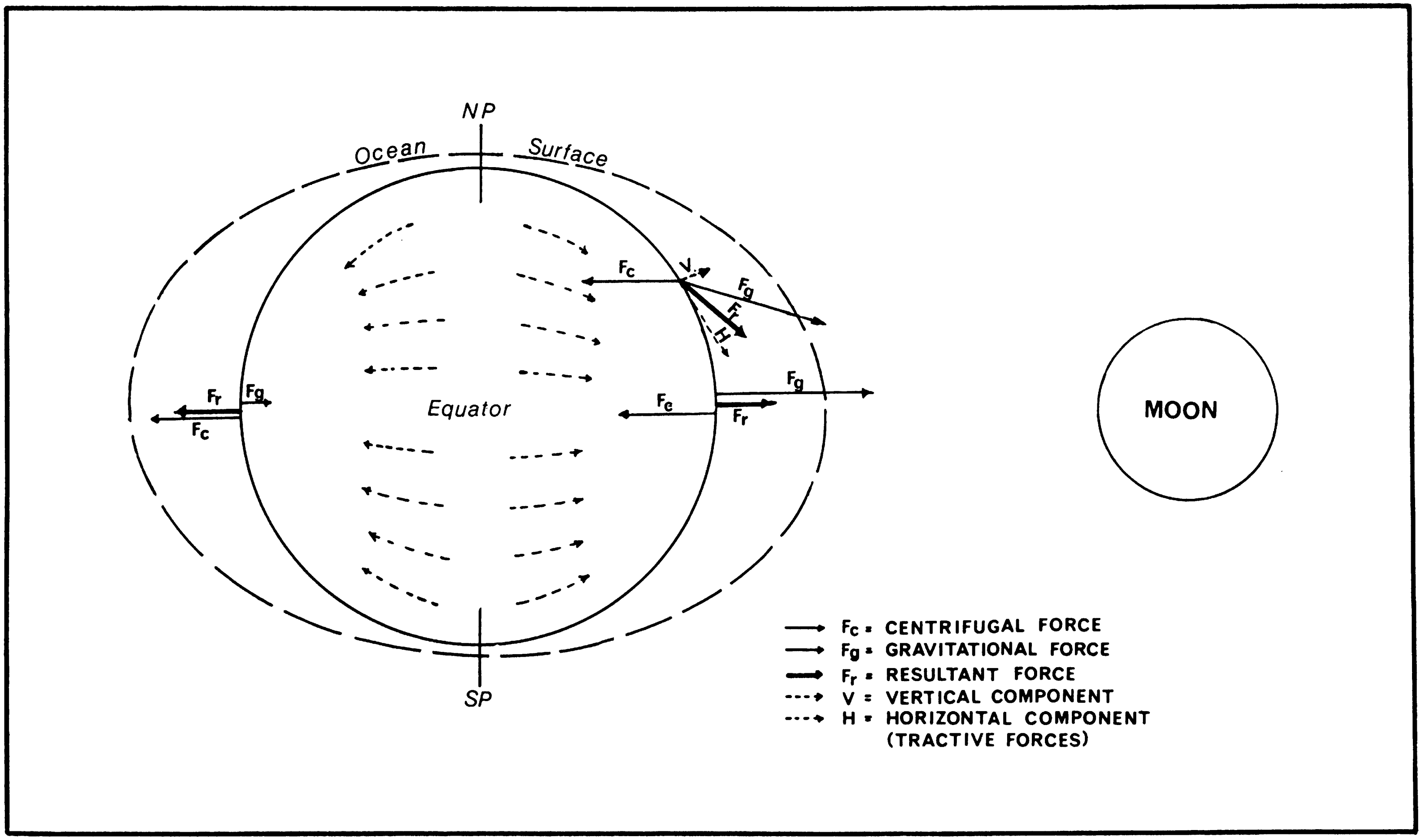

Figure 2.2: Equilibrium Tide - Tide Generating Forces

theoretically be 0.79 metres.[7] Observed tides differ markedly from these theoretical tides and the assumptions of the equilibrium theory must be modified to obtain a more realistic picture of tidal variations. Other temporal tidal variations can be derived from the equilibrium model by considering the changes in the relative positions of the earth, moon, and sun.

2.1.2 The diurnal inequality: diurnal and mixed tides

The diurnal inequality is caused by the rotation of the tide generating forces due to the declinations of the moon and the sun. Both the lunar orbit and the ecliptic, or apparent path of the sun, are inclined with respect to the equator. Therefore, the directions of the gravitational forces change and inequalities occur in the character of the semi-diurnal tidal wave.

Figure 2.3 illustrates the rotation of the tidal envelope caused by the moon's declination. Semi-diurnal tides still exist along the equator but diurnal tides, with only one high water and one low water daily, occur near the poles. Between the equator and co-latitudes equal to the declination of the moon, inequalities appear in the amplitudes of the tides, as well as in the times of successive high and low waters. These tides are known as mixed tides and can be either mainly diurnal or mainly semidiurnal, depending on the predominance of components (known as constituents) of the tidal wave that have periods of approximately 12 or 24 hours.

Monthly and longer period changes in the lunar and solar declinations also influence these inequalities. Variations occur within the lunar month as the moon's declination changes north and south of the

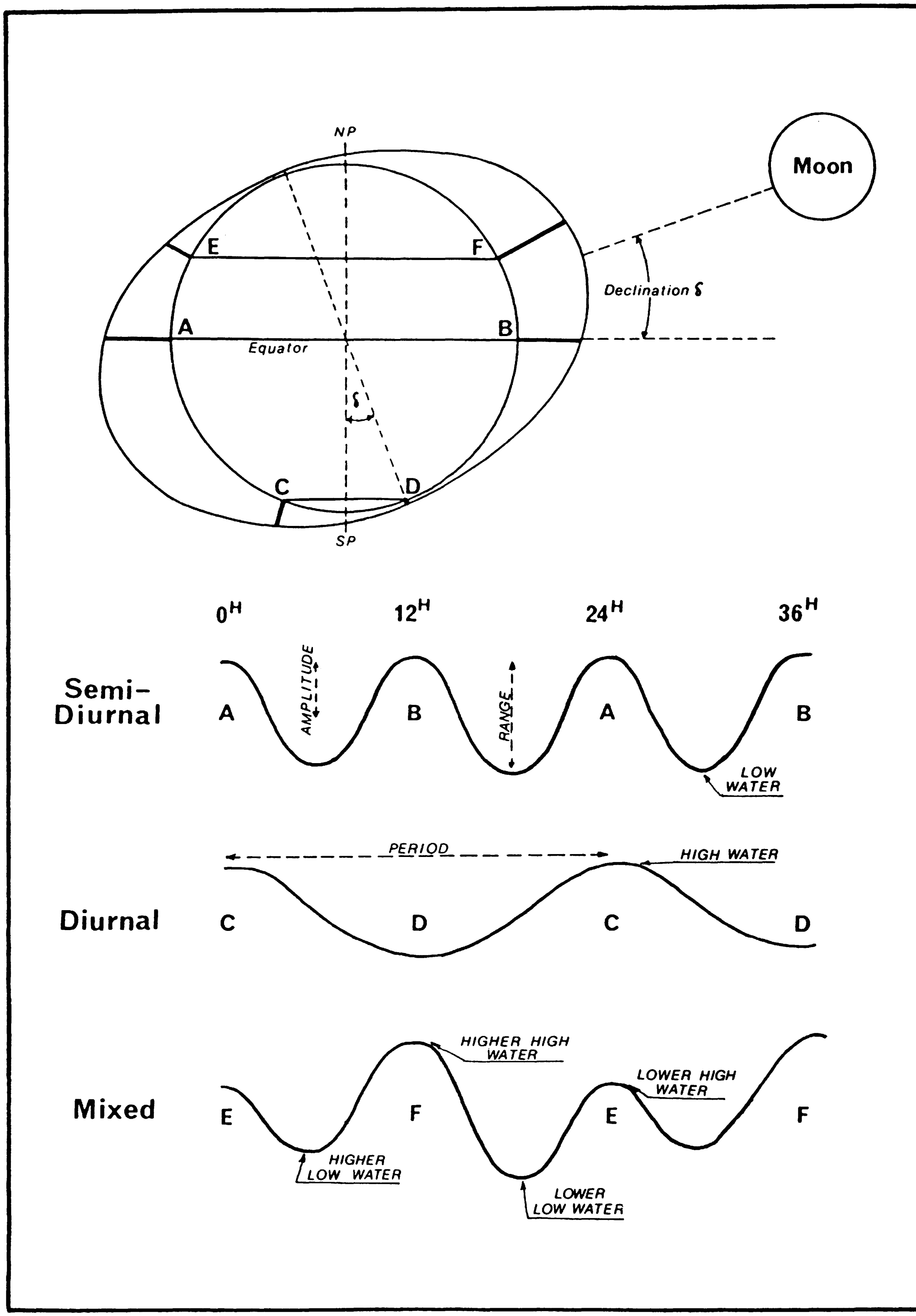

Figure 2.3: Diurnal Inequality[8]

equator. The solar declinational effect has a semi-annual period, the maximum declination of approximately 23.5° being reached at winter and summer solstices. Since the moon is also inclined approximately 5° with respect to the ecliptic, it reaches a maximum declination of 28.5° and a minimum of 17.5°. The period of these lunar variations, known as the regression of the moon's nodes, is 18.61 years.[9] This was the length of observations considered in the Borax case.

2.1.3 The phase inequality: spring and neap tides

As the moon orbits the earth approximately once every 29.53 solar days, its position with respect to the earth is designated by the phase of the moon. The accompanying changes in the net luni-solar gravitational forces introduce fortnightly variations, the spring and neap tides, that play an important role in tidal boundary definition.

As illustrated in Figure 2.4, the gravitational attractions of the moon and the sun are in alignment when the moon is full or new. The lunar and solar resultant forces are therefore added and spring tides with increases in range occur, where the range is the difference in height between successive high and low water levels. When the moon is in the first or third quarter phases, the resultant forces act in opposition causing neap tides with ranges smaller than average.

The phases of the moon also affect the arrival time of the tidal wave. Between the new and first quarter phases and between the third quarter and full phases, the tidal wave is accelerated and high tides occur before the meridian transit of the moon. This phenomenon is known as the priming of the tides. The lagging of the tides is a similar delay of the tidal wave during the remainder of the lunar month.[10] Spring and

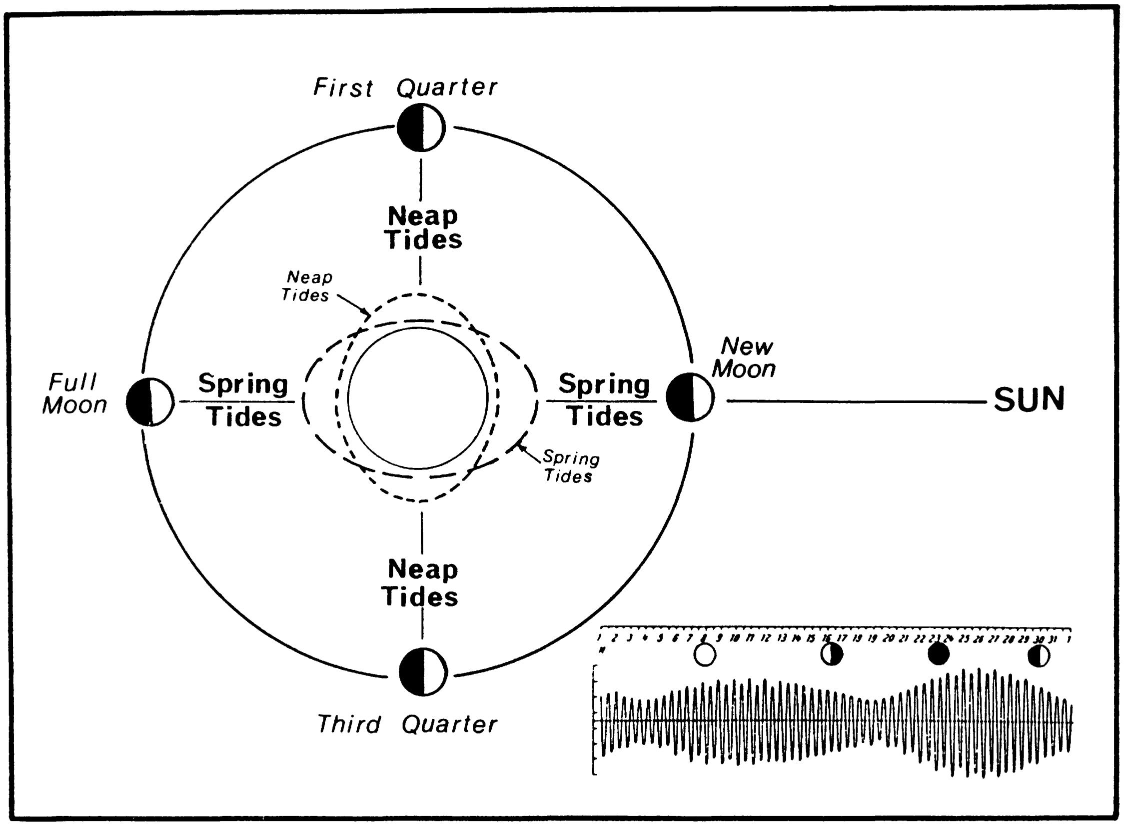

Figure 2.4: Phase Inequality[11] and Monthly Tidal Curve[12]

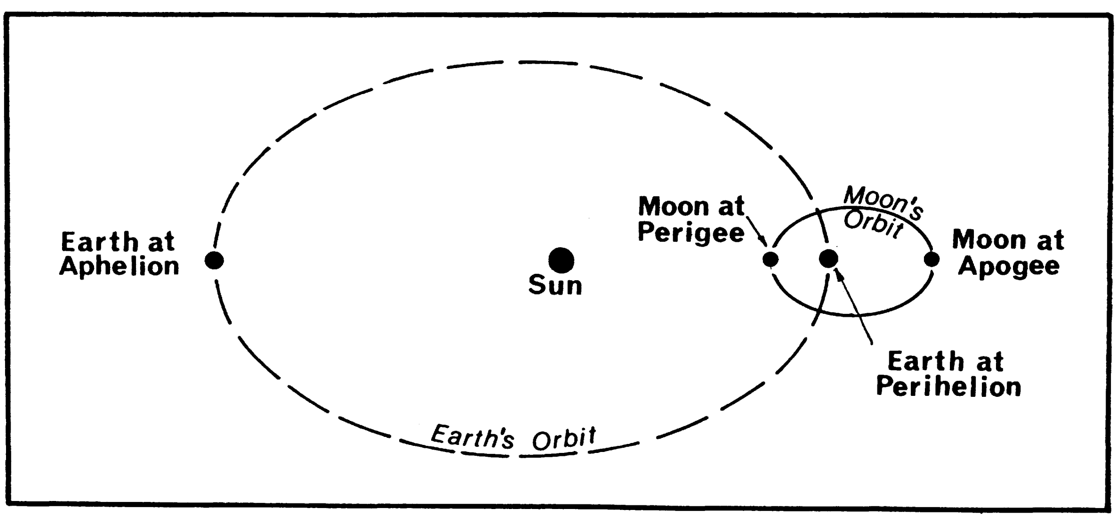

Figure 2.5: Parallax Inequality [13]

neap tides may also appear to precede or lag behind the corresponding phases because the relative positions of the earth, moon, and sun are also affected by declinational and orbital factors.

2.1.4 The parallax inequality: perigean and other long period tides

Since the lunar orbit and that of the earth around the sun are elliptical, the gravitational forces vary monthly and annually with the changing distances between these bodies. When the moon is at perigee, its closest position to the earth, the gravitational forces are increased and perigean tides with large ranges are produced. The tidal range diminishes at apogee, when the earth-moon distance is maximum. If perigee occurs near the time of new or full moon, perigean spring tides with unusually large ranges are observed.[14]

Similar range variations also occur annually at perihelion, the earth's closest approach to the sun, and at aphelion, when the earth-sun distance is maximum. Extreme tidal ranges are produced when perihelion, perigee, and the new or full moon coincide. This phenomenon is rare, since the precession of perigee, its revolution with respect to the earth's orbit, has a period of approximately nine years.[15]

The theoretical tide is a wave formed by the sum of the constiuent waves with periods equal to the astronomic variations. To compare the effects of some of the major tidal constituents, their relative amplitudes are given in Table I. It should be emphasized that these are theoretical values only. For example, nontidal seasonal variations can greatly influence annual sea levels and observations of at least one year would be required to isolate these effects, although the theoretical amplitude of S_a is relatively small. On the other hand,

Table I : Major Constituents of the Astronomic Tides[16]

Period of Temporal Variation	Name of Constituent	Relative Amplitude*
semi-diurnal	M_2 - lunar	1.00
semi-diurnal	S_2 - solar	.47
diurnal	K_1 - luni-solar	.58
diurnal	O_1 - lunar	.41
fortnightly	M_f - lunar	.17
monthly	M_m - lunar	.09
semi-annual	S_{sa} - solar	.08
annual	S_a - solar	.01**
18.61 years	precession of lunar nodes (nodal tides)	.07

* Theoretical Values: actual magnitudes will vary with latitude and the significance of nontidal effects.

** Although the theoretical value is relatively small, nontidal seasonal variations in sea level make the annual contribution more significant than the nodal tides.

Vanicek has reported that the

> amplitude of the nodal tide [with period equal to 18.613 years] appears to be too small to influence significantly an average [sea level] computed from a shorter data span.[17]

2.2 Coastal Modifications of the Astronomic Tides: Spatial Variations

In the equilibrium theory, the existence of landmasses and the retardation of the tidal wave through friction and inertia were ignored. Thus, the resemblance between the equilibrium tide and the observed tide along the coast is often slight. While the theoretical effects of the equilibrium tide are global in scale, coastal modifications of the tides cause temporal variations that are more closely related to local and regional factors. Characteristics such as the type of tide, the observed tidal range, and the variations in arrival times of the tidal wave are therefore discussed in this section as spatial variations. Analytical developments of coastal modifications are given by Defant[18] and Doodson and Warburg,[19] while Redfield examines the New England and Bay of Fundy tides in detail.[20]

2.2.1 Type of tide

One of the primary spatial variations is the existence of semi-diurnal, diurnal, or mixed tides in areas other than those expected through a consideration of only the diurnal inequality in the equilibrium theory (see Figure 2.3). Coastal configuration and ocean bottom topography modify the constituent waves of the astronomic tides through resonance and damping.

Each body of water has its own natural period of oscillation that depends on the length, width, and depth of the basin. If this period is approximately equal to a major semi-diurnal or diurnal tidal constituent, it will be amplified in a resonance effect. Since both the Atlantic Ocean and the Bay of Fundy have natural periods of oscillation approximately equal to the M_2 constituent, the tides are semi-diurnal. In the Northumberland Strait M_2 is damped and diurnal tides occur, while the Gulf of St. Lawrence has mixed tides.[21]

2.2.2 Variations in range

Resonance also greatly affects the theoretical tidal amplitudes. Again the constituent waves may be amplified or damped depending on the physiography and natural frequency of the basin. Thus in the Bay of Fundy, the relatively large M_2 amplitude is further augmented through resonance and extreme tidal ranges occur. The observed range can vary from approximately two metres at the mouth of the Bay to over 16 metres at in the Minas Basin as shown in Figure 2.6.

In narrowing basins with steeply shelving bottoms, a funnelling effect contributes to increases in range as the tidal wave progresses inland.[22] An extreme example of this phenomena is the occurence of tidal bores in several of the river tributaries of the Bay of Fundy. Islands, sandbars, headlands, breakwaters, or other obstructions can also affect the tidal ranges in inland basins. The tidal wave may be attenuated near the obstruction by friction with the bottom or partially deflected seaward.

An additional factor, less often considered, is the effect of changes in the coastal physiography. Avulsion and large scale

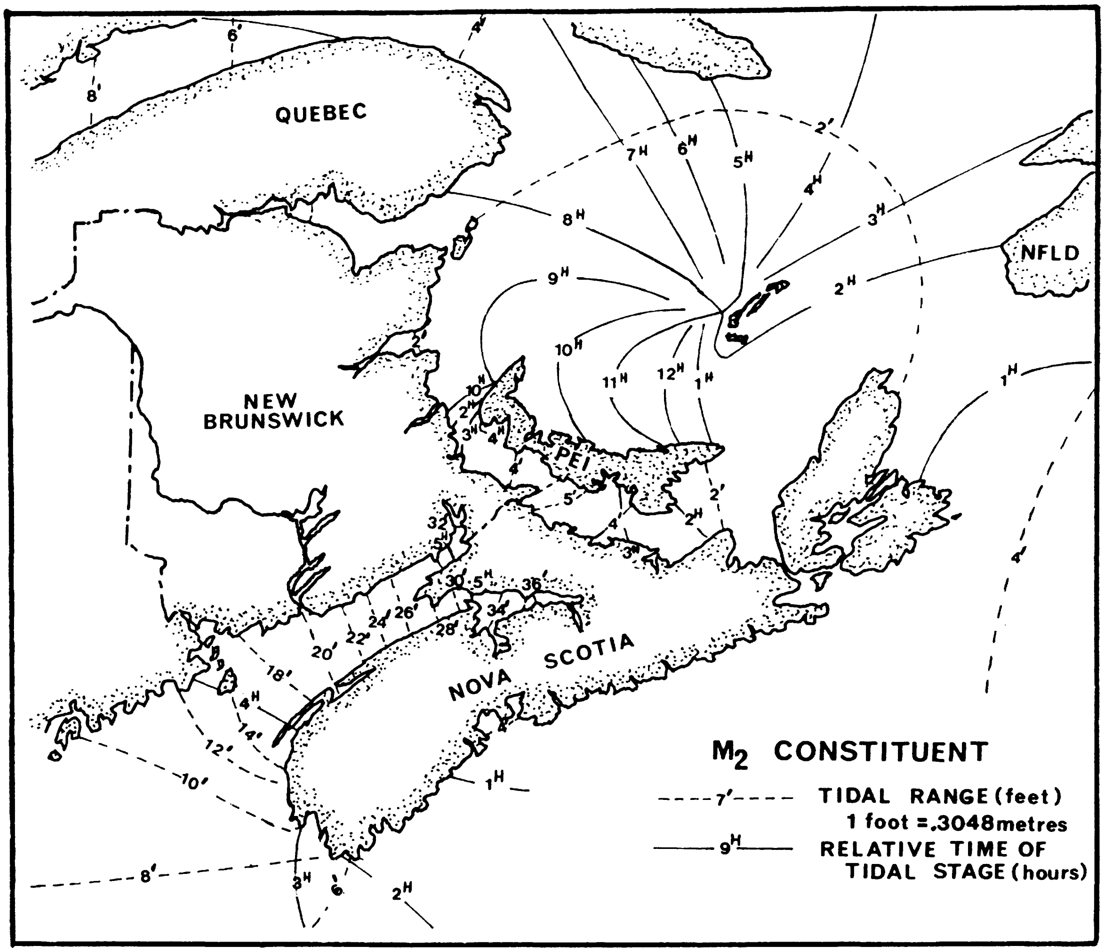

Figure 2.6: Co-tidal Chart of M_2 Constituent[23]

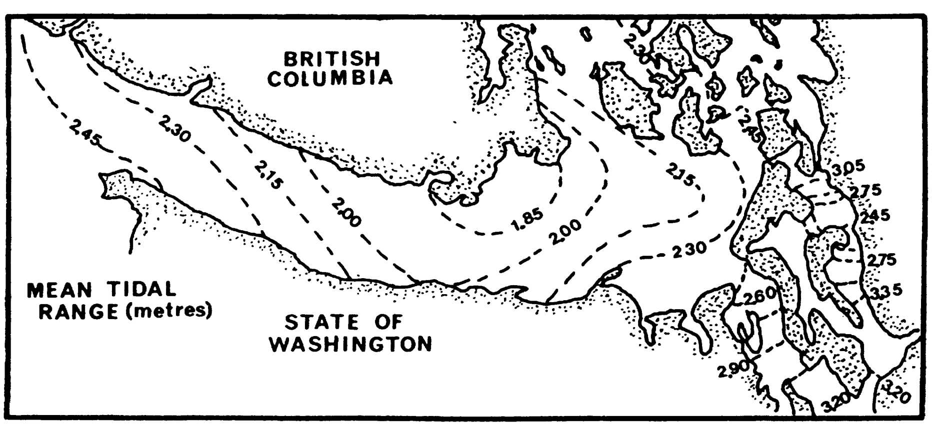

Figure 2.7: Mean Tidal Range in Jaun de Fuca Strait, B.C.[24]

sedimentation may alter the depth and configuration of shoreline features, thus influencing the tidal range. When large scale engineering projects cause coastal alterations, the effects on the tides can be widespread.

From numerical models, for example, changes in tidal amplitudes from approximately 0.05 to 0.15 metres in Boston have been predicted for the proposed barriers of the Bay of Fundy Tidal Power Project. Increases within the Bay of Fundy could be as great as 0.30 metres for particular barrier locations and both the amplitude and character of the tides behind the barriers would be subject to alterations both at the time of construction and through later water level control for power generation.[25]

2.2.3 Spatial variations in the time of tide

High water or low water levels do not arrive simultaneously at all points along any one meridian and the times between successive high and low tides may vary. Among the causes of these time variations are the rotation of the tidal wave by the Coriolis Force and distortions due to the topography and character of the seabed.

The Coriolis Force is a fictitious force that compensates for the fact that measurement of the acceleration of water on the earth's surface is relative to a rotating earth. This force acts at right angles to the direction of motion and increases with latitude. As an example of its effect, a ship travelling due North from 30° to 40° North latitude would appear to move in a northeasterly direction to an observer in space, due to the rotation of the earth during the ship's passage. In the northern hemisphere there is an apparent deflection to the right (left in the southern hemisphere). The Coriolis Force also deflects the tidal currents associated with the horizontal components of the tide producing forces. In enclosed or semi-enclosed basins, the theoretical effect of the Coriolis Force on the observed tide is the rotation of the tidal heights in a counter-clockwise direction.[26] This rotation is shown in Figure 2.6 for the M_2 constituent in the Gulf of St. Lawrence. Since the tidal wave travels in an approximate north-south direction in the Bay of Fundy, the deflection of the currents causes a slight rotation clockwise.

Seabed characteristics also influence the time of tide. Water turbulence from eddies or river outflow can dissipate energy and distort the tidal curve. In shallow areas, friction with the bottom also dissipates energy and can slow the tidal wave. Vegetation and small barriers entrap water at high tide, thus delaying the ebbing of the tide.

Although the modifications of the coastal tides discussed in the previous sections have not exhausted the spectrum of possible variations, they demonstrate the complexity of tidal effects in coastal regions, as illustrated in Figure 2.7. Tidal variations can be predicted by assessing, and in some cases modelling, the local physiographic and oceanographic conditions, but the magnitudes of these variations can only be precisely determined by tidal observations. An appreciation of these modifications is essential for tidal boundary delimitation because both tidal and nontidal changes in mean sea level cause temporal and spatial variations in tidal datum elevations.

2.3 Nontidal Sea Level Variations

The height of the instantaneous sea level, with respect to a fixed reference datum, can not be adequately predicted from the astronomical tides alone because geomorphology, oceanography, and meteorology are contributing factors in sea level variations. Only a sample of the nontidal variations are discussed here. Lisitzin[27] provides a more comprehensive review and Vanicek and Merry[28] have investigated some of the effects of wind, temperature, and pressure for Maritime ports. De Jong and Siebenhuener[29] and Thompson[30] discuss sea level variations for British Columbia.

2.3.1 Temporal nontidal variations

Temporal variations in sea level range from disturbances such as waves lasting only a few minutes to changes in the volume of the oceans occuring over centuries. Short term variations are generally dependent on meteorological conditions and their influence on coastal oceanography. Seasonal variations are also related to local meteorology, while glacial changes and vertical movements of the earth's crust produce the major long term variations in sea level.

Winds generate waves that may range in height from millimetres to metres, often making tidal measurement in surf zones difficult if not impossible.[31] Winds can also cause standing waves in enclosed or semi-enclosed basins, known as seiches, that oscillate with a period equal to the natural period of the basin. Onshore winds may produce a piling up of water along the coast. If this effect is superimposed on the tidal wave, extreme variations in sea level lasting several days can occur, an example of which is the 1869 Saxby tide that devastated Maritime coastal areas. Gale force winds accompanied a perigean spring tide and water levels approximately one metre higher than normal were observed 100 kilometers inland on the Saint John River.[32]

Winds, together with water density variations, are also the driving forces of short term and seasonal currents. Since the Coriolis Force deflects the mean direction of transported water perpendicular to the direction of the wind, longshore winds can induce either the piling up of water along the coast or upwelling as illustrated in Figure 2.8.

Barometric pressure is another major cause of sea level variations, although these effects are closely associated with winds. Acting as an inverse barometer as shown in Figure 2.9, air pressure creates water surface responses of approximately one centimetre for each millibar change in pressure.[33] When pressure zones move quickly over a region, the wave-like undulations can also contribute to storm surges. Blocked high or low pressure zones can produce significant sea level variations over weeks or months.

Diurnal and seasonal changes in air temperature cause surface water density variations and thus changes in water volume. The average annual variation in sea level related to air temperature is estimated to be approximately 11 centimetres, although polar and equatorial regions are subject to more extreme variations.[34] Annual variations of 12 centimetres due to meteorological conditions have been recorded on the western shore of Vancouver Island.[35]

Many sea level variations are evident only through long observations. Precipitation, evaporation, and river discharge cause seasonal variations in the volume of ocean water. In the melting and

Upwelling: Coriolis Force causes warm surface waters to move offshore with a longshore wind. Colder, denser bottom waters replace the surface waters causing a slight depression near shore.

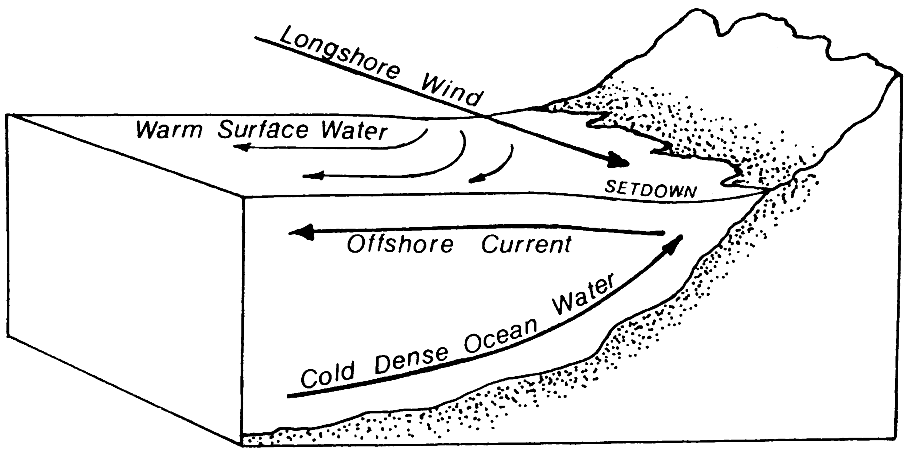

Figure 2.8: Upwelling Caused by Longshore Wind and Coriolis Force

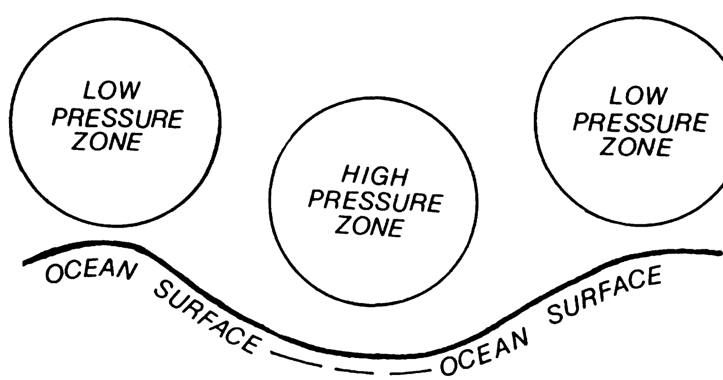

Figure 2.9: Effect of Barometric Pressure on Sea Level

formation of the polar ice caps, mean air temperature also contributes to the eustatic changes in global sea level. These eustatic changes include variations in the volume of the oceans, isostatic adjustments of the coastal landmasses, and folding of the seabed. Vertical movements of the earth's crust through tectonic activity and sediment loading are additional factors that can change water levels relative to the coast.

2.3.2 Spatial nontidal variations

Excluding the eustatic changes in global ocean volume, the temporal variations discussed above have local and regional dimensions as well. For example, meteorological patterns are partially determined by latitude and coastal configuration. Other nontidal spatial variations are related to coastal physiography, such as estuarian characteristics and bottom topography. Long term changes in sea level through vertical movements of the earth's crust may be widespread over a coastal region, but the degree of movement along the coast is not necessarily constant. Nontidal variations in sea level thus have spatial, as well as temporal, dimensions.

Estuaries are complex environments, which may exhibit sea level differences with respect to areas within the estuary itself and to the surrounding coast. If barriers block or diminish the ocean tides, for example, estuarian sea level may be meteorologically dominated.[36] River discharge is another factor because it creates salinity and temperature variations and is rarely distributed evenly within the estuary. Density driven currents and the Coriolis Force divert river outflow and set up sea surface slopes across the estuary.[37] Predominant currents, upwelling, and river disharge patterns may also affect local and

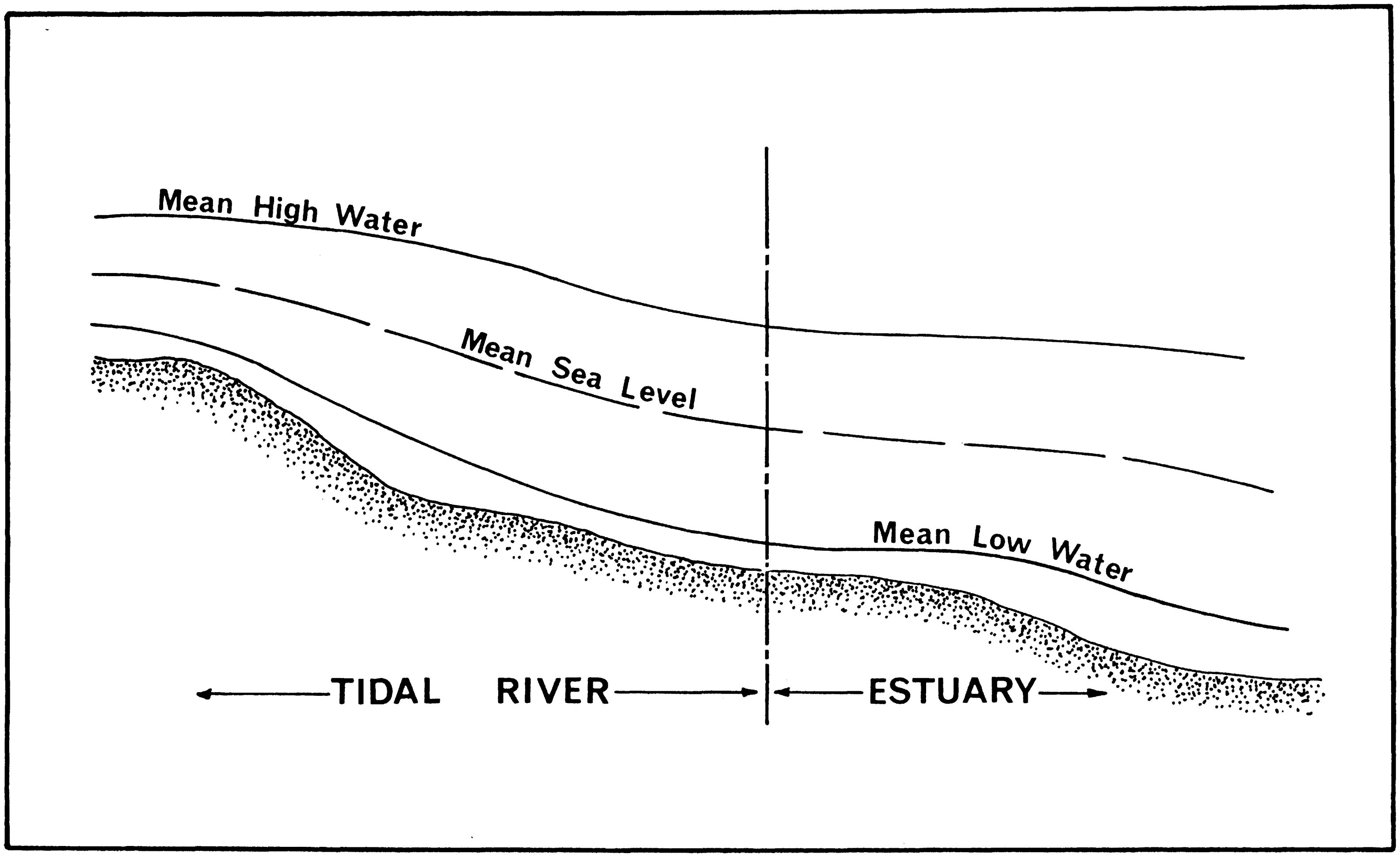

Figure 2.10: Sea Level Variations Caused by Changes in Bottom Topography

regional sea level on the open coast.

Seabed topography is another important factor in spatial variations, particularly in tidal rivers and embayments. Ocean water may be funnelled uphill by the tidal forces as depicted in Figure 2.10. The combined effect of tides and river outflow can raise the inland water level significantly with respect to the nearby coast.

The effects of nontidal variations on mean sea level are shown in Figure 2.11 for three ports along the Pacific and Atlantic coasts. In Alaska the major contribution is isostatic rebound, while the Gulf of Mexico is subject to variable crustal movements, including sediment loading from the Mississippi River.[38] The eastern United States is influenced by variable river discharge[39] in addition to isostatic adjustments. Similar variations are evident along Canadian coasts.[40]

To illustrate the multi-dimensional aspect of these and other nontidal sea level variations, Figure 2.12 depicts some of the causes and approximate temporal, horizontal, and vertical ranges. This summary is a simplification of actual events and is intended only to indicate the temporal and spatial relationships. A similar summary is provided by Stommel in graphical form.[41]

2.4 Tidal Datums

Tidal datums are related by definition to specific sea levels, and therefore also exhibit spatial and temporal variations. To establish a datum at a particular location, the elevation must be determined from a time series of sea level heights. Information derived from measurements of both tidal and nontidal variations is a prerequisite for precise

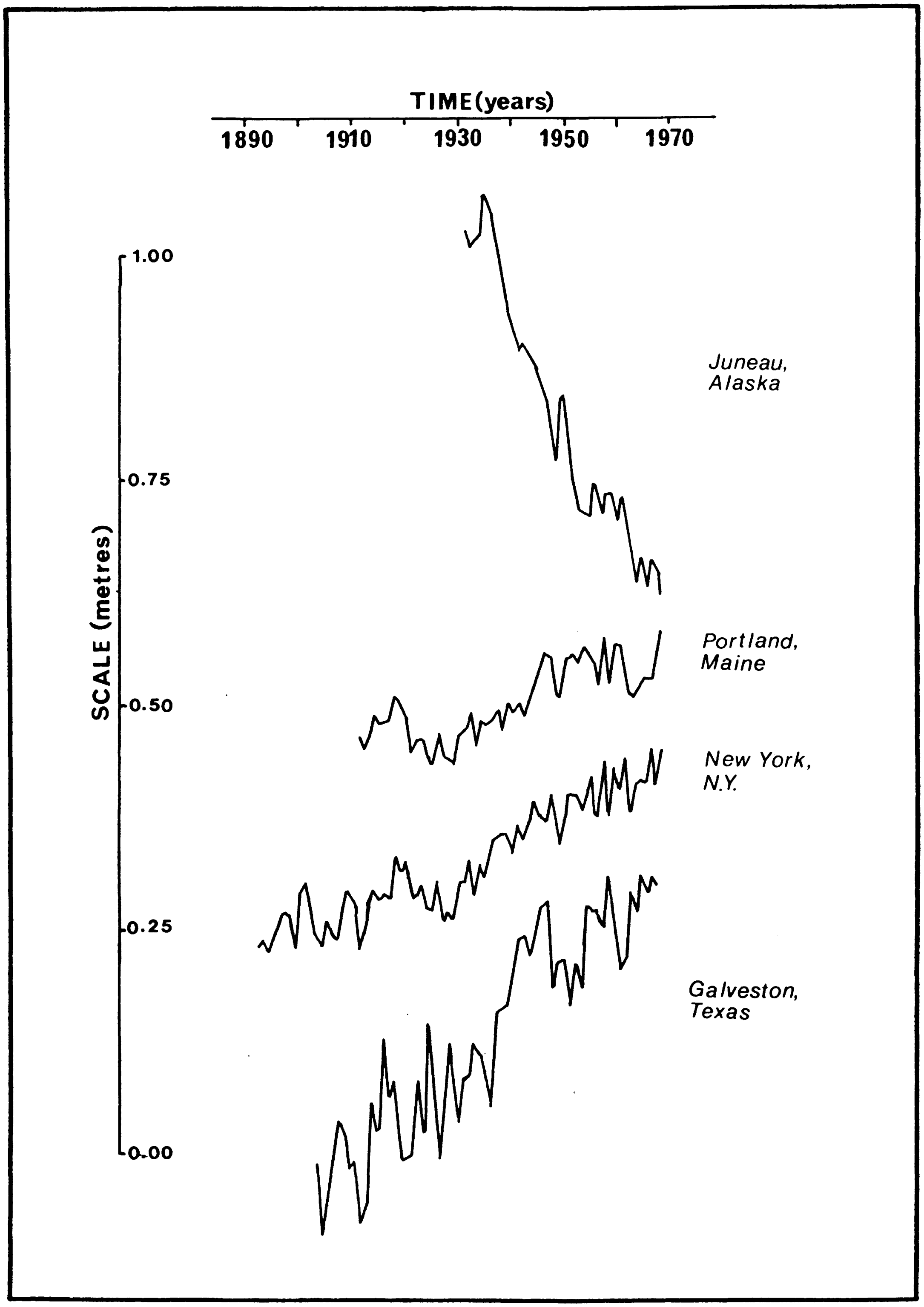

Figure 2.11: Long Term Trends in Mean Sea Level[42]

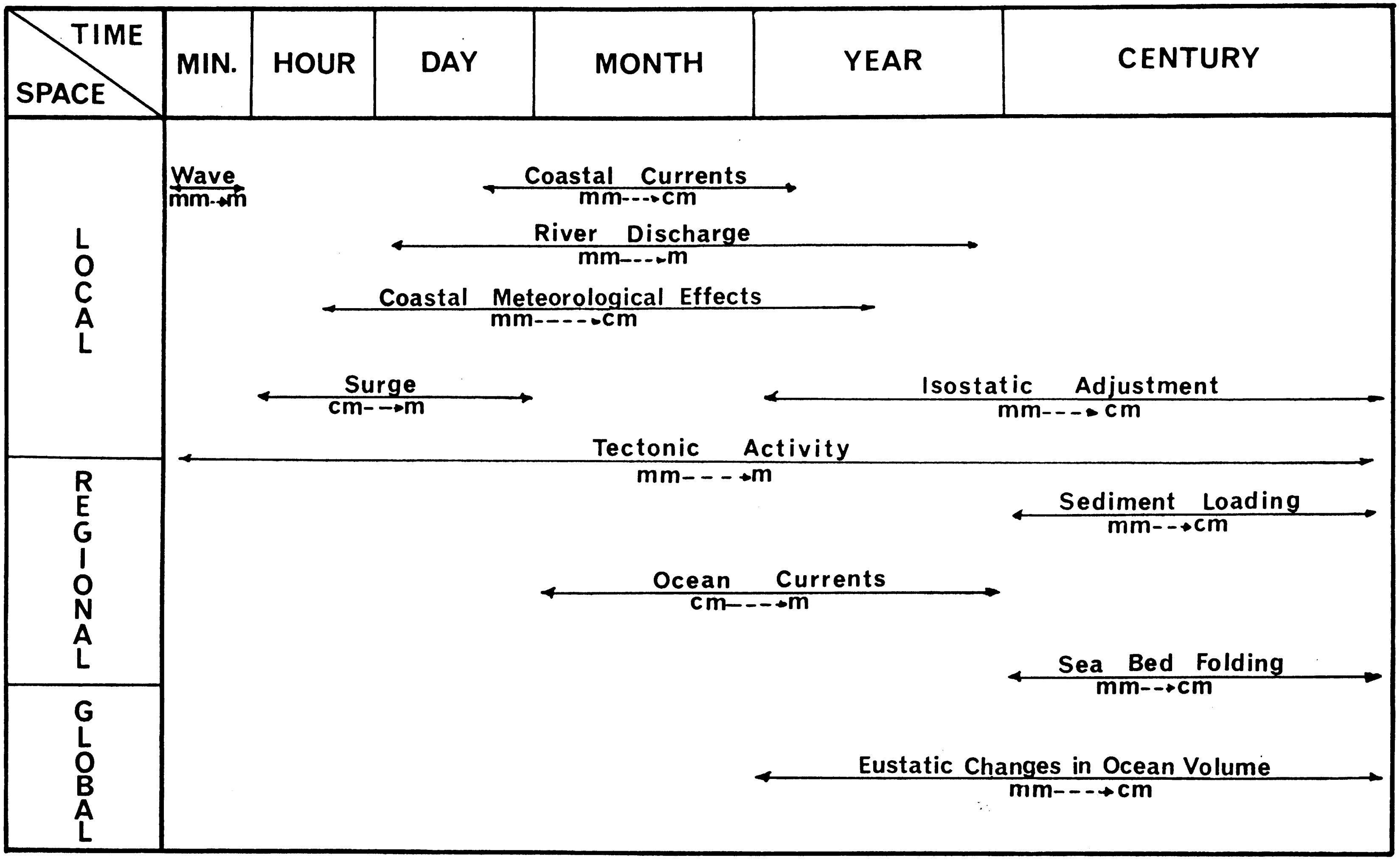

Figure 2.12: Spatial and Temporal Dimensions of Nontidal Sea Level Variations

datum determination. Tidal observation, analysis, and prediction are covered in depth by Hatfield,[43] Doodson and Warburg,[44] Godin,[45] and Schurman[46] among others and will not be discussed here in detail. Instead, emphasis is placed on tidal datum definitions and tidal information required for boundary delimitation.

2.4.1 Tidal observation, analysis, and prediction

Tidal datum elevations are derived from the observation and analysis of sea level variations. One purpose of analysis is to filter out the noise (meteorologically induced sea level changes, for example) to obtain the signal (tidal constituents) from a time series of sea level observations (tidal record).[47] Once these constituents are known for an observation station, predictions of future time series can be made for that station.

Tidal observations vary in length and technique. For short records, the time series can be recorded by observing water levels on a graduated tide staff. For records longer than a day, this method is generally inefficient and automatic gauges can be installed. Automatic gauges sense and record the variations in sea level mechanically or through pressure variations, reducing reading errors and damping short period wave motions. The records can be in graphical or digital format and are verified periodically by observations on a tide staff. To establish a permanent vertical reference, tidal benchmarks are set near the gauge site.

The record length often depends on the purpose of the observations and the accessibility of the observation station. Since tidal information is critical for safe navigation, long records are available for many major port areas. However, some of these gauges are located in areas subject to local influences, such as river discharge, and may not be representative of the adjacent coast. An example is the tide gauge in Saint John Harbour, New Brunswick, set at the mouth of the Saint John River.

Records of at least 18.6 years include the major astronomic tidal variations and facilitate tidal analysis. In the United States, a 19 year period of observations is required for primary tidal stations. American tidal datums are referred to the National Tidal Datum Epoch, which is periodically updated to include secular (nonperiodic) changes in mean sea level. The current Epoch consists of the 1960-1978 tidal time series.[48] By using 19 full year cycles, seasonal and lunar orbital variations do not bias the observations, but as noted in Section 2.1.4, 19 year records may not always be required to determine most significant variations.

Secondary tidal stations have shorter records that are analyzed through comparison with simultaneous observations at nearby primary stations. For accurate comparisons, the tidal influences at both stations should be similar or the magnitudes and periodicy of local influences, such as river discharge, should be known. Observations at secondary stations (secondary ports) are typically one month in duration in Atlantic Canada[49] and one year in length in the United States.[50] Shorter term observation techniques are discussed in Chapter 4 for tertiary or temporary stations.

For prediction purposes, the task of tidal analysis is to determine the relative amplitudes and phases of the constituent tidal waves. Harmonic analysis is based on the principle that a periodic wave (observed tidal wave, for example) is the sum of harmonically related constituent wave forms with periods corresponding to the temporal variations of the astronomic tides.[51] This standard type of analysis is applied in both Canada and the United States. Least squares spectral analysis may also be applied for its advantages in determining small amplitude variations of known frequencies.[52]

Once the frequencies and amplitudes of the majority of tidal constituents are known, a time series can be predicted. Tidal predictions can take several forms, the most common being tide tables. Tide tables are published annually in Canada and give a time and height listing for reference ports (primary stations) and corrections for secondary ports.[53] Since the tables are generally for navigational purposes, the information in the tide tables is referenced to chart datum. Other modes of prediction include co-tidal charts, illustrated in Figure 2.6, and numerical models of the tides.

2.4.2 Tidal datum definitions

The differences between Canadian and American tidal datum definitions reflect the purposes for which the datums are defined and the appropriate observation period for establishment. Canadian datums are defined for navigation and charting, while American datums are also defined for boundary delimitation. In addition, American datums are referred to the National Tidal Datum Epoch. In Canada no such epoch exists and datum elevations are predicted from the total series of tidal information.

With this background, two sets of datum definitions are given below and their approximate relationships are shown in Figure 2.13. The

Canadian Hydrographic Service (CHS) datums are included to clarify the datum elevations published in the Canadian tide tables and to contrast the American definitions. These American definitions and their variability are discussed in detail by Marmer[54] and are published in the National Register,[55] while the Canadian definitions may be found in the CHS Hydrographic Tidal Manual,[56] which is currently being revised. For simplicity, only the American definition of mean high water is provided in full.

Canadian Definitions

a. Higher High (Lower Low) Water Large Tides (HHWLT & LLWLT): the highest (lowest) predictable tide from the available constituents;

b. Higher High (Lower Low) Water Mean Tides (HHWMT & LLWMT): the average of the predicted heights of the higher high waters of each day;

c. Mean Water Level (MWL): the average of all the hourly water levels for a period of observations;

d. Mean Sea Level (MSL): as a local datum MSL is equivalent to MWL, but as a fixed geodetic datum MSL was established from observations at Canadian reference ports prior to 1910;

e. Chart Datum: lowest normal tide (LNT) which is equivelent to the LLWLT datum.

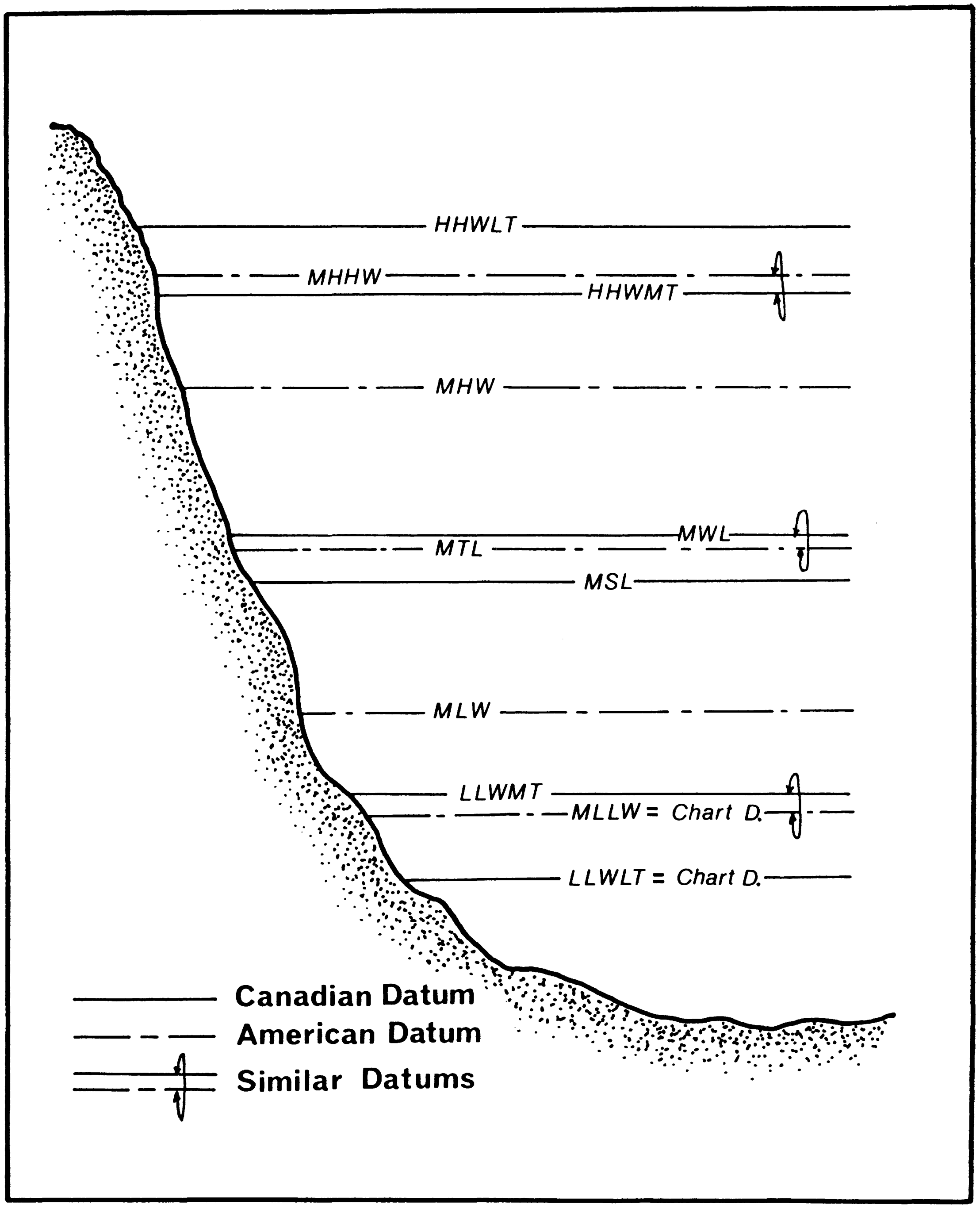

Figure 2.13: Tidal Datums

American Definitions

a. High (Low) Water (HW & LW): the maximum (minumum) height reached by a rising (falling) tide;

b. Mean High Water (MHW): A tidal datum. The average of all the high water heights observed over the National Tidal Datum Epoch. For stations with shorter series, simultaneous observational comparisons are made with a control tide station in order to derive the equivalent of a 19-year datum;

c. Mean Higher High (Lower Low) Water (MHHW & MLLW): The average of the highest (lowest) water height of each tidal day observed over the National Tidal Datum Epoch;

d. Mean Tide Level (MTL): the average of MHW and MLW (note that MTL is not necessarily equivelent to MSL);

e. Mean Low Water (MLW): A tidal datum. The average of all the low water heights observed over the National Tidal Datum Epoch;

f. Chart Datum (Atlantic Coast): MLLW.

The differences between these datums are significant in tidal boundary delimitation. Although Canada lacks definitions for MHW, the American definitions are currently inappropriate for direct use in Canada because they are referenced to the National Tidal Datum Epoch.

2.4.3 Variability in tidal datums

Tidal datums are based on sea levels and sea levels are subject to local tidal and nontidal influences. The fact that tidal datums are not fixed plane surfaces is an obvious but often ignored conclusion, the consequences of which can affect the accuracy of datum establishment.

Since tidal datums are generally defined as the mean of specific water levels over an extended period of time, most of the short term nontidal variations with zero mean are filtered out through averaging. However, nontidal changes in mean sea level, as shown in Figure 2.11, will affect the elevation of a particular datum with respect to a fixed reference surface such as geodetic datum. Similarly, the influence of river discharge, predominant winds or currents, and coastal configuration may appear as spatial variations in datum elevations between stations if the conditions are localized or as seasonal distortions if the period of observations is short.

Coastal modifications of the tides produce the most visible variations in tidal datums. In Figure 2.14, the changes in MHW, MLW, and MTL are shown for points along Long Island, New York. Similar variations in datums were observed between Rustico Harbour and Brackley Bay, as shown in Figure 2.15, during the delimitation of the high water boundary in R. Gordon Shaw v. The Queen[57] (hereafter referred to as the Shaw case: see Appendix II).

Spatial differences in the time of high water arrival may also be considered as datum variations. These time differences between reference stations and survey sites can affect the establishment of the horizontal components of datums when observations are time controlled, as pointed out in the review of Irving Refining Limited and the Municipality of the

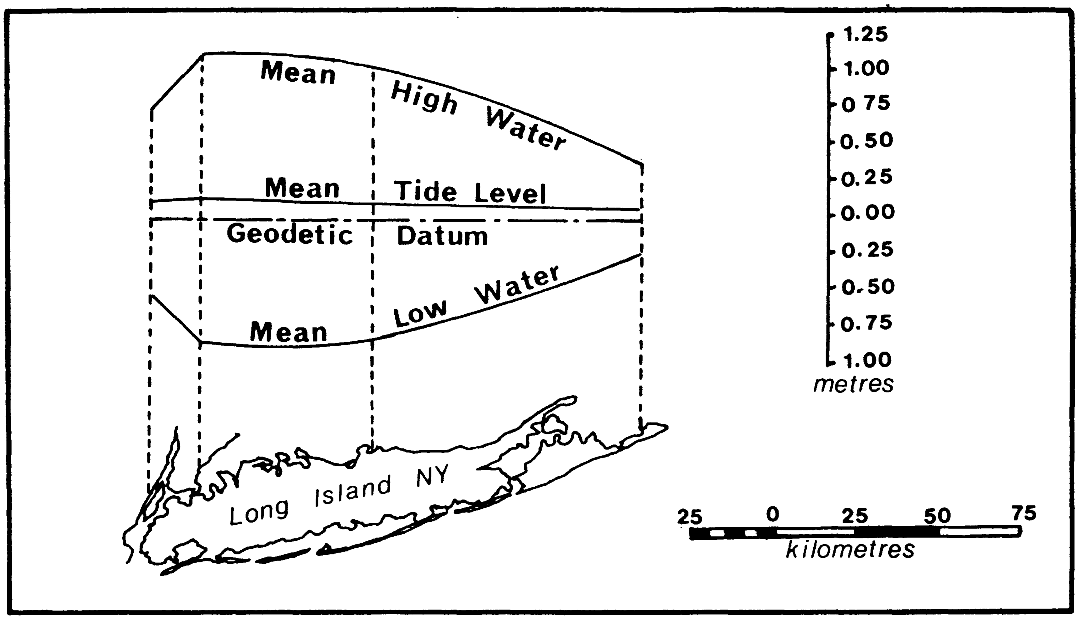

Figure 2.14: Variability in Tidal Datums[58]

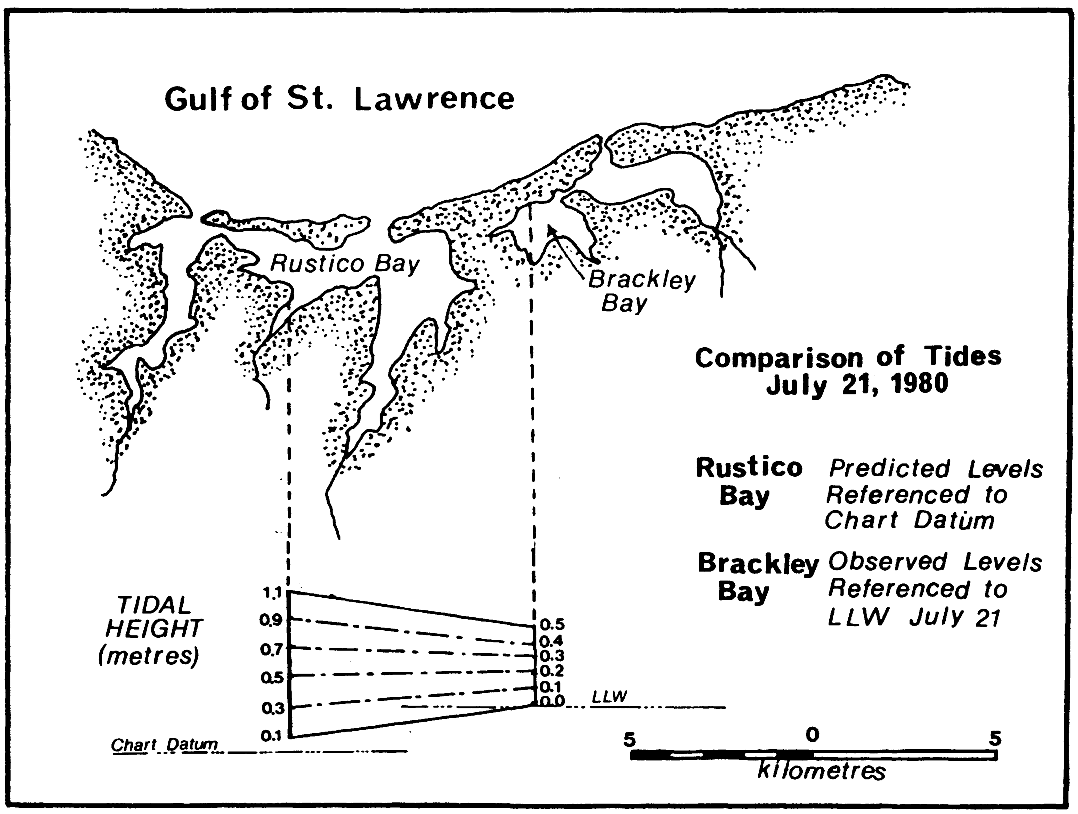

Figure 2.15: Water Level Variations in the Shaw Case, Prince Edward Island[59]

County of Saint John v. Eastern Trust Company[60] (hereafter referred to as the Irving case) in Appendix II.

2.4.4 Establishing local tidal datums

Once a datum elevation has been established at a primary or secondary station from tidal observations, it can be used to recover the datum at a future date or to determine local tidal datums at other points along the coast. At the reference station, datums can be recovered from the tidal benchmark elevation. Secular changes in sea level are not taken into account, but by referencing datums to particular tidal epochs, this factor need not be considered. Displacements of tidal benchmarks pose some problems, however, particularly when they are undetected. If a geodetic monument is used for recovery, adjustments in the levelling network subsequent to tidal benchmark ties should also be noted.

At stations remote from a primary or reference station, the method of establishing a tidal datum depends on the purpose of the project and the accuracy requirements. Coastal geography and the local tidal character are also important factors. Three general methods of determining datums at temporary stations are by transfer of elevation from vertical control, by interpolation or extrapolation, and by comparison of simultaneous observations.

By assuming that the elevation of the datum at a remote site is equal to that at the reference station, spatial variations are ignored. Levelling discrepancies are also superimposed on the datum elevation. Interpolation and extrapolation techniques give recognition to the general slope of tidal datums between reference stations, but no allowance is made for local conditions that cause anomalies in that slope.

For the comparison of simultaneous observations, the accuracy of datum determination depends on the similarity of the conditions between the temporary and reference stations and the length of observations. The standard method of comparison, in which the ratio of the tidal ranges at both stations is used to determine a datum correction, is described by Marmer[61] and Maddox.[62] Although Hatfield restricts his discussion of the range-ratio method to chart datum transfer, equations are presented for various tidal conditions.[63] Methods for using short records and partial tidal curves are discussed in Chapter 4, but Table II lists the expected accuracies for various observation periods.

2.5 Assessment of Tidal Information

This assessment of tidal information in the Maritime Provinces considers the information requirements for tidal datum determination in cadastral surveys and the availablility or quality of tidal information. The suitability of information currently available for tidal boundary delimitation is considered in more detail in Chapter 4. Based in part on the standards presented in Section 1.3, the following assessment is intended only to indicate some of the major problems and to provide a basis by which the survey methods in Chapter 4 can be evaluated.

2.5.1 Tidal information requirements

Assuming that the Maritime Accuracy Study[64] tolerances represent horizontal specifications for tidal boundaries, corresponding vertical

TABLE II: Estimated Accuracies of Datum Elevations for Comparison of Simultaneous Observations[65]

Period of Observations	Estimated Accuracy (metres)
1 day	.076
1 month	.040
1 year	.015
9 years	.005

TABLE III: Horizontal and Vertical Standards

Location	Horizontal Tolerance (metres)	Vertical Tolerance (metres)		
		5% slope	25% slope	50% slope
Urban	.050	.003	.013	.025
Suburban	.100	.005	.025	.050
Rural	.500	.025	.125	.250

tolerances can be derived. Table III provides examples of these tolerances for various percentages of beach slope. The tidal information required to meet these specifications will depend on the local tidal character and the procedures applied in establishing tidal datums. Since these conditions, as well as survey methods, differ throughout the Maritimes, no attempt is made here to derive specifications.

A more general consideration of tidal datum establishment for boundary purposes indicates the following requirements:

a. appropriate tidal datum definitions, possibly including general procedures for establishment;

b. information at the local level for areas subject to large datum variability;

c. frequently updated ties between tidal benchmarks and other vertical reference frameworks used by surveyors;

d. a network of primary and secondary stations with accurately established datum elevations and with sufficient density for datum transfer;

e. provision of the above information in a format suitable for boundary delimitation.

The availablility of tidal information of this quality is one criterion for evaluating the standards and procedures for tidal boundary delimitation.

2.5.2 Assessment of tidal information in the Maritimes

Tidal information is available in the Maritimes through the Tides, Currents and Water Levels Branch of the Canadian Department of Fisheries and Oceans. Additional information can be obtained from the Tides Division of the Bedford Institute of Oceanography. Publications include the Canadian Tide and Current Tables[66] and the Tide and Water Level Bench Marks.[67] Co-tidal charts are available on a regional basis but rarely at the local level for specific embayments, estuaries, and other areas with datum variations.[68]

The most common sources of information are the tide table predictions. Since these are designed to meet navigational requirements, both the density and quality of information is insufficient for boundary surveys in many coastal areas. Datum elevations are given for HHWMT, LLWMT, HHWLT, LLWLT, and MWL for reference ports, with corrections for secondary ports, although definitions appear only to be found in the CHS manual.[69]

For reference ports the predicted high waters may be averaged for the year to obtain a MHW elevation, but this is a tedious and error prone process. If the 1982 average of all the predicted high water elevations for Saint John is compared with the 1983 average, there is a 0.03 metre difference.[70] The cause of this discrepancy may be related both to the long period astronomic tides and to the fact that the 1983 predictions are updated on an additional year of observations containing annual variations in sea level. This elevation difference is significant because it represents a 0.60 metre horizontal displacement on a 5% slope, similar to the grades found on many tidal flats in the Bay of Fundy.

The sparsity of information can also be illustrated by the Bay of Fundy region, in which St. John and Yarmouth are the only reference ports with long tidal records for 64 secondary ports that have approximately one month of observations. No accuracies are given for the predictions, but from Table II a vertical error factor of approximately 0.04 metres might be expected for many of the secondary ports. Thus, comparison of simultaneous observations to determine datums would not meet the standards of Table III along many parts of the coast.

In the Tide and Water Level Bench Mark publications, the locations of tidal benchmarks and relationships between these benchmarks, chart datums, and geodetic reference surfaces are provided. However, the information is incomplete in some cases and elevation ties may not have been updated since the tidal observations were made. Recent policy has been to encourage elevation ties whenever a line of geodetic elevations is run in the vicinity of a tidal benchmark,[71] but the relationships between chart datum and other survey datums may be difficult to obtain in many rural areas.

Tidal information as presently available can therefore be summarized as being generally inappropriate for precise datum determination in tidal boundary delimitation. Among the major problems are the lack of suitable datum definitions and elevations for boundary purposes (MHW, for example). The sparsity of information for many coastal areas and the accuracy of secondary port data are also problems. Data is available, however, through the tidal constituent bank for the generation of datum elevations other those than are presently calculated, if there is sufficient demand.

It should be noted that the above assessment is based on the assumption that tidal boundary delimitation should meet the standards set in the *Maritime Accuracy Study* and should consist of procedures in which tidal datums are established. The suitablity of the tolerances considered in that study for tidal boundary delimitation in the Maritimes is an issue that should be addressed in conjunction with land tenure requirements, survey procedures, and potential costs or benefits, as well as the availablity of tidal information.

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CHAPTER 3

COASTAL LAND TENURE AND TIDAL BOUNDARIES

> As the history of its development would suggest, the current law of tidal areas is hardly a Cartesian product. It straddles different and sometimes inconsistent goals; it has ill-defined boundaries; it encompasses more or fewer interests at different times and places; the degree of enforcement varies depending upon the balance of interests asserted, when, for whom, and where...
>
> Comment (1970) 79 Yale Law Journal 774

The law governing the allocation and use of coastal resources has accomodated various socio-political and economic interests throughout its history. More recently, science has also had an impact on coastal land tenure; it has raised environmental concerns and has influenced traditional tidal boundary definitions. While the tide mark is a practical boundary that has served riparian proprietors and surveyors well for centuries, recent boundary definitions are more precise and are based on scientific knowledge of the tidal phenomena.

To place these boundaries within the context of the interests they delimit, this chapter first reviews coastal land tenure. Both the traditional common law and the more precise American boundary definitions are then examined, emphasis being placed on the high water boundaries generally encountered by surveyors. Consideration is also given to some of the problems raised by the ambulatory nature of tidal boundaries.

3.1 Coastal Land Tenure

The foreshore, also referred to as tideland, consists of that area alternatively covered and left dry by the ebb and flow of tides. On this narrow continental fringe, the interests of private land owners, the general public, and various levels of government merge and often conflict. These competing interests and coastal land tenure in general are particularly significant in the Maritimes, where approximately 80% of the population lives within 16 kilometres of the sea.[1]

In common law jurisdictions, the legal foundations of coastal land tenure evolved in England. Farnham[2] provides a detailed account of the historical development of coastal law, while more recent summaries are given by Graber,[3] Hildreth and Johnson,[4] and Maloney and Ausness[5] with regard to American land tenure issues and tidal boundary delimitation. The applicable British law has been documented by Wisdom.[6] Although the law of the foreshore and tidal boundaries has not been specifically investigated in depth for Canada, La Forest[7] has incorporated coastal land tenure in his review of water law in the Atlantic Provinces.

3.1.1 Tidal and navigable waters

The nature and extent of coastal rights often depend on the legal classification of waterbodies. Therefore, three problems are introduced briefly here: the definition of a watercourse; the limit of tidal waters; and the legal relationship between tidal and navigable waters.

A watercourse may be simply defined as the bed, banks, and waters of a stream or river flowing in a well defined channel.[8] Wisdom adds that a

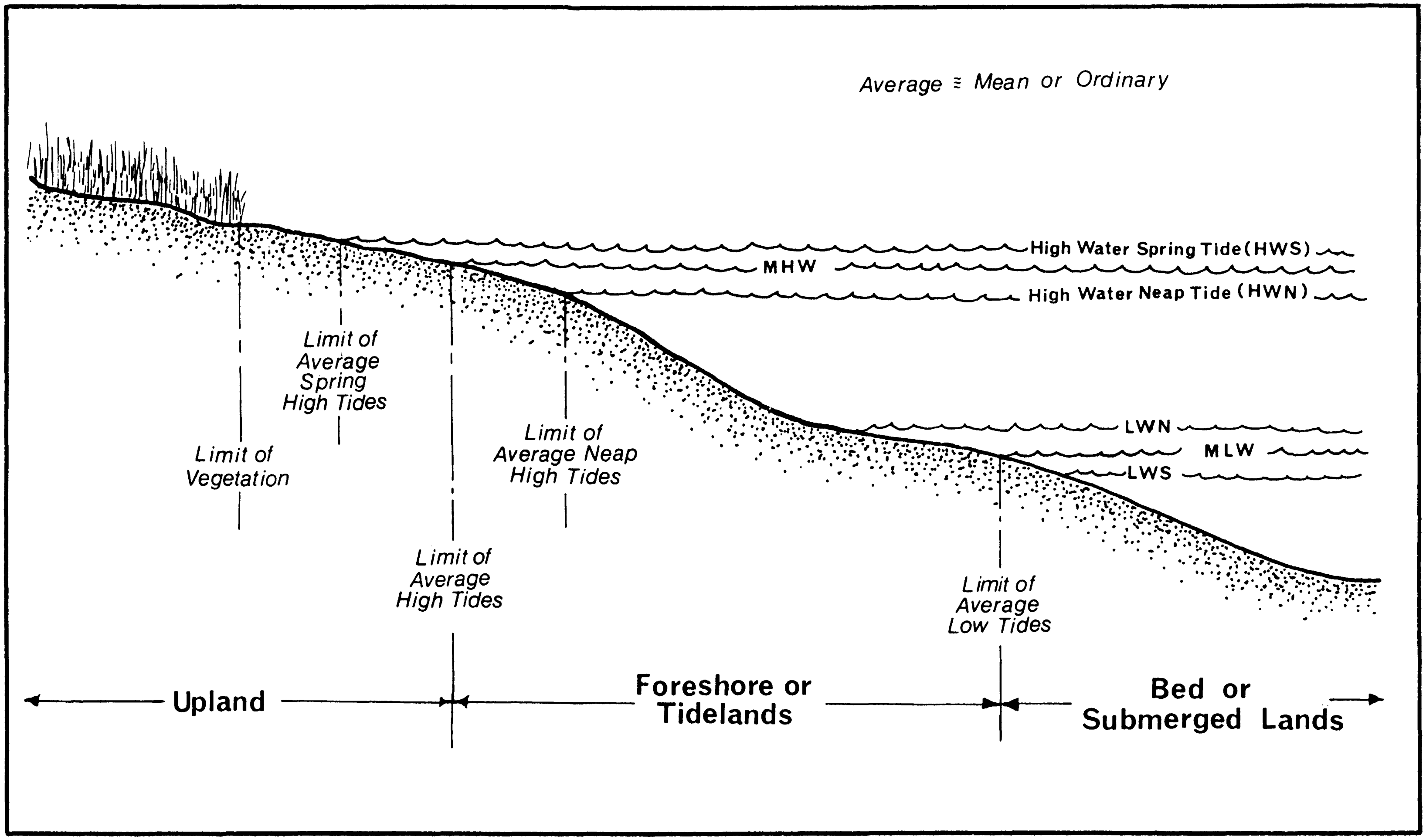

Figure 3.1: Upland, Foreshore, and Submerged Lands

watercourse must have a natural source and "terminates in tidal waters".[9] North American definitions, however, do not always explicitely exclude tidal waterbodies.[10] Such is the case in the Nova Scotia Water Act which specifies marshes, wetlands, and other bodies of water under Provincial jurisdiction as watercourses[11] but still leaves its effect in coastal areas unclear.

Another problem related to the interpretation of coastal law is the delimitation of the precise inland limit of tidal waters in rivers and estuaries. Sir Matthew Hale advocated what has become known as the 'ebb and flow' test in the common law, by claiming that an "arm of the sea" included fresh waters if it was subject to the "flow and reflow" of the sea.[12] Although it has been noted that extraordinary tides should be disregarded in determining the tidal limit,[13] the actual measurement of this limit at the appropriate stage of tide has been left to the surveyor with few guidelines. Maritime courts have acknowledged the ebb and flow test indirectly[14] but have been more concerned with the criterion of navigablility.

Waterbodies may be navigable in fact (de facto), in law (de jure), or both. In England only tidal waters are recognized as navigable in the common law.[15] This traditional definition has been rejected in many North American jurisdictions, where nontidal rivers have been traditionally used for commercial navigation. For example, Ontario, British Columbia,[16] and many American states[17] employ a navigability test to determine the extent and nature of rights and jurisdictions. A common criterion is potential or actual use of the watercourse for trade or commerce.[18]

The limited case law in the Maritimes appears to support the common law rule; only tidal waters are considered navigable for the purpose of defining coastal land tenure.[19] In Regina v. Robertson[20] and Fudge et al. v. Boyd,[21] for example, the issue of navigability was addressed with respect to private, public, and sovereign rights in rivers above the tidal limit. Although geographical similiarities with Britain may be a factor in the application of the common law rule, New Brunswick courts have also given judicial recognition to the laws of England made prior to the establishment of provincial government.[22]

3.1.2 Coastal land tenure: early history

Under Roman law the sea and the foreshore were res communes, that is, common to all and incapable of private appropriation. The seaward limit of the upland property was defined as the highest wash of the winter waves, a boundary definition inherited by many civil law jurisdictions.[23] Public access to the shore for mooring and drying nets, together with the common rights of free navigation and fishing in tidal waters, supported the commercial activities of the Roman Empire. Reference is sometimes made to this Roman doctrine of tidelands in support of public rights, but its influence was minimal throughout the development of the common law.[24]

With the decline of commercial navigation and effective government administration in early fuedal England, private rights to the foreshore and fisheries became characteristic of coastal land tenure. These rights originated through local custom and from grants by the Saxon and Norman Kings. When the Doomsday Book was completed in 1086, the foreshore was not recorded as a parcel separate from the upland manor, and it was commonly accepted that in rivers, tidal and nontidal, the manor extended to midstream.[25] Navigation in major rivers became sufficiently impeded by private fishing weirs that these were prohibited in the Magna Carta (1215) except along the open coast.[26]

Private rights in tidelands remained virtually unchallenged until the sixteenth century, when Elizabeth I sought to reaffirm sovereign ownership. In a treatise called "Proofs of the Queen's Interests in Land left by the Sea and the Salt Shores thereof" (c. 1568-1569), Thomas Digges proposed the theory that lands covered by tides were previously ungranted and title was therefore held by the Crown. His theory was based on the supremecy of the Queen's private interests and the fact that many early grants did not expressly include the foreshore.[27] It was

> eagerly accepted by the Stuart Kings, because it suggested a source of unlimited revenue to them in disposing of a strip of land thousands of miles in extent, which had in many cases become immensely valuable. This idea orginated at an opportune time, because the exchequers of those Kings were in a depleted condition, and they began to make use of their new-found prerogative by executing many grants of the seashore...[28]

In attempts to recover possession of the foreshore through the courts, Digges was defeated in every case. However, the persistent efforts of the Stuart Kings and their 'professional title-hunters', who searched for flaws in title that would benefit the Crown, incited landowners to protest the erosion of their customary property rights.[29] Title to the foreshore thus became one of many grievances that eventually led to the fall of Charles I in 1649.[30]

The turning point in gaining legal recognition for sovereign rights was the revival of Digges' theory by Sir Matthew Hale (1609-1685). In a treatise called De Jure Maris (c. 1666-1667), published after his death, Hale contended that

> land between ordinary high-water and low-water mark doth prima facie and of common right belong to the King, both in the shore of the sea and in the shore of the arms of the sea.[31]

In succeeding passages Hale appeared to be aware that, in view of the existing land tenure pattern, this was only legal theory,

> but his statement has been taken in subsequent cases to have established the theory, and has been declared by judge after judge, in every case down to the present day, so that it must therefore be taken as now established as law.[32]

The gradual acceptance of this doctrine by the courts can be partly attributed to radical changes in the British political environment during the seventeenth century and the manner in which Hale's treatise accommodated those changes. England was becoming a major sea power, with national interests in navigation and commerce. After the civil unrest of the mid 1600s, the distinction between the rights and interests of the King and those of the nation or public began to be clarified. The modern concept of lands held by the Crown in trust for the people was also emerging by the end of the century.[33]

Unlike Digges and the Stuart Kings, Hale conceded that sovereign rights to the foreshore could be defeated by evidence of a Crown grant or customary useage.[34] Therefore, existing private rights received some protection under the law. Hale also acknowledged certain public rights essential to the development of a maritime nation, such as navigation and fishing, by introducing the concepts of jus privatum and jus publicum.

Jus privatum refers to the private right of ownership of the soil in tidal waters, and is always subject to the jus publicum, or public rights of use. Title to tidelands can be held by a sovereign, quasi-sovereign, or private person but is prima facie in the Crown.[35] Although the nature of the jus publicum had become narrowly construed over the centuries, Hale's theory of 'public rights held in trust' by the sovereign reinstated, at least in part, the Roman doctrine of res communes. In American jurisdictions, it has provided a legal cornerstone for the protection and expansion of public rights in tidelands today.[36]

3.1.3 Jus privatum

The fact that Hale's doctrine did not become part of the common law until after the seventeenth century has important consequences in the granting of the foreshore in North America. As the majority of Canadian settlements occurred after the acceptance of the sovereign interests in tidelands, title to the foreshore remains primae facie in the Crown unless expressly included in a Crown grant.[37] In contrast, the colonial ordinances of 1649 for Maine and Massachusetts stated that

> in all creeks, coves, and other places, about and upon salt water where the sea ebs and flows, the Proprietor of the land adjoyning shall have proprietie to the low water mark where the Sea doth not ebb above a hundred rods, and not more wheresoever it ebs farther.[38]

These earlier laws reflect the dominant English tenure patterns and court decisions at that time, and the presumption that the foreshore is vested in the upland proprietor has been upheld in these states.[39]

Early grants in the Maritimes may also have extended to the low water mark in isolated cases, but most private rights to the foreshore have been gained through grants and leases of this area as a separate parcel. Where no lot has been issued, some foreshore structures may have established a claim to possessory rights. In the Irving case,[40] for example, the same criteria were to be established for adverse possession and colour of title in the foreshore, except for exclusive possession, as for claims to the upland. However, a claim based on a breakwater was defeated because it obstructed the public right of navigation.[41]

Leases avoid the problem of granting permanent rights to Crown lands, particularly if provincial or federal jurisdiction is in question. In such major ports as Saint John, the National Harbours Board has acquired title to the foreshore and bed, and leases are now issued for wharves and other harbour improvements.[42] Pier and wharf leases may extend below the low water line, as one lot or in tiers. Special purpose leases or licences can also be obtained in designated areas for such activities as harvesting Irish moss or cultivating oysters.[43] In all cases, the use of the foreshore and bed is subject to federal regulation of navigation,[44] and other legislation, such as the Nova Scotia Water Act, may seriously affect the status of private interests.[45]

Since public harbours fall under federal jurisdiction in the British North American Act,[46] the validity of some water lots granted or leased by the provinces after Confederation may also be in doubt. In his discussion of the issue, Masland concludes that

> in order to be valid, [the lot] (i) must have been issued before Confederation, (ii) if, after Union it must have been issued by the Dominion Government if the lot fell within a designated harbour, or (iii) it must have been issued by the Provincial authority if anywhere else.[47]

Major problems are determining whether a harbour is public in law and defining the seaward and landward jurisdictional boundaries.[48]

Whereas public harbours have been described as "a mosiac" of federal, provincial, and private ownership,[49] jurisdiction in submerged lands has been called "a sea of confusion".[50] In the leading Canadian precedent, provincial jurisdiction in British Columbia has been limited to lands above the ordinary low water mark.[51] The status of claims by the Maritime Provinces to the offshore may be more favourable because there is support on historical grounds. Such is the case in the Bay of Fundy, where the interprovincial boundary was delineated as the middle thread of the Bay after New Brunswick obtained provincial status.[52] Unlike British Columbia, the Maritime Provinces also enacted legislation affecting the traditional three mile territorial sea before Confederation.[53] The issue of the jus privatum in submerged lands has been at least temporarily suspended, however, since New Brunswick, Nova Scotia, and Prince Edward Island are focussing on management agreements with the federal government for offshore development.[54]

3.1.4 Riparian and littoral rights

Riparian rights are special property rights of natural advantage that are attached to land abutting tidal or nontidal waterbodies.[55] Derived from the word ripa or bank, the term 'riparian' should strictly refer only to lands bordering rivers. Although the term 'littoral' is reserved for lands bounded by oceans or lakes, riparian is often used in a general sense to cover both situations.[56]

La Forest has classified riparian rights to include the following: access to the water; drainage; flow (quantity); quality; use of the water; and accretion.[57] Of these, access and accretion are the main concerns in the delimitation of tidal boundaries. The right of access is fundamental because it is through access to coastal waters that the riparian owner is able to enjoy his other riparian rights.[58] Along tidal waters, the right of access includes the right to cross the foreshore, and obstructions that bar the riparian owner's access constitute an interference by law.[59]

Since shorelines shift over time, the right of accretion protects the riparian owner's access to the foreshore and water. Other rationales for the right of accretion include reciprocity in gaining or losing land over a period of years and the inability to measure changes from one day to another.[60] The following distinctions in terminology can be made regarding accretion:

a. accretion: the gradual and imperceptible deposit of alluvium on the banks of a riparian property;[61]

b. reliction: the addition of land to a riparian property due to the gradual and imperceptible recession of the water level;[62]

c. erosion: the gradual and imperceptible wearing away of land bordering on a body of water by the natural action of the elements;[63]

d. avulsion: either the sudden and perceptible alteration of the shoreline by the action of water, or the sudden change in the course of a stream, whereby it abandons its old bed.[64]

The chief test in determining whether a property boundary changes with alterations in the watercourse or shore is the criterion "gradual and imperceptible'. Only in cases of avulsion is the boundary not affected. 'Gradual and imperceptible' is a qualitative rather than quantitative criterion and it varies with the individual circumstances. For example, seasonal variations in land formation were considered accretion in <u>Clarke v. City of Edmonton</u>[65] because the process was imperceptible from day to day. In a Yukon case, however, the sudden breaking away of the top of a bank caused by daily slumping of the underlying soils was ruled avulsion.[66]

In the Shaw case[67] and in the prior decision Attorney-General of British Columbia v. Neilson,[68] a distinction was made between vertical and lateral accretion. The former is the accumulation of sediments on the bed in tidal waters and the latter results from deposits to the shore. Vertical deposition was ruled to remain with the owner of the bed in the British Columbia case and claims to accretion in both cases were limited to those lands lying above the ordinary high water mark (OHWM).[69]

Accretion need not be natural, but the intention of the parties and the rate of infilling may be factors. In Mahon v. McCully,[70] a breakwater was built for the purpose of reclamation, and the lands so formed over ten years were ruled not to be accretion. In the Irving decision, however, changes in the shoreline caused by the dumping of material over an embankment were held to be consistent with the riparian owner's right to protect his property against the forces of nature.[71] Infilling in marshlands in the United States have instigated state claims to former natural high water lines. Such measures to protect natural coastal resources from private appropriation have been based, at least in part, on the public trust doctrine.[72]

3.1.5 Jus publicum

Both the nature and legal support of public rights have undergone transitions over time, as illustrated in Figure 3.2. Throughout the development of the common law, only the right of navigation remained intact. Other public rights recognized in Roman law, including access and use of the foreshore, disappeared in prefeudal England. With the signing of the Magna Carta, private fisheries underwent minor

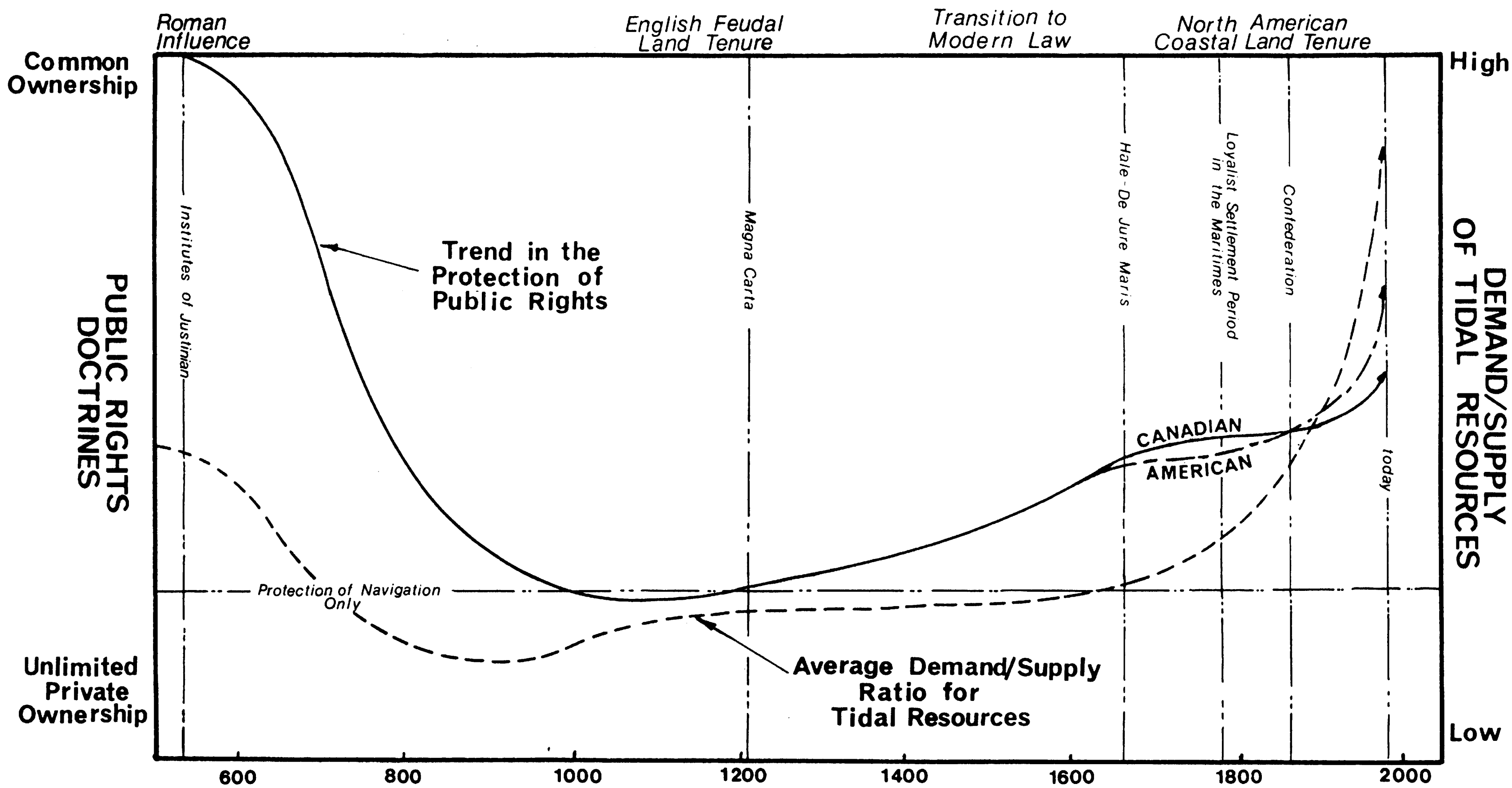

Figure 3.2: The Relationship Between the Demand/Supply of Tidal Resources and Support in Law for Public Rights[73]

restrictions to protect navigation, but the linkage of the public right of fishing to this doctrine, found in Canadian law,[74] has been disputed.[75]

In the transition to modern coastal law, the jus publicum concept was gradually accepted and became part of North American law. Public rights related to fishing were further protected in the Maritimes by Crown reservations from early coastal grants. However, as allocation of resources through the market became characteristic of North American land tenure and the competition for tidal resources grew, only specific public rights, often denoted as easements, were recognized over the many privately held tidelands and riverbeds.[76] Canadian legislation has since placed some limitations on private interests, including riparian rights,[77] but recent American law has placed more emphasis on the public trust doctrine and comprehensive coastal zone management (CZM) programs to resolve conflicting public and private interests in tidelands.[78]

In the Maritimes, the common law has mainly focussed on the protection of the traditional rights of public navigation, fishing, and the floating of logs. Navigation is

> a paramount right; whenever it conflicts with the rights of the owner of the bed or of a riparian owner it will prevail.[79]

Although public navigation may exist in fact on nontidal rivers, it is considered a public easement or right-of-way established by long customary useage.[80] The right of floating logs, which may interfere with other public and private rights, was protected by early legislation but easements may now exist in some rivers.[81]

As in the case of navigation, the public right of fishing only exists in tidal waters under the common law. Private fisheries, often called several fisheries,[82] belong to the owner of the bed in nontidal rivers, where title ad medium filum aquae is by presumption with the upland proprietor.[83] Along the coast, the public right of fishing includes the right to dig for clams or other shellfish on the foreshore, whether this is sovereign or private land.[84]

Public access for specific uses of the foreshore area was traditionally protected by reservation in the Maritimes. Fishing or fish rooms were reserved from original grants on a systematic basis in Prince Edward Island and more sporadically in Nova Scotia.[85] In Prince Edward Island, grants along the open coast were subject to reserves of five hundred feet (approx. 152 metres) landward of the high water mark for the erection of fish stages and drying nets.[86] Through more recent legislation, reservations have also been retained from grants along selected New Brunswick rivers.[87]

Public access for recreation has become a recent issue in many American states as demands for coastal resource use have intensified over the last several decades. The entrenchment of the public trust doctrine in the common law of the United States supports efforts to protect public interests in tidelands, although courts have not always interpreted this doctrine broadly.[88] Other legal means that have been proposed or implemented to secure public access include custom, dedication, prescription, and legislation.[89]

Along the Maritime coasts, national and provincial parks have maintained many beaches and shore areas for recreation. Despite the significance of tourism to the provincial economies and the increasing value and use of shore property, public access has not been a major legal concern to date. The issue has, however, been considered with regard to the need for CZM programs.[90]

3.1.6 Coastal zone management

The coastal zone may be defined as those regions adjacent to and including the shore that have an impact on or are directly affected by coastal resources or their use. It extends seaward and landward as far as the coast is a dominent influence, geographically, socio - economically, or environmentally.[91] For management purposes, coastal zone limits may be narrowly or broadly construed and/or made to coincide with jurisdictional limits.[92]

American CZM programs have been implemented in response to growing conflicts of interests in coastal resource use, the need for land use planning, and concerns for conservation.[93] No such comprehensive program currently exists in the Maritimes. Provincial legislation affecting coastal land tenure regulates such activities as beach and environmental protection, marshland reclamation, water resource use, and expropriation for large public works.[94] However, the present jurisdictional uncertainty and the lack of large scale resource and land use mapping in the coastal zone are impediments to providing a comprehensive management approach.

The design and implementation of land use plans was one recommendation of a 1973 Maritime coastal zone seminar.[95] In a detailed assessment of an administrative structure for CZM in Atlantic Canada, the need for coastal information systems to support such planning activities was also identified.[96] Tidal boundary delineation would be among the information requirements for implementing these or other CZM initiatives.[97] Based on American experience,[98] the delimitation of these boundaries could come under scrutiny as government agencies take a more active role in the Maritime coastal zone.

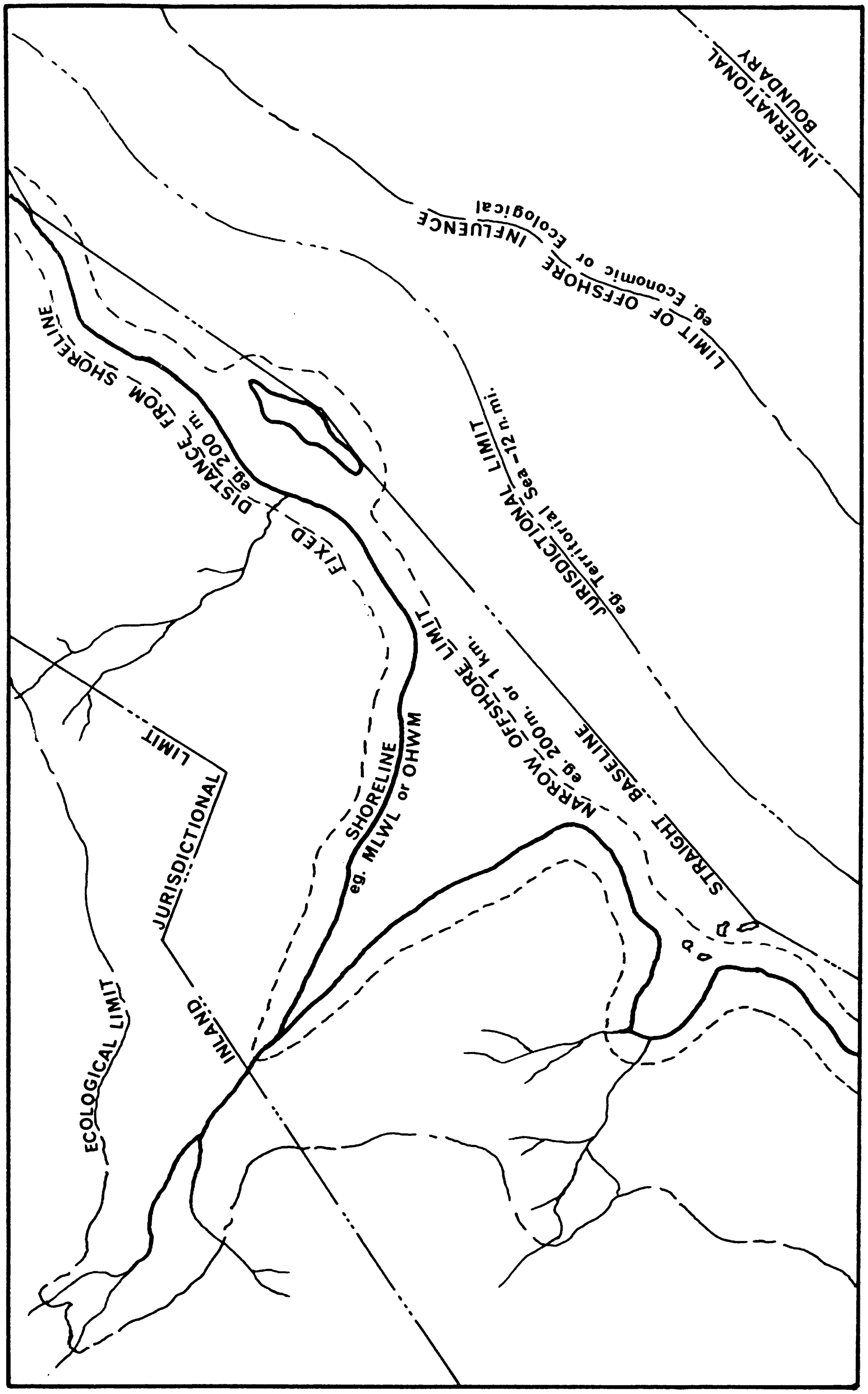

Figure 3.3: Examples of Coastal Zone Limits

3.2 Tidal Boundary Definitions

When Sir Matthew Hale defined the seaward limit of private ownership as the OHWM, the legal and surveying professions inherited the problem of interpreting this definition. The OHWM is the most prevalent term in the Maritimes, but medium, average, and mean high water mark are also in use. Although the mean high water line (MHWL) is mainly an American definition, it is reviewed here in light of its current and potential influence in the Maritimes. Shalowitz[99] and Maloney and Ausness[100] trace the history of both the OHWM and MHWL definitions as applied in the United States. Corker[101] provides an assessment of these definitions with regard to a landmark Washington state case. Maritime definitions are summarized by La Forest,[102] but are treated more extensively with respect to surveying by Doig[103] and MacDonald.[104]

3.2.1 The ordinary high water mark

In defining the interests of the sovereign in tidelands, Hale acknowledged three types of tides:

a. the high spring tides, which are the fluxes of the sea at those tides that happen at the two equinoxes; and certainly this doth not de jure communi belong to the crown. For such spring tides many times overflow ancient meadows and salt marshes, which yet unquestionably belong to the subject;

b. the spring tides which happen twice every month, at full and change of the moon, and the shore in question, is by some opinion not denominated by these tides neither, but the land overflowed by these fluxes ordinarily belong to the subject prima facie, unless the King hath a prescription to the contrary;

c. ordinary tides or neap tides, which happen between the full and change of the moon; and...that which is covered by the ordinary flux of the sea, is the business of this enquiry.[105]

One problem with this distinction, as pointed out by Shalowitz, is that ordinary tides are equated with neap tides, whereas in scientific terminology, neap tides are those with the smallest range that occur near the first and third quarters of the moon.[106] 'Ordinary' also has no scientific meaning that would distinguish these tides from any other class. Whether Hale meant average or neap tides is left unclear and his doctrine has been subject to both interpretations.

'Ordinary or neap' has been interpreted strictly as neap tides in Californian law, the decision of Teschemacher v. Thompson[107] setting the precedent. In the Maritimes, however, extraordinary or extreme levels were excluded from the meaning of ordinary tides in Lee v. Arthur.[108] Freshet levels in a tidal river were also not considered to be ordinary in Re McNichol.[109]

The major precedent for the Maritime Provinces was set in 1854 in the British decision Attorney-General v. Chambers,[110] in which the Court emphasized the significance of Hale's doctrine, noting that

> [all] the authorities concur in the conclusion that the right is confined to what is covered by "ordinary" tides, whatever be the right interpretation of that word.[111]

The Court in its judgement defined the ordinary tides as

> the medium tide between spring and neaps...It is true of the limit of the shore reached by these tides that it is more frequently reached and covered by the tide than left uncovered by it. For about three days it is exceeded, and for about three days it is left short, and on one day it is reached.[112]

Citing several Canadian interpretations of the OHWM, La Forest does not clarify the matter. Instead he lists all of the common terminology, stating that by

> ordinary high water mark is meant the medium high water mark at ordinary or neap tides...It is this medium tide that has been adopted as the ordinary or mean high water mark.[113]

Although tidal observations are mentioned, no attempt is made to define the boundary more precisely in terms of a MHW datum.[114]

Surveyors, who are concerned with locating the OHWM on the ground, have interpreted this boundary as a physical mark left on the shore. This is the case in the Instructions for Canada Land Surveyors[115] and in the regulations pursuant to the Nova Scotia Land Surveyor's Act.[116] In the latter, the OHWM is defined as

> the limit or edge of a body of water where the land has been covered by water so long as to wrest it from vegetation, or as to mark a distinct character upon the vegetation where it extends into the water or upon the soil itself.[117]

Similar definitions are found in the United States.[118]

This interpretation as a physical mark may have some support in case law. For example, in Attorney-General v. Chambers,[119] the Court referred to Hale's treatise and came to the conclusion that the intention was to delimit those lands that were "for the most part dry and manoirable," interpreted as being capable of cultivation.[120] The OHWM is often taken as the limit of vegetation, a convenient landmark for surveyors, but the relationship of shoreline features or the limit of cultivation to the average tides can be elusive and is discussed in more detail in the following chapter.

3.2.2 The mean high water line

In 1935, the Borax[121] decision set a new precedent in American federal law by recognizing the OHWM as the line of MHW. The United States Supreme Court emphasized in their decision that the OHWM

> meant the intersection of a tidal datum with the shore, and had no particular relation to a physical tide mark or vegetation line.[122]

In determining which tidal datum was to be used in delimiting riparian boundaries, judicial recognition was given to the MHW datum as defined by the United States Coast and Geodetic Survey (USC&GS). The Court held that "an average of 18.6 years of tidal observations should be used to determine the datum elevation."[123]

In his critique of the Borax definition, Corker points out that nontidal influences, which make a significant difference in the MWH elevation of Los Angeles Harbor, were ignored by the USC&GS and the court in that case.[124] This problem appears to have been alieviated because the current American MHW datum is based on observed water level heights (see Section 2.4.2). Another issue that has been addressed in the United States is the determinination of a MHW datum in areas where tides are mixed but mainly diurnal and large differences between successive high waters occur. Regardless of any difficulties in the Borax definition, however, its use has been promoted in the United States and it has been described as "a progressive decision which incorporates the most accurate methodology for determining tidal boundaries."[125]

The MHW line or mark has entered the case law and legislation of the Maritimes, but in a sporadic fashion and without precise definition. In most cases, the term 'mean' is only a synonym for 'ordinary' and no accurate determination of a tidal datum is implied. Although the Court referred to the riparian boundary in the Irving case as the mark of the ordinary or neap tides, throughout the trial the term 'mean' was employed in reference to the high water mark called for in expropriation documents. Since the boundary actually demarcated was the intersection of a tidal datum with the shore, the use of this terminology appears consistent with the American definition. In the judgement the Court conceded that

> [while] it would be difficult to arrive at this level [MHW] from a study of the tide tables alone, I accept 24.1 feet Saint John Harbour datum as the average high tide and as what is referred to in this case as the high water line. That is the dividing line between the upland and the foreshore.[126]

Other New Brunswick cases, including Ames v. New Brunswick Electric Power Commission,[127] call for the "level of mean high tide" as the riparian boundary on tidal waters. Nova Scotian legislation, such as the Beaches Preservation and Protection Act,[128] also refers to the "mean high water mark". No attempt is made to define either term, and the assumption could only be made that it is used as being equivalent to medium, as stated in Attorney-General v. Chambers. Without reference to a well defined datum, a MHW line or mark is neither a precise nor consistent interpretation of the OHWM.

3.2.3 Low water boundaries

Where grants or leases of the foreshore call for a low water boundary, definitions corresponding to high water boundaries are generally applied. In Doe d. Fry v. Hill[129] and in Delap v. Hayden,[130] for example, extraordinary low waters were excluded from the definition of the ordinary low water mark (OLWM). However, boundaries were occassionly referenced to low water spring tides or chart datum in some harbours, where safe navigation was the primary concern of harbour authorities who issued foreshore grants or leases. Low water boundaries in many American jurisdictions are also defined as the mean low water line (MLWL).

Jurisdictional and political boundaries often call for low water boundaries for delimiting offshore limits. In defining the seaward limit of provincial jurisdiction in British Columbia, the Supreme Court decision called for the OLWM.[131] Under the United Nations Third Law of the Sea Convention,[132] baselines may either be defined as the intersection of chart datum with the shore or as straight lines connecting headlands. Whereas Canada uses straight baselines for offshore boundaries,[133] American baselines are referred to chart datum, the MLLW datum currently being used on the Atlantic coast.[134] The actual location of the MLLW line may change, but for boundary delimitation it can be 'fixed' with respect to a particular chart.[135]

3.3 Ambulatory and Fixed Boundaries

The coast is never a static environment. Waves, winds, currents, and storms are continuously adding sediments in one area, while eroding the shore in others. Human activities and variations in mean sea level also affect the character and topography of the coast. Through these processes, the location of the lines or marks that define tidal boundaries also vary over time.

Both ambulatory and fixed boundaries entail a number of legal and surveying issues, only a few of which are touched on here. Graber[136] Maloney and Ausness[137] provide examples of some of these problems, while Dowden[138] and Nunez[139] examine a California decision involving seasonally fluctuating boundaries in detail. Methods for apportioning accretion between adjoiners are described by Brown et al.[140] In their discussion of relocating former tidal boundaries, Porro and Teleky[141] propose a method for evaluating evidence of former water boundaries now obscured by shore modifications.

3.3.1 Ambulatory boundaries

A tidal boundary may be considered ambulatory if changes in location do not affect its legal status as a property or jurisdictional limit. Among the problems that arise from the ambulatory nature of water boundaries are the legal weight of survey measurements, the apportionment of accretion, and the delimitation of seasonally fluctuating boundaries.

Since most tidal boundaries are ambulatory, survey measurements are only an indiction of the boundary location at the time of the survey.[142] An established rule of property law is the priority of natural monuments over measurements in legal descriptions,[143] based on the premise that a call for a natural feature best demonstrates the intention of the granting parties and is least susceptible to error.[144] When a boundary is defined by a waterbody, or its bank, shore, water line or mark, these natural monuments will, in general, govern any incompatible survey measurements.[145] On the other hand, if parcel boundaries are controlled by other natural or artificial monuments, they will continue to define the boundary regardless of the location of the waterbody.[146]

In a British Columbia case,[147] for example, a one chain Crown reservation defined as being landward of the high water mark was held to be ambulatory but fixed in width. It was argued that accreted land belonged to the owner of the adjacent upland, which in this case was the Crown reservation. Although the natural monument (HWM) controlled the position of the seaward boundary, the Court ruled that the landward boundary was governed by the width because no other measurement fixed its location. By holding the width constant, the reservation was also protected from decreases with the reciprocal process of erosion.[148]

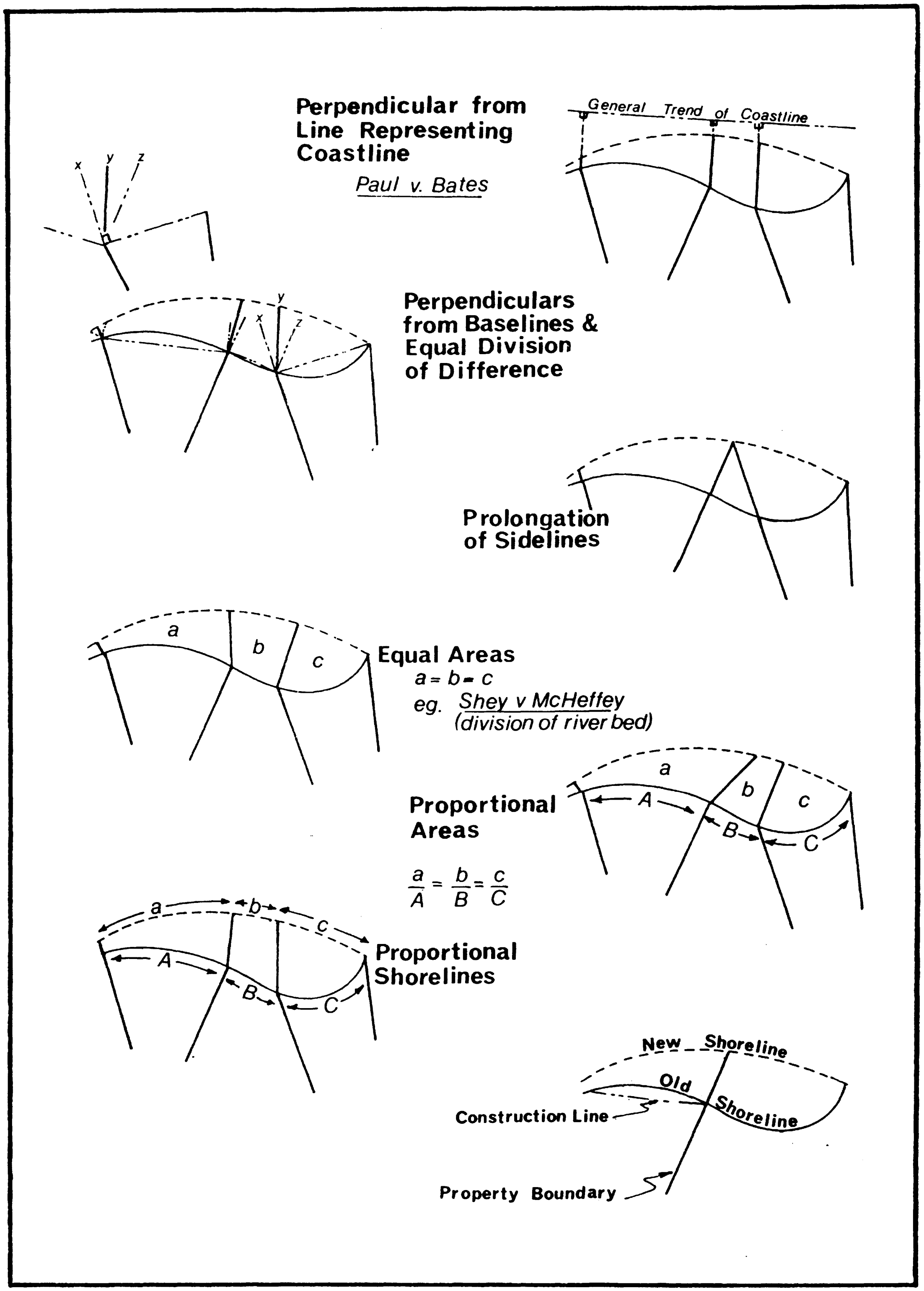

Figure 3.4: Methods of Apportioning Accretion[149]

In a legal survey of coastal property where the boundary is ambulatory and accretion has occurred, the boundary between adjacent landowners must also be delimited. Little guidance is given in Canadian case law for apportioning accretion, the most common survey procedure being the extension of the parcel sidelines. However, the sideline in the British Columbia decision, Paul v. Bates,[150] was defined as being perpendicular to the general direction of the coast. In Shey v. McLeffey,[151] a Nova Scotian salt marsh was divided equally in area after a stream changed its course. On a convex or concave coastline, divisions by proportional area or shorelines may be more equitable solutions as illustrated in Figure 3.4.[152]

Not all boundaries defined as a water line or mark are ambulatory, the test generally being whether movement is gradual and imperceptible. Where a coastline is subject to seasonal patterns of large scale sediment transport, highly fluctuating boundaries can cause problems in delimitation. For example, in a Californian case, People v. Wm. Kent Estate Co., et al.,[153] the summer location of the MHW boundary was approximately 25 metres seaward of the winter line.[154] A similar seasonal pattern was established in Trustees of Internal Improvement Fund v. Ocean Hotels, Inc.[155] in Florida, where the boundary fluctuated approximately 30 metres. The winter line, in both cases, was to the detriment of the upland proprietor, while the summer line would deprive the public of access to a large portion of the beach.[156]

After survey information and beach profiles were collected over several years in the Kent case, an Appeal Court decided that

> [in] order to fix the boundary between the upland and the tideland, the parties should determine the average line of the shore throughout the year, taking into consideration the seasonal movement of sand.[157]

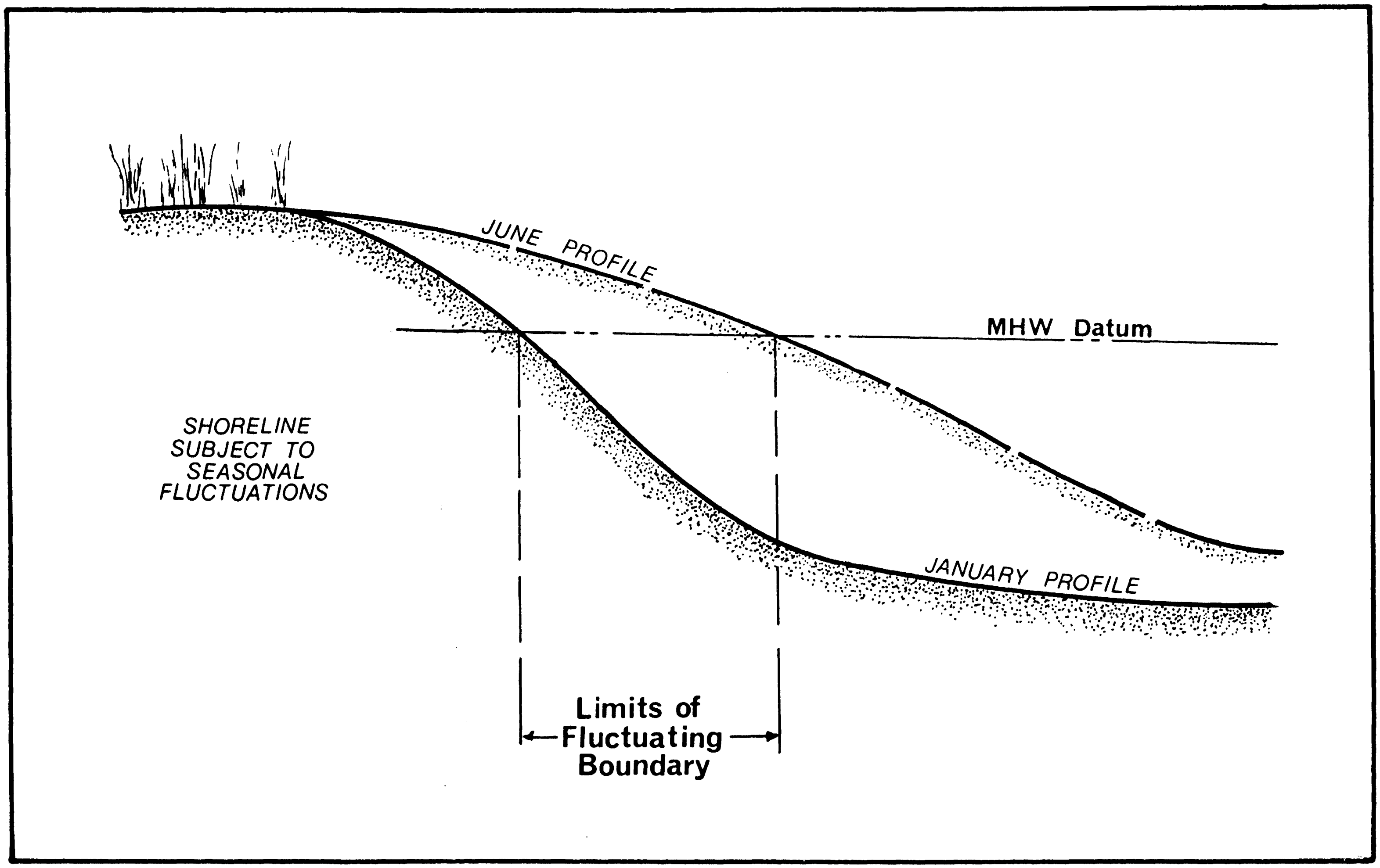

Figure 3.5: Profile of a Seasonally Fluctuating Shore Showing Horizontal Movement in MHWL Location

The Florida judgement ruled in favor of the winter line, thus placing more weight on the public trust doctrine, although this decision has since been appealed.[158]

In both cases, the fluctuations were not considered to be gradual or imperceptible and the concept of an ambulatory boundary was rejected. One practical reason for such decisions, as forwarded by Nunez, is that

> [the] parties would never be able to make permanent use of any portion of that strip [between summer and winter lines], because at some time during the year, the adverse party [state or upland proprietor] would own it...If there are any policy reasons in favor of permanence of boundaries, allowing adjoining landowners full knowledge of the extent of there ownership, a finding of accretion and erosion in this [Kent] case would surely create a conflict.[159]

It could be argued that a OHWM definition, interpreted as a vegetation line, may provide a relatively stable yet ambulatory boundary in such cases, since this line could be easily identified and would only reflect long term changes in the shore.

3.3.2 Fixed boundaries

As illustrated in the Kent and Ocean cases, situations arise in which the boundary of the shore is 'fixed' in time and location. Among other reasons for fixing boundaries are certainty of location, ease and efficiency in demarcation, and the protection of public interests, particularly in cases of significant artificial changes. Examples of fixed boundaries include erosion lines,[160] occupation lines, and former water marks or lines. In Saint John, for example, the National Harbours Board has defined portions of its landward boundaries as 'the line of occupation of 1936'.[161] Water lots in other harbours are also referred to former water marks or shore conditions, but relocating these boundaries after years of natural and artificial shoreline modifications is often difficult, if not impossible.[162]

One well documented encounter with these difficulties is provided by recent efforts to implement tidelands legislation in New Jersey.[163] Over the last century, large tracts of now valuable coastal land were reclaimed by upland proprietors. The State made several attempts through both legislation and the courts to invalidate titles to these former tidelands, particularly where changes were artificial.[164] Although a public referendum has recently placed a 40 year limitation on state claims, many titles are still in question.[165] Evidence of prior tidal boundaries, ranging from historic documents to modern scientific analyses, is often required to support each boundary position.[166] To evaluate this evidence and to settle adverse tideland claims efficiently, an arbitration procedure was proposed that would assign consistent weights or 'factor points' to the evidence based on its "conclusiveness and reliability".[167]

In Maritime litigation, the evidence collected to relocate former boundaries has also been diverse and sometimes contradictory. The Shaw case, for example, entailed several ground surveys, geomorphological and vegetation analyses, and tidal measurements to support the Crown's defense.[168] In the Irving trial, the proceedings were lengthened by confusion over the boundaries and datums shown on numerous charts and plans. Expert witnesses also testified as to the nature and extent of nineteenth century ship building in Saint John Harbour based on historical records and soil analysis. [169] As these cases have already demonstrated, relocating former boundaries add significantly to the cost and length of litigation. Although this may be unavoidable in some situations, fixing boundaries by former conditions greatly increases the possibilities for such litigation in the future.

3.4 Assessment of Land Tenure Problems and Boundary Definitions

No attempt can be made in this overview to outline specific land tenure requirements with respect to tidal boundary delimitation in the Maritimes. To provide a definitive analysis, a thorough study of land tenure, coastal land economy, and legislation would be required. The following assessment is therefore restricted to identifying some of the problem areas that currently exist or may be encountered. In the discussion of tidal boundary definitions, judgement on an appropriate definition for the Maritimes is reserved for the surveying and legal professions, but a few of the problems are indicated.

3.4.1 Coastal land tenure problems

Maritime coastal areas are subject to far less litigation than has been experienced in the United States. This may be partly due to lower property values, relatively stable land tenure, and the current low level of federal and provincial activities in tidelands. However, all of these factors are subject to change should, for example, economic development escalate or CZM legislation be implemented.

To assess tidal boundary requirements in the United States, the National Ocean Survey compared real estate values for coastal property and appraised tidelands that could be affected by small differences in tidal boundary delimitation. The average value per acre in 1974 for undeveloped land was estimated to range from approximately $4,000.00 (North Carolina) to $400,000.00 (New Jersey). Even when the lower limit was considered as representative of the American Atlantic coast, a strip of tidelands approximately 30 metres wide represented several billion dollars in property values.[170]

Similar regional differences could be expected within the Maritimes. If accuracy requirements are to be based on property values alone, then urban, residential, and recreational areas could be considered high risk areas for tidal boundary litigation, particularly in cases of expropriation. Marshlands or other lands proposed for environmental protection should also be given special consideration. An example of the scale of values placed on coastal areas undergoing land use transition is given in the Shaw case, where marshland valued at approximately $3000.00 in 1938 was the subject of a claim for two million dollars in 1978.[171] Although the Court dismissed the claim as unreasonable, similar property values have spurred costly litigation in the United States.

The current stability of coastal land tenure in the Maritimes, with regard to tidal boundaries, could be undermined by many factors, a few of which are identified below:

a. intensive or extensive port development: This has already been the cause of litigation in Saint John Harbour and the present confusion over federal/provincial jurisdiction raises the possiblity of further problems in other areas. The policy of fixing water lot boundaries by former shore conditions also creates difficulties in relocation;

b. expropriation: Since expropriation entails land valuation, accurate boundary surveys are generally required. Confusion in interpreting tidal boundary definitions could lead to adverse claims and litigation. In the Irving case, the Court also questioned the validity of expropriating riparian rights when no upland is taken, although both parties agreed to the procedures.[172] Other legislation may have the effect of limiting or expropriating riparian rights and property interests without compensation.[173] If the right of accretion is affected, this type of legislation could raise boundary issues;

c. coastal development: New development often involves expropriation and precise surveys and may also require clarification of legislative constraints and federal/provincial boundaries;

d. CZM legislation: Whether comprehensive or limited in scope, CZM legislation could focus attention on all coastal boundaries. Marshland and beach legislation, for example, has caused much of the tidal boundary debate in the United States. At the same time, CZM could offer an opportunity to clarify the existing law and jurisdictional issues;

e. Bay of Fundy Tidal Power Project: Minor property disputes have already occurred behind the barriers at the pilot project on the Annapolis River but these have been settled out of court.[174] However, changes in tidal levels throughout the Bay of Fundy and Gulf of Maine could affect property boundaries along the entire coast. If a major project proves feasible, it may be the impetus for CZM and shoreline mapping. Boundary delimitation, before and after a major project, would help to minimize potential litigation costs.

Although these do not exhaust the potential requirements for tidal boundary delimitation, they do indicate that the present lack of concern over these boundaries may be short lived.

3.4.2 Assessment of tidal boundary definitions

In spite of the ambiguity surrounding the OHWM, its use in the Maritimes has been accepted customary practice in both law and surveying. The general intent of the common law is generally apparent and is followed in most cases. Some of the major problems are the call for neap tides and the lack of distinction between the OHWM and the MHWL. Although precise definition may not be a concern of the legal profession, due to the ambulatory nature of the boundary, the present disregard for the tidal phenomena and consistent terminology has left few guidelines for surveyors.

The general inconsistency can be illustrated by the recent Shaw judgement, in which the Court used every term associated with high water boundaries interchangeably, first citing Wisdom on the definition of ordinary tide as

> taken at the point of the line of medium high tide between the spring and neaps, ascertained by the average of the medium high tides during the year[175]

and then quoting La Forest. In the latter definition, La Forest attempts to "add precision" by noting that "the law takes cognizance of three types of tides" and then defines the those tides distingished by Hale, including the "ordinary or neap tides".[176] Whether La Forest has added precision by this terminology is doubtful, but perhaps he is also pointing out a distinction between legal and scientific definitions of neap tides.

Wisdom's definition is more consistent with the American definition of MHW, however, no precise method of arriving at an "average" of "medium high tides" is indicated. Unless a tidal datum is defined as the mean of all the high tides over a period of observations,

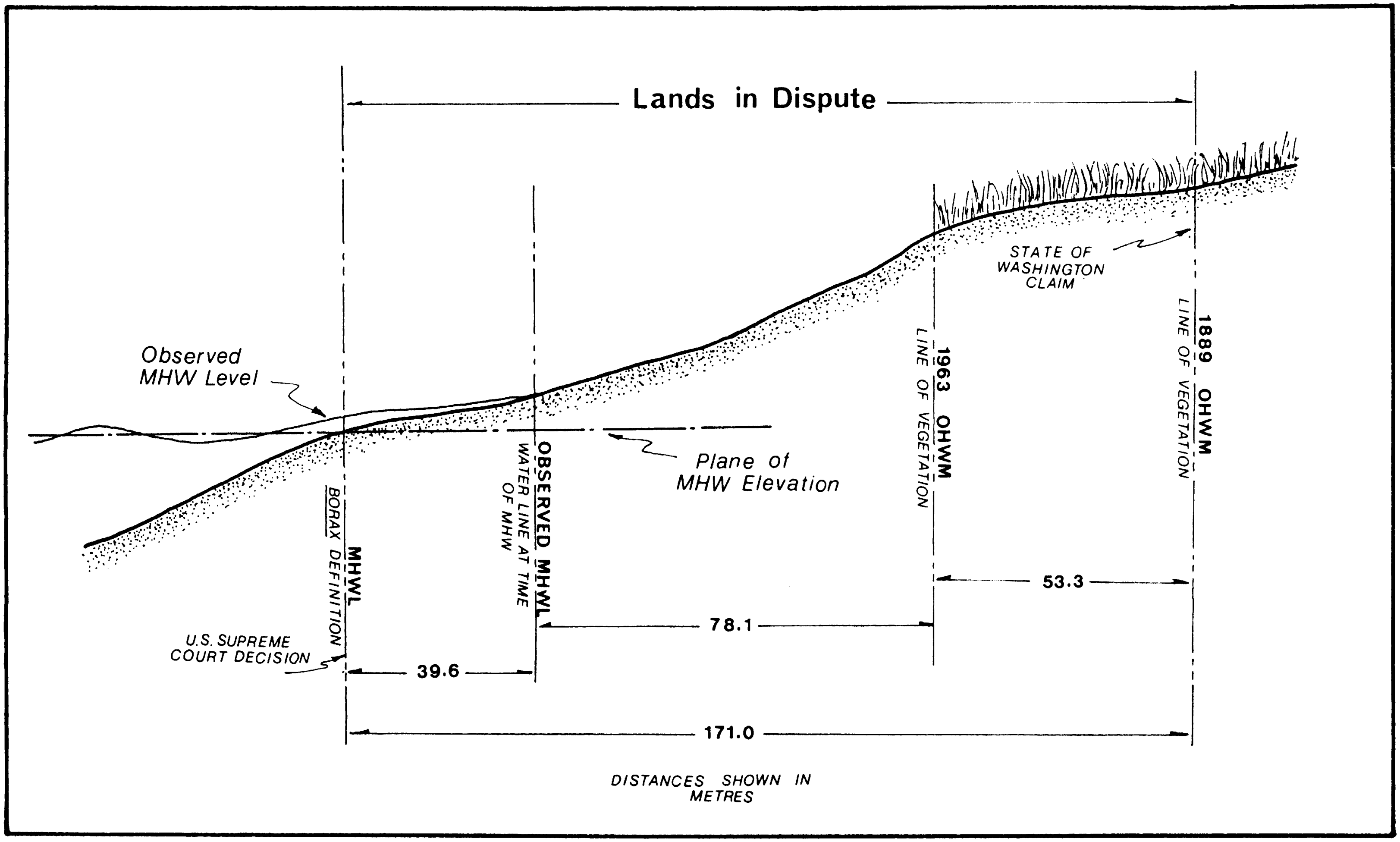

Figure 3.6: OHWM and MHWL Boundaries in Hughes v. Washington[177]

'extraordinary' tides must be specified and excluded from any datum determination. Not only would this be inefficient, but ample opportunity is left for inconsistent interpretations and demarcation procedures by surveyors.

The disparity between the various definitions in use in the Maritimes can be demonstrated by the boundaries considered in Hughes v. Washington,[178] which are shown in Figure 3.6 as reported by Corker.[179] The vegetation line has little relation to the reach of the 'average' tides. Corker also notes that the MHWL as determined by the Borax definition is approximately 40 metres seaward of the observed MHWL. While the former represents the intersection of the MHW datum plane with the shore, the latter reflects the influence of waves and other nontidal effects on the MHW elevation. One additional problem area Corker mentions is the potential discrepancy between the OHWM definition for nontidal boundaries and the MHWL for tidal boundaries in the transition zone of a river.[180]

While the OHWM conveys the intention of the law and probably meets most delimitation requirements in the Maritimes, the perpetuation of unscientific and inconsistent definitions encourages both legal and technical misinterpretations that could lead to litigation in the future. Time and effort is currently lost during legal proceedings whenever the 'correct' interpretation of the OHWM is sought. However, a decision to legally recognize a precise MHWL definition should only be made after an assessment of the need for such a change in law and the potential costs. Improved tidal information and survey procedures would be major considerations in implementing a MHWL definition and may not be warranted on the basis of the land tenure requirements.

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CHAPTER 4

TIDAL BOUNDARY SURVEYS

> Tradition by itself is not enough; it must be perpetually criticized and brought up to date under the supervision of what I call orthodoxy.
>
> T. S. Eliot

Cadastral survey standards should ensure that tidal boundary demarcation is appropriate and consistent, in addition to emphasizing accuracy. Consideration should be given to the boundary definitions recognized in law, land tenure requirements, customary practice, and the available technological or scientific support. Procedures for tidal boundary surveys should reflect, for example, the distinction between the definition of the OHWM and the MHWL. Existing or anticipated changes in coastal land tenure requirements should also influence procedural and accuracy specifications. Although new technologies, procedures, and information may also influence survey standards, in practice, changes in conventional procedures are often incremental and cost dependent.

This chapter reviews conventional survey procedures as applied in the Maritime Provinces and some of the recent developments in tidal boundary surveys in the United States. Rather than advocating particular survey methods, the objective of the assessment that follows is to initiate a more comprehensive critique by the survey profession. Some of the weaknesses in traditional surveys and limitations in adopting new methods without legal or scientific support are therefore indicated.

4.1 Conventional Tidal Boundary Surveys

For the purpose of this review, conventional surveys encompass both first and second generation methods as outlined in Section 1.2.2. Survey practices in the Maritimes include locating the tide mark by physical features, marking the visible water line at a particular stage of tide, and traversing the horizontal component of the tidal datum as a contour. While some form of tidal datum information is a prerequisite for all but the first procedure, the differences between the provision and use of this information in the Maritimes and in the United States justifies including these methods together in a discussion of conventional surveys. Conventional tidal boundary surveys are not well documented, particularly in the Maritimes. For this reason, interviews with practicing surveyors (see Appendix I) have been relied upon heavily, as well as legal references, the case reviews presented in Appendix II, and survey regulations.

4.1.1 Physical evidence of the tide mark

By defining the OHWM in terms of physical features, survey regulations, such as the N.S.L.S. and C.L.S. regulations,[1] specify the evidence that is to be gathered in tidal boundary surveys. Although the OHWM is sometimes narrowly construed as the limit of vegetation, Maritime surveyors actually rely on many physical features as evidence of this mark in their surveys. The diversity of the evidence has been described by MacDonald as follows:

> the identification on the ground of the feature as defined by these regulations, varies in complexity and exactitude depending on the nature of the geology, geography, vegetation and body of water at the particular site in question. Where you

> have vertical, rock or earth cliffs confining the bed of the body of water, there is no great problem. On the other end of the scale, where you are confronted with the marsh lands of many parts of the coastline or inland waters, it requires a much greater understanding and examination of the subtilties of the vegetation gradients as one moves from land borne to marine borne vegetation. Where the physical geology (cliffs, precipitous banks, etc.) or the vegetation gradient (marsh lands) are not present to aid in your quest, it is necessary to examine the action of the water on the soil itself. The word soil being used of course in its broad meaning of bedrock, boulders, gravel, etc. as well as earth. Even on the most barren stretches of rocky shoreline, the continued presence and action of the water leaves its mark, subtle though it might be.[2]

One of the most visible tide marks, particularly along many coastal rivers, is the limit of vegetation near the extent of tidal influence. Since regular inundation by salt water and wave action inhibits land vegetation growth, the edge of vegetation has long been recognized as an indication of the OHWM. In cadastral surveys, this line can be tied to a traverse by radial or stadia measurements or by offsets at appropriate intervals.[3] The edge of vegetation in a tidal marsh has also been delineated on aerial photographs in at least one instance in Nova Scotia.[4] However, as MacDonald has indicated, there are many regions in which the OHWM cannot be established by the limit of vegetation alone.

In sheltered tidal areas, vegetation often extends below the normal tidal action. Distinguishing salt water vegetation from that of the upland through remote sensing is a recent innovation, but several Maritime surveyors noted that, with experience, a visual inspection of the boundary area can provide evidence of the change in vegetation character. Some types of vegetation that thrive only in salt water environments are easily identified. Where the change in vegetation is not obvious, surveyors also rely on the 'spongy' feel of tide inundated areas or the occurrence of small ridges or furrows built up by tidal

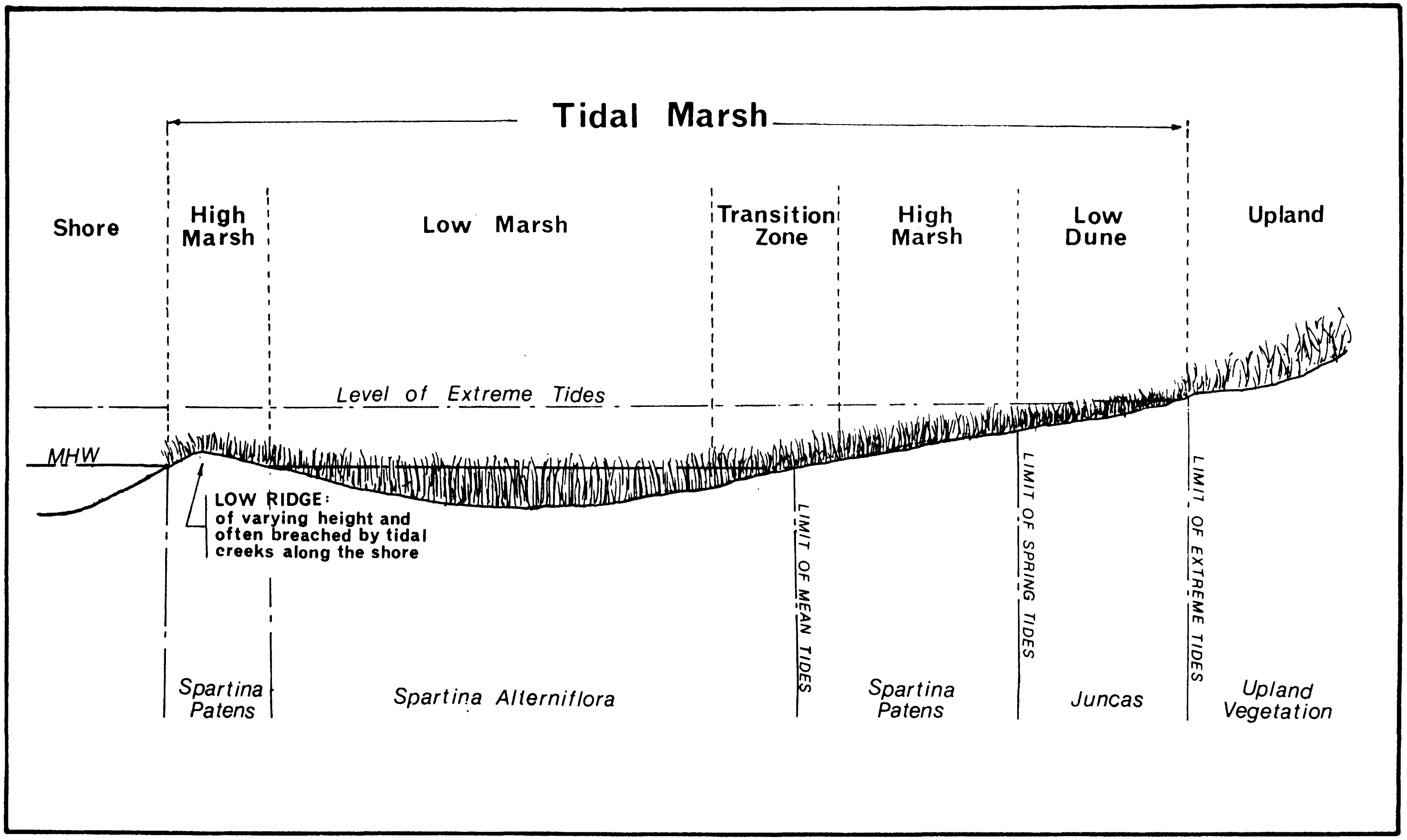


Figure 4.1: Example of Changes of Vegetation in a Tidal Marsh[5]
as Delineated in the Shaw case[6]

action.[7] If similar vegetation flourishes in both tidal and upland environments or if intertidal vegetation is slow to respond to long term changes in water levels, errors in interpreting boundaries by vegetation type alone can be significant, particularly on relatively flat tidal marshes.[8]

Another problem encountered by relying on vegetation lines occurs where the edge of vegetation is located much further upland than the reach of the ordinary tides,[9] as illustrated in Figure 3.6. Such conditions often exist on open coasts because storm waves and other beach processes strip the vegetation from areas above the average tide level. In a New Brunswick case, Lee v. Arthurs,[10] the Court emphasized that

> [high] water mark may go clean beyond the trees along the shore. It might be 100 feet below the grass...That does not affect where high water mark is...To the ordinary man I do not think the question of vegetation in connection with high water mark cuts any figure at all. That is my judgement.[11]

The boundary was settled as a ridge of gravel according to local custom.

Berms and ridges are often taken as evidence of the tide mark along sand or gravel beaches. In the Shaw[12] case, three surveyors recognized a low sand ridge on the seaward edge of a lagoonal marsh, approximately 20 to 40 centimetres in height, as the OHWM. The geomorphological report prepared for the defence questioned the validity of this evidence because

> this low ridge is breached in numerous places by tidal creeks which carry the rising tide into the lower areas inside the ridge...One is faced with the situation that there are large areas of tidal marsh, which receive regular inundation by saltwater, located inside what seems to be otherwise the most convenient, if not logical, limit, for surveying purposes, for the delineation of the OHWM.[13]

Large seasonal variability in sediment transport and winter ice conditions can also limit the consistency with which the tide mark can be located by these features.[14]

Among other physical features identified as evidence of the OHWM are lines of seaweed and debris. The use of driftwood lines was criticized in a British Columbia case, Nelson v. Pacific Great Eastern Railway Company[15] (hereafter referred to as the Nelson case). Since appropriate tidal information was not available for the survey site, customary practice was recognized and the driftwood line was accepted as the boundary.

Seaweed lines, common on the Atlantic coast, were mentioned by nearly all the surveyors interviewed, but both debris and seaweed become stranded by tides that have greater ranges than average. As many as four distinct seaweed lines can be found on some beaches marking the limits of various tides as depicted in Figure 4.2. The decision concerning which of these lines is best evidence of the OHWM rests entirely on the individual surveyor's experience and knowledge of local tidal conditions.

Where cliffs and granite rocks mark the land's edge, the limit of tidal action can sometimes be identified by weathering and other colouration changes on rocks frequently subjected to tidal waters. Surf and wave action place constraints on identifying the precise tide mark, but in most cases, the steepness of these slopes prevents the horizontal accuracy from being greatly affected by an approximate location of the OHWM.

Locating the OHWM by vegetation lines or other physical features is, in general, consistent with the vagueness and intent of Hale's original

OHWM definition. The accuracies obtained by these methods have been described as being "directly proportional to the complexity of the geography, geology, vegetation and water action at the site".[16] The accuracy estimated by the surveyors interviewed averaged approximately two to four metres. Since no 'true' OHWM exists other than the features identified on the particular day of the survey, survey standards specify procedures, rather than tolerances.

In most cases, these methods and the accompaning accuracies are probably appropriate for coastal land tenure conditions. However, the uniformity over time and between individual surveyors is questionable. Discretion is left to the individual surveyor, who demarcates the boundary through experience and an appreciation of accepted local practices.

4.1.2 Demarcating water lines

Marking the actual limit of the tidal influx at a particular stage of tide may be a more appropriate method than locating shoreline features, wherever the latter are absent or their location within tolerable limits is in question. However, the demarcation of water lines introduces additional problems that include the definition of specific tidal datums and the variability in those datums.

Time controlled water line surveys presuppose a boundary definition referred to a tidal datum. While datums are clearly defined in the United States for boundary purposes, no appropriate Canadian definitions of MHW or MLW exist. The *Irving* case[17] appears to be one of the few instances in which the OHWM has been recognized as the MHWL in the Maritimes.

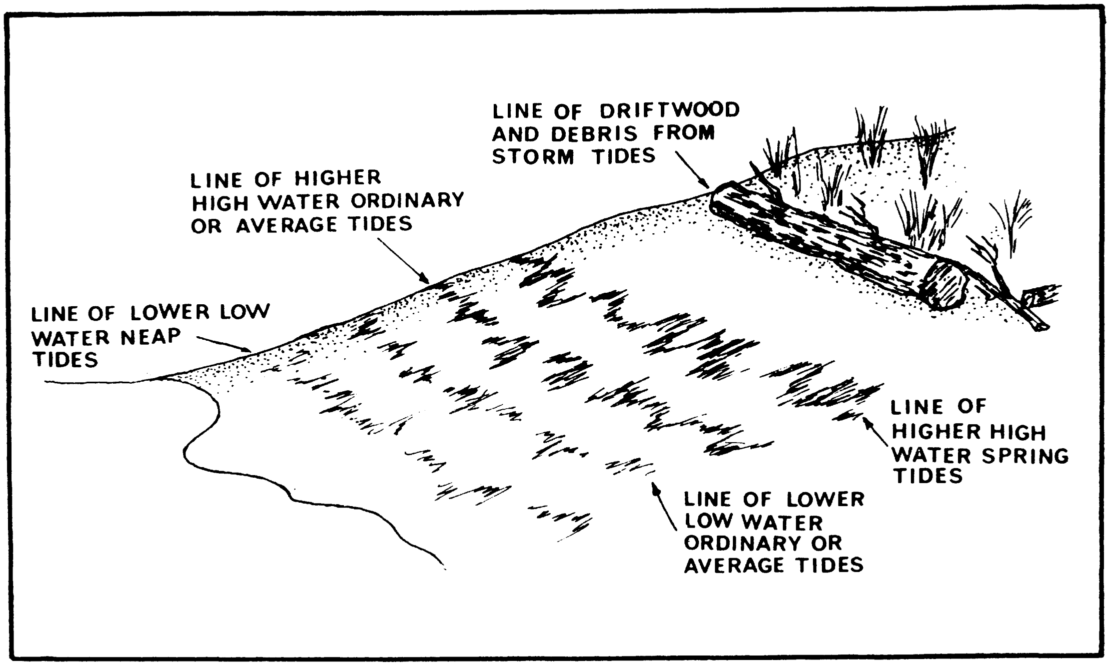


Figure 4.2: Discrepancies Between Seaweed Lines and Line of Driftwood and Debris

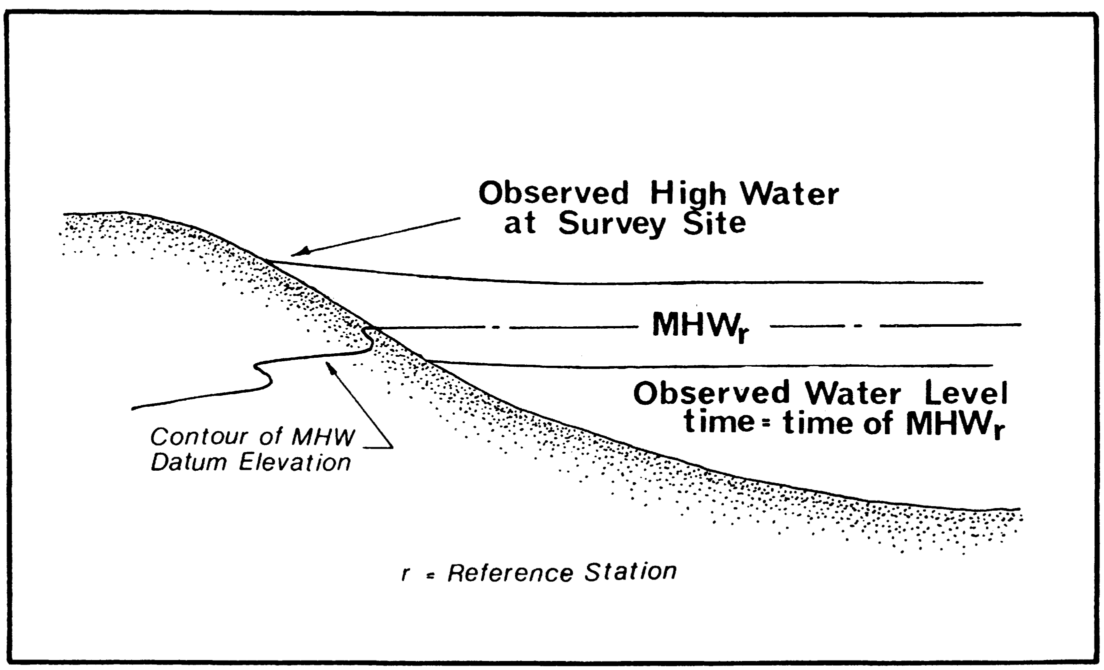


Figure 4.3: Potential Errors in Water Line and Contour Surveys When Based on MHW_r

The demarcation of a water line was discussed in the Irving case, although the decision was based on other grounds. On the assumption that the height of the MHW datum at the survey site was the average of all the predicted high waters at a nearby reference port, a datum elevation was calculated from the tide tables for the year of the survey. At a time when this level was predicted to occur at the reference port, the high water line was staked at the survey site. There was a 0.2 foot (0.06 metre) difference between the predicted and observed elevations at the tide gauge, but this was disregarded in later discussions of an apparent discrepancy in the survey.[18]

Local tidal datums are established in water line surveys, but variations in the time of high water between the reference station and the survey site are critical if the boundary is marked at a predetermined time. This type of error can be minimized by staking the edge of the water at the observed turn of the tide. However, the diffusion of water on tidal flats at low water can create other difficulties in MLWL surveys.

The time taken to stake a long water line can introduce additional timing errors. For a tidal range of 10 metres, an error of 5 minutes in time can produce a 0.07 metre vertical error in the water level that, in turn, would displace the boundary approximately 1.4 metres on a 5% slope. This type of timing error can be reduced by placing stakes simultaneously along the water line.

The use of tide table predictions to establish the local time or elevation of the MHW or MLW datum is a problem that was recognized as early as 1919 in Canadian law. In the Nelson case, the judgement contained the following observations:

> [plaintiffs] sought to apply the English definition [Attorney General v. Chambers], by adducing evidence, as to the state of the tide on particular days, as indicated by the tide tables at the Sand-heads, near the mouth of the Fraser River, at the same time. This would appear, upon first consideration, quite reasonable and accurate, but the evidence convinces me that it is subject to conditions, which would create an important margin of error. In the first place, the tide tables are only a pre-calculation or prophesy, as to the state of the tide on certain days. While of great assistance, especially for purposes of navigation, they do not prove absolutely correct. Then again, to compare the high-water mark at West Vancouver with the Sand-heads, you would require to assume the same sea level, also that the conditions of wind and current are the same.[19]

Depending on the slope of the beach, meteorological conditions, and the character of the local tide, this discrepancy between predicted and observed tidal elevations can be significant, as depicted in Figure 3.3.

4.1.3 Traversing a contour

O'Hargan classifies the demarcation of tidal boundaries by contours as a second generation method.[20] Based on a definition of the boundary as the intersection of a specific tidal datum with the shore, this method gained popularity in the United States after the Borax decision,[21] partly because it provided more uniformity in tidal boundary surveys than first generation methods.

The contour method has had limited use in the Maritimes and generally in conjunction with the identification of the tide mark. It was noted by New Brunswick surveyors that the contour established is verified by an examination of the physical evidence of the tide mark. In Nova Scotia, on the other hand, tidal datum elevations occasionally provide verification of the physical evidence of the OHWM in marshlands and other regions where its location is in question.

In the Saint John Harbour area, where physical evidence of the OHWM is sometimes scarce, a geodetic elevation related to a MHW datum has been used to demarcate the high water boundary in several surveys. One elevation currently employed in Courtenay Bay was established from a geodetic tie of a water line survey in 1959.[22] In other localities, the elevation is calculated from the tide tables for the year of the survey and referenced to a geodetic or tidal benchmark.

The contour elevation is also subject to temporal variations in tidal datums. Secular changes in sea level, vertical network and datum adjustments, and displacements of tidal benchmarks can affect the relationship between tidal datums and geodetic elevations. To illustrate these effects, an elevation of MHW established in Courtenay Bay in 1959 was 7.36 metres (referenced to chart datum),[23] while the present MHW, calculated in the same manner from the 1983 tide tables, is 7.49 metres.[24]

The contour method has also been heavily criticized by American surveyors because vertical undulations in local tidal datums are not considered.[25] These spatial variations may be significant along even short coastal distances. In the Annapolis Basin, for example, a vertical difference of 0.23 metres was observed between the predicted high water elevation at the secondary port of Digby, Nova Scotia and the observed water level at a survey site located approximately 15 kilometres from Digby. Difficulties in obtaining an accurate, up-to-date relationship between geodetic and chart datums at the survey site may have contributed to the discrepancy, but the 3.51 metre horizontal difference was consistent with that discussed in the Irving case where similar conditions prevailed.

As in water line surveys, the use of a datum elevation to establish a water boundary assumes a definition of the datum and consistent methods for calculating datum elevations. Although Canadian tide tables reflect the analysis of tidal observations at reference and secondary ports, averaging the predicted high waters over a year can produce differences from year to year due partly to long period tidal effects (see Section 2.5.2). Furthermore, the tide tables are predictions, not observations, as pointed out in the Nelson judgement.

The Irving case is one of the few Canadian decisions in which the actual method of demarcating a tidal boundary is addressed and in the judgement the Court endorsed the contour method with the following statement:

> [once] it was decided to run a survey of the high water line a very simple way to have done so would have been to fix the level of 10.38 feet geodetic datum which equals 24.1 feet Saint John Harbour datum, the level of the accepted average high tide, and run at that level along the lands to be expropriated.[26]

However, the variability of tidal datums still precludes the use of this procedure for accurate tidal boundary surveys at sites remote from the tidal observation stations. With recognition of the fact that tidal datums are not fixed, level surfaces, refinements in tidal boundary survey procedures have been advocated. Most of these developments O'Hargan classifies as third generation methods.[27]

4.2 Recent Developments in Tidal Boundary Surveys

With the clarification of American federal law in the 1939 Borax decision and the subsequent adoption of the MHWL as the seaward limit of private ownership in many states, methods for demarcating the horizontal component of the MHW datum are gradually replacing surveys of the OHWM.

Legislation and litigation involving wetlands and other valuable coastal areas in the United States has also spurred the development of precise procedures for establishing local tidal datums to demarcate tidal boundaries.[28] To demonstrate the need for accuracy, it has been estimated that a vertical error of 0.01 feet (0.003 metres) could involve 671,000 acres (271,540 hectares) of marginal tide land on the Atlantic and Gulf Coasts, valued at approximately 2.95 billion (1974) dollars.[29]

Since the American network of primary and secondary tidal stations is not sufficient to establish local tidal datums directly for most boundary surveys, three major developments have taken place. Procedures have been designed to determine datums accurately at temporary locations from short records by comparison with simultaneous observations at stations with 19 year mean datum elevations or the equivelent. Remote sensing techniques have also been expanded, both in support of boundary demarcation and in lieu of ground surveys, although the legal status of the latter is in doubt. Finally, to provide the scientific support for these new procedures and to co-ordinate marine boundary activities, federal-state programs have been implemented through the auspices of the National Ocean Survey (NOS).

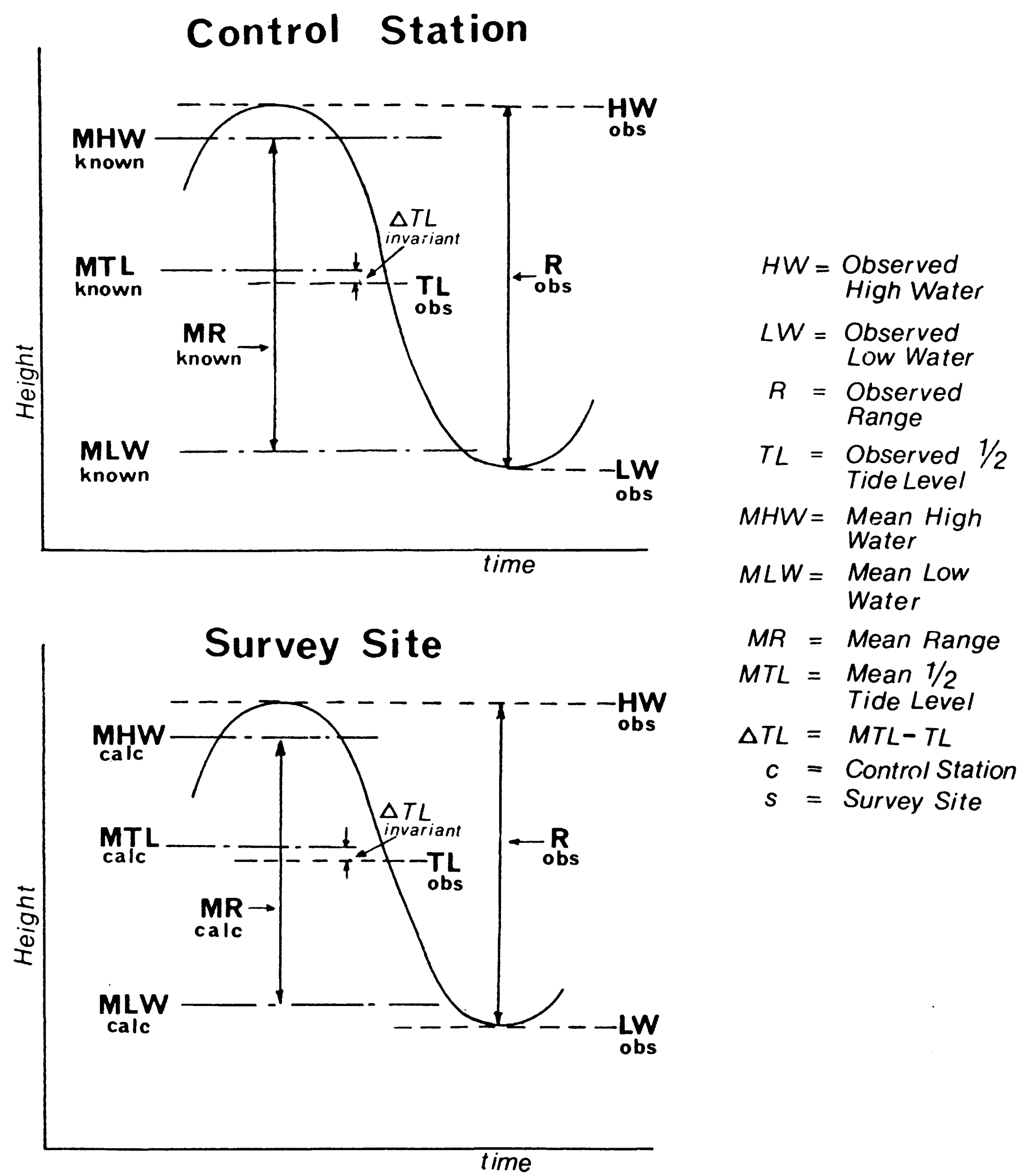
4.2.1 Local tidal datums from partial tidal records

The inaccuracy of conventional methods that disregard variations in tidal datums can be reduced by recording a time series of tidal heights at the survey site and comparing these records with simultaneous observations at a control station to obtain a derived 19 year mean datum elevation. However, to undertake a one year or even one month tidal study for each boundary survey is a luxury that most surveyors and their clients can ill afford. In addition, marshlands and other areas with shallow slopes often create difficulties in observing complete tidal cycles for comparison.

Within the last decade, therefore, attention has been focused in the United States on developing methods to minimize the period of observations, while maximizing the flexibility and precision of observation procedures. Only some of the advantages and limitations of the most common methods are outlined below, since Cole,[30] Weidener,[31] and Zetler[32] have recently provided summaries and evaluations of these methods. Although the new procedures have not been field tested in the Maritme Provinces, Aboh[33] has made a preliminary evaluation for New Brunswick tidal conditions using simulated tidal data.

a. range-ratio method: This method is the standard procedure for determining tidal datums by simultaneous comparisons, with expected accuracies similar to those given in Table 2-II. At least one full tidal cycle must be observed to apply this method, therefore, it is inappropriate in many areas where marshes and tidal flats make low water observations difficult,[34] such as found in many areas along the Bay of Fundy and Northumberland Strait.

b. height-difference method: In order to adapt the standard method for partial tidal cycles, NOS developed the height-difference method. Since this method assumes that the differences between the observed high water and MHW are equal for the survey site and control station, its reliability degrades when there is a significant difference between the



① $MR_S = MR_C\,(R_S/R_C)$ ② $MTL_S = MTL_C + (TL_S - TL_C)$

③ $MHW_S = MTL_S + \frac{1}{2} MR_S$

Figure 4.4: Range-Ratio Method[35]

tidal ranges at the two locations. If the ratio of the ranges differs from unity, the accuracy of one day's observations can also be affected by lunar phase inequalities.[36] Given the present distribution of tidal stations in the Bay of Fundy and the extreme variability in tidal range, this procedure may be inappropriate for this area.

c. extrapolated water level method: For stations with significant differences in tidal range, the modified time method (MTM), also known as the extrapolated water level method (EWE), has been applied with reasonable success.[37] However, the observed high water level must be greater than the MHW level, thus limiting the number of days appropriate for observations. This method also assumes that the shapes of the curves at both stations are similar. Tidal inequalities caused by shallow water effects could affect the reliability of this method.[38]

d. amplitude-ratio method: In this procedure, the range-ratio correction of the standard method is applied to the height differences through a ratio of amplitudes. This corrects some of the defects of both the EWE and height-difference methods and can be applied with only a partial tidal record at the survey site. For more than one day of observations, however, the AR method requires more computation.[39]

e. eduction method: This is a new procedure under consideration, which has been proposed by Maddox.[40] It is of particular interest in the Maritimes, since it appears to be the only method that makes use of predicted rather than observed tidal heights to obtain control station datum elevations. The objectives are to maximize the use of tidal

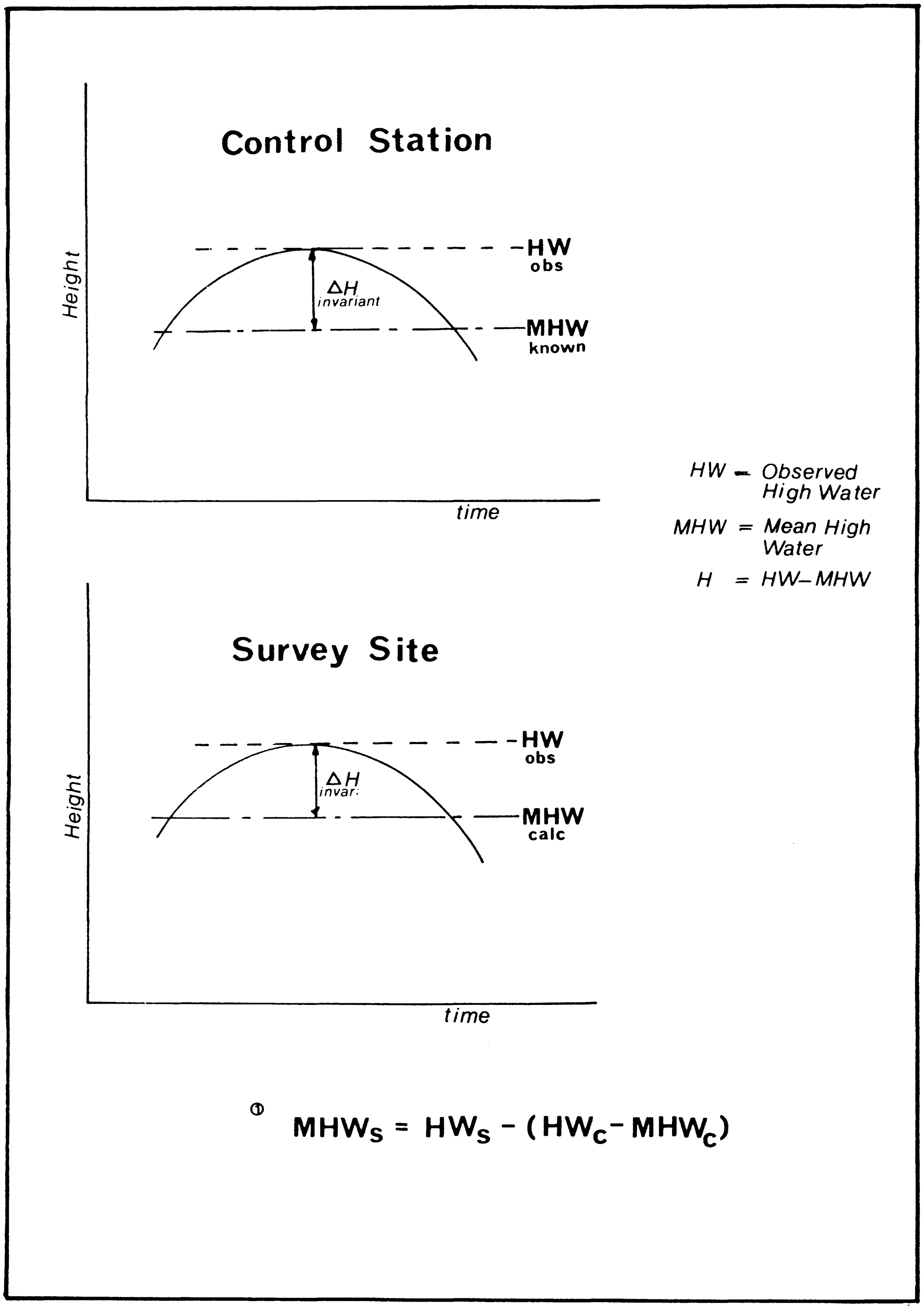


Figure 4.5: Height-Difference Method[41]

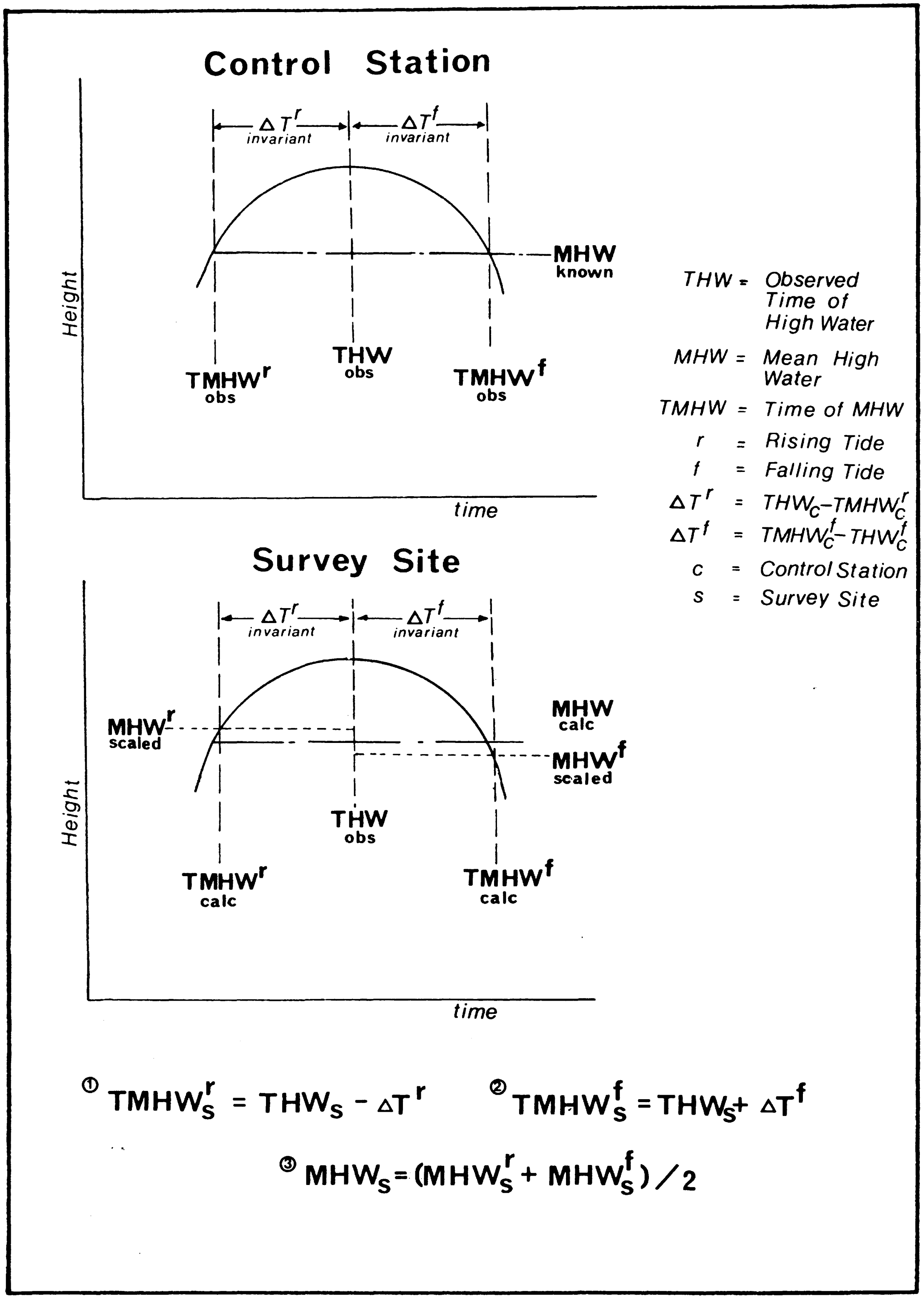
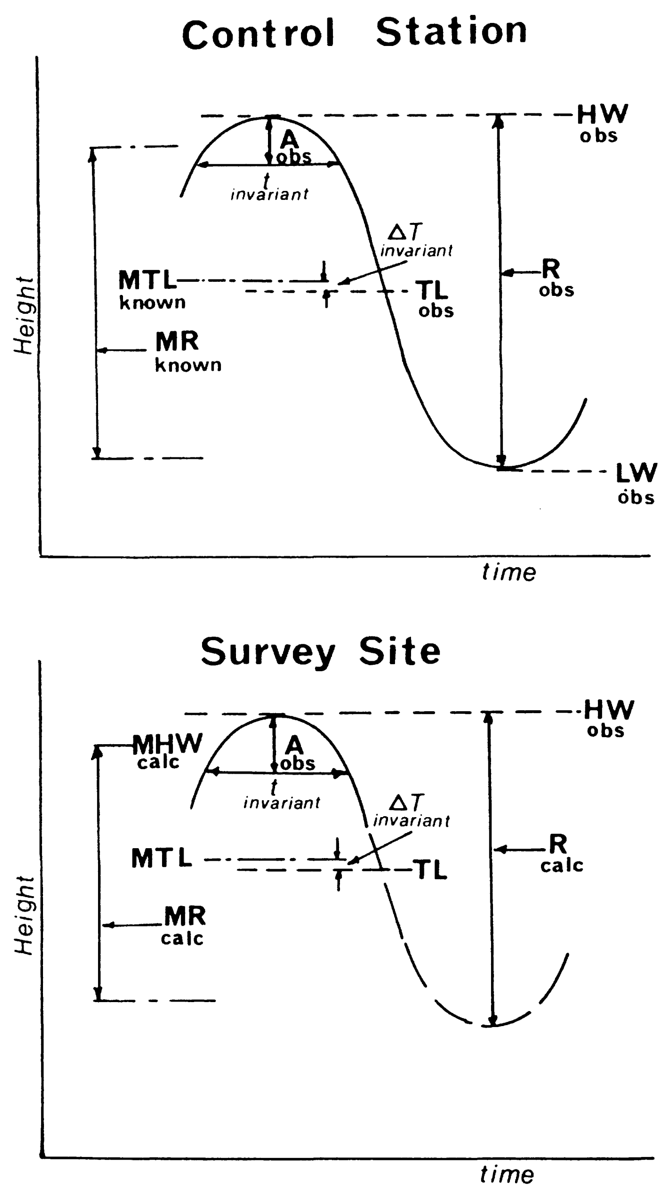


Figure 4.6: Extrapolated Water Level Method[42]



LW = *Observed Low Water*
HW = *Observed High Water*
R = *Range*
TL = *½ Tide Level*
A = *Observed Amplitude*
MHW = *Mean High Water*
MTL = *Mean ½ Tide Level*
MR = *Mean Range*
t = *time between 2 equal heights*
ΔT = *MTL - TL*
c = *Control Station*
s = *Survey Site*

① $R_S = R_C (A_S / A_C)$

② $MR_S = MR_C (A_S / A_C)$

③ $MHW_S = (HW_S - R_C/2) - (TL_C - MTL_C) + MR_S/2$

Figure 4.7: Amplitude-Ratio Method[43]

observation information (predictions for reference ports) and to provide reliability by making assumptions similar to those in the standard method.[44]

In his evaluation of some of these methods for three areas in New Brunswick, Aboh found that the range-ratio and height-difference methods produced the least error in MHW elevation when compared with known values in the Mirimichi eustuary. Residuals of less than 0.03 metres in elevation were within the derived tolerances for shallow slopes given in Table III (Section 2.4.4). In the Northumberland Strait, residual values for these methods were approximately 0.12 and 0.10 metres, respectively. Residuals of 0.30 and 0.27 metres, respectively, were recorded for the Bay of Fundy where variations in tidal range are extreme. The EWE method gave the largest residuals in all cases. It should be noted, however, that these results were based on simulated tidal data and the procedures were not tested under field conditions.[45]

All of the above described methods are subject to certain basic constraints, although some are more affected than others. In particular, the stations must be on the same body of water and the tidal characteristics should be similar in order to maximize accuracy in obtaining local datum elevations. An implication of this constraint is the necessity for an appropriate density of control stations and accurate datum recoverability at these stations.

The purpose of establishing local tidal datums is to precisely locate the horizontal component forming the boundary. The elevations determined by these procedures can be used to improve water line surveys, as stakes can be placed on the leading edge of the tide when the correct elevation is observed on a tidal staff erected at the site. A contour can also be transferred along the shore from the temporary station at the elevation established, but spatial variations in the datum still limit the distance over which this may be reliable. A third method of delineating the sinusoidities of the boundary between temporary tidal stations is through the application of tide controlled remote sensing.

4.2.2 Role of remote sensing

Aerial photography and other remote sensing techniques have provided flexibility and economy for coastal mapping purposes. Remote sensing has also had at least three direct applications in tidal boundary surveys: tide controlled water line surveys, elevation controlled surveys, and biological analyses. The horizontal accuracy achieved depends on the scale of the imagery and, in some cases, the beach slope and degree of timing control. Furthermore, the legal weight given evidence provided by remote sensing can be diminished if not controlled by ground surveys.

Once a local tidal datum elevation has been established at the survey site, aerial photography can be flown to delineate the boundary. Using air-to-ground communications, the photo images should be taken when the observed water level on a tide staff reaches the local MHW elevation. Both panchromatic and colour infrared photography have proved successful, the temperature change at the land-water interface being evident in vegetated areas.[46]

Cole has described the use of photogrammetric techniques for marshland surveys, in which the boundaries delineated on aerial photographs were submitted as evidence in two recent legal disputes.[47]

Local MHW datums were determined for the areas in question, and points along the boundary, established by water line or contour surveys, were targeted. With photography flown at 5000 feet (1524 metres), the co-ordinates of the targets were calculated by analytic aerotriangulation. Horizontal accuracies of the co-ordinates were reported to be .11 feet (.033 metres) at the one sigma level.[48]

Whereas these methods have combined remote sensing with tidal datum surveys, the State of New Jersey has attempted to establish wetland boundaries by circumnavigating traditional survey methodology. Using plant signatures related to tidal inundation,

> the biological techniques rely on the remote sensing of plant growth (or "vigor") and the assumption that the appearance of different vigor in colour infrared photography depicts the "mean high water line."[49]

However, when state boundary claims were compared with MHW lines demarcated from local tidal datums in one landmark New Jersey case,[50] land seaward of the MHW line on a 26 acre (10.52 hectare) parcel differed from over 90% of the parcel for the biological line to only 17.6% for a MHWL established by cadastral survey methods.[51]

In the judgement of <u>New Jersey Sports and Exposition Authority v. Borough of East Rutherford et al.</u>,[52] the trial was described as "a battlefield for scientific experts". The decision was in favour of the boundary demarcated by ground survey methods, which were augmented by tide co-ordinated photography and verified by physical evidence of the boundary location. Not only was the Court impressed with the multi-disciplinary approach in field testing, but also by the consistency of the results. In accepting the boundary established by ground survey methods instead of the state's biological line, the Court noted that

> [although] there may not be any exact science [for establishing the MHW line], the methods utilized have been accepted for many years. It was shown that the relative accuracy, both horizontally and vertically, of the methods and equipment utilized was well within the accepted conventional surveying standards.[53]

In the Shaw case, a biological boundary was delineated from aerial photographs. The vegetation changes established by plant signature were also verified by field evidence and tidal observations.[54] Despite the fact that the results were not consistent with conventional surveys based on visible evidence of the OHWM (see Figure II-6, Appendix II), the Court did not comment on the validity or merits of either method. Should biological remote sensing techniques be used in the future, they should be viewed as providing extrinsic, and not primary, evidence of the boundary location in light of the New Jersey experience.[55]

4.2.3 Coastal boundary programs

In response to the increase and significance of tidal boundary litigation in the United States, the implementation of coastal zone management (CZM) programs, and the need for tidal information to support boundary surveys, the NOS established a Marine Boundary Program.[56] Joint cost-sharing agreements have been set up for several coastal states, including Florida, New Jersey, South Carolina, Mississippi, and Louisianna, to densify tidal stations and benchmarks for boundary surveys.[57]

The first co-operative effort was initiated in 1969 with the State of Florida and will eventually result in the establishment of approximately 800 primary, secondary, and tertiary (30 to 60 days observations) tidal stations along over 11,000 miles (17,700 kilometres) of coastline.[58] To make tidal datum information available to surveyors and to regulate the delimitation of tidal boundaries within the state, further legal and administrative support was provided. Under the Florida Coastal Mapping Act of 1974,[59] the Coastal Mapping Program was initiated with the following functions:

> (a) To coordinate the efforts of all public and private agencies and organizations engaged in the making of tidal surveys and maps of the coastal areas of this state, with the object of avoiding unnecessary duplication and overlapping;
>
> (b) To serve as a coordinating state agency for any program of tidal surveying and mapping conducted by the Federal Government;
>
> (c) To assist any court, tribunal, administrative agency, or political subdivision, and to make available to them information, regarding tidal surveying and coastal boundary determinations;
>
> (d) To contract with federal, state, or local agencies or with private parties for the performance of any surveys, studies, investigations, or mapping activities, for preparation and publication of the results thereof...
>
> (e) To develop permanent records of tidal surveys and maps of the state's coastal areas;
>
> (f) To develop uniform specifications and regulations for tidal surveying and mapping coastal areas of the state;
>
> (g) To collect and preserve appropriate survey data from coastal areas;
>
> (h) To act as a public repository for copies of coastal area maps and to establish a library of such maps and charts.[60]

Within the Act, the MHWL is confirmed as the private/state boundary and survey procedures for establishing this boundary are outlined.[61] The procedures must be approved by the state, and only surveys complying with these standards are admissable as judicial evidence.[62] Similar legislation has been proposed for New Jersey.[63]

The strength of these American programs lies in their comprehensive approach to the need for accurate and consistent tidal boundary surveys by providing

a. a legal framework, within which appropriate regulations and survey standards can be set;

b. administrative support to co-ordinate scientific, surveying, and legal information.

With such a comprehensive program, the other developments in tidal boundary surveys can be efficient and appropriate in their applications. It is this co-ordination of tidal boundary surveys that should be emphasized in assessing the implementation of similar improvements in the Maritimes.

4.3 Assessment of Tidal Boundary Surveys

With the close association of the Maritimes to the United States with respect to geography, land tenure, and socio-economic development, American tidal boundary problems can provide some insight into potential Canadian legal and surveying issues. There are significant differences, however. Land values and the intensity of land use are significantly lower in the Maritime Provinces. Tidelands legislation and litigation is minimal and the precise location of tidal boundaries is not a general concern of most riparian proprietors nor of provincial and federal agencies to date. An assessment of tidal boundary surveys should also consider conventional methods in the context of these unique Maritime conditions, as well as in comparison with American standards.

In the following assessment, attention is first given to a critique of survey methods in the Maritimes in order to highlight some of the advantages and problems. A preliminary evaluation of implementing changes similar to those found in American programs is given, identifying a few of the potential benefits and costs. As indicated previously, the objective is not to advocate a particular course of action, but to point out a few of the issues that should be addressed in more comprehensive assessments.

4.3.1 Assessment of Maritime methods

Tidal boundary surveys in the Maritimes are based on an interpretation of English common law and on customary practice. Beyond the codification of the OHWM in some survey regulations, the law governing survey practices has remained nearly static since colonial times. In general, surveyors have continued to demarcate tidal boundaries by the physical tide mark on the shore.

The conventional methods employed are in keeping with the vagueness and ambiguity in the interpretation of the 'ordinary tides'. Until a precise legal definition provides a scientific standard for surveyors, the tide mark represents the intention of limiting only those lands that are 'dry and manoiriable' subject to private property rights. Although vegetation and driftwood lines have been questioned by the courts as evidence of the OHWM, the law has generally remained silent on survey procedures.[64]

In most cases, the land tenure requirements have been met in an efficient manner by these surveys. The lack of development and litigation in tidelands may justify approximate boundary delimitation. Furthermore, the ambulatory nature of the boundary contributes to the lack of concern over precise delineation of the OHWM. With conventional methods, survey costs are kept to a minimum and are generally consistent with the value of coastal property. Conventional methods appear to have been accepted by the legal profession and the riparian proprietors as being adequate.

Problems do exist. For example, the features to be identified as the OHWM are left to the discretion of the surveyor and as expressed in the Nelson case

> [it] would appear that the surveyor, at the time when he is fixing the high-water mark, under such practices, becomes a judge as to where it exists. He is uncontrolled by any authority. This practice [demarcation by driftwood lines], however, seems to be generally accepted and followed.[65]

Customary practice does leave room for inconsistency in the evidence gathered by individual surveyors. There are no uniform standards despite the survey regulations.

This inconsistency is particulary evident in the MHWL survey disussed in the Irving case and the vegetation analysis in the Shaw case. The judgement in the former may have set some precedent in recognizing the MHWL and the contour method, but no opinion was offered in the Shaw case regarding either the OHWM surveys or the more sophisticated analysis techniques. As experience in the United States has shown, precise tidal datum definitions and tidal information are necessary to raise water line surveys, the contour method, and remote sensing techniques above the level of approximation.

The lack of appropriate specifications in the Maritimes is illustrated by the reference to the determination of natural boundaries by 'controlled photogrammetric methods' in the N.S.L.S. regulations.[66] Whether this implies tide control in addition to standard control is not clear. Without legal guidelines or survey specifications, the application of new procedures is left to the discretion of the surveyor.

The traditional approaches of the Maritime legal and surveying professions appear to be adequate for general practice, but where expropriation or development of tidelands occurs, precise delimitation of tidal boundaries can become an issue. Both the Irving and Shaw cases demonstrate this problem. As coastal resources appreciate and legislative control in the coastal zone increases, the tide mark and its survey may come under legal scrutiny. How current procedures will be regarded by the legal profession may then depend on the degree of consistency and competency with which the methods are applied.

4.3.2 Assessment of a coastal boundary program for the Maritimes

If tidal boundary surveys become the subject of litigation in the Maritimes, the recent developments in the United States may also be considered for the Maritimes. The surveying profession should, therefore, not only be aware of these developments, but also be cognizant of the potential benefits and costs of implementing similar improvements. Pointing out some of the practicalities that must be considered in advocating precise tidal boundary surveys, Guth has commented that

> [it] is never impossible to establish a MHW line; however, it may not be economically feasible to accomplish by current technology. Conditions may be encountered when the cost or the time required for surveying or mapping such a line is unreasonable in relation to the need for the information or the ultimate use of the area.[67]

CZM programs, high land values, intense resource use, and costly litigation, as occurred in both the Shaw and Irving cases, could initiate the call for coastal boundary programs to regulate surveys and manage coastal resource information. In the proposed coastal boundary legislation for New Jersey, the land tenure requirements were outlined in the following manner:

> [the] legislature hereby declares that the accurate determination of coastal boundaries is mandatory to the basic rights of its citizens to free ownership and quiet enjoyment of their property. Accurate determination of coastal boundaries are [sic] also required for many public purposes including, but not limited to, the promotion of marine navigation, the enhancement of recreation, the implentation of coastal zone planning and management programs by state and local government agencies. Accordingly, a state coastal boundary program is declared to be in the public interest.[68]

If changes in land tenure, similar to those encountered in the United States, are anticipated for the Maritimes, such comprehensive programs may be justified. Some areas of the Maritimes, including metro Saint John and Halifax, could probably benefit from improvements immediately.

To implement the type of improvements advocated in the United States, the law regarding tidal boundaries and survey procedures must undergo considerable change. This is discussed in the New Jersey and Florida legislation with similar wide sweeping policy statements:

> [the] legislation further recognizes the desirability of confirmation of the mean high-water line, as recognized in the State Constitution [New Jersey: in the common law]...as the boundary between state sovereignty lands and uplands subject to private ownership, as well as the necessity of uniform standards and procedures with respect to the establishment of local tidal datums and the determination of the mean high-water and mean low-water lines, and therefore directs that such uniform standards and procedures be developed.[69]

Although accurate and consistent tidal boundary surveys could reduce the possibility and cost of future litigation, changes in boundary definitions and survey procedures could also become legal issues if contested. Unless the legal profession and appropriate government officials are well informed on the scientific and surveying problems, legislation could be as vague or ambiguous as the current case law, possibly creating rather than eliminating problems. Public information and political lobbying would be required for successful implementation of legislation but this could also focus attention on tidal boundary problems that may unsettle coastal land tenure. Among the issues that could arise are jurisdictional boundaries and claims to boundaries other than the OHWM. Clarification of these issues is already long overdue and if handled equitably and efficiently, their resolution through coastal boundary legislation could provide long term security of land tenure.

The information provided by a coastal boundary program would not only improve tidal boundary surveys, but also benefit other coastal initiatives, such as CZM. However, the current information base is insufficient and administrative costs could be high. To support the recovery of local tidal datums for boundary surveys, the present network of tidal stations and benchmarks requires densification. The cost of establishing five permanent tidal stations and adding 400 tidal benchmarks based on short term observations in Mississippi, for example, was estimated to be approximately one million dollars.[70] Tidal information must also be kept up-to-date and be available in formats suitable for surveying purposes.

If tidal boundary surveys are examined and information, such as datum elevations, remote sensing imagery, coastal maps, and survey plans, is to be collected and distributed efficiently by an appropriate agency, further administrative costs must be considered. These costs could be minimized by incorporating the program under existing provincial and/or regional survey and mapping authorities.

Even with appropriate information services, the costs of improving survey procedures to the surveyor in private practice would be significant. Establishing local tidal datums for boundary surveys would be a considerable alteration in conventional procedures, requiring tidal observations in most cases. Surveyors would need to become familar with new procedures in order to meet the standards deemed appropriate by the profession. Added to the cost of the survey would be equipment and the time for information gathering, field work, calculations and, if required, survey examinations. It is doubtful whether the average Maritime client could be easily convinced that the future benefits accrueing from accurate and consistent delimitation of an ambulatory boundary will exceed the immediate costs of improved tidal boundary surveys.

In some areas of active coastal development or in cases of valuation, the costs of improving surveys are probably justified. Should modifications be implemented in particular regions or on an incremental basis rather than as a comprehensive program, the the present lack of uniformity in tidal boundary surveys would be intensified. However, integrated survey areas have overcome this type of inconsistency for other cadastral reforms. As with these improvements, the initiative for changes in tidal boundary delimitation must come from within the surveying community. If the benefits outweigh the assessed costs, then the surveying profession should become the advocate of improvements, whether they concern only survey procedures or also extend to law and the provision of tidal information.

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CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

> Where there is much desire to learn, there of necessity will be much arguing, much writing, many opinions; for opinion in good men is but knowledge in the making.
>
> John Milton

While the surveying profession in the Maritimes has made great strides in improving the cadastral system in general, there have been few efforts made towards clarifying tidal boundary delimitation. Current survey practices do not always meet the accuracy standards set for other boundaries and new survey methods and terminology have been introduced without examining the legal or scientific foundations for these changes. Without an awareness of the merits and limitations of both traditional and improved tidal boundary delimitation, the Maritime surveying profession may be unprepared for the type of litigation and legislation that have made tidal boundaries a central issue in American coastal land tenure.

This preliminary study has provided an overview of tidal boundary delimitation in the Maritimes with the specific objective of identifying some of the issues for further discussion and research. The literature, case law, legislation, and contributions from those experienced in the field have not been exhausted. Rather than comprehensively reviewing any one aspect, this report has sketched the broad relationships that exist between law, surveying, and science at the land-water interface. To address the delimitation issues within any one discipline without considering the requirements of or impacts on the others, may only compound the current problems. The recommendations given in this chapter therefore stress an interdisciplinary approach to tidal boundary delimitation in the Maritimes.

5.1 The Tidal Boundary Issues

In the assessments at the the end of each chapter, some of the difficulties in providing precise tidal boundary delimitation have been identified. The following sections summerize the major issues within each discipline that require further clarification and research. Many of these problems can be addressed within the respective communities. However, an appreciation of legal definitions, surveys, and tidal information in the context of their interrelationships is a prerequisite in identifying the need for improvements and the direction these should take.

5.1.1 Legal issues

Among the major legal issues that have been identified are the uncertainties regarding jurisdictions, the vague and inconsistent tidal boundary definitions, and the need for an assessment of boundary requirements for Maritime coastal land tenure. Within these issues are the problems of water lots, former high water boundaries, and legislation affecting tidal boundaries and land tenure.

Although by presumption the OHWM is the limit of private riparian lands along tidal water bodies, jurisdiction and property rights below the OHWM vary. The validity of water lot grants, the expropriation of riparian rights, and the effect of watercourse legislation in tidal areas are three areas of uncertainty. Federal and provincial jurisdictional limits are also unsettled in the Maritimes, particularly in public harbours. Claims to former high water boundaries could provoke further problems in locating these boundaries, an issue that has been the cause of much litigation in the United States.

The OHWM has been recognized in law as the seaward boundary of upland property in the Maritime Provinces. Although the OHWM is surrounded by vague and ambiguous terminology, it is well accepted by both the legal and surveying professions. Since precise boundary delimitation is rarely an issue in the Maritimes, the OHWM serves as a practical definition and makes no requirement of datum establishment. As interpreted by the surveying profession, the OHWM definition specifies the evidence by which the boundary is to be located in the field. However, it has been subject to inconsistent, inaccurate, and sometimes contradictory interpretations. One particular problem is the ambiguous call for 'ordinary or neap' tides, terminology that has no scientific meaning. A second problem has been the tendency in both case law and legislation to equate the OHWM and MHWL definitions.

The MHWL refers to the intersection of a tidal datum with the shore, but no datum definition beyond 'the level of medium or average tides' has been recognized in Maritime law. Moving to a precise MHWL definition should depend on the current and potential needs of coastal land tenure and must also take surveying capabilities into account. Expropriation of coastal land currently warrants accurate boundary delimitation. Future issues that should be considered include coastal zone management, marshland legislation, and the Bay of Fundy Tidal Power Project.

5.1.2 Surveying issues

In briefly reviewing the survey procedures currently employed in the Maritimes, two patterns were apparent. Shoreline features generally serve as evidence of the OHWM, but new survey methods based on a MHWL definition have been applied, particularly in New Brunswick. The major issue to be addressed by the surveying profession is the specification of appropriate survey standards for tidal boundary delimitation.

Demarcating the tidal boundary by physical features appears to be satisfactory for most survey requirements. Both the general intent of the OHWM definition and accepted local practice are realized in these surveys. Since tidal boundaries are ambulatory and the call for a natural monument in a legal description takes precedence over any survey measurements, there is little incentive for precise surveys. OHWM surveys also minimize the cost of survey to the cadastral surveyor and therefore to his client.

However, reliance on the limit of vegetation is not suitable in many coastal areas and the choice of evidence is often left to the discretion of the individual surveyor. Demarcation can be inconsistent between surveyors and over time. Among the other problems that arise are the incompatibility of some of the features identified as the OHWM with the true limit of the ordinary, medium, or average tides and the legal weight that may be given this type of evidence by the courts in the future.

Other methods employed by Maritime surveyors are based on a MHWL interpretation of the riparian boundary. Although Canadian law gives few guidelines for these surveys, they are in keeping with recent American survey improvements. Water line, contour, and remote sensing surveys give the appearance of being more precise than OHWM surveys. Without a precise MHW datum definition and consistent standards that stress local tidal datum establishment, however, these methods may be more inaccurate in some cases than methods relying on physical features. Until tidal datum information is available to support these new methods, a precise MHW definition is legally recognized, and appropriate standards are set, current procedures will continue to be approximate and inconsistent, even though they may be acceptable for most surveys.

5.1.3 Scientific issues

Two major scientific issues should be addressed: the provision of appropriate tidal information to support improved survey procedures where required and the role of biological analysis in cadastral surveys. The major emphasis should be placed on the former problem in the immediate future, but in light of American experience with biological boundaries, an understanding of the limitations and advantages of new survey methods is critical.

Tidal information currently provided in eastern Canada is inadequate for precise tidal boundary delimitation. Datum definitions are inappropriate and American definitions are incompatible with Canadian tidal observation and analysis techniques. Of particular concern in MHWL surveys is the provision of accurate local tidal datum elevations and tide times. Given the large variations in tidal conditions in the Maritime region, the density of reference ports is insufficient for comparison with simultaneous observations using short term records at the survey site. Secondary ports are maintained mainly for tidal predictions and the accuracy of datum determination may not always meet cadastral survey requirements. Tidal information is also in the form of predictions and MHW datum elevations must be calculated from the tide tables. Interpolation and extrapolation of datum elevations or times are only approximations because these methods disregard local tidal and nontidal variations.

Other sciences play a supportive role in tidal boundary delimitation. Biological boundaries delineated from analysis of plant species signatures on remote sensing imagery give approximate locations of the extent of average tidal influence. This may be appropriate for coastal mapping but not cadastral surveys unless the evidence is verified by ground surveys. While geomorphological and other scientific evidence is particularly useful in locating former tidal boundaries, again the results are approximations and should be weighed against all other available evidence. Although these methods have legal limitations, they do indicate the value of an interdisciplinary approach in tidal boundary delimitation.

5.2 Recommendations for an Interdisciplinary Approach

Throughout this report, the interrelated roles and contributions of law, surveying, and science in tidal boundary delimitation have been emphasized. From the assessments, it is apparent that there has been little communication among the disciplines in the Maritimes to date. For example, appropriate tidal information is unavailable to cadastral surveyors and legal definitions have disregarded scientific terminology and surveying procedures. Survey standards are also based mainly on customary procedures, without strict adherence to legal definitions or regard for sea level variations and precise local tidal datum establishment.

Three areas of immediate changes that should be made in the Maritimes are the clarification of legal definitions, the setting of survey specifications, and the provision of tidal information. Other longer range improvements should only be made after an assessment of coastal tenure requirements is made and the impacts are clearly understood by all parties that will be affected.

The definition of the OHWM should be clarified by the elimination of the superfluous and contradictory term 'neap'. In this way ordinary tides may be correctly interpreted scientifically as average, medium, or mean. A MHW datum definition suitable for boundary delimitation should be recognized in law, but it must also take cognizance of Canadian tidal measurement and survey requirements.

A clear distinction should be made between the OHWM and the MHWL. The former indicates a physical mark left on the shore by the ordinary or average tides. The latter represents the intersection of a tidal datum with the shore, this datum being capable of accurate recovery at a later date. This distinction should be made clear in references to tidal boundaries in both case law and legislation and on plans of survey. Boundaries delineated on cadastral plans should also be refereced to the date the boundary was established in the field.

Survey standards as set out in the regulations and by-laws should recognize both definitions and provide adequate procedural guidelines for demarcating either boundary as conditions warrant. The objective should be to promote consistent survey methods that will be accepted in courts of law. Unless a local tidal datum has been determined, neither the OHWM or the MHWL should be regarded as precise boundaries and, where possible, both should be established for verification. Biological techniques should be limited to providing extrinsic evidence in cadastral surveys.

Survey standards should emphasize appropriate procedures rather than horizontal tolerances. Once suitable tidal information is available, the feasibility of vertical tolerances should be considered. In all cases, the standards should provide consistent procedural techniques for demarcating and delineating tidal boundaries when based on either a OHWM or MHWL definition. To determine which procedures are best suited to Maritime conditions, a review of Canadian methods and those of other countries should be undertaken.

To support improved survey methods, the Department of Fisheries and Oceans should densify the current tidal station network, particularly in areas subject to existing or potential litigation, jurisdictional problems, or intense coastal resouce use. The information gathered at both old and new tidal stations should meet the vertical accuracy standards set for surveying purposes and should be published or otherwise made available in a format suitable for surveyors. Included in this information should be MHW elevations, based on an appropriate definition, updated tidal benchmark elevations, and accurate relationships between tidal datums and local survey control.

Methods for determining local datums should also be developed and tested under Maritime conditions. Efforts should be made to introduce appropriate procedures that will minimize tidal information requirements, the length of tidal observations, and survey costs, while maximizing the accuracy of datum establishment. It will be the responsibility of the surveying associations to make tidal information requirements known to the appropriate agencies.

A comprehensive review of the case law and legislation affecting tidal boundary delimitation should be undertaken by the legal profession. The law and tidal boundary programs in the United States and other common law nations should be examined in view of their applicability to the Canadian situation. Research efforts should consider possible legislative ammendments and a coastal boundary program for the Maritimes.

One effective means of initiating these recommendations could be through tidal boundary and coastal mapping workshops, similar to those sponsored by the National Ocean Survey and the American Congress on Surveying and Mapping. Through well defined forums, the legal, surveying, and scientific communities could become aware of the present state of tidal boundary delimitation in the Maritimes and the issues that should be addressed. Workshops could provide the interdisciplinary approach necesary for assessing the requirements of each group, initiating changes, and evaluating the feasibility of a coastal boundary program for the Maritime Provinces. They may be sponsored by the surveying profession but should also involve experts in all areas of tidal boundary delimitation.

Before major changes are undertaken, the land tenure requirements should be assessed, as well as the impact that changes in one discipline will have on another. A benefit cost analysis could prevent the unnecessary committment of surveying and scientific resources if precise boundary delimitation is unwarranted. It should be emphasized that changes made at random and without regard to the legal and tidal information aspects would be inefficient and could lead to confusion if not failure. Although some improvements would incur the costs of education in new procedures, alterations in the common law, and provision of tidal information, an interdisciplinary approach would make maximum use of available resources and ease the implementation phase.

Change may be perceived as an opportunity and as a threat. Discussions within the professions and at workshops are sure to provoke a wide range of opinions on the merits or limitations of introducing changes in law or survey practice. Without changes tidal boundary delimitation will continue to lack the precision required of other boundaries, but only through active participation in future discussions by all those affected will measures appropriate to the Maritmes be taken to ensure that tidal boundary requirements are met. Awarenesss is the first step to resolving the issues; debate may be the second. Cooperation will be the third prerequisite in meeting the challenge of the tide mark.

APPENDIX I

CURRENT PRACTICE IN THE MARITIMES:

INTERVIEWS WITH MARITIME SURVEYORS

APPENDIX I

CURRENT PRACTICE IN THE MARITIMES: INTERVIEWS WITH MARITIME SURVEYORS

The following are a set of brief summaries of interviews conducted in June 1982 and January 1983 with nine surveyors in Nova Scotia and New Brunswick. Although an attempt was made to include surveyors who might be subject to various tidal boundary problems and experiences, the selection was limited by logistics. The locations of their practices, however, do represent a fair cross section of the two provinces, as shown in Figure I.1 Urban, rural, and harbour areas are represented, as well as varying tidal conditions, such as the extreme tidal range in the Bay of Fundy, marshland at the head of the Bay, the open Atlantic coast, and the Northumberland Strait.

These summaries were compiled from answers to a standard set of approximately thirty questions, as well as from comments and discussions that arose. All of the surveyors approached willingly gave one to three hours of their office time to discuss their experiences. However, the ultimate value of these interviews rests in the general awareness of the Maritime experience with tidal boundary problems that was gained, rather than in particular answers and comments. The contribution made by these surveyors and the many other persons who provided information will not be found only in the respective sections, but throughout the text of this report.

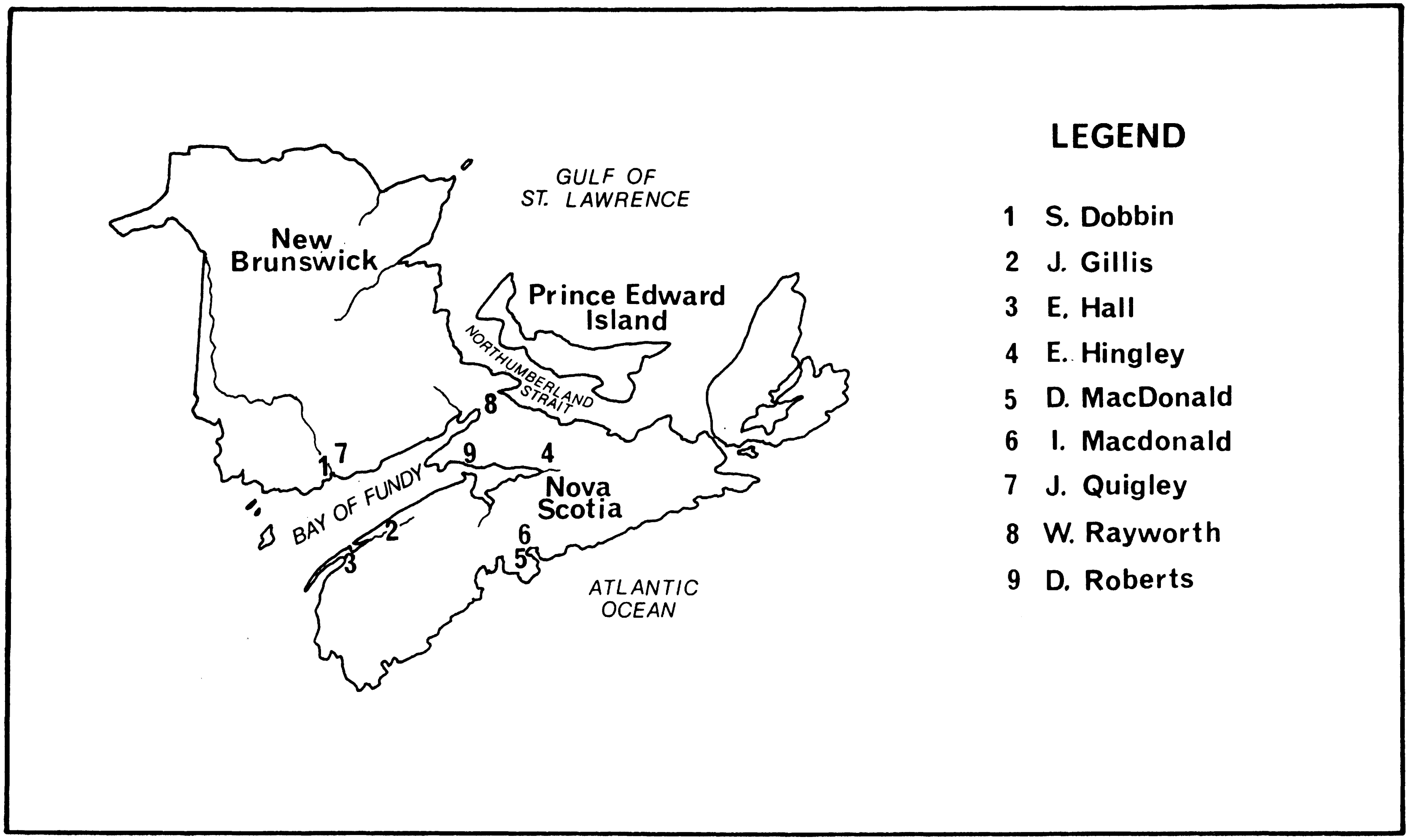

Figure I.1: Location of Interviews

Stuart Dobbin, N.B.L.S

Dobbin Surveys Limited

Saint John, New Brunswick

Mr. Dobbin began his career in surveying in 1947, articling under Deputy Surveyor G.G. Murdoch, and received his N.B.L.S. commission in 1951. Since this time, Mr. Dobbin has been in private practice and has conducted many tidal boundary surveys in Saint John Harbour and along both the Bay of Fundy and Gulf of St. Lawrence coasts. In regard to the harbour surveys, he noted the problems of jurisdictional boundaries, water lots, and the extremely gentle slopes of the tidal flats at some locations. Mr. Dobbin also has experience in establishing mean high water datums and boundaries for cable crossings on navigable rivers.

In Mr. Dobbin's opinion, the lines of mean high water (MHW) and ordinary high water (OHW) are equivalent. Where property values or the purpose of the survey warrant a precise boundary delineation, the MHW boundary is established as the intersection of this datum with the shore. This method had been discussed and accepted in one legal case in Saint John Harbour.

From the tide tables, an average of all the high water elevations for that year is calculated. On a day and time when this water level is predicted to occur, stakes are placed at approximately 50 foot intervals along the actual high water line and this line is then referenced to geodetic datum. Once a tie between geodetic and chart datums has been established from a previous survey near the site or from tidal benchmark information, this MHW elevation can be run as a contour for local boundary surveys and verified by visible evidence on the shore.

If no tidal reference station exists near the survey site, the elevation and time of MHW are interpolated from the tables. Meteorological conditions prior to the survey are also considered, and Mr. Dobbin related one survey on a tidal river in which the tide continued to rise well after the predicted time of MWH, the lag resulting from winter ice conditions downstream. During another survey on a navigable river behind a dam, the elevation of MHW was established from water level records at the dam.

Along the North Shore beaches, lines of seaweed are evidence of the MHW boundary, although Mr. Dobbin commented on the ambulatory nature of these exposed beaches. Recent tidal ranges can also be checked in the tide tables. On more rocky shores, a MHW elevation may be transferred from a nearby beach to supplement visual evidence, such as changes in rock colouration. The edge of vegetation is often used to delineate property boundaries on tidal rivers. Mr. Dobbin further noted the value of experience in weighing evidence of any tidal boundary location.

James B. Gillis, N.S.L.S., C.L.S.

James B. Gillis Land Surveying Ltd.

Middleton, Nova Scotia

Mr. Gillis graduated from the Nova Scotia Land Survey Institute (N.S.L.S.I.) in 1972 and, after receiving his N.S.L.S. commission, he established a private practice in the Annapolis Valley. He has conducted approximately 5 to 10 tidal boundary surveys per year in the Bay of Fundy and Annapolis River area and has had some experience in hydrographic surveying. Mr. Gillis recently established benchmarks for the environmental impact study of the Annapolis River Tidal Power Project.

Mr. Gillis indicated that his method of surveying a tidal boundary may vary with the coastal geography, purpose of the survey, and the value of the shoreline property. Along the Bay of Fundy beaches, the line of debris and seaweed often serve as evidence of the high water line, although allowances should be made for storm debris and variations in spring and neap high water lines. Mr. Gillis suggested that an approximate horizontal accuracy of 10 to 20 feet could be expected.On steeply inclined beaches, the base of the cliff may be shown as the boundary, but accurate surveys on extremely rocky shores would require the recovery of the appropriate tidal datum. The edge of vegetation on the banks of tidal rivers is used to delimit the upland parcel. The high water line shown on former survey plans may be used as a guide, depending on the degree of subsequent accretion or erosion.

Although Mr. Gillis does not presently use either tide tables or tide gauge data for these surveys, he expressed the opinion that accurate legal surveys should be based on an interpretation of the OHW line as the line of MHW, rather than a line based on vegetation or shoreline characteristics. The cost of the survey should not be an economic problem to the surveyor or the client, as in this case the client is receiving the benefits of a more accurate survey and security of tenure.

Everett Hall, N.S.L.S.

Scotian Surveys

Digby, Nova Scotia

A graduate of N.S.L.S.I., Mr. Hall received his N.S.L.S. commission in 1964 and set up private practice in 1968 after working with the Nova Scotia Department of Lands and Forests. His experience in tidal boundary surveying has been gained, for the most part, from rural and town property surveys in the Bay of Fundy region.

On the Bay of Fundy and Annapolis Basin tidal flats and beaches, Mr. Hall noted that the line of seaweed is a good indication of the high water line, whereas on more rocky or vertical shores, either the edge of the cliff or the MHW contour derived from tide tables may be used. The high water line on tidal rivers can usually be delimited by the bank or the change in vegetation.

In most cases benchmarks are set on the property sidelines on the top of the banks and a traverse is run, from which offset distances are taken to stakes along the last high water line of that day. On the plan of survey, the MHW line is referred to the date of survey, with the qualification 'more or less' for distances from the benchmarks.

One issue discussed by Mr. Hall was that of water lots that are particularly prevalent in the Annapolis Basin region. Some of these low water grants and water lots extend below the low water line for wharf allowances. In delimiting a low water boundary, approximate distances are taken from benchmarks at low tide and again the line shown on the plan is referred to the date of survey.

The choice of survey method and the accuracy desired usually depends on the characteristics of the coast, cost of the survey, value of the property, and the client's instructions. Land value would be an important consideration in delimiting marshland parcels. In general, however, the cost of the tidal boundary survey is estimated from the length of this boundary and is not a critical factor in the overall property survey.

G. Edward Hingley, N.S.L.S.

Debert, Nova Scotia

Mr. Hingley graduated from N.S.L.S.I. and returned as an instructor for three years, at which time his lectures included general survey law. He received his N.S.L.S. commission in 1967, and established a private practice near Truro. Approximately 5 to 10 tidal boundary surveys are conducted annually in an area covering a variety of tidal conditions that include marshland, the Bay of Fundy coast and the Northumberland Strait. Mr. Hingley also has experience in recovering tidal datums for cable crossings.

Referring to delimitation methods, Mr. Hingley stated that the choice of method and the corresponding accuracy may depend on the type of conditions encountered in the field, the purpose of the survey, and the value of the shoreline property. A reconnaisance is made before the the actual field work is started, although the tidal boundary is often only a small part of the total survey. The edge of vegetation or change of vegetation, as witnessed by the type of grasses, is good evidence of the tidal boundary in marshland areas, although a contour may be used in controlled marshland surveys. On rocky, wave-swept shores, the line of debris or dirt from the last tide, as well as marks left by wave action, would be more appropriate. Mr. Hingley estimated that the horizontal accuracy in this case to be approximately 10 to 15 feet. High water lines as found on previous plans of the area are not used for the boundary delimitation in recognition of shoreline changes.

Mr. Hingley noted the problem of water lot surveys for wharfing privledges on the North Shore and the problem of delimiting boundaries by vegetation changes where tidal bores had stripped the river banks of vegetation. Furthermore, he indicated that, in his opinion, there was a difference between ordinary and mean high water marks (OHWM and MHWM), the former as found in the Nova Scotia Land Surveyors regulations and the latter grounded in legal precedence.

Douglas K. MacDonald, N.S.L.S., C.L.S.

Servant, Dunbrack, McKenzie and MacDonald Ltd.

Halifax, Nova Scotia

Mr. MacDonald graduated from N.S.L.S.I. and holds both a N.S.L.S. and C.L.S. commission. He has 17 years surveying experience with the federal government, mainly in the Northwest Territories and the Yukon. Now located in private practice in the Halifax area, he conducts over ten tidal boundary surveys annually. These have included harbour studies, government surveys, and at least one large scale project for a private firm. Mr. MacDonald is also the author of a recent article regarding the definition of the OHWM.

In conducting a tidal boundary survey, the character of the shore, from the water line to the edge of the permanent vegetation, is observed to establish the best evidence of the OHWM, which, in Mr. MacDonald's opinion, is equivalent to the MHWM. Often the high water boundary can be delimited on beaches by the seaward edge of a gravel berm built up by wave action. Along tidal rivers, the edge of vegetation is evidence of the boundary, and photo interpolation is used between points fixed in the field in marshland areas.

Although a boundary shown on a previous plan is not used in the current survey, it may be shown on the plan as additional information. The boundary delineated on the plan from field work is referred to the year of the survey, particularly if the area is subject to shoreline changes. For verification of field evidence, the MHW contour may be established with the aid of tide table data, making allowances for water pile up due to wind in channels, the coastal configuration, and river outflow.

Mr. MacDonald discussed the survey of military lands on MacNab's Island, where the seaward limit of the lands was legally defined by the low water ordinary spring tidal datum. In this case, stakes were set at approximately 500 foot intervals at the time the tide would rise to this level, the time being derived from tide tables. The stakes were then tied in by a traverse. On checking the locations of these points against aerial photos, it was found that they corresponded well with the change in photo colouration.

One problem encountered by Mr. MacDonald has been the recovery of original high water boundaries in the Halifax Harbour area, to which water lot grants are referred in the deed descriptions. He pointed out that much infilling has occured along the shores and the granting of water lots in tiers from the shore further complicates the issue.

Ivan P. Macdonald, N.S.L.S., C.L.S.

Wallace, Macdonald & Lively Ltd.

Bedford, Nova Scotia

After graduating from N.S.L.S.I. in 1955, Mr. Macdonald joined the federal government for fourteen years, in which his work included tidal boundary surveys in British Columbia and Nova Scotia. He received his N.S.L.S. commission in 1955 and his C.L.S. commission in 1966. Mr. Macdonald also has taken several courses in hydrographic surveying and has surveyed water lots in the Bedford Basin and Halifax Harbour. Approximately 5 to 10 tidal boundary surveys are carried out annually in his present practice, which is located in a residential town on the Bedford Basin.

Mr. Macdonald cited land use, rather than land value, as a factor in determining the method of delimiting a tidal boundary. Survey time, contract instructions or regulations, and the type of shoreline characteristics might also be considered. The line of vegetation change or the edge of vegetation is generally delimited as the OHWM. The tidal sorting of stones, shore debris, and kelp are evidence of the high water boundary on beaches, although allowance may be made for seasonal changes and spring tide. This tidal information can be obtained from the Bedford Institute of Oceanography or from tide tables. On rocky shores, a brownish stain above the kelp line is an indication of the boundary.

The limit of tidal influence in marshes may sometimes be delimited by the occurence of 'dead furrows', small soil ridges built up from the lapping of waves. In all cases, the boundary delineated on the plan is referred to the date of the survey.

Mr. Macdonald discussed several other issues, including the delimitation of the tidal effect in rivers and the apportionment of accretion. Drawing on his experience in the former case, Mr. Macdonald explained the use of visual inspections over a one to two week period, in which he noted the location of ripples as the tide ebbed below the river back up. In the case of apportionment of accretion, his concern was the inequity sometimes incurred by one party if the property sidelines were prolongated. Apportionment by extending the boundaries perpendicular to the general trend of the shoreline would be a more equitable solution.

John Quigley, N.B.L.S.

Kierstead Surveys Limited

Rothesay, New Brunswick

Mr. Quigley graduated from the University of New Brunswick in 1978 with a Bachelor Degree in Surveying Engineering and received his N.B.L.S. commission shortly after that time. He is currently employed with a private surveying firm in the Saint John suburbs. Approximately 10 tidal boundary surveys are conducted annually, generally in the Saint John Harbour area and along tidal rivers. Mr. Quigley commented that, in general, the method of surveying a tidal boundary would depend on property value and land use, as well as on established survey practices in the area.

In Mr. Quigley's opinion, the terms OHW and MHW are equivalent, although OHW line or mark is usually shown on plans of survey. On tidal rivers and in marshland either the edge or change of vegetation is used to delineate the upland property boundary. Horizontal accuracies of approximately 10 feet could be expected in most tidal boundary surveys, and the distances are often shown as 'more or less' on the plan.

When the Saint John River is low, a MHW elevation established in a previous survey may be transferred to the survey site and the contour shown as the boundary. Similarly, the MHW elevation can be useful in marshes, where flooding occurs behind the outer banks and the change in vegetation is not distinct. In the winter, the edge of river ice is evidence of the water line and the water level can be checked through a hole cut in the ice.

Mr. Quigley noted several problems related to water lot leases and the location of present and former jurisdictional boundaries. For shoreline surveys in the harbour a contour is run, using a previously established MHW elevation, and this line is verified by ground evidence. When it is necessary to locate former high water boundaries for foreshore leases where the shore has been filled in, tie distances may be scaled from older plans. The time involved in researching Saint John Harbour boundaries was mentioned as an important factor in the cost of the survey.

Walter C. Rayworth, N.B.L.S., N.S.L.S., C.L.S

Rayworth and Roberts Surveys Ltd.

Amherst, Nova Scotia

An N.S.L.S.I. graduate, Mr. Rayworth received his N.B.L.S. commission in 1965, his N.S.L.S. commission in 1972, and his C.L.S. commission in 1982. His experiences in tidal boundary problems include the survey of water lots in Pugwash and the Baie De Chaleur, provincial and federal government surveys, and property surveys along the Atlantic coast. His present firm, which also does hydrographic work, is located in a small town on the marshy isthmus of Nova Scotia and bounded by the Bay of Fundy and Northumberland Strait shore.

Mr. Rayworth indicated that the method chosen for a tidal boundary survey may depend on the purpose of the survey, the type of shoreline, and type of land use, such as industrial development. Horizontal accuracies in the range of 5 to 10 feet would be expected for most surveys. Tide tables may be used to establish a contour elevation at the site, but it would also be verified by visual evidence. It was noted that tide tables provide only approximate datum heights and that corrections should be applied.

Visual evidence includes a line of seaweed or debris and, on the Bay of Fundy shore, assorted gravel lines. Water marks or discolouration on rocks may also be considered. Vegetation lines are often the best evidence in marshland areas, although Mr. Rayworth pointed out that even occasional flooding by saline water may cause changes in the vegetation.

One problem discussed by Mr. Rayworth was the change in lot size when coastal property is subject to erosion. In order to re-establish the rear line of a property, it is sometimes necessary to establish the original boundary at the time of the grant from aerial photos and parole evidence.

Mr. Rayworth has also been involved in determining the limit of the tidal effect in rivers in New Brunswick. This was again established from parole evidence, evidence of saline water, and vegetation change.

David T. Roberts, A.L.S., N.S.L.S, C.L.S.

Rayworth and Roberts Surveys Ltd.

Parrasboro, Nova Scotia

Mr. Roberts graduated from N.S.L.S.I. in 1965 and received his A.L.S. commission in 1970. Returning to Parrasboro, which is located in a rural region at the head of the Bay of Fundy, he received his N.S.L.S. commission in 1975 and a C.L.S. commission in 1981. Mr. Roberts carries out approximately 10 tidal boundary surveys annually and occasionally conducts near shore hydrographic work.

Mr. Roberts noted that the method of survey used in delimiting tidal boundaries may vary with the coastal charateristics and with the location of the property within specific jurisdictions. With regard to the latter, he cited a case in which old grant descriptions included land to the line of the high water spring tides, recognized as both the storm line and the line of occupation. In this particular instance, a gravel bar in Parrasboro was used by the public above the MHW line and the boundary was delimited by the upland occupation.

Along the broad Bay of Fundy beaches, evidence of the normal tide line is often found 30 to 40 feet from the base of the bank. In one Quieting of Titles case involving a barren beach, a stadia survey was conducted to tie stakes marking the water line at the time of mean high tide. This time was established from the tide tables for Parrasboro and the line was verified by several days of observations. Although only approximately 1 mile from the town, the time lag of high tide was estimated to be approximately 20 minutes. No other corrections were made as it was an open coast.

Mr. Roberts pointed out that low water boundaries could be delineated from aerial photos. Change in vegetation is evidence of the high water boundary in enclosed bays, and marshlands are delimited by the edge of vegetation. Mr. Roberts did, however, note that areas swept clean of vegetation might present problems. Horizontal accuracies in most surveys were estimated to be approximately three feet on the Northumberland Strait and approximately five feet on the Bay of Fundy coast, where more gentle slopes are encountered. Approximate distances are shown on the plan of survey and the boundaries are referenced to the date of survey.

APPENDIX II

TWO MARITIME CASE REVIEWS

APPENDIX II

TWO MARITIME CASE REVIEWS

Although the common law governing tidal boundary delimitation in the Maritime Provinces encompasses Canadian, English, Commonwealth, and, to a more limited extent, American case law, only two examples will be reviewed in detail here. These cases, Irving Refining Limited and the Municipality of the County of Saint John v. Eastern Trust Company[1] and Shaw v. the Queen[2] (hereafter referred to as the Irving and Shaw cases), have been chosen because they represent recent developments in the practice and law of tidal boundary surveys in the Maritimes. Neither case has received attention in surveying literature, but this may be partly due to the lack of emphasis placed on the survey in the final jugements. In preparing these reviews, therefore, additional material has been heavily relied upon.

Information regarding the Irving case was gathered from the somewhat lengthy transcripts of the 1962 to 1965 trial proceedings, the judgement, and plans made available by a New Brunswick survey firm. This case, which considered the expropriation of tidelands and riparian rights, is an excellent example of the many land tenure and survey issues that can arise as coastal land values appreciate and more precise survey methods are required. In this review the emphasis is placed on the tidal boundary survey, the consequences of an apparent discrepancy in that survey, and the delineation of former high water lines. The relationships of these findings to the property issues raised is discussed only briefly, but a more detailed analysis of these issues and the evidence presented may be found in the references.[3]

The judgement in Shaw v. the Queen was delivered in 1980 and again involves the expropriation of coastal land, in this case, for the formation of the Prince Edward Island National Park. Several issues not directly related to tidal boundary delimitation have been omitted in the following review. The findings of the Court did include comments on the legal definition of accretion but discussion on the various methods used to delimit high water boundaries was brief. To supplement the judgement on these matters and on the consequences of an error in the expropriation survey, the Atlantic Regional Surveyor, Department of Energy, Mines and Resources provided plans, aerial photographs, and a geomorphological report prepared for the Crown.

Both cases raise some of the issues in tidal boundary delimitation that have been addressed in the United States. Changes in the nature of coastal land tenure and the related increases in land values can create the need for more precise surveys and accurate definitions of tidal boundaries. What emerges from both the Irving and **Shaw** cases is the apparent inconsistency in the interpretation of the common law boundary and its delimitation in Maritime law and surveying.

II.1 Irving Refining Limited et al v. Eastern Trust Company

This case arose out of an action by the plaintiffs for a declaration of title to tidelands on the western shore of Courtenay Bay, in the City of Saint John, New Brunswick. Title to the parcel in question had been held by the plaintiffs, Irving Refining Limited, prior to the expropriation by the Municipality. After the expropration, title to the

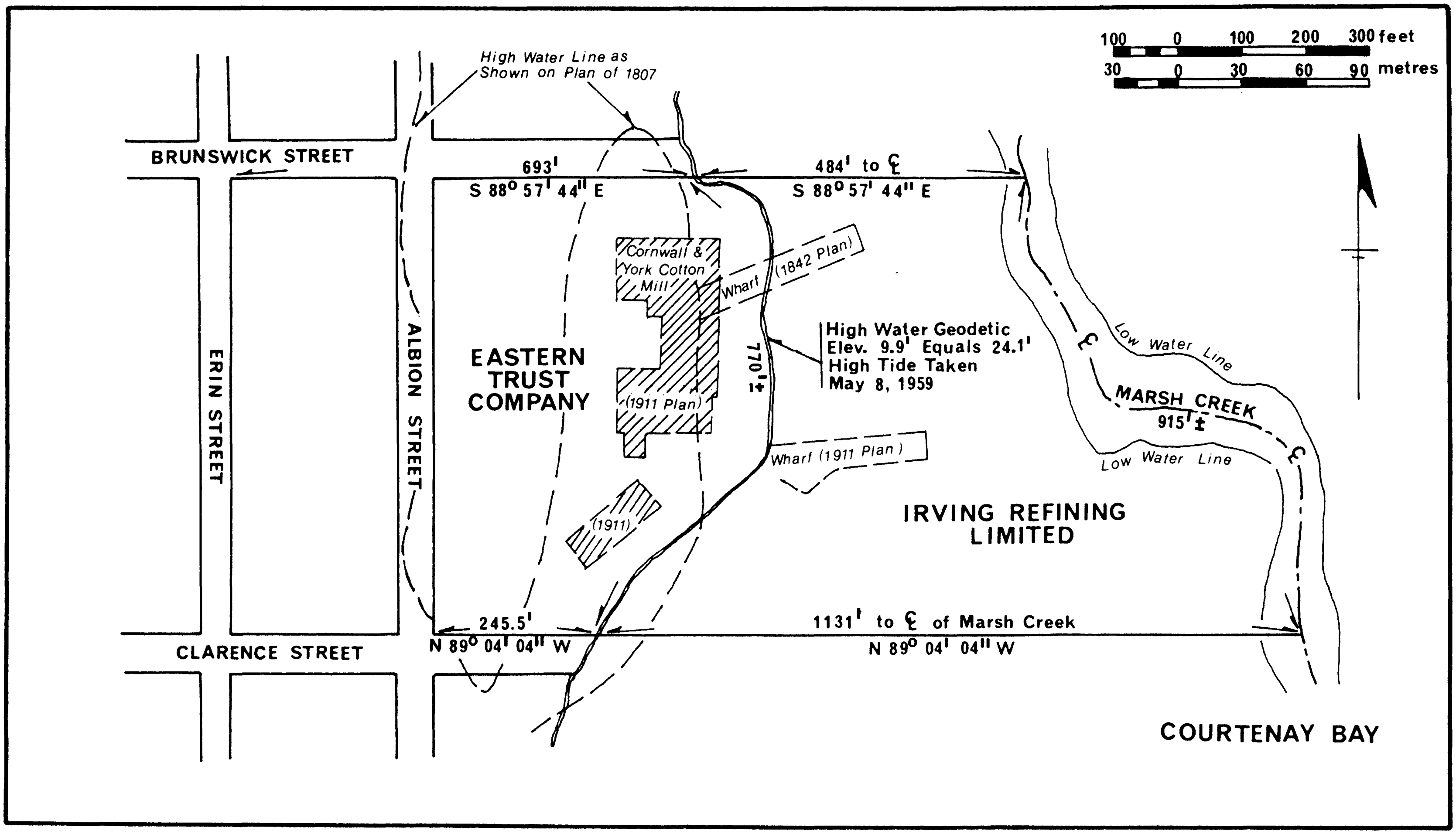

Figure II.1: Upland and Foreshore Parcel in the _Irving_ Case[4] lands below the high water mark was conveyed back to Irving Refining Limited for the construction of a causeway and reclamation of the tidelands for industrial purposes. The defendants, as owners of the adjacent upland property, claimed compensation for riparian rights that had been included in the expropriation order and also claimed title to the tidelands below the high water mark by virtue of a deed and occupation.

II.1.1 The issues

The upland parcel had been part of an original Crown grant to James Simonds and was made before the Charter of the City of Saint John in 1785, which passed all previously ungranted lands to the city. Various businesses had occupied the upland parcel, including a shipyard and a cotton mill. During their operations waste material had been dumped over a retaining wall on the shore and temporary structures had been built on the abutting tidal flats. These actions, as well as natural shoreline processes, resulted in a horizontal displacement of the high water boundary.

Based on a survey conducted by a local firm in April, 1961, the description of the expropriated parcel was prepared and registered in August of that year. The description called for the high water mark as the westerly boundary and the expropriation also included

> all riparian rights upon, over and across the above described lot of land owned or possessed by the owners or occupiers of any other lands bounded by high water in Courtenay Bay where such high water mark is also one of the boundaries of the above described lot of land.[5]

The defendants claimed title to and occupation of the foreshore on and before August 1, 1961, as well as ownership of the riparian rights.

Thus, they maintained they were entitled to compensation for the lands and rights expropriated. The plaintiffs counterclaimed that the property of the defendants was bounded on the east by the natural high water mark of 1785, as defined in the Charter, and that the defendants had encroached on the foreshore which had been held by the City as common lands until 1911. This led to a court action for a declaration of title.

Two legal issues were to be decided by the Court: title to the foreshore and whether the riparian rights of the upland parcel had indeed been expropriated. During the course of the trial many other issues were raised, including the use of ancient plans to establish tidal boundaries and the extent of occupation, the legal effect of artificial accretion, and the validity of adverse claims to the foreshore. The method of survey, the recovery of tidal datums, and the definition of the high water boundary were also discussed in order to resolve the issue of the riparian rights.

II.1.2 The survey and the issue of the riparian rights

In Canadian law the high water boundary is defined as the ordinary high water mark (OHWM). Although the OHWM was referred to during the trial proceedings, both the surveyor and the Court interpreted this line as the intersection of the mean high water (MHW) datum with the shore, a contour elevation that could be derived from the tide tables produced by the Canadan Hydrographic Service (CHS). The method of survey was based on this definition.

Testimony was given by the surveyors who conducted the expropriation survey and the facts established are summarized below:

a. In 1959 the high water boundary along Courtenay Bay was located by staking the observed water line at fifty foot intervals on the day (May 8) and time when the MHW level, calculated as 24.15 feet (7.36 metres) from the tide tables for that year, was predicted to occur;

b. A line of levels was run to a temporary benchmark and the elevation of the stakes was determined to be 9.9 feet (3.02 metres) referenced to geodetic datum;

c. Since 24.2 feet (7.38 metres) chart elevation equaled 10.4 feet (3.17 metres) geodetic, there appeared to be a discrepency of 0.5 feet (0.15 metres) in vertical elevation that was not discovered until the trial proceedings;

d. In April, 1961 stakes were placed on the northwesterly and southwesterly property corners using the 9.9 feet geodetic elevation and ties were made from street intersections to the high water boundary thus established;

e. The high water boundary for the 1961 expropriation plan was traced from the 1959 plan using the distances from the street intersections to position the boundary.

The problem raised by the survey was whether a strip of foreshore in front of the upland parcel had been excluded from the expropriation description. If so, the defendant's riparian rights would still apply to this strip and the expropriation of these rights would have no effect. To solve this problem, the nature of shoreline changes that had occured since 1785 were investigated, as well as the survey method and the apparent discrepency.

Many ancient plans were introduced as evidence of the high water boundary in the past, but confusion ensued over the relationship between various datums. Among those discussed were the High Water Spring and Saint John Sewer Datum (shown on many early plans), Geodetic Datum, Saint John Harbour Datum, and the Low Water Ordinary Spring Tidal Datum (to which the tide tables were referenced). The testimony of several witnesses, including Mr. Gerhart Dohler, the Chief Tidal Officer of the CHS, was required to provide a clear explanation of the datums and their relation to the 1959 survey. Only then could the plans and charts be interpreted correctly.

From the evidence presented, which also included sediment core samples along the northerly boundary of the upland, it was concluded that there had been a general extension of the upland parcel eastward since 1785 by both natural accretion and man's activities. Natural actions of waves and storm surges had been intensified by the construction of wharves and breakwaters. Artificial changes had occurred with the dumping of fill and cotton waste to reinforce the retaining wall, but the Court ruled that this material had been added "for the protection from action of the sea"[6] and was consistent with the upland owner's riparian right of title to lands so accreted. Since the boundary was ambulatory, the ties made in 1961 were only indications of the boundary location on the day of the survey and did not necessarily define the true position of the boundary at the time of the expropriation.

Further problems arose with respect to the method of survey, in particular, whether the line shown on the 1961 plan was actually the MHW line. The datum of 24.15 feet elevation was referenced to the Saint John Harbour tide gauge. Although tidal records had been produced for Saint John since 1895, the reliability of the gauge data for tidal predictions in Courtenay Bay was questioned. Testimony from Mr. Dohler established that the gauge was located on the eastern shore of the main harbour and subject to the influence of the Saint John River freshets in the late spring. The remoteness of the survey site from the tide gauge and the effects of wide shallows and breakwaters in Courtenay Bay were mentioned, but no attempt was made to determine what influence these factors might have had on the range and time of tides in Courtenay Bay in relation to the tidal predictions for the main harbour.

As the survey was conducted by staking the actual water line, the range factor would have been accounted for, but the difference in the time of mean high tide between the primary station and the survey area might have had a significant effect. This may have been partially compensated for by the method of survey, since the staking of the 770 foot water line would have extended over a certain time period. On the other hand, the rapidity with which the tides in the Bay of Fundy rise and fall could create a large displacement of the horizontal component in a short lapse of time. Meteorological conditions were not considered a factor because the difference between the predicted tides and those observed at the gauge on May 8, 1959 was within the .03 foot allowance given in the tables.

Although Mr. Dohler established that the level recorded on May 8,

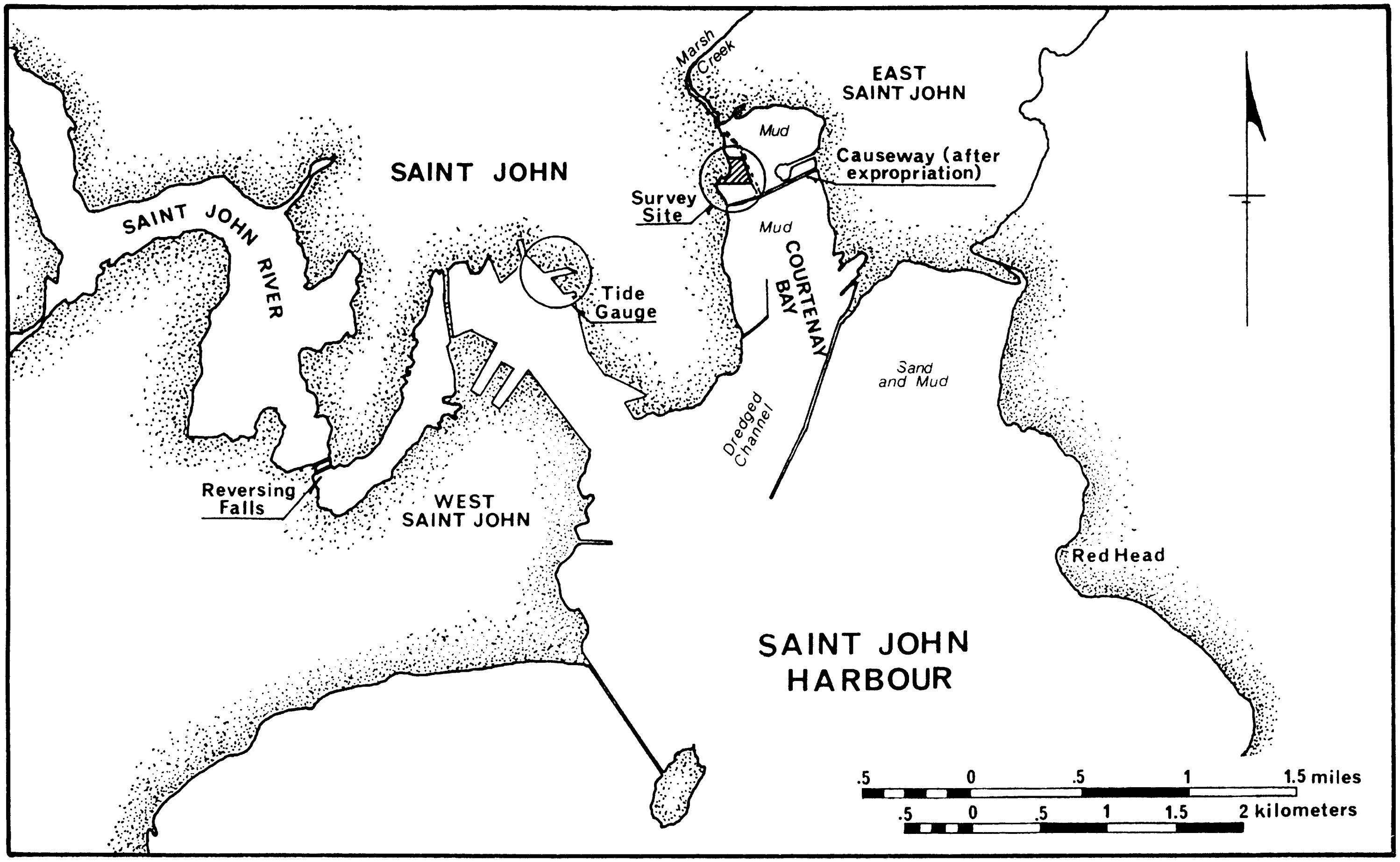

Figure II.2: Saint John Harbour Tide Gauge and Survey Site[7]

1959 was 23.9 feet (10.2 geodetic) and not 24.1 (10.4 geodetic) as predicted, the Court ignored this fact and any local tidal variations in discussing the 0.5 foot (10.4 - 9.9 geodetic) discrepancy. Finding that the elevation of the MHW datum was 24.1 feet and that this was also the elevation of the water line demarcated in 1959, the Court considered the discrepancy to be a survey error in tying to geodetic datum.

This 'error' was debated at great lengths throughout the trial. The original line of 1959 was not affected, as a local observed tidal datum was established. Rather the difficulty occured in using this elevation to determine the property corners in 1961. The Court approved the method of demarcating tidal boundaries as contour lines. However, the corners were established at 23.6 feet (9.9 geodetic) rather than at 24.1 feet (10.4 geodetic). The boundary shown on the 1961 plan was thus approximately 12.5 feet seaward of the MHW contour, assuming a 4% beach slope as mentioned in the proceedings.

It was on this strip of foreshore that the plaintiffs claimed the riparian rights of the upland parcel still operated. In deciding the issue, the Court referred to the text of the expropriation order that called for the high water mark as the western boundary and ruled that the call for the natural monument, the high water mark, overrode the call for any erroneous distance.

Counsels for both the plaintiffs and defendant agreed that the riparian rights could be expropriated without taking any upland. Although the Court questioned this decision, it was allowed to stand. Their arguments were based on the fact that other rights, such as easements, could be extinguished without affecting the boundaries of the parcel to which they were attached. Similarly, riparian rights run with the upland property and the riparian owner derives special benefits from his title to the upland. Therefore, these rights could be extinguished or expropriated as interests separate from the title to the upland. If the defendant's land was also bounded by the high water mark, it followed that the expropriation had the effect of taking these rights.

II.1.3 Title to the tidelands

The plaintiffs established a good chain of title, beginning with the Charter of the City of Saint John, to the lands below high water to the centreline of Marsh Creek (a river flowing in a defined channel at low tide). The defendant also claimed title to these tidelands and their defence rested on three separate claims: by reason of an 1850 warranty deed, by adverse possession, and by colour of title.

In 1763 lands in the Courtenay Bay area, which the defendants maintained included the tidelands in question, were granted to James Simonds and others. These lands were exempt from the Charter, and a warranty deed, attempting to convey lands extending to 'a Little Cove or River' and bounded on the west by the said Cove, was granted to two shipbuilders in 1850. An ambiguity lay in the call for the Cove (Courtenay Bay) and the River, which was interpreted by the defendant as Marsh Creek. The Court ruled that the second call for the Cove controlled the call for the River and that the Simonds Grant was bounded by the high water mark. It followed that the defendant did have riparian rights as the upland owner, that these were expropriated, and compensation was due.

The claim of adverse possession rested on structures built over the tidal flats, including several wharves and shipways, sewer pipes, and a breakwater. Following the decision of Tweedie v. King[8], the Court ruled that adverse claimants to the foreshore did not have to prove the same exclusive possession required in the case of uplands. In the Irving Case, however, no continuous possession for the statuatory period could be proved in spite of extensive evidence presented in the form of ancient plans, photographs, and expert testimony. Although the structures were shown on many plans from the shipbuilding period, the location and even the existence of the wharves was questionable. The breakwater, located in navigable waters, was viewed by the Court as obstructing the public right of navigation and could not be used to gain title through occupation. Since no actual and continuous possession for 20 years could be proved for the remaining structures, the defense of adverse possession failed.

Similarly, the case based on colour of title was defeated. The defendants claimed entry by their predesessors in title under the warranty deed of 1850. As the warranty deed was an indication of a defect in title, the Court ruled that they were not bona fide grantees. The Court also noted that the tidelands were then considered to be common lands of the city and there could not be two constructive possessions of the same land concurrently. Furthermore, the grantees had previously leased the property described in the deed, so no initial entry was made under the warranty deed. Evidence of colour of title must also satisfy the conditions for adverse possession, hence this defense was defeated on several grounds.

II.1.3 Summary of the decisions

Two legal issues had been addressed in the Irving case, the first being the expropriation of the riparian rights. To settle this matter, the Court examined the relation between the high water mark called for in the expropriation order and the defendant's upland tidal boundary at the time of the expropriation. Resolving the ambiguous 1850 deed description, the Court found that the defendant's title was bounded by the high water mark of Courtenay Bay. Since it was ruled that the defendant had property rights in the lands accreted after the Charter, the upland was also bounded by the existing high water mark in August, 1961. Following the well established rule that monuments govern distances in property descriptions, the Court also found that the expropriation order included all the foreshore below the high water mark. The riparian rights, which could operate only on this land, were thus expropriated, although the amount of compensation was not determined.

The second issue was the declaration of title to the tidelands expropriated, to which the plaintiffs had established a clear chain of title. Based on the failure of the defendant to prove possessory rights or prior title by deed, the Court ruled that title to the tidelands remained with the plaintiffs.

II.2 Shaw v. the Queen

This action was initiated by the plaintiff for compensation for, or alternatively, a declaration of title vested in his name to lands expropriated on the northern shore of Brackley and Covehead Bays in Prince Edward Island. The lands in dispute had purportedly been expropriated by the Province in 1937 as part of Parcel 3 of the Prince Edward Island National Park and after a second expropriation in 1956, the administration, control, and beneficial interests in these lands were transferred to the Crown in right of Canada.

II.2.1 The issues

The legal issues identified by the Court were the effect of the two expropriations, title to the area claimed by the plaintiff, and whether a declaration of title could be made. The Court dealt in some detail with an issue of jurisdiction, in particular, whether the plaintiff could file an action against the Crown in right of Canada when the lands had been expropriated by the Province and whether the Province could transfer title or beneficial interests to Crown Canada. Other questions raised in the judgement included the amount claimed in compensation ($2,000,000.00) and the expropriation procedures, but the concern in this review will be the tidal boundary issues.

Over a period of four decades surveys had been carried out, boundaries had been negotiated, and a geomorphological study had been conducted, all with the intention of resolving ambiguities in the extent of the lands expropriated. From the voluminous files and sometimes contradictory evidence, the Court did find a solution to the question of title in the disputed lands. Although no conclusions were explicitly drawn regarding the methods used for the tidal boundary delimitation or the claims to accretion made by both parties, these issues were discussed in the judgement and additional information was available in the 1978 geomorphological study.[9]

II.2.2 The claims of title

The defendant obtained title to a farm and hotel property in 1936, the eastern portion being bounded

> on the South and Southeast by the shore of Brackley Point Bay; and on the East by said shore and by the eastern portion of a sand bar enclosing the aforesaid Bay.[10]

Following a survey of the Brackley Point area, lands to the north and east of the hotel property were expropriated in 1937 for the National Park. Negotiations were undertaken to arrive at a settlement with the Province and in 1938 the plaintiff was paid $3,000.00 for approximately 117 acres of timber, marsh, beach, and pasture land.

The problem that emerged from the survey and the subsequent description of the expropriated lands was the possibility that Areas B and C, as shown in Figure II.3 had not been included. Since the description depended on the existence of an embayment delineated on the 1937 expropriation plan, the title to Area A was also in doubt.

Correspondence between the plaintiff and government officials at various levels flourished. From an examination of this material, the Court concluded that it had been

> quite generally conceded by all parties that in 1937 the expropriation did not in fact include these areas or that at least there was some doubt as to whether it did.[11]

In the course of the negotiations, the plaintiff agreed to retain only

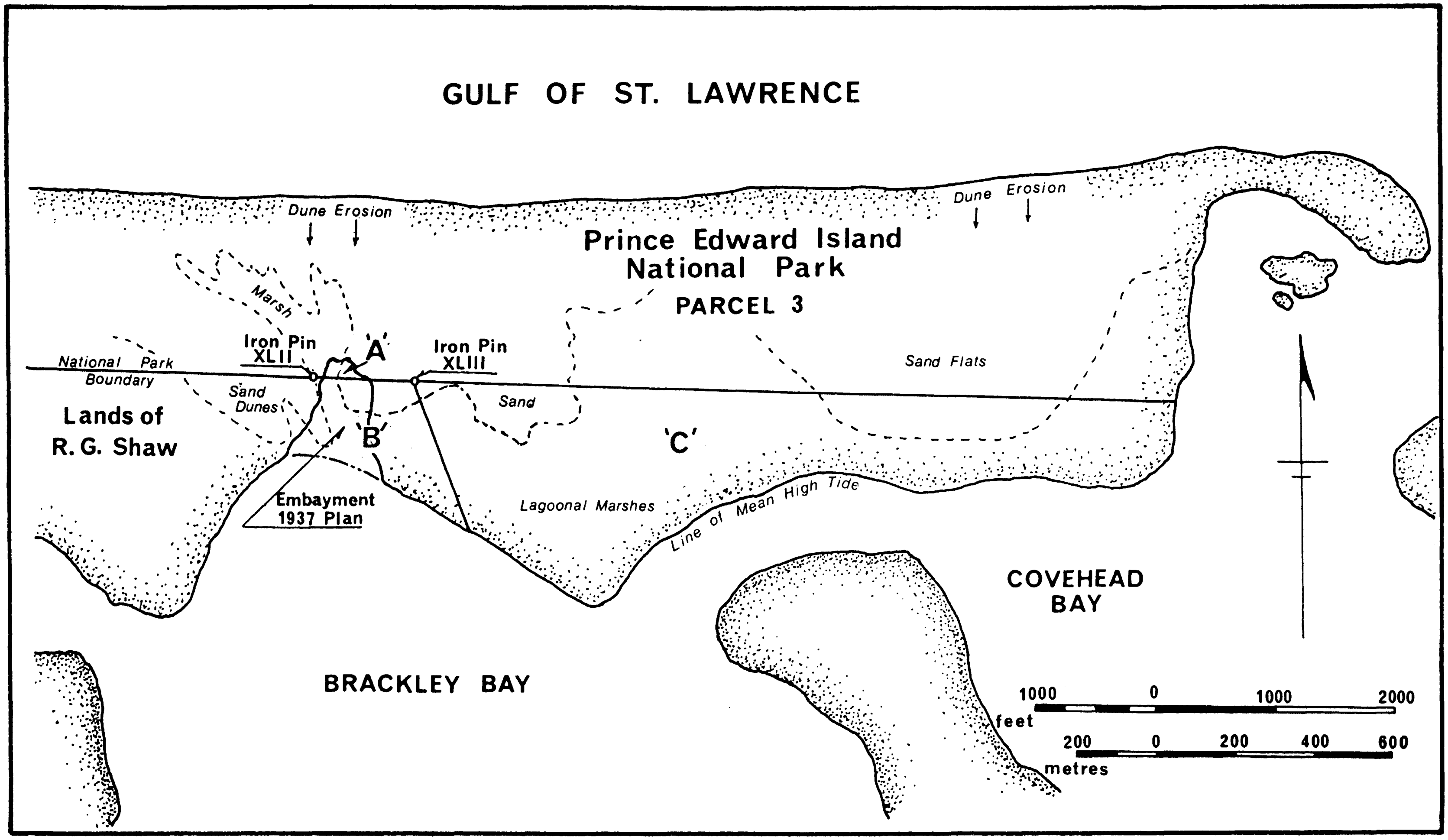

Figure II.3: The Embayment and Areas in Dispute in the Shaw Case[12]

Area B, but the issues of land use and title became the subject of political debate. Although the plaintiff claimed to have operated a golf course, extending into what is shown in Figure II.3 as an embayment and possibly into Area B, most of the disputed lands were marshlands suitable only for game bird hunting. The debate continued into the late 1950's as to exactly what lands might be excluded from the Park for the purpose of hunting. By 1970 the federal government had proposed that the entire area in dispute be retained for a migratory bird sanctuary.

Throughout the negotiations, attempts were made to correct the ambiguity in the 1937 expropriation by amending the description of the Park boundaries. In consultation with the plaintiff, various dimensions were proposed for Area B. After reaching some agreement, a second expropriation took place in 1954. This had the effect of including Areas A and C within the Park, but Area B was excluded. No further compensation was received by the plaintiff for Areas A and C, nor was Area B ever conveyed to him by the Province. In fact, the description of the new boundaries was not amended in the <u>National Parks Act</u>[13] until 1974.

After this expropriation, the plaintiff and others continued to pursue the matter of retaining a portion of Area C for hunting. To maintain its interests, the Crown then reverted to its original position that the 1937 plan correctly depicted the lands expropriated by the Province and transferred to Crown Canada. Based on the ambiguity in the original expropriation description and on the riparian right to accretion, the plaintiff claimed title to the disputed lands or, alternatively, compensation for the 1954 expropriation. The defendant counterclaimed that title was held by the Crown, relying on mutually exclusive arguements: the effect of the 1937 expropriation and the fact that the lands had always been Crown lands by the nature of the acceretion.

II.2.3 Title and the issue of accretion

To address the defendant's assertion of prior title, it was necessary to establish whether the plaintiff held title to the disputed lands before the 1937 expropriation either by deed or accretion, and if not, whether Crown Canada actually held these rights. In view of the effect of the 1954 expropriation, the Court often limited its discussion of accretion and title before 1937 to Area B. The Court considered the issue of accretion significant, but it was noted that

> [if] no expropriation had taken place and the claim had to be settled on the basis of ownership of accreted land the decision would indeed be very difficult.[14]

The arguments regarding prior title and accretion relied heavily on the findings of a 1978 geomorphological study conducted in the area. Using evidence from ancient charts and aerial photographs, in addition to vegetation, soil, and tidal studies, the origin and present characteristics of the disputed lands were documented in an unpublished report.[15]

In this report, the Brackley Point region is described as consisting of ocean beach, sand dunes, and lagoons. The latter are conducive to sedimentation and the development of intertidal marshes. Typical of the barrier beach and barrier island formation of the southern Gulf of St. Lawrence, the major portion of the promontory north of Brackley Bay appeared to have formed from the landward migration of an offshore sandbar. On these barrier islands, sediments from the Gulf shore are carried by wave, wind, and tidal action through washover channels between the dunes and are deposited on the landward side. Here the build up of alluvial fans and the subsequent growth of salt marsh vegetation entrap more sediments. These fans gradually emerge as intertidal marshes or eventually as new land forms. Over time the islands transgress toward and become part of the mainland, where the sediment deposition continues to form marshes and alluvial fans along the enclosed bays. Evidence of these processes in the Brackley Bay area was found on aerial photographs of 1935 and on older charts. Construction of a highway along the Gulf of St. Lawerence shore after 1935 arrested this southward migration and the northern shore of Brackley Bay began receeding.

In view of the manner of formation of the disputed lands, the Court first established whether the plaintiff had any prior claim by deed to what is now known as Brackley Point. In 1793, the plaintiff's predesessors in title were conveyed lands, the eastern portion of which was described as being partially bounded as follows:

> [on] the North and East by the Narrows of Brackley Point and Little Rustico Bay; On the South by York Bay or Cove.[16]

To interpret this description in terms of present geography, the defendant relied upon the evidence of ancient charts gathered for the above report.

Figure II.5 is an enlarged sketch derived from the 1775 map of a survey conducted by Captain Holland, whose knowledge of and delineation of the Prince Edward Island coastline was considered in the report to be reliable and accurate. On the basis of this map, the defendant interpreted the Narrows of Brackley Point to be the narrow channel connecting Harris Bay (now Rustico Bay) and York Bay(now Brackley Bay). Not until 1865 did the British Admiralty Charts of the region show the

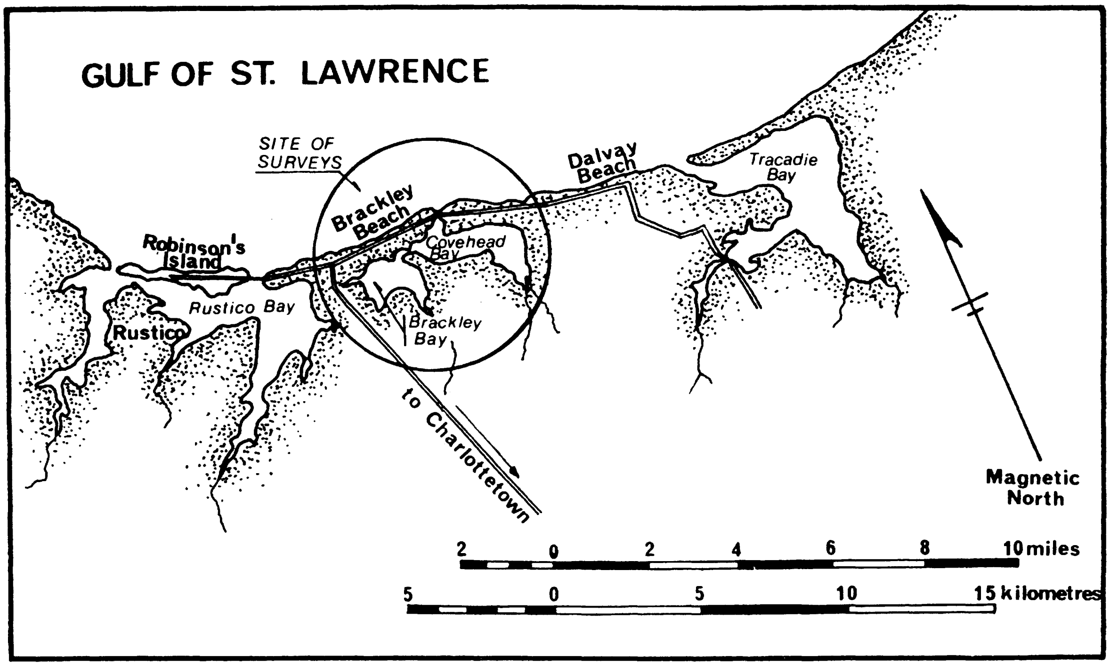

Figure II.4: Present Geography of Brackley Bay Area[17]

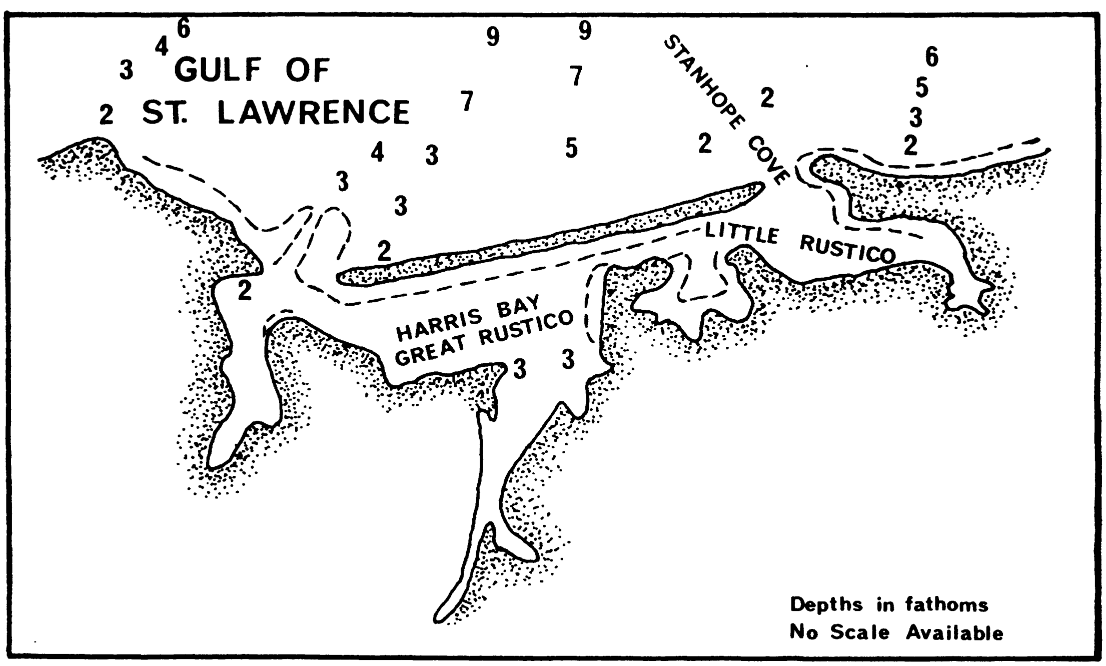

Figure II.5: Sketch from Captain Holland's 1775 Chart[18] channel to be closed by the migration of the barrier island southward. Although the judgement mentioned an 1880 sketch that showed Brackley Point as a much less pronounced promontory and separated from a sand bar by a narrow channel, this sketch was prepared from an 1847 survey. The above evidence indicated that only after the mid 1800's did the sandbar join the mainland. Therefore, the 1793 conveyance did not include the sandbar. Since the deed of 1936 described the plaintiff's lands as a farm and hotel property and since the acreage called for was far short of that included in the existing Brackley Point, it was ruled that the deed did not explicitly convey title to the Point.

Limiting the discussion of accretion to the lands in dispute, in particular Area B, the defendant's counsel questioned whether deposits gradually emerging in the southern lagoon areas of the Point could be defined as accretion and thus be subject of the riparian owner's rights. Alternatively, the defendant claimed that the southern shore of Brackley Point was Crown land by the nature of its formation.

To support this argument, the counsel for the defendant called the Court's attention to the decision of Attorney General of British Columbia v. Neilson[19] in which the distinction was made between accretion and vertical formation of land, the latter remaining with the owner of the bed. After noting the entrenchment of this distinction in the common law, the Court commented that

> [certainly] a sandbar or island off shore does not belong to the riparian proprietor unless it is clearly included in his title, and if with the passage of time silt and sand fills in the area between, this would not give him ownership of that area or of the sandbar, whereas a gradual extension of the land outwards by tidal and wind action would properly constitute accretion.[20]

By the nature of the deposition of the sediments in Area B, this would appear to limit the plaintiff's title by accretion. The Court, however, found the evidence inconclusive on this matter.

On the other hand, it was noted that even if part of Area B had emerged through vertical formation, then the defendant could not claim title. Following the decision in Re Jurisdiction Over Provincial Fisheries[21], title to these lands would be held by Crown Prince Edward Island as opposed to the Crown in right of Canada. The Court further concluded that the defendant's argument of prior title by virtue of accretion was "rather a thin reed on which to rest claim to title of land in which Crown Canada has no interest whatsoever."[22] Therefore, the defendant's claim was dismissed.

II.2.4 The tidal boundary surveys and the expropriation issues

Since the Park lands east of the hotel property were intended to be bounded on the south by Brackley Bay, the survey for the 1937 expropriation entailed the delineation of the ordinary or mean high water boundary. Although the original expropriation description called for the 'line of mean high tide' as the park boundary, this term was interpretated by later surveyors as the OHWM to be delineated by physical shoreline features. Except in the geomorphological studies, no attempt was made to establish a tidal datum. Mean high tide was not defined as a specific datum and the Court used the terms 'mean', 'ordinary', and 'medium' interchangeably throughout the judgement.

The title dispute had its genesis in the 1937 survey and at least four surveys of the Brackley Bay boundary were carried out before the trial to resolve this problem. Two plans were prepared for the Crown following the traditional methods of tidal boundary delimitation, one in

1953 for the second expropriation and the other in 1977. Included in the geomorphological study of 1978 were two independent delineations of the OHWM using vegetation analysis and tidal observations.

The original survey of 1937 was conducted by R.W. Cautley, D.L.S., a surveyor for the federal government. Arriving on the site in the late fall of 1936, Cautley wrote to the Surveyor General to inform him that it was

> an emergency survey being made at the wrong time of year in order to enable the local government to pass title to the Dominion so that the Parks Branch may give authority to expend the current appropriation for this park. It is a case of working against time to get the very considerable amount of survey work required finished before the country is completely frozen up.[23]

The portion of this survey of interest to this case is the delineation of the embayment shown in Figure II.3 and Figure II.6, just east of Iron Post XLII. Since Cautley was relying on shoreline features as evidence of the OHWM, winter conditions and the build up of ice along the shore may have caused the apparent error in depicting all lands within the embayment as being below the OHWM and therefore held by Crown Prince Edward Island. Aerial photographs, testimony by area residents, and the geomorphological report all indicated that significant dry land features existed in this embayment at the time of the survey, particularly in the northwest, although some of the area was probably intertidal marsh.

On the recommendation of the Surveyor General, a metes and bounds description was prepared from Cautley's plan. Beginning at Iron Post No. XLII, the easterly portion of Parcel 3 was said to be bounded as follows:

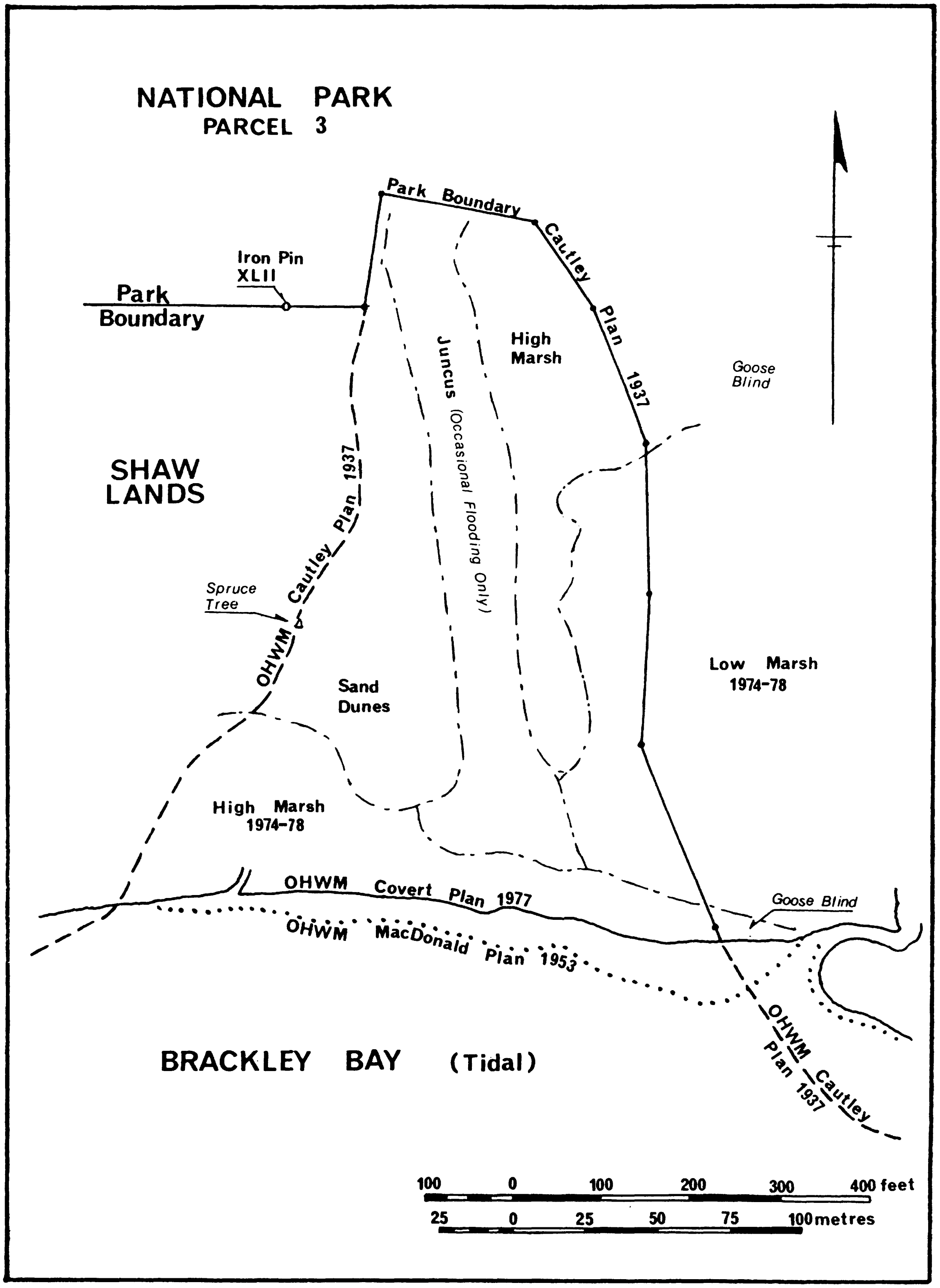

Figure II.6: Approximate Locations of Cautley's Embayment, OHWM's, and the Results of the Special Report[24]

> [thence] continuing in the same straight line on a bearing of S. 88 . 38' .2. E to intersect the line of mean high tide of Brackley Bay; thence easterly along the line of mean high tide of Brackley Bay and Covehead Bay to the entrance of Covehead Bay; thence westerly along the line of mean high tide of the Gulf of St. Lawrence......the whole as shown outlined in red on the attached plan.[25]

If the true OHWM (or MHWL) did not extend north of the line of easterly bearing, then the first waterbody intersected would have been Covehead Bay. It was from this interpretation that the question of title to Areas A, B, and C emerged. Although the defendant contended that the call for the red outline correctly expropriated the lands intended by Cautley, the Court ruled that

> if the description was wrong because of an erroneous indication of an embayment where none existed, then the red line can add nothing to the description or have the effect of increasing the area taken.[26]

From the evidence presented on the error in the 1937 survey and expropriation, the Court concluded that Areas B and C were excluded from Parcel 3, and "the small area at the tip of [the embayment] marked as A on subsequent plans was not covered by the 1937 expropriation."[27]

The survey of 1953 and the second expropriation of 1954 indicated that the Crown also recognized the ambiguity in the description of the Park bounds, if not the error in delineating the embayment. One of the conclusions of the geomorphological report was that in this survey and the later survey of 1977 a small sand ridge along the shore of the lagoon was used to delimit the OHWM. The ridge was described in the report as being approximately 20 to 40 centimetres above the level of the highest tides, often vegetated, and found on the outside of the marshes. Cautley also probably used this feature as evidence of the OHWM but deviated from it in the area of the embayment. Although the report indicated that it was "the most convenient, if not the most logical, limit, for surveying purposes,"[28] the tidal observations and vegetation studies in 1978 showed that it was often breached by tidal creeks and areas north of this OHWM were regularly inundated by salt water.

For the tidal studies, topographic profiles were constructed across the embayment area, and the tidal observations made in Brackley Bay were compared with predicted levels for Rustico Harbour. Since the observation period was free from unusual meteorological influences, a direct correlation between the tidal ranges at the two stations was established. From this ratio of tidal ranges, the frequency of specific tidal levels could be predicted for the study area. Visual observations at the time of higher high water and the projection of particular tidal datums onto the topographic profiles resulted in the identification of two main zones:

a. low marsh subject to tidal inundation by at least the daily higher high tide on most days of the year;

b. high marsh flooded approximately 71 days per year.[29]

The vegetation studies related the frequency and levels of tidal inundation in the study area to zones of marsh vegetation. Both the analysis of aerial photographs and on-site observations confirmed a similar pattern of low and high marsh regions, separated by a transitional zone. The characteristics of the plant species found in these zones supported the evidence of daily tidal inundation in the low marsh zone and less frequent flooding in the high marsh areas.

The frequency of inundation, rather than a specific tidal datum, was one of the criteria used in the report to identify the OHWM and this corresponded with the Court's interpretation of this high water boundary. Referring to several authorities on the definition of the OHWM, the Court adopted the term 'medium high water level,' a level which was said to occur during the ordinary or neap tides.[30] Relating this definition to the frequency of tidal inundation, the Court commented that

> [some] of the vegetation described by the witness McCann requires watering by sea water only four or five times a month. This would not be medium high tide but occasional high tide throughout the year. The medium high tide would be somewhat below this. There is a large sand area shown clearly in the photographs where most of the flooding occurs. Most of this is in the area designated as C but part of it appears to be in Area B. Some portions of Area B would therefore appear to be below the mean high water mark, but a substantial portion of it and in particular the higher area to the northwest on which for example there is a spruce tree some 45 years old would certainly be land.[31]

From the evidence of tidal inundation north of the OHWM as shown on the 1953 and 1977 plans, it was concluded that title to that portion of Area B below the ordinary or mean high water mark was held by Crown P.E.I., while the plaintiff appeared to have a valid claim to the remaining upland of Area B.

II.2.5 <u>Summary of the decisions</u>

Areas A, B, and C were apparently excluded from the 1937 expropriation, through the ambiguity of the description based on the erroneous survey of the embayment. The second expropriation was ruled to have the effect of carrying out the intentions of both parties. The plaintiff had not pressed for compensation for Areas A and C, on the grounds of procedural errors in the 1937 expropriation, until after 1954. Therefore, he was barred from asserting this claim by his unreasonable delay. Since Area B had not been properly included in either expropriation, the plaintiff was not entitled to compensation for this parcel.

However, title to Area B still remained in some doubt. On jurisdictional grounds, Crown Canada had no claim to title. The Court found that Crown Prince Edward Island had title to the lands below the line of mean high water, which extended north of the small ridge delineated as the OHWM on the plan of 1953 but that the plaintiff had a valid claim to the uplands not expropriated in 1954. Again on jurisdictional grounds, no declaration of title could be made by the Court. Instead, a remedy was suggested.

Unfortunately, no direct rulings were made on the issues of accretion and the delimitation of the high water boundary. In the judgement a distinction was made between vertical deposition of sediments and accretion as defined in Canadian case law, but the Court made few comments regarding the case in question. The common law definition of the OHWM was cited, but this appeared to be equated with the mean high water mark or line without further explanation. Although the validity of the vegetation and tidal surveys to determine present or former high water limits was not discussed in the judgement, the decision on the issue of title to Area B was founded, at least in part, on the evidence presented in these studies. The general silence of the Court on these tidal boundary issues, however, reflects the need in Canada for an evaluation of surveying practices and the legal precedents on which the delimitation of these boundaries is based.

II.3 References

1. Irving Refining Limited and the Municipality of the County of Saint John v. Eastern Trust Company (1967) 51 A.P.R. 155.

2. R. Gordon Shaw v. The Queen (1980) 2 F.C. 608.

3. Nichols, S. (1981) "Tidal Boundaries and the Surveyor: Irving Refining et al vs. Eastern Trust." Cadastral Studies Occasional Paper No. 10. Department of Surveying Engineering, University of New Brunswick, Fredericton, New Brunswick.

4. modified from Lingley, H. P. (1961) "Plan of Property situated in Prince Ward - City of Saint John, N. B., Ownership Claimed by The Eastern Trust Company." and "Plan of a Portion of Courtenay Bay Situated in the City of Saint John and Parish of Simonds, N.B." as ammended during the trial.

5. supra, reference 1, pp. 157-158.

6. supra, reference 1, p. 170.

7. modified from Canadian Hydrographic Service (1977) "Approaches to Saint John Harbour." Chart No. D7-4128 ed. 38.

8. Tweedie v. The King (1915) 52 S.C.R. 197, p. 214.

9. McCann, S.B. (1978) "Shore Conditions Between the Southern Gulf of St. Lawrence and Brackley Bay in the Vicinity of Brackley Beach." Unpublished Report prepared for the Canadian Department of Energy, Mines and Resources. Department of Geography, McMaster University, Hamilton, Ontario.

10. supra, reference, p. 614.

11. supra, reference 2, pp. 624-625.

12. modified from Plan No. P.E.I. 21-91.

13. S.C. (1974) National Parks Act, c. 11, p. 101.

14. supra, reference 2, p. 614.

15. supra, reference 9.

16. supra, reference 2, p. 613

17. modifed from Prince Edward Island Department of Highways (1976) "Map of Prince Edward Island."

18. from supra, reference 9, p. 11.

19. Attorney General of the Province of British Columbia v. Neilson (1956) S.C.R. 819; 5 D.L.R. 2d 449; reversing 16 W.W.R. 625; (1955) 3 D.L.R. 56; affirming 13 W.W.R. 241.

20. supra, reference 2, p. 631.

21. Re Jurisdiction Over Provincial Fisheries (1897) 26 S.C.R. 444, pp. 514-515.

22. supra, reference 2, p. 634.

23. supra, reference 2, p. 621.

24. modified from Covert, J. (1977) "PLAN OF CERTAIN TOPOGRAPHICAL FEATURES AND SPOT ELEVATIONS NEAR A PORTION OF THE SOUTHERLY BOUNDARY OF PARCEL 3, P.E.I. NATIONAL PARK." Plan Prepared for the Regional Surveyor, Atlantic Division, Surveys and Mapping Branch, Canadian Department of Energy, Mines and Resources; and from supra, reference 9, p. 30.

25. supra, reference 2, p. 622.

26. supra, reference 2, p. 624.

27. supra, reference 2, p. 623.

28. supra, reference 9, p. 5.

29. supra, reference 9, p. 26.

30. La Forest, G. V. A. et al. (1973) Water Law in Canada: The Atlantic Provinces. Ottawa: Information Canada, p. 240.

31. supra, reference 2, p. 630.