II. NEARSHORE ECOLOGY OVERVIEW

The habitats of the nearshore environment are a fundamental component in the diverse landscape mosaic of the Puget Sound ecoregion. Following is an overview of some key concepts related to defining the nearshore, its individual habitats, and the functions that they provide to Puget Sound.

A. DEFINING THE NEARSHORE

The nearshore environment is generally defined as the area encompassing the transition from subtidal marine habitats to associated upland systems. Williams and Thom (2001) define this in practical terms as the zone where direct functional interactions occur between upland and marine habitats. In Puget Sound specifically, this area typically includes habitats from the marine riparian zone to the lower limit of the photic zone (generally to a maximum of 30 m below mean lower low water [MLLW]). Within this range occur the strongest interactions between the marine environment and coastal processes. For example, upland vegetation (marine riparian habitat) contributes to beach and bank stability, provides shade for the upper intertidal zone, and contributes organic matter (leaf litter, woody debris) to the nearshore marine ecosystem (Williams and Thom 2001; Williams et al. 2001) (Figure II-1).

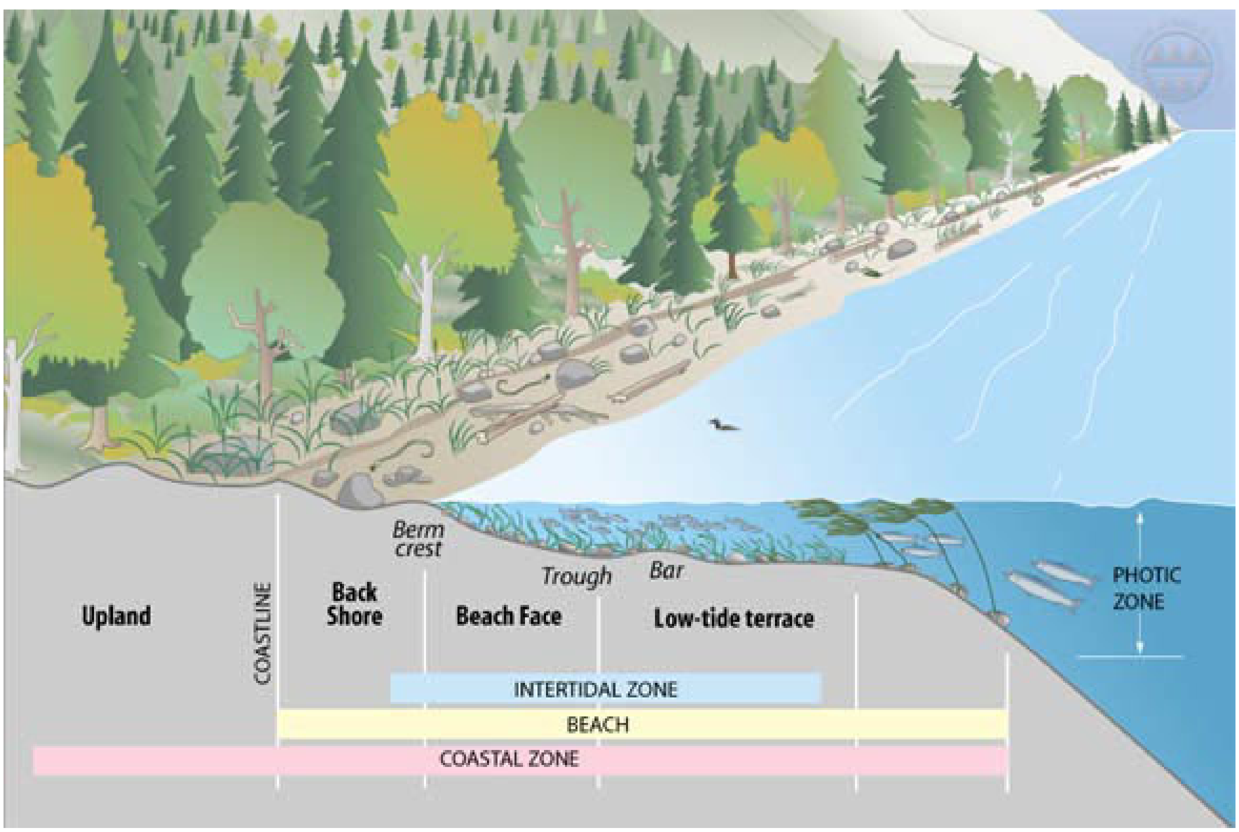

Figure II-1. Nearshore section illustrating typical tidal zonation (Source: King County Dept of Natural Resources)

B. Habitat Classification

Within the nearshore, natural marine and estuarine communities generally occur along predictable gradients. These gradients correspond to local physical attributes (specifically, elevation and depth, substrate, wave energy, and salinity), and these known habitats and corresponding physical environment relationships have been used to create standardized classification systems intended for habitat inventory and mapping work in Washington State (Dethier 1990). Summary examples of these classification systems can be found in Appendix B of this document.

The nearshore vertical zones for Puget Sound marine and estuarine systems can be generally divided into the following classifications (following Dethier 1990) (Figure II-2):

- Backshore/Supralittoral – habitats that are outside the typical range of tidal influence and may be wet only occasionally from spray or irregular flooding; above mean higher high water (MHHW) of spring tides
- Intertidal/Eulittoral – habitats between MHHW and MLLW (extreme lower low water of spring tides [ELLW] in Dethier 1990); regularly inundated by the fluctuation of tides
- Shallow Subtidal – habitats that are rarely uncovered by low tide, 15 m or less below MLLW
- Deep Subtidal – habitats that are never uncovered by low tide, deeper than 15 m below MLLW.

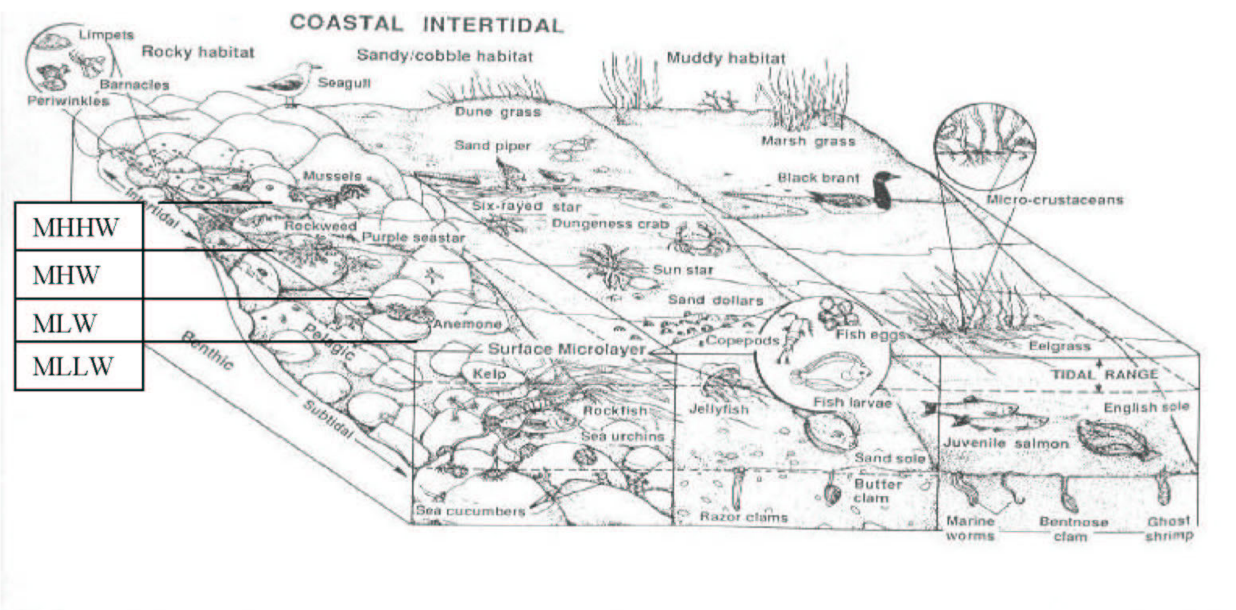

Figure II-2. Generalized distribution of major intertidal habitat types along an elevation (depth) gradient (from Nightingale and Simenstad 2001a., adapted from Krukeburg 1990, artist Sandra Noel).

Within these vertical classification zones, other physical, geological, and chemical factors (specifically, wave energy, substrate, and salinity) interact to constrain the distributions and interactions of marine plants and animals (Dethier 1990). A natural community can be defined as a distinct and recurring assemblage of plants and animals naturally associated with each other and with a particular physical environment. Thus, habitats are distinguished by their physical constraints and biotic communities. Habitat types found in Puget Sound include eelgrass meadows, kelp forests, banks, flats, marshes, sand spits, subestuaries, and marine riparian areas. The structure and typical species composition of habitat types relevant to Bainbridge Island are described in detail in Chapter IV of this document.

C. DEFINING FUNCTION

Ecological functions are natural attributes of a given habitat that "serve" the resources that rely upon that habitat. Ecological functions are defined by the structure (i.e., size, shape, substrate, and species composition) of the habitat, and the species interactions that occur therein. For example, bull kelp, found in the shallow subtidal zone of Puget Sound, provides a variety of functions to the nearshore ecosystem that are derived from its complex forest-like structure. These functions include refuge and feeding habitat for fishes (especially rockfish), spawning habitat for herring, and buffering of wave and current energy (Williams and Thom 2001). As ecosystems grow increasingly complex, functions that are provided by one habitat may also be beneficial to other habitats, resulting in a broad network of interactions. From a landscape perspective, the presence of a variety of nearshore habitats contributes a wider range of potential ecological functions (e.g., biodiversity maintenance) to the ecosystem as a whole.

To help evaluate the ecological functions of individual habitats for fish and wildlife within Puget Sound, standardized protocols have been developed that describe recommended techniques for quantitatively measuring habitat attributes that characterize these potential functions (Simenstad et al. 1991). Expert- and literature-derived guidance was used during this process to develop habitat-specific lists of representative fish and wildlife species, and their primary functional mechanisms (i.e., reproduction, feeding, refuge, and physiological adaptation). Specific examples of typical nearshore species and aspects of habitat functional dependence are discussed in Chapter V of this document.

It should be noted that within the Puget Sound ecoregion, the nearshore zone provides a number of necessary functional benefits to salmon, a key species that indicates local watershed health and provides cultural and economic resources to communities region-wide. Some of these functions include prey production (i.e., food for juvenile and adult salmon), migratory corridors, refuge for juveniles from predators, and juvenile rearing. In addition, salmon transport marine-derived nutrients back into freshwater streams and forests as they spawn and become prey for wildlife (see Cederholm et al. 2000), thus linking the functions of the nearshore ecosystem to the health of the entire watershed. The specific functional benefits of the nearshore to salmon are further explored in Chapter V.

D. NEARSHORE ECOLOGIC MODELS

As the classification systems have demonstrated, nearshore habitats are defined by a variety of complex interactions between physical, geological, chemical, and biological components. The effects of human-caused changes in physical conditions can cause a change in the structure of habitats, which will ultimately affect the habitat's function. From this general reasoning, we can derive simple relationships (models) that may help us predict or understand natural and human-caused effects on nearshore ecosystem functions. These models, based on existing knowledge and best professional judgment, are especially useful when there is a pervasive lack of empirical data.

The physical components of an ecosystem are referred to as its "controlling factors" because of the strong dependence of biological entities upon them. For example, the local combination of controlling factors (such as slope, depth, tidal cycle, and wave energy) will define the type of plant species that can exist in that area. Biological communities, which are often spatially constrained by these local controlling factors, serve to further define the structure and functions (e.g., refuge, nutrient cycling) of the nearshore ecosystem (Williams and Thom 2001; Williams et al. 2001) (Table II-1). Once established, biological components may, in turn, influence controlling factors; so biological alterations can impact the ecosystem from a foundational level (for example, temperature regulation and nutrient input from overhanging vegetation).

Table II-1. List of Controlling Factors and Associated Habitat Structural and Functional Attributes (from Williams and Thom 2001).

Controlling Factors	**Habitat Structure**	**Habitat Processes**	**Ecological Functions**
Depth Substrata Slope Light Wave Energy Hydrology Temperature Salinity Nutrients Water Quality	Density Biomass Individual Lengths Diversity Patch Size Patch Shape Landscape Position	Production Sediment Flux Nutrient Flux Carbon Flux Landscape Connectivity	Disturbance Regulation Prey Production Reproduction Refuge Carbon Sequestration Maintenance of Biodiversity Movement/Migration

A conceptual model approach can be used to illustrate the interactions that occur in the nearshore ecosystem as influenced by controlling factors and associated habitat structure and function (for example, the effect of wave energy and light on plant biomass, and resulting links to primary production). Empirical data are often lacking on the impacts of specific activities to a given habitat's structural and functional attributes. Conceptual models are useful because they allow us to use existing information to identify the linkages between (and among) the controlling factors and biological components of an ecosystem. When changes occur at the controlling factors level, the associated biological and ecological responses can then be inferred and tested. In its most basic form, impact assessment can be approached through the response chain illustrated in Figure II-3 (from Williams and Thom 2001).

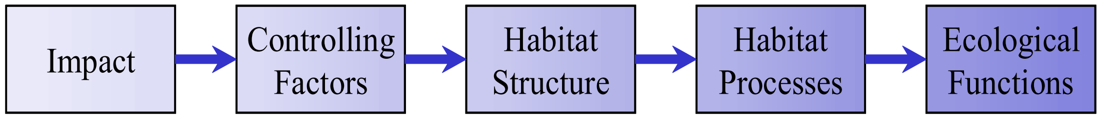

Figure II-3. Conceptual model linking shoreline impacts to ecological functions (from Williams and Thom 2001).

This approach provides the necessary framework for assessing complex systems - where data gaps often exist - and will be used throughout this document. The following chapters focus on surveying three key areas within this framework for the Bainbridge Island nearshore environment: physical characteristics and dynamics (Chapter III), habitats (Chapter IV), and biological resources (Chapter V). Based on an understanding of these factors, the potential impacts of nearshore modifications by humans can then be assessed in greater detail (Chapter VI).