A Field Guide for Characterizing Habitats using A Marine and Estuarine Habitat Classification System for Washington State

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The Department of Natural Resources, Division of Aquatic Lands' Nearshore Habitat Inventory is the first survey to use Dethier's Marine and Estuarine Habitat Classification System for Washington State as a guide for characterizing intertidal habitats in the field. The Classification is an invaluable tool for inventorying Puget Sound and other marine and estuarine areas of the state because it provides a standard system for classifying a wide variety of intertidal and subtidal habitats. All definitions for habitat classification are from Dethier (1990) (see pages 7-13), and that document should be used as the primary reference for habitat classification.

This report summarizes our experiences with the classification after two summers of field work (1991 and 1992). It contains elaborations on or refinements of the definitions given by Dethier in order to improve consistency in field use. This document is intended to assist field staff in arriving at consistent classifications on a site by site basis in the field. The Department of Natural Resources is doing a comprehensive mapping of Puget Sound using this classification, and the complexities of that approach are not addressed here. It should be noted that our experience from 1991 and 1992 is based on intertidal surveys, using a 15 meter diameter circle as the sample unit, so some testing of these guidelines on subtidal surveys and at different scales would be beneficial.

System:

Marine or **Estuarine**

The system can be determined from a map based on the boundary line defined by Dethier (page 10); (refer to attached map). The U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI) maps can be used as a secondary source to identify pockets of estuarine habitat within the marine area. However, the major marine/estuarine boundary defined by Dethier is slightly different from the NWI, so NWI should only be used to identify the estuarine pockets within the marine system. DNR Division of Aquatic Lands has a GIS coverage of the system boundary in ARC/INFO format.

Subsystem:

Intertidal or **Subtidal**

Subsytem is relatively easy to visually determine in the field, especially in the intertidal zone. The subtidal/intertidal line is delineated on the U.S. Fish and Wildlife Service's National Wetlands inventory maps, although we have not field checked it for accuracy. DNR Division of Aquatic Lands has a GIS coverage of the subsystem boundary in ARC/INFO format. If necessary, the intertidal/subtidal boundary can be determined by elevation: minus 4.5 feet is the generally accepted elevation for ELWS in Puget Sound.

Substrata:

Arriving at consistent results for substrate classification in the field is the most difficult aspect of habitat classification. Because Dethier's substrate definitions are often rather general, individuals could easily arrive at different classifications of the same beach. A beach seldom consists of one uniform grain size, but ultimately, a site may only have one substrate classification. In order to decrease subjectivity in substrate classifications, we chose to record the visually estimated percentage surface area covered by each grain size in our 15m circular plot and then develop numeric rules based on types of grain sizes present (cobble, gravel, sand, etc.) and the percentage of each. (Note: Percentages were recorded as a range or cover class where 1 = <1%, 2 = 1-5%, 3 = 6-25%, 4 = 26-50%, 5 = 51-75%, 6 = 76-99%, 7 = 100%). We then compared this "calculated" classification to a "visual" (subjective) classification of the substrate at each site. The overall agreement of visual classification with calculated classification for all 1991 sites was 86.6%. Therefore these numeric rules agree quite closely with our "best professional judgement" about the substrate classification at a particular site, and will be used by our program to classify substrate. These rules were refined in 1992 after an additional summer of field experience, and applied to the 1991 data resulting in the same overall agreement (86.9%).

Bedrock:

Bedrock can be of various rock types, ranging from soft sandstone to conglomerate to hard igneous and metamorphic types. Because bedrock is such a dominant component of the habitat, and because the rock often has other materials overlaying it, we classify an area as bedrock if it has at least 50% cover of bedrock.

Boulders: "Rocks >256 mm., large enough to not be rolled by moderate wave action" (Dethier 1990).

The Boulders category seems to be quite similar to bedrock, and they are often grouped together in the Classification, signifying unclear ecological differences between the two. Any site with at least 75% cover of boulders is classified as boulder. When boulders are present with bedrock, the habitat usually has the character of a consolidated substrate -- stable, lots of surface for attachment. When boulders are present with smaller grain sizes such as cobble and gravel and little bedrock, the habitat character is that of unconsolidated substrate -- unstable, movement of substrate by wave action. Therefore, a site with at least 50% cover of boulders is also classified as boulder if at least 6% bedrock is also present.

Hardpan: "Consolidated clays forming a substratum firm enough to support an epibenthos and too firm to support a normal infauna (clams, worms, etc.), but with an unstable surface which sloughs frequently" (Dethier 1990).

Hardpan is described as a "resistant basal till, composed of poorly sorted but well compacted glacial deposits often including clays" (Dethier 1990). This substratum is like a bedrock made of hard-packed clay with pebbles often worked in, but is much softer than solid rock and can be scraped with the toe of your boot. Any site with at least 75% surface cover of hardpan is classified as hardpan.

Cobble: "rocks <256 mm. but > 64 mm. diameter- unstable" (Dethier 1990).

Beaches that are dominated by cobbles, with little gravel or sand, fall into the Cobble category. Although this "hybrid environment" (Dethier 1990) always has sand lying beneath the cobbles and gravel lying among them, if cobbles comprise 75% or more of the surface substratum, the site is classified as cobble. Many surveyed beaches in our study had a high proportion of cobble, but few (36 out of 1248 total sites) had the required 75% cover to qualify for the Cobble category. Cobble beaches have been characterized as being found only in areas of moderate wave action, with higher energy beaches tending toward Sand, and those with lower energy tending toward Mixed Coarse (Dethier 1990).

Mixed Coarse: "Substrata consisting of cobbles, gravel, shell, and sand" (Dethier 1990).

Mixed Coarse beaches are composed of a clear mix of various substrata, with no one substratum occupying more than 75% of the surface cover. (Although Dethier uses 70% surface cover, we modified the cutoff point to 75% because our groupings of percent cover used 75% as an obvious break point). Boulders, cobble, gravel and sand are the most common combination of grain types found on these beaches, and mud may also be present in lower energy areas. There is often quite a wide range of grain sizes (for instance, boulder to mud), but sometimes just a mix of two similar grains such as cobble and gravel. If no single grain size exceeds 75% cover, and there is at least 6% cover of boulders or cobble the substrate is mixed coarse. Or, if no single grain size exceeds 75% and the cover class values for gravel, cobble, and boulders add up to 8 or more (indicating a predominance of the larger grain sizes) then the site is also classified as mixed coarse.

Gravel: "Small rocks or pebbles, 4-64 mm. in diameter" (Dethier 1990).

Gravel beaches seldom consist of one uniform grain size and usually have some sand underlying and mixed in with the gravel and pebbles. More protected areas tend to have more sand and are more stable and productive. Any site with at least 75% surface cover of gravel are classified as gravel.

Marsh: The gravel category for marshes is quite different from that of beaches in the Classification. Gravel marshes are described as being "a mix of gravel, sand, mud, and in some areas, cobbles" (Dethier 1990). From our field experience we would classify these substrates as Mixed Coarse. These-habitats are found on gravelly deltas or steep shores in inlets, and in areas with just enough energy to prevent siltation without damaging the rooted salt marsh vegetation.

Sand: "0.06- 4 mm" (Dethier 1990).

Sand beaches show some variation, mostly related to the energy level on the beach. High energy beaches tend to have sand that is coarse, pure, and free of silt and organic material. As a rule, the more protected a beach is, the finer the grain size of its sand, so that Semi-protected beaches with reduced wind and wave action have finer grain sand with some silt mixed in. If a site has at least 75% surface cover of sand (if percentage can be determined), it is classified as sand.

Marsh: The Classification's marsh habitat has a substratum description that is different from the intertidal description of the same category. While sand beaches are said to be free of silt, sand marshes are described as being "sand, silty sand, or gravelly sand," and may often have pockets of peat, silt, or clay.

Mixed Fine: "Mixture of sand and mud, with little gravel, likely to change seasonally" (Dethier 1990).

This is another category composed of a mix of various substrata. Sand, mud, and gravel are the most commonly found substratum types, with shells and woody debris often present. The category encompasses a broad range of substrata, from a pure mixture if sand and mud to a coarser "sand, shell, and gravel mix." In some places gravel and pebbles make up more than half the volume of the sediment, and many organisms are found only in these gravelly muds, which are habitats quite distinct from those without gravel (Kozloff 1983). Mixed Fine habitats have diverse and abundant biological communities, more so than either sand or mud habitats (Youngmann 1979). If a site has less than 75% of a single grain size, and less than 6% of boulder or cobble, and boulder, cobble and gravel cover classes add up to 7 or less, then it is classified as mixed fine.

Mud: "Fine substrata <0:06 mm., usually mixed with organics" (Dethier 1990).

Mud habitats are found in calm areas, especially the heads of bays and inlets, where wave action is low enough to deposit fine silt and sediment. Mud is composed of a mixture of silt and clay, and is quite smooth and slimy. However, don't misclassify a beach as Mixed Fine instead of Mud solely on the basis of a slightly gritty feel, as silt does have a distinguishable graininess. Mud differs from Mixed Fine in lacking gravel or a significant amount of sand, and it more clearly exhibits the "fine substratum" characteristics listed in the discussion of Sand vs. Mixed Fine vs. Mud: high water retention, anoxic layer, and hard to walk on. Mud flats really grab your boot and it is not uncommon to become completely stuck and have to flounder your way out on hands and knees. Wood and other organic debris can be retained here along with the fine sediments. If a site has at least 75% surface cover of mud (if percentage can be determined), it is classified as mud.

Sand vs. Mixed Fine vs. Mud:

There is a range of particle size as sand goes to mud, with sand, 4-0.06 mm., being the largest, followed by silt, 0.06-0.004 mm., and lastly clay, <0.004 mm (Kozloff 1983). Silt and clay both fall into the Mud category's grain size range, and a mixture of sand, silt, and clay-sized particles belong in Mixed Fine. As habitats become more sheltered, the finer sediments first become mixed with sand (Mixed Fine) and finally replace it (Mud). However, determining which category to place a site in is often complicated, because it becomes difficult to distinguish between silt and very fine sand, and to determine the percentage of each present in a sandy-muddy mix. Percentages are therefore not a reliable guide for distinguishing between these three substrata in the field, and qualitative differences between them are more useful.

When sandy beaches become more protected, the grain size diminishes, and correlated to this is a greater retention of water and cohesion of the grains to one another. Finer particles are better able to hold onto water by capillary action, and the presence of organic material in protected areas also increases both the substratum's water retention capacity and its grain cohesion (Kozloff 1983). Therefore, habitats where fine grain predominates usually have shallow pools of water and are very gooey, making them noticeably difficult to walk across. In contrast, exposed sandy beaches, with their larger particles, have a substratum that packs down when stepped on (Kozloff 1983). The saying , "If you can walk on it, it ain't mud," is a pretty good rule of thumb! Another sign of an increasing amount of silt and clay in the substratum is a sulfide smell and a black anoxic layer a few centimeters below the surface. In sandy beaches, where the particle size is coarse enough to allow circulation of water and the oxygen dissolved in it, there is no anoxic layer anywhere near the surface (Kozloff 1983). So, three factors indicative of high water retention, and thus particles finer than sand, will help you determine that a site is Mixed Fine or Mud rather than Sand:

1: presence of shallow pools (or generally a lot of water in the substratum)

2: gooey substratum that sucks in your boot (high cohesion)

3: anoxic layer

Although Mud is a lot smoother than Mixed Fine, it may still have a grainy feel to it, because it contains silt as well as clay, and silt "feels gritty when rubbed between the fingers, between finger and cheek, or between tongue and cheek" (National Ocean Survey 1976). For a simple, more definitive test to determine the presence of fine sand (as opposed to silt) in a substratum, refer to The National Ocean Survey Hydrographic Manual.

Although we have not used this method in on field work, The National Ocean Survey Hydrographic Manual describes a test to detect the presence of very fine sand in a substratum. To distinguish Mixed Fine from Mud, you can verify the presence of very fine sand in a substratum (as opposed to silt, for they both feel grainy) by putting about a quarter teaspoon of the substratum into a large test tube, adding water, and shaking well. If within less than a minute a moderate portion of the sediment settles out, sand is present (National Ocean Survey 1976).

Distinguishing between categories in the sand to mud range is bound to be subjective, but given this qualitative information, the data collector should be able to make an educated decision.

Organic: "Substrata composed primarily of organic matter such as wood chips, leaf litter, and other detritus" (Dethier 1990).

Organic substrata are only described in Partly Enclosed, Backshore marshes in the Classification. They are described as being peat soils, which are soils composed of visible bits of plant matter (small pieces of leaves, etc.). The organic materials in peat have begun to deteriorate, but are not decayed beyond recognition (Linda Kunze, personal communication). These habitats are only found in higher, backshore marshes, because in only these areas, the low energy and lack of regular tides allows the accumulation of plant matter.

Organic material in low marsh areas and estuarine channels is quite different from that of higher marshes. This is a substance called "muck," a black organic matter with a strong sulfide smell (Linda Kunze, personal communication). In these low marshes, leaf litter and dead plant material are carried away with the tides, so that organic muck results only from the very slow decay of marsh plant roots rather than an accumulation of vegetative material. Fragments of live roots or any distinguishable plant material are not visible in this substratum because marsh plants cannot grow in the muck areas of the marsh. While plants can grow in the gravel, silt, sand, or mud areas of the marsh, the muck areas are left unvegetated (Linda Kunze, personal communication).

If marsh plants are growing in a substratum that is very soft, brown and slimy, this is not organic, but likely to be silt or clay, which is not as black as muck, and in which fine particles can be felt. (Kozloff 1983, Linda Kunze, personal communication). Silt is not organic, but is a very fine mineral grain -- the next smallest particle from sand in the sand-silt-clay continuum.

Artificial: "Concrete blocks, tires, bulkheads, riprap, log booms, pilings (concrete or wood), oyster culture, junk/other" (Dethier 1990).

Any beach with 75% surface area or more artificial materials falls into this category. Only man-made objects or natural objects placed by man rather than natural processes qualify; for instance a log boom is artificial, but drift logs are not. In the field we classify artificial areas under a more specific name, such as riprap, log boom, aquaculture, etc., since different types of artificial substrates may serve vastly different habitat functions. Also, areas that have been filled or altered and now function as upland (common in urban bays), are not classified as artificial, but as upland.

Energy:

Energy level for a site is based on the definitions given by Dethier (pgs 11-12). Energy level is the most subjective parameter in the classification. No direct correlation between an easily measured parameter (such as fetch distance or wave height) and energy level exists, especially in an area as complex as Puget Sound. We used Dethier's "sites surveyed" list as examples for each energy level, and assessed a particular field site relative to those examples.

Generally a whole beach, from Extreme Lower Low Water (ELLW) to Extreme Higher High Water (EHHW) is given a single energy classification. There may be energy gradations from the foreshore to the backshore of the beach; for example, the lower intertidal zone may be receiving a lot of wave energy that is then dissipated and does not reach the high intertidal zone. However, the energy level definitions are broad enough to be interpreted on a "beach-by-beach" (or section of shoreline) scale, rather than on a "within beach" scale. The only exception to this rule is in the case of a salt marsh that is in the higher intertidal zone of a beach classified as open; by definition, the energy level of a salt marsh is partly enclosed or lower, therefore, that particular beach would have a different energy level for the salt marsh area than the lower intertidal "beach" area.

Marine Energy Levels

From the examples given by Dethier, the Exposed energy level should only be used for intertidal sites on the outer coast of Washington; anything in the Straits of Juan de Fuca or the San Juan Islands would be Partially Exposed, Semi-Protected, or Protected. The distinctions between each of the marine intertidal energy levels should be evaluated after more field experience in marine areas, using the "sites surveyed" as guidance. Clarifying distinctions between subtidal energy levels will also require field testing.

Estuarine Energy Levels

Some subjectivity is involved in differentiating between open and partly enclosed areas, so the "sites surveyed" list is used as guidance.

A lagoon can be identified from a map or visually on-site by the presence of a spit or barrier across the mouth of the embayment. There is the question of scale for a lagoon. For example, Sequim Bay is technically a lagoon because it is enclosed by a spit, however it is such a large area that the wave energy generated in the bay would be similar to other areas considered partly enclosed. We chose Burley Lagoon, a lagoon that is about two miles long, as an example of the largest area we would classify as a lagoon. A larger bay enclosed by a spit would fall into the partly enclosed energy level.

The channel/slough definition needs some clarification especially in relation to scale and extent: Small channels running across a tide flat are really too small to be considered a channel/slough. The Columbia River could be considered a channel/slough, but it is really too large. Skagit Flats is one of the surveyed sites for intertidal channel/slough--is the entire area classified as a channel/slough habitat, or just the existing channels? We have had minimal field experience with the channel/slough classification, and more field testing is needed to answer these questions.

Modifiers:

Water Regime (Depth):

Intertidal Water Regime (**Eulittoral** or **Backshore**)

Use of the backshore/eulittoral modifiers is most important for distinguishing types of salt marshes. The plant communities that inhabit a backshore marsh are significantly different from those that inhabit a eulittoral marsh because of different inundation and salinity tolerance. An exact line between eulittoral and backshore for marshes is difficult to determine in the field because plant communities are not discrete entities, however, there will be a general change in the plant composition.

When classifying "non-marsh" areas, the eulittoral modifier is assumed, and not included in the habitat name. Backshore is specified when appropriate. In these areas we use the visual clues of a water line or a berm to delineate eulittoral and backshore. Often there is no backshore area because the beach is at the base of a cliff or bulkhead.

Subtidal Water Regime (**Shallow** and **Deep**)

We have minimal field experience with the shallow and deep depth modifiers. Because the distinction is based on a specific depth (15 meters), it is easy to determine using a SCUBA depth gauge or boating depth sounder. In general, shallow habitats are those within the photic zone (where there is enough light for plant life to exist). Some of the deep subtidal habitats described by Dethier are subdivided into two habitats, a "shallow" deep and a "deep" deep, with separate lists of diagnostic species. The depth of this distinction varies by habitat. Field experience is needed to evaluate the implications and/or the validity of these distinctions.

Water Chemistry:

Salinity (**Hyperhaline, Euhaline, Polyhaline, Mesohaline, Oligohaline**)

We evaluated salinity to differentiate salt marsh types, and not for non-marsh habitats. Soil salinity can be measured by squeezing water from the soil through a piece of filter paper onto a refractometer calibrated for salinity. The soil should be taken from the plant rooting zone, a few inches below the surface. We use this data value to give an estimate of the salinity, but use the plant community as a more definitive indicator of the appropriate salinity modifier for that habitat. Measurement of salinity at a single point in time may not be an accurate representation of the salinity regime which is likely to change seasonally or even daily.

Special Modifiers:

Sand-Scoured

The sand-scoured modifier is specific to exposed rocky beaches on Washington's outer coast that are adjacent to sand beaches. Delineation of sand-scoured areas would have to be based on the diagnostic species list given for that habitat. We have not used this modifier in our field work in Puget Sound.

Marsh

The marsh modifier is used to distinguish areas with emergent salt marsh or wetland vegetation from unvegetated or algal dominated habitats that have the same physical parameters (for example, estuarine intertidal mixed fine: partly enclosed and estuarine intertidal mixed fine: partly enclosed (marsh)). There is one habitat that is technically not a salt marsh (estuarine intertidal organic, sand, mixed fine, or mud: partly enclosed, backshore, oligohaline), but the marsh modifier is used to make the distinction described above. The delineation between marsh habitats and other intertidal habitats is quite obvious in the field; generally the transition is from wetland plants to unvegetated beach. When classifying the habitat within our 15 meter circular plots, we used the marsh modifier if there was more than 25% cover of marsh plants.

Spit/Berm

From our experience we have found an additional nearshore habitat not described in the current version of the classification. This is the backshore spit or berm area. These areas are not regularly inundated, but receive some salt influence from spray or extreme high tides. The substrate is usually a mixture of sand and gravel, and drift logs are often present. The substrate is also relatively unstable, with movement caused by wind and wave energy from storms. *Elymus sp.* (dune grass), *Grindelia sp.* (gum weed), *Achillea sp.* (yarrow), and *Ambrosia sp.* are common plants found in these areas. The center of Dungeness Spit is an example of this habitat. These areas are classified as usual (system, subsystem, substrate, energy, water regime), with "spit/berm" as a modifier.

Because these areas have a much different plant community and physical regime than any of the other habitats in our classification, it is reasonable to add it as a new habitat to the Classification. The Washington Natural Heritage Program also classifies this type of area as a unique habitat, so we would be compatible with their scheme. To not add these areas to our inventory and classification would be an oversight because nearshore spit/berm areas are very common all around Puget Sound and they are an integral part of nearshore ecosystems.

Diagnostic species/dominance types

Diagnostic species are the organisms that are indicative of a particular habitat. (See pages 12 and 13 of Dethier's classification for a complete explanation of diagnostic species/dominance types). Dethier has listed diagnostic species for each habitat which are usually vegetation types or sessile invertebrates. More mobile organisms, such as fish and birds fall under the "common associates" list, because they are not reliably present in a habitat and may tend to occupy multiple habitats. Ideally this list of species will be confirmed and/or expanded by field surveys. However, the criteria for diagnostic species are somewhat varied: it may be an organism that is abundant numerically or by biomass; a functionally-important species, either strongly-interacting (key predator) or habitat-forming (eelgrass, mussel beds); or a species that is unique to a particular habitat even if it is not abundant. Therefore, there is no single method for evaluating diagnostic species in a habitat.

We evaluate vegetation species composition based on canopy cover class (goupings of percent cover). However, because abundance is not the only criteria for diagnostic species, we call these observed species rather than diagnostic species.