Appendix F

Monitoring Recommendations and Approach

The Bainbridge Island Monitoring Program

Background

While assessment is the quantitative evaluation of selected ecosystem attributes, monitoring can be defined as the systematic repetition of the assessment process. That is, monitoring is the systematic and objective measurement of the same attributes on a regular schedule over time (Callaway et al. 2001). Monitoring can serve two primary roles: evaluation of the quality of existing conditions of an area (e.g., site, reach, management area), and assessment of the development of an area following implementation of a management action (e.g., permit approval for shoreline development; habitat restoration, creation, or protection). In the latter case, the monitoring shows whether or not the management action has any effect on the quality of the area. In either role, monitoring provides valuable and sometime critical information for making accurate and cost-effective management decisions. Without objective quantitative information, decisions are driven by guesswork, which may lead to further degradation of an area and inefficient use of funds, resources, and effort.

In nearshore ecosystems, monitoring provides the basis for understanding existing conditions, and can be integral to determining the extent of improvement or degradation of a particular site, reach, or management area. For example, in evaluating the appropriateness of a particular site for restoring eelgrass, it would be useful to monitor light, temperature and sediment quality metrics to indicate conditions that are appropriate relative to eelgrass growth requirements. In addition, monitoring is critical to documenting the functioning of an ecosystem following implementation of management actions. It is at the heart of adaptive management by providing feedback required to determine progress and forming the basis for making mid-course corrections (Thom 1997).

For the purposes of this document, we use definitions that are consistent with Simenstad et al. (1991) and Williams et al. (2003). The nearshore ecosystem is defined as the area encompassing the marine riparian zone, across the beach, to the lower limit of the photic zone (water layer that is penetrated by sufficient sunlight for photosynthesis) (Williams et al. 2003). An “attribute” describes a distinct component or characteristic of the ecosystem or habitat, e.g., sediment, rooted vascular plants, or motile fishes. A “parameter”, frequently called a metric, is a specific variable that can be measured to describe an attribute or adequately assess its status, e.g. grain size, percent cover, or survival.

Monitoring involves sampling attribute parameters that are direct or indirect indicators of the health or quality of the environment. Environmental or physical monitoring parameters that relate to “controlling factors”, under the nearshore conceptual framework of Williams and Thom (2001), include water properties (e.g., temperature, dissolved oxygen [DO] levels), turbidity, toxic contaminants, light levels, sediment composition, depth, and inorganic nutrient concentrations. Habitat structure is often monitored in aquatic ecosystems by quantifying parameters such as substrate type, vegetation type and cover, shoot density and length, biomass, and plant species composition. Ecological function parameters include animal (i.e., invertebrate, fish, bird, mammal) species composition, density, standing stock, population structure, diet, reproductive state, growth rate, and activity patterns.

Issues to Consider

In any monitoring program, a number of issues must be carefully considered before data are collected, including monitoring goals, scale (effort in time and space), timing, sampling design and replication, reference site designation, attribute selection, sampling methods, and costs. Although it is beyond the scope of this chapter to provide a thorough exploration of each of these issues, we provide a brief overview and refer to several technical guidance documents (Simenstad et al. 1991, Fonseca et al. 1998, Callaway et al. 2001, Thayer et al. 2003) that may be consulted for more detail. We consider these issues relative to both long-term ecosystem monitoring and more specific site assessment goals.

Goal formulation plays a critical role in the restoration and assessment planning process, involving development of a vision that leads to specific performance criteria or objectives (Thom and Wellman 1997, Thom 1997). As such, goal formulation dictates the level of monitoring required for any project by defining major attributes of the system, as well as the parameters of interest. A common goal associated with long-term ambient monitoring programs is often to detect broad changes in ecosystem health and function, whereas site specific monitoring often seeks to measure improvement in particular ecosystem attributes relative to a particular management action.

The essence of monitoring should be consistency, although at the same time, monitoring procedures must be able to evolve, using knowledge gained to determine whether sampling can be streamlined, increased, or additional attributes considered (Callaway et al. 2001). Monitoring should be conducted at a frequency and duration most appropriate for the study, depending on the parameter being measured and the question being asked (NRC 1990, Kentula et al. 1992). For long-term ambient monitoring programs, the duration is assumed to be infinite whereas the frequency is driven by the characteristics of key ecosystem parameters. Site specific monitoring should generally be conducted most intensely immediately following a management action, with measurements becoming less frequent as habitats mature. Five years should be considered a minimum for monitoring projects with physical goals such as the restoration of tidal hydrology, with a longer monitoring time period recommended for any project including goals for ecological function (Thayer et al. 2003).

An adequate sampling design always incorporates three principal components of scientific quality: *repeatability* in terms of the potential to be exactly repeated, *reliability* as the quality to sustain scientific confidence, and *validity* because it is based on precedence and evidence (National Academy of Sciences 1989). The Estuarine Habitat Assessment Protocol (EHAP; Simenstad et al. 1991) describes and recommends techniques that meet these standards for quantitatively measuring attributes of estuarine habitats that characterize the potential ecological function of that habitat for fish and wildlife. All of these methods are recognized and accepted by the scientific community as appropriate for nearshore habitats in Puget Sound. The EHAP also provides a review of habitat descriptions, sampling theory, sampling strategies, sample replication, and statistical structure issues, as well as recommendations for sample preservation, processing and reporting. Callaway et al. (2001) provides a similarly useful overview of assessment and monitoring procedures appropriate for tidal wetlands.

Placement and timing of samples should be tailored to spatial and temporal variability of the parameter of interest, including species' phenology (periodic biological phenomena, such as flowering, breeding, and migration, in relation to climatic conditions) and population dynamics (Callaway et al. 2001). As an example, vegetation mapping and cover assessment are often conducted annually during the season of peak biomass (generally summer). In contrast, parameters that may change temporally (over time) or in response to major events (e.g., storms) should be evaluated with these issues in mind. For instance, efforts to monitor the rate and direction of nearshore sediment transport must take into account the seasonal influence of winds, waves, and currents as well as periodic events like landslides.

A broad goal applicable to monitoring programs is to compare existing conditions to pristine or historical conditions in order to gauge impairment and assess change. Wherever possible, background information should be gained from historical data or existing local sites to describe ecosystem structure and function (Zedler 2001). Long-term ambient monitoring programs that seek to detect changes in ecosystem health often seek to establish a contemporary baseline condition, especially in the absence of good historical data. This baseline becomes a point from which assessments of future conditions may be determined. With site-specific monitoring projects, initial baseline conditions at the project site and a reference site should be measured before management actions occur. It is of paramount importance that reference sites be selected with similar habitat, geomorphology, and landscape features (Callaway et al. 2001).

Thereafter, monitoring is conducted simultaneously at the project site and reference site(s) to evaluate progress toward reaching goals.

Under optimal conditions, a monitoring program would assess all attributes relevant to the habitat of concern. However, funding and the availability of qualified personnel often limit the number of measurements that can be taken and the number of samples that can be processed. Most monitoring programs seek to balance monitoring goals with these constraints by limiting the range of attributes that are monitored. Simenstad et al. (1991) provide a hierarchical organization of parameter attributes that should guide the decision process. Callaway et al. (2001) also include a list of minimal requirements and priorities for site monitoring.

Existing Monitoring Programs and Protocols

Ongoing aquatic monitoring programs in the region include the Puget Sound Ambient Monitoring Program (PSAMP), which brings together local, state, and federal agencies to monitor trends in environmental quality of the Puget Sound ecosystem. Through this program, data on marine and fresh waters, fish, sediments, and shellfish have been collected since 1989, surveys of nearshore habitat (e.g., eelgrass abundance) have been conducted since 1991, and marine bird populations have been surveyed since 1992. For example, the Washington Department of Natural Resources maps aquatic vegetation and physical shoreline conditions (Washington State ShoreZone Inventory), and established a program in 2000 to monitor long-term changes in eelgrass abundance and distribution in Puget Sound. PSAMP findings are coordinated by the Puget Sound Action Team and disseminated through a variety of articles, presentations, and reports, including an annual update on the condition of Puget Sound (Puget Sound Water Quality Action Team 2002).

It should also be noted that monitoring of nearshore “health” and research linking nearshore processes to ecological functions will intensify as the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) begins to develop, select, and evaluate actions that will help protect and restore the Puget Sound nearshore ecosystem. PSNERP is a cooperative effort among U.S. Army Corps of Engineers (Corps) and local sponsors that include state and other federal government organizations, tribes, industries and environmental organizations. The Washington Department of Fish and Wildlife represents the local sponsors of the project.

PSAMP utilizes a variety of standardized protocols for monitoring the general conditions of Puget Sound, although the broad spatial scale of the PSAMP sampling effort may not adequately characterize regional or local conditions. For example, sites where monitoring occurs may not be located in areas of interest, or sites may be so few or so infrequently sampled as to provide only very limited information about the area of interest to local communities. In order to comprehensively assess nearshore conditions within a locality such as Bainbridge Island, a region-specific monitoring program is required. Such a program may involve expanding the scale of PSAMP monitoring in the region of interest through agency partnerships, and may involve local and PSNERP sponsorship. As well, it would involve supplemental sampling of habitats and ecological function using appropriate regional protocols (Simenstad et al. 1991) while integrating ongoing local monitoring and assessment activities, such as the City of Bainbridge Island Nearshore Structure Inventory (Best 2003).

Bainbridge Island Monitoring Recommendations

Monitoring efforts should serve the two primary goals outlined at the beginning of this document: evaluation of existing conditions, and assessment following implementation of a management action. Management actions recently highlighted by PSAMP as central to restoring Puget Sound nearshore processes focus on shoreline armoring, sediment processes, and aquatic vegetation. These actions include: 1. providing marshes, mudflats, and beaches with essential sand and gravel materials; 2.

removing, moving and modifying artificial structures (bulkheads, rip rap, dikes, tide gates, etc.); 3. using alternative measures to protect shorelines from erosion and flooding; and; 4. restoring estuaries and nearshore habitat such as eelgrass beds and kelp beds.

Monitoring of Bainbridge Island's nearshore ecosystem should also build upon the findings, recommendations, and data gaps established in this report and previous studies. The summary of the Best Available Science (BAS) (Williams et al. 2003) outlines the ecological functions of the Bainbridge Island nearshore environment and provides a conceptual framework for understanding the linkages between human actions, physical processes (controlling factors), habitats, and biological components of the nearshore. The BAS also highlights specific impacts to Bainbridge Island nearshore and estuarine habitats due to various types of human shoreline modifications. The nearshore characterization and assessment (the main body of this document) uses the conceptual model to consistently quantify the most highly impacted and least impaired shorelines of Bainbridge Island with an approach that can be scaled to various landscape scales. Finally, the protocol for prioritizing management decisions (Appendix 1 of this document) provides specific guidelines for prioritizing restoration or conservation strategies on particular shorelines based on assessment results. Therefore, we recommend monitoring the following key attributes that encompass each level of the conceptual framework. In this way, monitoring will link processes to the nearshore habitat structure, integrate a multitude of nearshore habitats that support a variety of functions, establish relationships between structure and function, and ultimately can scale local processes to the broader Puget Sound ecosystem.

Controlling Factors

Water quality – Nearshore water quality affects the health of fish and invertebrates, as well as human health and recreation. Standard measures of water quality include water temperature, dissolved oxygen, nutrients (organic and inorganic nitrogen), water clarity/turbidity, and indicators of potential contamination, such as fecal coliforms. In order to establish and monitor baseline conditions, permanent stations representative of "typical" habitats or geomorphic settings (e.g., lagoons) should be established and sampled biweekly to monthly at the water surface and bottom to measure seasonal and annual patterns. Water bodies recognized to have impaired hydrology (i.e., with tide gates, culverts), altered circulation, or poor water quality should be identified and subjected to more intensive (e.g., hourly) water quality sampling with automatic dataloggers and sensors, especially during extreme events.

Sediment processes – Sediment processes are the foundation of nearshore habitat formation and variability. Monitoring of sediment supply potential, transport, and connectivity therefore are critical to the long-term evaluation of habitat structure and function, as well for planning and assessing management actions. For both long-term and site-specific project monitoring, sediment supply analysis should be undertaken to establish current baseline conditions, understand seasonal trends, verify potential problem areas, and model effects of extreme storm events. General guidance on recommended protocols for monitoring sediment processes in coastal and estuarine habitats can be obtained in Komar (1998) and Cahoon, et al (1999).

Shoreline Modifications – The type, extent, and relative impact of human modifications to the shoreline can have a range of effects to nearshore processes and functions (Williams and Thom 2001). Quantification of parameters (e.g., armoring extent, encroachment into intertidal zone) associated with this attribute provides a relative measure of human impacts over time, and can be especially useful when conducted in tandem with other environmental monitoring activities. Quantitative, geo-referenced ground surveys should be completed at multi-year intervals (e.g., every 5 years).

Habitat Structure

Land use-land cover – Land cover assessment is typically conducted using remotely sensed data (e.g., aerial imagery, satellite images, aerial photographs) and quantifies distribution of the distribution of primary habitats and how watersheds and shoreline habitats are altered by human activities and development. Land use and land cover changes are often tightly linked to changes in loadings of nutrients, sediments, and contaminants to streams and rivers that eventually end up in the shallow nearshore waters. Standard aerial photography is a useful tool for visually identifying broad changes in land cover over time, and annual records often are available from state or federal agency archives (e.g. Washington State Department of Transportation). Other remote sensing techniques, such as digital aerial photography, provides a georeferenced measure of ground reflectance to detect the extent and location of habitats, their patch characteristics, or vegetation structure and condition (standard protocols described in Dobson et al. 1995, Phinn and Stow in Zedler 1996, Finkbeiner 2001). This information should be collected during peak summer growth (greenness) at multi-year (1-10 year) intervals, with concomitant data classification, ground-truthing, and analysis. Land use assessment often focuses on total impervious area (TIA), a commonly used metric that reflects land use practices and watershed condition (May and Peterson 2003).

Nearshore riparian cover – Nearshore riparian habitats describe the upland vegetation bordering, and often overhanging, marine aquatic environments. Although understood as an extremely important ecological component in freshwater systems (i.e., forested watersheds), the functions of marine riparian cover have only recently been recognized, and are believed to represent an important factor in shading baitfish spawning areas, organic matter and prey production to nearshore aquatic habitats, and habitat for birds, reptiles, and mammals. This is also the area where development is often heaviest. Nearshore riparian cover can be assessed using remote sensing, in combination with ground-truthing, at multi-year intervals (see recommended methods in land use-land cover section). Large woody debris recruitment may also be a useful cover class to quantify using these remote sensing techniques in combination with groundtruthing.

Shallow water aquatic habitats – Vegetated habitats like tidal marshes, eelgrass, and kelp beds have been greatly impacted by humans over the past 150 years, and these structurally complex habitats are critical for the functions of many aquatic and fisheries resources, and well as for improving water quality. The distribution and health of these vegetated habitats should be monitored every 1-3 years to document changes. Monitoring of subtidal resources such as eelgrass should be stratified by habitat (“flats” and “fringing beds”) using underwater video and diver methods established by WDNR and WDFW, with sampling effort appropriately scaled to determine local trends (Berry et al. 2003). Remote sensing techniques can also be used to monitor kelp beds, intertidal eelgrass, and tidal saltmarshes at multi-year intervals (see land-cover section). Comprehensive nearshore mapping of both subtidal and intertidal resources have been developed using a combination of aerial imagery and underwater video techniques described above (Woodruff et al. 2002). Side-scan sonar technology also offers some opportunities for efficiently mapping submerged habitats. Water properties, including temperature, salinity, dissolved oxygen, light attenuation, and nutrients should be monitored coincident with vegetated habitat sampling (see water quality section).

Ecological Functions

Fish Assemblages – Fishes (i.e., forage fish, juvenile salmon, flatfish) are highly mobile animals that use nearshore habitats over a variety of scales for refuge, reproduction, feeding, and other functions. In turn, they serve as vehicles for nutrient cycling and energy transfer across habitats at a number of levels in the food web. Habitat quality may be reflected by community structure, including species richness, diversity of feeding types and life histories, specific abundance and biomass, and tissue health. Long term records can also provide information on the relative impact of invasive species, long-term climate change or cyclic phenomena (e.g. El Nino Southern Oscillation), harvest, trends related to freshwater inputs or water quality impairment, and nursery habitat value. Monitoring that would be useful at the local level includes annual assessment and verification of forage fish spawning areas using methods established by WDFW (2003). To derive an understanding of juvenile salmon distribution and abundance around Bainbridge Island, beach seine collections may be done following methods outlined by WDFW and Simenstad et al. (1991). Survey timing should coincide with species' peak outmigration, with frequency guided by project requirements and limitations; annual monitoring would be preferred to derive a long-term understanding of trends. Water properties, including temperature, salinity, and dissolved oxygen should be monitored coincident with fish community sampling.

Exotic Species – Exotic, or non-native, plant and animal species have been recognized as an increasing threat to global ecosystems, where they have altered basic ecosystem processes, habitat structure, and food webs. Exotics are more likely to become successfully established in aquatic ecosystems modified by humans. Monitoring facilitates the early detection of new invasions within a window of opportunity that eradication may be successful. Rapid assessment surveys of exotic species should be conducted at multi-year intervals following the methods of Cohen et al. (2001), with more intensive surveys conducted on a site-specific basis.

To summarize, our monitoring recommendations cover a range of key attributes that may be realistically collected at a local level to fill existing data gaps. Monitoring of toxic contaminants in sediment, water or biota is beyond the scope of this document. Regulation and/or cleanup of contaminants is addressed under both state and federal regulations, including Section 303(d) of the Clean Water Act and the Washington State Model Toxics Control Act (MTCA). It should not be assumed, however, that the existence of these federal and state regulations provide sufficient protection to sensitive species in all nearshore areas, since unregulated point and non-point source pollution continues to occur in Puget Sound. Further, the cumulative, sublethal effects of multiple contaminants or environmental stressors associated with nearshore communities are not clearly understood, and are not addressed in current environmental regulations. However, contaminant concentrations in tissues of some fishes (e.g., English sole) collected under the Bainbridge Island fish sampling effort could be evaluated on a site-specific basis in cooperation with PSAMP and WDFW. As well, we selected fish assemblages rather than subtidal macroinvertebrates as a measure of nearshore ecological function because of the cost-prohibitive sample processing time and expertise associated with identification of some invertebrate taxa, as well as the inherent value of having some discrete measure of salmon habitat use for Bainbridge Island. In the absence of funding constraints, another useful indicator of nearshore ecological function would be animal (bird, mammal, reptile, and amphibian) use of riparian habitats.

As previously discussed, a region-specific monitoring program would be required to comprehensively assess nearshore conditions of Bainbridge Island and inform an effective adaptive-management program. We assume this monitoring would serve two goals at different scales: 1. evaluate existing conditions for Bainbridge Island as a whole (comparable to annual Puget Sound Reports under PSAMP) to guide management decisions, and 2. assess site conditions following implementation of a particular management action to gauge its effectiveness. Given the current level of uncertainty typical at the planning stage, we provide summary guidance that can form the basis for a range of nearshore monitoring efforts on Bainbridge Island. Most of these recommendations address how Bainbridge Island can opportunistically fulfill a range of monitoring goals using rigorous methods under the limited resources (both funding and personnel) available at a local level.

Selectively monitor key nearshore parameters. Previous documents have summarized the critical linkages in Bainbridge Island nearshore ecosystems (Williams et al. 2003) and developed a conceptual framework for understanding these interactions (Williams and Thom 2001). We recommend focusing monitoring efforts on key parameters listed in the previous section that integrate the health of nearshore habitats. For example, eelgrass is used as an indicator of estuary health because it responds to many natural and human caused environmental variables. Changes in abundance or distribution of this resource are likely to reflect changes in environmental conditions, while likely affecting many other eelgrass-dependent species.

Focus monitoring efforts on ongoing local monitoring and assessment activities. The Bainbridge Island monitoring program should focus on sustaining established monitoring inventories, such as the City of Bainbridge Island Nearshore Structure Inventory (Best 2003). This project provides exceptionally detailed, georeferenced information on the number and extent of human modifications to the shoreline, and serves as a 2001 baseline that can be revisited to assess future change. As well, Bainbridge Island should seek to incorporate elements of other Puget Sound-wide monitoring programs, such as PSAMP, at a sampling effort appropriately scaled to determine local trends. For example, marine water sampling stations near Bainbridge Island could be selected and monitored in collaboration with the Washington State Department of Ecology. Similar monitoring surveys could be developed to better determine local trends in eelgrass habitat and the current extent of forage fish spawning areas, in collaboration with the Washington State Departments of Natural Resources and Fish and Wildlife, respectively. Site selection should prioritize the use of historically monitored sites wherever possible.

Use consistent and standardized protocols. Consistent and standardized protocols allow comparison of local data with other regional efforts, thereby allowing for scaled analysis of region-wide trends and increasing the relative value of the information collected. Sampling protocols of most ongoing programs (e.g., PSAMP) are well-documented, freely available (http://www.psat.wa.gov/Programs/Monitor.htm), and provide specific contact information. Other regionally appropriate protocols (e.g., Simenstad et al. 1991) should be used in the absence of ongoing efforts.

Forge partnerships and involve other stakeholders – Partnerships with agencies and other stakeholders in existing monitoring programs, such as PSAMP, are likely the best way for Bainbridge Island to develop a successful monitoring program. Not only would this lend consistent methods and appropriate technical knowledge to the local monitoring effort, but it takes advantage of existing resources and may lead to broader sponsorship by groups such as PSNERP. Besides the consortium of agency personnel involved in PSAMP, other stakeholder groups that may be interested in partnering include local Tribes, Kitsap County, local health districts and conservation districts, the Corps of Engineers, and the US Environmental Protection Agency. Organizations such as People for Puget Sound may also be enlisted to recruit volunteers with unique local knowledge and abilities to assist in monitoring efforts.

Leverage opportunities with existing resources unique to Bainbridge Island. The City of Bainbridge Island is uniquely situated to leverage its existing resources into additional opportunities for nearshore monitoring and research. A number of good relationships have already been established with regional stakeholders and the scientific community. Furthermore, the City of Bainbridge Island has developed a unique baseline inventory of nearshore structures (Best 2003), and has been exceptionally proactive in acquiring the knowledge for managing the local nearshore ecosystem (Williams et al. 2003, this document). These efforts put Bainbridge Island at a regional advantage for acquiring additional funding for nearshore monitoring, restoration, and research. For example, PSNERP will likely prioritize restoration and research efforts for sites with a well-established management framework for employing these actions. Furthermore, Bainbridge Island's quantitative inventory of nearshore structures, combined with this assessment document, provides excellent background justification for future funding proposals that seek to fill data gaps, such as linking and scaling land-use patterns to nearshore ecological functions. We recommend further attempts to involve researchers and graduate students from local universities in these efforts.

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