

## Moving Towards Nimble Spatial Reassessment

Every spatial assessment for ecosystem management involves a group of stakeholders asking questions of a data universe to determine where and how to achieve stated objectives. These assessments are unstable. If our spatial data change, or the stakeholders change, or our values and objectives shift, or we learn something new about ecosystems, we may choose to reassess.

The goal of “integrating the Nearshore Project and Watershed Characterization” was an attempt to answer questions not adequately resolved by either assessment in isolation. By assembling a stakeholder group and defining objectives, we discovered that we were best able to answer our new and refined questions by conducting a new assessment.

This kind of repeated spatial reassessment is likely inevitable and may be desirable. There are hundreds of agents working over tens of jurisdictions to manage the nearshore ecosystem. If we never reassess our priorities based on new knowledge, we are not adapting to stakeholder interests or new information.

The risks of continuous reassessment are at least two-fold. First, if we never develop comfort with our assessment, we never act and may become paralyzed in continuous reassessment. We must act, because action is the mechanism for actually testing our assumptions and strategies. Second, reassessment can become redundant when successive generations of technical staff unwittingly fail to build on previous work. We may waste effort reinventing the same assessments without integrating new learning or refining our strategies. There is an opportunity cost to assessment in the form of reduced action.

For spatial reassessment to be part of a coherent adaptive effort requires we need to 1) develop the social infrastructure to remember and refine our strategies over time, and to support this, 2) make our assessments systematic, accessible, and flexible. This chapter focusses on the technical aspects of nimble reassessment, that will more likely to support the development of social infrastructure.

## Systematic, Accessible and Flexible Assessments

Systematic spatial assessments use a coherent narrative (or “conceptual model”) that contains carefully defined concepts. Because of this systematic assessments are limited in scope—there is no single assessment that considers all aspects of ecosystem management. Accessible assessments are well documented, with primary data that are easy to evaluate. Flexible assessments are designed to be altered, repeated, and compared through the use of transparent calculations and shared assessment units.

We suggest four steps to achieve this kind of assessment:

1. **Develop an assessment narrative** including proposed objectives and management tools using clearly defined concepts.
2. **Select an assessment unit and scale** that is suited to the objectives and management tools.
3. **Link narrative concepts to the best available metrics**, while revealing the strengths and weaknesses of those best available metrics, and the logic of their selection.

### *To assess:*

***To evaluate (a person or thing); to estimate (the quality, value, or extent of), to gauge or judge.***

– Oxford English Dictionary

4. **Develop queries that reflect a strategy management strategy** to identify sites that are well suited to a particular course of action, and are then the focus of project development or tracking.

### Develop an Assessment Narrative

Each spatial assessment attempts to organize the landscape around a clear narrative. The Watershed Characterization was developed primarily to support local government planners making zoning and code decisions. The Nearshore Strategies were developed primarily to inform restoration and protection planning at the scale of “ecosystem sites.” They use different metrics to answer different questions, and the use of the results depends on the values, objectives, and intentions of the user.

An spatial assessment narrative defines those values, objectives and intentions. The development of metrics and queries depends on the precision of that narrative. Where assessments lack a clear and precise narrative it is difficult to interpret the results or to integrate or compare findings with other assessments. Development of a clear conceptual narrative is the first step in adaptive management (Figure ##).



**Figure ## - Adaptive Management Cycle from CMP.** Assessments occur within the Conceptualize phase, and inform action planning and are informed by learning.

The following narrative was developed as a demonstration of concept as part of our concluding case study:

***“We want to (1) protect the sediment supply on (2) beaches that (3) provide forage fish spawning as well as (4) other habitat services. We will use (5) regulation, incentives, acquisition, and education to (6) prevent shoreline landowners from building new armor on beaches that have (7) intact sediment supply, but are at the (8) highest risk of future armoring.”***

This language of the narrative defines eight concepts. These eight concepts define the metrics and the query structure.

A spatial assessment compares a population of units. In this case we are assessing things called “beaches”. We want to select beaches that are most suitable for our intent (“protective measures to prevent new armoring”). Not all beaches are of equal interest. The narrative points to four conceptual criteria that indicate a beach is of higher interest: 1) “forage fish spawning”, 2) “generally high levels of habitat services”, 3) “intact sediment supply”, and 4) “high risk of future armoring”.

The narrative implies a set of assumptions: 1) our goal of protecting sediment supply will result in the ecosystem services we desire; 2) beaches are the location where we can get these services; 3) beach conditions that affect these services are responsive to our tools, and they are the best tools; 5) that beaches that fit our criteria are the best beaches to achieve our goals using the proposed tools.

There are evidence and uncertainties underlying each assumption. These uncertainties are the basis for adaptive management—what we must learn through action, evaluation, and integration of new knowledge. In this way, an assessment narrative contains a policy proposal based on a set of beliefs, values, and scientific evidence. The

assessment does not reveal some kind of irrefutable truth, but is a way finding tool for applying effort and learning through the process.

### Select an Spatial Assessment Unit and Scale

In developing our spatial assessments we identify a type of unit, and one or more scales at which to assess the character of our units. In our example we indicate that we are attempting to identify units called “beaches”. We must define what we mean by a beach, and consider the scale(s) at which we should characterize those beaches.

Drift cells provide a natural organizing unit for beach ecosystems, and are a scale of analysis common to The Nearshore Project and the Watershed Characterization. In our case study we propose that based on our current knowledge of drift cell dynamics, this is the appropriate scale for site identification. This is because we have some evidence that over longer time spans and under predicted sea level rise, that adequate sediment input and transport at the scale of a drift cell is most likely to allow for resilience of the beach structure that support beach spawning of sand lance and surf smelt. In addition, it is difficult at the scale of Puget Sound to adequately identify smaller units that could be managed for the provision of beach spawning sites. In short, the drift cell unit is the best available unit, however there is ample room for more detailed analysis during project development, or for future improvements in assessment methods.

While our ecosystem management goals are best evaluated at a drift cell scale, our incentives, regulations, acquisition and educational activities typically operate at either a parcel scale, or target social communities. Our unit scale may be affected by both our ecological goals and the tools we use. Because the tool set in our example is easily scaled, we can allow our understanding of ecosystem dynamics to drive assessment unit scale.

If we are consistent in our definition of ecosystem units this greatly simplifies our integration of assessments over time. If my beaches are spatially different from your beaches it is more difficult to determine which beaches we value most. We provide a recommendation and discussion arguing for the establishment of consistent process-based ecological units at the Puget Sound scale in Appendix B.

### Link Narrative Concepts to Metrics

With a clear assessment narrative and appropriately scaled units, we can now develop metrics. These metrics are derived from spatial data, aggregated at the scale of our assessment unit, and based on our narrative.

There is likely more than one way to represent a concept using spatial data. For example, the concept “intact sediment supply” can be rendered in different ways depending on your intent, and your confidence in the underlying data. At least two steps are necessary to develop a metric. First the concept that the metric is intended to represent must clearly be defined. Second the metric must be justified as the best available to render that concept using spatial data. A single spatial feature (presence or absence of armoring) can be used to derive more than one metric (percent armoring vs. length of armoring). Consider the following metrics that could represent the concept of “intact sediment supply”:

- **Percent armoring** (Simenstad et al. 2011) – Percent armoring simply indicates the percent of the whole drift cell with armor present, regardless of landform.
- **Sediment input process degradation** – this PSNERP metric considers the proportion of “bluff backed beach” in a divergence or transport zone containing armor, roads or railroads, artificial shore forms, or fill (Schlenger et al. 2011).
- **Beach Degradation Score**– Beach degradation score considers the rank of a beach among all beaches in terms of three metrics: 1) sediment input degradation, 2) parcel density, and 3) a shoreline impervious surface

metric. Higher scores indicate a greater complexity and intensity of human modification of the shoreline, reducing the likelihood of successful restoration of sediment input processes (Cereghino et al 2012).

- **Percent Modification of Predicted Historical Sediment Sources** – This proposed metric uses more recent mapping of “modified shoreline” which revises Simenstad et al. (2011), and includes an estimation of which beach shorelines historically provided sediment supply.

All four of these metrics can result in a proportion from zero to one at the scale of a shoreline process unit. They all represent beach degradation in relation to sediment supply. Some make more assumptions about source of sediment—others integrate social factors that might affect the mutability of that supply. None actually consider bluff height, composition, or anticipated rate of retreat. They are all likely to be highly correlated. With different sources of error, they all describe aspects of degradation of sediment supply at the scale of a drift cell.

Each metric is an attempt to spatially described underlying concepts while minimizing sources of error. All metrics are accurate to varying degrees. As our ability to describe a concept improves we may choose to swap metrics, and repeat existing assessments using new underlying metrics. It is therefore important to clearly define our concepts, before selecting a best available metric. This prevents the erroneous assumption that metrics perfectly represent concepts, and encourages scientific debate, and refinement of metrics that are weak and need improvement.

Four kinds of spatial features are generally available for the construction of metrics to represent our concepts:

- **Physical Features** – some data describe the physical environment, including elevation zones, substrate texture, drift direction, exposure and sediment inputs. In the nearshore physical features are commonly used to define assessment units—distinct polygons or line segments anticipated to have a relatively homogeneous character. Some physical features could be used to infer biological use (for example beach texture to suggest suitability for spawning), or predict human system dynamics (for example high erosion rates suggesting a justified fear of erosion). Physical structure (for example bluff existence) is relatively reliable, while the characterization of physical processes is more challenging (for example predicted future bluff erosion rate).
- **Biological Features** – biological features might correlate with physical features, or may be distributed in a way that we don’t understand. We have various data to describe vegetation, and the confirmed occurrences, or predicted distributions of a particular taxa or life stages. Data describing biological features, and particularly the occurrences of mobile animals, may be a result of very limited sampling.
- **Anthropogenic Features** – a variety of features are used to indicate the extent and intensity of anthropogenic alterations. These alterations are in turn linked to loss of services through some body of scientific evidence. Different management strategies may be more or less suited to different kinds of development settings. Simenstad et al (2011) proposes division of anthropogenic impairment into four tiers, based on proximity to the shoreline.
- **Human System Features** – some data represent the relationship between human systems and ecosystems. These include property boundaries, demographic attributes of landowners, or designations like zoning that reflect institutional policy. These human system features might make a site more or less suitable for management or indicate potential sources of risk.

Each spatial feature contains at least two sources of error. First, a feature may not accurately reflect the real world at the moment of assessment. There could be data collection errors, mapping errors, or data describing a changing feature could be outdated. Second, a spatial feature may or may not strongly represent the concept being assessed. For example, presence of armoring alone may not indicate a loss of short term sediment supply,

as armoring may be configured in a way that does not actually affect sediment supply or some systems may have large historical sources of sediment supply that buffer the effects of lost bluff erosion.

### Develop Queries that Reflect a Strategy

There are two essential uses of assessment. Either 1) we define our objectives and then identify where in the landscape we are most likely to achieve those objectives—a suitability analysis, or 2) we identify a place, and through consideration of many assessments, we develop a place specific approach to management. Either we are looking for places suited to our strategy, or we are working to develop a strategy suited to a place.

While the difference is subtle, most assessments are of the first type, in that there is an implied or stated intention and toolkit which drives our judgment of places. A strategic assessment that develops a strategy for a place typically combines multiple assessments, and arrives at a suite of measures suited to each situation. Both the Watershed Characterization and the Nearshore Strategies are attempts to develop a complex approach using multiple assessments, and each of these efforts has struggled with explaining the use of these complex findings.

Queries use our selected set of metrics to inform decision making. There are four kinds of judgment common to most assessments. Each of these judgments should be represented in the assessment narrative and are combined in some way by the query architecture to identify or characterize units.

- **THE UNITS--What are the boundaries of the places we are considering for management?** Some kind of attribute is used to define the extent of a unit. Polygons or lines are often used to define shoreline units. A discussion of the potential for standardizing assessment polygons is provided in appendix B.
- **IMPORTANCE—which places provide the greatest resource value?** Some combination of biological and physical features is used to determine the relative importance of a site to a particular management objective. Importance usually attempts to identify those units that provide the greatest quantity of the services we are trying to manage. For example, if we are managing for shellfish harvest, we would look for sites with high levels of shellfish production and harvest. If we are managing for salmon rearing, we would look for sites with a combination of landscape position and features that indicate a high density of salmon receiving rearing services. Our ability to assess services over a complex life history requires more complex assessment methods, to look for vulnerability with in sequence of habitat services.
- **SUITABILITY—which sites are likely to respond positively to our management approach.** Some combination of metrics is used to define the settings that are most appropriate to our tool set and objectives. Suitable sites may have a particular pattern of anthropogenic degradation, or certain physical or biological attributes, and have some specific status within social systems.
- **RISK—which sites have factors that make our management outcomes particularly uncertain?** Some combination of multiple features may be used to determine if there are risk factors that make the pursuit of management objectives in a unit unpredictable or unreliable into the future. How we respond to risk is defined by our narrative, and is part of our strategy. We might be risk averse and seek units with low risk. We might also be interested in risk, evaluating sources of risks in the landscape, and seek locations where we can complete management experiments to reduce those risks in the future.

Development of a query will cause us to review and illuminate weaknesses in the narrative. For example, a word like “protection” reflects a suite of management actions, ranging from property acquisition to regulation to education to incentives. Different assessments may be necessary to identify suitable targets for these different measures, with overlap indicating opportunities where multiple measures could be employed with greater effect.

We envision that strong assessment may involve a series of queries that identify targets for different management objectives. By observing the overlap of these specific queries, we identify locations where there is a strong potential for integrated, intensive and collaborative ecosystem management.

## **Leveraging Existing Assessments in Reassessment**

If reassessment is the norm, what is the value of an old assessment? If an assessment is poorly organized, difficult to understand, and difficult to deconstruct, it is more likely to be discarded by future reassessments, in favor of original work. Increasing the cost and reducing the continuity of work. The steps described above are intended to make assessment work more resilient so that we can 1) review and refine our strategic narrative over time, 2) reuse high quality metrics, and 3) compare the results of successive assessments to better understand the landscape.

Having a short and concise narrative that reflects a strategy and that drives the selection of metrics and query language provides a starting point for refining assessment. Is the existing assessment still valid, or good enough for the purpose at hand? Has there been a substantive change in our understanding of factors that affect our work? Very elaborate models and narratives often include a level of complexity which interferes with discussion of strategy. Concepts should be nested so that it is possible to explain a strategy using a simple narrative. Concepts can be unpacked and expanded as necessary.

Several of the concepts in a past assessment, and the metrics developed to represent those concepts may still represent the best available thinking. For example, sediment input process degradation, developed by Schlenger et al (2011), was reused by Cereghino et al. (2012), and by this effort because it still reflects the best available estimate of sediment supply degradation. However we anticipate that feeder bluff mapping by Coastal Geologic Services may ultimately provide a more robust estimate by better characterizing current and historic sediment sources within systems.

One significant barrier to maintaining an evolutionary continuity in assessments is in the continuous revision of assessment units (a topic developed in Appendix B). If the assessment units remain constant over time, than successive efforts to assess and prioritize work in the landscape are difficult to compare. Standard units support tracking of status and change. Without a common framework of assessment units, we greatly complicate and impair our ability to conduct adaptive management.

Perhaps our greatest challenge is in developing the social infrastructure that can remember and value past strategic assessment work as a historical representation of the best strategic considerations of a stakeholder group, seeking to achieve specific objectives. Such a social infrastructure is necessary for adaptive management, and will likely cross lines that divide agencies, and cross issues areas that define stakeholder groups.

## **Avoiding Unprofitable Reassessment**

There is error in all assessment. Underlying data are imprecise or inaccurate, and our understanding of ecosystems is incomplete. Furthermore, an assessment may not reflect the values of all stakeholders.

Assessments need to be weighed as an initial step that leads to project development. Project development takes a more intensive and complete look at a situation to develop a plan of action. Project development is how we uncover and remove the inevitable error of assessments. Reassessment cannot resolve all error—we move from assessment to project development to implementation as a method of testing our assessments.

If our strategy changes, this may suggest value in reassessment. This could be due to the introduction of a new stakeholder interest (for example integration of flood management and salmon recovery in floodplain units). This

could be due to a shift in our understanding of ecological systems (for example consideration of the effects of sea level rise and the importance of sediment supply on delta restoration). A change in strategy is reflected by a shift in the assessment narrative, the addition of new concepts and metrics, and a revision of the query mechanisms. This work may change our priorities, or cause us to heed risk factors in our project development.

A change in underlying data may improve assessment, but if the new data significantly changes our metrics to the point where they change the assessment outcome. It may be wise to accumulate new data, until a full reassessment is truly warranted. Reassessment is more likely warranted when 1) there is a change in strategy or 2) improvements in accuracy or precision of underlying spatial data are great enough to change how we apply the assessment, given the various sources of error we accept when interpreting the assessment outcomes. Maintaining consistent assessment units allows for rapid comparison of new data to old data to determine whether new data are likely to affect assessment outcomes.

## **Review of Nearshore Strategies**

The Nearshore Strategies (Cereghino et al. 2012) is a collection of four assessments each containing two sub-models, describing deltas, beaches, barrier embayments, and coastal inlets. Each compares a different set of landform-based units. They do not consider water quality, or biotic indicators beyond those that can be correlated with landform. They were designed to provide a tool for evaluating the potential of construction-based restoration for resolving degradation at the scale of process units (whole drift cells, whole embayments and their watersheds, whole river deltas).

It follows recommendations in Simestad et al. (2011) to consider both proximate degradation (shoreline modifications) and more distal degradation (a 200 m shoreline zone, and associated watersheds). It uses metrics developed by Schlenger et al. (2011) to represent shoreline modification. Each assessment considers 1) the size and complexity of each unit as a surrogate for the potential to provide ecosystem services, and 2) the intensity and complexity of anthropogenic degradation. Both an index score and a clustering algorithm are used to more fully capture the character of each unit.

A preliminary recommendation for how to approach ecosystem management is provided by creating three groups of sites along gradient of increasing degradation. In addition, each strategy identifies a set of risk factors that could be used to narrow site selection, or inform project development.

## **Review of Watershed Characterization**

Watershed characterization is a collection of assessments built around two models which combine eight sub-models. Each model and sub-model look compares the same set of evenly-sized watershed units, derived from similar stream segments, such that several to many units form a single catchment. It differentiates between lowland and mountain units, and between units that drain to large rivers and units that drain to Puget Sound. It provides some mechanisms for reviewing information within mid-scale catchments (watershed management units). These models were developed to predict and compare how different watershed components contribute to water quantity or affect water quality. This was intended to inform how local jurisdictions develop growth management plans, to direct growth toward areas anticipated to have the least impact on water quality and quantity while protecting areas with the greatest contribution. These assessments don't consider how whole basin thresholds that might affect ecosystems functions.

In addition watershed characterization provides a terrestrial habitat assessment, which identifies areas with large contiguous islands of forest cover, and a freshwater habitat assessment that summarizes use by diverse salmon stocks.

Watershed characterization also provides a smaller habitat unit assessment of the shoreline, aggregating a wide range of species occurrence data to describe the potential contribution of a shoreline segment to biodiversity, as evidenced by the high level of occurrence of one taxa, or by the occurrence of many taxa. In general, these biological data are varied in quality, with both low and high quality data integrated into single metrics.