The Washington State Joint Legislative Audit and Review Committee (JLARC) conducted a review of the state's efforts to conserve habitat and expand outdoor recreation. This work included a review of existing or potential objective outcome measures that could be used to evaluate the success of 13 land acquisition and regulatory programs intended to protect and conserve habitat and expand outdoor recreation. Based on the effective outcome measures found in the peer-reviewed and gray literature, communications with managers from similar programs in the U.S., and the project team's professional opinion, it was found that there is very little literature that focuses specifically on outcome measures as they relate to land acquisition intended to protect and conserve species, habitats or to expand outdoor recreation; however a number of states and regions have implemented outcome measures for acquisition, and guidance is available from the extensive literature on restoration program and project effectiveness.

Introduction

Developing strategies to effectively measure ecological outcomes linked to specific programs and projects is an essential, but not simple, task that remains generally elusive in practice (Dale and Beyeler, 2001; Sawhill and Williamson, 2003; Niemi and McDonald, 2004; Doren et al., 2009; Margoluis et al., 2013). There are many examples of project-level effectiveness and projects that have laid out clear outcome measures linked to the project goals, such as Hartema et al. (2014). At the programmatic and regional levels, examples of these outcome measures are more difficult to find. For an example of a regional evaluation of the cumulative effectiveness of multiple projects see Diefenderfer et al. (2016). For a model-based evaluation of restoration project impacts at a watershed scale see Roni et al. (2010).

Some researchers note that the increased demand for outcome measurement, particularly ecological outcomes, does not imply that they are useful for decision making or that they are frequently used (Turnhout et al., 2007). Others argue that aligning outcome measures (indicators and metrics) with the mission and goals of an organization, program, or project can change it profoundly.

Margoluis et al. (2013) argue that to measure success in conservation three questions must be answered: (1) are we achieving our desired impact?; (2) have we selected the best interventions to achieve our desired impact?; and (3) are we executing our interventions in the best possible manner? Another question to add to this list is (4) who is the audience and who will care about the effectiveness of our program and our actions?

Outcome measurement processes are based on the selection of indicators and metrics, and the choice of indicators and metrics will directly impact the results of the process (Behan et al., 2017). To understand which indicators and metrics have been shown to effectively measure the performance of land acquisition and regulatory actions, we focused our efforts on peer-reviewed literature, agency publications, and on programs that would help provide information about 'best practices' for outcome measures that were not found in peer-reviewed or agency publications. By best practices we were looking for *outcome measures* (i.e., indicators and metrics) and programs that were effective, innovative, or promising.

Due to the complexity and nuances related to the protection of estuaries in Washington, this section is not intended to

be a comprehensive compendium of the indicators and metrics used to create effective outcome measures. Rather it is a compilation of effective outcome measures and practices based on our literature search, conversations with program managers, and the opinions of the project team within the timeframe of the project. The complete report (Behan et al., 2018) provides many more details concerning the development of outcome-based indicators from the literature, along with information on all of the other related programs and subject areas evaluated in the JLARC study.

Background

Estuaries integrate conditions from land, atmosphere, rivers and oceans and, as a result, their management is a complex undertaking. In Washington State, estuarine condition goals are derived from a combination of federal and state laws, regulations, treaties, and policies and missions of nonprofit organizations and communities. A major consideration for legal compliance is the Clean Water Act, which establishes that water quality should be consistent with public health and public enjoyment of waterbodies, the propagation and protection of wildlife, birds, game, fish and other aquatic life. It also sets a goal that all known available and reasonable methods by industries and others to prevent and control the pollution of the waters of the state of Washington should be implemented. Also relevant for legal compliance with federal law is the Endangered Species Act for the protection of threatened and endangered species that may depend on the estuary or connected ecosystems. A voluntary federal program, in which Washington State participates, requires coastal states to develop a Coastal and Estuarine Land Conservation Program Plan (CELCP) to effectively manage and preserve significant coastal and estuarine areas.

State laws and policies also generate more specific goals including: Recover salmon stocks (SRFB, PSAR); Restore the number and quality of coastal embayments (ESRP); Sustain economic development (growth & shoreline management); Conserve native species and ecosystems (DNR mission); Connect people with Washington's iconic landscapes and Provide Washington's recreation mainstays (Parks & Recreation, shoreline management). The many specific goals of the variety of laws, regulations, policies and government mission areas can be represented under the umbrella goals of the Puget Sound Partnership (PSP) Vital Signs.

1. Healthy Human Population
2. Vibrant Quality of Life
3. Thriving Species and Food Web
4. Protected and Restored Habitat
5. Abundant Water Quantity
6. Healthy Water Quality

Outputs

A short list of outputs identified in agency materials, or provided by JLARC, about the programs relevant to estuaries:

Drivers – Intensity of human use or alteration

- Land use percentages (e.g., agricultural, urban, forest, natural riparian buffers, septic density in riparian zones)
- Impervious surface in watershed and buffer zones (riparian or coastal)
- Quantity of freshwater inflows
- Pollution loads by source sector (wastewater treatment plants, agriculture, septics and stormwater)
- Invasive species abundance or extent

Actions – Implementation accounting

- Ecosystem restoration (wetlands, floodplains, etc). activities measured as area or length
- Pollution control efforts – # NPDES estuary permit holders adopting specific technologies
- Area of natural lands protected through acquisition, easement or designation
- Fish passage restoration (stream access restored)
- Public access sites
- Education (e.g., number of school children having an estuarine/watershed learning experience)

Outcome statements

The primary outcomes the project team identified from the objectives in the enabling legislation of the program:

- Protect fisheries: commercial species & fishing jobs
- Provide high quality water-based recreation options (boating, fishing and swimming)
- Assure biodiversity and ecosystem integrity by maintaining/restoring species, communities, and habitats
- Mitigate climate change risks

The Puget Sound Partnership has identified a comprehensive suite of indicators for use in tracking Puget Sound restoration progress based on sound science and public engagement. Nonetheless, these indicators and metrics merit review since it may be necessary to prioritize monitoring and select indicators and choose the most cost-

effective metrics best suited to answering policy questions. In the evaluation that follows, indicators are not nested under these broad goals because goals overlap and because many indicators and metrics address multiple goals. Instead, we group output indicators into categories of drivers and actions and relate outcome indicators to more specific goals.

Literature

To review the state of the science, we investigated the indicators in use by the major estuary or large water body management programs within the US (See Appendix B in Behan et al., 2017). Many of those programs have synthesized the published literature and been guided by science advisors in choosing their indicators, so the set of metrics in use by these programs has been vetted from a scientific and feasibility perspective. Further, large water body management programs have similar federal requirements and local goals for maintaining water quality for safe recreation and commercial or other uses, productive fisheries, and protection of species of concern. Also common is the goal to promote the long-term health of the waterbody and associated ecosystems. As a result of these common goals, many indicators are transferable across systems, although priorities for data collection vary.

The management literature on performance metrics for estuaries includes metrics of drivers, actions, and outcomes. *Drivers* include changes in air, land, and water that influence the estuary, such as land cover change in the watershed and freshwater inflow. *Actions* include activities that affect estuaries, such as tidal wetland acres restored. *Outcomes* are desirable results, as expressed through program goals, such as population responses for species of concern.

All the major estuary programs use driver and outcome indicators, only some use action indicators (Appendix B). All programs include water quality conditions to comply with the Clean Water Act and most track seagrass extent as an integrator of water quality and an indicator of fish habitat quality. Most programs also build indicators around commercial fish harvest data.

Beyond some of these common metrics, programs target monitoring to their issues of greatest concern. For example, within the Gulf of Mexico initiatives, Louisiana invests heavily in tracking coastal marsh extent since this outcome is a major program goal (Hijuelos and Hemmerling, 2016). Similarly, the Southern California Coastal Water Research Project Authority (SCCWRP) has made atypical investments in assessing toxics of emerging concern to support their goals of maintaining safe beaches and assessing acidification conditions to protect shellfish and other species (S. Weisberg, 2017).

Currently, programs differ markedly in the degree of comprehensiveness of outcomes monitored and whether the metrics represent outcomes that the public can readily understand. Most often, basic changes in ecological structures and processes (e.g., chlorophyll-*a* seagrass extent) are used and not outcomes of fisheries or birds. Impediments to using fish and birds are that they are expensive to monitor and may be responding to conditions beyond the control of the estuary restoration program.

In practice

To provide a set of indicators that 1) tracks progress towards outcome goals and 2) identifies which interventions are likely to be most cost-effective, indicator systems must include metrics of the watershed drivers and the relevant outcomes for the estuary. A critical indicator is pollution loads coming from the watershed, in addition to in situ monitoring, so that actions to alter pollution can be targeted to source sectors (wastewater treatment plants, agriculture, septics and stormwater) or locations.

Driver indicators are useful for correlating trends in water bodies to stressors and identifying management opportunities. Studies in which indicators are measured before and after actions, preferably with control sites to control for weather and other external drivers, offer the best ability to understand effects (as is conducted by PSP). In addition to the typical indicators of land cover and freshwater inflows, we suggest several driver indicators that reflect recent research that impervious surfaces, natural riparian buffers and septic density in riparian zones can have disproportionate effects on estuarine water quality and habitat condition. Metrics of shoreline alteration (i.e., length of bulkheads, riprap, etc.) are also commonly proposed as an estuarine driver, however a recent comprehensive study showed that effects of shoreline hardening can be mixed with some species showing declines (species often found in shallow water such as grass shrimp, mumichogs, killifish) and others showing increases (larger-bodied bottom- oriented species including spot, white perch, and striped bass) (Kornis et al., 2017).

The literature also suggests that different types of shoreline erosion control may have differential effects. Recommendations included results for Washington by Dethier et al. that demonstrate specific impacts of shoreline armor on fish, invertebrates, and birds. The summary page that cites the recent publications can be found online.

The ideal estuarine monitoring from a scientific perspective is to collect a comprehensive suite of driver, action and outcome variables to reveal sources of degradation and the effectiveness of actions in terms of outcomes to fish, birds and water quality. However, because such an approach can be costly, states manage the costs by developing a core set of metrics that are routinely monitored and supplement these metrics with temporally or spatially targeted investigations to provide additional data needed for increased understanding and adaptive management. Such targeted investigations also allow programs to take advantage of grants that may not pay for routine monitoring, but will pay for investigations that include extensive data collection.

Some programs, such as the Chesapeake Bay Program, are looking to manage risk of climate and land use change by building system resilience and designing management to be robust to extreme events. One approach is to add forward-looking indicators and metrics (rather than ones related to status) that provide early warnings of changes in drivers or condition. For example, the trajectory of submerged aquatic vegetation regrowth after hurricanes is an indicator considered as a measure of resilience in the Chesapeake Bay (Wainger et al., 2017). The concept of managing and tracking system resilience is still developing, but may include metrics that quantify recovery time after major acute stressors.

A core set of outcome measures categories for tracking broad program performance was selected by considering three main criteria:

1. the outcome measures categories represents a cross section of outcomes that address legal and community stakeholder interests;
2. data are often available to measure representative indicators within these categories to track conditions within large systems, with either existing or cost-effective monitoring; and
3. they include the concept of tracking risk-management activities rather than responding after the fact.

The indicators found in the literature or identified practices are listed in the table below. The specific indicators measured within these categories would still need to be determined. See Appendix B of the complete report (Behan et al., 2017) for examples that have been vetted elsewhere. Some indicators and metrics have not yet been widely employed (e.g., measuring wetland upslope migration potential) but including such indicators could drive an evaluation of existing research, as needed to promote indicators for estuary management that are forward-looking.

Conclusions

Methods for developing meaningful outcome-based indicators are clearly identified in the literature. They are being put into practice successfully in a few states, but generally very sparsely across the country, and rarely for species and habitat focused land acquisition programs. When evaluating program success, most agencies tend to focus on gathering information they need for adaptive management – either data needed to determine if their actions are achieving their goals, or the information needed to develop plans or strategies. However, understanding priorities for action or the effectiveness of actions may not inform if the program is achieving the desired outcomes.

The most effective programs for evaluating program success in land acquisition, restoration, and water quality protection had a few commonalities. First, the legislation that created these programs specifically described the outcomes desired, so designing an outcome based set of indicators was more straightforward. Second, the legislation required that indicators of program success be developed and reported on some regular schedule, and at a minimum funded the development of the indicators and their implementation, often requiring interagency cooperation, which is essential as many agencies and local or regional governments may be involved in program implementation. And, they required statewide (or jurisdiction wide for regional governments such as Tahoe) evaluation of outcomes – which helps to assure the development and measurement of the indicators are not focused on plans or projects.

To understand if ongoing acquisition and regulatory programs are effectively protecting estuaries and assure they continue to providing the expected benefits to citizens of the state, it is critical to have a reasonable understanding

of the baseline conditions of all the estuaries in the state. The extensive information at Padilla Bay National Estuarine Research Reserve and in other well studied estuaries provide important guidance as to issues, threats and estuarine habitats, but are not a substitute for statewide estuarine status and trends data, needed to understand if any existing programs are making a difference.

Tidal wetland condition outcome measures selected by expert panel (Palmer et al., 2011)	
Category	Indicators
Hydrologic	Tidal regime (range, inundation duration, velocity)
	Hydrologic connectivity
Geomorphic	Elevation
	Slope
	Topographic complexity
	Area (by physical zone), Edge complexity
	Sedimentation rates
Biotic	Vegetation cover & density
	Canopy complexity
	Vegetation (native) species richness
	Invasive plant species cover
	Invertebrate assessments (species richness, density, community composition)
	Species use (Fish and shellfish abundance, species richness, juvenile densities; wetland-dependent bird abundance; migratory bird counts)
	Breeding success (Bird fledgling counts, nests, eggs)
Physio-Chemical	Pore water salinity and pH
	Surface water quality (T, DO, chl-a, TSS, N, P, contaminants)
	Denitrification potential
	Soil properties (Grain size, organic matter, bulk density)
	Nutrient retention / removal

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