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Lessons learned from an ecosystem-based management approach to restoration of a California estuary

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ABSTRACT

Ecosystem-based management (EBM) is the dominant paradigm, at least in theory, for coastal resource management. However, there are still relatively few case studies illustrating thorough application of principles of EBM by stakeholders and decision-makers. At Elkhorn Slough, a California estuary, we launched an EBM initiative in 2004. Stakeholders collaboratively developed and evaluated large-scale restoration alternatives designed to decrease two types of rapid habitat change occurring in the estuary, erosion of channels and dieback of salt marsh. In the end, decision-makers rejected large-scale alternatives altering the mouth of the estuary, and instead opted for small- to medium-scale restoration projects and recommended an added emphasis on reduction of nutrient-loading. We describe seven challenges encountered during the application of EBM principles: (1) interdisciplinary collaboration is difficult due to differences in professional culture and values, (2) roles and responsibilities of different participants are often not sufficiently clear, (3) implementing EBM is very costly in time and human resources, (4) an ecosystem services framework may not resonate with stakeholders already committed to biodiversity conservation, (5) conflicts arise from differences in desired restoration targets, (6) multiple geographic and jurisdictional scales cannot be simultaneously addressed, and (7) understanding of ecosystem drivers and processes may change rapidly. We recommend approaches to overcoming each of these challenges so that our experiences implementing EBM at one estuary can inform collaborative decision-making initiatives elsewhere.

1. Introduction

> *"Ecosystem-based management is fundamentally about perceiving the big picture, recognizing connections, and striving to maintain the elements of ecosystems and the processes that link them."* [1]

Ecosystem management emerged in the 1980s as an alternative to traditional resource management approaches that focused on limited species or narrow political boundaries. Environmentalists and scientists advocated for broader landscape-scale planning, collaboration with stakeholders, and flexible adaptive management. The term 'ecosystem-*based* management' (EBM) was later adopted to convey that management efforts are focused on human activities affecting the ecosystem; the ecosystem itself is not being managed [2]. Many different definitions of EBM have been developed [3]. A recent review identified 17 different criteria that are commonly used to define ecosystem-based management [4]. These fall broadly into the general categories of sustainability, ecological health, and inclusion of human uses within the ecosystem framework.

Many natural resources agencies began to apply principles of EBM. However, by the mid 1990s, EBM fell out of favor with many land managers and terrestrial environmentalists, because political interests

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dominated some EBM processes, resulting in human resource uses being favored over ecological integrity and sustainability [2]. While EBM was declining in popularity in terrestrial systems, it gained momentum in marine systems: EBM became a major focus of marine conservation efforts, after being endorsed by various prestigious scientific panels [5–7]. By the early 2000s, EBM was the dominant paradigm, at least in theory, for managing natural resources around the world, in both marine and terrestrial systems [8].

Despite the ubiquity of the concept of EBM, there are still relatively few case studies of successful implementation, and the extent to which the EBM principles advocated by scientists have been adopted by managers and concretely applied to local projects is unclear [4]. Indeed, a review of recent management plans suggests that there is still a gap between the academic framework for EBM and its on-the-ground implementation, with many key tenets of EBM failing to be translated into management [4]. Furthermore, in some instances the original goals of ecosystem sustainability and resilience are not achieved due to dominance of political interests supporting human uses [2]. Thus, case studies have been valuable for elucidating tactics for successfully applying EBM to local management [1,9,10].

The majority of case studies of marine EBM are focused on open coast fisheries management and/or marine protected areas e.g. [10,11]. However, estuarine ecosystems also provide rich model systems for implementation of EBM – indeed, given the obvious linkages between watersheds and estuaries, and the multiplicity of human uses of estuaries, some principles of EBM were already being applied to estuaries before the term was invented. For instance, on the US Atlantic coast, resource managers in Chesapeake Bay began an initiative to restore multiple targets including water quality, vegetation, and oysters decades ago, at a broad geographic scale, although it has not made all the environmental gains that had been hoped for initially [12]. At another estuary, on the US Pacific coast, the Puget Sound Partnership is considered a model in the application of EBM [13].

The goal of this paper is to describe our application of the principles of EBM to Elkhorn Slough, an estuary in central California. While this estuary is small, the management issues there are comparably complex to many other coastal systems. We will characterize the framework and process used to generate, evaluate and select restoration alternatives for the estuary. We will then share broader lessons learned from our challenges and successes, so they can inform resource managers and stakeholders developing nascent EBM projects in other places, and so they can contribute to the on-going academic evolution of the concept and framework for EBM.

2. Case study: EBM at a California estuary

2.1. Elkhorn Slough: a rich but highly altered ecosystem

Estuarine habitat is rare along California's topographically rugged coast. In central California, there are only two large estuaries, Morro Bay and Elkhorn Slough, and both are relatively small. Elkhorn Slough thus provides regionally important representation of estuarine habitat types, including some of the most extensive salt marshes in the state, after San Francisco Bay. The estuary has been highly impacted over the past century by human activities, especially by hydrological alterations [14]. Today about half of the original estuarine wetlands are behind water control structures, and there has been extensive loss of salt marsh and degradation of water quality in these areas. In contrast, the portion of the estuary that has not been diked has been subject to a dramatic increase in tidal energy following the 1946 creation, and subsequent maintenance, of the Moss Landing Harbor. The artificially deep mouth to the estuary increased tidal amplitude and current speeds in the estuary, leading to substantial tidal scour of the main channel and contributing to salt marsh loss (Fig. 1) [14,15]. Channel banks erode at a rate of 0.3–0.6 m/year, with sediment export from the estuary estimated at $>50{,}000\ m^3$/year; about 50% of salt marsh in the estuary has been lost since 1870 [14].

In addition to these hydrological alterations that have greatly affected habitats at Elkhorn Slough, degraded water quality has strongly affected environmental conditions for organisms dwelling in the estuary. Elkhorn Slough is surrounded by some of the most intensely cultivated and productive farmlands in the nation. Nearly 6% of the world's strawberry production occurs within the watershed. The estuary receives substantial agricultural run-off, and nitrate concentrations observed in the estuary are high [16].

Despite the many human alterations, hundreds of species of plants, algae, invertebrates, fish, birds and mammals use these estuarine habitats, including over a dozen “estuarine endemics”, found only in estuarine or brackish coastal ecosystems [17]. Tens of thousands of people visit the estuary each year to experience these estuarine landscapes and the species that inhabit them (Fig. 2).

2.2. Formation and structure of EBM initiative

For many decades, conservation initiatives have grown and expanded in the Elkhorn Slough watershed, with wetlands and adjacent lands in the watershed protected by The Nature Conservancy, the California Department of Fish and Wildlife (CDFW), the Elkhorn Slough National Estuarine Research Reserve (ESNERR), a partnership between CDFW and NOAA, and the Elkhorn Slough Foundation. One of the challenges to decision-making about the estuary itself was the diversity of jurisdictions, regulatory authorities, landowners and community interests involved. In 2004, we launched the Elkhorn Slough Tidal Wetland Project in order to

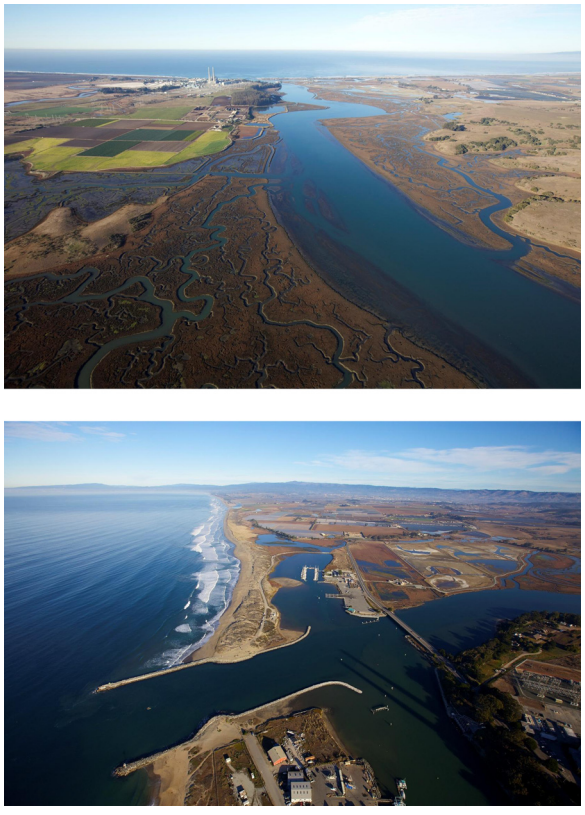

Fig. 1. Elkhorn Slough estuary. *Top*: View to West, of lower main channel and surrounding marshes. *Bottom*: View to Northeast, showing Moss Landing Harbor and the artificial mouth to the estuary constructed and maintained to support it. (Photos by K. Ellenbogen.)