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# Habitat and recreational fishing opportunity in Tampa Bay: Linking ecological and ecosystem services to human beneficiaries

Richard Fulford [a,*], David Yoskowitz [b], Marc Russell [a], Darrin Dantin [a], John Rogers [a]

[a] USEPA Gulf Ecology Division, 1 Sabine Island Rd, Gulf Breeze, FL 32561, USA
[b] Harte Research Institute, Texas A&M University-Corpus Christi, Corpus Christi, Texas, United States

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ABSTRACT

Estimating value of estuarine habitat to human beneficiaries requires that we understand how habitat alteration impacts function through both production and delivery of ecosystem goods and services (EGS). Here we expand on the habitat valuation technique of Bell (1997) with an estimate of recreational angler willingness-to-pay combined with estimates of angler effort, fish population size, and fish and angler distribution. Results suggest species-specific fishery value is impacted by angler interest and stock status, as the most targeted fish (spotted seatrout) did not have the highest specific value (fish$^{-1}$). Reduced population size and higher size at capture resulted in higher specific value for common snook. Habitat value estimated from recreational fishing value and fish-angler distributions supported an association between seagrass and habitat value, yet this relationship was also impacted by distance to access points. This analysis does not provide complete valuation of habitat as it considers only one service (fishing), but demonstrates a methodology to consider functional equivalency of all habitat features as a part of a habitat mosaic rather than in isolation, as well as how to consider both EGS production and delivery to humans (e.g., anglers) in any habitat valuation, which are critical for a transition to ecosystem management.

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## 1. Introduction

Healthy estuarine habitats are linked to human well-being through a variety of pathways including production of natural resources (Haas et al., 2004; Jordan et al., 2009), recreational use (Davis and Kidd, 2012; O'Higgins et al., 2010), and contributions to environmental quality (Cloern and Jassby, 2012; Engle, 2011). Yet, making this link in a manner that demonstrates how management decisions impact human well-being remains elusive. Further, a transition to ecosystem management requires that tradeoffs between different services provided by a resource be considered concurrently, which necessitates an understanding of their comparative value to humans, and more importantly how those values change in response to proposed actions. A suite of methods have been used to assign value to ecosystem services associated with estuarine habitat for management purposes (Bell, 1997; Beseres-Pollack et al., 2013; Grabowski et al., 2012; Quoc Tuan et al., 2012). Focusing specifically on utilitarian methods, value is typically tied to either contingent valuation, replacement value, or associated ancillary spending (Quoc Tuan et al., 2012). Ecosystem services can also be valued more broadly based on normative measures of human benefit (e.g., Human well-being index; Smith et al., 2013) which are a more comprehensive measure of human value, but are not commonly applied to managing natural resources. Independent of the approach used in a particular case, the management challenge lies in understanding the change in value associated with habitat change in terms of both service production and delivery.

Two very important estuarine habitat components that have demonstrated benefit to humans are salt marsh and seagrass. For example, the Tampa Bay Estuary Program has the goal of restoring the seagrass coverage in Tampa Bay Florida, USA to what it was in 1950, around 38,000 acres (Cicchetti and Greening, 2011). While this restoration effort has multiple projected benefits for humans (e.g., water quality, aesthetics), a key anticipated element of this restoration effort is maintenance of recreational fishing opportunities in Tampa Bay. Yet, these key habitat components potentially contribute to both service production (catchable fish biomass) and service delivery (interaction of anglers and fish), and both need to be accounted as influences to habitat value. In this research we attempt to bring together data on fishery valuation, fishery stock assessment, habitat quality, and behavior of recreational anglers to link the recreational value of fishing and essential fish habitat in a

* Corresponding author.
*E-mail addresses:* Fulford.Richard@epa.gov (R. Fulford), David.Yoskowitz@tamucc.edu (D. Yoskowitz), Russell.Marc@epa.gov (M. Russell), Dantin.Darrin@epa.gov (D. Dantin), Rogers.Johne@epa.gov (J. Rogers).

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manner suitable for apportioning value to habitat based on delivery of ecosystem services to humans.

Linking estuarine habitat components to fisheries production and its economic value is not new. For example, the development of a 'seagrass residency index' (SRI) for economically important species of fish, crustaceans, and mollusks (McArthur et al., 2003; Scott et al., 2000) has allowed for estimates of the value of seagrass based on important South Australian fisheries (McArthur and Boland, 2006). The SRI utilizes the species residence time to value the impact on commercial fisheries as a result of seagrass loss. Additionally, new acres of salt marsh along the Florida Gulf Coast were estimated to positively impact the blue crab fishery (Lynne et al., 1981). At the foundation of these studies is the quantitative link between changes in habitat availability and fishery return, yet each of these approaches targets a single habitat type independent of interactions with other habitat features (e.g, salinity, temperature), and attributes value to habitat based on past habitat occupancy without directly considering the consequences of future marginal habitat loss on fishery returns.

Understanding of the impact of estuarine habitat change on ecosystem services, like fishing, requires that we quantify habitat influences both mechanistically and across the entire supply chain from habitat to human endpoints. Fish habitat is a mosaic (Peterson, 2003) of multiple features that include structural features such as seagrass, but also include temporally dynamic features such as temperature and salinity regimes (Fulford et al., 2011). Understanding the influence of structural features has been a strong focus in habitat-fishery studies (Kneib, 2003; Minello et al., 2003; Peterson et al., 2003), yet placing change of these characteristics in context with other changes in the mosaic (e.g., annual, seasonal patterns) is critical to making accurate projections of fishery impacts (Fulford et al., 2011; Mitsch and Gosselink, 2000). In addition, habitat change has multiple potential impact points in the chain from habitat to humans. Changes in habitat quality may impact fish production and the resulting biomass available for harvest, but it can also change fish distribution, which may impact realized fishery return, and ultimately may impact angler behavior and perceptions of fishery value. Optimally, an assessment linking habitat change to human well-being will include all of these elements, but the latter elements involving service delivery have been the least developed. Here we will demonstrate a method for incorporating service delivery into the valuation of estuarine structural habitat features (e,g, seagrass) using recreational fishing as an example service and considering both the temporal and structural components of habitat composition.

Recreational fishing has a significant economic impact on the communities in which it takes place (Southwick, 2007). Bell (1997) utilized a production function approach to link recreational catch to the total amount of marsh habitat for the East and West Coast of Florida. Based on an equilibrium model, Bell (1997) demonstrated a marginal valuation to coastal wetlands by attributing the value of a human use (i.e., recreational fishing) onto the wetlands based on a hedonic pricing model. We introduce here an expansion of Bell's approach by considering not just production but also distribution of three recreationally important fish species to the habitat mosaic. This yields an allocation of recreational fishery economic value (hereafter value) to structural habitat components, but in the context of other habitat features and based on estimates of both fish and angler distribution.

The goal of this work is to demonstrate the utility of a more mechanistic approach to habitat valuation by asking how important habitat components like seagrass are associated with the functional equivalency of habitat using recreational fishing opportunities as our primary function. Functional equivalency is a comparative measure of management success in that it describes how function changes spatially based on habitat-mediated fish and angler distributions. By focusing specifically on recreational fishing as a human benefit we are willfully ignoring other important aspects of habitat value (e.g., water quality, aesthetics), however our intent is not to assess complete value of habitat but to focus on measuring change in value and to highlight the importance of considering the complete pathway between habitat quality and human benefit. This more mechanistic approach is critical to the transition from single-issue to ecosystem management. We focus here on a specific management example, seagrass habitat restoration in Tampa Bay, but the techniques developed in this paper would be applicable to other similar situations.

## 2. Methods

### 2.1. Study location

Tampa Bay is a large (surface area 1036 $km^2$), shallow (mean depth 3.7 m), Y-shaped embayment located on the west-central coast of the Florida peninsula, USA and surrounded by Hillsborough, Pinellas, and Manatee counties (Fig. 1). The bay is Florida's largest open-water estuary, and receives fresh water runoff from a 5700 $km^2$ watershed. Because of its relatively large size, the gradient of freshwater to saltwater habitats it provides, and its location in a transition zone between warm-temperate and tropical biogeographic provinces, the bay is a regionally significant environmental resource (Lewis and Estevez, 1988; Wolfe and Drew, 1990; Yates et al., 2011).

In addition to its environmental significance, Tampa Bay is also a critical component of the regional economy. Maritime trade, coastal tourism and development, and fishing contribute approximately $55 billion annually to the Tampa regional economy (TBEP, 1996). Recreational fishing in Tampa Bay is extensive with average annual angler trips in excess of one million trips $yr^{-1}$ (MRIP, 2012). The Tampa Bay watershed is highly urbanized, including the cities of Tampa, St. Petersburg, Clearwater, and Bradenton, as well as numerous smaller municipalities. More than two million people currently live within the three counties that directly border the bay; a number that has increased 400% since the early 1950s (Yates et al., 2011).

Population growth and urbanization have reduced the amount of natural habitat present in the bay and its watershed, with particularly large reductions occurring in coastal vegetation and seagrass (Lewis and Robison, 1995; Stetler et al., 2005). Cicchetti and Greening (2011), summarizing information from these sources, estimated that between 1900 and 1990, 76% of the high marsh (*Juncus*); 17% of mangrove/salt marsh; and 67% of seagrass acreage in Tampa Bay had been lost to water quality degradation and shoreline alteration. Of particular interest is seagrass (e.g., *Halodule wrightii*, *Syringodium filiforme*, & *Thalassia testudinum*), which is highly valued and subject to extensive restoration efforts (Bell et al., 2008; Carlson et al., 2010).

### 2.2. Fishery valuation

Prior to looking at mechanistic relationships between service delivery and human benefit, we must first establish a definition of value for comparison. Valuation approaches vary greatly but all carry implicit assumptions regarding how humans 'view' ecological resources. We use the term 'view' rather than 'use' to highlight non-utilitarian aspects of human well-being (Pinto et al., 2014; Yang et al., 2013) as a form of valuation. Human well-being is a combination of economic, social, and environmental drivers (Smith et al., 2013) that should optimally be examined together in order to measure human well-being. Change in such a holistic measure of human well-being would be far harder to link to