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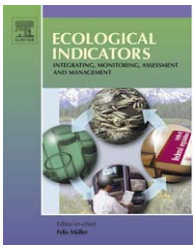

Roseate spoonbill reproduction as an indicator for restoration of the Everglades and the Everglades estuaries

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ABSTRACT

Ecological monitoring is key to successful ecosystem restoration. Because all components within an ecosystem cannot be monitored, it is important to select indicators that are representative of the system, integrate system responses, clearly respond to system change, can be effectively and efficiently monitored, and are easily communicated. The roseate spoonbill is one ecological indicator species that meets these criteria within the Everglades ecosystem. Monitoring of roseate spoonbills in Florida Bay over the past 70 years has shown that aspects of this species' reproduction respond to changes in hydrology and corresponding changes in prey abundance and availability. This indicator uses nesting location, nest numbers and nesting success in response to food abundance and availability. In turn, prey abundance is a function of hydrological conditions (especially water depth) and salinity. Metrics and targets for these performance measures were established based on previous findings. Values of each metric were translated into indices and identified as stoplight colors with green indicating that a given target has been met, yellow indicating that conditions are below the target, but within an acceptable range of it, and red indicating the measure is performing poorly in relation to the target.

1. Introduction and background

Adaptive management based on ecological monitoring is a key aspect of successful ecosystem restoration (Lovett et al., 2007; Williams et al., 2007). Because all components within an ecosystem cannot be monitored, it is important to select indicators that are representative of the system, integrate system responses, clearly respond to system change, can be effectively and efficiently monitored, and are easily communicated (Schiller et al., 2001; Doren, 2006; Doren et al., in this issue).

The Comprehensive Everglades Restoration Plan (CERP; U.S. Army Corps of Engineers, 1999) provides a framework to restore, protect and preserve the Greater Everglades ecosystem of southern Florida. One of the CERP's major emphases is restoration of hydrology; thus, in addition to the criteria mentioned above, indicators used for tracking progress of Everglades restoration should have clear relationships to hydrologic conditions (U.S. Army Corps of Engineers, 2004; Doren et al., in this issue).

The roseate spoonbill is an indicator that meets these criteria within the Everglades ecosystem. Monitoring of

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roseate spoonbills (*Platalea ajaia*) in Florida Bay over the past 70 years has shown that this species responds to changes in hydrology and corresponding changes in prey abundance and availability (Powell et al., 1989; Lorenz et al., 2002). We propose that spoonbill nesting location, nest numbers, and nest production in relation to prey fish abundance and availability may serve as powerful ecosystem indicators. Prey fish species composition, abundance, and availability are functions of hydrologic conditions (especially depth) and salinity (Lorenz and Serafy, 2006). Spoonbill nesting effort and success correlate with prey abundance and availability, and are therefore equally dependent on suitable environmental conditions. These relationships have been well documented such that spoonbill reproductive response can be directly related to changes in hydrology and salinity (Lorenz, 2000).

Correlations between spoonbills' biological responses and environmental conditions contribute to an understanding of the species' status and trends over time (Lorenz, 2000; Lorenz and Serafy, 2006). Positive or negative trends in spoonbill populations relative to hydrological changes permit an assessment of the effectiveness of restoration efforts (Lorenz, 2000; Lorenz et al., 2002; Bartell et al., 2004). Restoration success or failure can be evaluated by comparing past and predicted trends and status of spoonbills with historical population data and model predictions, as stated in the CERP hypotheses related to the food web (CERP Monitoring and Assessment Plan Section 3.1.2.4; U.S. Army Corps of Engineers, 2004).

The roseate spoonbill is representative of the Everglades system and its importance as an indicator of restoration is easily communicated. Spoonbills are one of several charismatic fauna found in the Everglades. They are both umbrella and flagship species (Hobbie et al., 1999; Bowman et al., 2003) of high interest and visibility to the public. In addition, parameters used to track trends are easy to understand: how has the number of spoonbill nests changed through time? Are they as productive as they were historically? Are the animals in optimal places? Is their prey as abundant as under natural conditions?

1.1. *Indicator history*

There is a 70-year intermittent database of roseate spoonbill nesting activity in Florida Bay (Fig. 1; Powell et al., 1989; Lorenz et al., 2002). Lorenz et al. (2002) demonstrated that nesting patterns are highly dependent on hydrologic conditions on the foraging ground nearest to the nesting colonies (Fig. 2). Spoonbills primarily feed on wetland fishes (Dumas, 2000) and time their nesting with low water levels, which results in prey base fishes becoming highly concentrated in remaining wetted areas (Loftus and Kushlan, 1987; DeAngelis et al., 1997; Lorenz, 2000; Bartell et al., 2004). Studies suggest that tactile feeding wading birds, such as the roseate spoonbill, are particularly dependent on high prey density to successfully forage, more so than visually oriented avian predators (Kahl, 1964; Frederick and Spalding, 1994; Gawlik, 2002). Tactile feeders are more efficient when prey density is very high, and visual predators are more efficient at lower prey densities (Kahl, 1964). Gawlik (2002) experimentally demonstrated that two species of tactile feeders (wood stork and white ibis) abandoned foraging sites while prey was still abundant enough to attract visually oriented wading birds in high numbers. Although no spoonbills visited their study site, Gawlik's (2002) experimental approach supports the idea that tactile feeders are more sensitive to prey availability. Because tactile foraging birds in general, and roseate spoonbills in particular, are more dependent on high prey concentration than other wading bird species (Kahl, 1964; Gawlik, 2002), they are more sensitive to changes in environmental conditions that determine fish concentrations, specifically water levels (Gawlik, 2002). The requirement for highly concentrated prey is exacerbated during nesting cycles, when the high-energy demands of their offspring require a consistently available high density of prey items (Kahl, 1964; Dumas, 2000; Lorenz, 2000).

Beginning with completion of a series of canals and water-control structures known as the South Dade Conveyance System (SDCS) in the early-1980s, water deliveries to Taylor Slough and northeastern Florida Bay (Fig. 2) changed

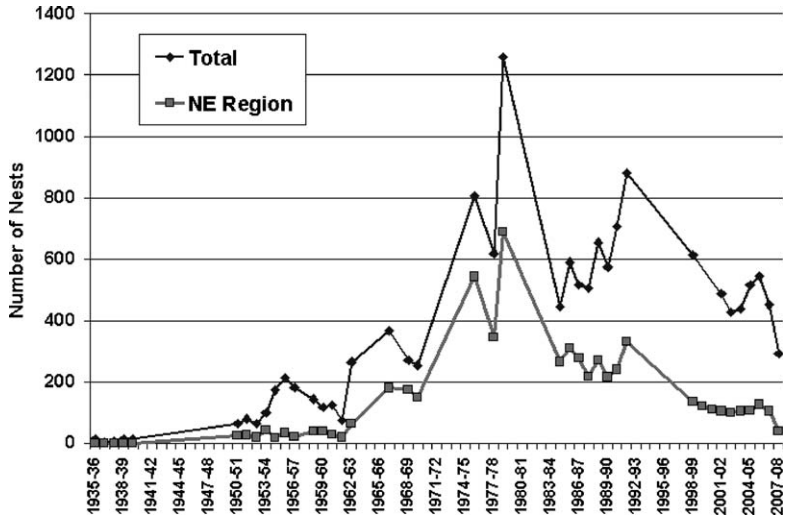

Fig. 1 – Annual number of roseate spoonbill nests for all of Florida Bay (Total) and for just the northeastern region of the bay from 1935 to 2008.