Indicator 3.9 - Aquatic Fauna Regional Populations in Everglades Wetlands

What are the desired restoration conditions?

The desired restoration conditions for aquatic fauna regional populations are 1) achieve late wet season population densities, size distributions, and taxonomic compositions of marsh fishes and other selected groups of aquatic fauna consistent with pre-drainage hydrologic and salinity patterns in the Everglades wetlands, 2) shift the distribution of high population densities and larger size classes from artificially impounded areas of the Water Conservation Areas to persistent pools to be restored in the southern Everglades, and 3) provide high-density patches of prey-availability across the Everglades landscape where wading birds can feed effectively as water levels recede during the dry season.

Why is the indicator important and why is it a good indicator of CERP restoration?

Regional populations of marsh fishes and other aquatic fauna are important to understanding the effects of the Comprehensive Everglades Restoration Plan (CERP) on the prey bases for wading birds and other higher consumers. Factors that influence the amount and availability of food for the higher consumers include the density and distribution of populations of aquatic fauna: this varies spatially and temporally, and is heavily influenced by season and by water management actions across the Everglades wetlands. The aquatic fauna that are anticipated to channel most of the energy to higher vertebrates under restored conditions include marsh fish, crayfish, grass shrimp, and amphibians. Understanding the effects of the CERP on the prey bases for wading birds and other higher vertebrates requires monitoring the concentration of fishes and other aquatic fauna in high-density patches where the birds can feed effectively as water levels recede during the dry season.

How is the interim goal for this indicator predicted?

Sufficient data are not currently available from many of the landscape subregions of the Everglades wetlands to establish quantitative relationships between aquatic fauna population densities and concentrations to hydrology and salinity patterns for this entire area. However, data that relate marsh fish density to the time since a site last dried are available for two sites in Everglades National Park (Trexler et al. 2003). Therefore, the aquatic fauna interim goal includes a qualitative description of desired restoration conditions for the Everglades region, and examples of quantitative desired restoration conditions for the two sites where data are available.

Qualitative predictions are based on the assumptions in the Everglades region conceptual ecological models (Davis 2004a, 2004b, Ogden 2004). In these models, the restoration of hydrology toward Natural System Model (NSM) conditions will result in the restoration of the density, seasonal concentration, size structure, and taxonomic composition of marsh fishes and other aquatic fauna to levels that support sustainable breeding populations of higher vertebrates. The links between aquatic faunal patterns in the Everglades and hydrologic parameters are supported by a number of research and monitoring studies conducted in the past 4 to 5 decades (Kushlan 1980, Loftus and Eklund 1994, Lorenz 1999, Hendrix and Loftus 2000, Trexler et al. 2001).

Calculation of the expected benefits of the CERP regarding increased density of marsh fishes and associated aquatic fauna are based on an empirical relationship of fish abundance to hydroperiod (time since the site was last dried out) that has been determined from field studies at selected long-term sampling sites in the Everglades (Figure 3.9.1).

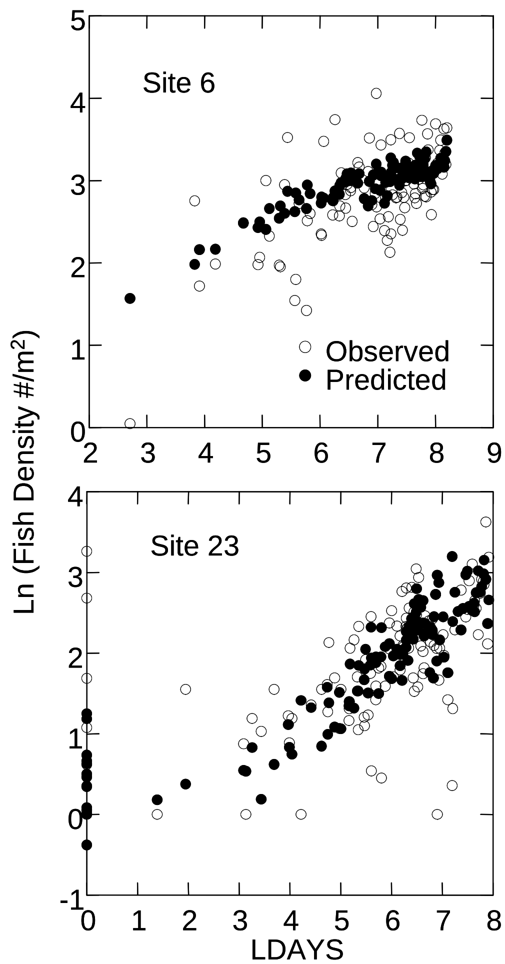

Figure 3.9.1. The relationship of fish abundance to hydroperiod (time since the site was last dried out) determined from field studies at selected long-term sampling sites in the Everglades (Trexler et al. 2003); fish density is in number per square meter (#/m^2)

What are the predictions for five-year increments?

Qualitative Description

Under base conditions, relatively high densities of marsh fishes are concentrated in the unnatural pools of water with prolonged hydroperiods in southern Water Conservation Area 3A. Relatively low fish densities in Shark Slough reflect shortened hydroperiods in Everglades National Park and Water Conservation Area 3B, in contrast to multi-year hydroperiods and persistent pools of water in these areas under natural conditions (NSM version 4.5).

Hydrologic simulations for 2050 (full CERP implementation) show the return of persistent pools of water with multi-year hydroperiods to Shark Slough, and the elimination of unnatural pooling of water in southern Water Conservation Area 3A. Corresponding predictions for fish population shifts include increased populations of larger size class fishes in the southern Everglades, adjacent to former wading bird nesting colony locations. Furthermore, seasonal patterns of water level recession in the southern Everglades appear more conducive to the concentration of the marsh fishes into high density patches that are required for successful wading bird foraging and nesting.

The changes in hydrology beneficial for marsh fish populations correspond to the implementation of Water Conservation Area 3 Decompartmentalization and Sheet Flow Enhancement, Flow to Northwest and Central Water Conservation Area 3A, Water Conservation Area 3A and 3B Levee Seepage Management, L-31 N Levee Improvement, Central Lake Belt Storage Area. Hydrologic conditions conducive to the desired shifts in marsh fish density and size class distributions should begin between 2010 and 2015.

Quantitative Predictions

Predictions of marsh fish abundance are made for two sample sites in Everglades National Park. Site 23 is located in northeastern Shark Slough, and is expected to get wetter as a result of the CERP, whereas site 6 is located in western Shark Slough and is expected to get somewhat drier. The results are presented in Tables 3.9.1 and 3.9.2. Table 3.9.1 is a summary of how fish abundance at different time periods during CERP implementation compares to the condition before CERP implementation (1995 base). Table 3.9.2 includes the raw data of fish density (number of fish per square meter) as a function of time since last drydown. The parameter “fish days” in Table 3.9.2 is an index of the total number of fishes produced in the sampling area over the 31-year period of record.

The average number of days since last drydown (Table 3.9.1) increases for both sites in 2010 and 2015 as compared to the 1995 base condition. For full CERP implementation, the average days since last drydown at the northeastern Shark Slough site decreases compared to 2015, but the site still has longer hydroperiods than under base conditions. The western Shark Slough site shows a very slight decrease in hydroperiod under full CERP implementation, which is possibly not significant.

Table 3.9.1. Summary of predictive data on hydrologic conditions and aquatic fish abundance at different time intervals of CERP implementation as compared to 1995 base conditions

		Differences from 1995 Base		
		Mean		
Simulation	Site	Depth (centimeter [cm])	Days Since Last Drydown	Fish Density (#/m^2)
2010	23a	11.9	110.5	0.2
2015	23a	13.5	156.0	0.6
2050	23a	5.7	40.3	0.0
2010	6a	5.9	39.4	0.0
2015	6a	7.5	84.0	0.6
2050	6a	4.2	3.0	-0.2

		Differences from 1995 Base		
		Maximum		
Simulation	Site	Depth (cm)	Days Since Last Drydown	Fish Density (#/m^2)
2010	23a	29	380	3.1
2015	23a	28	380	3.1
2050	23a	8	380	0.0
2010	6a	7	-3	2.4
2015	6a	6	-3	2.4
2050	6a	-2	-2	0.1

		Differences from 1995 Base		
Simulation	Site	Severity (days the drydown lasted)	Minimum Ground Water Depth (cm)	Fish Abundance Increase (%)
2010	23a	-4	9	64.4
2015	23a	-14	12	73.0
2050	23a	-8	5	31.0
2010	6a	24	5	20.3
2015	6a	23	7	25.5
2050	6a	-9	9	14.4

Table 3.9.2. Raw data for marsh fish abundance calculated using the relationship between fish density and days since last drydown

Simulation	Site	Mean: Depth (cm)	Mean: Days Since Last Drydown	Mean: Fish Density (#/m^2)	Maximum: Depth (cm)	Maximum: Days Since Last Drydown	Maximum: Fish Density (#/m^2)
1995 base	23a	19	291	5.0	54	1308	13.5
1995 base	6a	29	370	12.3	82	1691	25.4
2010	23a	30	402	5.2	83	1688	16.6
2010	6a	35	409	12.2	89	1688	27.8
2015	23a	32	447	5.6	82	1688	16.6
2015	6a	37	454	12.8	88	1688	27.8
2050	23a	24	332	5.0	62	1688	13.6
2050	6a	33	373	12.1	80	1689	25.5

Simulation	Site	Severity (days the drydown lasted)	Minimum Ground Water Depth (cm)	Coefficient of Variation: Depth (cm)	Coefficient of Variation: Days Since Last Drydown	Coefficient of Variation: Fish Density (#/m^2)	Summary: Fish Days
1995 base	23a	161	-75	104.3	101.5	59.0	209655
1995 base	6a	144	-65	83.7	100.9	49.4	331458
2010	23a	157	-66	81.4	100.6	59.3	344588
2010	6a	168	-60	74.0	98.3	48.6	398821
2015	23a	147	-63	74.1	91.9	57.1	362724
2015	6a	167	-59	69.1	90.2	46.7	415878
2050	23a	153	-70	84.1	109.5	59.2	274657
2050	6a	135	-56	69.6	99.8	48.0	379277

The marsh fish abundance index used to estimate CERP performance is found in the lower part of Table 3.9.1, and uses the parameter "fish days" described above. This index is a measure of the total abundance of marsh fish produced in the sampling during the entire 31-year simulation period, given the implementation of CERP projects up to the date of calculation and compared to the 1995 base condition. For example, for Site 23a in the simulated 2010 condition, the index represents the total abundance of fishes produced in all years if the system contained all the projects scheduled for completion by 2010, and it were operated for 31 years given the rainfall patterns observed during the latter half of the twentieth century. This total abundance is compared to the abundance that would be produced in 31 years if the system remained as it was in 1995. So, for Site 23a in 2010, marsh fish production is about 64 percent higher than the 1995 condition for the same site.

The marsh fish abundance index shows increases in fish abundance for both sites in 2010 and in 2015, and then decreases in abundance from 2015 to full CERP implementation (2050). At full CERP implementation, however, the system is still better at marsh fish production than the 1995 system without CERP.

How will we track whether the interim goals established for this indicator have been achieved?

Monitoring of regional populations of aquatic fauna is described in the *CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research* (RECOVER 2004). Field monitoring of marsh fishes and other aquatic fauna will provide information to assess progress of the interim goal at five-year intervals.

What additional work is needed to improve this interim goal?

The field monitoring referenced above will take place over the entire Everglades ecosystem. Relationships between aquatic fauna variables and hydrologic parameters, including that between marsh fish density and time since last drydown, will be developed using data collected during the first five years of monitoring of the pre-CERP reference condition (2004-2009). Using these relationships, an improved method will be developed to quantitatively estimate the effects of the CERP on fish density and size class distributions across the South Florida landscape. This method will include intermediate-scale population models for marsh fishes and other selected groups of aquatic fauna. An updated interim goal for aquatic fauna will be calculated from these intermediate scale population models.

Development of the desired restoration condition for aquatic fauna (as distinct from CERP Interim Goals) is necessary to guide the adaptive management of the CERP. If changes to the aquatic fauna interim goal result from updates to CERP hydrologic models, changes to the CERP, or from acquisition of new information from the field, the restoration condition should be used as the benchmark to assess ecological benefits and progress toward restoration. Calculation of quantitative restoration conditions for aquatic fauna populations will involve the use of the NSM to simulate pre-drainage hydrologic conditions, as well as the intermediate-scale population models developed during the first five years of CERP monitoring.

References

Davis, S.M. 2004a. Draft Southern Marl Prairies Conceptual Ecological Model. Pages A-29 – A-52 in RECOVER. CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research. Restoration Coordination and Verification, c/o United States Army Corps of Engineers, Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL.

Davis, S.M. 2004b. Draft Everglades Mangrove Estuaries Conceptual Ecological Model. Pages A-53 – A-77 in RECOVER. CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research. Restoration Coordination and Verification, c/o United States Army Corps of Engineers, Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL.

Hendrix, A. and Loftus, W.F. 2000. Distribution and relative abundance of the crayfishes *Procambarus alleni* (Faxon) and *P. Fallax* (Hagen) in southern Florida. Wetlands 20: 194-199.

Kushlan, J.A. 1980. Population fluctuations of Everglades fishes. Copeia 1980: 870-874.

Loftus, W.F. and A.M. Eklund. 1994. Long-term dynamics of an Everglades small-fish assemblage. Pages 461-483 in Davis, S.M. and J.C. Ogden (eds). Everglades: The System and its Restoration. St. Lucie Press, Delray Beach, FL.

Lorenz, J.J. 1999. The response of fishes to physicochemical changes in the mangroves of northeast Florida Bay. Estuaries 22:500-517.

Ogden, J.C. 2004. Draft Everglades Ridge and Slough Conceptual Ecological Model. Pages A-7 – A-27 in RECOVER. CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research. Restoration Coordination and Verification, c/o United States Army Corps of Engineers, Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL.

RECOVER. 2004. CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research. Restoration Coordination and Verification, c/o United States Army Corps of Engineers, Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL.

Trexler, J.C., W.F. Loftus, and J. Chick. 2003. Setting and monitoring restoration goals in the absence of historical data: the case of fishes in the Florida Everglades. Pages 351-376 in Busch, D., and J.C. Trexler. Monitoring Ecoregional Initiatives: Interdisciplinary Approaches for Determining Status and Trends of Ecosystems. Island Press, Washington, D.C.

Trexler, J.C., W.F. Loftus, C.F. Jordan, J. Chick, K.L. Kandl, T.C. McElroy, and O.L. Bass. 2001. Ecological scale and its implications for freshwater fishes in the Florida Everglades. Pages 153 – 181 in Porter, J.W. and K.G. Porter (eds). The Everglades, Florida Bay, and Coral Reefs of the Florida Keys: An Ecosystem Sourcebook. CRC Press, Boca Raton, FL.