Indicator 4.3 - Juvenile Shrimp Densities in Florida and Biscayne Bays

What is the desired restoration condition?

The desired restoration condition for juvenile shrimp densities in Florida and Biscayne Bays is increase juvenile pink shrimp density at peak abundance during the August-October period in optimal habitat (seagrass) in three regions of Florida Bay, in Ponce de Leon Bay on the lower southwestern mangrove coast, and in western nearshore southern Biscayne Bay. Specific desired restoration conditions include the following:

- 17 shrimp per square meter in Johnson Key Basin
- 7 shrimp per square meter in south central Florida Bay (when western monitoring area exceeds 15 shrimp per square meter)
- At least 5 shrimp per square meter in Whipray Basin (when western monitoring area exceeds 15 shrimp per square meter)
- 7 shrimp per square meter in outer bays (Ponce de Leon Bay) (when western monitoring area exceeds 15 shrimp per square meter)
- 2 shrimp per square meter in nearshore optimal habitat from Shoal Point to Turkey Point (South Biscayne Bay).

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

The pink shrimp is ecologically important in Florida and Biscayne Bays as a major link between the food web base and top consumers, including game fish and wading birds. The life cycle is best known for pink shrimp using Florida Bay as a nursery ground. They spawn offshore near the Dry Tortugas, migrate shoreward as larvae/postlarvae, and settle in seagrass beds in Florida Bay to spend their juvenile stage before returning to offshore spawning grounds, where they support a multimillion dollar fishery. Juvenile pink shrimp are present in coastal waters throughout South Florida. Juvenile densities are highest in western Florida Bay (Costello et al. 1986, Robblee et al. 1991, M. Robblee, US Geological Survey, personal communication). Biscayne Bay supports small local fisheries for food shrimp and bait shrimp. The mangrove estuaries of the southwestern coast also provide nursery area for pink shrimp; however, limited sampling with the same gear (throw-trap) used in Florida Bay (Rice 1997, Browder et al. 1999) suggest juvenile densities are lower in the mangrove estuaries than in western Florida Bay.

The potential for improving shrimp nursery habitat in Florida Bay may be greatest in the north-central bay, where water management changes associated with the Comprehensive Everglades Restoration Plan (CERP) could potentially reduce the frequency, spatial extent, and duration of hypersaline conditions. A target for eastern Florida Bay is not provided because shrimp densities are extremely low, are thought to have been low historically, and are not expected to change with CERP implementation. Based on present knowledge (Robblee and Browder 2003), pink shrimp densities are not expected to be as great in Biscayne Bay as in Florida Bay. Postlarval settlement rates may differ in the two areas and they may respond differently to a change in water management associated with any one component of the CERP.

How is the interim goal for this indicator predicted?

At each five-year evaluation interval (2010, 2015, etc.), average pink shrimp peak density in three areas of Florida Bay are simulated for each year of the 1965-2000 period of record using a model of growth and survival as functions of salinity and temperature (Browder et al. 1999, Browder et al. 2002). Growth and survival parameters for the shrimp model were developed based on laboratory trials with 2,000 shrimp collected primarily from northwestern Florida Bay. The model simulates the growth and survival of a July cohort of shrimp. July roughly corresponds to the period of peak immigration of postlarval pink shrimp into western Florida Bay from offshore spawning grounds. The number of shrimp remaining in the bay at 121 days from settlement and the number of days to grow from size at settlement (8.74 millimeters [mm]) to the size at recruitment from the bay (78.4 mm) are simulated independently for each year of the 31-year period of record.

Input data is the output of multiple linear regression models (Marshall et al. 2004) that relate daily average salinity at points in the bay to daily average freshwater stages at upstream sites in the Everglades, as simulated by the South Florida Water Management Model (SFWMM) for the same period (1965-1995). Model predictions are based on the assumption of optimum physical habitat and seagrass cover. The biggest year-to-year differences are expected in the north-central bay because this area frequently experiences hypersaline conditions, which have a detrimental effect on production. The frequency of densities at intervals of abundance are plotted for the 31-year simulation period for each scenario and are examined in relation to stated targets. To take into account annual variation in spawning strength and immigration of postlarvae to the bay from offshore grounds, predicted densities in each area are evaluated in relation to densities in western Florida Bay.

What are the predictions for five-year increments?

Shrimp predictions for the first five-year evaluation interval were only prepared for the north-central interior of Florida Bay because daily salinity predictions for western Florida Bay were lacking for the scenarios. Shrimp predictions were based on 31-year time series (1965-1995) of daily salinity data for Whipray Basin calculated by Frank Marshall using his multi-linear regression model (Marshall et al. 2004). The input data for the Whipray Basin salinity model was the daily salinity for Joe Bay, Little Madeira Bay, and Terrapin Bay, as calculated with multi-linear regression models using stage data from the SFWMM. Gaps in the 31 years of calculated daily salinity data were filled by repeating the last calculated value. A time series of Whipray Basin salinity data was produced for each of six scenarios: Natural Systems Model version 4.5 (NSM) (pre-drainage), 2010, 2015, 2050 without CERP implementation, 1995base (baseline), and D13R (full CERP implementation). The temperature time series used for the shrimp simulations was a time series of mean daily salinity calculated from data for the period 1987-1998 (from the Everglades National Park data base) and repeated for each of the 31 years of the simulations. Whipray Basin was chosen for this first application of the model because daily salinity data could be calculated for this basin.

Summary statistics of the salinity time series are provided in Table 4.3.1. Statistics for NSM and D13R are similar except that the median, mean, and minimum are slightly lower for NSM, and the maximum and standard deviation are slightly lower for D13R. In terms of salinity, the 1995base scenario differs most from NSM and the 1995base scenario is followed by the 2050, 2010, and 2015 scenarios, in that order.

Table 4.3.1. Summary statistics of calculated daily salinity time series for Whipray Basin.

	NSM	2010	2015	2050	1995base	D13R
maximum	53.87	61.04	59.49	62.23	64.17	53.83
median	31.68	34.50	34.14	34.59	35.35	32.94
mean	32.37	34.94	34.63	35.43	36.06	33.29
minimum	21.06	21.53	21.68	23.39	23.01	21.24
standard deviation	5.31	6.54	6.38	6.09	6.36	4.94

The scenarios with respect to support for pink shrimp can be compared with Figures 4.3.1 through 4.3.4. Figures 4.3.1 and 4.3.2 are histograms representing the number of years (out of the 31-year simulation) in which conditions specified in the legends are met. Figure 4.3.1 displays the index of relative juvenile density. Figure 4.3.2 displays an index of growth, which is the number of days to reach emigration size (78.4 mm). Values are relative because the model has not yet been calibrated to observed juvenile densities in Florida Bay, so it is possible to make comparisons among years and among scenarios but it is not possible to evaluate the output in relation to stated desired restoration conditions. The differences are small among years and small among scenarios in terms of both density and growth rate. Density at 121 days from settlement is highest (2.3-2.4) for the most number of years with the 2050 scenario. Growth rate is fastest, 140 days to emigration size, for the most years in the NSM scenario.

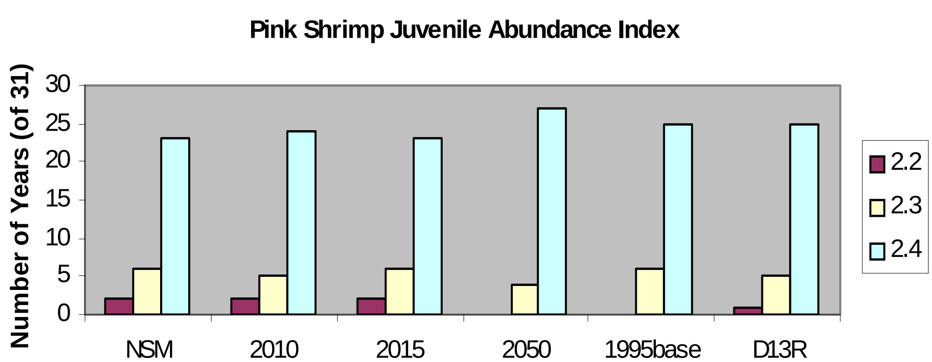

Figure 4.3.1. Number of years (of 31) in each scenario that predicted juvenile relative density (July cohort) was in ranges 2.1-2.2, 2.2-2.3, and 2.3-2.4.

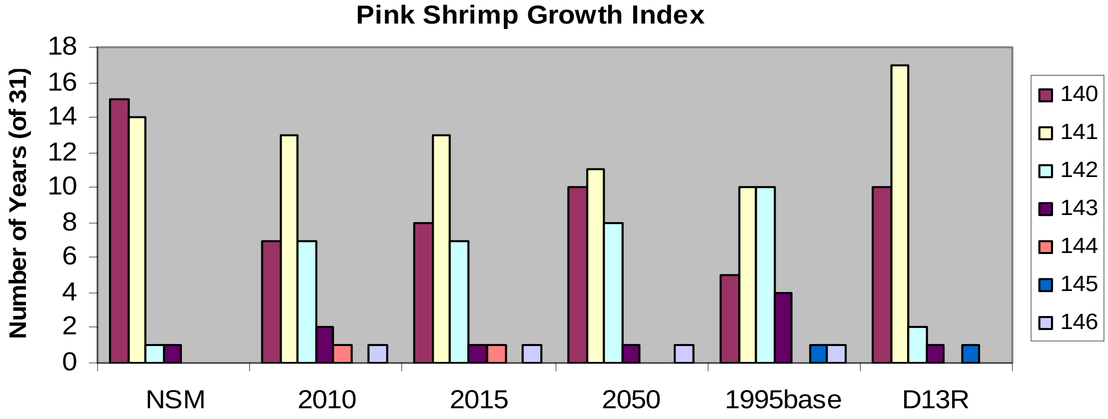

Figure 4.3.2. Number of years (of 31) in each scenario that juveniles were predicted to reach emigration size (78.4 mm total length) in the indicated number of days (juveniles grew fastest when they reach emigration size in 140 days)

Figures 4.3.3 and 4.3.4 are bar graphs showing the minimum, maximum, mean, and median values of the pink shrimp juvenile density index and the pink shrimp growth rate index (number of days to emigration size), respectively. The scenarios 1995base and 2050 had the highest minimum, maximum, mean, and median density over the 31-year simulation period, and the NSM scenario had the lowest (Figure 4.3.3). The 2010 and 2015 scenarios were intermediate between these. NSM had the highest maximum growth to emigration (140 days), followed distantly by D13R (145 days). The other scenarios had the lowest maximum growth (146 days). Mean days to emigration also was lowest for NSM, followed by D13R, and highest for 1995base, followed by the 2010, 2015, and 2050 scenarios.

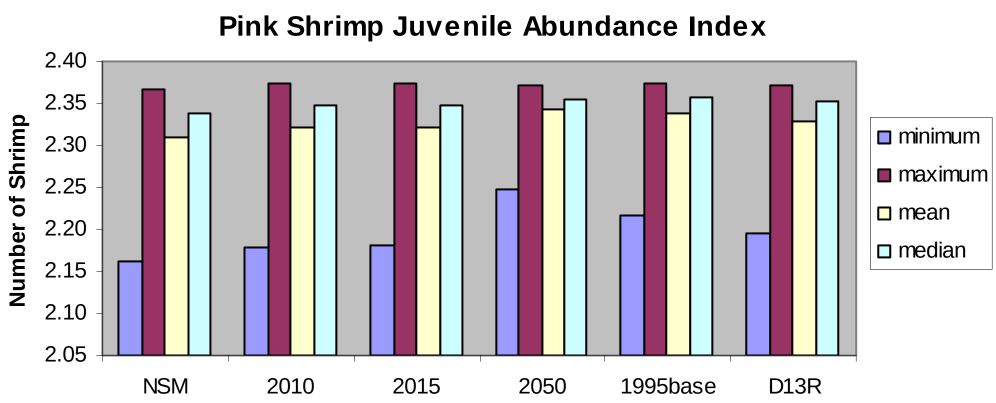

Figure 4.3.3. Pink shrimp juvenile relative density as the relative total number of shrimp in the interior of the bay at day 121. Day l21 was selected as an opportunity to count surviving shrimp without concern for loss to migration.

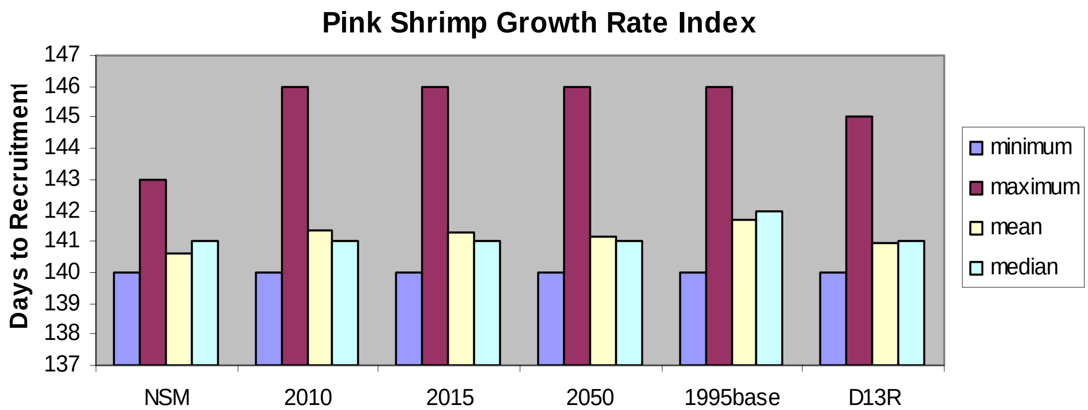

Figure 4.3.4. Pink shrimp growth rate index, as number of days to reach 78.4 mm in total length (estimated size at recruitment to offshore adult stock). Shorter bars (fewer days) indicate faster growth. Minimum, maximum, mean, and median values for each scenario are shown.

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

The *CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research* (RECOVER 2004) including salinity monitoring at each major region of the bay.

What additional work is needed to improve this interim goal?

The values of density and days to recruitment in these simulations are relative values among years and scenarios, rather than attempts to represent actual values. More realistic values await calibration to observed juvenile densities in optimum habitat in Johnson Key Basin (M. Robblee unpublished data), which cannot be fully accomplished until modeled daily salinity data for Johnson Key Basin are available. Additionally, while the growth and physiological survival parameters in the model were set based on laboratory trials, the parameter for survival from predation still needs to be improved with field data. The differences among years and scenarios may broaden when this parameter is improved. Variation in shrimp density with seagrass habitat will be determined for inclusion in model predictions when predictions from a seagrass landscape model become available.

References

Browder, J.A., V.R. Restrepo, J.K. Rice, M.B. Robblee, and Z. Zein-Eldin. 1999. Environmental influences on potential recruitment of pink shrimp, *Farfantepenaeus duorarum*, from Florida Bay nursery grounds. Estuaries 22: 484-499.

Browder, J.A., Z. Zien-Eldin, M.M. Criales, M.B. Robblee, S. Wong, T.L. Jackson, and D. Johnson. 2002. Dynamics of pink shrimp (*Farfantepenaeus duorarum*) recruitment potential in relation to salinity and temperature in Florida Bay. Estuaries 26(6B): 1355-1371.

Costello, T.J., D.M. Allen, and J.H. Hudson. 1986. Distribution, Seasonal Abundance, and Ecology of Juvenile Northern Pink Shrimp, *Penaeus duorarum*, in the Florida Bay Area. National Oceanic and Atmospheric Administration Technical Memorandum NMFS-SEFC-161, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, FL.

Marshall III, F.E., D. Smith, and D. Nickerson. 2004. Using Statistical Models to Simulate Salinity Variation and Other Physical Parameters in North Florida Bay. Cetacean Logic Foundation, Inc., New Smyrna Beach, FL. 36 pp.

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

Rice, J.K. 1997. An Analysis of Environmental Factors Influencing Juvenile Pink Shrimp (*Penaeus duorarum*) Abundance in Southwest Florida. Masters Thesis. University of Miami, Coral Gables, FL.

Robblee, M.B., S.D. Jewell, and T.W. Schmidt. 1991. Temporal and Spatial Variation in the Pink Shrimp, *Penaeus duorarum*, in Florida Bay and Adjacent Waters of Everglades National Park. Annual report of South Florida Research Center, Everglades National Park, Homestead, FL.

Robblee, M.B. and J.A. Browder. 2003. Faunal Density and Community Composition of the Nearshore Zone, Biscayne Bay Biological Community Performance Measures. Third Quarterly Report, Part 2, of Joint Project C-13401, National Marine Fisheries Service and United States Geological Survey. Submitted to the South Florida Water Management District, West Palm Beach, FL.