FUTURE IMPACTS ON BISCAYNE BAY OF EXTENDED OPERATION OF TURKEY POINT COOLING CANALS

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Florida Power and Light (FPL) has applied to extend operations of its Turkey Point power plants until the early 2050s. Currently, FPL is under orders from regulators to correct problems stemming from the canals that cool the water used to run the steam turbines. Among these, the cooling canals discharge nutrient-rich, hypersaline water into Biscayne Bay and the Biscayne aquifer. The Interceptor Ditch has failed its intended function to prevent contamination of the aquifer, and its continued operation comes at the cost of extracting around 3 mgd of freshwater from the wetlands in the Model Lands area. What are the consequences for the health of the bay and success of the C-111 and Biscayne Bay Coastal Wetlands Restoration projects if the cooling canals operate for another 30 years?

Results from an expanded monitoring program, initiated in 2009, reveal how the cooling canals interact with Biscayne Bay and the regional groundwater system through an active exchange of water between the canals and the aquifer. The cooling canals were constructed in the 1970s to prevent damaging discharge of heated water directly into the bay from the Turkey Point power plants. Until about 2009 it was widely assumed that the canals had little impact on the bay and adjacent wetlands. However, by 2012, investigations demonstrated the canals were the source of a plume of hypersaline groundwater extending several miles west, and nutrient-rich water from the canals was found in the bay.

Water in the canals is hypersaline as a consequence of high rates of evaporation. Evaporation is one of the primary mechanisms that cools the heated water as it circulates through the canals from the point of discharge on the west side of the power plants, returning to the water intake on the east side of the plant. For the first 40 years of operation, an inflow of saline water from Biscayne Bay made up the difference between losses from evaporation and water added by rainfall, pumping from the Interceptor Ditch and other minor sources. As a result, salt accumulated in the canals. Since 2010, the salinity of water in the canals has averaged around 60 psu. Seepage out of the canals provides a steady supply of hypersaline water to feed the growth of the groundwater plume.

In 2016, FPL initiated actions to remediate the discharge of hypersaline water into the aquifer. In particular, fresher water is being added to the canals from the Upper Floridan aquifer to decrease the average salinity to 34 psu. And, water is being withdrawn from the groundwater plume through a series of recovery wells and pumped into a deep injection well. These actions address the factors involved in the formation and westward migration of the saline groundwater plume. However, these measures do little to mitigate the discharge of water into Biscayne Bay. Monitoring results indicate that adding water to lower salinity has had the effect of increasing discharge toward Biscayne Bay. Discharge to the bay occurs intermittently in response to changes in plant operations, heavy rainfall, and fluctuations in bay water levels, the last two being also affected by climate change and accelerated sea level rise.

BIO (50-word maximum): Laura Reynolds is a biologist with over 20 years' experience working in and protecting Florida's ecosystems. With Conservation Concepts LLC she helps nonprofits bring environmental issues into the public eye and bridge the gap between science and policy to better protect Florida's ecosystems and resources.

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Future Impacts on Biscayne Bay of Extended Operation of Turkey Point Cooling Canals

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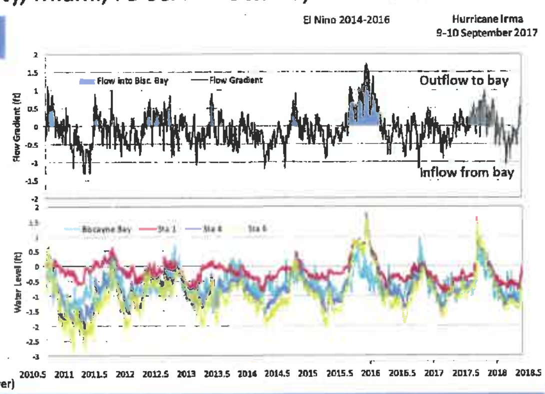
Background, Summary and Implications

The discharge of water from the cooling canal system (CCS) into Biscayne Bay occurs intermittently through multiple hydrological connections provided by the Biscayne aquifer and its transmissive bedrock. Changed operations of the CCS since 2012 have accelerated the seepage to Biscayne Bay. High concentrations of nutrients and tritium have been detected over a three year period in Biscayne Bay immediately adjacent to the CCS in deep canals and cave sites.

The highest nutrient levels occur during periods of sustained high-water levels in the CCS when the volume of water is at or near its maximum and Biscayne Bay tides are at a minimum, this occurs approximately 30% of the time. Due to current changes and planned future changes in operations to try to decrease the salinity and temperature of the CCS, these conditions are expected to worsen as more water is added to the CCS from a planned waste water treatment plant. Current seagrass species composition and abundance data collected by ongoing seagrass monitoring programs show that Turtle Grass biomass offshore from the CCS is unusually dense and dominated by fast growing and nutrient loving *Halodule Sp.* compared to other areas in southern Biscayne Bay, likely as a consequence of increased P availability in the near-shore area. P concentrations in the deeper canals offshore of the CCS and in caves offshore of Turkey Point are 10-20 times higher than the median concentrations (0.03 µM) of inorganic phosphorus in Biscayne Bay waters (Caccia and Boyer 2005)

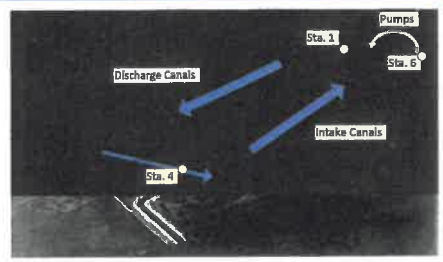
Operation of the CCS have likely 1) carried phosphorus-polluted groundwater to near-shore surface waters through the highly porous bedrock and 2) has dissolved carbonates in that bedrock, releasing additional phosphorus that had been incorporated into that rock. As this phosphorus reaches the seagrass meadows offshore in Biscayne Bay, it will continue to degrade the ecosystem and cause an imbalance and change the nature of the surrounding marine environment. An imbalance of the seagrasses that form the near-shore habitat adjacent to the CCS in Biscayne Bay and provide the food at the base of the food chain harms the fish and wildlife that depend on these habitats and therefore impact fishing, and other recreational activities such as birdwatching based on that habitat changes and eventual loss. The high salt and nutrient concentrations reaching the bay and the competing demand for water are in direct conflict with Everglades Restoration projects.



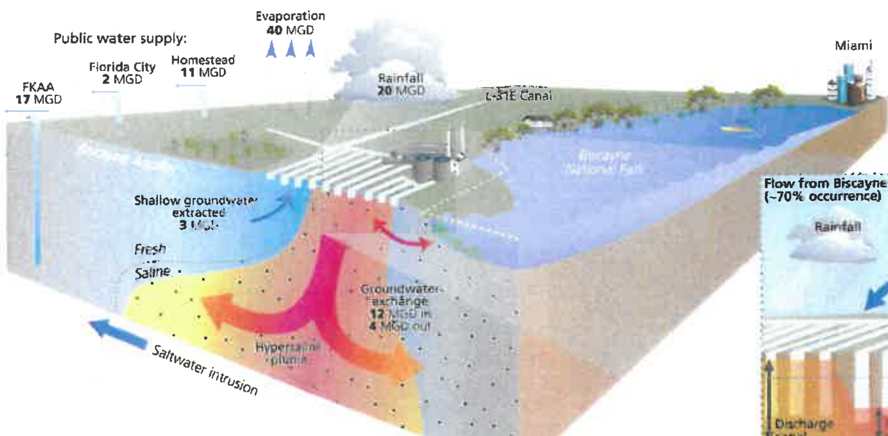
Right: intermittent flow from the CCS toward Biscayne Bay shown by the calculated flow gradient (upper) and supporting data (lower)

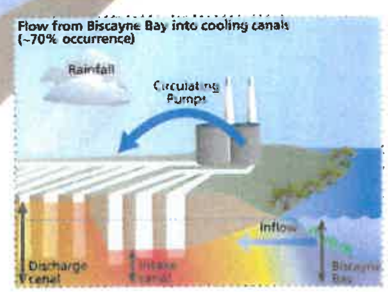
Water Quality and Salt Budgets Reveal Flows Between the Cooling Canals and Biscayne Bay 30% of the Time

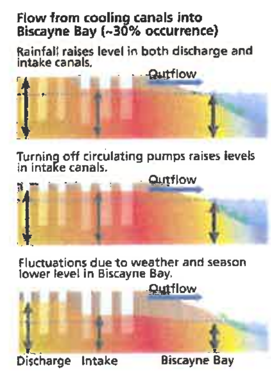
Detailed information on the water quality and salt budgets, the result of 10 years of in-depth monitoring by multiple agencies, reveals how the cooling canals interact with the Biscayne aquifer and Biscayne Bay. Miami Dade DERM's multi-year water quality monitoring data revel that discharge from the CCS into the surface waters of Biscayne Bay is occurring and those high levels of nutrient are violating Numeric Nutrient Standards as well as narrative water quality standards meant to protect Biscayne Bay, a historically nutrient poor system. On average, there is a net inflow of groundwater into the canals to help balance water loss due to high rates of evaporation. However, significant outflows of water from the cooling canals also occurs in response to the variation in water levels in space and over time. Under normal operations, pumps circulate water through the power plants. This draws down water level in the intake canals (Sta. 6) and raises water level where the pumps discharge into the canals (Sta. 1). The difference in water level between Sta. 1 and Sta. 6 drives flow down the discharge canals and up the intake canals back to the plants. Elevated water level at Sta. 1 drives the outflow of hypersaline water down into the aquifer. Most of the time lowered water level (Sta. 6) drives inflow to the intake canals. Outflow from the CCS toward Biscayne Bay occurs intermittently, about 30% of the time, in response to heavy rainfall, plant operations, and fluctuations in Biscayne Bay water levels, which occur in response to weather and seasonal changes in sea level. This open system is completely dependent upon weather patterns and is vulnerable in the future because it is at sea-level, dependent on rainfall and carved into porous limestone.



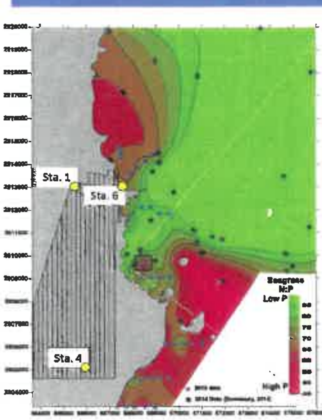
Cooling canals showing general circulation and locations of water level data.
(Image source: https://commons.wikimedia.org/wiki/File:HD.6B.314_(11842469035).jpg)





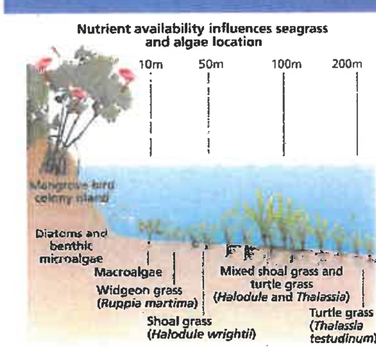


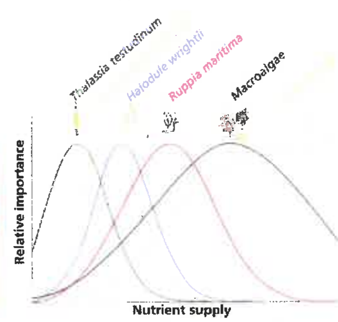
Seagrasses Response to Nutrient Availability Near Turkey Point



Biscayne Bay is a phosphorus-limited ecosystem, consequently the ratios of N to P in seagrass leaves is generally greater then 85. Immediately offshore from the CCS, seagrass N:P suggests that P availability is much higher than normal Biscayne Bay background levels. And time series aerials show that high P in this area is related to very dense seagrasses that collapsed over the period 2010-2014. Under P pollution, normally P-limited turtlegrass (Thalassia testudinum) first increase in density (see dark patch in 2010 aerial), then gets displaced by progressively faster-growing species until no benthic vegetation is left at the highest P pollution levels. Note the opening up of bare areas in the dense patch by 2017.

Increases in Phosphorus Availability Drive Ecosystem Change





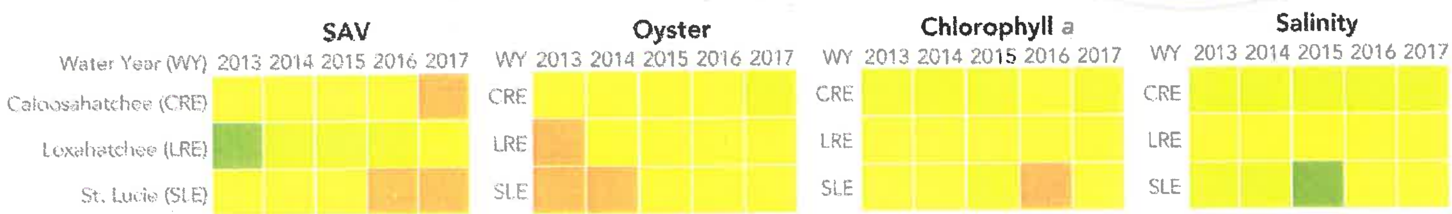
The patterns we see near Turkey Point are consistent with the predictions made by this model of the relationships between nutrient availability and seagrass status in south Florida under conditions of nutrient pollution. In the figure above those inputs come from a bird rookery, but adjacent to the CCS the P sources are likely to be the result of CCS operations within the CCS that includes chemical components added for cleaning, biomass death that occurred within the CCS in 2014, and any nutrient pulled into the system from the surrounding environment that has been concentrated overtime as the freshwater evaporates away.

2012–2017 EVERGLADES Report Card

This is a RECOVER product that provides a transparent, timely, and geographically detailed assessment of health of the Florida Everglades using data from May 1, 2012–April 30, 2017.

NORTHERN ESTUARIES: FAIR

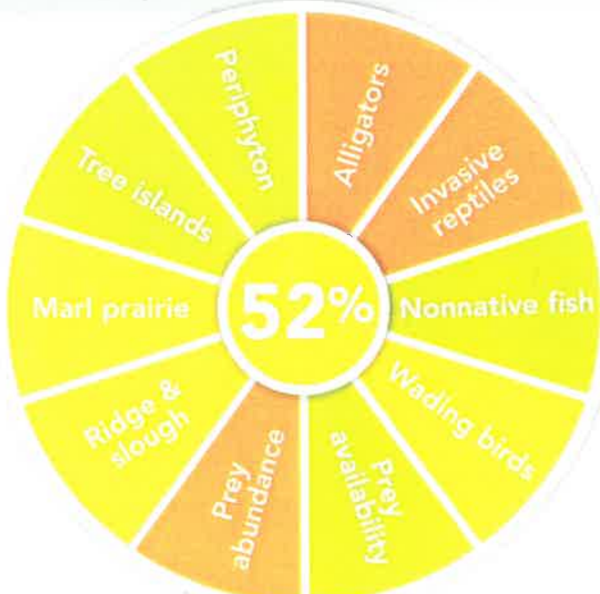
In general, the Northern Estuaries (Caloosahatchee River Estuary, Loxahatchee River Estuary, and St. Lucie River Estuary) are in fair to good condition. Submerged aquatic vegetation (SAV) declined or remained stable at low densities in all regions. Oyster scores ranged from poor to good throughout the five years with mostly fair scores. A cycle of salinity perturbations negatively affected oysters, but when salinities were favorable the oysters rebounded. Benthic infauna were in good condition, while salinity and chlorophyll *a* were in good to fair condition. The Northern Estuaries are impacted by human control of flows that alter volume, distribution, circulation, and temporal patterns of freshwater inflows, and natural events like hurricanes, El Niño, and drought. These cause sub-optimal salinities that have negative impacts on SAV, oysters, and benthic infauna.

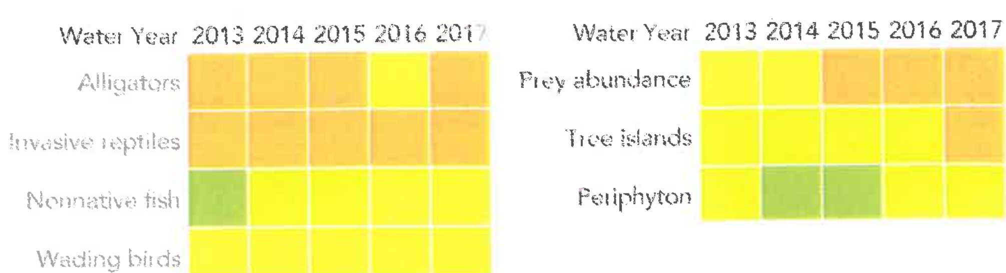


Select indicator scores by year from Water Years 2013–2017.

GREATER EVERGLADES: FAIR

In the Greater Everglades region, conditions varied throughout the five-year reporting period with indicator scores ranging from good to poor. Conditions for periphyton were good despite a shift in periphyton community structure. Tree islands were also in the good range due to resilience of the islands in conservation areas. Although nonnative fish had a good score overall, the score ranged from good to fair with more nonnatives in recent years. Invasive reptiles also continued to increase in number and expand their range, scoring poor overall. Multiple years of wet conditions impacted prey availability, and as a result, most wading bird targets were not met. Prey abundance and alligator indicators were impaired. Marl prairie and ridge and slough habitat were degraded; however some areas of marl prairie habitat have shown improvement.





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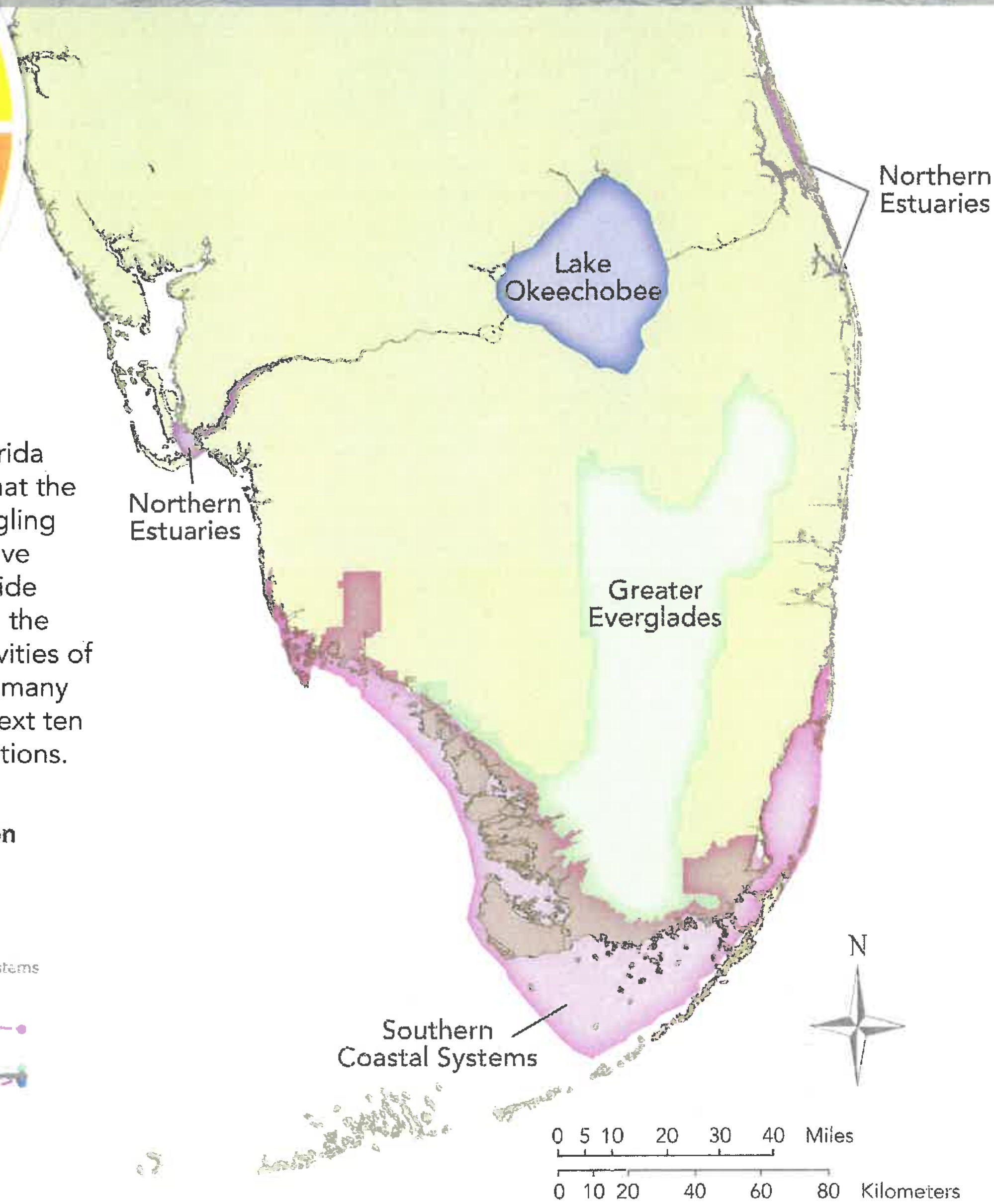
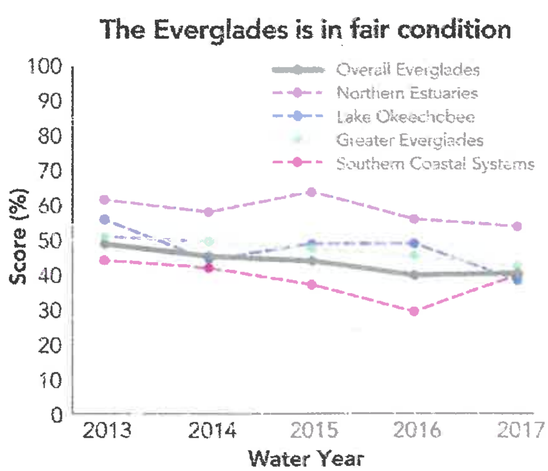
2012–2017 EVERGLADES: FAIR



An overall score of 45%, fair, for the Florida Everglades is concerning. This means that the ecosystems of the Everglades are struggling to support the plants and animals that live there and the natural services they provide to people. Without healthy ecosystems, the economy, tourism, and recreational activities of south Florida suffer. However, there are many restoration projects scheduled for the next ten years that will help improve these conditions.



Everglades overall and region scores from Water Years 2013–2017 (May 1, 2012–April 30, 2017).

evergladesecohealth.org

What do the scores mean?

0–20% Very poor
These regions or indicators are extremely vulnerable and are unable to provide ecosystem function. Essential ecological functions are extremely degraded and unsustainable.

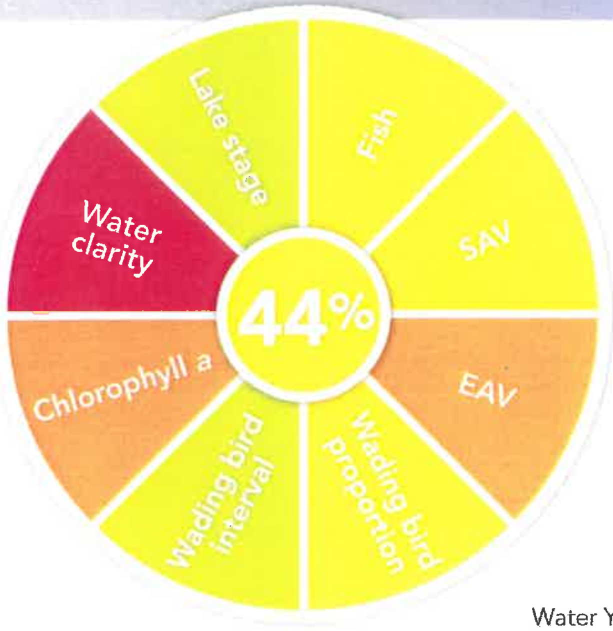
20–40% Poor
These regions or indicators are highly vulnerable and are struggling to provide ecosystem function. Essential ecological functions are highly degraded and unsustainable.

40–60% Fair
These regions or indicators are vulnerable to further ecological degradation and provide minimal ecosystem function. Essential ecological functions are degraded and unsustainable.

60–80% Good
These regions or indicators are slightly vulnerable, but are maintaining ecosystem function. Essential ecological functions are somewhat sustainable.

80–100% Very good
These regions or indicators are minimally vulnerable and are maintaining high ecosystem function. Essential ecological functions are sustainable.

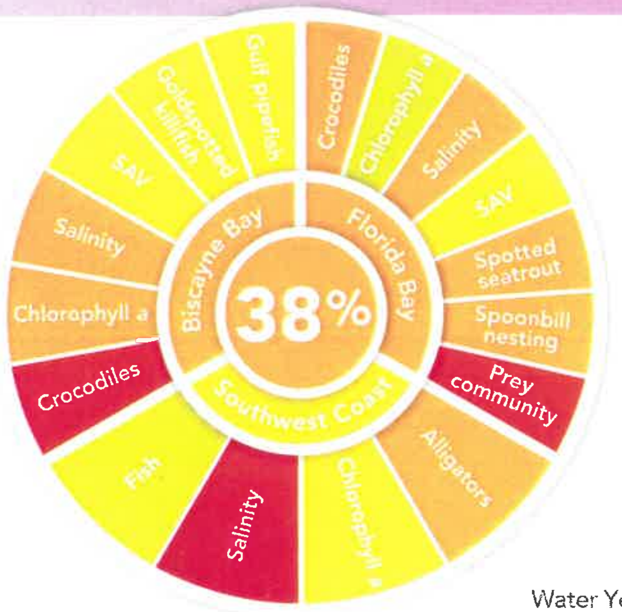
LAKE OKEECHOBEE: FAIR



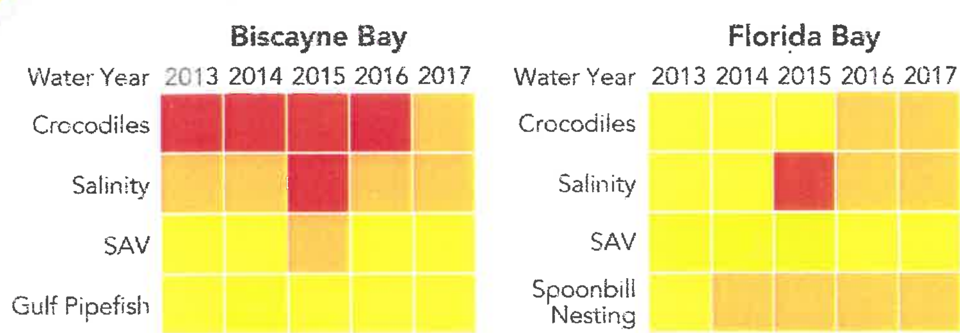
Indicators evaluated in Lake Okeechobee were fish, submerged aquatic vegetation (SAV), emergent aquatic vegetation (EAV), wading bird proportion (based on prey density), wading bird interval between exceptional nesting years, chlorophyll *a*, water clarity, and lake stage. Lake stages were close to desired targets, except for several high-water events during the peak of the summer growing season. These untimely exceedances may explain the difference between lake stage scores and those for flora and fauna. EAV and SAV were poor to fair, likely affecting fish and wading bird indicators; though the wading bird interval indicator scored well. Water clarity scores were very poor and chlorophyll *a* scores were poor, likely affecting SAV and fish indicators.

Select indicator scores by year from Water Years 2013–2017.

SOUTHERN COASTAL SYSTEMS: POOR



Overall, the Southern Coastal Systems regions (Biscayne Bay, Florida Bay, and the Southwest Coast) are in poor to fair condition. Reduced freshwater flow combined with sea level rise has resulted in increased salinity throughout the region. Elevated salinity, due to a local drought in 2014 and 2015, negatively impacted crocodiles, gulf pipefish, and submerged aquatic vegetation (SAV) in Biscayne Bay and Florida Bay. Spoonbill nesting, prey community, and spotted seatrout are in poor to very poor condition. Gold spotted killifish, gulf pipefish, and fish in the Southwest Coast region were in fair to good condition. To improve the ecological processes and overall health of the Southern Coastal Systems region, restoration of freshwater flow will need to continue in the years to come.



Select indicator scores in Biscayne Bay and Florida Bay by year from Water Years 2013–2017.

UNDERSTANDING SOUTH FLORIDA

Hydrology connects ecosystems in south Florida

The Everglades encompasses **four regions interconnected by water**—the Northern Estuaries (Caloosahatchee River Estuary, Loxahatchee River Estuary, and St. Lucie River Estuary), Lake Okeechobee, the Greater Everglades, and the Southern Coastal Systems (Biscayne Bay, Florida Bay, and Southwest Coast). When people talk about the Everglades, they are usually thinking about the Greater Everglades. This is a vast freshwater wetland mosaic composed of sawgrass ridges, sloughs, tree islands, and marl prairie.

Tree island in the Greater Everglades region. Photo by SFWMD.

Historically, the Greater Everglades received water flowing out of Lake Okeechobee at its northern end and discharged water south into the Southern Coastal Systems. The Northern Estuaries were isolated from outflow from the lake. Urban development and drainage for agriculture have disrupted this pattern. Water that used to flow south out of Lake Okeechobee is now redirected into the St. Lucie and Caloosahatchee estuaries. The capacity of the freshwater wetlands to store water also has been lost.

Development in south Florida has altered water flow and habitats. Photo by SFWMD.

These changes have degraded natural habitat needed by wildlife like fish and wading birds. Loss of water storage and connectivity diminishes options available to water managers to sustain natural ecosystems and satisfy the needs of south Florida residents for water supply and flood protection.

Restoration of the Everglades will improve conditions for both people and ecosystems and sustain the Everglades for generations to come. This is being done through numerous projects to improve conditions locally and through coordinated actions to improve conditions on a regional scale.

How was health calculated?

Environmental report cards are used by resource managers to assess and report on the ecosystem health of a region. Developing rigorous, quantitative assessments provides accountability to support environmental protection efforts. A five-step process of developing report cards is used to assess progress: 1) determine values and threats, 2) choose indicators, 3) define thresholds, 4) calculate scores, and 5) communicate results. This report card provides a transparent, timely, and geographically detailed assessment of health in the Everglades using data from May 1, 2012–April 30, 2017.

Everglades health is defined as the progress of region-specific indicators toward scientifically-derived thresholds, targets, or goals. The indicators for each region were developed by regional coordinators, principle investigators, and scientists with specific expertise in these regions. The indicators are combined into an overall region score for each of the four regions. These four region scores are area-weighted into an overall score for the entire Everglades system. The scoring system ranges from 0%–100%, with 100% as the best score, and 0% as the worst score. For more information on specific indicators, methodology, and scoring, please visit **evergladesecohealth.org**.

EVERGLADES RESTORATION

Projects are restoring flow and redistributing water in south Florida

Over the past five years, the Comprehensive Everglades Restoration Plan (CERP) has made progress in several restoration projects. Some projects implemented under the CERP are:

- First phases of the Picayune Strand Restoration Project
- Biscayne Bay Coastal Wetlands Project Phase 1
- C-111 Spreader Canal

Projects under construction:

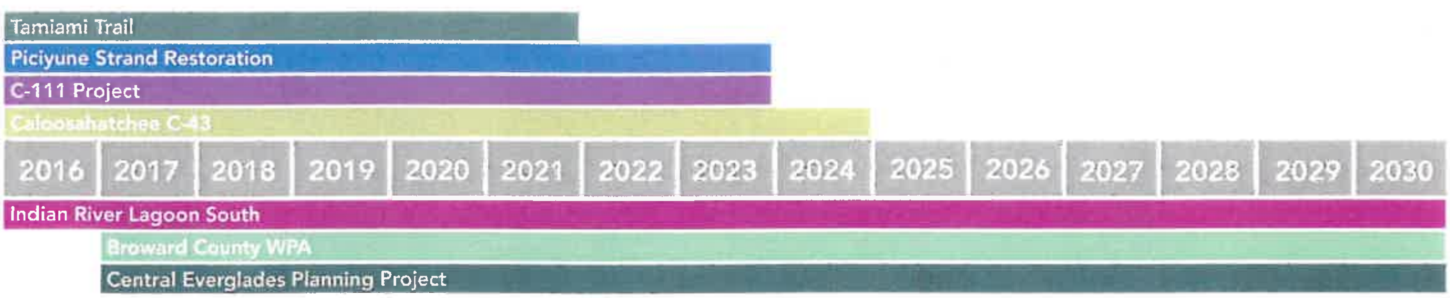
- C-43 Reservoir
- C-44 Reservoir and STA

Other important foundation projects that are contributing to early restoration success include:

- Kissimmee River Restoration
- Tamiami Trail Bridging
- Modified Water Deliveries to Everglades National Park

Water flowing under Tamiami Trail bridge. Photo by Susan Bennett.

Progress is expected to continue as more projects are planned and implemented. During the next five years, the Central Everglades Planning Project will make significant progress towards increasing water storage, improving water quality, and removing canals and levees to restore natural flow patterns. Planning is underway for the next phase of CERP, including the Western Everglades Restoration Project, the Lake Okeechobee Watershed Restoration Project, the Loxahatchee River Watershed Restoration Project, and the Lake Okeechobee System Operations Manual.



Timeline of important projects in Everglades restoration.

ACKNOWLEDGMENTS

This report card provides a transparent, timely, and geographically detailed assessment of health of the Florida Everglades using data from May 1, 2012–April 30, 2017 (Water Years 2013–2017). This report card was produced by RECOVER (REstoration COordination and VERification) and the Integration and Application Network, University of Maryland Center for Environmental Science and was released in March 2019. The data and methods underpinning this report card represent the collective effort of many individuals and organizations working within the Everglades scientific and management community. For more information on specific methodologies, indicators, thresholds, and scoring, please visit evergladesecohealth.org.

Cover photos clockwise from top left: Caloosahatchee River Estuary, SFWMD; Lake Okeechobee, SFWMD; Broad River, SFWMD; Aerial view of Rookery Branch, Franco Tobias. Banner photo page 4: Everglades National Park Service.

University of Maryland Center for Environmental Science Integration and Application Network