SYSTEM - WIDE ECOLOGICAL INDICATORS FOR EVERGLADES RESTORATION 2012

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Executive Summary

This report is a digest of scientific findings about eleven system-wide ecological indicators in the South Florida Ecosystem (Table 1). These eleven indicators have been carefully selected in order to focus our ability to assess the success of the Everglades restoration program from a system-wide perspective.

These indicators are key organisms that we know (through research and monitoring) respond to environmental conditions in ways that allow us to measure their responses in relation to restoration activities. Because of this, we also may see similar ecological responses among indicators. This logical agreement among indicators—a collective response, if you will— could help us understand how drivers and stressors act on more than one indicator and provides a better system-wide awareness of the overall status of restoration as reflected in the ecological responses of these indicators. The more indicators that collectively respond to the drivers and stressors, the stronger the signal that the underlying problem is ubiquitous to the system and is affecting the fundamental ecological and biological nature of the Everglades ecosystem. Fixing these problems is key to fixing the Everglades.

The big picture findings below stem from these collective responses and are clustered according to the organisms that responded to environmental conditions similarly. For example, while Roseate Spoonbills, Alligators, and Periphyton may appear to be unrelated, they are directly related through their biological and ecological responses to environmental drivers.

The following are the big picture findings that were common to more than one indicator, and to large, important regions of the natural system.

Water management and water structures still matter the most. As shown by many of the indicators, Everglades' habitats that are most insulated or removed from the effects (actions or impacts) of water management and water management structures appear to be relatively more ecologically and biologically stable. Generally, these habitats are the most amenable to the sustenance and restoration of Everglades species. Conversely those regions that are most impacted by water management and water management structures are the most erratic and unstable hydrologically and ecologically and the most unfavorable for Everglades species. For example, periphyton sites closest to canals are the sites with the greatest number of yellow and red stoplights.

Where water management operations have resulted in hydrology closer to targets, improvements for some species have been documented.
The green stoplight in water year (WY) 2011 for Lake Okeechobee reflects a period of recovery from drought conditions.

Nesting success of Roseate Spoonbills in Northeastern Florida Bay (NEFB) has improved greatly in recent years, probably due to favorable climatic conditions and to communication between biologists and operations mangers at the South Florida Water Management District (SFWMD) during nesting season. Better communication has led to greater success by reducing unnecessary disruptions to flow patterns to the foraging grounds in NEFB resulting in a positive effect on Roseate Spoonbills and their prey base. Thirteen percent of the total catch of prey base in 2011 was identified as freshwater species indicating higher prey production. Although this is still well below the target of 40%, it does improve the stoplight from red to yellow. Further improvements are expected when the C-111 Spreader Canal West project becomes operational in 2013, increasing freshwater flow to Taylor Slough, likely lowering salinity, and increasing the relative abundance of freshwater species and overall prey productivity. When water management and nature work together to provide more "natural" abundance and distribution of water, some Everglades species respond positively.

Where no improvements in water management operations have been implemented, species targets continued to remain low or decline. Most of the indicators show no substantial change from the previous reports. These indicators are either stable, but below target levels, or are still showing a decline away from targets. Oysters, Roseate Spoonbills (northwest regions of Florida Bay), Pink Shrimp, Submersed Aquatic Vegetation (Transition Zones), and Crocodilians all clearly show that water management operations and the availability of water during both the wet and dry seasons continue to be the limiting factors for species sustainability and recovery. Excess (too much) water at the wrong times and in the wrong places, or insufficient (too little) water most of the time in most areas, along with rapid reversals in water (either during marsh flooding or draining), are still causing most of the indicators to continue to remain unchanged and below targets overall. This continues to be the situation throughout most of the Everglades. For example, fish and macroinvertebrates in Taylor Slough showed improvement in 2007-2010 but then deteriorated in 2011 because of drier than normal conditions. In addition, the rapid and widespread drying/drought conditions of the marsh surface by the end of the nesting season resulted in generally poor nesting conditions for wading birds in 2011.

Executive Summary

Phosphorus continues to be a serious concern. Periphyton nutrient content indicates that areas near water management structures are higher in phosphorus than areas farther removed from structures. Movement of phosphorus into some southern areas that have been relatively free of phosphorus enrichment has resulted in the increase in nutrient concentrations in upper Taylor Slough. Water flows are key to restoration of the Everglades, but elevated concentration of phosphorus continues to be one of the main problems complicating the ability to supply more water.

There is still too little water everywhere in the dry season. Most areas also have too little water in the wet season while some impounded areas have too much water in the wet season. The timing of water releases is still causing large problems. All the indicators show that the Everglades ecosystem is still not getting enough water, and that in many locations that water is subject to management operations that cause serious harm to the ecosystem and the indicators by either piling water in areas that should not be so wet, or not supplying sufficient quantities of water resulting in drying of areas that need water. Oysters continue to show negative impacts from water management actions that cause rapid changes in the volume and timing of fresh water released to tide. Current water management practices have contributed to preventing "good" hydrological conditions from occurring over multiple successive years across the entire landscape; a situation that is inimical to the sustenance and recovery of the indicator species, particularly Wading Birds, Crocodilians, Pink Shrimp, Fish, and Oysters.

Predominant Themes

The predominant themes we can discern from the collective responses of these indicators include the following:

- Due to water management not delivering enough water, and also draining needed water away, the Everglades, as a whole, is not getting nearly enough water in either the wet or dry seasons and the southern portions of the Everglades system are most affected in this regard. These effects are more pronounced in dry years.
- Water management often causes extremes, and reversals, in water levels in the natural system both in the wet and dry seasons as water is routed around for human consumption and flood protection. Both of these hydrological extremes have caused deterioration of the natural system.
- The Everglades has been unnaturally enriched with phosphorus, with the impacts being most pronounced in the northern parts of the system where the majority of the nutrients are entering, and care must be taken to avoid extending that pollution to unimpacted areas.
- Invasive plant species present a serious threat to the restoration of the Everglades, and their capacity to impact the natural environment may operate independently from environmental change resulting from restoration efforts. Without control and management of invasive plant and animal species, restoration goals may not be achieved.

All of these major problems are reflected in the preponderance of red and yellow stoplights in the individual stoplight reports. Over the past two years, three restoration project groundbreakings have occurred. As restoration projects are completed and become operational, we expect to see system-wide trends moving towards more yellow and green stoplights.

Ecological indicators are used to communicate information about ecosystems and the impact human activity has on them. Ecosystems are complex and ecological indicators can help describe them in simpler terms. For example, the total number of different fish species found in an area can be used as an indicator of biodiversity.

There are many different types of indicators. They can be used to reflect a variety of aspects of eco-

Introduction

What are ecological indicators and why do we need them?

"An ecological indicator is a metric that is designed to inform us easily and quickly about the conditions of an ecosystem." (Bennett 2000)

"A useful ecological indicator must produce results that are clearly understood and accepted by scientists, policy makers, and the public." (Jackson et al. 2000)

systems, including biological, chemical, and physical. Due to this diversity, the development and selection of ecological indicators is a complex process.

National indicators for pollution (for example the ozone index one sees on the daily news) and the economy (for example the gross domestic product reported daily in the news as the measure of national income and output) have been used for decades to convey complex scientific and economic principles and data into easily understandable concepts.

Many ecological restoration initiatives globally and nationally are either currently using or developing ecological indicators to assist them in grading ecological conditions. A few of the larger US restoration programs that are developing and using ecological indicators include Chesapeake Bay, Maryland; San Francisco Bay-Delta-River System, California; Yellowstone National Park, Montana; Columbia River, Oregon; and the South Florida Ecosystem Restoration Program.

Indicators make understanding an ecosystem possible in terms of management, time, and costs. For example, it would be far too expensive, perhaps even impossible, to count every animal and plant in the Everglades to see if the restoration was a success. Instead, a few indicator species can be monitored in a relatively few locations to determine the success of the restoration. Indicators can be developed to evaluate very specific things or regions, or to evaluate broad system-wide aspects of an ecosystem.

This report is a digest of scientific findings about eleven system-wide ecological indicators in the South Florida Ecosystem (Table 1). These eleven indicators have been carefully selected in order to focus our ability to assess the success of the Everglades restoration program from a system-wide perspective.

These ecological indicators are organisms that integrate innumerable ecological functions in their life processes. For example, hydrology (water depth, timing, and duration) and water quality affect the types and quantities of periphyton, which affect the types and quantities and availability of fish that feed on periphyton, which affect the amount and availability of fish as food for alligators and wading birds.

They're all interconnected, and indicators provide a more pragmatic means to understand those complex interconnections.

Ecological indicators are used because we cannot measure everything all the time. Scientists measure a few attributes of a few indicators precisely because they integrate many ecological and biological functions that either we cannot measure because it would be too expensive and time consuming, or simply because some things are too difficult to measure. Thus—through measuring more simple aspects of the lives of key organisms—we are able to take into account the innumerable biogeochemical and environmental processes they integrate and, through more simple and affordable research and monitoring, we can begin to understand how indicators may respond to ecosystem drivers and stressors such as rainfall, hydrology, salinity, water management, nutrients, and exotic species.

PURPOSE

This suite of system-wide ecological indicators has been developed specifically to provide a mountaintop view of restoration for the South Florida Ecosystem Restoration Task Force (Task Force) and Congress.

The Task Force, established by section 528(f) of the Water Resources Development Act (WRDA) of 1996, consists of 14 members. There are seven federal, two tribal, and five state and local government representatives. The main duties of the Task Force are to provide a coordinating organization to help harmonize the activities of the agencies involved with Everglades restoration. The Task Force requested that the Science Coordination Group (SCG, a team of scientists and managers) develop a small set of system-wide ecological indicators (Table 1) that will help them understand *in the broadest*

Table 1. System-wide Ecological Indicators

- *Invasive Exotic Plants*
- *Lake Okeechobee Nearshore Zone Submersed Aquatic Vegetation*
- *Eastern Oysters*
- *Crocodilians (American Alligators & Crocodiles)*
- *Fish and Macroinvertebrates*
- *Periphyton & Epiphyton*
- *Wading Birds (White Ibis & Wood Stork)*
- *Southern Estuaries Algal Blooms*
- *Florida Bay Submersed Aquatic Vegetation*
- *Juvenile Pink Shrimp*
- *Wading Birds (Roseate Spoonbill)*

terms how the ecosystem, and key components, are responding to restoration and management activities via implementation of the Comprehensive Everglades Restoration Program (CERP) (www.evergladesplan.org), and other non-CERP restoration projects.

The CERP and REstoration, COordination, and VERification (RECOVER) programs (www.evergladesplan.org/pm/recover) were developed to monitor many additional aspects of the ecosystem, including such things as: rare and endangered species, mercury, water levels, water flows, stormwater releases, dissolved oxygen, soil accretion and loss, phosphorus concentrations in soil and water, algal blooms in Lake Okeechobee, hydrologic sheet flow, increased spatial extent of flooded areas through land purchases, percent of landscape inundated, tree islands, salinity, and many more. The set of indicators included here are a subset from those larger monitoring and assessment programs. They are intended to provide a system-wide, big-picture appraisal of restoration. Many additional indicators have been established that provide a broader array of parameters. Some of these are intended to evaluate sub-regional elements of the ecosystem (e.g., individual habitat types), and others are designed to evaluate individual CERP projects (e.g., water treatment areas). This combination of indicators will afford managers information for adjusting restoration activities at both large and small scales.

GOAL

Any method of communicating complex scientific issues and findings to non-scientists must: 1) be developed with consideration for the specific audience, 2) be transparent as to how the science was used to generate the summary findings, 3) be reasonably easy to follow the simplified results back through the analyses and data to see a clear and unambiguous connection to the information used to roll-up the results, 4) maintain the credibility of the scientific results without either minimizing or distorting the science, and 5) should not be, or appear to be, simply a judgment call (Norton 1998, Dale and Beyeler 2001, Niemi and McDonald 2004, Dennison et al. 2007). In reviewing the literature on communicating science to non-scientists we realized that the system of communication we developed for this suite of system-wide ecological indicators must be effective in quickly and accurately getting the point across to our audience in order for our information to be used effectively (Rowan 1991, 1992, Dunwoody 1992, Weigold 2001, Thomas et al. 2006, Dennison et al. 2007).

The approach we used to select these indicators focused on individual indicators that integrated numerous physical, biological, and ecological properties, scales, processes, and interactions to try to capture that sweeping mountaintop view. Based on the available science, we made the underlying assumption that these indicators integrated many additional ecological and biological functions that were not or could not be measured and thus provided an assessment of innumerable ecological components that these indicators integrated in their life processes.

Having too many indicators is recognized as one of the more important problems with using and communicating them (National Research Council 2000, Parrish et al. 2003). Identifying a limited number of focal conservation targets and their key ecological attributes improves the successful use and interpretation of ecological information for managers and policy makers and enhances decision making (Schiller et al. 2001, Parrish et al. 2003, Dennison et al. 2007). Our goal has been to develop a suite of indicators composed of an elegant few (Table 1) that would achieve a balance among: feasibility of collecting information, sufficient and suitable information to accurately assess ecological conditions, and relevance for communicating the information in an effective, credible, and persuasive manner to decision makers. For the purposes of this set of indicators, "system-wide" is characterized by both the physiographic and ecological elements that include: the boundary of the

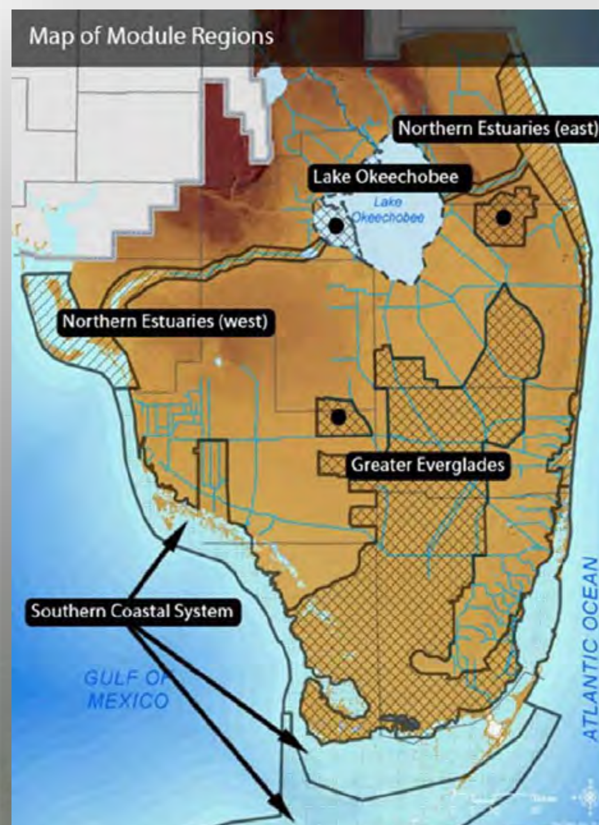


Figure 1. Map of south Florida illustrating the boundary of the SFWMD and the regional assessment modules. Figure courtesy of RECOVER's 2009 System Status Report.

SFWMD and assessment modules (Figure 1), and the ecological links among key organisms [see *Wetlands* 25:4 (2005) for examples of the Conceptual Ecological Models (CEM)].

In addition, these indicators will help evaluate the ecological changes resulting from the implementation of the restoration projects and provide information and context by which to adapt and improve, add, replace, or remove indicators as new scientific information and findings become available. Indicator responses will also help determine appropriate system operations necessary to attain structural and functional goals for multiple habitat types among varying components of the Everglades system. Using a suite of system-wide ecological indicators (Table 1) to present highly aggregated ecological information requires indicators that cover the spatial and temporal scales and features of the ecosystem they are intended to represent and characterize (Table 2; Figure 2). While individual indicators can help decision makers adaptively manage at the local scale or for particular restoration projects,
collectively, indicators can help decision makers assess restoration at the system scale.
We chose stoplights to depict indicator status. There are many different methods that are being used to communicate scientific information in easier-to-understand formats. We evaluated numerous methods and ideas on organizing and communicating complex science and found many helpful ideas. We also noted that most methods were, in the end, still quite complex, and it took more information and explanation to understand the method than we felt made sense if the goal was to make things easier to understand. Therefore, we chose to use one of the most clear-cut and universally understood symbols—the stoplight—with a simple and straightforward findings page to provide a reasonable context for the stoplights.

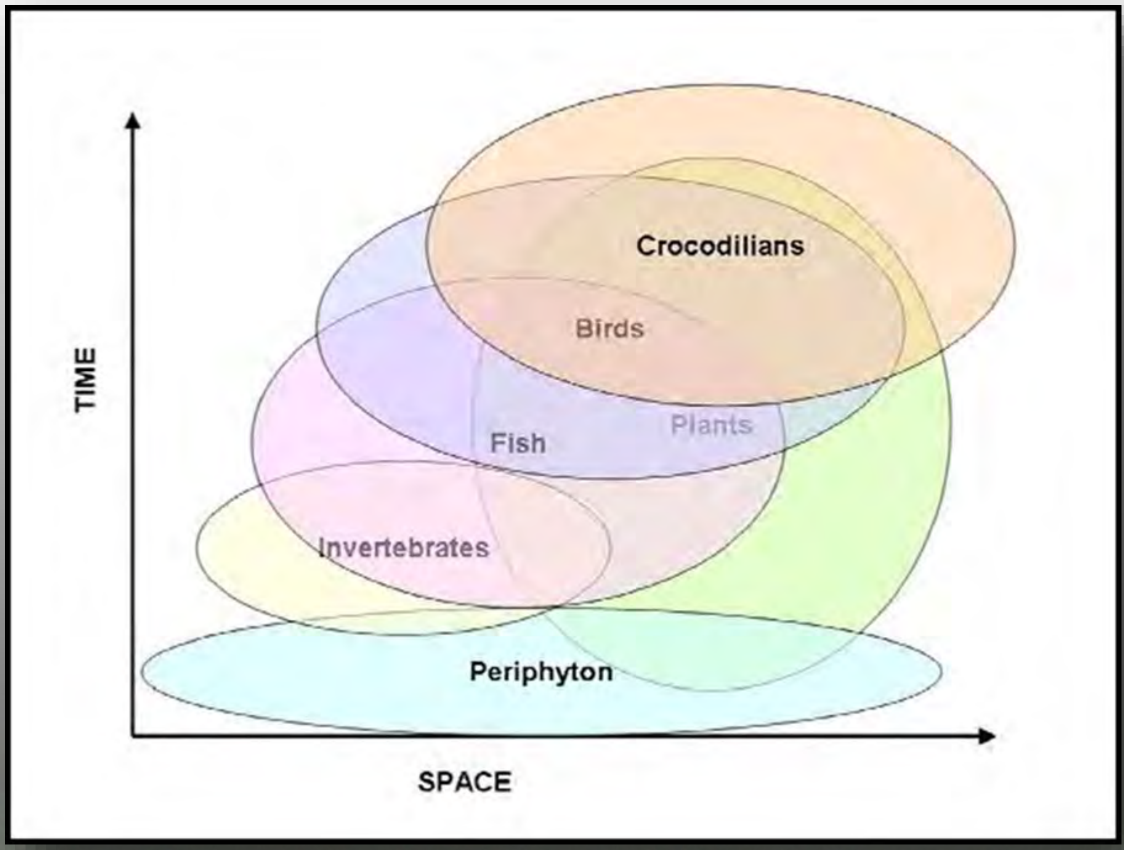


Figure 2. The suite of system-wide ecological indicators was chosen based upon their collective ability to comprehensively reflect ecosystem response in terms of space and time. For example, periphyton responds to change very rapidly at both small and large spatial scales while Crocodilians respond more slowly to change and at intermediate and large spatial scales. As indicators, they “cover” different aspects of the ecosystem. The system-wide ecological indicators collectively “cover” the ecosystem in terms of response to change over space and time.
This figure is an illustration of how individual indicators may interrelate and respond to restoration in terms of space and time. This figure uses six indicators as an example and is not meant to precisely represent the exact spatial and temporal interactions of the system-wide ecological indicators.

Table 2. List of South Florida Ecosystem Features

Landscape Characteristics
- Hydropatterns
- Hydroperiods
- Vegetation Pattern and Patchiness
- Productivity
- Native Biodiversity
- Oligotrophy (low in nutrients)
- Pristine-ness
- Intactness (connectivity/spatial extent)
- Trophic Balance
- Habitat Balance/Heterogeneity

Trophic Constituents and Biodiversity
- Primary Producers (autotrophs - organisms that obtain energy from light or inorganic com-
- pounds; and detritus - dead organic material)
- Primary Consumers (herbivores and detritivores - animals that eat plants or detritus)
- Secondary Consumers (animals that feed upon herbivores and detritivores)
- Tertiary Consumers (animals that feed upon secondary consumers)

Physical Properties
- Water Quality
- Water Management (i.e., when, where, and how much water is moved)
- Invasive Exotic Species
- Salinity
- Nutrients (e.g., Nitrogen, Phosphorus, Sulphur)
- Contaminants (e.g., pesticides, pharmaceutical chemicals, mercury)
- Soils

Ecological Regions (Figure 1)
- Greater Everglades
- Southern Coastal System
- Northern Estuaries
- Big Cypress
- Kissimmee River Basin
- Lake Okeechobee
- Florida Keys

Temporal Scales (Figure 2)
- Indicators that respond rapidly to environmental changes (e.g., periphyton)
- Indicators that respond both quickly and more slowly to environmental changes (e.g., body condition and relative density, respectively for crocodilians)

Hydrologic Context for the System-wide Ecological Indicators Water Years 2010 – 2011

Hydrology is a major driver of Everglades ecology. In this section we provide an overview of south Florida climate and a summary of the hydrologic conditions in water years 2010-2012, including the patterns in seasonal rainfall, surface water flows, water depths, and hydroperiods by area.

South Florida Climate Patterns

South Florida has two distinct hydrologic seasons, a wet season (generally from May-October) and a dry season (generally from November-April). Rainfall and water flows can vary greatly within those two seasons, and from year to year. This seasonal and inter-annual hydrologic variation plays an important role throughout the life cycle of most plants and animals found in the South Florida Ecosystem. South Florida hydrologic conditions are the result of both natural processes (rainfall, evapotranspiration, overland flow, groundwater infiltration, etc.) and water management changes (human manipulations to support flood control, urban and agricultural water supply, and environmental water demands) that are associated with operations of the Central and Southern Florida (C&SF) project.

South Florida is located in the sub-tropics, and the warm climate and associated tropical storm activity strongly influences the hydrology and ecology of the region. Although south Florida is generally considered a wet region (with an average annual rainfall of approximately 52 inches), serious droughts are common because of both longer-term climate variations, and the seasonal pattern of rainfall. On average, approximately 77% (or 40 inches) of the total annual rainfall occurs in the May through October wet season, while approximately 23% (or 12 inches) occurs in the November through April dry season (Figure 3).

Historically, prolonged drought cycles are broken by periods of increased tropical cyclone activity (tropical depressions, tropical storms, and hurricanes). In addition, large-scale climate drivers also have a significant impact on south Florida hydrology. The hydrologic conditions during water years 2010 through 2012 were highly influenced by the El Niño-Southern Oscillation (ENSO) a climatic phenomenon caused by warming sea surface temperatures in the eastern Pacific, which strongly influences dry season rainfall variability in south Florida. El Niño years have warmer Pacific sea surface temperatures, which translates into above average rainfall and surface water flows during the south Florida dry season. By contrast, La Niña years are associated with cooling Pacific sea surface temperatures, and conversely, dry season rainfall and water flows tend to be below-average (Figure 4).

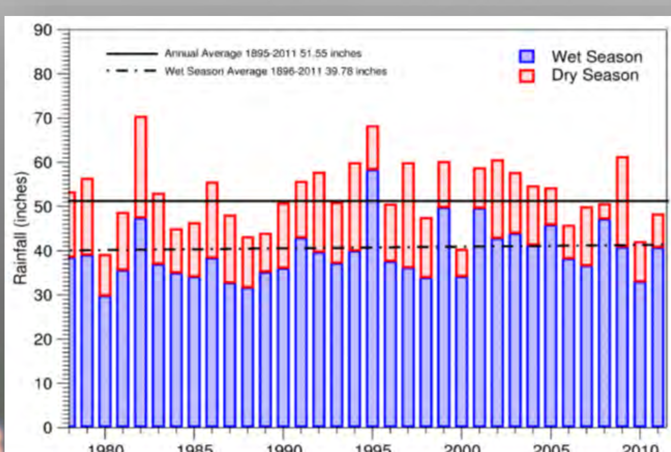


Figure 3. South Florida seasonal and annual rainfall for the last 35 years, based on rainfall over the Everglades-Southwest Florida region. Source: National Climate Data Center.

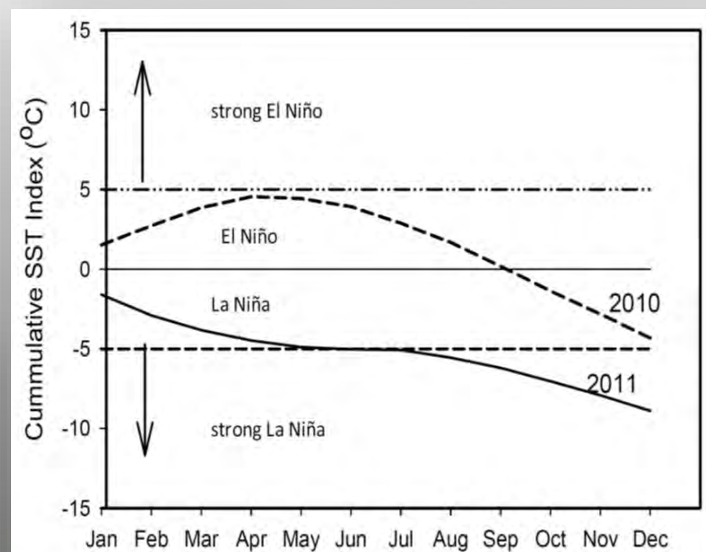


Figure 4. El Niño-Southern Oscillation (ENSO) cumulative sea surface tracking index for calendar year 2010 and 2011, source: South Florida Environmental Report, SFWMD, 2012. Positive values indicate the presence of an El Niño event, which generally brings above normal dry season rainfall in south Florida. Negative values indicate the presence of a La Niña event, which generally brings below normal dry season rainfall in south Florida.

Hydrologic Context for the System-wide Ecological Indicators Water Years 2010 – 2011

General Summary of Water Years 2010-2012

The last three water years are a good example of the range of hydrologic variations that can be observed in south Florida. Water year 2010 demonstrates the hydrologic characteristics of an El Niño year, with well above normal rainfall in the dry season. Under these conditions, Everglades marsh water depths and flooding durations were above normal, and surface water ponding persisted well into the following year. This was not a traditional "wet year" since WY2010 was preceded by a three-year drought. Water years 2011 and 2012 demonstrate the hydrologic characteristics of a La Niña year, with well below normal rainfall in the dry season. Everglades marsh water depths and flooding durations were greatly diminished by WY2012, and surface water ponding was highly restricted. Take note that marsh water depths and flooding durations are not distributed uniformly across the Everglades, but are strongly controlled by the man-made system of canals and levees that make up the C&SF Project.

The hydrologic conditions during water years 2010 through 2012 show how quickly the South Florida Ecosystem responds to variations in seasonal rainfall and water availability. These seasonal and inter-annual hydrologic variations were primarily driven by natural climate phenomenon, which create significant resource conflicts in the context of the multi-objective south Florida water management system (rapid shifts from flood fighting to water shortage management). The Everglades ecosystem is generally adapted to these natural variations, but water management actions can exacerbate their adverse effects. These negative impacts can be partially mitigated by increasing regional water storage, improving water conveyance, and removing obstructions to natural marsh sheetflow. All of these hydrologic improvements are key goals of Everglades ecosystem restoration.

Water Year 2010 (A Mild El Niño Event)

For consistency with the South Florida Environmental Report (SFWMD) we define the south Florida water year as extending from the beginning of May of the previous year through April of the reporting year. Using this convention, WY2010 covers the period from May 1, 2009 through April 30, 2010. Water year 2010 demonstrates the effects of an El Niño event on south Florida's dry season hydrology.

Rainfall and Surface Water Flows

Water year 2010 started out drier than normal because of the prior three years of drought conditions, which had a combined rainfall deficit of over 23 inches basin-wide (South Florida Environmental Report, SFWMD, 2011). At the beginning of WY2010, water levels were historically low throughout Lake Okeechobee and the Everglades. While WY2010 wet season rainfall was close to normal, the year ended wetter than normal because of well above normal dry season rainfall throughout all of the SFWMD basins. This was the result of a moderate El Niño event (Figures 3 and 4). A simplified surface water budget for the Everglades is presented in Figure 5 (left) for WY2010. The WY2010 water budget can be compared to the average conditions for the past twelve years (water years 2000-2012) shown in Figure 5 (right). These water budgets were calculated by summing the surface water flows for all of the major water control structures to define the total inflows/outflows for the seven major drainage basins in south Florida [these are, from north to south: Lake Okeechobee, Caloosahatchee and St. Lucie estuaries, the Everglades Agricultural Area (EAA), the Water Conservation Areas (WCAs), the Lower East Coast (LEC), and Everglades National Park).

Lake Okeechobee

Surface water inflows into Lake Okeechobee were slightly higher than normal during WY 2010 (South Florida Environmental Report, SFWMD, 2011). By contrast, outflows toward the northern estuaries were reduced to approximately 30-40 percent of their twelve-year average. Lake Okeechobee average water levels started the water year at 10.55 feet in May 2009, due to the prior drought period, and Lake Okeechobee inflows were retained to increase regional water availability. The wet season rainfall and water retention allowed Lake Okeechobee water levels to increase rapidly, and by September 2009 the Lake had risen by four feet (Figure 6). Extreme water level fluctuations in Lake Okeechobee affect south Florida regional water availability as well as the ecology of the Lake's littoral and open water areas. High Lake levels (such as in 2004-2005) drown the Lake's vegetation communities and raise concerns about increased risks of dike failure and flooding. Low Lake levels (such as the record low in 2008) dry out the Lake's littoral zone, causing a loss of submersed aquatic vegetation (SAV).

Lake Okeechobee water levels are managed according to a regulation schedule (LORS 2008) that attempts to optimize water management flexibility while balancing the health of the Lake's SAV, emergent marsh, and aquatic communities. The goal is to reduce extreme water level fluctuations by keeping Lake levels between a low stage of 10 feet, and a high stage of 17 feet. Lake stages are also managed for

Hydrologic Context for the System-wide Ecological Indicators Water Years 2010 – 2011

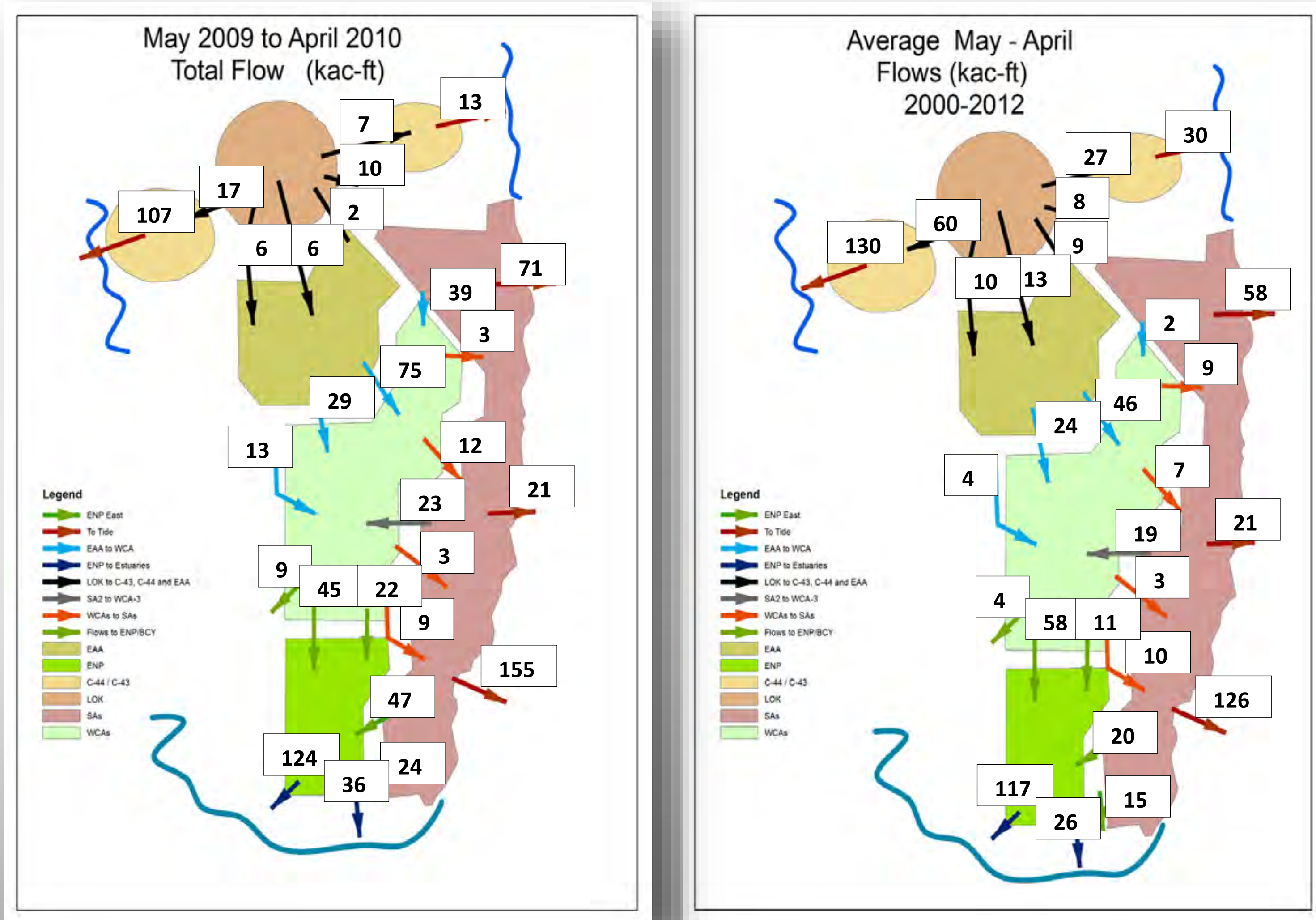


Figure 5. Surface water budget for WY2010 (left) and the average year (right).

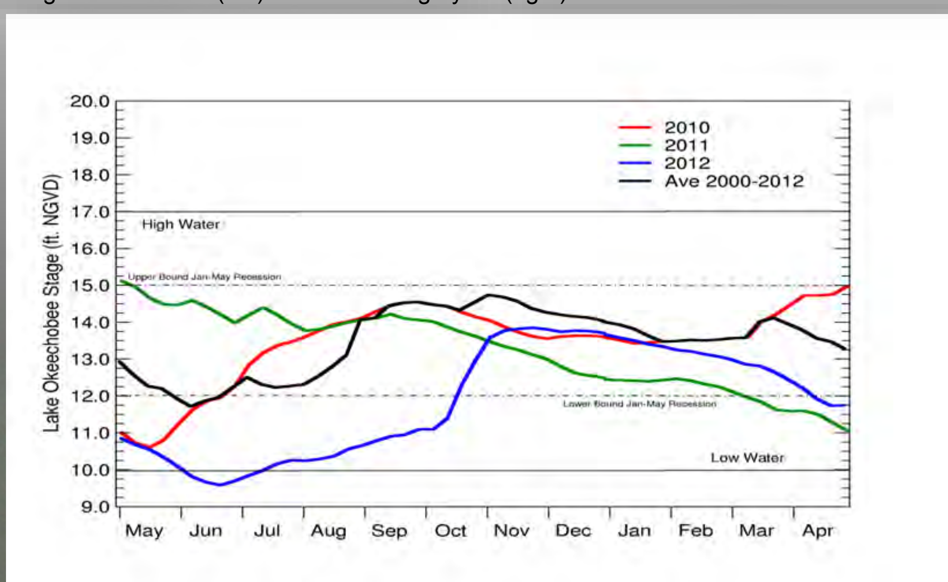


Figure 6. Water levels in Lake Okeechobee during water years 2010, 2011, and 2012 versus the twelve-year average. Water levels above 17.0 feet are in the high Lake management band. Water levels below 10.0 feet are in the water shortage management band.

ecological purposes to reduce the time above 15 feet to less than four consecutive months, and promote a spring water level recession from a high no more than 15.5 feet in January to 12.5 feet at the end of May (South Florida Environmental Report, SFWMD 2011). Figure 6 shows that the goals of reducing extreme high and low water level fluctuations were generally met in WY2010, but the spring recession rate was not achieved (Lake stages ended the year higher than they started). See the later section on Lake Okeechobee SAV restoration targets (acreage and percent vascular plants) and the 2010-2012 Lake Okeechobee ecological performance measures for more details.

Northern Estuaries

During WY2010, surface water flows down the Caloosahatchee and St. Lucie canals and into the downstream estuaries were below normal, as a result of reduced Lake Okeechobee diversions (reaching approximately 85% and 40% of their average annual flows, respectively). Each downstream estuary has a defined range of target flows that support healthy estuarine plant and animal communities. Average monthly flows into the downstream estuaries during water years 2010, 2011, and 2012 as well as the full 12-year monthly flow series are presented in Figure 7, along with their target ranges.

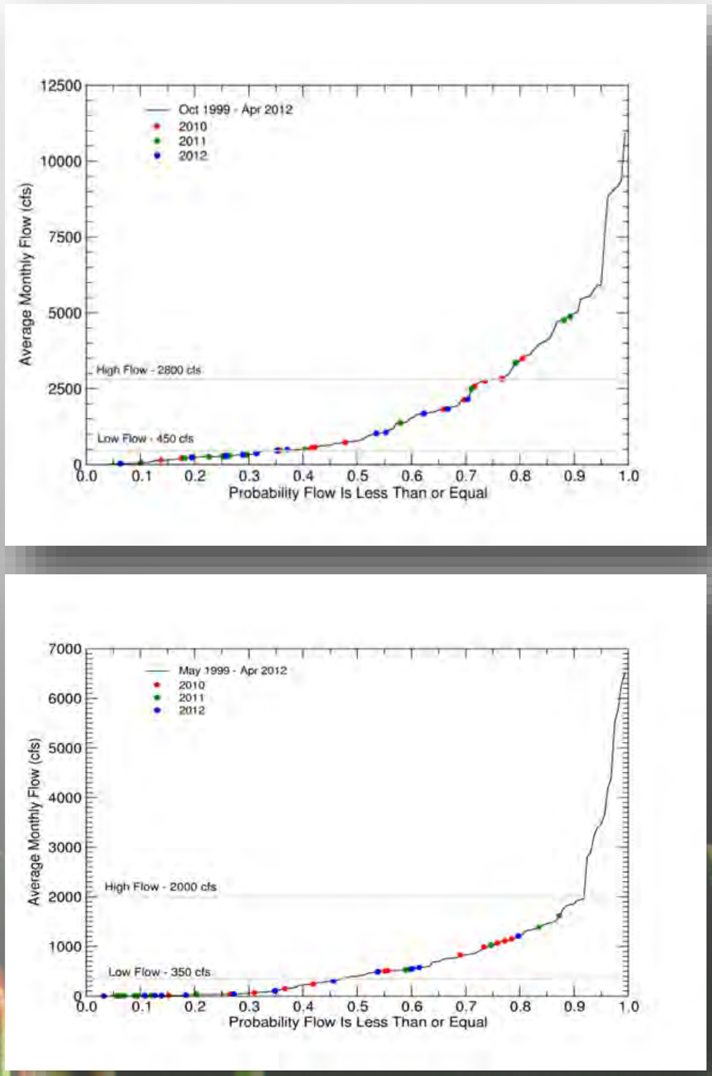


Figure 7. Average monthly flows into the downstream Caloosahatchee estuary (top) measured at S-79, and St. Lucie estuary (bottom) measured at S-80, during water years 2010, 2011, 2012. The solid line represents the average monthly flow values for the full twelve-year period (WY2000-WY2012).

Hydrologic Context for the System-wide Ecological Indicators Water Years 2010 – 2011

In WY2010, average monthly flows out of the Caloosahatchee canal and into the downstream estuary were within the prescribed 450-2,800 cubic feet per second (cfs) optimal flow range during 7 months of the year, below the low flow target for 3 months, and above the high flow target for 2 months (Figure 7, red values, top panel). The WY2010 average monthly flows out of the St. Lucie canal and into the downstream estuary were within the prescribed 350-2,000 cfs optimal flow range during 7 months of the year, and below the low flow target for 5 months of the year (Figure 7, red values, bottom panel). In general the flow targets established to protect eastern oysters and seagrass in these two estuaries were not met because of extreme high and low flow events in the Caloosahatchee, and persistent low freshwater inflows into the St. Lucie. See the sections on eastern oyster restoration targets and performance measures for the northern estuaries for more details.

Southward Flows (to the EAA, WCAs, LEC, and ENP/Southern Estuaries)

Flows from Lake Okeechobee southward into the EAA during WY2010 show a similar surface water flow reduction as noted for the northern estuaries, with EAA inflows representing just 30 percent of their annual average flows (Figure 5). The persistent rainfall throughout WY2010 apparently held water levels higher in the EAA delaying the normal drydown of the agricultural fields. As a result, much higher surface water flows were pumped southward from the EAA into the WCAs compared to a normal year. A similar pattern of higher than normal surface water flows out of the WCAs and into the LEC was also observed, and the majority of these flows were then passed through the LEC to tide. Unlike the substantially higher flows observed passing into the WCAs and the LEC, the flows into Everglades National Park and southern estuaries of Biscayne Bay and Florida Bay had just slightly greater annual freshwater inflows than normal.

Everglades Wetlands

The patterns of seasonal and inter-annual variations in marsh water depths and flooding durations are a defining characteristic of the Everglades ecosystem, and play an important role throughout the life cycle of most plants and animals found in south Florida. These hydropattern changes are closely linked to the health of key ecological indicators in the Everglades wetlands (including periphyton, fish and macroinvertebrates, wading birds, and alligators) and these indicators are all described in more detail in later sections of this report. At the beginning of WY2010 in mid May 2009, shallow surface water was present in portions of the Loxahatchee National Wildlife Refuge (NWR), WCA-2A, WCA-3A, and WCA-3B, but was absent in most of the freshwater marshes in Everglades National Park (Figure 8, center panel). The water depth conditions in late October 2009 indicate that by the end of the 2010 wet season, nearly the entire Everglades was inundated, except for the slightly higher elevated marl prairies in Everglades National Park (Figure 8, left panel). October water depths in the Loxahatchee NWR, WCA-2A, and WCA-3A generally ranged from less than 0.5 foot in their upstream higher elevated areas to more than 3.0 feet in the ponded downstream areas adjacent to the levees. By contrast, water depths in WCA-3B and Shark River Slough generally remained below 1.5 feet.

Dry season rainfall during WY2010 was above normal (175% of normal), and created more persistent surface water conditions throughout the Everglades. Flooding durations during WY2010 exceeded 330 days throughout the Loxahatchee NWR, the WCAs, and much of Shark River Slough, but were generally less than 120 days in the marl prairie areas of Everglades National Park (Figure 8 right panel). Appendix A presents a series of average-year water depth and hydroperiod maps as well as maps that show the deviations from normal during WY2010. The difference maps indicate that water depth and hydroperiod deviations across the Everglades system were spatially variable, ranging from conditions that were generally below the ten year average in Taylor Slough and the eastern marl prairie areas in Everglades National Park, to above the ten year average in WCA-3A north and portions of Shark River Slough.

The seasonal water depth distributions and hydropatterns in Figure 8 clearly show that surface water is not distributed uniformly throughout the WCAs and Everglades National Park. Instead the internal levee systems tend to block the natural marsh sheetflow and create deeper ponded areas upstream of flow obstructions (levees) and drier areas in the downstream shadow of levees. Similarly, the internal canal systems tend to short circuit natural marsh water flows and quickly redirect surface water into these deeper ponded areas, bypassing much of the wetlands in northern WCA-3A, WCA-3B, and Northeast Shark River Slough. The water depth patterns in the WCAs are also the result of water management practices

Hydrologic Context for the System-wide Ecological Indicators Water Years 2010 – 2011

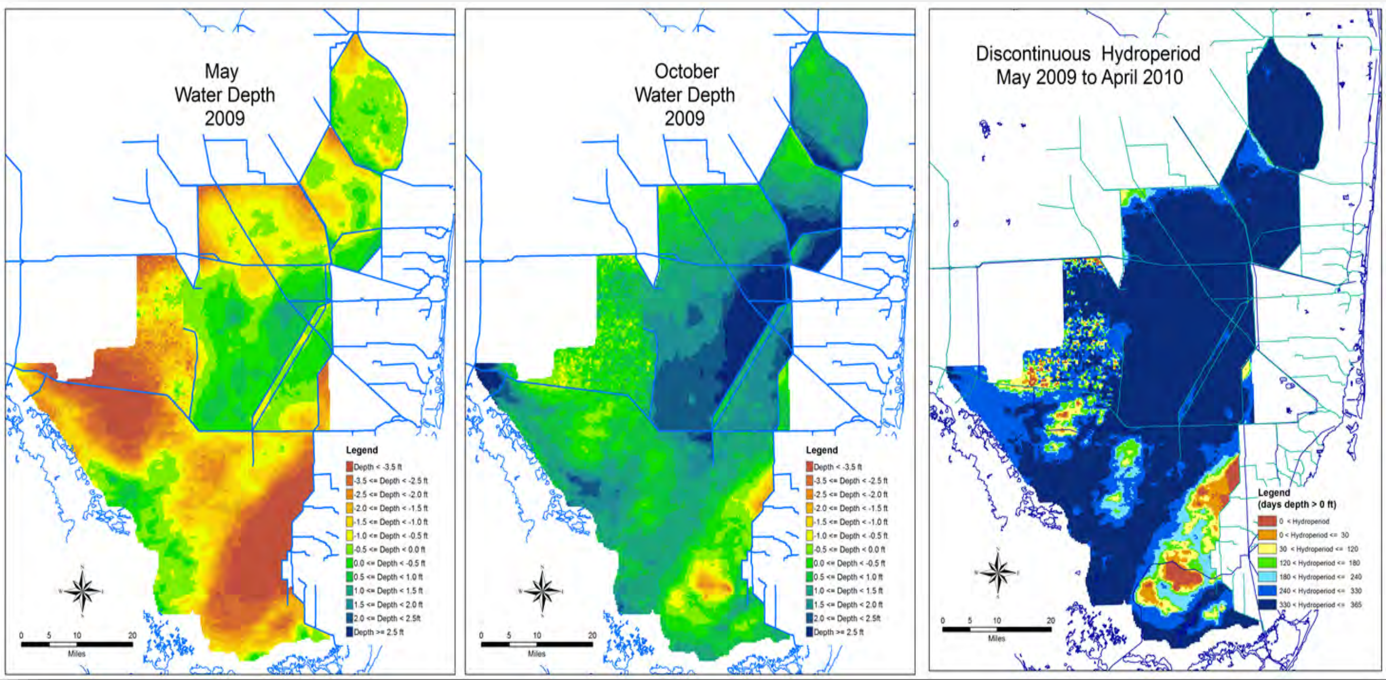


Figure 8. Water Depths and Hydroperiods during WY2010 (May 2009 through April 2010). May 2009 (left) represents the water depth conditions in the Everglades at the end of the prior dry season. October 2009 (center) represents the water depth conditions in the Everglades at the peak of the 2009 wet season. The May 2009 to April 2010 hydroperiod map (right) represents the total number of days that water was above the ground surface (flooding duration) during WY2010. Appendix A shows the difference maps comparing the water depths and hydroperiods in WY2010 to the average conditions experienced between 2000-2011. Blues and greens indicate wetter areas or longer hydroperiods, while yellows, oranges, and browns indicate drier areas or shorter hydroperiods. Source: Adapted from the Everglades Depth Estimation Network, USGS.

that are designed to retain wet season runoff for later dry season water supply deliveries to adjacent urban and agricultural areas. A major goal of Everglades restoration is to recreate more natural sheetflow patterns by reducing the impoundment effects and short circuiting of flows caused by the internal levees and canals within the WCAs (these projects are referred to as decompartmentalization and sheetflow enhancement).

Ecological Bottom Line for WY2010

Water levels in Lake Okeechobee were generally favorable for littoral zone and open-water vegetation, but flows down the Caloosahatchee and St. Lucie canals were highly variable and generally outside of their target ranges for many months in WY2010. Within the Everglades, persistent marsh inundation helped to sustain organic/peat soils and the abundance of marsh fish and invertebrates. The extended period of dry season high water in the northern portions of the WCAs and Shark River Slough could have a positive benefit in shifting marsh vegetation back toward slough dominated communities, but can negatively impact certain tree island plant species and some animals. In addition, high water levels in the dry season and recurring rainfall such as in El Niño events cause reversals (e.g. a period of increasing water level when it should continue to decrease) in natural water recessions that disturb wading bird foraging, and reduce availability of food for other aquatic animals such as alligators. Repeated hydrological reversals within a year are believed to reduce survival of aquatic animals more than would be expected by a single drydown event of the same total length.

Hydrologic Context for the System-wide Ecological Indicators Water Years 2010 – 2011

Water Year 2011 (The Start of a Strong La Niña Event)

Rainfall and Surface Water Flows

A weak La Niña event began to form in the eastern Pacific in late spring 2010. The 2011 wet season experienced slightly lower than normal rainfall, as the La Niña oscillation began to intensify, and by the end of the 2011 dry season, rainfall was well below normal throughout all of the SFWMD basins. Water year 2011 was characterized as a dry year, with approximately 76% of normal rainfall for the overall watershed. In spite of this reduced rainfall, surface water flows and marsh water depths over much of south Florida remained close to normal because of the higher antecedent conditions during the prior dry season. The surface water budget for the Everglades during WY2011 is presented in Figure 9. The high Lake Okeechobee water levels during WY2010 carried over into this drier WY2011, and led to above normal outflows from Lake Okeechobee toward the Northern Estuaries. By contrast, inflows to the EAA and WCAs generally returned to more normal conditions. Further downstream, the WY2011 drought conditions lead to below normal inflows to Everglades National Park and the southern estuaries of Biscayne and Florida Bay.

Lake Okeechobee

The higher than normal dry season rainfall in the prior year kept Lake Okeechobee water levels high at the start of WY2011, reaching 15.15 feet in early May 2010. Lake water levels generally fell throughout the rest of the year due to the combination of below normal rainfall and wet season discharges into the Northern Estuaries (Figures 6 and 9). By the end of April 2011, average Lake water levels had dropped to 10.93 feet (South Florida Environmental Report, SFWMD 2012). As Lake stages fell, gravity flows out of the Lake were restricted, and forward pumping of EAA flows back into Lake Okeechobee were initiated in May 2011. While the Lake was losing its water storage capacity, Lake stages generally remained in the ecologically optimum range throughout WY2011, and SAV communities in the Lake continued to recover from the pre-2010 drought conditions. See the later section on Lake Okeechobee SAV restoration targets (acreage and percent vascular plants) and the 2010-2012 Lake Okeechobee ecological performance measures for more details.

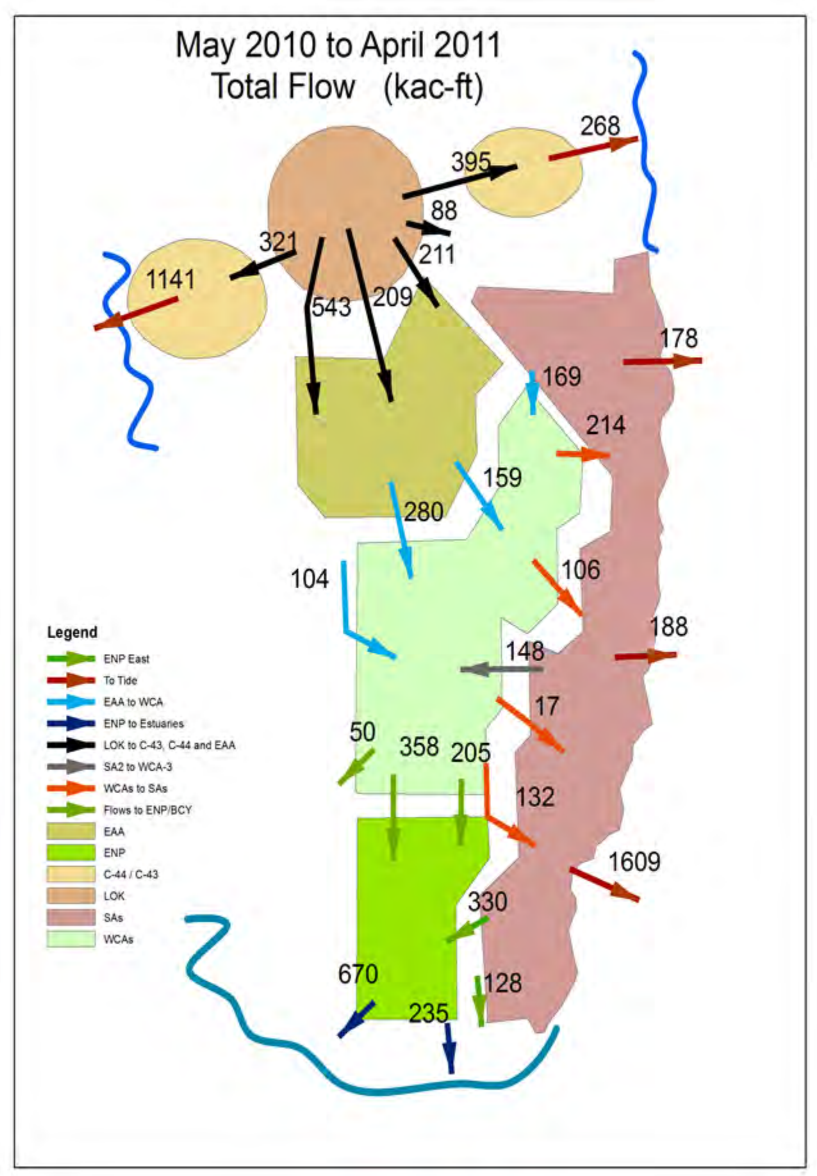


Figure 9. Surface water flows through the Everglades during WY2011.

Hydrologic Context for the System-wide Ecological Indicators Water Years 2010 – 2011

Northern Estuaries

In spite of the growing drought conditions during WY2011, the Caloosahatchee and St. Lucie canals experienced inflows that were near normal because of the rapid increases in Lake Okeechobee water levels in the prior WY2010. Again, each of these downstream estuaries has a defined range of target flows that support healthy estuarine plant and animal communities. The flow targets and the WY2011 average monthly flows are summarized in Figure 7 (see the green values in the two panels). The WY2011 average monthly flows out of the Caloosahatchee River and into the downstream estuary were within the prescribed 450-2,800 cfs optimal flow range for only 3 months of the year, below the low flow target for 7 months, and above the high flow target for 2 months (green values, left panel). The WY2011 average monthly flows out of the St. Lucie catchment and into the downstream estuary were within the prescribed 350-2,000 cfs optimal flow range during 5 months of the year and below the low flow target for 7 months of the year (green values, right panel). In general, the flow targets to protect eastern oysters and seagrass in these two estuaries were not met in WY2011 because of extreme high and low flow events in the Caloosahatchee, and persistent low freshwater inflows into the St. Lucie. See the sections on eastern oyster restoration targets and performance measures for the Northern Estuaries for more details.

Southward Flows (to the EAA, WCAs, LEC, and ENP/Southern Estuaries)

In spite of the reduced rainfall, flows from Lake Okeechobee southward into the EAA were slightly higher than normal during WY2011 (Figures 5 and 9). Discharges from the EAA into the WCAs were also close to normal, and slightly above normal flows went out of the WCAs and into the LEC. Flows into Everglades National Park, Florida Bay, and Biscayne Bay were also close to normal. Only the surface water flows into the southwest coastal estuaries showed a significant reduction (Figures 5 and 9).

Everglades Wetlands

The WY2011 water depth conditions started out wetter than normal, with persistent surface water present throughout the 2010 dry season in the Loxahatchee NWR, and in WCA-2A, WCA-3A, WCA-3B, and Everglades National Park. Surface water was just beginning to disappear in the northern portions of the WCAs and over much of Everglades National Park, particularly in the higher elevated marl prairies. The persistence of dry season surface water over much of the Everglades is an indication of the carry-over effect that El Niño events can have on south Florida's hydrology. The water depth conditions in late October 2010 indicate that by the end of the wet season, nearly the entire Everglades were inundated, except for the slightly higher elevated marl prairies in Everglades National Park.

October 2010 water depths in the Loxahatchee NWR, WCA-2A, and WCA-3A were similar to October 2009, and ranged from less than 0.5 foot in their upstream higher elevated areas to more than 3.0 feet in the lower ponded downstream areas adjacent to levees. Again, water depths in WCA-3B and Shark River Slough generally remained below 1.5 feet. By contrast, the water depth conditions in mid-May 2011 were much lower than in May 2010, and persistent surface water was generally limited to the WCAs in the areas just upstream of levees. Within Everglades National Park, dry season water depths were generally well below the ground surface, particularly in the higher elevated marl prairies. The loss of persistent surface water over most of the Everglades is a good indication of the role of La Niña events on south Florida's hydrology. Hydroperiods of 330 to 365 days were present only in the deeper ponded areas adjacent to levees in WCA-2A, WCA-3A, and the Loxahatchee NWR, while northern WCA-3A, WCA-3B, and central Shark River Slough generally had hydroperiods of 240 days or less and the higher marl prairies had hydroperiods of 120 days or less.

Ecological Bottom Line for WY2011

While water levels in Lake Okeechobee fell by more than 3.5 feet over WY2011, they were generally within the favorable range for littoral zone and open-water vegetation. Surface water flows down the Caloosahatchee and St. Lucie canals were highly variable and below their target ranges for more than half of WY2011, which can be harmful to eastern oysters and seagrass communities in these estuaries. Within the Everglades, there was less persistent marsh inundation needed to sustain organic/peat soils and the abundance of marsh fish and invertebrates. Extended periods of high water were only present in the deeper ponded areas of the WCAs adjacent to their downstream levees. Abnormally low water for much of WY2011 prevented high water damage to tree islands during the wet season. Good water level recessions for wading bird foraging and nesting began in November 2010 and lasted for many months, and minimal water level reversals occurred during the dry season foraging and nesting period.

Hydrologic Context for the System-wide Ecological Indicators Water Years 2010 – 2011

Water Year 2012 (Continuation of La Niña Conditions)

Rainfall and Surface Water Flows

Water year 2012 represented a continuation of the La Niña drought conditions from WY2011, and signaled a possible trend, with four of the last five years experiencing a rainfall deficit across south Florida (South Florida Environmental Report, SFWMD 2013). The 2012 wet season had slightly lower than normal rainfall, until a series of three high rainfall events in October. The 2012 dry season continued this drought trend, except for a wetter than normal April. Overall, WY2012 ended with 93 percent of normal rainfall across south Florida (South Florida Environmental Report, SFWMD 2013). A simplified surface water budget for the Everglades during WY2012 is presented in Figure 11. Surface water flows into Lake Okeechobee more than doubled in WY2012 versus WY2011 as a result of the high rainfall events in October 2011, but still remained less than normal. Outflows to the Caloosahatchee and St. Lucie canals were highly variable, but ended the year well below normal. The persistent drought conditions led to agricultural and urban water restrictions, and inflows to the EAA were reduced to slightly over 50 percent of the 2000-2012 average. Outflows to the WCAs were also well below normal, as were the outflows from the WCAs to the LEC and Everglades National Park.

Lake Okeechobee

Lake Okeechobee water levels started out the water year at 10.92 feet in May 2011, but dropped to 9.53 feet in late June due to below normal rainfall and increased water demands (South Florida Environmental Report, SFWMD 2012). The continuing drought conditions kept the Lake levels low throughout most of the wet season, until the three high rainfall events in October 2011. Water levels in the Lake increased by over 2.5 feet in October to reach 13.87 feet, which was the maximum for the water year. Lake levels changed quickly during the wet season but remained well below normal throughout WY2012. Water levels fell within the ecologically opti-

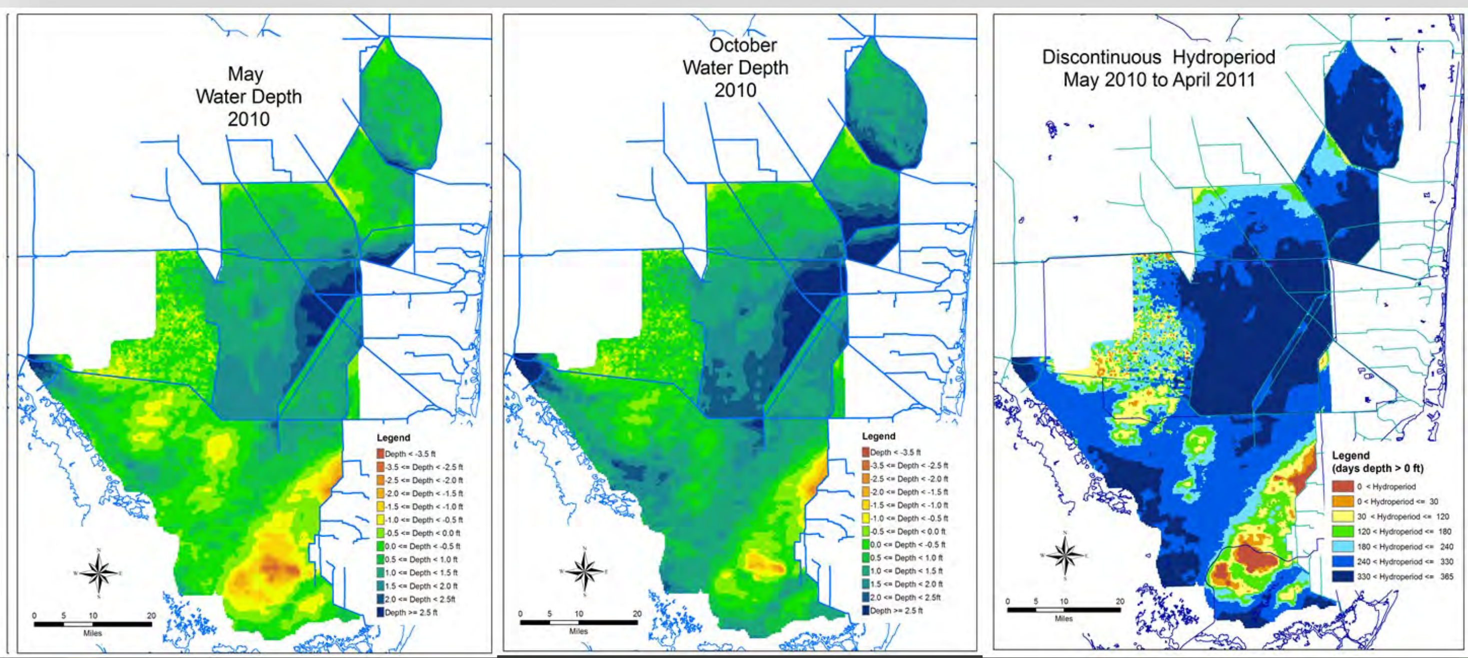


Figure 10. Water Depths and Hydroperiods during WY2011 (May 2010 through April 2011). May 2010 (left) represents the water depth conditions in the Everglades at the end of the prior dry season. October 2010 (center) represents the water depth conditions in the Everglades at the peak of the 2010 wet season. The May 2010 to April 2011 hydroperiod map (right) represents the total number of days that water was above the ground surface (flooding duration) during WY2011. Appendix A shows the difference maps comparing the water depths and hydroperiods in WY2011 to the average conditions experienced between 2000-2011. Blues and greens indicate wetter areas or longer hydroperiods, while yellows, oranges, and browns indicate drier areas or shorter hydroperiods. Source: Adapted from the Everglades Depth Estimation Network, USGS.

mum range during the period from mid-October through early April, and were below this optimal range throughout the remainder of the wet season.

Northern Estuaries

As stated previously, the Caloosahatchee and St. Lucie canals experienced well below normal inflows from Lake Okeechobee during WY2012. Flows from the upstream Caloosahatchee and St. Lucie basins into the downstream estuaries were also lower than normal during WY2012 because of reduced local rainfall. Again, each of these downstream estuaries has a defined range of target flows that support healthy estuarine plant and animal communities, and the flow targets and the WY2012 average monthly flows are summarized in Figure 7 (see the blue values in the two panels). The WY2012 average monthly flows out of the Caloosahatchee canal and into the downstream estuary were within the prescribed 450-2,800 cfs optimal flow range for 7 months of the year, and below the low flow target for the remaining 5 months (blue values, top panel). The WY2012 average monthly flows out of the St. Lucie canal and into the downstream estuary were within the prescribed 350-2,000 cfs optimal flow range during only 4 months of the year, and below the low flow target for 8 months of the year (blue values, bottom panel). In general the flow targets to protect eastern oysters and seagrass in these two estuaries were not met in WY2012 because of persistently low freshwater inflows into the Caloosahatchee and St. Lucie estuaries. See the sections on eastern oyster restoration targets and performance measures for the Northern Estuaries for more details.

Southward Flows (to the EAA, WCAs, LEC, and ENP/Southern Estuaries)

Flows from Lake Okeechobee southward into the EAA were well below normal during WY2012 (Figures 5 and 11). Discharges from the EAA into the WCAs were also close to normal, and slightly above normal flows went out of the WCAs and into the LEC. Flows into Everglades National Park, Florida Bay, and Biscayne Bay were also close to normal. Only the surface water flows into the southwest coastal estuaries showed a significant reduction (Figures 5 and 11).

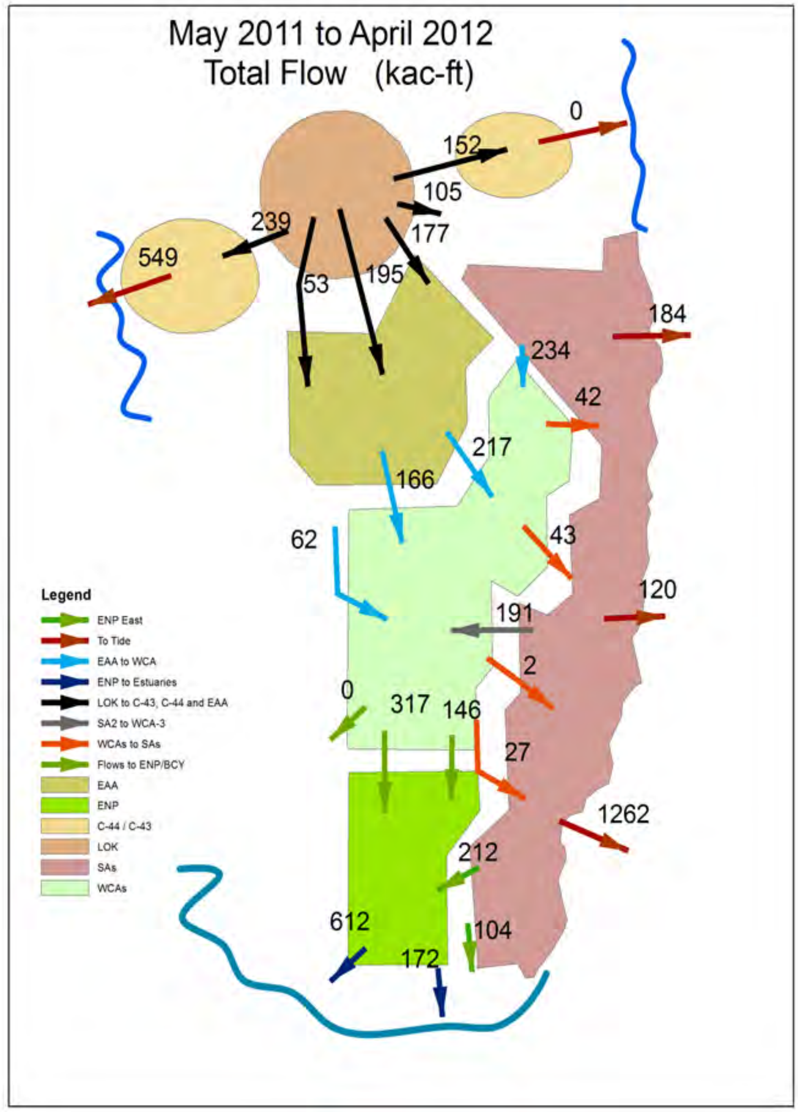


Figure 11. Surface water flows through the Everglades during WY2012.

Hydrologic Context for the System-wide Ecological Indicators Water Years 2010 – 2011

Everglades Wetlands

The water depth conditions at the beginning of WY2012 indicate that most of the Everglades were quite dry, with surface water confined to the downstream portions of the Loxahatchee NWR, the WCAs, and a small area south of the S-12s within Everglades National Park (Figure 12). Water levels rose in response to the high rainfall in October 2011, so that by the end of the wet season, nearly the entire Everglades was inundated, except for the slightly higher elevated marl prairies in Everglades National Park. October 2011 water depths ranged from 1.0 foot in their upstream higher elevated areas in the WCAs to more than 2.5 feet in the lower ponded downstream areas adjacent to levees. Again, wet season water depths in WCA-3B and Shark River Slough generally remained below 1.0 foot. By contrast, the water depth conditions in mid-May 2012 were slightly higher than in May 2011, and persistent surface water still covered most of the Loxahatchee NWR, WCA-2A, and WCA-3A. Within Everglades National Park, dry season water depths were generally below the ground surface, particularly in the higher elevated marl prairies. This continuing loss of persistence of surface water in large portions of the Everglades is a good indication of the role of a continuing drought condition in south Florida. Hydroperiods in the deeper areas of WCA-2A, WCA-3A, and the Loxahatchee NWR attained flooding durations of 240 and 365 days, longer than in WY2011, while northern WCA-3A, WCA-3B, and central Shark River Slough generally had hydroperiods of 180 days or less, and the higher marl prairies had hydroperiods of 120 days or less.

Ecological Bottom Line for WY2012

While water levels in Lake Okeechobee were very low throughout the year, they were within the favorable range for littoral zone and open-water vegetation from mid-October 2011 to early April 2012. The lower Lake water levels translated into much lower surface water flows down the Caloosahatchee and St. Lucie canals. These basins were below their coastal outflow target ranges for more than half of WY2012, which can produce salinity conditions that are harmful to eastern oysters and seagrass communities in these estuaries. Within the Everglades, the loss of surface water inundation over much of the 2011 dry season and early wet season caused the marsh to drop below the conditions needed to sustain organic/peat soils and the recovery of marsh fish and invertebrates. The low water for much of WY2012 did limit high water damage to tree islands during the wet season. Good water level recessions for wading bird foraging and nesting occurred within much of the WCAs during WY2012, but in Everglades National Park the drydown was very rapid, and the complete drydown of the marshes lasted for several months. eliminating wading bird foraging.

While drydowns are a natural part of Everglades ecosystem dynamics and can be beneficial to certain tree island plant species, intense or prolonged drydowns can have significant impacts on Everglades organic/peat soils, periphyton production, and the abundance of marsh fish and invertebrates, reducing their numbers, and in turn reducing success of the animals that feed on them (alligators and wading birds). These impacts may be observed immediately and for years after such an event. In addition, intense drydowns in the peat forming areas of the Everglades lead to soil subsidence and increased fire threats and increased potential for colonization by invasive exotic plant species. Natural drydowns are expected during La Niña events (such as in water years 2011 and 2012), but these conditions can be made even more extreme when surface water flows through the Everglades are also reduced. See the later indicator sections for more details.

Hydrologic Context for the System-wide Ecological Indicators Water Years 2010 – 2011

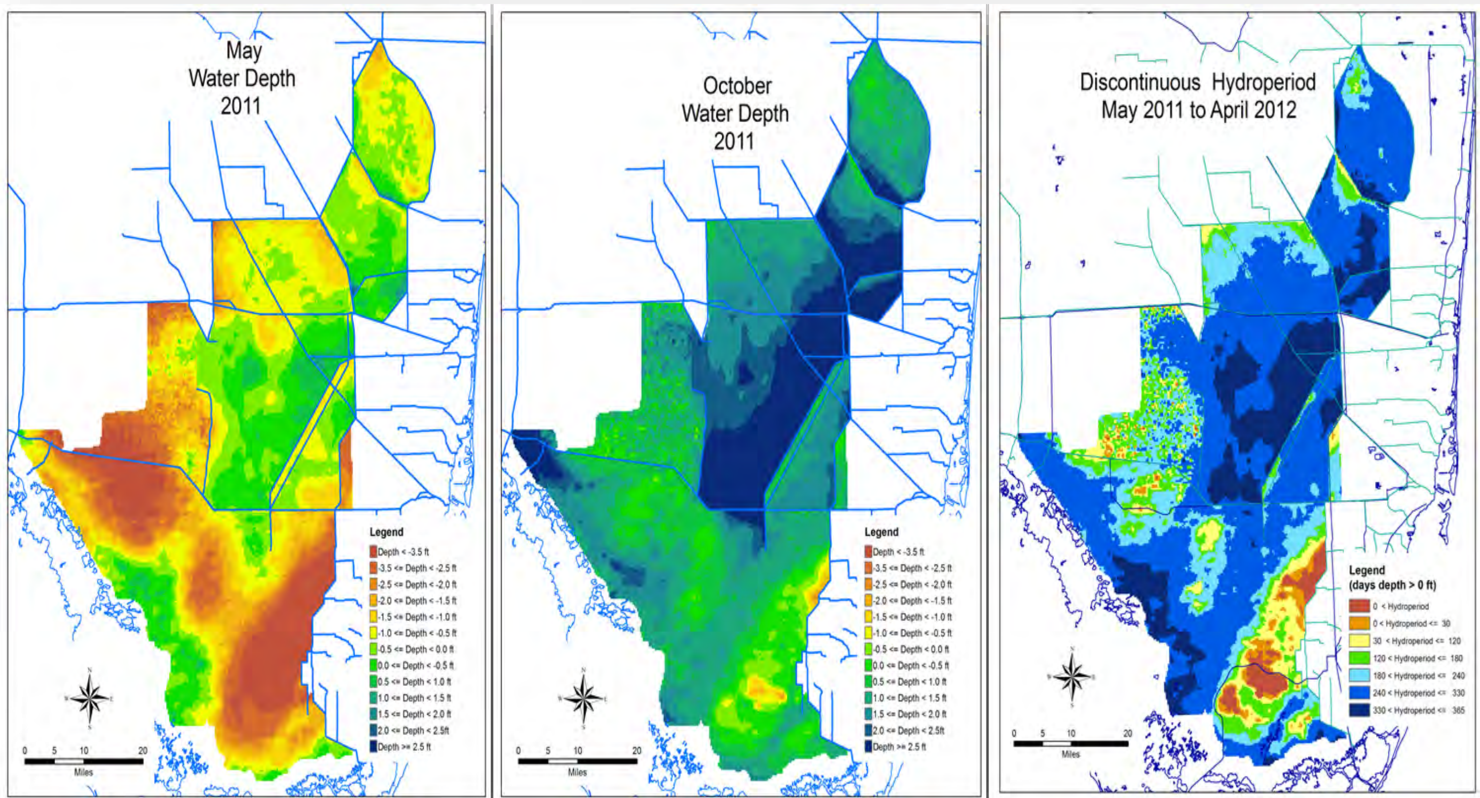


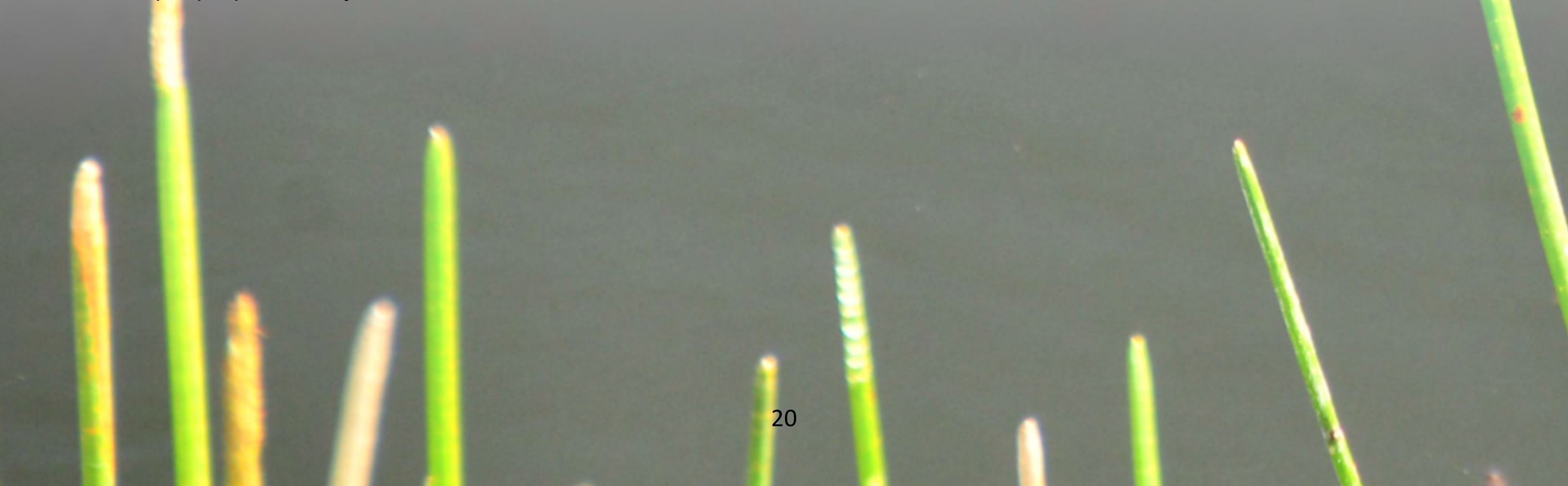
Figure 12. Water Depths and Hydroperiods during WY2012 (May 2011 through April 2012). May 2011 (left) represents the water depth conditions in the Everglades at the end of the prior dry season. October 2011 (center) represents the water depth conditions in the Everglades at the peak of the 2011 wet season. The May 2011 to April 2012 hydroperiod map (right) represents the total number of days that water was above the ground surface (flooding duration) during WY2011. Appendix A shows the difference maps comparing the water depths and hydroperiods in WY2012 to the average conditions experienced between 2000-2011. Blues and greens indicate wetter areas or longer hydroperiods, while yellows, oranges, and browns indicate drier areas or shorter hydroperiods. Source: Adapted from the Everglades Depth Estimation Network, USGS.

Stoplight Format

Our integrated summary uses colored traffic light symbols that have a message that is instantly recognizable, easy to comprehend, and is universally understood. We used this stoplight restoration report card communication system as a common format for all eleven indicators to provide a uniform and harmonious method of rolling-up the science into an uncomplicated synthesis. This report card effectively evaluates and presents indicator data to managers, policy makers, and the public in a format that is easily understood, provides information-rich visual elements, and is uniform to help standardize assessments among the indicators in order to provide more of an apples-to-apples comparison that managers and policy makers seem to prefer (Schiller et al. 2001, Dennison et al. 2007).

Research and monitoring data are used to develop a set of metrics for each indicator that can be used as performance measures (for example, the number of alligators per kilometer) for the indicator, and to develop targets (for example, 1.7 alligators per kilometer) that can be used to link indicator performance to restoration goals. These metrics and targets are different for each indicator. The stoplight colors are determined for each indicator using 3 steps. First, the ecological status of the indicator is determined by analysis of quantifiable data collected for each performance measure for each indicator (for example, the data might show that on average there are 0.75 alligators per kilometer). The status of each performance measure is then compared to the restoration targets for the indicators (for example, our target for restoration might be 1.7 alligators per kilometer). The level of performance is then compared to the thresholds for success or failure in meeting the targets and a stoplight color is assigned (for example, 0.75 alligators per kilometer indicates a low number of alligators compared to the target of 1.7 per kilometer and might result in a red stoplight being assigned for this performance measure). These numbers are used for example purposes only.

All of the stoplights were developed directly from the scientific data and the colors of the stoplights—red, yellow, or green—were determined using clear criteria from the results of the data. Because the report is purposely short and succinct, it was not possible to provide information on the approaches used for each indicator in determining thresholds for the individual colors. However, the assessments clearly show how the scientific findings relate directly to the color of the stoplights, providing a transparency from empirical field data to summary data and graphics and then to the stoplight color. Future activities by stoplight indicator scientists will include updating data to present condition, examining needed adjustments in the stoplights, and an analysis of the stoplight sensitivity to change in environmental condition allowing the scientists to know how quickly the stoplights will respond to improved environmental conditions.



Stoplight Format

Further Indicator Details

This 2012 Report includes a stoplight/key summary status report for each indicator. For more detailed information on these indicators please refer to references listed in each indicator section (if applicable), the Special Issue of Ecological Indicators: Indicators for Everglades Restoration (2008), the System-wide Ecological Indicators for Everglades Restoration 2010 Report (www.sfrestore.org/documents.html), and the RECOVER System Status Report (SSR) which addresses the overall status of the ecosystem relative to system-level hypotheses, performance measures, and restoration goals. The 2009 and 2012 SSRs provide an integrated assessment of RECOVER's Monitoring and Assessment Plan (MAP) and non-MAP data, spans multiple spatial scales, and in some cases decades worth of information. Because of the broad intergovernmental coordination, the SSR incorporates elements of the stoplight indicator update and provides the detailed underlying, data, theory, and analyses used in this report. The 2009 and 2012 SSRs are available on an interactive web page that allows managers, stakeholders, and scientists with varying interests and degrees of technical expertise to easily find the information they need (www.evergladesplan.org/pm/ssr_2009/ssr_main.aspx). This combination of indicator reports will provide managers with information they need to adjust restoration activities at both large and small scales.

Stoplight Legend

Red Substantial deviations from restoration targets creating severe negative condition that merits action.

Yellow Current situation does not meet restoration targets and may require additional restoration action.

Green Situation is within the range expected for a healthy ecosystem within the natural variability of rainfall. Continuation of management and monitoring effort is essential to maintain and be able to assess "green" status.

Clear Data have been collected but not processed yet.

Black No data or inadequate amount of data were collected due to lack of funding.

Trend Horizontal Arrow, indicator is stable; Up Arrow, indicator is improving; Down Arrow, indicator is declining.

Indicators Overview

What the stoplights represent and why these organisms are important as ecological indicators for system-wide assessment of restoration [see *Ecological Indicators* Special Issue (Vol 9, Supplement 6 November 2006) for more details].

Invasive Exotic Plants

- Exotic plants are an indicator of the status of the spread of invasive exotic plants and an indicator of progress in their control and management.
- Exotic plant distribution is used as an assessment of the integrity of the natural system and native vegetation.
- Exotic plants can cause ecological changes; therefore, prevention, control, and management are key to restoration of the ecosystem.

Lake Okeechobee Nearshore Zone Submersed Aquatic Vegetation

- The Lake's SAV community provides habitat for fish and wildlife, stability for sediments, and improves water quality.
- A healthy SAV community directly corresponds to healthy Lake conditions.
- The SAV community is directly influenced by hydroperiod, nutrients, and water quality.

Stoplight colors for Lake Okeechobee nearshore SAV indicators consist of two performance measures; total area of summer SAV coverage (in acres, $\geq$ 40,000 is target) and percent of SAV comprised of vascular taxa ($\geq$50% is target). These data are derived from the annual summer nearshore SAV mapping project.

Eastern Oysters

- Oysters provide essential habitat for many other estuarine species.
- Oysters improve water quality by filtering particles from the water.
- Water quality, particularly salinity, is directly correlated to the physical health, density, and distribution of oysters in the estuaries.
- Hydrological restoration in the estuaries should improve the overall distribution and health of oyster reefs.

Crocodilians (American Alligators & Crocodiles)

- Crocodilians are top predators in the food web affecting prey populations.
- Alligators are a keystone species and ecosystem engineers.
- Growth and survival rates of crocodilians are directly correlated with hydrology.
- Crocodilians integrate the effects of hydrology in all their life stages.

Stoplight colors for both the alligator and crocodile indicators incorporate current values, average values, and trends of performance measures over the last 3 or 5 years. For alligators, the performance measures are relative density (#/km), body condition, and occupancy of alligator holes in Everglades National Park measured over the last 5, 3, and 3 years, respectively. For crocodiles the performance measures are juvenile growth and survival measured over the last 3 and 5 years, respectively.

Fish and Macroinvertebrates

- They are critical as a food for predators such as wading birds and alligators.
- Their density and community composition are correlated with hydrology.
- They integrate the effects of hydrology in all their life stages.
- The positive or negative trends of this indicator relative to hydrological changes permit an assessment of positive or negative trends in restoration.

Periphyton & Epiphyton

- Periphyton is comprised of microbes that form the base of the food web.
- Periphyton is an abundant and ubiquitous Everglades feature that controls water quality and soil formation.
- The abundance and composition of periphyton is directly tied to water quality and quantity.
- The nutrient concentration of periphyton is a direct indication of upstream nutrient supply.
- Periphyton responds very quickly (days) and predictably to changes in environmental conditions and serves as an "early-warning-indicator."

Indicators Overview

Stoplight colors for periphyton are based on deviation from expected values for abundance, nutrient (phosphorus) concentration, and abundance of weedy diatom algae species. For each parameter, yellow and red are indicated for values more than one and two standard deviations from mean expected values, respectively. For each wetland basin, yellow is indicated if greater than 25% of sample sites are yellow or red, and red is indicated if greater than 50% of sites are red. Expected values are calculated from the long-term average values from least disturbed sites in each wetland basin.

Wading Birds (White Ibis and Wood Stork)

- Large numbers of wading birds were a defining characteristic of the Everglades.
- Their different foraging strategies indicate that large spatial extent and seasonal hydrology made it possible for the historic Everglades to support vast numbers of wading birds.
- Timing of nesting is directly correlated with water levels and timing of the availability of prey.
- Nesting success is directly correlated with water levels and prey density.
- Restoration goals for ibis and storks include recovering spatial and temporal variability to support large numbers of wading birds, restored timing of nesting, and restored nesting success

Southern Estuaries Algal Blooms

- The Southern Estuaries Algal Bloom indicator reflects the overall water quality condition within south Florida estuaries and coastal waters from the Ten Thousand Islands to Florida Bay to Biscayne Bay.
- Improved freshwater flows and healthy SAV are expected to significantly reduce the number, scale, and time-span of algal blooms and provide an important indicator of the overall health of the bays.

Thresholds for this indicator's stoplight colors were developed from long term chlorophyll *a* concentrations (CHLA) data (1989-present) collected monthly at large spatial scale. Chlorophyll *a* concentrations reflect algal biomass. The median and quartiles of CHLA were calculated to quantify the reference conditions for the ten subregions of the southern estuaries. These reference conditions were then used to establish criteria from which the status of CHLA and thus water quality in each of the subregions can be evaluated on an annual basis. If the annual median CHLA concentration is greater than the reference median, but lower than the 75th percentile, the subregion is marked yellow and if the annual median concentration is greater than the 75th percentile of the reference, the subregion is marked red.

Florida Bay Submersed Aquatic Vegetation

- Florida Bay has one of the largest seagrass beds in the world, covering 90% of the 180,000 hectares of the bay.
- Submersed aquatic vegetation serves many critical functions within estuarine and coastal ecosystems, such as habitat, food, and water quality.
- The SAV community is correlated to upstream hydrology and water quality.
- Florida Bay SAV condition is an important indicator for ecosystem restoration because the bay is located at the bottom of the hydrological system.

Juvenile Pink Shrimp

- Pink shrimp are an important and characteristic component of the estuarine fauna of the Everglades.
- Pink shrimp abundance is correlated to freshwater flow from the Everglades.
- Growth and survival of juvenile pink shrimp are influenced by salinity and are good indicators of hydrological restoration for the estuaries.
- Pink shrimp were found to be more closely correlated with salinity and seagrass (SAV) conditions than 29 other estuarine species evaluated.

Wading Birds (Roseate Spoonbill)

- Spoonbill responses are directly correlated to hydrology and prey availability.
- Spoonbills time their nesting to water levels that result in concentrated prey.
- Availability of Spoonbill prey is directly correlated with hydrology.
- Positive or negative trends of this indicator relative to hydrological changes permit an assessment of positive or negative trends in restoration.

Indicators Overview

Indicators at a Glance

This is a snapshot of the status of each indicator by geographic region (listed from north to south) for the last five years. Results shown here are consistent with an assessment done by the National Research Council (2012), reflecting the continued patterns of severely altered hydrology throughout the ecosystem. An exception is WY2011 in Lake Okeechobee where the Nearshore Zone Submersed Aquatic Vegetation exceeded the target level because of successive years where the Lake was near or below the lower end of the ecologically desired stage envelope with concomitant improved light penetration.

	Water Year 2008	Water Year 2009	Water Year 2010	Water Year 2011	Water Year 2012
Lake Okeechobee					
Invasive Exotic Plants Species					
Lake Okeechobee Nearshore Zone Submersed Aquatic Vegetation					
Northern Estuaries					
Invasive Exotic Plant Species					
Eastern Oysters					
Greater Everglades					
Crocodilians					
Fish and Macroinvertebrates (WCA-3 and ENP only)					
Invasive Exotic Plants					
Periphyton and Epiphyton					No species composition data
Wading Birds (White Ibis and Wood Stork)					
Southern Coastal System					
Crocodilians					
Southern Estuaries Algal Blooms**					
Florida Bay Submersed Aquatic Vegetation					
Invasive Exotic Plants					
Juvenile Pink Shrimp*	Data used as base	Data used as base	Data used as base		
Wading Birds (Roseate Spoonbill)					Prey community data not yet processed
Wading Birds (White Ibis and Wood Stork)					

*The status Juvenile Pink Shrimp contains information for data collected for September-October.

**Algal bloom indicator values are for calendar years 2007 through 2011, roughly corresponding to the water years shown.

Indicators Overview

Helpful Hints for Reading the Indicators

Within the system-wide indicator tables, stoplights are presented for water years 2008-2012 (WY2012 ends April 30, 2012). The trend column provides information that reflects best professional judgment on the direction that indicator will go in the next two years taking into account what we know about past performance of the indicator, projected CERP project implementation, and assuming no major natural or human caused disturbances.

The stoplight colors and trend arrows should be interpreted together to get a full understanding of what the indicator is saying about restoration progress and potential directions for restoration priorities. The stoplights show how the indicators have responded while the trend arrow provides insight for assessing what may happen in the future. These communication tools may help highlight where our investments may be most needed or where an adjustment in management strategy is needed. For example, an indicator with a yellow stoplight and a downward trend may merit additional or more urgent action than one with a red stoplight and an improving trend.

Invasive Exotic Plant Indicator

Summary Findings

Quantitative information on the status of invasive exotic species and the effectiveness of management program is limited in many parts of the south Florida environment. Here we assess the status of priority invasive plant species within eight subregions of south Florida (based on RECOVER modules) using various sources of information including local expert knowledge, SFWMD monitoring information, and reports from cooperating agencies. All regions have control programs for high priority invasive plant species on public and tribal lands, and progress toward control continues for some species such as melaleuca and Australian pine. Excellent coordination among land managers and researchers is yielding successes towards containment and control of many invasive species, particularly new introductions. In addition, the development and implementation of biological controls and other control techniques continue to improve regional invasive plant programs.

Unfortunately, many serious invaders remain problematic in most regions. For example, Brazilian pepper and Old World climbing fern continue to expand, presenting a significant threat to the ecological integrity of Everglades tree islands and other plant communities. Stagnant or decreasing funding for invasive plant management may set back recent achievements in controlling some priority species. While systematic aerial monitoring programs are established for several regions, much-needed ground-based monitoring is lacking. Such monitoring programs would help land managers contain the spread of invasive species to new areas. Finally, invasive plant management on private lands remains deficient in all regions, ensuring continued invasion vulnerability to conservation lands.

Key Findings

- Most of the regions have serious invasive exotic plant problems, which are affecting natural areas and altering natural habitats and processes. Control of invasive plants is successful for a few species, but only locally on some public lands.
- The responses of invasive plants to ecosystem restoration vary strongly by species. Hydrologic change initiated by ecosystem restoration may inhibit the invasive potential of some species while simultaneously creating niches for new invaders. For example, the aggressive expansion of Peruvian primrose willow on the Kissimmee River floodplain is attributed to lengthened hydroperiods.
- Three biological control agents for melaleuca are well established, and melaleuca reduction is documented. One agent for Old World climbing fern is established in some areas where it exerts pressure on the invasive fern.
- New biological control agents have been released for several other serious invasive plants, and other agents are in development for release within 1-2 years. Completion of the CERP biological control facility is anticipated in early 2013. The project will further successes in biological control throughout south Florida.
- Monitoring that would identify new invasive species or new distributions for existing species only covers the Greater Everglades regions and portions of the Kissimmee River, Lake Okeechobee, and Big Cypress regions. Therefore, the ability to determine where and when new species arrive and establish is limited. In many cases, invasive plant populations are not being systematically monitored.
- Stagnant or reduced funding for control (e.g., Everglades National Park, Florida Fish and Wildlife Conservation Commission Invasive Plant Control, USFWS) is a serious threat to long-term management success. As maintenance control is achieved for some priority species, other species continue to expand. Through coordination and collaboration, regional land managers and scientists are looking for innovations and improved efficiencies to continue progress.
- Overall, the picture is mixed for invasive plants. Although progress has been made on a number of species, we are still unable to control many species faster than they are invading and spreading. Prevention, monitoring, and control programs would have to be expanded in order to do that.

Additional information on this indicator can be found in these documents:

Rodgers, L. M. Bodle, D. Black, and F. Laroche. 2013. Status on Nonindigenous Species. In G. Redfield (ed.), 2013 South Florida Environmental Report. South Florida Water Management District, West Palm Beach, FL.

Center, T. D., M. F. Purcell, P. D. Pratt , M. B. Rayamajhi, P. W. Tipping, S. A. Wright, and F. A. Dray. 2012. Biological control of Melaleuca quinquenervia: an Everglades invader. BioControl 57 (2): 151-165.

Doren, R. F., J. C. Volin, and J. H. Richards. 2009. Invasive exotic plant indicators for ecosystem restoration: An example from the Everglades restoration program. Ecological Indicators 9(6): S29-S36.

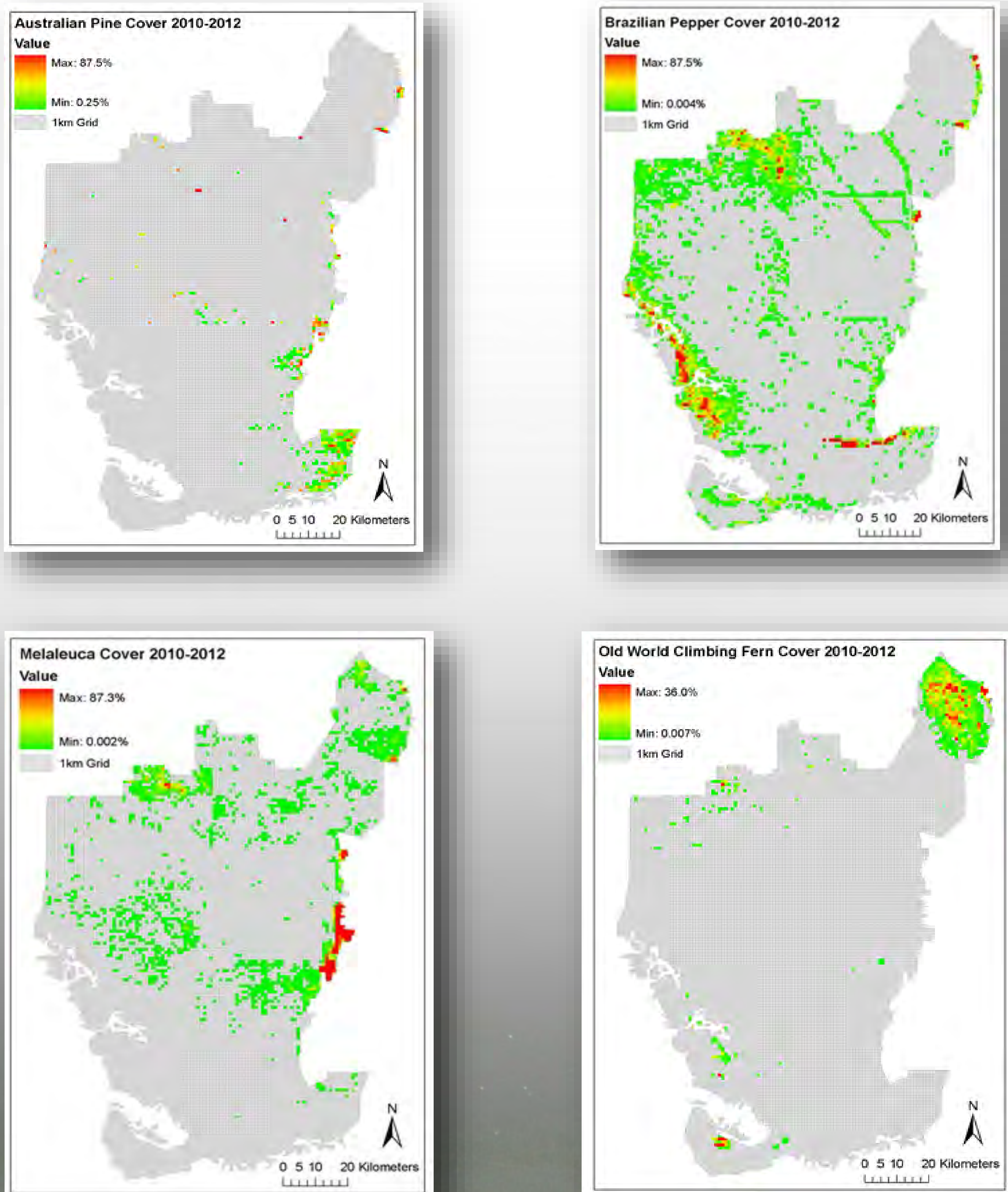


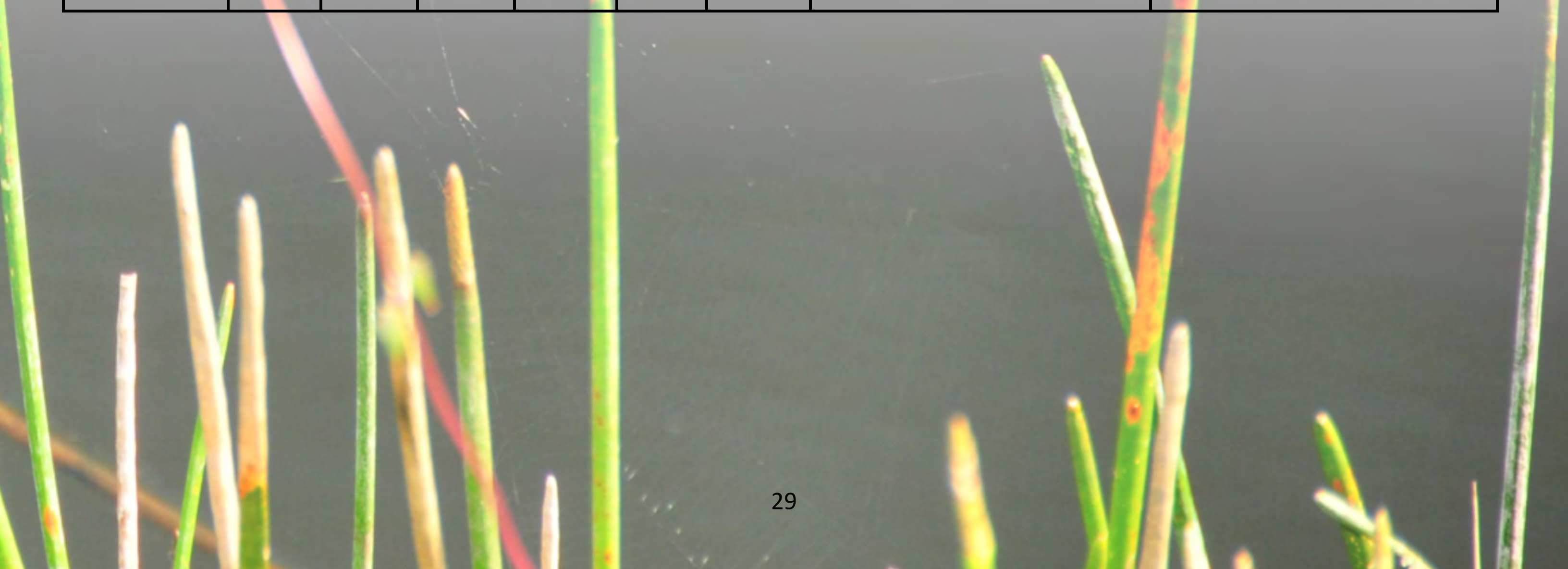
Figure 13. Exotic plant cover 2010-2012

Invasive Exotic Plant Indicator

LOCATION	WY 2008	WY 2009	WY 2010	WY 2011	WY 2012	Trend	CURRENT STATUS	2 year prospectus
Kissimmee River	●	●	●	●	●	↔	The Good: Successful control programs for water hyacinth, water lettuce, and melaleuca. Biological control agents for melaleuca well established. The Bad: Old World climbing and Brazilian pepper aggressively invading many areas within the river basin. Invasive grasses, including paragrass and limpograss, abundant in restoration areas, slowing the establishment of native flora.	Changes in hydrology within the floodplain are helping to limit the spread of some invasive plants, but are simultaneously creating habitat for other serious invaders (e.g., hydrilla, limpograss, water hyacinth), some of which may impact restoration goals. The lack of promising control strategies and limited funding for Old World climbing fern suggests that this species will continue to spread
Lake Okeechobee	●	●	●	●	●	↔	The Good: Existing melaleuca control program achieving maintenance control. Efforts to control dense stands of torpedo grass fostering recovery of native flora and increased wading bird habitat in some areas. The Bad: Invasive grass species expanding in the western marsh; Sustained control of these species is necessary to limit spread. Increased management challenges for floating aquatic weeds.	Ecological stresses from invasive plant species are likely to continue in the Lake's littoral zone. Reestablishment and spread of invasive grasses is expected given recent droughts. Controlling floating aquatic weeds in bulrush marsh will continue to pose management challenges.
Northern Estuaries--East Coast	●	●	●	●	●	↑	The Good: Melaleuca, Brazilian pepper, and Australian pine successfully managed on public lands. Biological control agents are exerting pressure on melaleuca and Old World climbing fern. Recent improvements in control techniques for downy rose-myrtle. The Bad: Old World climbing fern continues to aggressively re-invade previously treated areas. Cogongrass apparently expanding but this and other species not included in indicator monitoring programs.	Continued progress with biocontrol of melaleuca and Old World climbing fern is expected. Recent reductions in management resources may result in increasing ecological impacts from invasive species.

Invasive Exotic Plant Indicator

LOCATION	WY 2008	WY 2009	WY 2010	WY 2011	WY 2012	Trend	CURRENT STATUS	2 year prospectus
Northern Estuaries-- West Coast							**The Good**: Much progress made with floating aquatic weeds, melaleuca, and Australian pine, but significant infestations remain on private lands. **The Bad**: Brazilian pepper abundant on some public lands and widespread on private lands. Most species not included in indicator monitoring program; Little known about many invaders and not able to assess their status in an objective or systematic way.	Successes on public lands with several species are offset by increases in new species. Other species localized but numerous. Potentially serious invaders exist for which little is known about biology or spread. Monitoring programs are needed to improve management success.
Big Cypress							**The Good**: Melaleuca and Australian pine well controlled in most areas; Biological control on melaleuca very successful; Aggressive control programs for Brazilian pepper and Old World climbing fern underway; Systematic monitoring program in place; No new serious invaders detected. **The Bad**: Substantial infestations of Brazilian pepper in the Picayune Strand and Big Cypress National Preserve; Cogongrass expanding in some areas.	Continued systematic control of the most serious invaders expected on public lands. Maintenance control is anticipated for melaleuca, Australian pine, and Old World climbing fern in Big Cypress National Preserve. Aggressive control efforts within Picayune Strand expected to continue. Substantial infestations of invasive plants expected to continue on private lands.



Invasive Exotic Plant Indicator

LOCATION	WY 2008	WY 2009	WY 2010	WY 2011	WY 2012	Trend	CURRENT STATUS	2 year prospectus
Greater Everglades	🟡	🔴	🔴	🔴	🔴	⇔	**The Good**: Maintenance control achieved for melaleuca, Australian pine, and Brazilian pepper in some portions of the regions. Recent control efforts in Loxahatchee NWR achieving significant reductions of melaleuca; Systematic monitoring program in place. No new serious invaders detected. **The Bad**: Aggressive spread of Old World climbing fern and Brazilian pepper threatening integrity of Everglades tree islands and other habitats. Still several other species present (e.g., shoebutton Ardisia) with little or no control effort or efficacy.	Land managers continue to implement containment strategies for melaleuca and Old World climbing fern. Stagnant or declining management resources will limit progress for Brazilian pepper and Old World climbing fern in heavily impacted areas. Aerial monitoring program will help prevent establishment of new species, but ground-based tree island monitoring lacking.
Southern Estuaries	🟡	🟡	🟡	🟡	🟡	⇧	**The Good**: Control programs under way for many years. Significant control achieved for Australian pine. Successful early detection and control of a newly detected mangrove invader. **The Bad**: Several new species invasions, and their potential impacts unclea.; Latherleaf, a serious invader of rare habitats along the southern coast of the Everglades National Park, continues to expand. Most of Florida Bay not included in any monitoring program.	Uncertainty remains regarding several species invasions and potential impacts due to lack of systematic monitoring. Focused management efforts on some public lands will continue to move toward local maintenance control of some species (e.g. Australian pine). Latherleaf, Brazilian pepper, and other coastal invaders expected to continue expansion.

Invasive Exotic Plant Indicator

LOCATION	WY 2008	WY 2009	WY 2010	WY 2011	WY 2012	Trend	CURRENT STATUS	2 year prospectus
Florida Keys						⇔	**The Good**: Much progress made on Australian pine, sickle bush, laurel fig, and other priority species. Well-developed management programs in place; Progress in developing region-wide early detection/rapid response network. **The Bad**: Populations of some priority species on private lands remain uncontrolled. Continued use of some invasive species in private landscapes. Potential expansion of Guinea grass a concern.	Effective control programs in place. Progress on many species evident, continued monitoring and control needed to prevent reinvasions and new introductions.

The following assumption is being used for the 2-Year trend column: There will be no major changes in water management or significant natural events such as hurricanes from the date of the current status assessment.

LAKE OKEECHOBEE NEARSHORE ZONE SUBMERSED AQUATIC VEGETATION INDICATOR

SUMMARY FINDING

Looking at the past five water years of SAV data for Lake Okeechobee the influence of Lake stage, species succession, and community recovery lag times are clearly visible. In WY2007 the Lake experienced a severe drought achieving the lowest Lake stage on record. The resulting lack of inundated habitat resulted in SAV missing both its areal coverage and percent vascular targets. In WY2009 and WY2010, recovery continued with areal coverage expanding until it exceeded the 40,000 acre target in WY2010. However, in both WY2009 and WY2010, the predominant SAV species was the macroalga Chara, a typical pioneering species. Colonization by vascular SAV species lagged behind Chara, so that both the areal coverage and percent vascular targets weren't achieved until WY2011. In WY2012, another drought reduced Lake levels, drying out habitat that had previously been colonized by vascular SAV, but at the same time allowing a lakeward expansion of SAV, consisting primarily of Chara. Consequently, the Lake again missed both its areal coverage and percent vascular targets.

Lake stage generally continues to be somewhat lower than the long-term mean stage over the past several decades due to a combination of the adoption of the Lake Okeechobee Regulation Schedule (LORS) operating schedule in 2008 and a series of closely spaced drought years. As a consequence, previously SAV-dominated areas inshore have become dominated by emergent and terrestrial plants. For example, approximately 4,700 acres that was open-water SAV habitat in South Bay prior to WY2008 has changed to emergent marsh habitat.

KEY FINDINGS

1. The reporting period encompassing WY2008 through WY2012 reflected a period of recovery from the drought of WY2008 following by a decline in SAV community health resulting from the return of drought conditions in WY2012.
2. Since WY2008 there has been a gradual replacement of nearshore open water SAV habitat with emergent marsh and a corresponding shift of SAV more offshore, with Chara spp. as the predominant colonizing species.
3. If the Lake continues to remain near the lower end of the desired stage envelope or lower, the enlarged marsh habitat likely will continue to occupy formerly open-water SAV habitat while SAV colonizes areas offshore that were previously too deep and light limited to support substantial underwater plant growth. This prospect is predicated on the assumption that major disturbance events such as hurricanes and droughts are infrequent.
4. Chara spp. areal coverage continues to remain similar to or higher than pre-hurricane levels. The location of Chara beds is offshore relative to its previous distribution prior to the prolonged drought of 2007-08. Chara probably will not re-colonize its previous range unless emergent and terrestrial plant densities markedly decrease, probably as a result of a return to higher Lake stages or passage of a tropical system containing strong winds.
5. Vascular SAV taxa areal coverage during this reporting period is lower than during the peak summer of WY2005. This appears to be primarily due to less nearshore colonizable area associated with lower Lake stages and lakeward expansion of

LAKE OKEECHOBEE NEARSHORE ZONE SUBMERSED AQUATIC VEGETATION INDICATOR

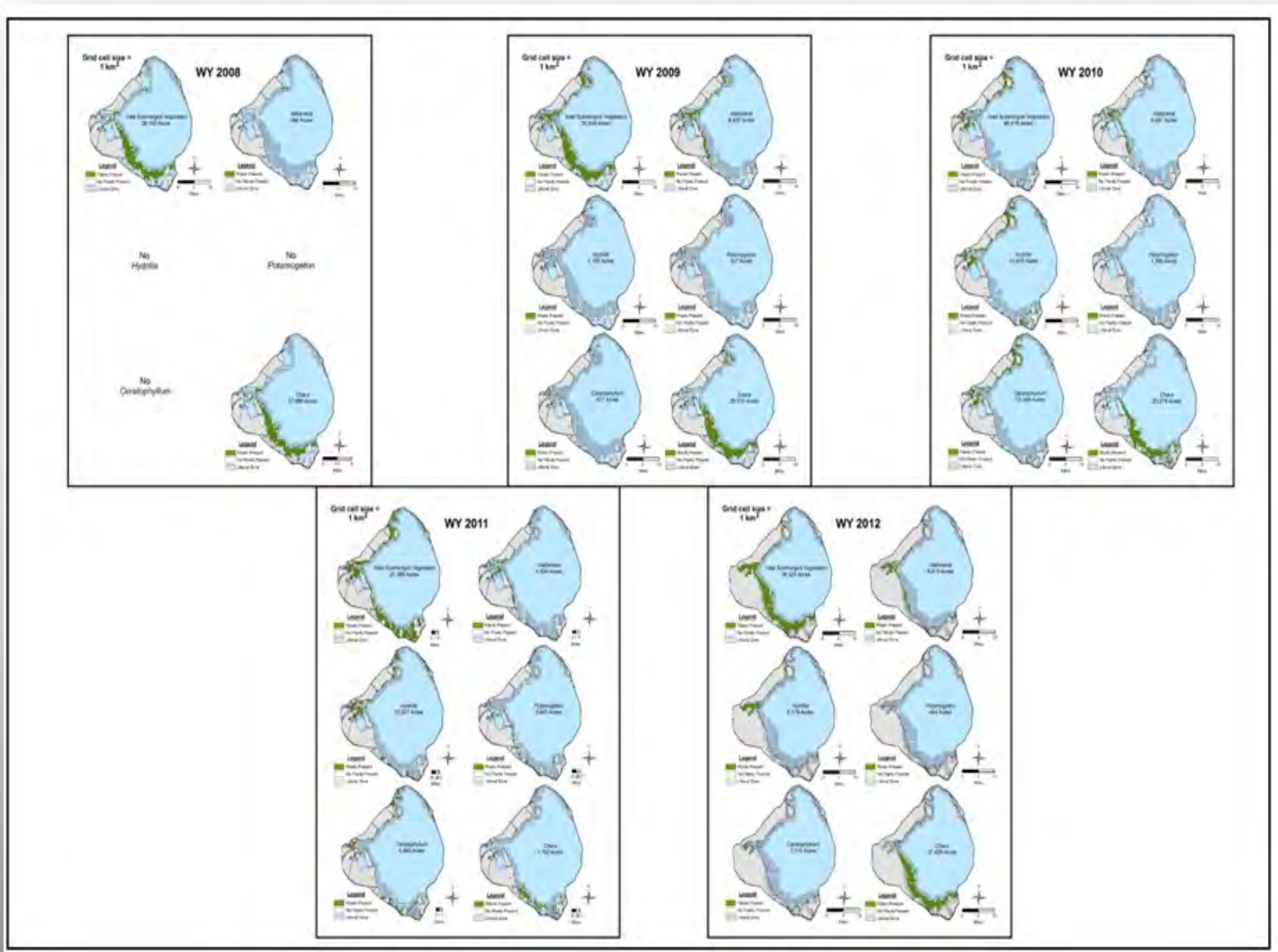
emergent marsh habitat. Potamogeton areal coverage during WY2012 was approximately 8% of that during WY2005, while Ceratophyllum and Hydrilla WY2012 areal coverage were approximately 25% of that in WY2005. Conversely, Vallisneria and Chara in WY2012 covered roughly 85% and 94% of the amount of area they covered in WY2005. In the case of Ceratophyllum, Hydrilla, and Potamogeton, it appears that these species are not colonizing further offshore at a rate proportional to their loss from nearshore open water habitat. Conversely, Chara and Vallisneria have colonized an area further offshore that is similar to the amount of nearshore habitat that has recently converted to emergent marsh habitat.

6. Keeping the Lake within the recommended stage envelope as often as possible is important for the continued reestablishment and maintenance of the vascular SAV community. The current Lake operating schedule (LORS 2008) should assist in doing this, barring the occurrence of frequent hurricane or drought events. Maintaining the preferred range of Lake stages also will enable the reestablishment of emergent vegetation in areas of the short hydroperiod marsh that have become dominated by terrestrial vegetation, and allow SAV to re-colonize areas that have become emergent marsh (although offshore beds of SAV may be lost due to increasing depth resulting in light limitation). Current risks are a) that continued low Lake stages might result in an extended recovery period once Lake levels return to more normal ranges and b) that a very rapid rise in Lake stage as occurred as a result of the hurricanes of 2004 and 2005 would nearly completely eliminate the existing submerged and emergent vegetation communities and require a multi-year recovery period before conditions could stabilize.

7. Although Lake Okeechobee SAV areal coverage and vascular, non vascular ratio is a key RECOVER performance measure the annual monitoring for this metric has always been done as an in-house effort. The SFWMD is currently reviewing all of its monitoring activities and it is therefore unclear at this time whether annual SAV mapping will remain a viable program in FY2013. However, Lake Okeechobee scientific staff have recommended to management that this program be continued.

Additional information on this indicator can be found in these documents: South Florida Environmental Reports 2008-2012 (http://www.sfwmd.gov/portal/page/portal/xweb%20about%20us/agency%20reports).

LAKE OKEECHOBEE NEARSHORE ZONE SUBMERSED AQUATIC VEGETATION INDICATOR



Figures 14: Map of Lake Okeechobee with SAV areal coverage in the nearshore region for WY 2008 through WY 2012.

LAKE OKEECHOBEE NEARSHORE ZONE SUBMERSED AQUATIC VEGETATION INDICATOR

LOCATION	WY 2008	WY 2009	WY 2010	WY 2011	WY 2012	Trend	CURRENT STATUS	2 year prospectus
Submersed Aquatic Vegetation Areal Coverage **NEAR-SHORE REGION**						↑	Submersed aquatic vegetation (SAV) coverage has varied between approximately 28,000 and 46,000 acres since WY2008. During this period, the Lake achieved its targets of 40,000 acres of SAV with 50% or more consisting of vascular species only once, in WY2011. In WY2008, WY2009, and WY2012 neither of the two performance targets was met, while in WY2010, the total acres target was met but the % vascular target was missed.	The SAV response to Lake stages within or below the Lake Stage Envelope since 2007 suggests that areal coverage will continue to be relatively high. However, since former inshore open-water SAV habitat has been replaced by emergent marsh habitat (especially in the southern area of the nearshore region) as a result of lower overall Lake stages, it is unclear whether either of the two performance measure criteria on which this metric is based will be regularly met in the future. Nevertheless, continued use of the LORS 2008 regulation schedule should mitigate in favor of Lake stages that support the maintenance of SAV habitat. However, it should be noted that neither the schedule, nor water control infrastructure of Lake Okeechobee is adequate to cope with major stochastic events such as hurricanes or droughts, so the 2 year prospect may not be valid when such events occur.

If Lake stages continue to remain near the lower end of the desired stage envelope or lower, the enlarged marsh habitat likely will continue to occupy formerly open-water SAV habitat, while SAV colonizes areas offshore which were previously too deep and light limited to support substantial underwater plant growth. However, south Florida's variable climate and frequent hurricanes, coupled with the disproportion between the Lake's potential tributary inflows and outflows, can result in rapid reversals to the current situation.

Eastern Oysters Indicator

SUMMARY FINDING

On the whole, Eastern oyster status remained constant up to 2011. It should be cautioned that the duration of monitoring for this species in the Southern Estuaries is very short (1 year or less) and hence trend data should be treated with caution while inferring status of this indicator. Continued monitoring will yield data to make trend and status assessments in the coming years and will strengthen the confidence of the status. Current conditions in the Caloosahatchee Estuary show deviations from restoration targets, therefore restoration actions are merited. For example, relatively dry years during the past three years has resulted in higher disease prevalence and increased predation and mortality of juvenile oysters and spat recruitment. Status of oysters is expected to improve if hydrologic conditions are restored to more natural patterns.

KEY FINDINGS

1. While there may be occasional dry years, in general, there is too much freshwater inflow into the Caloosahatchee and Faka-Union estuaries in the summer months and too little freshwater inflow into the estuary in the winter months, disrupting natural patterns and estuarine conditions. The oysters in both of these estuaries are still being impacted by this unnatural water delivery pattern. Too much fresh water impacts reproduction, larval recruitment, survival, and growth. Too little fresh water impacts the survival of oysters due to higher disease prevalence and intensity of Perkinsus marinus and predation; this appears to be occurring in the Lostman and Pumpkin Bay estuaries. 2010-2012 have been relatively dry years resulting in higher disease prevalence and intensity.
2. Overall status of oysters in all of the Northern Estuaries and Southern Estuaries is below restoration targets and requires action in order to meet restoration goals.
3. Oyster responses and populations in the Northern Estuaries and Southern Estuaries are below targets and may be in danger of declines under current salinity levels. Growth rates and recovery rates for abundances suggest that oyster index scores could be expected to increase given proper hydrologic conditions through restoration.
4. Restoration of natural patterns (less freshwater flows in the summer and more freshwater flows in the winter) along with substrate enhancement (addition of cultch) is essential to improving performance of oysters in the estuaries.

Continued monitoring of oysters in the Northern Estuaries and Southern Estuaries will provide an indication of ecological responses to ecosystem restoration and will enable us to distinguish between responses to restoration and natural variation.

Zone/ Performance measure	Water Year 2008	Water Year 2009	Water Year 2010	Water Year 2011	Water Year 2012	Trend	CURRENT STATUS	2-YEAR PROSPECTS
Northern Estuaries/Eastern Oyster								
Caloosahatchee Estuary							In general, oysters in the Caloosahatchee Estuary are still being impacted by too much fresh water in summer and too little fresh water in the winter. Too much fresh water impacts reproduction, larval recruitment, survival, and growth, while too little fresh water impacts the survival of oysters due to higher disease prevalence and intensity of *Perkinsus marinus* and predation. For example, the past 3 years have been dry years resulting in higher *P. marinus* prevalence values in oysters. Current conditions do not meet restoration criteria, signifying that this area needs further attention.	Management objectives for regulating freshwater inflows play an important part in determining oyster success in the Caloosahatchee Estuary. If conditions remain constant, prognosis for the future will be stable. However, if dry conditions persist, it will result in higher disease prevalence and predation of oyster spat and will result in decrease in oyster index score (from yellow to red). If the hydrological conditions remain the same, we do not expect to see an improvement in oyster responses in this estuary.
Lake Worth Lagoon							Oysters in Lake Worth Lagoon exhibit lower living densities, possibly due to high salinity conditions resulting in high predation of larvae. However, condition index and Dermo intensity of oysters is comparable to other estuaries in South Florida. Current conditions do not meet restoration criteria, signifying that this area needs further attention.	If conditions remain constant, prognosis for the future will be stable. However, if dry conditions persist, it will result in higher disease prevalence and predation of oyster spat and will result in decrease in oyster index score (from yellow to red). If the hydrological conditions remain the same, we do not expect to see an improvement in oyster responses in this estuary.

Eastern Oysters Indicator

Zone/ Performance measure	Water Year 2008	Water Year 2009	Water Year 2010	Water Year 2011	Water Year 2012	Trend	CURRENT STATUS	2-YEAR PROSPECTS
Loxahatchee River	●	●	●	●	●	⟷	Oysters in Loxahatchee River exhibit lower living densities and recruitment possibly due to high salinity conditions resulting in high predation of larvae. However, condition index and Dermo intensity of oysters is comparable to other estuaries in south Florida. Current conditions do not meet restoration criteria, signifying that this area needs further attention.	If conditions remain constant, prognosis for the future will be stable. However, if dry conditions persist, it will result in higher disease prevalence and predation of oyster spat and will result in decrease in oyster index score (from yellow to red). If the hydrological conditions remain the same, we do not expect to see an improvement in oyster responses in this estuary.
St. Lucie Estuary	●	●	●	●	●	⟷	The oysters in the St. Lucie Estuary are still being impacted by too much fresh water in summer and too little fresh water in the winter. Too much fresh water impacts reproduction, larval recruitment, survival and growth, while too little fresh water impacts the survival of oysters due to higher disease prevalence and intensity of *Perkinsus marinus* and predation. Current conditions do not meet restoration criteria.	Management objectives for regulating freshwater inflows play an important part in determining oyster success in the Caloosahatchee Estuary. If conditions remain constant, prognosis for the future will be stable. However, if dry conditions persist, it will result in higher disease prevalence and predation of oyster spat and will result in decrease in oyster index score (from yellow to red). If the hydrological conditions remain the same, we do not expect to see an improvement in oyster responses in this estuary.

Zone/ Performance measure	Water Year 2008	Water Year 2009	Water Year 2010	Water Year 2011	Water Year 2012	Trend	CURRENT STATUS	2-YEAR PROSPECTS
Southern Estuaries/Eastern Oyster								
Lostman's River	🟡	⚫	⚫	⚫	⚫		Oysters in Lostman's River receive very little fresh water, resulting in higher disease prevalence, intensity, and low spat recruitment, possibly due to predation. It should be cautioned that these results are based on just one year of sampling.	If conditions remain constant, prognosis for the future will be stable. However, if dry conditions persist, it will result in higher disease prevalence and predation of oyster spat and will result in decrease in oyster index score (from yellow to red). If the hydrological conditions remain the same, we do not expect to see an improvement in oyster responses in this estuary.
Pumpkin Bay (Southern Estuaries)			🟡	⚫	⚫		Oysters in Pumpkin Bay receive very little fresh water, resulting in higher disease prevalence, intensity, and low spat recruitment, possibly due to predation. It should be cautioned that these results are based on partial sampling in 2010 and 2011.	If conditions remain constant, prognosis for the future will be stable. However, if dry conditions persist, it will result in higher disease prevalence and predation of oyster spat and will result in decrease in oyster index score (from yellow to red). If the hydrological conditions remain the same, we do not expect to see an improvement in oyster responses in this estuary.

Eastern Oysters Indicator

Zone/ Performance measure	Water Year 2008	Water Year 2009	Water Year 2010	Water Year 2011	Water Year 2012	Trend	CURRENT STATUS	2-YEAR PROSPECTS
Faka-Union			🟡	⚫	⚫		The oysters in the Faka-Union are still being impacted by too much fresh water in summer and too little fresh water in the winter. Too much fresh water impacts reproduction, larval recruitment, survival, and growth, while too little fresh water impacts the survival of oysters due to higher disease prevalence and intensity of *Perkinsus marinus* and predation. For example, the past 3 years have been dry years resulting in higher *P. marinus* prevalence values in oysters. Current conditions do not meet restoration criteria, signifying that this area needs further attention.	Management objectives for regulating freshwater inflows play an important part in determining oyster success in the Faka-Union Estuary. If conditions remain constant, prognosis for the future will be stable. However, if dry conditions persist, it will result in higher disease prevalence and predation of oyster spat and will result in decrease in oyster index score (from yellow to red). If the hydrological conditions remain the same, we do not expect to see an improvement in oyster responses in this estuary.

The following assumption is being used for the 2-Year trend column: There will be no major changes in water management or significant natural events such as hurricanes from the date of the current status assessment.

Eastern Oysters
Photo by Aswani Bolety

Crocodilians (American Alligators & Crocodiles) Indicator

SUMMARY FINDING

On the whole, alligator and crocodile status remained constant during WY2012. We could not assess the Water Conservation Areas due to funding reductions that affected WY2012 sampling. However, the majority of locations show substantial deviations from restoration targets; therefore restoration actions are merited. Status of alligators and crocodiles are expected to improve if hydrologic conditions are restored to more natural patterns.

KEY FINDINGS

Alligator overall status at the Loxahatchee NWR is the highest in south Florida.

Overall status of alligators throughout WCA-2 and WCA-3 could not be assessed due to funding cuts. This is an important region as significant restoration projects are scheduled for WCA-3.

Overall status of alligators throughout Everglades National Park is below restoration targets and requires action to meet restoration goals.

Growth and survival components for crocodiles, while below restoration targets, appear stable at this time and are expected to improve with restoration of timing and amount of freshwater flow to estuaries.

Restoration of patterns of depth and period of inundation and water flow is essential to improving performance of alligators in interior freshwater wetlands.

Restoration of patterns of freshwater flow to estuaries should improve conditions for alligators and crocodiles.

Continued monitoring of alligators and crocodiles will provide an indication of ecological responses to ecosystem restoration.

Additional information on this indicator can be found in these documents:

Fujisaki, I., F.J. Mazzotti, K.M. Hart, K.G. Rice, D.Ogurcak, M. Rochford, B.M. Jeffery, L.A. Brandt, and M.S. Cherkiss. 2012. Use of alligator hole abundance and occupancy rate as indicators for restoration of a human-altered wetland. Ecological Indicators 23 (2012) 627–633.

Hart, K.M., F.J. Mazzotti, and L.A. Brandt. 2012. 2011 Annual Assessment Update Comprehensive Everglades Restoration Plan (CERP): American Alligator Density, Size, and Hole Occupancy and American Crocodile Juvenile Growth & Survival. MAP Activities 3.1.3.15 and 3.1.3.16 (Greater Everglades Wetlands Module). Prepared for: U.S. Army Corps of Engineers, Jacksonville, FL.

Liu, Z., L.A. Brandt, D.E. Ogurcak, and F.J. Mazzotti, 2012. Morphometric Characteristics of Alligator Holes in Everglades National Park, Florida from 1994 to 2007. Ecohydrology.

Mazzotti, F.J., K.M. Hart, B.M. Jeffery, M.S. Cherkiss, L.A. Brandt, I. Fujisaki, and K.G. Rice. 2010. American Alligator Distribution, Size, and Hole Occupancy and American Crocodile Juvenile Growth and Survival Volume I. MAP RECOVER 2004-2009 Final Summary Report, Fort Lauderdale Research and Education Center, University of Florida, Fort Lauderdale, FL.

Crocodilians (American Alligators & Crocodiles) Indicator

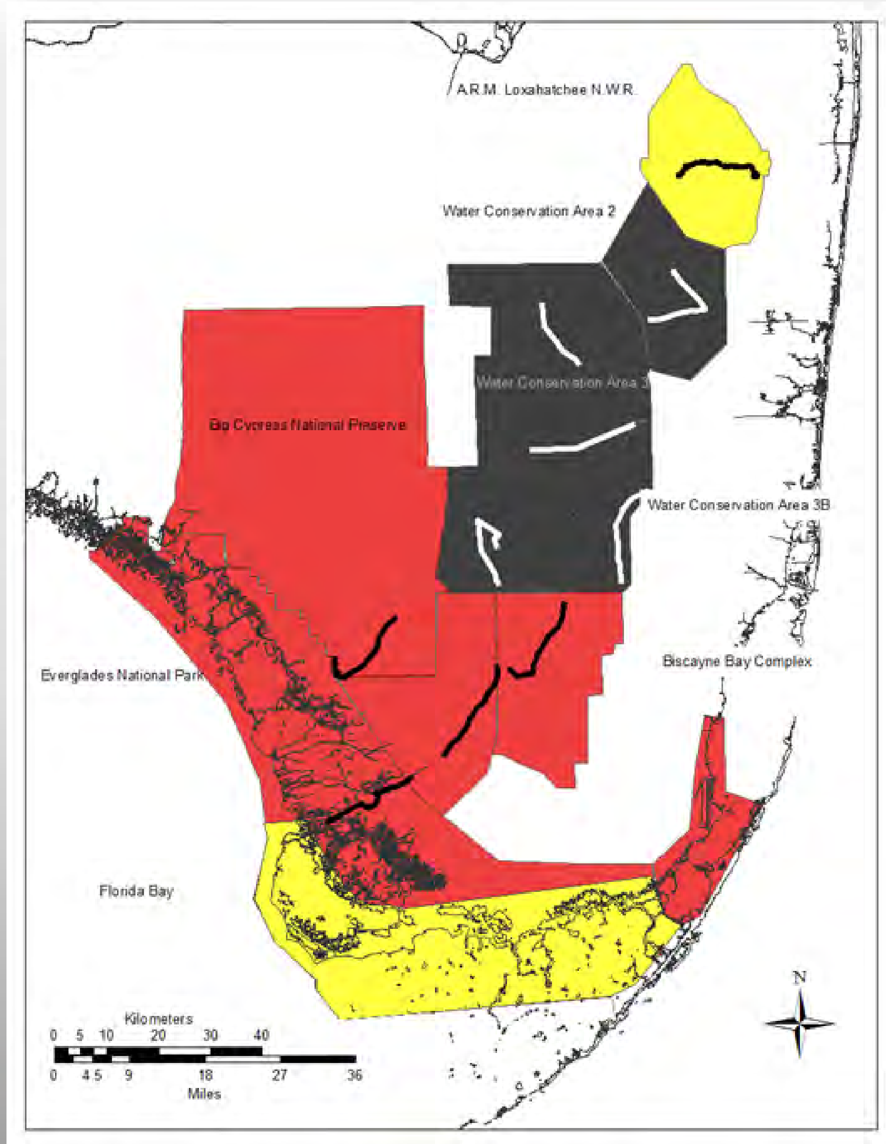


Figure 15. Water year 2012 stoplight colors for crocodilians by area.

Crocodilians (American Alligators & Crocodiles) Indicator

LOCATION	WY2008	WY2009	WY2010	WY2011	WY2012	Trend	CURRENT STATUS	2-YEAR PROSPECTS
American Alligator								
Loxahatchee National Wildlife Refuge	🟡	🟡	🟡	🟡	🟡	⟷	Relative density (component score = 0.83) and body condition (component score = 0.67) combined for a location score of 0.75 and so current conditions do not meet restoration criteria, signifying that this area needs further attention.	Loxahatchee NWR management objectives play an important part in determining success here. If conditions remain constant, prognosis for the future will be stable. Monitoring is not funded.
Water Conservation Area 2A	🔴	🔴	🔴	🔴	⚫	⟷	No data collected Spring 2012. Funds for monitoring suspended in FY2012.	Low and decreasing relative density are likely to continue under current conditions. Monitoring is not funded.
Water Conservation Area 3A	🟡	🟡	🟡	🟡	⚫	⟷	No data collected Spring 2012. Funds for monitoring suspended in FY2012.	Low relative density in the northern area and decreasing relative density in the central area are likely to continue under current conditions. Monitoring is not funded.
Water Conservation Area 3B	🔴	🔴	🔴	🔴	⚫	⟷	No data collected Spring 2012. Funds for monitoring suspended in FY2012.	Until hydrologic conditions improve relative density is not expected to improve. Monitoring is not funded.
Everglades National Park	🔴	🔴	🔴	🔴	🔴	⟷	Relative density in all three locations within Everglades National Park is low (red). Body condition is higher (yellow) in Shark Slough, northeast Shark Slough and estuarine areas. The combined score of these two components for the overall area is 0.34, which is well below restoration criteria. Alligator hole occupancy was not included in WY2012 calculation.	Increased flows south and Everglades National Park management objectives will play a direct role in determining success here. If conditions remain as they currently are, restoration goals will not be met. Monitoring is not funded.

Crocodilians (American Alligators & Crocodiles) Indicator

LOCATION	WY2008	WY2009	WY2010	WY2011	WY2012	Trend	CURRENT STATUS	2-YEAR PROSPECTS
Big Cypress National Preserve							Relative density (component score = 0.17) and body condition (component score = 0.33) combined for a location score of 0.25 and so current conditions do not meet restoration criteria.	Big Cypress National Preserve management objectives will play a direct role in determining success here. If conditions remain constant, prognosis for the future will be stable. Monitoring is not funded.
American Crocodile								
Everglades National Park							Juvenile growth (component score = 0.5) and survival (component score = 0.5) combined for a location score of 0.5 and so current conditions do not meet restoration criteria.	Increased flows to the estuaries and Everglades National Park management objectives will play a direct role in determining success here. If conditions remain constant, prognosis for the future will be stable. Monitoring is not funded.
Biscayne Bay Complex							Juvenile growth (component score = 0) and survival (component score = 0.3) combined for a location score of 0.3 and so current conditions do not meet restoration criteria.	Management objectives play an important part in determining success here. If conditions remain constant for survival, prognosis for the future will be stable for this component. Monitoring is not funded.

The following assumption is being used for the 2-Year trend column: There will be no major changes in water management or significant natural events such as hurricanes from the date of the current status assessment.

Fish & Macroinvertebrates indicator

SUMMARY FINDINGS

In 2011-2012, four of six monitoring sites in central Shark River Slough did not meet restoration targets (red) because of drier conditions than expected based on rainfall. The net effect was one of failure to meet targets (red) for the region. These conditions resulted from fewer fish that prefer wet conditions than expected, but levels of drought-tolerant species (flagfish and Everglades crayfish) were consistent with or above expectations. Water management is causing drier conditions than would be expected based on the amount of rainfall and water depth patterns in our baseline hydrological period of 1993 through 1999. Taylor Slough has returned to yielding many fewer fish than expected based on rainfall at two sites (red) and fewer than expected at two others; one site met the targets. Fish preferring wetter conditions were less abundant than expected, while short-hydroperiod taxa were at their targets. Taylor Slough met targets in the past two years because rainfall was low and fish abundance was also low. However, fish abundance there has continued to drop, more than expected by rainfall. Results were mixed in WCA-A and WCA-3B, yielding a yellow for both regions. In WCA-3A, two sites yielded fewer fish than expected based on rainfall and one yielded more than expected, but three others were within desired ranges. There were fewer fish than expected in southern WCA-3B (red). The long-term monitoring program indicates that water management was closer to targets in 2007 through 2010 than in years 2001 through 2006, but then appeared to over-dry the Southern Everglades in 2011-2012. Monitoring data indicate that non-native taxa continue to be most common at edge habitats, though widespread in Everglades marshes, and their frequency is increasing in Taylor Slough following a drop in 2010. This trend should receive further attention.

KEY FINDINGS

1. All but one of the sites coded red for fish density resulted from fewer fish than expected based on observed rainfall, and most were in Shark River and Taylor Slough. Shark River Slough was scored as not meeting targets (red) overall.
2. Taylor Slough showed an improvement in 2007 through 2010 compared to previous years (2001-2006), but then deteriorated in 2011. Overall, Taylor Slough is assigned a yellow light.
3. Results were mixed in WCA-3A, and the overall assessment is caution (yellow). There was evidence of more frequent drying than expected from observed rainfall in the western area. Everglades crayfish were infrequently collected in WCA-3A in the baseline period and afterwards.
4. There were no consistent deviations from rainfall-based expectations in WCA-3B for all fish summed.
5. Non-native fish are generally 2% or fewer of the fishes collected at all monitoring sites. However, higher numbers, particularly of Mayan cichlids, have been noted at the mangrove edge of Shark River Slough and Taylor Slough, in the Rocky Glades, and in canals in general. Non-native species were knocked back by the cold months in January 2010, but appear to be increasing again in 2011-2012.

The target hydrological years for this assessment include 1993-1999. Forecasting models (statistical models derived by cross-validation methodology) that link regional rainfall to surface water-depth at our monitoring sites were used to model hydrology. Alternative hydrological model outputs, such as those derived by the Natural System Model, generally yield longer target hydroperiods than used here leading to more frequent impacts.

Fish & Macroinvertebrates indicator

Water year 2012 stoplight colors for fish for WCA-3 and Everglades National Park by sample site.

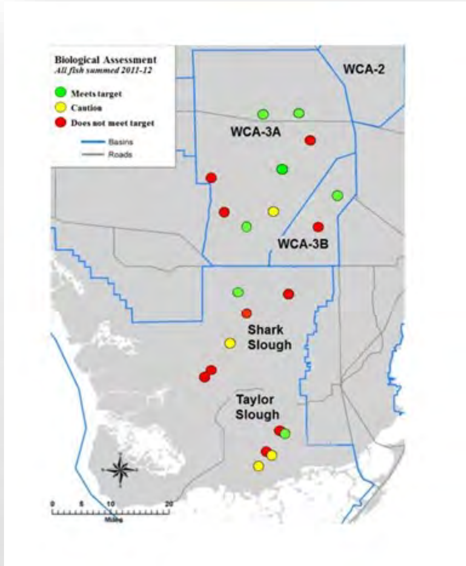


Figure 16: Dots show location of long-term study sites and the value of the total fish part of the indicator as an example of spatial coverage. The stoplight colors in the table that follows are the average of all sites within each geographic area for each part of the indicator.

Performance Measure	WY 2008	WY 2009	WY 2010	WY 2011	WY 2012	Trend	CURRENT STATUS	Trend
Water Conservation Area 3A								
Total Fish	🟡	🟡	🟡	🟡	🟡	⇔	Fewer than expected in western sites.	Areas of western WCA-3A have fewer fish than expected based on rainfall, while other areas do not.
Non-Native Fish	🟡	🟡	🟡	🟢	🟢	⇔	Very few collected this year. Relative abundance is very low.	Numbers of non-native fish have tended to be low in this area and were dropped further by the 2010 cold winter. Do not appear to have rebounded as in other areas.
Bluefin Killifish	🟡	🟡	🟡	🟢	🟡	⇩	Fewer than expected from rainfall.	Areas of western WCA-3A have fewer of this fish than expected based on rainfall, while other areas do not. This species recovers slowly from drying events and is representative of many fish species.
Flagfish	🟢	🟢	🟢	🟢	🟢	⇔	Abundance at or above expected.	This indicator is at expected levels based on rainfall; it is indicative of species that thrive in dry circumstances.
Eastern Mosquitofish	🟡	🟢	🟡	🟢	🟡	⇧	More than expected at some sites	This indicator recovers from drying quickly, but is decreased by severe or repeated drying conditions. Their numbers were high at some sites, consistent with local dry conditions forcing them to move across the landscape.

Fish & Macroinvertebrates indicator

Performance Measure	WY 2008	WY 2009	WY 2010	WY 2011	WY 2012	Trend	Current Status	Trend
Water Conservation Area 3B								
Total Fish	🟢	🟢	🟡	🟢	🟡	⇩	Fewer than expected at one site.	Total fish were lower than expected by rainfall at one monitoring site, but not the other.
Non-Native Fish	🟢	🟢	🟡	🟡	🟢	⇧	Very few collected this year. Relative abundance is low.	Non-native fish have generally been low in this area and very few were caught in the past year.
Bluefin Killifish	🟢	🟢	🟡	🟡	🔴	⇩	Fewer than expected from rainfall.	Both monitoring sites in WCA-3B had fewer of this fish than expected based on rainfall. This species recovers slowly from drying events and is representative of many fish species.
Flagfish	🟢	🟢	🟡	🟡	🔴	⇧	More than expected based on rainfall.	This indicator is above expected abundance based on rainfall; it is indicative of species that thrive in dry conditions. Such species were less abundant in WCA-3B in the 1990s and certainly were much lower in this area historically.
Eastern Mosquito fish	🟢	🟢	🟢	🟢	🟢	⇔	Abundance as expected based on rainfall.	No change.
Shark River Slough								
Total Fish	🔴	🟡	🔴	🟡	🔴	⇩	Fewer than expected.	Recent management has dried SRS more than expected by rainfall, leading to fewer fish than expected.
Non-Native Fish	🟡	🟡	🟡	🟡	🟡	⇔	Present, but less than 1% everywhere. Consistent with past years, most non-native fish were caught in southern SRS.	Stable.
Bluefin Killifish	🟡	🟡	🔴	🟡	🔴	⇩	Fewer than expected.	This indicator does best in wet conditions. Recent management has led to continually fewer of these species in Shark River Slough than expected based on rainfall.
Flagfish	🟡	🟡	🟡	🟡	🟡	⇔	More than expected.	This indicator does best in dry conditions. Their relatively high numbers is consistent with expectations of over drying relative to rainfall.

Fish & Macroinvertebrates indicator

Performance Measure	WY 2008	WY 2009	WY 2010	WY 2011	WY 2012	Trend	CURRENT STATUS	Trend
Eastern Mosquito fish	🟡	🟢	🟡	🟢	🟡	⇩	Fewer than expected.	This indicator recovers from drying quickly, but is de-creased by severe or repeated drying conditions.
Everglades Crayfish	🟡	🟡	🟢	🟢	🟢	⇔	More abundant.	This indicator does best in dry conditions. Is present in SRS only for 1-2 years following drought.
Taylor Slough								
Total Fish	🟢	🟡	🟢	🟢	🟡	⇩	Fewer than expected, very close to red.	Past years have been dry and led to green lights even though fish numbers were down. This year the numbers were below expectations after adjusting for rainfall.
Non-Native Fish	🟡	🟡	🟡	🟢	🟡	⇩	Present but fewer than 2%.	Non-native fish numbers dropped after cold winter of 2010, but increased this year.
Bluefin Killifish	🟢	🔴	🟢	🟢	🔴	⇩	Fewer than expected.	Numbers of this species were very low at all sites this year, indicative of all species requir-ing long-hydroperiod condi-tions.
Flagfish	🟢	🟢	🟢	🟢	🟢	⇔	At expected abun-dance.	This indicator is at expected levels for very low rainfall; it is indicative of species that thrive in such circumstances. Such species were less abundant in Taylor Slough in the 1990s and probably historically.
Eastern Mosquito fish	🟢	🟡	🟢	🟢	🟢	⇔	At or below expected abundance.	This indicator recovers from drying quickly, but is decreased by severe or repeated drying conditions. Their numbers are very low, but consistent with dry conditions.
Everglades Crayfish	🟢	🔴	🟢	🟢	🟢	⇔	At or above expected abundance.	This indicator is at expected levels for very low rainfall; it is indicative of species that thrive in such circumstances. Such species were less abundant in Taylor Slough in the 1990s and probably his-torically.

The following assumption is being used for the 2-Year trend column: There will be no major changes in water management or significant natural events such as hurricanes from the date of the current status assessment.

Periphyton & Epiphyton indicator

SUMMARY FINDING

Many of the sites coded as “altered” (red) are near the peripheral canals surrounding the wetlands, or in drainages downstream of canal inputs (see map). In Loxahatchee NWR, canals deliver above-ambient concentrations of both nutrients and calcium carbonate, causing changes in periphyton quality, including increased Total Phosphorus (TP) from nutrient enrichment and reduced organic content from calcium carbonate inputs. In WCA-2A, long-term delivery of above-ambient Phosphorus (P) in canal inputs has caused enrichment cascades throughout most of the system. This is most severe in the northeast portion of this wetland, where monospecific cattail stands predominate, precluding periphyton sampling. Enrichment in central WCA-3A, noted in 2005 and 2006, was less pronounced in 2007, while signals of enrichment were noted near the peripheral canals. Shark River and Taylor Sloughs have remained relatively free of enrichment or hydrologic modifications in the sampled areas. “Cautionary” points in southern Shark Slough are likely reflecting “natural” enrichment from waters of Florida Bay.

KEY FINDINGS

A total of 7% of sites had red-coded periphyton TP levels. The average number of these “failure” sites was lower in 2009-2010 (8%) than 2005-2008 (20%), primarily due to a reduction in the number of altered sites in WCA-3A, perhaps resulting from reduced inflows to this basin during relatively dry years and decreased P concentrations.

1. Similar to prior years, a total of 16% of sites had yellow-coded (cautionary) periphyton TP levels, and were primarily located downstream of canal inputs.
2. A total of 40% and 43% of sites were coded yellow or higher for biomass and species composition (not shown), primarily due to loss of biomass and native species.
3. Continued input of above-ambient P concentrations will both increase severity of enrichment effects near canals and cause these effects to continue to cascade downstream of inputs.
4. Increased input of water through restorative projects may increase periphyton development in areas formerly dry.

Periphyton & Epiphyton indicator

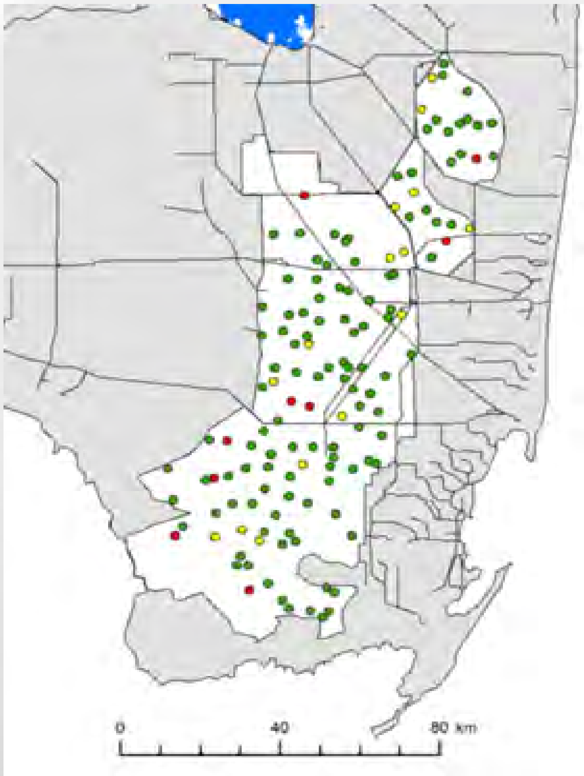


Figure 17. Water year 2012 stoplight colors for periphyton by sample site.

Additional information on this indicator can be found in these documents:

Trexler, J. and E. Gaiser. 2010. Periphyton and Aquatic Fauna. CERP Monitoring and Assessment Plan Annual Report. South Florida Water Management District.

Trexler, J. and E. Gaiser. 2011. Periphyton and Aquatic Fauna. CERP Monitoring and Assessment Plan. Annual Report. U.S. Army Corps of Engineers.

Gaiser, E., P. McCormick and S. Hagerthey. 2011. Landscape patterns of periphyton in the Florida Everglades. Critical Reviews in Environmental Science and Technology. 41(S1): 92-120.

Lee, S., E. Gaiser and J. Trexler. 2013. Diatom-based models for inferring hydrology and periphyton abundance in a subtropical karstic wetland: Implications for ecosystem-scale bioassessment. Wetlands. 33: 157-173.

Periphyton & Epiphyton indicator

PERFORMANCE MEASURE	2008	2009	2010	2011	2012	Trend	Current Status	2-YR Prospects
Loxahatchee National Wildlife Refuge (WCA-1)								
Quality (TP)	🟢	🟡	🟢	🟢	🟡	⇔	Problems are evident along the boundaries, where canal inputs of P and carbonates are changing quality and composition .	Unless canal inputs are reduced, problems will remain or expand.
Biomass	🟢	🟢	🟢	🟢	🟢	⇔		
Composition	🟡	🟡	🟡	🟡	⚫	⇔		
Water Conservation Area 2A								
Quality (TP)	🔴	🟡	🟡	🟡	🔴	⇧	Historical above-ambient inputs of P continue to degrade periphyton.	Problems will remain or extend further to the interior unless the criterion is met and historical P is buried in sediments.
Biomass	🟡	🟡	🟡	🟡	🟡	⇔		
Composition	🔴	🟡	🟡	🟡	⚫	⇔		
Water Conservation Area 3A								
Quality (TP)	🟡	🟡	🟢	🟢	🟡	⇔	Water levels are too deep to allow formation of calcareous mats; canal P input further reduces biomass.	If water depths remain high and P inputs are above the protective criterion, status will re main the same.
Biomass	🟡	🟡	🟡	🟡	🔴	⇧		
Composition	🟡	🟡	🟡	🟡	⚫	⇔		

Periphyton & Epiphyton indicator

PERFORMANCE MEASURE	2008	2009	2010	2011	2012	Trend	Current Status	2-YR Prospects
Everglades National Park Shark Slough								
Quality (TP)	🟡	🟡	🟡	🟢	🟡	⇔	P from the S-12 structures and increased coastal P encroachment are reducing periphyton quality.	Increased flow into SRS may further reduce biomass and quality if P is above the protective criterion.
Biomass	🟡	🟡	🟡	🟡	🟡	⇔		
Composition	🟡	🟡	🟢	🟡	⚫	⇔		
Everglades National Park Taylor Slough								
Quality (TP)	🟢	🟢	🟢	🟢	🟢	⇩	Periphyton quality is compromised in upper Taylor Slough near S-332 detention ponds.	Quality may decline if enrichment along the Taylor Slough boundary is uncontrolled.
Biomass	🟡	🟢	🟢	🟢	🟢	⇔		
Composition	🟢	🟢	🟡	🟡	⚫	⇔		

The following assumption is being used for the 2-Year trend column: There will be no major changes in water management or significant natural events such as hurricanes from the date of the current status assessment.

Wading Birds (Wood Stork & White Ibis) indicator

SUMMARY FINDING

Exceptionally cold winter conditions and rapid and widespread drying/drought conditions of the marsh surface by the end of the nesting season resulted in generally poor nesting conditions for wading birds in 2011. Nest starts were mediocre by comparison with recent years, and nest success was poor, with greater than 80% abandonment of Wood Stork nests. All wading bird indicators showed little change in trend or degree in 2011. One indicator (ibis supercolony nesting) now routinely exceeds the target while the other three appear to have reached a plateau well below the desired target. Although proportion of nesting that occurs in the coastal zone has improved in recent years (14 – 21%), it remains far from the 70% typical of the predrainage period. Nonetheless, storks seem committed to an increased tendency to nest in the coastal zone. The ratio of tactile foragers (storks and ibises) to sight foragers (Great Egrets) has shifted little in the past five years and is very far from the 30:1 ratio typical of predrainage colonies. Finally, during the last two years, storks have not initiated nesting until early March, some of the latest initiations on record. This practically guarantees that stork reproduction will continue into the wet season, when foraging opportunities disappear with rising water, and nests are routinely abandoned. While all of the information for the 2012 spring nesting season are not yet in, none of these trends appear to have changed substantially.

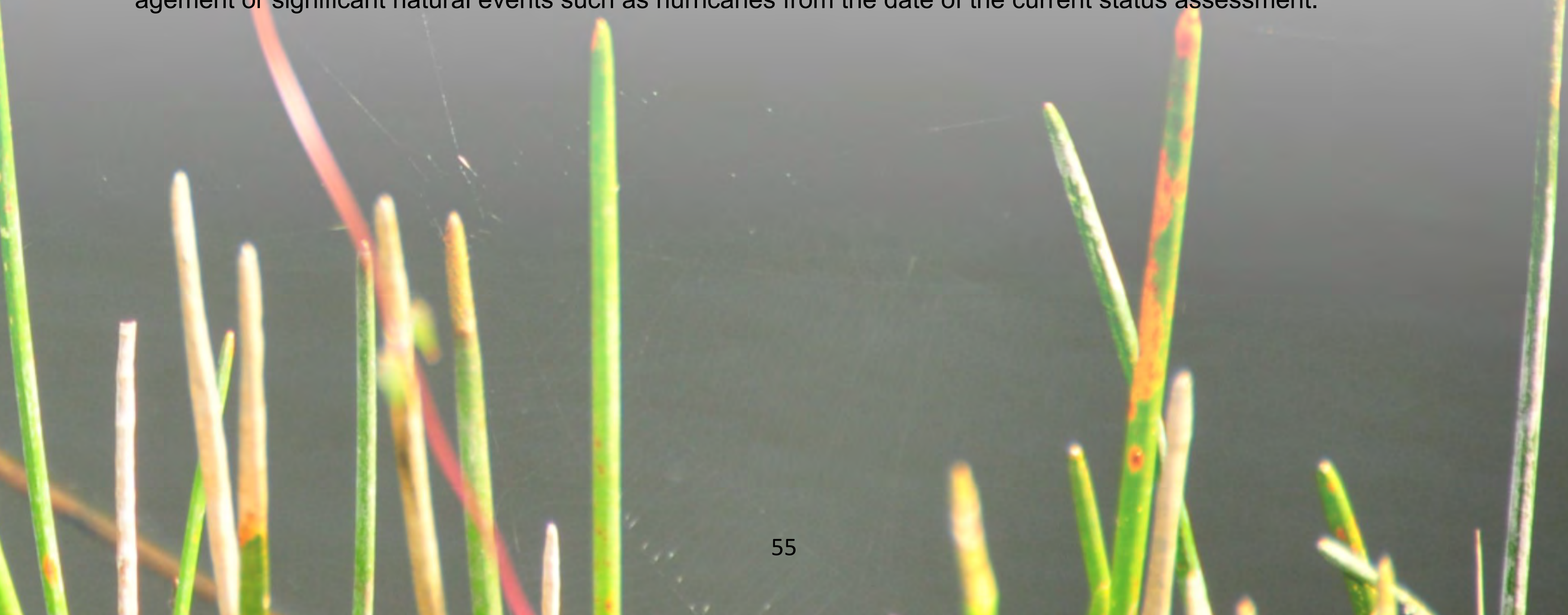
KEY FINDINGS

1. During the last five years, the trend for stork initiations has been towards later rather than earlier nesting (2009 was an exception). The nesting date index is numerical, with a 1 (March) being less desirable than a 5 (November). The 5-year running average index in 2011 was 2.4. The restoration target corresponds to nesting dates earlier than December 30th (4 – 5). This trend does not meet the restoration target.
2. The proportion of nesting birds occurring in the headwaters/ecotone in 2011 was 17%, and the 5-year running average was 18%, a considerable increase over the average of 8.1% over the last ten years. Storks have remained in most of the novel coastal colonies that initiated in the last ten years, suggesting the coastal ecosystem has better carrying capacity. However, the goal of 70% or greater of the birds nesting in the coastal zone remains distant.
3. The ratio of ibis+stork nests to Great Egret nests in 2011 (2.2:1) is still far below the 30:1 characteristic of predrainage conditions. In addition, there has been only a slight increase over the average of the last ten years (2.97), especially compared with the target ratio.
4. The frequency of exceptionally large ibis nesting events has improved dramatically since the late 1990s, and the mean interval between these events has changed from over 40 years to less than three in most recent years. While neither 2010 nor 2011 was an exceptional nesting year, the 5-year running average remains at 1.4 years, a considerable improvement and still within the restoration target of 1.45 years. This indicator of restored conditions therefore appears to have been met for every one of the last seven years.
5. With the exception of large ibis nestings, trends for wading bird indicators are stable (proportion in headwaters, ratio of tactile to nontactile feeders) or declining (timing of stork initiation). This suggests that progress in the wading bird indicators has stalled, and that little functional progress has been made in restoration of these indicators in the last five years.

WADING BIRDS (WOOD STORK & WHITE IBIS) INDICATOR

Location/ Performance Measure	WY2008	WY2009	WY2010	WY2011	WY2012	Trend	CURRENT STATUS
Wading bird Indicator Summary	Red	Red	Red	Red	Red	⇔	Overall, three out of four indicators are red because they do not meet performance criteria and do not show progress in that direction.
Ratio of Wood Stork + White Ibis nests to Great Egret nests	Red	Red	Red	Red	Red	⇔	This indicator is well below the threshold of 30:1 that was typical of predrainage conditions, and has not improved markedly in recent years.
Month of Wood Stork nest initiation	Red	Yellow	Red	Red	Red	⇔	Wood Storks nested markedly later than the November-December initiation typical of the predrainage time period, and has resulted in such poor nest success that the population is probably a demographic sink.
Proportion of nesting in headwaters	Red	Red	Red	Red	Red	⇔	While some progress was made in this indicator during the mid-2000s, there is no evidence now of increased use of the coastal zone by nesting wading birds.
Mean interval between exceptional ibis nesting years	Green	Green	Green	Green	Green	⇧	Ibises have nested in exceptional aggregations on at least a 3-year cycle in recent years, and this indicator now regularly exceeds the restoration threshold.

The following assumption is being used for the 2-Year trend column: There will be no major changes in water management or significant natural events such as hurricanes from the date of the current status assessment.



Southern Estuaries Algal Blooms indicator

SUMMARY FINDING

During the 2010-2011 reporting period (here reported as calendar years), no severe algal blooms were observed in the waters of Southern Coastal System estuaries (including Florida Bay, Biscayne Bay, and Whitewater Bay) and the Southwest Florida Shelf (SWFS). However, the strength of this assessment was decreased because coastal water quality monitoring programs used to develop the Algal Bloom Indicator (as chlorophyll-a) were altered due to funding cuts during the reporting period. Bias introduced by changing both number and location of monitoring stations required a significant new effort to adjust the stoplight threshold limits. For example, offshore sites on the SWFS were eliminated in 2010 and these stations typically have lower chlorophyll-a concentrations than inshore stations. Using inshore results in 2010 and 2011 with thresholds derived from long-term combined inshore and offshore values, scores for the SWFS would have been red in 2010 and 2011. For this report, the threshold had to be re-calculated using only the remaining (nearshore) stations in the section and the offshore section is listed as non-reporting due to this lack of data (black).

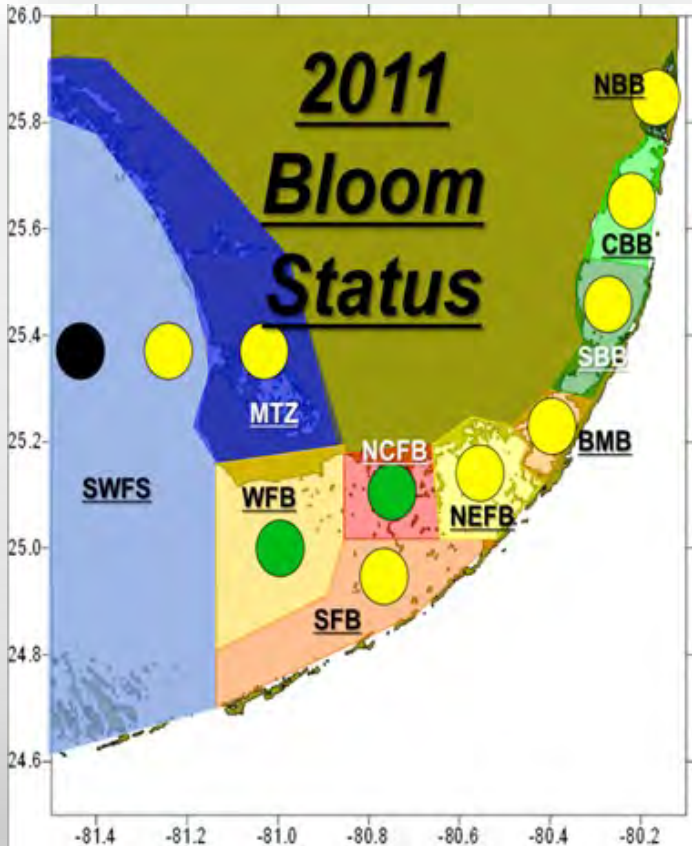


Figure 18.

Southern Estuaries Algal Blooms indicator

KEY FINDINGS

1. No chlorophyll-*a* concentrations indicative of severe algal bloom conditions were noted in 2010 or 2011 in the region.
2. The majority of subregions assessed showed chlorophyll-*a* concentrations above typical (median) historic levels, indicating moderate (yellow) algal bloom potential.
3. Reductions in funding for coastal water quality monitoring (RECOVER MAP, SFWMD, and NOAA) resulted in the loss of our ability to assess algal blooms over most of the SWFS.
4. No long-term trends in the Algal Bloom Indicator were observed. A two-year prospectus is not provided here because past blooms have been related to major disturbance events, such as runoff pulses and wind/wave impacts of hurricanes, and nutrient releases from seagrass die-off events. Such events are not reliably forecast. Water quality degradation reflected by this indicator is not expected to occur in two subregions where CERP projects are being implemented (NEFBa and SBB).

KEY RECOMMENDATIONS

1. Sustained water quality monitoring is needed to assess CERP effects on coastal ecosystems, including assessment via this indicator. Reductions made to these programs have reduced the rigor of the Algal Bloom Indicator. For example, information on the SWFS subregion is now spatially reduced. With less frequent sampling (from monthly to bimonthly) and fewer stations through most of the Southern Coastal System, the rigor of this indicator and our ability to detect restoration effects needs to be re-evaluated.
2. Monitoring of these regions within Florida Bay and Biscayne Bay is essential to assess the impact of the C-111 Spreader Canal Western and Biscayne Bay Coastal Wetlands projects, components of which are presently operational. Additionally, changes in operation of the C&SF system associated with the recently approved Everglades Restoration Transition Plan and changes along the Tamiami Trail (Modified Water Deliveries implementation) are anticipated to affect timing and volume of water delivery to the southern coastal systems. Robust assessment is required to improve ability to distinguish between restoration effects and other human or naturally driven changes.
3. Given that the Central Everglades Planning Project (CEPP) is targeting increased flow through Shark River Slough (SRS), water quality monitoring on the SWFS is needed to assess this indicator as CEPP proceeds. A National Research Council review panel cited the potential for increased SRS flow to cause a significant increase in algal blooms in this region, impacting the Florida Keys National Marine Sanctuary. While the Everglades and most of Florida Bay are phosphorous-limited, the SWFS is nitrogen-limited; increasing flows with low phosphorous (but high nitrogen) may still cause an increase in algal blooms on the SWFS.

Additional information on this indicator can be found in these documents:

Boyer, J.N., C.R. Kelble, P.B. Ortner, and D.T. Rudnick. 2009. Phytoplankton bloom status: Chlorophyll a biomass as an indicator of water quality condition in the southern estuaries of Florida, USA. Ecological Indicators 9: S56-S67

Southern Estuaries Algal Blooms indicator

PERFORMANCE MEASURE	2008	2009	2010	2011	CURRENT STATUS
NRTH BISCAYNE BAY (NBB)					Chlorophyll-*a* concentrations during 2010 and 2011 were higher than typical historic concentrations in this region, indicating a potential for algal blooms.
CENTRAL BISCAYNE BAY (CBB)					Chlorophyll-*a* concentrations each year since 2002 were higher than typical historic concentrations in this region, indicating a long-term increase. While these concentrations are not considered harmful, they may indicate that there was an increased potential for algal blooms over the past decade.
SOUTH BISCAYNE BAY (SBB)					Chlorophyll-*a* concentrations in 2010 and 2011 were higher than typical historical concentrations in this region, indicating a potential for algal blooms.
BARNES, MANATEE & BLACKWATER SOUNDS (BMB)					This region experienced an unusual cyanobacterial ("blue-green algae") bloom in 2006-2008. The bloom was initiated by a large spike in phosphorus from a combination of highway construction and canal releases in association with an active hurricane season. Currently, chlorophyll-*a* concentrations are above typical historic values, indicating a potential for renewed blooms.
NORTHEAST FLORIDA BAY (NEFB)					This region was also impacted by the cyanobacterial bloom in Barnes, Manatee and Blackwater Sounds but returned to baseline levels in 2007. Currently, chlorophyll-*a* concentrations are above typical historical values, indicating a potential for renewed blooms.

Southern Estuaries Algal Blooms indicator

PERFORMANCE MEASURE	2008	2009	2010	2011	CURRENT STATUS
NORTH-CENTRAL FLORIDA BAY (NCFB)	🟢	🟢	🟢	🟢	The current status is due to the lack of a seasonal cyanobacterial bloom from 2007 through 2011. These blooms do not appear every year, but intense blooms have occurred intermittently in this region over the past 15 years.
SOUTH FLORIDA BAY (SFB)	🟢	🟢	🟡	🟡	Chlorophyll-*a* levels are somewhat higher than typical historical concentrations, but are not indicative of an intense bloom. Blooms have occurred in, or extended from the north-central region into this area intermittently over the past 15 years and are expected to continue to do so in future, especially after the passage of hurricanes.
WEST FLORIDA BAY (WFB)	🟢	🟢	🟢	🟢	Since 2006, the seasonal diatom blooms in this subregion have not been as dense or widespread as in the past.
MANGROVE TRANSITION ZONE (MTZ)	🟡	🟡	🟡	🟡	Chlorophyll-*a* concentrations since 2008 were higher in this region than typical historic concentrations, indicating a potential for intense blooms. This region includes Whitewater Bay and riverine estuaries.
SOUTHWEST FLORIDA SHELF (SWFS)	🟢	🟡	◐	◐	A reduction in monitoring implemented in 2010 makes it impossible to assess the status of the offshore area of the SWFS. Chlorophyll-*a* concentrations during 2010 and 2011 in the most inshore area were higher (yellow values) than typical historical concentrations.

Note: Years reported here are calendar years and not water years. No trend arrows are provided for this indicator because scientists felt that there is very low confidence in ability to forecast changes because of variability of bloom causation and occurrence as well as diminished monitoring. Current Status year is 2011.

Florida Bay Submersed Aquatic Vegetation indicator

SUMMARY FINDING

The Composite Index that gives a summary of overall system status for SAV in Florida Bay (Figure 19) remains unchanged in 2010 and 2011 from 2009 showing good scores in the Northeast, Central, and Western Zones and fair scores for the Transition and Southern Zones.

KEY FINDINGS

1) The Abundance Index (combining both spatial coverage and average density indicators) were good in the NE and Western Zones, fair in the Central and Transition and poor in the Southern Zone, unchanged from 2009. Underlying indicators reflect generally good spatial coverage of SAV in almost all basins throughout the bay, except in Joe Bay, indicating no large-scale die-off events. There were mixed results for the density indicator, reflecting sub-optimal density where seagrass occurred, reducing the overall Index scores for some basins. Notably abundance remained poor in both Madeira Bay and Twin Key Basin.

2) In general, the Target Species Index, which combines indicators for species diversity and presence of desired species, showed continued "good" status in the Northeast, Central, and Western Zones, and maintenance of improvement from poor to fair in the Southern Zone since 2009, reflecting increased community diversity. Only the Transition Zone showed continued weakness, with Target Species Index scores remaining fair for 2010-11. Most zones showed scores of "good" for presence of target species but the Transition Zone's aggregate score of poor reflected the low Species Dominance scores for the lack of community diversity.

3) In all basins, where there have been changes in the past few years, they have been in the positive direction, reflecting continued improvement since the mid-2000s when hurricanes and a prolonged micro-algal bloom negatively impacted the SAV community. Despite some incidents of high salinity in recent years, large-scale die-off has not been observed. Some basins reflect one or more indicator scores in the fair or poor range. It is expected that with continued improvements to hydrology via restoration, that increases in these scores may occur in the near-term.

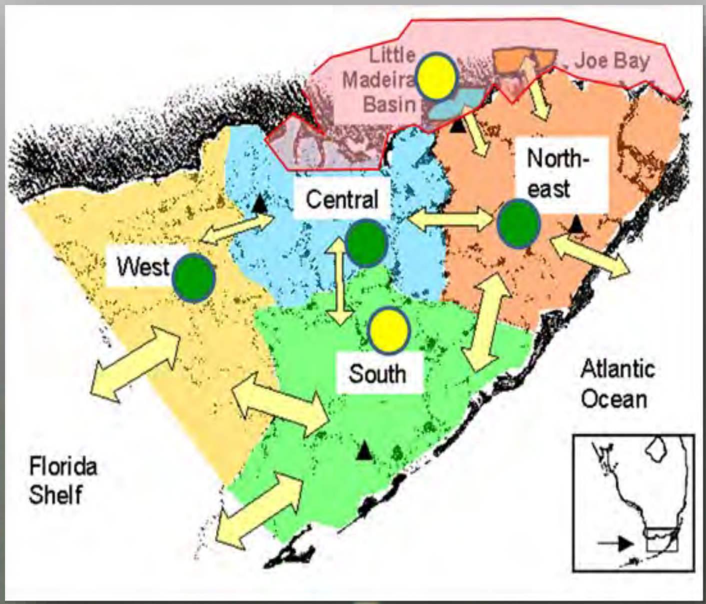


Figure 19. Map of SAV Indicator Zones with 2011 status.

Florida Bay Submersed Aquatic Vegetation indicator

Zone/Performance Measure	2008	2009	2010	2011	Current Status
Florida Bay Northeast Zone					
Abundance					The aggregate Abundance Index is in the good range for the Northeast Zone. The underlying component spatial extent scores remained at 0.93 (good) for years 2010 and 2011 (max=1) as the effect of the 2005-2008 algal bloom on SAV area covered have receded. Extent for all basins is in the good range. Density remains good for this zone and Long Sound and Eagle Key Basin have improved to good but declined to fair in Davis Cove.
Target Species					Target species aggregate score remained at good for this zone in 2010-2011, with good scores for target species indicator but fair or poor scores for most basins in the underlying species dominance score, meaning that desired mixed species communities have not yet been well-established.
Florida Bay Transition Zone					
Abundance					The aggregate Abundance Index for the Transition Zone was fair in 2010-2011, with the density index remaining at fair levels since declining from good in 2006. The spatial extent component of the index is in the good range and scored good for all basins in 2010 though declining to fair in Joe Bay in 2011.
Target Species					The aggregate Species Index remained fair for 2010 and 2011 in the Transition Zone. The aggregate species dominance indicator remained poor in both years, improving to fair in L. Madeira and declining to fair in Barnes Sound. The target species indicator averaged good overall but declined to poor in Duck and Eagle Key, while improving to good in L. Blackwater.
Florida Bay Central Zone					
Abundance					The Abundance Index in the Central Zone was in the fair range for 2010-2011, since improving from poor in 2008. Spatial coverage was good in all basins but low density in most basins (except Rankin, where it was good) reduced the density score and the overall score for the zone.
Target Species					The Species Index remained good for the Central Zone in 2010 and 2011 reflecting increasing presence of target species (Halodule and Ruppia). Species Dominance sub-scores remain only fair in this zone as most basins are overly dominated by Thalassia.
Florida Bay Southern Zone					
Abundance					The Southern Zone continues to reflect a poor rating in the Abundance Index in both 2010 and 2011 as in previous years. Despite high scores for spatial extent in all basins, aggregate scores were reduced by densities remaining in the fair or poor range and notably falling to poor in Twin Key Basin in 2011.
Target Species					The Species Index remained in the fair range in the Southern Zone for 2010-2011 after improving in 2009 from several years in the poor range. The species dominance component improved to fair for both years while the target species index remained at fair.
Florida Bay Western Zone					
Abundance					The Western Zone had high scores for the Abundance Index, with values in the good range for both extent and density in 2010-2011, sustaining the improvement from fair that occurred in 2008.
Target Species					The Western Zone continues to reflect good scores for the Species Index, as the target species component continues in the good range since 2006. The underlying species dominance sub-score improved to good in Johnson Key and remained fair in other basins and fair overall. Target species scores show a good mix of desired species throughout the zone and a good overall score.

No trend arrows are provided for this indicator because scientists felt that there is very low confidence in ability to forecast changes because of variability of causation of factors influencing the indicator. Current status is 2011.

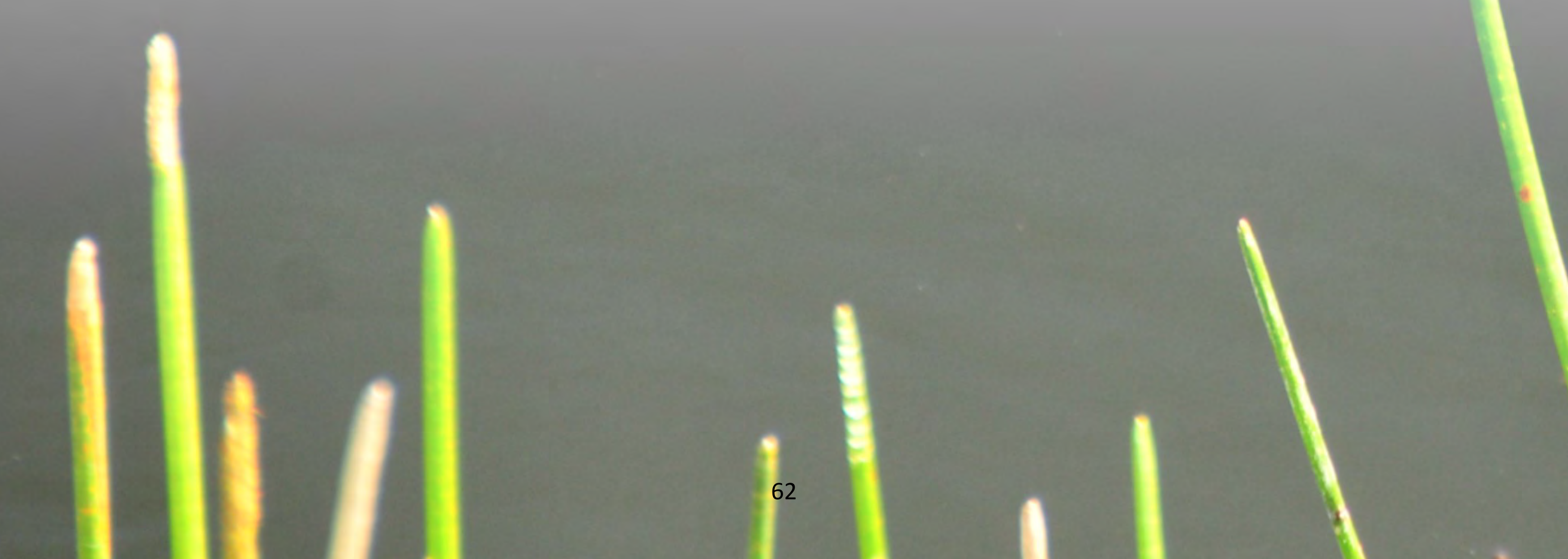
Juvenile Pink Shrimp indicator

SUMMARY FINDING

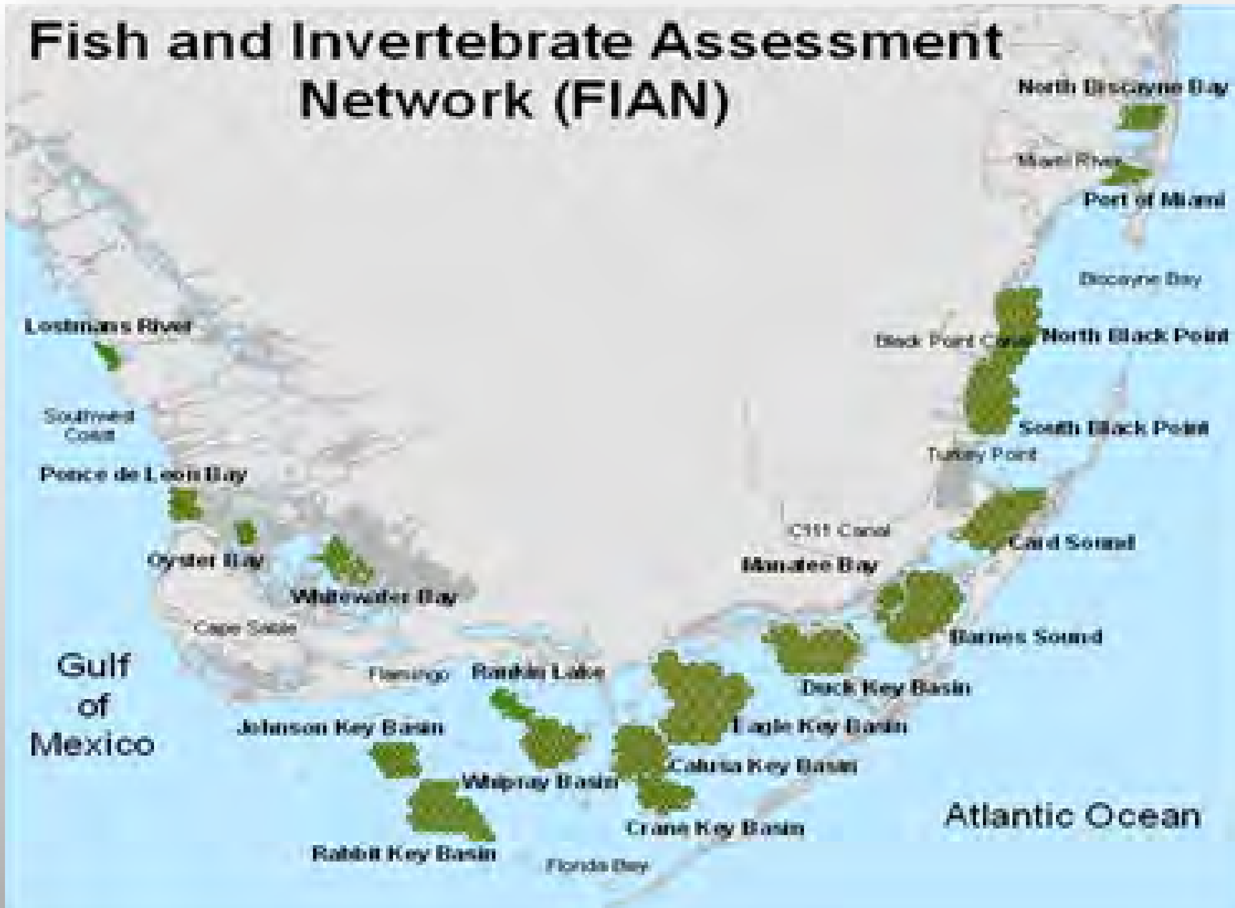
The WY2011 and WY2012 status of pink shrimp in 19 nursery locations in three southern coastal regions was determined by MAP's Fish and Invertebrate Assessment Network (FIAN) and is shown in stoplight colors. Status was determined in relation to a base of the first five MAP water years, 2006-2010, at each location. The water year status indicator was an abundance index, delta-density, in the months of annually greatest abundance, September and October of the previous calendar year. Delta-density quartiles from the five base years were used to classify WY2011 and WY2012 status as good (above 3rd quartile), neutral (between 1st and 3rd quartiles), or poor (below 1st quartile). By comparison to the five year base, WY2011 and WY2012 were poor (red) or neutral (yellow) for pink shrimp in most locations. Status was good (green) in Whipray Basin in WY2011 and WY2012, in Manatee Bay and Lostmans River in WY2011, and in Calusa Key Basin and Crane Key Basin in WY2012. FIAN sampling was discontinued after the September-October sampling of WY2012 by suspension of funding in FY2012.

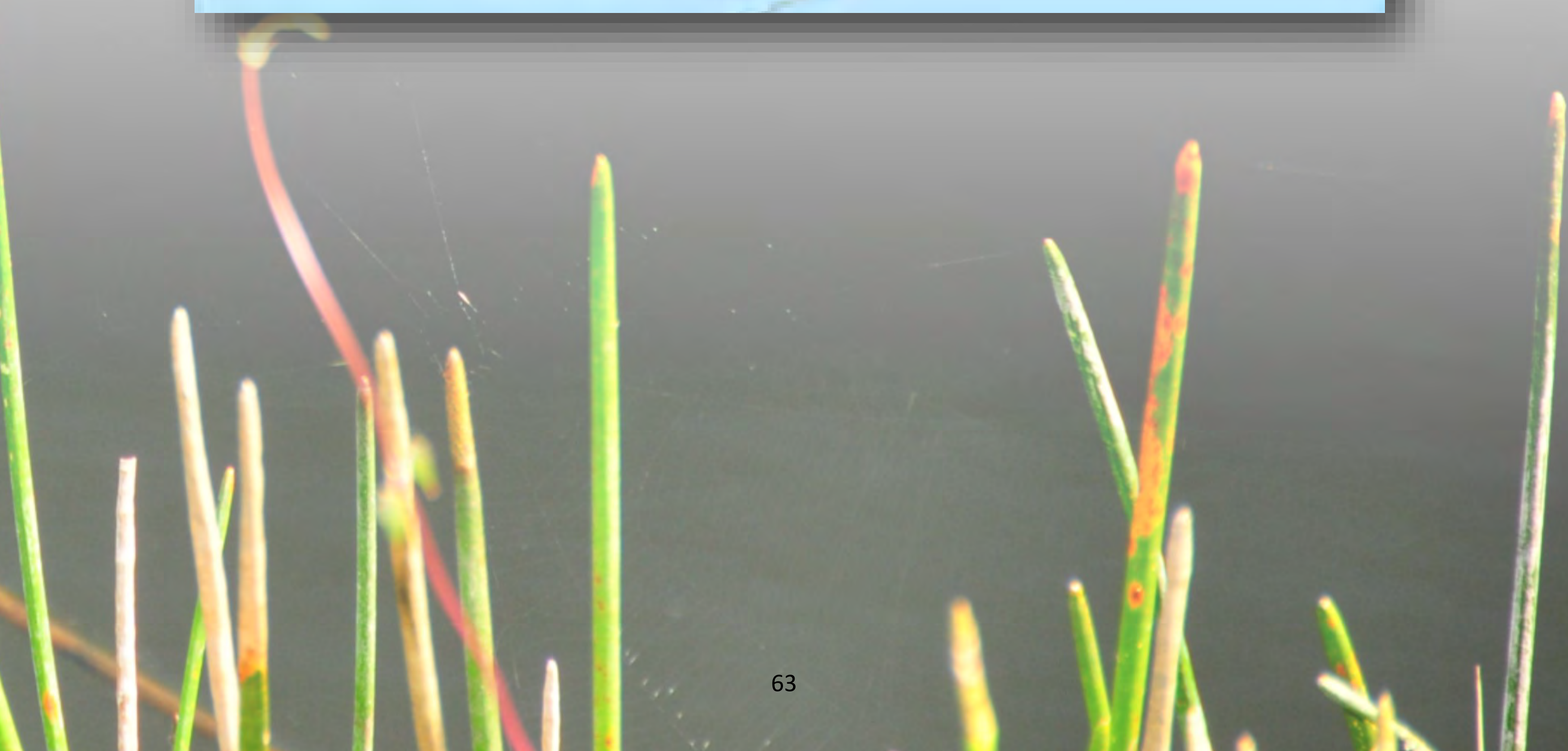
KEY FINDINGS

1. Pink shrimp status was poor or neutral in all but one Biscayne Bay location in both 2011 and 2012. Pink shrimp status was good in Manatee Bay in 2011. The regional overview pink shrimp status for Biscayne Bay was poor for both 2011 and 2012. The seven year (2006-2012) downward trend was not significant ($p>0.05$) for any Biscayne Bay location.
2. Pink shrimp status was poor in three out of eight Florida Bay locations in 2011, neutral in four locations, and good in one location, Whipray Basin. 2012 pink shrimp status was good in three locations. Pink shrimp status declined from neutral to poor in Johnson Key Basin, where juvenile shrimp are most abundant in south Florida. The regional overview pink shrimp status was neutral in both years. Downward trends in all Florida Bay areas were not significant.
3. Pink shrimp status in the lower southwest mangrove coast was good only in Lostmans River in 2011. It was poor in Ponce de Leon Bay in both 2011 and 2012 and in Oyster Bay in 2012. The overview pink shrimp status for this area was neutral for 2011 and poor for 2012. A significant seven year downward trend was noted in Oyster Bay. Other downward trends were not significant. The seven year trend was upward but not significant in Lostmans River.
4. The seven year trend is downward in 18 of the 19 locations; but significantly ($p \leq 0.05$) so only in Oyster Bay. The upward trend at Lostmans is not significant. Downward trends in all but one location suggest a coast-wide influence. Over the seven years, maximum abundance usually occurred in 2006, and lowest abundance often occurred in 2011 and 2012.
5. Current status refers to WY2012 (September-October of calendar year 2011).



Juvenile Pink Shrimp indicator





Juvenile Pink Shrimp indicator

Location/ Performance Measure	2010	2011	Trend	CURRENT STATUS
Biscayne Bay Region				
Regional Overview			⇩	In regional overview, pink shrimp density in Biscayne Bay was particularly poor in 2012, as well as 2011, compared to other regions.
North Bay			⇩	For this site, the bar was set in 2006, which strongly influenced the status thresholds, and no year has performed as well since. 2012 density was not exceptionally low.
Port of Miami			⇩	Although density was slightly higher in 2012 than in 2011, it was still in the red zone based on thresholds set by previous years.
North Black Point			⇩	This site had a moderate density of shrimp (~3.5/m2 in 2005 and ~2.3/m2 in 2009. In 2012, it was less than 1.5.
South Black Point			⇩	Density was slightly higher in 2012 (1.0/m2) than in 2010 (~0.5), but the 5 previous years were better (almost 3 in 2006)
Card Sound			⇩	Pink shrimp density was consistently around 1/m2; however it was above 1.0 most years and below 1.0 in 2011, as in 2011.
Manatee Bay			⇩	This is an area of extreme low shrimp density (~0.2/m2, at best, in 3 of 5 years. Almost zero in 2011 and 2012.
Florida Bay Region				
Regional Overview			⇩	The regional overview for Florida Bay 2012 was neutral, however within-region status ranged from good (3 locations) to poor (one location).
Duck Key Basin			⇩	Pink shrimp density was close to zero at this location in all years, including the base years, and density in 2012 was almost zero, although within the neutral band.
Eagle Key Basin			⇩	Pink shrimp density was close to zero at this location in all years, including the base years. Average density in 2012 was only slightly lower than in most previous years.
Calusa Key Basin			⇩	The higher density at this location approached 1.0/m2. Status was good in 2012 by criteria based on the base years, providing a major change from the poor status in 2011.
Crane Key Basin			⇩	This location had favorable pink shrimp densities in 2012 by criteria based on the base years, providing a major change from the poor status in 2011.
Rankin Lake			⇩	This location has higher density than the previous four (maximum year, 2006, greater than 6.0/m2), but no improvement over neutral in 2012.
Whipray Basin			⇩	The highest annual density in any year was greater than 2.5 in 2006, and 2012, like 2011, had a higher density than other previous years (2007-2010) and achieved good status.
Johnson Key Basin			⇩	Density in 2012 was slightly less than 5/m2 in Johnson Key Basin, and status was classified as poor compared to the 2005-2009 period, when density in 2007 exceeded 20/m2.
Rabbit Key Basin			⇩	2012 status was neutral at this location, where the highest annual density, achieved in 2006, was about 10/m2.

Juvenile Pink Shrimp Indicator

Location/ Performance Measure	2010	2011	Trend	CURRENT STATUS
Lower Southwest Mangrove Coast				
Regional Overview	🟡	🟡	⇩	Pink shrimp status in 2012 relative to the base years varied from location to location, but was not good at any location.
Lostmans River	🟢	🟡	⇧	Density greater than 8/m2 in 2011 was responsible for the upward but insignificant trend at Lostmans. Density declined to slightly less than 6 in 2012 and was within the neutral band.
Ponce De Leon Bay	🔴	🔴	⇩	Maximum annual density was about 3.5/m2 and occurred in 2008 at this location. Relatively poorer years immediately followed, with average monitored density in 2012 near zero.
Oyster Bay	🟡	🔴	⬇	Maximum annual density, slightly greater than 5/m2, occurred in 2006. The lowest annual density on record was in 2012.
Whitewater Bay	🟡	🟡	⇩	Maximum annual monitored density, ~9/m2, occurred in 2006. A moderate density of 4 occurred in 2012, as in 2011, and placed both years in the yellow zone.

*Trends are based on data from 2006-2012. Filled arrows indicate significance at p≤0.05 and unfilled arrows indicate not significant.

Wading Birds (Roseate Spoonbill) indicator

SUMMARY FINDING

Conditions in Northeastern Florida Bay (NEFB) appear to be improving while those in Northwestern Florida Bay (NWFB) are declining. Nesting success in NEFB has improved greatly in recent years, probably due to favorable climatic conditions and to communication between the author and his colleagues with operations mangers at the SFWMD during nesting season. Better communication has led to greater success by reducing unnecessary alternations to flow patterns to the foraging grounds in NEFB. The chicks fledged over this seven year period of high production are now coming into sexual maturity and may reverse the declining trend in nest numbers in NEFB. For the first time in over a decade, nest numbers increased from 87 in 2011 to 186 in 2012. In contrast, nest numbers in NWFB have declined to the point of having a yellow score (for the first time in over 25 years) starting in 2010. By 2011 they declined to being nearly scored in the red (140 nests counted and the threshold is 130). Furthermore, there were three consecutive years of failed nesting from 2010-2012. This has only happened once before (1996-1998) during an exceptionally wet set of years. Since 1984, there have only been eight years in which NWFB colonies have failed (including 1996-1998) prior to 2010. The cause for the decline in NWFB is not known but two highly speculative reasons can be put forth. One is that we have observed much more nest predation from crows over the last few years. This generally occurs in relatively close proximity to the city of Flamingo where crows have ample subsidies from human carelessness: crows regularly raid unattended food parcels and trash. This also has been observed to be more frequent in recent years. The second possibility is that the Homestead and East Cape canals have degraded the interior wetlands of Cape Sable (the primary foraging grounds of NWFB birds) to the point that they are no longer as productive in prey base fishes. These canals have since been plugged but a third canal (Raulerson Brothers Canal) has become an uncontrolled tidal canal continuing the degradation started by the Homestead and East Cape canals.

KEY FINDINGS

1. Nest numbers bay-wide were critically low in 2011: only 87 nests were found when the target number is 1260 nests. This was the lowest number since Florida Bay became part of Everglades National Park in 1949. Although this finding was very alarming, there were some positive findings in 2012. There were 186 nests found throughout the Bay in 2012. It is believed that this increase is the result of chicks fledged successfully from 2005 to 2009 reaching sexual maturity and entering the breeding population.
2. Aerial surveys cannot be used to estimate spoonbill nest numbers but they can be used to determine the presence of spoonbill nesting at colonies that are otherwise inaccessible. Beginning in about 2009, spoonbills were observed nesting at the Madeira Hammock colony (this was the first time any wading birds nested at this colony for several decades). This colony is located approximately 3km north of Little Madeira Bay in NEFB and is very nearly impossible to access however biologists made two excursions to the colony in 2012. They documented 164 spoonbill nests and a high degree of success (although no numerical estimates of success were made). These birds were observed flying toward active foraging grounds in NEFB and will be considered part of the NEFB population going forward. Therefore the total nest count for Florida Bay in 2012 was 350 (as opposed to the 186 nests in Florida Bay proper) and 184 nests in NEFB. It should also be pointed out the 2010 and 2011 estimates 223 and 87 total nests respectively (41 and 3 in NEFB) were artificially low since the Madeira hammock colony was not surveyed. Even though this discovery is highly promising, spoonbill numbers both bay-wide and in NEFB are dangerously low (red stoplight for both).
3. Aerial surveys have detected the presence of spoonbills nesting in significant numbers in several of the Shark River Slough estuary colonies: a target for this indicator. These colonies are prohibitively difficult and costly to survey so no nesting estimates can be made.

Wading Birds (Roseate Spoonbill) Indicator

4. Water management operations appear to be having a positive affect not only on NEFB spoonbills but also on their prey base. Thirteen percent of the total catch in 2011 was identified as freshwater species indicating higher prey production. Although this is still well below the target of 40%, it does improve the stoplight from red to yellow. The C-111 Spreader Canal West project will become operational in 2013 and will increase freshwater flow to Taylor Slough likely lowering salinity and increasing the relative abundance of freshwater species and overall prey productivity.

Additional information on this indicator can be found in these documents:

Lorenz, JJ, B. Langan-Mulrooney, P.E. Frezza, R.G. Harvey, and F.J. Mazzotti. 2009. Roseate spoonbill reproduction as an indicator for restoration of the Everglades and the Everglades estuaries. Ecological Indicators 9S:S96-S107.

Zone/ Performance Measure	WY 2008	WY 2009	WY 2010	WY 2011	WY 2012	Trend	CURRENT STATUS	Trend
Total Number of Nests								
Number of nests in FL Bay (5-year mean)						⇩	The target number of nests for the whole bay is 1,258. The 5-year mean number of nests for 2010-2012 was 336, 284, and 264 respectively or 30%, 23%, and 21% of the target respectively. This indicates that the FL Bay spoonbill population is not recovering.	The 5-year trend of the mean has declined from 36% to 21%, dropping below the 33% threshold for changing the stoplight from yellow to red. Although nest numbers appear to be increasing in the NE subregion, they continue to fall elsewhere throughout the Bay.
Location of Nests								
Nesting Location Overall						⇧	The overall score for nesting location is the lowest of the three component scores. In this case the number of nests in NE FL Bay is red therefore the overall score is red.	Water mgt operations have resulted in increasing success in NEFB thereby increasing the population. The C-111 spreader canal project is now on-line and may also promote greater success. Both the NE and NW colonies are trending toward yellow.
Number of nests in NE FL Bay (5-year mean)						⇧	The target number of nests is 688. The 5-year mean from 2010 to 2012 was 76, 51 and 67 respectively or 11%, 7%, and 10% of target indicating that the NE FL Bay spoonbill population is in jeopardy.	Spoonbills have successfully nested 5 of the last 7 yrs in NEFB and these birds are entering into sexually maturity thereby increasing the number of nests in this part of the Bay.
Number of nests in NW FL Bay (5-year mean)						⇩	The target number of nests in NW FL Bay is 210. The 5-year mean from 2010 to 2012 was 205, 166, and 140 respectively. The thresholds for yellow are from 130 to 210 nests.	2010 was the first year in the last 10 where the target was not met and has declined further in the last two years. In 2012, the percent of target was just 1% point above the yellow threshold.

Wading Birds (Roseate Spoonbill) indicator

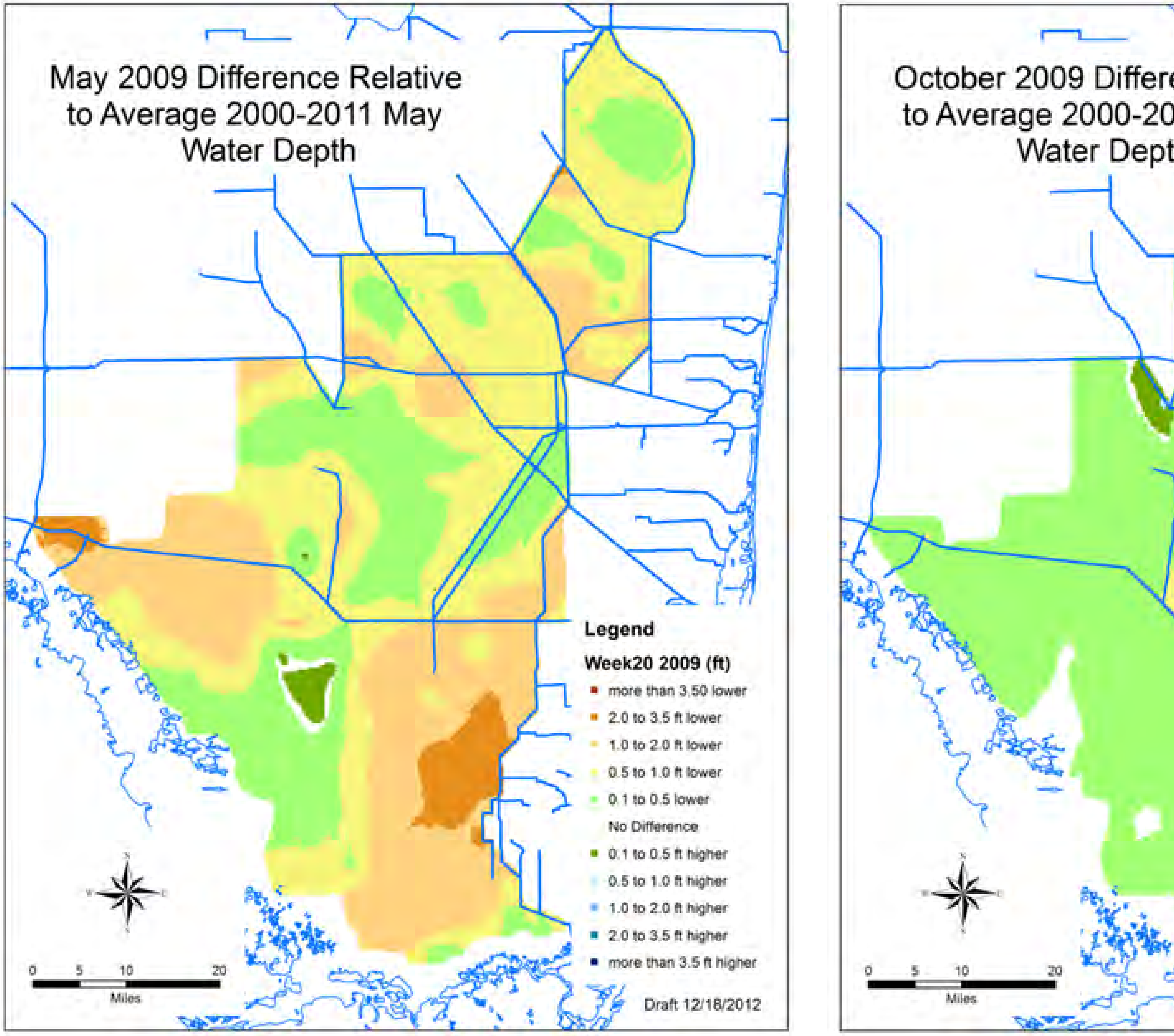
Zone/ Performance Measure	WY 2008	WY 2009	WY 2010	WY 2011	WY 2012	Trend	CURRENT STATUS	Trend
Nesting Production and Success								
Overall Nest Production and Success	🔴	🟡	🟡	🟡	🟡	⇧	The overall score for nesting success is the lowest score of the four component metrics. From 2010-2012, there were at least two metrics that scored yellow but none were red.	The greater sensitivity to the spoonbill nesting cycle by water managers has increased the possibility of nesting success during favorable climatic conditions, however, until the C-111 Spreader Canal Project is completed, there will still be limita-tions on maintaining favorable conditions resulting in a prospectus of yellow.
Chick Production in NE FL Bay	🔴	🟡	🟡	🟢	🟢	⇧	The 5-year mean of NE production was 1.31, 1.39 and 1.47 c/n1 from 2010-2012. The target of 1.38 c/n (based on pre-SDCS conditions) was exceeded for the first time since 1993.	Greater sensitivity to the spoonbill nesting cycle by water managers has resulted in greater nesting success during years with favorable climatic conditions. This sensitivity is expected to continue. Also the C-111 spreader canal may possibly add productivity.
Chick Production in NW FL Bay	🟡	🟢	🟢	🟡	🟡	⇩	The 5-year mean nest production was 1.4, 1.3, and 1.2 c/n respectively from 2010-2012. Nest production of >1 c/n in NW FL Bay is being maintained (yellow) however productivity dropped below the target of 1.38 c/	It is not clearly understood why nesting success is declining in NWFB but this likely explains the declining nest numbers as well. Potential sources may be increased nest predation by crows and adverse affects of the increasing impact of unregulated canals on the foraging grounds. The later has been partially fixed but the potential positive effects of the recent plugging of these

Wading Birds (Roseate Spoonbill) indicator

Zone/ Performance Measure	WY 2008	WY 2009	WY 2010	WY 2011	WY 2012	Trend	CURRENT STATUS	Trend
Percent successful years in NE FL Bay	🔴	🟡	🟡	🟡	🟡	⇧	Successful nesting (>1c/n) occurred in 5, 6, and 6 of the previous 10 years from 2010 - 2012 .	In 2012, 6 of the last 7 years were successful. If there is 1 more successful yr out of the next 3, the green condition (7 yrs) will be met.
Percent successful years in NW FL Bay	🟢	🟢	🟢	🟢	🟡	⇩	In 2011, the number of successful years for the prior 10 years was 6 dropping below the green threshold of 7.	It is not well understood why success has not occurred for the last 3 yrs but there is little reason to believe this trend will reverse unless the plugging of the canals has a profound effect on the productivity of the foraging grounds.
Prey Fish Community NE FL Bay								
Prey Community Structure NE FL Bay	🔴	🔴	🔴	🟡	⚪	⇧	In 2010 and 2011, freshwater species made up 3.6 and 13.7% of the catch. The target is 40% and the threshold for red/yellow is >5% (i.e. 2011 was yellow). Data for 2012 not yet available.	The C-111 spreader canal, if operated correctly, is expected to increase freshwater flow through Taylor Slough thereby increasing freshwater species as well as prey productivity.

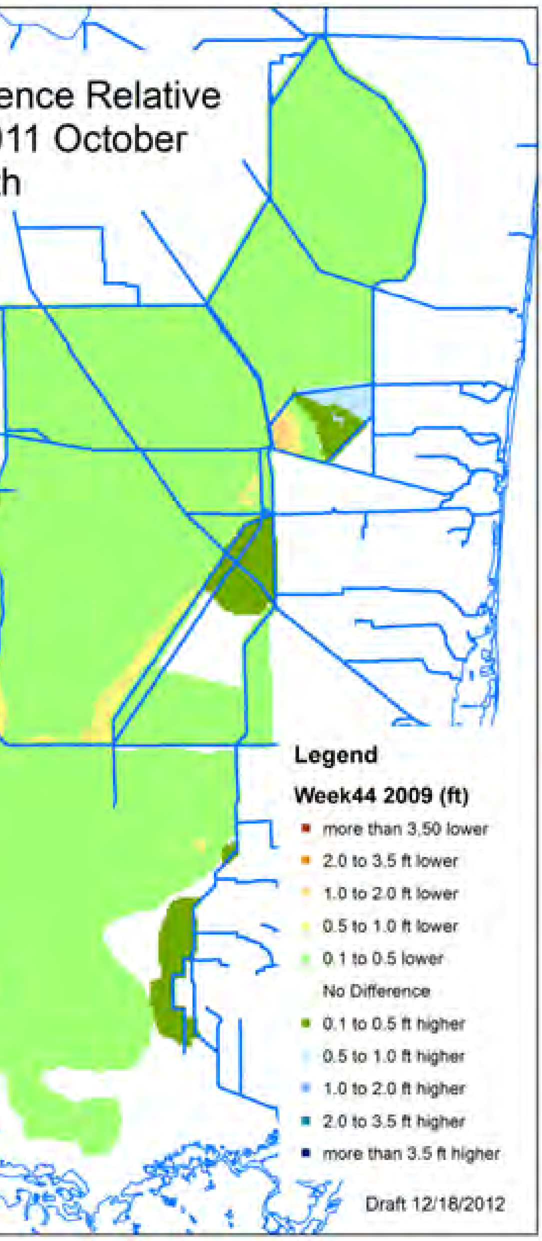
The following assumption is being used for the 2-Year trend column: There will be no major changes in water management or significant natural events such as hurricanes from the date of the current status assessment

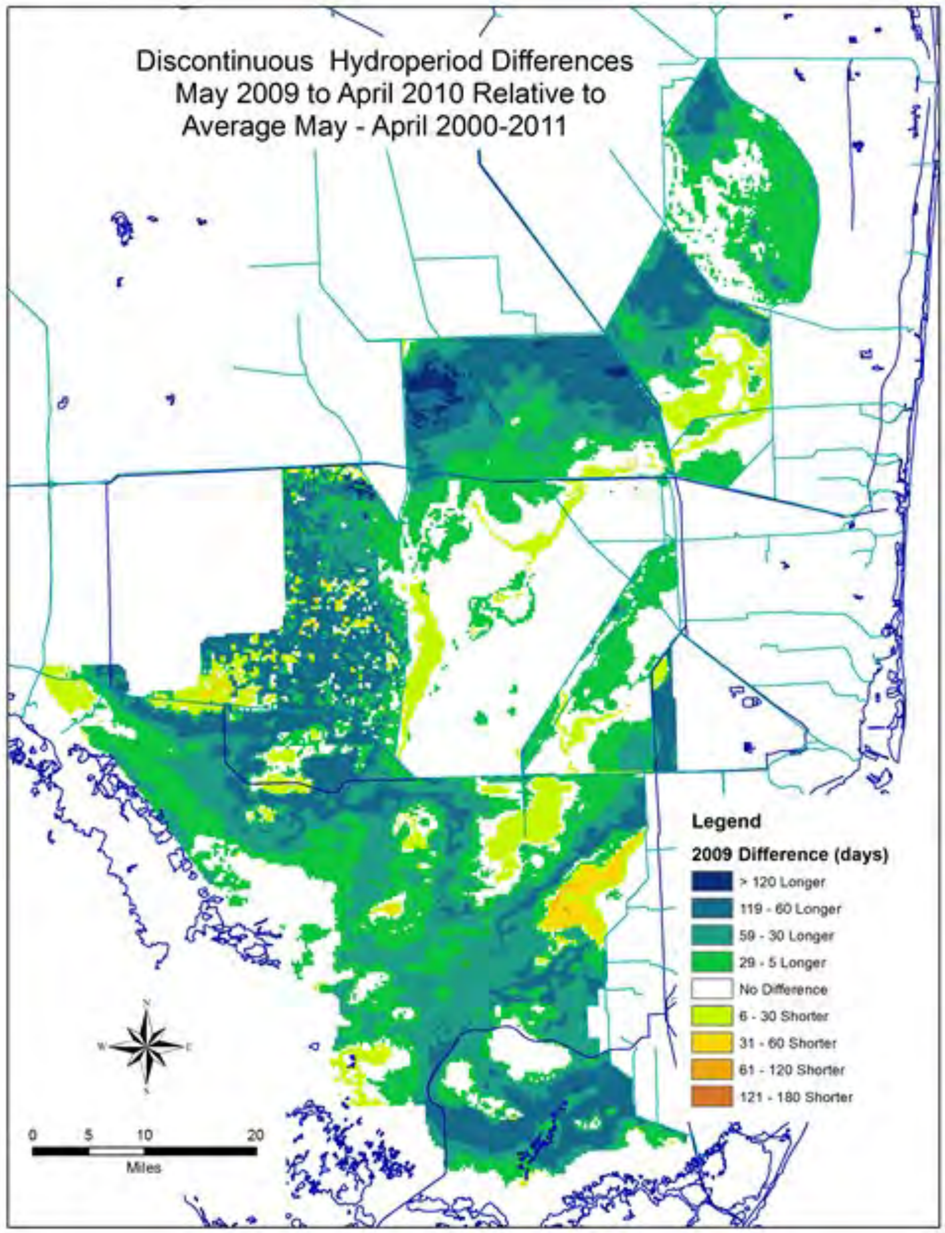
c/n (chicks per nest) is a unit of nest production that indicates the average number of chicks raised until they leave the nest per nesting attempt i.e. 1c/n indicates that on average a colony produced 1 chick for every nest that spoonbills initiated.



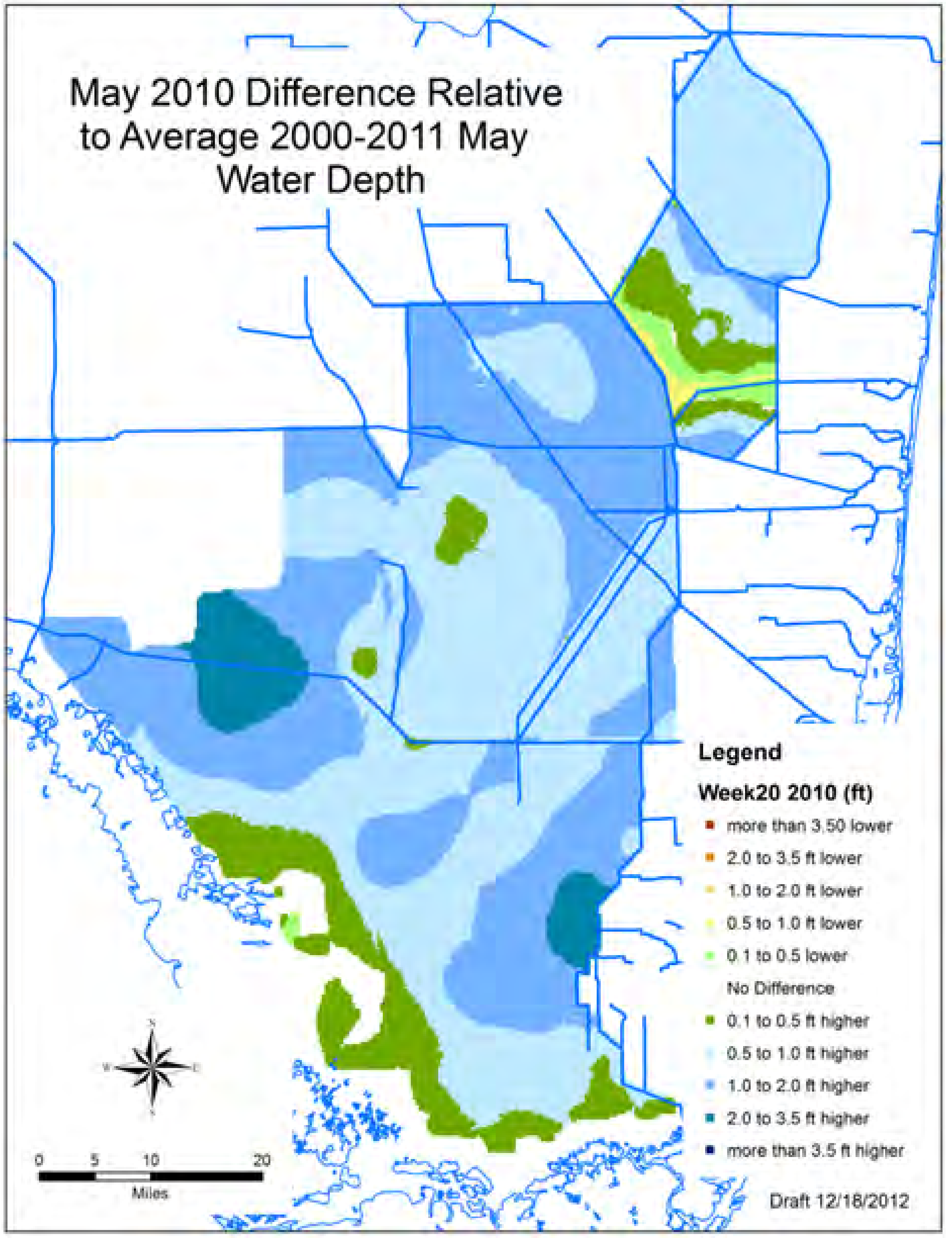
Appendix A: Difference between water year 2010 and average conditions experienced 2000-201
ter areas or longer than average hydroperiods, while yellows, oranges, and browns indicate drier
USGS.

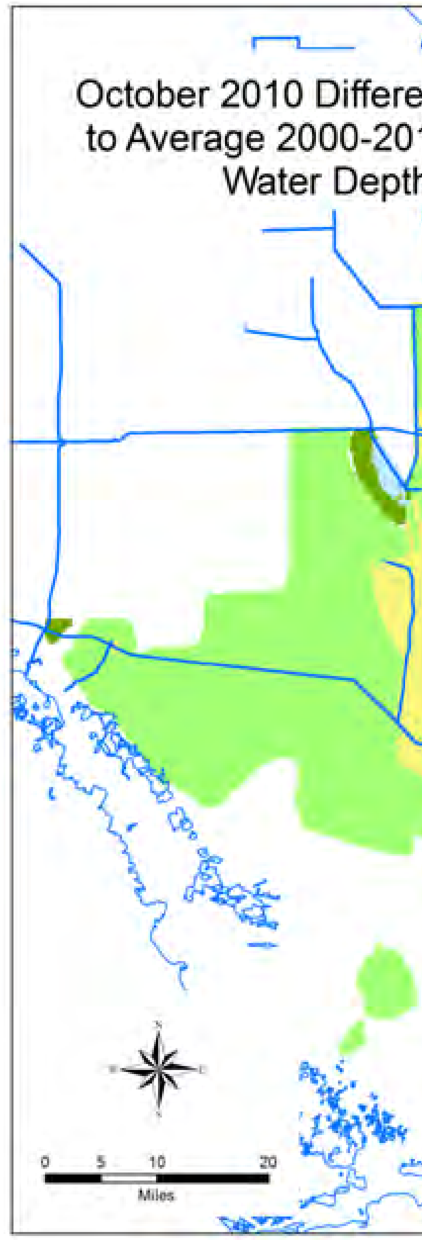
dix A



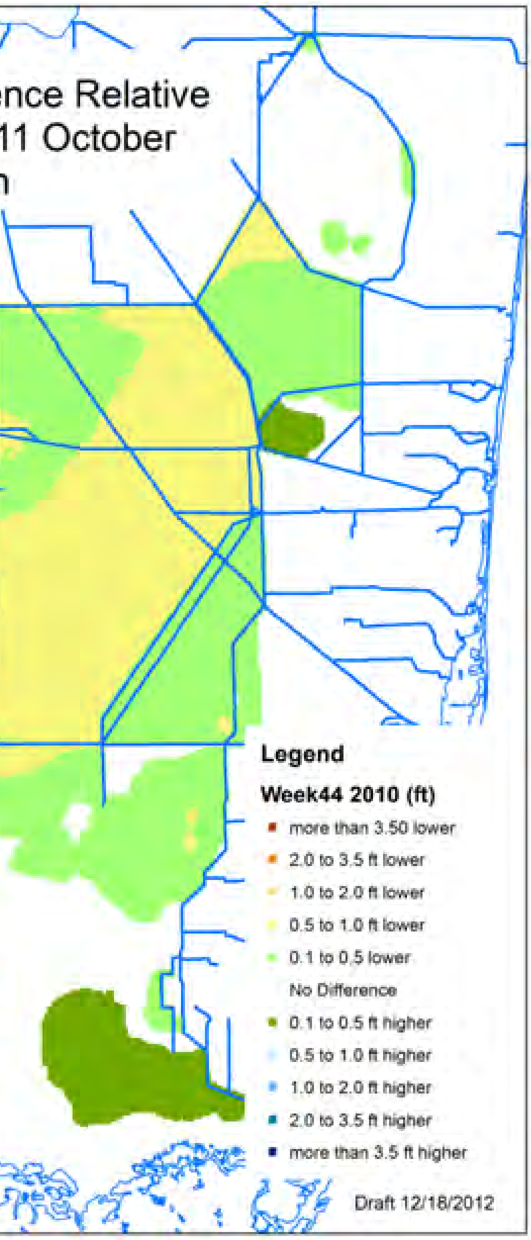


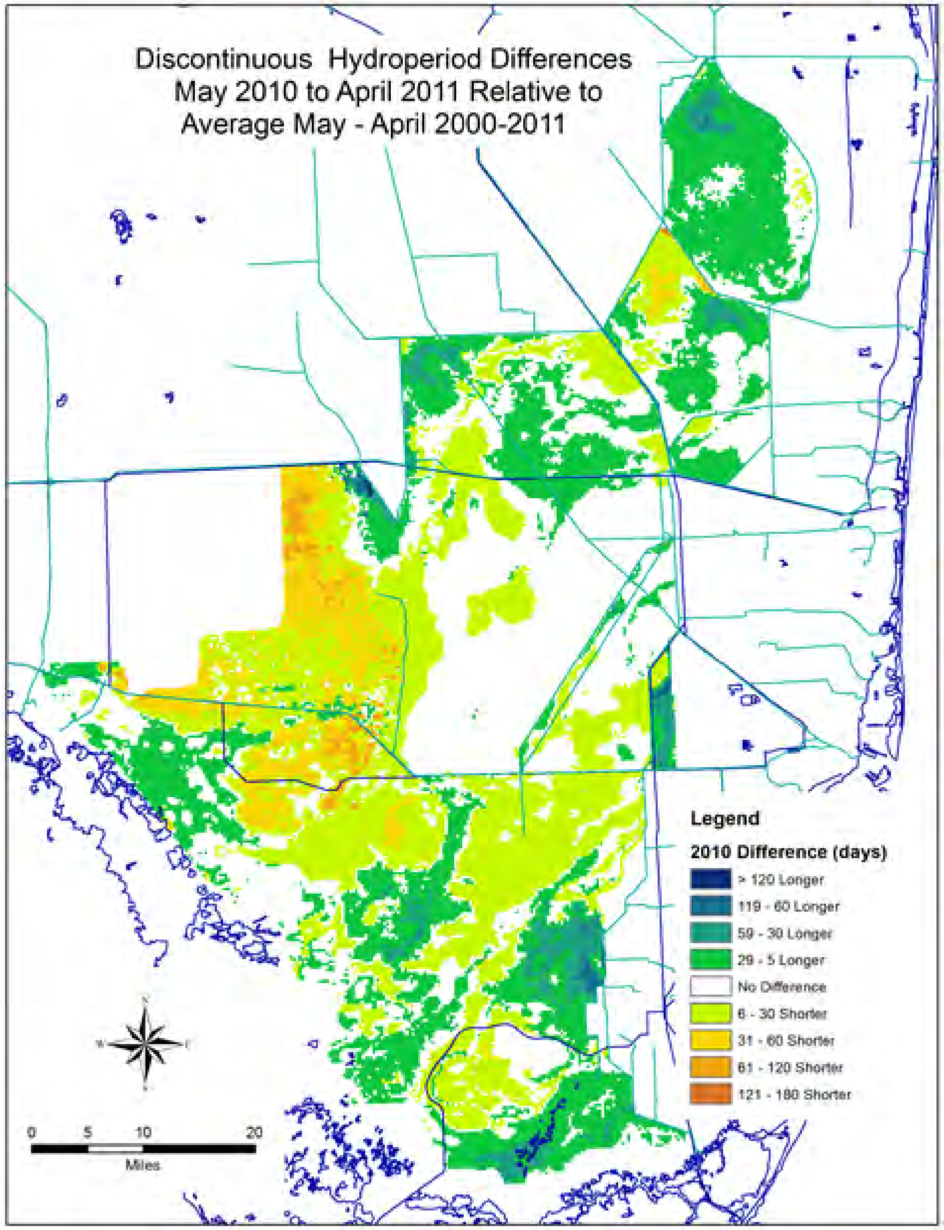
1 for dry (left) and wet (center) season water depths and hydroperiod (right). Blues and greens indicate wet- areas or shorter than average hydroperiods. Source: Adapted from Everglades Depth Estimation Network,



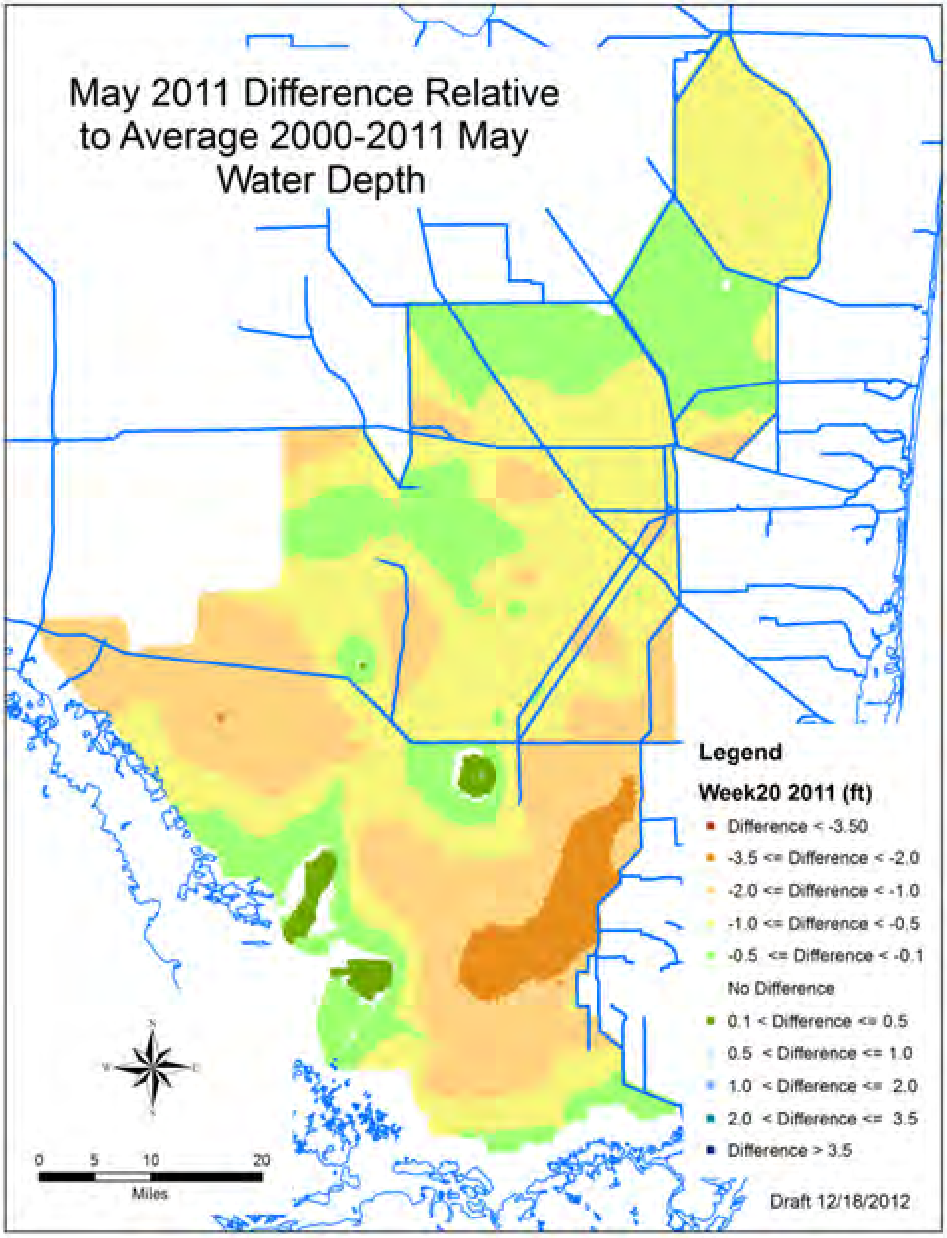


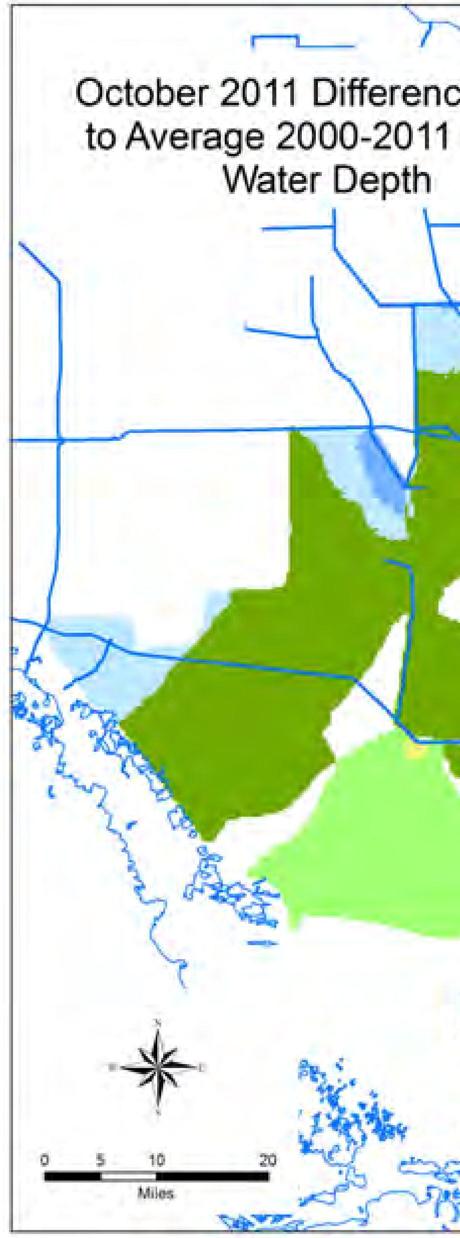
Difference between water year 2011 and average conditions experienced 2000-2011 for dry (left) a
as or longer than average hydroperiods, while yellows, oranges, and browns indicate drier areas or
USGS.



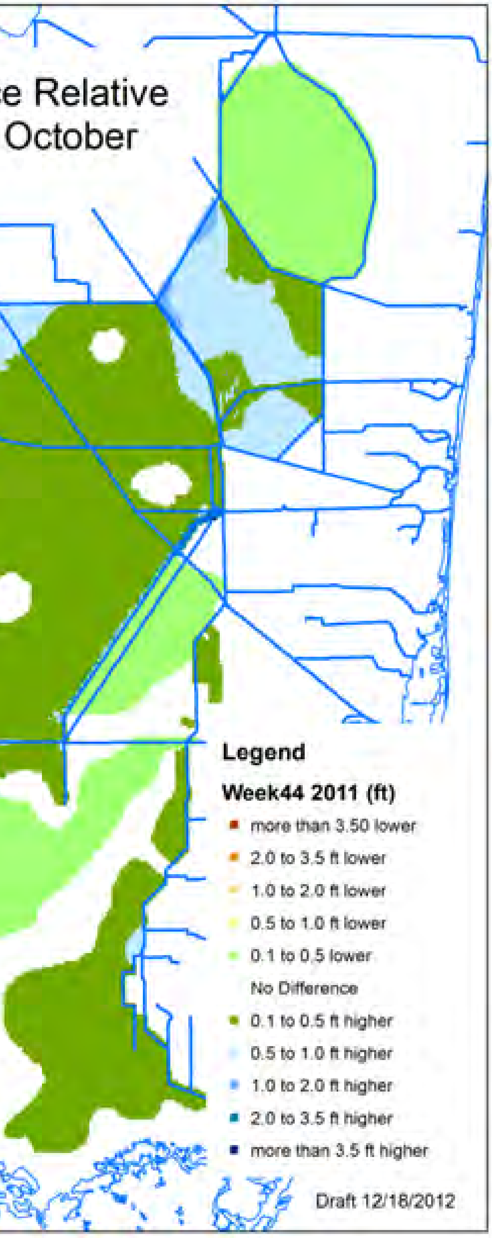


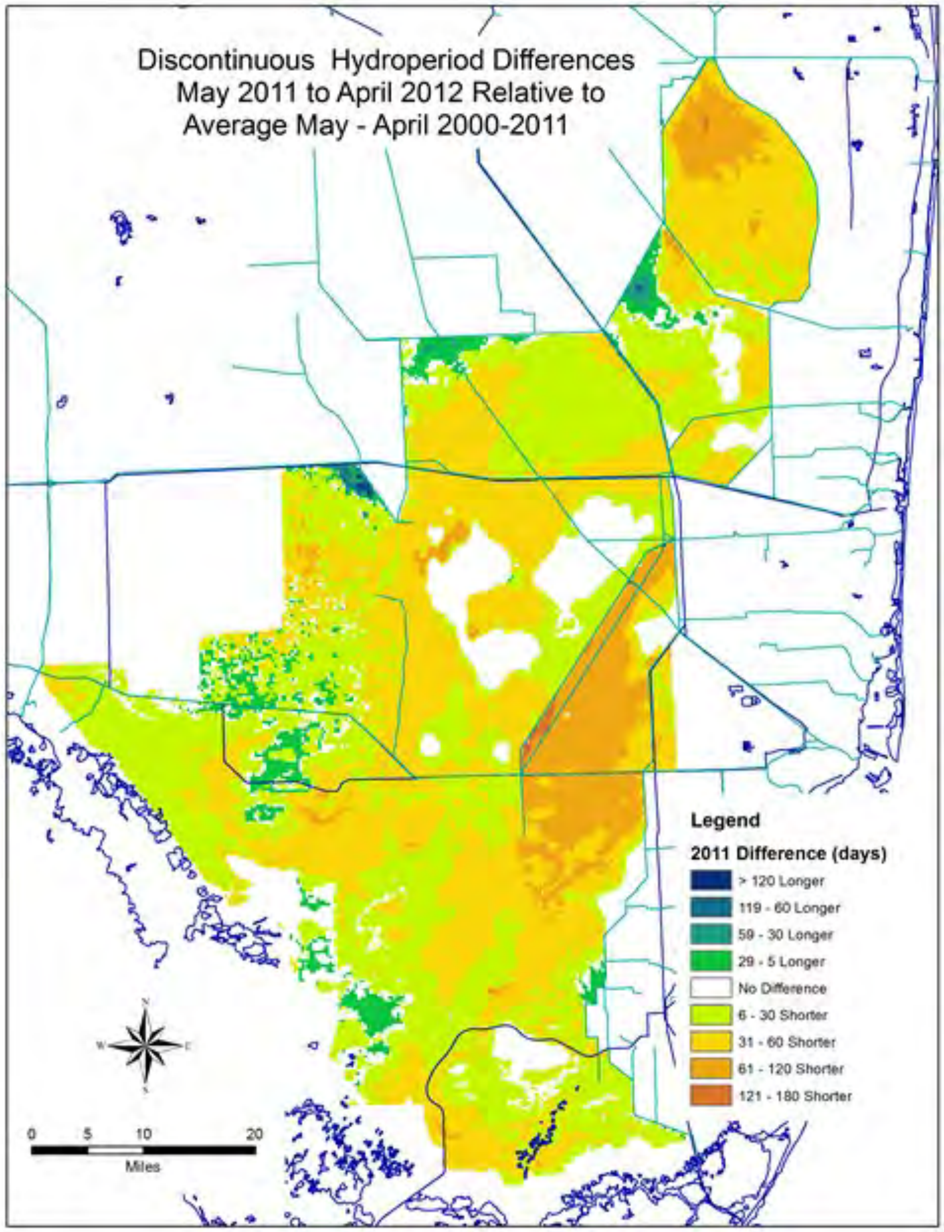
nd wet (center) season water depths and hydroperiod (right). Blues and greens indicate wetter are-
shorter than average hydroperiods. Source: Adapter from Everglades Depth Estimation Network,





Difference between water year 2012 and average conditions experienced 2000-2011 for dry (left) and
or longer than average hydroperiods, while yellows, oranges, and browns indicate drier areas or short





wet (center) season water depths and hydroperiod (right). Blues and greens indicate wetter areas
er than average hydroperiods. Source: Adapter from Everglades Depth Estimation Network, USGS.

Enlarged versions of Figures

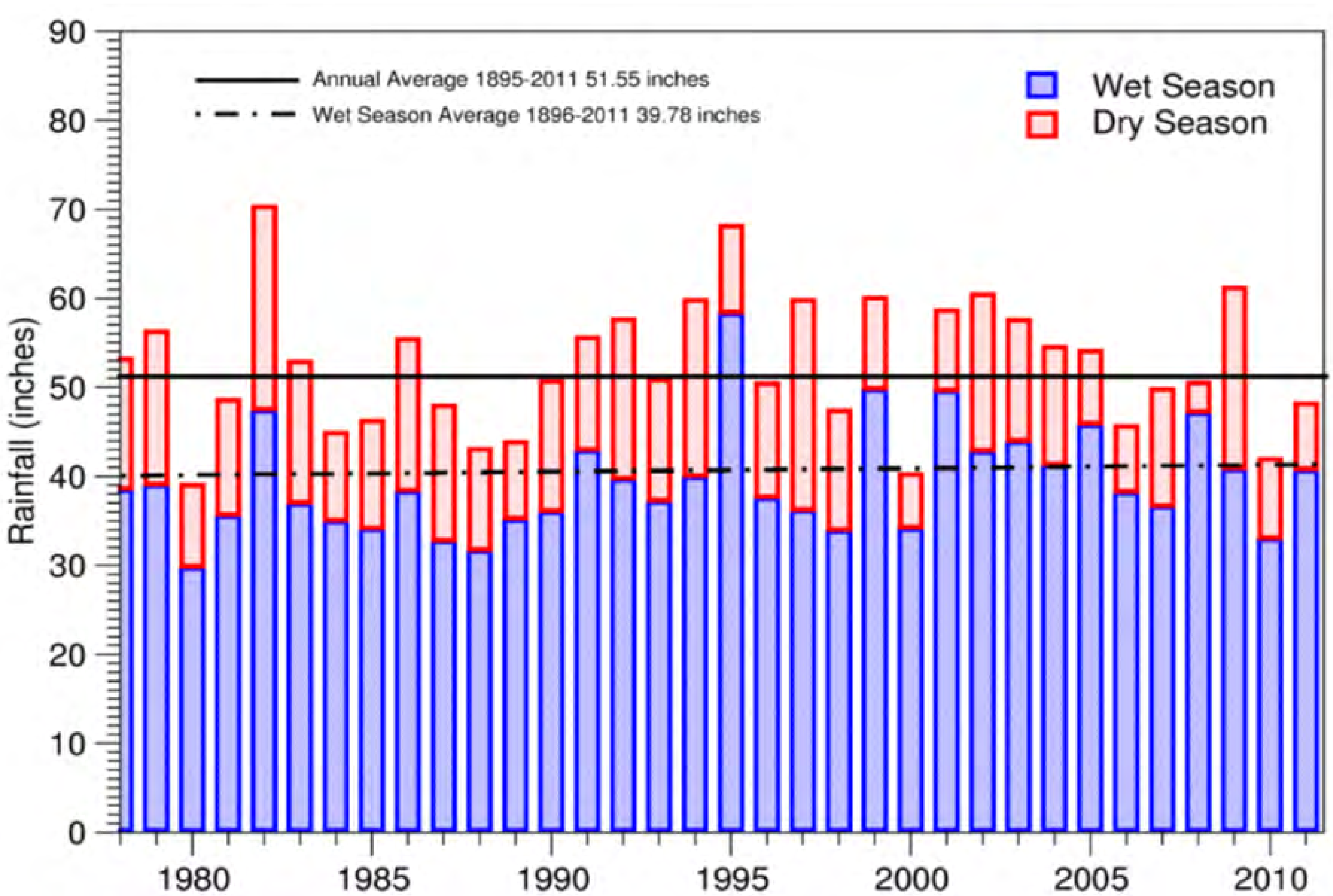


Figure 3. South Florida seasonal and annual rainfall for the last 35 years, based on rainfall over the Everglades-Southwest Florida region, source: National Climate Data Center.

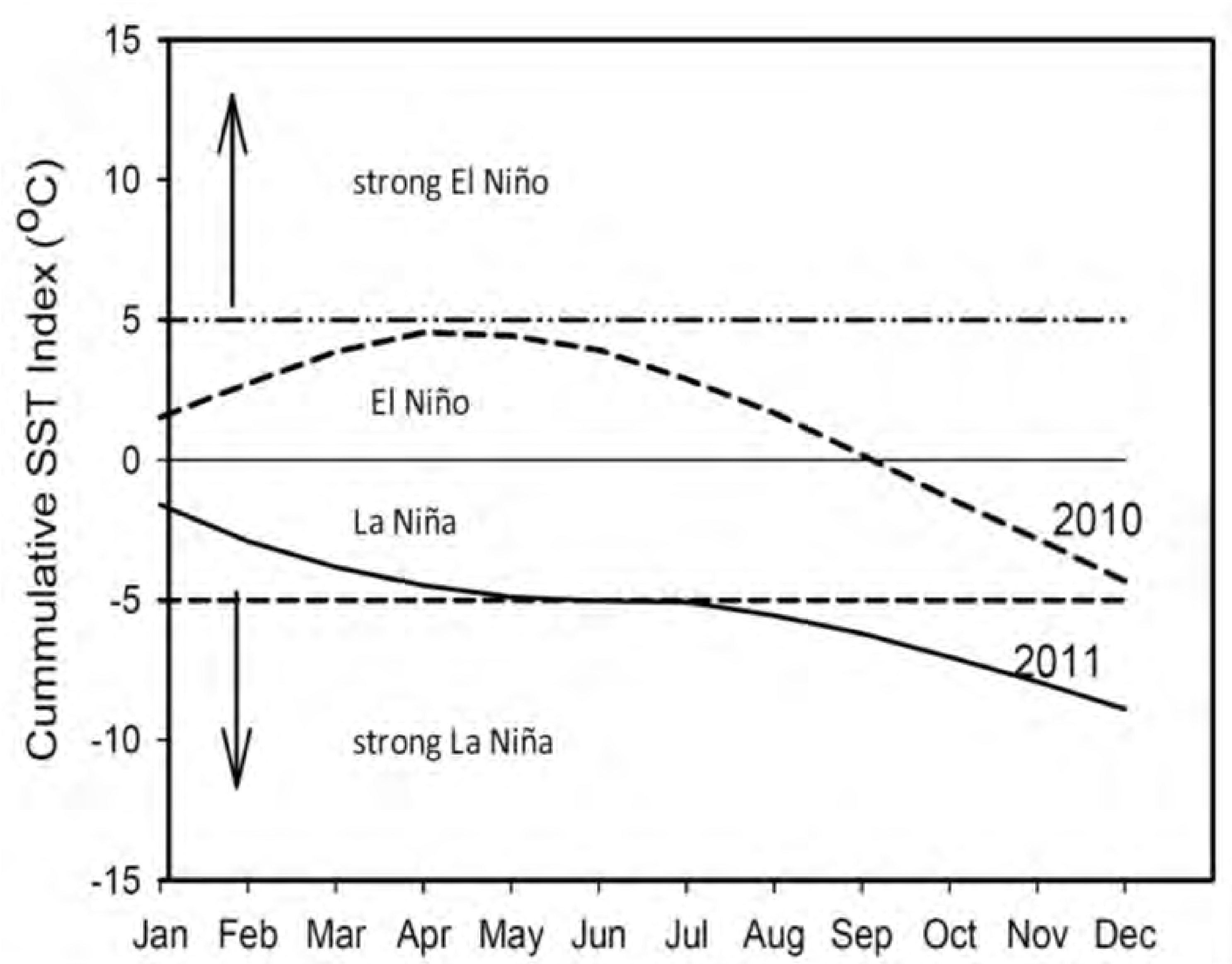


Figure 4. El Niño-Southern Oscillation (ENSO) cumulative sea surface tracking index for calendar year 2010 and 2011, source: South Florida Environmental Report, SFWMD, 2012. Positive values indicate the presence of an El Niño event, which generally brings above normal dry season rainfall in south Florida. Negative values indicate the presence of a La Niña event, which generally brings below normal dry season rainfall in south Florida.

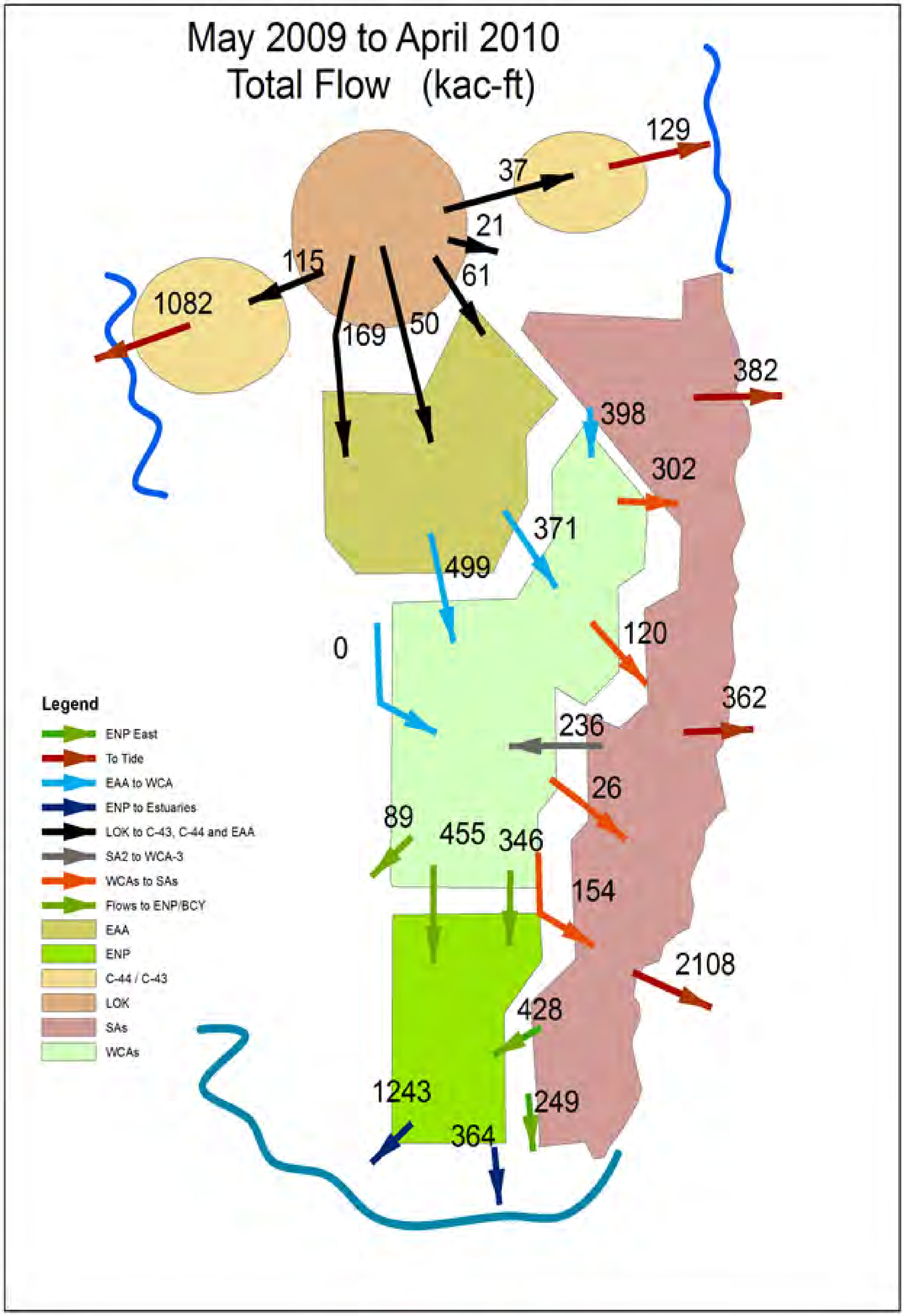
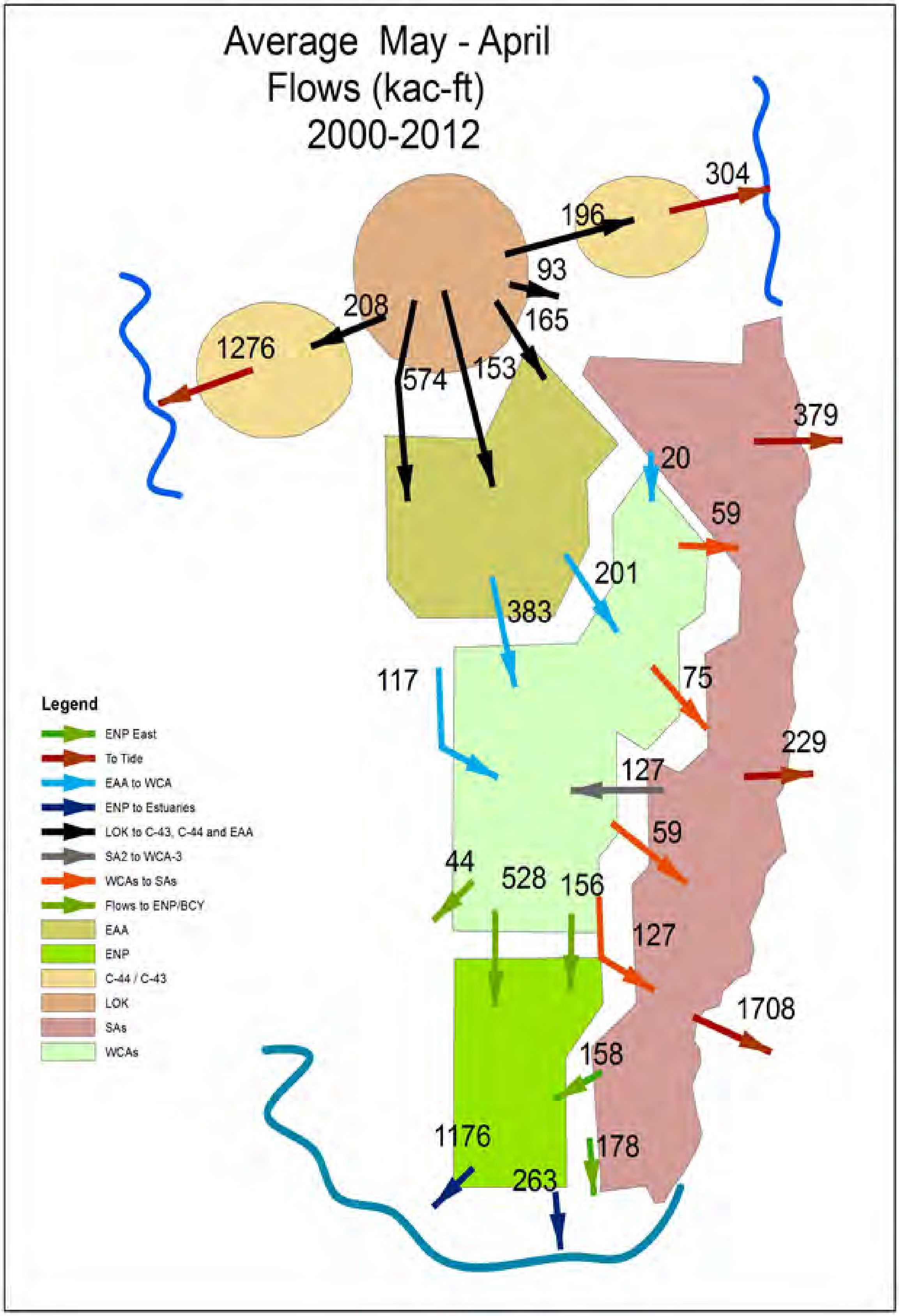


Figure 5. Surface water budget for water year 2010 (left) compared to the average wate



er budget for 2000-2012 (right).

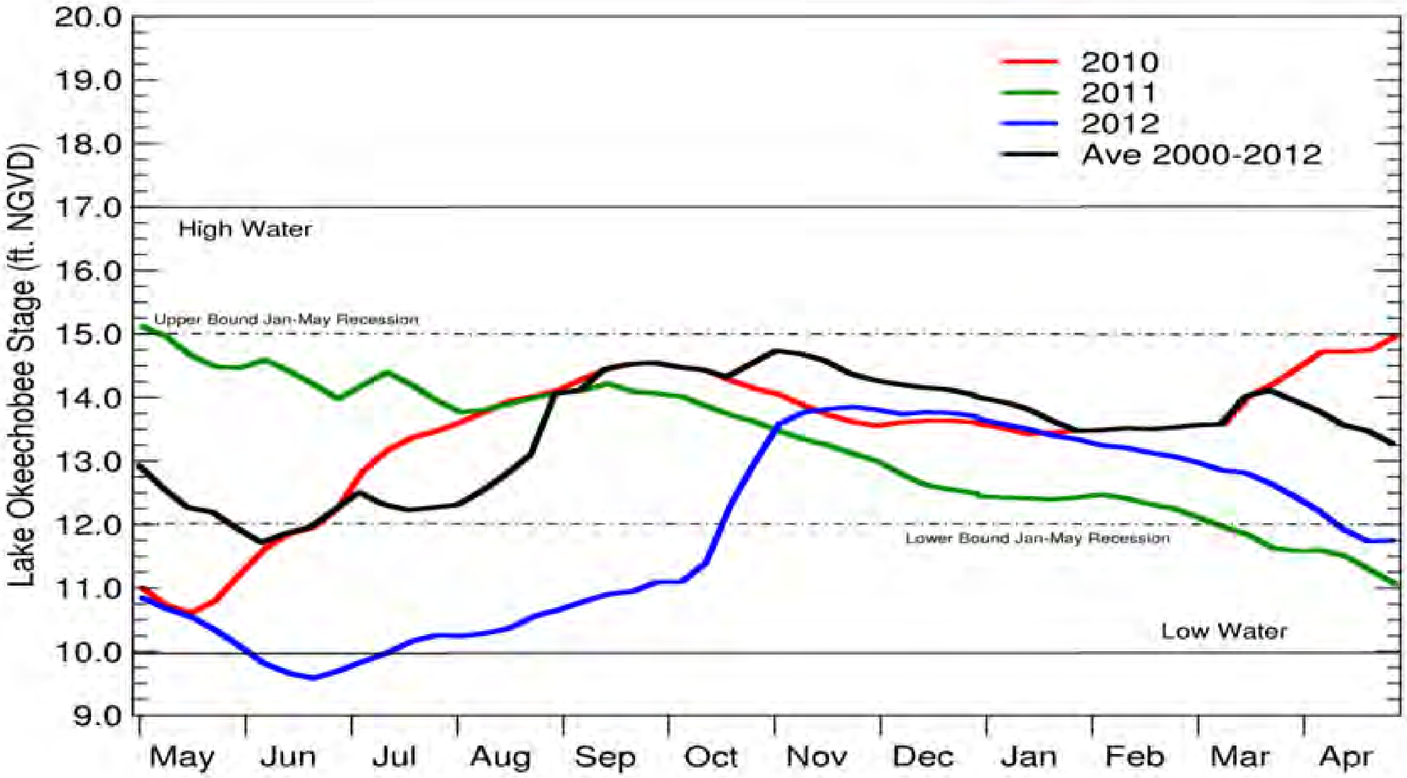
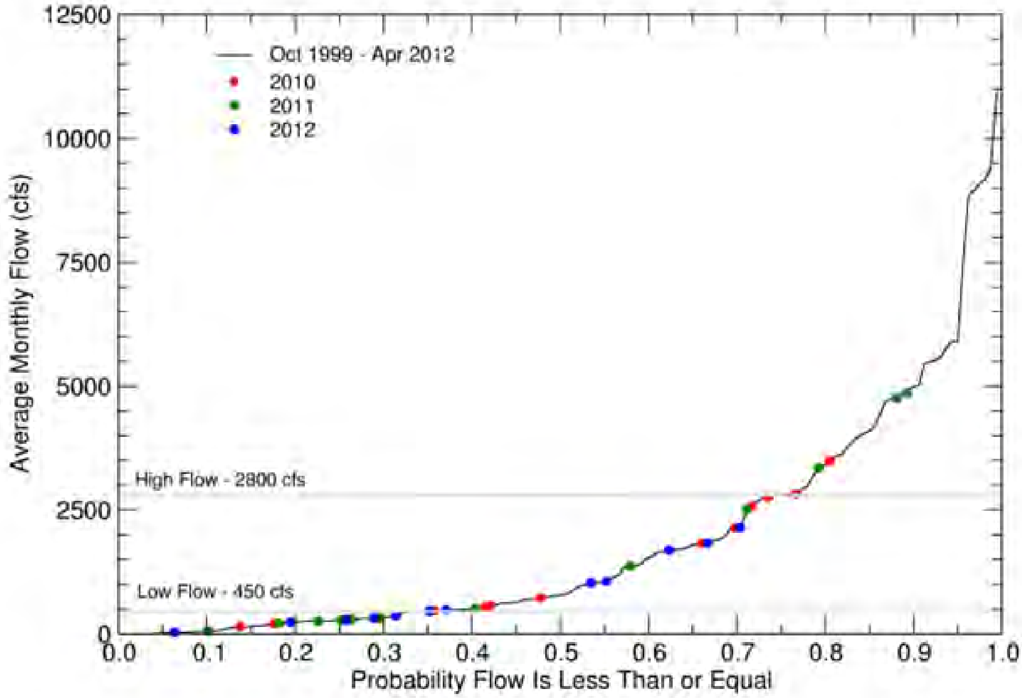


Figure 6. Water levels in Lake Okeechobee during water years 2010, 2011, and 2012 versus the twelve-year average. Water levels above 17.0 feet are in the high lake management band. Water levels below 10.0 feet are in the water shortage management band.



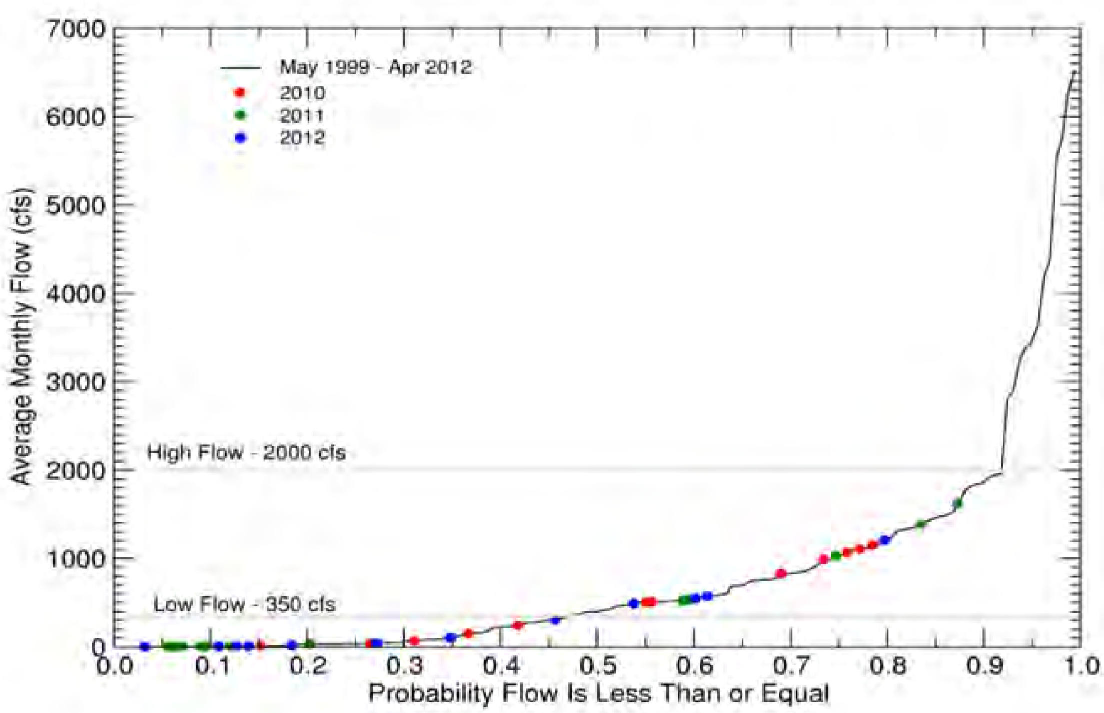
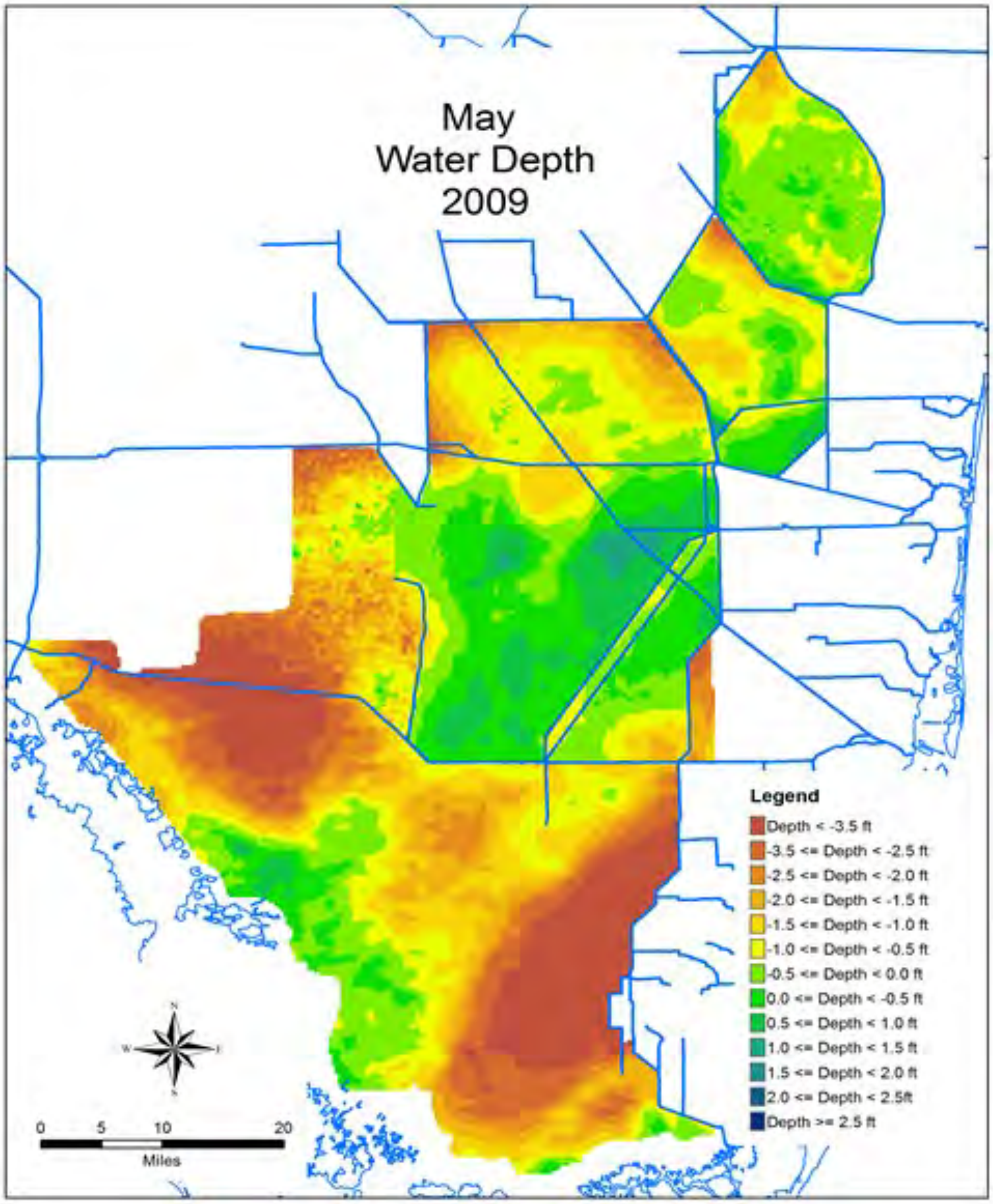


Figure 7. Average monthly flows into the downstream Caloosahatchee estuary (left) measured at S-79, and St. Lucie estuary (right) measured at S-80, during water years 2010, 2011, 2012. The solid line represents the average monthly flow values for the full twelve-year period (WY2000-WY2012).



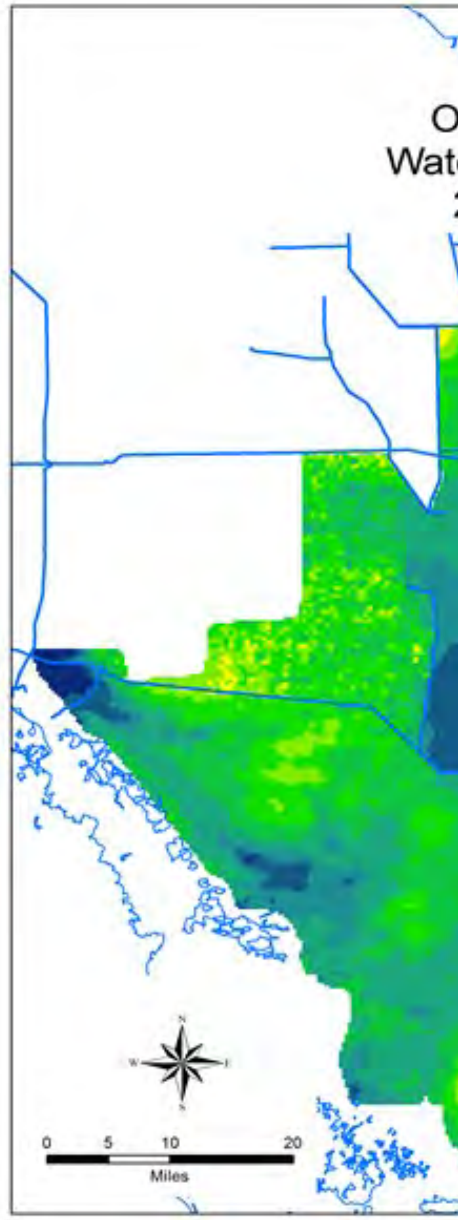
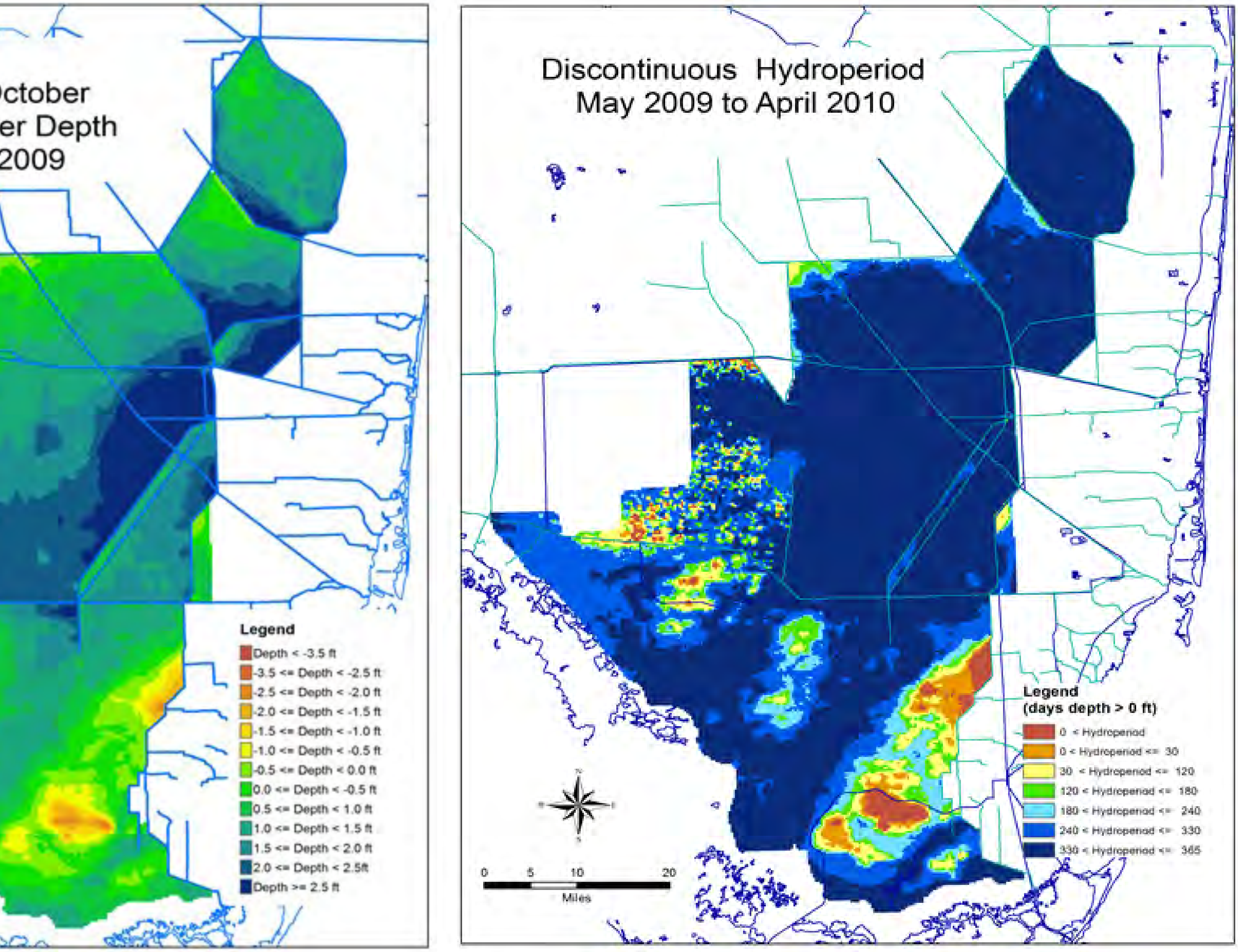


Figure 8. Water Depths and Hydroperiods during Water Year 2010 (May 2009 through April 2010). May
October 2009 (center) represents the water depth conditions in the Everglades at the peak of the 2009 w
that water was above the ground surface (flooding duration) during water year 2010. Appendix X shows
conditions experienced between 2000-2011. Blues and greens indicate wetter areas or longer hydroper
Adapted from the Everglades Depth Estimation Network, USGS.



2009 (left) represents the water depth conditions in the Everglades at the end of the prior dry season. wet season. The May 2009 to April 2010 hydroperiod map (right) represents the total number of days s the difference maps comparing the water depths and hydroperiods in water year 2010 to the average riods, while yellows, oranges, and browns indicate drier areas or shorter hydroperiods. Source:

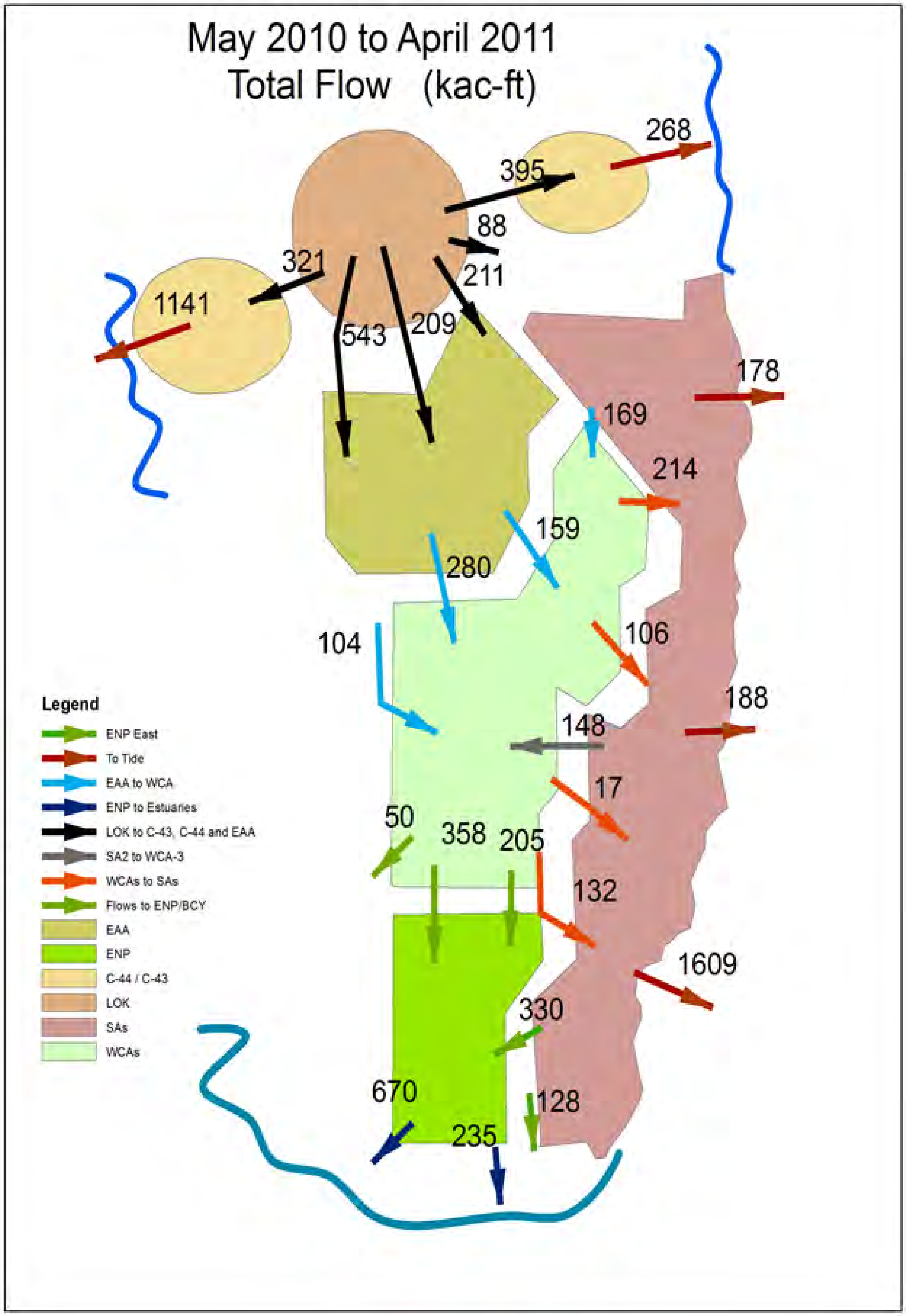


Figure 9. Surface water flows through the Everglades during water year 2011

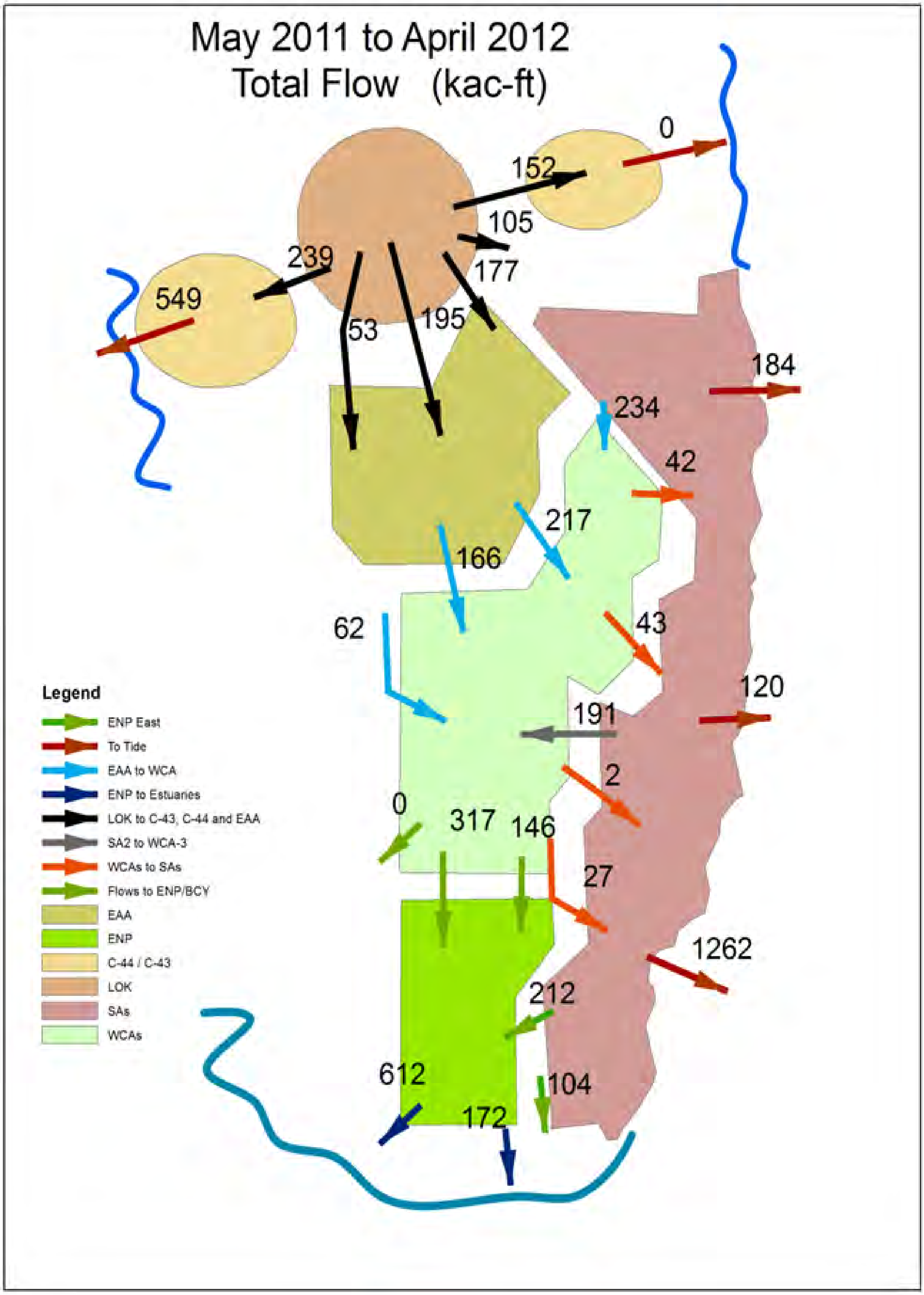


Figure 11. Surface water flows through the Everglades during water year 2012

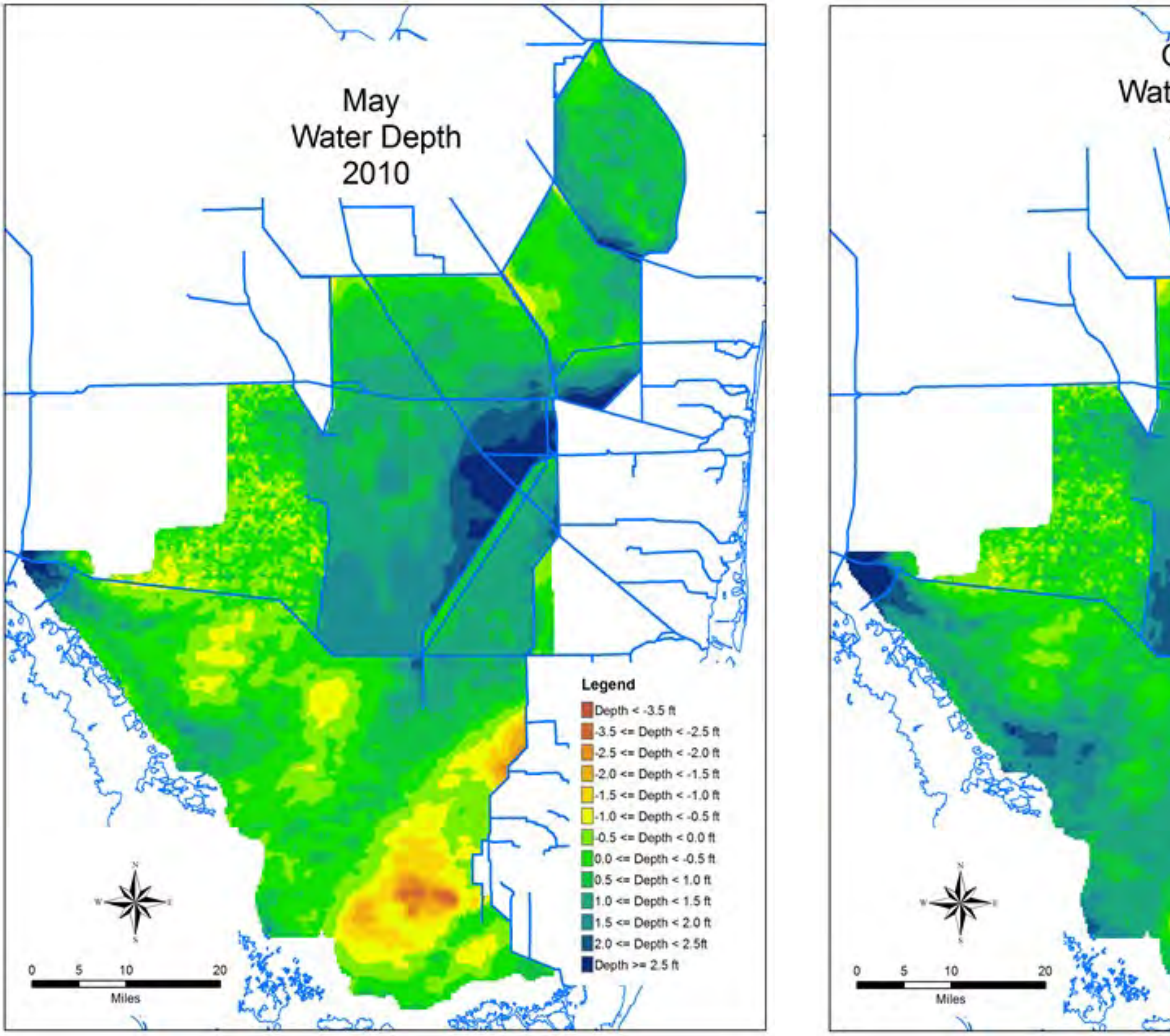
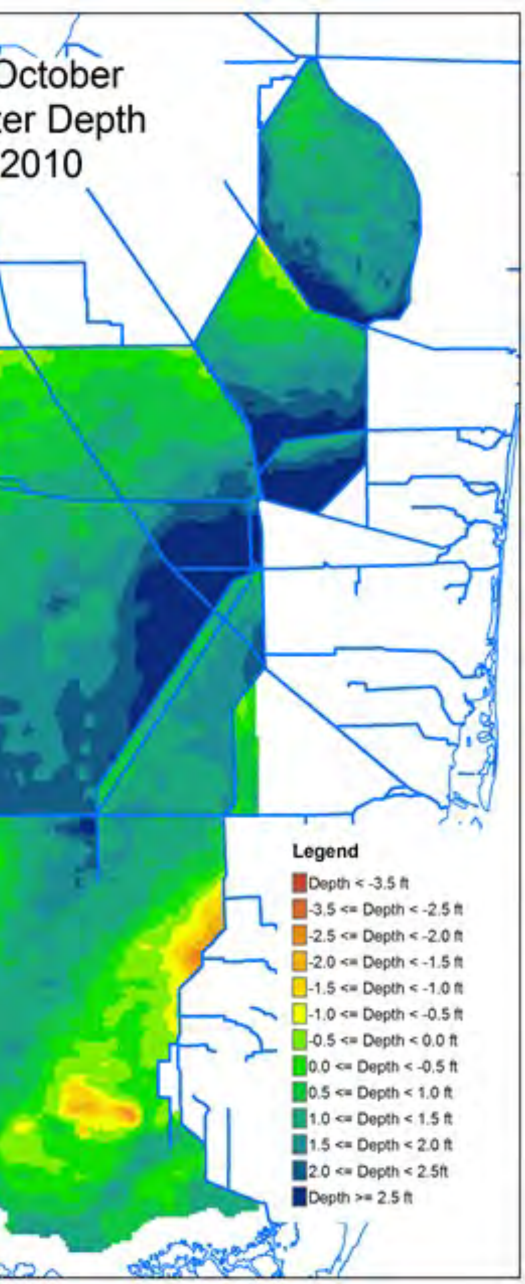
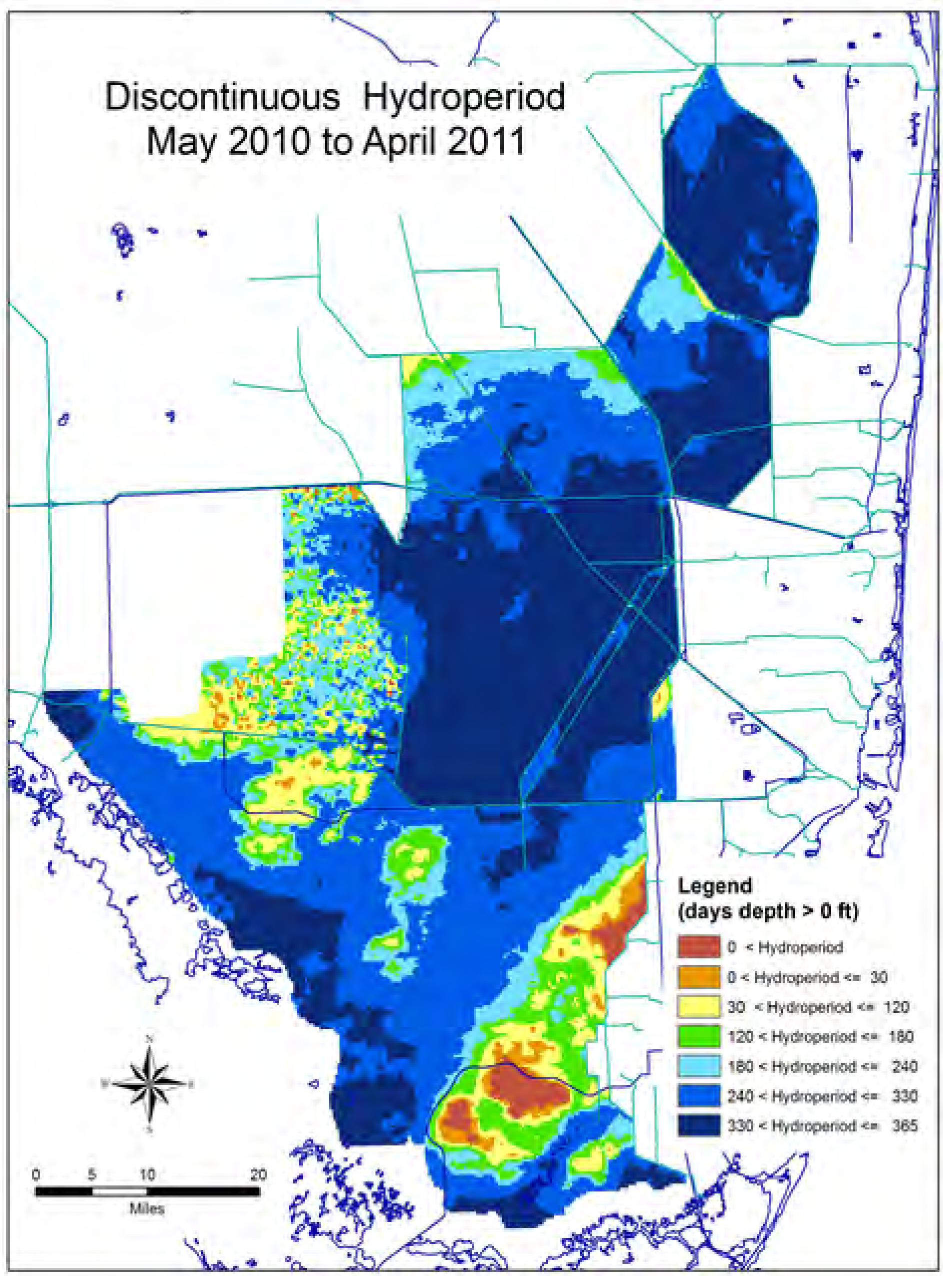


Figure 10. Water Depths and Hydroperiods during Water Year 2011 (May 2010 through April 2011).
son. October 2010 (center) represents the water depth conditions in the Everglades at the peak of th
of days that water was above the ground surface (flooding duration) during water year 2011. Append
the average conditions experienced between 2000-2011. Blues and greens indicate wetter areas or
Source: Adapted from the Everglades Depth Estimation Network, USGS.





May 2010 (left) represents the water depth conditions in the Everglades at the end of the prior dry sea-
ne 2010 wet season. The May 2010 to April 2011 hydroperiod map (right) represents the total number
dix X shows the difference maps comparing the water depths and hydroperiods in water year 2011 to
longer hydroperiods, while yellows, oranges, and browns indicate drier areas or shorter hydroperiods.

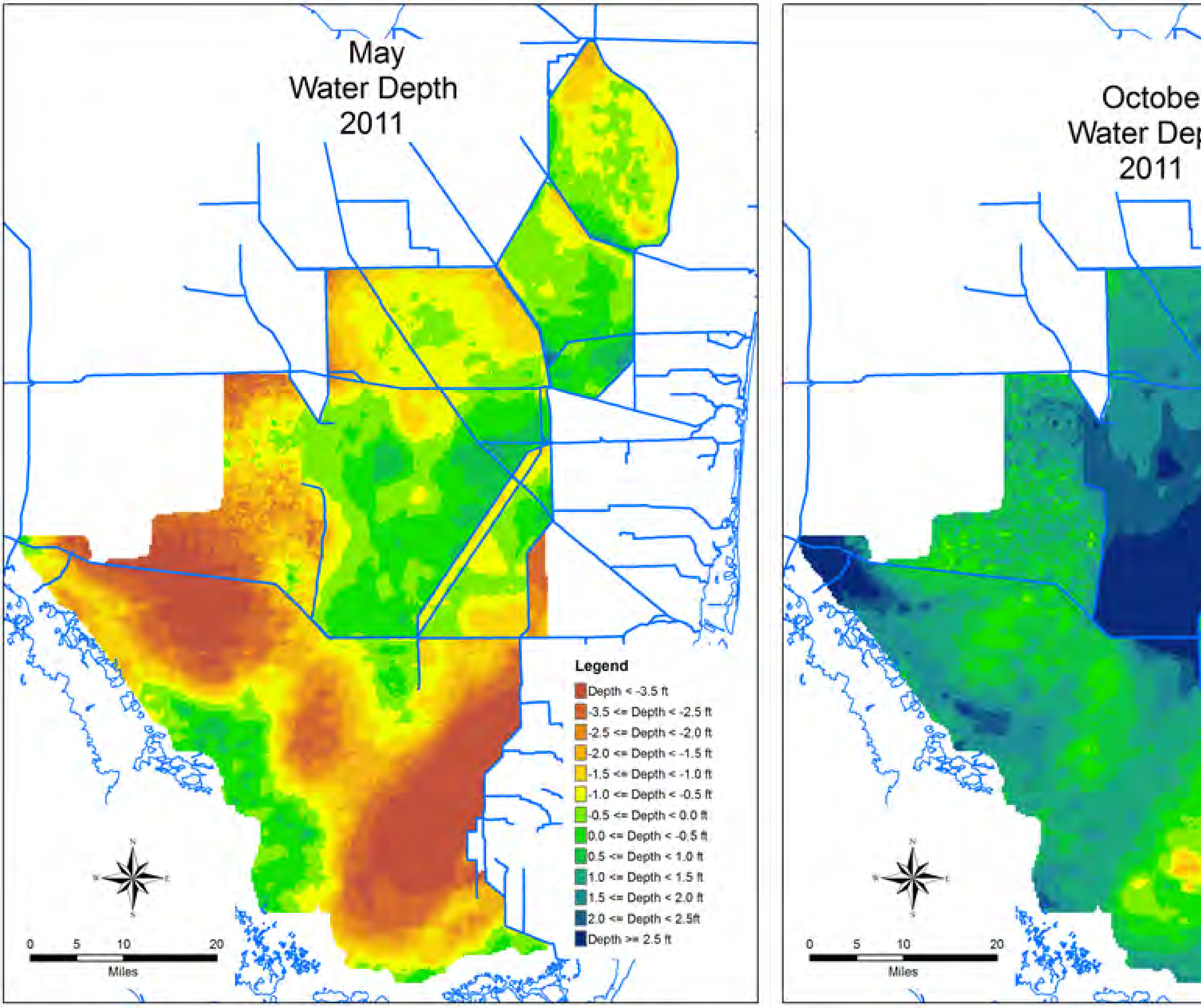
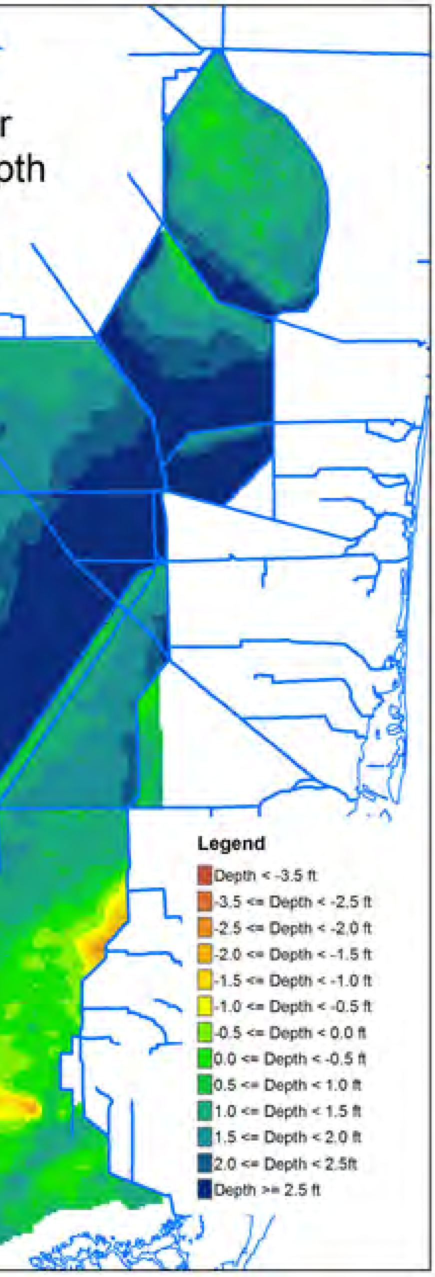
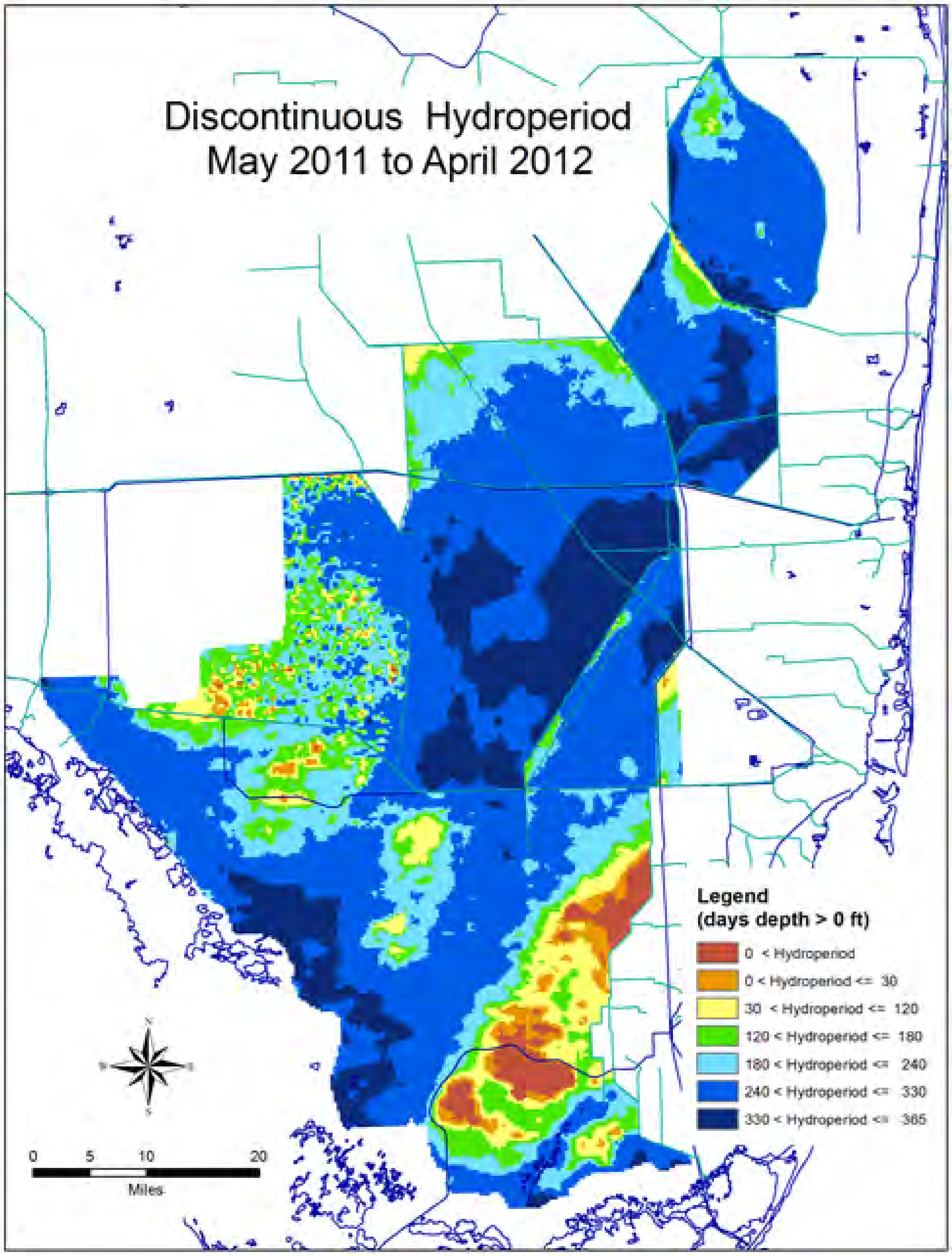


Figure 12. Water Depths and Hydroperiods during Water Year 2012 (May 2011 through April 2012). M
season. October 2011 (center) represents the water depth conditions in the Everglades at the peak of
number of days that water was above the ground surface (flooding duration) during water year 2011. .
year 2012 to the average conditions experienced between 2000-2011. Blues and greens indicate wet
shorter hydroperiods. Source: Adapted from the Everglades Depth Estimation Network, USGS.





May 2011 (left) represents the water depth conditions in the Everglades at the end of the prior dry f the 2011 wet season. The May 2011 to April 2012 hydroperiod map (right) represents the total Appendix X shows the difference maps comparing the water depths and hydroperiods in water ter areas or longer hydroperiods, while yellows, oranges, and browns indicate drier areas or

Acknowledgments

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