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Optimizing LOSOM's Preferred Alternative to Protect Lake Okeechobee Health

by Paul Gray, Audubon Florida

American Coots foraging on submerged aquatic vegetation (SAV) in Lake Okeechobee. Photo: Paul Gray

Executive Summary

In July 2021, the US Army Corps of Engineers selected Alternative CC as its Preferred Alternative for the Lake Okeechobee System Operating Manual (LOSOM) and is now seeking to optimize this alternative for all elements of the Greater Everglades Ecosystem. Ensuring that the benefits and adversity of operations are shared equally will ensure no one portion of the system is harmed unduly or irreparably until the promise of CERP is realized.

Audubon has a long history and expertise in the ecology of Lake Okeechobee and has synthesized the literature and impacts of past operation schedules to inform the Corps' consideration with to regard to this central element of the system.

We discuss the impacts of high and low Lake levels on key ecological considerations for optimization including submerged aquatic vegetation, short-hydroperiod marsh communities, sport and bait fisheries, water quality in pelagic and inshore areas and the littoral zone, and migratory and nesting bird use. Optimization to safeguard these ecosystem functions would reduce the number of deep water events and ensure regular drawdowns during the dry season.

Summary considerations for optimization of the Preferred Alternative are included on page 12 of this report.

Introduction

Tentatively Selected Plan CC was designated as the Preferred Alternative by the USACE on August 9, 2021, and will move forward with optimization toward a Final Alternative. Optimization includes considering all ecosystems and human infrastructure in the region. In Audubon's August 6, 2021 comment letter, we discussed harmful and beneficial releases from the Lake. This document focuses narrowly on the optimization process for Lake Okeechobee, one of many valuable south Florida resources.

Lake Okeechobee has had many regulation schedules in its history with different characteristics (see Havens 2018). In 1978, the deepest schedule ever was implemented, causing deep-water problems in the Lake. As a result, a somewhat lower schedule (Run 25) was adopted in 1992. Problems continued; WSE was adopted in 2000 to further lower the lake. That schedule also created deep-water problems, which combined with safety concerns about the Hoover Dike, led to LORS08 (2008), the lowest lake schedule since before 1978. LORS08 was better for Lake health but allowed the Lake to reach 16 feet six years in a row, further degrading the Lake.

Now that Hoover Dike repair is imminent, the USACE is developing a new schedule that can consider improved dike safety. The Preferred Alternative, in its present form, will result in a deeper Lake on average than LORS08. The frequent deep periods of this Preferred Alternative will not be as chronic as the very harmful schedules of the 1980s and 1990s, and the Preferred Alternative also includes more low water periods making it less onerous; nevertheless, harmful impacts appear imminent. This white paper provides a literature review and analysis of deep-water scenarios on the ecology of Lake Okeechobee that may assist the Corps in optimizing the Preferred Alternative to reduce harm to this and other Everglades resources.

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High Lake Levels

An initial warning sign of in-lake problems from the Preferred Alternative is the frequency of hitting 17-foot levels. The Lake is projected to reach this level 10 times[1] in the 52-year period of record (POR). When the lake reaches 17 feet, harm is significant. This is because deeper water increases stress on plants, but also because the lake requires drawdown periods of months of time to reach non-harmful levels of around 15 feet again. The combination of depth and duration make 17 feet an extreme harm threshold.

The RECOVER Stage Envelope performance measure (2020) for the Lake summarizes impacts of hitting 17 feet as:

> "2.2.1 Extreme High
> Extreme high stages (>17 ft [5.18 m]) allow wind-driven waves to directly impact the nearshore emergent and submerged plant communities, causing physical uprooting and creation of organic berms that impede hydrologic connectivity and movement of fish and wildlife (Havens and Gawlik 2005). High stages promote the transport of suspended solids and associated nutrients from the mid-lake region (where unconsolidated sediments are thickest) into the shoreline regions; reducing water clarity and light penetration, increasing nutrients, and reducing SAV and emergent plant densities (further destabilizing sediments and releasing more nutrients) (James and Havens 2005). High stages also allow deposition of unconsolidated mud into nearshore regions, covering sand and peat sediments and reducing their suitability for SAV. High stages transport nutrient-rich water into higher elevation littoral marshes where changes in periphyton biomass and taxonomic structure can occur, as well as expansion of invasive vegetation like cattail (Typha spp.). High stages reduce coverage of woody species that are important for wading bird and snail kite nesting, promote conversion of spikerush (Eleocharis spp.) prairies to lily habitat, and reduce coverage of high marsh grasses like cordgrass (Spartina bakeri) (Zhang and Welch 2018). High stages reduce foraging habitat and prey density for wading birds (Smith et al. 1995) and reduce nesting effort for both wading birds (Chastant et al. 2017) and snail kites (Fletcher et al. 2017). Wading bird foraging is limited by water depth, and virtually the entire marsh is too deep for even long-legged wading birds (e.g. great egrets, great blue herons, woodstorks) at stages >16.0 ft (4.88 m). Associated changes in habitat structure, like loss of SAV and associated prey, also reduce fish diversity, populations, and biomass (Rogers and Allen 2008). Overall, high lake stages result in loss of submerged plants, low-elevation emergent plants, reductions in fish populations, undesirable shifts in marsh vegetation composition (Sharfstein and Zhang 2017), and shifts in the macroinvertebrate community to those representative of disturbed ecosystems (Warren et al. 1995)."

The Atlantic Multi-decadal Oscillation and the 52-year Period of Record

Having the Preferred Alternative projected to have an overall return interval of reaching 17 feet once every 5 years (10 years of the 52-year period of record) is troubling, but closer examination of the patterns reveals greater concerns. A prominent climate pattern for Florida is the Atlantic Multi-decadal Oscillation (AMO). The Atlantic Ocean gets relatively warmer and cooler over periods of decades and when in the warm phase, the extra energy in the ocean results in Lake Okeechobee receiving an average of about one-and-a-half times more runoff than in cool phases (Enfield et al. 2001, SFWMD monthly hydrologic outlooks[2]). This pattern shows strongly in modeling for the Preferred Alternative. For the 30-year period from 1965-1994, the cool/dry phase, the Preferred

1 The high level in 2013 was projected as 16.9 feet and it is included as one of the 10 events.
2 See slide 1 of: https://www.sfwmd.gov/sites/default/files/documents/Hydrologic_Outlook_July_13_2021.pdf.

Alternative projects Lake Okeechobee to hit 17 feet just 4 times, one in 8 years (Fig. 1). For the 22-year warm/wet phase years from 1995-2016, the Lake hits 17 feet 6 times, a once in 3.7-year return interval. And while the exact cause of the wet/dry pattern has been debated (e.g., Qin et al. 2020), the existence of the pattern is agreed upon and shows prominently in the 52-year POR.

Because the warm and cool phases of the AMO have statistically different lake inflows from each other, using averages of the full 52-year POR gives poor predictions of how selected alternatives will will perform. First, averaging a wet period with a dry period yields an "in between" number that does not reflect conditions in either period. Second, about 60% of the years from 1965 to 2016 POR are dry years, further "drying out" predictions for a future that as of now, is in the warm/wet phase of the AMO. In the following analyses, Audubon looks at the warm/wet phase for future predictions because that is the pattern Florida is in.

As explained below, once Lake Okeechobee reaches 17 feet, substantial areas of plant communities are drowned, triggering cascading impacts on fisheries, water quality, and remaining marsh vegetation. Figure 1 assumes a "recovery interval" of about four years but considering the last 17-foot event on Okeechobee was Hurricane Irma, four years ago, and recovery remains marginal, four years is likely a shorter recovery period than reality.

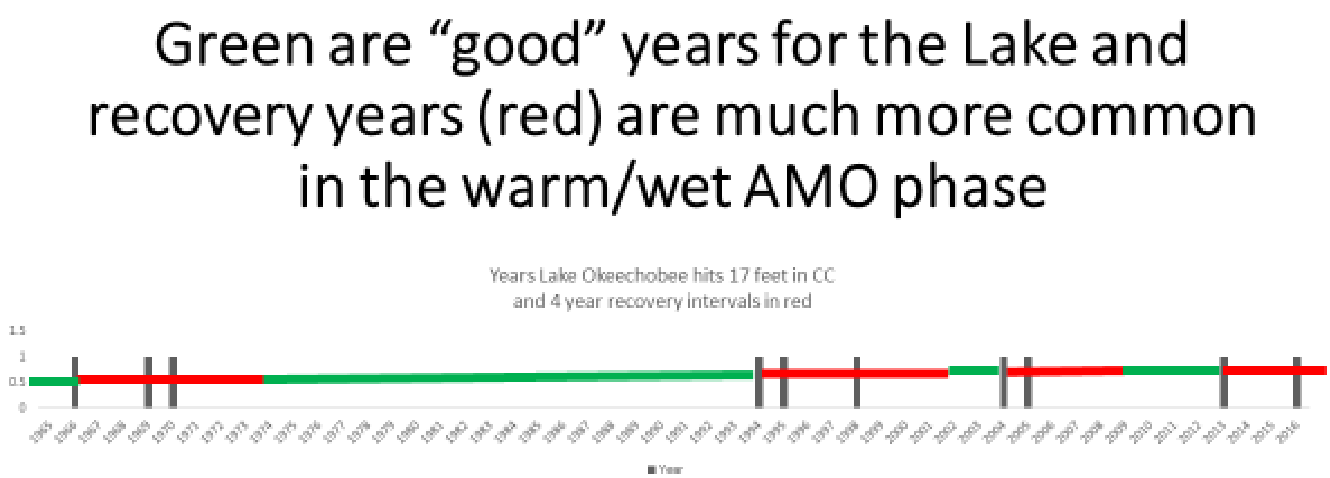

Fig 1. Each year that the Lake is projected to reach 17 feet is denoted by a vertical black bar. The preponderance of bars on the right side of the graph compared with the left is due to AMO patterns and with 4-year recovery periods in red, show the greater harm to the Lake. Specifically, in the AMO warm time frame, 22 years from 1995-2016, only 6 years might be considered non-impaired for SAV and fisheries.

Submerged Aquatic Vegetation and Fisheries

Reaching 17 feet is considered extremely damaging partly because it causes significant reductions in the ~40,000 acre submerged aquatic plant community (SAV, Fig. 2, Fig. 3), that can take years to recover (RECOVER 2020). The RECOVER 2016 goal for SAV in Lake Okeechobee was 50,000 acres of vascular and non-vascular plants (RECOVER 2016). After Hurricane Irma, the total SAV acreage

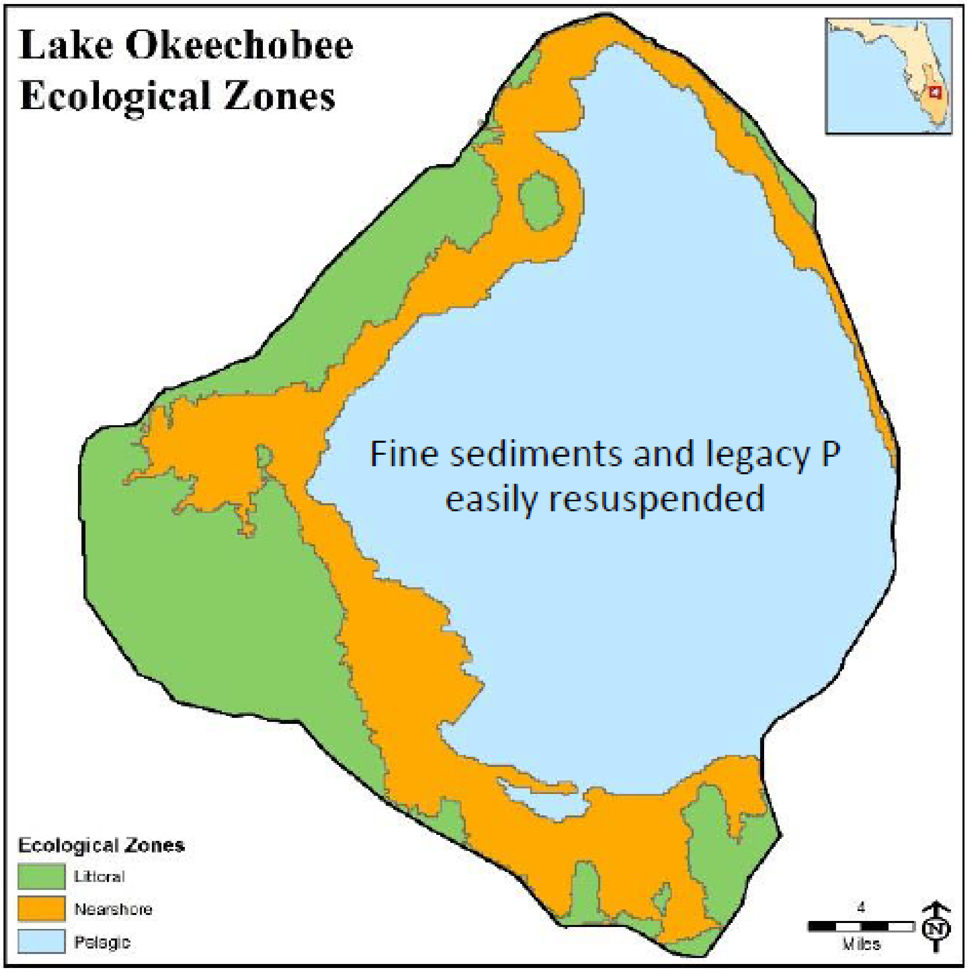

Figure 2. Three major communities in Lake Okeechobee. The Nearshore community is where most submerged aquatic plants grow and has recently ranged from 46,000 acres of plants in 2009 (Zhang and Scharfstein 2012) to only about 5,000 acres in 2018, the year after Hurricane Irma filled the Lake to above 17 feet.

acreage dropped to about 5,000 acres. The Lake reached optimal drawdown levels to 11 feet in 2019 and SAV recovered to 26,000 acres. Okeechobee reached 11 feet again in 2020 but total SAV levels dropped below 20,000 acres. The Lake then rose to 16.45 feet in late 2020 causing another loss of SAV, down to about 5,000 acres. Thus, four years after Hurricane Irma, the Lake has returned to post-Irma levels and future SAV recovery remains uncertain.

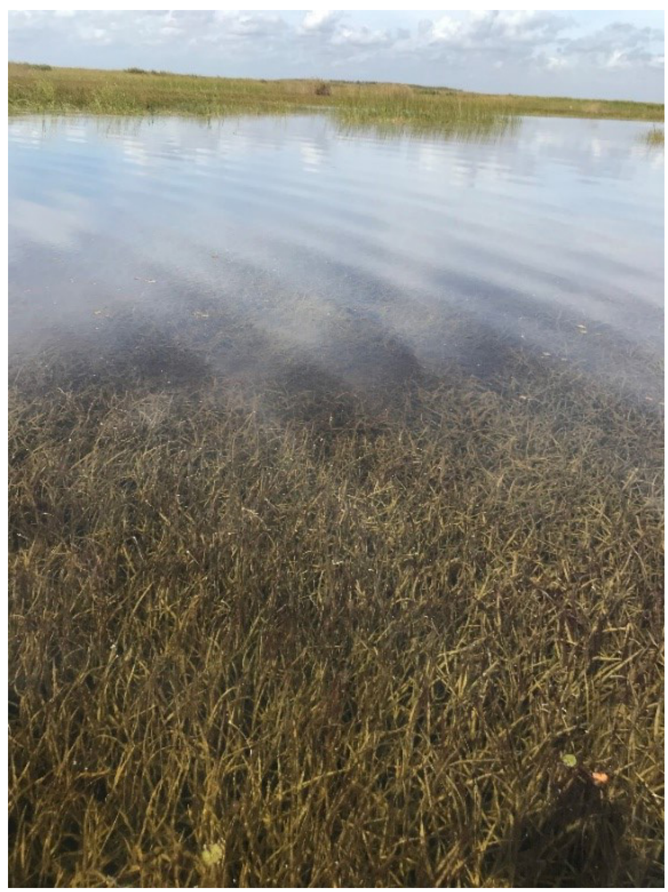

Fig 3. Eel grass (in foreground) is one species of submerged aquatic vegetation (SAV) in Lake Okeechobee that enhances water quality and is the heart of the world-renowned largemouth bass and black crappie fisheries.

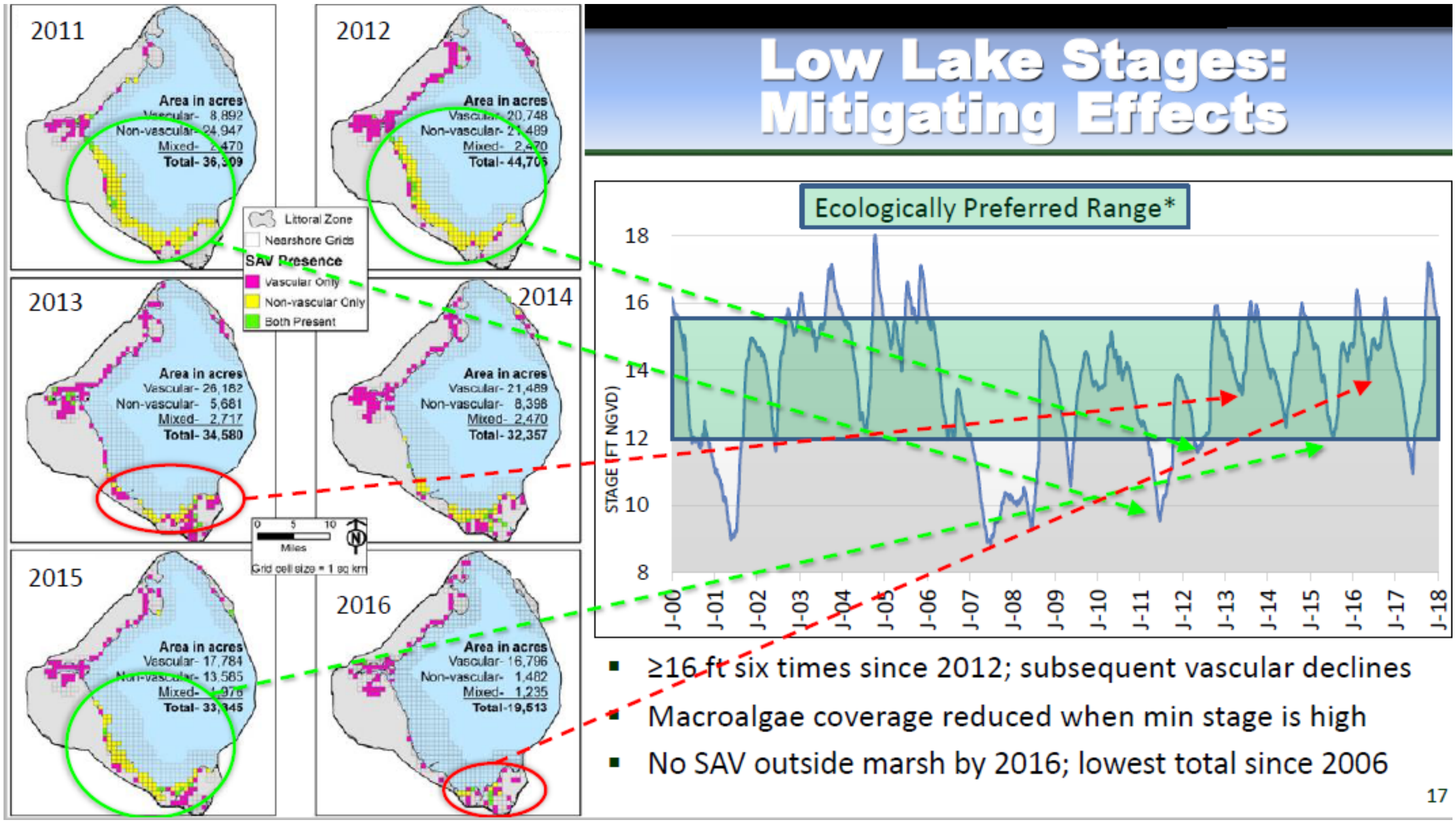

Figure 4. SAV and corresponding Hydrograph of Lake Okeechobee showing a steady decline in SAV acreage of Lake Okeechobee when hitting 16 feet in consecutive years, from 44,700 acres in 2012 to 19,600 by 2016 (Welch 2018). The lack of drawdowns to the 12-foot range also contributed to the inability of the SAV to bounce back.

Lake levels do not need to reach 17 feet to create significant degradation. Lake levels above 15 feet begin causing harm to plant communities (SFWMD 2010, Table 1). LORS08 allowed the Lake to reach 16 feet or deeper for 6 consecutive years which lead to a steady erosion in acres of SAV in Lake Okeechobee. Specifically, SAV acres decreased from 44,000 acres to 19,000 acres between 2012-2016 (Fig. 4, Welch 2018).

The SAV plant community is critical to the largemouth bass fishery in the lake and when it has severe reductions, the bass fishery crashes too (Havens et al. 2005). Fig. 5 shows such a relationship between SAV coverage and bass numbers. Fig. 6 has more FWC data showing depressed fishery populations in Lake Okeechobee four years after Hurricane Irma.

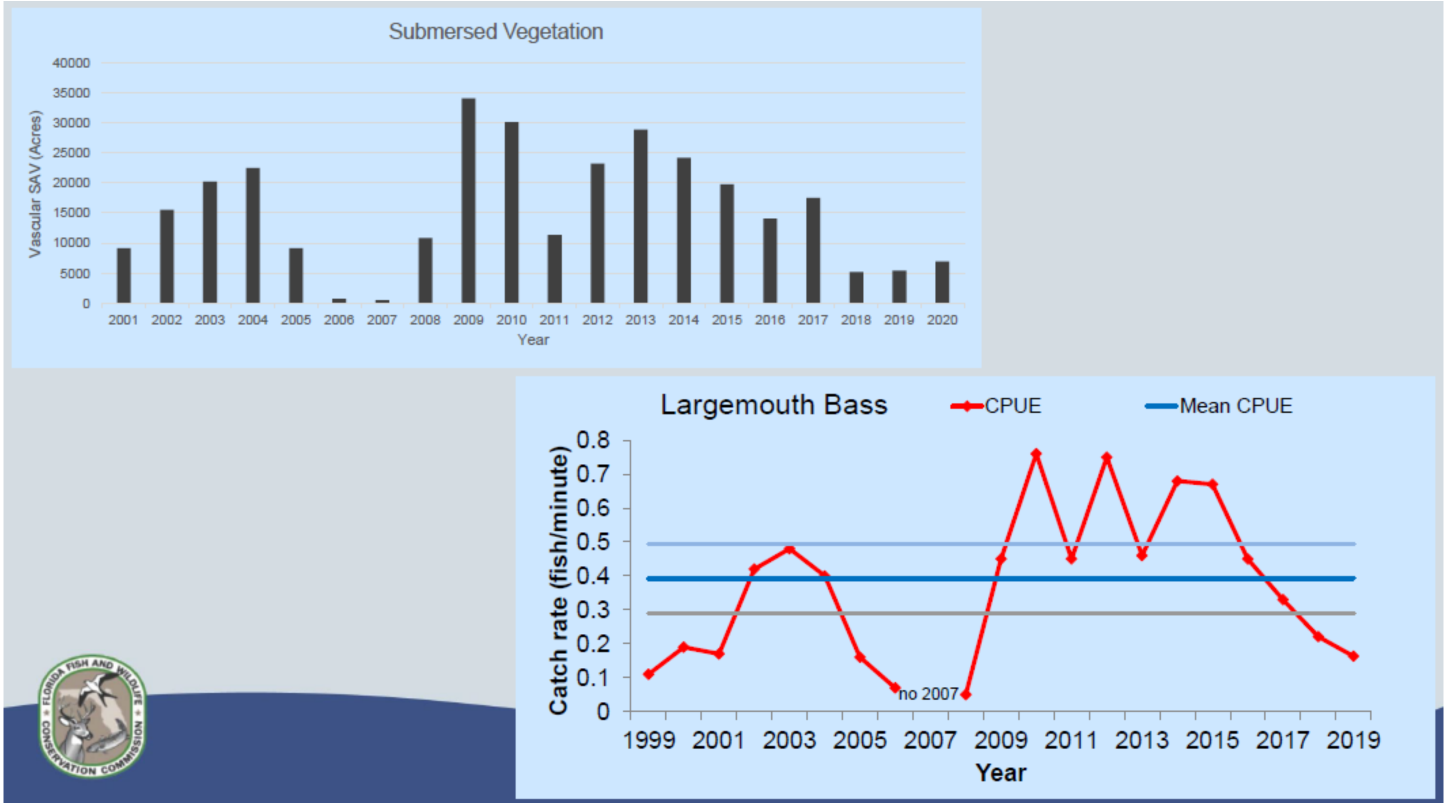

Fig. 5. Bass numbers in Lake Okeechobee increased in 2003 and 2004 as vascular submerged (SAV) vegetation increased until both crashed with the hurricanes of 2004-05 that took Okeechobee to 17+ foot levels. Vascular SAV acres increased after the 2007-08 drought and bass did too, until a persistent decline in SAV, and bass, occurred as a result of Lake Okeechobee hitting 16 feet every year from 2013-2017. The vascular SAV plant community is critical to the largemouth bass fishery in the lake and when it has severe reductions, the bass fishery crashes too (Havens et al. 2005, graph from FWC 2021).

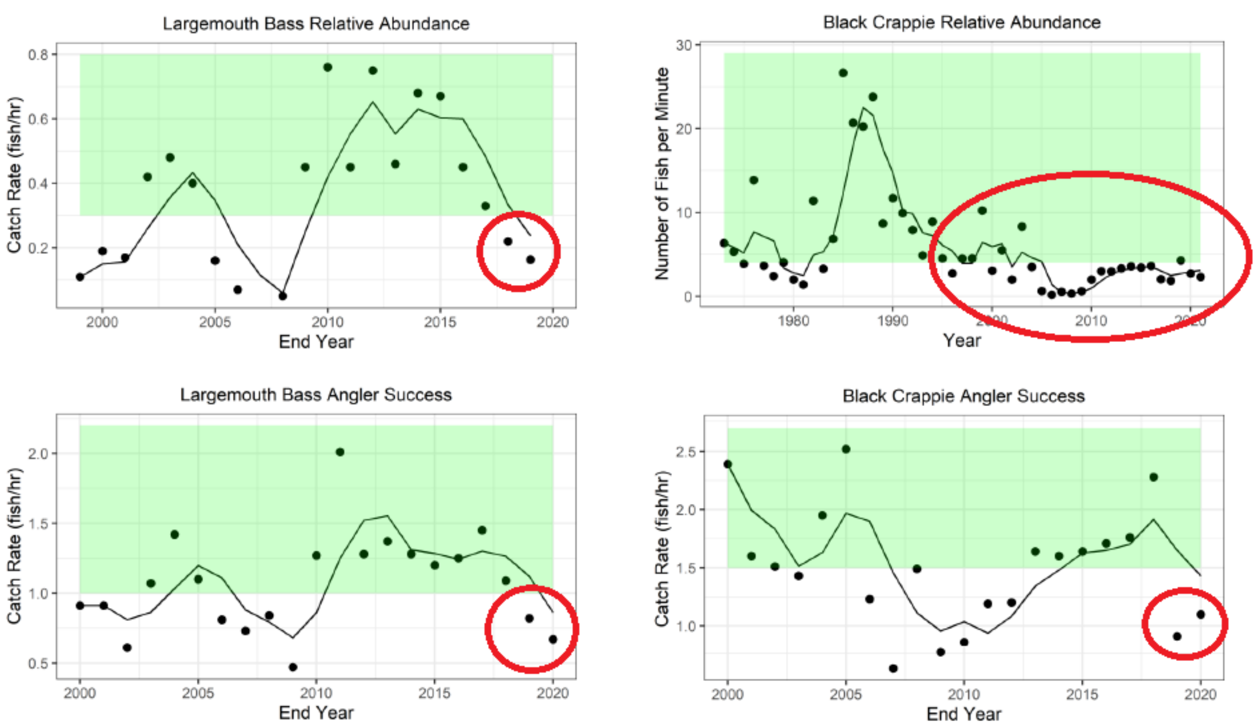

Figure 6. Largemouth bass and black crappie are the two most important recreational fisheries in Lake Okeechobee and remain at extremely low levels (red circles; green shading is desirable) years after Hurricane Irma in 2017 (FFWCC 2021). Red circles highlight recent low numbers. Black crappie had an apparent population crash in the early 2000s (especially after 2004-05) and have yet to fully recover.

Deep Water, the Pelagic Algal Community, and Fisheries

A deeper lake tends to have higher levels of turbidity and increased harmful algal blooms (Maceina 1993, Havens et al. 1994, Havens et al. 2003). Green algae and diatoms are considered "beneficial" algae because they form a good food chain base and thrive in cleaner waters. With nutrient pollution and turbidity, "good" algae give way to cyanobacteria who feed on the nutrients and can float to the surface to obtain sunlight. Because cyanobacteria are toxin formers, they make a poorer base of the algal food chain and can harm fisheries. Both threadfin shad and gizzard shad are abundant in the pelagic zone and feed on algae. Shad in turn are key forage for the largemouth bass and black crappie fisheries in the Lake (Welch et al. 2021). Thus, having the Preferred Alternative keep Okeechobee deeper more often will tend to result in a less desirable algal community with trophic impacts to the most important bait and game fish in the Lake.

SAV and Nutrient Effects in the Littoral Zone

The littoral zone is where emergent aquatic vegetation dominates (EAVs—grasses, sedges, "flags," and other plants growing out of the water). The littoral zone is buffered from the nutrient-enriched water of the pelagic zone by the SAV zone (see Fig. 2). Not only do the SAVs protect the EAV zone by cleaning the water in their zone, they physically stop wave and water flow penetration past the SAV zone. When the SAV zone is lost that protection is lost. During deep water events, nutrient-enriched pelagic water penetrates the EAV zone and contributes to the spread of cattail (Fig 7). This process not only degrades marsh habitat, it is unclear if the cattail encroachment is reversible even after SAVs recover.

For perspective, Florida has spent hundreds of millions of dollars on STAs, human-built marshes that function like smaller scale Lake Okeechobee's SAV zones to clean water. Lake Okeechobee can support a large-scale plant community and its water cleansing services for free, if we choose to sustain it.

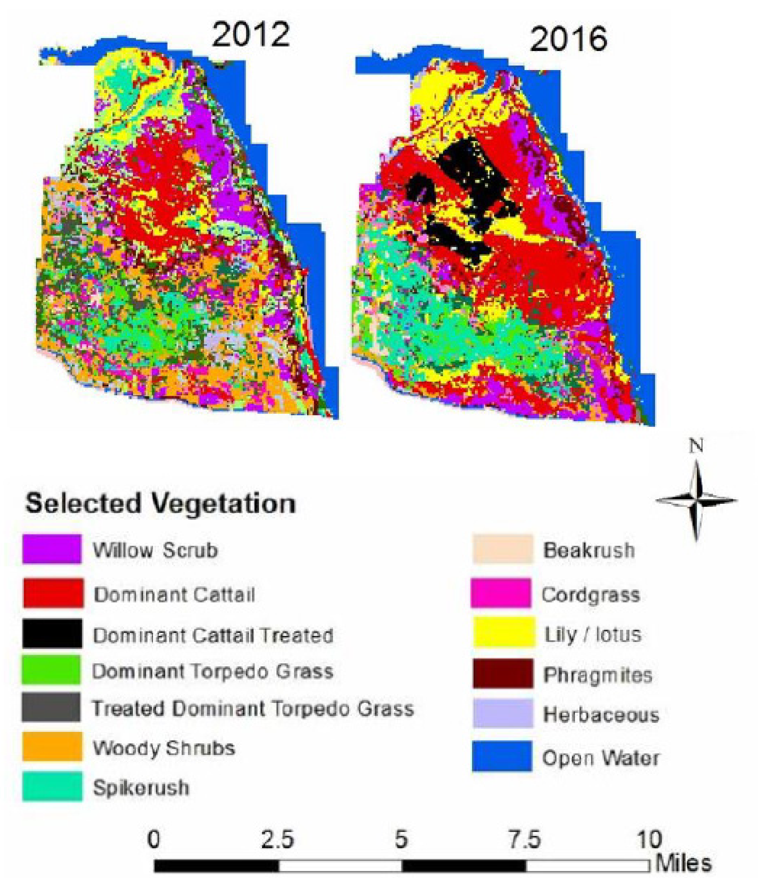

Figure 7. Deep Okeechobee levels (hitting the 16 foot range from 2013 through 2016) caused a decline in the SAV zone and buffering capacity, contributing to massive cattail expansion (red) in the Moonshine Bay region of Lake Okeechobee (Welch 2018). It is unknown if such impacts are reversible.

Moist Soil and Wet Prairie Plant Communities

Lake Okeechobee was deeper and larger in its pristine state. It would increase in area in wet weather and contract in dry, maintaining shallow edges and short hydroperiod wetlands in any pattern. Construction of the Herbert Hoover Dike along the 15-foot (Merriam) meander line on the upstream border of the Lake truncated the ability of the lake to spread out when getting deeper. Today, when levels rise above 15 feet, the water "stacks up" along the dike and there is no shallow water in the Lake.

Each wetland plant species has unique flooding requirements and grows along gradients of hydroperiod (Van der Valk 1981). In a pristine Okeechobee, plant communities could move up and down slope if hydroperiods changed over time. Today when Okeechobee rises above 15 feet, not only does it stack water in the short hydroperiod habitats, it lengthens their hydroperiod and can eliminate these habitat types altogether, including the species that depend upon them.

Short hydroperiod communities have a high percent of annual plants that need mudflats to germinate and are invaluable to waterfowl, songbirds (moist soil produces large seed crops for migratory seed-eating birds), rails, and other bird species (Fredrickson and Taylor 1982, Johnson and Montalbano 1984). Thus, consideration of biodiversity of Lake Okeechobee requires consideration of short hydroperiod habitats and the impacts that occur above 15-foot lake levels.

Specifically, the Preferred Alternative is projected to have the Lake above 14 feet about 40% of the time, creating concerns about how many years this plant community will be able to complete its "mudflat-dependent" life cycle. In 1978, when the Lake's regulation schedule changed to one that set 15.5 feet as the lowest level, Sincock (1957) predicted it would greatly diminish the moist soil zone. In 1981, just three years after the water level rise, Milleson (1987) compared vegetation community changes before and reported that "The most apparent changes were elimination of the spikerush *Eleocharis cellulosa* community, [and] expansion of the cattail *Thypha domingensis* zone…".

Similarly, the Lake Okeechobee Littoral Zone Technical Group (LOTZAG 1988) concluded the high water had induced changes including, "…loss of wading bird feeding habitat, decline in willow, and *loss of moist soil plant production*" [emphasis ours]. The Preferred Alternative is not projected to deep as the 1978 schedule was, but the Preferred Alternative's projections for deeper water for longer periods of time could create similar losses.

Snowy Egret. Photo: Paul Gray

Bird Communities

Wading Birds

The Everglades are famous for wading birds and Lake Okeechobee hosts large numbers of wintering and nesting birds. During the period of 1957-1978, when water levels were generally held below 15 feet, Okeechobee hosted an average of 4,767 wading bird nests. From 1979-1988 when levels were held generally above 15.5 feet, nesting dropped to an average of 1,928. David (1994a and 1994b) attributed the decline to deeper levels that reduced foraging areas and degraded the willow heads that held nesting. Deeper water near nests leads to longer foraging flights, which are increasingly energetically costly for nesting birds (Smith 1995, Smith et al. 1995).

The small Egretta species in south Florida (Snowy Egret, Little Blue Heron and Tricolored Heron) have experienced "consistent and steep declines in nesting numbers over recent years" (Cook and Baranaski 2020). Lake Okeechobee often hosts large percentages of their total nesting effort. In 2017, Lake Okeechobee held 54% of Tricolored Heron nests and 71% of Snowy Egret nests in the Greater Everglades Ecosystem (Cook and Baranski 2018). Nesting conditions in south Florida change annually but these numbers were not flukes, in 2018, the Lake Okeechobee held 40% of all Snowy Egrets nests and in 2019, Okeechobee hosted 21% of all the Tricolor Heron nests (Cook and Baranski 2019, 2020).

Water depth (feet)	Acres 1-6 inches deep	Cumulative drawdown acres
15.5	1,000	1,000
15	2,000	3,000
14.5	3,000	6,000
14	11,000	17,000
13.5	9,000	26,000
13	12,000	38,000
12.5	20,000	58,000
12	23,000	81,000
11.5	14,000	95,000
11	5,000	100,000
10.5	1,000	101,000

Table 1. Acres of area with water levels six inches or less in Okeechobee. Note that at 12.5 feet there are 20,000 acres of available habitat for wading birds and at 12 feet another 23,000 acres is available. Reaching these levels in the spring maximizes foraging opportunities for wading birds in Okeechobee.

Part of the justification for the stage envelope being between 12-15 feet is its match with wading bird nesting ecology (RECOVER 2020). Water depths below 6 inches are widely considered suitable for most wading bird feeding and Table 1 shows the number of acres of water less than 6 inches deep at different Lake elevations. Note that levels above 13 feet only make a cumulative total of about 38,000 acres available. Between 12-13 feet, another 43,000 acres of habitat become suitable, making this depth range a sweet spot for habitat availability. Thus, it is very desirable to lower the lake to around 12 feet for optimal wading bird foraging opportunities over the nesting season. The Preferred Alternative does not drop below 13 feet in 8 of 22 years in the AMO warm period (Table 2).

Min. level	>14 feet	13-14 feet	11-13 feet	<11 feet
	2016	2014	2015	2011
	2005	2010	2013	2008
	1998	2003	2012	2007
	1996		2009	2002
	1995		2006	2001
			2004	
			2000	
			1999	
			1997	
TOTALS	**5**	**3**	**9**	**5**

Table 2. The Preferred Alternative is projected to reach a favorable drawdown level between 11-13 feet in 9 years of the 22 year period of record. In 8 years, the lake stays above 13 feet, and in 5 years drops below 11 feet--years that are too high and low, respectively, for optimal wading bird nesting opportunity.

Waterfowl
Florida hosts large numbers of migratory waterfowl during the winter from all over North America. Ring-necked Ducks are the most harvested duck in Florida and because they feed heavily on SAV (especially hydrilla), will fare poorly with projections of SAV loss. Most of the wintering waterfowl on the lake are dabbling ducks (Anatini) that generally require water 6 inches or less for foraging (White and James 1978, Johnson and Montalbano 1984). Like wading birds, waterfowl benefit from drawdowns across most of the marsh. The moist soil community is highly utilized by dabbling ducks (Fredrickson and Taylor 1982) and its protection is important to their use of the Lake.

Eastern Black Rail: The Eastern Black Rail was listed as "threatened" in 2020 by the United States Fish and Wildlife Service [3] and is a species with "Greatest Conservation Need" for the Florida Fish and Wildlife Conservation Commission (FFWCC 2019). With recent population declines as high as 90%, it is thought that Florida may host most of the remaining population (Atlantic Coast Joint Venture 2020). This diminutive bird inhabits wetland areas less than one inch deep. As covered in the "moist soil" section of this document, the negative effects of deeper water on that community type and having the lake too deep 25% of the time (<15 feet) are of concern.

Migratory Shorebirds
Shorebirds (suborder Charadrii) are a large group of wetland birds restricted to shallow water and mudflats. At least 24 species have been documented on Lake Okeechobee (Gray et al. 2009). A FWC-sponsored Winter Shorebird Survey occurs each year in February and when water levels are favorable (<14.5 feet), thousands of shorebirds are counted. In February 2021, with Lake levels near 15.4 feet and virtually no shallow water inside the Hoover Dike, the 20-mile route through Indian Prairie yielded just one Killdeer and a Black-bellied Plover resting on floating vegetation (P. Gray, pers obs).

Everglade Snail Kite
Lake Okeechobee is federally designated as critical habitat for Everglade Snail Kites. Deep water in the Lake in the 1990s essentially terminated Snail Kite use and nesting (Martin et al. 2003) and the droughts of 2001 and 2007-08 contributed to a 75% drop in the statewide population. Since then, the population has slowly recovered in numbers, supported mostly by exotic apple snails (Fletcher et al. 2018).

Snail Kite nesting on Lake Okeechobee since the year 2010 has increased and had two super nesting events in 2016 and 2018, where about 250 and 200 nests, respectively, were initiated (Beck 2020). Statewide, Snail Kite recovery since the early 2000s seems to be fueled mostly by episodic super-nesting events that have been supported by a brief "bloom" of exotic apple snails that temporarily support large numbers of nests (Fletcher et al. 2021). While this has had benefit for Kites, episodic events form an unreliable base to support the Snail Kite population. In 2020, statewide Snail Kite populations declined by what could be more than 20%, due mostly to dry conditions and lack of nesting in Okeechobee and the Everglades (Fletcher et al 2021).

Notably, the super-events in Okeechobee occurred in a cattail treatment area in Moonshine Bay, that had been sprayed and partly burned (see Fig. 7, the black square in the 2016 image of invading cattails is the location of these events). The resulting community was dominated by open water and dead cattail shoots, which apparently formed good exotic snail habitat, but constituted a biological desert

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3 https://www.fws.gov/mountain-prairie/pressrel/2020/10072020-USFWS-Finalizes-Listing-Eastern-Black-Rail-Threatened-Under-ESA.php#.YQq_To5Kg2w.

for most vertebrate species that frequent the Okeechobee marshes, such as frogs, salamanders, snakes, round-tailed muskrats, and many birds. Plant diversity was similarly limited. Although the net results for Kites was good, this is a very poor result for Okeechobee marsh biodiversity and health, and not an acceptable goal for future marsh management.

It remains uncertain how the Preferred Alternative will perform for Snail Kites. Water level recession rates during nesting will need special attention, as noted in the updated LORS08 biological opinion (USFWS 2018). And along with doubts about exotic snail reliability, native snails have not returned to Okeechobee in numbers that could support viable Kite nesting. Okeechobee's wetland habitats will continue to need adaptive management to sustain Snail Kites.

The Importance of Drawdowns

Wetlands are characterized by being wet part of the time and dry the other. Unless the wetland is a peat-forming system, regular drawdowns are essential for marsh function. First, drawdowns allow decomposition of organic material[4], either through oxidation or fires, processes that keep the bottom mostly mineral (sand/rock in Okeechobee). Many wetland plant seeds must germinate on mudflats and thrive with reflooding. Some plants, such as SAVs, will germinate underwater but need sunlight, which in a turbid lake like Okeechobee, requires a drawdown as was coordinated by the Corps in 2019 to help SAV recover from Hurricane Irma. And as mentioned above, drawdowns also are essential for avian use of the marsh. In essence, drawdowns are necessary and are the antidote to harmfully high lake levels (Havens ad Gawlik 2005, RECOVER 2020). The Preferred Alternative allows more and better drawdowns than previous high schedules. However, the Zone F line, that would cut of flows to the Everglades and Caloosahatchee at 13 feet, also reduces drawdown effectiveness in the Lake, simultaneously harming all these systems. Audubon Florida previously recommended eliminating Zone F altogether (App. 1).

Conclusions on Optimizing the Preferred Alternative for Lake Okeechobee

This document traces trends in Lake Okeechobee as a result of varying water levels. Take away considerations for the ecology of Lake Okeechobee in the optimization of the Preferred Alternative include:

- Stopping environmental releases at the 13-foot line of Zone F would hamper essential Lake-recovering drawdowns while harming downstream ecosystems, therefore Zone F should be removed.
- The Zone A line already is very harmfully high and should not be raised.
- Because of the AMO phenomena, the 52-year period of record may underestimate harmful high water events, underestimate harmful estuary releases, and overestimate water shortage cutback severity.
- Because SAV recovery times take years, reaching 17 feet more than once every eight years should be eliminated from the Preferred Alternative if the worst impacts to Lake Okeechobee's ecology are to be avoided.

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4 Plants will not completely decompose under water due to low oxygen levels (anaerobic). In wetlands that do not dry, organics build up as peat. Lake Okeechobee's marshes were accumulating organic material during the high lake levels of the 1980s and 1990s and those sediments were partially bulldozed from the lake bottom in the 2001 drought due to their undesirability.

• Levels above 15 feet can be harmful in all seasons.
• Levels less than 15 feet can be harmful during the dry season, especially if they preclude drawdowns that are essential for marsh community health and bird foraging.
• Harm to plant communities translates to animal communities.
• Harm to plant communities translates to water quality degradation.
• Deep water reduces avian use of the Lake: The lower the spring dry down, the more acres of avian habitat become available.
• The Preferred Alternative will need flexibility in its water control manual to enable the Corps to adapt to unpredictable but certain damaging future events and equitably manage for multiple interests in ever-changing conditions and weather patterns.

Optimization is not just an exercise in equity, it is an investment in the resilience of the entire Everglades system. Ensuring that the benefits and adversity of operations are shared equally will ensure no one portion of the system and the organisms that rely on it, are harmed irreparably until the promise of CERP is realized.

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