EXPERT REPORT OF JAMES FOURQUREAN, Ph.D.

I have been retained to offer my expert opinions on behalf of the intervenors in this matter. I have attached a C.V. with my qualifications and publications as Attachment 1 to the report. A list of all other cases in which, during the previous 4 years, I have testified as an expert at trial or by deposition is attached as Attachment 2.

My opinions are based on the data on seagrass distribution, nutrient availability and water quality of both surface water and groundwater available to me as of June 23, 2019. I will continue to search for new data to inform my opinions as set forth below.

My earlier report on this matter that was filed during the scoping process has been updated with information first compiled for the Greater Everglades Ecosystem Restoration Conference (GEER) on April 23, 2019 (submitted as an electronic supplement with this report). That poster and the abstract from this conference is attached as supplemental electronic material, and it was the first time the information was presented.

In addition, I have provided the pore water sampling data from the SFWMD monitoring plan requirements which is relevant to the reasons we are going to expand this effort and continue to sample and analyse all available data and information on degradation to the East of the CCS and work toward publishing a paper once a full 3 years of data are collected and is corelated with all existing data. Porewater sampling at the C, D, and E transects in each monitoring area in Biscayne Bay was discontinued after May 2013 as part of the monitoring reductions approved by the Agencies in July 2013. Because this Data does not overlap with the years we have sampled the N:P ratio within the pore water a resampling effort needs to be undertaken before any license extension should be considered. (These data are submitted as an electronic supplement to this report)

SUMMARY OF OPINIONS

Seagrasses are the foundation species for the essential fish habitat in the shallow underwater environments to the east of the Turkey Point Cooling Canal System (CCS). Seagrasses only proliferate and survive in places with low nutrient availability. In Biscayne Bay, the availability of the nutrient phosphorus (P) controls the abundance, productivity and species composition of seagrasses. Additions of P to this kind of system first fertilizes the seagrass and create denser seagrass meadows, but P accumulation is cumulative and permanent, so continued P loading leads to replacement of the seagrasses by macroalgae and finally macroalgae as enough P gets capture by the system. Since seagrass are the foundation species in the essential fish habitat in Biscayne Bay, P pollution disrupts this essential fish habitat. Currently, seagrasses show signs of abnormally high P concentrations in areas that hydrological models and field data show receive P-laden discharge from the CCS. Further, preliminary analysis of time series of aerial Google

Earth images collected since the 1990's show that some patches of seagrass offshore of the CCS first became much denser than the historical seagrass communities, then died back leaving bare mud. CCS water itself has very high P concentrations compared to Biscayne Bay, but it is likely that P concentrations of CCS water increase as they discharge subterraneanly because of interactions between changing salinity of groundwater and the properties of the aquifer through which it passes. The spatial pattern of the increased P availability (and recent dieoff of dense patches coincides with discharge of CCS water. It is likely that operations of the CCS are leading to the increased P availability and therefore the balance of flora and fauna in Biscayne Bay and Biscayne National Park.

OPINIONS

Specific opinions and evidence to support them:

1. The seagrass beds of Biscayne Bay and the rest of south Florida require very low nutrient loading to survive. In essence, seagrasses are killed and replaced by fast-growing, noxious seaweed or planktonic algae if nutrient delivery is increased. Nutrient delivery can be increased either by increasing the concentration of nutrients in discharges, OR by increasing the volume of water containing nutrients, even at very low nutrient concentrations that would pass drinking water quality standards.

All plants, including seagrasses, require light, water, and mineral nutrients, such as phosphorus and nitrogen, to grow. The required supply of nutrients for any plant population to grow is a function of the plant's relative growth rate. Plants that grow quickly require high rates of nutrient supply, while plants that grow more slowly require a lower rate of supply. As a consequence, rapidly growing plants are found where nutrient supplies are high, and slow-growing plants where nutrient supplies are low. High nutrient supplies are not necessarily bad for slow-growing plants, but at high nutrient supply rates fast growing plants can overgrow and shade out the slow growers.

In general, the size of a plant is a good indicator of its relative growth rate, with smaller plants having higher growth rates. In seagrass beds in Biscayne Bay, the fastest growing plants are the single-celled algae that live either in the water, in the sediments, or attached to surfaces, such as seagrass leaves. Filamentous algae that grow on surfaces grow slightly slower, followed by more complex macroalgaes, like the fleshy and calcareous seaweeds. Seagrasses grow even slower. Different species of seagrass have different growth rates and nutrient requirements. The narrow-bladed species widgeon grass (*Ruppia maritima*) and shoal weed (*Halodule wrightii*) grow faster than the spaghetti-like manatee grass (*Syringodium filiforme*) which in turn has a faster growth rate, and therefore higher nutrient requirements, than turtle grass (*Thalassia testudinum*). It quite common in south Florida, that nutrient supplies can be so low as to constrain the growth of even the slowest growing species (Fourqurean and Rutten 2003).

Evidence to support the relationship between growth rate and nutrient requirement come from both the distribution of seagrasses around natural nutrient "hot spots" in south Florida (Powell et al 1991) and from fertilization experiments (Armitage et al 2011, Ferdie and Fourqurean 2004). For example, the natural state of eastern Florida Bay is very low nutrient availability. However, on some of the mangrove islands in Florida Bay, there are large colonies of wading birds that hunt for food around the bay (Figure 1).

Those birds roost and nest on the islands, and bring food home to feed their young. Both adults and young defecate on the islands, causing natural point sources of nutrient supplies around these small islands. In response to this point source, nutrient availability is very high within a few meters of the islands and decreases with distance away from the mangrove shoreline. In response to this gradient, there are concentric halos of different plants growing on the bottom. Closest to the island where nutrient pollution is greatest, there is only a coating of microalgae covering the sediments. Further away from the island there is a macroalgae zone, followed by a halo of dense widgeon grass, a halo of dense shoal weed, then a zone of mixed shoal grass and dense turtle grass. Farther away still, outside the zone of influence of nutrients from the bird colony, turtle grass declines in density to very sparse coverage.

Fertilization experiments have confirmed that a change in nutrient supply first leads to a change in the density, and then the species composition, of seagrass beds in south Florida (Fourqurean et al 1995). In Florida Bay, fertilizing sparse turtle grass beds with phosphorus first results in an increase in the density of turtle grass; however, once shoal grass becomes established in the fertilized patches, it rapidly displaces the turtle grass (Figure 2). Less controlled experiments illustrate how the seagrass beds of the Florida Keys changed as the Keys became developed. Early developments relied on cesspools or septic tanks for wastewater "treatment." Neither provide nutrient removal in the rocky limestone substrate of the Keys. Thus, wastewater and stormwater nutrients emanating from the shoreline development resulted in the growth of lush seagrass beds immediately off shore of Key Largo (Figure 3). This observation could be interpreted as a "good" thing because seagrass growth and coverage expanded. However, data from other observations and experiments temper this optimism.

A model has been developed to illustrate how normally low-nutrient seagrass beds of south Florida will change as nutrient availability changes (Fourqurean and Rutten 2003, Figure 4). The model shows that seagrass beds composed of abundant turtle grass, the slowest-growing species, become lush with increased nutrient conditions. But, as nutrient supply continues to increase, the species composition gradually changes as faster-growing species replace the slower-growing ones. At the highest nutrient levels, seagrasses are replaced by seaweeds and microalgae, Loss of the seagrass community will result in a dramatic change in community structure and function. Animal species dependent on seagrass for food and shelter (e.g., speckled trout, redfish, bonefish and tarpon) are replaced by less desirable species (e.g., jellyfish). The model predicts that the relative abundance of benthic plants at a site is an indicator of the current rate of nutrient supply. Changes in the relative abundance from slow-growing to fast-growing species at any site indicates an increase in nutrient supply.

2. The seagrasses along the coastline of the Cooling Canal System (CCS) existed for thousands of years in a nutrient-limited state, which means any addition of new nutrients changes the balance of these ecosystems. Increased nutrients harm the ecosystem by increasing the rates of primary production by marine plants. Increase in growth rates means that faster-growing, noxious marine plants, like macroalgae (seaweeds) and microscopic algae and photosynthetic bacteria, overgrow and outcompete seagrasses and corals for light, leading to the losses of corals and seagrasses.

The density and species composition of the seagrasses of southern Biscayne Bay are controlled by the availability of phosphorus. The water column in southern Biscayne Bay has very low concentrations of dissolved phosphorus, and the grand mean TN:TP ratios (ie, the ration of moles of nitrogen to the moles of phosphorus) of the water in southern Biscayne Bay average 177.9 (Caccia and Boyer 2005). When TN:TP of oceanic water is above 16 it indicates that the availability of phosphorus limits the growth of plankton (Redfield 1958). Seagrasses are more complex than phytoplankton, so that the critical ratio determining whether N or P limits plant growth for seagrasses is 30 (Fourqurean and Rutten 20013). The N:P of Turtle Grass (*Thalassia testudinum*) collected in the vicinity of Turkey Point was 88.6 in 2013, a clear indication of phosphorus limitation (Dewsbury, 2014). Fertilization experiments (Armitage et al 2011, Ferdie and Fourqurean 2004) clearly show that phosphorus fertilization of turtle grass with N:P > 80 first leads to an increase in density of turtle grass, then a replacement of turtle grass by faster-growing seagrasses, followed by a loss of seagrasses as P loading continues.

3. Around the world, there are many nutrients that can limit noxious plant growth, but most often, the nutrients that limit this growth are either nitrogen or phosphorus. In south Biscayne Bay, phosphorus is limiting to phytoplankton and macroalgae. This means that addition of phosphorus will upset the ecological balance of seagrass beds as has been exhibited in Northern Biscayne By and Florida Bay. Upsetting the balance of populations of aquatic flora and fauna by nutrient addition is a violation of Florida surface water quality standards.

As set forth in F.A.C. 62-302.520(48)(b), Nutrients, “In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna.” Although there are numeric nutrient criteria for Biscayne Bay, F.A.C. 62-302.532(h), the narrative criterion still applies. F.A.C. 62-302(48)(a) states, “Man-induced nutrient enrichment (total nitrogen or total phosphorus) shall be considered degradation in relation to the provisions of Rules 62-302.300, 62-302.700, and 62-4.242, F.A.C.” Because Biscayne Bay is Outstanding

Florida Waters under 62-302.700, man-induced nutrient enrichment from the FPL CCS is considered degradation, which is prohibited.

4. Current seagrass species composition and abundance data collected by ongoing seagrass monitoring programs show that there are places where Turtle Grass biomass offshore from the CCS is unusually dense compared to other areas in southern Biscayne Bay, likely as a consequence of increased P availability in the region and concentrated by the operations of the adjacent CCS The P sources are likely to be the result of Turkey Point operations that includes chemical components added for cleaning, biomass death that occurred within the CCS in 2014, and any nutrient pulled into the system from the surrounding environment that has been concentrated overtime as the freshwater evaporates away over the life of the plant.

Seagrass density data collected around Turkey Point in the late 1960's-early 1970's describe a system with very sparse turtle grass interspersed with a few slightly denser patches more than a few hundred meters offshore (Zieman 1972). In addition, long-time fisherman report that the dense Turtle Grass flats they fished further offshore near the Arsenicker Keys in the early 1970's are now devoid of seagrasses, likely because of continued P addition. In my opinion, there is an imbalance in the seagrass meadows of southern Biscayne Bay in the vicinity of the CCS, likely caused by increased P discharged from the CCS. Anecdotal statements from keen observers about the results of ongoing seagrass monitoring programs in the vicinity suggest seagrasses are denser than elsewhere along the southern coastline of Biscayne Bay.

I have begun following up these anecdotal report with scientific investigation. In 2018 we established transects within the nearshore area of Turkey Point to identify potential areas of elevated nutrient inputs as a result of the operations of Turkey Point, we added this filed season together with existing data from 2014 to establish a map that shows the influence of nutrients in surface waters of Biscayne Bay. Biscayne Bay is a phosphorus-limited ecosystem, consequently the ratios of N to P in seagrass leaves is generally greater than 85. Immediately offshore from the CCS, seagrass N:P suggests that P availability is much higher than normal Biscayne Bay background levels. And time series aerials from Google Earth show that high P in this area is related to very dense seagrasses that collapsed over the period 2010-2014. Under P pollution, normally P-limited turtlegrass (*Thalassia testudinum*) first increase in density (see dark patch in 2010, aerial figure 5), then gets displaced by progressively faster-growing species until no benthic vegetation is left at the highest P pollution levels as indicated by the bare patch in 2017, Figure 5. This has occurred in several hot spots found near the Arseniker Keys and we plan to sample the area again to better define these areas in late July of 2019.

5. The nearshore seagrass beds are incredibly efficient at removing P from the water column and storing P at vanishingly small concentrations. In fact, even 30 feet from large point-sources of P in Florida Bay, it is not possible to measure increases in P concentrations in the water column because it has all been captured by the algal and seagrass communities. This P capture causes increased plant growth and ecosystem imbalances. This imbalance first leads to an actual increase in the abundance of seagrass, but rapidly it causes a change in species composition, first to faster-growing seagrasses, then to seaweeds, then to microscopic algae.

6. Groundwater discharges along the coast of southern Biscayne Bay contain elevated concentrations of phosphorus and tritium, so that any process that causes groundwater discharge to the local seagrasses will supply the limiting nutrient (P) that upsets the balance of the ecosystem. Groundwater under the seagrass meadows of this part of Biscayne Bay contain tritium at concentrations that can only be explained by this water coming from the CCS.

P concentrations in the deeper canals offshore of the CCS and in caves offshore of Turkey Point are 10-20 times higher than the median concentrations (0.03 µM) of inorganic phosphorus in Biscayne Bay waters (Caccia and Boyer 2005). The discharge of water from the cooling canal system (CCS) into Biscayne Bay occurs intermittently through multiple hydrological connections provided by the Biscayne aquifer and its transmissive bedrock. Changed operations of the CCS since 2012 have accelerated the seepage to Biscayne Bay. (Nuttle, 2018) High concentrations of nutrients and tritium have been detected over a three year period in Biscayne Bay immediately adjacent to the CCS in deep canals and cave sites. (Martin, 2018) The highest nutrient levels occur during periods of sustained high-water levels in the CCS when the volume of water is at or near its maximum and Biscayne Bay tides are at a minimum, this occurs approximately 30% of the time (Nuttle, 2018). Preliminary sampling indicate that tritium, a tracer of water with CCS origin, are elevated in the groundwater and porewater of the seagrass supporting regions of Biscayne Bay adjacent to the CCS (see SFWMD-FPL porewater sampling report, appended to these opinions, as well as Brand 2018). Due to current changes and planned future changes in operations to try to decrease the salinity and temperature of the CCS, these conditions are expected to worsen if nutrient-laden reuse water is added to the CCS from a planned waste water treatment plant agreement with Miami Dade County as shown in Figure 6. (see Miami-Dade county Joint Participation Agreement with FPL, dated 4-10-18). Recent modeling completed by EJ Wexler indicates freshening the CCS to 34 PSU and sustaining that through the life of a new extended permit (if granted) would require additional water inputs beyond what is identified in the SEIS from the Floridan Aquifer.

7. The geology underlying the CCS and the adjacent seagrass meadows is based on limestone, which is made of calcium carbonate minerals. Calcium carbonate minerals strongly absorb orthophosphate onto their surfaces. But, respiration by plants, animals and bacteria dissolve calcium carbonate minerals, releasing the orthophosphate absorbed to the surfaces. During normal conditions, south Florida ecosystems are incredibly efficient at holding on to captured phosphorus– so much so that the impacts caused by adding P to seagrass beds in south Florida for even short periods can still be measured 30 years after the P additions. On the other hand, bacteria cause added N captured by south Florida ecosystems to be rapidly removed from those ecosystems. These facts result in P additions causing permanent and cumulative imbalances in nearshore marine waters of the Keys while N additions cause imbalances that can be corrected by the cessation of N addition.

Inorganic phosphorus strongly sorbs onto limestone minerals, retarding the transport of phosphorus through the limestone aquifer. However, the binding of phosphate to those minerals is a function of both the salinity of the groundwater (Price et al 2010) as well as the oxidation state of that groundwater (Flower et al 2017a). Both large increases and decreases in the salinity can desorb the phosphate, and make it mobile in the groundwater The seawater of Biscayne Bay and the fresh groundwater of the Biscayne Aquafer are both supersaturated with respect to limestone minerals, and therefore they will not liberate phosphate immobilized on limestone in the groundwater, but calcite will dissolve, and phosphorus will be released, where these two waters mix (Wigley and Plummer 1976). Hence, mixing of saltwater and freshwater in the aquifer can liberate phosphorus and transport it to the surface. This phenomenon explains the plant biomass and productivity increases along the coast of south Florida where brackish groundwater discharges (Price et al 2006). Further, injection of salty groundwater into freshwater aquifers through saltwater intrusion drives phosphorus release from that bedrock (Flower et al 2017b).

When saline and fresh groundwater mix in south Florida sources mix, they create a brackish water solution that dissolves calcium carbonate minerals, releasing orthophosphate stored on the surfaces of the limestone particles.

When this P-laden water reaches the surface, it will be captured by the ecosystem and cause an imbalance because it will be used by the ecosystem resulting in the growth of noxious plants (algae) which outcompete the seagrasses.

The operations of the CCS create saline water that infiltrates the groundwater and is transported and discharged under the seagrass It is my opinion that operation of the CCS has 1) carried phosphorus-polluted groundwater to near-shore surface waters through the highly porous bedrock and 2) has dissolved carbonates in that bedrock, releasing additional phosphorus that had been incorporated into that rock. As this phosphorus reaches the seagrass meadows offshore in Biscayne Bay, it will continue to degrade the ecosystem and cause an imbalance and change the nature of the surrounding marine environment.

8. An imbalance of the seagrasses that form the near-shore habitat near the CCS in Biscayne Bay and provide the food at the base of the food chain harms the fish and wildlife that use these habitats and therefore effects fishing, recreational activities such as bird watching and other activities based on that habitat change and eventual loss.

Salinity and the abundance and species composition of Biscayne Bay's seagrass beds interact to control the types and numbers of animals that live in the area (Santos et al 2018, Zink et al. 2017). For example, Biscayne Bay's fish populations reflect the salinity regime along the shoreline, with lower salinity sites having fewer fish like bluestriped grunt, schoolmaster snapper and sailors choice, and higher densities of fishes like killifishes, than higher-salinity sites (Serafy et al 2003). Salinity variability can be as important as mean salinity along this coastline in influencing fish communities (Machemer et al 2014).

OPINIONS on the Draft Supplemental Environmental Impact Statement

<u>Specific Concerns Regarding Estimation of Risk to Aquatic Resources</u>

On Page 3-95, Line 9-19, the authors state their assumption that Biscayne Bay is a lagoon and that the salinity is 24-44PSU. In fact, the nearshore area of Biscayne Bay offshore of Turkey Point is currently completely blocked by the CCS from receiving fresh surface and groundwater that would naturally flow into Biscayne Bay along the entire shoreline. Historically, fresh water from inland sources would travel through the same limestone passages which now bring polluted CCS discharges into the surface waters of Biscayne Bay when conditions are right.

The historical estuarine nature of Biscayne Bay is reflected in the restoration goals of the Everglades Restoration Project Biscayne Bay Coastal Wetlands project, known as RECOVER. RECOVER calls for mesohaline conditions (10-18ppt) and clearly estuarine indicator species in the very nearshore coastal regions of Biscayne Bay. According to Biscayne National Park, at no time should salinities exceed 30 ppt in this part of the Bay. As can be seen from the environmental report card for the Everglades just published by the RECOVER group, Biscayne Bay and the southern estuaries are failing due a lack of freshwater inflow and resulting high salinities, and these operations are indirect conflict with the goals outlined in CERP.

On Page 3-96 through page 3-112, the authors describe aquatic resources at Turkey Point from the review and perspective of FPL. To my knowledge no third party or regulator has done a complete analysis of the impact of the CCS operations on aquatic resources of Biscayne Bay. Monitoring and Analysis in the bay has not been sufficient enough and needs to be expanded to delineate the full extent of the migration of CCS water beneath and into the surface waters of Biscayne Bay and its impact on fish and wildlife completely understood. I have begun to do this by monitoring the seagrass and several years of data show alarming results. It is not advisable to issue a new license extension until this is fully understood.

Another assumption contained in this report is the idea that FPL will be capable of solving the problem of regular algal blooms within the CCS at any point in the medium –term future. The concern is that the authors may be overly optimistic about FPL's capacity to relieve the CCS of its recurring algal blooms. Page 3-99 discusses FPL's nutrient management plan and experimentation in the use of flocculants, skimming, etc. for algae control. There is little to no evidence that this nutrient management or algae control plan will be effective. Numerous previous efforts by FPL to control algal blooms using methods such as the application of copper sulfate herbicide have failed. And, such herbicides may kill the target algal species but they do nothing to reduce the phosphorus contamination that lead to the algal blooms in the first place and have the potential to cause more harm when they are exported from the CCS through groundwater.

The achievement of a seagrass target of 50% of the CCS water acreage is totally hypothetical at this time and should not be counted upon as a given. On page 3-99 the authors noted that the seagrass colonies in the CCS began to die off as a result of increased temperature and salinity levels. Seagrass bed creation is a very difficult and expensive process, and such smallscale restoration efforts with the species common to south Florida generally fail. Without addressing the drivers of seagrass loss, seagrass restoration efforts almost always fail (Van Katwijk et al 2016). Considering that subsequent to the finalization of Turkey Point's uprate in 2014 the salt concentration and temperature conditions within the CCS have risen markedly, it is possible the conditions for maintaining a healthy seagrass community no longer exists within the canals.

Furthermore, even should FPL achieve their target for seagrass coverage, there is absolutely no reason to believe that another seagrass die-off in the CCS would not occur. The phosphorus fueling these blooms will not be addressed. Considering that FPL has not shown itself capable of controlling these periodic algae blooms in the near-decade since the problem first arose, it is wholly premature to presume the emergence of a long-term solution at any point in the near future. Projections for the future impacts of the CCS system should instead assume the perpetuation of an algal-based system, with all the accompanying potential for nutrient pollution such a scenario entail.

Specific Concerns Regarding Estimation of Risk to Special Status Species and Habitats

As stated in the preceding paragraph there is a concern that the report did not delve into the possibility of seagrass habitat degradation as a potential result of continued operation of the CCS. I am concerned that the Generic Environmental Impact Statement does not properly recognize the importance of the seagrasses of the region to the east of the CCS, even though these plants form the basis of the essential fish habitat near Turkey Point, described on pages 3-112 and 3-113. Further, while the potential for impacts of cooling canal operations on emergent salt tolerant vegetation is recognized and assessed beginning on page 4-24, this general assessment only applies to saltmarsh vegetation. Herbaceous saltmarsh vegetation, however, is rare surrounding the Turkey Point CCS, while emergent woody vegetation (mangroves) and submerged herbaceous plants (seagrasses) are quite common. These special plant communities deserve a proper consideration because such consideration could change the conclusions of the GEIS. I believe we are recognizing environmental degradation of the seagrasses offshore of the CCS, as detailed above. Recent data (Miami Dade DERM) and modeling runs (done by E. J. Wexler) suggest that the input of heated water at the north end of the CCS is so great that water not only flows south into the CCS as designed, but also flows north, through the mangrove forest and into Biscayne Bay to the northeast of the CCS. There is evidence that this water is causing harm to the mangrove forests visible on Google Earth aerial images, and I believe that we can also see the footprint of this water in the enhanced P content of seagrasses along the shore (Figure 5).

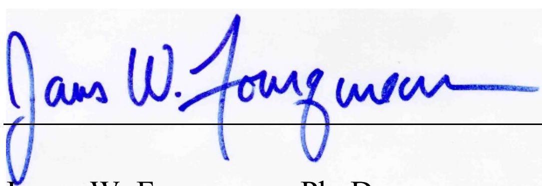
Nutrient-loaded CCS water can have pronounced negative impacts on the ecological resources of Biscayne Bay. Phosphorus pollution specifically is a major concern arising from these discharges. The average concentration of phosphorous measured in the CCS canals is 0.035 mg/l, which is five times the numerical criteria for phosphorous in the south-central inshore region of Biscayne Bay, 0.007 mg/l. Concentrations in the deeper canals offshore of the CCS and in caves offshore of Turkey Point are 10-20 times higher than the median concentrations (0.006 mg/L) of inorganic phosphorus in Biscayne Bay waters. However, a major issue may also exist in the form of legacy phosphorus sorbed onto limestone over the course of many decades of CCS operations. Phosphorus strongly sorbs onto limestone minerals, retarding the transport of phosphorus through the limestone aquifer. However, the binding of phosphate to those minerals is a function of both the salinity of the groundwater as well as the oxidation state of that groundwater. Both large increases and decreases in the salinity can desorb the phosphate, and make it mobile in the groundwater. 'Freshening' activities which will serve to flush additional CCS water into the surrounding channels could provide the catalyst for desorption and transport into Biscayne Bay Surface Waters .

The seagrass beds of Biscayne Bay require very low nutrient loading in order to remain stable and healthy. Phosphorus concentration is the principal limiting factor in the seagrass beds and benthic communities of Southern Biscayne Bay as the Surface waters of Biscayne Bay are naturally low in concentrations of dissolved phosphorus. Experiments have confirmed that a change in nutrient supply first leads to a change in the density, and then the species composition, of seagrass beds in south Florida. Seagrass beds first experience increased density, then displacement. At the highest nutrient levels, seagrasses are replaced by seaweeds and microalgae.

Unfortunately, it can be exceedingly difficult to accurately assess phosphorus contamination using traditional sampling methods. Seagrass beds are incredibly efficient at removing phosphorus from the water column and storing it at vanishingly small concentrations. In fact, even 30 feet from large point-sources of phosphorus in Florida Bay, it is not possible to measure increases in phosphorus concentrations in the water column because it has all been captured by the seagrass communities. Although these phosphorus discharges are difficult to detect, they are nonetheless incredibly impactful, causing increased plant growth and ecosystem imbalances first resulting in increased abundance, then displacement and potential collapse.

I submitted this updated report on June 24, 2019.

Signed:



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QUALIFICATIONS

My resume is attached hereto and contains my qualifications and a list of all publications that I have authored.

PRIOR TESTIMONY

During the past 4 years, I have participated in the following cases:
(1 deposition and 1 administrative hearing)

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STATE OF FLORIDA
DIVISION OF                  Case No. 15-1233
ADMINISTRATIVE HEARINGS
MIKE LAUDICINA; DON
DEMARIA; CUDJOE GARDENS
PROPERETY OWNERS ASSOC.
INC.; AND SUGARLOAF
SHORES PROPERTY OWNERS
ASSOC., INC.,
PetitionerS,
vs.
FLORIDA KEYS AQUADUCT
AUTHORITY AND DEPARTMENT
OF ENVIRONMENTAL
PROTECTION,
Respondents.
```

I gave deposition in this case on October 14, 2015 at Veritext Legal Solutions, 2 South Biscayne Blvd., Suite 2250, Miami, FL 33131

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STATE OF FLORIDA             Case No. 14-5302
DIVISION OF ADMINISTRATIVE
HEARINGS
LAST STAND (PROTECT KEY
WEST AND THE FLORIDA
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KEYS,b/d/a LAST STAND, AND
GEORGE HALLORAN,
Petitioners,
vs.
KET WEST RESORT UTILITIES
CORPORATION, AND STATE OF
FLORIDA DEPARTMENT OF
ENVIRONMENTAL PROTECTION,
Respondents
__________________________/

The final hearing in this matter was held on April 21-May1, 2015 at the Freeman Justice Center, Conerence Room A, 302 Fleming Street, Key West, Florida, before Cathy M. Sellers, an Administrative Law Judge of the Division of Administrative Hearings ("DOAH").

FIGURES

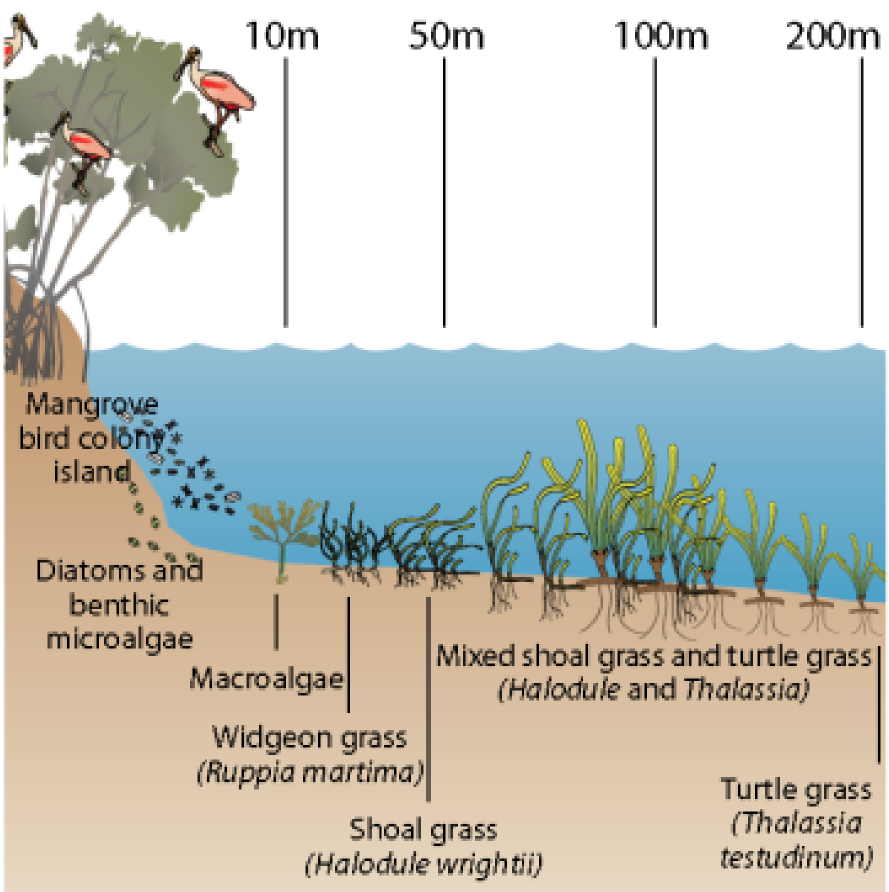


Figure 1. Islands with large bird colonies in Florida Bay are natural nutrient sources that cause zonation of the benthic habitat, with fast-growing microalgae dominant near the nutrient source and slow-growing turtle grass dominant far from the nutrient supply. See Powell et al 1991. Figure reproduced from Kryczynski and Fletcher 2012, page 276.

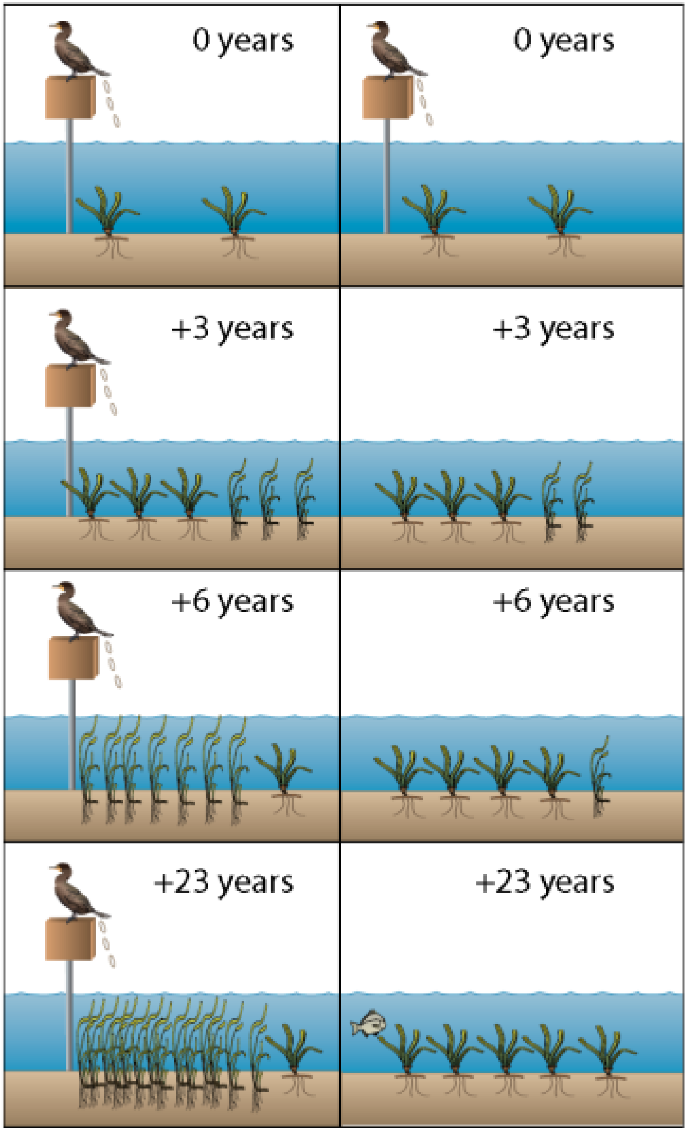


Figure 2. Artificial bird perches have been used to study the effects of nutrient additions to nutrient-limited seagrass beds in south Florida (Fourqurean et al 1995). Fertilization initially leads to more turtle grass, but that turtle grass is replaced by faster-growing shoal weed (left column). Short term fertilization has impacts that last for decades (right column). Figure reproduced from Kryczynski and Fletcher 2012, page 276.

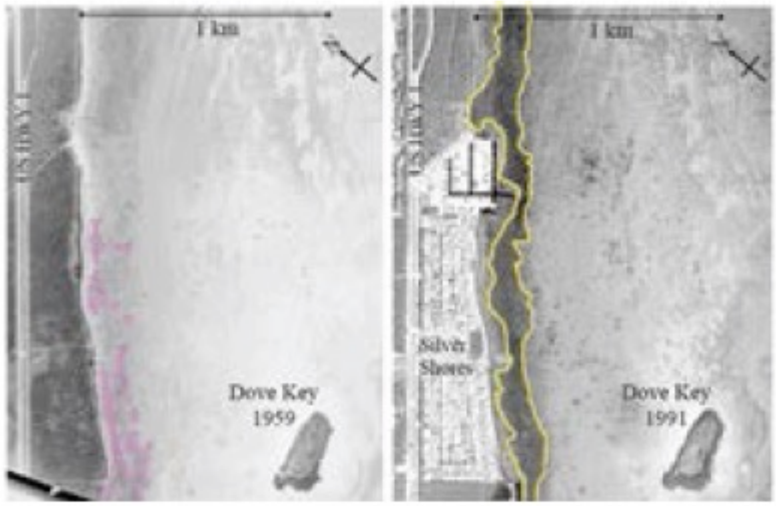


Figure 3. Seagrass distribution along the shoreline of Key Largo near Dove Key in 1959 (left) and 1991 (right). Prior to development, seagrass coverage was sparse along the shoreline. However, by 1991 seagrass coverage and density increased substantially along the shoreline in response to nutrients emanating from development. Figure reproduced from Kryczynski and Fletcher 2012, page 277.

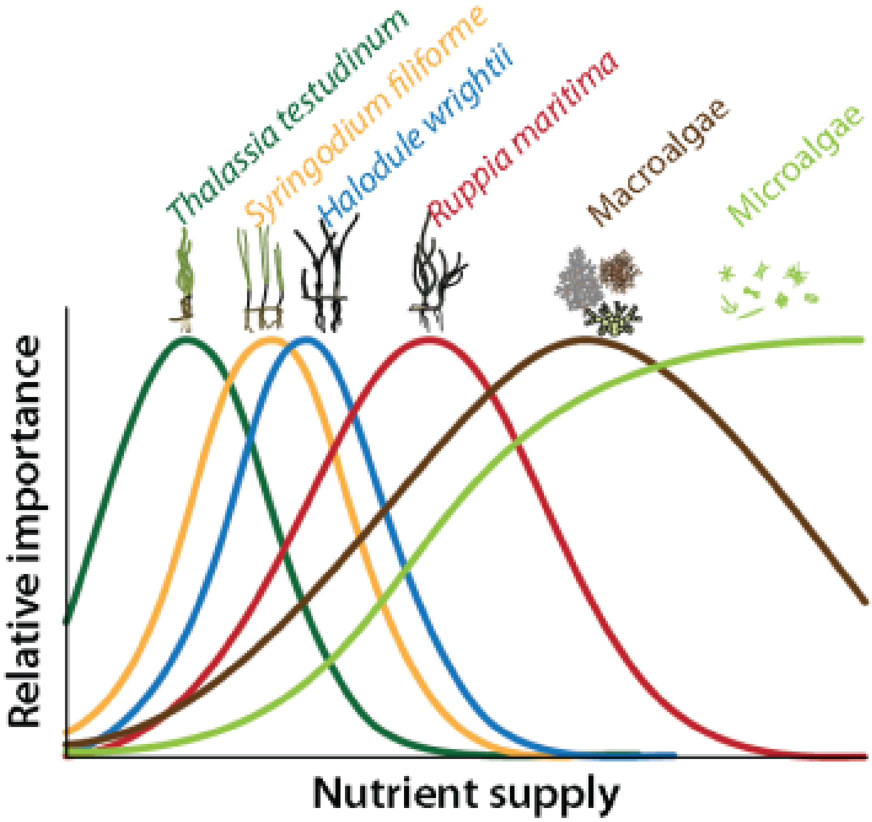


Figure 4. This model describes how the dominant organisms from shallow Biscayne Bay change with addition of nutrients. Nutrient supply can increase either with an increase in concentration OR and increase in volume of nutrient sources. This figure is based on Fourqurean and Rutten (2003) and is reproduced from Kryczynski and Fletcher 2012, page 276.

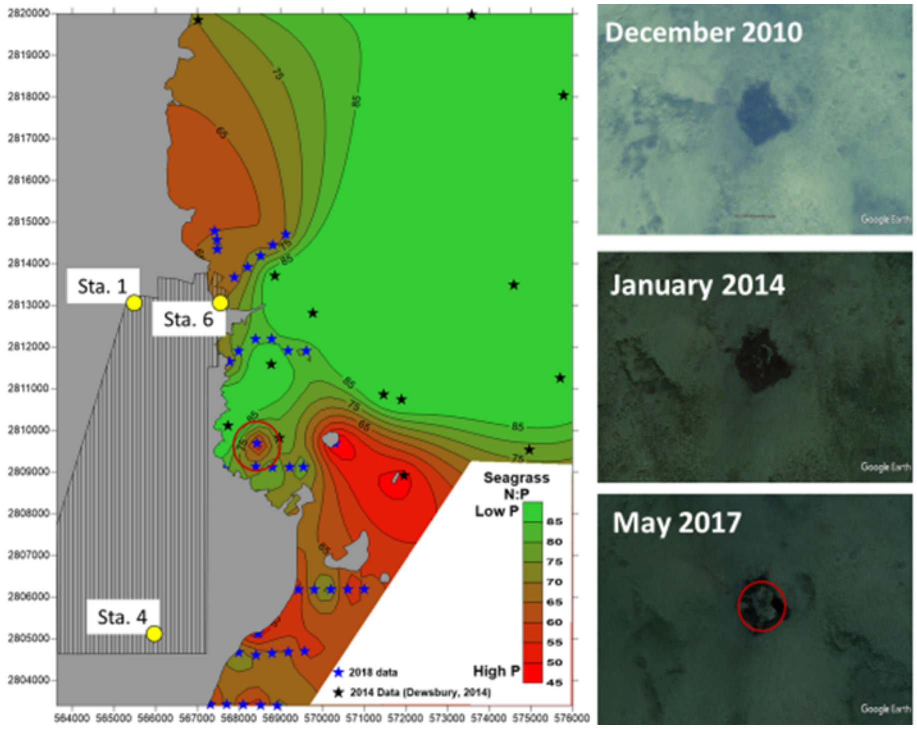
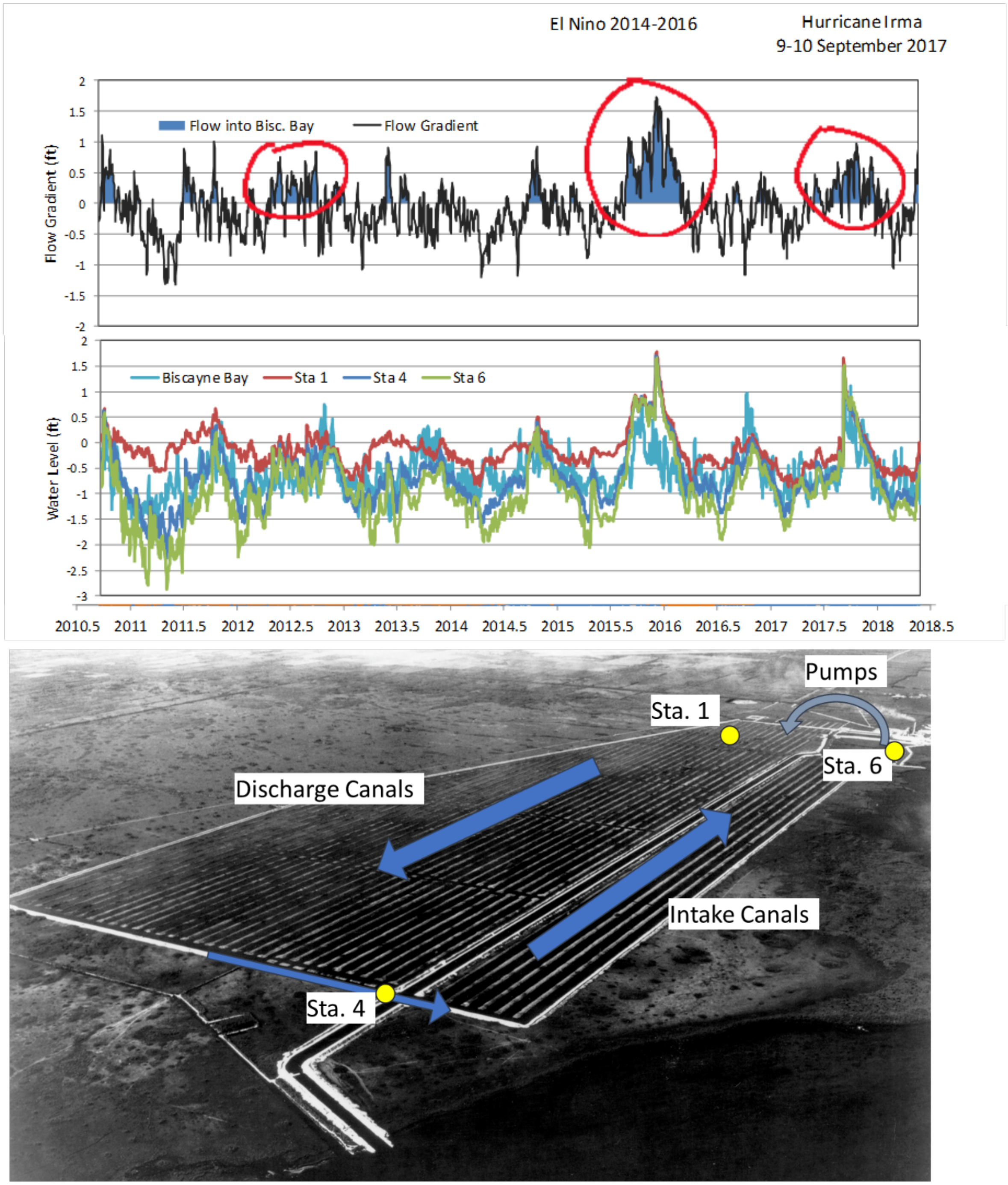


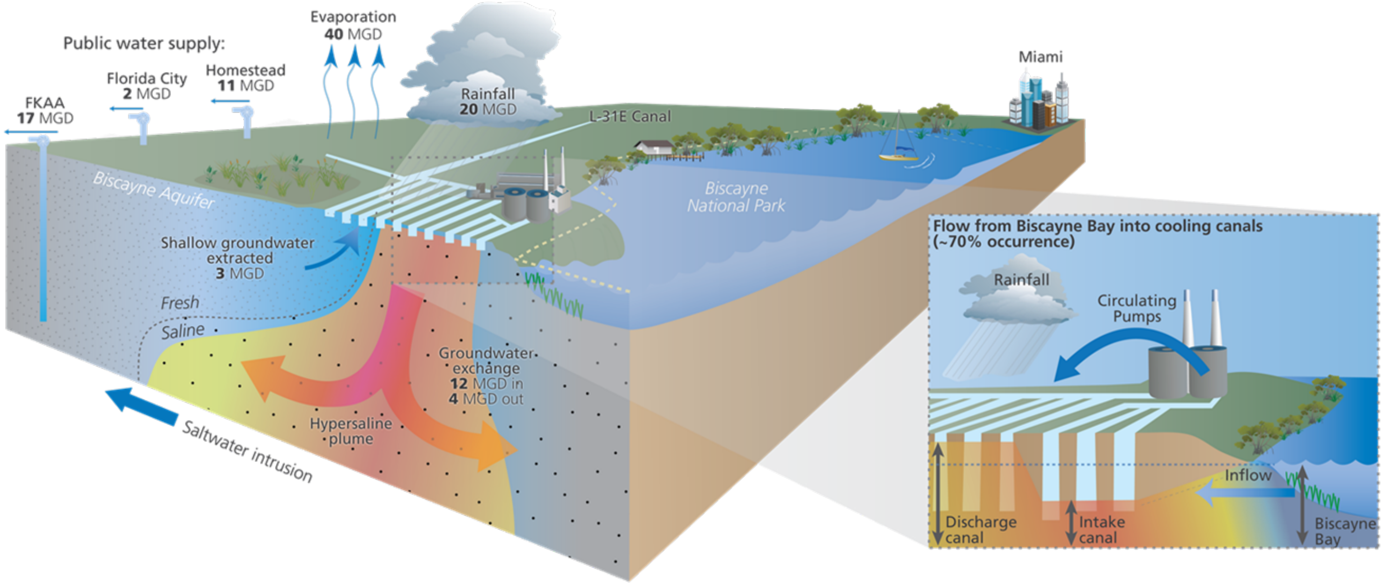
Figure 5. Biscayne Bay is a phosphorus-limited ecosystem, consequently the ratios of N to P in seagrass leaves is generally greater then 85. Immediately offshore from the CCS, seagrass N:P suggests that P availability is much higher than normal Biscayne Bay background levels. And time series aerials show that high P in this area is related to very dense seagrasses that collapsed over the period 2010-2014. Under P pollution, normally P-limited turtlegrass (Thalassia testudinum) first increase in density (see dark patch in 2010 aerial), then gets displaced by progressively faster-growing species until no benthic vegetation is left at the highest P pollution levels. Note the opening up of bare areas in the dense patch by 2017. (Froquean, et al 2019)



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

Figure 6. Detailed information on the water quality and salt budgets, the result of 10 years of in-depth monitoring by multiple agencies, reveals how the cooling canals interact with the Biscayne aquifer and Biscayne Bay. Miami Dade DERM's multi-year water quality monitoring data revel that discharge from the CCS into the surface waters of Biscayne Bay is occurring and those high levels of nutrient are violating Numeric Nutrient Standards as well as narrative water quality

standards meant to protect Biscayne Bay, a historically nutrient poor system. On average, there is a net inflow of groundwater into the canals to help balance water loss due to high rates of evaporation. However, significant outflows of water from the cooling canals also occurs in response to the variation in water levels in space and over time. Under normal operations, pumps circulate water through the power plants. This draws down water level in the intake canals (Sta. 6) and raises water level where the pumps discharge into the canals (Sta. 1). The difference in water level between Sta. 1 and Sta. 6 drives flow down the discharge canals and up the intake canals back to the plants. Elevated water level at Sta. 1 drives the outflow of hypersaline water down into the aquifer. (Nuttle et al, 2019)



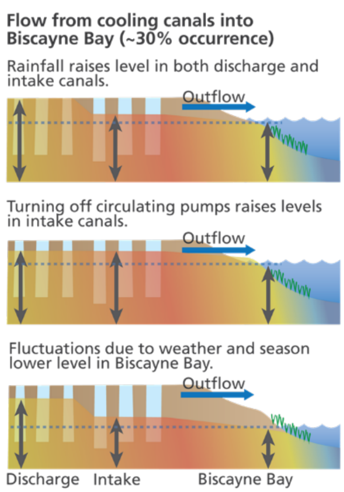


Figure 6. Outflow from the CCS toward Biscayne Bay occurs intermittently, about 30% of the time, in response to heavy rainfall, plant operations including additional water inputs from remediation, and fluctuations in Biscayne Bay water levels, which occur in response to weather and seasonal changes in sea level. This open system is completely dependent upon weather patterns and is vulnerable in the future because it is at sea-level, dependent on rainfall and regional water availability and carved into porous limestone that communicates with surface waters of the US that are protected. (Nuttle, 2018)

Curriculum Vitae

James W. Fourqurean, Ph.D.

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Palmetto Bay, FL 33157

Profile

James Fourqurean is a marine and estuarine ecologist with a special interest in benthic plant communities and nutrient biogeochemistry. He received his undergraduate and graduate training in the Department of Environmental Sciences at the University of Virginia, where he became familiar with the Chesapeake Bay and its benthic communities. He developed a love of tropical ecosystems while doing his dissertation research in Florida Bay. After a post doc at San Francisco State studying planktonic processes in Tomales Bay, California, he was recruited to return to south Florida to join a new research group at the newest research university in the country, Florida International University. He has at FIU since 1993, where he is now Professor of Biological Sciences and the Director of the Center for Coastal Oceans Research in the Institute for Water and Environment. For the past three decades, his main research areas have been in the seagrass environments of south Florida, but he has also worked in coastal environments around the Gulf of Mexico, in Australia, Indonesia, Mexico, Panama, Bahamas, Bermuda, the United Arab Emirate and the western Mediterranean. He is the lead scientist and overall manager of FIU's Aquarius Reef Base, the world's only saturation diving habitat and laboratory for research, education and outreach. He has served as the Principal Investigator of over $25M in grants and contracts at FIU, and published 127 papers in the refereed scientific literature and 13 book chapters. Seven graduate students have received PhD degrees working under his direction, along with 15 MS students. His global leadership in coastal oceans research was recently recognized when he was elected President of the Coastal and Estuarine Research Federation, the world's leading body of scientists who study coastal issues.

Education

Ph.D.	1992	University of Virginia, Department of Environmental Sciences
M.S.	1987	University of Virginia, Department of Environmental Sciences
B.A.	1983	University of Virginia, Depts of Biology and Environmental Sciences

Career Summary

2006-	Professor, Department of Biological Sciences, Florida International University
2017 -	President-elect, Coastal and Estuarine Research Federation
2014 -	Adjunct Professor, School of Plant Biology, University of Western Australia
2014	Visiting Research Fellow, Oceans Institute, University of Western Australia
2012-	Director, Center for Coastal Oceans Research, Institute of Water and Environment, Florida International University

2012-	Director, Center for Coastal Oceans Research, Institute of Water and Environment, Florida International University
2012-	Visiting Research Fellow, Oceans Institute, University of Western Australia
2002 - 2006	Chair, Department of Biological Sciences, Florida International University
2001 - 2002	Visiting Professor, Institut Mediterrani d'Estudis Avançats, CSIC-Universitat des Illes Balears, Esporles, Mallorca, Spain
1998 - 2006	Associate Professor
1993 - 1998	Assistant Professor, Department of Biological Sciences and Southeast Environmental Research Center, Florida International University
1992	Postdoctoral research associate, San Francisco State University
1983 - 1992	Graduate research assistant, University of Virginia. J.C. Zieman, advisor.
1983 - 1987	Research biologist, National Audubon Society

Scientific Publications

Scientific Journals

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M.L. Chen, C. Coronado-Molina, S.E. Davis, V. Engel, C. Fitz, J. Fourqurean, T. Frankovich, J. Kominoski, C. Madden, S.L. Malone, S.F. Oberbauer, P. Olivas, J. Richards, C. Saunders, J. Schedlbauer, L.J. Scinto, F. Sklar, T. Smith, J.M. Smoak, G. Starr, R.R. Twilley, and K. Whelan. 2013. Integrated carbon budget models for the Everglades terrestrial-oceanic gradient: Current Status and Needs for Inter-Site Comparisons. Oceanography 26:98-107.

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