Fourqurean testimony – effect of nutrient addition on marine ecosystems of the Florida Keys

1. The iconic ecosystems of the Keys – the coral reefs and seagrass beds – require very low nutrient loading to survive. In essence, the charismatic plants and animals that typify the valued marine ecosystems of the Keys – the seagrass and corals – are quickly killed and replaced by fast-growing, noxious seaweed if nutrient delivery in 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 concentrations that would pass drinking water quality standards.
2. They exist in a nutrient-limited state, which means any addition of new nutrients changes the balance of these ecosystems. Increased nutrients increase 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.
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 Florida, phosphorus is limiting to algae, macroalgae in Florida Bay and close to shore in the Florida Keys. Offshore on the Keys barrier reef tract, nitrogen limits primary production of algae and macroalgae. This means that addition of phosphorus will upset the balance nearshore, while the addition of nitrogen will upset the balance at the reef tract.
4. 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 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.
5. Human waste contains large amounts of both phosphorus and nitrogen. The prevalent forms of phosphorus in this waste are orthophosphate (also known as soluble reactive phosphorus, or SRP) and organic forms of phosphorus. The prevalent forms of nitrogen are ammonium, nitrite, nitrate, and organic forms of nitrogen. In general, plants take up phosphate, ammonium and nitrate – but rapid processing of organic forms of N and P by the bacterial community turn organic forms into phosphate, ammonium and nitrate which can then feed noxious algal blooms.
6. The geology of the Florida Keys 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.

7. When sea water and freshwater from 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.
8. Wastewater generated by human communities is fresh water. The groundwater under the Florida Keys surrounding the injection wells is saltwater. The mixing of fresh wastewater and salty groundwater results in a brackish solution which will dissolve the bedrock and release phosphorus.
9. Fresh and brackish waters are less dense that salt water, so they will tend to migrate up towards the surface, bringing with them not only the waste N and P in the original wastewater, but also the P released by dissolving limestone rocks in the underground zone around the injection of the waste.
10. 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 and corals.

STATE OF FLORIDA

COUNTY OF MIAMI-DADE

Under penalty of perjury, I declare that the above is true based upon my personal knowledge.

James W. Fourqurean, Ph.D.

NOTARY PUBLIC

As sworn and subscribed before me this 14 day of April 2015 by James W. Fourqurean, Ph.D., who is either personally known to me _____, or produced identification X, type of identification produced Florida Drivers License.

Notary Stamp

ANGELA FERNANDEZ
MY COMMISSION #EE105130
EXPIRES: JUN 20, 2015
Bonded through 1st State Insurance

Notary Public

State of Florida

County of Miami-Dade