# Meeting Minutes
# Texas Commission on Environmental Quality (TCEQ) Nutrient Criteria Development Advisory Workgroup (NCDAWG)
# October 1, 2014

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Location: Building F, 2nd Floor, Room 2210

Time: 9:00 am – 5:00 pm

### ***9:00 am: Welcome and Workgroup Introductions*** *– Jill Csekitz, TCEQ*

### ***9:15 am: National Update, Latest from EPA and RTAG Workshop*** *– Jill Csekitz, TCEQ*

The goal of Ms. Csekitz's talk was to provide an overview of priorities observed at the national level, and provide a status update on topics of interest.

- Update on number of states with numeric nutrient criteria:
  - The number of states with numeric nutrient criteria has increased since 1998.
  - Despite this progress, less than half of the states have adopted numeric criteria for total phosphorus (TP), total nitrogen (TN), or chlorophyll *a* (CHLA).
- Increasing use of response variables among states:
  - There is an increasing trend among states to base numeric nutrient criteria upon response variables.
  - Examples of response variables used by states include: CHLA, water clarity, phytoplankton and algal growth potential.
- Florida timeline and status update:
  - In 2009, EPA entered into a consent decree to promulgate numeric nutrient criteria for Florida's waters.
  - The Florida Department of Environmental Protection (FDEP) continued to develop numeric criteria for the state, and continued to coordinate with EPA.
  - EPA approved water quality standards submitted by FDEP in 2012 and 2013.
  - In 2014, EPA proposed to withdraw their federal standards for Florida. The proposal was finalized in September 2014.
- Topics of Increased Interest:
  - On a national scale, there has been an increased emphasis on nutrient reduction efforts, while states continue to develop numeric nutrient criteria.
  - The hypoxia observed in the Gulf of Mexico is a driver for the emphasis to reduce nutrients.
  - The prevention of harmful algal blooms and protection of source waters for drinking water is also an emerging priority.
  - Recently, EPA has developed guidance for states to use biological response variables along with causal variables (nitrogen and phosphorus) as co-variables to develop criteria.

- EPA's emphasis on Nutrient Reduction Efforts is exemplified in a new performance measure, WQ-26.
  - Examples of activities that can be counted towards this measure include:
    - Prioritization of watersheds on a statewide basis that are in need of nutrient reductions
    - Set watershed load reduction goals
    - Implement effective permitting in priority watersheds
    - Target agricultural areas
    - Target storm water and septic systems
    - Implement accountability and verification measures
    - States should report progress toward implementation and load reductions
    - Develop a work plan and schedule for numeric criteria development
- Example Case Study from Texas:
  - The San Antonio Water System Source Water Protection Program (Edwards Aquifer) is a holistic program that includes best management practices such as education, stormwater management, well head protection and other measures.
- Emphasis on state development of Nutrient Reduction (Management) Strategies
  - These strategies are comprehensive plans that describe how nutrients are managed and addressed in the state. They cover management activities related to:
    - Permitting
    - Agriculture
    - Source water protection
    - Finances for infrastructure
    - Total Maximum Daily Loads (TMDLs) and nonpoint sources (NPS)
    - WQ standards
    - Monitoring and assessment
    - Cooperative agreements
    - Reduction goals and reporting
- States in EPA Region 6 have different ways of documenting their strategies for addressing nutrients.
  - Texas documents management activities for point sources and non-point sources in two different plans:
    - Point sources: Water Quality Management Plan
    - Non-point sources: Texas' Nonpoint Source Management Program
    - Arkansas has a nutrient reduction strategy in development.
    - Louisiana finalized their nutrient reduction strategy in 2014.
    - New Mexico finalized their strategy in 2014.
    - Oklahoma has a nutrient reduction framework similar to that used in Texas.
- Addressing the hypoxia in the Gulf of Mexico continues to be a driver in the national effort to reduce nutrients.
  - This was exemplified in the September 2014 report by the EPA's Office of the Inspector General, *Nutrient Pollution: EPA Needs to Work with States to Develop Strategies for Monitoring the Impact of State Activities in the Gulf of Mexico Hypoxic Zone.*
  - The report highlighted the importance of state nutrient reduction strategies to address hypoxia in the Gulf.
  - Areas noted for improvement in state plans included:
    - The lack of reduction targets and timelines for activities
    - The limited ability states have to monitor effectiveness of nutrient reduction activities and measure progress of the strategies
- Preventing harmful algal blooms and protecting source waters is another national priority.
  - The harmful algal bloom in Lake Erie drew national attention in August 2014.
  - The extent of the bloom impacted the water supply for the city of Toledo.

    - Fortunately, Texas has not experienced blooms to this degree. Continued efforts to manage nutrients can help protect source waters.
- EPA has recently devoted resources towards considering bioconfirmation in criteria development.
    - This methodology combines multiple nutrient-related benchmarks into a single criterion.
    - It integrates cause (TN and TP) and response parameters (algal component, dissolved oxygen, pH, water clarity) as part of the criterion.
    - Benefits of this methodology include use of multiple lines of evidence to increase the certainty of impairment.
    - It can also be used to "translate" narrative nutrient criteria using thresholds, which are like screening levels rather than criteria (and are non-regulatory).
    - The response variables should be sensitive to nutrient pollution and have a link to a designated use.
- New Mexico's reservoir assessment methodology was described as an example of using bioconfirmation to translate their narrative criteria.
    - TCEQ is reviewing New Mexico's methodology for reservoirs, which evaluates causal variables (TN and TP) and response variables (secchi depth, CHLA, cyanobacteria, or dissolved oxygen).
- There are a number of examples available that demonstrate EPA's support for bioconfirmation. These include the following:
    - In April 2013, EPA held a *Nutrient Indicators in Streams* workshop with national experts to study the issue. Current science suggests that the most sensitive and predictive indicators are as follows: TN, TP, algal biomass, algal assemblage, dissolved oxygen and pH.
    - Using results of this workshop, EPA released Guiding Principles for using a combined approach in September 2013.
    - Bioconfirmation was discussed at the May 2014, *EPA Region 6 Technical Advisory Workgroup*. The discussion included consideration of making impairment determinations based on narrative translators (thresholds). One benefit of using translators of narrative nutrient criteria, rather than numeric criteria, is that it can bridge gaps and are more flexible than regulatory criteria.
- TCEQ is interested in modeling approaches to aid in criteria development, particularly in estuaries.
    - TCEQ is evaluating a model selection decision toolkit developed by the Water Environment Research Federation.
    - Use of models would be particularly useful for development of site-specific criteria in estuaries.

Question: Is there any idea/opinion about what algal assemblages are more desirable than other?

Answer: We have no specific preferences. Instead, we are looking more at what is driving shifts in communities.

Question: Has EPA noted any benefits in our plan over other states, especially in this EPA region?

Answer: Not in particular. Other states are taking very different approaches. For example, Louisiana has more of a management strategy that is less about load reductions and more about outreach.

### ***9:30 am: Texas 2014 Nutrient Criteria Development Plan Update*** *- Jill Csekitz, TCEQ*

Ms. Csekitz's presentation provided a status update on nutrient criteria development at TCEQ.

- What are the major developments regarding nutrient criteria development at TCEQ?
    - EPA approval of 39 site-specific reservoir criteria based on CHLA
    - The revision of TCEQ's nutrient criteria development plan
    - Adoption of the 2014 revisions to the Texas Surface Water Quality Standards
    - A project with the University of Arkansas to continue stressor response work

- Status of Nutrient Criteria for Reservoirs
  - The TCEQ adopted 75 site-specific CHLA criteria for reservoirs in June 2010.
  - TCEQ submitted these criteria for EPA review in July 2010.
  - The EPA requested additional information to consider the criteria in May 2011. TCEQ provided all of the requested information.
  - The EPA issued an action letter that reviewed the numeric nutrient criteria for 75 reservoirs in the 2010 Texas Surface Water Quality Standards (TSWQS) in July 2013.
- As part of their review, EPA included a Technical Support Document that describes their approach to considering TCEQ's criteria. EPA's action letter as well as their Technical Support Document, are available on TCEQ's website.
- EPA's review resulted in:
  - Approval of criteria for 39 reservoirs, whose adopted criteria range from 5.00 – 19.77 µg/L
  - Disapproval of criteria for 36 reservoirs, whose adopted criteria range from 11.21 – 55.80 µg/L
- EPA's review methodology evaluated the TCEQ's critical underlying assumption for the 75 reservoirs. They concluded that TCEQ's approach was repeatable and scientifically defensible; and consistent with the intent to maintain existing water quality in the reservoir. Supporting information submitted with the criteria (and gathered by EPA) suggested not all criteria were sufficient to protect designated uses such as recreation, aquatic life, and public water supplies.
- As part of their review, they considered information from the following sources:
  - TCEQ Integrated Reports (IR) identifying impairments (last 10 years)
  - TCEQ Integrated Reports identifying water quality "concerns" (last 10 years)
  - Treated drinking water chemical data
  - Microcystin, cyanobacteria, and CHLA data from the EPA's 2007 National Lakes Assessment
  - TCEQ CHLA trend analysis results
  - EPA CHLA trend analysis results, including magnitude of CHLA accumulation.
  - TCEQ trophic state classification information (last 10 years)
  - Comparison of reservoir-specific CHLA criteria to water quality management thresholds (30 ug/L of CHLA) published in the scientific literature TCEQ's approach was repeatable and scientifically defensible.
- Lake Buchanan was provided as an example of a reservoir whose criterion was approved.
  - This waterbody did not have any impairments for DO or pH, exceedances for drinking water maximum contaminant levels, or CHLA measurements greater than 30 ug/L.
  - However, it did have concerns for nutrient related parameters in headwaters of the reservoir as identified in several IR cycles. The reservoir also showed an increasing trend in CHLA concentrations, although the slope of these trends was moderate.
  - EPA considered all of the available information and approved the criterion.
- Twin Buttes Reservoir was provided as an example of a reservoir whose criterion was not approved.
  - This waterbody did not have any impairments for DO or pH, or exceedances for drinking water maximum contaminant levels. It did have a few CHLA measurements greater than 30 ug/L.
  - However, it did have multiple concerns for nutrient related parameters identified in several IR cycles. The reservoir also showed an increasing trophic trend, as exhibited by a high rate of CHLA accumulation, hyperutrophic status, and increasing concentrations of CHLA.
  - EPA considered all of the available information and disapproved the criterion.
- The future of reservoir criteria development was discussed, particularly in light of EPA's disapproval of 36 criteria.
  - TCEQ provided a response to EPA's action letter, saying TCEQ intends to reconsider these criteria in a future submission of the TSWQS.
    - TCEQ's review of both the disapproved and approved reservoir criteria will be conducted with input from stakeholders in the Nutrient Criteria Development Advisory Workgroup
    - Use of multiple lines of evidence to develop and possibly include in the expression or attainment of criteria may be useful to address the criteria. Evaluation of alternative statistical methods to develop criteria or determine standards attainment may also be useful.

- Nutrient Criteria Development Plan Update
  - TCEQ revised the plan by incorporating stakeholder input received from 2012 - 2014. The revised plan was sent to the EPA in August 2014.
  - The plan was last updated in 2006.
  - The revised plan included an updated schedule of criteria development, which was revised based on stakeholder input. The schedule emphasizes work in estuaries and their contributing watersheds which have a robust data set and there is stakeholder interest.
- 2014 Revisions to the TSWQS
  - Revisions were adopted by the Commission on February 12, 2014 and sent to EPA in April, 2014.
  - TCEQ received an EPA action letter regarding the 2014 TSWQS on September 23, 2014.
    - The approvals included in the letter are as follows:
    - Temperature revisions (industrial cooling area, mixing zones)
    - Human health criteria
    - Sole-source drinking water supplies
    - Some site-specific changes in Appendices A, C, D, and G)
- TCEQ's current project with the University of Arkansas focuses on estuary analyses:
  - Estimate constituent influx into estuaries using standard load estimations
  - Investigate trends in long-term, seasonal and drought flow variability
  - Investigate salinity versus flow and salinity versus nutrient correlations
  - These evaluations may help predict which estuaries may be more sensitive to enrichment
  - The project also includes further refinement of stressor / response analyses using fish and macroinvertebrate data

Question: Is there any stance/opinion regarding trend analysis of inflows driving events?

Answer: There is an issue with no detect data within the CHLA dataset. Drivers were teased out when they could be, but events were considered as a whole. The period of record considered dated back to the 1990s and did include periods of drought.

Question: Was water volume of a water body (say a lake) considered in conjunction with the measured CHLA value? Less water should equal a higher concentration, right?

Answer: Productivity varies widely in any given water body. For this reason, we use the monitoring station located at the dams of reservoirs where the water is at its deepest.

Question: It looks like EPA was rather subjective when deciding which reservoir criteria to approve or disapprove. Was a weight of evidence used in their decision process?

Answer: An EPA representative answered that yes, a weight of evidence approach was used when determining what criteria to approve. One factor was not enough to disapprove any of the state proposed nutrient criteria for a reservoir. Their decision document provided to the TCEQ explains how this decision process worked.

Question: Some reservoirs, Like Twin Buttes, have been really low over the last five to ten years. Twin Buttes also has salt cedar issues. Wouldn't algal productivity be expected to rise under such circumstances?

Answer: The data used in criteria development stopped at 2012, which was near the beginning of the large drought we recently had. The period of record used to develop criteria are believed to show trends truly.

Question: How are we currently measuring CHLA? What methods are being used?

Answer: Both spectrophotometric and fluorometric methods are currently being used to measure CHLA, and each method can yield different results.

Question: What is the timeframe for developing numeric nutrient criteria for streams, rivers, and estuaries?

Answer: The short answer? Later. We first have to prioritize them.

Question: Is there a timeframe to replace the reservoir criteria that were rejected by the EPA?

Answer: As shown in the talk (slide regarding "Future Reservoir Criteria Development"), there are several paths forward on that issue. Right now we are looking at options, and we'd like to get this group's input. This was one of the questions posed to the group in the survey that was out just prior to this meeting.

### ***10:00 am: Texas Association of Clean Water Agencies (TACWA) Update*** *– Dr. Peggy Glass, TACWA*

TACWA has no official policy on nutrients, but the association recognizes the impact nutrient standards can have on municipalities and other regulated entities.

- Goals of Publicly Owned Treatment Works:
  - Provide the treatment necessary to maintain the quality of the State's waters
  - Be good stewards of limited financial resources and other resources
- Of concern:
  - Relationship between nutrient discharge concentrations and instream impacts is highly variable.
  - Nutrient concentration targets in EPA guidance may be substantially more stringent than needed to protect water quality.
- Results of a study conducted by the Upper Trinity Water Quality Compact. They initiated data collection to develop a model for the upper Trinity River.
  - Data to be collected over two years (2013 and 2014). Collection efforts this year have been hampered by rainfall.
  - Data collected last year showed CHLA concentrations to be lower below the discharge location although phosphorous and nitrogen were higher.
  - Overall CHLA concentrations were relatively low. One possible explanation for the lower CHLA values below the discharge point may be due to clarity. Above the discharge point the geology is mostly limestone and therefore the water rather clear. Uptake from plants can also explain the discrepancy.
- Dissolved oxygen model for Oso Bay:
  - The TCEQ asked the City of Corpus Christi to develop a model for dissolved oxygen (DO) to assess the effect of 24 million gallons per day (MGD) discharge from Oso Water Reclamation Plant to bay.
  - Includes effects of nutrients, algal growth, and aquatic vegetation on average DO concentration and diurnal variability
  - Dynamic model
- Relationship between TP and chlorophyll in reservoirs:
  - Study performed for Tarrant Regional Water District to look at the effects of nutrients and algae on downstream water quality with an interest in protecting the drinking water quality of lakes.
  - Compared the relationship between total phosphorous and CHLA in reservoirs in New York with the relationship in reservoirs in North Texas
  - New York data collection and analyses were conducted by Callinan, et. al. and published in the Journal of the American Water Works Association (2013 Vol. 105).
  - Results showed that it takes more phosphorous to create the same conditions in Texas than it does in New York:
    - New York Target Criteria:
      - CHLA = 4-6 ug/L
      - TP = 12-17 ug/L
    - Analogous North Texas Target Criteria:

        - CHLA = 23 ug/L
        - TP = 57 ug/L
    - Possible Variability Factors for this:
        - Clay substrate
        - Temperature too high for optimum algal growth
        - Intense sun producing photo-inhibition
        - Surface agitation due to wind
        - Different levels of dissolved organic carbon (DOC) and treatment methods
- TCEQ data shows how uncertain the relationship is between phosphorus and chlorophyll in reservoirs. Significant amounts of money can be spent by facilities to reach nutrient limits based on this uncertainty.
    - Reliably meeting a limit of 0.5 mg/L phosphorous is achievable, but it is difficult to reliably reach limits lower than this level.
    - Limits currently in permits below 0.5 mg/L so far have been court imposed limits.
    - Standards for nutrient criteria should be based on a response variable approach (similar to the dissolved oxygen to biochemical oxygen demand).
- Costs associated with modifying a one to five MGD plant:
    - Permit limit of 0.5 mg/L = $0.60 per gallon
    - Permit limit of 0.25 – 0.5 mg/L = $1.40 per gallon
    - Permit limit of 0.10 - 0.25 mg/L = $4.90 per gallon

Regulation of nutrients should be based on an adaptive management program because of the variability of the response of surface waters to nutrient enrichment, the cost of treatment, and the cost of studies to determine appropriate, site-specific permit limits. When permit limits are determined to be appropriate, in the absence of site-specific studies, initial limits for TP should not be less than 0.5 mg/L.

Question: Has anyone seen any impacts on drought and its effect on phosphorous removal in treatment plants? BRA has noticed that low flows do impact a plant's ability to remove phosphorous in treatment plants.

Answer: No, but this is good information to share with the group and needs to be documented.

Question: Regarding the Tarrant Regional Water District Study: how far downstream did you look for effects on CHLA concentrations?

Answer: CHLA concentrations here are more uniform than you might think. They are fairly constant throughout the reach.

Question: Once the phosphorous is filtered out, where does that waste go?

Answer: That's a good point. There are often unintended consequences that need to be considered.

Question: Has anyone looked at the costs for removing nitrogen? Or for that matter, is there a protocol for determining what the limiting nutrient is in the first place – nitrogen versus phosphorous – so you know you are removing the right nutrient? How do you know which constituent you really need a permit limit for?

Answer: Some states have nitrogen limits as low as 4 mg/L. We all recognize that nitrogen tends to be more important in coastal systems. A nitrogen limit below 4 mg/L is difficult to meet. We need site-specific data on each system before deciding which nutrient is the limiting nutrient. Oklahoma has started looking more at this issue, but they are approaching it more from an assessment angle.

Comment: BRA has noticed the Lake Somerville appears to be driven more by nitrogen than phosphorous. GBRA suspects this may also be the case with Lake Dunlap.

Question: Does the same treatment method used to remove phosphorous also remove nitrogen?

Answer: No.

Question: For this presentation, what were the sources used to develop treatment costs?

Answer: The engineers at Alan Plummer came up with them. They developed costs for both new facilities and for modifying existing facilities. The modification costs are shown on the slides in this presentation. These are strictly capital costs.

Comment: It's also important to note that a facility is usually modified because of growth in the municipality. That means the costs of a plant upgrade can be negated by more paying customers. Upgrades to a plant not based on population growth in the service area means higher rates for all customers.

Comment: Facilities wishing to reuse their effluent for irrigation purposes may not always want to remove nutrients from their effluent.

Question: Is anyone harvesting the removed nutrients to sell?

Answer: Not that anyone is aware of here in Texas. This has been happening on the international stage, though. They may also be considering this in the West Coast area, especially in the San Francisco Bay area.

### ***10:30 am: Nutrient Criteria Implementation: Texas and Beyond*** *– Brad Caston, TCEQ*

While nutrients are essential to all life, including humans, there can be too much of a good thing. This talk focuses on lessons learned from an EPA conference Mr. Caston attended in August of this year.

- High nutrient levels can cause eutrophication.
  - Natural elements/compounds at unnaturally high levels
  - Ecosystem impacts
  - Economic impacts to tourism, fisheries, and drinking water sources
- High nutrient levels cause harmful algal blooms that can impact, among other things, drinking water sources.
  - Recent tap water ban for Toledo residents
  - Treating drinking water for blooms takes money and chemicals and causes public relations issues.
- Purpose of the EPA workshop:
  - Step towards progress
  - Allow for focused consideration of issues
  - Get feedback from states
  - Provide a forum for sharing
- National statistics:
  - Impairments:
    - 11,000 impairments
    - 8,000 TMDLs approved
  - Nutrient limits (phosphorus or nitrogen):
    - 8% of all permits
    - 20% of majors
    - Monitoring only: 18% of all permits
- Two basic types of NPDES permit limits
  - Technology standards:
    - TN and TP technology-based effluent limits (TBELs) for a few industries
      - 40 CFR Part 412: Concentrated Animal Feeding Operations
      - 40 CFR Part 426: glass manufacturing
    - 40 CFR §125.3(c) – method for imposing TBELs on non-Publically Owned Treatment Works (POTWs)
    - 40 CFR §125.3(c)(2) – authority for case-by-case TBELs

    - POTWs – none for nitrogen or phosphorous
    - Why hasn't EPA developed TBELs?
        - Recently petitioned
        - Cost, variability
        - Mixed reactions from the states
- Water Quality Based Effluent Limitations (WQBELs):
    - Identify applicable WQ standards
    - Delineate waters of concern
        - Example: Lake Spokane is in Washington and downstream from Idaho. EPA approved a TMDL for the lake, and as a result the EPA proposed limits for three Idaho wastewater treatment plants.
    - Numeric criteria
        - Can be seasonal or annual averages
        - Can be based on warm versus cold water fisheries
        - Duration and frequency are important
        - May be based on a causal or response variable
    - Narrative criteria
        - Guidance is needed to know how to integrate these criteria into permit limits.
        - Risk assessment and exposure data
        - TMDL target
        - EPA Gold Book 1996
            - Lakes and reservoirs = 25 µg/L TP
            - Streams/rivers = 100 µg/L TP
        - EPA Ecoregional Criteria (2000)
    - Identify nutrients of concern
        - Single versus dual nutrient control
        - Emerging studies
        - EPA reports: EPA-820-F-13-039: Integrating causal and response ;EPA-820-S-12-002: Dual nutrient criteria
    - Determine need for WQBELs
        - Technical Support Document for Toxics (TSD)
        - NACWA review and critique (June 2014)
        - Reasonable potential analysis (RPA)
            - Select WQ model for quantitative RPA
            - Select model condition
        - Quantitative or qualitative
        - Texas local effects - qualitative RPA
        - Texas main reservoir – quantitative RPA
- Interpretation may be required.
    - Narrative criteria
        - No nuisance algal growth = 0.00001 µg/L TP
    - Numeric response variable criteria
        - 10 µg/L CHLA = ????? mg/L TP
    - Numeric causal variable criteria
        - 20 µg/L TP = Over an averaging period of a month of Sundays, average TP cannot exceed 20 µg/L. Daily maximum may not exceed 50 µg/L except on holidays.
- Alternatives, Innovations, and Revelations
    - Longer averaging periods for limits (like in Lake Spokane or Chesapeake Bay)
    - 40 CFR §122.45 (d) requirements for POTWs
    - Might not be practicable (2004 EPA memo)
    - WQ trading and Watershed-based permitting for nutrients

        - Wisconsin
    - Longer permit compliance schedules
        - Cahaba River, Alabama
        - 15-year compliance period
        - Phased approach
- What Texas has now:
    - Narrative criteria for nutrients
    - General/Aesthetic narrative criteria
    - 2010
        - Numeric criteria for major reservoirs
        - Quantitative screening for main pool effects
        - Qualitative screening for local effects
    - No TBELs for nutrients
    - Nutrient limits
- Utah's approach:
    - Develop nutrient standards to protect beneficial uses
    - Statewide monitoring
    - Cost Study
    - TBELs
    - Guidance, funding, and certification program for nonpoint sources
    - Cost Studies:
        - Four treatment levels (30 mechanical plants)
            - 1.0 mg/L TP only
                - 23.7 million capital, 4.5 M per year operation and maintenance
            - 1.0 mg/L TP and 20 mg/ L TN
            - 0.1 mg/L TP only
            - 0.1 mg/L TP and 10 mg/L TN
                - 1,041.1 million capital, 5.0 M per year operation and maintenance
    - Utah's proposed rule:
        - Statewide TBELs for TP
        - Mechanical plants: 1.0 mg/L TP
        - Lagoons: 125% of present load
        - Compliance by Jan. 1, 2020
        - Cost = $1.19 per month per household
        - Benefit = 66% from wastewater treatment plant (WWTP); 50% ambient
- South Dakota:
    - No numeric criteria
    - Narrative criteria only
    - No discharge of pollutants that:
        - Produce nuisance aquatic life to form
        - Impact biological integrity
    - Few permits currently have limits
        - 2 with phosphorus; several with nitrate limits)
    - CAFO permit regulates 410 facilities
        - 87 million pounds of nitrogen and 34 million pounds of phosphorous
    - Stream assessment
    - Seeking waiver for lagoon systems: compare a small town to surrounding nonpoint influences
        - Small town with lagoon system
            - Discharge once per year, approximately 1 MGD over 3 days
            - 284 pounds nitrogen

    - Nonpoint source study
        - 23,000 acre watershed in eastern SD
        - 2 lb nitrogen per acre per year
- Wisconsin:
    - TBELs (1.0 mg/L TP) since 1993
    - Rule: All permits reissued after December 2010 evaluated for WQBELs for phosphorus
    - Criteria:
        - Rivers = 100 µg/L
        - Streams = 75 µg/L
        - Lakes = 15 - 40 µg/L
        - Great Lakes = 5 - 7 µg/L
    - Compliance options
    - Negotiated compliance periods are longer than the permit term.
    - WQ trading
    - Impracticability of 122.45 (d) demonstrated
        - 6-month and annual monthly average for TP less than 0.3 mg/L
        - Annual limits for RW residence time greater than 1 year

Question: Nonpoint sources seem to be a big issue here. How do we get a handle on those?

Answer: The EPA can only go after point sources, so that's what we have to target. Some states have started a trading system with nonpoint sources. If they can reduce their input, they can earn trading credits to sell to point source dischargers. If you make it financially advantageous to nonpoint sources, you can hopefully get more participation from them.

Comment: Nonpoint sources aren't always the major contributor. You have to look at each watershed on a case-by-case basis. Don't throw your money away because you didn't take the time to understand what was driving the nutrient issue in your watershed.

Question: Was such trading in Wisconsin limited to watersheds with lakes?

Answer: That's not known. The EPA website may have more information.

Question: At the conference you attended, did the EPA tout on state's implementation of nutrient criteria over another?

Answer: No

Question: Did the EPA talk about their opinion regarding long-term implementation strategies (20 or more years in length)?

Answer: Both Utah and Colorado have implantation plans last 10 or more years.

Question: Did the workshop cover industry nutrient inputs?

Answer: Yes. They discussed adding technology-based effluent limits as appropriate.

Comment: The Texas steady state model has been mentioned during recent national conference calls.

### ***11:00 pm: Watershed Rules Update*** *– Gregg Easley, TCEQ*

Nutrient criteria lead to implementation procedures to establish permit controls/limits.

- How Nutrient Controls Can Get Into Discharge Permits?
    - Nutrient screening in Implementation Procedures (IPs)
    - Antidegradation provisions for protecting impaired waters
    - TMDL or TMDL Implementation Plan
    - Watershed protection or aquifer protection rules
- What Are Watershed Protection Rules?

    - Stipulate permit requirements for specific types of discharges or specific areas of the state
    - Intent to address real or potential threat to water quality
    - Can be initiated by TCEQ or by outside rule petition
- Where Can They Be Found?
    - Chapter 311 of TX Administrative Code
        - Nine separate subchapters
        - Five focus on water supply reservoirs
        - Some narrowly focused – quarries, pesticides
    - Edwards Aquifer Rule
        - Chapter 213 of TAC
        - Similar function as watershed protection rule
- Watersheds Covered in 311:
    - Highland Lakes (3 subchapters)
    - Clear Lake
    - Lake Houston
    - Colorado River Below Austin (including Onion Creek)
    - TRWD water supply reservoirs (7 total)
    - John Graves Scenic Riverway (quarries only)
- Which Rules Specify Nutrient Controls?
    - Colorado River
        - 1mg/L TP (TP) for tributaries only
    - Edwards Aquifer
        - 1 mg/L TP limit – 5 mi. from Recharge Zone
    - Benbrook Lake (pending)
        - 1 mg/L TP limit – flow and location specific
    - ammonia limits in many of the rules
- Historical Watershed Rule Change Requests
    - Barton Creek/Onion Creek
        - COA-BS/EACD petition in 2008
        - Stakeholder process – no final rules
    - Highland Lakes revisited
        - Leander/Granite Shoals 2009 petition
        - Petition denied
        - Recent interest in potential change in rules
- Recent Watershed Rule Change Requests
    - Benbrook Lake (311 Subchapter G)
        - Feb. 2013 petition submitted by TRWD
        - Increasing eutrophication, population growth
        - Adds 1 mg/L TP limit to new/expanded plants
            - Inside WQ Area (5 mi.), ≥0.10 MGD flow
            - Outside WQ Area, ≥0.25 MGD flow
        - rule amendment to be finalized by Jan. 2015
    - Lake Palestine
        - Jan. 2014 petition by UNRMWD
        - Similar need, but growth less a factor
        - Requested 1 mg/L TP limit and other conventional effluent parameters
        - Petition denied – insufficient support
        - Could be revived by stakeholder activity

Question: What's the agency's opinion about moving forward with a watershed rule when the science shows it is needed but the local population is against it?

Answer: Stakeholder input is always important to the TCEQ, but it is difficult to say what level of influence they would have on the final decision made by our commissioners.

### *11:30 pm Lunch*

### *1:00 pm: Database Analysis to Support Nutrient Criteria Development FY2012-2013* – *Dr. Thad Scott, University of Arkansas*

The University of Arkansas is under contract with the TCEQ to help develop numeric nutrient criteria from existing TCEQ water chemistry and biological data. This presentation focuses on changepoint analysis of geospatial data and stressor-response relationships conducted for streams, rivers, and estuaries.

- Methods: Available Data
  - Texas water quality data (2000 – 2010)
  - Includes nutrient and response parameters, such as:
    - TP and nitrogen (TN and TP)
    - Dissolved inorganic nutrients
    - CHLA and Secchi transparency
  - Median database includes stations, where $n \geq 10$ observations for a given parameter.
- Methods: Changepoint analysis
  - Identifies a threshold where a change in the response variable occurs.
  - Useful for identifying specific nutrient concentrations where shifts occur.
  - Often we see the variability change in the biological response at a given nutrient concentration, but it is apparent that not all sites express impact or impairment above a given nutrient concentration.
  - Other times we see the variability change in the biological response at a given nutrient concentration, but it is apparent that sites above that change-point always show impact or defined impairment.
- Evaluating changepoint models with statistical parameters
  - Model statistical significance:
    - Measured with p values
    - $p<0.05$ considered statistically significant in these analyses.
    - All thresholds shown today considered significant
  - Model explanatory power:
    - Measured using $r^2$
    - As $r^2$ increases up to 1.0, model strength increases
    - Changepoint analysis on real-world data, $r^2$ rarely >0.50
  - Objectives for changepoint analysis on Texas median databases:
    - Geospatial analysis:
      - Identify threshold values in geospatial variables that are linked to shifts in nutrient and biological response variables.
    - Stressor-response analysis:
      - Identify threshold values in potential stressor variables, such as nutrient concentrations that are linked to shifts in biological response variables.
- Parameters of interest:
  - Geospatial Analysis:
    - Response variables:
      - TP and TN
      - CHLA

        - Secchi transparency
    - Explanatory variables:
        - Land use/land cover
        - Municipal WWTP discharge
        - Regions (streams and rivers)
        - Salinity (estuaries)
- Stressor-response analysis:
    - Response variables:
        - Secchi transparency
        - CHLA
        - Fish (IBI) and macroinvertebrate biometrics (RBIBI)
    - Stressor variables:
        - TP
        - TN
        - Habitat scores (HQI)
- Results: Texas Streams and Rivers
    - Geospatial analysis:
        - Models with highest explanatory power:
            - Area-weighted municipal WWTP discharge (WWTP discharge per watershed area; mgd/km$^2$) for TP.
            - Basin-Ecoregion III groups for TN, CHLA, and transparency.
        - High and low nutrient station median groups derived from area-weighted municipal WWTP discharge threshold.
        - TP and TN versus Area- Weighted WWTP discharge
            - Threshold = 0.031 mgd/km$^2$ for both TP and TN
            - Above this discharge threshold, TN and TP concentrations 3 – 5x higher on average.
    - Stressor-response analysis:
        - Secchi versus TP:
            - All data and low nutrient threshold = 0.063 mg/L.
            - High nutrient threshold = 0.091 mg/L, constrained by number of observations below threshold.
            - All data and low nutrient threshold = 0.063 mg/L.
            - High nutrient threshold = 0.091 mg/L, constrained by number of observations below threshold.
        - CHLA versus TP:
            - Lower thresholds for fluorometric CHLA (0.069-0.079 mg/L versus 0.1-0.11 mg/L).
            - Similar threshold in All Data and Low Nutrient groups.
            - No High Nutrient thresholds.
        - TN thresholds:
            - TN thresholds = 0.70 – 1.1 mg/L
            - All TN models were statistically weak (low $r^2$).
            - No models were statistically significant for high nutrient groups or fluorometric CHLA.
        - Bioassessment database
            - Smaller data subset contains bioassessment metrics:
                - Fish Index of Biotic Integrity (IBI)
                - Macroinvertebrate Rapid Bioassessment Index of Biotic Integrity (RBIBI)
                - HQI
            - Analyzed over multiple time scales:
                - Period of record medians
                - Annual medians
                - Seasonal medians: critical versus index

        - Individual paired observations
    - Strongest relationships consistently for period of record medians, which are presented here.
  - Fish IBI:
    - Strongest models for fish IBI were TN> TP> HQI.
    - High nutrients and low habitat quality associated with reduced Fish IBI.
  - RBIBI:
    - Strongest models for RBIBI were HQI> TP.
    - No significant model for TN.
    - High TP and low HQI associated with reduced RBIBI.
- Major findings for Texas streams and rivers:
  - TP thresholds = 0.063 – 0.11 mg/L
    - Thresholds for low and high nutrient groups similar to all data.
    - Transparency responded more strongly than CHLA to nutrient gradients.
  - TN thresholds = 0.70 – 1.1 mg/L
    - TN thresholds generally statistically weaker or not detected.
  - Fish IBI responded to nutrient gradients, but macroinvertebrate RBIBI responded most to habitat.
- Further exploration: FY2014-2015
  - Can we use changepoint analysis to identify thresholds in CHLA?
  - Do nutrient thresholds differ regionally within Texas?
  - Do regional differences in background streamflow relate to variability in IBI's?
  - Do nutrient and habitat thresholds differ if more specific fish and macroinvertebrate indices are response variables?
- Texas estuaries:
  - Geospatial analysis:
    - Models with highest explanatory power:
      - Salinity for TP, TN, and Secchi transparency
      - %Developed+Agricultural land for CHLA
    - Salinity was included as a geospatial variable that was a proxy for regional variability in hydraulic loading.
      - Low salinity = high riverine inputs
      - High salinity = low riverine inputs; increased tidal influence
    - TP and TN versus salinity:
      - Thresholds = 17 – 21 ppt for TP, TN and Secchi
      - Above this salinity threshold, TN and TP concentrations up to two times higher on average.
  - Stressor-response analysis:
    - Secchi transparency versus TN and TP:
      - TP threshold = 0.068 mg/L
      - TN threshold = 0.85 mg/L
      - Above these thresholds transparency is approximately 30% lower on average.
    - CHLA versus TP:
      - TP thresholds = 0.11 – 0.25 mg/L
      - Above these thresholds CHLA up to two times higher on average.
    - CHLA versus TN:
      - TN thresholds = 1.1 – 1.3 mg/L
      - Above these thresholds, CHLA is up to three times higher on average.
      - Very high model explanatory power indicates TN is an important control on algal biomass in Texas estuaries.
  - Major findings for Texas estuaries:

    - Gradients in nutrients and transparency were well explained by salinity thresholds.
    - TP thresholds = 0.068 – 0.25 mg/L
        - Secchi transparency response was best explained by TP.
        - TP thresholds for CHLA were high relative to transparency.
    - TN thresholds = 1.1 – 1.3 mg/L
        - CHLA response was best explained by TN.
        - TN is an important control on algal biomass in these systems.
- Current exploration in Texas estuaries:
    - Possible ways to groups estuaries that make sense for criteria development:
        - Geospatial parameters
        - Differences in flow
    - Weighting variables by flow prior to stressor-response analysis

Question: Might other methods give smaller error bars?

Answer: All methods used here were nonlinear. Linear might work as well.

Question: Were all estuaries lumped together?

Answer: Yes, and without discrimination. The same is true for other water body types.

Question: When looking at the streams, was a presence/absence of reservoirs considered?

Answer: Yes, it was considered in the watersheds to a HUC 8 level.

Question: When looking at the graphs you presented, can you only determine a single threshold level? Also, some of the graphs depicted really high and/or really low values. Do you think those are real?

Answer: Yes, you can determine more than one threshold value. We saw no reason to disregard the high and low values. Most of the data was screened by the TCEQ staff before being given to us.

Question: How can you truly test your model results? They seem really low. How does that help us?

Answer: Some relationships you may want to weigh more than others. These are the things you need to consider in your weight of evidence approach. We can develop thresholds of shifts of data that are biologically meaningful. Being above a threshold isn't "bad" per se. It does not mean you will necessarily have an impairment of a water body. This is just a means by which to understand relationships and develop meaningful categories.

Question: Some of the data you presented had an R squared value of 0.25 or less. Doesn't this mean something else is driving the system?

Answer: These data come from vastly different systems all over the state. We are looking for explanatory power. This is not a calibration curve.

Comment: It seems like we may want to take an ecosystem approach. Perhaps it would be better to divide these out by some method instead of lumping all water bodies across the state together.

Question: Why did you not break them out by ecoregion?

Answer: We are working on that now by looking at watersheds that cross over ecoregions. This gives us over 300 different areas to analyze. Our first step in this process is to prioritize which of these 300 plus areas to look at first.

Question: Could some of those super high values be outliers? They seem to be driving the final answer on your graphs.

Answer: Each data point represents a median of at least ten data points. The TCEQ screened the data before handing it over to us specifically to build a better database. Keep in mind that detection limits are also an issue.

Question: Can't phosphorous be both a stressor and a response? Won't it correlate eventually under certain circumstances?

Answer: If we were only interested in bioavailable concentrations, we'd miss the low end of things recognizing that on the high end the CHLA is likely bound up in biomass.

Question: Did the program you used have the ability to draw the threshold line independently?

Answer: Yes.

Question: Did you look specifically at macrophytes in the habitat?

Answer: Not specifically. Our analysis used the HQI score which includes many habitat factors.

Question: It's discouraging to see that the HQI scores don't correlate with the IBI scores. Any thoughts on that?

Answer: We were discouraged as well, but we need more periphyton data. Also, this analysis lumps together all types of streams, which masks our tiered aquatic life use structure.

### ***2:00 pm: Evaluating Stressor-Response Relationships in Censored Datasets*** – *Dr. Thad Scott, University of Arkansas*

- What are censored data?
  - Censored data are observations for which the exact value is unknown.
  - However, it is known that the exact value falls within a range of possible values.
  - Don't delete! Censored data contain information.
  - In environmental datasets, the value of a censored observation is most often constrained by:
    - The value of a quantification limit (QL) as upper limit
    - Zero as lower limit
  - Applies to common water quality metrics, including:
    - Nutrient concentrations (e.g. TN, TP)
    - CHLA
- Why do censored data matter for Texas?
  - The percentage of qualifying stations (n≥12) in reservoir water quality median database with >50% censored dataequals:
    - 40% for TP
    - 22% for CHLA
  - Common QL's:
    - CHLA: 10 µg/L
    - TP: 0.050-0.060 mg/L
- What to do with censored data?
  - To use censored data in analyses, assumptions have to be made about:
    - The value of censored observations, or
    - The value of censored observations relative to other dataset attributes, such as frequency of censoring and data distribution or rank.
  - Non-statistical approaches to handling censored data assume a value for individual observations.
  - Common non-statistical assumptions:
    - Substitute the value of the quantification limit.
    - Substitute ½ the value of the quantification limit.
  - Statistical approaches to handling censored data do not assume a value for individual observations.
  - Statistical methods estimate and correct for an effect of censored observations on an analysis.
  - Common statistical methods :

    - Kaplan-Meier survival analysis (KM) – non parametric, uses ranking
    - Maximum likelihood estimate (MLE) – parametric, uses data distribution
    - Regression order statistics (ROS) – parametric, uses data distribution
  - Kaplan-Meier survival analysis:
    - Fundamental tool in survival analysis for estimating summary statistics
    - Modified procedure for environmental datasets
    - Ranks censored and non-censored values and calculates probability of exceedance
  - Parametric methods:
    - MLE computes summary statistics using:
      - assumed distribution of uncensored values
      - Proportion of data below QLs
    - ROS computes summary statistics using:
      - Least squares regression
      - Probability plots
    - Robust partially parametric methods of MLE and ROS exist but are more time and labor intensive.
- Objective 1:
  - Compare station TP and CHLA medians calculated using non-statistical and statistical methods:
    - Substitute the QL
    - Statistically based methodologies
  - Median comparison metric equals the percent difference between station medians.
  - Changepoint analysis to identify changes in the percent difference as the level of censoring increases.
  - Methods: Which statistical method to use?
    - Each method has strengths and weaknesses.
    - The percent censored data and size of dataset determine which method is used.
    - No appropriate statistical method for stations with more than 80% censored data.
  - Methods: Change-point analysis
    - Identifies a threshold in the independent variable.
    - Threshold indicates a change in the response (dependent) variable.
    - For this analysis, percentage censored data (%Cen) = independent, percentage difference between medians (%Diff) = dependent.
  - Results: Objective 1
    - Changepoint = 5% confidence interval for lowest threshold
    - Differences in medians detected in range of 16 – 35% censored data.
  - Model to predict medians for highly censored stations:
    - Linear regression of %Diff versus %Censored creates predictive model for medians with greater than 80% censoring in two steps:
      - Where %Cen is known, and
      - a and b are regression coefficients.
- Objective 2:
  - Identify and compare TP thresholds using CHLA, Secchi transparency, and TP station medians.
  - Medians calculated using multiple approaches to handling censored data.
  - Thresholds identified using changepoint analysis
  - Results: Comparing substitution methods
    - CHLA versus TP:
      - For substitution methods, the value of the threshold is a function of the substituted value
    - Secchi versus TP:
      - For stations with >50% censoring, the median equaled the substituted value.
      - Vertical line forms in data interpreted as a threshold.
  - Results: Comparing statistical methods

    - CHLA versus TP:
        - Including median estimates for most censored stations decreased TP threshold.
        - Reduction was minor.
    - Secchi versus TP:
        - Including median estimates for most censored stations decreased TP threshold.
        - Reduction was substantial.
    - For both response variables, the value of the TP threshold almost always differed between approaches to handling censored data.
- Comparing across methods:
    - For CHLA versus TP models:
        - Subbing ½QL appeared to underestimate the TP threshold.
        - Subbing QL resulted in a reasonable approximation of thresholds found using statistical methods.
    - For Secchi versus TP models:
        - Different TP threshold for each dataset.
        - Thresholds from subbing QL and statistics (0-80%) functionally similar, both in eutrophic range.
        - But, hybrid dataset threshold suggested that important information was lost when highly censored stations were excluded, potential low range threshold obscured.
- Conclusions and implications:
    - Treatment of censored observations affects analytical outcomes.
    - Substituting values for censored observations introduced trends to the data.
    - Applicability of statistical methodologies is limited for Texas due to highly censored datasets with high detection limits.
    - Missing or introduced information from highly censored stations may obscure low-range nutrient thresholds.
    - Multiple answers to the same question equal uncertainty for policy makers.
    - States need datasets with lowest QLs possible.

Question: Could you explain the difference between/when you used the hybrid versus Kaplan-Meier?

Answer: If the data was over 80% censored, don't use the Kaplan-Meier

Question: When you use the Kaplan-Meier, what accounts for the median differences?

Answer: Different detection levels

Question: Are you ranking non-detects?

Answer: Yes.

Question: Did you take out the less than 1 mg/L?

Answer: That issue was with the ortho-phosphorous data which was not used here.

### ***2:30 pm: River-Estuary Coupling in South Texas: Nutrient Transport and Transformations*** *– Dr. James McClelland, UT Marine Science Institute*

This presentation focuses on the San Antonio, Guadalupe, Mission, and Aransas River watershed impacts on nutrients in their terminating bay systems. The target was to sample during high flow events to enrich the USGS data set and to see how CHLA concentrations flux with peak flows.

- Guiding Questions:
    - What are the quantities of nutrients exported from watersheds to estuaries?
    - How does nutrient delivery to coastal waters via rivers vary between storm flow and base flow?
    - How do nutrient input dynamics influence coastal ecosystem properties?

    - How do human activities influence the linkage between watershed export and coastal ecosystem properties?
- Presentation outline:
    - Watershed export events and coastal ecosystem responses in the Mission-Aransas National Estuarine Research Reserve
    - Broader look at nitrogen concentrations during base flow and high flow
    - Development of coupled watershed-estuary modeling framework
    - What's happening between high flow events: the role of the tidal freshwater zone
- Nitrate versus dissolved organic nitrogen:
    - Nitrate values tend to be lower when flows are higher.
    - Dissolved organic nitrogen spikes at higher flows.
    - Does this change in the type of nitrogen and how it enters the system (steady versus pulse) effect productivity?
- Nutrient cycling and sinking:
    - A single storm water pulse event over a day or two can sustain algal growth in a bay system for months.
    - Blooms occur and then nitrogen fixation maintains productivity.
    - The model had issues dealing with reservoirs in the watershed which act as nutrient sinks.
    - During normal and low flow conditions, nutrients can also be lost in tidal streams which can behave as sinks (much like reservoirs).
    - Water residence time throughout the watershed is key.
- Summary points
    - N concentrations in river water vary widely as a function of flow conditions.
    - Estimates of N fluxes from rivers to estuaries can be improved by accounting for flow-related variability in concentrations.
    - N inputs during high flow events help sustain elevated productivity in estuarine waters for extended periods following the events.
    - Tidal freshwater zones may serve as major N sinks between high flow events.

Question: Has macrodetrital input been considered?

Answer: No.

Question: Storm water sampling in boats?

Answer: Yes, but mostly from bridges. The boat sampling was mostly conducted in the bay, and we had a little extra time to sample since the effects of a storm water pulse can last for several days after the event.

Question: In a larger watershed such as a bay, is the "first flush" not as important?

Answer: Yes and no. It depends on the dilution and the point source.

Question: Different watersheds/portions of watersheds have different uses. Is San Antonio's influence easy to spot?

Answer: Yes, but it is harder to tell other sources (such as different croplands) from one another.

Question: How do you determine tidal versus freshwater zones during higher flows?

Answer: It's based on an interaction between the height of the water and the landscape.

Follow Up Question: What about saltwater wedges?

Answer: If there is no saltwater from top to bottom, it is not part of the estuary.

Question: It sounds like storm water events are more important than wastewater treatment plant discharges. Do you think bays may be dependent on the nutrients provided by wastewater treatment plants?

Answer: Maybe, but during low flow events the nutrients provided by the wastewater plants likely doesn't make it to the bay.

### ***3:15 pm: Influence of Nutrient Load on Phytoplankton Communities in Galveston Bay*** *– Dr. Antonietta Quigg, Texas AandM Galveston*

Examination of the impacts of freshwater inflow and bay circulation are priority areas for EPA National Estuary Programs, specifically defining flows necessary for salinity, nutrient and sediment loading regimes adequate to maintain productivity of economically important and ecologically characteristic species.

- Galveston Bay watershed:
  - 62,000 km2 (24,000 miles2)
  - Two major metroplexes
  - Approximately 12 million people in this watershed
  - Galveston Bay contributes 1/3 of Texas' commercial fishing income.
  - Over 1/2 of our state's expenditures for recreational fishing are related to Galveston Bay.
- With a rapidly expanding urban population in Texas coastal municipalities, water regulators and managers are faced with the challenge of meeting human needs, potentially by freshwater diversions, while maintaining critical freshwater inflows into estuaries.
  - Senate Bill 3
    - In 2008 Texas addressed water rights by establishing advisory committees to define the "state of the bay" for each of the seven major estuaries.
    - In June of 2011, new regulations for Galveston Bay are set to be passed into law.
    - An examination of the impacts of changes in freshwater inflow and bay circulation.
    - Developing bioindicators for "healthy" estuaries.
    - Developing protocols for "flow rates and frequencies."

Herein, we examine how phytoplankton community structure responds to the nutrient loading characteristics in Galveston Bay.

- Freshwater inflows to Galveston Bay:
  - We collect:
    - Freshwater inflows data from USGS and TWDB
  - We measure:
    - Water quality on fine spatial scales using a Dataflow:
      - Temperature, salinity, chlorophyll, CDOM, water clarity, etc…
    - At fixed stations:
      - phytoplankton biomass
      - phytoplankton community composition
      - nutrients (dissolved and total particulate)
      - resource limitation assays
  - Phytoplankton community composition
    - Phytoplankton - Pulse Amplitude Modulated (PHYTO-PAM) Fluorescence Analyser
      - Measures fluorescent properties of cells
      - Generates rapid light curves which are similar to Photosynthesis-Irradiance curves
      - Deconvolutes fluorescence spectra into 3 major taxonomic groups:
        - Cyanobacteria
        - green algae (chlorophytes)
        - diatoms+dinoflagellates

    - HPLC – taxonomic groupings (aka Pinckney magic)
    - Microscopy – traditional approach
        - Good guys:
            - April, Station 4, Thalassionema
            - July, Station 6, Noctiluca
        - Bad guys:
            - January, Station 1, Dinophysis
            - April, Station 1, Prorocentrum
            - August, Station 2, Akashiwo
            - September, Station 1, Psuedonitzchia
    - Canonical Correspondence Analysis and other statistical tools:
        - Tease out patterns and look for possible forcing factors.
        - Determine mechanisms behind patterns.
    - Challenges:
        - Phyto-PAM – correlating findings with those of HPLC and microscopy; training instrument and inherent assumptions
        - New instrument which has better alogrithms than that available with the Phyto-PAM
        - HPLC – improving algorithm for Galveston Bay
        - Microscopy – time and taxonomy
- Freshwater inflows to Galveston Bay:
    - Trinity River (dissolved) nutrients:
        - Measured above tidal zone adjacent to USGS gauge site
        - River waters N limited (DIN:P<10) during low flows but P limited (DIN:P>13) during high flows.
    - Estuarine (dissolved) nutrients:
        - Northern station (Trinity River basin) patterns mimic those in river.
        - Southern station – DIN:P ratios indicate potential for N limitation year round.
    - Estuarine (total) nutrients:
        - Similar (but same) findings as for dissolved nutrients
- Resource Limitation Assays:
    - Conducted RLAs in the Northern and Southern sectors of the Bay
    - Conducted on a monthly-bimonthly basis in order to capture high flow or "wet" periods and low flow or "dry" periods
    - Treatments:
        - Control
        - +N (as nitrate)
        - +P (as phosphorus)
        - +NP
        - +Grazing (excluded >330mm)
        - +Sediment (additional shade cloth)
- PRI = phytoplankton response index = change in biomass over time
    - PRI response can be related to antecedent flow conditions in 2008.
    - PRI scale 0-2700
    - PRI response can be related to antecedent flow conditions in 2009:
        - PRI scale Feb and March 0-2700
        - PRI scale remainder of year 0-900
- Major findings:
    - We found that phytoplankton were often nitrogen-limited and/or nitrogen and phosphorus co-limited but never silicate limited.
        - Shift from earlier studies performed which found almost exclusively nitrogen-limitation
    - Depending on antecedent conditions, the response appears to be related to freshwater inflows.

    - More evident in the northern RLAs than the southern RLAs
    - Suggest phytoplankton using different strategies in response to different nutrient regimes: frequent versus pulse.
    - Potential light limitation in northern RLAs versus southern RLAs
  - Our findings are being used to develop intense process-based understanding of the linkages between the magnitude of freshwater inflows and nutrient loading on primary productivity for the Galveston Bay ecosystem.
    - Particularly important given water rights issues which are currently being debated in Texas (Senate Bill 3)
    - Will help state and federal agencies develop strategies for nutrient reduction criteria
- Challenges:
  - Interpretation of multiple parameters collected as part of the assays, e.g., PRI versus PAM versus FIRe
  - Conducting assays more frequently
  - Interpretation of assays within context of other work done as well as the literature.
- Phytoplankton responses to freshwater inflows in Galveston Bay:
  - Develop model to drive new experiments and describe findings
  - Discrete measurements on a monthly basis
  - Resource limitation assays to define controlling factors in nutrient (and sediment) loading on phytoplankton productivity in the water column
  - Using sediment cores to examine processes at the sediment-water interface including nutrient fluxes and O2 exchange
  - Phytoplankton respond quickly to changes in freshwater inflows – good bioindicators.
  - Phytoplankton are sensitive to salinity, nutrient, and sediment loading to Galveston Bay – good bioindicators.
  - Phytoplankton base of the food web – healthy phytoplankton population will support higher trophic levels (aka oysters and fish) – good bioindicators.
  - However, defining protocols for "flow rates and frequencies" requires multi-disciplines to work together and an integrated approach.

Question: I didn't see this in your slide show, but did you treat just for phosphorous to show phosphorous limitation?

Answer: Yes.

Question: Do you think inflow is responsible for co-limitation?

Answer: That's likely, especially from the San Jacinto River. Also, population growth in the watershed means more people using the water.

Question: Is there a temperature impact? 2012 was warmer than 2011.

Answer: Dr. Quigg pulled up her slide and demonstrated that their positioning may be deceptive in regards to what graph was what year.

### *3:45 pm: Survey Results Question/Answer, Discussion – Chip Morris, TCEQ*

- Mr. Morris relayed that eight individuals had answered the survey distributed to the group prior to today's meeting. Not all eight respondents answered all questions presented in the survey.
- Mr. Morris began to read each question and the received responses, but a participant then asked if the survey could be redistributed to the group. The group discussed this comment and felt that they could better answer the questions after today's presentations, and time was running out on today's meeting.

- TCEQ staff agreed with the group suggestion. The survey will be opened again, and the group will be notified via the listserv regarding where to find the survey online and when the survey will be closed.

***4:00 pm: Adjourn***