*Drought Impact and Recovery in Texas Estuaries Workshop: January 30, 2013*

# Summary of Participant Survey Responses

At the time of this summary, 36 participants contributed survey responses on their experience with *Drought Impacts and Recovery in Texas Estuaries*. Below are four graphs showing the general distribution of survey participants followed by a summary of the key issues identified in the survey as well as a list of important long-term statewide programs discussed. The final section of this document is a specific question-by-question summary of the responses, including an overview of monitoring efforts across bays (Table 1 on Page 6).

## 1. General Distribution of Participants

- Overall, participants represented views from throughout Texas coastal estuaries (Figure 1) and were knowledgeable about a range of estuarine issues (Figure 2), including public health and invasive species as well as education/outreach.
- Participants also represented a variety of professional roles which allowed for differing perspectives on both the knowledge available and the information lacking to properly assess and communicate drought impacts (Figure 3).
- Finally, Figure 4 offers an overall view of participants' opinions on the impact and status of the 2011 drought. Interestingly, 32% of participants classified the effects of the 2011 drought as "ongoing", while 24% of participants felt the impacts were still "Unknown" (or at least unknown to them at the time of the survey), and 21% of participants classified the 2011 drought as "Severe". **This one question highlights two commonly stated responses for the survey: (1) scientists and resource managers lack the necessary data and analyses which can determine drought impacts and (2) scientists and resource managers need to improve communication with each other and with stakeholders, policy makers, and the general public.**

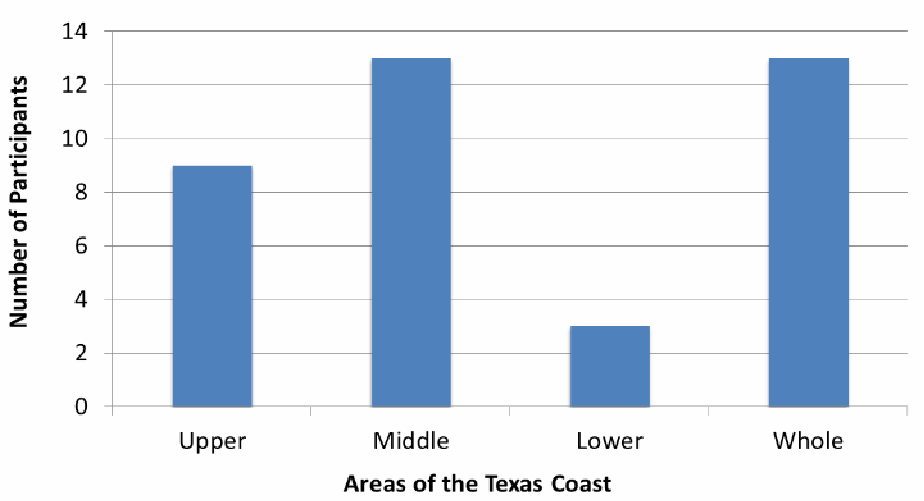


Figure 1. The distribution of participant expertise representing each area of the Texas Coast. Thirty-six participants were surveyed, with some participants expressing expertise in more than one area of the coast.

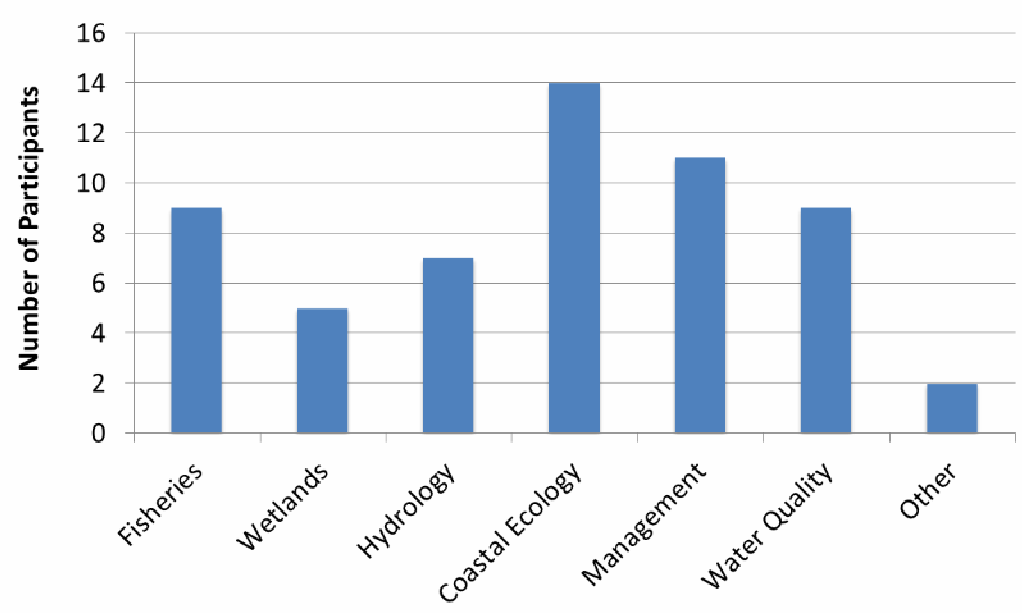


Figure 2. The distribution of participant expertise representing various estuarine disciplines. Thirty-six participants were surveyed, with some participants expressing expertise in more than one area of the coast. The category for other includes participants experienced in education/outreach and invasive species work.

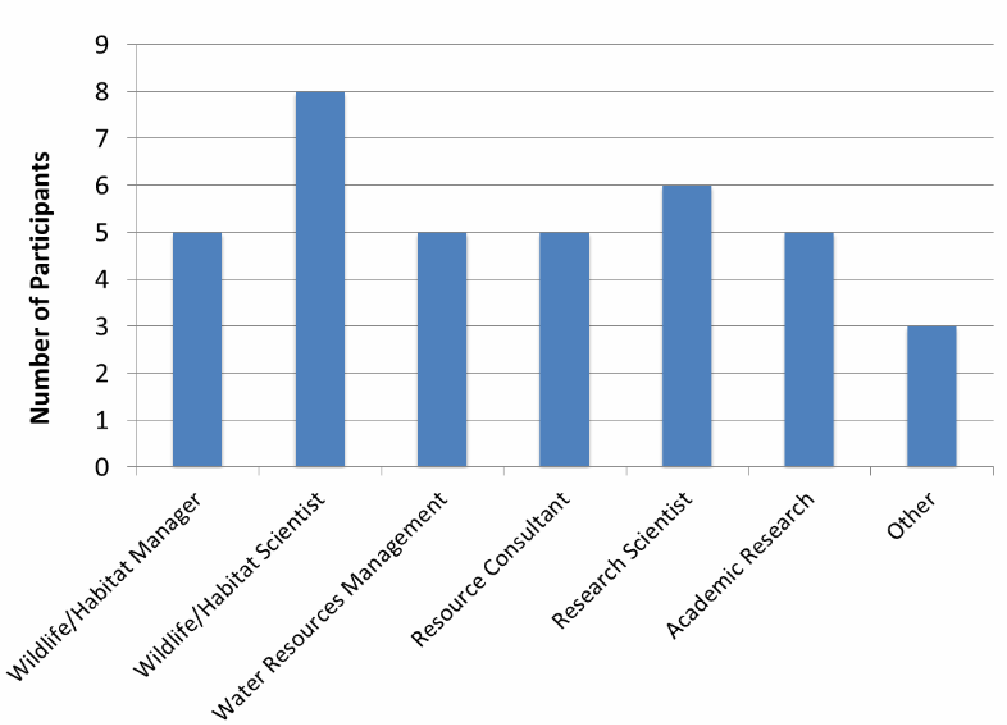


Figure 3. The distribution of participants' primary roles in their professional career. The category for other includes participants involved in education/outreach, non-governmental organizations, and public health.

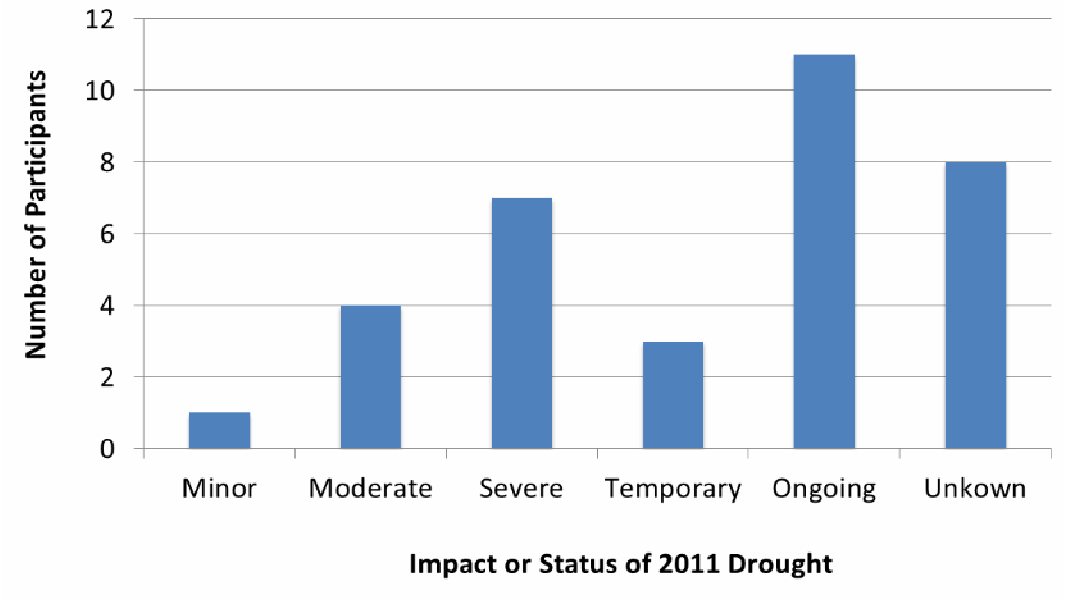

Figure 4. The distribution of participant opinions regarding the impact or status of the 2011 drought on Texas estuaries.

## 2. Key Overarching Issues and Needs Identified in the Survey

- Need for increased funding to support long-term monitoring and research as well as focused research studies. All programs, whether long-term monitoring or research efforts, are threatened by limited or increasingly reduced funding (and staffing) resources.

- Need to communicate available data and relevant contact information to all coastal scientists and managers.

- For data that is collected privately, with confidentiality restrictions – how to obtain access to and make greater use of this data, while maintaining confidentiality, but especially as this data becomes "historical" with the passage of time.

- Need to better quantify the economic value of ecosystem services and coastal resources for stakeholders, policy makers, and the general public, and better communicate the ecological and economic impact of drought and low freshwater inflows on these systems. This communication needs to extend beyond the coastal zone to reach across the state to elected officials and the public.

## 3. Important Long-term Statewide Programs

TPWD Fisheries Monitoring (Fisheries-Dependent and Fisheries-Independent
Monthly fishery-dependent and fishery-independent data is collected in each of the major estuaries and the Texas Territorial Seas. Fishery-independent data has been collected in the eight major estuaries since the mid-1970's and is collected using various sampling gear (otter trawls, oyster dredges, bag seines, gill nets, bottom longlines) within a random sampling design to collect species population data across life history stages. Basic water quality data (temperature, salinity, dissolved oxygen, turbidity) also are collected for each sample. Contact Dr. Mark Fisher, Coastal Fisheries Science Director at TPWD, 361-729-2328; mark.fisher@tpwd.state.tx.us.

TWDB Datasonde Program
TWDB (with assistance from TPWD) collects time-series (hourly) water level, conductivity, temperature, salinity, and sometimes dissolved oxygen data at one or more locations in each of the major estuaries as part of the Datasonde Program. (Some sites have been active since 1987.) TWDB also has collected similar data in the San Bernard/Cedar Lakes estuary and nearby wetland (including a tidal stream, shallow lakes, and shallow soil wells) since 2009 as part of an ongoing special study of freshwater inflow needs. Contact TWDB for information or data at: coastal-data@twdb.texas.gov

TWDB Coastal Hydrology Program
TWDB compiles and estimates daily freshwater inflow to Texas coastal estuaries. This includes acquiring USGS stream gage measurements, NCDC precipitation estimates, and TCEQ diversion and return data, as well as estimating rainfall-runoff from ungaged watersheds. Data is available for all major coastal basins from 1941 to 2010 and for minor estuaries from 1977 to 2010 and more recent updates are in progress. Contact TWDB for information or data at: coastal-data@twdb.texas.gov

TWDB Hydrodynamic Models

TWDB is capable of simulating salinity patterns in all Texas estuaries using the TxBLEND (or other similar) hydrodynamic and salinity transport models. Contact TWDB for information or data at: coastal-data@twdb.texas.gov

Oyster Sentinel

This monitoring program is continuing although on a limited basis due to a lack of resources for routine and regular oyster sampling. Contact person: Dr. Ray at Texas A&M University at Galveston (rays@tamug.edu, 409-740-4526) www.oystersentinel.org

Mission-Aransas National Estuarine Research Reserve System-Wide Monitoring Program
This Program conducts (1) water quality and weather indicators and (2) biological monitoring. The Reserve has five water quality monitoring stations. In operation since 2007, each station measures temperature, salinity, dissolved oxygen, depth, pH, turbidity, and chlorophyll/algal biomass every 15 min. Nutrients, such as nitrates and phosphates, are monitored at bay stations on a monthly basis and diel monthly samples are collected at the Port Aransas Ship Channel. Weather information, such as air temperature, wind direction, wind speed, barometric pressure, and relative humidity are collected from one station every 15 min. Seagrass beds and emergent marsh habitats have been measured since 2011 for abundance, percent cover, shoot/stem densities, and maximum leaf length, and groundwater level (for emergent marsh). To download water quality and weather data, go to: http://www.missionaransas.org/science_data.html. For questions about water quality or weather data, contact Dr. Ed Buskey (ed.buskey@utexas.edu, 361-749-3102). For questions or to obtain biological monitoring data, contact Kiersten Madden (kiersten.madden@utexas.edu, 361-749-3047).

## 4. Specific Question-By-Question Summary of Responses

### *Drought Impact Questions*

**5. Please provide a brief description of data you collected or research you conducted, if any, during 2011 or 2012 regarding the impact or effect of drought on estuarine and coastal systems.**

***And***

**6. Please describe (short paragraph) any research you have conducted related to Texas coastal systems that is relevant to understanding drought impacts. This may include ongoing monitoring and data collection efforts that were conducted prior to, during, and after drought.**

Basic water quality, fisheries, and harmful algal bloom or oyster condition data was collected in all of the major bays. Some data was collected intensively (monthly assessments over one or two days) across a wide-geographic area of a bay, and other data was collected regularly (hourly time-series) for a year or

more at designated locations throughout bay areas. Dermo and wetland salinity/vegetation was monitored in most of the upper and mid-coast bays. Nutrients, productivity, and benthic invertebrate surveys were the least collected type of data throughout the bays; this data generally is collected only by academic researchers who may not have the capability to implement coast-wide monitoring.

Refer to Table 1 for an overview of monitoring efforts across bays.

Many of the participant's answers for Question 5 applied to Question 6; however, some participants described planned or on-going projects that may shed direct light on the impact of drought. These include: (1) developing an ecological simulation model of San Antonio Bay (SARA & USACE); (2) understanding the interaction between mangroves and marsh vegetation (UofH); (3) conducting a literature review and summary analysis of drought impacts to estuaries (TWDB); and (4) conducting quarterly monitoring of brackish marsh restoration sites in the Lower Neches Wildlife Management Area (TAMU-Galveston).

Types of Monitoring Programs Described by Survey Participants

- Oyster habitat mapping
- Oyster and dermo monitoring
- Oyster Toxicity
- Wetland and pore-water salinity and redox
- Bay Salinity monitoring
- Wetland and Soils salinity monitoring
- Wetland and Plant Community monitoring
- Phytoplankton monitoring (including Coastal Golden Algae and Harmful Algal Bloom (HAB))
- Nutrient monitoring
- Fisheries-Dependent (Harvest) monitoring
- Fisheries-Independent monitoring
- Fish Kill Investigations
- Physicochemical water quality data in tidal, above tidal and in open bays
- Coastal Hydrology (Freshwater inflow)

Table 1. Description of data collected during the 2011/2012 drought – much of the data was collected as part of long-term routine monitoring efforts or as part of studies not designed or implemented specifically to document drought impacts.

| Bay System | Water Quality & Salinity | Nutrients & Primary Productivity | Benthics & Oysters | Fisheries | Seagrass or Wetlands | Dermo | HABs, Bacteria, Oyster Toxicity |
|---|---|---|---|---|---|---|---|
| Sabine | Yes | | | Yes | Yes | Yes | Yes |
| Galveston | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Brazos | | | | | | | |
| San Bernard/Cedar Lakes | Yes | | | Yes | Yes | | Yes |
| East Matagorda | | | | Yes | | | Yes |
| Matagorda | Yes | | | Yes | Yes | Yes | Yes |
| San Antonio | Yes | | | Yes | | Yes | Yes |
| Mission-Aransas | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Nueces/Corpus Christi | Yes | | Yes | Yes | | | Yes |
| Upper Laguna Madre | Yes | | | Yes | | | Yes |
| Lower Laguna Madre | Yes | | | Yes | | | Yes |

**7. Please list the two or three most important types of data that are needed for achieving a better understanding of drought impacts in Texas coastal systems but are currently lacking or severely limited.**

**The top contender for "most important types of data" is "long-term monitoring".** Participants repeatedly stressed the need for more long-term monitoring, whether the request was for more salinity data, benthic data, vegetation or fisheries data, everyone recognizes the need for "more". The State fortunately has had the ability to support several programs which have allowed for decades of monitoring – namely those for fisheries-independent monitoring, salinity, freshwater inflow, and some benthic invertebrate monitoring. While some may recommend changes to these programs to better suit addressing new scientific and management questions, changes cannot be made without considering the impact of potentially losing the ability to compare the "new" data to the "historical" data.

<u>Among the specific data "needs" for better understanding drought include:</u>

- Better estimates of freshwater inflows, including estimates from ungaged watersheds, more comprehensive (and ideally daily) diversion and return data, more real-time estimates. Better estimates of groundwater inflows to estuaries.
- Increase the number of long-term salinity monitoring stations, including in tidal rivers and streams, Sabine Lake, etc.; Improve real-time delivery of salinity data.
- Improved access to water quality data.
- Better measurements of dissolved oxygen
- Increased monitoring of benthic invertebrates in all major estuaries.
- Increased monitoring of marsh vegetation diversity, density, & changes and soil & pore-water salinities.
- Increased monitoring of species/populations in transitional habitats (tidal streams, brackish marshes).
- Routine monitoring of oyster abundance, density, and condition at specified bay locations, as well as comprehensive oyster habitat mapping and population monitoring
- Routine phytoplankton and nutrient monitoring.
- Routine seagrass monitoring.
- Identification and (quantitative) monitoring of drought-indicator species, assemblages, or communities.
- Estuarine circulation and improvements to hydrodynamic and salinity transport models.
- More spatially and temporally intensive monitoring of fish using technologies like DIDSON to help understand habitat utilization, movements, diurnal variability, etc. associated with salinity and other influencing factors.
- Status and evaluation of habitats and communities before and after drought (*e.g.*, wetlands, oyster reefs).

- Geographically relevant down-scaled global circulation models that can make more meaningful predictions of climate patterns and be used to evaluate system responses, such as changes in freshwater inflow.

- Improve understanding of the relationship between inflow rates, nutrients (dissolved and particulate), autotrophic biomass, and detritivore biomass in all estuarine systems.

- Improve understanding of the use of marsh vegetation by aquatic species, particularly *under changing hydrologic conditions.*

- Improved understanding of the life-cycle, life-history, and salinity tolerances of key faunal species used to make inflow recommendations (*e.g.*, *Rangia*, blue crabs, white shrimp).

**8. If you had a $50,000 budget for an assessment or data collection effort to improve understanding of drought impacts on one or more bay systems in Texas, in broad terms (short paragraph) what would you recommend be done?**

A number of participants commented that $50,000 would not allow for substantial data collection, but given the variety of ideas, most clearly felt something could be done with $50,000 to improve our knowledge of drought impacts to estuaries. Below are several common topics recommended by survey participants.

- Given the limited amount of funding, several participants recommended analyzing existing data, rather than collecting new data. These analyses could focus on (1) relating freshwater inflow and salinity to measures of ecosystem health and habitat availability during drought; (2) conducting quantitative comparisons of community diversity and composition (*e.g.*, benthics, wetlands, fishery species) during drought and non-drought periods. Some studies recommended focusing directly on "impacts" including (3) understanding the response times of estuarine and wetland communicates to drought; (4) and identifying more suitable indicator species for future monitoring. Two participants also recommended studies which would examine the role of wastewater treatment plant return flows in providing needed inflows to bay systems and how increased re-use may limit this source of inflow during drought periods.

- In terms of new data collection, participants recommended increasing salinity data collection, ranging from intensive salinity monitoring during drought periods, to increased monitoring in tidal streams, wetlands, and oyster reefs, to generally expanding the datasonde network to include more locations throughout more bays. Additional monitoring requests included baseline data collections of species diversity, abundance, density, and condition that would allow for "before and after" comparisons of the changes in habitats or communities as a result of reduced freshwater inflows. Preferred habitats included wetlands, tidal streams, oyster reefs, seagrasses, as well as baseline monitoring of *Rangia* clams, nutrients loading and phytoplankton communities.

- Two additional efforts were recommended that are important to all researchers and managers efforts to address drought impacts and recovery. These include a recommendation to create a database for use by researchers to archive water quality and population & species data and to

generally improve data accessibility. This is important, because while the State agencies often have a means for archiving data, individual researchers may not; and so, as their research programs change, graduate students leave, and professors retire, the original data and observations become lost to science. Finally, one participant recommended using the $50,000 to better inform elected officials (and the public) across the state of the ecological and economic impacts of drought to coastal ecosystems.

**9. If you had a $1,000,000 budget for an assessment or data collection effort to improve understanding of drought impacts on one or more bay systems in Texas, in broad terms (short paragraph) what would you recommend be done?**

Many of the projects identified for a budget of $50,000 also were also recommended for a budget of $1,000,000, though many of the projects were expanded either in scope or in geographic coverage. Most of the re-stated projects involved long-term monitoring of salinity, oysters, benthics, wetlands, tidal streams, seagrasses, nutrients, and phytoplankton. It was suggested that these efforts become part of a coordinated coastal monitoring program and that a long-term commitment (e.g., 20 years) be given to these programs to ensure sufficient records are collected to allow for proper analysis and understanding of drought impacts. Participants also identified the need to obtain better maps and to quantify important habitats and key populations throughout the estuaries.

Again, participants recommended developing a shared database and analyzing existing data to address the information needs identified in Question 8. However, with an increased budget, the analyses could allow for more informative work, such as (1) to establish baseline conditions in each estuary, from which further analysis and monitoring can be compared, and also (2) to allow for assessing ecosystem-wide responses. With a larger budget, some participants recommended that investigative and experimental studies be conducted to better understand the triggers and impacts of drought on key species as well as to better understand the life history strategies of important species which can determine their physical or physiological ability to respond to drought conditions.

Most of the analyses and research questions identified rely on having good estimates of freshwater inflows to the bay systems. Therefore, participants again noted the need to improve estimates of freshwater inflow and the impact of diversions and return flows as well as the need to understand groundwater contributions to the bays. Additionally, because it is not possible to measure salinity conditions at every location of interest, many researches rely on simulated estimates of salinity using the TWDB's TxBLEND (or other similar) hydrodynamic and salinity transport models. Some participants requested continued improvements in the model so that it can better simulate salinity conditions in upper estuaries and delta areas.

Several participants noted the need for improved education and outreach regarding Texas' water limitations, the need for water conservation, and the importance of coastal ecosystems. To aid in this effort, one participant noted the need to have a better assessment of the economic evaluation of coastal habitats, including not only the value of ecosystem services, but also the value of coastal resources for domestic, industrial, and agricultural use.

**10. Please briefly describe (short paragraph) any interesting data observations or research findings related to recent drought impacts in Texas coastal systems that should be further investigated.**

Quite a few respondents stated that they had no research observations related to the recent drought which they could share at this time. This may be because these participants serve in management roles or because they have not had time to process and analyze data collected during the last couple of years. However, some participants offered observations of habitat degradation and population or community changes during the 2011/2012 period – implying drought impacts, but failed to indicate whether any analysis or experimental studies showed the direct relationship between reduced inflows and biotic responses. Regardless, a list of observations, organized by estuary and provided by participants, is below.

**Sabine-Neches Estuary:**

- TPWD staff noted that Sabine Lake had a higher salinity than the Gulf (out to a distance of 10 miles off Sabine Pass) during June and July 2011.

**Trinity-San Jacinto Estuary**

- TAMU-Galveston researchers have been unable to locate the salinity sensitive plant, *Vallisneria*, in the Trinity River Delta.
- TAMU-Galveston researchers observed *Rangia* populations, but noted unusual sex ratios.
- Presumably new populations of oysters and *Rangia* were discovered nearer to the mouth of San Jacinto Bay than expected based on previous surveys.
- Wetland plant species diversity was lower and plant height was shorter along a salinity gradient adjacent to Onion Bayou, Oyster Bayou, and East Bay. Additional observations noted less plant productivity and earlier seed set during 2011.
- Bay and adjacent wetland salinities (including pore-water salinities) were higher than normal.
- Galveston Bay water quality has recovered to pre-drought levels but the flora and fauna are lagging in recovery. Recovery in the bays and estuaries may take years.

**Laguna Madre and Baffin Bay**

- Drought conditions in Baffin Bay led to a dramatic decrease in the primary food source for black drum which resulted in emaciated fish during the summer and fall 2012 which impacted the commercial fishery and shifted fishing efforts into the Lower Laguna Madre.

*** No observations were listed for Colorado-Lavaca, Guadalupe, Mission-Aransas or Nueces Estuaries.**

**Other Observations and Comments**

- Some species experienced reduced useable habitat while others experienced increased useable habitat.
- Oyster harvest areas were closed as a direct result of elevated salinities. Oyster condition was degraded, with specimens being watery and of low quality.
- Episodes occurred where bay salinities were higher than Gulf salinities, and marine species (such as sharks) were reported in higher numbers than typically observed.

- Many estuarine species are adapted to the highly variable salinity conditions found within bays and therefore may not be good indicators of drought conditions, except as measured by their presence or absence in the system.
- Reduced freshwater inflows increase salinity leading to impacts on submerged aquatic vegetation and changes in fish and invertebrate species composition within communities.
- TWDB (in partnership with TPWD) supports over 15 datasonde stations throughout the Texas coast. Preliminary analysis of the data from 2011 shows that monthly mean salinity generally was higher than historic means at all sites for all or some of the year and at many sites new salinity maximums were recorded.

**11. If relevant to your role, what information is most important for effectively communicating drought impacts on coastal systems to stakeholders and policy makers?**

Most participants indicated the need for more detailed information on drought impacts, which is available in graphical or presentation-ready format, for use in communicating to stakeholders, policy makers, and the general public. The first and most important facet will be to develop quantifiable information about the economic value of freshwater inflows, ecosystem services, and coastal resources, particularly when these are lost or reduced as a result of drought and limited freshwater inflows. Scientists and managers also need to educate folks on the types of negative impacts caused by drought, including impacts exacerbated by anthropogenic causes, and the delayed, but often complex, estuarine response to and recovery from drought.

Participants also mentioned the need to be sure that scientists are collecting data and addressing the questions that are most relevant to policy makers. For example, this might include developing a better understanding of how short-term or long-term reductions in inflows affect estuarine-wide salinity conditions, especially with respect to current or future expected water use demands. This might also include an analysis of the importance of recently adopted Senate Bill 3 environmental flow standards for protecting future inflows and estuarine health during drought conditions.

**12. If relevant to your role, what information were you lacking when trying to communicate the impact of the recent drought on coastal systems?**

A number of participants note the lack of relevant and accessible information for use in summarizing and preparing materials for communicating to stakeholders, policy makers, and the general public. In some cases, information exists but is not easily accessible. Participants recommended an email list-serve for communicating drought related monitoring, observations, and activities among scientists and resource managers. In other cases, scientists and resource managers lack the necessary pre-drought baseline data, freshwater inflow data, or other important data which can be used to quantify drought impacts. Managers also lack the necessary information to describe the economic impact of drought effects in estuaries. Moving forward, the scientific community will need to agree upon the definition of "good health" for estuarine communities and will need to agree upon the species or communities that can serve as good indicators of drought. One participant noted that the role of State and Federal agencies in documenting and reporting drought impacts, both presently and for the future, should be clarified to ensure water resources issues, such as freshwater inflow needs, are adequately addressed.

## *Drought Recovery Questions*

**14. Please describe any ongoing or planned research to assess drought recovery in the coastal systems you study.**

While the 2011 drought raised awareness of the need to implement or continue existing long-term monitoring programs for water quality (salinity), nutrients, oysters, dermo, HABs, *Rangia*, benthics, seagrasses, wetlands, and fisheries, most State agencies and research scientists do not have immediate plans to initiate drought-specific monitoring and research programs. However, many managers of existing long-term monitoring programs intend to continue these programs as long as funding is available, and a few new programs to measure bay salinity (Guadalupe Estuary) and wetland composition (Mission-Aransas Estuary) have recently begun. Additionally, several research scientists currently assessing bay nutrients, phytoplankton, and wetland monitoring intent to continue their research for the near-term. Several research scientists mentioned their continued efforts to analyze existing estuarine and inflow data to look for important trends and relationships.

**15. Please list the two or three most important types of data that are needed for better documenting drought recovery in Texas coastal systems.**

Summarized from all of the participant responses, the singular most important data requested was that of salinity. Scientists and resource managers want to have more long-term, continuously recording salinity monitoring stations throughout the estuaries, including in the tidal streams, deltas, and fringing wetlands and then extending across the salinity gradient down to the Gulf passes. While participants again reiterated the need for increased monitoring of wetlands, oysters, and other important habitats, the ecosystem component most in need of monitoring – in order to better address drought impacts – is the lower trophic level, namely the phytoplankton and benthic macrofaunal communities. Additionally, it will be important to dramatically increase our monitoring and knowledge of nutrient loading to estuaries and also to continue to improve our estimates of freshwater inflows to the bays. Finally as scientists and resource managers, we all need to improve the avenues of communication, data archiving and accessibility, and program coordination with respect to our data collection efforts.