N2N GoM Workshop Summary
Merida, Yucatan, Mexico
1-3 October 2019

Network-to-Network Gulf of Mexico (N2N GoM) is an international collaboration of experts, decision-makers and stakeholders in the Gulf that seek to:

- Establish a scientific framework across existing GoM networks relating to climate impacts that can be developed into a multinational research decadal plan focused on solutions
- Use the establishment of N2N GoM as a case study on how to build existing networks into new networks-to-networks

With funding from the National Science Foundation (NSF), and the sponsorship of Yucatan's Department of Research, Innovation and Higher Education (SIIES), the Society for Underwater Technology in the U.S. (SUT-US), and the Yucatan Initiative Project at Texas A&M University (YIP-TAMU), a team of public and private researchers held an inaugural N2N meeting 1-3 October 2019 in Merida, Yucatan. This workshop, which brought together 40 representatives of GoM networks and stakeholders, began to build convergence research that uses the power of networks to identify and prioritize active Threats in the Gulf of Mexico (both of natural and anthropogenic origin), the state of Vulnerability of the systems that withstand them, and the economic, environmental and societal Consequences these can produce.

Network:

A number of entities (e.g., individuals, societies, companies, agencies, institutions) that are structured and actively working toward on a shared/common vision/mission.

Summary & Next Steps

The following summary provides highlights and next steps from that meeting. Immediate next steps are summarized as follows:

1. All workshop participants are asked to approve release of their contact information to be shared internally among the group, as well as a summary paragraph on their network or stakeholder group activities relevant to N2N.
2. A moderated group listserv group will be established to facilitate communication.
3. An inaugural working group will be established to identify and make available (as appropriate) data related to climate variability, resilience and adaptation in GoM.
4. The Planning Team will establish the N2N Steering Committee.
5. N2N Steering Committee will seek partners and funding to continue this work.

N2N GoM Objectives

N2N GoM is focused on establishing an international interdisciplinary network-to-network collaboration that provides convergence in shared priorities to find scientific, technological, social and policy solutions in a systematic and strategic response to climate forcing in the GoM region. The use of a risk framework provides the means for partial alignment of networks and stakeholders through shared priorities as it pertains to threats, vulnerabilities, and consequences. First order priorities pertaining to threats and vulnerabilities include:

i. Advance solutions to the impact of climate forcing based on an integrated system of regional risk awareness and risk assessment for the GoM and surrounding natural and human ecosystems.
ii. Identify existing data baselines and the critical variables needed to measure climate impacts on physical, chemical, biological and social systems, including spatial and temporal gaps.
iii. Understand the physical, biological, and ecosystem changes in the context of human capacity to address climate impacts, from the community to international scale.
iv. Identify shared scientific research priorities and opportunities for leveraging resources including data, models, infrastructure, concepts, etc.
v. Develop a framework of existing scientific rationale addressing natural and anthropogenic threats (e.g. climate forcing) aligned to its social, economic and environmental impacts.
vi. Identify research priorities and recommendations for coordination/collaborations between states and countries, and between academic, market sectors and government agencies that address societal requirements.

Workshop Methodology & Initial Results

The workshop incorporated a variety of strategies and methods to attain the overall goals. The first two days focused on the science plan while the third day focused on network development. For the science plan, the workshop methodology framework focused on risk theory as inspired by the United Nations Disaster Relief Office (UNDRO, 1979). This theory introduces the concept of Risk Assessment as a state for a given spatial and time domain, with Risk = Hazard × Vulnerability × Consequences = $P(T) \times P(C|T) \times u(C)$. Where $P(T)$ is the Hazard or probability of a given threat intensity (T); $P(C|T)$ is the Vulnerability or conditional probability of experiencing a consequence or damage level (C) given likely threat intensities (T). This represents the fragility of the system or systems which holds the consequence or damage level. These consequences have a value u(C) in terms of social, economic, and/or environmental losses. The units for a state or risk are therefore expressed in the units of the values of the Consequences u(C).

A series of breakout group exercises were conducted to use the methodology in establishing an initial science plan, which involved coordinating Working Groups (WGs) of 6-8 participants to focus on the identification and prioritization of threats facing the GoM region resulting from climate forcing, prioritizing five threats to identify vulnerabilities across market sectors and regions that were associated with each threat, and identifying potential solutions. WGs 1, 2 and 3 were formulated to "identify" and "characterize" the GoM's top priority threats, systems/vulnerabilities, and consequences and solutions respectively. WGs 4 and 5 were used to identify desirable network attributes, functions and potential barriers to success.

***Working Group* 1**: To encourage public-private partnerships, WG1 focused on identifying and prioritizing threats to market sectors, as defined by the Global Industry Classification Standard. Given the expertise of the participants, three working groups focused on the specific market sectors of Energy, Materials and Technology. An additional two focused more generally on

Broader Impacts of climate forcing in the GoM. The task to each breakout group was to: a) identify climate-related threats for the coming ten years in the GoM, b) provide a clear definition of these relevant threats, and c) prioritize the top three most relevant threats, including a discussion of the arguments used to support prioritization. After these independent evaluations per sub-group sector were completed, and representatives of each sub-sector identified their top three threats, a discussion was organized with all workshop participants to reach a consensus in the selection of the top five threats, which was the deliverable of WG1. The summary of the independent evaluation of representatives of the five sub-groups representatives is presented in the following table.

WG SECTOR	THREAT Priority 1	THREAT Priority 2	THREAT Priority 3
ENERGY	**Climate Change:** Changes in weather patterns and environmental, physical, chemical characteristics, which would modify system behavior and impact land and marine infrastructure and ecosystems; sea level.	**Geopolitics and Economics:** Public and private policies and economies can significantly change the management of resources, from local, to regional and global. Social tensions may arise at different scales, disrupting the function of ecosystems and infrastructure. This may lead to social stratification.	**Innovation:** Transition to a more variable and uncertain climate will demand having information available to better plan future developments of local, regional and global sectors, requiring food, energy, water.
MATERIALS	**Water Quality & Quantity:** Contamination and availability.	**Extreme Weather / Tipping Points:** Climate variability (sea level rise, sargassum increase, altered hydrological cycles, acidification, rising temperature, intensity/frequency hurricanes).	**Innovation (or Lack of):** Solutions require data and information to better understand relevant problems, strategize for optimal solutions, produce technology transfer, and motivate investment.
TECHNOLOGY	**Extreme Weather Events:** Increasing and direct threats to human populations.	**Oil Spills:** Health impacts, fishing industry, large mammals and pelagic communities.	**Plastics:** Ecosystem disruption, health impact, people care; knowledge transfer
BROADER IMPACTS-A	**Changes in Ocean Chemistry due to Climate Change:** Acidification, point and non-point pollution, plastics.	**Sea Level Rise:** Captures a broad range of problems, including ocean acidification, pollutants, plastics, etc. Gulf-wide, habitat loss.	**Extreme Weather Events**: Hurricanes/cold fronts, flooding; increasing frequency and intensity.
BROADER IMPACTS-B	**Sea Level Rise** (long term planning) and **Extreme Weathe**r (short term response).	**Social Stratification:** Impacts (e.g. extreme weather, climate change) would amplify social inequalities, produce migration.	**Political Climate:** Needs to keep pace with climate change and be proactive in a short-term; think long-term effects.

From the summary table, a group discussion followed to analyze results and reach a consensus to define the **top five threats for market sectors and the GoM as: Extreme Weather, Geopolitics, Innovation (or Lack Of), Water Chemistry, and Sea Level Rise.** These top five threats were the focus of discussions for WG2 and WG3.

Working Group 2: For WG2, each breakout group focused on a specific threat and developed a listing of the systems (social, economic and environmental) that would be impacted by each threat, as well as *how*, i.e., the specific vulnerabilities that would be affected in each system. Vulnerabilities were prioritized based on potential impacts of the vulnerability to the economic, environmental and social resilience of the GoM and surrounding coastal communities. The systems that were considered are summarized below. The full meeting notes also include the list of vulnerabilities across these systems.

a. Social systems: The fact that there is a lot of infrastructure in coastal regions creates risk, places social systems at risk, and may cause political instability if populations and infrastructure need to be relocated. Different GoM regions will require different responses to risk. The challenge is to align local responses with regional, national and international responses to ensure an overall common and shared framework. Key systems identified include the following: Coastal and inland communities; Vulnerable populations; Native/close cultural communities; Infrastructure; Workforce; Physical aspects.
b. Economic systems: Economic impacts resulting from climate forcing cross all market sectors. Combined with policy decisions, economic impacts can be magnified. For example, in a flood context, policies typically invest resources in rebuilding instead of relocating structures. Key systems within the economic arena related to climate forcing include: Markets; Utilities; Transportation; Tourism; Gas/oil industry; Insurance systems; Housing/residential; Military infrastructure; Agriculture; Developers/construction; Real estate; Intellectual proprietary; Funds for research and development; Capacity to move from a climate disaster.
c. Environmental systems: Environmental systems often become vulnerable due to decisions made locally, as well as in other countries. For example, best practices and policies focused on upriver areas will affect down river, estuaries, and the GoM. Key systems to consider include: Ecosystems and ecosystem services; Wetlands; Shorelines; Coastal habitats; Coral reefs; Geo-hydrological systems; Mangroves; Freshwater aquifers; Habitats; Organisms; Water availability (freshwater); Algal blooms; Disease vectors.

Working Group 3: The objective of WG3 was for participants to engage in a process to identify the consequences of the identified threats and vulnerabilities, and then dream solutions, i.e., what could be/what is required, who is already working and where, where the gaps are, what technologies and best practices exist, network linkages, etc. The groups instructed to use this information to propose both the optimal solution (their "moonshot") as well as their more practical solution or solutions, which were formed considering existing resources (i.e., funding, data, people and models) as well as resource gaps.

a. Innovation: For innovation, negative consequences were identified as redundancy, inoperability, and a lack of database access. Addressing the need for enhanced innovation would lead to integrated data across fields, improved decision-making and prediction, and technology integration. A "moonshot solution" here could be to establish an entity across the GoM, without any barriers (i.e. country, private/public, academic, etc.) to improve communication and access to data.

   In a summary of resources and gaps, existing data were identified as raw and processed data, including real-time data (mostly in the U.S.) as well as models (atmospheric, aquatic, etc.). Gaps were identified as a lack of communication, trust, technology, data, funds, education, algorithms, and human capacity. The group also highlighted key goals including: sharing data; improved quality and quantity of data; open access/sources; a minimum amount of data to prevent/react to a disaster; develop new prediction tools to prevent/react to a disaster; collaboration across institutions and countries to access and share data; prevent theft of equipment; improve communication to understand where data are most needed; promote democratization of data processing; establish guidelines for data standardization; establish normative obligations and diffusion; establish a specific "trade" to share data/information; and protect stakeholders and academia interests.

b. Sea Level Rise: This group was joined by the Water Chemistry group due to low participation in continuing to examine the water chemistry threat. Participants imagined the scenario of a 15cm rise by 2030 and 40cm rise by 2070. Consequences were defined across the systems as follows: Wetlands-Loss of resiliency and function/services; Shorelines-Loss of beaches, waterfronts, exacerbated by weather events; Coastal habitats-Loss or change linked to biological and recreational value, species migrations or habitat use patterns, fisheries production; Geo-hydrological systems-Loss of freshwater availability and decreasing quality; Archeological sites-Increased cost of restoration and conservation, loss of cultural heritage; Native communities-Loss of local cultures and heritage/activities; Tourism-Loss of infrastructure; Transportation-Loss of ports, roads, ships, highways, workforce mobility; Housing-Loss of and increased cost of housing due to design requirements; Insurance system-Increased insurance costs, insurance no longer available; Utilities-Loss of utilities, increased cost of re-building or adapting utilities, degradation/loss of waste management systems and energy distribution/supply; Coastal agriculture-Loss of irrigation due to saltwater intrusion; Fisheries-Loss of production due to nursery habitat loss/degradation; Military facilities-Loss of infrastructure.

   Two moonshots were identified by this group: (1) Develop a Gulf-wide program to restrict development in flood risk areas, protect existing infrastructure and ecosystems, promote awareness and facilitate ecosystem and human community resilience and adaptation to SLR; and (2) Promote the creation of a Mexican Oceanographic and Coastal Agency to monitor, develop and/or advice ocean policy and provide information/data to all economic sectors (Mexican NOAA), in collaboration with other entities. Specific solutions and "transversal" cross-sector solutions also were identified for each of the systems listed above and are detailed in the full notes.

In a summary of resources and gaps, key networks were identified as: CIGOM, REMTUR, REDESCLIM, RECORECOS, UGM, CREST, AMC and N2N partners. A subset of existing data was identified primarily for Mexico, including Sistema Mareográfico Nacional (Mexico), Tidal Level Monitoring System, INEGI, CENAPRED (Centro Nacional para Prevención de Desastres), and CCA (Centro de Ciencias de la Atmósfera de la UNAM). Key gaps include: funding for assessment of local impacts, education and awareness, public infrastructure; integrated spatial analysis that considers risk of SLR (and interacting processes) under different scenarios; enforcement strategies; institutional limitations; and in Mexico, a national agency that performs assessments and advices policy.

This group also identified existing capabilities, which include: An integrated approach to forecast coastal flooding, and to push for or participate in monitoring; Generate gulf-wide maps with SLR/storm flooding risks and make it public (use technology and models to develop maps of areas susceptible to SLR); Implement education and awareness programs that capitalize on network experience and capacities to minimize impacts; Implement engineering solutions and designs and building codes to increase house elevation; Promote regulations that prohibit development in sensitive/fragile coastal areas and further use of renewable energies; Build levies and sea walls to protect areas considered high risk, raise roads; In the U.S., promote the need to develop, implement and enforce updated regulations that prohibit development in coastal areas estimated to have a high flooding risk given a 40 cm increase over the next 50 years (data are available to make a diagnostic), monetize the true cost of risk (insurance) and eliminate all subsidies that allow for coastal development in high risk areas; Legislation to reduce and eliminate the subsidies over time; In Mexico, promote the need to prohibit development in coastal areas estimated to have a high flooding risk given a 40 cm increase over the next 50 years. However, note that many people do not have insurance, and many coastal communities are low-income and vulnerable. Tourist facilities tend to be given permits to build in those areas due to corruption, which is a challenge. There also is a need to identify key coastal habitats that are vulnerable, advise the implementation and design of coastal restoration programs, and increase connectivity between networks with stakeholders and industry.

c. Extreme Events: The group focused on the extreme event they considered as the highest threat in the near-term, tropical cyclones. Participants identified consequences across the systems, as follows (note: in the full notes, the participants also identified whether the impact would be high, medium, low): Public housing-displacement, deteriorated housing stock, incomplete recovery; Homeowners-decreased property value, displacement, incomplete recovery; Disruption of transportation-life loss, economic loss; Infrastructure failure (water, electricity, IT, pumps, levees, facilities)-life loss, economic loss; Developers-build back, economic gain; Construction builds back-economic gain jobs, community enhancement; Public health/wellness-lack access, lack services, mental health impacts/PTSD; Underserved populations-life loss (unaccounted), displaced/homeless, lack services/ access/metal health support; Indigenous populations-life loss (unaccounted), displaced/replacement, lack services/access/metal health support; Community

networks/integrity (social cohesion)-reduced isolation, access to assistance; Cultural heritage /identity-historical and meaningful places, tie to identity (need to stay/return); Mitigation, preparedness, adaptation-execution (of policies with funding), education, political will; Funds for disaster relief-budget, political will; Long-term recovery groups-budget, capacity, lack of plans; Emergency management-budget, resources (machinery, tools, wo/man power); Oil and gas-production stops, supply chain impacts, damaged infrastructure; Fisheries-damaged infrastructure, access to water, loss in fishing effort; Farming-loss of crops, increased water supply, loss of livestock; Tourism-loss of life (including foreigners), economic loss (long term, perceptions), lack of plans; Local economy-loss of business/jobs, partial recovery; Ports-closure/suspended, supply chain impacts, infrastructure damage; Insurance rates-displacement/priced-out, underinsured, incomplete/protracted recovery; Ecosystems-loss of structure, function, reorganization to different system; Organisms-loss of life, habitat, displacement; Water quantity-baseline levels v. post event; Loss of ecosystem services-depends on habitat and service being provided; Sargassum impacts-distribution, economic loss; Algal bloom impacts-density, distribution, economic loss; Disease vectors impacts-density, distribution, economic loss.

The group identified a number of potential moonshots, including: understanding and communicating risk and uncertainty (preparedness, mitigation, risk mapping, education, and improving social cohesion); governance, laws and implementation/enforcement (including for policy – both risk-mitigating and risk-incentivizing, whether, where and how to rebuild, and where and how to invest in habitat protection and restoration); early warning systems/communications (citizen science, crowdsourcing, how to convey information, volunteer networks); infrastructure resilience; weather forecasting (including private sector opportunities); communication systems; and education.

In a summary of resources and gaps, participants highlighted those “moonshot” areas where the most progress could be made, including in education, risk portfolios, risk mapping, preparedness, mitigation and social cohesion. The group identified the following for gaps and opportunities: Education-training and capacity building (translating at local level, iteratively (turnover), and in a way that is relevant); Risk mapping-parcel level risk mapping, layering data from various maps and other data sources; Preparedness-implementation (when people do not evacuate), non-voluntary evacuation, understanding evacuation and alternatives; Social cohesion-connect informal efforts (validated information) with command/control structure of feds, provide an open-source portal for existing information to be deposited. In the full notes, the group also ranked the relevancy of these solutions to addressing the issues identified in the “consequences” discussion, across social, economic and environmental systems.

Working Group 4: Here, participants were asked to identify and rank the network functions, attributes and barriers to success that were considered most important for N2N. Network functions answer the question: what do you want your network to do? Attributes describe the characteristics of a network that contribute to its success, and barriers are challenges or

conditions that may hinder network success and need to be addressed explicitly. In addition, participants were asked to address the following two questions in writing: identify your network needs pertaining to N2N GoM and identify what your network can contribute. Those responses will be analyzed by the Steering Committee. The ranking of functions, attributes, and barriers to success allows for the clear identification of the vision, priories and concerns the workgroup attendees had regarding N2N GoM.

- Network function ranking: Results indicate that workshop attendees highly value the stewardship of knowledge, solving problems and building community. Good practices and professional development ranked low. Particular breakout groups also identified proposing policy changes and establishing an international shared vision as important.
- Network attributes ranking: Overall results indicate that attendees consider establishing a shared vision of identity and purpose, effective engagement and connectivity and maximizing impacts to enable actions as the most desirable attributes. Particular breakout groups also identified commitment, having a clear mandate to execute, adequate representation of different sectors and planning/regular reviews of goals and timelines important, and ranked them highly.
- Barriers to success: Results were very clear as to the three top barriers to success: time (interpreted as the necessary investment by network participants), failing to establish a vision and mission and obtaining funding (for operating and sustaining network goals).

Working Group 5: The objective of this final Working Group was to obtain input from all participants concerning the content of a DRAFT collaborative framework for N2N GoM. This workshop input is being integrated into the development of the N2N GoM framework in the next phase. The full workshop notes include details of the draft framework crafted by participants, which includes key elements of: purpose, goals, values, resources, membership, organization, governance, coordination and member incentives.

Case Study

In parallel, a case study documented the methodology used to develop an international interdisciplinary network-to-network collaboration. Successful development of the N2N GoM has the potential to positively change the social, economic and environmental conditions of the GoM region. Funding for this project was provided, in part, as a case study focused on documenting how to successfully build a new international community through engagement of existing networks, especially those of large magnitude and scale. The case study component of the project centers on the following elements, and is detailed in the full meeting notes:

i. Document the value and types of step functions attainable through leveraging the convergence of existing networks into new communities across and within disciplinary, institutional, and cultural boundaries.
ii. Provide a roadmap on how to establish successful N2N collaborations that integrate private, federal, academic, non-governmental and international sectors.
iii. Identify possible solutions to barriers and effective mechanisms to establish a successful network based on lessons learned.
iv. Be accessible to the community at large through open access publication of results.