CREST: Center for Aquatic Chemistry & the Environment (CACE)

Subproject 1: Advanced Sensing of Environmental Exposure to Anthropogenic Contaminants, Pollutants and Other Natural Stressors: Developing Cutting Edge Technologies for Tomorrow's Environmental Quality Challenges

Project Summary

During the past three decades, incidents involving pesticides, industrial chemicals, oil, pharmaceuticals, nutrients and metals have attracted worldwide attention and greatly affected environmental conditions (e.g., the Gulf of Mexico Deep-water Horizon Oil spill). These events demonstrate a regional, national and international need for enhanced research on the effects of toxic substances in the environment. The proposed CREST Center for Aquatic Chemistry & the Environment (CACE) at Florida International University (FIU) will transform the institution by integrating discrete campus-wide programs across 10 departments and 4 colleges in fields from environmental chemistry through computer intensive data analysis and visualization, in order to tackle one of the regions most complex challenges: **environmental contamination**. CACE will create innovative opportunities for students, especially encouraging those from underrepresented minorities (URM), to participate in authentic research and foster their development as future STEM professionals. FIU CACE will unify this talented pool of researchers into a cohesive Center that will enhance collaborations, partnerships and synergies. The Center will bridge academic programs that exist across campuses by integrating graduate and undergraduate students into all research subprojects, emphasizing evidence-based educational approaches, technology advances, and analytical chemistry infrastructure, while providing authentic research experiences and solutions. CACE will transform cutting-edge research into technological and science-based solutions for various forms of water contamination using a framework that includes detection/identification, transport and fate in complex ecosystems, and data analytics and visualization. CACE will develop a modeling platform that will enable policy makers and managers to make informed decisions. FIU's CACE will work in collaboration with governmental and private sector partners in S. Florida to develop practical solutions to problems related to water quality in a natural-agricultural-urban setting. This partnership includes the South Florida Management District, the National Park Service, The Miccosukee Tribe of Indians, the Environmental Protection Agency, Everglades National Park, Department of Interior, and others.

Intellectual Merit

FIU CREST CACE will increase opportunities for graduate and undergraduate students, especially encouraging those from URMs, to conduct authentic research while advancing aquatic and environmental chemistry research and data analytics, methodologies, ecological risk assessments. CACE will generate significant new knowledge regarding contaminants and pollutants in aquatic environments, as well as produce innovative new methodologies for detecting and assessing contaminant quantities and impacts, including the use of molecular detection techniques. Using new data analytic approaches for visualization and synthesis of complex data, CACE will provide managers and policy makers, including governmental and private sector partners in S. Florida, real-time, accessible decision tools. The proposed program will advance current efforts on the biological effects, transport, transformation and distribution of contaminants in the environment into new collaborative research areas that investigate the sources and transport of contaminants and pollutants in aquatic systems. The research conducted by the Center will inform the economic, environmental, societal, policy, regulatory, and legal implications of water quality issues.

Broader Impacts

CACE will build on the success of FIU's evidence-based transformation of STEM instructional practices to provide enhanced support for students to pursue and complete STEM graduate degrees, both at FIU or elsewhere. Through an innovative program that spans the graduate school to high school spectrum, CACE will increase the success of students in graduate programs, especially supporting participation of underrepresented students in aquatic chemistry and environment (ACE) fields and future professions. CACE will develop technologies for improving water quality analysis and contaminant detection, as well as translate research findings into actionable information for decision-makers and stakeholders. By providing potential scenarios for understanding the risks, sources, transport and impacts of chemical contaminants that threaten aquatic ecosystems and human wellbeing, CACE can impact global water quality.

Subproject Relevancy Statement

Subproject 1: Advanced Sensing of Environmental Exposure to Anthropogenic Contaminants, Pollutants and Other Natural Stressors: Developing Cutting Edge Technologies for Tomorrow's Environmental Quality Challenges

Technological advances in instrumentation and analytical approaches have significantly augmented the capacity of chemists and environmental scientists to quantify ultra-trace amounts of organic and inorganic substances with enormous precision, and characterize these substances on the molecular level. In addition, advanced fingerprinting using molecular biology methodologies such as gene expression, have significantly enhanced the conditions needed to sense environmental stress on aquatic organisms with high sensitivity and specificity. The combination of both approaches now allows scientists to conduct research to address complex challenges of environmental contamination and risk assessment. The CREST Team will not only enhance existing pollutant sensing methodologies, but also apply them to field studies across land-use boundaries (Subproject 2), and interface analytical data-intensive methodologies with advanced computational modeling and visualization, designed for the development of transformative and scalable methods for data mining and management (Subproject 3). As such, the research conducted by this Subproject will facilitate collaboration with the other two Subprojects and support researchers at the proposed CREST Center to better detect and understand the sources, transport, transformation and ecosystem responses to contaminants, pollutants and other natural stressors in the aquatic systems of south Florida. Using advanced analytical and molecular biology methodologies, researchers will be able to: 1) Develop sensing technologies to determine known traditional or emergent pollutants at environmentally relevant concentrations; 2) explore the relations between chemical stressors and biological responses through advanced molecular biology approaches, 3) generate products through collaboration efforts with the other Subprojects to communicate more effectively with decision and policymakers. **The ultimate goal of Subproject 1 is to advance and enhance the effectiveness of existing analytical approaches for the analysis of traditional pollutants, develop novel analytical methodologies and approaches for the identification, characterization and quantification of novel, previously unknown contaminants of concern, enhance and extend the applicability of molecular biology methodologies to assess environmental stressors to aquatic organisms across land-use boundaries**.

Links between CACE subprojects	**Subproject 2: Quantifying the Fate and Transport of Contaminants across Natural, Agricultural and Human Systems**	**Subproject 3: Data Analytics for Effects Assessment and Decision Making**
Subproject 1: **Advanced Sensing of Environmental Exposure to Anthropogenic Contaminants, Pollutants and Other Natural Stressors: Developing Cutting Edge Technologies for Tomorrow's Environmental Quality Challenges**	• Generate robust, environmentally relevant analytical chemistry and molecular biology data on contaminants, pollutants and other stressors in support of fate and transport process assessment through land-use boundaries • Provide spatially distributed water, sediment, soil and organism samples collected along land-use boundaries for pollutant and molecular biology analysis • Provide feedback on analytical and molecular biology methods' needs for adequate assessment of environmental risk and pollutant flux determinations	• Provide feedback on techniques for managing complex analytical data • Provide feedback on techniques for managing complex molecular biology data • Design and development trans-formative and scalable computational methods for sensor data mining and management • Generate robust, environmentally relevant analytical chemistry and molecular biology datasets on contaminants, pollutants and other stressors in support of the data mining, prediction and modeling efforts.

Subproject 1: Advanced Sensing of Environmental Exposure to Anthropogenic Contaminants, Pollutants and Other Natural Stressors: Developing Cutting Edge Technologies for Tomorrow's Environmental Quality Challenges

I.-Introduction:

Advanced Sensing of Environmental Exposure to Anthropogenic Contaminants, Pollutants and Other Natural Stressors: Developing Cutting Edge Technologies for Tomorrow's Environmental Quality Challenges.

Despite a constant growth in numbers, the identity and nature of human-derived environmental contaminants have changed from traditional pollutants such as nutrients, trace metals, DDT and PCBs to other biologically active compounds such as endocrine disruptors, antibiotics and, more recently, a wide range of chemicals broadly classified as emergent chemicals of interest. Chemicals such as mercury, natural and synthetic estrogens, antibiotics, high use pharmaceuticals and even natural toxins produced as the result of algal blooms are now recognized as having significant effects both directly, in receiving ecosystems, and indirectly, to humans. Processes such as eutrophication, produce a direct and striking visual response for water quality degradation often evidenced by microorganism blooms, drastic changes of water color and in some cases animal deaths. The causes, however are often hidden in more subtle changes of the chemical ecology of an ecosystem triggered by chemicals (present in treated domestic effluents), contaminants (e.g. the combination of mercury and sulfate leading to mercury methylation) or natural stressors (wildfires, climatic disturbances and others) whose introduction affects the delicate balance of natural systems, particularly those in the direct path of urban development. The first signs of impact are often presented in water streams where small concentrations of these chemicals are constantly introduced and transported through multiple boundaries (air, water, soil, and organisms). Water quality is not only the most critical driver in ecosystem sustainability but also a major limiting factor for human development due to its effects on water scarcity. As a result, water tends to be progressively laced with anthropogenic signatures from components that elude treatment as it continues its journey from release to recharge to reuse. With few exceptions, in surface water bodies used as sources for drinking water, contamination is largely affected by dilution, so "exposure" needs to be characterized at very low concentrations for early intervention to be effective. The remaining challenges beyond the characterization of the environmental stressor, are establishing the links between the chemical indicator (CI) and its receptors, and determining the biological conduits and physiological events that will result in an adverse outcome pathway (AOP). Addressing these two key issues is essential in producing meaningful, population-based science in support of the decision making and regulatory processes.

The CREST team has taken on these challenges using multiple approaches creating new technologies, developing analytical methods, implementing extensive environmental assessments and characterizing the processes and mechanisms that control the "exposome" using engineering, chemistry, biology, statistics and molecular and traditional ecotoxicology. The principle behind the work of the sensing group is *to understand nature, one molecule at a time.*

II.-Research Plan:

Goals and Objectives:

The driving hypothesis for the sensing group is that *detection of environmentally relevant levels of pollutants, contaminants or stressors using high throughput technologies with high degree of specificity and at ultra-low concentrations will lead to the recognition of important pathways, interactions, changes and transport along environmental gradients and across land-use boundaries, that could negatively affect ecosystem functioning through anthropogenic activities, natural forces and altered biogeochemical cycles.*

Our research will:

1) Develop sensing technologies to determine known traditional or emergent pollutants at environmentally relevant concentrations (parts per billion to parts per-trillion) in multimedia samples (biotic and abiotic).
2) Take advantage of recently developed cutting-edge analytical chemistry tools to assess changes of the overall molecular composition of target, suspect and unknown components present in environmental samples through a relevant ecosystem boundary.
3) Apply molecular biology know-how to simultaneously assess the genetic and functional responses of relevant organisms or receptors to identify the role of these pollutants or stressors in the creation of adverse outcome pathways that may influence ecosystem functioning.

Methodologies and strategies developed in **Subproject 1** will be applied in field studies along relevant land-use boundaries defined by **Subproject 2** to generate information to feed the activities of **Subproject 3**. The availability of high resolution "big data" sets from the sensing group will greatly influence the capabilities of the ecosystem links and prediction and forecasting groups to create and fine-tune the management tools needed to assure South Florida's ecosystems future sustainability.

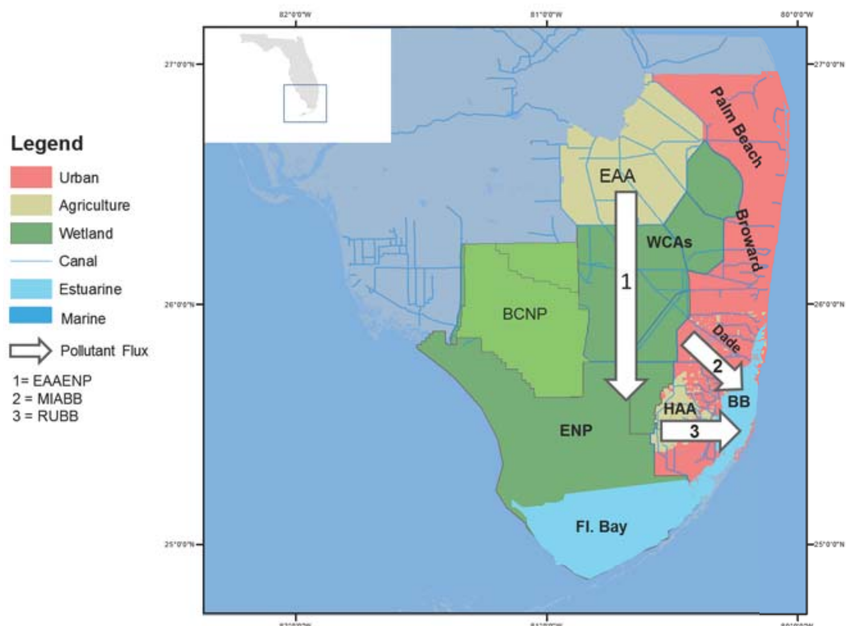

Figure 1. Major land-use and coastal areas of south Florida. Pollutant flux arrows represent three example transects investigated in this research: 1) EAAENP: Everglades Agricultural Area (EAA) to Everglades National Park (ENP) including the managed Water Conservation Areas (WCA); 2) MIABB: urban Miami (MIA)to Biscayne Bay (BB) via the Miami River; and 3) RUBB: the Redland Agricultural District across the suburban landscape of Miami and eventually to BB.

Experimental Approach:

Within this context, the research team has contributed to the advance of scientific inquiry in the following concentration areas and such expertise will be used to address processes described for the land-use transects described in Figure 1 as the basis for studies in **Subproject 2** (EAAENP, MIABB and RUBB).

Analytical Environmental Chemistry approaches:

Analytical Chemistry of Emergent Pollutants at Trace Levels. The use of advanced high resolution MS coupled with online solid phase extraction (SPE) and UHPLC has extended our interpretation of environmental exposure from trace analysis of critical compounds (Wang and Gardinali, 2013; Ramirez et al., 2014) to the detailed analysis of metabolites and degradation products so that a more accurate mass balance of the releases of emergent contaminants could be constructed (Wang and Gardinali, 2014). In addition, assay automation has produced high-throughput analysis of specific wastewater intrusions using recalcitrant tracers such as sucralose (Batchu et al., 2013), linking the traditional water quality approach, using non-specific nutrient and pathogen analysis, to a human-derived signature at costs which allow us to use the novel water tracer in large scale projects. Moving a step forward, the application of full scan mass spectrometry at resolution powers above 100K followed by all-ion fragmentation or specific (MS/MS) mass spectrometry experiments has greatly expanded the frontier of chemical characterization of the exposome by allowing retrospective identification of known-unknown or even unknown-unknown chemicals. Using these tools we can now identify suspect compounds, such as drugs of abuse and their transformation products, with the potential for molecular epidemiological studies targeting consumption at population levels without intrusive monitoring (Heuett et al., 2014). The same principle could be easily expanded to characterize the unknown recalcitrant portions of wastewaters in an effort to improve and redesign treatment technologies or even track previously undetected biological stressors in archived samples.

Analysis of emissions and byproducts from energy consumption in urban areas and intermediates during environmental transformation.

Resolving the transformation steps of energy consumption sources and byproducts to their molecular composition is a great challenge to analytical and environmental chemists because of the complex nature of the samples (Marshall and Rodgers, 2004; Qian et al., 2001a, 2001b). Moreover, commonly used energy sources (e.g., fossil fuel samples) and their transformation byproducts are composed of thousands of individual molecules derived from highly diverse populations of compound types (Labadibi et al., 2013; Gaspar et al., 2012; Panda et al., 2011; Altgelt and Boduszynski, 1992; Boduszynski, 1987,1988). Numerous approaches have been utilized to fully characterize energy sources and byproducts, but no single technique is fully descriptive, and some analyses generate conflicting data for the same sample (Aske et al., 2001; Zadro et al., 1985; Wang et al., 2005). As a result, complete description of the transformation of energy sources is often difficult, if not impossible. Identification and quantification of a limited number of a priori selected compounds have been used for their identification and fingerprint (Daling et al., 2002). Ultrahigh resolution MS (e.g., Fourier transform ion cyclotron resonance, FTICR- MS) has shown potential to resolve components from energy sources (e.g., fossil fuels) and identify the elemental composition, double bond equivalents (DBE = rings plus double bonds to carbon), and carbon number, based on accurate mass measurements at the required resolving power (Marshall and Rodgers, 2004; McKenna et al., 2014; Hughey et al., 2002; Qian et al., 2001a, 2001b). More recently, it has been shown that coupling fast, gas-phase post-ionization techniques (e.g., ion mobility spectrometry mass spectrometry, IMS-MS) provides an extra, orthogonal separation dimension for the analysis of fossil fuels (Fernandez-Lima et al., 2009; Ahmed et al., 2010,2014). In particular, ion mobility spectrometry (IMS) when combined with theoretical modeling, has proven to be the most versatile technique for conformational analysis of intermediate and equilibrium structures of molecular ions (Dugourd et al., 1997; Scott et al., 2007; Becker et al., 2008; Fernandez-Lima et al., 2008). That is, high resolution IMS-MS provides rapid separation of isomers (Kanu and Hill, 2007; Schenk et al., 2014a; Pierson et al., 2013; Merenbloom et al., 2009), conformers (Sawyer et al., 2005; Schenk et al., 2014b; Molano-Arevalo, 2014), and species of differing chemical class (Ruotolo et al., 2002; May et al., 2014) (based on differences in functional groups, polarities, and atomic compositions), which is advantageous for the rapid characterization and screening of intermediates and end products of the transformation of fossil fuel samples. Ion mobility measurements have been used to explore molecular dynamics and follow structural changes occurring on the millisecond time scale by comparison to CCS of candidate structures under controlled conditions (e.g., reactive/inert, polar/nonpolar bath gas at different temperatures, Kanu and Hill, 2007; Zilch et al., 2007, Fasciotti et al., 2013). With the advent of new variants of IMS analyzers with higher resolving power and the recently coupling to FTICR-MS in our laboratory, (Schenk et al., 2014a, 2014b, 2015 Hernandez et al., 2014; Castellanos et al., 2014; Fernandez-Lima et al., 2011a, 2011b) our efforts in CREST will be on the development of SA-TIMS-FTICR-MS (Benigni et al., 2015) methods to better understand and characterize at the molecular level the transformation intermediates and end products from energy consumption in urban areas during environmental transformation.

Black Carbon (BC) an overlooked source affecting global carbon dynamics. BC results from the partial combustion of organic matter during events such as wildfires and fossil fuel burning (Goldberg, 1985). A significant portion of BC is incorporated into soils, potentially affecting long-term carbon cycling in the environment. It has been estimated that BC comprises between 2 – 45% of soil organic carbon (Skjemstad et al., 1999; and others), and was initially thought to be refractory, persisting in soils for thousands of years. Recent studies however, have shown that turnover rates can occur on much shorter timescales (Singh et al., 2012 and references therein) and a significant portion of BC (char) is solubilized and exported as dissolved BC (DBC) (Jaffé et al., 2013; Ding et al., 2013). The environmental effects and implications of these chemicals remain undetermined to a large extent due to the lack of structural information. However, evidence for the effects of land-use on the distribution of DBC compounds has recently been observed (Wagner and Jaffe, unpublished). Thus, to gain a better understanding of the driving forces behind BC stability and mobility, a deeper knowledge of its chemical characteristics is necessary. While FT-ICR/MS characterizations have resulted in a series of potential DBC structures, their identity has not been confirmed as isolation from the bulk dissolved organic matter (DOM) has not been achieved. Heteroatomic compounds within the DBC pool may also be significant, such as dissolved black nitrogen (DBN) (Maie et al., 2006; Jaffé et al., 2012; Ding et al., 2014) and dissolved black sulfur (DBS) (Jaffé et al., unpublished) have been discovered, but very little is known about the molecular structure of these compounds (Wagner et al., 2015). While significant progress has been made in assessing the environmental dynamics of dissolved pyrogenic products, much work is still needed to constrain the molecular structures and reactivity of these molecules. This is needed to better assess their sources, transport and fate in the environment and predict their roles in global biogeochemical cycles and climate change. Through CREST we will focus on the physical isolation of DBC, DBN and DBS to enhance our capacity to fully characterize the molecular structures of these substrates.

Mercury in the Everglades. Mercury (Hg), a long recognized notorious pollutant, poses severe health risks to millions of people worldwide. The most recent global response, the signing of the Minamata Convention on Mercury by over 140 United Nation (UN) member states in Oct 2013, prompts the immediate needs for an advanced understanding of Hg biogeochemical cycling. Elevated levels of Hg have been found in fish, wading birds, and large predators in the Florida Everglades (Ware et al., 1990). Efforts have been made to investigate the scope and magnitude of Hg contamination and to understand Hg biogeochemical cycling in this subtropical wetland ecosystem (Gilmour et al., 1998; Krabbenhoft et al., 1998; Cai et al., 1999; Liu et al., 2008, 2009, 2011; Li et al., 2010, 2012). Several important aspects of Hg biogeochemical cycling, including source, transport, transformation (especially methylation/demethylation), and bioaccumulation have been investigated to various degrees. However, Hg cycling and the corresponding biogeochemical controls in this complicated ecosystem are not fully understood. In the CREST program, we will address a key issue that currently hampers our understanding of the mass budget and fate of mercury, i.e. the role of photochemical processes played in overall mercury cycling in the Everglades. One of our long-term research goals is to identify the importance, mechanism, and system-diversity of Hg photoreactions (oxidation, reduction, methylation, and demethylation) in aquatic environments (Li et al., 2012; Yin et al., 2014). The work proposed here is not only an expansion of our previous studies on methylmercury (MeHg) photodemethylation in the Florida Everglades, but also an essential step toward our long-term goal of producing a complete conceptual model of the Hg biogeochemical cycle. Photodemethylation was found to be a critical process for MeHg cycling in the Florida Everglades (Li et al., 2010; Tai et al., 2014), and could be driven by DOM. Our previous work further suggests that mechanisms of MeHg photodemethylation in aquatic systems may be system-specific (Li et al. 2010). Thus, a fundamental understanding of environmental chemical processes involved in MeHg photodemethylation is required to reveal the mechanisms of this process and its overall role in the cycling of MeHg (and Hg in general). This research aims to validate the relative importance of DOM, among other factors, in MeHg photodemethylation, to identify the major fractions and functional groups of DOM that are involved in the photodemethylation of MeHg, and to elucidate the pathways through which DOM is involved in MeHg photodemethylation in aquatic systems. Successful accomplishment of this proposed research will help us achieve our goals, providing essential information on understanding the fundamental chemistry of MeHg photo-demethylation and the role of this photochemical process in the overall Hg biogeochemical cycling.

Organismal and molecular biology approaches:

Organismal and molecular sensing: the roadmap from exposure to management. Aquatic ecosystems, especially coastal areas, can be subject to a variety of anthropogenic and natural stressors (e.g. nutrients, turbidity, pollutants, hypoxia, altered habitat/hydrologic cycles). Ultimately, the biotic responses to stressors manifest as changes in survival, growth, development, and reproduction (SGDR), affecting individuals, communities and populations. Given the complex nature of aquatic systems, a variety of molecular and biological endpoints are needed to understand the receptors, pathways and mechanism(s) of adverse outcomes and, more importantly, their environmental significance and prediction value. Among the levels at which single chemical contaminants and mixtures operate (Figure 2), molecular alterations stand out as being significant indicators of exposure and effect, and are also typically more sensitive than those at higher levels of organization. Furthermore, changes at the molecular level underlie the effects at higher levels of organization and, depending on the system affected and the type of response, can represent surrogates for effects at the organ and whole organism level.

Current advances in ‘omics’ research, and our basic toxicological understanding of molecular events, have increased the information available to make informed decisions. Accordingly, molecular biology tools can be applied to monitor the impact of contaminants in ecosystems (Fig. 2).

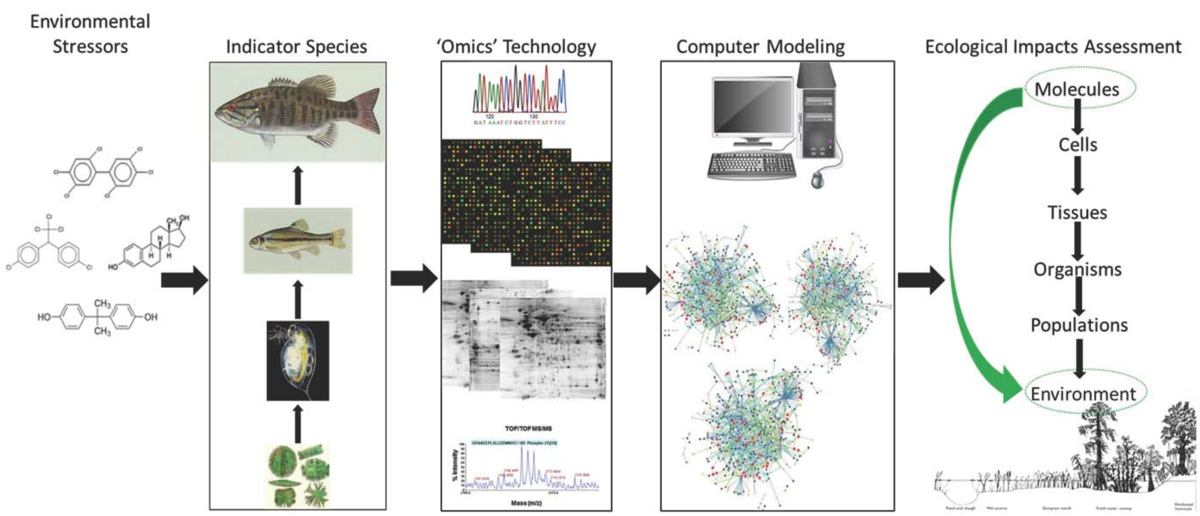

Fig. 2 High-Throughput Molecular Biological Analysis of Environmental Stressors: Since the function of an ecosystem can be viewed in the context of gene function rather than organism function, molecular biology tools such as high-throughput ‘omics’ technology that include genetic, epigenomic, and protein expression profiling can be applied to monitor the impact of environmental stressors on populations of diverse species and interacting communities at different strata of the ecosystem. Using high-throughput technologies to measure the molecular effects of stressors on biological indicator species, we will generate complex datasets to be analyzed computationally to identify key molecular pathways altered in response to stressors.

We propose to use a three-tier approach. In the first tier, we will evaluate DNA damage using a high throughput variant of the single cell gel electrophoresis assay (the comet assay; Karbaschi and Cooke, 2014) to identify the dose, mixtures of, and target organs for, environmental stressors causing DNA damage to biological indicator species. Single cell gel electrophoresis is widely used to evaluate DNA damage in regulatory toxicity testing, and therefore a perfect intermediate assessment between traditional primary ecotoxicology endpoints (SGDR), and the emerging ‘omics approaches (see below). The comet assay has been applied to the detection of damage in cells of tissues such as gills, liver, and digestive glands, as a biomarker of deleterious effects of pollutants on fish and other aquatic organisms (e.g. Mitchelmore and Hyatt, 2004; Sullivan et al., 2007; Kang et al., 2014). Additionally, assessments of DNA damage at the single nucleotide resolution (using Damaged DNA Immuno-precipitation-seq, DDIP-seq, Hu et al. 2015; Yoshihara et al., 2015), have the potential to identify new genes important in the cellular response to environmental insult, and classify genotoxins based upon the distribution of damage.

Second, we will assess the impact of stressors on gene networks and damage at single nucleotide resolution. For that purpose we will develop the microarray characterization of gene expression responses to genotoxic compounds. Since these changes constitute the earliest response to adverse outcomes, the identification of specific group of genes involved in such process constitutes a highly sensitive biomarker of insult exposure (Venier et al. 2006; Steinberg et al. 2008). Additionally, the study of the epigenetic mechanisms mediating exposure-response relationships can elucidate how environmental factors influence phenotypic variation (Baccarelli and Bollati 2009; Bolatti and Baccarelli, 2010). The dynamic and potentially reversible nature of epigenetic changes has outstanding potential for the development of rapid and sensitive environmental biomonitoring programs in diverse ecosystems (Dolinoy and Jirtle, 2008; Huang et al., 2012; Suarez-Ulloa et al., 2015). DNA damage, determined by single cell gel electrophoresis, is widely used in regulatory toxicity testing, and therefore a perfect intermediate assessment between traditional primary ecotoxicology endpoints (SGDR), and the emerging 'omics' approaches. In the third-tier, we will take these large and complex gene datasets to construct ecologically relevant gene regulatory networks by computational model building and predict ecological impacts by model analysis methods. Accordingly the above experimental information will feed into our systems biology approach to develop mathematical models, visualization tools and prediction algorithms that could be expressed through the environmental gradients explored in Subproject 2 using the methods, techniques and technologies developed in Subproject 3. In addition, the large amounts of data resulting from molecular analyses will be organized into data warehouses providing full access to reads, consensus sequences and unigenes linked to gene ontology information (function, process and subcellular compartment).

In summary, the research focus from the organismal and biomolecular sensing group will (1) apply innovative, interdisciplinary approaches of genotoxicity profiling in biological indicator species, (2) determine the relationship between molecular effects/responses and effects in traditional ecotoxicological endpoints (i.e. SGDR); (3) develop a sophisticated and informative molecular ecological network modeling system to predict ecological impacts from complex mixtures; and (4) support a creative and integrated education program to attract and educate underrepresented students from our feeder magnet high-schools and throughout FIU's undergraduate and graduate education programs.

Broader Impacts

Subproject 1 pursues developing and applying a set of innovative molecular sensing technologies following a 3-tier approach. In doing so, this subproject will provide unique hands-on research and discovery experiences for minority students (undergraduate and graduate) and postdoctoral researchers, exposing them to state of the art research in analytical chemistry, genetics, toxicology and molecular biology. Additionally, as one of the major goals of this subproject is to trace relationships between stressors and biological responses using these tools, this work will set a framework for applying these results in environmental biomonitoring, improving quickness and sensibility of pollution detection. Therefore, an obvious societal impact of this subproject will be the transfer of these technologies, and the vast information they generate, to end-users and stakeholders, fostering the collaboration with industry partners and helping the decision making for managers and policy makers.

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