Pew Research Proposal Form
Union University

Cover Sheet

Name(s) of Applicant(s):

James R. Kerfoot, Jr. and Michael H. Schiebout

Title of Proposed Project: **A Multilevel Approach to Investigate the Influence of Scale and Community Stability On Seagrass Management and Ecomorphology.**

Primary Discipline: **Biology Professors** Secondary Discipline(s):

Has this proposal been submitted to another agency, publication, or program (including for the Union University Research/Study Leave)?
No, this direct proposal has not been submitted to another agency, although some of the research proposed will be conducted during Spring semester 2022 during Dr. Schiebout's Research Leave and will contribute to the research leave experience. The timeline for this proposal extends beyond the spring semester 2022.

If so, which one(s)? **N/A**

Location of proposed research:
Locations for this project include Charlotte Harbor Aquatic Preserve (Punta Gorda, FL) and Rookery Bay National Estuarine Research Reserve (Naples, FL) which are in Southwest Florida and Jobos Bay National Estuarine Research Reserve located in southeast Puerto Rico.

Desired start date: **December 2021/January 2022**

Recommending Scholars and their disciplines:

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In consultation together, we recommend the approval of the proposal as an acceptable project and affirm that the applicant has the professional wherewithal to accomplish the project satisfactorily.

Chair of your department Mark Bolyard Date: 9/29/2021

Dean of your school: Hunter Baker Date: 9/29/2021

PEW RESEARCH PROPOSAL

Title: A Multilevel Approach to Investigate the Influence of Scale and Community Stability On Seagrass Management and Ecomorphology.

Statement of the end product(s):
Selected topics and results from this work will be presented at local and national scientific conferences (Association of Southeastern Biologists annual meeting, State agency conferences that manage the estuaries that we are researching, etc.). A goal is to publish the results in a peer-reviewed journal that can be utilized by water resource management groups in their effort to effectively manage their governed assignment.

Explanation of the scholarly activity.

As climate change and human alteration of natural ecosystems in coastal areas increases through development and increased population densities, management that balances socioeconomic growth and environmental protection is needed. An understanding of the correct use of methodologies, the ability to identify the spatio-temporal extent of changes, and location of ecological degradation is paramount in determining best management practices. In various locations throughout Florida there have been historically large regions of the coastline composed of dense seagrass communities, but, over the last two decades, many those regions have seen a severe reduction or a complete local extinction. However, this decrease in seagrass cover has not occurred in all areas of the Caribbean basin. Some seagrass communities seem to be thriving. Why are some seagrass communities thriving while others are declining in the Caribbean basin? This a question that we are proposing to address at both a local and regional scale.

As climate change and human development continues to impact coastal environments, studying the ability of species to cope with environmental fluctuations is fundamental in predicting their fate over time. In areas where there is species overlap between thriving and declining communities, we hope to gain an understanding of possible physiological adaptations that may allow those species to persist in varying habitats.

The specific goals of these studies are:

1) To model the fluctuations in seagrass communities at various spatio-temporal scales (local, regional, and Caribbean basin wide; as well as monthly and annually) to identify potential environmental drivers of those systems.
2) To compare how environmental drivers may change based on spatio-temporal scales, and how the use of scale may dictate the best management practice to halt or reverse declines in specific seagrass communities.
3) To determine if the morphologies of *Thalassia testudinum* (turtlegrass) and *Syringodium filiforme* (manatee grass) are different between stable and unstable seagrass community sites within the southwest region of Florida.
4) To establish whether there are differences in environmental parameters between stable and unstable seagrass community sites within the southwest region of Florida.

Brief examination of scholarly literature or context of the activity within your discipline.

Over the past three years we have had the opportunity to develop a seagrass research program with our research colleagues in Puerto Rico and Southwest Florida. These collaborations have been very productive by way of a completed Master's in Conservation Biology thesis and three undergraduate research projects. Two projects dealt with investigating the role of biotic and abiotic factors influencing seagrass communities in Puerto Rico/Southwest Florida and provide a foundational understanding of the current plight of seagrasses in those locations. Another project explored the possibility of bringing the estuary to Union University's greenhouse and seeing if we could successfully establish the seagrass species *Thalassia testudinum* (Turtlegrass) in controlled greenhouse conditions to conduct laboratory experiments. With each project and result that we conclude we keep developing novel ways to study various aspects of estuaries and seagrass communities in the laboratory and field settings. This proposal aims to contribute to increasing our understanding of these vibrant ecosystems and how to sustain them.

<u>The ecomorphology of *Syringodium filiforme* and *Thalassia testudinum* in stable and unstable communities.</u>

Ecomorphology is the study of how organisms are morphologically adapted to a niche and the ecological tradeoffs of those specializations (Koehl 1996). In some cases, small changes in morphology or size can lead to novel functions, while at other times, changes in form do not confer any performance consequences (Koehl 1996). An organism that has a broad spatial reach across heterogenous environments may have flexible morphologies to account for subtle environmental changes.

As climate change and human influence continues to impact coastal environments, studying the ability of species to cope with environmental fluctuations is fundamental in predicting their fate over time (Pazzaglia et al. 2021). Rapid and extreme environmental changes strongly affect the performance of foundational species (i.e., species with a structural role within an ecosystem) altering the resiliency (i.e., the ability to recover and continue functioning after a disturbance) of the entire ecosystem (Thrush et al. 2009, Pazzaglia et al. 2021). Phenotypic plasticity is a mechanism that is thought to confer an increase in fitness for the organism by allowing it to overcome environmental heterogeneity and expand its population. Climate change, along with anthropogenic pressures, threatens to shift the stability of local communities' species diversity and ecosystem functioning that have persisted for hundreds of years (Pazzaglia et al. 2021). Many have pointed to the critical need for investigations on the direct effects of the various aspects of global climate change on seagrass communities (Zieman 1975, Durako and Moffler 1987, Laboy-Nieves 2009, Sunny 2017). The abundance and distribution of most aquatic primary producers is closely related to a combination of salinity, temperature, and light conditions (Dawes et al. 1985, Laboy-Nieves 2009).

Some seagrass beds seem to be thriving and population numbers stabilized while others seem to be declining and unstable (Orth et al. 2006, Laboy-Nieves 2009). *Thalassia testudinum* and *Syringodium filiforme* have a large distributional area and, historically, dominate seagrass communities in south Florida (Fourqurean et al. 2001). Studies have shown that *T. testudinum* has variation in phenotypic traits (shorter flowering times and wider/shorter blades, etc.) across Florida Bay and throughout its Gulf of Mexico range (Hackney and Durako 2004, McDonald et al. 2016) with implications that environmental factors are driving those differences. Do *T. testudinum* and *S. filiforme* show phenotypic plasticity between stable and unstable sites in Southwest Florida? We have an ongoing study that has been comparing regional sites in Southwest Florida at Cape Romano shoals in Rookery Bay National Estuarine Research Reserve (RBNERR, unstable site), where seagrass populations have been considerably reduced over the last decade and continue to decline, (Cunniff and Laakkonen 2016) and Charlotte Harbor Aquatic Preserve (CHAP, stable site), where seagrass communities have been expanding since 2008, with *T. testudinum* increasing in abundance and *S. filiforme* remaining stable in abundance over the last 15 years (Brown et al. 2016).

The purpose of this study is twofold: (1) to determine if the morphologies of *T. testudinum* and *S. filiforme* are different between stable (CHAP) and unstable (RBNERR) sites within the same region in southwest Florida and (2) compare environmental parameters of stable (CHAP) and unstable (RBNERR) seagrass communities to identify differences in specific environmental drivers of these seagrass communities. Understanding the impact of current and future environmental stressors may yield insight into the capacity of *T. testudinum* and *S. filiforme* to adapt to change, and potentially which populations can persist.

This study will consist of field observations during summer and winter seasons at both locations. For both CHAP and RBNERR sites, four transects with 5 quadrats each (a total of 20 quadrats at each site) have already been established as a part of a long-term monitoring study and will be utilized in this current study. Each quadrat will be examined using SCUBA and snorkeling. All submerged aquatic vegetation species will be identified, percent cover estimated for each species, and morphometrics will be collected for 20 representative individuals (shoots) for *T. testudinum* and *S. filiforme* in each quadrat. For each *T. testudinum* living shoot, the number, length from point of attachment to each leaf tip, and width of the shoot just above the sheath (the protective covering consisting of dead leaves) of all green blades will be recorded, and the shoot age will be estimated using plastochrone intervals (the number of leaf scars plus the number of green and white blades, following Hackney and Durako 2004). For each *S. filiforme* living shoot, the length from point of attachment to each leaf tip, width of the leaves where the stem and sheath meet, and shoot age estimated using plastochrone intervals of leaf scars on the stem will be recorded (following Kenworthy and Schwarzchild 1998). Water quality parameters such as water temperature, salinity, dissolved oxygen, pH, depth, turbidity, photosynthetically active radiation (PAR), detritus presence, and substrate type will be measured at each quadrat using a YSI ProDSS Multimeter and a LI-COR LI-193 Quantum Sensor.

For each quadrat, differences in water quality parameters, community composition, and morphometric measures will be summarized using a series of one-way Multivariate Analysis of Variance (MANOVA) tests. Site characterization (stable and unstable) will be the independent variable by which the dependent variables will be compared. Post-hoc analyses will include a series of student t-tests when warranted. All statistics will be performed using R Statistical language and Microsoft Excel at an *a priori* α-level of 0.05.

<u>Deciphering site-specific environmental drivers in seagrass communities over various spatio-temporal scales.</u>

As human alteration of natural ecosystems in coastal areas continues alongside environmental management that proposes to develop a balance between socioeconomic growth and environmental protection our understanding of the correct use of methodologies, the ability to identify the spatio-temporal extent, and location of ecological degradation is paramount (Borja and Dauer 2008). Spatial and temporal variability in seagrass community composition and productivity have been well studied in local and regional systems of Florida (Zieman 1975, Dawes et al. 1985, Fourqurean et al. 2001). Some seagrass communities seem to be thriving and population numbers stabilized while others seem to be declining and unstable (Laboy-Nieves 2009, Orth et al. 2006). For example, *T. testudinum* is a nearshore dominant seagrass that thrives across the Caribbean basin (Laboy-Nieves 2009, Orth et al. 2006), but populations are fluctuating drastically from historical levels in some regions (Carlson et al. 1994, Durako 1994, Fourqurean and Robblee 1999, Crigger et al. 2005) due to various proposed drivers: from dredging to freshwater input to increases in sediment sulfide. However, Caribbean-wide, and regional-specific comparisons of stable and unstable seagrass populations and their variability in productivity and water quality are lacking.

As evidenced from the recent (Spring 2021, [Jamasmine 2021]) influx of nitrogen and phosphorus (e.g., Piney Point phosphate plant) into the coastal water bodies of Tampa Bay Estuary (Florida) from phosphate-mining operations and agricultural practices, nonpoint sources are the dominant contributors of nutrients, which are difficult to control due to the diversity of spatial areas that contribute different nutrient sources within watersheds (Duan et al. 2021). As scientists move from investigating localized seagrass beds to incorporating regional inputs into the watersheds that feed these estuarine systems a more complete assessment of the state of these estuarine communities can be realized and managed more precisely.

Investigating the influence of scale is important in how scientists and environmental managers assess drivers of ecological systems. Studies have demonstrated the sensitivity of size-frequency distributions to differences in environmental factors and the significant control that the physical and chemical environment of systems exerts on seagrass morphology (small scale, localized effects) and regional seagrass community dynamics (large-scale, regional effects) (Hackney and Durako 2004). We are specifically investigating both regional and local drivers to seagrass communities in the Gulf of Mexico/Caribbean, but generalities of this research can be applied to other ecological communities under stress. It is important to include both regional and local influences on estuarine systems, especially seagrass beds, to decipher which variables are most influential in these systems and to develop best management practices to halt or reverse declines in seagrass communities.

First, we will access Florida's Statewide Ecosystem Assessment of Coastal and Aquatic Resources (SEACAR) databases for the southwest coastal region and describe the seagrass communities over the last 10 years over a broad, regional scale. Those databases include environmental parameters (temperature, dissolved oxygen, salinity, pH, etc.) and seagrass community composition measures (percentage coverage per species) at various spatial (specific seagrass beds to continuous regional beds) and temporal scales (monthly and annually). These datasets will be utilized to develop models to show correlations between environmental variables and seagrass community composition over time in the region. Additionally, ArcGIS software will be used to map out distribution of environmental characteristics at different spatial levels in relation to individual collection sites to help visualize sources of freshwater input, impact of urbanization, and possible nutrient sources. A similar process will be used to analyze databases in Jobos Bay National Estuarine Research Reserve (JBNERR), Puerto Rico, and comparisons will be conducted with Florida sites to assess the variability across the Caribbean basin.

Second, we will continue to add to our local seagrass database at established transects (as outlined above) in CHAP, RBNERR, and JBNERR to see if similar drivers are influencing community structure on a smaller temporal and spatial scale. These comparisons will help estimate the influence of drivers in the intra-regional system in southwest Florida and on a Caribbean basin scale. Scale is an important component to consider when developing the best management practices for natural areas and this study aims to determine whether locale scale drivers continue to matter as scale increases (spatially and temporally) in estuarine systems.

Models will be developed that include various combinations of spatial, temporal, and environmental response variables to test which model(s) best explain total seagrass abundance and community composition – locally, regionally in southwest Florida, and Caribbean wide. Akaike's Information Criterion (AIC) will be utilized to evaluate how well the developed models explains the patterns of total seagrass abundance on the local scale, regional scale, and Caribbean basin scale, and which models are a best fit. Once the best fit model(s) are determined, response variables will be scrutinized to tease out any relationships present with total abundance and community composition.

All statistics will be performed using R Statistical language and Microsoft Excel at an *a priori* α-level of 0.05.

Literature Cited

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Essay on Christian faith and biology

Albert Einstein is credited with proclaiming, “I have no special talent, I am only passionately curious.” We believe that God instilled within all of us a passion to be curious, a reason to ask *why*? This curiosity and wonder were driving factors for why we both ended up pursuing biology as a career. Biological research helps to answer, or at least address, some of the various questions of *why* observed in nature. The object of discovering the answers to questions ultimately leads to other questions that help to fill that curiosity. Since the chief end of man is to glorify God, and to enjoy him forever (Is. 60:27, Rom. 11:36), then with each discovery, each answer to our questions, we gain a better understanding of the Creator, for by faith we understand that the universe has been framed by the word of God, so that what is seen has not been made out of things which are visible (Heb. 11:3). Through discovering how seagrass communities fluctuate over time or how certain species can adapt to changing climatic regimes, we describe the self-sufficiency of God and His creation.

Science has been described as the pursuit of truth. From a secular biologist point of view, we might deem that to mean gaining a better understanding of how nature operates. From the Christian biologist perspective, it means that we get to capture a glimpse of the Creator's handiwork and arrive at a better understanding of His goodness and justice over all creation (Ps. 103:19). As both a Christian and a scientist, we find that these truths that scientists pursue describe limited aspects of God's nature and His truth. The Lord even challenges us to come alongside Him in this pursuit through his word, "if any of you lacks wisdom, let him ask of God who gives freely and without reproach and it shall be given" (James 1:5).

God placed non-human creation under the responsibility of humans (Gen. 1:26-28) and Romans 1:20 indicates that observing and learning about nature are a part of God's revelation to humans. Even in a world that has been corrupted by sin, nature itself cries out of the Creator and the need for His healing from the consequences of that sin nature. Interestingly, those saved by the grace of God are called to be instruments of Christ's reconciliation to all of nature (2 Cor. 5:18-19). This indicates that humans, even more so biologists, should be good stewards of the environment, engaged in learning more about ecological systems, their interconnectedness, and how to manage more appropriately as our understanding and knowledge grows (through discovery!). This fits perfectly with the goal of the proposed project as it is a quest of trying to interpret how these seagrass systems are being impacted, determine which ecological factors are driving these systems, and then developing the best management plans to aid in restoring these critical marine habitats. In the end, this is an effort to be the best stewards of our environment. As biologists we need to take the act of being stewards of our environments seriously and manage natural systems with cunning and resourcefulness, without being ignorant in our understanding of how our human footprints impact nature. Isaiah 5:8-10 yields a warning that the land will stop yielding its fruits and protection if its stewards do not show reverence for these natural systems. Through our example of being good stewards of nature with these types of research projects that aim to reduce habitat loss for critical ecosystems, we simultaneously build onto our Christian testimony, on display for other scientists to see (Proverbs 20:11, James 2:14-26), providing opportunities for the Gospel to be shared.

Timeline of Project

- December 2021/January2022 – Begin data collection at southwest Florida and Puerto Rico sites for both projects.
- February – April 2022 – Contact aquatic preserve and marine protected area managers to discuss historical/current databases (SEACAR) to use in the project for each site. Begin compiling dataset, culling the information for similar temporal scales and environmental parameters.
- June – July 2022 – Continue collecting data at southwest Florida and Puerto Rico sites for both projects.
- August 2022 – Develop models based on current data collected. Run preliminary AIC analyses, fine-tuning the model development if necessary. Conduct preliminary analysis of ecomorphological data.
- December 2022/January 2023 – Continue collecting data at southwest Florida and Puerto Rico sites for both projects. Begin writing manuscript for eventual publication.

- April 2023 – Present results of the ecomorphological study of seagrass adaptation at the annual Association of Southeastern Biologists meeting. Present results of the studies at PEW Research Luncheon.
- June – July 2023 – Finish collecting data at southwest Florida and Puerto Rico sites for both projects.
- August 2023 – Finish data analyses for both projects from final compilation of the data and continue to polish manuscript of the studies.
- September 2023 – Submit manuscript for journal review.

Budget

These studies will require travel to Jobos Bay, Puerto Rico, and southwest Florida multiple times to allow for replication of seasons that will be used in these studies. For trips to Jobos Bay roundtrip flights would depart from the nearest airport (Memphis, TN) and fly into San Juan, PR (or Fort Myers, FL). A vehicle would be rented for the duration of each stay (4 days). Lodging would take place at the dormitories provided to researchers at Jobos Bay National Estuarine Research Reserve, or in the homes of scientific colleagues in south Florida. Union University is providing the main pieces of the field equipment such as the YSI ProDSS Multimeter and LI-COR LI-193 Spherical Underwater Quantum Sensor for measurement water quality parameters, and snorkeling/scuba equipment. The monies would be spent by April 2023 if approved to do so.

Budget Breakdown

Travel	Cost
Roundtrip flights - $450 x 2 (Researchers: Kerfoot and Schiebout) x 3 trips	$2700
Vehicle Rental/gas - $315 x 3 trips	$945
Equipment	
Field notebooks and rulers	$40
Tank Rental	$200
BCD/Scuba Equipment Maintenance	$200
Site license – ArcGIS, computer software	$150
Conference Expenses – Registration/membership Assoc. Southeastern Biologists	$265
Total:	$4500