Article Title

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Abstract

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# Introduction

Seagrass beds provide important ecosystem services for both the environment and the coastal economy. Seagrass beds fulfill multiple important ecological roles including erosion control (Nordlund et al. 2016),  marine organisms' food source (Heck, Nadeau, & Thomas 1997), and a nursery for juvenile fish communities (Heck, Nadeau, & Thomas 1997). Seagrass beds provide food, shelter, and protection for many fish species, including commercially valuable species (Blandon & Ermgassen 2014). Many coastal communities, such as those in the Caribbean Sea, depend on commercially valuable species for income and sustenance. Fishing plays an important cultural and economic role in coastal communities, where many locals engage in fishing activities as a major part of their culture, food, income (Stoffle 2011).

There are three native species of seagrass that support juvenile fish communities in the U.S. Virgin Islands: Turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*), and shoal grass (*Halodule wrightii*). While each type of seagrass fulfills a similar ecological niche as nursery habitat, they each exhibit different characteristics that are favored by different fish communities [REF = needs a reference from the literature]. The abundance, composition, and density of these seagrass beds directly affect fish communities.

**[need a transition sentence ]**

In recent years, an non-native seagrass species originating from the Indian ocean, *Halophila stipulacea*, has become prevalent throughout the Caribbean [REF]. In 2002, *Halophila stipulacea* was observed off the coast of Grenada (Ruiz and Ballantine 2004). Two decades later, *H. stipulacea* has spread throughout the Caribbean Sea. Most literature surrounding *H. stipulacea* documents the impacts of this invasive seagrass on native sea grass composition (Willette et al. 2014; Willette and Ambrose 2012).

The spread of the invasive seagrass in the carribbean, *Halophila stipulacea,* can be attributed to the combination of storms, inter-island vessel transportation, and near-shore fishing practices (Willette and Ambrose, 2012; Willette et al., 2014). These disturbances can contribute to the expansion by fragmenting *H. stipulacea* and uprooting native seagrass beds. When native seagrasses are disturbed and uprooted, *H. stipulacea* has the opportunity to establish and replace them (Cruz-Palacios & Tussenbroek 2005).

The attributes that make invasive plants so successful are high reproductive capacity (sexual and/or asexual), wide phenotypic plasticity, high dispersal ability,  and strong competitive ability (Williamson and Fitter, 1996; Kolar and Lodge, 2001; Sol et al., 2012). *H. stipulacea* fragments, created by storms, wave action, grazers, boat anchoring and fishing, can survive in the water column for several days before settling down and taking root (Willette et al. 2020)

Compared to native seagrass, *H. stipulacea* has shorter, wider leaves and grows thin, segmented rhizomes. These unique characteristics enable *H. stipulacea* to spread and grow rapidly, making it an exceptional colonizer species (Sghaier 2011) that is outcompeting native seagrass species in the Caribbean (Willette and Ambrose 2012; Smulders et al. 2017). *H. stipulacea* has been observed to grow at deeper depths than native Caribbean seagrass species, with a known maximum depth of up to 50m globally and an observed maximum depth of 32m in the Caribbean (Sharon et al. 2011; Maréchal et al. 2013; Molina Hernández & van Tussenbroek 2013).

**Methods**

*Site Selection*

This study was conducted in Brewers and Perseverance Bays located on the southwest side of St. Thomas, USVI (Figure 2). These bays were selected because they are known to contain *H. stipulacea* and other native seagrasses from previous literature and local observations (Olinger et al. 2017; Smith Unpublished). All data collection occurred during February 2023.

*GPS Sample Point Placement*

To determine sampling locations, using ArcGIS Pro, we randomly dispersed points throughout a defined polygon of soft bottom habitat in Brewers and Perseverance Bays. Benthic habitat data (NOAA, 2001) collected between 1999 and 2001 was first clipped to an outline of the study site, then clipped to exclude hard and rocky substrate such as coral, rock, rubble, and other. We defined hard substrate as coral, coral rubble, rock, or any artificial material. The resulting polygon only had benthic data for soft bottom habitats such as sand, seagrass, and algae, confined to Brewers and Perseverance Bays. The bays were split into three depth bins: 1.5-9.4 m, 9.5-16.8 m, and 16.9-24.4 m (NOAA, 2014). In each depth bin, 40 sample points were randomly placed only in areas with the soft bottom habitat with 20 of those being extra points in case some of the points fell on areas with hard substrate. To sample evenly across the depth gradient, at least 20 points from each depth bin were sampled.

*Field Methodologies*

Fish counts and estimations of percent seagrass cover were accomplished using 25 x 4m belt transects with flagging tape indicating every 5m increments. T-bars were constructed from PVC pipes to assist with assessment of fish counts and seagrass percent cover. The T-bar was 2 meters in length centimeter increments to allow for the divers to easily visualize and estimate fish sizing on either side of the transect.

 For the fish count method, a dive team consisting of two divers each with a T-bar were assigned a random sample point and a random compass heading to lay the transect. Divers visually examined the transect for hard substrate to ensure there is not more than 10% hard substrate cover in the direction in which the transect was to be laid. If there was more than 10% hard substrate cover, the divers would adjust their heading 180 degrees and lay the transect in the new direction. Water temperature, depth, weather conditions, and visibility were collected at each site. Diver pairs swam side by side along the transect tape holding their respective T-bars at the top of the seagrass height and recorded species and size of fish seen (Figure 4).

Benthic cover assessments were conducted on the same transect immediately following fish counts. The dive team swam back along the transect tape using the 2-meter T-bar as reference. Once the dive team reached the first 5-meter increment marked with flagging tape, they recorded the estimated percent cover of *H. stipulacea, H. wrightii, T. testudinum, S. filiforme*, macroalgae, and rubble within the 5x2 m quadrat they just swam (Figure 4). Percent cover was estimated every 5 meters along the transect until the 25m transect was complete for a total of 5 quadrats per diver.

Seagrass cover is estimated within 0.25 m2 (50 cm X 50 cm) quadrats. The transects were randomly placed transects centered around three specific sampling points in the south, central, and north portions of the eastern Brewers Bay from 2009 to 2022. Ten quadrats were placed at randomly determined positions along the three transects of 25 m length on the left side of the tape. The total percent cover of all seagrass species was estimated visually within the quadrat, and then separately for all seagrass species. The occurrence of other sessile benthic species, such as algae, within the quadrat should also be quantified by estimating their cover.

Statistical *Analysis*

Percent Cover

The weighted average of benthic covers for each transect was calculated. The three native seagrasses, *H. wrightii, T. testudinum,* and *S. filiforme*, were observed at very low frequencies so percent cover of all three were combined into total native percent cover for analysis. A logistic regression was used to determine the depth that native seagrass no longer naturally occurs. Transects were divided at this depth to compare the effects of depth and benthic cover on fish communities when native seagrass was either present and or absent.

Fish

Three metrics were used to characterize fish communities: abundance, species richness, and diversity. Species diversity was assessed using Simpson’s index of diversity (1-D) (SOURCE)

Prior to simpsons diveristy analysis, a squared transformation was performed due to the right skew of the data.

In transects shallower than the point where native seagrass stopped growing, a multiple linear regression was used to determine the effect of depth, native percent cover, *H. stipulacea* percent cover, and the interaction between depth and *H. stipulacea* percent cover on Simpson’s Diversity of the fish community. To assess the overall and concurrent effects of native native percent cover, depth and *H. stipulacea* percent cover on abundance and species richness, we fitted poisson regression using the function “glm” of the tidyvR package ().

In transects deeper than the point where native seagrass stopped growing, a multiple linear regression was used to determine the effect of depth, *H. stipulacea,* percent cover, and the interaction between depth and *H. stipulacea* percent cover on Simpson’s Diversity. A Poisson regression was used to determine the effect of depth and *H. stipulacea* percent cover on abundance and species richness.

In 2009, only one transect was recorded due to limited resources. It was included because it was collected pre-Hurricane Earl. The mean cover of seagrass per transect (all species combined) was calculated by averaging the values from each quadrat. A one way ANOVA was used to compare the total seagrass cover.

*Fish Community Data Analysis*

All fish community analyses were performed in RStudio version 4.2.1. The tidyverse 2.0.0 package was used to group fish species into families, merge the fish community data with the seagrass cover data based on transects, and group the seagrass cover into categories of transects with 100% *H. stipulacea* deeper than 15 meters, 100% *H. stipulacea* less than 15 m deep, and a mix of native seagrass and *H. stipulacea* less than 15 m deep. The “vegan” package (v.2.6.4) was used to run a Bray-Curtis dissimilarity between family counts and visualized through an nMDS with ellipses showing the three categories of seagrass. To test our hypothesis that the fish communities differed between the seagrass categories, a Permutatinal Analysis of Variance (PERMANOVA) with 999 permutations was performed using the adonis function in the “vegan” package. When a significant difference was determined, a SIMPER analysis with 999 permutations was performed to determine which families were driving the differences.

The families contributing to the top 90% of the differences between the three seagrass categories were analyzed to determine if their densities differed between categories. The densities of the fish families were calculated by dividing the total count of each family and dividing by the area of the transects. The densities did not fit the assumptions needed for an Analysis of Variance (ANOVA) and transformations were not effective. Therefore, a Kruskal-Wallace test was run on each family to determine if there was a difference in their densities between the three seagrass categories. When a significant difference was found for a family between the three different categories a Dunn’s post hoc, part of the “FSA” package (v.0.9.5), was performed to determine which category the family density was significantly different in.

Based on (paper name here), a final analysis was performed to determine if one of the three snapper species observed, species name here, was driving the trends seen with the Lutjanidae family or if both species were playing an equal role. The tidyverse package (v.2.0.0) was used to separate the three species based on transects and calculate their densities. A Kruskal-Wallace analysis was performed on each species to determine if there was a significant difference between each seagrass category. A Dunn’s test was performed on the species that did exhibit a significant difference between the three categories. A box plot was used to visualize the densities and differences of each species between the different seagrass categories.

*THE BENTIC CITATION:*

*Citation\_Information:*

*Originator:* NOAA/NOS/NOAA/Biogeography Team

*Publication\_Date:* 20010501

*Title:* Benthic Habitats of the U.S. Virgin Islands; St.Thomas and St.John, USVI

*Edition:* 1

*Geospatial\_Data\_Presentation\_Form:* vector digital data

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*Publisher:* NOAA Coastal Services Center

*Range\_of\_Dates/Times:*

*Beginning\_Date:* 1999

*Ending\_Date:* 2001

***Using the raster data created 3 polygons representing different depth categories of ….***

***We created random points***

***Equal sampling across depth gradient***

*<origin>U.S. Geological Survey</origin>*

*<origin>Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), National Centers for Coastal Ocean Science (NCCOS)</origin>*

*<origin>Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), Office for Coastal Management (OCM)</origin>*

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**Results**

MAIN RESULTS:

* Seagrass cover in the study area has significantly varied across the study period. (Tyler)
* Native seagrass was found on 27.4% of all the sites H. stipulacea was found on 91.9% of all the sites surveyed, and only two sites were mixed beds with only native seagrass
* The fish community below 15 m was significantly different than the fish community in greater 15 m or less when there was less 100% Halophila present. The fish community in 15 m or less when there was less 100% Halophila present was also significantly different from the fish community in 15 m or less when there was 100% Halophila present. There was no significant difference between  fish community the below 15 m and the fish community in 15 m or less when there was 100% Halophila present. (when there is native seagrass present the community is significantly different)
  + Fish in the family Lutjanidae (aka snappers) account for 21.3% of the   dissimilarity between the greater than 15m category and the less than 15 m with less than 100% Halophila category (p=.001)
  + Fish in the family Labridae (aka wrasses) account for 37.6% of the   dissimilarity between the less than 15 m with less than 100% Halophila category and the less than 15 m with 100% Halophila category (p=.001)
  + There were no significant differences between families between the less than 15 m with 100% Halophila category and the greater than 15 m category.

There were significant differences in the density of fish in the Labridae, Lutjanidae, Gobiidae, Serranidae, Labrisomidae families. There were significantly less Labridae deeper than fifteen meters, and significantly less Lutjanidae and Serranidae in shallow water.

* Commercially important Family Find more information on Carangidae and Lutjanidae (HOLD ON ON STATEMENTS)

Results

Seagrass

The dominant benthic cover in Brewers Bay is split between seagrass cover and sand, while Perseverance Bay is dominated by seagrass (Figure 4). The three species of native seagrasses were found in 27.4% of all the sites sampled and only occurred on two sites without H. stipulacea (Table 1). The two sites that had only native seagrasses present were mixed beds of S. filiforme and T. testudinum. Both these sites had the highest observed percent native seagrass cover of 87.0% and 69.8% respectively. The percent of native seagrass cover ranged from 0.1 - 87.0% across the 62 sites. S. filiforme was found in 20.6 % of sites with a range of 0.1 to 68% cover. T. testudinum and H. wrightii only occurred in 4.7% of the sites. T. testudinum percent cover ranged from 1.8 to 23%, and H. wrightii percent cover ranged from 2.6 to 20%. H. stipulacea was found on 91.9% of all the sites surveyed, and only two sites were mixed beds with native seagrasses (Table 1). H. stipulacea percent cover ranged from 0.1 to 97.4%. The dominant benthic cover in Brewers Bay is split between seagrass cover and sand, while Perseverance Bay is dominated by seagrass (Figure 4)

There was a significant effect of depth on the presence of native seagrass (logistic regression, p=0.00047, Z = -3.5, y = -0.19877x+1.1617). Based on Zieman’s (1986) report and the probability determined by the logistic regression, the depth range for native seagrasses in Brewers is from 0 to 15m (Figure 5). Nearly half (45.2%) of sites sampled fall into the native seagrass depth range. The maximum depth of H. stipulacea from the sites sampled was found to be 25 m.

The percent total seagrass cover significantly varies across the study period (Chi-squared = 88.92, df=12, p-value= 7.98e -14) (Figure –). A Kruskal-Wallis non-parametric ANOVA and a fisher post hoc test with a Bonferroni correction were used for the analysis. From 2009 to 2010, there was a decrease in seagrass cover from 28.7% to 2.23% (Figure –). The 2009 average does not fall in the 95% confidence intervals from 2010 of 0.78% to 3.67% (Table –). Since 2009 was not within the 2010 confidence intervals, there is a possibly

*Fish Communities*

A total of 1,498 fish comprised of 55 different species were observed during this study. The top ten fish species recorded were Slippery Dick (*Halichoeres bivittatus*), Yellowtail Snapper, Bridled Goby, Colon Goby, Rosy Razorfish, Masked Goby, Chalk Bass, Striped Parrotfish, Blue Runner, and Dwarf Sand Perch. Out of the total fish observed, 24.3% were commercially important species in the U.S. Virgin Islands (Table 2).

Simpson’s index of diversity was not affected by depth or the percent cover of *H. stipulacea;* however, in 0-15 m, Simpson’s index of diversity significantly decreased as the percent cover of native seagrass increased (multiple linear regression, p-value = 0.0102, F = 2.722, 29 degrees of freedom). Fish community compositions differed depending on the presence or absence of native species (Figure 6).

Species richness was higher in depths less than 15 meters (n = 33) and lower in depths greater than 15 meters (n = 28). The species richness in 0 - 15 m significantly increased as depth increased (Poisson Regression, p = 0.031, z = 2.119). Species richness in 0 - 15 meters was not affected by percent cover of *H. stipulacea* (Poisson Regression, p = 0.3638, z = -0.908). In 15 - 25 meters, species richness significantly increased as percent cover of *H. stipulacea* increased (Poisson Regression, p = 0.0108, z = 2.549) with no significant effect of depth. Native seagrass cover did not affect species richness.

Abundance of fish in 0 to 15 meters significantly decreased when the percent cover of *H. stipulacea* (Poisson Regression, p = 5.69e-5 , z = -3.446) and native seagrass increased (Poisson Regression, p = 4.34e-12, z = -6.925). Depth had no effect on the abundance of fish in 0 to 15 meters. Abundance of fish in 15 – 25 meters significantly increased as depth (Poisson Regression, p = < 2e-16, z = 9.981) and percent cover of *H. stipulacea* increased (Poisson Regression, p = 1 .32e-11, z=  6.766).

**Discussion**

**Discussion Draft**

[**https://link.springer.com/article/10.1007/s12237-014-9907-1**](https://link.springer.com/article/10.1007/s12237-014-9907-1)

Seagrass composition and cover in Brewers and Perseverance Bays has varied throughout the past decade, likely due to severe weather events and changing oceans due to climate change. Hurricanes can aid in the reduction of native seagrasses and the expansion of *H. stipulacea* in the Caribbean (Hernández-Delgado et al. 2020). Changes in seagrass cover due to hurricanes have been well documented in Brewers Bay through a long term seagrass monitoring study. After the 2010 category 4 hurricane, Earl, Brewers Bay witnessed a significant decline in overall seagrass cover, creating an opportunity for the rapid invasion of *H. stipulacea* in 2012. This non-native species took over areas where native grasses struggled to recover post-hurricane, ultimately becoming the sole seagrass species in 2017 (Olinger et al. 2017) after the category 5 hurricanes Irma and Maria. Furthermore, warming ocean waters could contribute to the expansion of *H. stipulacea* according to models from Wesselmann et al. 2021. More frequent and severe weather events are expected due to global climate change, which could help accelerate the spread of *H. stipulacea.*

The combination of the high reproductive success and  dispersal ability of *H. stipulacea* makes it concern for future spread outside of the caribbean.  {need to find a place to put this}

One of the visible changes in Brewers and Perseverance Bays with the arrival of *H. stipulacea* is the loss of open sandy habitat. Unlike the native seagrasses, *H. stipulacea* is able to grow in deeper depths replacing sandy habitats deeper than 15 meters. It is unknown if the arrival of *H. stipulacea* into deeper water will maintain similar ecosystem function as the open sandy habitat and how ecosystem changes will affect existing communities. There is no research that indicates that loss of unvegetated habitats and the native seagrass beds can be substituted ecologically by *H. stipulacea.*

There is potential for *H. stipulacea* to act as a pioneer species facilitating future settlement of the native seagrass species once environmental conditions are favorable (Viana et al. 2019). The two native pioneer seagrass species, *S. filiforme* and *H. wrightii,* have been susceptible to replacement by *H. stipulacea* due to the higher reproductive success and dispersal ability of *H. stipulacea* (Willette et al. 2020; Viana et al. 2019; Steiner and Willette 2015). The benefit of having  *H. stipulacea* as a pioneer species only would be beneficial if environmental conditions return and remain within the range of the native seagrass species tolerance in future. *H. stipulacea* does not provide the same ecosystem services as its native counterparts, however it's important to consider if the potential advantages of its spread can outweigh the loss of native seagrass beds in the caribbean.

The changes in Brewer's Bay's seagrass communities are expected to continue, with *H. stipulacea* potentially maintaining its dominance and a loss of seagrass biodiversity. High seagrass cover has been cited to support higher fish and invertebrates in comparison to bare substrate (SOURCE.. ). This shift in seagrass composition has influenced the local fish community based on our results. Previous studies indicate lower juvenile fish abundance and diversity in Caribbean *H. stipulacea* beds compared to native beds (Willette and Ambrose, 2012; Hylkema et al., 2015).

The strong relationship between commercially important species, such as the Yellowtail Snapper and Lane Snapper, and seagrass habitats becomes evident in deeper waters dominated by *H. stipulacea.* The expansion of the nursery habitats of these commercially relevant species into deeper waters (beyond 15m), where *H. stipulacea* almost exclusively dominates warrants consideration regarding the importance of these nursery habitats in supporting various life stages of fish, especially juveniles as outlined in Table 2. From an ecological and commercial perspective, understanding the mechanisms driving such shifts in seagrass community composition, and their effect on local fish assemblages becomes crucial, particularly regarding sustaining healthy fishery stocks and their management. A similar study conducted in 2012, which placed fish traps in *H. stipulacea* and *S. filiforme* dominated beds, found that Yellowtail Snapper (*Ocyurus chrysurus)* were caught proportionately more often in *H. stipulacea* dominated beds, whereas Lane Snapper (*Lutjanus synagris)* were caught proportionately more often in *S. filiforme* dominated beds (Willette & Ambrose 2012). In comparison, our results indicate that both these commercially relevant species of snappers were most abundantly observed along transects at depths greater than 15 meters and that there was no significant difference between the two. Willette and Ambrose  (2012) determined that non-native *H. stipulacea* beds displayed significantly larger average fish sizes, along with increased fish abundance and species diversity in comparison to native *S. filiforme* beds. However, they could not determine the viability *H. stipulacea* of *H. stipulacae* as a nursery habitat due to the close proximity of their study sites. They argued that these findings may be the result of morphological differences in seagrass structure*,* despite observing twice as many juvenile fish within *S. filiforme* dominant beds (Willette and Ambrose, 2012). The differences in fish communities below and above 15m, where the presence and proportion of *H. stipulacea* significantly varied, provides a legitimate area of inquiry pertaining to habitat selection across different fish life stages. With Ambo-Rappe et al. (2013) highlighting the importance of seagrass morphology in influencing fish habitat selection, an examination of how different fish species leverage seagrass characteristics across varying depths and life stages becomes essential. Additionally, how these depth-related differences in fish communities translate into aspects like food availability, habitat viability, and predator-prey interactions, particularly within native vs. non-native seagrass habitats, offers an area for further investigation.

          A distinct aspect that emerged from our results is the variance/variability – right word? of fish communities in relation to depth and seagrass type – with species richness and fish abundance exhibiting varied trends across the depth and type of seagrass cover. The increased presence of commercially vital species within non-native *H. stipulacea* bedsat depths greater than 15m (Figure 6) begs the question: what underlying mechanisms could be instigating this prevalence? Food availability, predation pressure, and opportunistic behaviors related to altered ecological parameters within these deeper seagrass beds are all possible drivers.

          While the relationship between seagrass and their associated fish communities is well-documented, the subtle differences of this interaction, particularly considering non-native seagrass species like *H. stipulacea*, add additional complexity to this dynamic. A significant alteration in fish communities was observed when non-native *H. stipulacea* was prevalent, even more so within depth variations. Consequently, the role of *H. stipulacea*, its density, and morphological attributes in shaping fish assemblages (Figure 7) requires further inquiry.

          Undoubtedly, the conservation and management of commercially important fish species, including those identified as major contributors to the dissimilarity in fish communities across our studied categories (like the yellow-tail snapper), requires a firm understanding of their ecological roles and associated seagrass habitats. These observations highlight the need to further investigate the causal mechanisms, particularly the relationship between seagrass (native vs non-native) characteristics, fish behaviors, reproductive strategies, and predator-prey interactions.

          The investigation into the dynamics between seagrass habitats and fish communities, particularly within the context of commercially relevant species like the Yellowtail  and Lane Snapper, reveals potential areas for further research and practical applications within fishery resource management. Further investigations into the ecological and behavioral adaptations of fish communities within non-native seagrass habitats, and their subsequent implications on fisheries management and conservation strategies, present promising areas for future research. Moreover, investigating the causal relationships and underlying mechanisms that underpin the observed correlations from our research will enhance our comprehension of these dynamic interactions, setting the stage for informed, sustainable, and ecologically cognizant fisheries management strategies.

The invasion of *H. stipulacea* into the Caribbean warrants continuing research. Brewers and Perseverance Bays will serve as case studies on how *H. stipulacea* can affect fish communities along a depth gradient yet this research needs to be replicated across the Caribbean to fully understand the effects of  *H. stipulacea* expansion. While commercially important species such as the yellowtail and lane snapper have been found utilizing *H. stipulacea* beds (Willette & Ambrose, 2012), the long-term implications of the spread of *H. stipulacea* on commercial fisheries are relatively unknown and should be monitored. *H. stipulacea* could impact total ecosystem stability and resiliency by affecting not only fish, but marine turtles (Cassell et al. 2023; Johnson et al. 2019; Christianen et al. 2018) and invertebrates (Winters et al. 2020; Willette & Ambrose 2012). *H. stipulacea* can serve a similar ecological function to native seagrass by providing shelter for fish, despite exhibiting different densities and morphological characteristics. This study highlights the need for further research on the impacts of nonnative and invasive seagrasses on ecosystem functions and the effectiveness of seagrass restoration efforts.

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**For articles submitted in the domain of Health or the journals Frontiers in Physics and Frontiers in Applied Mathematics and Statistics please apply the Vancouver system for in-text citations.**

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# Supplementary Material

Supplementary Material should be uploaded separately on submission, if there are Supplementary Figures, please include the caption in the same file as the figure. Supplementary Material templates can be found in the Frontiers Word Templates file.

Please see the [Supplementary Material section of the Author guidelines](https://www.frontiersin.org/guidelines/author-guidelines#supplementary-material) for details on the different file types accepted.

# Data Availability Statement

The datasets [GENERATED/ANALYZED] for this study can be found in the [NAME OF REPOSITORY] [LINK]. Please see the “Availability of data” section of [Materials and data policies in the Author guidelines](https://www.frontiersin.org/guidelines/policies-and-publication-ethics#materials-and-data-policies) for more details.

1. For Original Research articles, please note that the Material and Methods section can be placed in any of the following ways: before Results, before Discussion or after Discussion. [↑](#footnote-ref-1)