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Fieldwork Statistics and Experimental Design Report

Module Code: JBIM002_A_1_202526

Date: 21/01/2026

Student ID No: 750035031

Effects of seagrass bed age and location sites on blade length in *Zostera marina*

Abstract

Blade length serves as important indicator of health and productivity in *Zostera marina*, however, influence of bed age on blade length is understudied. This study investigated whether blade length differs between *Z. marina* of different ages and site locations in Jersey coastal waters. Sampling was conducted via SCUBA diving transects across four seagrass meadows at two sites (St Catherines Bay and Anneport), with bed ages of 9 and 20 years at both sites. Blade length was measured from samples collected at randomly placed quadrats at each site. Results showed that seagrass beds of age 20 have significantly longer blades than 9-year-old beds, indicating age influences blade length. Additionally, sites differed significantly between blade lengths, with St Catherines Bay being longer at both age groups than Anneport, indicating for a site effect independent of age. These patterns from the results likely reflect age related improvements in nutrient accumulation and hydrodynamic conditions in older beds, as well as specific site difference in wave exposure and shelter due to St Catherines Bay protective breakwater. These findings highlight the importance of long-term protection of older seagrass beds and demonstrate that sheltered sites provide more favourable conditions for restoration efforts. Future research should incorporate younger age categories, site locations, and additional metrics to thoroughly assess seagrass health and inform management strategies for Jersey's ecologically important seagrass ecosystems.

1 Introduction

Seagrass beds are among the most important marine coastal ecosystems by providing important habitat for nurseries, shelter, and feeding grounds, which harbour many species of important

commercial value for fisheries (Jackson 2003; Jackson et al. 2001). Seagrass beds also important for nutrient cycling, providing organic matter to the ecosystem, and carbon storage, thus enhancing the health of the marine ecosystem (Jackson et al. 2001). In the UK, seagrass meadows are mostly dominated by *Zostera marina* (eelgrass), which support biodiversity by providing crucial ecological functions and structure for the ecosystem whilst also being an important indicator species of coastal health (Bertelli & Unsworth 2014; Boström et al. 2014). Blade length of seagrass is closely related to seagrass growth, productivity, and environmental conditions, and also can be an indicator of health through nutrient content (higher in longer blades) and disease (infected seagrass has shorter blades) (Fox et al. 2022; Graham et al. 2021). Shoot age has been shown to be an influence on blade growth, with older seagrass normally producing longer blades with increased photosynthetic capacity and available resources (Vermeer & Hunte 2008; Gaeckle et al. 2006). Blade length is commonly used as a metric for monitoring seagrass, however, variation in seagrass bed ages is not frequently accounted for within studies. Thus, making it challenging to distinguish between age related morphological differences. Hence, broadening the understanding of blade length variation among different age groups is important to improve the interpretation of seagrass monitoring and meadow assessments. Investigating the age-related variation in *Z. marina* blade lengths will help shed light on the extent to which morphological differences are reflective of demographic structure age or environmental health stressors. This information can be useful for management and conservation, as seagrass beds are vital for managing fish populations for Jersey fisheries. The aim of this study is to quantify differences in blade length among *Z. marina* beds of different ages and locations. The objectives are to compare blade length between 9-year-old vs 20-year-old seagrass beds and assess whether blade length differs between sites after accounting for age.

2 Methods

2.1 Study site

The sampling was carried out on four subtidal *Z. marina* meadows across two sites (St Catherine's Bay and Anneport) on the East coast of Jersey (Channel Islands) (Fig 1). St Catherine's Bay is the northernmost site and Anneport is the southernmost, with both sites having *Z. marina* meadows split between age categories of 9 years and 20 years (Fig 1). The age of the meadows was determined through a previous postgraduate study, which used aerial photography from regular photographs taken to map out the coverage of the seagrass beds. St Catherine's Bay features an artificial breakwater of over 700m in length (completed 1856) as seen in Figure 1, which protects the seagrass and Bay by providing shelter from stronger waves and wind (Dunn et al. 2024). Anneport seagrass beds are divided intertidally by a rocky outcrop, with more exposure to hydrodynamic mechanisms compared to St Catherine's Bay (Dunn et al. 2024).
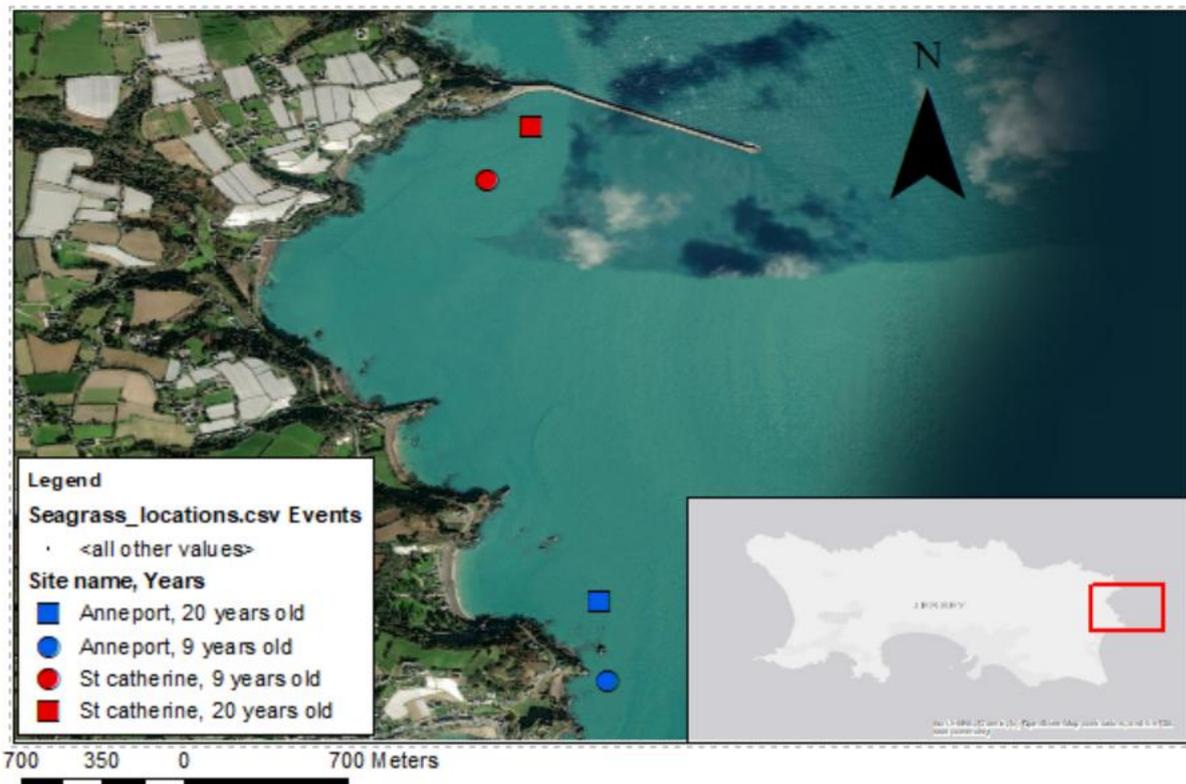

Figure 1 – *Study site map showing the locations of Zostera marina meadows sampled along the East coast, colours indicate different sites and shape correspond to age of seagrass bed. The map was created using ArcMap 10.8.2 (Esri 2021).*

2.2 Sampling

Sampling of the *Z. marina* meadows was undertaken through SCUBA diving in April 2021 to avoid data inconsistency from seasonal variance. Two 30m transects were conducted at each of the seagrass meadow sites, with $0.5m^2$ quadrats randomly placed (pre-determined by number generator) ten times along the transect. *Z. marina* samples were collected at every other quadrat interval from a smaller $0.25m^2$ quadrat from within the area, which helped preserve organic material and reduce disturbance to the seagrass bed. The blades were pulled through the quadrat then carefully dug out and placed into labelled bags for each sample. Back on the surface, the blades were rinsed to remove any sediment, then subsamples of five randomly selected plants from each sample and then the blade length was measured in mm.

2.3 Data analysis

The data analyses were carried out using R Studio version 4.5.2 (R Core Team 2025). Packages utilized include ggplot2, dplyr, and tidyverse to create visuals and carry out statistical tests.

For testing blade length and age, the null hypothesis is there will be no significant difference between blade lengths of different age groups. Before testing the difference between blade length and age groups, descriptive tests were undertaken to inform whether to use parametric or non-parametric tests. A t-test or Mann-Whitney will be carried out because of comparing two different groups. The Shapiro-Wilk test was carried out for testing normality, as t-test assumes for a normal distribution. As the sample size is fairly large (N>500 for both age groups), Q-Q plots were also used to help with the visualization and strengthening validity of the results. The Shapiro-Wilk tests compared blade length against age group of 20 years and blade length against age group of 9 years, as normality should be tested for different individual groups being compared. Both tests resulted in $p<0.05$ and indicating for a non-normal distribution, which was also visually supported by the Q-Q plots. Therefore, the normality

assumptions were not met and a non-parametric test, in this case a Mann-Whitney, was undertaken. A box plot was created to visually illustrate the raw data used for the Mann-Whitney (Fig 2).

To test blade length against location, the null hypothesis is that the blade lengths will not differ in seagrass beds at different site locations after accounting for age. To test the difference of blade lengths across different site locations with age accounted for, a General Linear Model (GLM) was carried out. Normality tests do not need to be undertaken, because GLMs do not assume normality distributed errors unless you choose a Gaussian GLM and the distribution types is specified by the model (Gamma in this case as continuous and skewed distribution). A GLM was used as it can analyse multiple predictors, and the predictor variables are more flexible in a GLM (handle both categorical and continuous). The raw data for the GLM was represented in a box plot (Fig 3).

3 Results

3.1 Results of blade length against age groups

From the Mann-Whitney U test used for blade length vs age, the results indicated a significant difference between sea grass blade lengths across different age groups of 9 years and 20 years (Mann-Whitney U test: W = 85215, df = 1122, $p<0.05$) (Fig 2). The blades of seagrass beds of age 20 years (mean = 78.5) were significantly larger than younger seagrass beds of age 9 years (mean = 53.1) (Fig 2). Thus, not conforming to the null hypothesis and suggesting that age has an influence over the length of seagrass blades.
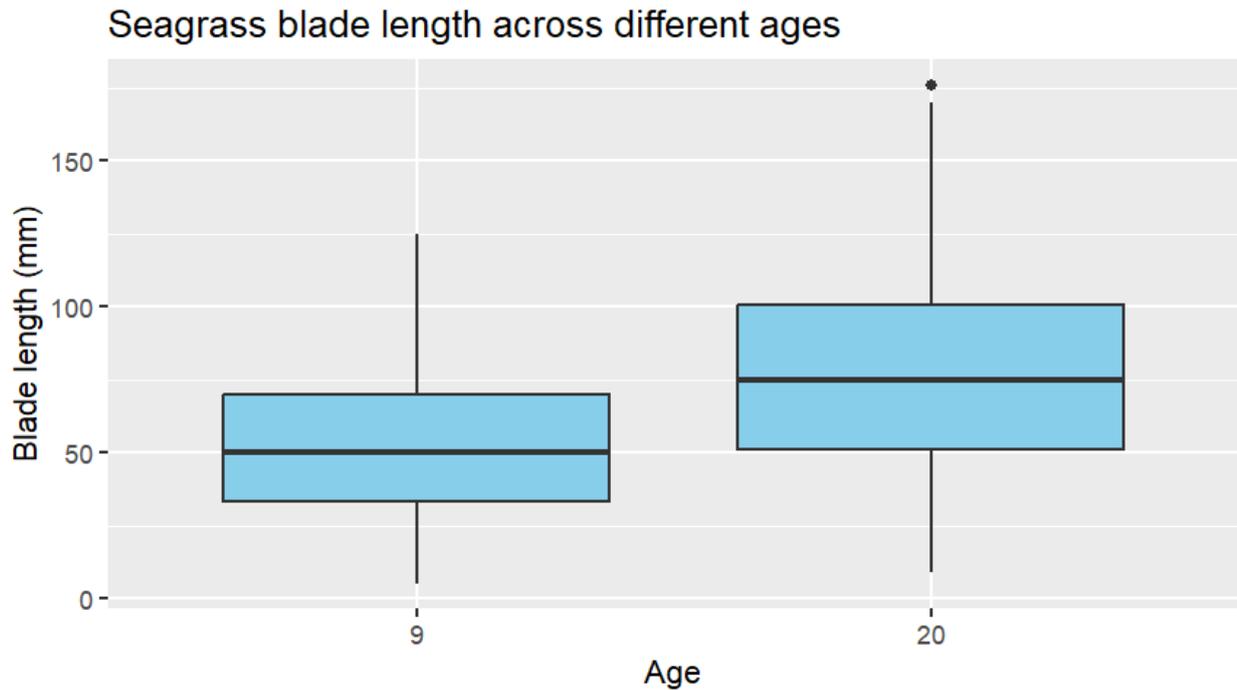
Figure 2 – *A box plot representing the difference in blade lengths (mm) across different age groups (9 and 20 years) in Z. marina.*

3.2 Results of blade length against location

The GLM used predicted the blade length using location and age, with results suggesting that location (β = -0.006, SE = 0.0005, t = -13.6, p<0.05) and age (β = -0.004, SE = 0.0004, t = -9.4, p<0.05) are significant predictors of *Z. marina* blade length (Fig 3). This result indicates that there is a significant difference of blade length between different sites and age groups, not conforming to the null alternative hypothesis (Anneport: age 9 Mean = 46, SD = 21.5, SE = 1.3, age 20 Mean = 56.2, SD = 23.2, SE = 1.7) (St Catherines: age 9 Mean = 63.7, SD = 27.1, SE = 2, age 20 Mean = 87.2, SD = 33.7, SE = 1.5) (Fig 3). Blade lengths for both ages 9 and 20 are higher at St Catherines Bay compared to Anneport (Fig 3), supporting the GLM results that location is significantly different. Therefore, blade length differed significantly among locations when seagrass beds were of the same age, indicating a site effect independent of age.
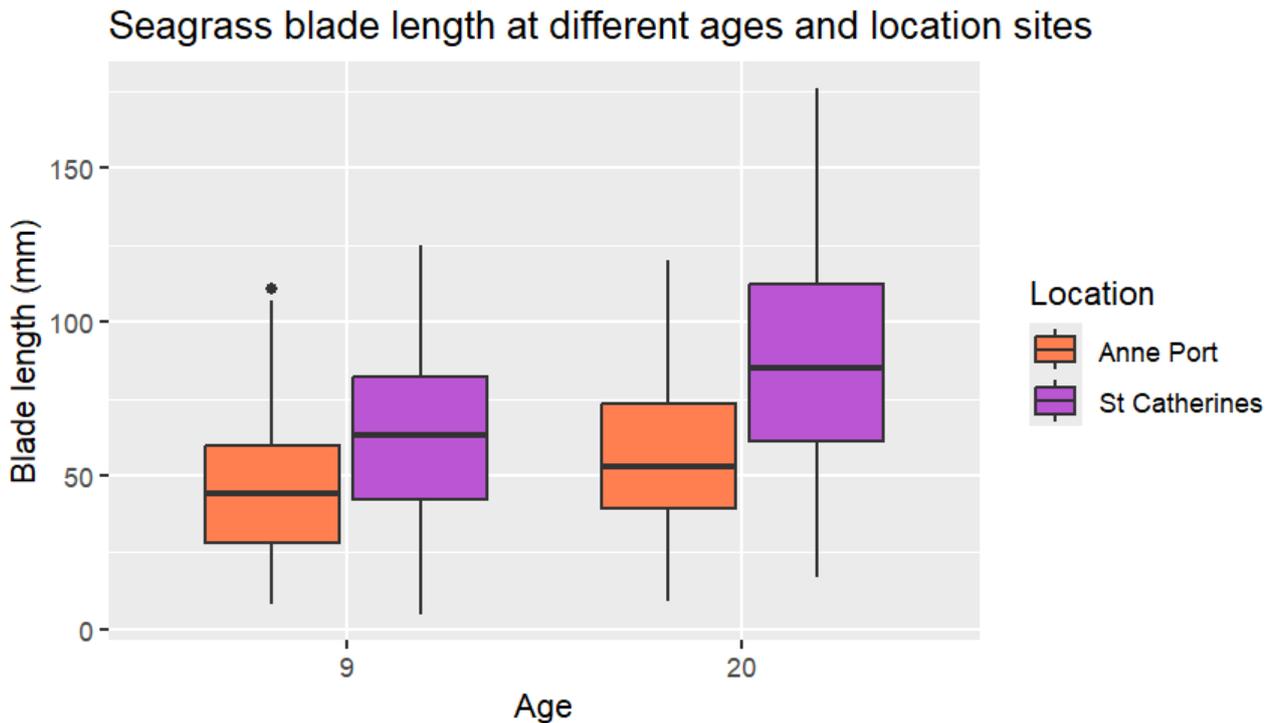
Figure 3 – A box plot illustrating the difference in Z. marina blade length (mm) between age groups (9 and 20 years) and site locations (Anneport and St Catherines). Colour represents the site locations, indicated by the legend.

4 Discussion

There was shown to be a significant difference between *Z. marina* blade lengths of different age groups, with older seagrass beds having longer blades. There have not been any specific studies that analyse the difference in blade length in *Z. marina* across age groups, which mostly compare seasonal differences across blade lengths (Fang et al. 2018). However, studies on *Z. marina* have implied that age does influence seagrass morphology and growth rates (Gaeckle et al. 2006). From this we can predict that older seagrass has longer blades, but there is not enough data to fully support this in *Z. marina*. A study on *Thalassia testudinum* (a tropical seagrass) in Barbados, found similar findings and showed that older leaves (blades) had larger maximum length compared to younger leaves with higher growth rates with increased age (Vermere and Hunter 2008). This supports that seagrass age does impact blade length and that older seagrass has longer blades. Even though this is a different species of seagrass, *Z. marina*

has been shown by this study's results to support this characteristic, therefore, it is likely following the same pattern.

A possible explanation could be related to sediment accumulation and nutrient availability, as seagrass beds tend to accumulate organic matter and fine sediments over time (Greiner et al. 2013). Sediment nutrient and carbon accumulation rates were shown to be higher in 10-year-old seagrass meadows compared to 4-year-old meadows in *Z. marina* (Greiner, et al. 2013). Therefore, older seagrass beds should create more nutrient rich substrates, increasing their carbon, nitrogen, and phosphorous accumulation rates (Miyajima et al. 1998), which increases their growth rates. A study on *Z. marina* has shown that blade length is positively correlated with sediment content and nutrient availability (Touchette & Burkholder 2000). This provides further support that the older seagrass beds have longer blade lengths, as age increases nutrient availability in the sediment and providing the ability to increase blade growth rates. However, keeping past studies conducted in mind, 10 years was considered to be old from Greiner et al (2013). This is a very similar age to the youngest category from this study (9 years), hence, could be a mature age. Therefore, it is difficult to distinguish between the 9 years and 20 years ages on whether there would be a difference between their sediment nutrient accumulation abilities, without further studies comparing different mature ages. Another possible explanation to the blade length difference between ages could be due to improved hydrodynamic conditions. As *Z. marina* seagrass beds mature, there is a progressive increase in shoot density and rhizome development (McGlathery et al. 2012), which creates more effective wave and current attenuation (Hansen & Reidenbach 2013). The improved hydrodynamic environment will reduce the mechanical stressors on the shoots, potentially allowing for more allocation of resources to increasing blade length rather than structural reinforcement or damage recovery. This could explain why 20-year blade lengths exceed that of 9 years, as they have had more time to accumulate better hydrodynamic conditions.

For the second result, there was shown to be significant difference between *Z. marina* blade lengths at different sites even when seagrass beds were the same age, with St Catherines Bay seagrass blades being longer at both ages compared to Anneport (Fig 3). Past studies on *Z. marina* have found similar results of differing blade lengths across different sites. For example, a study in Shandong Peninsula (China), showed that at the study site Mashanli *Z. marina* had smaller blade length compared to Moon Lake (Li et al. 2023). Another study along the coast of Nova Scotia (Canada) containing multiple sites (<10), with varying light and temperature regimes, showed differences in blade lengths across the sites (Wong & Dowd 2025). These studies show that it is common for seagrass beds at different locations to have differing blade lengths and supporting the results. However, the past studies show that there are varying explanations to why there is difference between sites, due to site physical characteristics and exposure to disturbance (Wong & Dowd 2025; Li et al. 2023). A likely explanation to the site location blade length difference, could be that St Catherines Bay has more shelter compared to Anneport. St Catherines Bay has a 700m breakwater, which protects the seagrass beds from stronger waves and wind, whereas Anneport is surrounded by rocky outcrop and exposed to stronger hydrodynamic mechanisms (Dunn et al. 2024). Therefore, the seagrass at Anneport needs to spend more resources and nutrients to recovering from damage and enhancing structural reinforcement from waves (Hansen & Reidenbach 2013). This would indicate for smaller blade lengths compared to St Catherines, as they can expend more resources on growing blade lengths, due to lack of wave pressure. This interpretation is consistent with studies like Li et al (2023), as the study site with smaller blades (Mashanli) was more wave exposed compared to the more sheltered site with longer blade lengths (Moon Lake), which parallels with St Catherines and Anneport findings, further supporting the possible explanation of the results. There are no studies that compare blade lengths with location sites that contain different age groups, so cannot distinguish whether it is also common for different locations

containing seagrass beds of varying age groups to show differing blade lengths. However, the results have indicated that age is not an influencing factor for the difference in blade lengths across sites, as the lengths were higher for both of St Catherines age groups, confirming that it must be an external factor (shelter).

These results have shown that carrying out blade length studies is important, as blade length (vital indicator) is useful in understanding seagrass bed development and identifying site specific environmental drivers. This data can be used to help with conservation and management applications, such as age dependent restoration targets. The seagrass beds have been shown to continue to develop after maturity, proving that mature seagrass beds need long term protection rather than short term protection, as many restoration projects are short term. The data can also be used for site selection for management and restoration, as sheltered sites support higher blades lengths and better growth conditions. Therefore, important for protection or restoration efforts, as they are likely to provide more ecosystem services for nursery habitats, fish biomass, and carbon sequestration. Furthermore, wave exposed sites will require additional interventions to achieve a comparable success. This data can be used for climate change resilience planning, as older beds may be more resilient due to enhanced sediment and wave attenuation capabilities. This can be used to plan management efforts for protecting the most vulnerable younger seagrass beds from degrading or potentially prioritising resilient beds, as they cannot not be replaced as quickly.

One of the limitations of this study is the limited number of age categories (9 and 20). These are both mature ages (compared to past studies), restricting the analysis against young and old as really none of the seagrass beds are truly immature. Therefore, incorporating more age categories (data on younger ages) will be beneficial to improve the analysis of young against old and provide more complete picture of development trajectory. Another limitation is the low number of site locations, restricting the generalization of the results. Incorporating more sites,

will help definitively attributing the difference of environmental variables and rule out confounding variables. Further studies on seasonal blade growth and change between age and sites would be beneficial, as this could analyse the potential impacts of weather and storms compared to sheltered and exposed sites. Analysing just blade length alone on age and location is not enough to explain overall productivity and health of the seagrass meadows. The seagrass in exposed sites is more likely develop greater biomass in rhizomes below ground to provide better anchoring and tolerate the disturbance (Hemminga and Duarte 2000). Therefore, including shoot density, below ground biomass, and other metrics will provide a more complete picture for analysing the difference in health across ages and locations.

5 Concluding remarks

This study demonstrates that both age and location significantly influence the blade length of *Z. marina* in Jersey waters. Older seagrass beds produced longer blades than younger seagrass beds, supporting that age related factors, such as improved nutrient accumulation, sediment conditions, and hydrodynamic stability, contribute to increased blade growth with time. St Catherines Bay supported longer blades compared to Anneport at both age categories, suggesting that site specific factors play a crucial role to blade length. This is likely reflective of the sheltered environment provided by St Catherines Bay breakwater, reducing the wave exposure and enabling more resource allocation to blade length rather than reinforcement from wave exposure. These findings can have important implications for conservation and restoration management in Jersey or globally. For example, long-term protection of mature meadows, as they continue to develop after maturity, and protection for sheltered habitats, due to having more favourable conditions for ecosystem services. Further research should include additional age categories and location sites, to reduce generalization, improve analysis between younger and old, and isolate specific environmental factors. Furthermore, integrating more metrics such as shoot density, biomass, and seasonal growth patterns would provide further

understanding of *Z. marina* health and productivity across ages and locations, supporting more

effective conservation strategies for Jersey's important seagrass ecosystems.

Acknowledgements

References

Bertelli, C. M. and Unsworth, R. K. 2014. "Protecting the hand that feeds us: Seagrass (*Zostera marina*) serves as commercial juvenile fish habitat." *Marine pollution bulletin* **83**: 425-429.

Boström, C., Baden, S., Bockelmann, A. C., Dromph, K., Fredriksen, S., Gustafsson, C., Krause-Jensen, D., Möller, T., Nielsen, S. L., Olesen, B. and Olsen, J. 2014. "Distribution, structure and function of Nordic eelgrass (*Zostera marina*) ecosystems: implications for coastal management and conservation." *Aquatic conservation: marine and freshwater ecosystems* **24**: 410-434.

Dunn, K., Blampied, S. and Bennet-Jones, L. 2024. *Jersey Seagrass Report*. Available from: file:///C:/Users/Nathan%20Mcclements/Downloads/Jersey%20Seagrass%20Report%202024.pdf [Accessed: 18/12/2025].

Esri 2021. ArcGIS Desktop: ArcMap *(Version 10.8.2)* [Computer software]. Redlands, CA: Environmental Systems Research Institute (Esri).

Fang, C., Zhang, P., Wang, X., Zhao, J. and Li, W. 2018. "Seasonal variation in leaf age structure of the Eelgrass *Zostera marina* on the eastern coast of the Shandong Peninsula, China." *Aquatic Ecosystem Health & Management* **21**: 70-81.

Fox, E., Evans, A. J., Furness, E., Jones, B. and Unsworth, R. K. F. 2022. *AN ASSESSMENT OF SEAGRASS (ZOSTERA MARINA) HEALTH IN SOUTH ENGLAND IN RELATION TO WATER QUALITY NUTRIENTS.* Report for Natural England and WWF, UK.

Gaeckle, J. L., Short, F. T., Ibarra-Obando, S. E. and Meling-López, A. E. 2006. "Sheath length as a monitoring tool for calculating leaf growth in eelgrass (*Zostera marina L.*)." *Aquatic Botany* **84**: 226-232.

Graham, O. J., Aoki, L. R., Stephens, T., Stokes, J., Dayal, S., Rappazzo, B., Gomes, C. P. and Harvell, C. D. 2021. "Effects of seagrass wasting disease on eelgrass growth and belowground sugar in natural meadows." *Frontiers in Marine Science* **8**: 768668.

Greiner, J. T., McGlathery, K. J., Gunnell, J. and McKee, B. A. 2013. "Seagrass restoration enhances "blue carbon" sequestration in coastal waters." *PloS one* **8**: 72469.

Hansen, J. C. and Reidenbach, M. A. 2013. "Seasonal growth and senescence of a *Zostera marina* seagrass meadow alters wave-dominated flow and sediment suspension within a coastal bay." *Estuaries and coasts* **36**: 1099-1114.

Hemminga, M. A. and Duarte, C. M. 2000. *Seagrass ecology*. Cambridge University Press.

Jackson, E.L. 2003. *Importance of seagrass beds as a habitat for fishery species around Jersey* Thesis. University of Plymouth. Available at: http://dx.doi.org/10.24382/3262 [Accessed: 17/12/2025].

Jackson, E. L., Rowden, A. A., Attrill, M. J., Bossey, S. J. and Jones, M. B. 2001 "The importance of seagrass beds as a habitat for fishery species." *Oceanography and marine biology* **39**: 269-304.

Li, W. T., Liang, N., Zhan, J., Wang, H. and Zhang, P. 2023. "Morphological and anatomical characteristics of eelgrass *Zostera marina L.* at two distinct environments of Shandong

Peninsula, China: An implication of adaptation strategy of seagrasses." *Aquatic Botany* **186**: 103612.

McGlathery, K. J., Reynolds, L. K., Cole, L. W., Orth, R. J., Marion, S. R. and Schwarzschild, A. 2012. "Recovery trajectories during state change from bare sediment to eelgrass dominance." *Marine Ecology Progress Series* **448**: 209-221.

Miyajima, T., Koike, I., Yamano, H. and Iizumi, H. 1998. "Accumulation and transport of seagrass-derived organic matter in reef flat sediment of Green Island, Great Barrier Reef." *Marine Ecology Progress Series* **175**: 251-259.

R Core Team, 2025. *R: A language and environment for statistical computing (Version 4.5.2)* [Computer software]. R Foundation for Statistical Computing. https://www.R-project.org/

Touchette, B. W. and Burkholder, J. M. 2000 "Overview of the physiological ecology of carbon metabolism in seagrasses." *Journal of experimental marine biology and ecology* **250**: 169-205.

Vermeer, L. A. and Hunte, W. 2008. "Effects of shoot age on leaf growth in the seagrass *Thalassia testudinum* in Barbados." *Aquatic Biology* **2**: 153-160.

Wong, M. C. and Dowd, M. 2025. "Eelgrass (*Zostera marina*) Trait Variation Across Varying Temperature-Light Regimes." *Estuaries and Coasts* **48**: 13.

Appendix
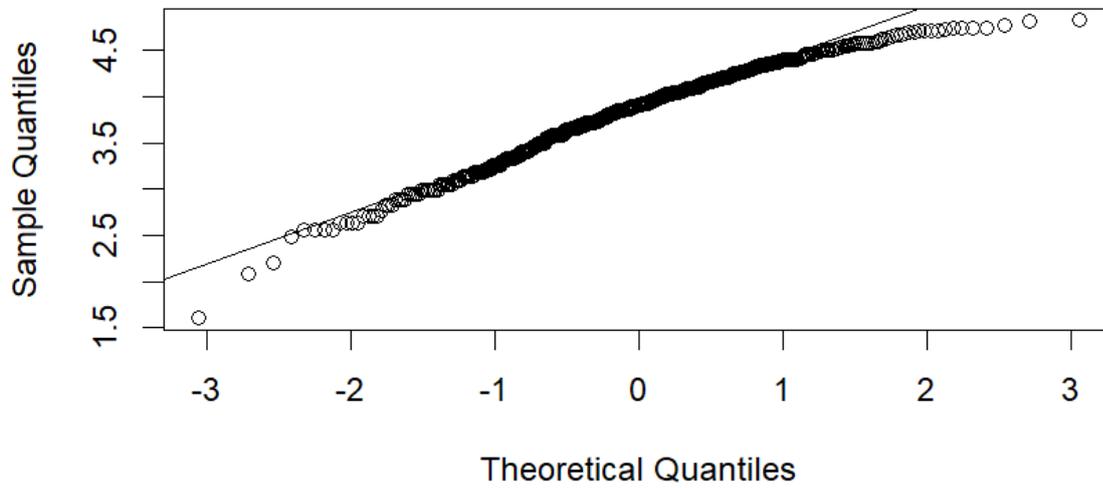

Q-Q Plot of log-transformed blade length (mm) of age 9

Figure A1 – Quartile-Quartile plot of log transformed blade length of ages 9.

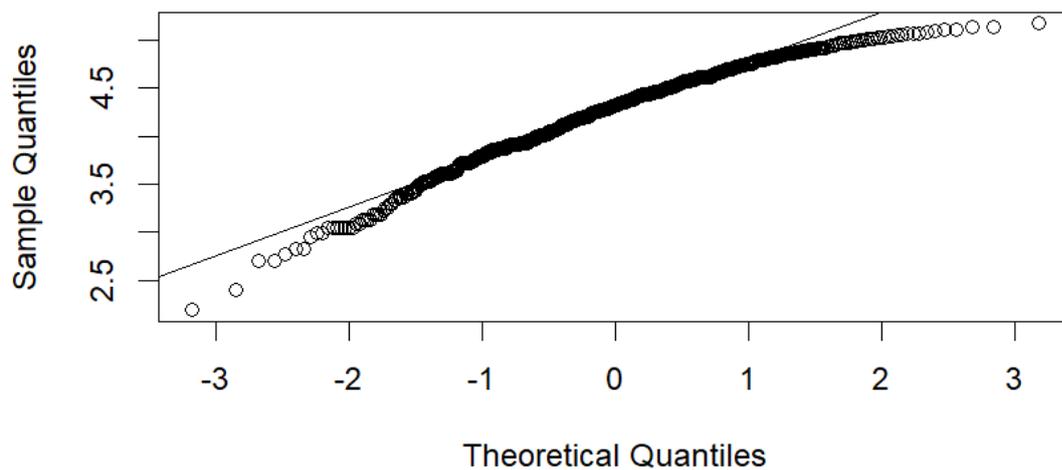**Q-Q Plot of log-transformed blade length (mm) of age 20 yea**

Figure A2 – Quartile-Quartile plot of log transformed blade length of ages 20.

Table A1 – Shapiro-Wilk test outputs from blade length as function of age.

Shapiro-Wilk test	W	p-value
Blade length vs ages 9	0.96953	0.00000004909
Blade length vs ages 20	0.97941	0.00000003901

R code

```
library(dplyr)

library(tidyverse)

library(ggplot2)


Bladelength <- read_csv("Data input/Seagrass_Blade_Lengths.csv") %>%

  dplyr::mutate(Location=if_else(Location=="Petit Port", "Anne Port", Location)) %>%

  dplyr::mutate(Location=if_else(Location=="Anne Port", "Anne Port", Location))
#Standardise location names to avoid duplicate factor levels


#Extract year from date for temporal analysis

Bladelength$Year <- format(as.Date(Bladelength$Date, format="%d/%m/%Y"), "%Y")


#Convert categorical predictors to factors

Bladelength$Age<-as.factor(Bladelength$Age)


(plot1<-ggplot()+

  geom_boxplot(data=Bladelength, mapping=aes(x=Age, y=Blade_length), fill =
"skyblue") +

  labs(x="Age", y="Blade length (mm)", title="Seagrass blade length across different
ages"))


Bladelength$Year<-as.integer(Bladelength$Year)


shapiro.test(Bladelength$Blade_length)
```

```
#Compare youngest and oldest cohorts

Subsetold <- subset(Bladelength, Bladelength$Age=="20")

Subsetyoung <- subset(Bladelength, Bladelength$Age=="9")

shapiro.test(Subsetold$Blade_length)

qqnorm(log(Subsetold$Blade_length), main = "Q-Q Plot of log-transformed blade length
(mm) of age 20")

qqline(log(Subsetold$Blade_length))

shapiro.test(Subsetyoung$Blade_length)

qqnorm(log(Subsetyoung$Blade_length), main = "Q-Q Plot of log-transformed blade
length (mm) of age 9")

qqline(log(Subsetyoung$Blade_length))


wilcox.test(Bladelength$Blade_length ~ Bladelength$Age)

length(Bladelength$Blade_length)

mean(Subsetold$Blade_length)

mean(Subsetyoung$Blade_length)


#Fit candidate Gamma GLMs appropriate for positive continuous response data

GLM1 <- glm(Blade_length~Location*Age, family="Gamma", data=Bladelength)

GLM2 <- glm(Blade_length~Age+Location, family="Gamma", data=Bladelength)

GLM3 <- glm(Blade_length~Location+1, family="Gamma", data=Bladelength)

GLM4 <- glm(Blade_length~Age+1, family="Gamma", data=Bladelength)

GLM5 <- glm(Blade_length~1, family="Gamma", data=Bladelength)


#Compare candidate models using AIC

AIC(GLM1, GLM2, GLM3, GLM4, GLM5)

# GLM2 was best fitting


#Evaluate model assumptions

plot(fitted(GLM2), resid(GLM2)) #Check for Nonlinearity
```

```
qqnorm(resid(GLM2)) #Assess whether residuals are approximately normally
distributed

qqline(resid(GLM2))

hist(resid(GLM2))

acf(resid(GLM2)) #Check for autocorrelation in residuals


options(scipen=1000000000)

GLM_df <- as.data.frame(summary(GLM2)$coefficients)


(plot2<-ggplot()+

  geom_boxplot(data=Bladelength, mapping=aes(x=Age, y=Blade_length, fill=Location))
+

  labs(x="Age", y="Blade length (mm)", title="Seagrass blade length at different ages and
location sites")) +

 scale_fill_manual(values = c("coral", "mediumorchid"))


SD <- Bladelength %>%

 dplyr::group_by(Location,Age) %>%

 summarise(Mean=mean(Blade_length),

      SD=sd(Blade_length),

      SE=(sd(Blade_length)/sqrt(length(Blade_length))))
```