JERSEY SEAGRASS REPORT

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EXECUTIVE SUMMARY

This report reviews seagrass biology, ecology, and global status before focusing on seagrass meadows around Jersey, Channel Islands, highlighting their distribution, biodiversity, health, and carbon storage capacity. Seagrass ecosystems support marine biodiversity, coastal protection, and climate change mitigation. However, Jersey's seagrass habitats have shown significant changes in recent years, reflecting both their ecological importance and the pressures they face.

Mapping efforts using aerial photographs reveal seagrass distribution and extent along Jersey's coast, notably in St Aubin's Bay, Grouville Bay, and St Catherine's Bay, and offshore at Les Minquiers and Les Écréhous. Historical and current data reviewed in this report reveal both expansion and contraction of seagrass meadows over different time periods.

Jersey's seagrass meadows are critical for biodiversity, providing habitats for commercially important species and contributing to blue carbon. However, the health of these meadows varies, with some areas showing signs of stress due to pollution, declining water quality, and coastal activities. Many research studies have been carried out on Jersey's seagrass habitats over the past couple of decades with various focuses including but not limited to:

- Biodiversity
- Distribution and extent
- Impact of pollution
- Fisheries value
- Carbon storage

This report summarises all the local research on seagrass and brings together the key findings, identifying critical knowledge gaps and proposing directions for future research.

This report highlights the recent expansion of seagrass meadows, likely due to natural regeneration and local conservation efforts. While this expansion is promising, further research is needed to understand the impact of human activities–such as coastal development, anchoring, and pollution–on these habitats. The future health and extent of Jersey's seagrass meadows remains uncertain. A clearer understanding of what constitutes a "healthy" seagrass meadow in Jersey is essential for effective management and conservation. While biodiversity assessments show that seagrass supports diverse species, there is limited knowledge of the trophic networks and the long-term changes in species composition, especially for populations dependent on seagrass for critical life stages. Additionally, while current data highlights the significant role of Jersey's seagrass beds as carbon sinks, more research is needed to assess their carbon sequestration potential fully.

This report synthesises current research on Jersey's seagrass, emphasising the need to protect these habitats to enhance their contribution to biodiversity, fisheries, and climate resilience. It stresses the importance of integrating seagrass conservation into broader marine spatial planning. Despite protections from mobile fishing gears, areas of high human activity overlap with these key habitats. Improved management of water quality, anchoring, and development is necessary to sustain seagrass expansion and long-term ecosystem health. By addressing knowledge gaps through research and adaptive management, Jersey can continue to protect and expand its seagrass meadows, which provide vital ecosystem services.

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1 INTRODUCTION

1.1 WHAT IS SEAGRASS?

Submerged within sheltered coastal waters, seagrasses comprise an important part of our coastal seascape but are widely overlooked (United Nations Environment Programme, 2020). Best known for forming vast green blankets of seabed known as 'meadows', seagrass is a key foundation species of significant ecological value.

Seagrasses are a group of flowering plants uniquely adapted to life in saltwater. Having developed novel adaptations, including submarine pollination, internal gas transport and marine dispersal (Orth *et al.*, 2006), seagrasses have achieved the extraordinary evolutionary feat of returning to life underwater (Les, Cleland and Waycott, 1997). Seagrass plants consist of a root system and rhizome topped with shoots (known as leaves or blades) and can produce flowers and seeds (Figure 1) (Hemminga and Duarte, 2000c; Unsworth, 2021). The rhizome is the underground stem produced by seagrass, which grows vertically or horizontally and is responsible for the extension of the plant into its surroundings.

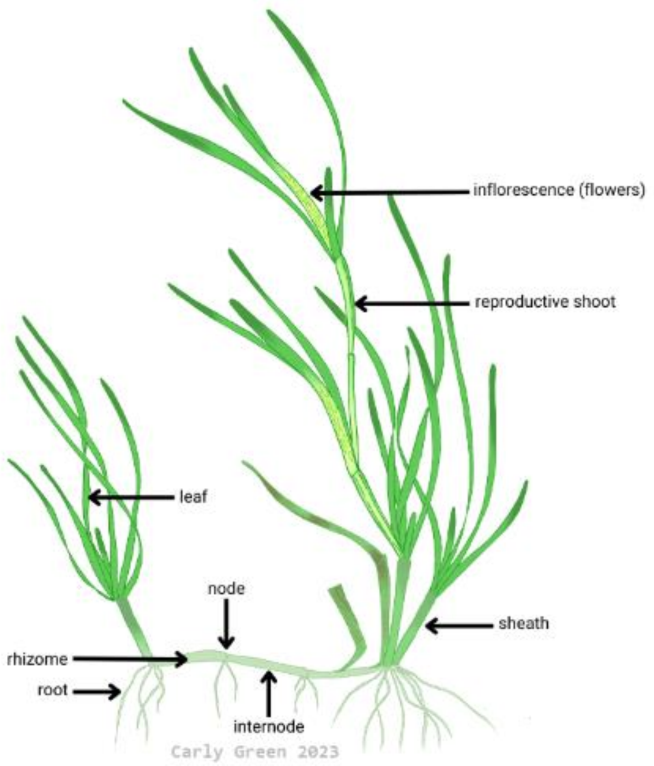


Figure 1 - Image of seagrass structure. Taken from https://www.projectseagrass.org/why-seagrass/.

Seagrasses can reproduce sexually (via pollination) and asexually (via drifting rhizome fragments) (Hemminga and Duarte, 2000b). Like terrestrial grasses, seagrasses enlist the help of seed dispersers and pollinators for submarine reproduction, including fish (McMahon *et al.*, 2014) and crustaceans (van Tussenbroek *et al.*, 2016). Seagrass spread clonally via its rhizomes, with one bed of seagrass *Zostera marina* in the Baltic Sea thought to be over 1000 years old, having sustained itself through cloning (Reusch *et al.*, 1999). Cloning allows not only exceedingly old beds but also exceptionally large ones. In Western Australia, one genetically identical seagrass bed extends over 180 km in area, gaining it the title of the 'largest plant in the world' (Edgeloe *et al.*, 2022).

Seagrasses are distinctly different to seaweeds (macroalgae), having descended from a single monocot[i] ancestor between 70 and 100 million years ago (Les, Cleland and Waycott, 1997), meaning seagrasses are more closely related to terrestrial plants than seaweeds. Today, three seagrass lineages exist (Hydrocharitaceae, Cymodoceaceae complex, and Zosteraceae) (Les, Cleland and Waycott, 1997), with just over 70 species globally (Short *et al.*, 2011). This group boasts a resilience that has allowed them to colonise coastal waters worldwide despite their relatively low taxonomic diversity (Orth *et al.*, 2006). Seagrasses can be found along the coast of six continents and 159 countries but are absent from the earth's most polar seas (Figure 2) (Orth *et al.*, 2006).

Seagrasses have devised ingenious solutions to the challenges posed by life underwater. Yet, they are not undemanding, requiring one of the highest light levels of any plant group (Orth *et al.*, 2006). Being limited by light, seagrasses colonise soft substrates (sand, mud, and cobbles) in the intertidal and shallow subtidal zones, where around 11% of surface light reaches the seafloor (Duarte, 1991). Seagrasses are resourceful, playing host to nitrogen-fixing bacteria, allowing them to survive in nitrogen-poor environments (Mohr *et al.*, 2021). They typically settle in sheltered areas away from thrashing waves and harsh currents (Koch *et al.*, 2006). Despite these specificities, all species act as 'ecosystem engineers', transforming coastal sediments into green meadows.

[i] Monocot is a commonly used term for monocotyledons, one of the two major groups separating flowering plants (angiosperms).

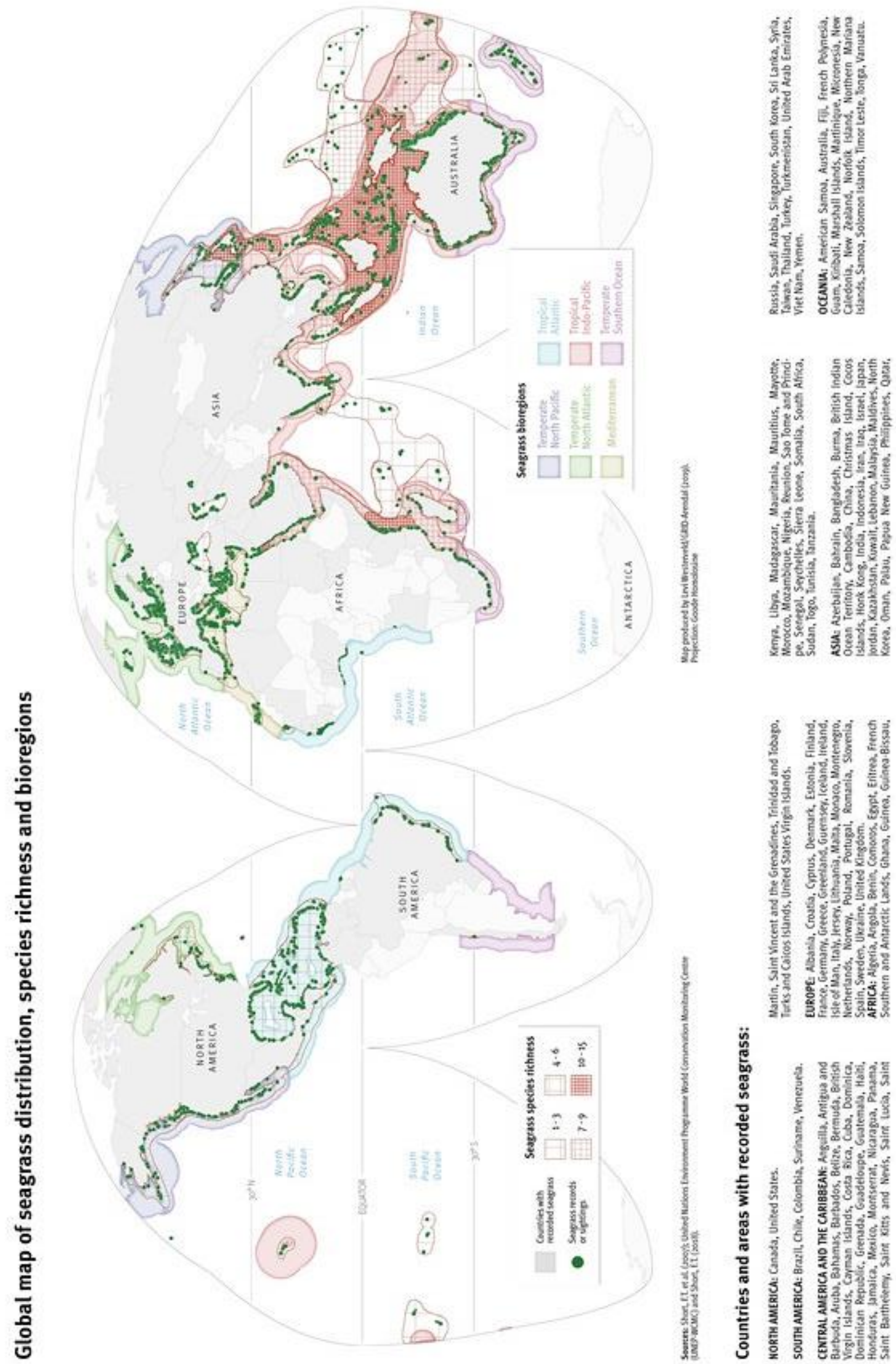


Figure 2 - Map of the global distribution of seagrass. Taken from United Nations Environment Programme (2020)

1.2 IMPORTANCE OF SEAGRASS

The individual characteristics of seagrass species vary significantly (Nordlund *et al.*, 2016) as they are adapted to different geographical regions. Seagrass leaves can extend metres above the seafloor, forming a forest-like canopy, whilst others creep just above the sediment, creating a carpet-like appearance (Nordlund *et al.*, 2016). Beneath the sediment, the roots and rhizomes of different species descend to various depths (Nordlund *et al.*, 2016). This means that around the globe, seagrasses have differing impacts on their surrounding environment. However, all seagrasses are commended as "ecosystem engineers" in that they influence their surrounding environment (Orth *et al.*, 2006). They play an essential role in habitat creation, boosting biodiversity, providing coastal protection, mitigating climate change, and promoting the health and functioning of the surrounding ecosystem (Figure 3) (McKenzie *et al.*, 2021; Unsworth, 2021). Further, seagrass provides support to fisheries and can be of cultural importance to coastal communities. One investigation counted at least 28 ecosystem services[ii] provided by seagrasses worldwide (Nordlund *et al.*, 2016).

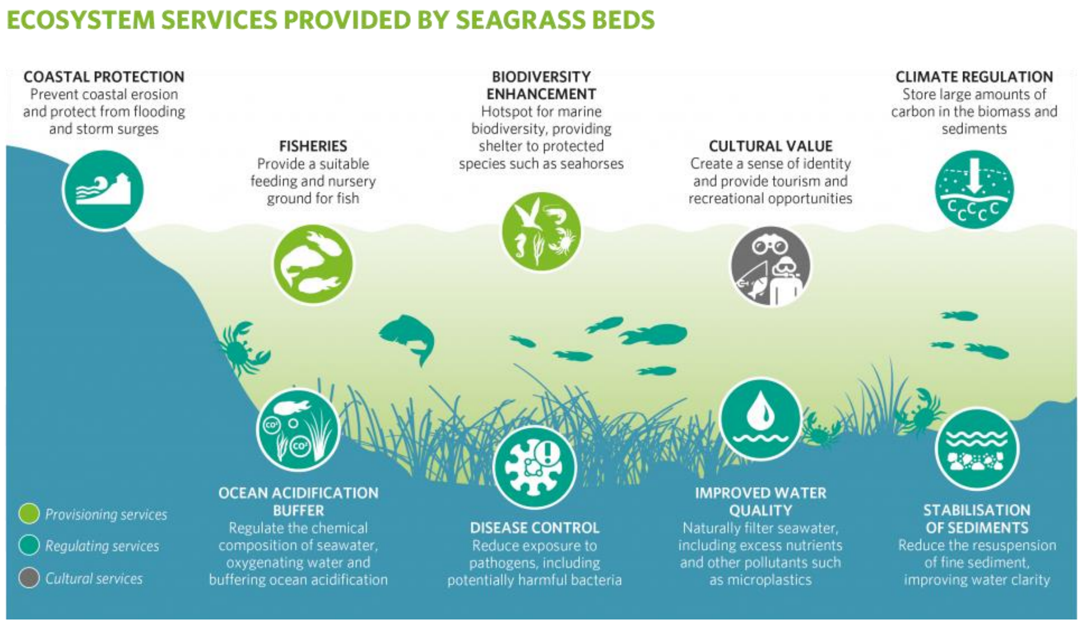


Figure 3 - Important ecosystem services provided by seagrass. Taken from Gamble et al. (2021)

[ii] Ecosystem services are defined as 'the direct and indirect contributions of ecosystems to human wellbeing, and impact our survival and quality of life'. Unsworth, R., Butterworth, Freeman, Fox, Priscott. (2021) The ecosystem service role of UK Seagrass meadows: Project Seagrass. Available at: https://www.projectseagrass.org/wp-content/uploads/2022/06/ES-of-UK-seagrass-Unsworth-et-al.pdf.

1.2.1 HABITAT CREATION AND BIODIVERSITY SUPPORT

Seagrasses create biogenic[iii] habitats (Unsworth, 2021), increasing environmental complexity (Smale *et al.*, 2019) and supporting diverse marine life. These habitats serve as permanent homes, nurseries, feeding grounds, and temporary shelters for various species (Jackson *et al.*, 2001), making seagrass meadows global biodiversity hotspots (United Nations Environment Programme, 2020) (Jackson et al., 2001; United Nations Environment Programme, 2020).

Compared to adjacent unvegetated sediment, studies unanimously report that seagrass beds house significantly more individual animals and a wider variety of species (Hemminga and Duarte, 2000a). Further, the community structure between seagrass beds of the same seagrass species can differ wildly, meaning no two beds are the same (Hemminga and Duarte, 2000a). This can be attributed to various factors, including variability in environmental conditions, species characteristics, and seascape variability. Many species only spend a short period of their lifecycle inhabiting seagrass, so considerable changes occur as generations come and go (Hemminga and Duarte, 2000a).

The complexity of seagrass habitats creates new niches for life to thrive (Boyé *et al.*, 2017). For invertebrate infauna[iv] communities, seagrass oxygenates the sediment during photosynthesis, creating an ideal home environment (Brodersen *et al.*, 2018). Epifauna[v] and epibenthic[vi] species benefit from the diverse food sources and shelter (Unsworth, 2021; Hemminga and Duarte, 2000a). Seagrass beds facilitate trophic interactions, with small fish preying on lower food web species whilst they act as prey for larger fish (Hemminga and Duarte, 2000a).

1.2.1.1 SUPPORT FOR CHARISMATIC SPECIES

Given the habitat creation and biodiversity support provided by seagrass meadows, many species above and below the water benefit from their existence. In some cases, this benefit is directly linked to the survival of a species. This is well documented in the case of the dugong (*Dugong dugon*), the world's only herbivorous marine mammal that relies on seagrass as a food source (The Dugong and Seagrass Conservation Project., 2024). This species has a slow reproduction rate and is threatened by many

[iii] Biogenic habitats are those created by plants and animals.

[iv] Infauna are animal species living within the sediment.

[v] Epifauna species are those living attached to the seabed or attached to submerged objects (in this case, seagrass leaves).

[vi] Epibenthic species are larger mobile animals associated with the seagrass bed, e.g. fishes.

human activities, including habitat destruction. Therefore, Dugongs are vulnerable to extinction (per IUCN Red List (IUCN, 2024)). Similarly, the survival of green turtles (*Chelonia mydas*) is intrinsically linked with seagrass habitats (Figure 4). In the Central South Pacific, it is reported that over half the adult green turtle population migrates over 1600 km to Fiji to forage in the seagrass beds (Craig *et al.*, 2004). This makes seagrass in Fiji a regionally critical resource for green turtles in the South Pacific, vital to their reproductive success and the longevity of the turtles in this area.

Birds are often overlooked in connection with seagrass habitats despite considerable support for bird conservation (Unsworth, 2021), their direct link with coastal ecological processes, and cultural significance (Signa, Mazzola and Vizzini, 2021). In the UK, seagrass is a significant dietary component of brent geese (*Branta bernicla*), mute swans (*Cygnus olor*), and whooper swans (*Cygnus cygnus*) (Unsworth, 2021). Further, wigeon (*Anas Penelope*) and teal (*Anas crecca*) are known to consume seagrass. Declines in seagrass in Nova Scotia, Canada, were directly linked to a 50% reduction in the abundance of Canada geese (*Branta canadensis*) (Seymour, Miller and Garbary, 2002). Many more seabird species rely on seagrass habitats as a foraging ground for fish, with species including cormorants and herons hunting within meadows (Huang, Essak and O'Connor, 2015).

Figure 4 – Green turtle over seagrass, Martinique. Credit: Michele Roux / Ocean Image Bank

A final charismatic species of note is the seahorse. In the UK, both the spiny seahorse (*Hippocampus guttulatus*) and short-snouted seahorse (*Hippocampus hippocampus*) are documented to live in seagrass meadows. A study in Studland Bay suggested that these species have a home range of 30– 400 m^2 within a 500,000 m^2 meadow (Garrick-Maidment *et al.*, 2011). The short-snouted seahorse is primarily associated with seagrass habitats and is listed as an OSPAR priority species. The degradation of this meadow by boat moorings was highlighted as a cause for concern for the resident short-snouted seahorse (Garrick-Maidment *et al.*, 2011).

1.2.2 COASTAL PROTECTION

As a foundation species (Potouroglou *et al.*, 2017), seagrasses support coastal ecosystems by profoundly impacting their physical and chemical qualities (Orth *et al.*, 2006) and providing 'regulating services' to their surroundings (Unsworth, 2021). Seagrass beds are renowned for providing natural coastal protection, dissipating the energy of waves (Ondiviela *et al.*, 2013) and consequently reducing coastal erosion. Further, seagrass blades reduce the velocity of water travelling in one direction, such as in flooding events, reducing their impact (Ondiviela *et al.*, 2013). Protection from extreme events, such as flooding and storm surges (United Nations Environment Programme, 2020), is of growing importance as coastal communities deal with the consequences of a changing climate. The shoots of seagrass act as a net, catching free-floating sediment from the water column and channelling it down to the seafloor, where it is consolidated and secured by the root system (Potouroglou *et al.*, 2017). This facilitates the stabilisation of the sediment and elevates the seafloor, further increasing coastal protection.

1.2.3 CLIMATE CHANGE MITIGATION

1.2.3.1 BLUE CARBON

Seagrass ecosystems are global hotspots for carbon sequestration (Duarte, Middelburg and Caraco, 2005). Through photosynthesis, seagrasses capture sunlight using chlorophyll pigments to convert CO_2 dissolved in the seawater into organic compounds like sugars (Barbier *et al.*, 2011). These sugars are used to form tissues, such as leaves and roots, thus storing the carbon in the process. As the plant grows, its capacity to extract and store carbon increases.

Seagrass stores carbon in its shoots and leaves (above-ground) and roots and rhizomes (below-ground). However, the rhizomes and roots of seagrasses also play a critical role in trapping and stabilising other carbon in the sediment around the plant. This includes the organic matter of the seagrass itself, including dead leaves and detritus from other sources, such as animal remains. The sediments supported by seagrass are predominantly anaerobic, allowing carbon to be stored over millennia (Fourqurean *et al.*, 2012).

About half of the total carbon buried in the ocean is estimated to be from detritus burial in vegetated coastal habitats (Duarte, Middelburg and Caraco, 2005). Quantifying the global carbon sequestration by seagrass is challenging due to limited estimates of the global coverage of seagrass (Unsworth *et al.*, 2022). Sequestration rates vary among seagrass species due to their different life histories (Unsworth, 2021). However, estimates suggest up to 19.8 Pg (19.8 billion tonnes of carbon) of carbon could be stored in seagrass meadows globally (Fourqurean *et al.*, 2012), equivalent to around 48 years of the total UK carbon emissions (at the 2023 rate) (Office for National Statistics, 2023).

The largest documented seagrass meadow (made up of *Thalassia testudinum* and *Syringodium filiforme*) is in the Bahamas, covers 66,990–92,524 km^2, and is estimated to hold 424–586 Tg (424–586 million tonnes) of organic carbon within the top meter of sediment, sequestering an additional 2.1–2.9 Tg (2.1–2.9 million tonnes) per year (Fu *et al.*, 2023). Estimates for the carbon storage capacity of *Zostera marina* in the northern hemisphere vary from 318 g C/m^2 to 26,523 g C/m^2, with variation attributed to sediment and environmental variables (Röhr *et al.*, 2018). Globally, seagrass meadows are estimated to sequester 27.4 Tg (27.4 million tonnes) per year, roughly 10% of the total carbon buried in ocean sediments yearly (Duarte, Middelburg and Caraco, 2005). The potential restoration area for seagrasses has been estimated at 830,000–2,540,000 km^2 (Macreadie *et al.*, 2021). Increasing recording and mapping of existing seagrass coverage suggests significant potential for seagrass in combating climate change.

1.2.3.2 OCEAN ACIDIFICATION BUFFERING

Seagrass provides more than blue carbon storage for climate change mitigation. As global CO_2 levels rise, the ocean absorbs more carbon from the atmosphere, causing ocean acidification globally (Figure 5). Since the Industrial Revolution, ocean surface pH has dropped by 0.1 (Caldeira and Wickett, 2003), significantly impacting marine life by decreasing growth, development, calcification[vii], overall survival, and abundance (Kroeker *et al.*, 2013). Seagrass helps counteract this by releasing oxygen into the seawater during photosynthesis (United Nations Environment Programme, 2020). Oxygenation of seawater can reduce acidification as the oxygen reacts with molecules in the water, including CO_2, forming less acidic compounds. Worldwide, evidence shows that pH in seagrass ecosystems is higher (less acidic) than in adjacent non-vegetated areas (Ricart *et al.*, 2021).

[vii] Calcification is the process some marine organisms use (e.g. oysters) to form shells and bones from calcium carbonate found in seawater.

The sequestering of carbon and oxygenation of seawater, along with the coastal protection and sediment stabilisation provided by seagrass, enable these ecosystems to mitigate climate change while naturally adapting to its challenges (Duarte *et al.*, 2013).

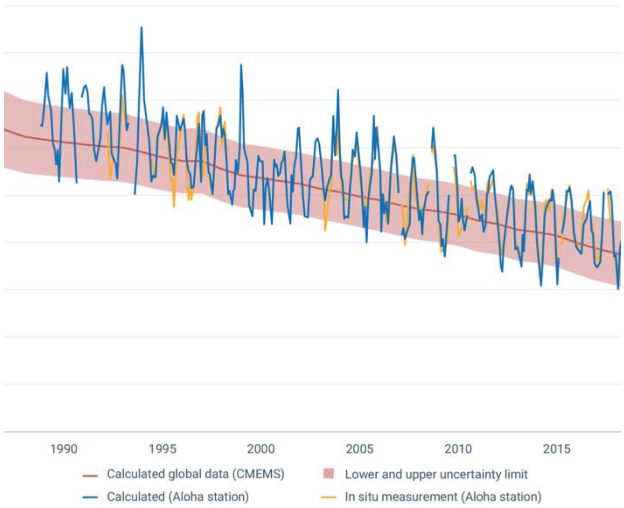


Figure 5 - Decline in ocean pH measured at the Aloha station and yearly mean surface seawater pH reported on a global scale. EEA (2022)

1.2.4 PROMOTION OF ECOSYSTEM HEALTH AND FUNCTIONING

Seagrass not only creates habitats, supports biodiversity, and mitigates climate change but also enhances the health and functioning of its surrounding ecosystem. Additionally, as seagrasses are acutely receptive to environmental influences, they can be used as environmental indicators (Orth *et al.*, 2006).

One key way seagrasses promote ecosystem health is through water filtration (Unsworth *et al.*, 2022). They trap natural sediments and anthropogenic particles like microplastics and remove excess nutrients such as nitrogen and phosphorous, thereby improving water quality (Unsworth *et al.*, 2022; United Nations Environment Programme, 2020; Unsworth, 2021). Effective filtration by seagrass helps prevent eutrophication and algal blooms (Unsworth, 2021). However, when the balance is tipped too far (e.g. when excessive nitrogen is present), seagrass health will degrade, indicating poor environmental conditions (Short and Short, 1984).

Seagrasses also filter pathogens, including bacteria and viruses (Unsworth *et al.*, 2022). In Indonesia, seagrasses reduce the occurrences of pathogenic marine bacteria by 50% (Lamb *et al.*, 2017), mitigating diseases in humans, fish, and corals (United Nations Environment Programme, 2020). In the Baltic Sea, seagrass meadows contain 63% fewer *Vibrio* bacteria species (associated with cholera) than non-vegetated areas (Reusch *et al.*, 2021). Thus, seagrasses play a crucial role in maintaining ecosystem and human health.

However, seagrass is not the only essential coastal habitat, so considering seagrass within the context of the seascape[viii] is crucial. The services provided by seagrass are enhanced by their proximity to other ecosystems, such as kelp forests (United Nations Environment Programme, 2020). For instance, juvenile fish in seagrass areas near kelp forests consume higher-quality prey, exhibit better body condition, and experience enhanced recruitment[ix] compared to those in seagrass areas adjacent to sand (Olson *et al.*, 2019). This interconnectedness across the seascape fosters mutual support among habitats, creating a positive feedback loop that promotes overall seascape health.

1.2.5 ECONOMIC BENEFITS

1.2.5.1 FISHERIES AND FOOD

Seagrass ecosystems offer immense and often unquantifiable value to both people and the planet. However, when examined closely, the significant economic benefits of seagrass become apparent. The fishing industry, in particular, reaps substantial rewards, with around 20% of the world's major fisheries, including those for Atlantic cod, blue crab, shrimp, and seabream, being supported by seagrasses (Unsworth, Nordlund and Cullen-Unsworth, 2019; United Nations Environment Programme, 2020).

Seagrass beds play a fundamental role in supporting fisheries, both directly and indirectly (Jackson *et al.*, 2001). Directly, they provide permanent habitats that serve as nurseries, refuges, and feeding areas for various commercially targeted species (Jackson *et al.*, 2001). This support is crucial for maintaining populations of fish, crustaceans, and bivalves (Jackson *et al.*, 2001; United Nations Environment Programme, 2020). For example, walleye pollock, the most landed species globally, relies on seagrass as a nursery habitat (Unsworth, Nordlund and Cullen-Unsworth, 2019). On a local scale, many coastal communities depend on seagrass habitats for their food supply (Nordlund *et al.*, 2018). The well-being of these communities often correlates with the health and productivity of seagrass ecosystems (Dewsbury, Bhat and Fourqurean, 2016). In Eastern Indonesia, seagrass meadows support at least 50% of fished species, which locals rely on for their daily protein intake (Unsworth *et al.*, 2014).

[viii] Seascape is a term analogous to 'landscape' and considers the marine environment as a mosaic of interconnected habitats and species.

[ix] Recruitment is an ecological term that describes when individuals have founded a population or are added to an existing population.

Additionally, seagrass beds serve as vital fishing grounds for subsistence and artisanal fishers, as well as commercial fisheries (Figure 6) (Unsworth, Nordlund and Cullen-Unsworth, 2019) and provide a substrate for mariculture[x] (Nordlund *et al.*, 2016). In the Caribbean, lobsters caught in seagrass beds generate approximately USD $450 million annually (Winterbottom *et al.*, 2012; Unsworth, Nordlund and Cullen-Unsworth, 2019). In the Mediterranean, seagrass-associated species contribute at least €200 million per year to the fisheries industry (both commercial and recreational), accounting for 10% of the industry's income despite seagrass beds covering less than 2% of the area (Jackson *et al.*, 2015).

Indirectly, seagrasses support fisheries through coastal protection, nutrient cycling, water filtration, and carbon sequestration (Jackson *et al.*, 2001). These services enhance fisheries' infrastructure, secondary production, and ecosystem health while mitigating the impacts of climate change, thus promoting the sustainability and longevity of fisheries. The benefits of seagrass extend beyond local habitats. Many species associated with seagrass are caught in the deep ocean as adults, not in their seagrass nurseries (United Nations Environment Programme, 2020). This catch is then distributed globally, creating jobs in multiple industries (fishing, shipping, food manufacturing, and restaurants) and providing food worldwide (United Nations Environment Programme, 2020). Hundreds of millions of people consume seagrass-associated food daily (United Nations Environment Programme, 2020), linking seagrass directly to global food security.

1.2.5.2 GOODS AND SERVICES

Globally, seagrass is utilised in various ways that contribute to local economies and livelihoods (United Nations Environment Programme, 2020). Although these uses may not generate the same economic value as commercial and subsistence fisheries, they are often intertwined with the daily lives of local communities. Historically, seagrass has been harvested as a raw material in many countries. For instance, it is used as fertiliser in Tanzania, Australia, and Portugal and as packing material for transporting seafood in the United States (Barbier *et al.*, 2011; Hemminga and Duarte, 2000d; de la Torre-Castro and Rönnbäck, 2004). In the Solomon Islands and East Africa, locals occasionally consume seagrass shoots and roots (Barbier *et al.*, 2011; de la Torre-Castro and Rönnbäck, 2004). Seagrasses are also valued as a genetic resource and for their applications in traditional and pharmaceutical medicine (Nordlund *et al.*, 2016).

[x] Mariculture is the cultivation, management, and harvesting of marine organisms in their natural environment.

Figure 6 - Fisher in seagrass. Credit: Ben Jones / Ocean Image Bank

1.2.6 TOURISM SUPPORT

As international biodiversity hotspots, seagrass ecosystems are a significant draw for the tourism industry. These thriving ecosystems provide exceptional opportunities for wildlife viewing both above the water, such as bird-watching, and below the water, such as snorkelling and diving (Figure 7) (United Nations Environment Programme, 2020). The enhanced ecosystem health, water clarity, and coastal protection offered by seagrass habitats also provide indirect value to various coastal users, including swimmers, boaters, and beachgoers. A robust tourism industry can be vital for the livelihoods of small coastal communities.

As eco-tourism grows globally, seagrass meadows are increasingly linked with small tourist-focused enterprises (Syukur, Al-Idrus and Zulkifli, 2020). In Trang Province, Thailand, ecotourism related to seagrass ecosystems was estimated to generate around USD $5 million in 2008 (Praisankul and Nabangchang-Srisawalak, 2017). Additionally, recreational fishing is a highly popular coastal activity with significant economic value. In the Mediterranean, recreational fishing of seagrass-associated species generates around €112 million annually (Jackson *et al.*, 2015).

Figure 7 - Divers in seagrass meadow. Credit: Dimitris Poursanidis/ Ocean Image Bank

1.2.7 CULTURAL VALUE

Seagrass ecosystems are intrinsically linked to communities around the world, both directly and indirectly. One of the most significant connections is through food systems. However, seagrass-associated foods are not only vital for daily nutrition but often have deep cultural significance. In many Western cultures, there is a detachment from the origins of food and the processes involved in its cultivation, harvest, and processing. Conversely, in many other parts of the world, obtaining food is a communal, lifestyle-oriented, and cultural activity, deeply embedded in daily routines.

In various regions, women and children traditionally fish for food within seagrass meadows. For instance, in the Wakatobi National Park, Indonesia, women and children engage in gleaning[xi] techniques, passing down knowledge from generation to generation (Nordlund *et al.*, 2010). These seagrass habitats empower community members to provide food, foster relationships, and maintain local skills and expertise.

The management and preservation of seagrass ecosystems are often closely tied to the conservation of local cultures. The seagrass meadows around Green Island, within the Great Barrier Reef Marine Park and World Heritage Area, are historically important fishing grounds for the Gungandji people, the traditional Aboriginal landowners (Cullen-Unsworth *et al.*, 2014). This cultural heritage is preserved in

[xi] Gleaning (also referred to as low-water fishing) is a form of shallow-water fishing, most often performed by hand or with very basic equipment.

the area, with fishing rights reserved exclusively for the Gungandji people, supporting their cultural well-being (Cullen-Unsworth *et al.*, 2014). These connections to seagrass ecosystems provide spiritual fulfilment, hold religious value, and enable communities to maintain traditional practices (de la Torre-Castro and Rönnbäck, 2004; Cullen-Unsworth *et al.*, 2014).

Western communities also reap benefits from seagrass ecosystems. Seagrass is appreciated for its aesthetics (de la Torre-Castro and Rönnbäck, 2004) and is noted for promoting a sense of identity within local communities (United Nations Environment Programme, 2020). A case study in Porth Dinllaen, Wales, demonstrated that seagrass significantly bolstered the well-being of the local fishing community by creating tourism opportunities (Cullen-Unsworth *et al.*, 2014).

The environmental enhancements provided by seagrass facilitate various recreational activities. By maintaining a clean and stable environment and boosting biodiversity, seagrass improves water and beach-based activities and increases the likelihood of sighting species such as birds. Access to healthy natural environments positively impacts the physical and mental health of surrounding communities by reducing stress, increasing outdoor activities, and fostering a sense of place. Our connection to and care for charismatic species, such as birds, is evident from the substantial charitable donations for their conservation (Cullen-Unsworth *et al.*, 2014). Protecting habitats that these species rely on, such as seagrass, increases the chances of observing them in their natural environment, thereby deepening the connection between communities and their natural surroundings.

1.3 GLOBAL STATE OF SEAGRASS ECOSYSTEMS

1.3.1 GLOBAL COVERAGE

In recent decades, scientists have made significant strides in closing the knowledge gaps about seagrass ecosystems (Orth *et al.*, 2006). Despite these efforts, seagrass ecosystems remain largely overlooked in the media compared to more well-known coastal habitats such as coral reefs, mangroves, and salt marshes, which have historically received up to 100 times more attention (Orth *et al.*, 2006). As a result, our understanding of the global state of seagrass, particularly its coverage, remains limited.

Estimates of the global seagrass coverage vary wildly in the scientific literature. The first global estimate, published in 2003, suggested a conservative estimate of 177,000 km^2 of seagrass coverage worldwide (Green and Short, 2003). A 2010 study assessing the global carbon sequestration capacity of seagrass quoted a maximum global coverage of 600,000 km^2 (Duarte *et al.*, 2010). The latest review from 2020 estimates that the global spatial distribution of seagrass at 160,387 km^2 (with moderate to high confidence) and an additional 106,175 km^2 (with low confidence), giving a combined potential area of 266,562 km^2 across 193 countries (McKenzie *et al.*, 2020). With this estimate, global seagrass ecosystems cover a larger area than mangrove, kelp, and saltmarsh habitats but slightly less than coral reefs (McKenzie *et al.*, 2020). Unlike coral reefs, mangrove, and kelp habitats, seagrasses importantly extend to temperate and polar latitudes (McKenzie *et al.*, 2020).

1.3.2 CHANGE IN EXTENT

The lack of comprehensive data on seagrass coverage leads to a poor understanding of how its extent has changed over time. The first global assessment in 2009 estimated that since 1879, 29% of the measured seagrass area had disappeared (3,370 km^2 of the 11,592 km^2 measured), with an average annual decline of 1.5% (Waycott *et al.*, 2009). Significantly, the rate of decline is thought to have increased over time, from 0.9% per year before 1940 to 7% per year after 1990 (Waycott *et al.*, 2009). However, the trajectories of change were not uniform worldwide, with 58% of sites showing declines, 25% increasing, and 17% showing no change (Waycott *et al.*, 2009). A 2021 expansion of this study concluded that since 1880, there has been an overall decline in seagrass extent across all seven bioregions, amounting to a net loss of 5,602 km^2, or 19.1% of the total surveyed area (29,293 km^2) (Dunic *et al.*, 2021).

Recent years have seen researchers model the potential extent of seagrass via habitat suitability modelling, which pairs real-life observations of seagrass with environmental variables to make predictions. These models provide a reasonable representation of the potential area seagrass could occupy (Bertelli *et al.*, 2022). Compared to the current mapped area of seagrass meadows, the modelled results are eye-opening. A major 2018 study using the software MaxEnt predicted that the global seagrass biome could occupy 1,646,788 km^2, using 43,037 seagrass occurrence records and 13 environmental variables (Jayathilake and Costello, 2018). This prediction is double the estimated coverage of 600,000 km^2 (Duarte *et al.*, 2010) and around six times more than the commonly quoted actual coverage (McKenzie *et al.*, 2020). On a smaller scale, habitat suitability modelling in South Australia accurately predicted approximately 745 hectares as a potential seagrass recovery area, later confirmed by mapping (Erftemeijer *et al.*, 2023). While these models do not confirm where seagrass was in the past, they enhance our understanding of the potential area lost and indicate where seagrass may exist in the future. The ability to accurately model potential seagrass habitats is immensely beneficial for coastal management.

1.4 THREATS TO SEAGRASS

Seagrasses are vital coastal ecosystem engineers, forming the foundation of diverse ecosystems. However, their coastal location exposes them to various threats, impacting not only the seagrass but also the species reliant on these meadows. Key pressures include pollution, physical disturbances, rising coastal populations and development, climate change, biotic factors, and societal awareness gaps (Figure 8). Further, the interaction of multiple threats can have significant consequences on seagrass persistence. The variation in susceptibility to different threats by different seagrass species further complicates this.

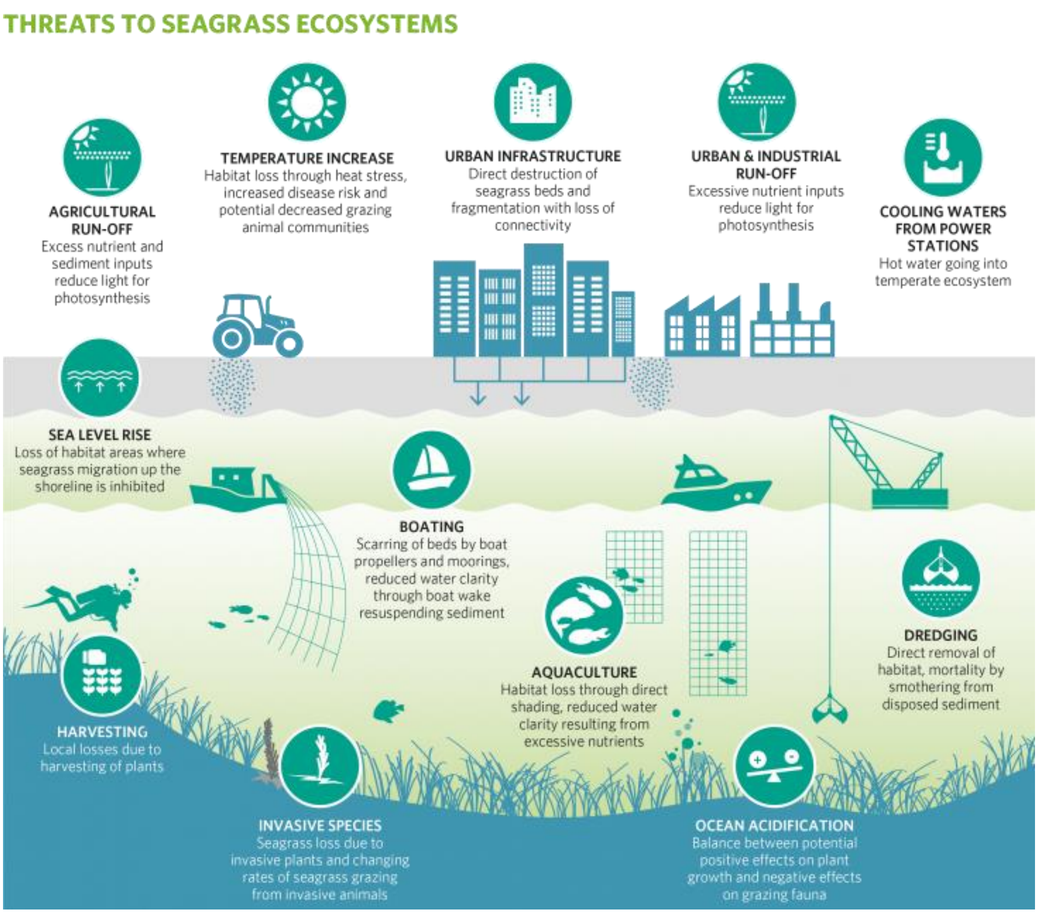


Figure 8 - Threats to seagrass. Taken from Gamble et al. (2021)

1.4.1 POLLUTION

Seagrass decline due to pollution arises from both land and marine-based activities. Land-based sources include agricultural runoff and land clearing, introducing nutrients, organic chemicals, and sediments into coastal waters. Globally, organic chemical run-off (e.g. pesticides) has been associated with rapidly declining seagrass trajectories (Turschwell *et al.*, 2021). Sediment run-off smothers seagrass as particulate matter becomes suspended in the water and sticks to seagrass leaves, reducing light availability and leading to tissue death (Bainbridge *et al.*, 2018). Marine-based activities, such as shipping, contribute to pollution through oil spills, ballast water, and plastic waste. Pressures from increased shipping traffic have been linked with rapidly declining seagrass trajectories globally (Turschwell *et al.*, 2021).

1.4.2 PHYSICAL DISTURBANCES

Physical disturbances from increased fishing activity, and particularly destructive demersal fishing such as trawling and dredging, have been identified as the most substantial pressure on seagrass globally [65]. This fishing activity can directly impact seagrass through the physical uprooting of the plant and indirectly through the resuspension of sediment, reducing the amount of available light. Alongside fishing, the movement of boats and ships causes water displacement, causing physical uprooting and disturbance to the surrounding sediment. Circular patches of bare sediment, called mooring scars, are generated from mooring chains or anchors persistently dragging along the seabed, uprooting plants, and inhibiting regrowth (Figure 9).

1.4.3 COASTAL DEVELOPMENT

Rising coastal populations lead to habitat loss and degradation. For instance, more than one billion people lived within 100 km of a seagrass meadow in 2003 (Small and Nicholls, 2003), and this number increased to 2.15 billion by 2020 (Reimann, Vafeidis and Honsel, 2023). Notably, almost one billion of these people live within 10 km of the coastline, with population numbers decreasing the further you move away from the coast (Reimann, Vafeidis and Honsel, 2023).

In South Eastern France, *Posidonia oceanica* experienced a 73% decline in shallow seagrass limit between the 1920s and 2012, directly linked to coastal infrastructure development, such as harbours and artificial beaches (Holon *et al.*, 2015). In the Chesapeake Bay, urbanisation led to a 50% loss of deep-water seagrass beds with a concurrent 35% increase in shallow-water beds (Lefcheck *et al.*, 2017). This was linked to watershed development and urbanisation, which caused sediment resuspension and decreased water quality. Due to less available light, seagrass was pushed into shallower waters where growing conditions could be met.

Figure 9 - Boat anchoring in seagrass meadow. Credit: Dimitris Poursanidis/ Ocean Image Bank

1.4.4 CLIMATE CHANGE

Climate change significantly impacts seagrass ecosystems. The world's oceans absorb heat and carbon, leading to rising marine temperatures and more frequent marine heatwaves; as a result, marine temperatures in Europe have consistently increased since the 1970s (European Environment Agency, 2023). Extreme sea surface temperatures (Turschwell *et al.*, 2021) and increasing frequency of marine heatwaves (IPCC, 2019) as a result of climate change have been associated with rapid declines in seagrass extent globally. For example, Shark Bay, Australia, experienced a 90% dieback of seagrass, *Amphibolis antarctica,* following a record-breaking heatwave in the summer of 2010-2011 (Thomson *et al.*, 2015). Based on global climate model projections (CMIP5), marine heatwaves in the 21st century are predicted to see further increases in number and intensity, with many areas existing in a state of permanent marine heatwave by the end of the 21st century (Oliver *et al.*, 2019).

Increased prevalence and intensity of extreme weather events as a result of climate change, such as storms and flooding, also threaten seagrass meadows, reducing their ability to recover [75]. In 1999, 90% of intertidal seagrass meadows at Sandy Strait, Queensland, disappeared following severe flooding

(Campbell and McKenzie, 2004). This meadow took three years to recover fully. With events like flooding becoming more frequent, meadows will have less and less time to replenish.

1.4.5 BIOTIC INTERACTIONS

Historical and current biotic interactions significantly affect seagrass. The 'wasting disease' of the early 1930s, caused by the pathogen *Labyrinthula* (Short, Muehlstein and Porter, 1987), wiped out up to 90% of seagrass meadows in the North Atlantic (Graham *et al.*, 2021).By the summer of 1933, the epidemic was recorded to have 'almost entirely destroyed' meadows of seagrass, *Zostera marina,* along the Atlantic coasts of North America and Europe. (Short, Muehlstein and Porter, 1987) This loss of seagrass had substantial knock-on effects on associated animal populations, including migratory waterfowl, scallops and fish, as well as the ecosystem services (Orth *et al.*, 2006; Graham *et al.*, 2021). Many areas that lost seagrass have been permanently altered to this day.

Bioinvasions or competition from other species are a threat to seagrass ecosystems, occurring naturally or due to human introduction. For example, seagrass *P. oceanica,* endemic to the Mediterranean Sea, is threatened by multiple invasive algal species (Montefalcone *et al.*, 2010). Notably, non-native species, *Caulerpa taxifolia* and *Caulerpa racemosa* are strong colonisers that occupy and reduce *P. oceanica* meadows.

1.4.6 PUBLIC AWARENESS AND KNOWLEDGE GAPS

Effective seagrass protection requires appropriate management, baseline knowledge, and public awareness. In a review of 20 case studies chosen to represent a range of seagrass regions, seagrass protection was deemed inadequate in most cases (Griffiths, Connolly and Brown, 2020). Many management plans fail due to a lack of integration across jurisdictions, inadequate baseline data and ongoing monitoring.

The lack of societal awareness of the importance of seagrass is still reported as the greatest challenge for global seagrass conservation (Unsworth *et al.*, 2019). There are significant discrepancies in the research effort within coastal habitats, with 60% of all published research focusing on coral reefs and only 11–14% addressing seagrass meadows, salt marshes, and mangroves (Duarte *et al.*, 2008). In the media, seagrass habitats receive by far the least attention (1.3%) compared to mangroves (20%) and coral reefs (72%) (Duarte *et al.*, 2008).

1.4.7 INTERACTION OF THREATS

The interaction of threats, particularly where they coexist, magnifies their impact on seagrass ecosystems. For example, Turschwell *et al*. (2021) found that destructive fishing practices and reduced water quality often co-occur, leading to significant seagrass decline (Turschwell *et al.*, 2021). Effective management must consider the cumulative effects of multiple threats and species-specific responses to these pressures to mitigate future seagrass declines (Griffiths, Connolly and Brown, 2020).

Variations in life-history strategy further complicate our understanding of threats to seagrass. Seagrass can be classified by habitat type, meadow form, and reproductive strategies (Kilminster *et al.*, 2015). These differences in traits materialise differently in response to threats. Meadows that are 'persistent' are likely to display slow and stable changes, whilst 'opportunistic' meadows are likely to show rapid declines (and rapid increases) (Turschwell *et al.*, 2021). Understanding these species-specific differences is fundamental to identifying pressures acting against seagrass ecosystems.

1.5 GLOBAL PROTECTION OF SEAGRASS

Despite their importance, most seagrass areas lack management plans and are not safeguarded against human threats. Seagrass ecosystems are underrepresented within marine protected areas (MPAs). Globally, only 26% of recorded seagrass habitats are protected within MPAs, compared to 43% of mangroves and 40% of coral reefs (United Nations Environment Programme, 2020).

This is surprising considering the conservation of seagrass habitats aligns with multiple international commitments, such as the United Nations' Sustainable Development Goals (SDGs) (Figure 10). Conserving seagrass contributes to 26 targets associated with 10 of the 17 SDGs (United Nations Environment Programme, 2020).

In the UK, the total seagrass area is 43 km^2 (MPA Reality Check, 2024). Of these, 39 km^2 fall within MPA boundaries, but only 27 km^2 are protected from bottom-towed fishing gear, leaving the remaining 12 km^2 at risk of destruction. Additionally, 4 km^2 of seagrass is neither within an MPA nor protected by bylaws restricting bottom-towed fishing gear.

Seagrass ecosystems are crucial for the Convention on Migratory Species and the Ramsar Convention on Wetlands due to their significance for migratory birds and their role as key coastal wetland species. Countries party to these agreements are required to take necessary steps to protect seagrass habitats. Given the carbon sequestration potential of seagrass beds, protecting these meadows also supports countries' nationally determined contributions (NDCs) under the Paris Agreement (2015 United Nations Climate Change Conference) (United Nations Environment Programme, 2020). Moreover, as hotspots for biodiversity, preserving seagrass ecosystems contributes to achieving the Aichi Biodiversity Targets (2015 and 2020).

Figure 10 - How seagrasses support various international agreements. Taken from United Nations Environment Programme (2020).

1.6 RECOVERY OF SEAGRASS ECOSYSTEMS

The trajectory of seagrass extent varies significantly both within countries and between species. For instance, in Wales, United Kingdom, while many subtidal seagrass beds are in decline, intertidal meadows appear stable or are increasing (Bertelli *et al.*, 2018). This is a trend mirrored throughout Europe (de los Santos *et al.*, 2019). In 2021, it was estimated that 554 km² of global seagrass extent had recovered since 1990, equating to about 1.9% of the surveyed area regained worldwide (Dunic *et al.*, 2021). On a regional scale, data from 2000 to 2010 showed significant recovery in several areas: 81% of sites in the Tropical Atlantic, 65% in the Mediterranean, and 60% in the Temperate North Atlantic East reported increases in seagrass extent (Turschwell *et al.*, 2021).

On a local scale, numerous records document seagrass meadow recovery linked to changes in human activities. In Chesapeake Bay, USA, the relationship between agricultural practices and seagrass coverage was evaluated using records of nutrient pollution and aerial surveys. Between 1984 and 2015, an average 23% reduction in nutrient pollution correlated with a 316% increase in seagrass (and other underwater vascular plants) coverage, growing from 78.78 km^2 to 248.74 km^2 (Lefcheck *et al.*, 2018). Further, a restoration project in the Mondego estuary, Portugal, reduced nitrogen levels by approximately 50%, improving water transparency and promoting the recovery of the intertidal seagrass species, *Zostera noltei*, along with associated microbenthic species (Cardoso *et al.*, 2010). This benthic community had previously been absent for over 15 years (Cardoso *et al.*, 2010).

2 SEAGRASS IN JERSEY

2.1 NATIVE SEAGRASS SPECIES

Europe hosts four species of seagrass: *Zostera marina, Zostera noltei, Cymodocea nodosa*, and *Posidonia oceanica* (Borum and Greve, 2004). Jersey is home to two of these species, *Z. noltei* and *Z. marina*, both members of the Zostera genus, also known as eelgrass. Despite belonging to the same genus, they occupy different ecological niches and fulfil distinct roles within Jersey's coastal ecosystem.

2.1.1 ZOSTERA MARINA

Zostera marina, commonly referred to as eelgrass, inhabits the waters of Northern Norway, the Baltic Sea, the North Sea, and the Atlantic coasts extending down to Northern Spain (Borum and Greve, 2004). Small, isolated patches of this species are also found in the Mediterranean. *Z. marina* grows in the intertidal and subtidal zones but favours subtidal areas at depths of 10-15 meters, depending on water clarity. In arctic waters, it can even survive under ice coverage (Borum and Greve, 2004). Preferring muddy to relatively coarse sediment (Unsworth, 2021), this species typically grows shoots 30–60cm long, but they can reach up to 1.5m in length (Figure 11) (Borum and Greve, 2004). The shoots grow in plants of 3-7 leaves, each 2-10 mm wide. Intertidally, *Z. marina* is often interspersed with *Z. noltei* between the mid to low tide mark.

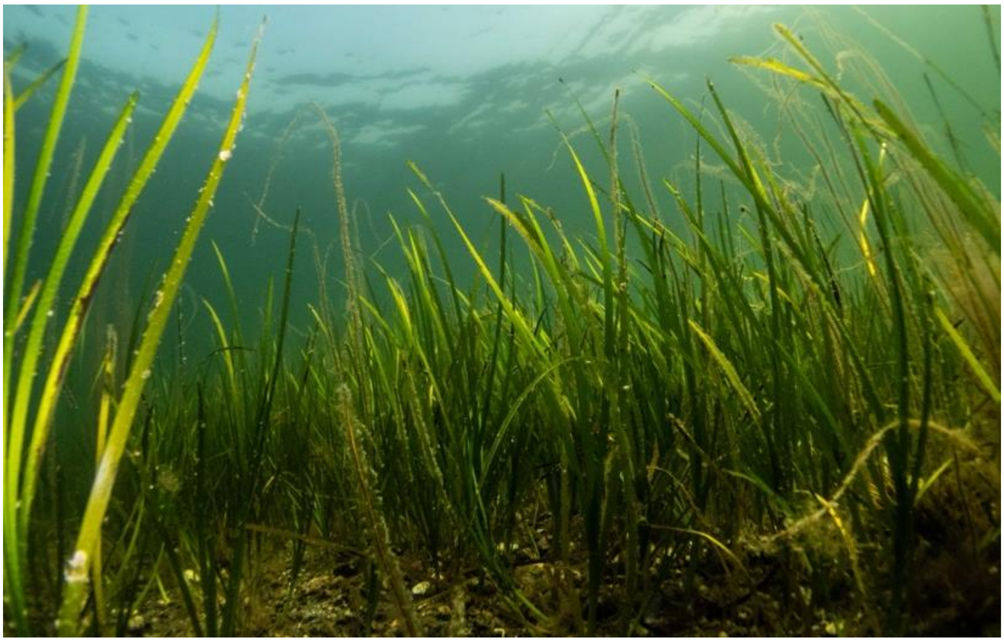


Figure 11 - *Zostera marina*. Credit: Ben Jones / Ocean Image Bank

2.1.2 ZOSTERA NOLTEI

Zostera noltei, or dwarf eelgrass, is named for its shorter length. It is found from the southern coast of Norway to the Mediterranean Sea, the Black Sea, the Canary Islands, and the coasts of North Africa (Borum and Greve, 2004). This species is small and specialised to grow up to the high tide mark in the intertidal zone (Figure 12). Dwarf eelgrass grows on various sediment types, from mud to sand, and is resistant to desiccation (Unsworth, 2021). Its narrow, short leaves are often fully exposed to air and can withstand complete drying out during the lowest tides (Unsworth, 2021; Becheler *et al.*, 2010). Plants consist of 3–5 leaves attached to a horizontal rhizome. While *Z. noltei* can survive in the subtidal zone, it is often outcompeted by larger species such as *Z. marina*. It is fast-growing and short-lived, efficiently colonising new areas under favourable conditions (Borum and Greve, 2004).

NOTE: The taxonomy and nomenclature of these Zostera species often need clarification. *Z. noltei* may be recorded at *Zostera or Zosterella noltei, noltii* or *nana*, whilst there is also discussion about assigning the species to a new genus, *Nanozostera noltei* (Unsworth, 2021). Additionally, a third species, *Zostera angustifolia* or narrow-leaved eelgrass, is recorded as a species in the UK under the Water Framework Directive and in Europe, within the EUNIS biotope for seagrass meadows alongside *Z. noltei* (Unsworth, 2021). When growing intertidally, *Z. marina* is often recorded as *Z. angustifolia* or *Z. marina var. angustifolia.* However, this species is now considered a genetic variety or 'ecotype' of *Z. marina* (Becheler *et al.*, 2010).

Figure 12 - *Zostera noltei*. Photo: Ed Stikvoort

2.2 HISTORY OF SEAGRASS IN JERSEY

Historical records of seagrass in Jersey provide insights into how Jersey's seagrass beds have transformed over time. These records were retrieved from various sources, including the Jersey Biodiversity Centre and the Société Jersiaise Annual Bulletin Archive.

The earliest known record of seagrass in Jersey's waters dates to 1812. During a survey of Les Minquiers reef, Captain White documented the presence of 'grass and sea weed' along with five areas of finer sediment (Figure 13) (Chambers, Binney and Jeffreys, 2016). The authors highlight that three of the five fine sediment areas identified by Captain White have seagrass present today. Additionally, Captain White documented several areas of mud, particularly around the Maîtresse Île anchorage. These areas are now described as silty-clay-rich sediments, indicating a loss of mud-rich sediments and, consequently, the sediment stabilisation provided by seagrass since the 19th century (Chambers, Binney and Jeffreys, 2016). Although Captain White's observations cannot be confirmed with certainty, these records suggest the presence of seagrass around the Les Minquiers at the beginning of the 1800s and possibly even earlier.

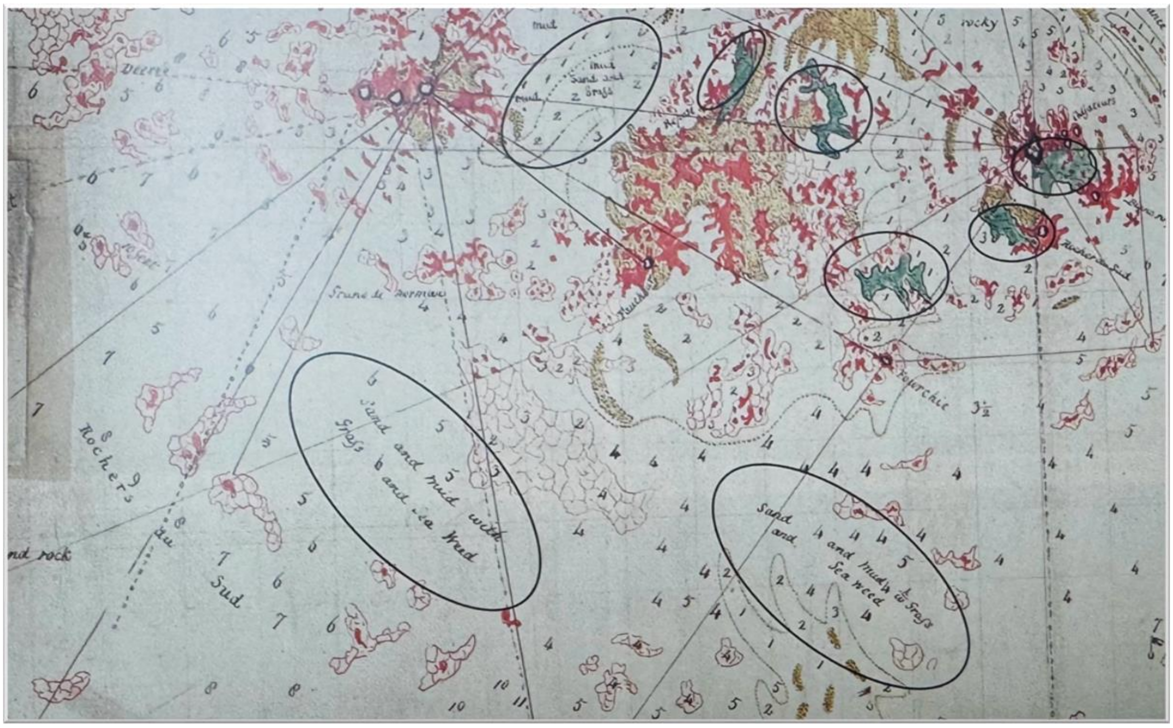


Figure 13 – 1812 Les Minquiers survey map by Captain White, documenting areas of finer sediment, suggesting a more extensive area of subtidal Eelgrass (*Zostera marina*) than at present. Uk Hydrographic Office; Taken from Chambers, Binney and Jeffreys (2016)

Later in the 19th century, numerous accounts of *Zostera* in Jersey can be found. Firstly in 1862, Charles Maybury Archer wrote in the Jersey Independent and Daily Telegraph on 'The great cotton question', as cotton supply at this time was limited. He discussed a suggestion made in the *Manchester Guardian* that *Zostera marina* "or common grass wrack" may be a good substitute for cotton. He speaks of its common use for packing and stuffing "cottagers' cushions and beds" and medicinally as a poultice for tumours. Archer quotes a Mr Sandford who wrote in the Journal of the Society of Arts of a proverb from the Channel Islands – "point de vraic, point de haugard" – meaning 'no seaweed, no cornyard' (Archer, 1862). Mr Sandford further stated that on a trip to Jersey, he encountered a mother and her family "employed in the drying and burning of weed, composed entirely of the marine plant known as grass wrack, *Zostera marina*". Sandford stated that this was "one of the poorest and most common of our seaweeds" and that the mother was burning the weed to sow the ash with her corn the next day. Later that month, R. Goodwin Mumbray wrote to the editor of the Jersey Independent in response. Goodwin stated that he had spent the autumn and winter months of 1860 in Jersey and devoted much time to marine botany, identifying over 200 species, including *Z. marina* (Mumbray, 1862). Unfortunately, no reference is given to where the species was found. However, he concluded it would not function as a substitute for cotton and dissuaded further debate about its use.

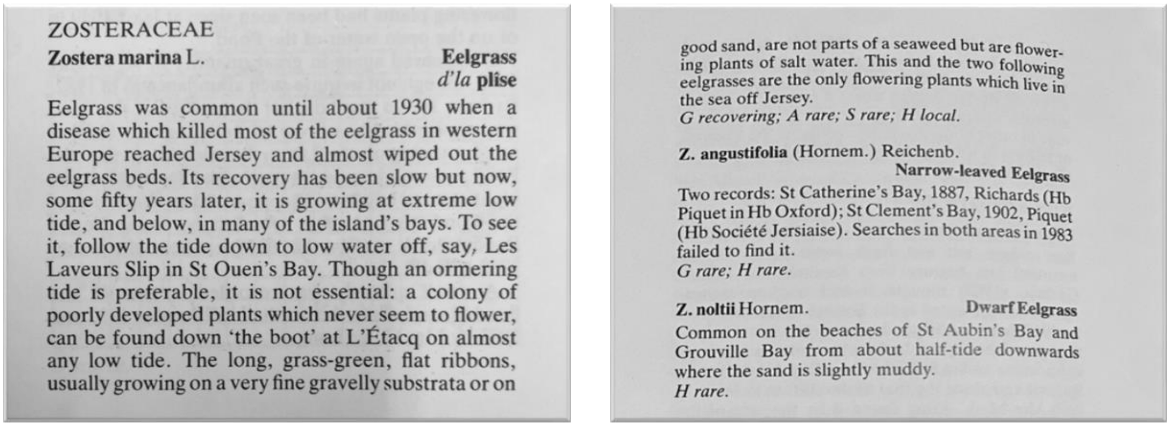
Second, university student E. Duprey published a list of intertidal 'marine shells' in the Société Jersiase Annual Bulletin of 1877–78 (Duprey, 1877) and again in 1880 (Duprey, 1880). Although not focused on seagrass, Duprey provided multiple notes on the habitat and location of each species around the island. These reports suggest the presence of seagrass in St Aubin's Bay and along the Southeast Coast of Jersey (Table 1).

Table 1 – Extracts from "Coquilles de Jersey" by E. Duprey. Published in the Annual Bulletin 1877-78 & 1880 (Duprey, 1877; Duprey, 1880)

<table>
<tr><th>Species</th><th>Record</th><th>Translation</th><th>Page</th><th>Reference</th></tr>
<tr><td>Pecten maximus</td><td>"Parmi la zostère à La Rocque"</td><td>Among the eelgrass at La Rocque</td><td>97</td><td rowspan="3">(Duprey, 1877)</td></tr>
<tr><td>Lepton clarkia</td><td>"Baies de St.-Aubin et de Samarès. Obtenu en tamisant de petites algues et aussi dans du sable avec Zostère."</td><td>Bays of St Aubin and Samarès. Obtained by sieving small algae and also in sand amongst eelgrass.</td><td>98</td></tr>
<tr><td>Loripes lacteus</td><td>"Vit dans le sable parmi la zostère"</td><td>Lives in the sand among eelgrass</td><td>98</td></tr>
</table>

Trochus striatus	"Commun sur lal zostère"	Common on eelgrass.	102	
Scalaria communis	"Vit dans le sable parmi la Zostère; à la Pointe-des-Pas, Baie de Samarés, La Rocque et Ico.	Lives in the sand among eelgrass; at Pointe-des-Pas, Bay of Samarés, La Rocque and Ico.	104	
Loligo media	"Dans la baie de St.-Aubin. Ces petits calmars avaient été arrêtés par un long filet avec des touffes dol zostère."	In the bay of St Aubin. These little squid had been stopped by a long net with tufts of eelgrass.	205	(Duprey, 1880)

The ecotype, *Z. angustifolia*, was first noted at St Catherine's Bay in 1887 and again in 1902 in St Clement's Bay, as documented in "The Flora of Jersey" by Francis Le Sueur (Figure 14) (Le Sueur, 1984). Although this species classification is not currently used in Jersey, these records suggest that seagrass existed in St Catherine's Bay and the Southeast Coast during this period.


ZOSTERACEAE
Zostera marina L. **Eelgrass**
d'la plise
Eelgrass was common until about 1930 when a disease which killed most of the eelgrass in western Europe reached Jersey and almost wiped out the eelgrass beds. Its recovery has been slow but now, some fifty years later, it is growing at extreme low tide, and below, in many of the island's bays. To see it, follow the tide down to low water off, say, Les Laveurs Slip in St Ouen's Bay. Though an ormering tide is preferable, it is not essential: a colony of poorly developed plants which never seem to flower, can be found down 'the boot' at L'Étacq on almost any low tide. The long, grass-green, flat ribbons, usually growing on a very fine gravelly substrata or on

good sand, are not parts of a seaweed but are flowering plants of salt water. This and the two following eelgrasses are the only flowering plants which live in the sea off Jersey.
G recovering; A rare; S rare; H local.

Z. angustifolia (Hornem.) Reichenb. **Narrow-leaved Eelgrass**
Two records: St Catherine's Bay, 1887, Richards (Hb Piquet in Hb Oxford); St Clement's Bay, 1902, Piquet (Hb Société Jersiaise). Searches in both areas in 1983 failed to find it.
G rare; H rare.

Z. noltii Hornem. **Dwarf Eelgrass**
Common on the beaches of St Aubin's Bay and Grouville Bay from about half-tide downwards where the sand is slightly muddy.
H rare.

Figure 14 – Records of *Zostera spp* in "The Flora of Jersey" by Le Sueur (Le Sueur, 1984)

In 1920, the Société Jersiase Geological Section investigated the volcanic rock on Jersey's Southeast coast. During this study, they reported the presence of long, narrow pools near L'Avarizon (Seymour Tower), covered with vegetation, particularly *Z. marina* (Duprey, 1920).

In 1937, H. J. Baal wrote to the Jersey Leader newspaper stating that seahorses were "not as rare in our waters as most people imagine", stating that they were frequently caught in shrimping nets in the *Zostera*, where "the growth is stunted and mixed with bits of fucus" (Baal, 1937). Unfortunately, no specific location was described.

In 1947, the Ornithological section reported on the presence of around 250-300 brent geese residing in Jersey over the winter, leaving early in May 1948 (Figure 15). These dark-breasted brent geese were split into two flocks, with around 70 in St Aubin's Bay and the remainder staying around Le Hocq. They noted that the birds were attracted by the *Zostera marina*, on which they would feed at low tide (Graham, 1948). In the winter of 1973-1974, Le Sueur noted well over one thousand brent geese (mostly dark-bellied with a few pale-bellied) arriving in St Aubin's Bay and Grouville Bay. They stayed from November to April, feeding on areas of dwarf-eelgrass ('*Zostera nana'* also known as *Zostera noltei)* within the bays (Le Sueur, 1976). This number represented a substantial increase compared to the previous years' counts of only a few hundred birds, indicating a potential improvement in Jersey's intertidal seagrass. In 2004, the Ornithological section reported again on brent geese, recording 1,131 on 25th January (the highest count since February 1995), with other exceptionally high numbers (1000+) recorded in mid-October, with birds spread around the south and east coasts (Painter, 2005).

This recovery followed the seagrass "wasting disease" epidemic that affected Europe and the North Atlantic. Le Sueur noted that this disease nearly wiped-out Jersey's *Z. marina* beds in the early 1930s, which then slowly recovered over the following 50 years. In 1984, she described the beds in Guernsey as still 'recovering', whilst the seagrass was classed as 'rare' in Alderney and Sark (Le Sueur, 1984). Le Sueur reports that in 1984, *Z. marina* was found in 'many of the island's bays', growing at extreme low tide and below. Notably, she mentioned that the beach below Les Laveurs Slips and L'Étacq in St Ouen's Bay were good places to observe eelgrass. These locations are not associated with seagrass growth today, likely due to their exposed west coast location. Additionally, Le Sueur noted that *Z. noltei* was common on the beaches of St Aubin's Bay and Grouville Bay in 1984, where it grew on muddy sand from about half tide downwards (Le Sueur, 1984).

Figure 15 - Brent geese feeding on seagrass at low tide. Taken from Kollars *et al.* (2017)

In 1989, the Société Jersiase Marine Biology Section initiated a survey to explore the annual variation in flora and fauna at Archirondel Beach and proposed a study to examine the productivity of Zostera beds within the bay (Kerr, 1990). The subsequent reports of these studies have not been located at this time. Since then, the Marine Biology Section has participated in numerous studies, consultations, and reports related to Jersey's seagrass. In 2007, the section consulted on the environmental impact of the proposed Jersey Electricity Company cable link with France. They raised concerns about the cable's landfall location and discussed how best to minimize disturbance to marine life during construction, particularly expressing concern for *Z. marina* beds at Anne Port, one of the proposed cable sites (Jouault, 2008).

In 1998, Emma Jackson conducted Jersey's first major academic study dedicated to seagrass. Jackson researched "The importance of seagrass habitats to fisheries species in Jersey, English Channel Islands" at the University of Plymouth, completing her PhD in 2003. This work highlighted several key conclusions identifying seagrass as a critical habitat, especially as a nursery area, feeding ground, and refuge for both temporary and permanent resident species, many of which are commercially targeted. This research marked an increase in academic interest surrounding Jersey's seagrass, resulting in multiple scientific publications that shared knowledge gained in Jersey with the broader scientific community.

Today, the Jersey Biodiversity Centre holds 512 records of seagrass across Jersey and the offshore reefs. These records are roughly equally divided between the two resident seagrass species: *Z. marina* (288) and *Z. noltei* (224).

2.3 PROTECTION OF SEAGRASS IN JERSEY

Jersey is a signatory of numerous multilateral environmental agreements, that mandate a commitment to protecting its diversity of species and habitats. These agreements include the Convention on Biological Diversity, signed in 1994; the Bern Convention on the Conservation of European Wildlife and Natural Habitats; the Ramsar Convention on Wetlands, the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), and the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS), which came into force in 2002. There are several other management measures, plans, and initiatives that may benefit seagrass including:

- EU Habitats Directive
- EU Marine Strategy Framework Directive
- Wildlife (Jersey) Law 2021
- EU Water Framework Directive

- Jersey National Park
- Environmentally friendly moorings systems
- Biodiversity Action Plans
- Fisheries management
- Jersey Marine Spatial Plan

The UK signed the Ramsar Convention on Wetlands of International Importance in 1976 and extended its obligations to Jersey in the same year (Government of Jersey, 2024b). In 2000, Jersey designated its first 'Wetland of International Importance' on the Southeast Coast, recognised for its array of habitats, including seagrass beds. In 2001, No-Mobile-Gear-Zones (no trawling or dredging) were established in Fliquet, St Brelade's, St Aubin's Bay, and Grouville Bay (Sea Fisheries (Inshore Trawling, Netting and Dredging) (Jersey) Regulations 2001) (Chambers, Binney and Jeffreys, 2016), protecting the mosaic of seafloor habitats, including seagrass, from destructive bottom-towed fishing practices. In 2005, Jersey's Ramsar sites were extended to include the offshore reefs of Les Minquiers and Les Écréhous, which are home to seagrass. Today, these three areas are classified as Marine Protected Areas (MPAs) (Figure 16). The Southeast Coast MPA was designated in 2010 (and extended in 2014), while Les Minquiers MPA and Les Écréhous MPA were designated in 2017.

In 2002, the UK extended the OSPAR Convention to Jersey (Government of Jersey, 2024a). Jersey has three coastal habitats designated under OSPAR: seagrass, kelp forests, and maerl (Government of Jersey, 2021).

Today, 3.94 km^2 of seagrass, representing 97.4% of the total 4.06 km^2, falls within Jersey's Marine Protected Areas (MPAs) (Figure 17) (Blampied et al., 2022b). In total, Jersey has 190 km^2 of key habitats designated as Ramsar areas and 150 km^2 of seabed and marine waters designated as MPAs under the OSPAR Convention (Government of Jersey, 2021).

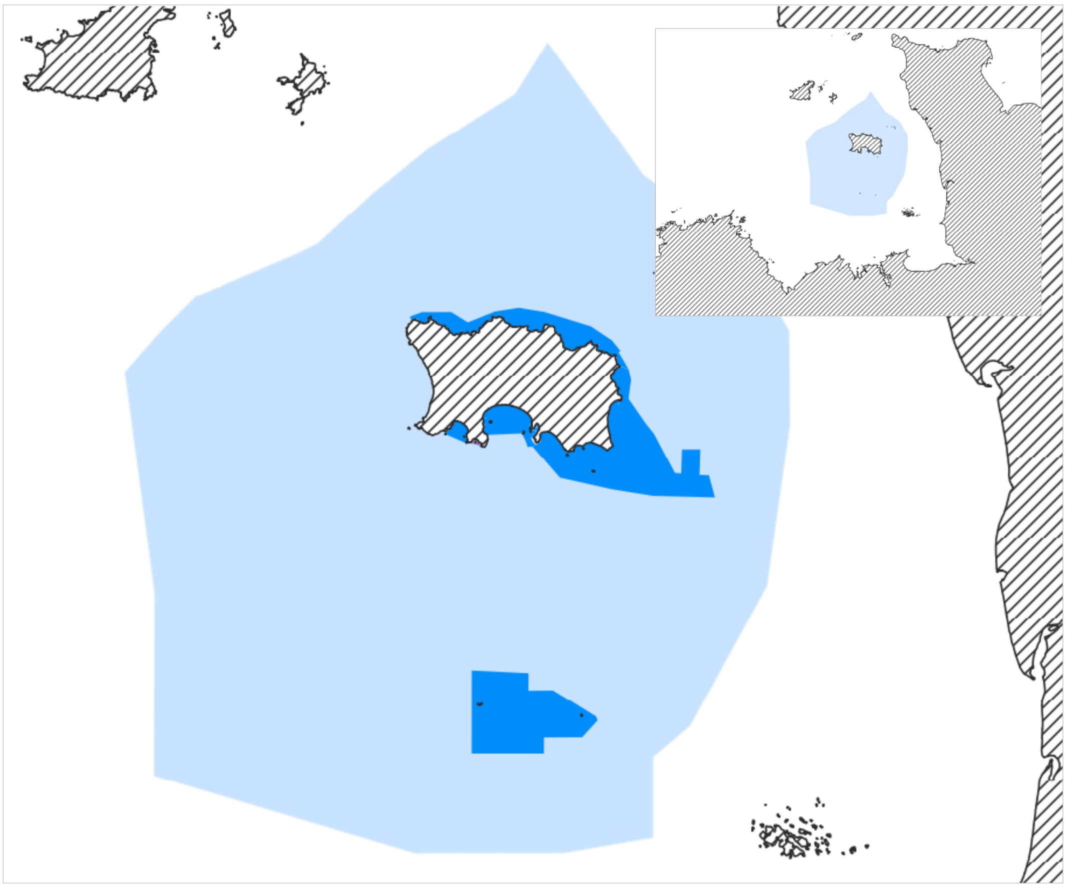


Figure 16 – Jersey's Marine Protected Areas (that exclude mobile gear – trawling and dredging) (in dark blue). Insert: Map of the Channel Islands, showing Jersey's territorial seas (in light blue)

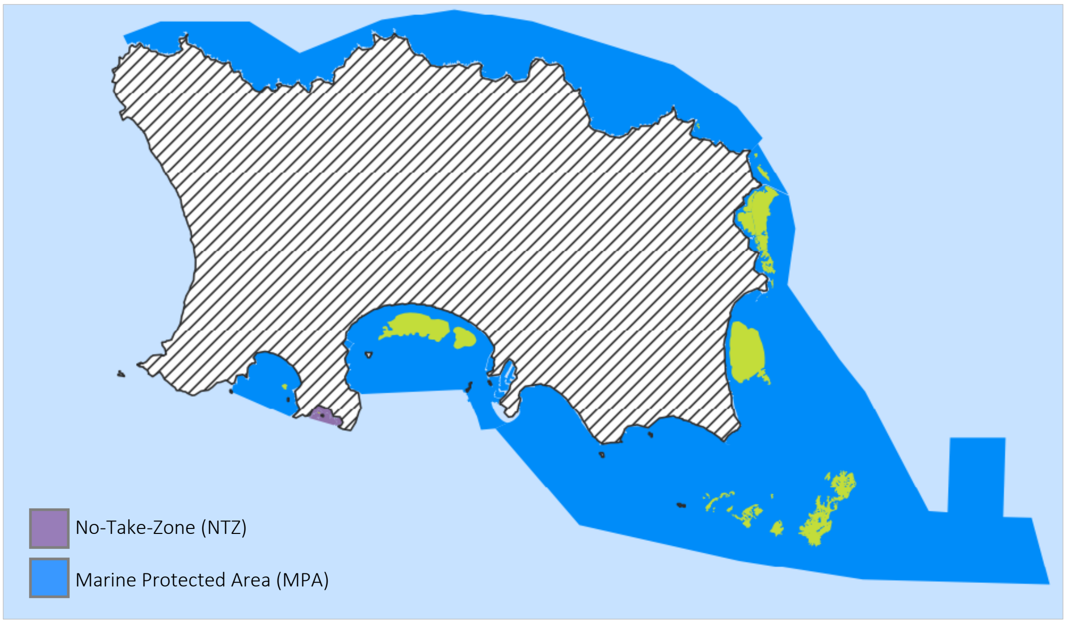


Figure 17 - Coastal seagrass areas (in green), within Jersey's MPAs (dark blue) and No-Take-Zone (purple)

2.4 SEAGRASS LOCATIONS

Seagrass can be found along Jersey's south, east, and occasionally north coasts. Both intertidal and subtidal seagrass meadows grow in these regions, either sharing the coastline or existing separately. Additionally, seagrass is present in Jersey's offshore reefs, Les Minquiers and Les Écréhous. Seagrass around Jersey's coast often falls within Jersey's No Mobile Gear Zones (NMGZ) which excludes mobile fishing (dredging and trawling). These zones are also OSPAR recognised Marine Protected Areas (MPAs).

2.4.1 SOUTH COAST

2.4.1.1 ST AUBIN'S BAY

St Aubin's Bay, the largest bay on Jersey's south coast, is an area of significant importance for intertidal seagrass. The wastewater outlet from the Bellozanne Wastewater Treatment Works has ranging impacts on the seagrass and notably divides the seagrass into two separate beds, east and west. The bay, with a low gradient and fine sandy beach, is bordered by Elizabeth Castle/La Collette/St Helier harbour to the east and the Noirmont headland to the west. St Aubin's Bay is the only bay on the south coast where intertidal seagrass, *Z. noltei*, is found. The bay is protected by the St Aubin and St Helier NMGZ.

2.4.1.2 PORTELET BAY & OUAISNE

Portelet Bay, a small south-facing bay on the south coast, is located at the southern end of the Noirmont headland. The bay is divided into east and west by L'Île au Guerdain, which connects to the beach via a sandbar at low tide. The west side hosts a small stretch of subtidal seagrass. Portelet Bay is protected by a No-Take-Zone, prohibiting the extraction of any marine life (States of Jersey, 2022).

Ouaisne, located in the east of St Brelade's Bay in the southwest corner of Jersey, has subtidal seagrass just off La Cotte de St Brelade. This seagrass is protected by the St Brelade's No-Mobile-Gear-Zone (NMGZ).

2.4.1.3 SOUTHEAST CORNER

The Southeast Coast is crucial for Jersey's *Z. marina*, hosting one of the island's largest extents of subtidal seagrass. Natural rock formations shelter the beds, creating a mosaic pattern. This area is designated as a Ramsar Site of International Importance and is protected from towed fishing gear and destructive extractive processes due to its designation as a Marine Protected Area (MPA), the Southeast

No-Mobile-Gear-Zone (NMGZ) (Government of Jersey, 2011). Historical records have documented the seagrass in this area, providing valuable insight into this vital ecosystem's historical presence.

2.4.2 EAST COAST

2.4.2.1 GROUVILLE BAY

Grouville Bay, home to one of Jersey's largest beds of intertidal seagrass, *Z. noltei*, is relatively flat with a large sandy intertidal area. The bay, bordered by intertidal rocks and artificial oyster beds to the south and Gorey Harbour to the north, has no significant wastewater runoffs or streams. The seagrass here forms one large bed, with smaller patches documented on the east side of Gorey Pier and recent expansion to the south into the aquaculture area. This area is part of Jersey's Southeast Coast Ramsar site (Government of Jersey, 2011) and the Southeast NMGZ.

2.4.2.2 LA COTE

La Cote, located on the headland between Grouville Bay and Archirondel, faces east and is home to a single subtidal seagrass bed with no intertidal seagrass. This area is included within Jersey's Southeast NMGZ.

2.4.2.3 ARCHIRONDEL & ANNE PORT

Archirondel and Anne Port host both *Z. noltei* and *Z. marina*. Separated by a rocky outcrop, one continuous bed of subtidal seagrass connects these bays underwater. Intertidally, the seagrass beds are divided by large rocks, with three distinct beds at Anne Port and two beds at Archirondel. Both bays are included within Jersey's Southeast NMGZ.

2.4.2.4 ST CATHERINE'S BAY

St Catherine's Bay, well-known for its substantial subtidal seagrass, hosts both *Z. noltei* and *Z. marina*. The bay features a large artificial breakwater, completed in 1856 (Allsop, 2017). Extending 700 meters long, this breakwater provides shelter for the seagrass. Historical records from 1887 noted *Z. angustifolia* in the bay (Le Sueur, 1984)[xii].

The bay, a popular anchorage with permanent moorings, is protected within Jersey's Southeast NMGZ.

[xii] The status of *Z. angustifolia* as a separate species from *Z. marina* has been debated and is currently considered to be synonyms.

2.4.3 NORTH COAST

2.4.3.1 FLIQUET

Fliquet Bay, located in Jersey's northeast corner on the northern side of St Catherine's breakwater, is home to subtidal *Z. marina*. The seagrass here, more exposed, forms two large beds surrounded by smaller patches. Fliquet is protected by its own NMGZ.

2.4.3.2 ROZEL

Rozel Bay, located on Jersey's north coast within the North Coast NMGZ, hosts a single bed of subtidal seagrass to the north of Rozel Harbour.

2.4.4 LES MINQUIERS AND LES ÉCRÉHOUS

The seagrass at Les Minquiers is the subtidal *Z. marina,* with the bed primarily concentrated in the channel running east to west to the south of the main island, Maîtresse Îsle. Further afield, there are beds scattered around the reef (approximately ½ mile to the south and east of the main island) in the most sheltered areas. The seagrass at Les Minquiers grows in coarse sediment and even gravel/pebble-dominated mixed substrates in some areas (Pers. comm. SB).

The seagrass as Les Écréhous is the subtidal *Z. marina,* growing in small areas to the north and south of the main island. This area of seagrass is one of the least documented in Jersey's waters.

2.5 IMPORTANCE TO JERSEY

In 2022, Blampied *et al.* (2022b) assessed the fisheries value of Jersey's coastal habitats to its commercial fisheries, concluding that the habitats within Jersey's territorial waters contributed a total annual economic value of £14,664,729. Seagrass alone contributed £2,025,192 per year to Jersey and French fisheries combined. Yet, to gain an understanding of the 'true' value of coastal ecosystems, we must look beyond pure monetary gain and consider the full array of benefits received by humans. In 2023, Marine Resources released their 'Ecosystem Service Assessment Of Jersey's Marine Habitats' (Government of Jersey, 2023a). This report aimed to value the ecosystem services essential to human well-being and ecological health.

Ecosystem services are provided by the mosaic of habitats within an ecosystem and can be categorised into supporting, regulating, provisioning, and cultural services. These services rely on healthy, functioning ecosystems and fulfil a range of basic to higher-level needs, such as, oxygen, food supply, culture, and well-being (Government of Jersey, 2023a). The assessment of ecosystem services and mapping them to their habitats is one of the core actions of the EU Biodiversity Strategy for 2030.

Jersey's habitats were grouped into 14 key habitat types then assessed against a matrix of values, scored using a weighting system (high value = 2, low value = 1, negligible/unknown = 0). Scores were determined based on consensus of the services provided by each habitat within the scientific literature.

Overall, seagrass beds ranked highest out of the 14 key habitats for their cumulative ecosystem services. Seagrass beds scored the maximum possible for supporting services (12 of 12) and cultural services (8 of 8). Further, despite not reaching the maximum score for regulating services, seagrass beds were the highest-ranked habitat (9 out of 12). Under provisioning services, seagrass beds ranked second (5 out of 8) behind "Rock: seaweed communities" (6 out of 8). Notably, in areas where seagrass beds received lower rankings, this was either attributed to a lack of understanding/research (e.g., biological control) or because the high-value services in other areas prohibit it in others (e.g., the harvesting of seagrass for biofuel is likely to be prohibited due to the high value it contributes to biodiversity and carbon sequestration).

The significance of Jersey's seagrass beds extends far beyond their economic contribution. They epitomize the intricate and multifaceted benefits provided by healthy ecosystems, delivering ecosystem services that are indispensable to both human well-being and ecological balance. The robust scores in supporting, regulating, provisioning, and cultural services highlight the critical role seagrass beds play in maintaining the ecological integrity and cultural heritage of Jersey.

3 REPORT AIMS

Seagrass has long captivated the interest of the people of Jersey, with numerous groups and individuals emphasizing its significance over the past two centuries. Recently, reflecting a global recognition of the importance of seagrass, research and monitoring efforts in Jersey have intensified. Jersey, as the custodian of extensive coastal and offshore marine environments, benefits greatly from the presence of seagrass, which contributes to a mosaic of habitats and supports a diverse array of species.

This section of the report aims to:

1. Summarise the current knowledge of seagrass ecosystems in Jersey, drawing on information from various sources and focusing on four main themes:
   - Distribution and Extent
   - Biodiversity
   - Health and Condition
   - Carbon
2. Discuss the current state of seagrass in Jersey
3. Identify knowledge gaps to be addressed in future research, management, and conservation efforts.

3.1 KEY RESEARCH REPORTS & PUBLICATIONS

A selection of key reports and publications concerning seagrass in Jersey. Further documents can be found in the reference list.

3.1.1 STUDENT RESEARCH REPORTS

Table 2 - List of student research reports concerning seagrass in Jersey between 2001 and 2023

Author	Year	Title	Degree level
B. Greenaway	2001	Beach and oceanographic processes surrounding Jersey, Channel Islands.	Doctor of Philosophy
Emma Jackson	2003	Importance of seagrass beds as a habitat for fishery species around Jersey.	Doctor of Philosophy

E. R Holmes	2010	Estimated inorganic nutrient loading to intertidal regions from catchment and wastewater sources and the observed effects on marine benthic macro-algae in Jersey, Channel Islands	BSc Environmental Science
Louise Bennet-Jones	2014	The impact of a wastewater treatment works on the health of a *Zostera noltei* bed in Jersey, Channel Islands.	BSc Marine Biology and Coastal Ecology
Andrew Le Page	2014	An investigation into the effect of dissolved nitrates on the health and distribution of *Zostera noltei* seagrass in two intertidal regions of Jersey's Coast.	International Baccalaureate Diploma
Delaney	2015	The impact of the Bellozanne Wastewater Treatment Works outfall on the health of macrobenthic infaunal populations in St Aubin's Bay, Jersey (Channel Islands).	BSc Ecology and Wildlife Conservation
Callum McLean	2015	A study of the ecology and health status of Jersey's intertidal seagrass (*Zostera noltei*) areas.	BSc Biological Sciences
Sam Gorvel	2017	Health Status of Jersey Dwarf Eel Grass (*Zostera noltei*) beds and the anthropogenics forcing their decline.	BSc Marine Biology
Cordeil Sinclair	2017	Intertidal Seagrass in Jersey, Channel Islands: Temporal Structure and Associated Communities.	BSc Marine Biology
Stephanie Skiming	2018	The Potential for Seagrass Replacement in St Aubin's Bay, Jersey, Channel Islands.	BSc Environmental Science
Pilar Ferrer de Sant Jordi	2021	Does age matter? A study assessing the age of seagrass (*Zostera marina*) and its influence on blue carbon and species diversity in Jersey, UK Channel Island.	MSc Marine Conservation
Victoria Smith	2022	Assessing the variability of sedimentary carbon, carbonate content and biomass density between two intertidal *Zostera noltei* beds in Jersey, Channel Islands.	BSc (Hons) Marine Biology and Coastal Ecology
YiLin Kuo	2022	Investigating the carbon sequestration potential of seagrass (***Zostera spp***.) in St. Catherine's Bay, Jersey.	MSc Island Biodiversity and Conservation
Emily Dow	2022	The mooring scars of Jersey: Examining the extent of block and chain mooring damage to seagrass in St. Catherine's Bay, and the influence of mooring depth and location	MSc Island Biodiversity and Conservation
Esme Audland	2022	Conservation of *Zostera* in Jersey: a case study analysis of barriers to conservation and the role of contextual factors from a governance perspective.	MSc Sustainability Science, Policy and Society
Samantha Blampied	2022	A socio-economic and ecological approach to informing sustainable marine management in Jersey, Channel Islands	Doctor of Philosophy
Emily Dow	2023	The impact of block and chain swing mooring damage to the seabed within seagrass (*Zostera marina*) meadows; Jersey, Channel Islands.	MSc Island Biodiversity and Conservation
Caroline Millan	2023	The assessment of species diversity and carbon storage of Jersey's seagrass beds in relation to their age and condition, and partial condition evaluation of seagrass beds in the UK Channel Islands.	MSc Marine Conservation

3.1.2 SCIENTIFIC PUBLICATIONS

Table 3 - List of scientific publications concerning seagrass in Jersey between 2000 and 2023

Citation	Title	Publication
Stapleton, C. M. (2000)	Estimated inorganic nutrient inputs to the coastal waters of Jersey from catchment and wastewater sources	Wat. Res. Vol. 34, No. 3, pp. 787-796, 2000
Jackson *et al*. (2001)	The importance of seagrass beds as a habitat for fishery species	Oceanography and Marine Biology: An Annual Review 2001, 39, 269-303
Jackson *et al.* (2002)	Comparison of fish and mobile macroinvertebrates associated with seagrass and adjacent sand at St. Catherine's Bay, Jersey (English Channel): emphasis on commercial species	Bulletin of Marine Science, 71(3): 1333–1341, 2002
Jackson, Attrill, and Jones (2006)	Habitat characteristics and spatial arrangement affecting the diversity of fish and decapod assemblages of seagrass (Zostera marina) beds around the coast of Jersey (English Channel)	Estuarine, Coastal and Shelf Science 68 (2006) 421-432
Jackson *et al.* (2006)	Seagrass complexity hierarchies: Influence on fish groups around the coast of Jersey (English Channel)	Journal of Experimental Marine Biology and Ecology 330 (2006) 38–54
Blampied *et al*. (2022)	Value of coastal habitats to commercial fisheries in Jersey, English Channel, and the role of marine protected areas	Fisheries Management and Ecology. 2022. Volume 29. 734–744
Blampied *et al*. (2022)	Removal of bottom-towed fishing from whole-site Marine Protected Areas promotes mobile species biodiversity	Estuarine, Coastal and Shelf Science. 2002. Volume 276.
Alldread *et al.* (2023)	Diffuse and concentrated nitrogen sewage pollution in island environments with differing treatment systems	Nature. Scientific Reports. 13, Article number: 4838 (2023)

3.1.3 GOVERNMENT & ENVIRONMENTAL CONSULTANT REPORTS

Table 4 - List of reports produced by the Government of Jersey and environmental consultants concerning seagrass in Jersey between 2002 and 2021

Author	Year	Institution	Title
Mercer, T and Fuller, R	2002	Aquatic Environments	Survey of St Aubin's Bay adjacent to St Aubin village.
Linley et al.	2009	PML Applications Ltd	Review of the current ecological status of the SE coast Jersey Ramsar site
Berry, D.	2010	Environmental consultant (Centre for Research into	Reassessment of the trophic status of St Aubin's Bay, Jersey 2009-2010

		Environment and Health)	
Department of Planning and Environment	2011	Government of Jersey	Jersey's Southeast Coast Ramsar Management Plan
Leverett, D.	2015	WCA Environment Limited	The Environmental Status of St. Aubin's Bay, Jersey According to the Requirements of the Water Framework Directive - Data Management and Assessment of Monitoring Programmes: Monitoring Programme Results and Status Assessments (2012-2015)
Fairhead, A.	2016	Cascade Consulting (in collaboration with Nurture Ecology & Société Jersiaise)	St Aubin's Bay Ulva Studies 2014-2015
Department of Environment	2017	Government of Jersey	A Report on a Ploughing Trial at St Aubin's Bay
Bennet-Jones, L.	2019	Government of Jersey	Temporal analysis of Zostera noltei in Jersey, Channel Islands (draft/unpublished)
Blampied, S.	2021	Government of Jersey	Seagrass Biomass Report (draft/unpublished)
Chambers, P. M., Blampied, S., Binney, F., Austin, W. E. N. and Morel, G.	2022	Government of Jersey	Blue carbon resources: an assessment of Jersey's territorial seas, Jersey: Government of Jersey.
Marine Resources	2023	Government of Jersey	Ecosystem service assessment of Jersey's marine habitats
Infrastructure and Environment	2021	Government of Jersey	Jersey Marine Spatial Plan - Priorities and Actions Plan – Public Consultation Draft

3.1.4 SOCIÉTÉ JERSIAISE

Table 5 - List of publications by the Société Jersiaise holding key historical references to seagrass in Jersey

Author	Publication/Year	Title
E. Duprey	Annual Bulletin 1877-78	Coquilles de Jersey
E. Duprey	Annual Bulletin 1880	Coquilles de Jersey – Liste supplémentaire
Paul Chambers	Annual Bulletin 2011	An insight into the ecology and beach processes on Jersey's east coast
Louise Bennet-Jones	Annual Bulletin 2016	An investigation into the health of intertidal eelgrass beds in Jersey

4 DISTRIBUTION & EXTENT

Seagrass in Jersey's waters has been mapped on various occasions using a variety of techniques. This first mapping focused solely on *Z. marina* as part of Emma Jackson's PhD research. This study provides an extremely detailed and ground-truthed map of *Z. marina* for 1997. Later in 2022, as part of a Jersey-wide marine habitat mapping project, both *Z. marina* and *Z. noltei* were mapped using predictive GIS modelling. Finally, in 2024 (as part of this report), both species were mapped using aerial photographs taken across a maximum of 88 years to gain an understanding of the change in area over time.

4.1 *ZOSTERA MARINA* - 1997

Despite local interest, before 1997, no studies had mapped the distribution of either *Zostera* species in Jersey. Jackson (2003) used aerial images to create an area coverage map of *Zostera marina* habitats around Jersey's coastline. Further, acoustic surveys were conducted to consider the structure of seagrass beds (see Health and Condition). Ground-truthing was conducted via SCUBA diving, snorkelling or glass-bottom box, and drop video camera surveys.

Aerial photos were taken on 21st July 1997. Cluster-based colour analysis and modelling were performed to identify seagrass habitats. Estimates from this analysis suggested that *Z. marina* covered 129.07 ha (1,290,700 m2) of the shallow subtidal area along Jersey's coasts. Seagrass beds were predominantly found on the south and east coasts, as well as some small patches in the northeast (Figure 18). The largest areas of seagrass were St Catherine's Bay at 27.39 ha (273,900 m2), Les Elavees at 13.42 ha (134,200 m2), and Violet Channel at 11.54 ha (115,400 m2) (Figure 18). Jackson further analysed several environmental parameters (collected whilst undertaking surveys) to assess the environmental setting of Jersey's seagrass beds. The mean depth of *Z. marina* was 2.1 meters below the chart datum, and seagrass was never found below 6 meters (for the beds surveyed acoustically) (Figure 19). All beds of *Z. marina* were considered subtidal, apart from Grand Haise, Anne Port, and La Coupe, which were classified as lower intertidal. The upper limit of the *Z. marina* was approximately at the low water spring tide mark. There were significant differences in the depth of seagrass beds between locations, with those on the east coast (Fliquet, St Catherine's Bay, and Anne Port) displaying large depth ranges, whilst those on the south coast (Karame, Violet, Icho and Elizabeth Castle) having much narrower depth ranges.

In general, seagrass was only found on very slightly sloping seabed. However, there were significant differences in seabed slope across sites, with the slope at Fliquet significantly greater than any other site. The Relative Exposure Index used to assess the levels of exposure at each site categorised St Catherine's Bay as the most sheltered site while La Coupe was the most exposed.

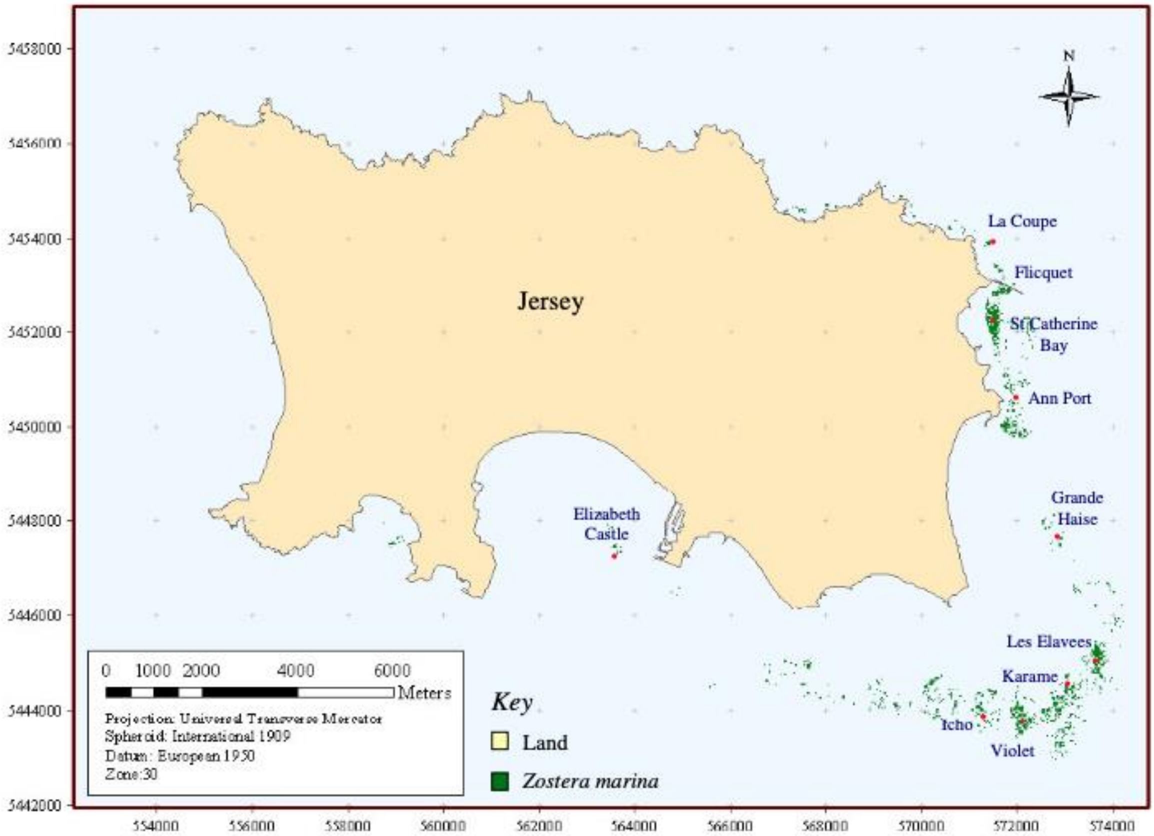


Figure 18 - 1997 distribution of *Zostera marina* (in green) around Jersey. Taken from Jackson (2003)

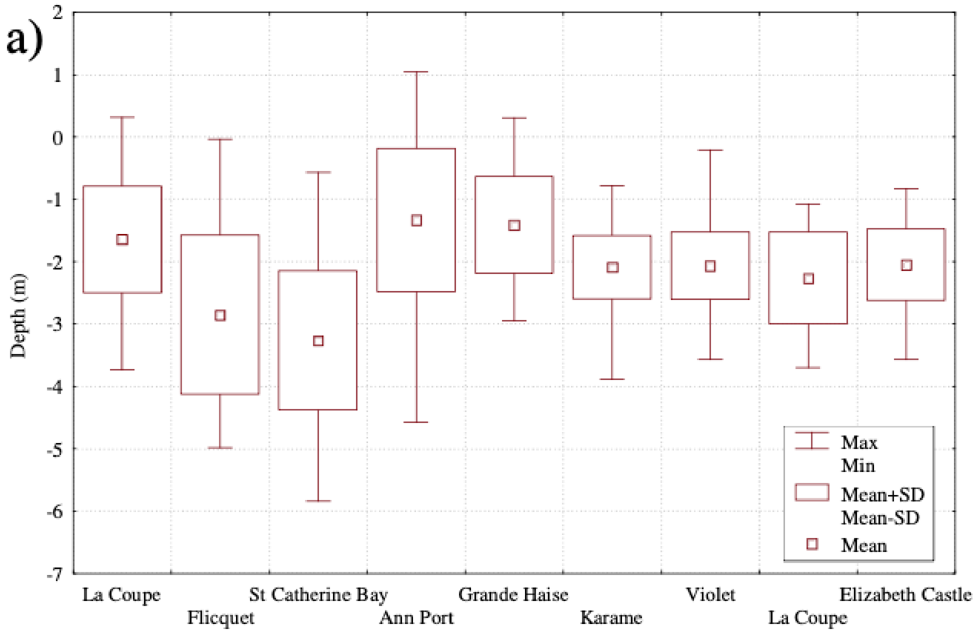


Figure 19 – Depth ranges (below chart datum) of nine *Zostera marina* beds around Jersey. Taken from Jackson (2003)

4.2 MODELLED EXTENT - 2022

The extent of Jersey's seagrass habitats was modelled as part of the 'Blue Carbon Resources Report', published in 2022 (Chambers *et al.*, 2022). This project assessed Jersey's territorial seas using an area-based approach to estimate the blue carbon potential of benthic habitats. For this, all of the intertidal and subtidal habitats were classified using habitat survey data from various local sources, biological and sedimentological data, and GIS modelling (Figure 20; See Chambers *et al.* (2022) for full methodology).

Intertidal seagrass habitats covered 2,341,973 m^2 (Table 6). These were located in Portelet Bay, St Aubin's Bay, Grouville Bay, Anne Port, Archirondel and St Catherine's Bay. Subtidal seagrass habitats covered 1,782,098 m^2. These were located in La Coupe Bay, Fliquet, St Catherine's Bay, Anne Port, Archirondel, La Cote, Les Minquiers, and Les Écréhous.

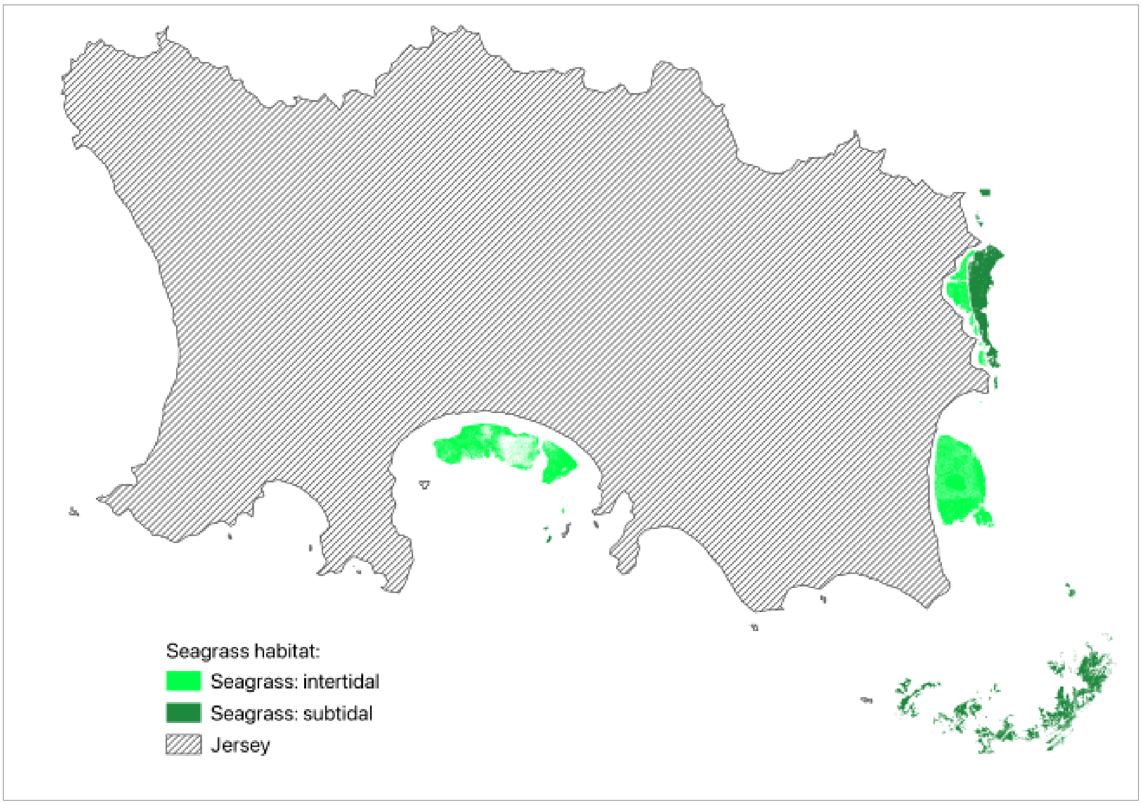


Figure 20 – Habitat map of *Zostera marina* (in dark green) and *Zostera noltei* (in light green) (Chambers *et al.*, 2022).

Table 6 – Area (m^2) of intertidal and subtidal seagrass within Jersey's waters as per the Jersey-wide marine habitat map (Chambers *et al.*, 2022).

	EUNIS	Description	Area (m2)
Seagrass	A2.6111	Intertidal	2,341,973 m^2
	A5.5331	Subtidal	1,782,098 m^2
		Total	4,124,072 m^2

4.3 TOTAL SEAGRASS EXTENT

Aerial images taken in 2021 were analysed as part of this report using open-source Geographical Information Software, QGIS, to quantify the extent of seagrass beds in Jersey. Seagrass areas were visually identified and mapped through the creation of polygons, identified by location and seagrass type (intertidal or subtidal). The area of each polygon, in meters squared, was then extracted to offer the most up-to-date record of seagrass extent.

In 2021, Jersey's seagrass covered a total area of 4,646,116 m^2. This is slightly more than the parish of St Clement, which covers 4,000,000 m^2 (4% of Jersey's land area) (Government of Jersey, 2024c). Just over half (57%) of the total seagrass area is comprised of intertidal seagrass *Z. noltei,* whilst the remaining 43% is subtidal *Z. marina* (Figure 21)[xiii].

The area supporting the greatest extent of seagrass is the Southeast corner of Jersey, where the subtidal *Z. marina* covers 1,225,775 m^2, second only to St Catherine's Bay at 505,208 m^2 (Figure 22). Small patches of subtidal seagrass can also be found at Portelet, Ouaisne, Fliquet, Rozel, and La Cote (Figure 23). Grouville Bay on the east coast and St Aubin's Bay on the south coast support the second and third-largest seagrass areas overall. These areas support large intertidal meadows of *Z. noltei*, 1,198,395 m^2 and 1,157,890 m^2, respectively. St Catherine, Anne Port, and Archirondel are significant areas where subtidal and intertidal seagrass coexist, whilst St Catherine's Bay supports the fourth largest area of seagrass overall.

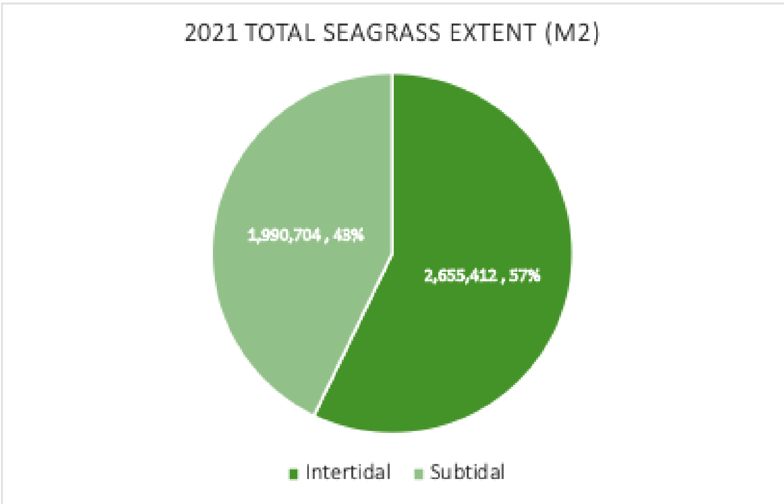


Figure 21 - Proportion *Z. marina* and *Z. noltei* across the total area (4,646,116 m^2) of seagrass in Jersey, 2021.

[xiii] These percentages are approximate. In Jersey, areas of *Z. noltei* and *Z. marina* occasionally overlap. This transitional zone can be identified in aerial photographs. However, to avoid overestimation of the seagrass area, intertidal and subtidal polygons were not overlapped.

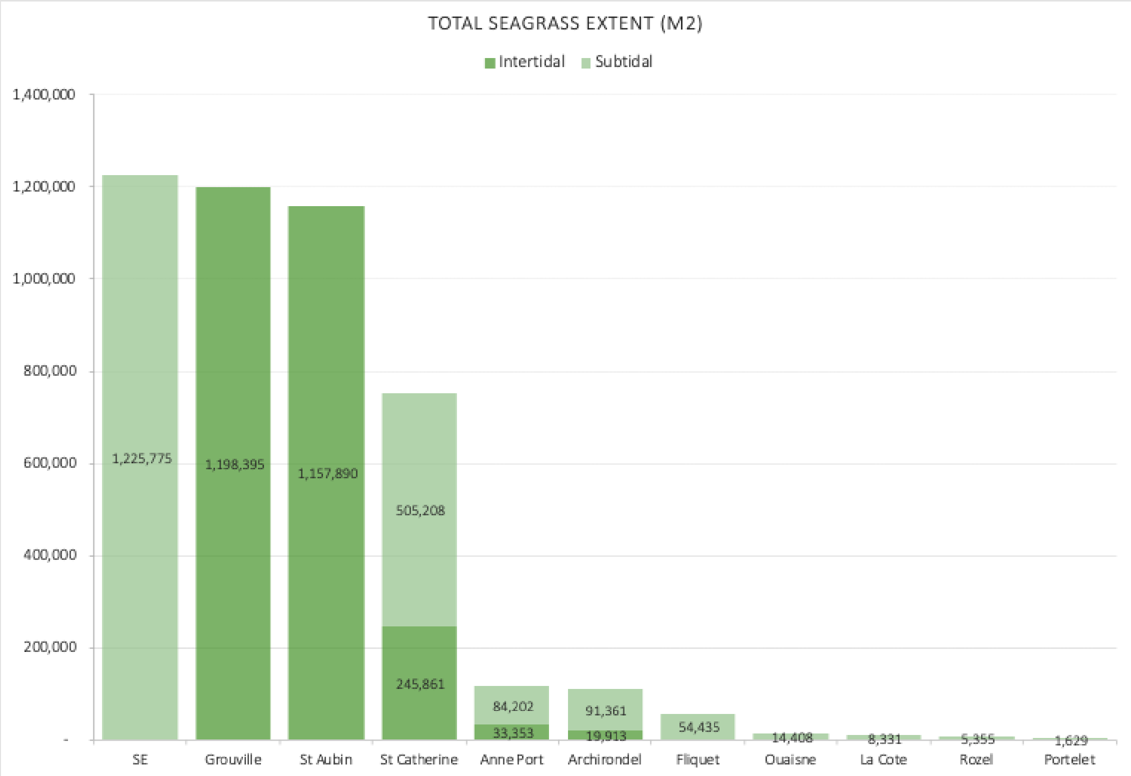


Figure 22 - Amount of seagrass supported across each area/bay in Jersey, 2021. Light green indicates *Z. marina,* dark green indicates *Z. noltei.* SE refers to seagrass to the southeast of Jersey.

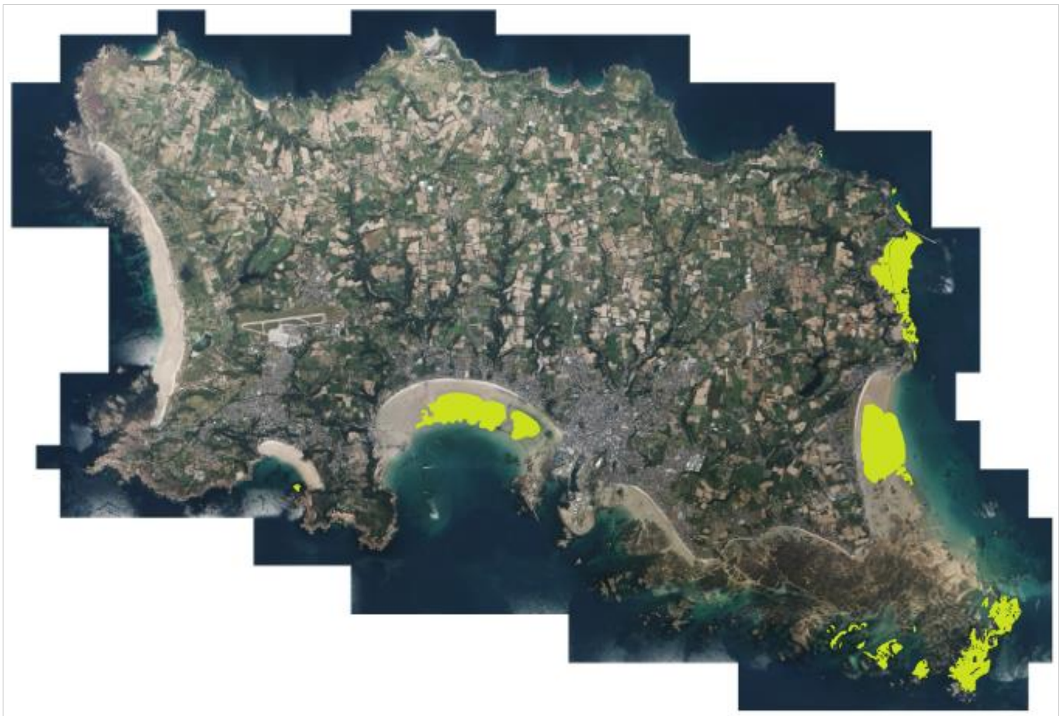


Figure 23 – Distribution of seagrass (*Z. marina* & *Z. noltei*) in Jersey, as visible in the 2021 aerial photograph

4.4 CHANGE IN EXTENT

To examine the change in the extent and distribution of seagrass in Jersey over time, aerial photographs taken between 1933 and 2021 were used. Photos from 1933 and 1944 were obtained from the Government of Jersey Marine Resources (Table 7). Both these years' photos were taken on black and white film. These photos only cover snippets of the Jersey coastline but allow us to look back over 88 years. Photos from 1997 onwards were taken in colour and have a pixel resolution of 10cm, giving a clear and detailed view of the whole island. These images were not taken initially to monitor seagrass. However, flights were typically planned to occur around low tide and encompass the island's coastal zones, making many usable in this study. Mapping was performed using open-source Geographic Information System software, QGIS.

Reference areas were used to monitor the change in extent over the years. This was mainly to facilitate using the 1933 and 1944 photos within the comparison, as these images only cover select areas. Further, despite photos from later years covering the whole island, the coverage of coastal regions varies, so reference areas standardised the comparison area. Despite having multiple years of photos, only some years were suitable for the comparison. This was primarily due to tidal coverage or glare on the water obscuring the view of seagrass in certain areas. Reference areas are irregular shapes to maximise their potential area (Figure 24). In total, two subtidal and three intertidal reference areas were generated. Subtidal reference areas included the northern end of St Catherine's Bay up to the breakwater and a large area on the Southeast coast, east of Icho Tower. Both subtidal areas have photos from 1933 to 2021, offering the most extended comparison. Intertidal reference areas were generated, covering the whole of St Aubin's and Grouville Bay and the northern half of St Catherine's Bay.

Photographs were analysed visually (for examples of usable and unusable photographs, see Figure 25), and polygon layers were created to represent the area of seagrass present each year. Polygons were then cropped to match the reference areas. The area of the polygons was then extracted to calculate the extent of seagrass within each reference area across the years.

Table 7 - Details of aerial photography used to map the change in seagrass extent between 1933 and 2021

Year	Date of flight	Flight Time/duration (GMT)	Approximate water level at time of survey (meters)	Image pixel resolution
1933	Unknown			
1944	Unknown			
1997	21st July	13.00-14.12	2.7-1.4m	1:10,000 20c GSD

2003	16th April 17th April	12.06-13.57 14.08-14.36	2.3-0.8m 0.6-0.5m	1:6250 20cm
2006	10th June	11.38-13.42	Unknown	1:6250 20cm
2007	1st August	10.41-12.32	Unknown	1:6250 20cm
2008	23rd July	14.00-15.40	Unknown	10cm
2009	8th September	12.29-14.36	Unknown	10cm
2010	21st September	15.15 – 17.24	Unknown	10cm
2011	1st September	10.41-12.32	Unknown	10cm
2012	18th August 20th August	15.35 – 16.26 14.40 – 15.34	Unknown	10cm
2013	23rd September 24th September	16:00 – 16:45 11:12 – 12:15	Unknown	10cm
2014	10th September	11:45 – 13:46	Unknown	10cm
2015	23rd June	07:24 -09:10	Unknown	10cm
2016	14th August	08:54 – 11:03	Unknown	10cm
2017	27th August	14:11 – 15:37	Unknown	10cm
2018	27th September	12:45 – 17:49	Unknown	10cm
2019	3rd August	12:48 - 14:37	Unknown	10cm
2020	22nd July	12:54 - 14:34	Unknown	10cm
2021	22nd July	10:20 – 11:35	Unknown	10cm

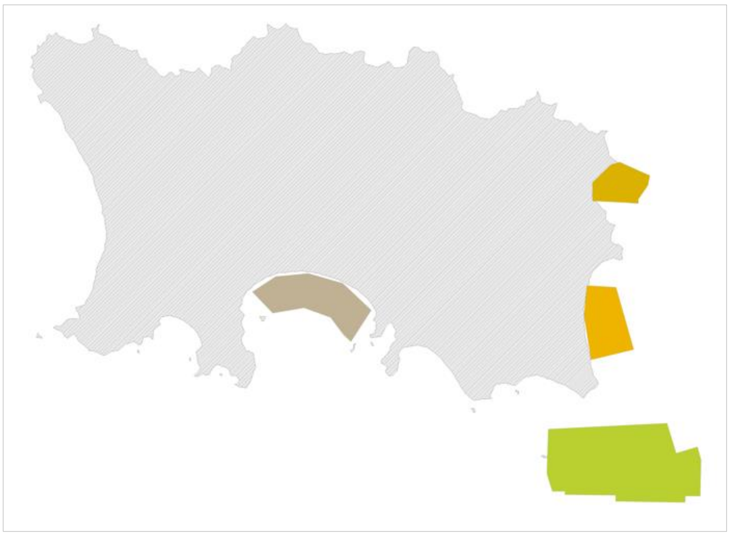


Figure 24 - Reference areas use to compare change in seagrass extent over time.

Figure 25 - Examples of aerial images. Visible intertidal seagrass in 2018. Seagrass was obscured by hightide in 2013. Grouville Bay, Jersey.

4.4.1 SUBTIDAL

4.4.1.1 SOUTHEAST COAST

The southeast coast is the only location where aerial photography from 1993 and 1944 is present, making it a key place to examine change over time. This area appears to show the most dramatic changes of any reference area. In 1933, the seagrass covered 634,000 m^2, dropping to its lowest recorded extent in 1997 at 136,000 m^2 (Table 8; Figure 26). The highest extent was observed in 2021 at 907,000 m^2.

It is generally thought that the area covered by seagrass in the Southeast was much larger before 1931 (Chambers, Binney and Jeffreys, 2016). Thus, the 1933 area had likely already undergone a significant decline. The wasting disease epidemic was undoubtedly the cause of this decline and likely took hold in 1930 (or just prior) (Renn, 1936; Graham *et al.*, 2021). In the 11 years between 1933 and 1944, a total 66.1% decrease in extent was recorded, averaging a loss of 6% per year. From the data, it is impossible to tell the exact time of this change. Seagrass in the Southeast could have steadily declined over those years. However, this decrease was more likely to have happened over a short period early in the 1930s due to the wasting disease.

Over the 53 years between 1944 and 1997, a further 36.2% decrease is seen, but at a slower rate of decline at an average of <1% per year. Due to the lack of yearly photographs between 1933 and 1997, we cannot discern if this decline was constant or underwent many periods of decline and recovery. However, 1997 appears to be a turning point in the time series, with the lowest recorded extent at 136,953 m^2, followed by a drastic increase of 563% by 2021. This over 5.5x increase in seagrass exceeds the extent recorded in 1933, suggesting a greater distribution was possible before 1993.

Seagrass in this area has shifted eastward as it has recovered, colonising a previously unrecorded area. This new growth zone has likely contributed to the success of seagrass in this area and its significant recovery (Figure 27).

Table 8 - Area measurements and corresponding changes for the Southeast (subtidal) reference area between the years 1933 and 2021. Area changes calculated relative to the previous measurement and average area change per year (m2) calculated using the number of years between measurements.

Image Year	Measured area (m2)	Time difference (years)	Area change (m2)	Area change (%)	Average area changes per year (m2)	Average area changes per year (%)
1933	634,115					
1944	214,676	11	-419,439	-66.1%	-38,131	-6.0%
1997	136,953	53	-77,723	-36.2%	-1,466	-0.7%
2003	339,601	6	+202,648	148.0%	+33,775	24.7%
2011	525,292	8	+185,691	54.7%	+23,211	6.8%
2019	897,971	8	+372,679	70.9%	+46,585	8.9%
2020	905,591	1	+7,620	0.8%	+7,620	0.8%
2021	907,714	1	+2,123	0.2%	+2,123	0.2%

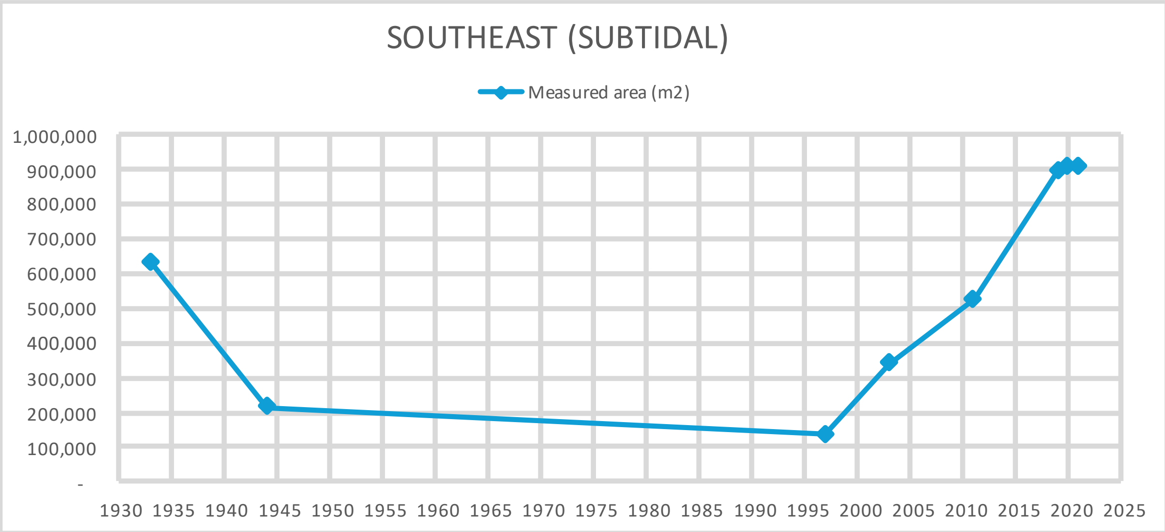


Figure 26 - Change in *Z. marina* extent between 1933 and 2021 in the Southeast coast (reference area only)

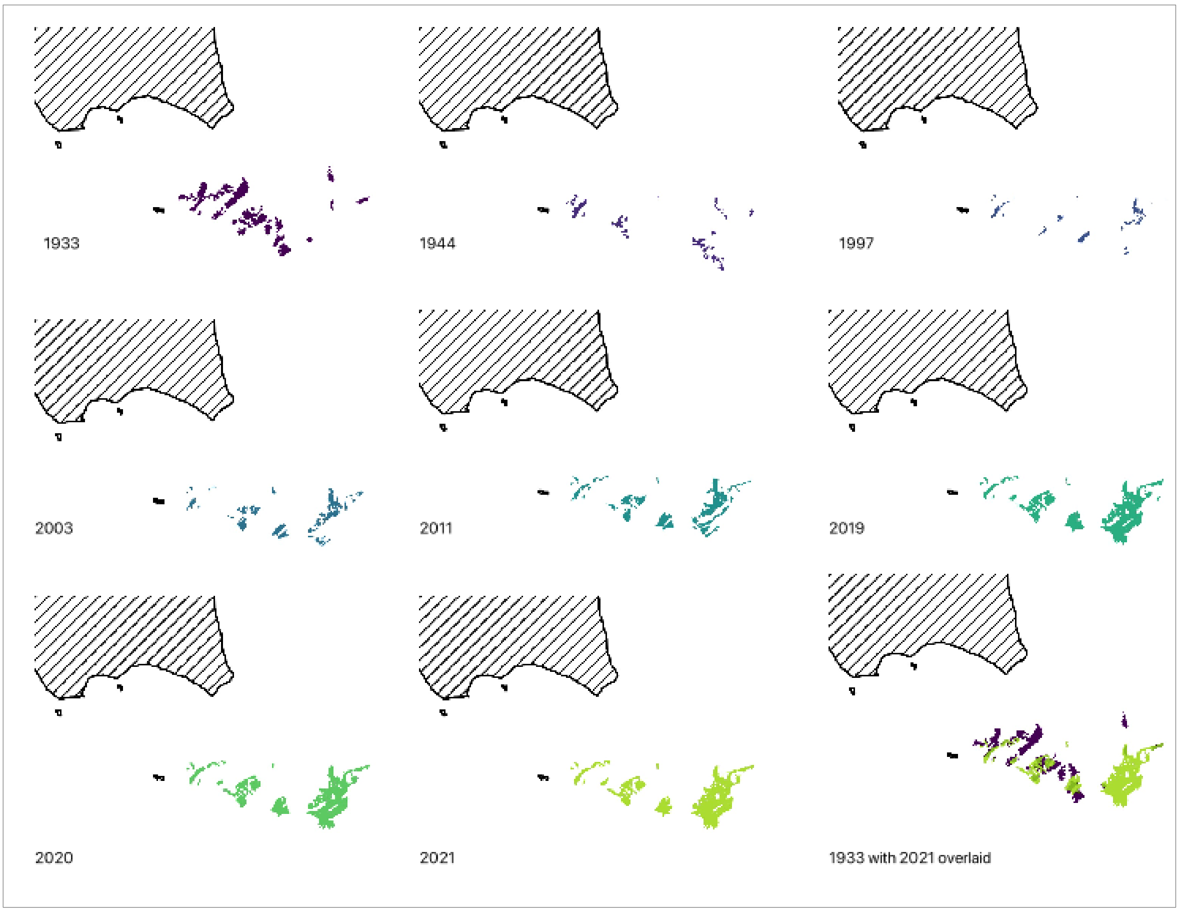


Figure 27 - Map showing change in *Z. marina* distribution and extent with the Southeast coast reference area between 1933 and 2021

4.4.1.2 ST CATHERINE'S BAY

St Catherine's Bay is one of two areas with an aerial photo for 1993, making it a key location for observing the effects of wasting disease. The scope of the reference area was primarily determined by the coverage of the 1933 photo, which covers the northern half of the bay.

Changes in seagrass extent can be seen throughout the 88 years between 1933 and 2021 (Figure 28). The highest extent was recorded in 1933 at 528,000 m^2. However, due to the quality of the black-and-white image in 1933, it must be noted that the extent taken was determined as a 'middle ground' whilst the actual area may have been higher or lower. The lowest extent was in 1997 at 341,000 m^2. This estimate is roughly 20% more than Jackson (2003), who estimated an area coverage of 27.39 ha. The difference can be attributed to the use of different measures (full bed extent, which includes the mosaic of sand and seagrass within each bed versus area coverage which emits areas without seagrass) and differences in research methodology.

A significant decrease occurred between 1993 and 1997 when approximately one-third of the seagrass within the St Catherine's reference area disappeared (Table 9). This is significantly less than in the Southeast reference area, which displayed a 78% reduction (compared to 35% at St Catherine). As mentioned, the photo from 1933 only covers the northernmost extent of the bay and thus does not encompass the entire extent of seagrass at St Catherine's Bay (Figure 29). The limited scope of the reference area may have limited the recorded decline, which could have occurred outside of the reference area at the southern fringe of the bed. If a larger image from 1933 had been measured, we may have observed a decline comparable to the Southeast coast. Jackson (2003) concluded that the Relative Exposure Index (REI) greatly influenced seagrass bed and landscape attributes, including the percentage of core bed area and the Largest Patch Index (LPI). As REI increased in seagrass sites around Jersey's coasts, the core bed area and LPI percentage decreased. Jackson (2003) classified St Catherine's Bay as the most sheltered seagrass site, with an REI of only 4.88 (x10^6) and home to the highest LPI (27.7%). Further, St Catherine's also reported the highest mean core area of seagrass as a percentage of landscapes at 23.95%. This means that the seagrass bed at St Catherine's provides a homogenous landscape, only broken up by anthropogenic disturbances (mooring chains). The continuous nature of the seagrass at St Catherine's Bay, likely makes it more resistant to declines and more able to recover from losses.

A recovery in extent within the St Catherine's reference area is seen over the 2000s, with 2019 seeing the highest extent overall at 461,263 m^2. Over the 24 years between 1997 and 2021, a 34% increase in extent is observed. This is notably different from the SE reference area, which increased by 563% over the same period. The bed at St Catherine is likely limited in its extent, existing within the shelter provided by the breakwater and natural rocks, whilst the seagrass in the Southeast can spread and colonise new areas.

The artificial breakwater structure likely increased the available habitable area for seagrass by offering protection from harsh currents and swell. There are no records of seagrass before the construction of the breakwater in 1847. The earliest record of seagrass in this area is *Z. angustifolia* (synonym for *Z. marina*) in 1887 (Le Sueur, 1984). It is generally considered that much, if not all, of the seagrass area at St Catherine's Bay was colonised following the breakwater development due to the increased protection. Seagrass found in neighbouring bays of Fliquet, Anne Port and Archirondel, likely also benefit from the shelter of the breakwater. If seagrass was present before the creation of the breakwater, it may have been severely impacted over the mid-19th century due to increased boat traffic, major turbidity, and pollution created in the construction process (Figure 30).

Within the St Catherine's reference area, there is a particularly strong recovery rate between 2008 and 2019, at an average of 2% per year. A decrease of 4.2% was noted in 2020, but this is short-lived and recovered by 3.8% in 2021.

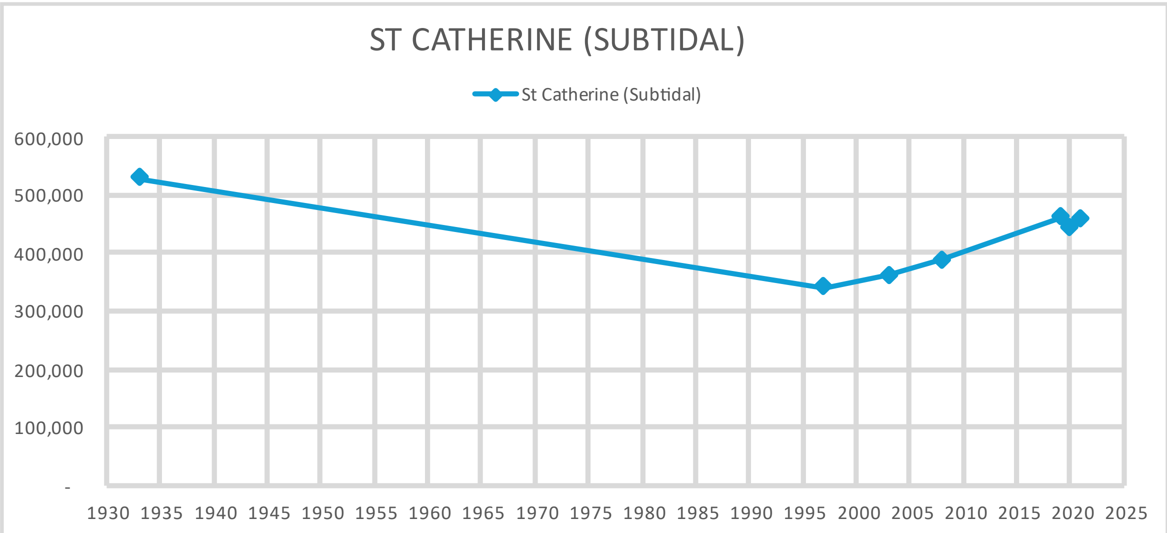


Figure 28 - Change in *Z. marina* extent between 1933 and 2021 in the St Catherine's Bay (reference area only)

Table 9 - Area measurements and corresponding changes for the St Catherine (subtidal) reference area between years 1933 and 2021. Area changes calculated relative to previous measurement and average area change per year (m2) calculated using the number of years between measurements.

Image Year	Measured area (m2)	Time difference (years)	Area change (m2)	Area change (%)	Average area changes per year (m2)	Average area changes per year (%)
1933	528,666					
1997	341,117	64	-187,549	-35.5%	-2,930	-0.6%
2003	361,743	6	+20,626	6.0%	+3,438	1.0%
2008	387,384	5	+25,641	7.1%	+5,128	1.4%
2019	461,263	11	+73,879	19.1%	+6,716	1.7%
2020	442,079	1	-19,184	-4.2%	-19,184	-4.2%
2021	458,756	1	+16,677	3.8%	+16,677	3.8%

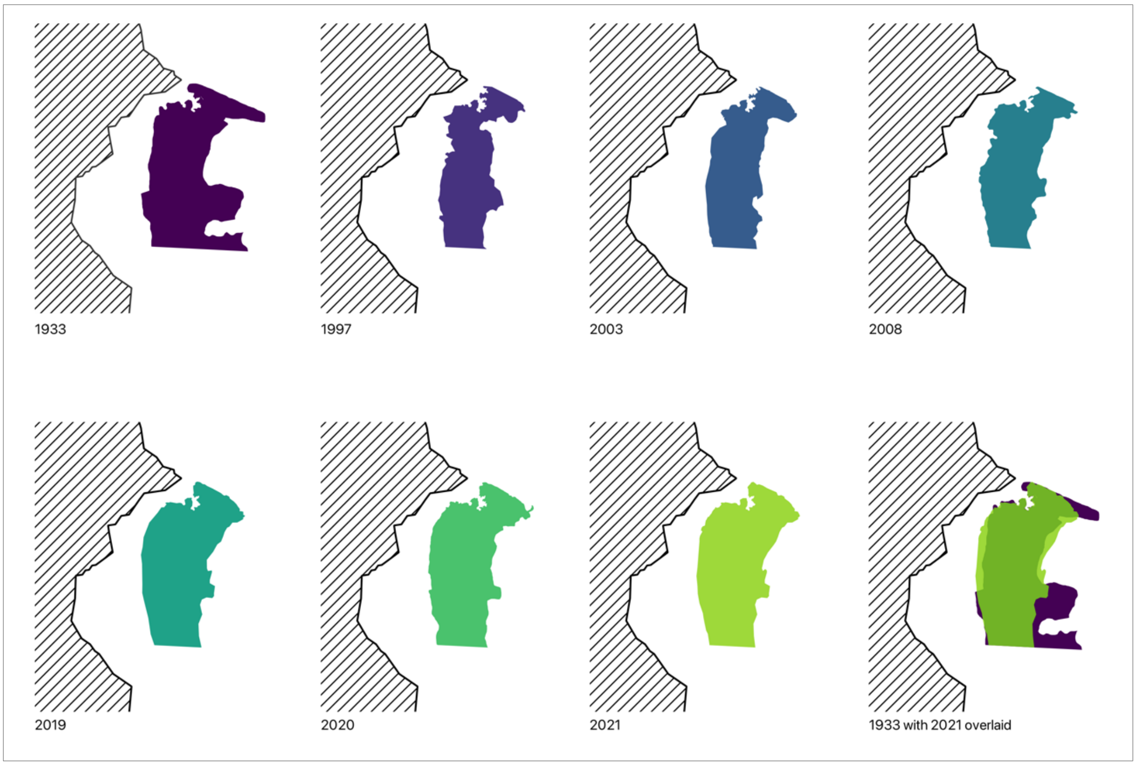


Figure 29 - Map showing change in *Z. marina* distribution and extent with the St Catherine's Bay reference area between 1933 and 2021.

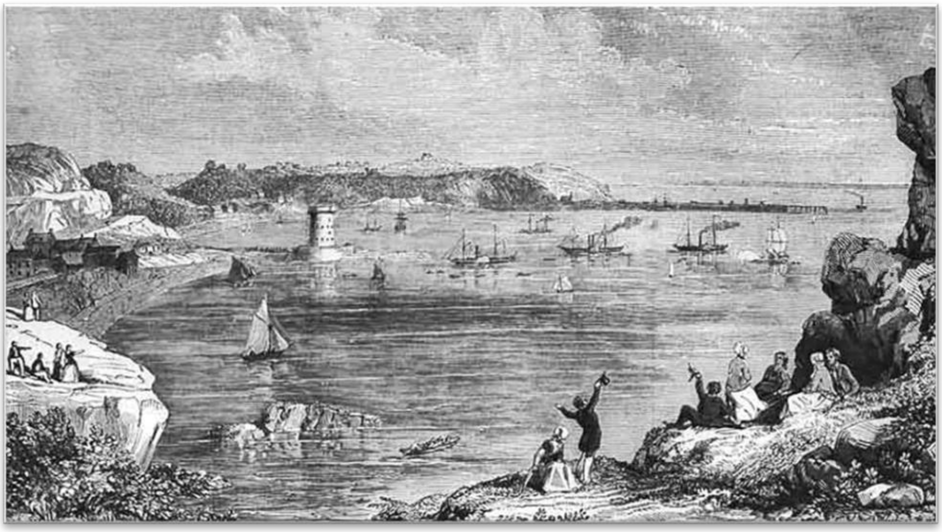


Figure 30 - Illustration of the St Catherine's Harbour construction in 1852. Image obtained from www.theislandwiki.org/index.php/St_Catherine

4.4.2 INTERTIDAL

4.4.2.1 GROUVILLE BAY

The earliest measured extent of intertidal seagrass in Grouville Bay was from the 1997 aerial photograph, with a recorded extent of 934,607 m^2 (Table 10). The bed decreased by 6% to its lowest recorded extent of 877,087 m^2 in 2012 (Figure 31). Over the 24 years between 1997 and 2021, the seagrass bed increased by 28%, reaching the maximum recorded extent of 1,198,215 m^2. Notably, the bed is expanding southwards into the area of artificial oyster beds (Figure 32). This is first documented in the 2017 aerial photo (Figure 33).

Overall, Grouville experiences the smallest change over time of the three measured intertidal beds. This is likely due to it being least impacted by anthropogenic factors and the presence of one principal, continuous bed. The absence of significant anthropogenic disturbances may mean that the seagrass bed may have faced fewer periods of decline than in other regions. The bed does not appear to significantly expand over the recorded time series, and due to the lack of data before 1997, it is unclear why this is.

Table 10 - Area measurements and corresponding changes for the Grouville (intertidal) reference area between years 1997 and 2021. Area changes calculated relative to previous measurement and average area change per year (m2) calculated using the number of years between measurements.

Image Year	Measured area (m2)	Time difference (years)	Area change (m2)	Area change (%)	Average area changes per year (m2)	Average area changes per year (%)
1997	934,607					
2008	1,022,395	11	87,788	9.4%	7,981	0.9%
2009	973,331	1	-49,064	-4.8%	-49,064	-4.8%
2012	877,087	3	-96,244	-9.9%	-32,081	-3.3%
2017	1,080,335	5	203,248	23.2%	40,650	4.6%
2018	1,176,137	1	95,802	8.9%	95,802	8.9%
2019	1,068,885	1	-107,252	-9.1%	-107,252	-9.1%
2020	1,121,731	1	52,846	4.9%	52,846	4.9%
2021	1,198,215	1	76,484	6.8%	76,484	6.8%

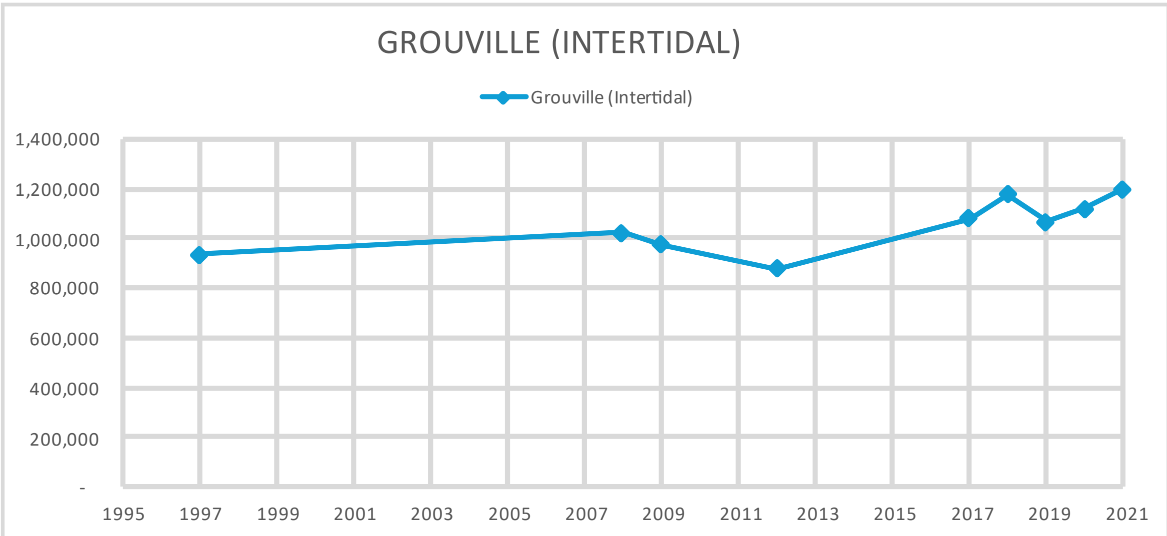


Figure 31 - Change in Z. *noltei* extent between 1997 and 2021 in Grouville Bay (reference area only)

Figure 32 - Photo of the Oyster beds located at the south of Grouville Bay. Photo: George Mantzos

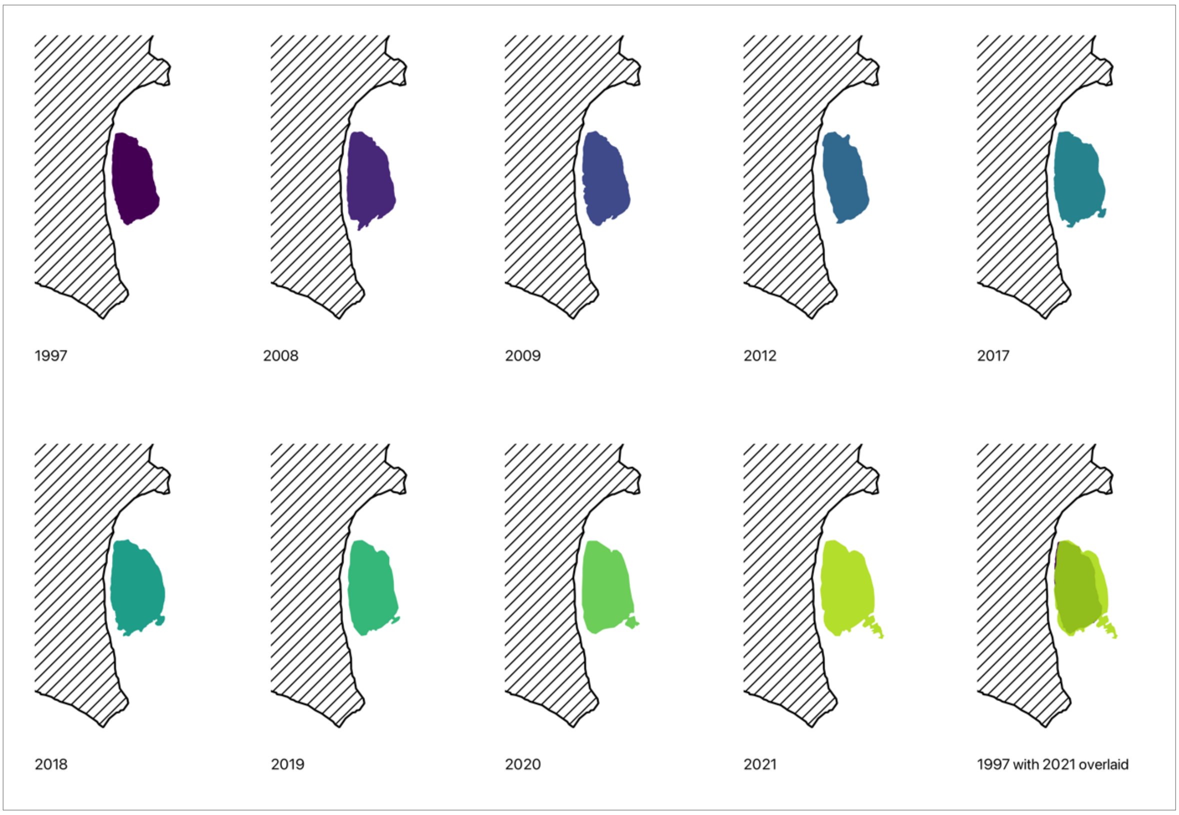


Figure 33 - Map showing change in *Z. noltei* distribution and extent within the Grouville Bay reference area between 1997 and 2021.

4.4.2.2 ST AUBIN'S BAY

The intertidal seagrass at St Aubin's Bay is split into two beds by the wastewater outlet. Overall, the lowest total extent observed in St Aubin's Bay was in 1997, at 860,391 m^2 (Table 11). The highest total extent was in 2019, at 1,334,759 m^2. Over the 24 years between 1997 and 2021, the total seagrass area increased by 35%. However, between 2011 and 2012, a decrease of 10.9% was recorded, whilst between 2019 and 2021, a 7.5% decrease was observed, indicating substantial annual fluctuations.

The two seagrass beds at St Aubin's Bay are unique and experience different fluctuations over time (Figure 34). The eastern bed appears to have reached a natural maximum extent due to its surrounding environment, which includes the mean high-water line to the north, marine lake and intertidal rocks to the east, the waste-water outlet to the west, and deeper water to the south. However, the western bed is limited on three sides, with the westernmost edge open to expansion. Much of the total variation in seagrass extent comes from the bed to the west of the water outlet. Most of the change in extent can be attributed to an expansion westwards and fluctuations on the southern fringe of the western bed (Figure 35). Fluctuations in the south may be attributed to pooling wastewater, causing the seagrass to die back. Fluctuations observed may also be exacerbated by the faint appearance of *Z. noltei* in some aerial images as lower densities of seagrass make it harder to visually distinguish.

Table 11 - Area measurements and corresponding changes for the St Aubin (intertidal) reference area between years 1997 and 2021. Area changes calculated relative to previous measurement and average area change per year (m2) calculated using the number of years between measurements.

Image Year	Measured area (m2)	Time difference (years)	Area change (m2)	Area change (%)	Average area changes per year (m2)	Average area changes per year (%)
1997	860,391					
2008	971,247	11	110,856	12.9%	10,078	1.2%
2009	998,502	1	27,255	2.8%	27,255	2.8%
2011	1,043,062	2	44,560	4.5%	22,280	2.2%
2012	929,877	1	-113,185	-10.9%	-113,185	-10.9%
2017	1,040,131	5	110,254	11.9%	22,051	2.4%
2018	1,208,139	1	168,008	16.2%	168,008	16.2%
2019	1,334,759	1	126,620	10.5%	126,620	10.5%
2020	1,310,686	1	-24,073	-1.8%	-24,073	-1.8%
2021	1,157,890	1	-152,796	-11.7%	-152,796	-11.7%

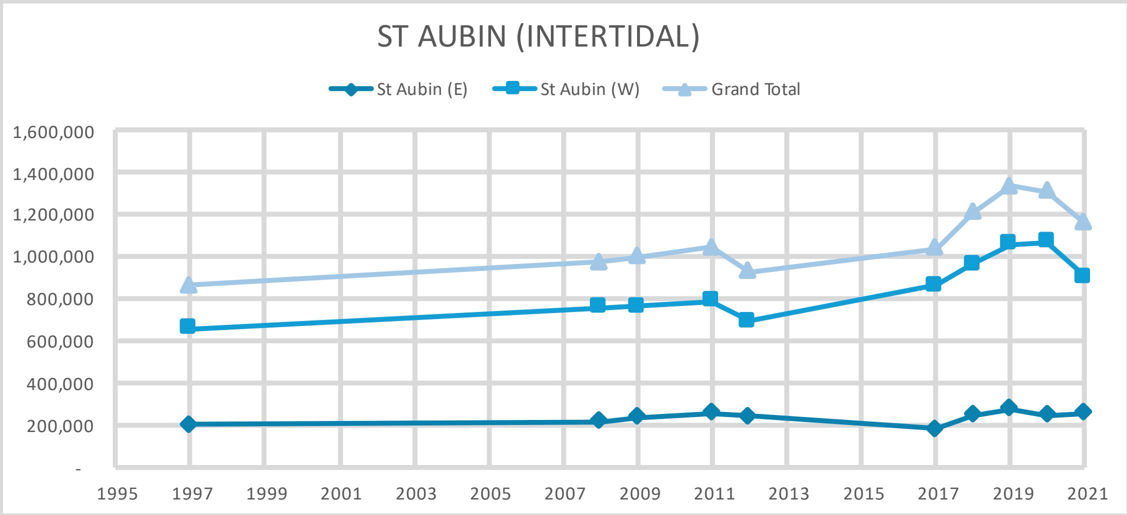


Figure 34 - Change in *Z. noltei* extent between 1997 and 2021 in the St Aubin's Bay (reference area only). St Aubin's west bed in blue. St Aubin's east in dark blue. Cumulative changes of both intertidal beds in St Aubin's Bay in light blue.

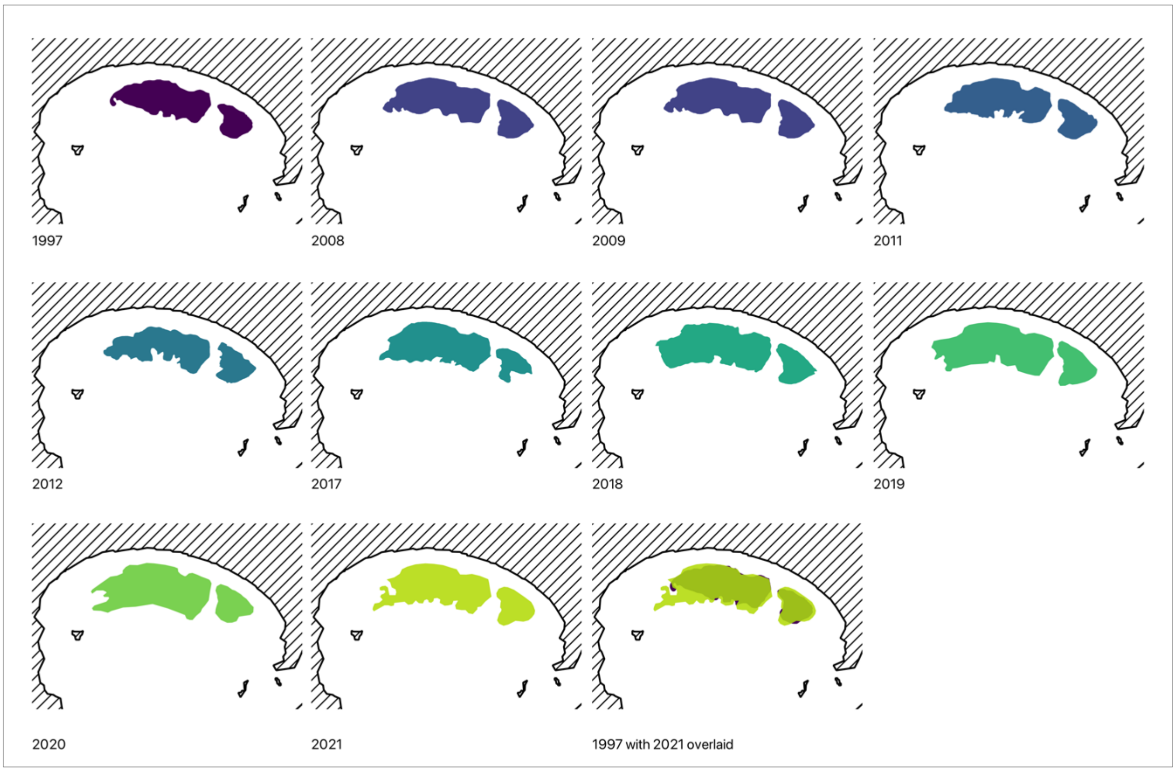


Figure 35 - Map showing change in Z. *noltei* distribution and extent within the St Aubin's Bay reference area between 1997 and 2021.

4.4.2.3 ST CATHERINE'S BAY

The intertidal seagrass at St Catherine's Bay is split into two beds by a freshwater runoff. Over time, large fluctuations in the total extent of seagrass are seen. The earliest recorded extent in 1997 measures 152,228 m^2, dropping by 16.2% to the lowest recorded extent of 127,563 m^2 in 2003. The highest measured extent was in 2021 at 210,210 m^2 (Table 12).

From 1997 to 2021, the intertidal extent at St Catherine's Bay increased by 45%. This is a more substantial increase than in St Aubin's Bay (35% increase) and Grouville Bay (28% increase) over the same period. This increase can mainly be attributed to the 1997 to 2008 period when the St Catherine's bed increased by 32% whilst St Aubin's bed increased by 13% and Grouville's bed increased by only 9% (Figure 36).

The most considerable fluctuations in extent are seen in the southern bed (Figure 37). This bed is less restricted in extent, whilst the northern bed is limited to the south by the freshwater runoff. The northern bed reached its maximum natural extent in 2008 and has since remained roughly the same.

Table 12 - Area measurements and corresponding changes for the St Catherine's Bay (intertidal) reference area between years 1933 and 2021. Area changes calculated relative to previous measurement and average area change per year (m2) calculated using the number of years between measurements.

Image Year	Measured area (m2)	Time difference (years)	Area change (m2)	Area change (%)	Average area changes per year (m2)	Average area changes per year (%)
1997	152,228					
2003	127,563	6	-24,665	-16.2%	-4,111	-2.7%
2008	201,217	5	+73,654	57.7%	+14,731	11.5%
2011	174,256	3	-26,961	-13.4%	-8,987	-4.5%
2017	201,459	6	+27,203	15.6%	+4,534	2.6%
2018	203,617	1	+2,158	1.1%	+2,158	1.1%
2019	191,124	1	-12,493	-6.1%	-12,493	-6.1%
2020	181,445	1	-9,679	-5.1%	-9,679	-5.1%
2021	210,210	1	+28,765	15.9%	+28,765	15.9%

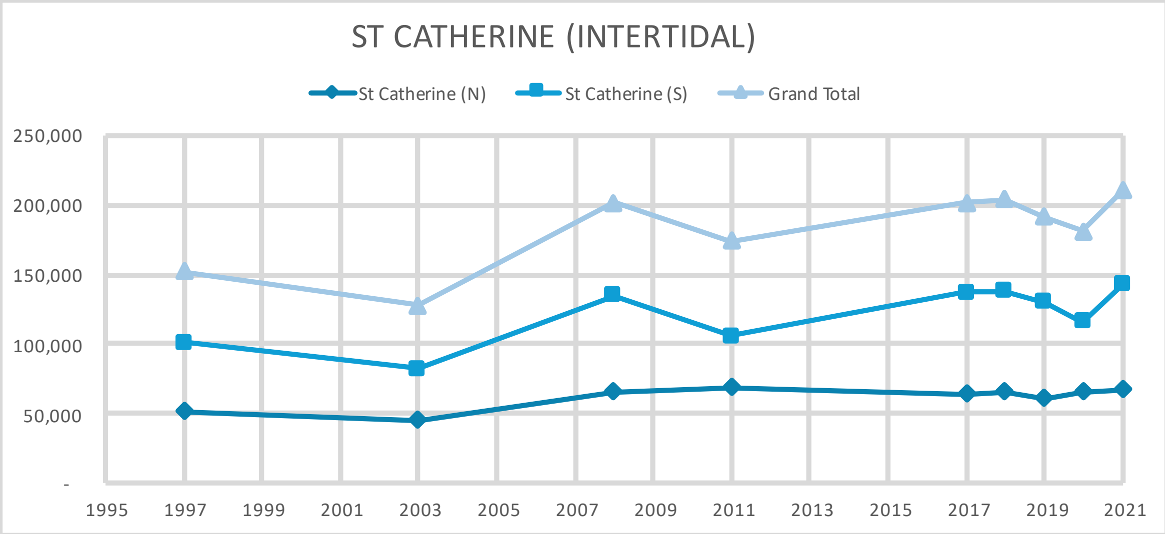


Figure 36 - Change in Z. *noltei* extent between 1997 and 2021 in the St Catherine's Bay (reference area only). St Catherine's Bay south bed in blue. St Catherine's Bay north bed in dark blue. Cumulative changes of both intertidal beds in St Catherine's Bay in light blue.

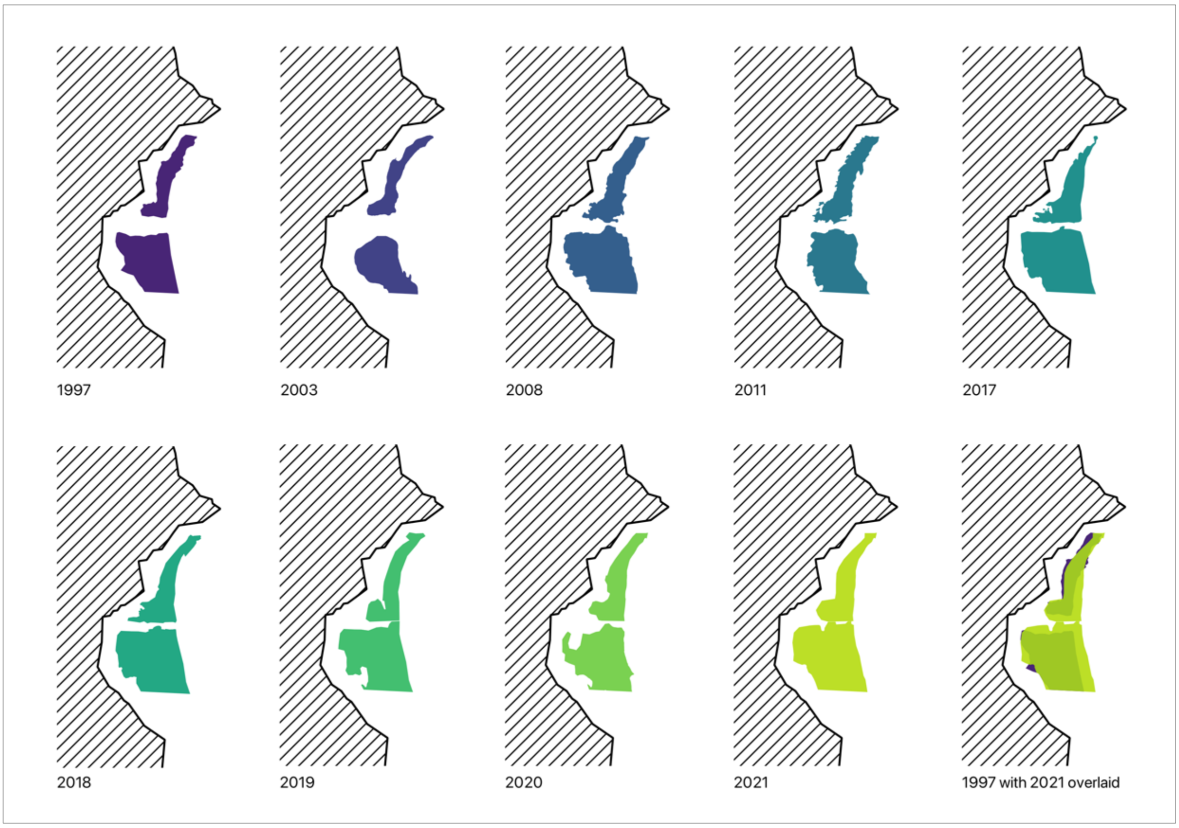


Figure 37 - Map showing change in *Z. noltei* distribution and extent within the St Catherine's Bay reference area between 1997 and 2021.

4.4.3 REGIONAL CHANGE

In 2008, Godet *et al.* conducted a study to map *Z. marina* in the Chausey Archipelago, France. This group of islands is situated around 40 km southeast of Jersey, off the coast of Normandy. This study used aerial photographs of the islands from 1924, before the wasting disease outbreak, up to 2002 (Godet *et al.*, 2008). These images created a 78-year timeline of the seagrass decline and regrowth in the archipelago.

The highest recorded extent in Chausey was 763 ha in 1924, with 490 ha defined as subtidal and 273.1 ha classified as intertidal. The lowest recorded extent was 60.4 ha, 50.5 ha of intertidal, and 9.8 ha intertidal. The most recent recorded extent was in 2002, when seagrass covered 342.2 ha (233.6 ha subtidal and 109.6 intertidal) (Table 13).

This study provides a valuable comparison to the seagrass mapping conducted in Jersey due to the similarities in location, environment, and methodology. However, it is important to note that the Chausey and Jersey datasets differ significantly. The aerial photographs used for Jersey span from 1933 to 2021, with eight images, while the Chausey study utilised only five photos between 1924 and 2002. As a result, any comparisons can only be inferred. The best areas for comparison are the Southeast coast and St Catherine's Bay, which have photos from the same period (1933 and 1944). Other reference areas in Jersey need more overlapping data points for a meaningful comparison.

The average area change per year can be used to compare the decline in seagrass immediately following the wasting disease. The decrease in Chausey is documented between 1924 and 1953 at a rate of 3.1% per year. On the Southeast coast of Jersey, there was an average yearly decrease of 6% between 1933 and 1944. As expected, both locations experienced significant average annual declines throughout the wasting disease epidemic. Jersey's decline is likely higher as the data points cover a shorter period.

A similar decrease is seen when comparing the total percentage decline between the highest and lowest recorded extent between locations. In Chausey, a reduction of 90% was recorded between 1924 and 1953, whilst in the Southeast Coast of Jersey, a 78% decline was recorded between 1933 and 1997. As wasting disease had already taken effect in Jersey before the 1933 photo, some of the decline is likely missed in our time series, and comparison with Chausey suggests that up to a 90% decline could have occurred. Since the area measured at Chausey covers the entire archipelago, there may have been a greater opportunity to detect changes. Further, the true extent of the decline in Jersey's Southeast Coast may have been missed due to the lack of photos between 1944 and 1997. The true lowest extent of seagrass in Jersey likely occurred before 1997. We can see that the lowest extent measure in Chausey was in 1953 (Figure 38).

The recovery between locations is difficult to compare due to the difference in time series. Between 1997 and 2003, the Southeast Coast of Jersey increased by 148% at an average rate of 24.7% per year, whilst between 1993 and 2002, Chausey experienced a 98% increase at an average rate of 9.8% per year. Both locations appear to have recovered well, whilst the recovery rate in Jersey appears particularly strong. However, earlier between 1953 and 1982, significant recovery (124%) was recorded across Chausey. It is likely that considerable seagrass recovery in Jersey also started earlier (before 1997).

Overall, between 1933 and 2003, the Southeast coast saw a 46% decrease, while in Chausey, between 1924 and 2002, there was a 52% decline. This is expected as the comparison period is very similar. Chausey's decline is likely larger as the photos preceded the wasting disease when the extent would have been at its healthiest, and cover more area so are better suited to detect landscape scale changes.

In recent years, there has been a significant increase in the extent of seagrass in Jersey. To better understand whether the changes observed in Jersey are localised to the island or shared on a more regional scale, it would be beneficial to compare the rate of change in surrounding meadows, such as other Channel Islands, Chausey, and the French Coast.

Table 13 - Area measurements (taken from Godet et al., 2008) and corresponding changes for the Chausey archipelago (*Z. marina*) between the years 1933 and 2021. Area changes calculated relative to the previous measurement and average area change per year (m2) calculated using the number of years between measurements.

Image Year	Measured area (ha)	Time difference (years)	Area change (ha)	Area change (%)	Average area changes per year (ha)	Average area changes per year (%)
1924	490					
1953	51	29	-440	-89.7%	-15	-3.1%
1982	113	29	+62	+123.6%	+2	4.3%
1992	118	10	+5	+4.6%	+1	0.5%
2002	234	10	+116	+97.8%	+12	9.8%

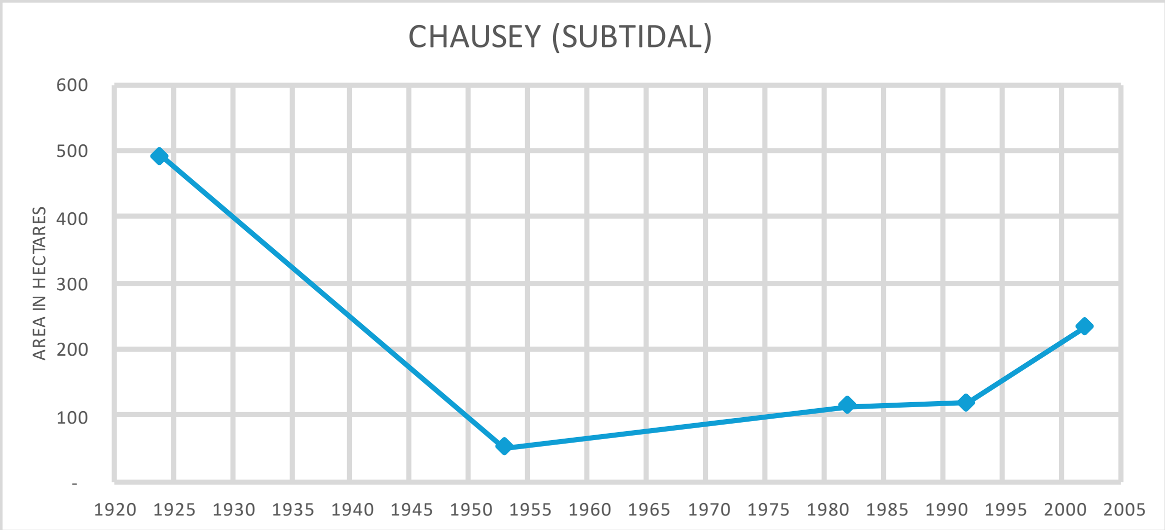


Figure 38 - Map showing change in *Zostera spp.* distribution and extent within the Chausey archipelago between 1924 and 2002. (Area measurements taken from Godet *et al*. (2008))

5 BIODIVERSITY

5.1 JERSEY BIODIVERSITY CENTRE

Species records were extracted from the Jersey Biodiversity Centre (JBC) in February 2024. The JBC has been in operation since 2013 and holds over 420,000 biological records, representing over 8,000 species from across Jersey (JBC, 2024). Any community member can submit a wildlife sighting to the JBC through the website. Each sighting is verified and then added to the database.

Marine records also include those collected by Jersey Seasearch (Jersey Marine Conservation). Diver surveys provide valuable records of species and assemblages found within and associated with Jersey's seagrass beds. Jersey Marine Conservation are the primary collectors of this data.

When submitting a sighting, recorders are asked to select a habitat. The list of habitats currently includes a variety of terrestrial habitats including 'Arable land, gardens or parks', 'Grassland', 'Woodland', and 'Heathland, scrub and hedgerow'. However, for marine sightings, habitat classifications are broader with 'Coast' and 'Marine' being the only two options. For this reason, it is impossible to know exactly which marine habitat each species has been sighted in.

5.1.1 *ZOSTERA* RECORDS

From the 'marine' flagged records of the JBC database, all *Zostera* species records were extracted. The earliest record of *Z. marina* comes from 1902, whilst *Z. noltei* significantly later in 1984 (Table 14). The presence of *Z. marina* has been the most recorded of the two species, with 288 records. Further, these records are notably distributed across many more years. The occurrence of *Z. noltei* has been submitted 224 times. However, most of these records occurred in 2010.

Records of *Zostera* species in Jersey can also be found on iNaturalist.org and seagrassspotter.org. These have not been included in this report.

Table 14 - Number of records per year of *Zostera marina* and *Zostera noltei* held by the Jersey Biodiversity Centre between 1902 and 2022.

Year	Zostera (Zostera) marina	Zostera (Zosterella) noltei
1902	1	
1984	1	1
1997	2	
2000	169	
2006		1
2009	6	9
2010	15	194
2011	11	3
2012	16	2
2013	32	13
2015	4	
2016	9	
2017	3	
2018	7	1
2019	8	
2020	2	
2021	1	
2022	1	
Total	288	224

5.1.2 SEAGRASS ASSOCIATED SPECIES

Although a 'seagrass' habitat classification with the JBC database does not exist, all sightings are geolocated to various geographic scales. To bypass the lack of seagrass habitat classification, geographic information was used to infer species-habitat associations. All 'marine' records to date were extracted from the JBC and loaded into the geographic information software QGIS. These species records were then overlayed with the *Zostera* habitat map. This habitat map encompasses the extent of Zostera in Jersey from 2021 aerial photos. Species records that fell within the Zostera boundary were kept, whilst those outside were discarded.

A total of 2836 species records coincided with recorded *Zostera* habitat locations. These records span from 1851 to 2021. These included 2281 records of animals from 427 species and 425 records of plants from 112 species.

NOTE: *The occurrence of species within Zostera habitats is purely inferred. Species records span from 1851 to 2021. Zostera extent in 2021 does not represent the Zostera extent across these years. Many species records were likely not directly recorded in seagrass habitats. However, on an ecosystem level, these records give us an idea of the potential biodiversity that lives in the vicinity and is supported by seagrass habitats in Jersey. Further, these records provide a guide to which species may warrant future study within Jersey's seagrass habitats.*

5.1.2.1 MOST RECORDED SPECIES

The five most recorded Animalia were Aves (1152 records from 65 species), Gastropoda (283 records from 66 species), Malacostraca (236 records from 104 species), Bivalvia (160 records from 44 species) and Actionopterygii (137 records from 45 species). Jersey's seagrass beds not only provide essential habitat for marine species but also play a significant role in supporting a variety of bird species, many of which rely on the unique coastal environment for feeding and shelter. A few species stand out due to their close associations with these ecosystems.

Among the birds, brent geese (*Branta bernicla*) are one of the most notable species (Table 15), directly feeding on seagrass. These migratory birds, which winter in Jersey, use seagrass meadows for nourishment during their stay. This connection underscores the critical importance of seagrass habitats in supporting migratory species. Similarly, the oystercatcher (*Haematopus ostralegus*), though not exclusively dependent on seagrass, benefits from the abundance of invertebrates in these areas. Using their specialised beaks, oystercatchers feed on molluscs and small crustaceans that thrive in the sandy and muddy substrates surrounding seagrass beds, highlighting the indirect benefits of these ecosystems.

Beyond these, other notable wading birds, such as the bar-tailed godwit (*Limosa lapponica*) and curlew (*Numenius arquata*), both near-threatened species, have been recorded in the coastal areas around seagrass beds. Both have near-threatened conservation status (as per the IUCN Red List), which highlights the importance of maintaining healthy seagrass ecosystems, as these birds rely on the rich food resources found in these habitats. Species like the sanderling (*Calidris alba*), turnstone (*Arenaria* *interpres*), and dunlin (*Calidris alpina*) are also regular migratory visitors, drawn to the shoreline areas that host an abundance of marine life.

Diving birds, such as the great northern diver (*Gavia immer*) and the common scoter (*Melanitta nigra*), have also been recorded. Though not as directly tied to seagrass habitats, these species depend on the surrounding marine environment during their migration, for hunting fish and other prey.

Below the water, the seagrass beds attract a host of invertebrate and fish species. Among gastropods, the American slipper limpet (*Crepidula fornicata*) is an invasive species in the English Channel, posing a threat to local biodiversity by outcompeting native species. Conversely, species like the common whelk (*Buccinum undatum*) are commercially sought and harvested in Jersey under strict regulation. Green ormer (*Haliotis tuberculata*) was also associated with seagrass locations. However, this species exclusively lives under rocks, and so records have likely come from rocky areas adjacent to seagrass habitats.

Crustaceans like the European lobster (*Homarus gammarus*) and common spider crab (*Maja brachydactyla*) are commercially important species that have been recorded in seagrass beds (Table 15). These species thrive in the diverse habitats surrounding seagrass beds, with local fisheries benefiting from their abundance. Fish species such as the black sea bream (*Spondyliosoma cantharus*) are not only recreationally fished but also rely on seagrass for shelter, feeding, and nursery grounds, contributing to the biodiversity and economy of the region. Black sea bream has relatively low records in the JBC database, likely due to their wariness of humans making them one of the fewer sighted species. However, other studies using trawl (Jackson, 2003) or remote video methods (Blampied *et al.*, 2022a) have recorded a strong association of black sea bream with seagrass, particularly juveniles.

In summary, Jersey's seagrass beds serve as a crucial ecological hub, supporting a diverse range of species from migratory birds to commercially valuable marine life. The conservation of these habitats ensures the continued health of this vibrant ecosystem, sustaining both wildlife and human activities.

Table 15 – Most recorded species from each class. Records extracted from the Jersey Biodiversity Centre. Observations were submitted under the 'marine' habitat and overlapped with the Jersey's 2021 seagrass extent.

Aves	Common name	Total records
Limosa lapponica	Bar-tailed godwit	81
Haematopus ostralegus	Oystercatcher	79
Calidris alba	Sanderling	73
Pluvialis squatarola	Grey plover	70

Calidris alpina	Dunlin	68
Charadrius hiaticula	Ringed plover	63
Arenaria interpres	Turnstone	57
Tringa totanus	Redshank	43
Numenius arquata	Curlew	39
Gavia immer	Great northern diver	38
Hydrocoloeus minutus	Little gull	37
Somateria mollissima	Eider	36
Gavia arctica	Black-throated diver	35
Melanitta nigra	Common scoter	35
Sternula albifrons	Little tern	35
Chroicocephalus ridibundus	Black-headed gull	32
Branta bernicla	Brent goose	28
Chlidonias niger	Black tern	23
Alca torda	Razorbill	20
Stercorarius parasiticus	Arctic skua	20
Gastropoda	Common name	Total records
Crepidula fornicata	American slipper limpet	26
Aplysia punctata	Sea hare	22
Patella vulgata	Common limpet	21
Tritia nitida / reticulata agg.	Netted Dog whelk	20
Nucella lapillus	Dog whelk	16
Steromphala umbilicalis	Flat top shell	13
Haliotis tuberculata	Green ormer	10
Buccinum undatum	Common whelk	9
Calliostoma zizyphinum	Painted top shell	9
Jujubinus striatus	Grooved top shell	9
Malacostraca	Common name	Total records
Carcinus maenas	Green shore crab	13
Palaemon serratus	Common prawn	13
Maja brachydactyla	Common spider crab	11
Homarus gammarus	Common lobster	8
Necora puber	Velvet swimming crab	7
Pagurus bernhardus	Hermit crab	7
Bathyporeia guilliamsoniana	Sand digger shrimp	6

Corystes cassivelaunus	Masked crab	6
Synchelidium haplocheles		5
Bodotria scorpioides		4
Bivalvia	Common name	Total records
Cerastoderma edule	Common Cockle	27
Ensis magnus	Razor Clam	12
Venus verrucosa	Warty Venus	12
Glycymeris glycymeris	Dog-cockle	10
Solen marginatus	Grooved Razor Shell	9
Spisula solida	Thick Trough Shell	9
Venerupis corrugata	Pullet carpet shell	9
Magallana gigas	Pacific oyster	8
Polititapes rhomboides	Banded carpet shell	8
Laevicardium crassum	Norway cockle	4
Actinopterygii	Common name	Total records
Labrus bergylta	Ballan wrasse	12
Symphodus melops	Corkwing wrasse	12
Callionymus lyra	Common dragonet	10
Gobius niger	Black goby	8
Pollachius pollachius	Pollack	6
Pomatoschistus spp.	Goby spp.	6
Ctenolabrus rupestris	Goldsinny	5
Syngnathus acus	Greater pipefish	5
Apletodon dentatus	Small-headed clingfish	4
Callionymus spp.	Dragonet spp.	4
Centrolabrus exoletus	Rock cook	4
Gobiusculus flavescens	Two-spotted goby	4
Gobius paganellus	Rock goby	3
Parablennius gattorugine	Tompot blenny	3
Pomatoschistus minutus	Sand goby	3
Spinachia spinachia	Fifteen-spined stickleback	3
Spondyliosoma cantharus	Black seabream	3
Syngnathus typhle	Deep-snouted pipefish	3
Taurulus bubalis	Sea scorpion	3
Tripterygion delaisi	Black-face blenny	3

Figure 39 – Pipefish (*Sungnathus acus*) within a seagrass bed (Tenerife, Spain). Credit: Liam McGuire / Ocean Image Bank

5.2 INTERTIDAL RESEARCH

The intertidal zone of Jersey's seagrass beds is a hotspot of biodiversity where marine and terrestrial species intersect. Research here focuses on understanding how species, such as invertebrates and birds like brent geese, utilise these habitats. The fluctuating conditions create a dynamic ecosystem, supporting a range of species that rely on seagrass for feeding and shelter.

5.2.1 INFAUNA

Three research projects have examined the intertidal infauna within *Z. noltei* seagrass meadows in Jersey. All studies have been focussed on the impact of the wastewater outlet in St Aubin's Bay. The studies by Bennett-Jones (2013), Sinclair (2016), and Delaney (2015) offer complementary insights into the health of Jersey's seagrass ecosystems.

Bennett-Jones (2013) aimed to establish baseline health data for the *Z. noltei* beds in St Aubin's Bay, investigating the potential impacts of nutrient loading from the Bellozanne Wastewater Treatment Works (BWwTW). The study employed a variety of methods, including infaunal sampling (Bennett-Jones, 2014). The results indicated a clear detrimental effect on seagrass health downstream of the outfall pipe, with a significant 'dead zone' observed directly downstream. St Aubin's West showed lower seagrass biomass and infaunal abundance compared to other sites like Grouville and St Catherine's Bays. Notably, the infaunal communities in St Aubin's West were significantly less diverse and less abundant, especially concerning crustacean species. These findings suggest that nutrient enrichment from the BWwTW negatively affects both seagrass and infaunal communities, primarily to the west of the outfall, due to dominant water flow patterns.

Delaney (2015) focused specifically on the impact of the BWwTW outfall on the health of macrobenthic infaunal populations in St Aubin's Bay, using Grouville Bay as a comparison site. This study employed the European Water Framework Directive's Infaunal Quality Index (IQI) to assess the health of infaunal populations (Delaney, 2015). The results indicated that St Aubin's Bay was heavily dominated by *Capitella capitata*, a species tolerant of polluted conditions, particularly near the outfall. The IQI for St Aubin's Bay was classified as poor, with the worst conditions found down and to the right of the outfall. In contrast, Grouville Bay exhibited a generally good IQI, with a more diverse infaunal community and higher overall ecological status. This study further confirmed that St Aubin's Bay is significantly impacted by the BWwTW, with lower species richness and diversity indicative of eutrophic conditions.

Sinclair (2016) extended the scope by examining temporal changes in seagrass beds over several years (2013, 2014, 2016) and further assessing the BWwTW's impact. Similar methods were used, including seagrass density mapping and sediment and infaunal analysis. Sinclair's findings corroborated those of Bennett-Jones (2013) and Delaney (2015), showing consistent negative effects of the BWwTW on the infaunal communities in St Aubin's Bay. The infaunal analysis revealed a marked reduction in polychaete worms and overall infaunal abundance in St Aubin's Bay compared to Grouville and St Catherine's Bays (Sinclair, 2017).

In summary, these three studies collectively reveal a clear and consistent pattern of reduced infaunal abundance and diversity, dominance of pollution-tolerant species, and spatial variation in community composition related to proximity to the BWwTW outfall. These findings reveal the significant negative impact of nutrient enrichment and pollution from wastewater discharge on infaunal communities within *Z. noltei* seagrass meadows in St Aubin's Bay.

5.2.2 BIRDS

There are many observations of birds occupying and feeding on *Zostera* habitats along the south and east coasts, mostly in reports by the Société Jersiaise Ornithology section (see section 3.2). Increasing counts of dark (and some light-bellied) brent geese (*Branta bernicla*) were noted by Le Sueur in the 1970s (Le Sueur, 1976), at numbers well over 1000. Similar numbers were reported in 2004 by the

Ornithological Section (Painter, 2005), suggesting that brent geese have maintained their prominent visitor status on Jersey's shores.

In 2002, the States of Jersey Environmental Services Unit commissioned an ecological study of Harve de St Aubin (west side of St Aubin's Bay) in response to a development proposal. This study included assessing the area's use by overwintering shorebirds. On the 14th November 2001, 1589 waterbirds of 11 species were recorded in St Aubin's Bay (Mercer and Fuller, 2002). Three species were deemed to occur in nationally important numbers: sanderling (*Caldris alba* - 158 individuals), dark-bellied brent goose (*Branta bernicla bernicla* - 413 individuals), and ringed plover (*Charadrius hiaticula* – 86 individuals) (Table 16). The count of brent geese was reportedly much higher than previous records suggest, with the average November count for St Aubin's Bay over the previous 5 years at 190 birds (Société Jersiaise unpub. data; Mercer and Fuller, 2002). Over the three days of fieldwork, the dark-bellied brent goose was the most numerous species (maximum count of 122 individuals) (Figure 40). Brent geese were reported to feed in the western area of the bay mostly around the mid-tide height, where green seaweeds (*Enteromorpha spp)* were available. It was noted that their preferred food choice, the *Zostera* beds to the east, were then covered at mid-tide. The bay was deemed important for the juvenile dark-bellied brent geese in the flock using St Aubin's Bay. The juvenile geese were using the area for supplementary feeding, moving across the bay with the rising and falling tide to maximise their feeding time.

Table 16 - Total number of waterbirds of each species observed in St Aubin's Bay on the 14th of November 2001. Table taken from Mercer & Fuller (2002)

Species	**Total**	**Nationally-significant threshold**[1]
dunlin (*Calidris alpina*)	590	5300
dark-bellied brent goose (*Branta bernicla bernicla*)	413	1000
sanderling (*Caldris alba*)	158	230
oystercatcher (*Haematopus ostralegus*)	151	3600
ringed plover (*Charadrius hiaticula*)	86	290
turnstone (*Arenaria interpres*)	58	640
grey plover (*Pluvialis squatarola*)	47	430
curlew (*Numenius arquata*)	44	1200
pale-bellied brent goose (*Branta bernicla hrota*)	29	200
redshank (*Tringa totanus*)	11	1100
little egret (*Egretta garzetta*)	1	-
black-tailed godwit (*Limosa limosa*)	1	70

[1]Taken from Musgrove *et al*. (2001)

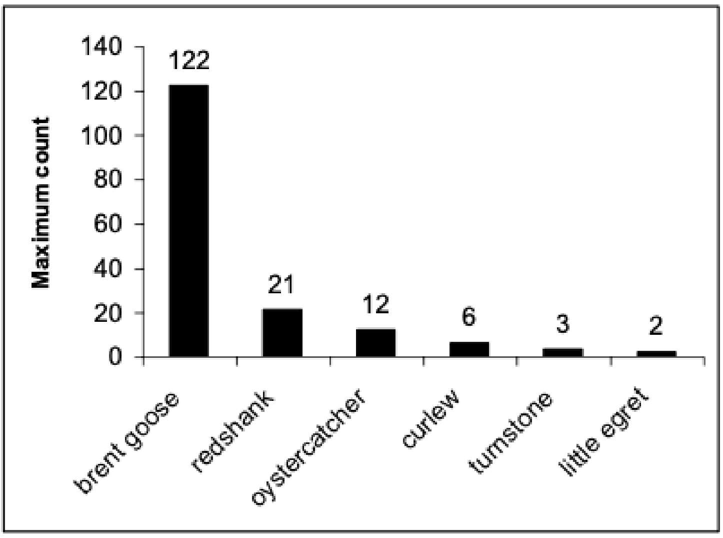


Figure 40 – Maximum counts of waterbirds within the St Aubin's Bay study area (13th-15th November 2001). Figure taken from Mercer & Fuller (2002)

5.3 SUBTIDAL RESEARCH

In the subtidal zone, Jersey's seagrass beds provide a stable, submerged habitat that supports a rich diversity of marine life. Research in this zone examines the variety of species, from small invertebrates to larger fish, that thrive in these constantly submerged ecosystems. The subtidal seagrass meadows serve as important nursery grounds and feeding areas, contributing to the overall marine biodiversity of the region.

5.3.1 INFAUNA

The four studies conducted by Millan (2023), Dow (2023), Blampied (2022), and Jordi (2021) offer insights into the diversity, abundance, and distribution of infaunal communities within subtidal seagrass beds in Jersey's waters. These studies highlight the crucial factors influencing infaunal health and diversity within Jersey's seagrass ecosystems by examining the impacts of seagrass bed age, condition, and anthropogenic disturbances.

Across four sampling locations on the east coast, Millan (2023) recorded a total of 1,712 individuals from 115 different taxa (Figure 41). Infauna was dominated by Annelida (52.4%), Arthropoda (29.0%), Mollusca (12.5%) and Nematoda (5.1%). The remaining 1% comprised of Sipuncula, Echinodermata, Cnideria, and Bryozoa. Within St Catherine's Bay, Dow (2023) recorded 246 individuals from 28 taxa.

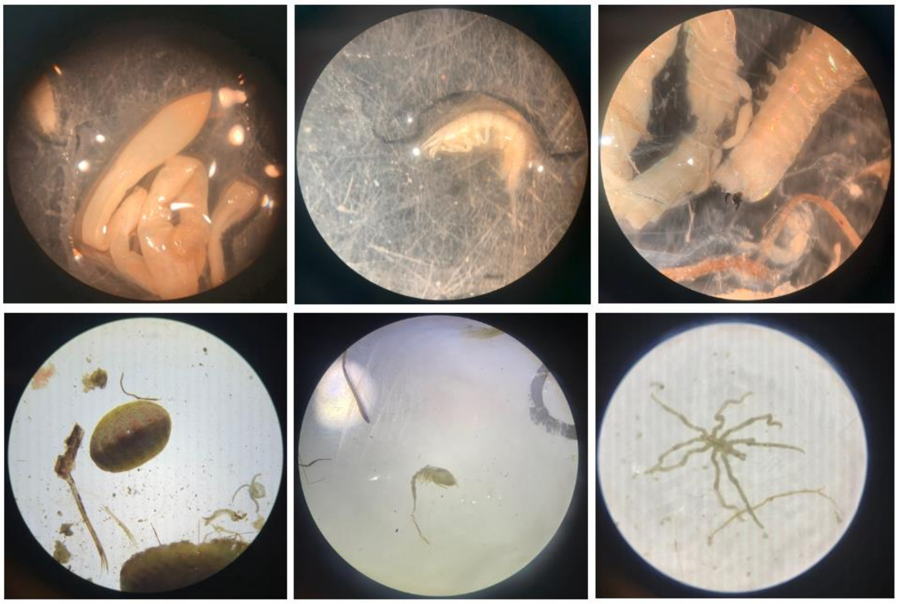


Figure 41 - Images of infauna species retrieved by Millan (2023) in sediment grab samples from within Jersey's seagrass beds. Top left to bottom right: *Golfingia vulgaris, Apseudes latreilli, Lumbrineris fragilis, Leptochiton cancellatus, Diastylis rugosa,* and *Nyphon gracile.*

5.3.1.1 SPECIES RICHNESS AND ABUNDANCE

5.3.1.1.1 BED AGE

Millan (2023) and Jordi (2021) examined the influence of seagrass bed age on infaunal communities across multiple locations. Seagrass bed age refers to the time since the establishment of a new, spatially distinct bed. Locations included Karame, Gorey (encompassing the area from Petit Port behind Gorey Castle and north to Anne Port), St Catherine's Bay and Northeast (Northeast refers to Fliquet and La Coupe) (Figure 42). Between 2012 and 2017, several new spatially distinct seagrass beds developed. These are considered 'young' beds (4 – 9 years old), whilst 'old' beds were those established between 1996–2001 (between 20–25 years old).

Millan (2023) found that older seagrass beds had significantly greater species richness than younger beds across all sample locations (Figure 43). The older beds at St Catherine's Bay had the highest species richness, with an average of 21 species. Similarly, Jordi (2022) reported that older seagrass beds supported a higher mean species richness in Gorey, Karame, and St Catherine's, with the latter displaying the biggest differences in species richness between old and young beds. However, Jordi (2021) reported that the older seagrass bed at Northeast supported a greater species richness than the younger bed.

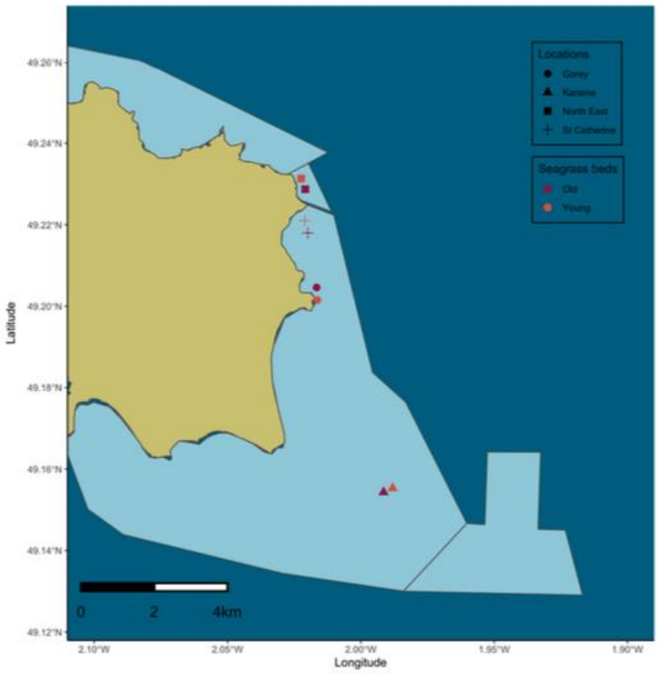


Figure 42 - Map of four study sites used by Jordi (2022). Red dots indicate old seagrass beds whilst orange dots indicate young seagrass beds. Taken from Jordi (2022).

Millan (2023) reported no significant difference in species abundance between old and young beds. However, older beds at Karame, La Coupe, and St Catherine's Bay displayed a higher mean abundance, whilst Gorey's older seagrass bed had a lower species abundance (Figure 44). Interestingly, Jordi (2022) reported significantly higher species abundance in older beds across all locations, with Gorey and Karame having the highest abundances.

Despite some differences in their results, these studies suggest that seagrass bed age is important in fostering diverse and abundant infaunal populations. Further, they suggest that differences in location and, therefore, environmental influences may impact infauna within seagrass beds.

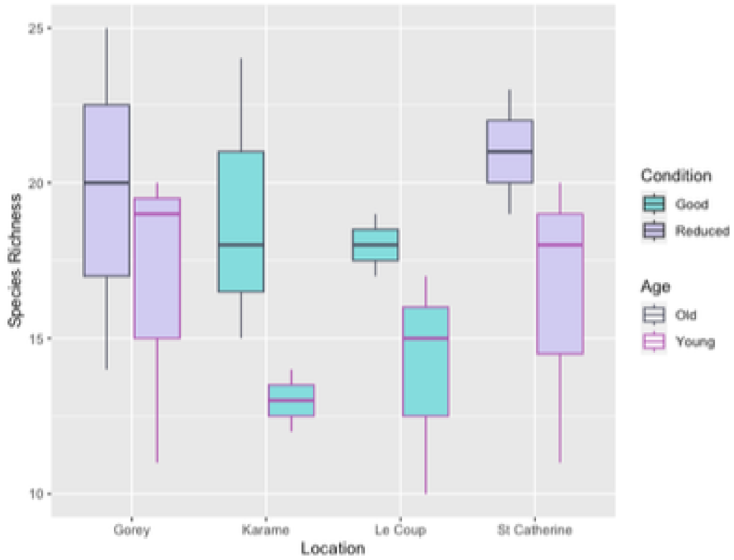


Figure 43 - Infauna species richness in old (black) and young (purple) seagrass beds in 'good' (blue) and 'reduced' (lilac) condition over four sample locations. Figure taken from Millan (2023).

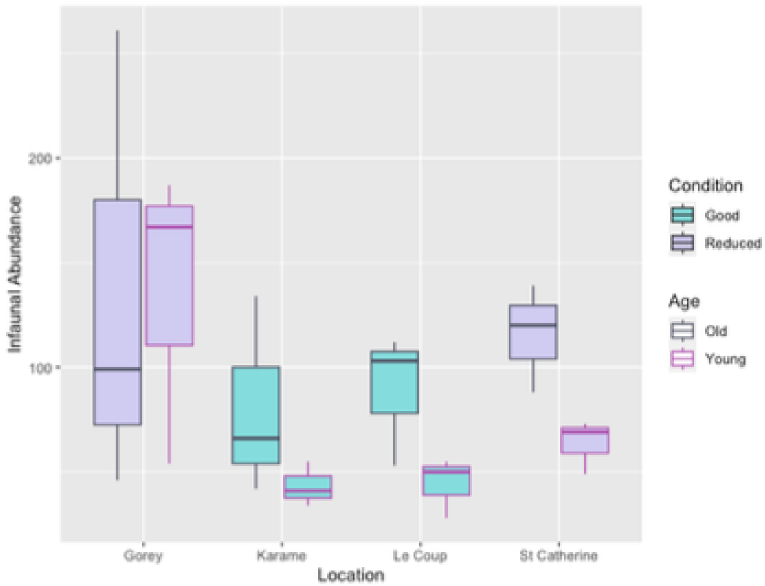


Figure 44 - Infauna species abundance in old (black) and young (purple) seagrass beds in 'good' (blue) and 'reduced' (lilac) condition over four sample locations. Figure taken from Millan (2023).

5.3.1.1.2 BED LOCATION

When comparing across locations (ignoring the age element), Jordi (2022) reported that Karame and Gorey had significantly greater species abundance and richness than St Catherine's Bay and the Northeast. The Northeast was noted to have the lowest species richness. Similarly, Millan (2023) reported variation in abundance across all locations, with Gorey supporting significantly higher abundance than Karame. However, species richness was not reported to be significantly different across locations.

Similar differences in species abundances across locations were observed in another study (Blampied, 2022). Seagrass sites within the Southeast MPA (close to the 'Karame' in the above studies), had an average infaunal taxa number of 24.2 (Figure 45) which was significantly greater than in the seagrass sites within the Les Minquiers MPA, which had an average taxa number of 12.1. In this case, the lower species abundance within Les Minquiers' seagrass was attributed to a larger sediment particle size.

Again, these results suggest that differences in location and, therefore, environmental influences may impact infauna within seagrass beds. This means that results cannot be generalised from one location to the next and highlights the importance of studying seagrass in a range of locations to understand their individual differences.

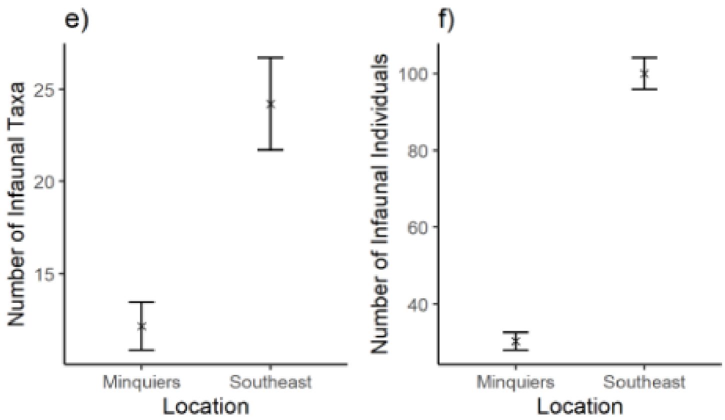


Figure 45 - Total numbers of e) taxa and f) individuals on seagrass habitat within the Jersey's MPAs. Figure taken from Blampied (2022).

5.3.1.2 ANTHROPOGENIC DISTURBANCE

Dow's (2023) assessed the impact of block and chain moorings on infaunal biodiversity in St Catherine's Bay. Block and chain moorings scour the area of seagrass below, leaving an area of bare sand around 95m^2. The results revealed a stark contrast in species diversity between mooring scars and unscarred areas (Figure 46). Inside the mooring scars, species richness and abundance were significantly lower. An average of 16 taxa were recorded as present inside the scars, compared to 22 taxa outside. Notably, Annelida, the most abundant phylum, were more prevalent outside the scars indicating that anthropogenic disturbances like mooring can severely impact infaunal diversity and abundance within seagrass beds.

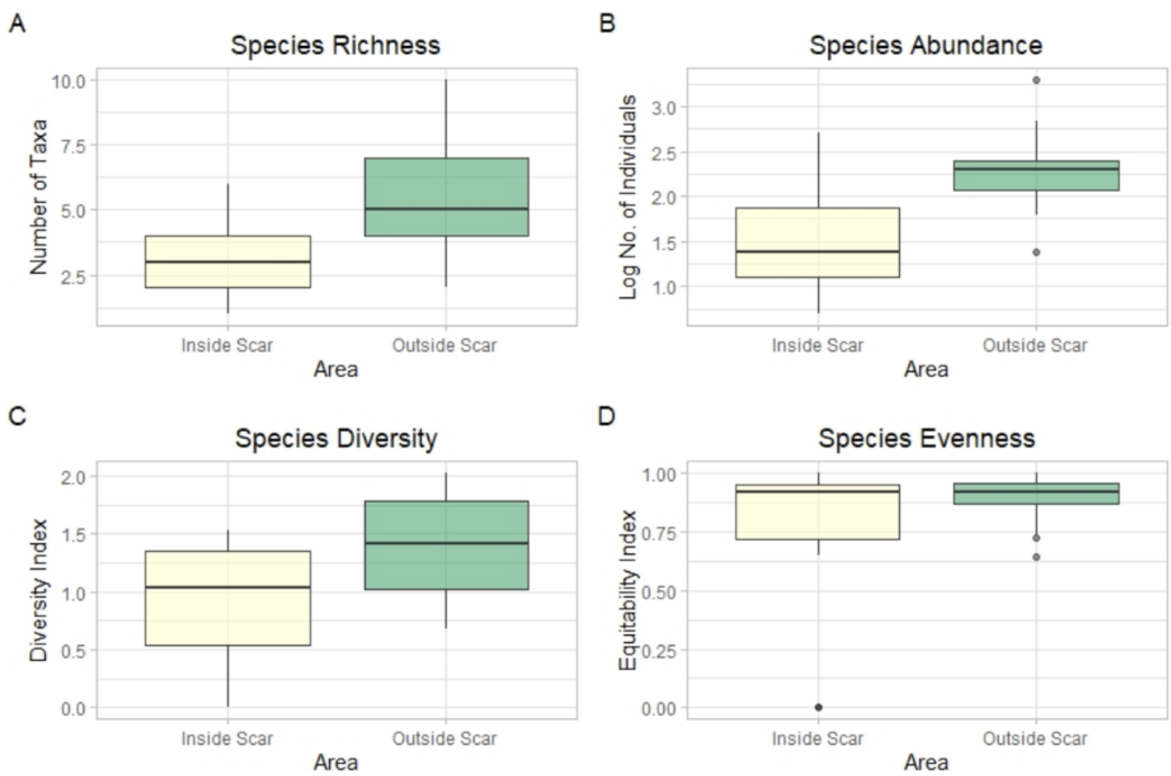


Figure 46 - Boxplots displaying the mean a) species richness, b) species abundance, c) species diversity, and d) species evenness inside (yellow) and outside (green) the scars. Figure taken from Dow (2023).

5.3.1.3 SPECIES ASSEMBLAGES

Examining infaunal assemblages sheds light on the drivers of change in diversity and abundance metrics. Infaunal assemblages can be used as ecological indicators, informing us about ecosystem functioning, biodiversity, food web dynamics, and habitat quality and resilience.

Within Jersey's subtidal seagrass beds, the composition of infaunal assemblages is reported to vary significantly with seagrass bed age and location. Millan's (2023) study highlighted significant differences in infaunal assemblages between old and young seagrass beds, particularly in Gorey, where assemblages were the most dissimilar. Older beds were dominated by families such as Maldanidae, Spionidae, and Capitellidae. Jordi's (2022) research similarly found that older seagrass beds had distinct infaunal assemblages with higher species abundance, particularly in Gorey and Karame, suggesting that bed age and environmental conditions play a critical role in shaping infaunal communities.

Blampied (2022) compared infauna species assemblages in seagrass in the Southeast MPA and Les Minquiers MPA. Species assemblages in the Southeast seagrass had greater average abundances of Maldanidae, Ampeliscidae and Glyceridae. Further, Sabellidae was present within the Southeast but not within Les Minquiers.

Dow (2023) further emphasised the impact of physical disturbances on infaunal assemblages, noting that species diversity was significantly lower inside mooring scars. For example, there were, on average, more than 50% fewer Nematoda species inside the scars than outside. The presence of unique taxa inside and outside the scars suggests that mooring disturbances can alter the composition of infaunal communities. When measuring at a seascape level, having unique taxa both inside and outside the scar increases overall biodiversity. There are anecdotal reports from spearfishermen that the mooring scars are where fish are more likely to be found. This has been attributed to the scars providing a 'point of interest' in an otherwise dense seagrass seascape. Knowing exactly which species benefit or are negatively affected by the more complex habitat mosaic of seagrass and scars is important for management measures. For example, species such as seahorses have small home ranges and rely on seagrass; thus, just one mooring scar could destroy an individual's habitat. Protecting one species, such as seahorses, could be deemed more important than the overall biodiversity of the area as they have limited opportunities to live elsewhere. When considering impacts beyond biodiversity, the loss of carbon from mooring scars must be factored in. If carbon sequestration is considered more important than species biodiversity, then mooring scars are undoubtedly detrimental.

5.3.1.4 IMPACT OF MARINE PROTECTED AREAS

As very little seagrass exists outside of Jersey's MPAs, a comparison between protected and unprotected seagrass is unavailable. However, comparisons between the time since MPA implementation can be made. Blampied (2022) reported that the seagrass in the older Southeast MPA had greater numbers of infaunal individuals and taxa when compared to the younger Les Minquiers MPA. Further, the seagrass beds within the Southeast MPA had a higher proportion of finer, mud-sized particles compared to Les Minquiers MPA seagrass.

The finer sediment size within (longer-protected) seagrass beds within the Southeast is thought to be the key driver for this increased diversity, rather than its protection status. Typically, mud is a more biodiverse habitat due to the increased availability of organic matter as a food source for infaunal species. The protection afforded by the MPAs reduces the disturbance from bottom-towed fishing, allowing finer sediment to accumulate within the seagrass habitats. Despite this, sediment samples taken from within the seagrass beds at Les Minquiers had a greater number of taxa and individuals than samples taken in the coarse sediment (outside the seagrass beds). This emphasises the localised impact of seagrass in boosting biodiversity within Jersey's MPAs.

5.3.1.5 SEAGRASS CONDITION AND ENVIRONMENTAL IMPACTS

The condition of seagrass beds, as evaluated by Millan (2023), concluded that old and young seagrass beds in Jersey shared a similar condition relative to their coastal location. Further, bed condition was reported to have no effect on the species diversity with the seagrass beds. These results suggest that age and location are the driving forces influencing differences in species richness between beds. This finding aligns with Jordi's (2022) results, which suggest that older, more sheltered seagrass beds support more diverse infaunal communities.

However, Dow's (2023) research provided additional context on the impact of anthropogenic activities, demonstrating that traditional block and chain moorings reduce infaunal diversity and richness and disrupt the overall health of seagrass beds. The loss of seagrass plants and the destabilisation of sediments in mooring scars can lead to long-term negative effects on infaunal communities, highlighting the need to mitigate anthropogenic impacts.

5.3.1.6 CONCLUSIONS

Overall, these findings highlight the critical role of seagrass bed age and location in supporting diverse and abundant infaunal communities. Older seagrass beds typically support higher species richness and abundance, underscoring the importance of protecting these habitats to maintain biodiversity. However, anthropogenic disturbances, such as mooring, significantly reduce infaunal diversity, illustrating the detrimental impact of human activities on seagrass ecosystems. To maintain or improve the biodiversity of infauna within seagrass beds in Jersey, it is crucial to mitigate harmful activities. Additionally, safeguarding younger seagrass beds as they mature will further promote increased biodiversity, contributing to the overall ecological health of Jersey's coastal waters.

5.3.2 MOBILE FAUNA

Seagrass beds in Jersey, Channel Islands, play a significant role in supporting the biodiversity of mobile species, including fish and decapod crustaceans. In 1999, beam-trawl surveys were performed in St Catherine's Bay at both day and night and at a range of tide heights (Jackson *et al.*, 2002). A total of 3117 individuals were collected from 45 different species. This included 25 fish species, 14 decapod, and six mollusc species. This variety of species included ten species considered commercially important. Factors such as habitat complexity, age of seagrass bed, and species-habitat associations affect the diversity of species found within Jersey's seagrass beds.

Figure 47 - Green shore crab (*Carcinus maenas*) within a seagrass bed, Isles of Scilly, UK. Credit: Michiel Vos/ Ocean Image Bank

5.3.2.1 SPECIES RICHNESS AND ABUNDANCE

According to Jordi's (2021) study, older seagrass beds at St Catherine, Gorey, and Karame exhibited greater mobile species richness compared to younger ones. However, at the Northeast site, there was no significant difference in mobile species richness across different seagrass bed ages (Jordi, 2021). Species abundance also varied, with older beds at St Catherine, Gorey, and Northeast showing higher abundance, whereas Karame's older bed had lower mobile species abundance. Among all locations, Northeast had the lowest mobile species richness, and St Catherine had the lowest mobile species abundance. In contrast, Gorey exhibited both the highest mobile species richness and abundance. These results indicate that the age of seagrass beds contributes to mobile species biodiversity. Millan (2023) did not study mobile species assemblages so no further comparisons can be made.

5.3.2.2 SPECIES-HABITAT ASSOCIATIONS

Jackson *et al.* (2002) compared fish and mobile macroinvertebrates in seagrass and adjacent sand habitats at St Catherine's Bay. The study found a significantly higher number of species in the seagrass habitats compared to sand during all tidal heights and times of day. While total species densities did not differ significantly between sand and seagrass habitats, certain species exhibited preferences for specific habitats. For example, plaice (*Pleuronectes platessa)* were only found in sand, whereas bib

(*Trisopterus luscus*) was only recorded in seagrass. However, as some species are flexible in their habitat associations and use, the seagrass-sand mosaic in St Catherine's Bay is thought to benefit a wider diversity of species. Habitat mosaics generally increase biodiversity, whilst homogenous seagrass habitats offer better support to juvenile species and sequester more carbon. It is important to understand the species-habitat associations within Jersey's seagrass areas to inform management and conservation measures.

5.3.2.3 HABITAT COMPLEXITY AND FAUNAL DISTRIBUTION

Research by Jackson *et al.* (2006) explored how different scales of seagrass complexity influenced the distribution of fish groups across Jersey's seagrass habitats. The study identified greater seagrass canopy height and homogeneity associated with higher diversity and density of small, cryptic fish species (Jackson *et al.*, 2006). Conversely, fragmented seagrass landscapes supported fewer juvenile fish but provided temporary feeding grounds for larger fish. The study highlighted the importance of contiguous seagrass landscapes for juvenile fish survival due to protection from predation and stable environmental conditions.

5.3.2.4 IMPACT OF MARINE PROTECTED AREAS

Approximately 97% of Jersey's seagrass is encompassed within MPAs (Blampied *et al.*, 2022b). Research into the removal of bottom-trawling highlighted the positive impact of MPAs on mobile species diversity in Jersey's waters (Blampied *et al.*, 2022a). In both Les Minquiers and Southeast MPAs, seagrass habitats are present. Data from within the MPAs was compared to control sites outside the MPA boundaries where bottom-trawling is permitted.

Les Minquiers MPA is thought to be least affected by bottom-trawling before MPA implementation. The mobile species assemblage at Les Minquiers MPA significantly differed from the unprotected control site, with a greater diversity of species making up the assemblage within the MPA (Blampied *et al.*, 2022a). Further, a greater proportion of juvenile bream (*S. cantharus)* was found compared to the Open Control sites. The relatively unimpacted condition of this MPA and the presence of seagrass are thought to contribute to this increased diversity through greater habitat heterogeneity and complexity. Although there is no comparative data from before the MPA implementation, it is believed that continued protection from bottom-towed fishing will protect the diversity of species, higher occurrence of young individuals and increased structural diversity (provided by seagrass and other habitat types), found within Les Minquiers MPA.

However, no significant difference was found between the mobile species assemblage composition between Southeast MPA and its open control site, despite the presence of seagrass. This confirms that seagrass is not the only factor driving species composition and that other factors, such as geographical location, will also contribute to the difference in species composition seen. Many mobile species are also wide-ranging, and many of the species that contributed to the similarity of the sites at the Southeast MPA were common species such as catshark, bream, and spider crab. It may be more appropriate to look at infauna species to investigate the localised biodiversity impacts on sedimentary habitats.

5.3.2.5 HABITAT VALUE TO COMMERCIAL FISHERIES

Blampied *et al.* (2022b) discussed the economic value of various coastal habitats to Jersey's commercial fisheries, emphasising the importance of seagrass beds (Blampied *et al.*, 2022b). Five of the most commercially valuable species were identified (brown crab, lobster, scallop, spider crab, and whelk) and assessed in terms of their habitat usage. Seagrass served as a crucial foraging habitat for three of the five most commercially valuable species to Jersey fisheries. The value of seagrass habitats was calculated at £1,324,117 for Jersey fisheries and £701,075 for French fisheries per year.

In 2002, Jackson *et al.* recorded a total of 45 species in St Catherine's Bay via beam-trawl sampling (Jackson *et al.*, 2002). Of these species, ten were deemed commercially important (four fish, four decapod and two mollusc species). All the 'commercially' important fish sampled during beam trawls were classed as juvenile (except for two adult sole caught on sandy habitats), whilst eight of the ten species were sampled in seagrass habitats. This suggests that St Catherine's Bay constitutes a nursery ground supporting commercially important mobile species in both seagrass and sand habitats. Thus, Jersey's seagrass is thought to provide essential feeding grounds and nursery areas, maintaining populations of fished species and their associated biodiversity.

5.3.2.6 CONCLUSIONS

Overall, seagrass beds in Jersey are critical habitats that enhance mobile species biodiversity, offering significant ecological and economic benefits. These habitats support a diverse range of species, including those of commercial importance, by providing essential feeding grounds and nursery areas (Figure 48). Studies have demonstrated that seagrass beds host greater species richness compared to adjacent sand habitats and that older seagrass beds tend to support higher biodiversity. The structural complexity of seagrass also plays a key role in influencing species distribution and abundance.

The protection and management of these habitats within Marine Protected Areas (MPAs) are essential for maintaining species richness and supporting commercial fisheries. The positive impact of MPAs, especially in areas less affected by bottom-trawling, highlights the importance of habitat heterogeneity and complexity in promoting species diversity. However, the presence of seagrass alone is not the sole determinant of species assemblages, confirming the influence of other environmental and geographical factors.

Given the significant role of seagrass habitats in sustaining marine biodiversity and their economic value to fisheries, site-specific conservation strategies are crucial. These strategies should aim to optimise biodiversity outcomes and ensure the long-term sustainability of marine ecosystems in the Channel Islands. Continued research and monitoring are necessary to understand the dynamics of these habitats better and to implement effective management practices.

Figure 48 - Juvenile fish within seagrass habitat. Isles of Scilly, UK. Credit: Michiel Vos / Ocean Image Bank

6 HEALTH AND CONDITION

6.1 INTERTIDAL SEAGRASS

The health and condition of intertidal seagrass are influenced by a range of environmental, anthropogenic, and biological factors. Key threats include poor water quality, nutrient pollution, reduced light availability, herbivory, and the presence of invasive species. To assess the health of seagrass, researchers employ a variety of techniques, including physical assessment (such as monitoring seagrass coverage, density, leaf length, and biomass), water quality monitoring, biological indicators (like epiphytic load), and chemical analyses (for nutrient content) among others.

6.1.1 BACKGROUND

Concerns regarding the health and condition of intertidal seagrass *Zostera noltei* in Jersey were raised in 2009 during a review of the ecological status of the Ramsar site on the island's Southeast coast (Linley *et al.*, 2009). Both species of *Zostera* found in Jersey are included within the island's Ramsar sites. Biotope mapping surveys performed in March 2009 highlighted significant epiphytic seaweed growth on *Z. noltei,* attributed to terrestrial runoff that introduces excess nutrients into coastal waters. Although high levels of epiphytic growth generally indicate pollution, the report did not reach a definitive conclusion about the health status of *Z. noltei*. However, further monitoring was recommended to better understand the health of *Z. noltei* around Jersey.

Algal growth issues are also reported within St Aubin's Bay, where during the summer, sea lettuce (*Ulva lactuca)* frequently blankets the bay (Figure 49). This event is often covered by media outlets, raising concerns about public access, tourism, business losses, unpleasant odours, and the release of toxic gases (BBC News, 2012; BBC News, 2014; Morris, 2017; Jersey Evening Post, 2022). Algal blooms are typically linked to ecological imbalances, particularly due to anthropogenic nutrient inputs. St Aubin's Bay is especially vulnerable to this threat, as it is home to Jersey's only wastewater outlet.

This section provides a synopsis of research on the health and condition of *Zostera* habitats in Jersey to date. Studies have explored changes in seagrass percentage cover and density over time, water quality, macroalgae presence, seagrass biomass, associated infaunal communities, and anthropogenic damage to seagrass beds.

Figure 49 – Sea lettuce (*Ulva spp*.) proliferation on St Aubin's beach. Image from BBC News (2014)

6.1.2 SEAGRASS PERCENTAGE COVER AND DENSITY

In 2012, Bennet-Jones (2014), in collaboration with Marine Resources and The University of Plymouth, initiated a research project (commencing in the summer of 2013) to generate baseline data regarding the health and ecology of Jersey's intertidal seagrass populations. This project formed the basis for future monitoring of *Z. noltei* in Jersey.

The first surveys documenting the percentage cover of *Z. noltei* were undertaken in July and August 2013 (Bennett-Jones, 2014). Three study sites were chosen to best represent Jersey's intertidal seagrass: St Aubin's Bay, Grouville, and St Catherine's Bay. Seagrass beds at Archirondel and Anne Port were not considered to be established enough for comparison.

Sampling was carried out in July and August 2013 (Bennett-Jones, 2014), when *Z. noltei* reportedly reached its maximum growth (Vermaat and Verhagen, 1996). Over 350 sample sites across St Aubin's Bay, Grouville, and St Catherine's Bay were plotted at 100-metre intervals across the beds. A 50 cm^2 quadrat was placed at each sample site and photographed for analysis. Overlaying seaweed was moved aside to avoid under or overestimating seagrass. Photographs were analysed using the image processing software Image J to obtain an accurate measure of percentage cover. This data was subsequently used to create a density map for each bay to visualise the average cover. The methodology established in this study was repeated in the summers of 2014 (McClean, 2015) and 2015 (data collected by Marine Resources), 2016 (Sinclair, 2017) and 2017 (Gorvel, 2018). The data from these studies has been collated for comparison.

Since 2017, data collection in St Aubin's Bay has been continued yearly by Marine Resources but not in Grouville due to limited resources within the team. Further, a master's student (K. Neild) took on data collection in 2024 (both in St Aubin's and Grouville) as part of their research project, but results from this research were not available at the time of writing this report.

6.1.2.1 2013 TO 2017 COMPARISON

Across Jersey's bays, the percentage cover of intertidal seagrass fluctuates annually (Figure 50; Marine Resources Pers. comm). This is to be expected as *Z. noltei* experiences a seasonal growth and die-back cycle whilst also being heavily influenced by changes in environmental conditions. The pattern of change in the percentage cover of *Z. noltei* is generally consistent across all locations from year to year. This indicates that fluctuations in percentage cover are Jersey-wide and are likely due to wide-scale changes in environmental conditions.

However, significant change can be seen between locations on Jersey's coastline. Annually, the mean percentage cover at Grouville and St Catherine's Bay was consistently greater than that of St Aubin's Bay between 2013 and 2017. The highest percentage cover (25%) over the five years was observed at Grouville in 2017. St Aubin's Bay observed the lowest average percentage cover each year, with the lowest value occurring in 2014 (4.3%). Each year, the percentage cover at St Aubin's Bay was reported to be significantly lower than the other sites. When Grouville and St Catherine's Bay were compared, no significant difference was found annually. These results indicate that percentage cover at St Aubin's Bay is significantly impaired compared to other sites in Jersey due to localised environmental conditions.

St Aubin's Bay exhibited patchy growth throughout the five-year study period (Figure 51). There was no centralised growth area and many pockets of bare sand within the main meadow. Clear boundaries between *Z. noltei* and bare sediment can be observed on the meadow's upper and lower limits. The size and density of the meadow change drastically each year within St Aubin's Bay. The weakest growth occurred in 2014 (4.3%), with weak growth continuing in 2015. Regeneration of meadow density and size occurred in 2016, with peak size and density occurring in 2017 (9.2%). Significant loss of *Z. noltei* within the eastern meadow of St Aubin's Bay can be observed between the 2016–2017 growth season. In every year (2013–2017), the channel that separates the western and eastern meadows of St Aubin's Bay is visible, becoming most prominent in 2015.

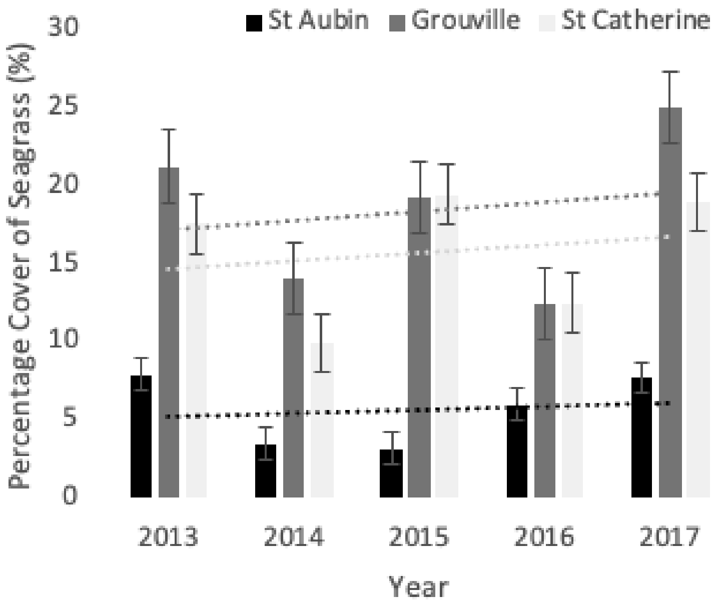


Figure 50 - Annual mean percentage cover of seagrass *Z. noltei* across St Aubin's Bay, Grouville Bay, and St Catherine's Bay between 2013–2017 (Marine Resources Pers. comm)[xiv].

The Grouville bed exhibited natural fringing due to shore height along the upper shore (exposure) and the lower shore (subtidal submersion). The northern limits were well defined each year, whilst the southern edge showed signs of expansion and contraction across the five years. Centralised meadow growth and size appear strong annually. However, a small central area of reduced density was apparent in 2014. The density of *Z. noltei* has shown a gradual increase over the five-year monitoring period when comparing annual density maps. The most substantial growth of the Grouville meadow was in 2017 (25%). The weakest percentage cover was observed in 2016 (12.4%).

Within St Catherine's Bay, natural upper growth limits were defined by shore height and exposure, whilst dominance of the subtidal *Z. marina* defines the lower limit. The highest density was observed in the north of the bed, whilst eulittoral rock prevents significant expansion along much of the southern limit. However, patchy growth was observed at the lower southeastern intertidal limits in 2017. Temporal changes in density are dynamic, with no single year showing similar density or distribution, although growth has, on average, increased across the five-year study period. Similarly to Grouville, 2014 also exhibited patchy growth, from which the bed soon recovered. The weakest meadow density was observed in 2014 (10%), with the strongest in 2015 (19.4%).

[xiv] Report not completed by the author before leaving the Marine Resources team. The draft report was provided for use and expansion in this report.

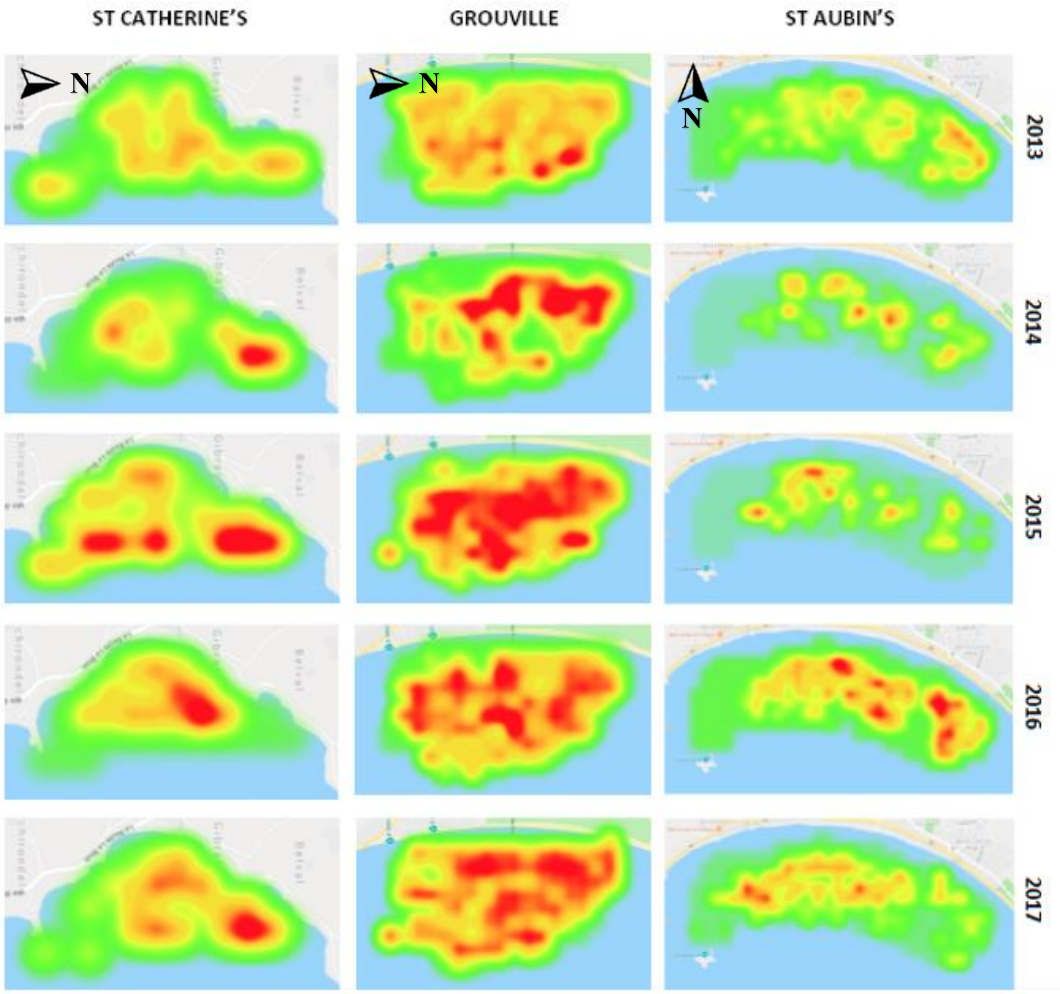


Figure 51 - Heatmaps displaying the density of *Z. noltei* between 2013 and 2017 in St Catherine's Bay, Grouville Bay, and St Aubin's Bay. (Marine Resources Pers. comm).

Between 2012 and 2017, environmental consultants performed an annual survey of the seagrass within St Aubin's Bay as part of a water quality monitoring programme. They assessed the seagrass species present, coverage, and total extent of the east and west beds (Leverett, 2015). Overall, the ecological status of seagrass was deemed as "High". However, there are notable caveats to this classification, which was generated using a ratio grading system. In this instance, the metrics used were taxonomic composition, shoot loss, and bed extent loss. Firstly, taxonomic status is considered "High" throughout the study period as only one species is resident in the bay (1:1). This increases the overall ecological rating for seagrass. This is especially notable in 2015, in which the two other metrics were rated "Moderate" whilst the overall status was deemed as "Good". Secondly, there was an overall reported loss of seagrass habitat, with a "moderate" level of shoot loss in 2013 and 2015, despite the "High" overall ecological status. It is important to note that due to differences in data collection methods for bed extent across the study years, these figures are estimations. However, these estimates agree with the previously mentioned seagrass density and percentage cover results.

6.1.2.2 2013 TO 2023 COMPARISON (ST AUBIN'S BAY)

Marine Resources, supported by the Société Jersiaise volunteers and various university students, has continued annual monitoring of the percentage cover of *Z. noltei* within St Aubin's Bay. Data collection at the other study sites of St Catherine's Bay and Grouville was not continued due to capacity within the team. With this continued monitoring at St Aubin's Bay, a data set from 2013 to 2023 is available to assess longer-term temporal changes of *Z. noltei* within the bay[xv].

Over the 11 years, the average percentage coverage of seagrass at St Aubin's was variable (Figure 52). Seagrass coverage continued to display patchy growth, whilst the area showing the highest percentage of cover varied in location from year to year (Figure 53). This appearance can partially be attributed to the sampling method combined with the patchy nature of the seagrass. A consistent area of no seagrass growth separates the two beds annually due to the wastewater outfall. The east-to-west and upper-to-lower shore extents of the beds have stayed relatively consistent over the 11 years, suggesting that the conditions and substrates within St Aubin's Bay are still suitable for seagrass growth. However, inconsistency in yearly seagrass coverage is evident, indicating that overall water quality may be a limiting factor for prolific seagrass growth.

The seagrass in St Aubin's Bay has been suspected to be in poor condition for some time. Comparisons with Grouville Bay and St Catherine's Bay support this, but geographical variation cannot be ruled out. The continuation of intertidal surveys has shown the percentage coverage of seagrass in St Aubin's Bay to be low but stable over time. This baseline coverage data provides a measure against future change due to pollution or development works near St. Aubin's Bay.

[xv] The survey in 2022 was carried out but was incomplete due to capacity within the team. Further surveys in 2019 and 2021 were only partially completed.

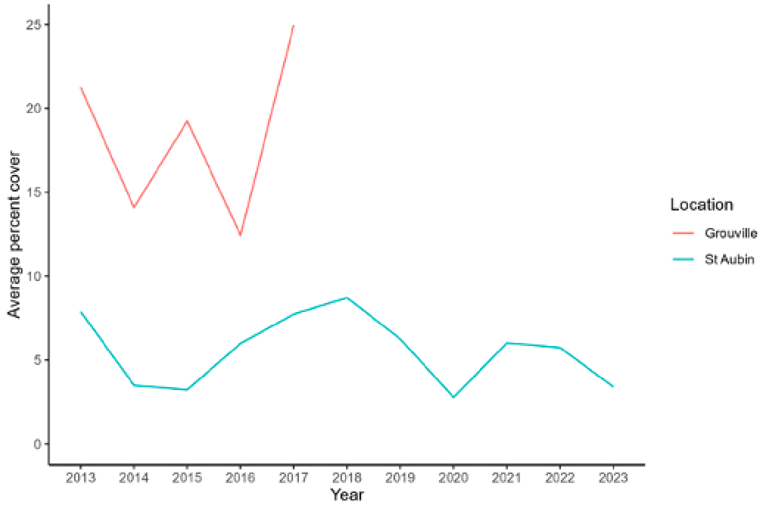


Figure 52 - Average percentage cover of seagrass across all quadrats by year in Grouville Bay (red) and St Aubin's Bay (Blue) (Pers. comm Marine Resources).

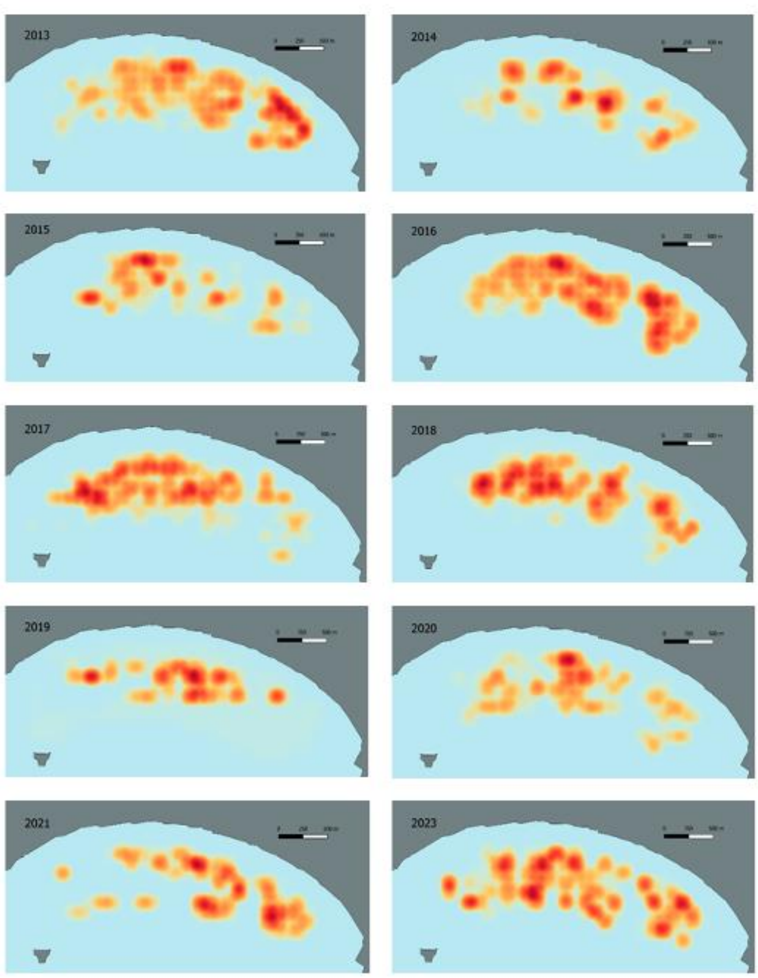


Figure 53 - Heatmap of seagrass between 2013 and 2023 (excluding 2022 as data was incomplete) in St Aubin's Bay. Darker red indicates greater percentage cover of seagrass. Colours only comparative within each year (Pers. comm Marine Resources).

6.1.3 SEAGRASS BIOMASS

In 2021, research was conducted on the biomass of the intertidal seagrass of St Aubin's Bay and Grouville Bay (Smith, 2022). Data was collected in September and October using transect across the seagrass beds to gain samples at the high, mid, and lower shore. Seagrass shoots, roots, and rhizomes were extracted from a 0.25 x 0.25 m quadrat. Samples were separated into above-ground (shoots) and below-ground (roots and rhizomes) biomass before drying and weighing.

Grouville Bay had a higher mean above-ground biomass than St Aubin's Bay. Significant differences were found between the two sites at both the mid and lower shore height, with Grouville having significantly higher above-ground biomass than St Aubin's Bay (Figure 54).

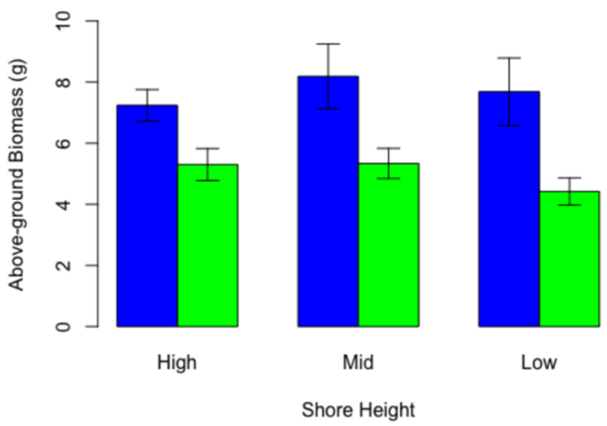


Figure 54 - Mean above-ground biomass (grams) in Grouville Bay (blue) and St Aubin's Bay (green). Figure taken from Smith (2022)

Similar results were seen for below-ground biomass, with Grouville Bay having a higher mean biomass than St Aubin's Bay. Significant differences were found between the two sites at high and mid-shore heights, with Grouville having significantly higher below-ground biomass than St Aubin's Bay (Figure 55).

Reduced biomass in St Aubin's Bay, both above and below-ground, was suggested to be attributed to excessive nutrient enrichment from the Bellozanne Wastewater Treatment Works, which outlets exclusively into St Aubin's Bay. Reduced water clarity and light penetration, eutrophication, increased competition for oxygen, and competition from other species (*Ulva)* were noted as consequences of this anthropogenic pollution.

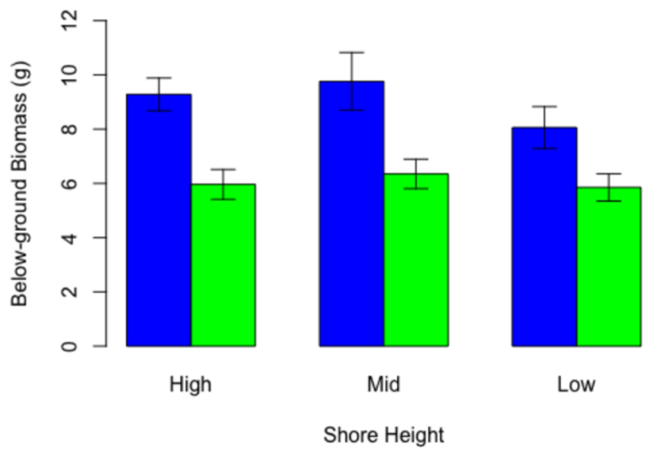


Figure 55 - Mean below-ground biomass (grams) in Grouville Bay (blue) and St Aubin's Bay (green). Figure taken from Smith (2022).

6.1.4 WATER QUALITY

As the life history of seagrass is directly influenced by water quality, knowledge of the water quality surrounding Jersey is of great significance to our understanding of the health of Jersey's seagrass. Eutrophication in the Channel Islands is generally limited due to the large tidal movements, which can retreat up to 12 metres on a spring tide. This creates a harsh intertidal environment, which experiences high rates of tidal movement, with large areas exposed to air. Despite these large tidal fluctuations, water can circulate Jersey for up to six days before moving out into the surrounding Gulf of St Malo (Greenaway, 2001). Additionally, water to the east of Jersey can circulate for up to eight weeks before leaving the gulf (Greenaway, 2001). Jersey's coastal characteristics vary significantly, with bays in the north and west being largely exposed and those in the south and east sheltered (broadly speaking). Generally, southern and eastern intertidal areas along Jersey's coastline have a relatively flat gradient. Further, freshwater inputs and terrestrial runoff can be found on most (if not all) beaches. These combined characteristics make Jersey intertidal environments unique and complex and create huge abiotic variations for intertidal communities, including seagrass.

6.1.4.1 WASTEWATER

St Aubin's Bay is Jersey's largest southern bay and is a focus area for water quality monitoring in Jersey. This is mainly due to the wastewater outlet from the Bellozanne Wastewater Treatment Works (BWwTW), which outlets the entirety of Jersey's treated wastewater into the bay. Construction of BWwTW was commissioned in 1959, and before this, untreated sewage was released (Alldred *et al.*, 2023). In 1997, research by the Centre for Research into Environmental Health indicated that St Aubin's Bay experienced winter hyper-nutrification despite the existing nutrient removal performed at the BWwTW (CREH, 1997). The position of the Bellozanne outlet corresponded with the elevated nitrogen isotopes (δ15N) detected in macroalgae samples, indicating the anthropogenic effluent as the cause.

Stapleton *et al.* (2000) later estimated the dissolved available inorganic nitrogen (DAIN) and dissolved inorganic phosphorus (DAIP) load within St Aubin's Bay. Analyses of the origin of these major inorganic nutrients were undertaken using hydrological data and samples from local streams and the wastewater outlet. This research concluded that the BWwTW contributes 97% of the total inorganic phosphorus load and 54% of the total inorganic nitrogen load in St Aubin's Bay (Stapleton *et al.*, 2000). However, they also noted that a winter peak in DAIN may result from the leaching of fertilisers, which the crops (potatoes) no longer utilise following the harvest. Initially, the BWwTW was built to accommodate only 57,000 inhabitants. Thus, in 2000, it was already operating beyond its capacity, and upgrades were required. Stapleton *et al.* (2000) recommended additional nutrient removal be performed at the BWwTW.

In 2010, a reassessment of the BWwTW reported that 72% of the annual DAIN input to St Aubin's Bay originated from the BWwTW outlet, an increase from 1997 (Berry, 2010). Further, despite having reduced compared to the 1997 levels, the majority of DAIP in the bay was delivered from the BWwTW. It was suggested that the bay still experienced winter hyper-nutrification and that the bay was at risk from eutrophication in the summer. These results suggest that there had been elevated levels of nutrients in the bay and thus reduced water quality for at least 13 years. In 2012, a water quality assessment programme commissioned by the Department of the Environment was established to better understand the impact of human pressures on Jersey's marine environment (Leverett, 2015). Chemical monitoring of seawater at three sites across the bay was undertaken, reporting "Good" ecological status throughout. However, dissolved inorganic nitrogen from five sites across the bay suggested "Moderate" nutrient enrichment was present. Throughout this period of research, the health of *Z. noltei,* in relation to water quality, was not considered.

6.1.4.2 WATER QUALITY AND SEAGRASS HEALTH

In 2014, a student research project investigated the effect of dissolved nitrates on the health of *Z. noltei* in Grouville and St Aubin's Bay (Le Page, 2014). Water quality data was collected as part of the Government of Jersey's environmental monitoring scheme and provided for analysis. Average nitrate concentrations at St Aubin's Bay were 52 ppm, whilst at Grouville, they were just 10 ppm. When water was tested directly from the BWwTW outlet, readings exceeded 160 ppm (10 ppm is considered a safe level for human consumption). Further, seagrass health at St Aubin's Bay was reported as significantly poorer than at Grouville. This was the first study to suggest that water quality in St Aubin's Bay may be negatively affecting seagrass health. Consequently, student projects investigating the relationship between water quality and intertidal seagrass health in Jersey were repeated over the following years.

Water quality was tested in 2015 (McLean, 2015), again indicating that nitrate concentrations in St Aubin's Bay were greater than in Grouville. The sample site nearest the BWwTW had significantly higher ammoniacal nitrogen concentrations as well as large amounts of sulphates and salts. Similarly, it was concluded that seagrass at St Aubin's was less healthy than the comparison sites. In 2017, 7 months (April to October 2017) of data was analysed to understand the seasonal changes in water quality in St Aubin's Bay (Gorvel, 2018). This study indicated significant variation in ammonia and nitrite levels between two locations (St Aubin's Harbour and First Tower) over the time series. Higher values of nitrite and ammonia were recorded at First Tower (near the BWwTW outlet) compared to St Aubin's Harbour throughout the data period, peaking in July–September. This study concluded that the BWwTW outlet caused an evident environmental disturbance which negatively affected the health and condition of *Z. noltei* within St Aubin's Bay.

In 2020–2021, Alldred *et al.* (2023) used macro-algae as a bioindicator to assess anthropogenic pollution on two island case studies (Jersey and St Mary, Isles of Scilly). By performing nitrogen isotope analysis on *Fucus vesiculosus* and *Ulva spp*. elevated nitrogen levels were found in St Aubin's Bay compared to other locations around Jersey's coast (as found by CREH in 1997) (Figure 56) (Alldred *et al.*, 2023). This clear geospatial pattern of nitrogen loading again suggested that the anthropogenic effluent released from the BWwTW is the source. Further, it suggests that any potential negative impacts on ecosystem health are only felt within the vicinity of St Aubin's Bay.

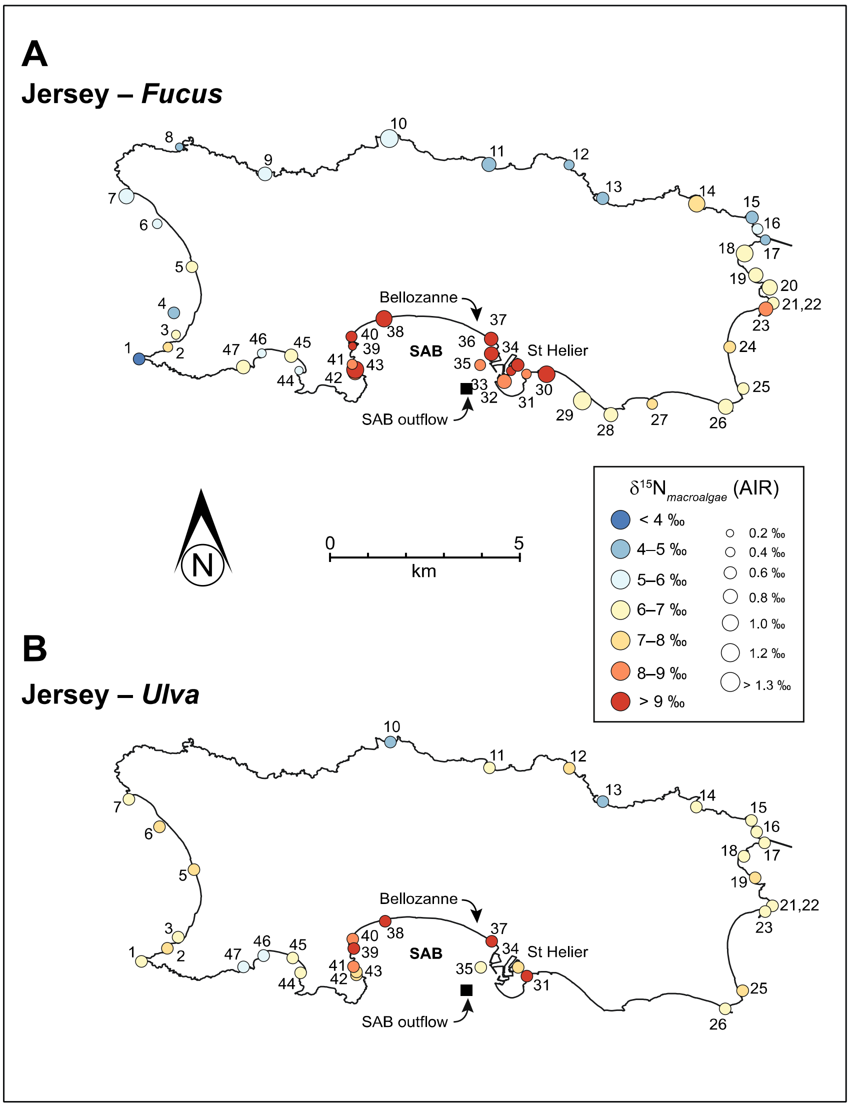


Figure 56 - Map of macroalgae nitrogen isotopes values for a) *Fucus* and b) *Ulva* around Jersey. Size of circle represents standard deviation. Colour range represent distinct ^{15}N values. Taken from Alldred *et al.* (2023)

6.1.5 MACROALGAE

Macroalgae are integral to the health and dynamics of Jersey's intertidal seagrass ecosystems, but their proliferation can pose significant challenges. The introduction of excess nutrients into coastal waters often leads to eutrophication, triggering algal blooms that can smother seagrass beds and obstruct essential light. This phenomenon is particularly evident in St Aubin's Bay, where nutrient runoff has been linked to extensive macroalgal growth. Furthermore, the presence of epiphytic algae on seagrass can indicate declining health, influencing the habitat preferences of species such as brent geese. Understanding these dynamics is critical, as they can impact the biodiversity and resilience of the intertidal ecosystem. Effective monitoring and management strategies are essential to mitigate the effects of macroalgal proliferation on Jersey's seagrass and its associated fauna.

6.1.5.1 ALGAL BLOOMS

The input of nutrients into the marine environment is directly linked to the proliferation of macroalgae. Eutrophication occurs when a waterbody receives excessive nutrients and can trigger algal growth far beyond natural levels. The degradation of algae can create hypoxic (low oxygen) conditions as large amounts of CO_2 are released, causing the water to become more acidic. There can be many knock-on effects from eutrophication in intertidal habitats. However, one of the simplest impacts is algal blooms, which smother the surrounding ecosystem. This can be especially negative for seagrass, which requires high levels of light to grow.

Again, St Aubin's Bay is a focal point for monitoring macroalgae proliferation in Jersey. The bay is heavily impacted by human pressures, receiving large amounts of natural runoff and treated sewage discharge from the BWwTW whilst being heavily modified, including sea defences, the expansion of St Helier Port, and a waste reclamation site (Leverett, 2015). Stapleton *et al.* (2000) noted that green macroalgae *Ulva* was prolific in Jersey's coastal waters. Historically, this algae has been harvested from St Aubin's Bay by the Public Services Department for application to agricultural land as a type of 'green manure' (Stapleton *et al.*, 2000). The removal of *Ulva* from the bay was also trialled as a management technique in 2012, with reportedly "limited success" (BBC News, 2012). Further, a ploughing trial was undertaken in November 2015 to see whether artificial furrows would aid the movement of *Ulva* down the beach and ultimately out to sea (Department of the Environment, 2017). This trial was deemed to have no measurable effect on *Ulva* distribution, and no further attempts were made. Overall, the proliferation of *Ulva* within St Aubin's Bay is a long-standing topic of concern.

6.1.5.2 EPIPHYTIC ALGAE

Reports of prolific algae are not limited to *Ulva* species in St Aubin's Bay. In 2009, during a review of the Southeast Coast Ramsar Site, consultants noted high levels of epiphytic algae growing directly on seagrass *Z. noltei* on Jersey's eastern beaches over the winter months (Linley et al., 2009). The growth was attributed to terrestrial runoff introducing excess nutrients into coastal waters. Further, it was suggested that this growth may be causing a shift in the feeding grounds of brent geese, which were reportedly moving inland to feed during winter. Brent geese were identified as a key species within the Southeast coast ecosystem, with stable population numbers reported over a 10-year period. It was suggested that the high level of epiphytic growth and potentially poor seagrass condition had pushed the geese to feed elsewhere.

Later, in 2009 and 2010, a study looking at the 'ecological and beach process of Jersey's East Coast' identified four dominant species of epiphytic macroalgae present on the *Z. noltei* bed at Grouville Bay, namely *Ceramium nodulosum*, *Sphacelaria cirrosa, Blidingia marginata*, and *Micocoleus chthonoplastes* (Chambers, 2011). Other heavily colonising seagrass species included diatoms, namely *Licmophora abbreviata*, hydroid *Laomedea angulata* (Seagrass sea fir), and amphipod *Echinogammarus stoerensis*. This study agreed with Linley et al. (2009), suggesting that investigating the health of Jersey's intertidal seagrass beds would be prudent.

6.1.5.3 *ULVA* MONITORING

With concerns growing each year regarding the impact of *Ulva*, in 2013, The Department for Infrastructure commissioned Cascade Consulting to investigate the conditions controlling and promoting the proliferation of *Ulva* within the bay. In 2014 and 2015, in partnership with Nurture Ecology and the Société Jersiaise, summer surveys were undertaken to elucidate the volume of *Ulva* being transported in and out of the bay. On each tide, around 0.6–70 tonnes (wet weight) of *Ulva* was reported to travel in and out of the bay, whilst the total mass of *Ulva* across the intertidal area of St Aubin's Bay was estimated to be 8774 tonnes (wet weight) (Fairhead, 2016). The eastern side of the bay contained the highest volume of *Ulva*, whilst the highest density and coverage of *Ulva* occurred in July at sea temperatures above 15°C. *Ulva rigida* was identified as a key species related to the blooms. The average 30-year sea temperature for St Helier was reportedly 16.5°C whilst *Ulva's* optimum growth temperature is between 15-20°C. This indicated that environmental conditions in Jersey were optimal for the proliferation of *Ulva*.

In 2014, a student research project recorded an increased presence of *U. lactuca* across St Aubin's Bay, surpassing levels observed in Grouville (Le Page, 2014). The highest concentrations of this macroalgae were found near the BWwTW outlet, with no records at Grouville. In 2015, it was suggested that light reduction due to macroalgae (*Ulva)* cover might contribute to the decline of *Z. noltei* within St Aubin's Bay (McLean, 2015). Similar observations were made in 2017, indicating that *Ulva* was most prolific to the east of the BWwTW outlet (as reported in 2014 (Fairhead, 2016)) (Gorvel, 2018). This study reported *Ulva intestinalis* to be abundant, a species known to prefer nitrogen-rich environments. Additionally, the health of infauna was observed to decline with increased proximity to the BWwTW (Delaney, 2015). Although the link between excessive *Ulva* growth and infauna health was not investigated, it was recommended for further study. These findings suggest that the proliferation of macroalgae, driven by reduced water quality from excessive nutrient inputs, has wide-ranging impacts on the ecosystem of St Aubin's Bay, including seagrass health.

6.1.5.4 ALGAE COMMUNITIES

Macro-algae communities themselves can be negatively affected by elevated nutrient levels. In 2010, an undergraduate research project estimated the inorganic nutrient loading to intertidal regions of Jersey from catchment and wastewater sources and its subsequent effect on macroalgae (Holmes, 2010). The ecological quality ratio (EQR) of macro-algae populations in St Aubin's Bay was classified as "bad" to "poor" and were said to be in a degraded state. Lower species richness and diversity, as well as higher proportions of opportunistic species (such as *U. lactuca*), were reported for St Aubin's Bay compared to St Ouen's Bay.

Between April 2012 and September 2015, water quality monitoring was undertaken by WCA Environment Limited (commissioned by the Environment Department), assessing various ecological measures, including macroalgae and seagrass. Overall, the ecological status of the bay was classed as "Moderate" for opportunistic macroalgae and "Good" for rocky shore macroalgae. These results contrast slightly with Holmes (2010), suggesting that rocky shore macroalgae displayed reasonable levels of biodiversity and a healthy proportion of different seaweed species. Further, it suggested that St Aubin's Bay was neither a good nor bad ecosystem for opportunistic algae but somewhere in between. Overall, these two studies suggest that there is room to improve macroalgae health within St Aubin's Bay and that opportunistic species are prevalent.

6.1.5.5 SEAGRASS REPLACEMENT

A higher proportion of opportunistic macroalgae species may cause a shift in community structure. This could pose a risk to seagrass habitats as biodiversity and ecosystem health are reduced. In 2018, a study assessed the potential for seagrass in St Aubin's Bay to be replaced by macroalgae over time (Skimming, 2018). Using abundance data of *U. lactuca* and *Z. noltei* between 2014 and 2016, changes in abundance were evaluated. No uniform change in the *U. lactuca* abundance was reported within St Aubin's Bay over the time series. However, different trends in abundance were noted between the east and west of the bay. Overall, no significant relationship between *Z. noltei* abundance and *U. lactuca* abundance was established, and the potential for replacement was deemed "very low". However, important limitations were raised regarding this study, including the limited time series for testing the relationship and the use of a small amount of abundance data, which limited the conclusions.

6.1.5.6 INVASIVE RED SEAWEEDS

There are currently two, possibly three, small but invasive red seaweeds present in Jersey's waters, which are being monitored (Pers. Comm. Bob Tompkins). Although little can be done to mitigate their impact, it is essential to track how these species affect the marine ecosystem.

The species which may be a cause for concern is *Gracilaria vermiculophylla*, a species native to the Northwest Pacific, particularly along the coasts of Japan, Korea, China, and Vietnam. This species poses a potential threat to dwarf eelgrass (*Zostera noltei*) in Jersey. Currently, *G. vermiculophylla* can be found spreading from Le Hurel Slip down to the oyster beds and Gorey Harbour (Pers. Comm. Bob Tompkins). It typically attaches to small stones and can be found in rock pools along the Southeast coast. However, *G. vermiculophylla* is also capable of anchoring itself to fine beach sediments, where intertidal seagrass grows. While it is vulnerable to dislodgement by harsh swells during early colonisation, once established, it can form extensive mats across the seabed. Notably, *Z. noltei* is spreading into the area around the oyster beds in Grouville Bay. The continued spread of *G. vermiculophylla* into this area would be concerning for the health of the intertidal seagrass bed.

6.1.6 INFAUNA

The infaunal communities within Jersey's intertidal seagrass habitats, particularly in St Aubin's Bay, Grouville Bay, and St Catherine's Bay, have been extensively studied to understand how pollution, especially from the BWwTW, impacts these vital ecosystems. These studies shed light on species abundance, diversity, and the overall health of seagrass meadows across different sites.

Bennett-Jones (2014) collected sediment samples across four sites and identified a total of 724 individual infauna from 49 different species (Bennett-Jones, 2014). It was found that St Aubin's West had significantly fewer species and individuals compared to Grouville Bay and St Catherine's Bay. There were notable differences in species composition and Crustacea abundance between St Aubin's East and West seagrass beds. These findings suggest that the wastewater outfall in St Aubin's Bay negatively affects seagrass biomass and infaunal diversity and abundance, particularly to the west of the outfall. This disruption of infaunal communities can have cascading effects on the health and resilience of the seagrass meadows they inhabit.

Delaney (2015) further highlighted the adverse effects of pollution in St Aubin's Bay, where the infaunal community was dominated by *Capitella capitata*, a species indicative of degraded and polluted conditions (Delaney, 2015). Pollution-sensitive species were more abundant further from the outfall.

The Infaunal Quality Index (IQI) rated the overall condition of St Aubin's Bay as poor, reflecting the detrimental impact of pollution on seagrass-associated infauna. In contrast, Grouville Bay, dominated by pollution-sensitive *Bathyporeia* species, exhibited a healthier ecological status with a higher IQI score. This study underscores the direct relationship between distance from pollution sources and improved seagrass habitat health, suggesting possible eutrophication issues in St Aubin's Bay that can undermine seagrass vitality.

Sinclair (2017) provided a detailed comparison of infaunal abundance across the different sites, reporting a total of 914 individual organisms (Sinclair, 2017). St Aubin's Bay had the lowest number of polychaetes, but higher numbers of crustaceans and molluscs compared to Grouville Bay and St Catherine's Bay. The study concluded that the BWwTW significantly reduced the overall infaunal abundance in St Aubin's Bay, particularly impacting polychaete worms, which are crucial for the health of seagrass beds. A reduced infaunal population can impair the nutrient cycling and sediment stability provided by these organisms, thereby affecting seagrass growth and sustainability.

Leverett (2015) reported on the environmental status of St Aubin's Bay, using benthic invertebrates to analyse chemical contamination and its effects on the bay's ecological status (Leverett, 2015). High concentrations of pollutants such as benzo(a)pyrene and fluoranthene were detected in samples from St Aubin's Beach, suggesting significant localised pollution, which can be detrimental to seagrass health. Despite these findings, the overall ecological status of the bay based on benthic invertebrate assessments was deemed 'Good', although the harbour area consistently showed poorer conditions due to its developed and active nature. This highlights the importance of continuous monitoring and accurate assessment of data to understand and mitigate the impacts on seagrass ecosystems effectively.

Overall, these studies collectively reveal that St Aubin's Bay is heavily impacted by pollution from wastewater, leading to lower species diversity and abundance within its seagrass habitats. Comparatively, Grouville Bay exhibits better ecological health with richer species diversity and less pollution impact. Maintaining healthy infaunal communities is crucial for the overall health and resilience of seagrass meadows.

6.2 SUBTIDAL SEAGRASS

The health and condition of subtidal seagrass is influenced by a range of environmental, anthropogenic, and biological factors. Key threats include poor water quality, reduced light availability, and physical disturbance from anthropogenic activities. To assess the health of seagrass, researchers have employed a variety of techniques, including density mapping, biomass analysis, monitoring of mooring scars, and assessment of infaunal species. This section examines the various research carried out on subtidal seagrass.

6.2.1 LANDSCAPE CHARACTERISTICS

Jackson (2003) used a variety of research techniques to assess the landscape patterns of subtidal *Z. marina* beds around Jersey. The Largest Patch Index (LPI), edge density, and mean core area of seagrass as a percentage of landscapes (CPLAND) varied across seagrass beds.

The LPI quantify the dominance of the largest patch of seagrass within a landscape. It represents the proportion of the landscape's total area that is occupied by the largest contiguous patch of seagrass. Higher LPI generally indicates increased habitat connectivity and reduced fragmentation within the habitat. The highest LPI was at St Catherine's Bay (LPI; 27.7%), followed by Fliquet (22.1%), Icho (17.2%), and Les Elavees (16.3%). Beds well below the average LPI for Jersey (14%) were Elizabeth Castle (6.6%), La Coupe (6.0%) and Grande Haise (6.8%) (see Figure 57 for locations).

Edge densities were calculated for each bed, given as a length of the boundary (or "edge") between seagrass patches and non-seagrass areas (such as bare sand or water) within a specific unit of area. Higher edge densities indicate higher levels of fragmentation and potentially decreased ecological health. Fliquet (3074.3 mha^{-1}), Icho (3044.74 mha^{-1}) and Violet (2663.38 mha^{-1}) were all above the average (2282 mha^{-1}) for the area. The lowest edge density was recorded at La Coupe (1279.42 mha^{-1}).

CPLAND is calculated by determining the mean core area of all seagrass patches and then expressing this mean as a percentage of the total landscape area. High CPLAND indicates that a significant portion of the landscape is occupied by the core areas of seagrass beds, suggesting that the seagrass patches are large, relatively unfragmented, and less affected by edge effects. CPLAND was highest at St Catherine's Bay (23.95 %), followed by Violet (14.88%) and Karame (14.43%) (Figure 58). The two sites with the lowest CPLAND were La Coupe (2.36%) and Grande Haise (2.94%).

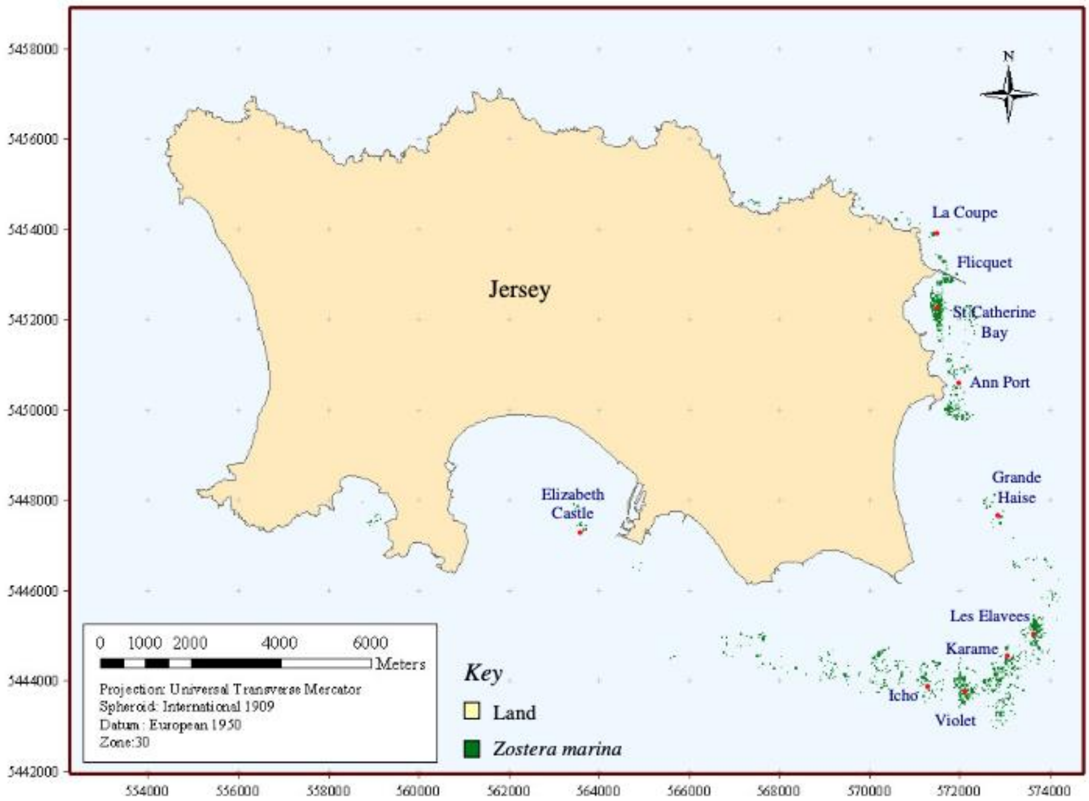


Figure 57 - Locations of *Z. marina* survey sites around Jersey's coast (red dots). Map taken from Jackson (2003).

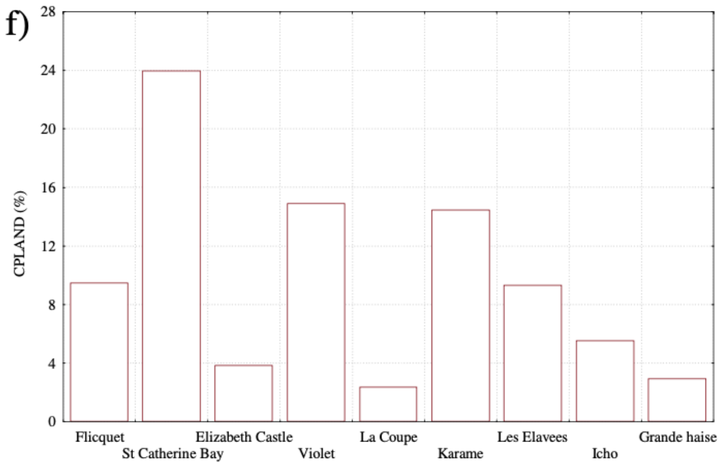


Figure 58 - Bar chart showing the variation in core area of *Z. marina* as a percentage of the landscape (CPLAND) for nine beds around the coast of Jersey. Taken from Jackson (2003).

6.2.2 BED CHARACTERISTICS

Jackson (2003) used echograms to assess the different characteristics of seagrass beds around Jersey, including leaf height, shoot density and epiphyte cover. Characteristics of subtidal seagrass, *Z. marina*, were visualised in the echogram as layers of -30 to -60db echo returns in green (Figure 59). Variability in plant height can be seen at the top of the canopy (ranging between 0.2 to 1.2m), whilst a continuous line yellow represents the seabed (-20 db).

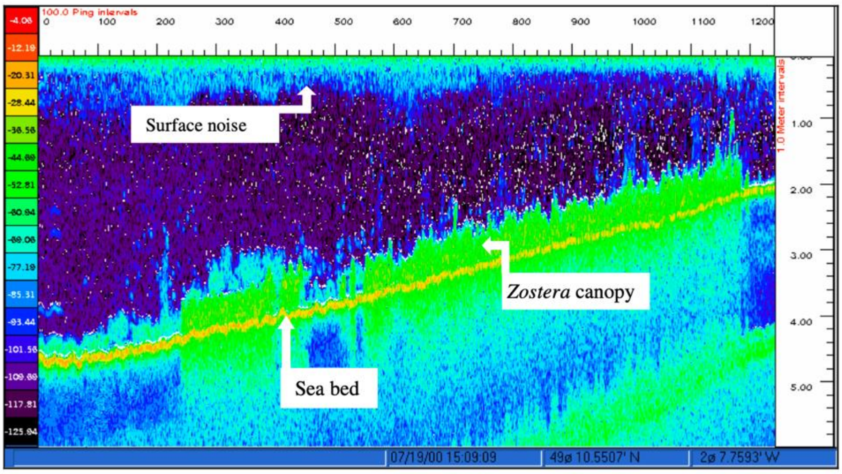


Figure 59 - Example of Biosonics DT4000 echogram used by Jackson (2003) to identify areas of seagrass around the coast of Jersey. Taken from Jackson (2003).

Significant differences in leaf height were reported across Jersey subtidal seagrass beds (Figure 60). The neighbouring bays of St Catherine's Bay and Anne Port had the highest mean leaf height (approximately 0.8 m). These two bays had significantly greater leaf heights than the other sites. Fliquet had the shortest leaf height (approximately 0.4 m), closely followed by Elizabeth Castle (approximately 0.5 m) and was significantly shorter than the other sites.

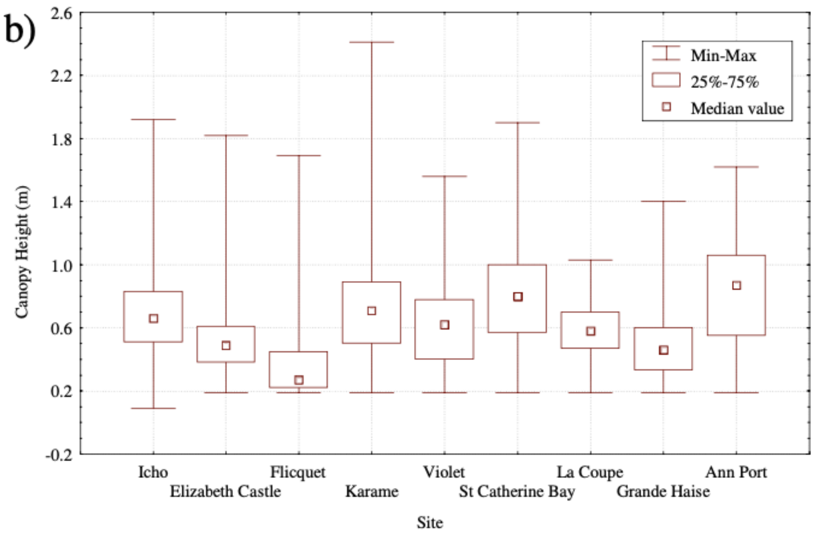


Figure 60 – Box plot showing the variation *Z. marina* leaf height as measured using the Biosonics DT4000^{TM} echo sounder system for nine beds around the coast of Jersey. Taken from Jackson (2003).

The mean shoot density across all Jersey subtidal seagrass sites was 390 shoots m^{-2}. The highest mean shoot densities were reported at Grand Haise (approximately 597.3 shoots m^{-2}), Icho (~560 m^{-2}), Les Elavees (~522.7 m^{-2}) and Karame (~485.33 m^{-2}) (Figure 61). These four sites had significantly higher shoot densities than all other sites, except for St Catherine's Bay (~357 m^{-2}). The lowest mean shoot density was observed at La Coupe (~241 m^{-2}).

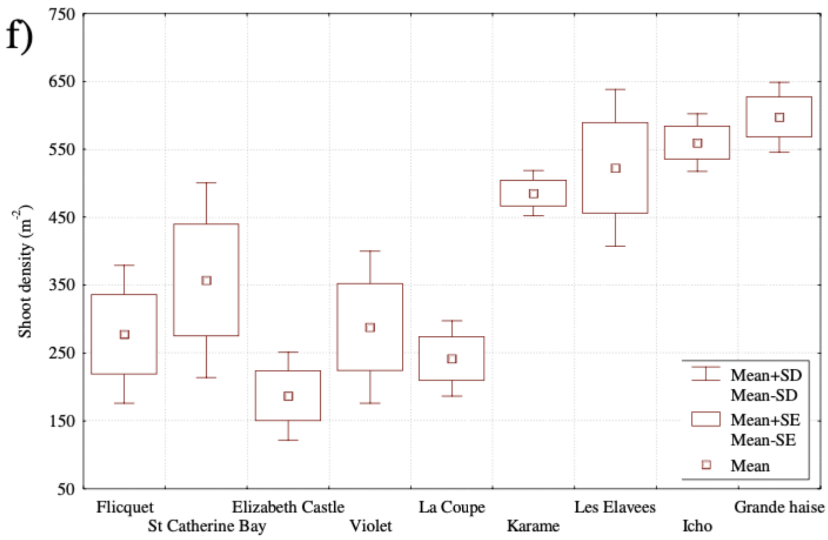


Figure 61 - Box plot showing the variation *Z. marina* shoot density for nine beds around the coast of Jersey. Taken from Jackson (2003).

Significant differences were reported for the epiphyte index of seagrass at different sites across Jersey. Elizabeth Castle displayed the highest levels of epiphytic index (mean epiphyte index approximately 0.35) and was significantly higher than Anne Port (~0.2), Karame (~0.06), and Fliquet (~0.046) (Figure 62). However, it was not reported as significantly higher than Grande Haise (~0.138), Icho (~0.334) or Violet (~0.148). The lowest level of epiphytes was found at St Catherine's Bay, Les Elavees and Anne Port, although they were only significantly lower than Elizabeth Castle and Icho. Overall, epiphytes at most sites were dominated by a crustose coralline alga (genus Fosliella). However, at Anne Port, the polychaete *Nicolea zostericola* was dominant, whilst at Elizabeth Castle, Grande Haise, and Icho, the filamentous alga *Polysiphonia lanosa* was dominant.

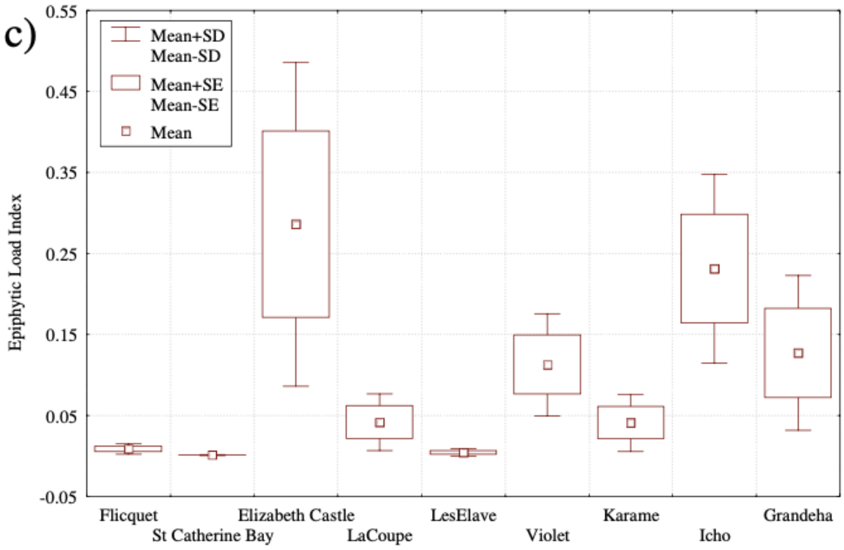


Figure 62 - Box plot showing the variation in the mean epiphytic load index for nine beds around the coast of Jersey. Taken from Jackson (2003).

6.2.3 DENSITY MAPPING (ST CATHERINE'S BAY)

In July and August 2022, an extensive survey of the subtidal seagrass bed at St Catherine's Bay was undertaken (Kuo, 2022). The data was collected using drop cameras with the support of Jersey Marine Conservation. In total, 296 locations (50 meters apart) were sampled across the meadow extent. Underwater images were assessed using Image J to measure seagrass density within the 50 x 50 cm quadrat.

Across the meadow extent, seagrass density ranged from 0.00% to 87.56%. The lowest visible seagrass density was 0.14%. The most common density was 50-60%, representing over one-quarter of the samples with seagrass. In total, the area of seagrass recorded covered 356,663 m^2.

A heat map was created to show the change in density across the meadow. The highest density of seagrass is localised in the centre of the meadow (Figure 63). Notably, only small patches reached the highest densities (in green). A small patch of low density (10-20%) can be seen within the centre of the northern end of the bed. This patch is located next to an area of high density, suggesting that the decrease in density is localised. Overall, density reduction can be seen towards all edges of the bed.

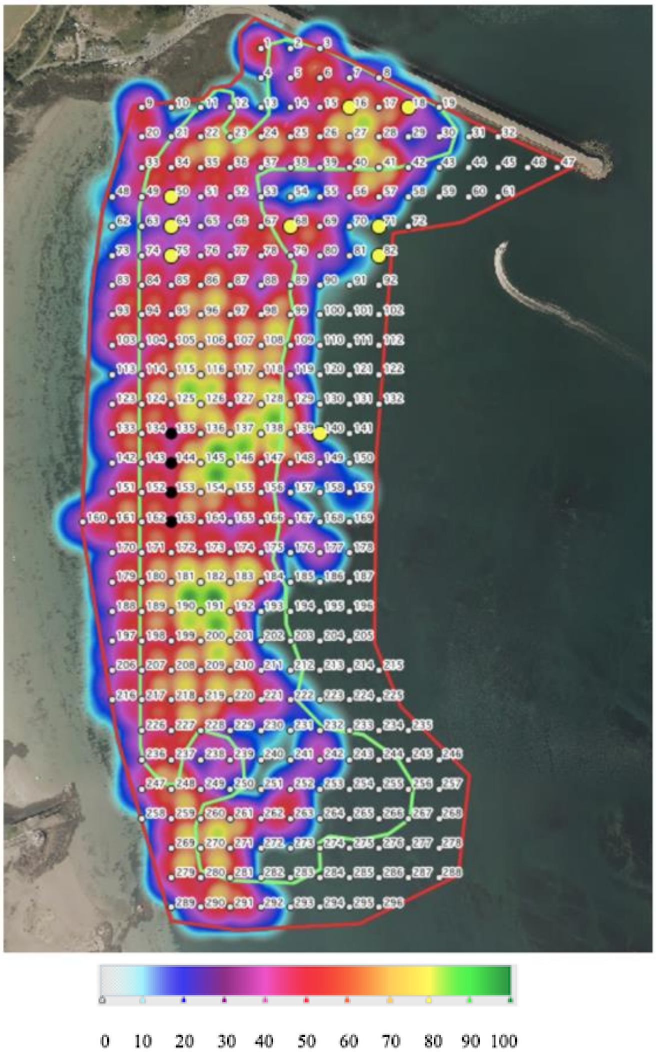


Figure 63 - Heatmap showing seagrass (*Z. marina*) density within St Catherine's Bay, 2022. Taken from Kuo (2022)

6.2.4 SEAGRASS BIOMASS

In 2022, a dive study by the Blue Marine Foundation (data currently unpublished but analysed in-house) examined whether the biomass composition and blade density of seagrass beds in Jersey are influenced by the age and location of the beds. The research compared older seagrass beds, those over 25 years old, with younger beds, aged 4 to 9 years, at two primary sites: St Catherine’s Bay and Anne Port.

Data was collected in July 2021 and August 2022, using scuba divers to survey along two 30-metre transects at each site. Seagrass samples, including roots and shoots, were collected. In the laboratory, the above-ground biomass (blades) and below-ground biomass (roots) were separated, dried, and weighed. Blade lengths of five plants per sample were measured, and the number of blades per plant was counted. Statistical analyses, including General Linear Models (GLMs), were used to compare biomass and blade measurements across different age groups and locations.

The results did not reveal significant differences in below-ground biomass (BGB) or above-ground biomass (AGB) for the age (across both locations) or the location (across both ages) of the seagrass beds (Figure 64). However, at St Catherine's Bay specifically, both BGB and AGB were significantly greater in the old bed compared to the young bed. The opposite trend was observed for Anneport, with younger beds exhibiting greater BGB and AGB than older beds, although this effect was not significant.

Regarding seagrass density, older beds had longer blades than younger beds at both sites, with St Catherine's oldest bed showing the greatest mean blade length (Figure 65). However, there was no significant difference in the mean number of blades per plant across the variables of age and location.

The study highlights the variability in seagrass biomass and density between different aged beds and locations. At St Catherine's Bay, older beds had more AGB and BGB, indicating a significant role as a carbon sink. Conversely, Anne Port's older beds had less biomass but longer blades than the younger beds. This variability suggests that conservation efforts based solely on the age of seagrass beds may be inadequate. St Catherine's Bay was noted as a critical site for conservation due to its higher biomass levels. Overall, the study underscores the complexity of the relationship between seagrass bed age, biomass, and density and the need for multifaceted conservation strategies for seagrass habitats in Jersey.

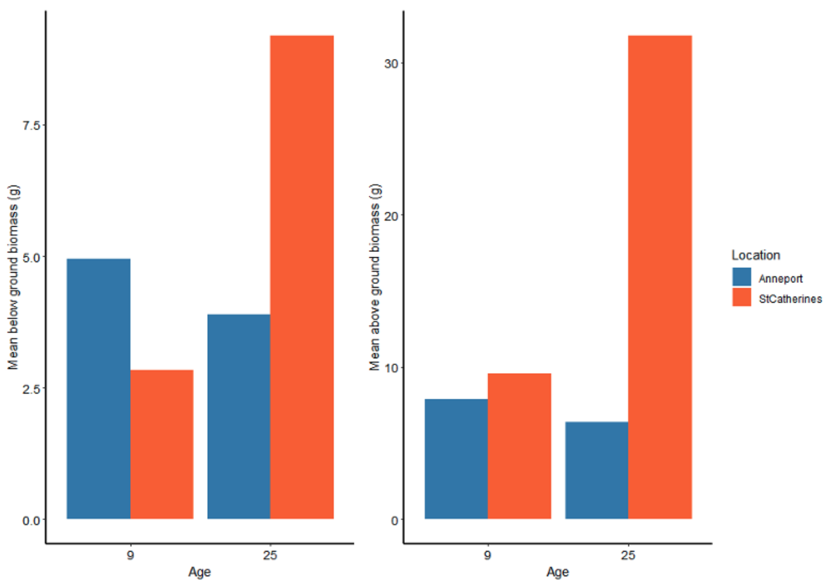


Figure 64 - Modelled mean estimates of above-ground biomass and below-ground biomass of seagrass at St Catherine's Bay and Anne Port, 2022. (Unpublished data).

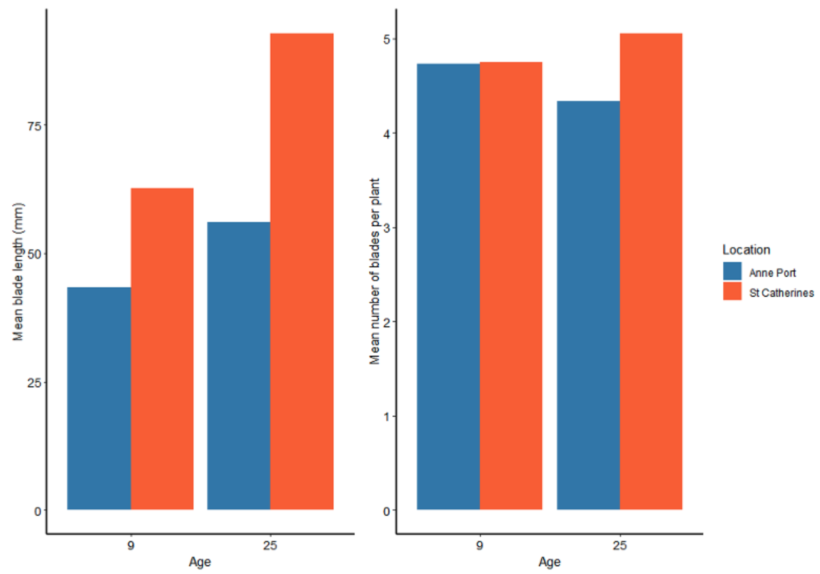


Figure 65 - Modelled mean estimates of blade lengths (mm) and mean number of blades per plant of seagrass at St Catherine's Bay and Anne Port. (Unpublished data).

6.2.5 DAMAGE TO SEAGRASS BEDS

Halos of bare sand created by boat moorings were noted in 1997 during an assessment of the distribution of Jersey's seagrass habitats (Figure 66) (Jackson, 2003). In 2022, the extent of mooring damage in St Catherine's Bay was analysed using aerial photographs from 2020 to 2021 to map the meadow extent and trace scar boundaries for both years (Dow, 2022). Bathymetric data was overlayed to determine the depths of the scars, and statistical analyses were conducted to assess the impact of mooring depth and location on scar size (Figure 67).

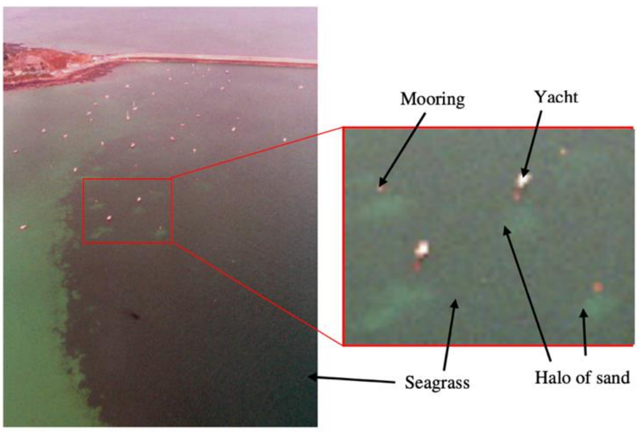


Figure 66 - Photographs of mooring scars in St Catherine's Bay. Taken from Jackson (2003).

The results indicated an increase in the overall seagrass meadow area from approximately 518,000m² in 2020 to 529,000m² in 2021 (Dow, 2022). Conversely, the total damage from mooring scars decreased from 3,831m² in 2020, with a mean scar area of 127.7m², to 3,264m² in 2021, with a mean scar size of 75.9m². The largest scars recorded were 293m² in 2020 and 235m² in 2021, occurring at different locations. The reduction in scar size from 2020 to 2021 was reported as significant.

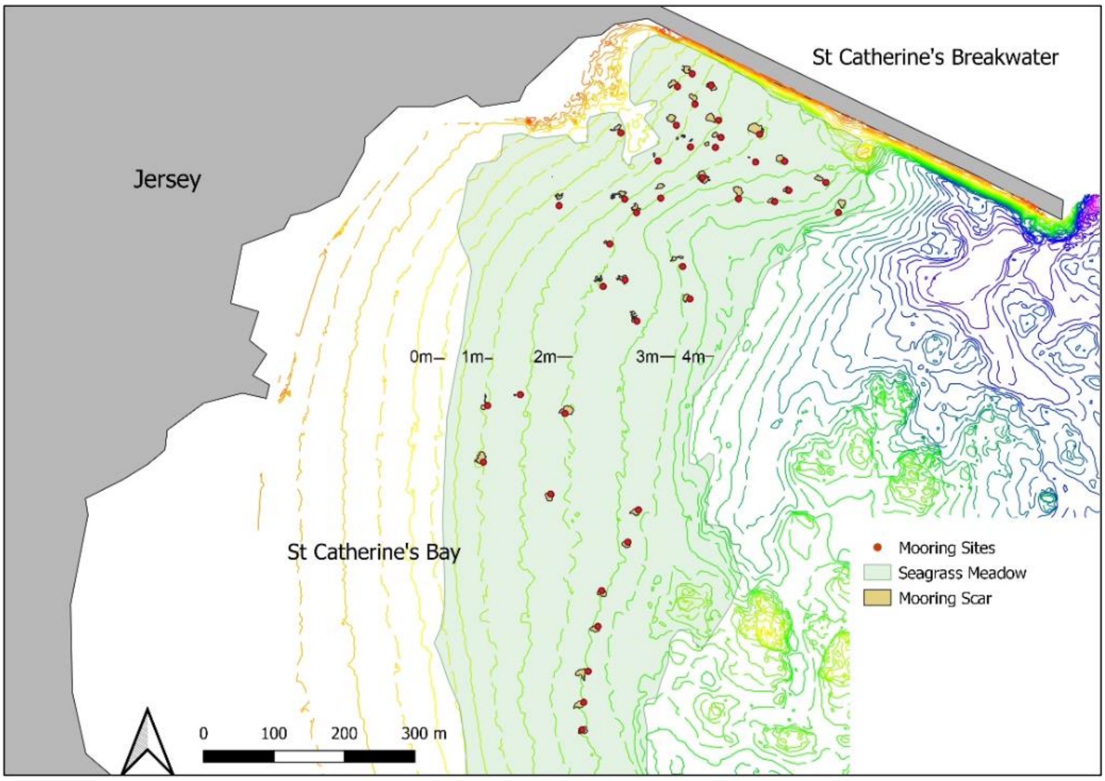


Figure 67 - Map indicating location of mooring sites, mooring scars and area of seagrass in St Catherine's Bay. Taken from Dow (2022).

Further analysis revealed weak, non-significant correlations between scar size and mooring depth, distance from the coast, and distance from the breakwater. These findings suggest that other factors, beyond depth and location, influence the size of mooring scars. Dow (2022) highlighted the seagrass meadow's expansion and reduced scar areas across the two study years. However, the study's reliance on only two years of data is a significant limitation, as long-term trends cannot be accurately determined. Additionally, the use of aerial imagery may underestimate scar sizes by about 7%, as suggested by previous research (Unsworth et al., 2017). Ground-truthing through diving was recommended for more precise measurements. Other potential impacts, such as anchoring and boat traffic, were noted but not quantified, possibly leading to an underestimation of total damage.

In September 2022, seagrass samples were collected from St Catherine's Bay, with five random samples collected across three mooring scar sites (Dow, 2023). Above-ground biomass was extracted, leaving roots and rhizomes in place. Samples were dried and weighed to calculate the mean above-ground biomass (by multiplying the average dry weight per site by the average number of shoots per site) using a conversion factor to get the grams of dry weight per metre squared (g DW/m2 unit). No seagrass was present within mooring scars; thus, zero values were reported for all three sites inside the scar. Outside the mooring scars, site three had the highest above-ground biomass, 216 (± 203.0) g DW/m2 and the largest number of shoots, whilst site one displayed the lowest biomass, 158 (± 46.7) g DW/m2.

Damage to the seagrass beds not only reduces the overall seagrass coverage but can have a knock-on effect on the species utilising the habitat. When assessing the impact habitat characteristics of Jersey's seagrass beds, researchers found that juvenile fish used the bed at St Catherine's Bay as a temporary nursery habitat (Jackson *et al.*, 2002). However, the occurrence of these juveniles decreased in areas where seagrass beds were more fragmented (Jackson *et al.*, 2006). Conversely, more fragmented areas reportedly benefitted larger fish, providing a mosaic of habitat types beneficial for feeding.

The findings from the studies conducted in St Catherine's Bay emphasise the complexity of seagrass meadow dynamics and the significant impact of human activities, such as mooring, on these vital habitats. While the overall seagrass area is reportedly increasing, the presence of scars indicates ongoing disturbances. The data suggests that current mooring practices impact the long-term health of seagrass meadows and require sustained monitoring and potentially further mitigation measures. The importance of ground-truthing and consideration of additional factors, such as boat traffic, cannot be overstated, as they may reveal the true extent of damage more accurately. Protecting seagrass ecosystems is crucial, not only for maintaining biodiversity but also for supporting the ecological services that seagrass beds provide, including their role as nurseries for juvenile fish. Therefore, a long-term approach to conservation, such as sustained monitoring and improved mooring technology, is essential for the longevity of seagrass habitats in Jersey.

6.2.6 INFAUNA

In recent years, research has provided valuable insights into the relationship between seagrass bed characteristics and benthic infaunal diversity and abundance in Jersey's subtidal seagrass habitat (See section 5.3.1.1 for more information). These studies provide a clearer picture of how factors, such as seagrass bed age, location, and environmental conditions, impact infaunal communities associated with seagrass beds.

Jordi (2021) focused on assessing the influence of seagrass bed age on blue carbon storage and species diversity, including infauna. The research found that older seagrass beds had higher mean infaunal species richness and significantly higher species abundance compared to younger beds across all sampled locations (Gorey, Karame, North East, and St Catherine's Bay) (Figure 68 and 69 and 70) (Jordi, 2021)[xvi]. When comparing locations, the Northeast and St Catherine's Bay had significantly lower species abundance and richness than Karame and Gorey. This suggests that older subtidal seagrass beds provide more favourable conditions for infaunal communities, possibly due to more established and complex habitat structures.

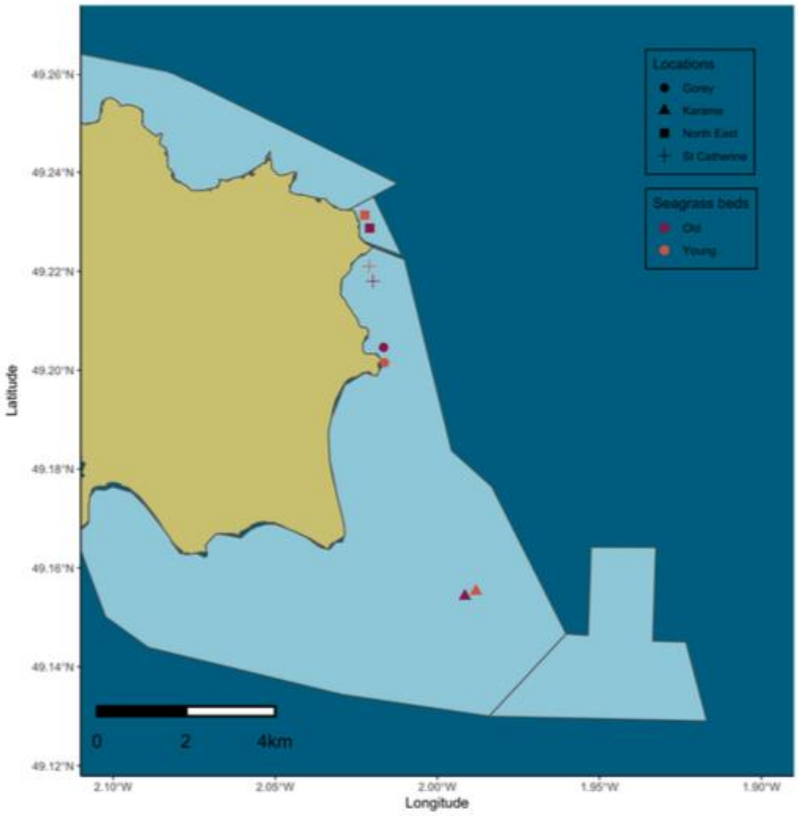


Figure 68 - Map of four study sites used by Jordi (2022). Red dots indicate old seagrass beds whilst orange dots indicate young seagrass beds. Taken from Jordi (2022).

[xvi] The location recorded as Gorey is located at Anne Port and Petit Port (behind Gorey castle).

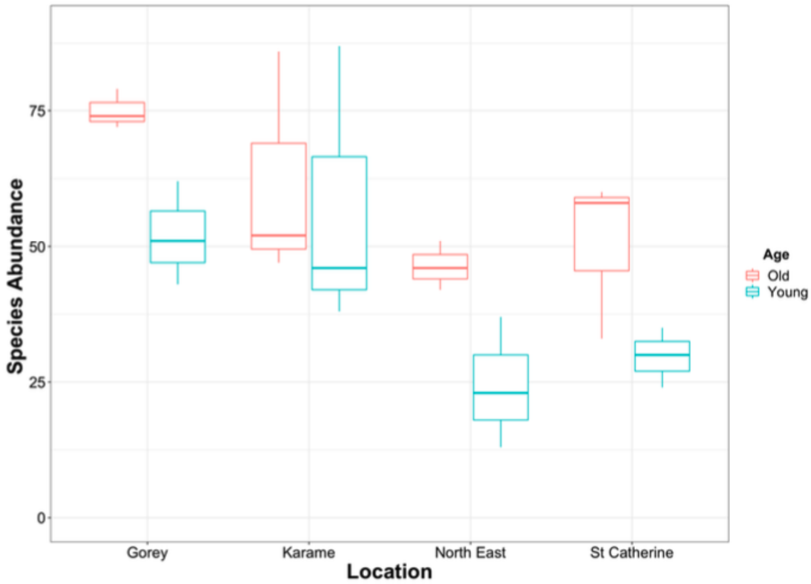


Figure 69 - Boxplot of mean infauna species abundance across the four sample locations. Red indicates old beds, whilst blue indicates young beds. Taken from Jordi (2021).

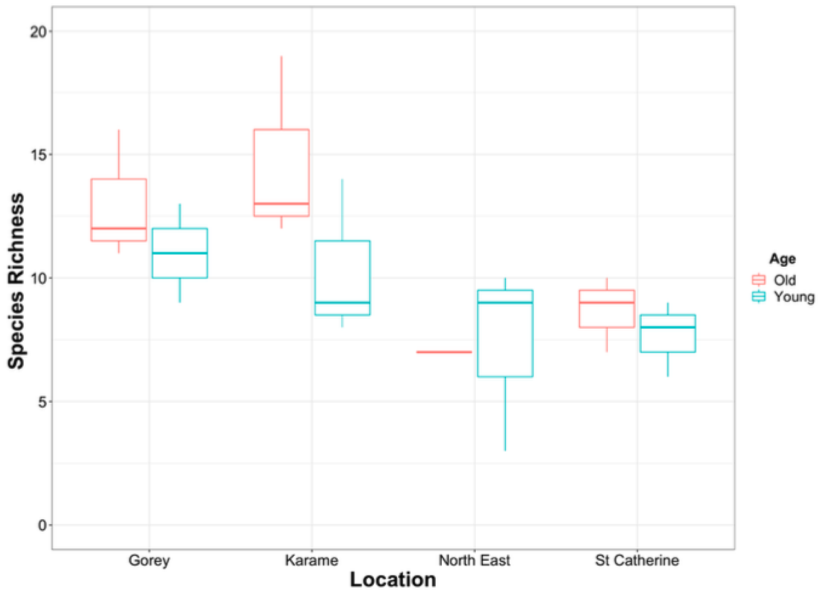


Figure 70 - Boxplot of mean infauna species richness across the four sample locations. Red indicates old beds, whilst blue indicates young beds. Taken from Jordi (2021).

Millan (2023) repeated elements of this study and also included the condition of seagrass beds across Jersey and the surrounding Channel Islands. Like Jordi's (2021) findings, it was found that older seagrass beds generally had greater infaunal species richness than younger beds. However, it was found that infaunal abundance did not significantly differ between old and young beds, though it varied significantly by location. The study also found significant differences in infaunal assemblages between different seagrass bed locations, with older beds supporting distinct communities.

Dow (2023) researched the impact of block and chain moorings on infaunal biodiversity within St Catherine's Bay. The study found that mooring scars significantly reduced infaunal diversity and abundance. Inside the scars, only 16 taxa were recorded compared to 22 outside, with 162 individuals inside and 84 outside. Annelida were the most abundant group, making up about 60% of all individuals. The results indicated that mooring disturbances have a detrimental effect on infaunal communities, highlighting the importance of minimising such impacts to preserve seagrass ecosystem health.

These studies reveal consistent trends regarding the influence of seagrass bed age and human impacts on infaunal communities. Older seagrass beds typically support higher infaunal diversity and abundance, underscoring their ecological importance. However, human activities such as mooring can significantly disrupt these communities, leading to reduced diversity and abundance within affected areas. Overall, the combined research highlights the importance of older seagrass beds. Further, it indicates the need to study each bed as a unique habitat, each with different influencing factors (anthropogenic and environmental) impacting their ecological makeup. Treating each bed as unique will help preserve the ecological functions and biodiversity of seagrass ecosystems in Jersey and the wider Channel Islands region.

6.3 CURRENT CONDITION (2023)

Jones and Unsworth (2016) developed a method to rapidly assess the ecological and environmental status of seagrass meadows by analysing seagrass biochemistry alongside other measures, such as levels of epiphytic algae. The carbon-to-nitrogen (C:N) ratio is classified as an indicator of high light availability if above 20, reduced light availability if between 14 and 20, and low light availability if below 14 (Jones and Unsworth, 2016).

Based on Jones and Unsworth (2016), Millan (2023) used the C:N ratios to categorise seagrass bed conditions across the Channel Islands as 'Good', 'Reduced', or 'Poor'. Millan (2023) used seagrass biomass samples to calculate carbon-to-nitrogen (C:N) ratios. These ratios were used to define a condition proxy in relation to global averages as per Jones and Unsworth (2016). Samples of *Zostera marina* and *Zostera noltei* were collected from sites across the Channel Islands (Figure 71). For *Zostera marina*, a total of 24 beds were sampled, including Jersey's offshore reefs, whilst ten *Z. noltei* beds were sampled. Seagrass beds in Jersey were categorised by geographic location (east or south) in addition to age (old or young), where appropriate.

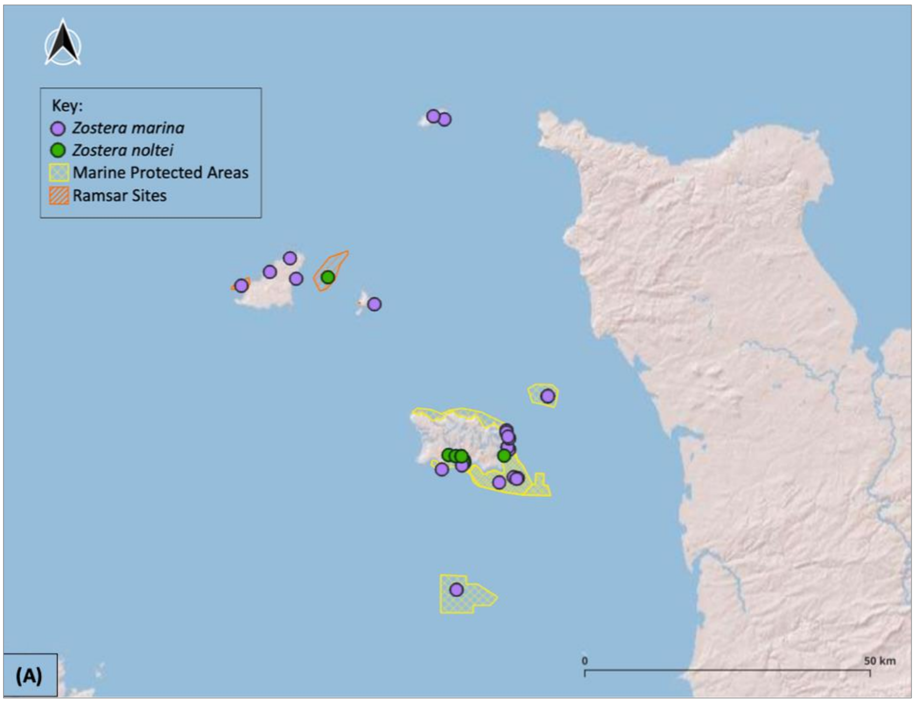


Figure 71 - Overview of *Z. marina (purple) and Z. noltei (green)* sampling locations across the Channel Islands used by Millan (2023). Taken from Millan (2023)

Across Jersey's waters, conditions differed for *Z. marina* beds. Portelet Bay (in Jersey South) and Seymour Tower, Petit Port, Anne Port, and St Catherine's Bay (old and young) (in Jersey East) were reported to be in 'Reduced' condition (Table 17). However, La Coupe (young), Fliquet (old), and Karame (old and young) (in Jersey East) were in 'Good' condition. At Les Minquiers, the *Z. marina* bed was in 'Good' condition, whilst At Les Écréhous, two sites were 'Good' whilst one site was 'Reduced'.

Over the four locations in Jersey with defined young and old beds, the bed condition was similar relative to their coastal location and did not differ by bed age (Table 18; Figure 72). Overall, La Coupe and Karame were reported to be in 'Good' condition, whilst St Catherine and Gorey were in 'Reduced' condition.

Zostera marina in Guernsey's Cobo Bay and Belgrave Bay were 'Good', whilst at Grand Harve was classified as 'Reduced'. Throughout the rest of the Bailiwick of Guernsey, *Z. marina* at Lihou was 'Good', whilst at Sark and Herm was 'Poor'. In Alderney, *Z. marina* in Longis Bay was 'Poor', whilst Maggies Bay was 'Reduced'.

Zostera noltei beds across Jersey were generally in poor condition. Of the seven samples in St Aubin's (Jersey South), six were in 'Poor' condition whilst one was 'Reduced'. In Jersey East, both Anne Port and Grouville were considered 'Poor'. In Guernsey, Herm was also in 'Poor' condition.

Table 17 – Condition of seagrass beds around the Channel Islands. Results taken from Millan (2023, unpublished).

Seagrass	Island	Location	Condition proxy
Zostera marina	Alderney	Longis Bay	Poor
	Alderney	Maggies Bay	Reduced
	Ecrehous	Exrehous	Good
	Ecrehous	Ecrehous North	Good
	Ecrehous	Ecrehous South	Reduced
	Guernsey	Sark	Poor
	Guernsey	Grand Harve	Reduced
	Guernsey	Cobo Bay	Good
	Guernsey	Lihou	Good
	Guernsey	Belgrave	Good
	Guernsey	Herm	Poor
	Jersey East	Icho	Reduced
	Jersey East	Seymour Tower	Reduced
	Jersey East	Le Coup	Good
	Jersey East	Fliquet	Good
	Jersey East	Petit Port	Reduced
	Jersey East	Anne Port	Reduced
	Jersey East	St Catherine's (Old)	Reduced
	Jersey East	St Catherine's (Young)	Reduced
	Jersey East	Karame (Young)	Good
	Jersey East	Karame (Old)	Good
	Jersey South	St Aubins West Eliz (2)	Reduced
	Jersey South	Portelet	Reduced
	Minquiers	Minquiers	Good
Zostera noltii	Guernsey	Herm	Poor
	Jersey East	Anne Port	Poor
	Jersey East	Grouville	Poor
	Jersey South	St Aubins South Victoria Pool	Reduced
	Jersey South	St Aubins West Eliz/South Victoria Pool	Poor
	Jersey South	St Aubins West Eliz (1)	Poor
	Jersey South	St Aubins West	Poor
	Jersey South	St Aubins Mid Bay	Poor
	Jersey South	St Aubins Outfall West	Poor
	Jersey South	St Aubins Outfall East	Poor

The overall health of seagrass beds across the Channel Islands shows considerable variation depending on the location and species. While some areas, particularly in Jersey and Guernsey, maintain 'Good' conditions for *Zostera marina*, other locations, especially those containing *Zostera noltei*, appear to be struggling with 'Poor' or 'Reduced' conditions. This mixed picture indicates that seagrass health is influenced by localised factors, suggesting the need for targeted conservation efforts that address specific regional challenges to improve and maintain the health of these critical habitats. Continued monitoring and management are essential to prevent further degradation and to promote recovery where conditions are currently suboptimal.

Table 18 - Condition of old and young seagrass beds across the four Jersey grab sample locations. Taken from Millan (2023).

Location	Old	Young
Le Coup	Good	Good
St Catherine	Reduced	Reduced
Gorey	Reduced	Reduced
Karame	Good	Good

It is important to note that the 'Poor' condition as defined by the C:N ratios is not necessarily a negative sign for Jersey's seagrass. 'Poor' could indicate that seagrass is surviving despite adverse conditions. For example, seagrass in Jersey may be able to inhabit slightly deeper or lower-light waters due to the large tidal range, which permits greater access to light. However, 'Poor' does indicate that there is potential for improvement in the condition of seagrass. Definitions of health need to be localised, in order to best represent the condition of seagrass and measure changes in relation to local changes.

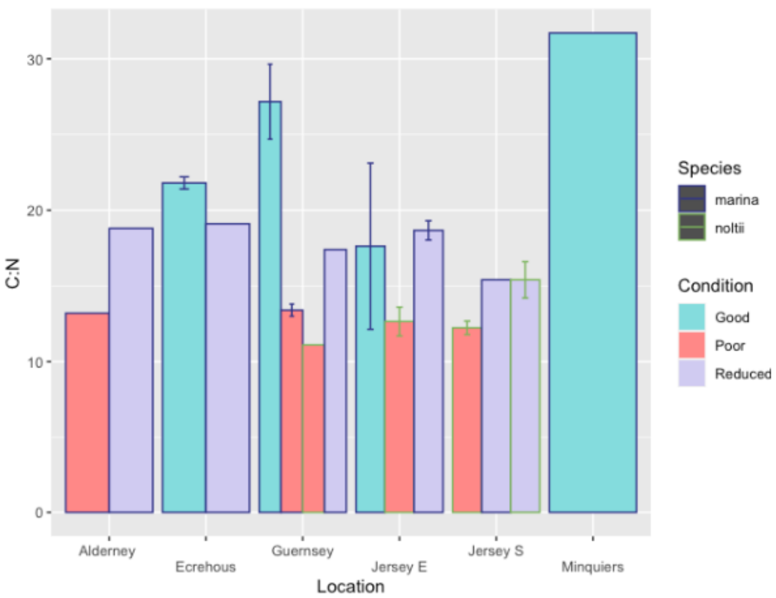


Figure 72 - Mean variability in carbon-to-nitrogen (C:N) levels in *Z. marina* (dark blue outline) and *Z. noltei* (green outline) in seagrass beds across the Channel Islands. Taken from Millan (2023).

6.3.1 TEMPORAL AND SPATIAL CHANGES IN CONDITION

Millan (2023) used seagrass biomass samples to calculate carbon-to-nitrogen (C:N) ratios. The same study on seagrass biochemistry was carried out in 2017 by the Société Jersiase Marine Biology Section and the Government of Jersey, who provided data for analysis and comparison with the 2023 results.

Overall, *Zostera marina* beds across the Channel Islands were in reduced condition in 2023 compared to 2017. A reduction in C:N in 2023 compared to 2017 can be seen in Les Écréhous, Guernsey, Jersey South, and Jersey East (Figure 73). However, in Les Minquiers and Alderney, C:N is higher in 2023. The location of *Z. marina* beds significantly impacted the C:N levels, with beds that Les Écréhous and Les Minquiers having significantly higher C:N ratios than Jersey East and Alderney across both 2017 and 2023. This was unexpected as seagrass extent has been expanding in this region over the same time period. The difference reported may be due to different laboratory methods used to obtain elemental measurements (due to the original laboratory from 2017 no longer offering this kind of analysis). While the 2017 to 2023 comparison is interesting, it is the difference in location that should be focussed on here.

The location of *Z. noltei* beds was significantly affected by their location, with Jersey East having significantly greater C:N than Jersey South (Figure 74). Contrastingly, no significant differences were reported between 2017 and 2023 for *Z. noltei*. However, *Z. noltei's* condition was reduced in 2023 for Guernsey and Jersey East compared to 2017, whilst Jersey South saw a slight improvement in condition.

In conclusion, this study highlights the significant spatial variability in seagrass conditions across the Channel Islands, with distinct differences observed between various locations. The decline in *Zostera marina* and *Zostera noltei* condition from 2017 to 2023 in most sites suggests potential environmental stressors or changes in light availability, underscoring the need for ongoing monitoring to verify the reported temporal variation. However, the observed spatial differences, particularly the higher C:N ratios in the offshore locations, Les Écréhous and Les Minquiers, indicate that local environmental factors may play a crucial role in seagrass health. The lack of significant temporal change in *Zostera noltei* suggests stability in certain areas, though monitoring spatial variability remains important.

These findings highlight the complexity of seagrass ecosystems and the importance of localised monitoring and management strategies to address the specific conditions and challenges faced by different areas within the Channel Islands. Continued research and consistent methodologies are essential for accurately tracking changes and informing effective conservation measures.

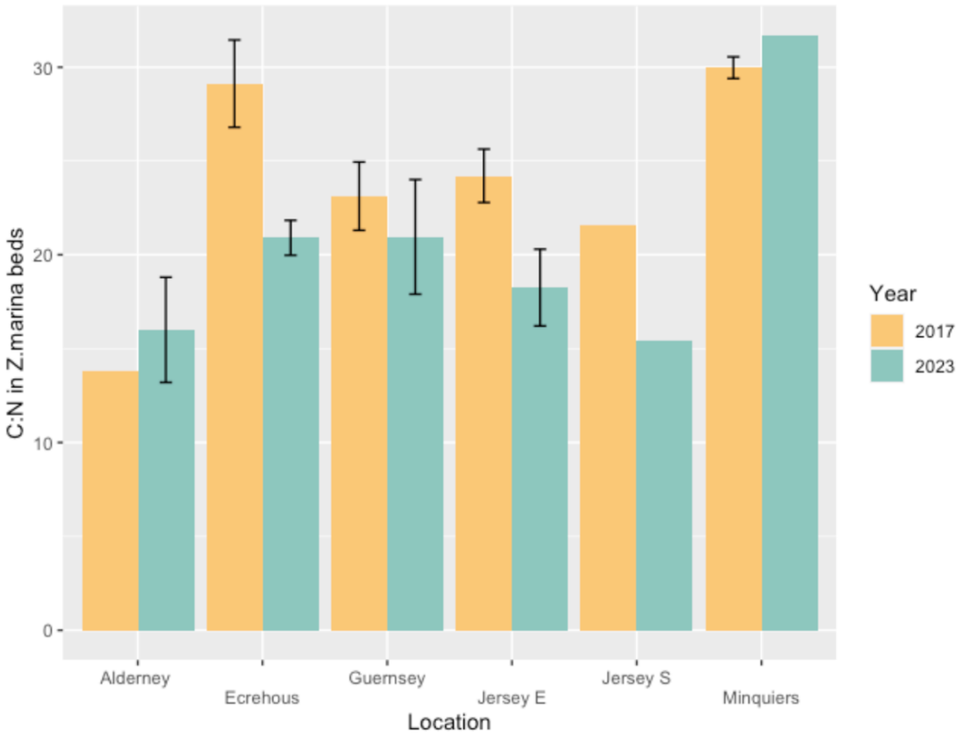


Figure 73 -Mean variability in C:N levels in Z. marina seagrass beds across the Channel Islands in 2017 and 2023. Taken from Millan (2023).

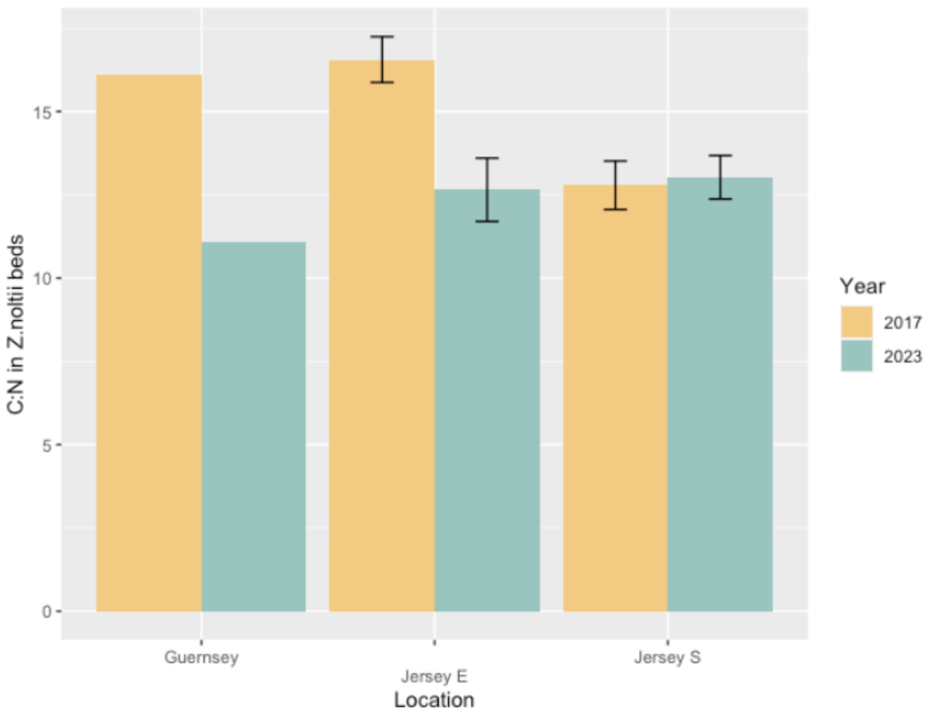


Figure 74 - Mean variability in C:N levels in *Z. noltei* seagrass beds across the Channel Islands in 2017 and 2023. Taken from Millan (2023).

7 CARBON

Seagrass beds play a significant role in carbon storage and are often referred to as blue carbon[xvii] habitats. Seagrass meadows are highly productive ecosystems. The plants photosynthesise and produce organic matter, some of which gets buried in the sediment. The dense root and rhizome network of seagrasses stabilises sediments and facilitates the trapping and accumulation of organic material. The organic carbon stored in seagrass sediments can remain buried for millennia, making it an effective long-term carbon sink.

Carbon is stored within seagrass via two mechanisms: seagrass living biomass (considered a short-term carbon sink) and the sediment underlying seagrass meadows (long-term carbon sink) (Fourqurean *et al.*, 2012). Living biomass carbon comes from the above-ground biomass (leaves and stems of seagrass) and the below-ground biomass (the roots and rhizomes). Seagrass absorbs carbon dioxide (CO_2) from the ocean and uses it during photosynthesis. During this process, carbon dioxide is converted into glucose and oxygen. The oxygen is released into the water as a byproduct whilst the glucose is utilised for growth. This process 'fixes' the carbon into the plant's structures, providing the necessary building blocks for growth. By calculating how much carbon is present in a sample of seagrass, an estimate of the total carbon stored within the living plants of a seagrass bed can be calculated. In seagrass, the roots and rhizomes often make up a large quantity of the biomass.

Secondly, sediment carbon comes from the organic carbon of decayed plant material as well as trapped organic matter from the water column deposited as sediment. The accumulation of organic-rich sediments contributes to blue carbon storage over extended periods. However, multiple factors can influence the carbon storage potential of seagrass beds. These factors include seagrass species, sediment type, environmental conditions and human impacts. As these factors vary considerably from place to place, it is important to consider their individual and combined effects on the carbon storage within seagrass meadows in each area.

Further, researching sediment characteristics within seagrass beds is crucial for understanding their carbon sequestration potential. Fine sediments, such as clay and silt, are particularly important due to their higher surface area, which allows them to trap and hold more organic matter and carbon. These sediments also provide greater stability, reducing the likelihood of erosion and disturbance, thus preserving carbon over longer periods. Assessing the organic carbon content and composition of

[xvii] A blue carbon habitat is a coastal or marine ecosystem, such as mangroves, seagrass meadows, or salt marshes, that captures and stores carbon from the atmosphere and ocean, playing a key role in carbon sequestration and climate regulation.

sediments helps determine the effectiveness and longevity of carbon storage in seagrass meadows, providing essential insights for climate change mitigation and conservation strategies.

7.1 INTERTIDAL

The carbon storage of Jersey's intertidal seagrass has only been addressed once throughout the literature. This research was completed in 2022, with data collected between September and October 2021 (Smith, 2022). Samples were taken at intertidal seagrass beds in St Aubin's Bay and Grouville Bay across transects covering the high, middle, and lower shore. At each sampling location, a 0.25 x 0.25m quadrat was placed. From within this quadrat, sediment was collected via a core and shoot/root biomass was manually extracted.

Assessment of the carbon content was conducted in a laboratory. Above and below-ground seagrass biomass was calculated (weighing before and after drying). Sediment carbon was estimated through loss on ignition (LOI). Sediment samples were dried, sieved, weighed and placed in a furnace at 550 °C for two hours. Samples were weighed post-heating to determine the amount of carbon lost. Another round of heating was then conducted to establish the presence of the carbonate minerals. These metrics (carbon and carbonate contents) were then used to calculate the LOI using an established formula. Further, grain size analyses were performed for each sediment sample. This involved measuring the laser diffraction of samples to classify sediment into three size categories: coarse sand, fine sand, and silt.

7.1.1 SEDIMENT CARBON

Overall, the mean organic sediment carbon was significantly higher in St Aubin's Bay than in Grouville Bay. Further, there was significantly more organic sediment carbon at St Aubin's Bay at each shore height compared to Grouville (Figure 75). No significant interaction was found between shore height and site overall. Further, no significant differences were found between carbon content across shore heights at each site.

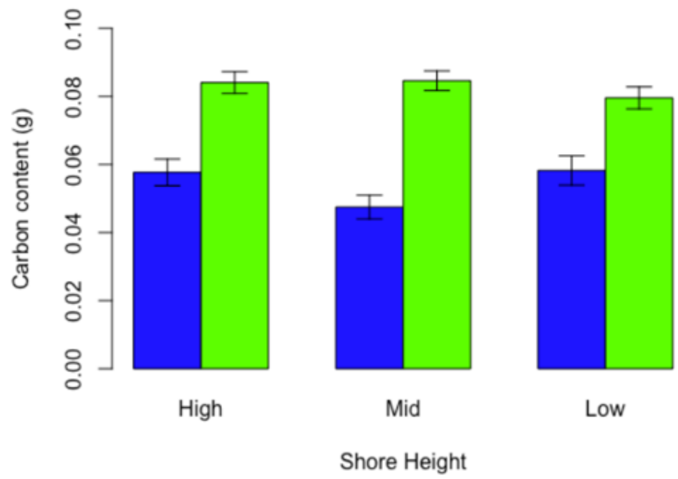


Figure 75 - Mean carbon content within the sediment at St Aubin's Bay (green) and Grouville Bay (blue) and high, mid, and low shore heights. Taken from Smith (2022).

St Aubin's Bay displayed a higher mean carbonate content within the sediment compared to Grouville. There were significant differences in the carbonate content between St Aubin's Bay and Grouville for each shore height, with St Aubin's Bay having significantly higher carbonate content (Figure 76). However, there was no significant interaction between carbonate content and shore height.

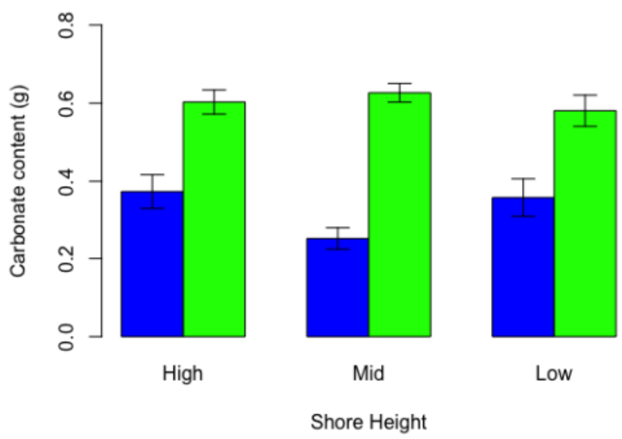


Figure 76 - Mean carbonate content within the sediment at St Aubin's Bay (green) and Grouville Bay (blue) and high, mid, and low shore heights. Taken from Smith (2022).

7.1.2 SEDIMENT CHARACTERISTICS

St Aubin's Bay was represented by fine sand, with a small amount of coarse sand and silt. Grouville Bay was predominantly fine sand with higher percentages of coarse sand and less silt. There was a significant difference in the particle grain size between St Aubin's Bay and Grouville at each shore height (Figure 77).

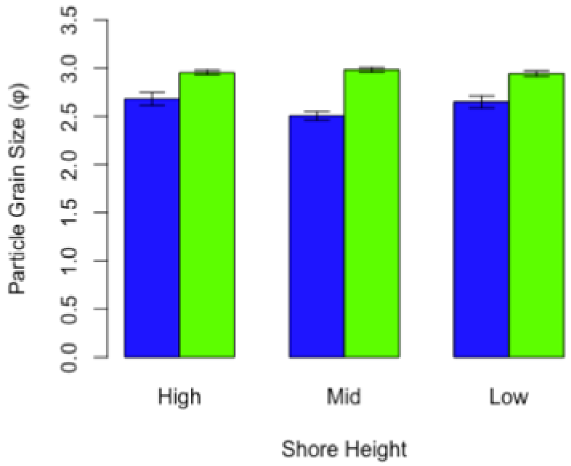


Figure 77 - Mean particle grain size of the sediment at St Aubin's Bay (green) and Grouville Bay (blue) and high, mid, and low shore heights. Taken from Smith (2022).

7.1.3 SEAGRASS BIOMASS CARBON

Grouville Bay displayed a higher mean above-ground biomass than St Aubin's Bay at all shore heights (Figure 78). No significant interaction was reported between above-ground biomass and shore height. However, there was a significant interaction between above-ground biomass and the site. There was a significant difference between St Aubin's Bay and Grouville Bay at the mid and low-shore heights (but not high), with Grouville having a significantly higher above-ground biomass overall.

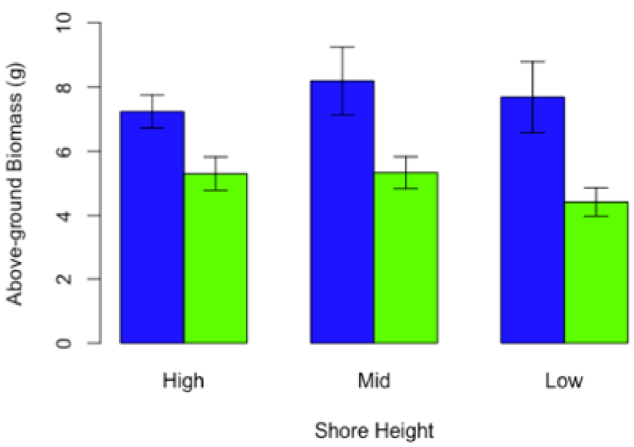


Figure 78 - Mean above-ground biomass (g) at St Aubin's Bay (green) and Grouville Bay (blue) and high, mid, and low shore heights. Taken from Smith (2022).

Similarly, Grouville Bay displayed a higher mean below-ground biomass than St Aubin's Bay (Figure 79). No significant interaction was reported between below-ground biomass and shore height at both St Aubin's and Grouville. However, there was a significant interaction between below-ground biomass and the site. This time, there was a significant difference between St Aubin's Bay and Grouville Bay at the high and mid-shore heights (but not low). Grouville had a significantly higher below-ground biomass than St Aubin's Bay.

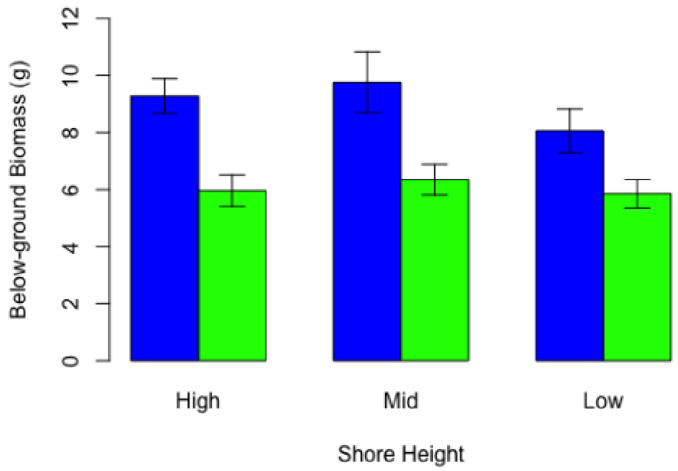


Figure 79 - Mean below-ground biomass (g) at St Aubin's Bay (green) and Grouville Bay (blue) and high, mid, and low shore heights. Taken from Smith (2022).

7.2 SUBTIDAL

The carbon storage of Jersey's subtidal seagrass bed has been a focus of study in recent years. The importance of blue carbon for Jersey was highlighted in 'Blue Carbon Resources: An Assessment of Jersey's Territorial Seas' (Chambers *et al.*, 2022). As a small island nation with significant coastal and offshore territory covering 2,455 km^2, blue carbon can play an important role in offsetting Jersey's annual CO_2 emissions of 0.4 megatonnes (estimated 2019 figures).

Student research projects in 2021 (Jordi, 2021), 2022 (Dow, 2022), and 2023 (Dow, 2023; Millan, 2023) have addressed the carbon storage of Jersey's subtidal seagrass meadows. These papers have addressed the impact of seagrass bed age, location, condition, sediment characteristics, and anthropogenic damage (mooring scars) on the blue carbon sequestered in Jersey's seagrass.

7.2.1 SEAGRASS BIOMASS CARBON

Jordi (2021) collected samples of above and below-ground seagrass plant tissues to determine the carbon stored with the seagrass biomass of four seagrass beds in Jersey (St Catherine's Bay, Gorey, Northeast, and Karame)(Figure 80)[xviii]. Sediment samples were collected using a large Van Veen grab (0.2 m^2) and included *Z. marina's* above-ground biomass (leaf blade and sheath) and below-ground biomass (rhizome and root). Above and below-ground biomass samples were separated for analysis. The plant biomass was determined by heating the above-ground biomass (leaf, sheath) and below-ground biomass (roots, rhizome) for 72 h at 60°C. The carbon within the seagrass biomass was measured by multiplying the dry weight (kg) of a sample for a given density (m^3) by a carbon conversion factor (0.34) (as per (Lima, Ward and Joyce, 2020; Howard *et al.*, 2014)).

In 2023, the same sites were revisited (St Catherine's Bay, Gorey, Northeast[xix], and Karame) and a total of 24 samples were taken across both young and old beds (Millan, 2023). Sediment samples were obtained using a Van Veen grab (0.2 m2), with three replicate grabs being taken at the old and young seagrass beds at each site. Samples were homogenised by bed during analysis, providing one data point per site.

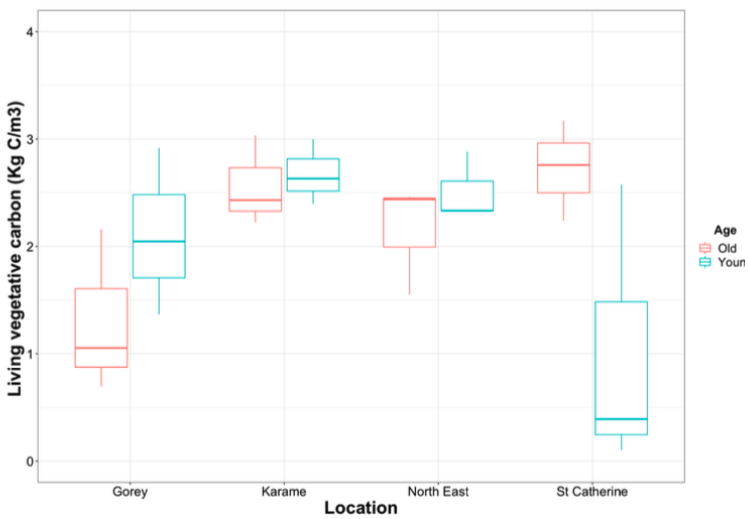


Figure 80 - Boxplot of mean living vegetative carbon (seagrass biomass carbon) in old (red) and young (blue) seagrass beds across the four Jersey sample locations in 2021. Taken from Jordi (2021).

[xviii] Seagrass biomass is referred to as "living vegetative carbon" in the 2021 study Jordi (2021), whilst it is referred to as "internal carbon" in the 2023 study Millan (2023)
[xix] Labelled as Le Coup in Millan (2023)

In 2023, older seagrass beds had significantly greater seagrass biomass carbon than younger beds in all locations (Figure 81) (Millan, 2023).

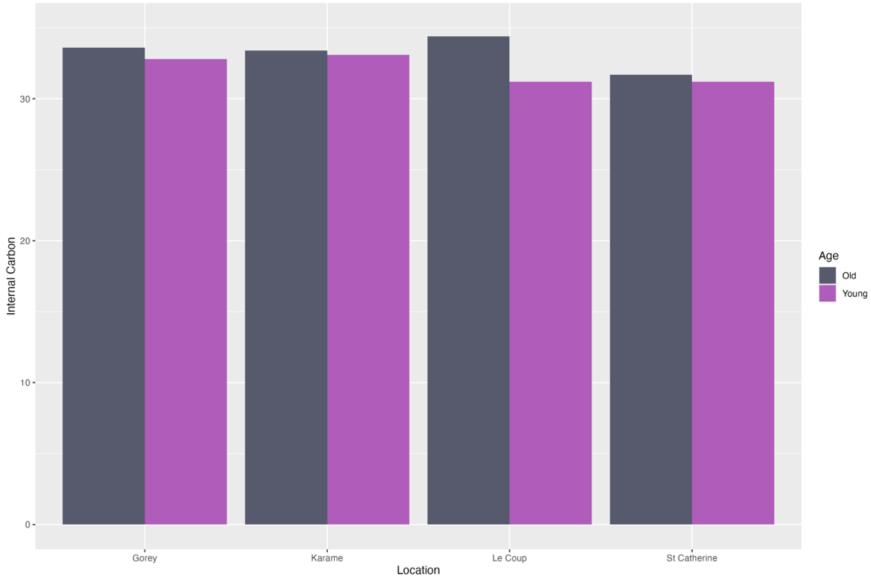


Figure 81 - Bar chart of the internal carbon content (seagrass biomass carbon) in old (grey) and young (purple) seagrass beds across the four Jersey sample locations in 2023. Taken from Millan (2023).

7.2.2 SEDIMENT CARBON

Seagrass meadows not only store carbon within their living biomass but also play a crucial role in capturing and storing carbon in the sediment beneath them. As seagrass absorbs carbon dioxide (CO_2) from the water for photosynthesis, it contributes to the formation of organic matter. When seagrass plants die or shed their leaves, this organic matter settles and accumulates in the sediment, along with the remains of other species associated with the seagrass (e.g. algae and infauna) and other sediment found within the water column. Additionally, the root and rhizome systems of seagrass stabilise the sediment, reducing erosion and promoting the burial of organic carbon. Over time, these sediments can sequester substantial amounts of carbon. By assessing the carbon content in the sediment layers within seagrass beds, the total carbon storage capacity of these ecosystems can be estimated.

Two recent studies have examined sediment carbon in subtidal seagrass beds across Jersey's south and east coasts (see locations in Figure 82) (Jordi, 2021; Millan, 2023). Researchers collected sediment samples using a $0.2m^2$ Van Veen grab from various locations: La Coupe, St Catherine’s Bay, Gorey, and Karame. The 2021 study collected 24 samples from young and old seagrass beds between June and July (Jordi, 2021). This methodology was replicated in June 2023 (Millan, 2023). Both studies used organic matter (OM) as a proxy for organic carbon content (C_{org}), with subsamples undergoing loss on ignition (LOI) at 550°C to determine C_{org} percentages. Calculations for sediment carbon stock (C_{stock}) were calculated from the dry bulk density and sediment organic carbon density [following methods adapted from (Howard *et al.*, 2014)].

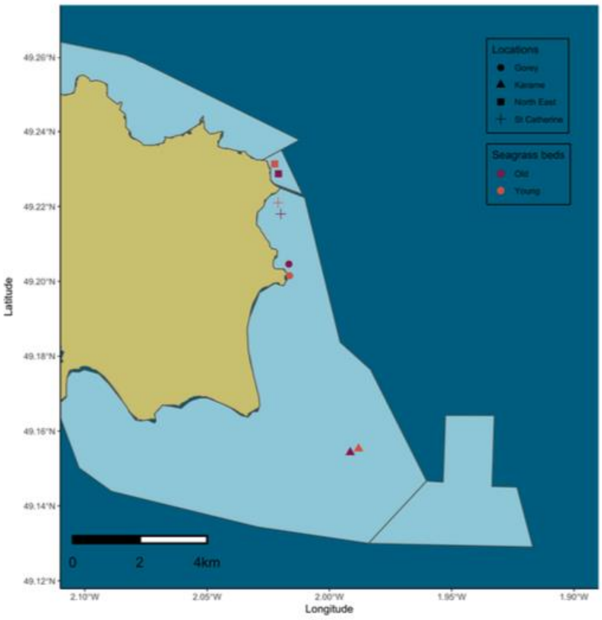


Figure 82 - Map of four study sites used by Jordi (2022) and Millan (2023). Red dots indicate old seagrass beds whilst orange dots indicate young seagrass beds. Taken from Jordi (2022).

DEFINITIONS:

ORGANIC MATTER (OM): Organic matter refers to the fraction of sediment composed of decomposed plant and animal materials. It includes a variety of organic compounds, such as decomposed leaves, roots, and microorganisms, which contribute to the sediment's carbon content.

Organic matter is crucial for nutrient cycling, soil structure, and as a habitat for microorganisms. In the context of sediment carbon studies, OM is often used as a proxy to estimate sediment organic carbon content (C_{org}).

LOSS ON IGNITION (LOI): A common method for measuring organic matter involves burning a known mass of dried sediment at a high temperature (e.g., 550°C) for a specified period (e.g., 6 hours). This process combusts the organic matter, leaving behind the inorganic mineral content. The difference in weight before and after ignition represents the organic matter content.

C_{ORG} (SEDIMENT ORGANIC CARBON CONTENT): C_{org} represents the organic carbon content within sediment samples. It quantifies the amount of organic carbon derived from decomposed plant and animal material present in the sediment. C_{org} is typically expressed as a percentage of the total sediment weight. It is often determined by measuring the loss of organic matter through combustion (e.g., Loss on Ignition, LOI) and then calculating the organic carbon content using established correlations.

C_{STOCK} (SEDIMENT CARBON STOCK): C_{stock} refers to the total amount of carbon stored in a specific volume or area of sediment. It is an estimate of the overall carbon storage capacity of a seagrass bed or other sedimentary environment. C_{stock} is calculated by combining the sediment organic carbon content (C_{org}) with the sediment's dry bulk density and the area of the sediment bed. It provides a comprehensive measure of the carbon storage potential in terms of mass per unit area, typically expressed in grams per square meter (g/m²) or megagrams per hectare (Mg/ha).

DRY BULK DENSITY: Dry bulk density is a measure of the mass of sediment per unit volume. It is typically measured by drying a known volume of sediment to remove all moisture and then weighing it. The dry bulk density is then calculated using an established formula, resulting in dry bulk density units of grams per cubic centimetre (g/cm³).

Sediment carbon storage was compared across subtidal seagrass beds of different ages and locations. In 2021, older beds in all locations had a higher mean C_{stock} than young beds (Jordi, 2021). Further, significant differences in C_{org} were reported, with older beds in St Catherine's, Karame, and Gorey having greater mean C_{org} than younger beds (Figure 83). In particular, St Catherine's older bed had significantly greater C_{org} than the younger bed. Northeast was the only site showing the opposite trend, where the younger seagrass bed had more C_{org}. Across locations, the C_{org} varied, with St Catherine's having significantly greater C_{org} than in Gorey and Karame. However, there was no significant variation between St Catherine's and the Northeast. Additionally, the C_{org} in Gorey was significantly less than in Karame and the Northeast.

In 2023, neither age nor location of seagrass beds were reported to have a significant effect on C_{org} or C_{stock} within the sediment (Millan, 2023). These findings differ from the 2021 results, where older seagrass beds demonstrated high sedimentary carbon stocks. Millan (2023) noted that it was likely that "the contradictory findings result from human error during the processing of sediment cores, causing a loss of organic matter" in the 2023 sample. This is further corroborated as the age of the seagrass bed significantly affected the carbon stored in the seagrass biomass in the 2023 study (Millan (2023) - see above).

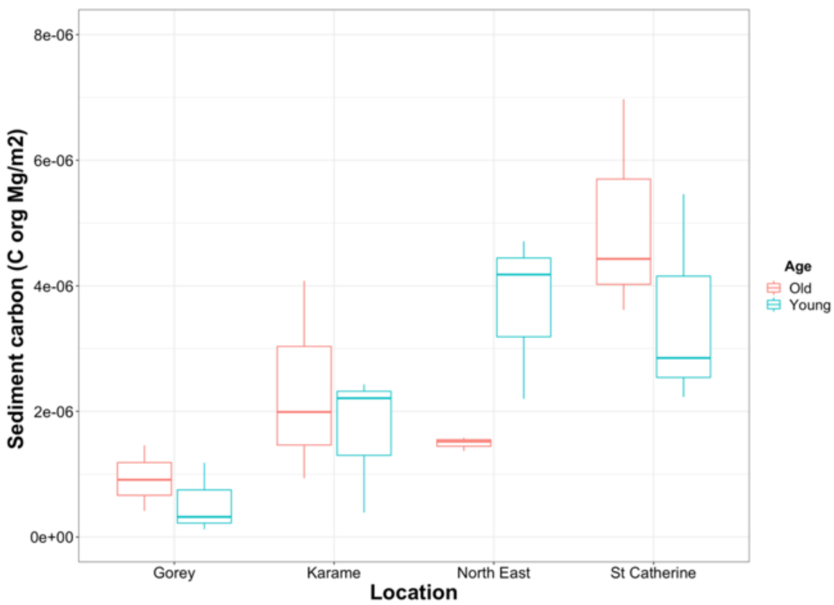


Figure 83 - Boxplot of mean sediment carbon in old (red) and young (blue) seagrass beds across the four Jersey sample locations in 2021. Taken from Jordi (2021).

Blampied (2022), used 0.2 m^2 Van Veen Grab to sample sediment across Jersey's MPAs. Within seagrass habitats, organic carbon content was greater in the Southeast MPA sediments compared to Les Minquiers (consistent with smaller sediment sizes in the Southeast) (Figure 84).

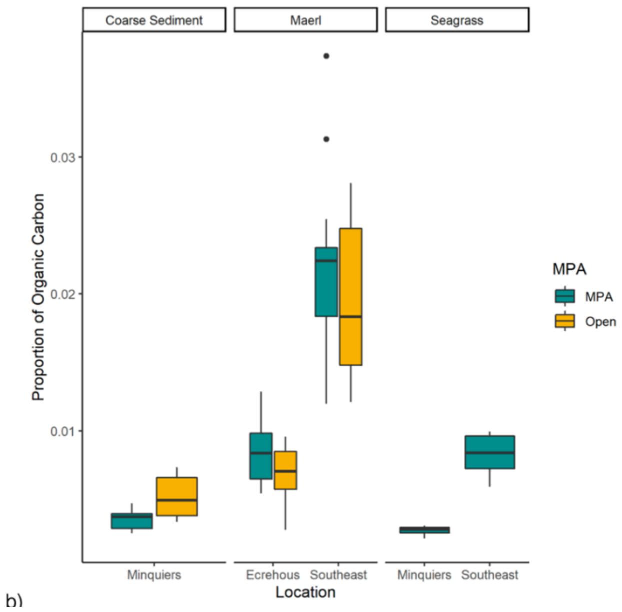


Figure 84 - Boxplot of the mean proportion of organic carbon within seagrass habitats at Les Minquiers MPA and Southeast MPAs. Taken from Blampied (2022)

7.2.3 MOORING SCARS

Dow (2023) studied the impact of block and chain mooring systems within the seagrass meadow at St Catherine's Bay. This mooring method creates visible 'scars' within the meadow as the chain's movements dislodge seagrass to leave bare patches of the seafloor. Investigating the differences in environmental characteristics inside and outside these scars' boundaries provides insights into the finer-scale changes occurring within Jersey's seagrass beds.

Sediment cores were taken from three sites within St Catherine's Bay, five located within the scar and five in the surrounding seagrass meadow (Figures 85 & 86) (Dow, 2023). Carbon content was analysed using the methods outlined in Howard *et al.* (2014) (as in Millan, 2023 and Jordi, 2021). The mean of the carbon content (g/cm^2) for each scar was used to calculate the total estimated carbon content (kg).

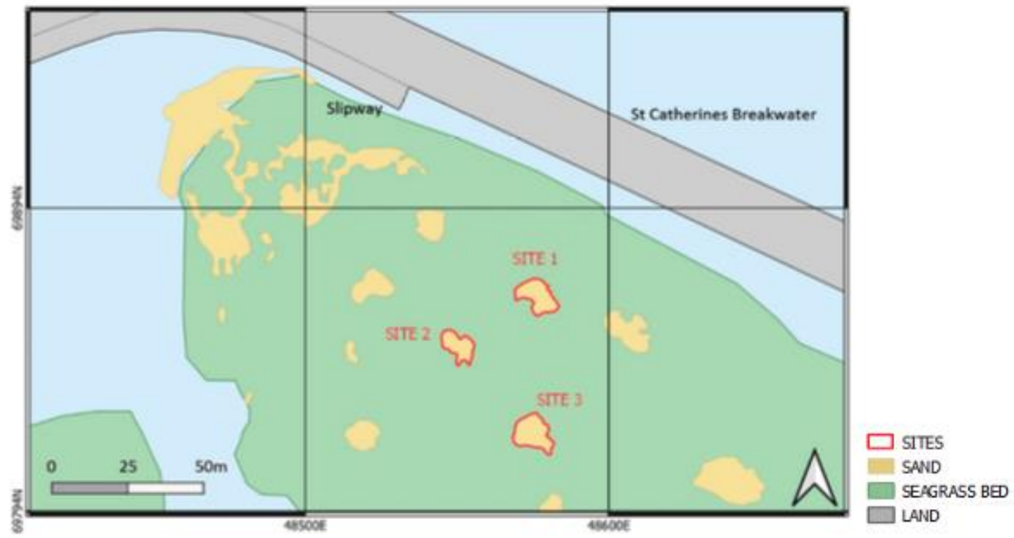


Figure 85 - Map indicating the locations of three survey sites within St Catherine's Bay. Taken from Dow (2023).

Across all three scars, sediment carbon content was higher outside the scar (within the seagrass meadow) than inside the mooring scar. Across all scars, the average sediment carbon inside the scar was 22.1 Mg C_{org}/ha whilst outside was 25.9 Mg C_{org}/ha (a difference of 3.8 Mg C_{org}/ha) (Table 19). No significant difference was found between the %C_{org} and %OM inside and outside the scars. Despite this, these results are consistent and suggest that sediment carbon is lower within mooring scars where seagrass has been lost.

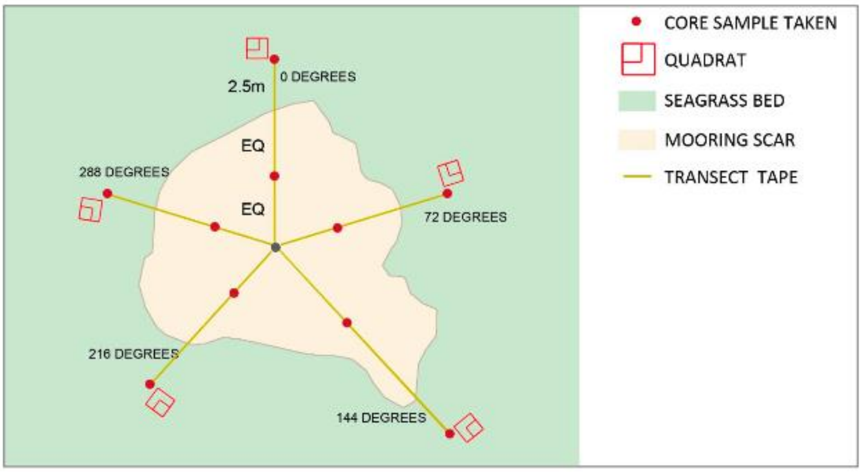


Figure 86 - Diagram representing the method used (transect positing, location of core samples and quadrat positions) to sample the three mooring scar sites within St Catherine's Bay. Taken from Dow (2023).

Within St Catherine's Bay, estimates suggest that mooring scars have caused a loss of an estimated 6000m^2 of seagrass (Chambers *et al.*, 2022). Further, it has been noted that the extent and locations of these scars change year on year (Dow, 2022). Using the 6000m^2 estimate, Dow (2023) approximated that the mooring scars in St Catherine's Bay account for a total loss of 2280kg of carbon (C_{org}).

Table 19 - Total carbon content per mooring scar site 1, 2, and 3 within St Catherine's Bay. Table taken from Dow (2023)

	SCAR AREA	INSIDE SCAR (Mg C_{org}/ha)	OUTSIDE SCAR (Mg C_{org}/ha)	DIFFERENCE (Mg C_{org}/ha)	TOTAL LOSS (Mg C_{org})
SITE 1	100m^2 (0.01ha)	26.5	29.9	3.4	0.034
SITE 2	74m^2 (0.0074ha)	19.9	24.6	4.7	0.03478
SITE 3	112m^2 (0.0112ha)	19.8	23.2	3.4	0.03808
SITE AVERAGE	95.33m^2 (0.0953ha)	22.1	25.9	3.8	0.036227
MEADOW TOTAL	6000m^2 (0.6ha)	-	-	-	2.28

7.2.4 SEDIMENT CHARACTERISTICS

Both Millan (2023) and Jordi (2021) analysed the particle size of sediments collected from *Z. marina* meadows. After sorting, sediment was categorised under three size classifications: sand, silt, and clay.

In 2021, particle size varied across all locations. Particle size did not vary between old and young beds in three of the four locations. However, in the Northeast, the older seagrass bed had fine sand, whilst the younger bed had medium/gravelly sand.

In 2023, particle size varied significantly across locations. In particular, the mean particle size at Karame was significantly larger than Gorey, La Coupe, and St Catherine's Bay. However, there was also significant variation in particle size between old and young beds. At three of the four sites (Gorey, La Coupe, and Karame), the younger beds had significantly greater mean particle size compared to older beds. Whilst at St Catherine's Bay, no significant difference in particle size was reported between old and young beds, with both beds having 'very fine sand'.

This is consistent with findings from Dow (2023), who measured sediment grain size inside and outside mooring scars at St Catherine's Bay. All three sites sampled within St Catherine's Bay were classified as 'very fine sand'. All samples were primarily made up of sand (80%), with small amounts of gravel and mud. One site displayed a difference in particle size between the inside and outside of the scar, with 'fine sand' within the scar boundaries and 'very fine sand' in the surrounding seagrass meadow. However, there was no statistical difference in the average particle size within scars compared to outside scars (Figure 87). When comparing sediments from seagrass habitats within Jersey's MPAs, Blampied (2022) reported that particle size differed between the two MPAs. The Southeast MPA seagrass sediment was characterised by muddy sediments, whilst Les Minquiers MPA contained more gravel (Figure 88).

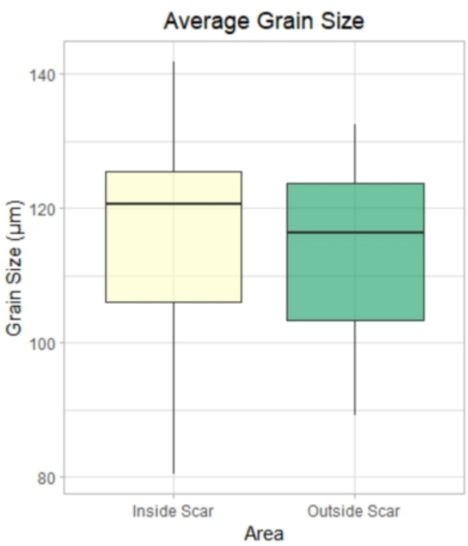


Figure 87 - Boxplot of average grain size inside (yellow) and outside (green) the mooring scars at St Catherine's Bay, 2023. Taken from Dow (2023).

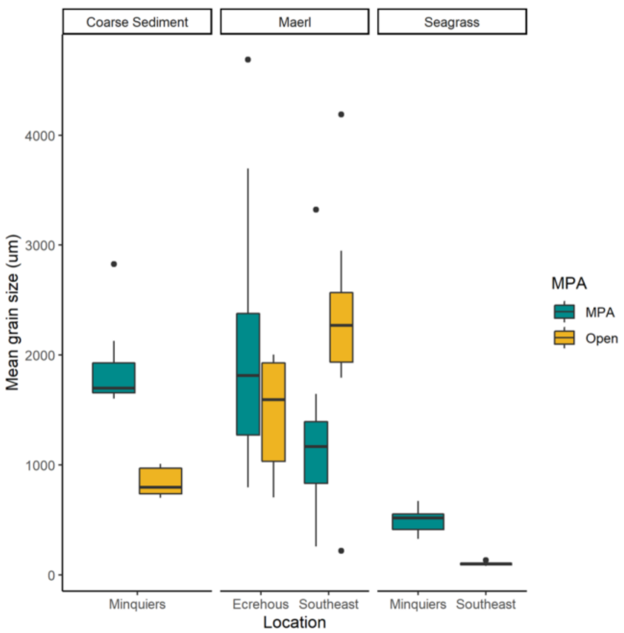


Figure 88 - Mean grain size in Les Minquiers MPA and Southeast MPA. Taken from Blampied (2022).

8 MANAGEMENT AND CONSERVATION

8.1 ST CATHERINE'S HARBOUR MANAGEMENT

St Catherine's Bay, a significant harbour on Jersey's east coast, is protected by the man-made St Catherine's Breakwater, which has inadvertently encouraged the growth of one of the island's largest seagrass habitats. This area, comprising *Zostera noltei* and *Zostera marina* species, is vital to the Jersey's marine ecosystem. The Ports of Jersey (PoJ) are responsible for overseeing all of Jersey's harbours and their associated ecosystems, including St Catherine's Bay.

As of 2024, the harbour accommodates approximately 60 moorings. Traditionally, these moorings have been swing moorings using a block and chain system. They are situated both inshore, where they become exposed at low tide, and in deeper waters. Typically, boat users install moorings under the guidance of PoJ, which also provides public visitor moorings. However, St Catherine's Bay is much more than just a mooring site; it is a vibrant community space used for activities such as swimming, snorkelling, dinghy sailing, and kayaking.

In 2021, Jersey Marine Conservation raised concerns about the degradation of the seagrass beds at St Catherine's Bay, primarily due to the impact of boat moorings. These seagrass beds are essential for supporting biodiversity, serving as a nursery habitat, and acting as a significant blue carbon resource. The degradation is evident from aerial photographs, which show scars in the seagrass bed caused by disturbance to the seabed. These scars, areas of sandy sediment, are created as mooring chains move along the seafloor, preventing seagrass from taking root and disrupting the bed's continuity. In 2021, the average scar size was reported to be approximately 100 m^2, with the largest scar reaching 350 m^2. This suggests that some moorings are up to twice as long as recommended, causing more damage than necessary.

Historically, some moorings have been deployed without proper authorisation from the Harbour Authority, and guidelines on mooring installations, such as chain length, have not always been strictly followed. This practice has contributed to the current state of the seagrass beds.

In response to the concerns raised by Jersey Marine Conservation, a working group was established by PoJ on the 21st December 2021. The group includes representatives from PoJ, Jersey Marine Conservation, the Blue Marine Foundation, Marine Resources (Government of Jersey), and St Catherine's Users. To generate the required environmental data to inform decision-making, the group's primary aims were to:

1. Determine the coverage and boundaries of the seagrass beds.
2. Identify protected species inhabiting the site.
3. Map the extent of seagrass beds in relation to mooring locations.
4. Monitor seagrass recovery in areas where unused moorings have been cleared.
5. Assess the ecosystem service value of seagrass in Jersey.

A key aspect of the group's work involved consulting with boat users to identify which moorings were in use and which were unclaimed, documenting them accordingly. The group also invested significant resources into researching and trialling various environmentally friendly mooring solutions that would be compatible with Jersey's unique tidal range. Additionally, raising awareness about the biodiversity supported by St. Catherine's Bay was prioritised to foster a broader understanding and appreciation of the bay's ecological importance.

8.1.1 ENVIRONMENTALLY FRIENDLY MOORING BUOYS (EFMB)

To meet the complex environmental and safety requirements for boat moorings, PoJ worked with Blue Parameters in Guernsey, who are agents for Seaflex and specialists in advanced sustainable mooring systems, to design a swing mooring system specific to Jersey and it's tidal range. A French designed mooring, Temano, already commission on the Brittany coast were also trialled. These moorings are designed to create minimal disturbance to the seafloor using a bungee and dynema rope system. Following the trials, one Seaflex mooring and two Temano moorings were deployed in 2023. In July 2024, a further three Temano buoys were deployed as visitor moorings and were immediately popular. In 2025, an additional six Seaflex moorings are scheduled for deployment.

8.1.2 TRADITIONAL MOORINGS AND ANCHORING

The management plan for St Catherine's extends beyond the installation of EFMBs to include enhanced management of existing moorings. EFMBs are significantly more expensive than traditional moorings and require specific inspections and maintenance. While the hope is that more EFMBs can be deployed sustainably, it is crucial to recognise the positive impact that can be achieved through proactive management and monitoring of existing moorings.

This is intended to be achieved in three ways:

1. REDUCING THE OVERALL NUMBER OF MOORINGS

The working group aims to reduce the number of moorings in St Catherine’s Bay. Mooring owners have been required to declare the use of their mooring to the Harbour Authority. Any unclaimed moorings will then be removed.

2. STRICTER REGULATION ON TRADITIONAL MOORING SPECIFICATIONS

Within St Catherine’s Bay, a maximum chain length for traditional moorings is required to minimise unnecessary disturbance to the seabed. The Harbour Authority aims to enforce stricter regulations on the length of chains and ropes on moorings to reduce their impact whilst maintaining their role in the harbour.

3. NO-ANCHORING ZONES

Further to traditional mooring buoys, anchoring causes disturbance to the seagrass habitats at St Catherine’s Bay. No-anchoring zones already exist within the bay due to underwater pipelines and cabling, and to ensure continued access to areas, including the slipway. An extension of existing zones or new no-anchoring zones could be designated for the preservation of seagrass. This will require a consultation period followed by designation and enforcement by the Harbour Authority.

8.1.3 INFORMATION SHARING

PoJ has commissioned a report compiling research on sustainable harbour management and environmentally friendly moorings. This report will share lessons learned from the implementation of EFMBs at St Catherine’s Bay. The information will be relevant to other harbours and anchorages in Jersey, the other Channel Islands, Northern France, and areas that face similar challenges posed by significant tides.

In the wider Channel Islands, there have been efforts by the Alderney Wildlife Trust and partners to incorporate seagrass areas onto navigation apps such as SavvyNavvy. This will help improve the visibility of seagrass beds to boat owners.

8.2 JERSEY MARINE SPATIAL PLAN

The marine environment makes up 96% of Jersey's territorial area. The Marine Resources team has been developing Jersey’s first Marine Spatial Plan (MSP), which the States of Jersey recently approved during a States Debate on 23rd October 2024. The plan aims to understand how people value and interact with Jersey's marine environment, seeking a balance between the different uses. There are a number of priorities and actions in the plan which, when enacted, will aim to ensure Jersey's marine environment is better managed for future generations.

8.2.1 SEAGRASS HABITAT MANAGEMENT AREAS

The main seagrass bed areas on the Southeast Coast of Jersey have been included under 'Seagrass Habitat Management Areas' in Jersey's first Marine Spatial Plan (MSP) (Figure 89). This includes the seagrass bed in St Catherine's Bay, as well as Archirondel and Anne Port, the Royal Bay of Grouville, Southeast reefs and St Aubin's Bay (Government of Jersey, 2023b). Currently, seagrass beds in the offshore reefs are not included within the Seagrass Habitat Management Areas.

Priority areas for seagrass management include (but are not limited to) the reduction of degradation from boat moorings (e.g., by installing seagrass-friendly moorings) and mitigating negative impacts of pollution and coastal development on seagrass health. Additionally, addressing knowledge gaps would help to inform future management plans. These gaps include understanding the impact of climate change on Jersey's seagrass, learning more about the food webs associated with and supported by Jersey's seagrass beds, and discerning the genetic composition of Jersey's seagrass to better understand its resilience and growth patterns (see more in the Discussion).

Once enacted, the MSP will provide direction to the Marine Resources team and other relevant departments and organisations to develop a comprehensive management plan for these seagrass areas.

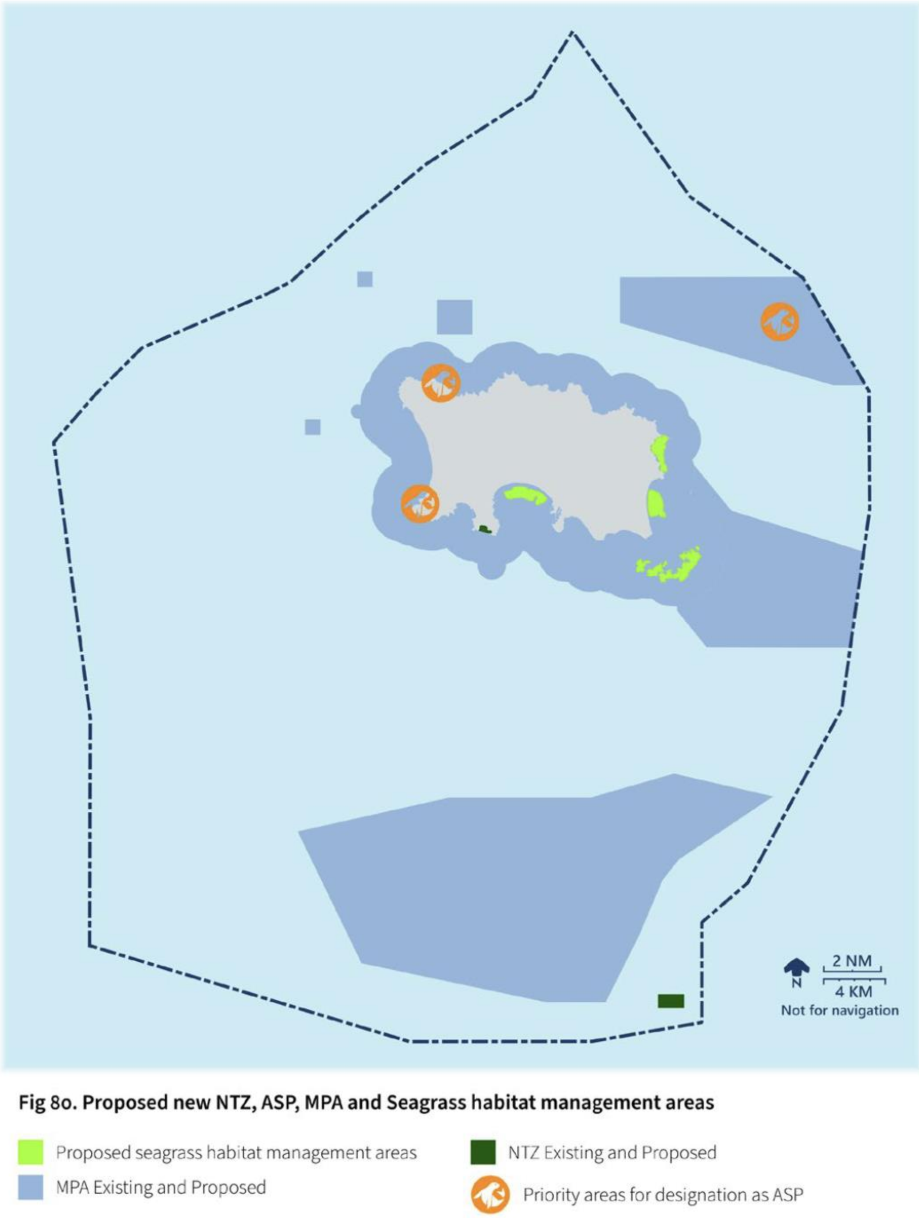


Figure 89 – Proposed seagrass habitat management areas (in green) in the Jersey Marine Spatial Plan (MSP) draft proposal. Taken from Government of Jersey (2023b).

8.2.2 INFORMING SEAGRASS MANAGEMENT PRACTICES

While the MSP doesn't detail specific management strategies for these seagrass areas, it is hoped that the information in this report will guide future management to "promote the protection and regeneration of seagrass" in Jersey. A critical focus for the Seagrass Habitat Management Areas is the ongoing and expanded monitoring of seagrass beds. Well-informed management decisions depend on accurate and current data. Importantly, monitoring should extend beyond high-pressure areas (such as St Aubin's Bay) to include locations where seagrass is currently healthier. This will enable early identification of rising pressures and declines in health and extent, while also providing a comparison for worse affected beds.

Research reviewed in this report (see sections 6.2.5 *Damage to Seagrass Beds* and 7.2.3 *Mooring Scars*) supports the implementation of seagrass-friendly moorings to preserve and enhance ecosystem services within Jersey's seagrass beds, such as biodiversity support, nursery habitat provision, and carbon sequestration.

8.2.3 ADDRESSING CHALLENGES AT ST AUBIN'S BAY

St Aubin's Bay has long been identified as the most impacted seagrass area due to anthropogenic waste entering the bay. This report acknowledges that addressing the impacts in this area requires a holistic, cross-departmental management approach. Such a strategy would need to address broader marine ecosystem health, including seagrass habitats, and cannot be resolved through seagrass management alone. Priority IT3 in the MSP calls for continued monitoring of seawater quality and that appropriate actions should be triggered if water quality falls. While this priority is not specific to seagrass, it should inform the seagrass habitat management areas.

8.2.4 SUPPORTING SEAGRASS EXPANSION

Across Jersey's seagrass habitats, an expansion in area has been recorded. Given this natural regeneration, transplantation of seagrass is not currently necessary in Jersey. Activities within the designated Seagrass Habitat Management Areas should support the continued growth of seagrass and encourage its spread into a "buffer zone" surrounding the current beds. For example, activities that have the potential to damage seagrass (e.g., driving cars or horse riding) should be prohibited not only within the current area of seagrass extent but also the area surrounding the meadow where possible, to promote undisturbed natural expansion. In this way, the Seagrass Habitat Management Areas recommended in the JMSP should follow a more 'whole site' approach to conservation (Solandt *et al.*, 2020). This would require an adaptive management plan that evolves with the seagrass meadows as they shift and expand.

8.3 REGIONAL COLLABORATION AND KNOWLEDGE SHARING

Collaboration with neighbouring islands (Guernsey, Alderney, and Chausey) and nearby coastal regions (Brittany and the UK) should be encouraged in future management and research. Information and resource sharing can benefit all parties involved and contribute to protecting the wider seascape. Furthermore, efforts should be made to stay informed on current research and best practices for seagrass monitoring, management, and conservation by reviewing recent literature and engaging with other experts in seagrass research.

9 DISCUSSION

This discussion is split across the four main review topics (distribution and extent, biodiversity, health and condition, and carbon). For each topic, a short summary is followed by a list of knowledge gaps (identified from the above review), action points for future research, and conclusions.

9.1 EXPLORING THE DISTRIBUTION AND EXTENT OF SEAGRASS IN JERSEY

Seagrass meadows are an integral part of Jersey's marine ecosystems, primarily distributed along the south, east, and parts of the north coasts. Extensive intertidal seagrass beds are found in St Aubin's Bay and Grouville Bay, with substantial subtidal meadows in St Catherine's Bay and along the Southeast coast. Additionally, offshore reefs, Les Minquiers and Les Écréhous, host seagrass beds, though the extent of these offshore meadows is less thoroughly documented compared to the coastal areas.

Historical records from the 19th century indicate the long-term presence of seagrass in several areas, including St Aubin's Bay, the Southeast coast, and Les Minquiers. This suggests that seagrass meadows have been a long-standing feature of Jersey's marine environment. However, these records also hint at potential changes in distribution, especially in Les Minquiers, where seagrass presence may have diminished over time. Although historical data offer valuable insights, comprehensive information before the 20th century is limited, making it difficult to assess the full scale of historical distribution shifts.

Efforts to map and monitor seagrass have been ongoing, with key surveys conducted in 1997 and 2022. Jackson (2003) used multiple survey techniques to generate the most extensive map of subtidal seagrass, *Z. marina*, in Jersey. The current report utilised aerial photos to track the extent of seagrass over time, revealing areas of stable, declining and increasing seagrass coverage. These mapping efforts have contributed significantly to understanding the current distribution of seagrass in Jersey's waters.

Despite these advancements, there are still gaps in geographic coverage and methodological consistency. For instance, much of the focus has been on coastal zones, while deeper subtidal and offshore areas remain less studied. These remote regions could harbour significant seagrass beds, which are likely less impacted by human activity, but their full extent is unknown. Moreover, current mapping techniques vary widely, which can lead to inconsistencies in data collection and analysis, making it difficult to compare findings across different studies.

9.1.1 KNOWLEDGE GAPS

While significant progress has been made in mapping and understanding seagrass distribution, several key gaps remain in Jersey's seagrass research:

- UNDER-SURVEYED SUBTIDAL AND OFFSHORE AREAS: The extent of seagrass meadows in deeper subtidal zones and offshore reefs, such as Les Minquiers and Les Écréhous, remains largely unknown. These areas may support substantial seagrass beds, which are crucial for conservation planning but are difficult to access and study.

- HISTORICAL DISTRIBUTION: Historical data on the long-term trends in seagrass distribution is limited, especially before the 20th century. A clearer historical baseline, especially prior to 1930, would help assess the degree of seagrass loss or recovery over time and provide insights into the impact of human activities and natural changes.

- FRAGMENTATION AND ISOLATED PATCHES: Small, isolated seagrass patches are often overlooked in mapping efforts. Their role in overall ecosystem health, biodiversity, and recovery of larger meadows is not fully understood. Furthermore, the full extent and impacts of meadow fragmentation on ecosystem connectivity and resilience remain unclear.

- IMPACT OF HUMAN ACTIVITIES: Certain human activities, such as anchoring and dredging, are known to affect seagrass health. However, the full range of human activities potentially harming seagrass health is understudied, and the different impact zones are relatively unknown. Further, there is insufficient data on how these activities may influence the broader distribution of seagrass meadows around Jersey. Understanding these impacts is crucial for developing protective zoning measures and spatial planning to mitigate further damage.

- INCONSISTENT MAPPING TECHNIQUES: Current seagrass mapping techniques vary in accuracy and consistency. Manual mapping, diver surveys, and aerial imagery are the main methods used, but these often fail to capture the full extent of seagrass, particularly in remote or deeper areas. A lack of standardisation in mapping methods, spatially and temporally, also hinders the ability to accurately track changes over time or between studies.

- POTENTIAL FOR FUTURE DISTRIBUTION CHANGES: There is no modelling on how climate change and other environmental pressures could affect seagrass distribution in Jersey. Rising sea levels, changing water temperatures, and increased human activities could all impact the future distribution of seagrass. Investigating this effect could highlight areas for increased conservation efforts.

- RESTORATION POTENTIAL: There has been no focused research on identifying areas with the potential for seagrass restoration or natural establishment, particularly in regions where meadows have declined. Natural regeneration is currently considered the best conservation strategy. This may require increased management actions to promote natural processes to take hold. Further, if more hands-on restoration efforts were required in the future, identifying suitable restoration sites would be key to expanding seagrass coverage.

The current understanding of seagrass distribution in Jersey provides a solid foundation, particularly in well-studied coastal areas. However, significant gaps remain in our knowledge of deeper and more remote areas, as well as the long-term trends in distribution. Improving our understanding of the factors influencing seagrass distribution, from natural barriers to human impacts, will be crucial for future conservation efforts. Expanding research into under-surveyed areas, standardising mapping techniques, and developing predictive models will be essential to better protect and manage these valuable ecosystems in the face of environmental change.

9.1.2 FUTURE RESEARCH SUGGESTIONS

To build on the current knowledge of seagrass distribution and address the existing gaps, several key areas for future research and monitoring have been identified:

1. EXPANDED MAPPING OF UNDER-SURVEYED AREAS: There is a need for focused surveys of deeper subtidal zones, offshore meadows, and isolated patches, particularly in regions like Les Minquiers and Les Écréhous. These areas are less accessible but may contain important, stable seagrass meadows that play a critical role in biodiversity and ecosystem health.

2. HISTORICAL DISTRIBUTION STUDIES: Further research into historical records, sediment cores, and other archival materials could help establish a clearer baseline for past seagrass distribution. This would allow for a more comprehensive understanding of long-term trends and provide insights into natural changes versus human-induced impacts.

3. IMPACT OF HUMAN ACTIVITIES AND FRAGMENTATION OF SEAGRASS DISTRIBUTION: While the effect of certain human activities on seagrass health is documented, there is a need for more detailed research into how activities such as anchoring, dredging, and mooring specifically influence the spatial distribution, fragmentation, ecosystem connectivity, resilience, and genetic diversity of Jersey's seagrass habitats. Understanding how fragmented meadows affect species movement and the long-term sustainability of seagrass habitats will inform conservation strategies and potential restoration efforts. This research would be essential for developing effective spatial planning and protective zoning measures.

4. MODELLING POTENTIAL DISTRIBUTION: The use of habitat suitability modelling and the development of predictive models to project how changes in climate (such as rising sea levels and changing water temperatures) and coastal development could impact seagrass distribution would be beneficial. These models could help identify areas vulnerable and to habitat loss as well as areas that may be suitable for future conservation and restoration efforts.

5. STANDARDISING AND IMPROVING MAPPING TECHNIQUES: To improve the accuracy and consistency of seagrass data, future efforts should focus on refining and standardising mapping methodologies. This could include the use of advanced technologies such as:

    - HIGH-RESOLUTION SATELLITE IMAGERY for large-scale monitoring.
    - AI AND MACHINE LEARNING to automate seagrass identification from aerial or underwater images.
    - COLOUR ANALYSIS to differentiate seagrass from other marine vegetation in aerial photos.
    - ROVS (REMOTELY OPERATED VEHICLES) or underwater drones for ground-truthing and collecting accurate data in deeper waters.
    - YEAR-ROUND IMAGERY collection to account for seasonal variations in seagrass distribution and health.

6. POTENTIAL FOR SEAGRASS RESTORATION AREAS: Investigating areas with the potential for restoration or reestablishment of seagrass meadows could be key to expanding seagrass habitats in Jersey. While natural regeneration is currently favoured, exploring hands-on restoration methods in regions where meadows have declined may be necessary in the future

if expansion stops. Identifying suitable restoration sites (for example via habitat suitability modelling) will help maximise the ecosystem services provided by seagrass, such as carbon sequestration and biodiversity support.

By addressing these research gaps, Jersey can develop a more comprehensive understanding of its seagrass ecosystems, enabling more effective conservation and management strategies to ensure the sustainability of these vital habitats in the face of future challenges.

9.2 BIODIVERSITY IN JERSEY'S SEAGRASS HABITATS

Jersey's seagrass meadows are recognised as vital biodiversity hotspots, supporting a diverse array of marine species, including fish, invertebrates, and microorganisms. They serve as crucial nursery habitats for juvenile species, particularly those of commercial significance to local fisheries. These meadows also provide essential trophic linkages within the wider marine ecosystem, acting as feeding grounds for larger fish species and birds. The biodiversity within these habitats plays a key role in ecosystem services such as nutrient cycling, carbon sequestration, and sustaining healthy fish populations. However, invasive species, like the slipper limpet (*Crepidula fornicata*), have been recorded in Jersey's seagrass meadows, though the extent of their impact on local biodiversity is not yet fully understood.

Figure 90 - Nudibranch (*Polycera* spp.) nudibranch on seagrass. Credit: Shannon Moran/ Ocean Image Bank

9.2.1 KNOWLEDGE GAPS

- COMPREHENSIVE SPECIES INVENTORIES: There is currently no exhaustive inventory of the species inhabiting Jersey's seagrass meadows, particularly for smaller invertebrates and microorganisms. Surveys tend to focus on commercially or ecologically significant species, leaving many species undocumented. Further, species data from much of the most recent research has not been assimilated into a comprehensive dataset. This could be facilitated by the Jersey Biodiversity Centre. However, adaptations to the current database need to be made.

- GENETIC DIVERSITY: The genetic diversity of seagrass in Jersey is poorly understood. Insights into genetic diversity could help assess the resilience of seagrass to disease, environmental stressors, and climate change. Understanding how the genetic make-up of Jersey's seagrass influences its growth and regeneration and how it affects responses to environmental factors would help inform future management, conservation, and potential restoration strategies. One study has been undertaken (currently unpublished) investigating the genetics of Jersey's seagrass in relation to other beds around the UK. However, no study has focussed solely on the diversity within Jersey or the wider Channel Islands, or how genetics influence seagrass success in Jersey.

- IMPACT OF INVASIVE SPECIES: The effects of invasive species, such as the slipper limpet and red seaweed species, on seagrass biodiversity are not well-studied. It is unclear whether these species are affecting native species or ecosystem functions within Jersey's seagrass beds.

- TROPHIC NETWORKS: Limited research exists on the broader trophic linkages within Jersey's seagrass meadows. The role of these ecosystems in supporting marine predators, including migratory species, needs further exploration.

- TEMPORAL VARIABILITY: There is little information on how biodiversity within seagrass meadows changes over time, including seasonal shifts or long-term trends resulting from human activities or climate change.

- FUNCTIONAL ROLES OF LESS-STUDIED SPECIES: The ecological functions of smaller, less-studied species in Jersey's seagrass remain unclear. Understanding their roles could reveal new insights into nutrient cycling and sediment stability.

Jersey's seagrass meadows are critical for maintaining marine biodiversity and supporting key ecosystem services. However, there are notable gaps in our understanding of species diversity, genetic resilience, the impacts of invasive species, and trophic dynamics. Filling these knowledge gaps is crucial for ensuring the long-term sustainability and resilience of these vital habitats.

9.2.2 FUTURE RESEARCH SUGGESTIONS

To build on the current knowledge of the biodiversity found within Jersey's seagrass beds and address the existing gaps, several key areas for future research and monitoring have been identified:

1. COMPREHENSIVE BIODIVERSITY SURVEYS: Employ modern techniques like eDNA analysis, light traps, acoustic monitoring, and BRUVs or underwater drones (potentially with AI-based recognition analysis) to document all species within Jersey's seagrass meadows, including those that are harder to detect.

2. MAP THE STRUCTURE AND COMPLEXITY OF SEAGRASS MEADOWS: Apply photogrammetry techniques or 3D mapping to obtain detailed information about the physical structure of the meadows. This provides a spatial representation of habitat complexity, which is essential for understanding the conditions that support biodiversity, how different species utilise the habitat, and for monitoring long-term changes in specie-habitat associations.

3. LONG-TERM MONITORING: Establish programs to track changes in species composition over time, particularly in response to environmental stressors, invasive species, and climate change.

4. TROPHIC INTERACTION STUDIES: Investigate food web dynamics within seagrass meadows to better understand their role in supporting economically valuable species, marine predators and the wider ecosystems.

5. EXAMINE THE GENETIC DIVERSITY OF JERSEY'S SEAGRASS: Assess the genetic diversity of seagrass populations around Jersey (and the wider Channel Islands) to identify potential genetic hotspots. Further, examine which genetic traits are associated with ecological

resilience, investigate how genetic diversity influences physiological responses to environmental factors, and what effect genetic diversity has on growth and regeneration. UNCOVERING GENETIC TRAITS THAT PROMOTE SEAGRASS EXPANSION OR AREAS OF HIGH GENETIC DIVERSITY MAY INFORM FUTURE RESTORATION EFFORTS. SUCH AREAS COULD ACT AS A 'RESERVOIR' OF GENETIC VARIATION FROM WHICH GENETICALLY 'SUPERIOR' SEAGRASS PLANTS CAN BE CULTIVATED FOR TRANSPLANTATION IN OTHER AREAS.

9.3 EVALUATING THE HEALTH AND CONDITION OF JERSEY'S SEAGRASS

Seagrass meadows in Jersey exhibit varying health between intertidal and subtidal zones. Intertidal meadows, such as those found in St Aubin's Bay, are more prone to stress due to pollution, while subtidal beds, though more stable, are vulnerable to physical disturbances such as mooring activities. Water quality plays a crucial role in seagrass health, with meadows in areas of higher water quality, like the Southeast coast, being in presumed better condition. However, nutrient loading, particularly from agricultural runoff and wastewater outlets, contributes to eutrophication and algal blooms, which threaten seagrass. Research tends to focus on areas with poorer water quality, such as St Aubin's Bay, while relatively healthier areas, like Grouville, are understudied, potentially overlooking changes in these regions.

Physical disturbances, including boat moorings and anchoring, are significant threats to the health of seagrass meadows. For example, in St Catherine's Bay, areas have been mapped where anchoring has caused damage, leading to mooring scars. Other critical threats include the presence of pollutants in coastal waters, especially in St Aubin's Bay. Despite the spatial expansion of seagrass meadows in Jersey, Millan (2023) classified most meadows as being in a "reduced" condition, suggesting that area expansion is not necessarily a sign of improved health. Research also shows that seagrass health fluctuates over time due to environmental pressures such as nutrient levels and physical damage.

9.3.1 KNOWLEDGE GAPS

- DEFINITION OF A HEALTHY SEAGRASS MEADOW: There is a lack of consensus on what specifically constitutes a "healthy" seagrass meadow in Jersey. Although factors such as shoot density, biomass, and species diversity are used to assess health, it remains unclear which combination of these factors most accurately reflects long-term meadow health.

- LONG-TERM DATA ON SEAGRASS HEALTH: Long-term data on the biomass, density, and overall condition of Jersey's seagrass meadows is limited, particularly beyond St Aubin's Bay. This gap limits the understanding of how meadows respond to pressures like pollution and climate change.

- LINKING WATER QUALITY TO SEAGRASS HEALTH: The direct relationship between water quality parameters (e.g., nutrient levels, pollutants, and sediment composition) and seagrass health is not fully understood in Jersey. Research in this area has targeted solely St Aubin's Bay due to the wastewater outlet. However, runoff from agricultural practices or coastal developments may be impacting seagrass beds around the coast. Further, comparisons could be drawn regarding the water quality at the offshore reefs.

- CLIMATE CHANGE IMPACTS ON RESILIENCE: The effects of climate change on the resilience of Jersey's seagrass meadows remain unexplored, particularly in relation to rising sea temperatures, ocean acidification, and increased storm activity.

- RECOVERY RATES AND MECHANISMS OF REPRODUCTION AND MEADOW FORMATION: There is limited understanding of the natural recovery potential of Jersey's seagrass meadows following disturbances and the processes through which seagrass spreads. The mechanisms that contribute to seagrass reproduction and meadow formation in Jersey are not well understood. In particular, the conditions that promote natural recolonisation and expansion are unknown.

- LOCALISED IMPACT OF HUMAN ACTIVITIES: Knowledge of the localised impacts of human activities on seagrass is limited. Attention has been brought to the impacts of moorings in St Catherine's Bay. However, other activities such as such as anchoring, dredging, and coastal development on seagrass health in Jersey have not been assessed.

- ROLE OF MICROBIAL COMMUNITIES, DISEASES AND PATHOGENS: There is no detailed research on diseases or pathogens that may affect seagrass in Jersey, such as wasting disease. Further, the role of microbial communities, such as nitrogen-fixing bacteria, in supporting seagrass health in Jersey is under-researched.

- MULTIPLE STRESSOR INTERACTIONS: Research has not addressed how multiple stressors—including pollution, climate change, and human activities—interact to impact seagrass health in Jersey.

- IMPACT OF MACROALGAE OVERGROWTH AND INVASIVE SPECIES: There is a lack of clarity on the impact of macroalgae overgrowth on seagrass meadows, particularly in areas where eutrophication is a concern. Further, the potential impact of invasive species is unclear.

Jersey's seagrass meadows are vulnerable to a variety of environmental pressures, particularly those related to water quality degradation and physical disturbances caused by human activities. These factors may have a significant impact on the resilience and recovery of seagrass meadows. Consequently, the effective management of these pressures is critical for their conservation. Local environmental conditions are key determinants of seagrass health. Protecting these conditions by managing pollution and minimising physical disturbances will be essential to maintaining healthy meadows.

9.3.2 FUTURE RESEARCH SUGGESTIONS

To build on the current knowledge of seagrass health and condition and address the existing gaps, several key areas for future research and monitoring have been identified:

1. LONG-TERM HEALTH MONITORING: Continue and broaden efforts to track changes in biomass, density, and overall condition over time, with a focus on expanding beyond St Aubin's Bay into other intertidal areas and, crucially, subtidal beds.

2. HUMAN ACTIVITY IMPACT STUDIES: Conduct detailed research on the localised effects of activities such as anchoring and coastal development to guide better management practices.

3. MECHANISMS OF REPRODUCTION AND SPREAD: Investigating the conditions that promote seagrass reproduction, meadow expansion, and recolonisation, along with methods to enhance natural restoration.

4. CLIMATE CHANGE EFFECTS: Assessing the impacts of climate-related factors (and their cumulative effects), such as temperature rise, ocean acidification, and storm activity, on seagrass resilience in Jersey.

5. WATER QUALITY IMPACTS: Conduct further research into how specific water quality parameters, such as nutrient levels and pollutants, affect seagrass health to better target conservation efforts to improve seagrass health. These parameters could be further assessed in relation to agricultural practices and coastal development.

Further investigating the health and condition of Jersey's seagrass will promote the safeguarding of its meadows from further degradation and ensure their resilience against environmental pressures. With improved management of local conditions and mitigation of threats, these vital ecosystems will be better positioned to thrive, supporting biodiversity and maintaining their crucial ecological functions.

9.4 CARBON CONTRIBUTIONS OF JERSEY'S SEAGRASS

Seagrass meadows in Jersey play a vital role in carbon sequestration, capturing and storing carbon both in their biomass and in the sediments they stabilise. This makes them significant contributors to Jersey's climate change mitigation efforts. This makes them significant contributors to Jersey's climate change mitigation efforts, as carbon trapped in seagrass sediments can remain stored for centuries or millennia, preventing its release back into the atmosphere. Given Jersey's extensive territorial waters, the carbon storage potential of these meadows is particularly valuable.

However, this stored carbon is vulnerable to disturbances. Activities such as mooring or dredging can disrupt the sediment and release stored carbon, reducing the overall carbon sequestration potential. This highlights the importance of managing human activities around these ecosystems to preserve their role as carbon sinks.

Enhancing carbon sequestration in Jersey's seagrass meadows could be achieved through natural expansion or restoration projects. Improved management to support natural regeneration and potentially future restoration initiatives could increase their carbon storage capacity. Such efforts align with both local and global climate action goals by restoring degraded meadows and improving carbon capture efficiency.

9.4.1 KNOWLEDGE GAPS

- LIMITED LOCAL DATA ON CARBON STOCKS: Although measurements of carbon storage (both in seagrass biomass and sediment) have been carried out in Jersey, these recent studies only provide a starting point. Quantifying the total carbon stored in Jersey's seagrass beds is required to understand their contribution to Jersey's blue carbon strategies. Long-term monitoring is essential to track carbon storage changes over time and gain reliable measurements.

- SEAGRASS GROWTH RATES AND CARBON TURNOVER: The rate of seagrass growth and associated carbon sequestration in Jersey's waters is not well understood. Seagrass growth varies with environmental conditions, affecting its efficiency in capturing carbon. Detailed studies on growth rates and seasonal variability could provide valuable insights into how these meadows cycle carbon over time.

- SEDIMENT CARBON DYNAMICS AND CARBON BURIAL RATES: The stability of sediment carbon in Jersey's seagrass meadows is still under-researched. Both natural disturbances (e.g., storms) and human-induced activities (e.g., mooring and coastal development) may release stored carbon from the sediment. The rate at which seagrass meadows bury carbon in Jersey remains unknown. Research on burial rates is important for determining the long-term sequestration potential and the role that these meadows can play in achieving carbon targets.

- IMPACT OF ENVIRONMENTAL STRESSORS: The influence of environmental changes, such as rising water temperatures, ocean acidification, and nutrient loading, on the carbon sequestration efficiency of Jersey's seagrass is not well known. These stressors may affect seagrass health and, in turn, its capacity to capture and store carbon.

- SEAGRASS HEALTH AND CARBON SEQUESTRATION: The relationship between seagrass health and carbon sequestration is underexplored. Identifying which health indicators (such as shoot density or root depth) are most closely tied to carbon capture could help guide conservation priorities.

- ROLE OF BIODIVERSITY IN CARBON CYCLING: There is limited knowledge about how biodiversity within Jersey's seagrass meadows influences carbon cycling. Certain species, such as burrowing organisms, may affect sediment stability or carbon burial rates and, consequently, carbon storage.

- LONG-TERM CARBON SEQUESTRATION POTENTIAL UNDER CLIMATE CHANGE: Predicting how Jersey's seagrass meadows will fare in the face of climate change, including sea-level rise and increasing storm intensity, is essential. The long-term ability of these meadows to remain carbon sinks under changing environmental conditions remains unknown.

Seagrass meadows in Jersey are an important natural ally in mitigating climate change due to their ability to store carbon in both plant biomass and sediment. However, their capacity to sequester carbon is vulnerable to physical disturbances and environmental stressors. Protecting these meadows should be prioritised as part of climate action plans. Furthermore, more localised studies are needed to fully understand the potential of Jersey's seagrass meadows to serve as long-term carbon sinks and to develop informed management strategies.

9.4.2 FUTURE RESEARCH SUGGESTIONS

To address the identified knowledge gaps and enhance conservation efforts, future research should focus on the following areas:

1. QUANTIFY CARBON STORAGE: Detailed studies are needed to measure the total carbon storage capacity of Jersey's seagrass meadows, focusing on both biomass and sediment. Long-term monitoring should be implemented to track changes over time. Further, the storage of carbon within Jersey's MPAs could be quantified.

2. STUDY ENVIRONMENTAL STRESSORS: Research on how local environmental changes—such as temperature increases, nutrient loading, and ocean acidification—affect seagrass productivity and carbon sequestration is essential for predicting future resilience and ensuring the correct management for healthy seagrass beds today.

3. LINK SEAGRASS HEALTH AND BIODIVERSITY TO CARBON STORAGE EFFICIENCY: Investigate which indicators of seagrass health are most closely tied to carbon storage efficiency to inform management and restoration strategies.

4. ASSESS SEDIMENT STABILITY: Studies on sediment carbon dynamics, particularly in response to human activities (bottom trawling and coastal development) and natural events (storms), are critical for protecting stored carbon and preventing its release into the atmosphere. How these disturbances influence the release or retention of carbon stored in Jersey's seagrass beds remains under-researched.

5. EXPLORE BIODIVERSITY'S ROLE IN CARBON CYCLING: Investigate how biodiversity, particularly burrowing organisms and species interactions within the meadows, influences carbon storage and sediment stability. Understanding this relationship could inform better management strategies for maximising the carbon sequestration potential of these ecosystems.

6. EXPLORE LONG-TERM RESILIENCE: Predictive modelling of seagrass meadows under different climate scenarios to help evaluate their long-term role in carbon sequestration and to anticipate potential shifts from carbon sinks to sources.

This research will contribute to both local conservation efforts and global climate goals, ensuring that Jersey's seagrass meadows continue to provide vital ecosystem services, including carbon sequestration.

10 CONCLUSION

The findings of this report highlight the critical ecological, environmental, and economic importance of Jersey's seagrass meadows. These habitats are not only essential for supporting marine biodiversity and providing ecosystem services, but they also play a vital role in mitigating climate change through carbon sequestration. However, Jersey's seagrass meadows remain vulnerable to a range of pressures, including habitat degradation and pollution. Strengthening conservation efforts, improving water quality, and conducting further research on their resilience and carbon storage potential are crucial steps to ensure their protection. As the custodian of these valuable ecosystems, Jersey must continue to prioritise seagrass conservation within broader marine management strategies, safeguarding these habitats for future generations while supporting global biodiversity and climate goals.

Figure 91 - Catshark sheltering in seagrass meadow. Credit: Shannon Moran/ Ocean Image Bank.

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