Survey and monitoring of seagrass beds, Studland Bay, Dorset

Second seagrass monitoring report

(reporting on data collected between October 2009 and October 2011)

A report by Seastar Survey Ltd. for The Crown Estate and Natural England

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SEASTAR SURVEY

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SUMMARY

Survey and monitoring of seagrass beds, Studland Bay, Dorset

Background

Seastar Survey Ltd. was in 2009 contracted by The Crown Estate and Natural England to investigate the long term potential impact of anchoring on the seagrass habitat at Studland Bay. The study has been overseen by a project steering group comprising of the Dorset Wildlife Trust, Natural England, the Royal Yachting Association and The Crown Estate. The study was to be run over two years, with the potential to extend monitoring to a third year, in order to assess whether the seagrass is exhibiting decline due to the potential effect of anchoring associated with recreational boat activity.

The null hypothesis for the study: “no differences in seagrass health between the voluntary no anchor zone (VNAZ) and the control zone (CTZ) in Studland Bay”.

Main Findings

The Studland Bay seagrass monitoring study only started in earnest in October 2009 following the installation of the VNAZ marker buoys. Since then, baseline diver survey data and five sets of monitoring data have been collected. A large amount of qualitative and quantitative data has been collected and analysed since then. The main findings are:

- The baseline dive survey data and the seagrass mapping survey data collected in October 2009 showed the *Zostera marina* seagrass cover to be fairly continuous (60-70 % cover) across the two zones.

- The data collected between April 2010 and October 2011 suggest higher numbers and larger-sized bare sediment patches present in the CTZ compared to the VNAZ, particularly in the western and north-western sections of the CTZ.

- In October 2011 the seabed in the VNAZ was smooth and homogenous whilst the seabed in the CTZ was noticeably different being uneven and undulating.

- The seagrass was shown to produce seeds in 2009 and 2011 but whether seed germination was successful remains unknown (not in the scope of the original study).

- The range of characterising species was typical for Studland Bay, based upon earlier surveys.

- The statistical analyses showed that the variations in seagrass frond length and seagrass percentage cover appear to follow a seasonal pattern.

- There were significant differences in shoot density between and within the VNAZ and the CTZ but not consistently from 2009 to 2011.

- Although the statistical results do not show a consistent significant difference between the VNAZ and the CTZ there is a trend of increasing differences in shoot density between the two zones, suggesting a need for continued monitoring of the seagrass shoot density in the VNAZ and CTZ at Studland Bay.

- Observance of the Voluntary No Anchor Zone increased from 2010 to 2011.

- Overall anchoring in the VNAZ was lower in 2011 compared to 2010 both in terms of actual events but also as a proportion between the VNAZ and the CTZ.

- Currently, based on the quantitative data collected over two years, there is no consistent evidence of differences in seagrass health between the VNAZ and CTZ - the null hypothesis can therefore not be rejected.

There is therefore no consistent evidence of boat anchoring impacting the seagrass habitat at Studland Bay. However, the trends in the data (see figures 3.4 and 3.5) suggest an increased difference in seagrass health between the VNAZ and the CTZ, and therefore a need for a continuation of seagrass health monitoring at Studland Bay.

There are a number of recommendations as part of the study with the main one being that based on the trends in the data collected to date, the dive survey work should continue for another year at least, to further establish the natural variability in the bay, allow the current data trends to develop, take advantage of increased observance of the VNAZ and allow more detailed assessments of the potential effects of anchoring at Studland Bay.

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1 INTRODUCTION

Seastar Survey Ltd. was in 2009 contracted by The Crown Estate and Natural England to investigate the long term potential impact of anchoring on the seagrass habitat at Studland Bay. The study has been overseen by a project steering group comprising of the Dorset Wildlife Trust, Natural England, the Royal Yachting Association and The Crown Estate. The initial element of the study was to establish the positions of a voluntary no anchor zone (VNAZ) and an equivalent control zone (CTZ) to allow monitoring of the seagrass habitats within these areas. The study was to be run over two years, with the potential to extend monitoring to a third year, in order to assess whether the seagrass is exhibiting decline due to the potential effect of anchoring associated with recreational boat activity.

1.1 Original objectives for the study

1. To establish a marked Voluntary No Anchor Zone (VNAZ) and equivalent Control Zone (CTZ);
2. Conduct scientific dive surveys over two years to collect seagrass density and health data;
3. Assess whether the seagrass bed is exhibiting long-term decline due to the damage caused by anchoring boats.

The study has now been running for just over two years with six seagrass monitoring surveys completed between October 2009 and October 2011. This document aims to describe the methodologies used and report on the results of the study to date.

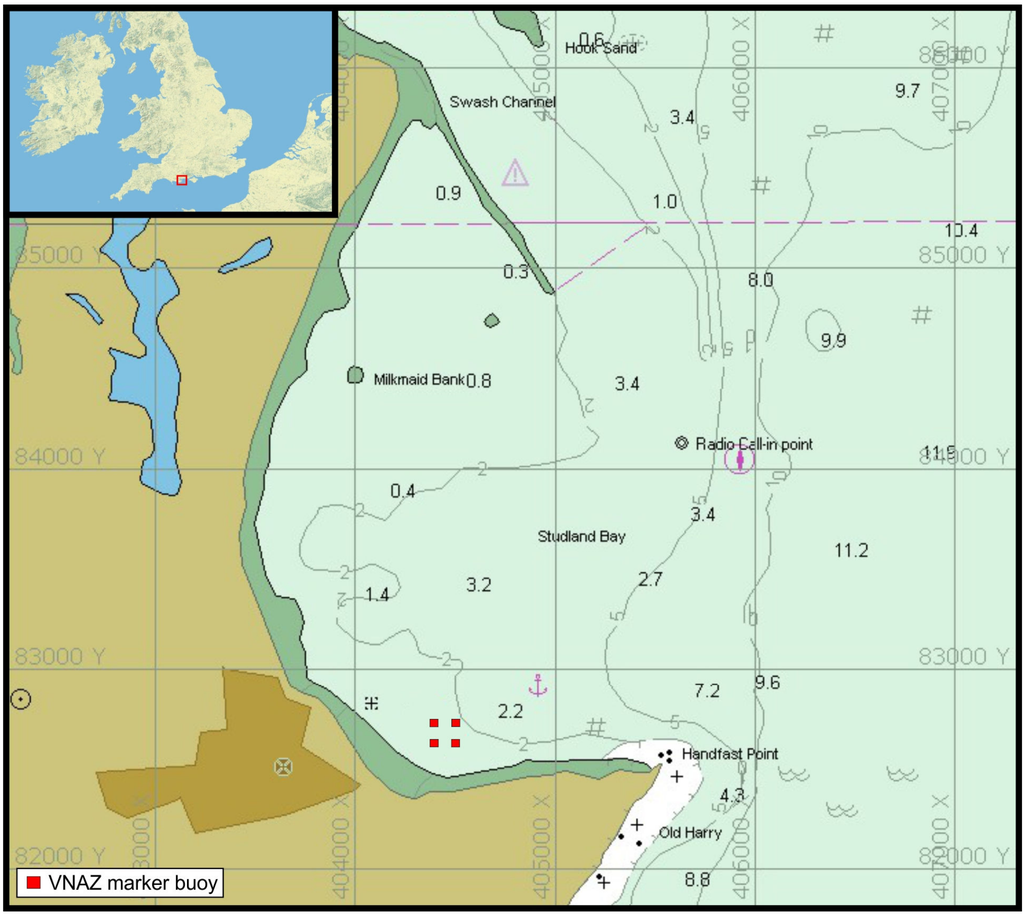
1.2 Hypothesis

To investigate the potential long term impact of boat anchoring on the seagrass habitat in Studland Bay a number of seagrass health parameters (including shoot density, average blade length and seagrass cover) have been measured and sampled over the last two years. The null hypothesis for the study is that “there are no differences in seagrass health between the VNAZ and the CTZ in Studland Bay” (seagrass health defined below) and that anchoring associated with boat activity therefore has no adverse effects on the seagrass habitat.

1.3 Study location

Studland Bay is a shallow bay located in Dorset on the south coast of England (figure 1.1). The bay is bounded by Handfast Point that separates Studland Bay from Swanage Bay to the south and sand dunes and the Swash channel that marks the entrance into Poole Harbour in the north. Studland Bay is protected from the prevailing south-westerly waves by the chalk headland known as Old Harry Rocks at Handfast Point. The bay is fringed by a sandy beach approximately three miles in length. At its deepest, the bay is marked at 3.8 m below chart datum (BCD). On admiralty charts the seabed within the bay is characterised by fine sand and fine sand with weed. The seagrass beds within Studland Bay are dominated by *Zostera marina* with a substantial seagrass bed found in the south-west corner of the bay.

Figure 1.1. Studland Bay and the VNAZ marker buoys.



1.4 A broad overview of the literature relating to the study

Seagrass habitats have been studied extensively around the world with numerous publications as a result. This section is not an exhaustive literature review but aims to give a broad overview of seagrass habitats (focusing on seagrass habitats in the UK), give examples of some potential threats to these habitats and give some contextual information to the seagrass habitat at Studland Bay.

1.4.1 Seagrass and seagrass beds in the UK

Seagrasses are marine flowering plants found in shallow coastal areas around the world, typically on sheltered sandy or muddy substrata to a maximum depth of approximately 10 m (Davison and Hughes, 1998). Seagrasses often grow in dense, extensive beds or meadows, creating a productive and diverse habitat that provides shelter and food for a wide variety of other plant and animal species. In addition, the meadows provide food for wildfowl and for the juveniles of some commercially important fish species, and also act to stabilise the underlying substratum, thus reducing coastal erosion (Tubbs and Tubbs, 1983; Davison and Hughes, 1998).

Zostera marina has a wide but patchy distribution in the south west of England, the Solent and Isle of Wight on the south coast, Wales, western Ireland, western and eastern Scotland including Orkney and the Shetland Islands. Historically, extensive beds of *Zostera* spp. were found throughout the Solent, including in the Lymington River and Southampton Water and in the harbours of Portsmouth, Langstone and Chichester. The extensive beds in the

Lymington River and Southampton Water have disappeared; those in Langstone and Chichester Harbours continue to exist but at decreased extents. Other significant populations occur at Beaulieu and Calshot off Hampshire, Totland and Yarmouth on the north west coast of the Isle of Wight and large beds extending down the north east coast of the Isle of Wight from Cowes to Bembridge (Chesworth *et al.*, 2008).

In Dorset seagrass has been recorded in Poole Harbour, Studland (Poole Bay) and Weymouth Bay (RPS, 2006; Davison and Hughes 1998; Royal Haskoning, 2004). Seagrass has also been recorded off Swanage and Durlston (Black and Kochanowska, 2004). Further west seagrass beds are also found in Lyme Bay, Torbay, south Devon and in Cornwall at sites such as the Helford River and Mounts Bay as well as Isles of Scilly (Davison and Hughes 1998; Sharrock, 2008).

1.4.2 Seagrass (Zostera marina)

Globally there are approximately 60 species of seagrass, with four occurring in the UK. Two species of eelgrass of the genus *Zostera* occur in the UK; *Z. marina* and *Z. noltii* (Davison and Hughes, 1998; Appeltans *et al.*, 2012). These two species of *Zostera* differ slightly in their typical depth, substratum and salinity preferences. The seagrass found in Studland Bay is *Zostera marina*. The remaining sections of the report will therefore focus primarily on *Z. marina* unless stated otherwise.

1.4.3 Zostera marina growth, reproduction and potential recovery

Growth in *Z. marina* is seasonal and closely related to environmental parameters such as solar radiation, nutrient levels, salinity and temperature (Greve and Binzer, 2004; Andrade and Ferreira, 2001). While solar radiation is the most important parameter for growth (Greve and Binzer, 2004), the optimum salinity for *Z. marina* is believed to be between 10 and 20 ‰ with optimum temperatures lying between 10 and 20 °C (Nejrup and Pedersen, 2008). In the UK, growth generally occurs during the spring and summer, from April to September (Davison and Hughes, 1998). If the environmental conditions allow, flowers and seeds are generally produced between early/late summer (May/July) and early autumn (September) (Tubbs and Tubbs, 1983; Brown, 1990).

Z. marina invests a large proportion of its resources in the maintenance of rhizomes and roots (Davison and Hughes, 1998). The underground mat of horizontal rhizomes branches during growth, producing vertical leaf shoots, which are responsible for the lateral expansion of patches. Populations of *Z. marina* can therefore expand either by vegetative growth or sexually, by production of seed.

It is widely believed that subtidal perennial populations of *Z. marina* in the UK persist almost completely as a result of vegetative growth rather than by seed production (Davison and Hughes, 1998). It has been reported that relatively high temperatures (above 15 °C) are required for flowering and seed germination (e.g. Setchell, 1929; Yonge, 1949), and this has led to the conclusion that sexual reproduction does not play a major role in the life history of *Z. marina* at northern latitudes. Few field studies have been conducted to assess this hypothesis, particularly in the UK, however, many authors report that growth and seed production are not, or are only in part, controlled by water temperature (e.g. Jacobs, 1979; Bulthuis, 1987; Giesen *et al.*, 1990). Furthermore, *in vitro* experiments investigating temperature responses of *Z. marina* generally do not correspond with field observations (Bulthuis, 1987; Giesen *et al.*, 1990). More recent studies of sexual reproduction in *Z. marina* indicate that seed production and germination may successfully occur at temperatures of as low as 7 – 10 °C (e.g. Morita *et al.*, 2010). This suggests that it is possible that seed production and germination do contribute to the maintenance and propagation of *Z. marina* populations in the UK.

The environmental conditions required and the role of the various environmental factors to ensure seagrass bed recovery are not fully understood (Cunha *et al*., 2004) but several studies have been conducted investigating the ability of *Z. marina* to recover following a decline in shoot density or meadow size. Some studies report recovery entirely due to vegetative growth. For example, Boese *et al.* (2009) reported that neither natural nor artificially enhanced seedling recruitment contributed to recolonisation of experimentally denuded patches within a seagrass meadow. By contrast, other studies report that germination of seeds was the main mode of recolonisation, with no evidence of recolonisation from rhizomes (e.g. Greve *et al.*, 2005). Others show that recolonisation occurs due to a combination of seedlings and vegetative expansion (e.g. Plus *et al.*, 2003; Cunha *et al*., 2004). It is possible that these differences are due to the varying environmental conditions in which *Z. marina* was studied or to phenotypic variation between populations.

Valdermarsen *et al.* (2010) suggested that vegetative expansion by clonal growths is efficient for recovery of small gaps (up to 100 m^2) but insufficient for large-scale recolonisation due to the slow rate (0.3 – 0.5 m yr^{-1}) of rhizome elongation. Recolonisation of larger areas, therefore, depends primarily on seed dispersal and the subsequent growth of seedlings. However, 95 % of seeds from *Z. marina* are believed to be retained within 30 m from the source plant, restricting the ability of the plant to spread and produce new patches of seagrass (Cunha *et al*., 2004).

1.4.4 Ecological importance

1.4.4.1 Ecological function

Seagrass meadows are considered to be the most productive of shallow, sedimentary environments (Davison and Hughes, 1998). The network of roots and leaves in extensive beds of *Zostera* spp. provides ecological niches for a wide range of associated fauna and flora, so that these biotopes are important in maintaining coastal biodiversity. Seagrass meadows exhibit high rates of primary productivity and this supports a rich, resident fauna and seagrass meadows are used as refuge and nursery areas by many species, including commercial fish species

1.4.4.2 Epiphytes and other algae

Living leaves of *Zostera* spp. provide a suitable substratum for numerous epiphytic algae, while other algae live between the seagrass shoots and within the surface layers of the underlying sediment. Beds of *Zostera* spp. are generally rich in epiphytes but poor in associated macroalgae owing to the shading effect of the dense seagrass swards. In sandy habitats *Chorda filum* is often found with *Z. marina*. On mixed substrata, a layering of flora can be observed, with *Zostera* spp. plants protruding up through stones colonized by macroalgae such as *Halidrys siliquosa* and *Saccharina latissima*, often with *Cystoseira* sp. at the margins of the seagrass bed (Whelan and Cullinane, 1985).

The algae found within beds of *Zostera* spp. are more digestible than the seagrass itself and support the majority of the abundant grazers found (Davison and Hughes, 1998). In relatively open stands, the benthic algae may account for 70 % of the total primary production of the bed. However, in dense beds, the thick carpets of seagrass leaves can reduce light availability for the algal understory and, as a result, productivity is lower (Davison and Hughes, 1998).

1.4.4.3 Invertebrates and fish

A wide variety of invertebrate species occur on and among the plants of an seagrass bed. Small gastropods grazing the algal epiphytes on the leaves of *Zostera* spp. include *Hydrobia* spp., *Rissoa membranacea* and *Littorina littorea*. The sediments underlying the beds support large numbers of polychaete worms (including *Arenicola marina*, *Lanice conchilega* and *Scoloplos armiger*), bivalve molluscs (e.g. *Cerastoderma edule*, *C. glaucum*) and burrowing anemones (e.g. *Cereus pedunculatus*). Amphipod and mysid crustaceans are among the most abundant and important of the mobile fauna living amongst the seagrass leaves. Cephalopods such as cuttlefish *Sepia officinalis* are also found amongst seagrass beds (Davison and Hughes, 1998).

Seagrass beds are widely recognized to be important spawning and nursery areas for many species of fish, including commercial species (Davison and Hughes, 1998). Smaller fish species found associated with seagrass beds include two-spot gobies *Gobiusculus flavescens*, and 15-spined stickelbacks *Spinachia spinachia*. Larger, commercially-important species using seagrass beds as feeding grounds include bass (*Dicentrarchus labrax*).

1.4.5 Natural impacts on seagrass

Olesen and Sand-Jensen (1994a, b) reported that in Danish waters, new *Zostera marina* beds took at least five years to become established and stable, and that the survival and viability of the bed was strongly influenced by its size. Small patches with less than 32 shoots showed high mortality, but as the sizes and ages of the patches increased, mortality declined. Once established, a dense bed of *Zostera* spp. plants reduces current flow, leading to increased deposition of suspended sediment and organic detritus. This enhanced deposition rate, together with the sediment-binding effect of the rhizome network, reduces erosion and acts to stabilize the substratum. Conversely, if an established, unbroken bed becomes fragmented for any reason, the bed will tend to become less stable and more vulnerable to the normal forces of erosion. It is possible that there is a threshold of loss, below which destabilization and further losses of beds can occur (Holt *et al.*, 1997).

Like all marine habitats, seagrass beds are subject to natural change. Beds of *Zostera* spp. are known to be spatially dynamic, and undergo natural fluctuations in populations, which may be precipitated by sediment transport regimes, grazing and weather events.

Meadows of *Zostera* spp. typically occur in physically-sheltered environments such as shallow inlets and lagoons. The plants stabilize the sediment within the beds and the canopy of leaves reduces current flow (Davison and Hughes, 1998). However, increased wave action and current flow, particularly during storms or floods, can remove sediments and cause damage to the seagrass beds.

The largest natural loss of *Zostera* spp. was attributed to what is known as the “wasting disease”, which wiped out extensive areas in the North Atlantic in the early 1930’s (e.g. Giesen *et al.*, 1990). This disease has in part been attributed to the fungus *Labyrinthula macrocystis*. This organism is probably naturally present at low levels but undergoes occasional large-scale outbreaks for reasons which are still not fully understood (Giesen *et al.*, 1990). It is possible that severe seagrass losses occur only when the plants are under stress from some other factor such as temperature. Populations of *Zostera* spp. have not returned to pre-wasting disease levels, possibly due to further anthropogenic impacts (Chesworth *et al.*, 2008), although there is some suggestion that even under reduced anthropogenic impacts recovery is slow (Valdermarsen *et al.*, 2010).

Other factors influencing the health of seagrass beds include grazing by wildfowl, which can remove a high proportion of the available seagrass biomass (over 90% in some cases), but beds can normally withstand this grazing pressure unless under stress from some other factor (Davison and Hughes, 1998). Declines in populations of epiphyte grazers can indirectly affect the health of beds of *Zostera* spp. by allowing increased growth of fouling algae. Any factors (natural or anthropogenic) which reduce grazer populations or cause increased proliferation of algae may therefore have an indirect adverse impact on seagrass meadows. The factors most likely to cause such changes are pollution incidents (causing grazer mortality) or excessive nutrient enrichment (Davison and Hughes, 1998).

1.4.6 Anthropogenic impacts on seagrass

A large proportion of the UK's population lives on or adjacent to the coast. As a result, pollution, development and recreation pressures are increasingly affecting the coastal environment, and their impacts can be especially acute in the shallow bays, estuaries and lagoons where *Zostera* spp. habitats most commonly occur (Davison and Hughes, 1998). Holt *et al.* (1997) concluded that *Z. marina* is extremely sensitive to human-induced changes in the coastal environment, which may include eutrophication, changes to the sediment regime, pollution and physical disturbance, including the effects of boat mooring and anchoring.

1.4.6.1 The potential effect of anchoring on seagrass

There is extensive literature that has investigated the potential impact of boat anchoring and boat moorings on seagrass beds but relatively few studies focus specifically on *Z. marina*. Generic impact studies on seagrass may have relevance to *Z. marina* meadows. However, differences in habitat and plant structure may result in differences in sensitivity to impact events.

Seagrasses are not physically robust and the rhizomes are likely to be damaged by human activities such as boat anchoring, which may also bury seeds too deep to germinate (Duarte *et al.*, 2004). Numerous studies have suggested that boat anchoring and boat moorings deployed in seagrass beds result in mechanical damage to seagrasses (e.g. Walker *et al.*, 1989; Hastings *et al.*, 1995; Francour *et al.*, 1999; Rhodes *et al.*, 2005; Collins *et al.*, 2010) having a negative impact both at the individual plant level (pulling up leaves and rhizomes) and at the population level (i.e. affecting the structure of the meadow; e.g. Francour *et al.*, 1999; Milazzo *et al.,* 2004). Direct mechanical disturbance and uprooting of seagrasses has long-term impacts on seagrass beds as seagrasses are generally slow growing plants requiring long periods for re-colonisation (Borum *et al.,* 2004). Duarte *et al.* (2004) and Collins *et al.* (2010) both reported that boat anchoring and boat moorings leave 'scars' in Mediterranean and Studland Bay seagrass meadows respectively, which may take decades to be re-colonised by large meadow-forming seagrasses.

Van der Heide *et al.* (2007) suggested that when seagrass is absent, current and wave velocities are no longer reduced, resulting in suspended sediment and turbidity levels becoming too high to sustain seagrass growth or recovery. This effect is likely to be greater in shallow waters where there are increased shear stresses on sediment beds arising from the wind-driven currents and waves. The increased fragmentation of the seagrass would not only lead to a loss of detritus and nutrients from the damaged area and potentially greater erosion of the surrounding area, but also in greater sediment re-suspension of the barren areas and hence a deterioration in the light conditions for the remaining seagrass bed.

A number of studies have investigated the impact of different types of anchor and different parts of the anchoring cycle (anchor fall, dragging/locking in and retrieval) on seagrass beds. Francour *et al.* (1999) studied the direct effect of anchoring on *P. oceanica* seagrass beds in the Port-Cros National Park in the Mediterranean by measuring the number of uprooted and broken shoots which occurred during the 'locking in' of an anchor into the substratum and the retrieval of the anchor using an electric windlass. The study also compared seagrass bed 'vitality' parameters (percentage of substrate covered by seagrass leaves; number of shoots per unit surface area; extent of rhizome baring; the proportion of horizontal rhizomes and the degree of meadow fragmentation) between fives sites with different anchoring histories, ranging from no anchoring over last 15 years to areas with high anchoring pressure.

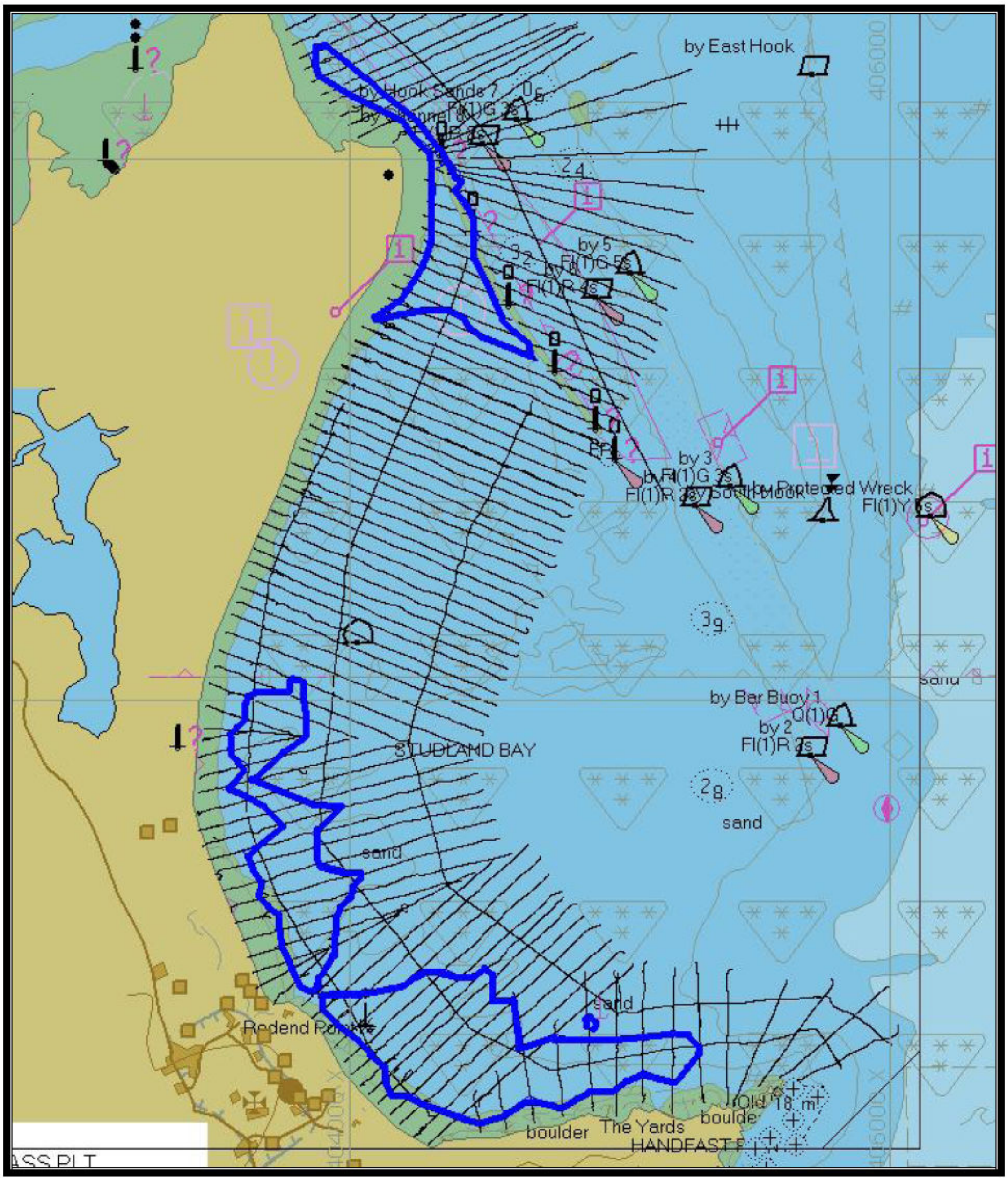
The results showed that the locking-in stage of the anchoring cycle caused the greatest damage and that, on average, 34 shoots were damaged (broken or uprooted) during each complete anchoring 'cycle' (locking in and retrieval). The number of uprooted shoots was significantly greater than the number of broken shoots. The authors calculated that this represented a loss of approximately 50 shoots m^{-2} based on the average size of the anchor scar (2.2 x 0.3 m). The results also suggested that the effect of anchoring was influenced by the density of the root mat at the shallow sites (5 m) and the extent of rhizome baring. The authors interpreted the results from sites with different levels of anchor usage as showing that the proportion of horizontal rhizomes (an indicator of an expanding meadow, possibly in response to stress) and the degree of meadow fragmentation were positively correlated with moderate anchoring pressure whilst seagrass meadow cover and shoot density were negatively correlated with high anchoring pressure.

Milazzo *et al.* (2004) quantified the damage caused to *P. oceanica* shoot density by boat anchoring in the Ustica Island marine protected area (MPA), Italy. Specifically, the study assessed whether the extent of damage was related to the type of anchor, the use of chain compared to rope attached to the anchor and the stage of the anchoring cycle (anchor fall, dragging/locking in and retrieval). In contrast to the findings of Francour *et al.* (1999), the results showed that the greatest level of damage was inflicted during the weighing (retrieval) stage of the anchor cycle whilst limited damage occurred during the anchor drop and dragging/locking-in stages. It was proposed that the discrepancy in results could have been due to the difference between the size of the boats and anchors used in each study. Milazzo *et al.* (2004) also showed that the 'folding grapnel' anchor caused the greatest level of broken and uprooted shoots and the 'Hall' anchor caused the lowest level of damage. The level of damage to the seagrass was not affected by the presence of chain compared to rope. The authors concluded that the magnitude of impacts inflicted on *P. oceanica* depended upon the anchor type used but that even anchoring by small boats using low-impact anchors may have potentially detrimental consequences at vulnerable sites.

1.4.7 Seagrass (Z. marina) in Studland Bay

Surveys of *Z. marina* in Studland Bay date back to 1990 and are documented in a number of studies (e.g. Jensen *et al*., 1990; Collins, 2002; Black and Kochanowska, 2004; Pearce, 2009; Collins *et al*., 2010). These studies report the largest beds along the southern margin of Studland Bay with smaller patches in the north and along the western margin (figure 1.2). However, the available data appear inconsistent (see e.g. Black and Kochanowska, 2004; Pearce, 2009) regarding the extent of the seagrass habitat and therefore little seems to be known about any changes to the extent of the seagrass habitat in the bay. Anecdotal evidence from local residents suggests an increase in the extent of the habitat (SBPA, 2011) but a detailed baseline survey followed by several monitoring surveys over several years would most likely be required to fully assess any such changes.

Figure 1.2. Track plot from Poole Harbour Bathymetric Survey, September 2008 (extent of seagrass habitat outlined in blue; from Pearce, 2009).



As mention above, there are few studies on the potential impacts of anchoring associated with recreational boat activity on *Z. marina*. In Studland Bay there appears, apart from the current study, to be only one such study (Collins *et al*., 2010) carried out in recent years. Collins *et al*. (2010) reported a number of 'scars' (typically 1-4 m^2) in Studland Bay caused by anchoring recreational boats and that there was an expansion of these scars between 2008 and 2009 with 'no evidence of re-colonisation'. Differences in sediment composition, sediment shear strength and infaunal species between scars and seagrass habitats were reported with the silt fraction, organic content and shear vane stress as well as the infaunal species diversity being lower in the scars than within the seagrass habitat. It was also suggested that 'the impacts of anchoring and mooring could potentially lead to the decline of the Studland Bay seagrass habitat and its associated species' but whether this was believed to effect the overall extent of the Studland Bay seagrass habitat remains unclear.

1.4.7.1 The fauna and flora in the Studland Bay seagrass habitat

In previous studies many species of fauna and flora have been recorded including a wide variety of fish species. A number of the families and species listed have known association with seagrass habitat including: Gobiidae, especially two spot gobies (*Gobiusculus flavescens*), 15-spined stickleback (*Spinachia spinachia*) (Davison and Hughes, 1998; Chesworth *et al.*, 2008), pollack, (*Pollachius pollachius*) and pipefish, Syngnathidae (Chesworth *et al.*, 2008). The Seahorse Trust have reported that Studland Bay is a breeding habitat for seahorses (Dorset Wildlife Trust, 2010) but the size and the importance of the population still appears to be unknown.

Crustacea found include *Crangon crangon* and *Palaemon* spp. that have long been associated with seagrass beds on account of the importance of the habitat as shrimping and prawning grounds in the Solent (Chesworth *et al.*, 2008). Of the crab species recorded, spider crab (*Maja squinado*), shore crab, (*Carcinus maenas*), and hermit crab (*Pagurus bernhardus*) were encountered most frequently (Chesworth *et al.*, 2008; Sutton and Tompsett, 2000).

The seagrass meadows in Studland Bay are typical in that they contain a wide range of algae. Some of these algal species grow epiphytically on the surface of the seagrass leaves or stems (including *Cryptopleura ramosa*, *Ceramium* spp., *Gracilaria gracilis*, *Brongniartella byssoides* and *Ulva lactuca*) and are characteristic of seagrass beds (Davison and Hughes, 1998).

Frequently encountered mollusc species include the slipper limpet (*Crepidula fornicata*), an invasive species that is found extensively in soft sediment habitats in the English Channel (Browning, 2002). Also frequently recorded are the common cockle, (*Cerastoderma edule*) and the netted dog whelk, (*Hinia reticulata*), although neither are specific to seagrass habitats. However, the other families and species recorded are all characteristic of seagrass beds (Davison and Hughes, 1998; Sutton and Tompsett, 2000). The molluscs listed include a number of grazing species (e.g. *Calliostoma* spp. and *Gibbula cinerea*) that play a vital role in ensuring that algal cover does not out-compete the seagrass (Davison and Hughes, 1998).

2 METHODOLOGY

2.1 Design of the survey

2.1.1 VNAZ location selection criteria and baseline mapping survey

The Studland Seagrass and Seahorse Study Group* (SSSSG) had during a meeting in February 2009 decided that the southwest corner of Studland Bay was the preferred location for the VNAZ and the CTZ. Following award of the contract the final positions of the VNAZ and CTZ were determined after a literature and data review and a detailed mapping survey of the seagrass cover in the southern area of the bay. This was achieved using underwater video and stills photography and bathymetry transects. The bathymetry and drop-down camera survey took place on the 28th and 29th May 2009. Camera transects were established as pre-planned shore normal survey lines at 50 m line spacing across the survey area. A total of 26 camera lines between 250 m and 900 m in length, were completed across the Studland Bay survey area resulting in a total length of all the survey lines of 14.48 km.

Establishing the positions of the marked VNAZ and the CTZ were challenging tasks as a result of all the factors that had to be taken into consideration but there were three main selection criteria. The first criterion to fulfil was that the seagrass percentage cover and seagrass health in the two zones were to be the same, or as similar as possible. The second criterion was that the two zones also had to be the same (or as similar as possible) in environmental terms (e.g. sediment grain size and water depth). The third criterion was that both areas had to be actively used by anchoring vessels of various sizes visiting the bay.

The level of anchorage within the different areas of the bay was established by monitoring the bay and taking still photographs throughout the summer of 2009 (for three hours each day from 23rd June to 13th September) from a fixed position, altitude and bearing.

In addition to these three main criteria there were a number of other factors to consider including the positions of the current mooring buoys (ensuring no interference between moored vessels and the positions of the VNAZ buoys), the positions of vessels anchoring within the bay, the level of anchorage within the different areas of the bay and avoiding the coarse sedimentary channels to the east (devoid of seagrass). The final positions of the two zones were established taking all the above information into consideration as well as consulting The Crown Estate and Natural England (project managers).

2.1.2 Position of the Voluntary No Anchor Zone (VNAZ)

Following the literature and data review, detailed mapping of the seagrass bed in the south-west corner, as well as an assessment of the level and positioning of anchorage in the bay the positions of the VNAZ (table 2.1) and CTZ were established (position of VNAZ given in figure 2.1 with details of the survey lines within the VNAZ in figure 2.2 and the actual VNAZ in figure 2.3). The central buoys (C1 and C2) were installed to aid the delineation of the zone (in case a buoy went missing for example) and to discourage anchoring in the zone by reducing the size available for potential anchoring within the zone.

2.1.3 Dive monitoring surveys

The monitoring of the seagrass beds within the VNAZ and the CTZ has now been carried out using diving surveys. These surveys started in the autumn of 2009 with the last survey completed in the autumn of 2011. There was one diving survey in the spring and autumn of each year (pre and post boating season) as well as a survey in September 2010, making it a total of six diving surveys. The first dive survey in the autumn of 2009 (on the 7th, 8th and 12th October 2009) was to form the 'baseline dive survey' for the subsequent surveys (see result section) and allow the assessment of any potential changes in the seagrass health, cover and extent within the two zones.

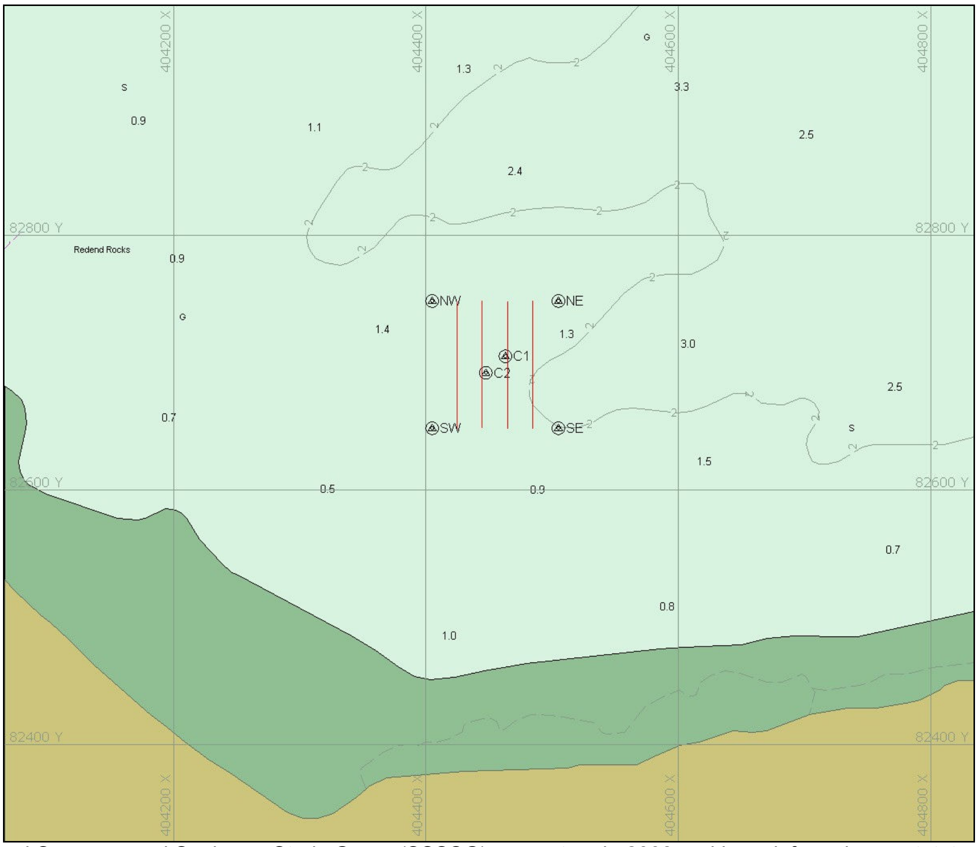
2.1.4 The selection of qualitative and quantitative parameters

The selection of the main quantitative parameters was based on the methodology by Short *et al.* (2004) but initially all visible and relevant parameters were recorded as little published comparable data were available for Studland Bay. All these qualitative and quantitative data were then assessed for validity in terms of seagrass health with a number of parameters (see below) finally selected for further detailed analysis.

Table 2.1. Positions of the Voluntary No Anchor Zone buoys.

VNAZ Buoy	**Voluntary No Anchor Zone buoy positions** (OSGB36 East and North)	
	Easting (m)	**Northing (m)**
NW	404405.00	82748.50
NE	404505.00	82748.50
SW	404405.00	82648.50
SE	404505.00	82648.50

Figure 2.1. Position of the VNAZ in Studland Bay (with the two central buoys, C1 and C2).



* The Studland Seagrass and Seahorse Study Group (SSSSG) was set up in 2008 and is an informal, non-statutory, focus and discussion group, formed by residents, local yacht clubs, environmental groups and other interested parties. In November 2010, the group was superseded by The Studland Bay Conservation and Recreational Activity Working Group set up by the Marine Management Organisation (MMO). The MMO is an executive non-departmental public body established and given powers under the Marine and Coastal Access Act 2009.

Figure 2.2. VNAZ in Studland Bay with marker buoys and diving survey transect lines.

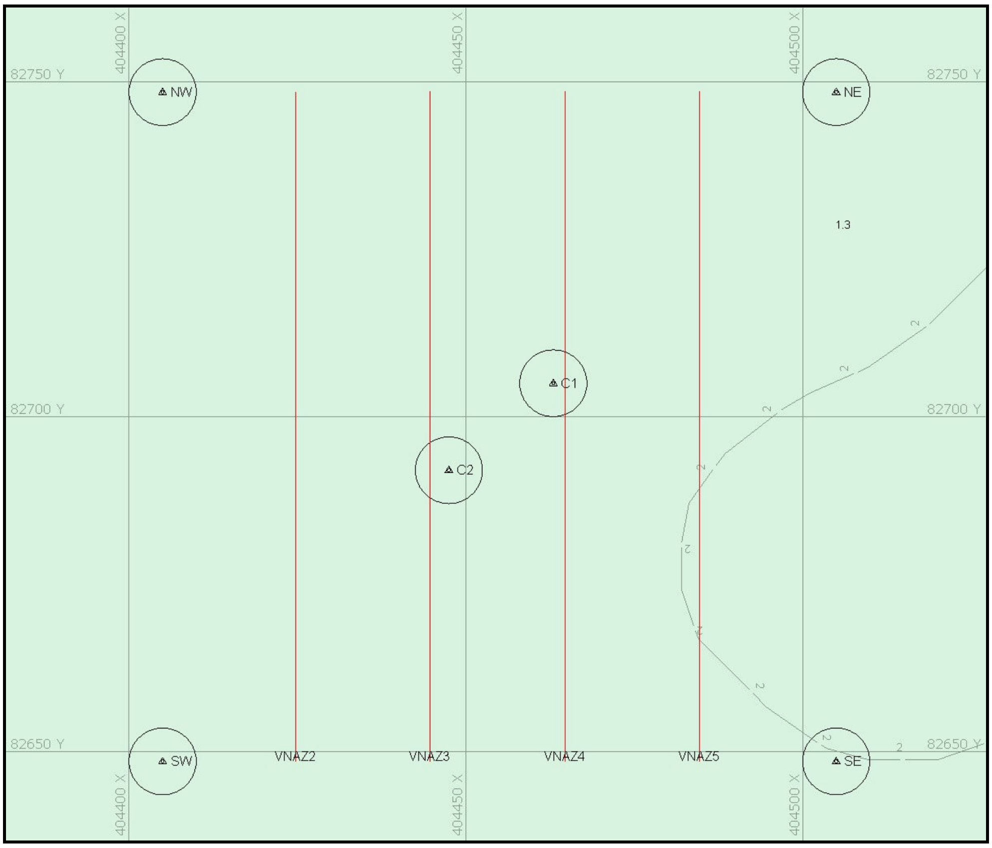


Figure 2.3. VNAZ in Studland Bay with marker buoys (shore photograph taken from the boat monitoring position with five yellow VNAZ buoys (NE, NW, SE, SW and C2) as well as three of the some 20 mooring buoys (two red and one white) in the bay).

2.1.5 Dive survey methodology

The methodology used to conduct all the dive surveys in Studland Bay was as follows:

- Four temporary pre-marked survey transects 100 m in length were established in each zone. The lines are 20 m apart and run in a north-south direction with the two outer lines laid 20 m from the west and east boundaries of the 100 m zone (figures 2.1 and 2.2) to avoid the potential interference of anchoring vessels at the boundaries.

- The transects were marked with a 100 m long rope with a sinker and marker buoy at each end. These ropes were deployed from the survey vessel prior to the start of the dive survey (one line at a time). The ropes were pre-marked at 20 m intervals using coloured tape and were laid by deploying the sinker weight and buoy over the stern of the vessel at the start of line. The transect rope was then paid out while the vessel traversed a pre–determined survey line using Hypack survey software. A sinker weight and buoy attached to the end of transect line was then deployed as the vessel reaches the end of the line. The GPS start and end position of each transect was recorded.

- Positioning for the transects was obtained using Leica GPS. The Leica GPS obtained a satellite derived position in WGS84 latitude and longitude, which was logged using Hypack survey software running on a survey computer. A data transformation was performed within the survey software to convert the positions to OSGB36 eastings and northings. Both the raw data and the converted positions were logged and times were recorded in GMT.

- For each transect two divers worked along the transect line (the ‘transect swim’), one using a hand held video recorder and the other making *in-situ* observations (qualitative data). Video footage was recorded along each transect (diver approximately 0.5 m above the rope) and notes were taken of the seagrass percentage cover, patchiness and general heath, as well as other flora and fauna observed, approximately 1 m either side of the transect. Notes were made regarding any bare patches (patch of clear sediment within the seagrass habitat), recent scaring (deep cut with a linear horizontal mark in the sediment), dead seagrass patches, algal cover and other features of interest. The sizes of the patches were estimated with reference to the marked rope and only recorded if present along the transect line. The algal cover (%) was estimated (qualitative) during the swim.

- On the return swim along the transect a quantitative quadrat survey (the ‘quadrat swim’) was conducted (based on the standard methodology used for seagrass studies by Short *et al*., 2004). A 50 x 50 cm quadrat was placed at 20 m pre-marked intervals along the transect line. The rope deployment methodology results in random positioning of the quadrats on the seabed (as a result of the movement of the vessel by winds and tides during the deployment). For each quadrat the seagrass and epiphyte density was estimated (diver 0.5 m above quadrat). In addition, within a quarter (25 x 25 cm) of the quadrat (selected randomly) all the seagrass shoots were counted, blade (frond) lengths were measured (five representative samples) and any other flora and fauna were counted and recorded. An epiphyte sample was taken of any plants of interest for later identification in the laboratory. Video footage was also taken of each quadrat. A total of five quadrats are therefore surveyed along each of the transect lines resulting in a total of 20 quadrats in each zone.

- For each zone quadrat positions are staggered along each of the transect lines to ensure greater coverage across the survey area. The positions of the quadrats for the baseline dive survey are shown in table 2.2. The same positions were used for the monitoring surveys in 2009, 2010 and 2011.

The quantitative data from the diving survey (quadrat data) was entered into a spreadsheet (appendix 01) for subsequent assessment of any potential differences in the seagrass cover, health and extent between the VNAZ and CTZ.

Table 2.2. Quadrat positions within the VNAZ and CTZ at Studland Bay (bearing of quadrat survey swims refer to the 2009 survey but the same distances were used throughout).

Transect number	Quadrat number	Distance along transect line (m)	Bearing of quadrat survey swim (^{o})
VNAZ 2	Q1	20	360 (S-N)
VNAZ 2	Q2	40	360 (S-N)
VNAZ 2	Q3	60	360 (S-N)
VNAZ 2	Q4	80	360 (S-N)
VNAZ 2	Q5	100	360 (S-N)
VNAZ 5	Q1	0	360 (S-N)
VNAZ 5	Q2	20	360 (S-N)
VNAZ 5	Q3	40	360 (S-N)
VNAZ 5	Q4	60	360 (S-N)
VNAZ 5	Q5	80	360 (S-N)
VNAZ 3	Q1	0	360 (S-N)
VNAZ 3	Q2	20	360 (S-N)
VNAZ 3	Q3	40	360 (S-N)
VNAZ 3	Q4	60	360 (S-N)
VNAZ 3	Q5	80	360 (S-N)
VNAZ 4	Q1	20	360 (S-N)
VNAZ 4	Q2	60	360 (S-N)
VNAZ 4	Q3	40	360 (S-N)
VNAZ 4	Q4	80	360 (S-N)
VNAZ 4	Q5	100	360 (S-N)
CTZ 2	Q1	0	360 (S-N)
CTZ 2	Q2	20	360 (S-N)
CTZ 2	Q3	40	360 (S-N)
CTZ 2	Q4	60	360 (S-N)
CTZ 2	Q5	80	360 (S-N)
CTZ 3	Q1	20	360 (S-N)
CTZ 3	Q2	40	360 (S-N)
CTZ 3	Q3	60	360 (S-N)
CTZ 3	Q4	80	360 (S-N)
CTZ 3	Q5	100	360 (S-N)
CTZ 4	Q1	20	180 (N-S)
CTZ 4	Q2	40	180 (N-S)
CTZ 4	Q3	60	180 (N-S)
CTZ 4	Q4	80	180 (N-S)
CTZ 4	Q5	100	180 (N-S)
CTZ 5	Q1	20	360 (S-N)
CTZ 5	Q2	40	360 (S-N)
CTZ 5	Q3	60	360 (S-N)
CTZ 5	Q4	80	360 (S-N)
CTZ 5	Q5	100	360 (S-N)

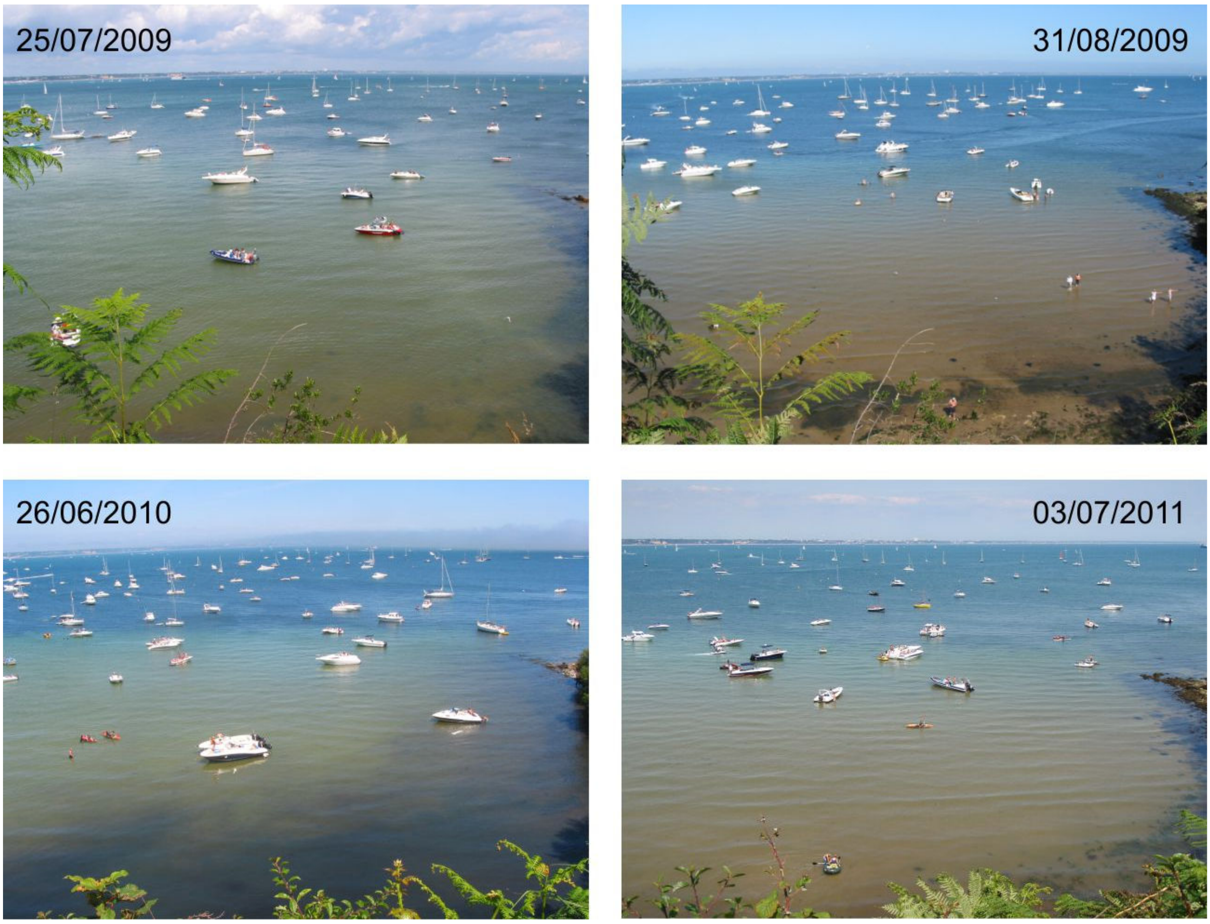
2.2 Boat monitoring

To aid the project additional funding was made available for boat monitoring of the bay by students from Southampton Solent University (2009) and the National Oceanographic Centre, Southampton (2010 and 2011). During 2009 the VNAZ was not yet operational but the boat monitoring was able to collect data on the level of anchoring in the different sections of the southwest corner of the bay, which added to the evidence regarding the most suitable location for the VNAZ. Subsequent monitoring was aimed at establishing the effectiveness of the VNAZ and assessment of the potential differences in the level of anchoring between the VNAZ and the CTZ.

Data was recorded of boats visiting of the bay both inside and outside of the VNAZ on specially designed log sheets (see appendix 02) during most days (for three hours each day) throughout the summer of 2009 (23rd June to 13th September) and 2010 (21st June to 12th September). In 2011 this was changed to monitor the bay for three to four days most weeks but for 9 hours per day, to ensure activity was recorded during the busiest times and to identify any boats at anchor overnight. The monitoring days always included weekends as well as at least either Friday or Monday (including Bank Holiday weekends).

Still photographs were taken from a fixed position, altitude and bearing to allow comparisons between years, months and days over the three years (see figure 2.4 and logs in appendix 03).

Figure 2.4. Boat monitoring in Studland Bay (examples of boat monitoring photographs taken in 2009, 2010 and 2011).



2.3 Data analysis

A lot of qualitative and quantitative data have been collected at Studland Bay over the last 2 years. The qualitative data collected during the 'transect swim' comprised general descriptions of the seagrass habitat along the dive transects including percentage cover, patchiness and general heath, as well as *in-situ* identification of the flora and fauna observed. In addition, notes have been made regarding any bare patches, recent scaring, dead seagrass patches and any other features of interest.

The quantitative data were collected during the quadrat surveys and involved counts or assessments within the quadrats following the methodology outlined in Short *et al*. (2004). The parameters measured were shoot density, frond length, percentage seagrass cover, epiphyte cover and counts of any benthic taxa present (e.g. snakelock anemones). Whilst the qualitative data allow for a general overview of the seagrass habitat in terms of the fauna and flora present within the bay, the quantitative data allow for more detailed analysis of some of the parameters.

During the 'transect swims' notes were made of any patches of seabed devoid of seagrass. The size and location of these patches were only recorded if the patches were found along the dive transect (1 m either side of the line). The origin of the patches was often impossible to determine as most patches were old (flat sediment surface, no evidence of scaring and even some low abundance of seagrass shoots within the patch). However, on occasion the patch showed evidence of having been created by an anchor (i.e. a deep (c. 10-20 cm), narrow (c. <0.5 m) furrow). All of these records were entered into the GIS and the patches mapped in the VNAZ and the CTZ to illustrate the distribution of patches within these two zones.

The boat monitoring photographs were not fully analysed as this was not part of the original scope of the study. However, the photographs have been used to assess the approximate relative use of the two zones in terms of anchoring but also to assess the level of observance and compliance of the VNAZ. The counts refer to the number of anchoring events within the two zones. Whilst counts in 2011 were made during the boat monitoring surveys, the counts in 2010 have been recorded subsequently using the photographs acquired. The total number of events will most likely be underestimates (e.g. boat monitoring did not take place every day, some events may take place before or after monitoring starts or ends on any given day) but the ratio of relative 'use' can be assessed.

In terms of both qualitative and quantitative data many floral and faunal taxa have been identified during the dive surveys to date. In terms of quantitative data five key indicators were initially identified as consistent parameters suitable for consideration in statistical analysis to allow assessments of any potential impact of anchoring on the seagrass habitat in Studland Bay. These indicators were shoot density, average blade length, number of Snakelock anemones, epiphyte cover and seagrass cover. However, after an initial analysis the epiphyte cover and snakelock anemones records were excluded from further detailed analysis, with the former being excluded due to sampling variability and the latter as it is not clear whether snakelock anemones are directly linked to seagrass health.

Statistical analysis of the three remaining variables has been undertaken - seagrass shoot density, percentage seagrass cover and seagrass frond length data. These parameters are defined as indicators of 'seagrass health' as stated in the null hypothesis and therefore allow assessments of seagrass health as defined in the null hypothesis. Data gathered from the VNAZ and CTZ from each sampling period were treated separately as the difference in the sampling times could potentially represent a huge source of variation.

2.3.1 Tests for normality

Seagrass shoot density from the VNAZ and CTZ from each time period were tested against a normal distribution using Kolmogorov-Smirnov tests (see Fowler and Cohen, 1990; Sokal and Rohlf, 1995). Some of the data were found not to be normally distributed, and transformations were attempted. The data were first transformed using a logarithmic transformation (i.e. $x = \log(x + 1)$) adjusted for zero counts (some quadrats placed on bare sediments hence zero counts for shoot density), but the transformation did not result in normally distributed data. A square root transformation adjusted for zero counts (i.e. $x = \sqrt{(x + 1)}$) was also applied to the raw shoot density data, but also failed to achieve a normal distributions. Therefore several parametric and non-parametric tests were used for this variable with parametric tests being used on normally distributed data and non-parametric tests used on data that are not normally distributed.

The percentage seagrass cover data were converted into proportions, before undergoing an arcsine square-root transformation. The transformed data were then tested for normality using Kolmogorov-Smirnov tests (see Sokal and Rohlf, 1995). The majority of the data were found to be significantly different from a normal distribution, ruling out the use of any parametric statistical tests for seagrass percentage cover.

The seagrass frond length data was examined for normality using a Kolmogorov-Smirnov test. The majority of the data were found not to have a normal distribution. Several data transformations (logarithmic and square root transformations) were applied to the data, but normal distributions could not be obtained. Summary tables of the normality tests for each variable are given in appendix 04.

2.3.2 Statistical tests

For each variable, statistical tests were used to assess whether any significant differences were present between data from the VNAZ and CTZ at each sampling period. In addition, two sample Kolmogorov-Smirnov tests were used to examine if the distribution of the data from different time periods varied significantly from each other at each site, and whether the distribution of data from the VNAZ and CTZ varied significantly from each other at each sampling period.

When testing between the VNAZ and CTZ at each sampling period, either t-tests or Mann-Whitney U tests were used depending on whether the data was normally distributed or not. To test between differences in the data from each sampling period in the VNAZ and CTZ either one-way ANOVAs or Kruskal-Wallis tests were used, again depending on whether the data had a normal distribution or not.

The counts of shoot density from the each sampling period in the VNAZ and CTZ were classified into classes, and the percentage frequency of each size class was calculated. Kolmogorov-Smirnov two-sample tests were used to test if there were any significance differences between the distributions of shoot density counts from the sampling periods from each site, and between the distributions from each site at each sampling period. Two count size classes (i.e. 0-1 shoots, 2-3 shoots etc.) were chosen, although other size classes were tested and found to produce the same results. Similar Kolmogorov-Smirnov two-sample tests were performed on size frequency distributions for percentage seagrass cover based on 10% size classes, and for seagrass frond lengths with 5 cm size classes.

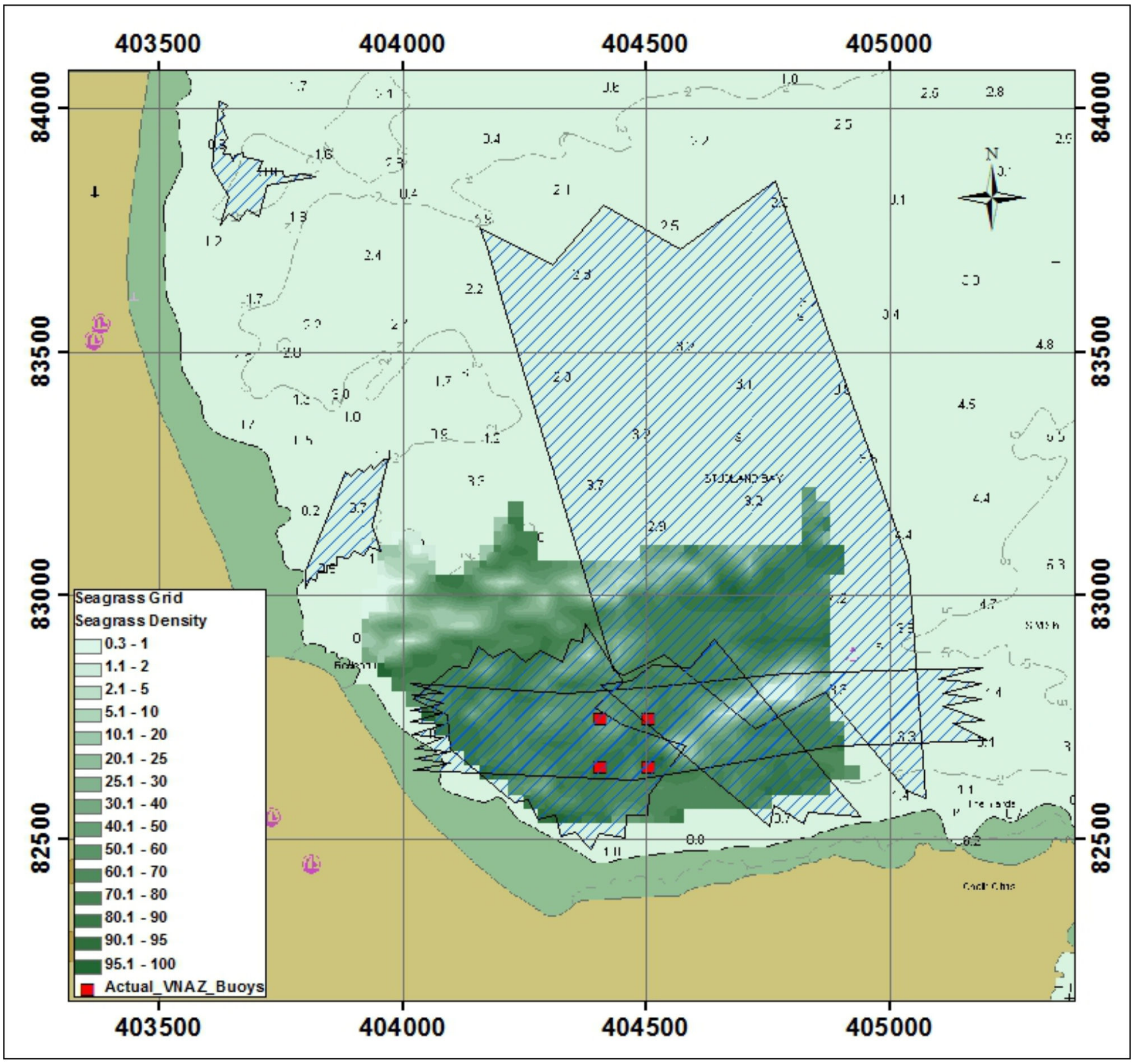
3 RESULTS

3.1 Baseline camera and bathymetric survey

The results of the 2009 mapping survey (completed on 28-29 May 2009 by Seastar Survey Ltd.) have been overlaid with seagrass plots from earlier surveys. However, it should be noted that the 2009 mapping survey was not designed to establish the extent of the seagrass bed in the entire bay, but to map the seagrass cover and density in the southwest corner of the bay to establish the positions of the VNAZ and CTZ.

Figure 3.1 shows an interpolated plot of seagrass density (the 2009 mapping survey data) along with the 2004 seagrass extent (in blue) incorporated within the Inventory of Eelgrass beds in Devon and Dorset (see Black and Kochanowska, 2004). The quality and accuracy of the 2004 data are unknown and the results can therefore not be verified. Without being in receipt of all the track plots or data for surveys that fed into the 2004 Devon and Dorset seagrass inventory, it is difficult to assess to what degree, if any, the extent of seagrass has changed although it could be inferred that incompleteness in the original survey extent accounts for the differences observed rather than any significant changes in seagrass bed size.

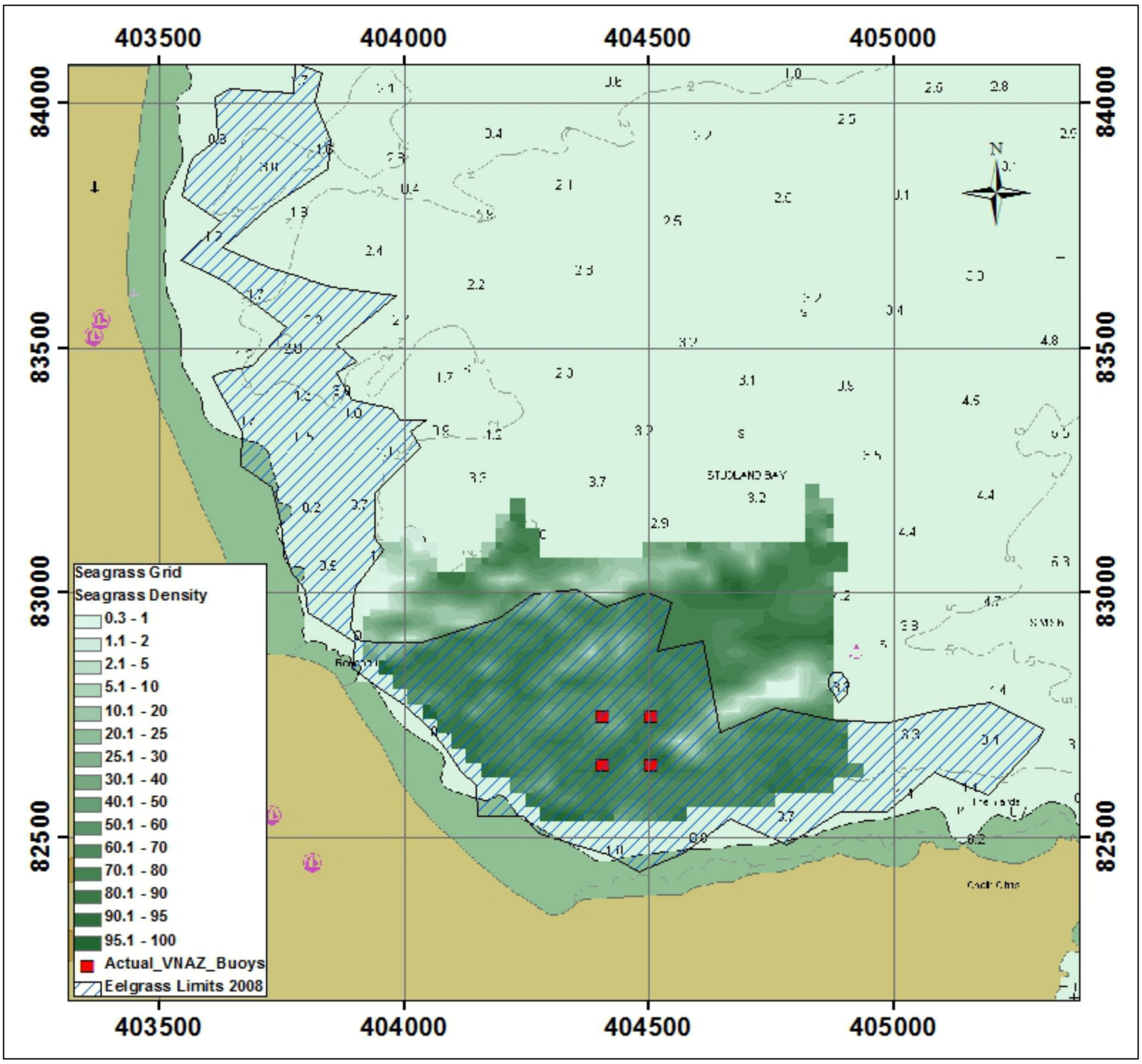
Figure 3.1. Studland Bay seagrass density in 2009 (seagrass density from the study area only) and extent in 2004 (in blue; from Black and Kochanowska, 2004).



Comparison of the 2009 mapping survey with the extent of the Studland seagrass recorded during the 2008 South Studland Survey (in blue) undertaken by Poole Harbour Commissioners (PHC) provides a higher degree of resolution of seagrass extent than was possible from the original bathymetric trace analysis completed in 2004. The seagrass extent derived from the PHC echosounder trace is shown together with the 2009 mapping survey data in figure 3.2 but whether the seagrass habitat has changed in size between 2004 and 2009 is difficult to assess.

A feature of particular note identified in the 2009 mapping survey (see figures 3.1 and 3.2) is the deeper channel immediately east of the VNAZ. This is a natural seabed feature dominated by coarse sediments and the deeper section of the channel was found to be devoid of seagrass. A second similar channel is found just to the north of the first channel but it is less obvious (see figure 3.2). The sedimentary environment in this channel is of mixed nature and there is a sparse seagrass habitat present.

Figure 3.2. Studland Bay seagrass density in 2009 (seagrass density from the study area only) and extent in 2008 (in blue; by Poole Harbour Commissioners).



3.2 Seagrass monitoring dive surveys

The original scope of the works was to undertake a baseline dive survey at the start of the project prior to Easter weekend and the commencement of the main boating season in 2009 and then monitor change at the close of the season with an early autumn dive. A pre and post season monitoring dive would be undertaken during the second year of the survey.

The securing of the necessary statutory consents resulted in a delay before the baseline survey commenced in October 2009. Discussions with Natural England staff and The Crown Estate resulted in a change to the proposed scope to include one additional monitoring dive (ideally be completed mid-season to establish peak seagrass health) and extension of the monitoring into a total of six surveys to ensure data are collected over at least two seasons. A second mid-season dive in 2011 was not considered essential to the objectives of the current study.

To date the following diving surveys have been completed:

- Baseline dive survey: 7, 8 and 12 October 2009;
- First monitoring survey: 7, 8 and 9 April 2010;
- Second monitoring survey: 8, 9 and 10 September 2010;
- Third monitoring survey: 6, 7 and 8 October 2010;
- Fourth monitoring survey: 19, 20 and 21 April 2011; and
- Fifth monitoring survey: 27, 28 and 29 September 2011.

The results of these surveys are recorded in the Dive Survey Logs summarised in appendix 01. A qualitative characterisation of the VNAZ and CTZ is provided in section 3.2.1 and the results of the statistical analysis of the data are discussed in 3.2.3.

3.2.1 Characterisation of the VNAZ / CTZ

Both the VNAZ and CTZ are generally characterised by fairly continuous seagrass cover with occasional patches of bare seabed being rarely more than 2 m across in any direction but instances of 5 m by 5 m patches were recorded. The extent of bare patches of seabed from the baseline onwards (but not at baseline) appears to be higher in the CTZ than the VNAZ, particularly CTZ transects 3, 4 and 5. On occasion a bare patch could be described as a scar (caused by an anchoring boat) as these tended to be deep (c. 20 cm) with obvious recent disturbance (trough with a linear cut).

The cover varied with the highest estimates of percentage cover occurring during the dive baseline survey in October 2009 with cover generally between 50% and 60% but as high as 90%. Characteristically seagrass cover reduced during the winter months and the April 2010 as well as the April 2011 surveys recorded seagrass cover as being generally around 30%. The seagrass cover in September 2010, October 2010 and October 2011 returned to similar values to the dive baseline survey in 2009.

The seabed conditions were generally homogenous being sandy (muddy sand) without areas of mixed sediments or hard ground. For the first 4 monitoring surveys the seabed was even in both the VNAZ and CTZ with little small-scale relief across the areas apart from the odd recent scar. However, the dive monitoring survey in September 2011 did reveal a perceived difference in seabed condition between the VNAZ and CTZ. Whilst the seabed in the VNAZ was smooth and homogenous, the seabed in the CTZ was apparently different being uneven and undulating. These features were relatively small in scale (~10 cm in depth) but sufficiently large to be noticeable and were seen virtually across the entire CTZ.

Characterising species that were regularly encountered in the study areas included (see summary in table 3.1): Snakelock Anemone (*Anemone viridis* - ubiquitous), Lugworm (*Arenicola marina)*, Peacock worm (*Sabella pavonina),* Sand Mason Worm *(Lanice conchilega),* Netted Dog Whelk (*Hinia reticulata)*, Two-spotted Goby (*Gobiusculus flavescens),* Pollock *(Pollachius pollachius),* Corkwing Wrasse *(Crenilabrus melops)* and Goldsinny Wrasse *(Ctenolabrus rupestris).*

In addition to the above, there were occasional sightings of the Harbour Crab *(Liocarcinus depurator)*, the European Spider Crab (*Maja squinado),* the Velvet Swimming Crab *(Necora puber)*, the Shore Crab (C*arcinus maenas),* Razor Shells (*Ensis* spp.), Dragonet (*Callionymus lyra)*, Ballan Wrasse (*Labrus bergylta)* and Syngnathidae (pipefish not seahorses). The range of species present within Studland Bay is more extensive than that recorded during the dive surveys. One explanation for this is that there are areas of hard substrata including boulders present in the bay that are not included within the VNAZ or CTZ. Furthermore, certain species are only observed in particular parts of the bay, exemplified by the Spiny Seahorse (*Hippocampus guttulatus),* which has been encountered at the central inshore fringe of the seagrass. Notably, neither species of seahorse thought to be resident within the bay, was encountered at any time during this project.

Table 3.1. Summary of the taxa recorded at Studland Bay during the dive surveys from October 2009 to October 2011.

Plantae	**Porifera**	**Mollusca**
Rhodophyta sp.	*Suberites* sp. (on shell)	*Rissoa* sp.
Heterosiphonia plumosa	*Leucosolenia* sp.	*Hinia reticulata*
Bonnemaisonia hamifera	**Cnidaria**	*Ensis* sp.
Polysiphonia sp.	*Anemonia viridis*	*Aplysia punctata*
Plocamium cartilagineum	*Kirchenpaueria* sp.	**Bryozoa**
Ceramium sp.	**Polychaeta**	*Bugula* sp.
Audouinella sp.	*Sabella pavonina*	*Electra pilosa*
Callithamnion sp.	*Lanice conchilega*	*Scrupocellaria scruposa*
Asparagopsis armata	*Arenicola marina*	*Celleporella hyalina*
Callithamniaceae sp.	*Spirorbis* sp.	**Fish**
Phaeophyceae sp.	**Crustacea**	*Pomatoschistus* sp.
Dictyota dichotoma	*Necora puber*	*Gobiusculus flavescens*
Desmarestia sp.	Amphipoda tubes (on fronds)	*Callionymus lyra*
Saccharina latissima	*Atylus* sp.	Blenniidae sp.
Chlorophyta sp.	*Caprella acanthifera*	*Syngnathus acus*
Ulva sp.	Corystes cassivelaunus	*Symphodus (Crenilabrus) melops*
Cladophora spp.	*Palaemon* sp.	*Centrolabrus rupestris*
	Maja squinado	*Trisopterus luscus*
	Majidae sp.	*Pollachius pollachius*

Some inter-survey variation was also noted where the spiny spider crab (*Maja squinado*) was common (C on the SACFOR scale; see Connor *et al*., 2004) in May 2009 it has not been seen in large numbers since then (recorded as Rare or Occasional; see Connor *et al*., 2004). Cuttlefish (*Sepia officinalis*) and cuttlefish eggs were common in April 2010 and April 2011 but have not been seen at other times.

In September 2010 juvenile Netted Dog whelks were highly abundant, a feature not seen in 2011 (although note that the survey in 2011 was at a slightly different time of the month because of unfavourable weather conditions).

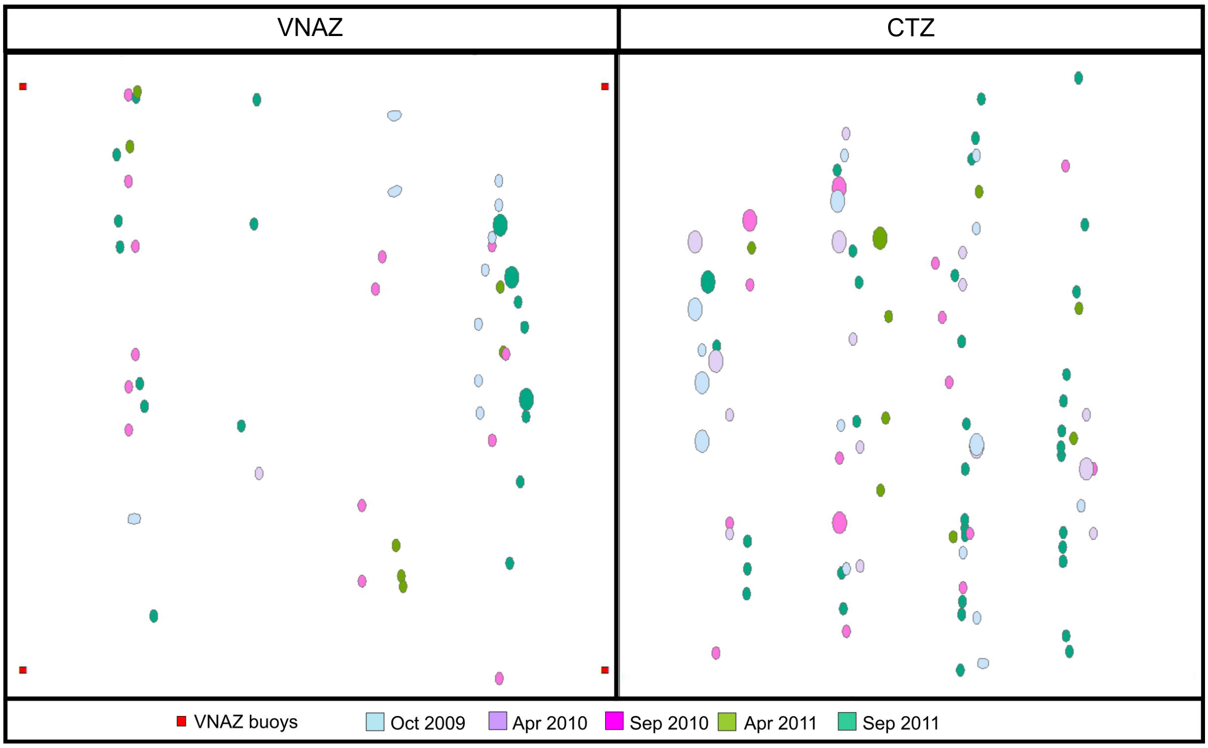
The principal characterising algal species, apart from *Zostera marina*, recorded during the dive surveys included (see summary in table 3.1): Sea Lettuce (*Ulva* spp.), Forkweed (*Dictyota dichotoma), Cladophora* spp., Siphoned Feather Weed *(Heterosiphonia plumosa),* Black Beard Algae *(Audouinella sp.), Plocamium cartilagineum* and *Callithamnion* spp.

Algal cover varied considerably between the different survey periods but these data were only estimated (appendix 01) and not measured quantitatively. In October 2009 the summer bloom had persisted to some degree but early autumn storms had caused wash up of algae upon Studland beach. A fairly extensive cover of *Cladophora* spp. was evident during the summer months in both 2010 and 2011 but also particularly evident during the spring (April) of 2011. During April 2010, however, algal cover was smaller in comparison, a cover believed to be more typically associated the spring period following the winter die back.

3.2.2 Analysis of the patches of exposed sediment within the seagrass bed

The notes made regarding any exposed patches of seabed within the VNAZ and CTZ during the dive surveys have been added as layers (see figure 3.3) within the GIS project. The patches varied in shape and size but were classified as small (≤ 2 m in any direction) and large (>2 m in any direction) indicated by the two different sized shapes in the figure. The positions of any exposed seabed were estimated from the pre-marked guide-rope laid prior to commencing the dive surveys (survey covering the area around the pre-determined transects only), making all these positions approximate. The actual size of the patches were estimated and recorded but only if part of the patch was found within 1 m either side of the guide rope. Of note is also that unattached seaweed covered exposed sections of seabed (particularly in the spring of 2011) making this aspect of the survey work challenging.

Figure 3.3. Areas of exposed seabed (estimates) in the seagrass habitat in the VNAZ and CTZ at Studland Bay *(NB. overlaps occur on a number of occasions).*



At the onset of the project (the 2009 mapping survey and the baseline dive survey) the qualitative data collected suggested little difference between the two zones overall with healthy seagrass, even sedimentary conditions and a similar number of patches across the two zones. However, the dive monitoring surveys from 2010 (along the pre-laid transects) suggested slightly higher number of patches in the CTZ compared to the VNAZ (supported by results in figure 3.3) but note that these records are rough estimates and focused on areas around the pre-laid dive survey lines.

Of particular note is that overall (from 2009 to 2011) the analysis of the patches illustrated in figure 3.3 resulted in a lower number of patches in the centre of the VNAZ (around buoys C1 and C2) compared to the centre of the CTZ. This suggests the presence of buoys C1 and C2 may have discouraged anchoring in this part of the zone. There are also a relatively large number of patches in the eastern section of the VNAZ.

Within the CTZ patches are present throughout. Of particular note are the several large patches in the western and north-western sections of the zone.

Some of the patches within both the VNAZ and CTZ were recorded several times (i.e. in the same position on different survey occasions) but overall there is inconsistency in the positions of patches between surveys. This is most likely a result of subjectivity among surveyors in deciding the positions of the patches. This could potentially be rectified by marking the guide-ropes at one metre intervals with a suitable marking system but issues with estimating patch size and exact location may still persist.

3.2.3 Results of the statistical analyses from the monitoring survey data

The statistical analyses below are based on data collected over a two-year period. As with many studies additional survey data (collected over a longer time period) with the associated analyses would allow further and potentially more substantive conclusions to be made, particularly as any differences between natural variability and potential anthropogenic effects are more likely to be evident over a longer study period (see e.g. Hiscock, 1998).

3.2.3.1 Seagrass shoot density

The mean shoot density counts from the VNAZ and CTZ over time can be seen in figure 3.4. There was a significant difference in seagrass shoot density at each of the different sampling times in the VNAZ (H = 22.867 with 5 d.f.; P <0.001) and the CTZ (H = 28.036 with 5 d.f.; P <0.001). There is therefore a significant difference within both the VNAZ and CTZ over time.

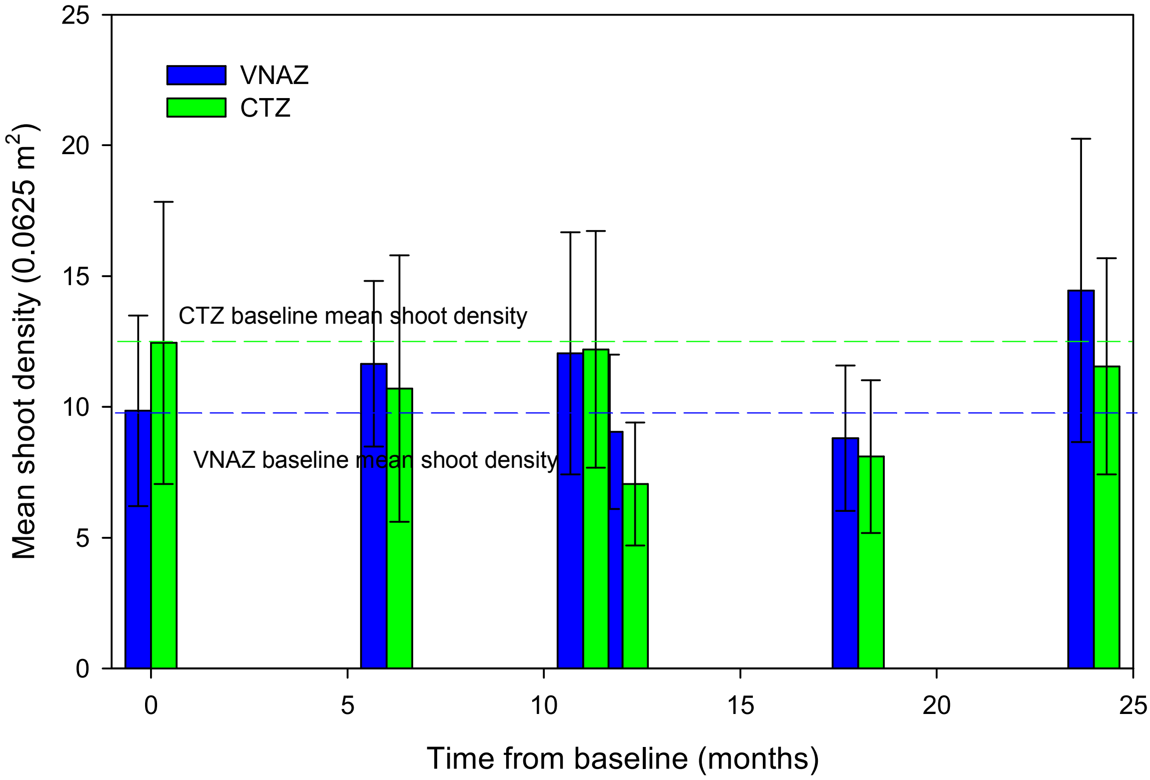
Table 3.2 summarises the comparative tests between the VNAZ and CTZ at each time period (between zones tests). The only significant difference between the mean shoot density in VNAZ and CTZ occurred in October 2010 (t = 2.373 with 38 d.f.; P <0.05).

Table 3.2. Statistical test results for differences in average shoot density counts between the VNAZ and CTZ at each time period (ns = not significant).

VNAZ vs CTZ	Test	Result	Significance
Oct-09	Mann-Whitney *U* test	*U* = 117	ns
Apr-10	*t*-test	*t* = -0.708, 38 d.f.	ns
Sep-10	*t*-test	*t* = -0.104, 38 d.f.	ns
Oct-10	*t*-test	*t* = 2.373, 38 d.f.	*P* <0.05
Apr-11	Mann-Whitney *U* test	*U* = 156.5	ns
Oct-11	Mann-Whitney *U* test	*U* = 153.000	ns

Although the statistical tests showed that shoot density varied significantly in the VNAZ and CTZ over time, the mean shoot density does not appear to follow a seasonal cycle. Shoot densities appeared to be relatively similar to data from the previous sampling period, but with a reduction in shoot density shown in both the VNAZ and CTZ from September 2010 to October 2010. The two sampling periods after October 2010 show an increase in shoot density back to values comparable to September 2010 by October 2011. This temporal change is mapped in both the VNAZ and CTZ, suggesting that an environmental disturbance on a larger scale than either of the zones may have been responsible for the reduction in shoot density (e.g. storm events or other physical disturbance). However, other factors (e.g. increased but equal levels of anchoring within the both zones or sampling variability) may also be responsible for this pattern.

Figure 3.4. Mean shoot density over time at Studland Bay in the VNAZ and CTZ (error bars ± 1 SD).



The frequency distributions for the VNAZ shoot density counts (figure 3.5) were not significantly different from each other (table 3.3), apart from data sampled from April 2010 and April 2011 ($P < 0.05$), and between October 2011 and October 2010 and April 2011 ($P < 0.05$ in both cases). The frequency distributions of the shoot density counts from the CTZ showed some significant differences, summarised in table 3.4. The distribution of shoot density counts in October 2010 was significantly different from all of the other time periods, except April 2011. Likewise, the shoot density distribution in April 2011 was also significantly different from all of the other time periods, except October 2010.

Table 3.3. Kolmogorov-Smirnov test results for differences in VNAZ shoot density count frequency distributions from different time periods (within zone tests).

VNAZ	Oct-09	Apr-10	Sep-10	Oct-10	Apr-11	Oct-11
Oct-09	-	-	-	-	-	-
Apr-10	ns	-	-	-	-	-
Sep-10	ns	ns	-	-	-	-
Oct-10	ns	ns	ns	-	-	-
Apr-11	ns	P <0.05	ns	ns	-	-
Oct-11	ns	P <0.05	ns	P <0.05	ns	-

Table 3.4. Kolmogorov-Smirnov test results for differences in CTZ shoot density count frequency distributions from different time periods (within zone tests).

CTZ	Oct-09	Apr-10	Sep-10	Oct-10	Apr-11	Oct-11
Oct-09	-	-	-	-	-	-
Apr-10	ns	-	-	-	-	-
Sep-10	ns	ns	-	-	-	-
Oct-10	P <0.001	P <0.01	P <0.001	-	-	-
Apr-11	P <0.001	P <0.05	P <0.01	ns	-	-
Oct-11	ns	ns	ns	P <0.01	P <0.05	-

When comparing the size frequency distributions (figure 3.5) of the shoot density counts from the CTZ and VNAZ at each sampling period (table 3.5), the only significant difference was from October 2009 ($P < 0.05$).

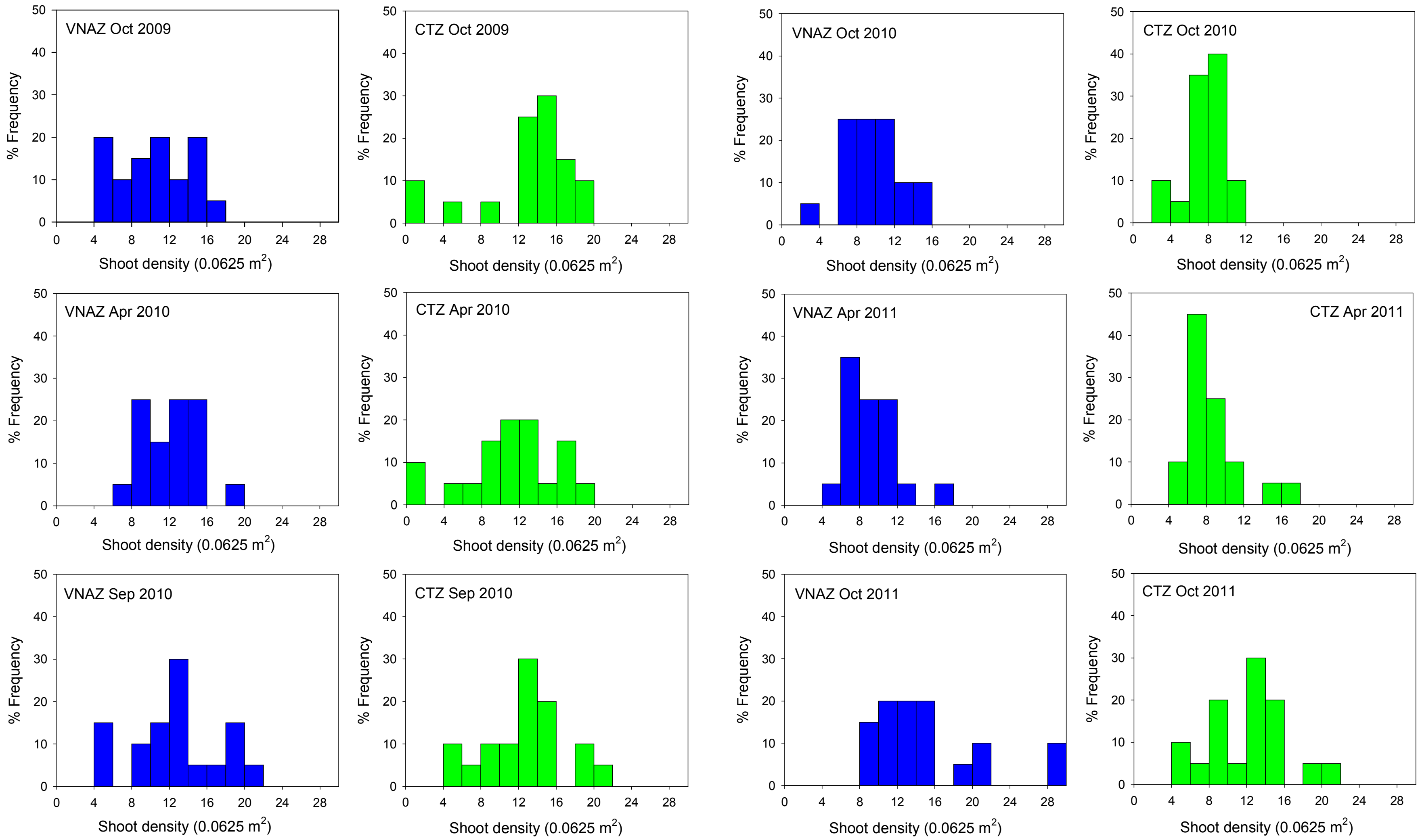
Table 3.5. Kolmogorov-Smirnov test results for differences in shoot density count frequency distributions between the VNAZ and CTZ at each time period (between zones tests).

VNAZ vs CTZ	Significance
Oct-09	P <0.05
Apr-10	ns
Sep-10	ns
Oct-10	ns
Apr-11	ns
Oct-11	ns

The frequency distributions of the shoot density counts can be seen in figure 3.5. The distributions in the VNAZ and CTZ appear to follow the same patterns of change over time, with shifts in the peak distributions matched in both zones. These temporal shifts in distribution appear to be different from a seasonal pattern, as the distributions from April 2010 and 2011 were not very similar (significantly different in the VNAZ and CTZ). Likewise, the distributions from October 2010 and October 2009 and 2011 were not very similar. This suggests the shoot density may be less influenced by seasonal changes, but may respond more to other environmental factors. There were strong storms in the autumn of 2010 that may have damaged the seagrass beds, potentially reducing shoot density between September 2010 and October 2010. The lower shoot density values from April 2011 could represent the lack of seagrass recovery from the storm damage caused the previous year.

As a final point note that although the statistical results do not show a consistent significant difference between the VNAZ and the CTZ there is a trend of increasing differences in shoot density between the two zones (see figures 3.4 and 3.5).

Figure 3.5. Size frequency distributions of shoot density counts for each sampling period in the VNAZ and CTZ, October 2009 to October 2011.



3.2.3.2 Percentage seagrass cover

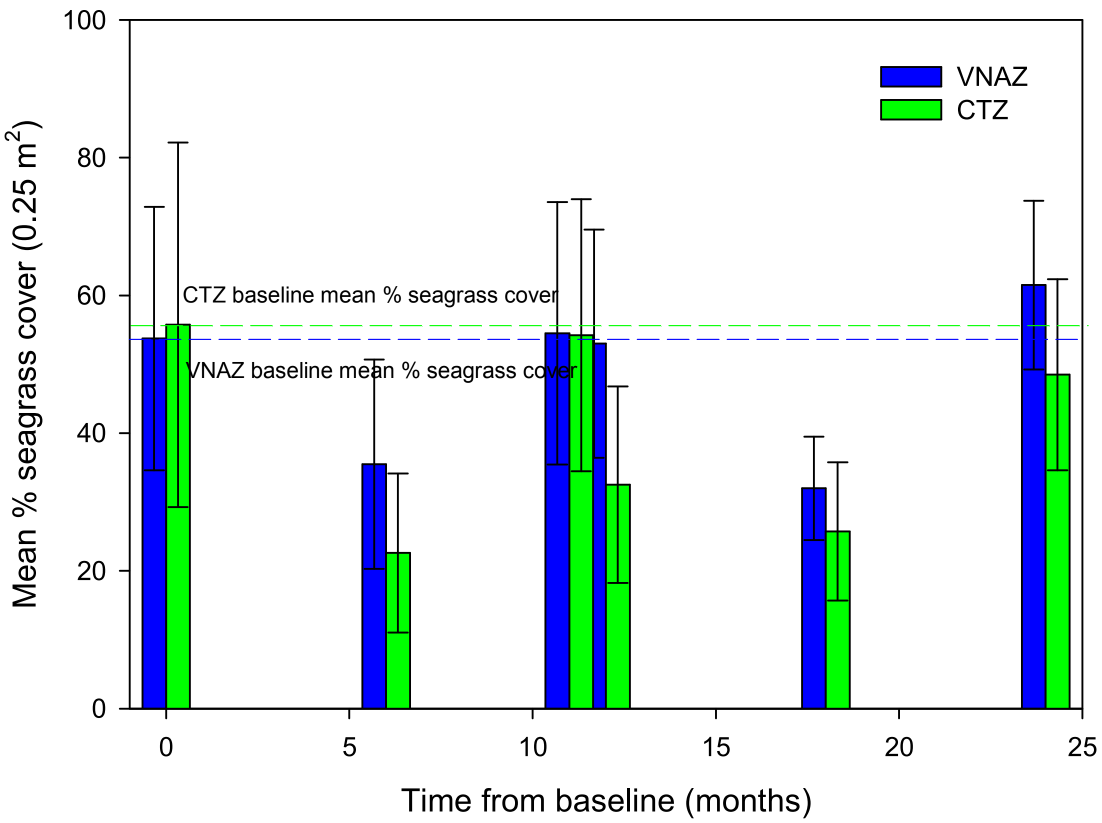
There was a significant difference between the percentage seagrass cover from the VNAZ (H = 40.112 with 5 d.f.; P <0.001) and CTZ (H = 48.328 with 5 d.f.; P <0.001) over time. Table 3.6 summarises the comparative tests between the VNAZ and CTZ at each time period. There were significant differences between the median percentage seagrass cover in the VNAZ and CTZ in all time periods, except for October 2009 and September 2010.

Table 3.6. Statistical test results for differences in average percentage seagrass cover between the VNAZ and CTZ at each time period (ns = not significant).

VNAZ vs CTZ	Test	Result	Significance
Oct-09	Mann-Whitney *U* test	U = 174.00	ns
Apr-10	Mann-Whitney *U* test	U = 101.5	*P* <0.01
Sep-10	Mann-Whitney *U* test	U = 197	ns
Oct-10	Mann-Whitney *U* test	U = 66	*P* <0.001
Apr-11	Mann-Whitney *U* test	U = 121.5	*P* <0.05
Oct-11	Mann-Whitney *U* test	U = 91.000	*P* = 0.001

Mean percentage seagrass cover was between 5-15 % lower in the CTZ than the VNAZ in April 2010, October 2010, April 2011 and October 2011. In October 2009 and September 2010 mean percentage seagrass cover was comparable between the VNAZ and CTZ (figure 3.6). The VNAZ appears to exhibit a seasonal trend, with higher mean percentage seagrass cover in September/October compared to April. This appears to be matched in the CTZ, apart from a low mean percentage seagrass cover from October 2010.

Figure 3.6. Mean percentage seagrass cover over time at Studland Bay in the VNAZ and CTZ (error bars ± 1 SD).



The size frequency distributions (figure 3.6) also highlight a seasonal signal in the size frequency distributions of the percentage seagrass cover. In the VNAZ, the distribution of seagrass cover from October 2009, September 2010, October 2010 and October 2011 do not differ significantly from each other, but are significantly different from April 2010 and April 2011, which in turn do not have significantly different distributions from each other (table 3.7). A similar pattern could be seen in the CTZ, although the percentage cover distribution from October 2010 was significantly different from October 2009 and September 2010, but not from April in 2010 and 2011 (table 3.8). In addition, October 2011 had a significantly different distribution from all other time periods except September 2010. There was no significant difference between the differences of the distributions from the VNAZ and CTZ, apart from in October 2010 and October 2011 (table 3.9; see also figure 3.7).

Table 3.7. Kolmogorov-Smirnov test results for differences in VNAZ percentage seagrass cover size frequency distributions from different time periods (within zone tests).

VNAZ	Oct-09	Apr-10	Sep-10	Oct-10	Apr-11	Oct-11
Oct-09	-	-	-	-	-	-
Apr-10	$P < 0.05$	-	-	-	-	-
Sep-10	ns	$P < 0.05$	-	-	-	-
Oct-10	ns	ns	ns	-	-	-
Apr-11	$P < 0.001$	ns	$P < 0.01$	$P < 0.001$	-	-
Oct-11	ns	$P < 0.01$	ns	ns	$P < 0.001$	-

Table 3.8. Kolmogorov-Smirnov test results for differences in CTZ percentage seagrass cover size frequency distributions from different time periods (within zone tests).

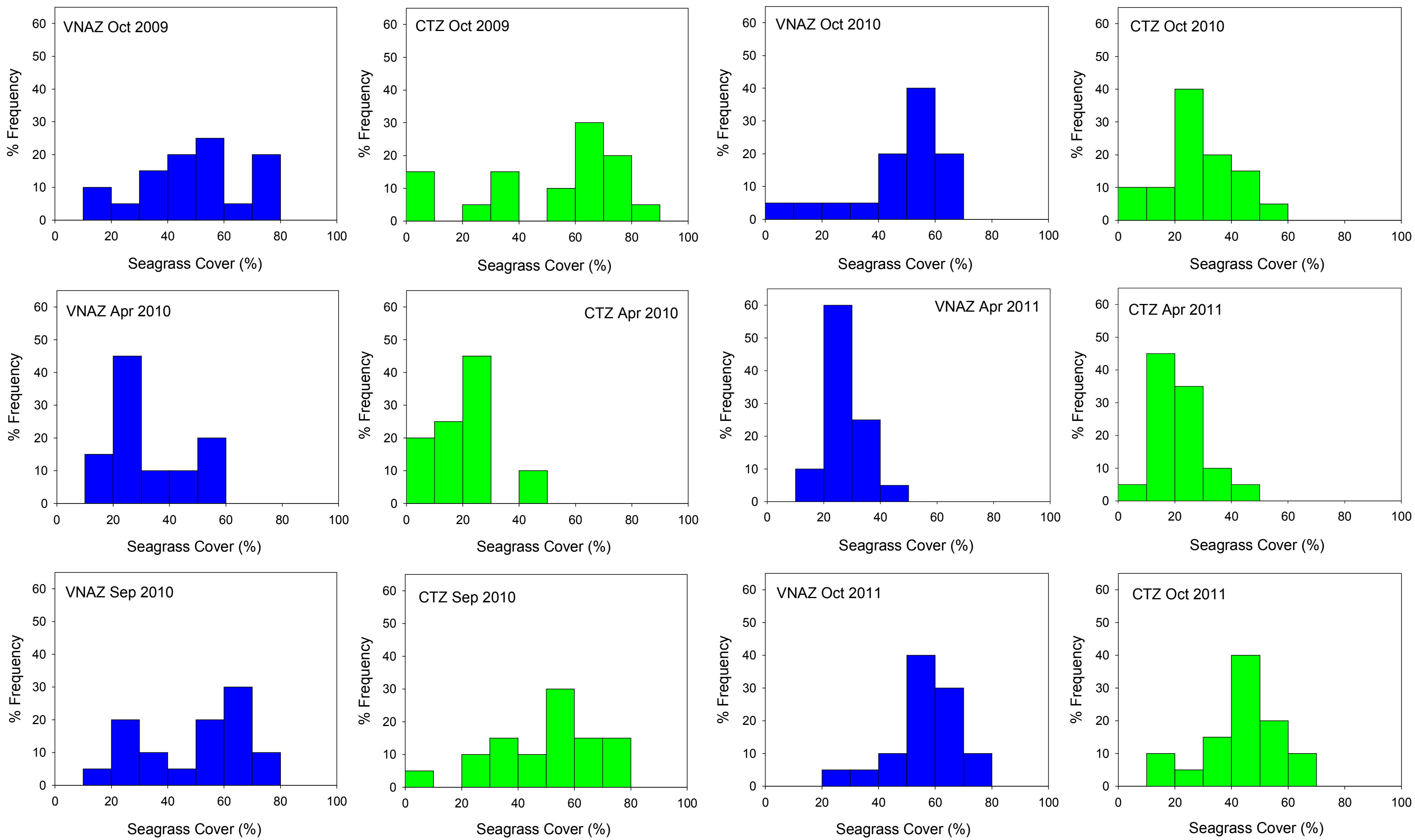
CTZ	Oct-09	Apr-10	Sep-10	Oct-10	Apr-11	Oct-11
Oct-09	-	-	-	-	-	-
Apr-10	$P < 0.001$	-	-	-	-	-
Sep-10	ns	$P < 0.001$	-	-	-	-
Oct-10	$P < 0.01$	ns	$P < 0.01$	-	-	-
Apr-11	$P < 0.01$	ns	$P < 0.01$	ns	-	-
Oct-11	$P < 0.05$	$P < 0.001$	ns	$P < 0.05$	$P < 0.001$	-

Table 3.9. Kolmogorov-Smirnov test results for differences in percentage seagrass cover size frequency distributions between the VNAZ and CTZ at each time period (between zones tests).

VNAZ vs CTZ	Significance
Oct-09	ns
Apr-10	ns
Sep-10	ns
Oct-10	$P < 0.01$
Apr-11	ns
Oct-11	$P < 0.05$

The distributions of percentage seagrass cover in the VNAZ and CTZ at each sampling period can be seen in figure 3.6. The distributions from the VNAZ and CTZ appear to follow the same patterns over time, with higher proportions of the larger % seagrass cover size classes seen in October/ September compared to April regardless of the year sampled.

Figure 3.7. Size frequency distributions of percentage seagrass cover for each sampling period in the VNAZ and CTZ, October 2009 to October 2011.



3.2.3.3 Seagrass frond length

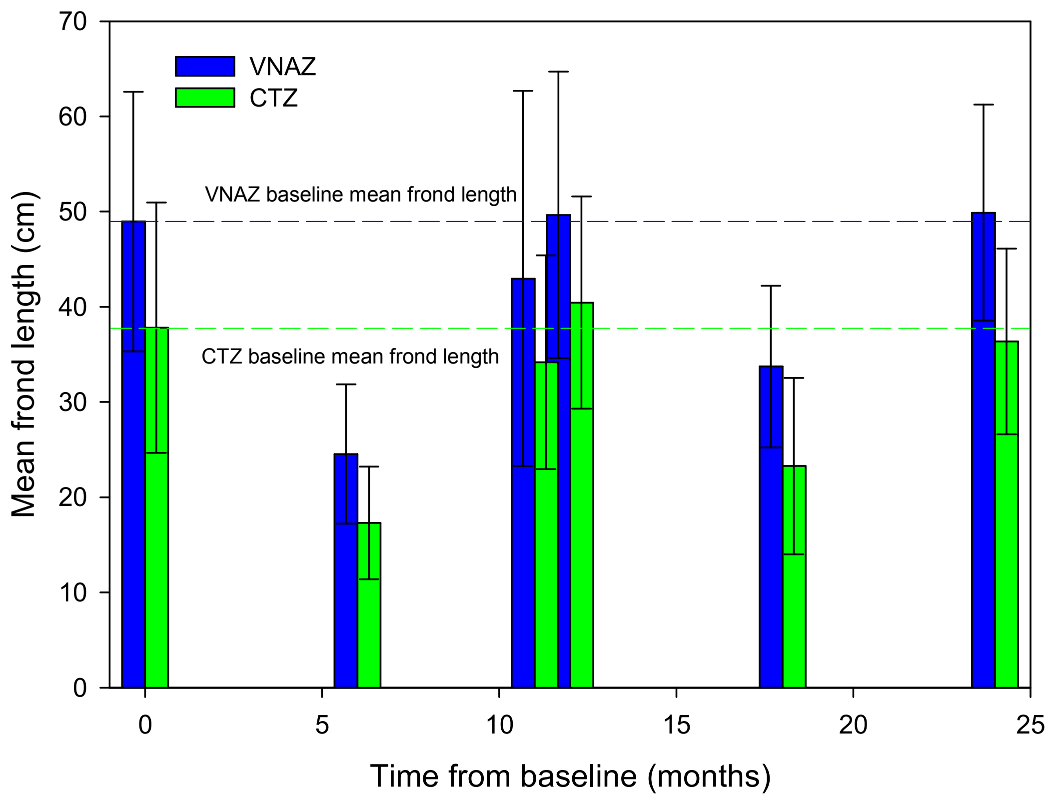
There was a significant difference between the seagrass frond length from the VNAZ (H = 216.962 with 5 d.f.; P <0.001) and CTZ (H = 247.181 with 5 d.f.; P <0.001) over time. Table 3.10 summarises the comparative tests between the VNAZ and CTZ at each time period. There were significant differences between the average seagrass frond length in the VNAZ and CTZ (within zone tests) in all time periods (seasonal).

Table 3.10. Statistical test results for differences in average seagrass frond length between the VNAZ and CTZ at each time period (ns = not significant).

VNAZ vs CTZ	Test	Result	Significance
Oct-09	*t*-test	*t* = 5.882, 198 d.f.	*P* <0.001
Apr-10	Mann-Whitney *U* test	*U* = 1969.500	*P* <0.001
Sep-10	Mann-Whitney *U* test	*U* = 3649.500	*P* = 0.001
Oct-10	Mann-Whitney *U* test	*U* = 2781.000	*P* <0.001
Apr-11	*t*-test	*t* = 8.329, 198 d.f.	*P* <0.001
Oct-11	*t*-test	*t* = 9.029, 198 d.f.	*P* <0.001

Seagrass frond length appeared to exhibit a seasonal signal. Mean frond length was higher in October 2009, September 2010, October 2010 and October 2011 compared to April 2010 and 2011 (figure 3.8). Mean frond length appeared to reach a maximum in October, declining to April, before increasing again in length to October. The differences between the CTZ and VNAZ appeared to be relatively consistent over time, with about a 7 – 10 cm difference in mean frond length between the two zones. This difference is most likely linked to the slight difference in overall depth between the two zones.

Figure 3.8. Mean seagrass frond length over time at Studland Bay in the VNAZ and CTZ (error bars ± 1 SD).



The size frequency distributions (figure 3.9) of seagrass frond length were generally significantly different from each other. The only exceptions were between the three October sampling dates in VNAZ, where the size frequency distributions were not significantly different. In the CTZ the only non-significant differences were between the size frequency distribution of October 2009 compared to September 2010, October 2010 and October 2011, and between September 2010 and October 2011 (tables 3.11 and 3.12). The size frequency distributions of seagrass frond length were significantly different between the VNAZ and CTZ at every time period sampled (P <0.001) (table 3.13).

Table 3.11. Kolmogorov-Smirnov test results for differences in VNAZ seagrass frond length size frequency distributions from different time periods (within zone tests).

VNAZ	Oct-09	Apr-10	Sep-10	Oct-10	Apr-11	Oct-11
Oct-09	-	-	-	-	-	-
Apr-10	*P* <0.001	-	-	-	-	-
Sep-10	*P* <0.01	*P* <0.001	-	-	-	-
Oct-10	ns	*P* <0.001	*P* <0.01	-	-	-
Apr-11	*P* <0.001	*P* <0.001	*P* <0.001	*P* <0.001	-	-
Oct-11	ns	*P* <0.001	*P* <0.001	ns	*P* <0.001	-

Table 3.12. Kolmogorov-Smirnov test results for differences in CTZ seagrass frond length size frequency distributions from different time periods (within zone tests).

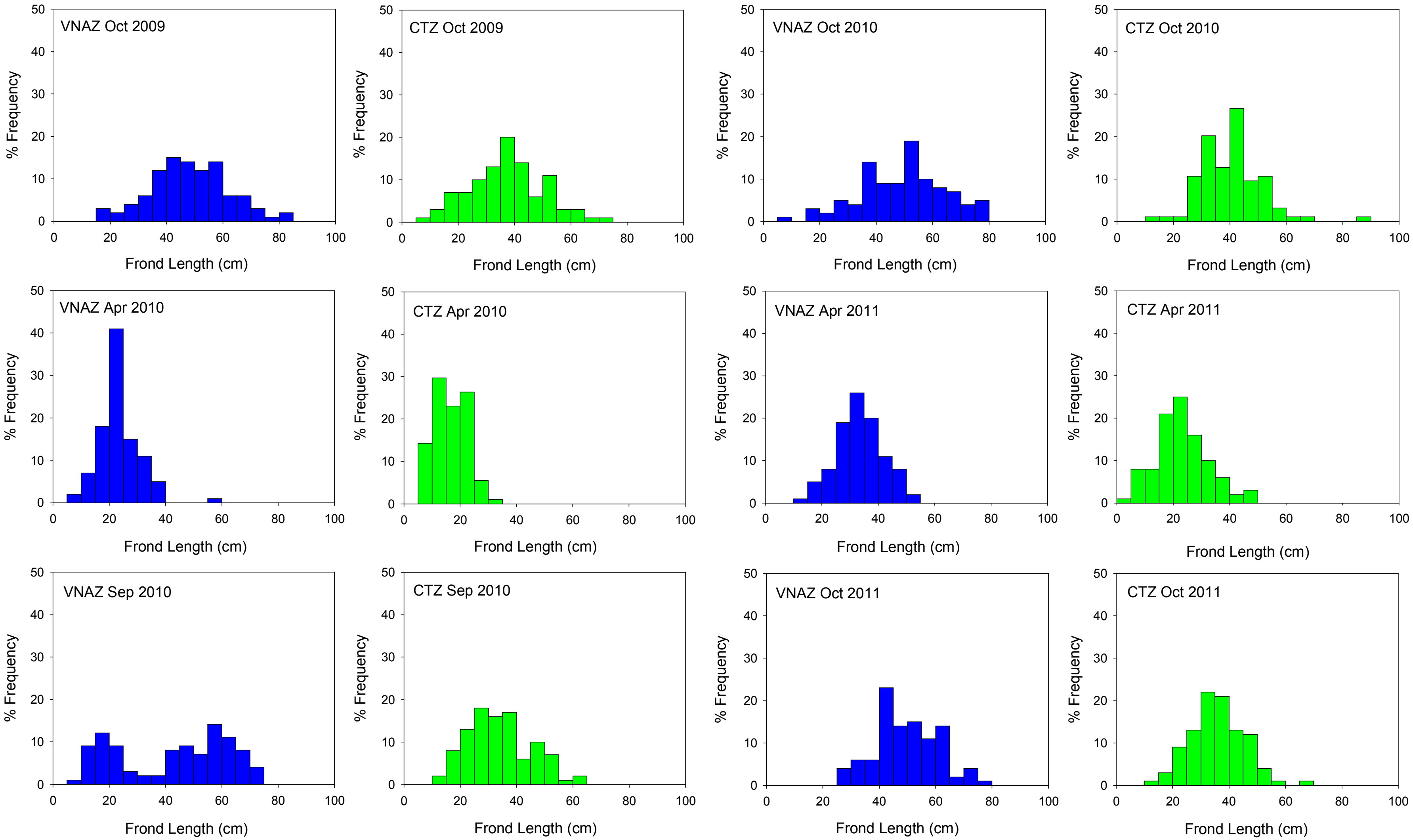
CTZ	Oct-09	Apr-10	Sep-10	Oct-10	Apr-11	Oct-11
Oct-09	-	-	-	-	-	-
Apr-10	*P* <0.001	-	-	-	-	-
Sep-10	ns	*P* <0.001	-	-	-	-
Oct-10	ns	*P* <0.001	*P* <0.01	-	-	-
Apr-11	*P* <0.001	*P* <0.001	*P* <0.001	*P* <0.001	-	-
Oct-11	ns	*P* <0.001	ns	*P* <0.05	*P* <0.001	-

Table 3.13. Kolmogorov-Smirnov test results for differences in seagrass frond length size frequency distributions between the VNAZ and CTZ at each time period (between zones tests).

VNAZ vs CTZ	Significance
Oct-09	*P* <0.001
Apr-10	*P* <0.001
Sep-10	*P* <0.001
Oct-10	*P* <0.001
Apr-11	*P* <0.001
Oct-11	*P* <0.001

The size frequency distributions of seagrass frond length are shown in figure 3.9. Although the VNAZ and CTZ distributions are significantly different at each time period (most likely linked to the subtle difference in depth between the two zones), the distributions shift in the same patterns over time. In general the VNAZ had a greater range of seagrass frond lengths, and higher frequencies of the larger size classes compared to the CTZ. There appeared to a seasonal signal, with a broader range of frond length in October and September. In April, the majority of frond lengths were less than 40 cm long, whereas in the other sampling dates the majority of frond lengths were greater than 40 cm in length.

Figure 3.9. Size frequency distributions of seagrass frond length for each sampling period in the VNAZ and CTZ, October 2009 to October 2011.



3.3 Seagrass reproducing by seed production at Studland Bay

The understanding of the biology of seagrass habitats in the UK is improving but there is still a lack of publications relating to the understanding of seagrass seeding and germination success in UK waters. This knowledge is fundamental to any assessments or studies into potential threats, damage and recovery of seagrass habitats in the UK. The current study is not aimed at resolving this issue but some of the recorded data may improve the current knowledge base overall and illustrate some of the natural variability in Studland Bay in particular.

Since the onset of the project, and particularly since the introduction of the VNAZ moorings and buoys, six dive surveys and a number of additional visits to the bay involving diving have been required. These latter visits have been recreational or involved replacing and inspecting the buoys as well as the mooring lines. In terms of the seagrass habitat most of these visits have not revealed anything unusual. However, on two occasions (29 May 2009 and 29 June 2011) the seagrass in the VNAZ were shown to be seeding (see figure 3.10). This is a significant discovery as *Z. marina* at northern latitudes are generally believed to reproduce almost completely as a result of vegetative growth rather than by seed production (see further details above and Davison and Hughes, 1998).

The relative importance of various environmental parameters in controlling seed production remains unclear but seawater temperatures of 15 °C, or more, are generally believed to be required for flowering and seed germination in *Z. marina* (e.g. Setchell, 1929; Yonge, 1949). There are no available long-term seawater temperature data records for Studland Bay. In addition, there are no available records of seeding seagrass in the bay. At this stage it is therefore not possible to assess whether seed production is an annual (or even possibly bi-annual) event at Studland Bay, if germination of the seeds is successful or if there are any links between seeding (or germination) and temperature. However, the temperatures recorded during the monitoring surveys (table 3.14) in the bay together with the CEFAS temperature records from Bournemouth (CEFAS, 2011) suggest that seeding could be a regular feature in the bay, and therefore important in terms of seagrass recolonisation or recovery.

Table 3.14. Seawater temperature in the VNAZ (records from dive computers) and off Bournemouth (CEFAS data).

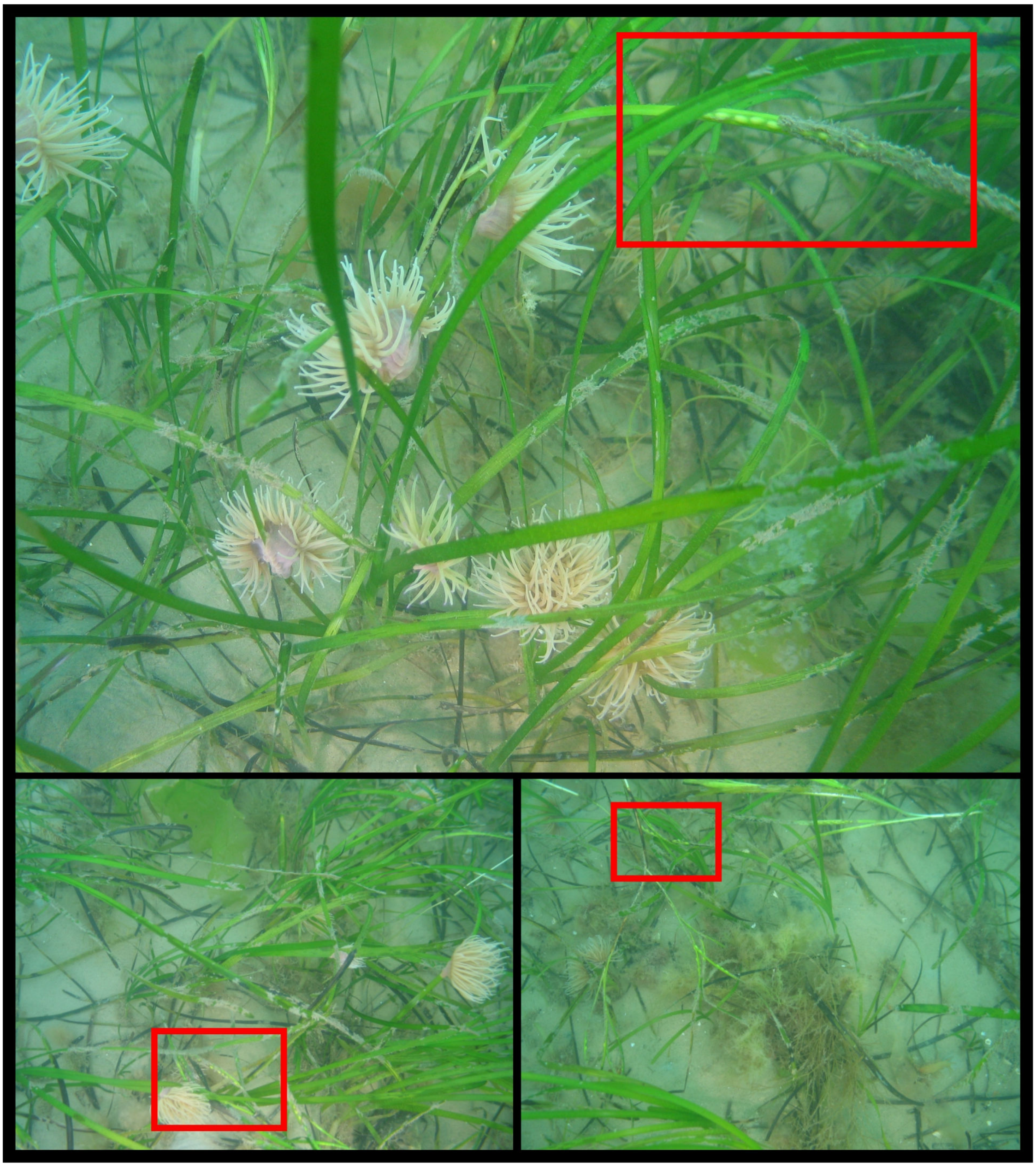
Survey	**Date**	**Sea water temperature** (°C)	
		VNAZ *	Bournemouth ^
Baseline Survey	7-12 Oct 2009	14 – 15 °C	14 °C
First monitoring survey	7-9 April 2010	-	8 °C
Second monitoring survey	8-10 Sept 2010	17-19 °C	17 °C
Third monitoring survey	6-8 Oct 2010	16-17 °C	15 °C
Fourth monitoring survey	19-21 April 2011	11-12 °C	8 °C
Fifth monitoring survey	27-29 Sept 2011	17 °C	17 °C

* Recorded on dive computers during a dive in the VNAZ (range of temperatures during the days in the field).
^ Seawater temperature as recorded by CEFAS off Bournemouth (CEFAS, 2011).

The evidence to date suggests seeding to occur in late May and June when the temperature ranges from 13 to 16 °C (CEFAS, 2011). Unfortunately CEFAS stopped recording temperatures off Bournemouth in 2008 so comparable records between the current study and the CEFAS data are not available. However, due to the sheltered nature of Studland Bay, seawater temperatures may be higher in the bay compared to the areas surrounding Bournemouth (see table 3.14 and CEFAS long-term temperature data; CEFAS, 2011). The seawater temperature may therefore regularly reach 15-16 °C at Studland Bay in May and June. In addition, the seawater temperatures in the autumn regularly reach 17 °C, or more.

Despite the short duration of the current study (2 years) the current evidence of seeding and the ranges of temperature in the bay suggest that seed production may be an important factor both in spring and during the autumn at Studland Bay. However, long-term monitoring of both abiotic parameters and the occurrence of seeding would be required to fully establish whether this is the case or not and allow a full assessment of the potential factors influencing seeding and the success of germination.

Figure 3.10. Seeding seagrass at Studland Bay in June 2011 (also occurred in May 2009).



3.4 Boat monitoring survey

Analysis of the boat monitoring data is not currently part of the scope of works for this project to date and detailed analysis has therefore not been undertaken. However, a brief review of the data indicates that observance of the VNAZ has been ‘good’ (on a four-point rating scale as follows: 1 – very poor (>15 anchoring events/month); 2 – poor (8-15 events/month); 3 – good (4-7 events/month); and 4 – very good (0-3 events/month)) considering the size of the VNAZ in relation to the rest of the bay, the space available for visiting vessels and the large quantity of vessels visiting the bay on a busy day (see table 3.15). On occasion there have been several vessels in the VNAZ, particularly during the height of season exemplified by Sunday 26th June 2010 when there were 13 different vessels visiting and anchoring within the VNAZ. However, this was a particularly busy day and a total of 178 boats visited the southwest corner of the bay that day resulting in limited space available for anchoring.

The boat monitoring photographs have only been briefly analysed in an attempt to ascertain any differences in use between the two zones. Additional detailed analysis of the boat monitoring data (e.g. georeference the boundaries of the two zones and the positions of the vessels in the photographs to allow more exact assessments of the level of anchoring in the two zones) would therefore be beneficial to the project to allow assessing the difference in the levels of anchoring in the two zones and relate this detailed information to the statistical analysis of the seagrass parameters measured during the dive surveys.

The data and the observations analysed to date suggest that most boats would arrive in the bay, put the anchor down and stay for most of the day. Overall anchoring in the VNAZ was lower in 2011 compared to 2010 both in terms of actual events but also as a proportion between the two zones (0.22 in 2010 and 0.07 in 2011), although the total number of events in 2011 was also lower overall. In addition, the total number of anchoring events per day in the CTZ was the same in 2010 and 2011 but there was a reduction in the number of events in the VNAZ from 2010 to 2011.

These results are believed to be a reflection of an increased acceptance and awareness of the VNAZ project among boat users but also as the VNAZ remained intact for most of 2011 making it easier to identify the zone (N.B. the VNAZ marker buoys moved or disappeared on a number of occasions in 2010 but only once (mooring rope believed to have been cut) in 2011). As the use (i.e. anchoring) of the VNAZ affects the scientific objective of the trial, to some extent, in that the VNAZ is being impacted, albeit to a lesser degree than the CTZ, continued monitoring of the two zones would be beneficial in terms of achieving the objectives of this study.

Table 3.15. Relative use of the VNAZ and CTZ in terms of anchoring (number of anchoring events in each zone during the boat monitoring survey).

	2010	2011
CTZ	244	115
VNAZ	54	8

4 DISCUSSION

4.1 General observations

4.1.1 The introduction of a Voluntary No Anchor Zone

The introduction of the VNAZ has been scrutinized closely by the stakeholders that have an interest in the outcome of this project. From the outset, the introduction of the VNAZ has been controversial perhaps because of fears on the part of the boating community that it is a pre-cursor to a blanket ban on casual anchoring within the bay. The marker buoys moved on several occasions during the first two years (2009 and 2010) in particular and there have been instances of interference with the VNAZ marker buoys with evidence that on one occasion the elasticated eco-riser, which connects the Helix screw-in anchor to the marker buoy, was believed to have been cut with a knife.

Notwithstanding the interference with the trial, there has been an increasing observance of the VNAZ with time. This is to be expected both because it takes time for new arrangements to be understood by the majority of users and because conformity to the new arrangements will increase commensurately as growing numbers of visitors observe the voluntary no anchoring zone. It has to be remembered, however, that it is a voluntary measure and, as such, 100% observance is not guaranteed. In addition, the popularity of the bay together with the relatively limited space available for anchoring boats makes a voluntary measure difficult, particularly at the height of the summer season and during Bank Holidays.

Increased observance of the VNAZ with time would improve the study in terms of the results of the statistical tests used as any potential effects of anchoring on seagrass is more likely to be detectable if the anchoring continues in the CTZ and ceases in the VNAZ. As observance currently is improving, an increase in the length of the study is therefore likely to improve the statistical results and the outcome of the study.

4.1.2 The positioning of the Voluntary No Anchor Zone

The data from the mapping survey (see Plastow, 2009) was used to establish the positions of the VNAZ and CTZ ensuring the seagrass percentage cover and environmental parameters (such as depth and sediment grain size) and anchoring levels were the same in both zones (as far as possible). These three criteria were set within the confines of certain other but less important parameters including avoiding any interference with the permanent moorings (and vessels using these moorings) and avoiding the coarse sediments to the east (devoid of seagrass). Ultimately all these factors restricted the choice of areas suitable for the VNAZ and the CTZ but after two years of boat monitoring and survey work the choice of the positions of these two zones have been shown to be justified.

4.1.3 Scientific community participation

Since the onset of this study several attempts have been made to encourage the involvement of individuals and organisations (e.g. The Seahorse Trust and some members of the scientific community) to contribute to this study for the greater good of the project as well as the fauna, flora and habitats in Studland Bay but to date any such attempts have been turned down. Relatively little is known about the potential effects of anchoring on *Z. marina* in particular (most studies have been carried out on other species of seagrass) but other factors such as *Z. marina* regeneration and recovery from natural and anthropogenic damage in UK waters are also poorly understood. The lack of positive involvement in the project therefore seems like a missed opportunity to: 1) improve the scientific knowledge base regarding UK seagrass habitats; and 2) positively influence the long-term future of the fauna and flora within Studland Bay.

4.1.4 The duration of the study

A long-term study would improve the knowledge and understanding of the natural variations in the Studland Bay seagrass habitat and this is therefore more likely to allow distinguishing between any natural variability and variations produced by any potential anthropogenic factors (see Hiscock, 1998; Davies *et al*., 2001). However, there is no current guidance as to the length of a particular study to establish the natural variations (see Davies *et al*., 2001). Statements similar to "a procedure by which a series of surveys is conducted in a sufficiently rigorous manner for changes in the attributes of a site (or species) to be detected over a period of time" (in Hiscock, 1998) do exist but the actual number of years required to establish natural variability are not given.

The current study has been running for two years and the bi-annual sampling methodology adopted in this study has resulted in the identification of seasonality in some of the seagrass parameters. However, the natural variability in many biotic and abiotic parameters at Studland Bay remains unknown. This is exemplified by the difference in temperature and algal cover in the spring of 2010 and the spring of 2011, suggesting a need for a longer monitoring period as well as a need for an expansion of the study to include sampling of both abiotic and biotic parameters.

4.2 Comparisons with other studies

Seagrass beds are a Biodiversity Action Plan (BAP) priority habitat (UKBAP, 2010) and OSPAR threatened habitat (OSPAR, 2003). Although seagrass beds are not listed as an Annex I habitat under the European Community (EC) Habitats Directive, they are a recognized component of several of these habitats; ‘Lagoons’, ‘Estuaries’, ‘Large shallow inlets and bays’, ‘Intertidal mud and sandflats’ and ‘Sandbanks covered by sea water at all times’ (Jones *et al.*, 2001). It is also listed as a ‘scarce’ nationally important marine feature (Lieberknecht *et al*., 2003).

It has been argued that to qualify as a *Zostera* ‘bed’, plant densities should provide at least 5% cover (OSPAR, 2009). More typically, however, *Zostera* plant densities provide greater than 30% cover. The seagrass in the southwest corner of Studland Bay provides plant cover of approximately 50-60 % (see Plastow, 2009; Axelsson *et al*., 2010) and therefore qualify as a seagrass ‘bed’.

Zostera beds are highly species-rich, particularly the subtidal beds of *Z. marina* (Jacobs and Huisman, 1982). The community composition of an seagrass bed depends upon a combination of factors, including the species of seagrass, the stability of the bed, the substratum type, salinity, tidal exposure and location. The richness of the community reflects the variety and density of microhabitats and the local ecological conditions. The network of roots and leaves in an extensive *Zostera* bed provide ecological niches for a wide range of associated fauna and flora, so that these biotopes are important in maintaining coastal biodiversity.

The Studland Bay seagrass bed appears similar to the bed described at Yarmouth (see Chesworth *et al*., 2008) both in terms of general seagrass density and fauna and flora present. Faunal species found living within the *Zostera* beds in both studies included the sand mason worm (*Lanice conchilega*) and the peacock worm (*Sabella pavonina*). Both species are suspension feeders which live in tubes in the sand and extend feeding tentacles into the water column. These taxa are commonly associated with *Zostera* beds as the plants shelter the relatively vulnerable worm tubes from currents. Snakelock anemones (*Anemonia viridis*) were particularly common in the *Zostera* beds in both studies and were found on the fronds and at the base of the seagrass.

Whilst the spiny spider crab (*Maja squinado*) was commonly observed during the initial seagrass survey (completed in May 2009) of the south-west corner of Studland Bay, it was not abundant in the autumn of 2009 or in the spring of 2010. Large numbers of both live and dead spiny spider crabs were recorded in Yarmouth but perhaps this taxon only appears in Studland Bay at certain times of the year due to its migration patterns (see for example Clark, 2008).

Fish species recorded in the *Zostera* bed at Studland Bay included sand gobies (*Pomatoschistus* sp.), blennies and juvenile wrasse but the grey mullets (*Liza* spp.) recorded in Yarmouth were not apparent at Studland Bay.

The green algae sea lettuce (*Enteromorpha lactuca*) was common in both studies but whilst the gutweed (*Enteromorpha intestinalis*) was present at Yarmouth, it has not been observed during the Studland Bay seagrass study. The brown seaweeds *Fucus serratus* and sugar kelp *Saccharina latissima* occurred at low densities at Yarmouth (Chesworth *et al*., 2008) but these have only been seen unattached within the beds in Studland Bay. An explanation could be that some taxa, such as *Halidrys siliquosa* and *Saccharina latissima,* are often found at the margins of seagrass beds (Whelan and Cullinane, 1985) and as the Studland Bay study is focused on the centre of the bed in the south-west corner of the bay, these taxa may not be recorded.

Other epiphytes recorded during the current study were *Heterosiphonia plumosa, Bonnemaisonia hamifera, Polysiphonia* sp., *Plocamium cartilagineum, Callithamnion* sp., *Ceramium* sp. and *Audouinella* sp. but few epiphyte species are recorded in most studies making any direct comparisons difficult. Of note is the presence of *Cladophora* spp., which was particularly widespread during the summer periods and in April 2011, but was not commonly recorded during the autumn (2009 and 2010) or spring (2010) surveys.

4.2.1 Growth and seasonality

The analysis of the data collected between October 2009 and October 2011 has shown some important trends. The variations in the data suggest seasonality in the results for seagrass percentage cover and frond length. The data showed that the seagrass beds have less cover and shorter fronds in April than in October. These two variables are probably linked, as longer seagrass fronds would visually cover a greater area of the seabed, increasing the seagrass percentage cover. Growth in *Z. marina* is seasonal with frond lengths increasing from spring to late summer only to start dying off in the autumn to reach minimum size in early spring. This seasonality is closely related to environmental parameters, particularly solar radiation and temperature (see below; Andrade and Ferreira, 2011). In the UK, growth generally occurs during the spring and summer, from April to September (Davison and Hughes, 1998). Flowers and seeds are generally produced between early/late summer (May/July) and early autumn (September) (Tubbs and Tubbs, 1983; Brown, 1990) but whether this is generally applicable to seagrass beds in the UK remains unknown.

There was no evidence of any seasonality in the seagrass shoot density data. The shoot density size frequency distributions tended to be similar to that of the previous sampling period, suggesting that variations in seagrass shoot density are probably driven by environmental factors. Decline in shoot density may be caused by storm events or other physical disturbances, whilst an increase would be a result of natural growth and reproduction. Therefore it is more likely that monitoring changes in seagrass shoot density would be the most informative measure whether there are any adverse impacts from anchoring in the Studland Bay area.

4.2.2 Seagrass density and recovery

The current seagrass shoot density in the Studland Bay seagrass study is approximately 170 shoots/m^2 (based on six seagrass surveys). This can be compared to the wider Weymouth Bay and Portland area where seagrass occur in densities between 100 to 300 shoots/m^2, although lower densities of up to 21 shoots/m^2 (mean being approximately 4 shoots/m^2) have also been recorded in Weymouth Bay (RPS, 2006). Previous studies in Studland Bay also record seagrass densities of between 100-300 shoots/m^2 (RPS, 2006), indicating that the current study reveal similar results.

The ability of seagrass to reproduce both sexually and asexually is important in establishing the recovery potential for seagrass habitats in the UK. Valdermarsen *et al.* (2010) suggested that vegetative expansion by clonal growths is efficient for recovery of relatively small areas of exposed seabed. Re-colonisation of larger areas, therefore, depends primarily on seed dispersal and the subsequent growth of seedlings. Improving the scientific knowledge regarding whether *Z. marina* reproduces through vegetative growth as well as by seed production in the UK is therefore of high importance in understanding and estimating any potential recovery of seagrass beds at these latitudes.

Until the onset of this study, subtidal *Z. marina* beds in the UK were, as mentioned above, believed to persist almost completely as a result of vegetative growth rather than by seed production (see Davison and Hughes, 1998). The evidence from the current study has shown seed production to occur at Studland Bay during late spring and early summer months. However, whether this is an annual event and if seeding occurs both in the spring and the autumn remain unknown.

The parameters controlling seed production also remain uncertain and the relatively high temperatures (above 15 °C) reportedly required for flowering and seed germination (e.g. Setchell, 1929; Yonge, 1949) still have to be considered a potentially important parameter at Studland Bay. Additional UK field studies are required to fully establish this relationship, however, the evidence from this study together with evidence from other studies (e.g. Morita *et al.*, 2010) support the suggestion that seed production and successful germination could take place twice a year, particularly as high seawater temperatures recorded both in spring and autumn at Studland Bay.

A further consideration is the ability of seeds to successfully germinate and provide growth and recovery of a seagrass habitat. It has been shown in some studies that seed mortality can be very high (up to 96 %; see Greve *et al*., 2004) and in some cases where all seedlings die, recolonisation must rely on seed spreading from neighbouring populations, a process which can be very long (Krause-Jensen *et al*., 2004; Källstrom *et al*., 2008) or not exist at all. As the discovery of seeding at Studland Bay is recent there is no information about seedling survival rates or any information regarding seeds spreading from neighbouring populations.

The size of the seagrass habitat at Studland Bay is unknown and a detailed survey would be required to fully assess the extent and health of the beds across the bay. It is therefore also impossible to assess any changes to the extent or recovery of the habitat that has occurred in the last few years but with the recent discovery of the potential for reproduction by seeding, knowledge of the size of the habitat is of considerable interest.

4.2.3 Potential effects of anchoring on seagrass

As discussed in the introduction, there is extensive literature investigating the potential impact of boat anchoring and boat moorings (e.g. damage by mooring chains) on seagrass beds (e.g. Walker *et al.*, 1989; Hastings *et al.*, 1995; Francour *et al.*, 1999) but relatively few studies focus specifically on *Z. marina* beds. Boat anchoring and moorings have been identified as a potential threat to *Z. marina* beds in the UK (e.g. Sutton and Tompsett, 2000; Rhodes *et al.*, 2006; Boyes *et al.*, 2008), causing the loss of seagrass and the creation of bare sand patches.

At Studland Bay the only evidence to date of any significant differences between the VNAZ and CTZ appears in October 2010, with the VNAZ having a higher shoot density and percentage cover of seagrass than the CTZ. However, it is too early to tell whether these results represent actual differences between the VNAZ and CTZ caused by boat anchoring, or are just natural variations between the sites. Data from future surveys should be able to elucidate on this point, particularly as the observance of the VNAZ has improved since the onset of the study (from 2010 in particular) and the representation of the collected data is likely to improve with time. The significant differences in seagrass frond length between the two zones are constant over time and are most likely a reflection of the differences between the two areas at the start of the project. Further sampling, combined with boat monitoring to examine whether the VNAZ is being observed, may help to resolve the ultimate aims of the project – i.e. whether anchoring has a negative impact on seagrass.

4.2.4 Other factors

Seagrass leaves provide a substratum for the growth of many species of epiphytic algae (Davison and Hughes, 1998). These epiphytes may smother the seagrass plants unless kept in check by the grazing activities of gastropods and other invertebrates. Healthy populations of epiphyte grazers are therefore beneficial to the maintenance of seagrass beds. The dive surveys in October 2009 and April 2010 revealed the presence (abundance approximately F-C) of adult *Hinia reticulata* on the fronds. The summer and autumn surveys of 2010 revealed a high abundance of juveniles, as well as the presence of adult *H. reticulata*, indicating a healthy population and regeneration of epiphytic grazers on the Studland Bay seagrass.

The Japweed or Wireweed (*Sargassum muticum*) was not observed in the VNAZ or CTZ. However, it was abundant in the shallow water along the south-west corner of Studland Bay with a few individuals seen further out in the bay. This non-native species appeared on the south coast in the early 1970s and has spread rapidly. It is thought to be a potential competitor to seagrass due to its high growth rate and ability to shade large areas, limiting the available light filtering down to the seagrass plants (Chesworth *et al.*, 2008). This taxon is arguably a considerable threat to the seagrass beds in Studland Bay and this must also be considered in assessing any threats to the seagrass within the wider bay.

Physical factors (e.g. waves) are likely to have some effects on the Studland Bay seagrass habitats, particularly when the winds are from the east – northeast as the bay opens up in this direction. In September and October 2010 the seagrass dive survey data suggested that there were some large-scale event affecting the seagrass habitat as the number of shoot, fronds lengths and seagrass cover were reduced when comparing October 2010 and September 2010 data. The wind speeds and directions during this period were generally light and from the south. However, immediately around the October survey the wind speeds were high (up to 17 knots) and blowing from the east – northeast (WindGuru, 2010). There was also a 4-day period in September (24 – 27 September 2010) with wind speeds reaching 18 knots from the north. These conditions may have had an effect on the seagrass beds around the VNAZ at that time, and could potentially explain the change in seagrass health over this period.

5 SUMMARY AND CONCLUSIONS

The Studland Bay seagrass monitoring study only started in earnest in October 2009 following the installation of the VNAZ marker buoys. Since then, baseline diver survey data and five sets of monitoring data have been collected. A large amount of qualitative and quantitative data has been collected and analysed since then. The main findings to date are:

Seagrass meadow

- The baseline dive survey data collected in October 2009 (and original seagrass mapping survey data) showed the *Zostera marina* seagrass cover to be fairly continuous (60-70 % cover) across the two zones.
- The data collected between April 2010 and October 2011 suggest higher numbers and larger-sized bare sediment patches present in the CTZ compared to the VNAZ, with several large patches in the western and north-western sections of the CTZ.
- In October 2011 the seabed in the VNAZ was smooth and homogenous whilst the seabed in the CTZ was noticeably different being uneven and undulating.
- The seagrass was shown to produce seeds in 2009 and 2011 but whether seed germination was successful remains unknown (not in the scope of the original study).

Seagrass associated fauna and flora

- The range of characterising species was typical for Studland Bay, based upon earlier surveys.

Seagrass health parameters

- The five main quantitative variables in the study are frond length, seagrass cover, shoot density, snakelock anemones and epiphyte cover but the latter two are currently too variable to merit inclusion in any detailed quantitative analysis. However, these together with the other records provide useful qualitative descriptors and should continue to be logged in any future surveys.

Frond length

- There are consistent significant differences in frond length between the VNAZ and the CTZ at Studland Bay, a difference attributed to the slight overall difference in depth between the two zones.
- The statistical analyses showed that these variations in seagrass frond length appear to follow a seasonal pattern.

Seagrass cover

- There are consistent significant differences in seagrass cover between the VNAZ and the CTZ at Studland Bay.
- The statistical analyses showed that these variations in seagrass percentage cover appear to follow a seasonal pattern.

Shoot density

- There were significant differences in shoot density between and within the VNAZ and the CTZ but not consistently from 2009 to 2011.
- There was a significant difference in mean shoot density between the VNAZ and CTZ in October 2010 but not in October 2011.
- The observed variations in seagrass shoot density appeared to be independent of a seasonal cycle.
- Although the statistical results do not show a consistent significant difference between the VNAZ and the CTZ there is a trend of increasing differences in shoot density between the two zones, suggesting a need for continued monitoring of the seagrass shoot density in the VNAZ and CTZ at Studland Bay.

Boat monitoring data

- Boat monitoring of recreational anchoring activity was carried out in the summer months of 2009, 2010 and 2011.
- Observance of the Voluntary No Anchor Zone increased from 2010 to 2011.
- Overall anchoring in the VNAZ was lower in 2011 compared to 2010 both in terms of actual events but also as a proportion between the VNAZ and the CTZ (0.22 in 2010 and 0.07 in 2011), although the total number of events in 2011 was also lower overall.

Null hypothesis assessment

- Currently, based on the quantitative data collected over two years, there is no consistent evidence of differences in seagrass health between the VNAZ and CTZ - the null hypothesis can therefore not be rejected.

There is therefore no consistent evidence of boat anchoring impacting the seagrass habitat at Studland Bay. However, the trends in the data (see figures 3.4 and 3.5) suggest an increased difference in seagrass health between the VNAZ and the CTZ, and therefore a need for a continuation of seagrass health monitoring at Studland Bay.

5.1 Recommendations

1. Increase information provision and communication with the general public regarding the long-term plans for Studland Bay;
2. Based on the trends in the data collected to date, the dive survey work should continue for another year at least, to further establish the natural variability in the bay, allow the current data trends to develop, take advantage of increased observance of the VNAZ and allow more detailed assessments of the potential effects of anchoring at Studland Bay;
3. Continued use of the statistical analyses reported here for any future monitoring;
4. Start recording abiotic parameters including seawater temperature, to improve the knowledge of the natural landscape in Studland Bay;
5. Consideration of additional resources being allocated for analysis of the boat monitoring survey data to date and allow continued boat monitoring during any future surveys;
6. Consideration of additional resources being made available for further seagrass research within Studland Bay to assess the levels of seagrass seeding, the success of germination, and therefore the potential for recovery of seagrass beds at this latitude.

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APPENDIX 01. Scientific diving log sheets.

Client	Crown Estate											Job Number	J/09/169
Location	Studland Bay											Vessel	SV Mariner
Survey	Studland Bay Seagrass Survey											Date	October 2009

Transect number	Quadrat number	Distance along transect (m)	Date	Heading of Video Swim (°)	Heading of Quadrat Swim (°)	Depth (m)	Seagrass (1/1) cover (%)	Number of shoots (1/4)	Frond lengths (cm)	Average frond length (cm)	Epiphyte Sample Collected Yes/No	Epiphyte (1/1) cover (%)	Comments	Other fauna (in 1/4 of quadrats): *Anemonia viridis*	*Sabella pavonina*	*Pomatoschistus sp*	*Gobiusculus flavescens*	*Callionymus lyra*	*Necora puber*	*Lanice conchilega*	*Arenicola marina*	*Blenniidae sp.*	
VNAZ 2	Q1	20	07/10/2009	180	360	N/A	80	15	62, 71, 63, 60, 58	62.8	No	5		4									Dense seagrass (60-70 %) with 1-5 % seaweed cover.
VNAZ 2	Q2	40	07/10/2009	180	360	N/A	20	9	38, 42, 34, 42, 37	38.6	No	10		9									
VNAZ 2	Q3	60	07/10/2009	180	360	N/A	40	7	35, 47, 50, 35, 42	41.8	No	5		17									
VNAZ 2	Q4	80	07/10/2009	180	360	N/A	40	12	52,45, 44, 22, 20	36.6	No	5		6									
VNAZ 2	Q5	100	07/10/2009	180	360	N/A	60	8	35, 40, 40, 53, 38	41.2	No	5		17									
VNAZ 3	Q1	0	08/10/2009	180	360	2.9	50	14	37, 44, 47, 54, 49	46.2	Yes	20		12									Medium density seagrass (50 %) with 10 % seaweed cover overall.
VNAZ 3	Q2	20	08/10/2009	180	360	3.1	60	16	58, 55, 61, 60, 70	60.8	Yes	10		7									
VNAZ 3	Q3	40	08/10/2009	180	360	3.0	40	9	72, 57, 52, 81, 46	61.6	Yes	40	Extensive red algae	2									
VNAZ 3	Q4	60	08/10/2009	180	360	2.6	25	14	45, 40, 20, 28, 40	34.6	Yes	40		7									
VNAZ 3	Q5	80	08/10/2009	180	360	2.7	60	13	60, 53, 61, 60, 42	55.2	Yes	5		8									
VNAZ 4	Q1	20	08/10/2009	180	360	2.7	50	10	45, 38, 60, 42, 61	49.2	Yes	20		5								1	0-30 m and from 50-70m m medium density seagrass (40-50 %) with 10-20 % seaweed cover overall, between 30-50 m and 70 m-100m 60-70 % seagrass cover with 5-10 %
VNAZ 4	Q2	60	08/10/2009	180	360	2.5	80	10	56, 68, 69, 67, 83	59.2	Yes	10		9									
VNAZ 4	Q3	40	08/10/2009	180	360	3.1	80	10	63, 50, 45, 59, 77	58.8	Yes	20		7									
VNAZ 4	Q4	80	08/10/2009	180	360	N/A	20	5	25, 30, 49, 27, 16	29.4	Yes	30		6									
VNAZ 4	Q5	100	08/10/2009	180	360	2.7	80	14	41, 60, 58, 44, 46	49.8	Yes	5		8					1				
VNAZ 5	Q1	0	07/10/2009	180	360	3.5	70	5	32, 47, 30, 42, 31	36.4	No	10	Less epiphyte cover	5									Dense seagrass (60 %) with 5 - 10 % seaweed cover.
VNAZ 5	Q2	20	07/10/2009	180	360	3.5	60	6	72, 58, 69, 47, 70	63.2	No	20		5									
VNAZ 5	Q3	40	07/10/2009	180	360	3.6	60	5	40, 48, 37, 51, 54	46	No	10		5									
VNAZ 5	Q4	60	07/10/2009	180	360	3.6	50	10	47, 38, 54, 52, 50	48.2	No	10		4	1								
VNAZ 5	Q5	80	07/10/2009	180	360	3.1	50	5	53, 56, 43, 46, 52	50	No	20		3									
CTZ 2	Q1	0	12/10/2009	180	360	N/A	80	15	50, 70, 54, 52, 55	56.2	Yes	5		5			1						Medium density seagrass (50 - 60 %) with 10 % seaweed cover overall.
CTZ 2	Q2	20	12/10/2009	180	360	N/A	40	8	53, 41, 31, 33, 53	42.2	Yes	5		2									
CTZ 2	Q3	40	12/10/2009	180	360	N/A	10	4	34, 21, 15, 18, 36	91.2	Yes	1											
CTZ 2	Q4	60	12/10/2009	180	360	N/A	40	15	72, 59, 44, 23, 36	46.8	No	10		4									
CTZ 2	Q5	80	12/10/2009	180	360	N/A	30	12	30, 35, 24, 25, 31	29	Yes	5		1							1		
CTZ 3	Q1	20	12/10/2009	180	360	N/A	80	16	37, 14, 16, 37, 26	26	Yes	5		4									Dense seagrass (60-70 %) with 5 - 10 % seaweed cover.
CTZ 3	Q2	40	12/10/2009	180	360	N/A	70	13	47, 38, 40, 39, 43	41.4	Yes	5		2									
CTZ 3	Q3	60	12/10/2009	180	360	N/A	70	17	37, 47, 17, 20, 50	34.2	Yes	5		3									
CTZ 3	Q4	80	12/10/2009	180	360	N/A	60	12	29, 35, 26, 10, 29	25.8	Yes	5		4									
CTZ 3	Q5	100	12/10/2009	180	360	N/A	60 to 70	13	61, 51, 52, 35, 33	46.4	Yes	5		4									
CTZ 4	Q1	20	08/10/2009	360	180	3.4	80	13	40, 33, 34, 28, 55	38	Yes	10	Extensive red algae	10							P		Dense seagrass (60-70 %) with 5 - 10 % seaweed cover.
CTZ 4	Q2	40	08/10/2009	360	180	3.4	5	0	32, 34, 36, 21, 44	33.4	Yes	1		1		1							
CTZ 4	Q3	60	08/10/2009	360	180	3.3	90	14	40, 37, 59, 65, 36	41	Yes	5											
CTZ 4	Q4	80	08/10/2009	360	180	2.6	70	16	40, 37, 59, 65, 36	47.4	Yes	10											
CTZ 4	Q5	100	08/10/2009	360	180	2.5	80	15	44, 42, 30, 62, 48	45.2	Yes	5		7									
CTZ 5	Q1	20	12/10/2009	180	360	N/A	70	19	18, 44, 40, 26, 37	33	Yes	5		5									Dense seagrass (60-70 %) from 0 - 30 m, 65-100m with 5 - 10 % seaweed cover.
CTZ 5	Q2	40	12/10/2009	180	360	N/A	40	18	41, 50, 52, 56, 18	43.4	Yes	5 to 10		5									
CTZ 5	Q3	60	12/10/2009	180	360	N/A	5	0	14, 16, 36, 39, 44	29.8	No	0											
CTZ 5	Q4	80	12/10/2009	180	360	N/A	60	15	45, 28, 51, 42, 25	38.2	Yes	5		2									
CTZ 5	Q5	100	12/10/2009	180	360	N/A	70	14	26, 44, 40, 24,41	35	Yes	5		2				1					

Client	Crown Estate	Job Number	J/09/169
Location	Studland Bay	Vessel	SV Mariner
Survey	Studland Bay Seagrass Survey	Date	April 2010

Transect number	Quadrat Number	Distance along transect (m)	Date	Heading of Video Swim (°)	Heading of Quadrat Swim (°)	Photograph Yes/No	Seagrass (1/1) (%)	Number of shoots (1/4)	Blade lengths (cm)	Average blade length (cm)	Epiphyte Sample Collected Yes/No	Epiphyte Cover (%) 1/1	Comments	Other fauna (in quadrats) *Anemonia viridis*	*Sabella pavonina*	*Pomatoschistus sp*	*Gobiusculus flavescens*	*Callionymus lyra*	*Necora puber*	*Lanice conchilega*	*Arenicola sp*	
VNAZ 2	1	20	07/04/2010	180	360	Yes	40	12	20,30,60,30,25	33	Yes	5	Poor visibility	3								SOL Seagrass patchy, 30%. Seagrass more dense towards EOL 80% with longer blades.
VNAZ 2	2	40	07/04/2010	180	360	Yes-video	15	8	38,20,30,27,25	28	NA	0	Some red algae	10								
VNAZ 2	3	60	07/04/2010	180	360	Yes-video	25	12	18,21,40,31,24	26.8	Yes	5	Some red algae	10								
VNAZ 2	4	80	07/04/2010	180	360	Yes-video	50	10	23,25,40,20,20	25.6	NA	0		7						1		
VNAZ 2	5	100	07/04/2010	180	360	Yes-video	20	15	23,15,24,25,27	22.8	NA	0		6								
VNAZ 3	1	0	07/04/2010	180	360	Yes-video	60	13	17,19,23,24,25	21.6	NA	2	Red algae	1								Even seagrass cover betwwn 0 and 80 m (50%) increasing to about 60-70% from 80 to 100m. Seaweed about 5% throughout.
VNAZ 3	2	20	07/04/2010	180	360	Yes-video	60	13	20,23,24,25,26	23.6	NA	0	Poor visibility, silty	1	1							
VNAZ 3	3	40	07/04/2010	180	360	Yes-video	60	14	14,21,21,23,24	20.6	NA	10	Some epiphytes	2								
VNAZ 3	4	60	07/04/2010	180	360	Yes-video	60	18	19,19,25,25,26	22.8	Yes	5	Some epiphytes	4								
VNAZ 3	5	80	07/04/2010	180	360	Yes-video	30	6	14,14,18,20,26	18.4	Yes	5	Sparse seagrass									
VNAZ 4	1	20	08/04/2010	180	360	Yes & video	20	8	30,23,28,38,37	31.2	NA	0	Red algae	6								Even seagrass coverage between 0-40m, short blades and low density, interspersed with small sand patches. Seagrass density and length of blades increased from 40-100m.
VNAZ 4	2	40	08/04/2010	180	360	Yes & video	45	8	35,32,24,34,22	29.4	Yes	5	Red algae	8								
VNAZ 4	3	60	08/04/2010	180	360	Yes & video	25	15	21,22,26,10,14	18.6	NA	0		9								
VNAZ 4	4	80	08/04/2010	180	360	Yes & video	40	15	23,30,32,31,21	27.4	Yes	5	Red algae	6								
VNAZ 4	5	100	08/04/2010	180	360	Yes & video	30	15	10,16,35,20,25	21.2	Yes	5	Red algae	10								
VNAZ 5	1	0	08/04/2010	180	360	Yes & video	25	9	14,35,25,22,18	22.8	Yes	5	Some red algae	2								0-50 m 50% seagrass cover with 5 % seaweed 50-80m 30-40% seagrass cover with 10% seaweed, 80-100m 50% seagrass cover.
VNAZ 5	2	20	08/04/2010	180	360	Yes & video	25	10	20,23,23,25,29	24	Yes	5	Sparse seagrass		1							
VNAZ 5	3	40	08/04/2010	180	360	Yes & video	25	9	22,25,29,13,24	22.6	Yes	05 to 10	Sparse seagrass	2	1							
VNAZ 5	4	60	08/04/2010	180	360	Yes & video	30	13	17,22,23,33,35	26	Yes	05 to 10	Sparse seagrass	2								
VNAZ 5	5	80	08/04/2010	180	360	Yes & video	25	10	17,21,24,27,32	24.2	Yes	10	Sparse seagrass	1						3		
CTZ 02	1	0	08/04/2010	180	360	Yes & video	20	9	11,23,18,25,14	18.2	Yes	5	Sparse seagrass	1						3		0-100m 20-25% seagrass cover with 2-5% seaweed cover.
CTZ 02	2	20	08/04/2010	180	360	Yes & video	10	9	15,11,15,9.10	12	No	2	Sparse seagrass	4						3		
CTZ 02	3	40	08/04/2010	180	360	Yes & video	2	0	-	-	No	0		1						1		
CTZ 02	4	60	08/04/2010	180	360	Yes & video	20	10	18,19,19,22,23	20.2	Yes	25	Sparse seagrass	1	1							
CTZ 02	5	80	08/04/2010	180	360	Yes & video	30	12	14,14,28,25,28	21.8	No	5	Red epiphytes	2						1		
CTZ 03	1	20	08/04/2010	180	360	Yes & video	10	5	18,15,18,17,10	15.6	No	0		3								Seagrass cover of c. 25% 30% throughout with c. 5% seaweed.
CTZ 03	2	40	08/04/2010	180	360	Yes & video	25	17	13,9,17,14,15	13.6	No	0	Red algae	15						1		
CTZ 03	3	60	08/04/2010	180	360	Yes & video	50	10	19,24,25,23,22	22.6	Yes	10	Red algae	10	1					4		
CTZ 03	4	80	08/04/2010	180	360	Yes & video	15	13	7,9,14,15,22	13.4	No	0	Red algae	7								
CTZ 03	5	100	08/04/2010	180	360	Yes & video	25	8	16,8,19,22,16	16.2	Yes	2	Red algae	8						3		
CTZ 04	1	20	09/04/2010	360	180	Yes & video	25	11	14,16,29,30,23	22.4	Yes	5	Red algae	6						2		Seagrass cover of c. 40%-55% throughout with c. 5% seaweed.
CTZ 04	2	40	09/04/2010	360	180	Yes & video	45	13	14,24,28,8,13	17.4	No	0	Red algae	7						3		
CTZ 04	3	60	09/04/2010	360	180	Yes & video	30	19	20,10,8,13,14	13.0	No	0	Red algae	20						1		
CTZ 04	4	80	09/04/2010	360	180	Yes & video	20	10	11,13,13,15,20	14.4	No	0	Lots of red algae	7	1					2		
CTZ 04	5	100	09/04/2010	180	180	Yes & video	25	13	22,16,14,31,22	21.0	No	0	Lots of red algae	2	2							
CTZ 05	1	20	09/04/2010	180	360	Yes & video	25	14	18,18,22,22,23	20.6	No	5	Red algae present	2						1		Seagrass cover of c. 30% (to 40% max) with seaweed around 10% from 0m to 90 m. After 90 m seagrass cover thinned to c. 20%.
CTZ 05	2	40	09/04/2010	180	360	Yes & video	5	6	6,8,10,11,11	9.2	Yes	20	Some ephiphytes	5								
CTZ 05	3	60	09/04/2010	180	360	Yes & video	20	1	25	25	No	1	2 shoots in quadrat									
CTZ 05	4	80	09/04/2010	180	360	Yes & video	25	17	13,13,17,22,25	18.0	No	5	Some epiphytes	3								
CTZ 05	5	100	09/04/2010	180	360	Yes & video	25	17	16,18,22,23,23	20.4	Yes	15	Red seaweed	4	1							

Client	Crown Estate	Job Number	J/09/169
Location	Studland Bay	Vessel	SV Mariner
Survey	Studland Bay Seagrass Survey	Date	September 2010

Transect number	Quadrat Number	Distance along transect (m)	Date	Heading of Video Swim (°)	Heading of Quadrat Swim (°)	Photograph Yes/No	Seagrass (1/1) (%)	Number of shoots (1/4)	Blade lengths (cm)	Average blade length (cm)	Epiphyte Sample Collected Yes/No	Epiphyte Cover (%) 1/1	Comments	Other fauna (in quadrats): *Anemonia viridis*	*Sabella pavonina*	*Pomatoschistus sp*	*Gobiusculus flavescens*	*Callionymus lyra*	*Asparagopsis armata*	*Necora puber*	*Lanice conchilega*	*Dictyota dichotoma*	*Arenicola sp*	
VNAZ 2	1	20	09/09/2010	180	360	yes	70	10	22,20,20,24,18	20.8	Yes	5	Macroalgal - loose						P					Generally 30-40% seagrass cover.
VNAZ 2	2	40	09/09/2010	180	360	yes	30	10	15,16,16,17,21	17	No	5	Macroalgal - loose											
VNAZ 2	3	60	09/09/2010	180	360	yes	30	14	15,13,13,14,18	14.6	Yes	5	Macroalgal - loose	12	1									
VNAZ 2	4	80	09/09/2010	180	360	yes	20	8	15,15,16,20,21	17.4	Yes	20	Macroalgal - loose	5					P					
VNAZ 2	5	100	09/09/2010	180	360	yes	40	12	21,15,17,9,21	16.6	Yes	5	Macroalgal - loose		1									
VNAZ 3	1	0	10/09/2010	180	360	yes	60	12	45, 46, 50, 51, 58	50	yes	10	Some algae	1										Seagrass 40% and short in length. From about 70m onwards seaweed cover of nearly 100% and from 92, seagrass barely present.
VNAZ 3	2	20	10/09/2010	180	360	Yes	60	11	58, 68, 66, 72, 74	67.6	yes	10	Some algae	4										
VNAZ 3	3	40	10/09/2010	180	360	Yes	80	18	56, 57, 62, 64, 68	61.4	no	5	Some algae	4										
VNAZ 3	4	60	10/09/2010	180	360	Yes	70	9	65, 66, 68, 67, 61	65.4	yes	10	Some algae	1										
VNAZ 3	5	80	10/09/2010	180	360	Yes	60	12	40, 42, 47, 55, 57	48.2	yes	10	Some algae	1										
VNAZ 4	1	20	10/09/2010	180	360	Yes	70	18	69,72,58,59,62	64	Yes	10	Loose algae	3										Medium dense (40-50%), long seagrass, mostly throughout transect.
VNAZ 4	2	40	10/09/2010	180	360	Yes	30	5	18,44,52,60,62	47.2	Yes	40	Loose algae	3										
VNAZ 4	3	60	10/09/2010	180	360	Yes	50	12	62,57,58,58,16	50.2	Yes	30	Algae mostly loose	2	1									
VNAZ 4	4	80	10/09/2010	180	360	Yes	80	21	39,47,48,48,52	46.8	Yes	5		6	1									
VNAZ 4	5	100	10/09/2010	180	360	Yes	70	16	21,42,45,46,52	41.2	Yes	5	Algae mostly loose	1										
VNAZ 5	1	0	10/09/2010	180	360	Yes	70	13	52, 57, 58, 62, 63	58.4	No	5	Algae mostly loose	3										Seagrass cover of 60% with long, healthy fronds. Fairly large proportion of red macroalgal component but most loose on the seabed filling in the space between the shoots.
VNAZ 5	2	20	10/09/2010	180	360	Yes	30	5	33, 42, 54, 63, 74	53.2	Yes	20	Algae mostly loose	1										
VNAZ 5	3	40	10/09/2010	180	360	Yes	60	4	13, 34, 28, 50	31.25	Yes	20	Algae mostly loose	1									1	
VNAZ 5	4	60	10/09/2010	180	360	Yes	70	18	42, 49, 60, 62, 70	56.6	Yes	10	Algae mostly loose	4										
VNAZ 5	5	80	10/09/2010	180	360	Yes	40	13	22, 26, 24, 30, 44	29.2	Yes	5	Algae mostly loose	3										
CTZ 02	1	0	08/09/2010	180	360	yes	70	19	42, 46, 52, 54, 62	51.2	No	0	Little epiphyte cover	6										60 % seagrass cover with near 0 % seaweed cover.
CTZ 02	2	20	08/09/2010	180	360	Yes	60	12	24, 26, 38, 49, 22	31.8	No	2	Little epiphyte cover	5										
CTZ 02	3	40	08/09/2010	180	360	Yes	40	9	32, 34, 34, 44, 48	38.4	No	0	Little epiphyte cover	6	1									
CTZ 02	4	60	08/09/2010	180	360	Yes	40	10	34, 34, 44, 47, 47	41.2	No	0	Little epiphyte cover	6										
CTZ 02	5	80	08/09/2010	180	360	Yes	80	14	34, 37, 38, 40, 41	38	No	0	Little epiphyte cover	2										
CTZ 03	1	20	08/09/2010	180	360	Yes & video	25	6	29, 26, 21, 22, 40	27.6	No	0	Little epiphyte cover	7										Dense seagrass (70%). Red alage present throughout but not attached to live healthy seagrass.
CTZ 03	2	40	08/09/2010	180	360	Yes & video	50	4	27, 28, 30, 34, 40	31.8	No	0	Little epiphyte cover	13		1								
CTZ 03	3	60	08/09/2010	180	360	Yes & video	55	13	30, 34, 22, 29, 26	28.2	No	0	Little epiphyte cover	14							2			
CTZ 03	4	80	08/09/2010	180	360	Yes & video	30	21	18, 23, 26, 28, 21	23.2	No	0	Little epiphyte cover	9	1									
CTZ 03	5	100	08/09/2010	180	360	Yes & video	80	8	32, 17, 46, 51 37	36.6	No	0	Little epiphyte cover	6										
CTZ 04	1	0	09/09/2010	180	360	Yes	70	12	54, 47, 48, 37, 34	44	No	0	Little epiphyte cover	2										60-70% seagrass cover from 0 m until 80 m where grass was longer and more dense (80%).
CTZ 04	2	20	09/09/2010	180	360	Yes	60	15	34, 34, 32, 31, 29	32	Yes	5	Little epiphyte cover											
CTZ 04	3	40	09/09/2010	180	360	Yes	60	13	54, 52, 36, 37, 32	42.2	No	0	Little epiphyte cover	3										
CTZ 04	4	60	09/09/2010	180	360	Yes	5	5	15, 15, 17, 19, 26	18.4	No	0	Little epiphyte cover	2										
CTZ 04	5	80	09/09/2010	180	360	Yes	60	13	24, 24, 36, 30, 17	26.2	No	5	Little epiphyte cover	3	1							1		
CTZ 05	1	20	09/09/2010	180	180	Yes	80	19	36, 48, 54, 58, 61	51.4	Yes	5	Little epiphyte cover	3										Overall a very healthy seagrass bed with 60% seagrass cover with 5 % seaweed cover.
CTZ 05	2	40	09/09/2010	180	180	Yes	50	14	16, 18, 20, 21 22	19.4	Yes	2	Little epiphyte cover	2	1									
CTZ 05	3	60	09/09/2010	180	180	Yes	70	15	35, 36, 39, 40, 41	38.2	No	2	Little epiphyte cover	5										
CTZ 05	4	80	09/09/2010	180	180	Yes	40	10	22, 24, 26, 27, 30	25.8	Yes	10	Little epiphyte cover	2										
CTZ 05	5	100	09/09/2010	180	180	Yes	60	12	26, 36, 37, 44, 46	37.8	Yes	2	Little epiphyte cover	3										

Client	Crown Estate											Job Number	J/09/169									
Location	Studland Bay											Vessel	SV Mariner									
Survey	Studland Bay Seagrass Survey											Date	October 2010									
														Other fauna (in 1/4 quadrat)								
Transect number	Quadrat Number	Distance along transect (m)	Date	Heading of Video Swim (°)	Heading of Quadrat Swim (°)	Photograph Yes/No	Seagrass (1/1) (%)	Number of shoots (1/4)	Blade lengths (cm)	Average blade length (cm)	Epiphyte Sample Collected Yes/No	Epiphyte Cover (%) 1/1	Comments	*Anemonia viridis*	*Sabella pavonina*	*Pomatoschistus sp*	*Gobiusculus flavescens*	*Callionymus lyra*	*Necora puber*	*Lanice conchilega*	*Arenicola sp*	
VNAZ 2	1	20	06/10/2010	180	360	Yes	60	8	33,52,53,56,61	51	No	5	Loose red algae	**3**								Seagrass 50-60% form 0m but a lot of loose algae between shoots.
VNAZ 2	2	40	06/10/2010	180	360	Yes	50	10	35,52,53,54,65	51.8	No	0	Loose red algae									
VNAZ 2	3	60	06/10/2010	180	360	Yes	70	12	45,66,54,52,56	54.6	No	0	Loose red algae	**5**								
VNAZ 2	4	80	06/10/2010	180	360	Yes	70	14	67,27,57,53,44	49.6	No	0	Loose red algae	**5**								
VNAZ 2	5	100	06/10/2010	180	360	Yes	30	8	37,37,36,38,51	39.8	No	0	Loose red algae	**5**								
VNAZ 3	1	0	06/10/2010	180	360	Yes	60	11	44,44,48,51,36	44.6	Yes	0	Loose red algae	**4**								Seagrass 50% with 0-5% seaweed but a lot of loose algae between shoots.
VNAZ 3	2	20	06/10/2010	180	360	Yes	60	8	26,31,56,46,38	39.4	No	0	Loose red algae									
VNAZ 3	3	40	06/10/2010	180	360	Yes	60	6	69,64,61,48,62	60.8	No	0	Loose red algae	**1**								
VNAZ 3	4	60	06/10/2010	180	360	Yes	70	11	35,38,42,43,43	40.2	No	0	Loose red algae	**6**								
VNAZ 3	5	80	06/10/2010	180	360	Yes	40	8	48,68,52,46,56	54	No	0	Loose red algae	**2**								
VNAZ 4	1	20	06/10/2010	180	360	Yes	20	6	30, 23, 36, 37, 20	29.2	Yes	2	Loose red algae	**1**								Seagrass 40-50% from 0 m. Lots of red algae present but mainly loose.
VNAZ 4	2	40	06/10/2010	180	360	Yes	10	3	8, 36, 37, 38, 40	31.8	No	0	Loose red algae	**1**								
VNAZ 4	3	60	06/10/2010	180	360	Yes	50	7	64, 77, 77, 78, 80	75.2	No	0	Loose red algae	**2**						**2**		
VNAZ 4	4	80	06/10/2010	180	360	Yes	70	11	45, 62, 57, 58, 68	58	Yes	0	Loose red algae	**7**					**1**	**1**		
VNAZ 4	5	100	06/10/2010	180	360	Yes	50	9	40, 49, 53, 54, 55	50.2	No	0	Loose red algae	**3**								
VNAZ 5	1	0	06/10/2010	180	360	Yes	60	11	50,60,62,73,58	60.6	No	0	Loose red algae	**4**								Seagrass 60% plus 2% seaweed cover. Lots of loose algae between shoots and on seabed.
VNAZ 5	2	20	06/10/2010	180	360	Yes	60	6	17,24,20,27,48	27.2	No	0	Loose red algae									
VNAZ 5	3	40	06/10/2010	180	360	Yes	60	6	51,52,52,28,50	46.6	No	0	Loose red algae	**1**	**1**							
VNAZ 5	4	60	06/10/2010	180	360	Yes	50	12	69,71,72,74,77	72.6	No	2	Loose red algae	**2**								
VNAZ 5	5	80	06/10/2010	180	360	Yes	60	14	44,55,66,54,60	55.8	No	0	Loose red algae									
CTZ 02	1	0	07/10/2010	180	360	Yes	60	8	37,44,54,53,57	49	No	0	5% loose algae	**3**								Seagrass cover 50% with 0-2% seaweed cover.
CTZ 02	2	20	07/10/2010	180	360	Yes	40	8	35,42,42,43,43	41	No	2	10% loose algae	**2**								
CTZ 02	3	40	07/10/2010	180	360	Yes	5	4	33,70,59,90	63	No	0	30% loose algae									
CTZ 02	4	60	07/10/2010	180	360	Yes	30	10	26,44,52,53,37	42.4	No	0	20% loose algae	**5**								
CTZ 02	5	80	07/10/2010	180	360	Yes	50	9	27,32,47,47,45	39.6	No	0	20% loose algae	**1**								
CTZ 03	1	20	07/10/2010	180	360	Yes & video	20	9	37,51,46,52,27	42.6	No	0	10% loose algae	**3**								Seagrass cover 50% with 0-2% seaweed cover. 90m a lot of dying seagrass frond tips.
CTZ 03	2	40	07/10/2010	180	360	Yes & video	40	6	41,41,31,32,51	39.2	No	0	10% loose algae	**1**								
CTZ 03	3	60	07/10/2010	180	360	Yes & video	30	6	26,30,31,32,51	34	No	0	10% loose algae	**1**								
CTZ 03	4	80	07/10/2010	180	360	Yes & video	20	3	33,41,44	39.3	No	0	10% loose algae									
CTZ 03	5	100	07/10/2010	180	360	Yes & video	30	6	40,41,46,44,44	43	No	0	10% loose algae	**2**								
CTZ 04	1	0	08/10/2010	180	360	Yes	50	11	37, 38, 38, 43, 42	39.6	No	0	10% loose algae	**1**								Seagrass of 50% plus 0-2% epiphytes (attached) with some 10% loose on seabed.
CTZ 04	2	20	08/10/2010	180	360	Yes	40	9	32, 32, 33, 27, 44	33.6	No	0	10% loose algae									
CTZ 04	3	40	08/10/2010	180	360	Yes	25	6	12, 18, 38, 28, 27	24.6	No	0	10% loose algae									
CTZ 04	4	60	08/10/2010	180	360	Yes	25	8	38, 42, 33, 44, 32	37.8	No	0	10% loose algae	**1**								
CTZ 04	5	80	08/10/2010	180	360	Yes	30	9	28, 32, 47, 48, 36	38.2	No	0	10% loose algae	**1**								
CTZ 05	1	20	08/10/2010	180	180	Yes	30	6	27,32,34,42,49	36.8	No	0	10% loose algae									Seagrass of 50% plus 0-2% epiphytes (attached) with some 10% loose on seabed.
CTZ 05	2	40	08/10/2010	180	180	Yes	5	2	21,31	26	No	0	30% loose algae									
CTZ 05	3	60	08/10/2010	180	180	Yes	30	6	32,37,42,52,53	43.2	No	0	20% loose algae									
CTZ 05	4	80	08/10/2010	180	180	Yes	40	9	42,44,49,32,38	41	No	0	20% loose algae	**1**								
CTZ 05	5	100	08/10/2010	180	180	Yes	50	6	42,44,46,58,62	50.4	No	0	30% loose algae	**2**								

Client	Crown Estate	Job Number	J/09/169
Location	Studland Bay	Vessel	SV Mariner
Survey	Studland Bay Seagrass Survey	Date	April 2011

Transect number	Quadrat Number	Distance along transect (m)	Date	Heading of Video Swim (°)	Heading of Quadrat Swim (°)	Photograph Yes/No	Seagrass (1/1) (%)	Number of shoots (1/4)	Blade lengths (cm)	Average blade length (cm)	Epiphyte Sample Collected Yes/No	Epiphyte Cover (%) 1/1	Comments	Other fauna (in quadrats): *Anemonia viridis*	*Sabella pavonina*	*Pomatoschistus sp*	*Gobiusculus flavescens*	*Callionymus lyra*	*Necora puber*	*Lanice conchilega*	*Maja squinado*	*Arenicola sp*	*Hinia reticulata*	*Majidae sp.*	
VNAZ 2	1	20	20/04/2011	180	360	Yes	25	8	46,47,37,23,51	40.8	yes	5%	Seaweeds abundant	1											0m to 40 m seagrass 30-40% (30-40% seaweed) increasing to 50-60% (30-40% seaweed) between 40 and 100 m.
VNAZ 2	2	40	20/04/2011	180	360	Yes	30	7	30,38,36,16,21	28.2	no	5%	Seaweeds abundant	1	1										
VNAZ 2	3	60	20/04/2011	180	360	Yes	20	7	21,35,37,28,35	31.2	yes	10%	Seaweeds abundant	2											
VNAZ 2	4	80	20/04/2011	180	360	Yes	30	10	28,34,48,32,37	35.8	no	5%	Seaweeds abundant	2											
VNAZ 2	5	100	20/04/2011	180	360	Yes	30	8	23,26,31,29,33	28.4	no	5%	Seaweeds abundant	3											
VNAZ 3	1	0	20/04/2011	180	360	Yes	50	7	26,35,26,42,16	29.0	no	2%	Seaweeds abundant	4											0m to 80m seagrass cover 40-50% (50-60% algae), from 80m - 100m seagrass cover decreased to approximately 30%. Large amounts of seaweed present.
VNAZ 3	2	20	20/04/2011	180	360	Yes	40	9	26,28,12,24,44	26.8	no	2%	Seaweeds abundant	1											
VNAZ 3	3	40	20/04/2011	180	360	Yes	30	6	17,25,27,27,23	23.8	no	5%	Seaweeds abundant												
VNAZ 3	4	60	20/04/2011	180	360	Yes	20	7	26,31,36,34,38	33.0	no	5%	Seaweeds abundant	5					1						
VNAZ 3	5	80	20/04/2011	180	360	Yes	30	7	30,32,37,34,49	36.4	no	5%	Seaweeds abundant	4											
VNAZ 4	1	20	20/04/2011	180	360	Yes	40	8	45,30,30,31,28	32.8	yes	5%	Seaweeds abundant	3											0m-20m seagrass cover 30% with 50-60% seaweed cover (?Cladophora sp). From 20m-100m 50-60% seagrass cover with 30% seaweed cover.
VNAZ 4	2	40	20/04/2011	180	360	Yes	30	11	32,32,31,42,33	34.0	no	5-10%	Seaweeds abundant	2											
VNAZ 4	3	60	20/04/2011	180	360	Yes	30	11	32,33,35,32,40	34.4	no	10%	Seaweeds abundant	2											
VNAZ 4	4	80	20/04/2011	180	360	Yes	40	17	30,36,37,48,32	36.6	no	5%	Seaweeds abundant	5											
VNAZ 4	5	100	20/04/2011	180	360	Yes	30	12	23,28,31,32,42	31.2	no	5%	Seaweeds abundant	3											
VNAZ 5	1	0	21/04/2011	180	360	Yes	30	6	37,48,43,37,43	41.6	yes	5%	Seaweeds abundant										1		Seagrass cover of 50-60% with various seaweeds at 40% seagrass.
VNAZ 5	2	20	21/04/2011	180	360	Yes	30	11	38,39,40,45,48	42.0	no	5%	Seaweeds abundant												
VNAZ 5	3	40	21/04/2011	180	360	Yes	25	5	19,20,32,32,36	27.8	no	5%	Seaweeds abundant	1											
VNAZ 5	4	60	21/04/2011	180	360	Yes	40	11	28,31,36,42,48	37.0	no	5%	Seaweeds abundant	4											
VNAZ 5	5	80	21/04/2011	180	360	Yes	40	8	36,40,54,44,45	43.8	no	5%	Seaweeds abundant	2											
CTZ 02	1	0	19/04/2011	180	360	Yes	20	6	20,22,31,10,27	22.0	yes	10%	Seaweeds abundant	2											Seagrass cover 30 % with c. 60% unattached red and green seaweed.
CTZ 02	2	20	19/04/2011	180	360	Yes	30	5	17,21,23,20,24	21.0	yes	10%	Seaweeds abundant	2											
CTZ 02	3	40	19/04/2011	180	360	Yes	10	6	18,12,24,8,12	14.8	yes	5%	Seaweeds abundant												
CTZ 02	4	60	19/04/2011	180	360	Yes	20	8	37,28,31,12,17	25.0	yes	10%	Seaweeds abundant	1											
CTZ 02	5	80	19/04/2011	180	360	Yes	30	15	22,27,34,27,29	27.8	yes	10%	Seaweeds abundant	2											
CTZ 03	1	20	19/04/2011	180	360	Yes	30	8	17,24,36,36,44	31.4	no	5%	Seaweeds abundant	1						1					Seagrass cover 30 % with c. 50% unattached red and green seaweed.
CTZ 03	2	40	19/04/2011	180	360	Yes	30	10	14,17,20,21,24	19.2	no	5%	Seaweeds abundant	3											
CTZ 03	3	60	19/04/2011	180	360	Yes	15	7	12,17,24,26,27	21.2	no	5%	Seaweeds abundant	4											
CTZ 03	4	80	19/04/2011	180	360	Yes	20	6	12,21,25,25,24	21.4	no	5%	Seaweeds abundant	2	1										
CTZ 03	5	100	19/04/2011	180	360	Yes	40	16	37,31,28,48,14	31.6	no	5%	Seaweeds abundant	2						1					
CTZ 04	1	0	19/04/2011	180	360	Yes	30	7	32,31,36,37,26	32.4	no	2%	Seaweeds abundant	5					1						c. 50% unattached red and green seaweed throughout.
CTZ 04	2	20	19/04/2011	180	360	Yes	20	7	25,5,6,27,26	17.8	yes	10%	Seaweeds abundant	6											
CTZ 04	3	40	19/04/2011	180	360	Yes	20	6	16,20,10,9,18	14.6	no	2%	Seaweeds abundant	3						1	1				
CTZ 04	4	60	19/04/2011	180	360	Yes	30	8	24,23,16,18,28	21.8	yes	10%	Seaweeds abundant	2											
CTZ 04	5	80	19/04/2011	180	360	Yes	15	7	30,33,7,21,23	22.8	no	0%	Seaweeds abundant	3					1						
CTZ 05	1	20	20/04/2011	180	360	Yes	20	9	21,26,7,17,46	23.4	yes	<3%	Seaweeds abundant	4				1							0m - 25m seagrass 30-40% cover with c. 50-60% red and green seaweed throughout. From 25m -100m seagrass coverage with approximately 50%.
CTZ 05	2	40	20/04/2011	180	360	Yes	40	10	19,46,42,18,16	28.2	no	0%	Seaweeds abundant	3										1	
CTZ 05	3	60	20/04/2011	180	360	Yes	15	5	16,17,24,25,27	21.8	no	0%	Seaweeds abundant	2						2					
CTZ 05	4	80	20/04/2011	180	360	Yes	50	7	21,14,22,24,29	22.0	no	3%	Seaweeds abundant	4											
CTZ 05	5	100	20/04/2011	180	360	Yes	30	9	34,35,8,16,33	25.2	no	0%	Seaweeds abundant	3											

Client	Crown Estate	Job Number	J/09/169
Location	Studland Bay	Vessel	SV Mariner
Survey	Studland Bay Seagrass Survey	Date	October 2011

Transect number	Quadrat Number	Distance along transect (m)	Date	Heading of Video Swim (o)	Heading of Quadrat Swim (o)	Photograph Yes/No	Seagrass (1/1) (%)	Number of shoots (1/4)	Blade lengths (cm)	Average blade length (cm)	Epiphyte Sample Collected Yes/No (*=unattached seaweed)	Epiphyte Cover (%) 1/1 ^	Comments	Other fauna (in quadrats): *Anemonia viridis*	*Sabella pavonina*	*Pomatoschistus sp*	*Gobiusculus flavescens*	*Callionymus lyra*	*Necora puber*	*Lanice conchilega*	*Maja squinado*	*Arenicola sp*	*Hinia reticulata*	*Dragonet*	*Spider crab*	
VNAZ 2	1	20	27/09/2011	180	360	Yes	40	20	37,44,48,49,49	45.4	Yes*	0	Decaying pom-pom weeds.	**0**												Healthy seagrass bed with approximately 60-70% seagrass density, and a smaller percentage of actual epiphytes (2-5%) but surrounded by an unattached seaweed component of both filamentous and macroalgal species
VNAZ 2	2	40	27/09/2011	180	360	Yes	70	14	32,35,38,42,51	39.6	Yes*	0+10	Decaying pom-pom weeds.	**3**						**2**						
VNAZ 2	3	60	27/09/2011	180	360	Yes	80	21	42,42,46.32.41	40.6	Yes*	2+10	Decaying pom-pom weeds.	**6**								**P**				
VNAZ 2	4	80	27/09/2011	180	360	Yes	70	14	51,54,54,55,56	54	Yes*	0+15	Decaying pom-pom weeds.	**5**												
VNAZ 2	5	100	27/09/2011	180	360	Yes	70	9	42,43,44,51,56	47.2	No	0+10	Decaying pom-pom weeds.	**2**	**1**											
VNAZ 3	1	0	27/09/2011	180	360	Yes	70	12	41,42,42,46,51	44.4	Yes	2+10	Decaying pom-pom weeds.	**3**												
VNAZ 3	2	20	27/09/2011	180	360	Yes	80	11	48,49,56,61,62	55.2	Yes	2+10	Decaying pom-pom weeds.	**2**												
VNAZ 3	3	40	27/09/2011	180	360	Yes	70	10	55,55,56,58,62	57.2	No	0+10	Decaying pom-pom weeds.	**3**												
VNAZ 3	4	60	27/09/2011	180	360	Yes	60	14	41,44,46,50,61	48.4	Yes*	0+20	Decaying pom-pom weeds.	**6**								**1**				
VNAZ 3	5	80	27/09/2011	180	360	Yes	60	12	43,46,48,58,58	50.6	Yes*	0+25	Decaying pom-pom weeds.	**6**												
VNAZ 4	1	20	27/09/2011	180	360	Yes	30	9	42,61,64,64,60	58.2	Yes*	0+70	Die back of some blades.	**4**												
VNAZ 4	2	40	27/09/2011	180	360	Yes	60	12	62,60,57,27,51	51.4	No	5+30	Die back of some blades.	**5**												
VNAZ 4	3	60	27/09/2011	180	360	Yes	50	19	45,32,35,42,43	39.4	No	5+40%	Die back of some blades.	**4**												
VNAZ 4	4	80	27/09/2011	180	360	Yes	60	28	26,36,42,43,28	35	Yes*	5+30	Die back of some blades.	**4**												
VNAZ 4	5	100	27/09/2011	180	360	Yes	60	28	38,41,41.30.37	37.4	Yes*	5+30	Die back of some blades.	**3**			**2**									
VNAZ 5	1	0	28/09/2011	180	360	Yes	60	10	44,46,48,64,64	53.2	Yes*	0+20	Decaying seaweed	**5**												
VNAZ 5	2	20	28/09/2011	180	360	Yes	50	11	63,68,71,73,70	69	Yes*	0+50	Decaying seaweed	**4**												
VNAZ 5	3	40	28/09/2011	180	360	Yes	60	9	53,60,61,63,35	54.4	Yes*	0+25	Decaying seaweed	**3**												
VNAZ 5	4	60	28/09/2011	180	360	Yes	70	12	73,75,76,65,52	68.2	Yes*	0+20	Decaying seaweed	**3**												
VNAZ 5	5	80	28/09/2011	180	360	Yes	60	14	48,36,54,52,54	48.8	Yes*	0+30	Decaying seaweed	**11**												
CTZ 02	1	0	28/09/2011	180	360	Yes	70	12	54,49,48,42,43	47.2	No	0+5	Shorter than VNAZ	**2**								**1**				Healthy seagrass bed with approximately 50-60% seagrass cover and 2-5% epiphyte cover at most. Unattached seaweed present throughout but approximately 10% of sediment surface also visible. Seabed surface very uneven/undulating with furrow-like featrues.
CTZ 02	2	20	28/09/2011	180	360	Yes	70	15	47,60,42,40,39	45.6	Yes	5+20	Shorter than VNAZ	**3**												
CTZ 02	3	40	28/09/2011	180	360	Yes	50	12	32,33,40,38,35	35.6	Yes	5+25	Shorter than VNAZ	**4**								**1**				
CTZ 02	4	60	28/09/2011	180	360	Yes	50	13	28,29,33,44,46	36	No	2+30	Shorter than VNAZ	**4**												
CTZ 02	5	80	28/09/2011	180	360	Yes	20	5	27,32,35,70,37	40.2	Yes*	5+50	Shorter than VNAZ	**3**												
CTZ 03	1	20	28/09/2011	180	360	Yes	40	19	30, 14, 40, 28, 26	27.6	Yes*	0+30	Thin but healthy seagrass	**2**												
CTZ 03	2	40	28/09/2011	180	360	Yes	50	20	22, 44, 35, 50, 28	35.8	Yes*	2+25	Thin but healthy seagrass	**3**		**1**						**2**				
CTZ 03	3	60	28/09/2011	180	360	Yes	50	8	48, 30, 28, 21, 36	32.6	Yes	0+40	Thin but healthy seagrass	**4**	**1**					**1**						
CTZ 03	4	80	28/09/2011	180	360	Yes	50	12	30, 22, 30, 44, 42	33.6	Yes*	0+30	Thin but healthy seagrass	**5**								**1**	**1**			
CTZ 03	5	100	28/09/2011	180	360	Yes	40	9	25, 20, 25, 53, 31	30.8	Yes*	5+25	Thin but healthy seagrass	**1**		**2**										
CTZ 04	1	0	29/09/2011	180	360	Yes	60	13	41, 44, 45, 47, 50	45.4	Yes*	0+20	20% open space	**5**	**1**											
CTZ 04	2	20	29/09/2011	180	360	Yes	50	10	39, 40, 47, 47, 48	44.2	No	0+25	Small scar in quadrat	**4**	**2**							**1**				
CTZ 04	3	40	29/09/2011	180	360	Yes	60	12	31, 33, 33, 37, 34	33.6	Yes*	0+35	3 small shoots.	**3**	**1**											
CTZ 04	4	60	29/09/2011	180	360	Yes	30	6	21, 29, 39, 29, 41	31.8	Yes*	5+50%	In small scar	**1**												
CTZ 04	5	80	29/09/2011	180	360	Yes	40	8	31, 32, 32, 51, 52	39.6	Yes*	0+40	20% open space	**4**	**1**											
CTZ 05	1	20	28/09/2011	180	360	Yes	60	14	36,38,38,44,46	40.4	Yes*	5+20	Healthy area	**4**												
CTZ 05	2	40	28/09/2011	180	360	Yes	50	15	32,33,33,37,38	34.6	Yes*	5+40	Healthy area	**6**												
CTZ 05	3	60	28/09/2011	180	360	Yes	60	14	32,33,34,37,39	35	Yes*	5+30	Healthy area	**2**												
CTZ 05	4	80	28/09/2011	180	360	Yes	50	9	19,21,21,22,32	23	Yes*	5+20	Recent scar	**3**												
CTZ 05	5	100	28/09/2011	180	360	Yes	20	5	16,36,38,40,42	34.4	Yes*	0+40	Thin but healthy seagrass	**1**												

^ = first value refers to actual epiphytes and the second to unattached seaweed

APPENDIX 02. Boat monitoring log sheets.

Studland Bay Voluntary No Anchor Zone Boat Monitoring Survey

Name of Observer:	
Date:	
Time Observations Start:	
Time Observations End:	

Observation Position	50.64057	001.94108 W

Weather Conditions (please circle the appropriate answer)

General Conditions:	Sun	Rain	Additional Notes:							
Visibility:	Good	Moderate	Poor	Very Poor	Additional Notes:					
Wind (Use Beaufort Scale):	0	1	2	3	4	5	6	7	8	9
Sea State (Use Beaufort Scale)	0	1	2	3	3-4	4	5	5-6	6	7

Photographs Taken (Time)	11:00	11:15	11:30	11:45	12:00	12:15	12:30	12:45	13:00	13:15
Please Tick										

Photographs Taken (Time)	13:30	13:45	14:00							
Please Tick										

SeaStar Survey Ltd - Marine Data Acquisition
Ocean Quay Marina, Belvidere Road, Southampton, SO14 5QY
Tel/Fax: (023) 8063 5000 - Mobile: 07977 571 781
info@seastarsurvey.co.uk - www.seastarsurvey.co.uk

Certificate No: 3647/03

Boat Activity (please record the boats coming into the bay and anchoring)				
Additional Notes	**Voluntary No Anchor Zone** **Boat Activity 11:00 - 12:00 (Please tally)**		**Control Area** **Boat Activity 11:00 - 12:00 (Please tally)**	
	Motor Boats		**Motor Boats**	
	Small	Large	Small	Large
	Sail Boats		**Sail Boats**	
	Small	Large	Small	Large
	Ribs		**Ribs**	
	Small	Large	Small	Large

Additional Notes	Voluntary No Anchor Zone Boat Activity 12:00 - 13:00 (Please tally)		Control Area Boat Activity 12:00 - 13:00 (Please tally)	
	Motor Boats		Motor Boats	
	Small	Large	Small	Large
	Sail Boats		Sail Boats	
	Small	Large	Small	Large
	Ribs		Ribs	
	Small	Large	Small	Large

Additional Notes	**Voluntary No Anchor Zone** **Boat Activity 13:00 - 14:00 (Please tally)**		**Control Area** **Boat Activity 13:00 - 14:00 (Please tally)**	
	Motor Boats		**Motor Boats**	
	Small	Large	Small	Large
	Sail Boats		**Sail Boats**	
	Small	Large	Small	Large
	Ribs		**Ribs**	
	Small	Large	Small	Large

APPENDIX 03. Studland Bay boat monitoring log – anchoring records (2009).

Studland Bay Boat Monitoring June 2009
J/09/169
Observation Position: 50.64057 N 001.94108 W

Date	Observers	Time	General Weather Conditions	Visibility	Wind (beaufort)	Sea State (beaufort)	Total Number of Small Motor Boats	Total Number of Large Motor Boats	Total Number of Small Sail Boats	Total Number of Large Sail Boats	Total Number of Small RIBs	Total Number of Large RIBs	Comments
							Control / VNAZ	Control / VNAZ	Control / VNAZ	Control / VNAZ	Control / VNAZ	Control / VNAZ	
23/06/2009	Amy / Emma	11:00 - 12:00					No Data	No Data	No Data	No Data	No Data	No Data	No Data
23/06/2009	Amy / Emma	12:00 - 13:00	Sun	Good	2	1	0	0	0	0	0	0	
23/06/2009	Amy / Emma	13:00 - 14:00					4	6	2	1	0	0	
24/06/2009	Neil / Amy	11:00 - 12:00					0	0	0	0	0	0	
24/06/2009	Neil / Amy	12:00 - 13:00	Sun	Good	1	1	0	0	0	0	0	0	
24/06/2009	Neil / Amy	13:00 - 14:00					1	2	1	4	0	0	
25/06/2009	Michelle / Emma	11:00 - 12:00					0	0	0	0	1	0	
25/06/2009	Michelle / Emma	12:00 - 13:00	Sun. Overcast from 11:30 then showers at 12:30 for half an hour	Moderate	2	2	0	1	0	0	0	0	
25/06/2009	Michelle / Emma	13:00 - 14:00					0	0	1	0	0	0	
26/06/2009	Amy / Emma	11:00 - 12:00					0	0	0	3	0	0	
26/06/2009	Amy / Emma	12:00 - 13:00	Overcast then sunny from 12:30	Moderate then good from 12:30	1	1	1	0	0	2	0	0	
26/06/2009	Amy / Emma	13:00 - 14:00					1	0	0	0	0	0	
27/06/2009	Michelle / Emma	11:00 - 12:00					0	1	4	3	0	0	
27/06/2009	Michelle / Emma	12:00 - 13:00	Sun	Good	1	1	6	1	2	0	0	0	
27/06/2009	Michelle / Emma	13:00 - 14:00					3	4	2	2	0	0	
28/06/2009	Amy / Michelle	11:00 - 12:00					5	2	10	3	0	0	
28/06/2009	Amy / Michelle	12:00 - 13:00	Sun and Rain. Light showers around 11:00-12:30. Generally overcast and muggy.	Moderate	3	2	4	3	2	3	0	0	
28/06/2009	Amy / Michelle	13:00 - 14:00					5	1	7	2	0	0	
29/06/2009	Neil / Amy	11:00 - 12:00					0	1	1	3	1	0	
29/06/2009	Neil / Amy	12:00 - 13:00	Sun	Good	1	1	0	1	1	1	0	0	
29/06/2009	Neil / Amy	13:00 - 14:00					0	0	0	0	0	0	
30/06/2009	Amy / Michelle	11:00 - 12:00					1	1	0	5	0	0	
30/06/2009	Amy / Michelle	12:00 - 13:00	Sun at first then rain	Poor	1	2	0	0	0	0	0	0	**No Data Students left due to heavy rain.**
30/06/2009	Amy / Michelle	13:00 - 14:00					0	0	0	0	0	0	**No Data Students left due to heavy rain.**

Studland Bay Boat Monitoring July 2009

Observation Position: 50.64057 N 001.94108 W

Date	Observers	Time	General Weather Conditions	Visibility	Wind (beaufort)	Sea State (beaufort)	Total Number of Small Motor Boats	Total Number of Large Motor Boats	Total Number of Small Sail Boats	Total Number of Large Sail Boats	Total Number of Small RIBs	Total Number of Large RIBs	Comments
							Control / VNAZ	Control / VNAZ	Control / VNAZ	Control / VNAZ	Control / VNAZ	Control / VNAZ	
01/07/2009	Neil / Amy	11:00 - 12:00	Sun	Good	1	1	2	1	0	1	1	0	
01/07/2009	Neil / Amy	12:00 - 13:00					3	0	0	2	0	0	
01/07/2009	Neil / Amy	13:00 - 14:00					0	0	1	0	0	0	
02/07/2009	Amy / Michelle	11:00 - 12:00	Hazy am overcast pm	Moderate	2	2	1	1	0	3	0	0	
02/07/2009	Amy / Michelle	12:00 - 13:00					2	1	0	4	0	0	
02/07/2009	Amy / Michelle	13:00 - 14:00					1	0	0	2	0	0	
03/07/2009	Neil / Amy	11:00 - 12:00	Sun	Good	1	1	1	1	2	7	0	0	
03/07/2009	Neil / Amy	12:00 - 13:00					0	0	0	0	1	0	
03/07/2009	Neil / Amy	13:00 - 14:00					0	0	0	0	1	0	
04/07/2009	Amy / Michelle	11:00 - 12:00	Sun and cloud	Moderate	1	1	1	0	7	3	0	0	
04/07/2009	Amy / Michelle	12:00 - 13:00					1	0	8	1	0	0	
04/07/2009	Amy / Michelle	13:00 - 14:00					8	1	13	2	0	0	
05/07/2009	Amy / Michelle	11:00 - 12:00	Sun / showers	Good	No data	No data	2	2	5	11	0	0	
05/07/2009	Amy / Michelle	12:00 - 13:00					1	2	1	2	0	0	
05/07/2009	Amy / Michelle	13:00 - 14:00					2	1	0	0	0	0	
06/07/2009	Neil / Michelle	11:00 - 12:00	Sun / showers	Moderate	1	1	3	1	0	6	0	0	
06/07/2009	Neil / Michelle	12:00 - 13:00					0	0	0	0	0	0	
06/07/2009	Neil / Michelle	13:00 - 14:00					0	0	0	0	0	0	
07/07/2009	Neil / Michelle	11:00 - 12:00	Sun and heavy showers	Moderate / Poor	3	3	0	0	1	0	0	0	
07/07/2009	Neil / Michelle	12:00 - 13:00					0	0	1	0	0	0	
07/07/2009	Neil / Michelle	13:00 - 14:00					0	0	0	2	0	0	
08/07/2009	Amy	11:00 - 12:00	Overcast am, Sunny noon, overcast pm	Good	2	2	0	0	0	1	0	0	
08/07/2009	Amy	12:00 - 13:00					1	0	0	0	0	0	
08/07/2009	Amy	13:00 - 14:00					0	0	0	0	0	0	
09/07/2009	Neil / Amy	11:00 - 12:00	Overcast but bright am,pm	Good	1 leading to 3 by pm	1 leading to 3 by pm	0	0	1	3	0	0	
09/07/2009	Neil / Amy	12:00 - 13:00					0	0	0	0	0	0	
09/07/2009	Neil / Amy	13:00 - 14:00					0	1	0	0	0	0	
10/07/2009	Neil / Michelle	11:00 - 12:00	Sun ocassionally from 11:30-12:30, showers. Mainly overcast.	Moderate	1	1	1	1	5	2	0	0	
10/07/2009	Neil / Michelle	12:00 - 13:00					0	1	2	1	0	0	
10/07/2009	Neil / Michelle	13:00 - 14:00					0	0	0	0	0	0	
11/07/2009	Amy / Michelle	11:00 - 12:00	Rain and drizzle all day	Poor	4	3 to 4	0	0	0	3	0	0	
11/07/2009	Amy / Michelle	12:00 - 13:00					1	0	0	1	0	0	
11/07/2009	Amy / Michelle	13:00 - 14:00					0	0	1	1	0	0	
12/07/2009	Amy / Michelle	11:00 - 12:00	Sun and cloud. Gentle breeze.	Moderate	2	2	2	0	1	1	0	0	
12/07/2009	Amy / Michelle	12:00 - 13:00					0	2	1	2	0	0	
12/07/2009	Amy / Michelle	13:00 - 14:00					4	2	2	5	1	0	
13/07/2009	Amy / Emma	11:00 - 12:00	Overcast with showers	Good	2	1	0	0	1	2	0	0	
13/07/2009	Amy / Emma	12:00 - 13:00					0	0	2	0	0	0	
13/07/2009	Amy / Emma	13:00 - 14:00					0	0	0	2	0	0	
14/07/2009	Neil / Amy	11:00 - 12:00	Sun	Good	1	1	0	0	4	7	0	0	
14/07/2009	Neil / Amy	12:00 - 13:00					1	0	0	0	0	0	
14/07/2009	Neil / Amy	13:00 - 14:00					0	1	0	0	2	0	

15/07/2009	Michelle / Emma	11:00 - 12:00					0	0	3	6	0	0	
15/07/2009	Michelle / Emma	12:00 - 13:00	Sun and cloud. Clear sky 12:00-13:00	Moderate	2, 3 from 11:30	1 then 2	1	0	0	0	0	0	
15/07/2009	Michelle / Emma	13:00 - 14:00					0	0	0	1	0	0	
16/07/2009	Neil / Amy	11:00 - 12:00					0	0	2	3	0	0	
16/07/2009	Neil / Amy	12:00 - 13:00	Overcast with some sun	Good	1	1	1	0	1	2	0	0	
16/07/2009	Neil / Amy	13:00 - 14:00					0	0	0	0	0	0	
17/07/2009	Amy / Emma	11:00 - 12:00					0	0	0	1	0	0	
17/07/2009	Amy / Emma	12:00 - 13:00	Overcast at first, followed by rain	Good	2 inc to 3	2	0	0	0	0	0	0	
17/07/2009	Amy / Emma	13:00 - 14:00					0	0	0	0	0	0	
18/07/2009	Michelle / Emma	11:00 - 12:00					0	0	0	1	0	0	
18/07/2009	Michelle / Emma	12:00 - 13:00	Sun	Good	2	1	0	0	3	2	0	0	
18/07/2009	Michelle / Emma	13:00 - 14:00					1	0	0	0	0	0	
19/07/2009	Michelle / Emma	11:00 - 12:00					0	0	2	4	0	0	
19/07/2009	Michelle / Emma	12:00 - 13:00	Overcast followed by sun from 12:30	Moderate	3 inc to 5	2 inc to 3	0	0	1	0	0	0	
19/07/2009	Michelle / Emma	13:00 - 14:00					0	0	0	0	0	0	
20/07/2009	Neil	11:00 - 12:00					0	4	3	2	0	1	
20/07/2009	Neil	12:00 - 13:00	Overcast but warm	Good	1	1	0	0	1	0	1	0	
20/07/2009	Neil	13:00 - 14:00					2	0	3	1	1	0	
21/07/2009	Neil	11:00 - 12:00					0	0	1	2	0	0	
21/07/2009	Neil	12:00 - 13:00	Rain	Moderate	1	1	0	1	5	1	0	0	
21/07/2009	Neil	13:00 - 14:00					0	0	0	0	0	0	
22/07/2009	Neil / Emma	11:00 - 12:00					0	0	1	2	0	0	
22/07/2009	Neil / Emma	12:00 - 13:00	Sun	Good	1	1	0	1	0	2	0	0	
22/07/2009	Neil / Emma	13:00 - 14:00					0	0	0	0	0	0	
23/07/2009	Michelle / Emma	11:00 - 12:00			3	1	0	0	0	0	0	0	
23/07/2009	Michelle / Emma	12:00 - 13:00	Sun	Good	3	1	0	0	0	0	0	0	
23/07/2009	Michelle / Emma	13:00 - 14:00			3	1	1	1	5	5	0	1	
24/07/2009	Michelle / Emma	11:00 - 12:00			3	2	0	0	0	0	0	0	
24/07/2009	Michelle / Emma	12:00 - 13:00	Sun	Good	3	2	0	0	0	0	0	0	
24/07/2009	Michelle / Emma	13:00 - 14:00			3	2	1	0	3	2	0	0	
25/07/2009	Michelle / Emma	11:00 - 12:00			2	1	0	0	0	0	0	0	
25/07/2009	Michelle / Emma	12:00 - 13:00	Sun	Good	2	1	0	0	0	0	0	0	
25/07/2009	Michelle / Emma	13:00 - 14:00			2	1	16	7	17	12	1	0	
26/07/2009	Amy/Michelle	11:00 - 12:00			1	1	0	0	0	0	0	0	
26/07/2009	Amy/Michelle	12:00 - 13:00	Sun	Moderate	1	1	0	0	0	0	0	0	
26/07/2009	Amy/Michelle	13:00 - 14:00			1	1	3	2	10	5	1	0	Overcast, intermittant sun
27/07/2009	Amy/Emma	11:00 - 12:00			2	2	0	0	0	0	0	0	
27/07/2009	Amy/Emma	12:00 - 13:00	Sun	Good	2	2	0	0	0	0	0	0	
27/07/2009	Amy/Emma	13:00 - 14:00			2	2	0	4	1	1	0	0	Small fishing boat off headland at 1230 with net - unsure if weighted
28/07/2009	Amy/Emma	11:00 - 12:00			2	1	0	2	3	5	0	1	
28/07/2009	Amy/Emma	12:00 - 13:00	Sun	Good	2	1	0	0	0	0	1	0	
28/07/2009	Amy/Emma	13:00 - 14:00			2	1	1	0	3	3	1	0	Cloud cover at times
29/07/2009	Neil/Amy	11:00 - 12:00			1	1	0	1	2	6	0	0	
29/07/2009	Neil/Amy	12:00 - 13:00	Rain	Good	1	1	1	2	0	0	0	0	Started to get cold around 12.30 then wind picked up
29/07/2009	Neil/Amy	13:00 - 14:00			1	1	1	0	1	1	0	1	Light rain
30/07/2009	Michelle / Emma	11:00 - 12:00			3	2	1	1	1	4	0	0	
30/07/2009	Michelle / Emma	12:00 - 13:00	Sun	Good	3	2	2	0	2	0	0	0	Showers approximately 1240-1310
30/07/2009	Michelle / Emma	13:00 - 14:00			3	2	0	0	3	1	0	0	
31/07/2009	Michelle/Neil	11:00 - 12:00			1	1	1	2	1	8	0	0	
31/07/2009	Michelle/Neil	12:00 - 13:00	Sun	Good	1	1	1	2	0	3	1	0	
31/07/2009	Michelle/Neil	13:00 - 14:00			1	1	3	2	0	0	0	0	Warm, little wind

Studland Bay Boat Monitoring August 2009

J/09/169

Observation Position: 50.64057 N 001.94108 W

Date	Observers	Time	General Weather Conditions	Visibility	Wind (beaufort)	Sea State (beaufort)	Total Number of Small Motor Boats	Total Number of Large Motor Boats	Total Number of Small Sail Boats	Total Number of Large Sail Boats	Total Number of Small RIBs	Total Number of Large RIBs
							Control / VNAZ	Control / VNAZ	Control / VNAZ	Control / VNAZ	Control / VNAZ	Control / VNAZ
01/08/2009	Michelle / Emma	12:00 - 13:00	Rain	Poor	2	2	0	0	0	2	0	0
01/08/2009	Michelle / Emma	13:00 - 14:00			2	2	0	1	1	3	0	0
01/08/2009	Michelle / Emma	14:00 - 15:00			2	2	1	0	0	1	0	0
02/08/2009	Michelle / Emma	11:00 - 12:00	Sun	Good	2	1	8	4	1	3	0	1
02/08/2009	Michelle / Emma	12:00 - 13:00			2	1	3	1	4	3	1	0
02/08/2009	Michelle / Emma	13:00 - 14:00			2	1	4	3	6	3	3	1
03/08/2009	Neil/Emma	11:00 - 12:00	Sun	Good	1	1	2	0	0	0	0	0
03/08/2009	Neil/Emma	12:00 - 13:00			1	1	0	0	1	1	0	0
03/08/2009	Neil/Emma	13:00 - 14:00			1	1	1	0	3	5	1	0
04/08/2009	No data											
04/08/2009												
04/08/2009												
05/08/2009	Neil/Emma	11:00 - 12:00	Rain	Moderate	1	1	3	1	0	0	0	0
05/08/2009	Neil/Emma	12:00 - 13:00			1	1	0	2	1	1	0	0
05/08/2009	Neil/Emma	13:00 - 14:00			1	1	0	0	0	0	0	0
06/08/2009	Michelle/Neil	11:00 - 12:00	Rain	Poor	2	2	0	0	2	3	0	0
06/08/2009	Michelle/Neil	12:00 - 13:00			2	2	0	1	0	0	0	0
06/08/2009	Michelle/Neil	13:00 - 14:00			2	2	0	1	0	0	0	0

07/08/2009	Michelle/Neil	11:00 - 12:00			3	3	0	2	3	3	2	0	
07/08/2009	Michelle/Neil	12:00 - 13:00	Sun	Good	3	3	0	2	1	2	0	0	
07/08/2009	Michelle/Neil	13:00 - 14:00			3	3	2	0	1	0	0	0	Warm with some wind, bit cloudy
08/08/2009	Michelle / Emma	12:00 - 13:00			2	1	6	4	9	7	0	0	
08/08/2009	Michelle / Emma	13:00 - 14:00	Sun	Good	2	1	10	7	0	1	0	0	
08/08/2009	Michelle / Emma	14:00 - 15:00			2	1	6	7	9	7	1	1	
09/08/2009	Michelle / Emma	12:00 - 13:00			1	1	5	5	6	4	1	0	
09/08/2009	Michelle / Emma	13:00 - 14:00	Sun	Good	1	1	4	6	0	1	0	1	
09/08/2009	Michelle / Emma	14:00 - 15:00			1	1	4	3	1	0	3	0	
10/08/2009	Amy/Emma	11:00 - 12:00			1	1	0	1	2	6	0	0	
10/08/2009	Amy/Emma	12:00 - 13:00	Rain	Moderate	1	1	0	1	1	0	0	0	
10/08/2009	Amy/Emma	13:00 - 14:00			1	1	0	0	0	0	0	0	
11/08/2009	Amy/Emma	11:00 - 12:00			1	1	1	0	7	3	0	0	
11/08/2009	Amy/Emma	12:00 - 13:00	Sun	Good	1	1	1	3	1	0	1	0	
11/08/2009	Amy/Emma	13:00 - 14:00			1	1	0	2	3	1	0	0	
12/08/2009	Amy/Emma	11:00 - 12:00			1	1	1	2	3	10	0	0	
12/08/2009	Amy/Emma	12:00 - 13:00	Sun	Good	1	1	0	0	0	3	0	0	
12/08/2009	Amy/Emma	13:00 - 14:00			1	1	0	0	0	2	0	1	
13/08/2009	Neil/Shell	11:00 - 12:00			1	1	2	3	5	3	0	0	
13/08/2009	Neil/Shell	12:00 - 13:00	Sun	Good	1	1	0	0	1	0	0	0	
13/08/2009	Neil/Shell	13:00 - 14:00			1	1	2	1	0	1	0	0	Very Clear skies with minimal cloud coverage

14/08/2009	Neil/Shell	11:00 - 12:00			1	1	2	3	6	5	0	0	
14/08/2009	Neil/Shell	12:00 - 13:00	Sun	Good	1	1	2	3	3	1	0	0	
14/08/2009	Neil/Shell	13:00 - 14:00			1	1	0	2	1	1	1	1	Very warm, sunny with a few clouds
15/08/2009	Amy	11:00 - 12:00			0	0	-	-	-	-	-	-	
15/08/2009	Amy	12:00 - 13:00	Sun	Good	0	0	3	3	2	5	1	0	
15/08/2009	Amy	13:00 - 14:00			0	0	0	0	0	0	0	0	Overcast
16/08/2009	Amy	11:00 - 12:00			1	1	1	6	4	3	0	0	
16/08/2009	Amy	12:00 - 13:00	Sun	Good	1	1	4	3	0	3	0	0	
16/08/2009	Amy	13:00 - 14:00			1	1	3	5	1	3	0	0	Some cloud coverage
17/08/2009	Neil/Amy	11:00 - 12:00			1	1	1	1	1	4	0	0	
17/08/2009	Neil/Amy	12:00 - 13:00	Sun	Moderate	1	1	1	1	2	0	0	0	
17/08/2009	Neil/Amy	13:00 - 14:00			1	1	0	2	1	1	0	0	Overcast
18/08/2009	Neil/Amy	11:00 - 12:00			1	2	2	2	6	6	0	0	
18/08/2009	Neil/Amy	12:00 - 13:00	Sun	Moderate	1	2	4	1	3	0	0	0	
18/08/2009	Neil/Amy	13:00 - 14:00			1	2	1	0	4	3	0	1	Very Over cast
19/08/2009	Neil/Amy	11:00 - 12:00			1	1	4	5	4	5	0	0	
19/08/2009	Neil/Amy	12:00 - 13:00	Sun	Good	1	1	1	1	0	2	0	1	
19/08/2009	Neil/Amy	13:00 - 14:00			1	1	3	1	6	1	1	0	Clear Sky
20/08/2009	Shell	11:00 - 12:00	Rain	Moderate	3	3	0	0	8	5	0	0	
20/08/2009	Shell	12:00 - 13:00	Rain	Moderate	3	3	0	0	1	0	0	0	
20/08/2009	Shell	13:00 - 14:00	Sun	Moderate	3	3	0	0	0	0	0	0	Alot of Cloud coverage until around 1:30 when there was clear blue sky

21/08/2009	Neil / Michelle	11:00 - 12:00					0	0	4	8	0	0	
21/08/2009	Neil / Michelle	12:00 - 13:00	Sun	Moderate	2	1	0	0	2	3	0	0	
21/08/2009	Neil / Michelle	13:00 - 14:00					0	1	0	0	0	0	
22/08/2009	Michelle	11:00 - 12:00					2	1	11	6	0	0	
22/08/2009	Michelle	12:00 - 13:00	Sun	Moderate	2	2	3	5	2	1	0	0	Very Coudy
22/08/2009	Michelle	13:00 - 14:00					2	2	3	2	1	1	
23/08/2009	Michelle	11:00 - 12:00					15	6	12	7	0	0	
23/08/2009	Michelle	12:00 - 13:00	Sun	Good	2 then 3	2	7	3	12	7	2	1	Few clouds
23/08/2009	Michelle	13:00 - 14:00					6	2	9	3	1	0	
24/08/2009	Michelle	11:00 - 12:00					2	1	7	6	0	0	
24/08/2009	Michelle	12:00 - 13:00	Rain	Poor	1	1	0	0	1	0	0	0	Bright sun vis moderate from 13:00
24/08/2009	Michelle	13:00 - 14:00					0	0	2	0	0	0	
25/08/2009	Neil	11:00 - 12:00			1	1	0	0	2	6	0	0	
25/08/2009	Neil	12:00 - 13:00	Sun	Moderate	1	1	0	0	0	0	0	1	
25/08/2009	Neil	13:00 - 14:00			1	1	0	0	1	2	0	0	Overcast
26/08/2009	Neil	11:00 - 12:00	Rain	Moderate	1	2	0	0	0	0	0	0	Heavy Rain and Wind returned to car at 12:00
26/08/2009	Neil	12:00 - 13:00	-	-	-	-	-	-	-	-	-	-	
26/08/2009	Neil	13:00 - 14:00	-	-	-	-	-	-	-	-	-	-	
27/08/2009	Amy	11:00 - 12:00			1	1	1	1	0	1	0	0	Overcast
27/08/2009	Amy	12:00 - 13:00	Sun	Moderate	1	1	1	0	0	1	0	0	
27/08/2009	Amy	13:00 - 14:00			1	1	0	0	0	1	1	0	
28/08/2009	Amy	11:00 - 12:00			4	4	0	0	1	4	0	0	Cloud Cover
28/08/2009	Amy	12:00 - 13:00	Sun	Good	3 to 4	4	0	0	0	0	0	0	Heavy Shower 12:05, 12:15 Clear Skies, 12:30 Heavy Shower
28/08/2009	Amy	13:00 - 14:00			3 to 4	4	0	0	0	0	0	0	
29/08/2009	Shell	11:00 - 12:00			2	2	6	6	4	3	0	0	Cloudy but Strong Sunlight
29/08/2009	Shell	12:00 - 13:00	Sun	Good	2	2	5	1	2	6	0	0	
29/08/2009	Shell	13:00 - 14:00			2	2	1	1	3	3	0	0	
30/08/2009	Shell	11:00 - 12:00			2	1	3	3	11	6	0	0	Very Cloudy
30/08/2009	Shell	12:00 - 13:00	Sun	Poor	2	1	2	2	1	0	0	0	
30/08/2009	Shell	13:00 - 14:00			2	1	1	0	0	0	0	0	
31/08/2009	Shell	11:00 - 12:00	Rain	Poor	4	2	4	2	6	10	0	0	Very Cloudy and Misty
31/08/2009	Shell	12:00 - 13:00		Moderate	3	0	5	3	4	6	1	0	Clear Skies
31/08/2009	Shell	13:00 - 14:00	Sun	Good	3	0	3	3	6	3	0	0	

APPENDIX 04. Tests for Normality

NB. A test that fails indicates that the data varies significantly from the pattern expected if the data was drawn from a population with a normal distribution. A test that passes indicates that the data matches the pattern expected if the data was drawn from a population with a normal distribution.

		Seagrass Shoot Density			% Seagrass Cover			Seagrass Frond Length		
Zone	**Time**	**K-S Dist**	**P value**	**Pass/ fail**	**K-S Dist**	**P value**	**Pass/ fail**	**K-S Dist**	**P value**	**Pass/ fail**
VNAZ	**Oct 2009**	0.134	P>0.200	Pass	0.131	P>0.200	Pass	0.057	P>0.200	Pass
	Apr 2010	0.149	P>0.200	Pass	0.228	P = 0.008	Fail	0.154	P<0.001	Fail
	Sep 2010	0.119	P>0.200	Pass	0.207	P = 0.025	Fail	0.149	P<0.001	Fail
	Oct 2010	0.146	P>0.200	Pass	0.260	P<0.001	Fail	0.066	P>0.200	Pass
	Apr 2011	0.213	P = 0.018	Fail	0.295	P<0.001	Fail	0.071	P>0.200	Pass
	Oct 2011	0.281	P<0.001	Fail	0.244	P = 0.003	Fail	0.078	P = 0.138	Pass
CTZ	**Oct 2009**	0.267	P<0.001	Fail	0.214	P = 0.017	Fail	0.059	P>0.200	Pass
	Apr 2010	0.119	P>0.200	Pass	0.206	P = 0.027	Fail	0.115	P = 0.004	Fail
	Sep 2010	0.132	P>0.200	Pass	0.158	P>0.200	Pass	0.070	P>0.200	Pass
	Oct 2010	0.178	P = 0.099	Pass	0.166	P = 0.157	Pass	0.098	P = 0.026	Fail
	Apr 2011	0.214	P = 0.017	Fail	0.204	P = 0.028	Fail	0.073	P = 0.199	Pass
	Oct 2011	0.143	P>0.200	Pass	0.246	P = 0.003	Fail	0.065	P>0.200	Pass