Estimating the Degree of Exposure to Leisure Vessel Anchoring

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Conservation advice (as for Marine Conservation Zones) issued by Natural England involves an assessment of a feature's **Sensitivity** to a pressure or external factor (itself a combination of the feature's **intolerance** to the pressure combined with its **resilience** or recovery time from the pressure), and then assessing the feature's degree of **Exposure** to the pressure. The combination of these scores gives a **Vulnerability** score. Therefore the **Exposure** assessment is an important part of the overall assessment of Vulnerability.

To help in this process, this report presents estimates of the exposure of eelgrass (seagrass *Zostera marina*) to leisure boat anchors in the specific case of Studland Bay. It also gives an estimate of the highest likely exposure in the general case, applicable to Studland and elsewhere. It is based on the author's 20 years experience with sailing yachts, including regular anchoring, sometimes at Studland, coupled with long experience of data analysis as a professional research scientist. But here, the analysis requires no more than simple arithmetic.

<u>1. Studland Bay, Overall Area:</u>

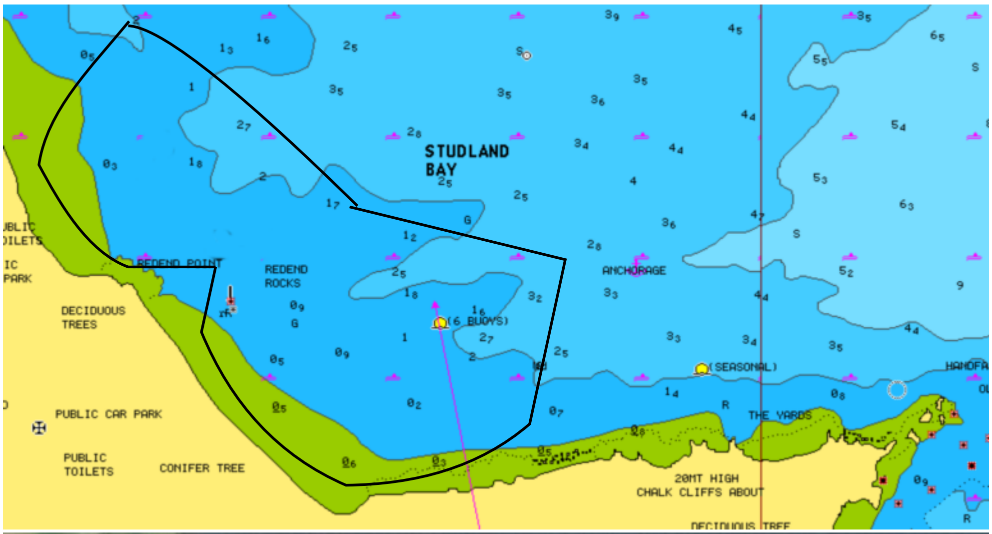

Fig. 1. Navionics ® chart of part of Studland Bay, with the approximate area used for anchoring outlined with black lines. This is necessarily approximate, there being no lines of demarcation on the sea. It is based on a radar scan from the author's boat, taken on a busy Saturday afternoon in July 2014, and is supported by the aerial image below. (This updates the author's earlier estimate and shows a larger area in use: see Appendix).

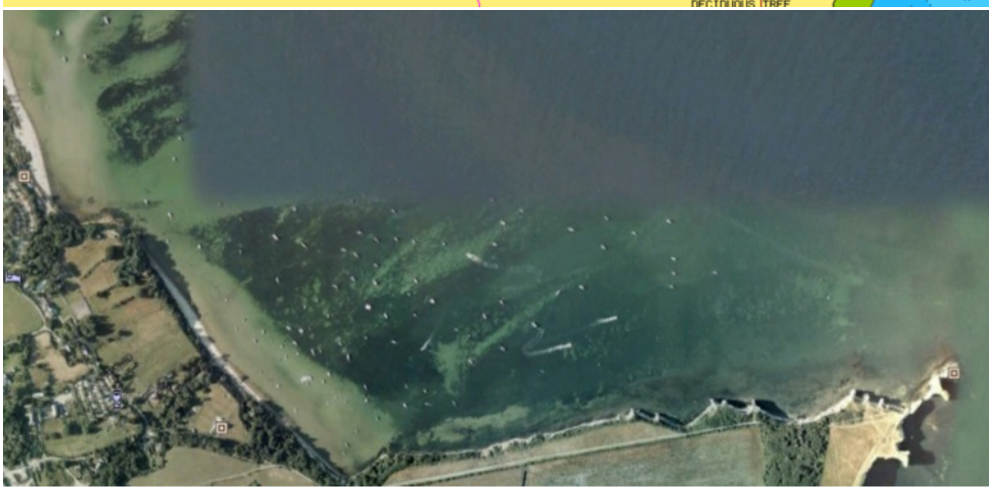

Fig. 2. Google Earth aerial image of boats anchored in Studland Bay in 2005, for comparison with Fig. 1. The dull coloured band towards the top is an area of low resolution in the Google image with detail obscured. The boats without wakes were confirmed as at anchor by examination in the original high resolution Google Earth image. Here, some boats were further to the east than in the 2014 radar scan.

In this analysis of anchoring intensity, we will use estimates which tend to over- rather than under-state the anchoring intensity. The anchoring area shown on the above chart is approximately 1080 x 460 m (taking an average for its width), and the area is about 500,000 sq metres. It was a busy day, perhaps 150 boats, which were spread out further than sometimes, so we will adopt a normal anchoring area of 400,000 sq m. Following discussions with the Seahorse Trust we will suppose there are on average 75 anchoring events per day, 50% above our earlier estimate, over 4 months, June to September inclusive, or about 120 days per season. That is 75x120 = 9000 anchoring events. This is probably an over-estimate, for while there may be 200 or more boats on certain days in peak season, the numbers during early June and late

September will generally be well below 50.

Now the area impacted by an anchor might normally be of the order of 0.3 x 0.5 m, or 0.15 sq m (see Anchor Footprint, below). The area impacted by all the anchoring events in a season will be 0.15 x 9000 = 1350 sq m. So the fraction of the eelgrass bed in the anchoring area impacted by anchoring is 1350/400,000 = 1/296 . If only about one part in 296 (about 0.34%) of the eelgrass bed is actually impacted by an anchor during a whole year, the degree of exposure to the activity **must** be considered low, and hence the vulnerability low. Even if there is a two-fold uncertainty in this estimate, that is still less than 0.7% of the area affected by an anchor in a season.

It is worth noting that a study by Boese et al, 2009, shows eelgrass to have high resilience to moderate mechanical damage and that regrowth from adjacent rhizomes can cover a gap of 0.5m in six months if it occurs from each side. (slide 27 in http://boatownersresponse.org.uk/Workshop_presentation7.pdf) Thus the 0.34% of the eelgrass bed impacted by anchoring should re-grow within 6 months anyway, in time for the next boating season. That study involved digging up and removing the eelgrass: in an earlier study by Boese in 2002 eelgrass plots were raked (4 tine hoe, 20 cm tines) three times at monthly intervals and found to be fully recovered in 2 weeks. That treatment seems closer to simulating anchor disturbance than complete removal, and suggests very rapid recovery indeed.
(Refs: Boese et al.2009: http://www.sciencedirect.com/science/article/pii/S0022098109001427 ;
Boese 2002 http://www.sciencedirect.com/science/article/pii/S0304377002000049).

These considerations can explain why evidence shows the Studland Bay eelgrass beds have continued to flourish despite ongoing anchoring over a period exceeding 50 years. The evidence includes data from the Seastar Survey Report (see next section) which gives eelgrass shoot densities in the area studied as 170 - 190 shots per m^2 , typical for the wider Portland / Weymouth area. The present analysis gives a semi-quantitative explanation: low exposure coupled with high recovery (resilience).

2. Direct observation of anchoring craft in Studland Bay

The Seastar Survey report
(http://www.thecrownestate.co.uk/media/313222/Seastar%20survey%20Studland%20Bay%20second%20seagrass%20monitoring%20report.pdf)
studied, over two years, the eelgrass condition in a voluntary no-anchor zone (VNAZ) and a zone (CTZ) in which anchoring continued, possibly at increased intensity because of displacement from the VNAZ. As part of the study, a partial record of the number of boats anchoring was kept. The report does suggest that a more detailed analysis, particularly of the location of the boats relative to the zones, would have given improved information. Therefore these results should be viewed with caution.

In the summer period of 20010, June 21st – September 12th, about 80 days, the number of boats anchoring in the CTZ was monitored for 3 hours a day for “most days” (p. 15). During that period, 244 anchoring events were reported in the 100 x 100 m zone. Multiplying this by 1.5 to give a 120 day boating season gives 366 anchoring events. However the 3 hr mid-day observation period would miss boats which came and went outside these hours, so we suggest increasing the number by 50% to 550 for the season.

In the summer period of 2011, approximately June 21st – September 12th, about 80 days, the number of boats anchoring in the CTZ was monitored for 9 hours a day for 3 or 4 days a week, always including weekends plus the Friday or Monday, and all bank holidays (p. 15). During that period, 115 anchoring events were observed in the 100 x 100 m zone. To compensate for the 3 – 4 of the less busy days per week not monitored, we could round that up to 200 events over the 80-day period, and to cover the 120 day period we suggest a total of 300 anchoring events. We will increase this by 25% to allow for boats coming and going outside the 9 hrs, to 375 for the season.

Taking the average area impacted by an anchor as 0.3 x 0.5 m = 0.15 sq m, that is 550 x 0.15 = 82.5 sq m impacted by anchors over the 2010 season, and 375x 0.15 = 56 sq m over the 2011 season, which is 83/10,000 = 0.0083 or 0.8% of the area of the CTZ for 2010 and 56/10,000 = 0.0056 or 0.6% of the CTZ for 2011.

The CTZ is in the most intensively anchored area of the Bay, so these figures are in reasonable accord with the 0.34% (deliberately generous) estimate for the wider Bay, above. Again, we have estimates of below 1% of the seabed impacted by anchoring over the season.

3. Highest normal anchoring density: a general case

Some popular areas may be more heavily anchored than others. A reasonable estimate of maximum exposure can be made in this case. The reason is that competent boat skippers will always anchor so as to avoid collision with other anchored vessels as the boats swing around the anchor under the influences of tide and wind. Because it is widely understood that different craft can respond differently to changes in wind and tide (current), normal practice is to anchor at such a distance from nearby vessels that if they should swing in opposite directions, they will not make contact with each other. The example below is for a 30 ft, 9 m, boat, which is around the average for the wide variety of craft anchoring at Studland Bay and along the South Coast. We'll assume that a single anchor is deployed, which is the usual practice, and that the depth at high water (HW) is 3 – 5 m (and a metre less at mean LW).

Typically in such conditions 12 – 15 m of anchor chain will be deployed, so assume a swinging radius of 10 m plus a hull length from the bow of 9m, giving a total radius of 19 m. There should therefore be twice this, i.e. 38 m between the anchors of adjacent boats. In practice, in limited space, skippers might risk a closer spacing, say 33m between anchors (which makes for simpler arithmetic). This is just over 3 boat lengths.

In a space of 100m x 100m, there would then be room for 9 boats if a 33m spacing was observed between anchors. The total area is 100x100 = 10,000 sq m. Again assuming a 0.3 x 0.5 anchor footprint or affected area, the boats' anchors in total will affect 9 x 0.15 = 1.35 sq m, which is 1.35 / 10,000 = 0.000135 or 0.0135% of the total. Over 120 days, 120 x 0.000135 = 0.016 or 1.6% of the seabed will have been affected by anchoring events in this high density anchoring situation on the basis of one boat anchoring per space per day. On some days there may a greater turnover of boats than this, but on many others there will be a lower occupancy. Experience shows that really high occupancy of any anchorage only occurs on limited days per year, particularly at weekends in high season and in good weather. On weekdays in June and September occupancy is generally low. There seem to be no grounds for increasing the estimate of area impacted above 1.6% over the season, and in fact 1.0% would be a more reasonable upper annual estimate.

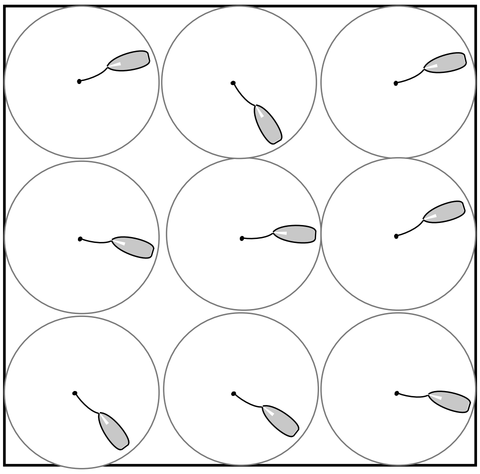

Fig. 3 Schematic diagram of nine 9.1 m (30 ft) boats anchored in a space 100 x 100 m, each boat occupying a "closest approach" swinging circle of 33.3 m diameter

4. Anchor Footprint

The suggested 0.3 x 0.5 m area impacted by an anchoring event arises from the width of a typical anchor blade, such as a 10 kg Delta anchor, which is 31 cm wide, times the estimated distance along the line of pull in which the anchor digs in, perhaps 0.5 m. This gives an area of 0.3 x 0.5 = 0.15 sq m.

This is very close to a figure in Natural England Commissioned Report NECR108 (2012) which mentions (p.4) "anchor scars of up to 0.16 m^2". This in turn may come from a report by Williams S.L. 1988 *Assessment of anchor damage and carrying capacity of seagrass beds in Francis and Maho Bays for green sea turtles* (Biosphere Reserve Report no. 25 US Dept of Interior National Park Service), which studied beds of *Thalassia testudinum* seagrass (turtlegrass) in the US Virgin Islands and reported that between zero and one scar occurred per 10 sq m and that the average anchor scar area (depression in seabed) was 0.16 sq m. It is greater than the estimated area of anchor scars reported by Otero (2006) in a report into mechanical damage to seagrass beds in Puerto Rico, which gives an estimated scar area of 1 sq ft (0.09 sq m). (Otero, E. 2006. *Task Characterization of Mechanical Damage to Seagrass Beds in La Cordillera Reefs Natural Reserve. CRI-10 Conservation and Management of Puerto Rico's Coral Reefs* Award Number NA04NOS4190112).

It should be pointed out that our estimate does not necessarily mean 0.15 sq m of damaged eelgrass – it is quite possible for much of the seabed, roots and rhizomes to slip back into place when the anchor is withdrawn. A study by Milazzo et al (2004) studied anchoring in Posidonia oceanica beds in Italy, and the numbers are remarkable: they did a series of anchoring operations while divers watched how many shoots became dislodged. They used smaller (5 m) boats with relatively light, 4 kg, anchors. In a seagrass bed having 500 shoots per sq m, the mean number of shoots broken / dislodged in a setting and retrieving cycle was just 6. It therefore could be argued that an anchoring event damaged only 6/500 = 0.012 sq m of seagrass bed, which is one twelfth of our footprint estimate. (Milazzo et al. 2004: http://www.researchgate.net/publication/222181339_Boat_anchoring_on_Posidonia_oceanica_beds_in_a_marine_protected_area_%28Italy_western_Mediterranean%29_effect_of_anchor_types_in_different_anchoring_stages_)

A study on larger boats was reported by Francour et al. (1999), which studied 9 m boats with 12 kg Brittany type anchors anchoring in *Posidonia oceanica* beds in France (Port Cros, an island off the Cote d'Azur). The average number of shoots either broken or uprooted during the complete anchoring cycle was 34. The shoot density in the seagrass beds studied averaged about 450 shoots / m². Therefore the average area which experienced this shoot damage on each anchoring cycle was 34/450 = 0.076 m², about one half of our anchor footprint estimate. (Francour et al 1999 www.vliz.be/imisdocs/publications/54789.pdf)

Creed et al (1999) found that the mean size of anchor scars in the tropical seagrass *Halodule Wrightii* was 0.16 m², closely in line with our estimate, and it was estimated that 0.5% of the seagrass beds were damaged per year by boat anchoring. (Creed, J.C., Filho, A. & Gilberto, M., 1999. Disturbance and recovery of the macroflora of a seagrass *Halodule wrightii* (Ascherson) meadow in the Abrolhos Marine National Park, Brazil: an experimental evaluation of anchor damage. *Journal of Experimental Marine Biology and Ecology*, 235 (2), 285-306. The experimentally damaged areas recovered to show properties close to those of undamaged areas within 13 months, although this was *Halodule Wrightii* not *Zostera marina.*

It appears that our estimate of an impacted area of 0.15 m² is consistent with the upper end of measured anchor scar areas in the literature.

5. Summary and Conclusions

The area of seabed potentially affected by an anchoring event is estimated to be 0.15 m², in agreement with other reports. This may be an overestimate, as Francour et al (1999) report direct damage to the seagrass *Posidonia oceanica* which corresponds to 0.075 m², using boats and anchors of a size corresponding to around the average size encountered along the English South Coast, including Studland Bay. Nevertheless, we will keep to our estimate of 0.15 m² to allow for possible damage below the seabed which was not initially apparent to Francour et al..

The number of boats anchoring in Studland Bay in a season may be estimated for the wider Bay, and also calculated for a smaller, heavily anchored area which was monitored during the Seastar Survey study. The total percentage of the relevant area of seabed impacted during the course of a yearly leisure boating season is estimated as less than 0.4% in the first case, and 0.8% in the busier of the two years in the second case.

It is possible to estimate the maximum likely percentage area exposed to anchor impact in the general case (applicable anywhere) by using the condition that boats are anchored in a "swinging circle" sufficient to ensure they do not collide with each other. Using the same anchor footprint, and an average boat length of 30ft (9.1 m), this maximum likely percentage area is estimated at 1% of the seabed.

The low proportion (less than one part in one hundred) of the seabed impacted in a year, coupled with the resilience, or powers of regrowth, of eelgrass (*Zostera marina*), provides an explanation of why there have been no confirmed reports of significant anchor damage to eelgrass beds in Studland Bay nor elsewhere in the world. Further, a series of historic aerial photographs show a steady expansion of the eelgrass beds in Studland Bay despite ongoing anchoring over decades: see http://boatownersresponse.org.uk/Aerial-1972-2011.pdf

It is hoped the methodology outlined here, or developments of it, will help inform estimates of the vulnerability of eelgrass to the pressure of leisure boat anchoring in the future.

Appendix

Radar scan plot overlaid on Navionics ® chart shown in Fig 1. Position of radar scanner, on the author's anchored boat, indicated by red cross. Note the dense dark area surrounding the cross is an artefact (the blind area very close to the boat). The discrete dark blobs beyond this area, often overlapping, represent boats. The radar set used has a 5 deg beam width, so objects further from the set return a wider reflection, as shown by the increasing width of reflections from the cliffs along the south edge of the Bay. The concentric rings are at 0.25 nautical mile spacings from the centre, except the dashed variable range marker (VRM) spaced at 0.424 nm, and the dimensions of the indicated anchoring area can be confirmed by reference to these markers. They have also been confirmed by measurements made on the chart. The boundaries of the anchoring area were drawn to contain the majority of anchored boats. The north west boundary is somewhat arbitrary as boats were also anchored, at greater spacing, off Knoll Beach for some distance beyond the area shown.