Appendix XIV

Poole Harbour Channel post-deepening EIA studies 2006-8

Report to Poole Harbour Commissioners

December 2008

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Summary
This study includes the key areas for biological monitoring detailed in Section 5 of the Poole Harbour Approach Channel Deepening EIA: Proposed Monitoring Programme, Haskoning UK Ltd., Ref :9P07171/N/MAS/Exet, 5.3.05. The post-dredging studies undertaken in Poole Bay and Poole Harbour in 2006-7 were:

- Sedimentation rate studies, Poole Bay
- Maerl (*Phymatolithon calcareum*) density off Ballard Down
- Reef species
- Algal densities on Poole Bay patch reefs
- Pink seafan (*Eunicella verrucosa*)
- Biogenic worm reefs (*Sabellaria spinulosa*) off Swanage
- Seagrass (*Zostera marina*), Studland Bay and Poole Harbour

Studies of the first 3 were continued through to 2008.

No significant changes post-dredging and spoil deposition were detected from the studies of Seagrass (*Zostera marina*), *Sabellaria spinulosa* reefs, reef biota, algal density on patch reefs and Pink seafans (*Eunicella verrucosa*).

The decline in maerl density post-dredging has been confirmed by more extensive studies in 2008. Average densities were found to be 60% of pre-dredging levels, a statistically significant change at the majority of sites. Pre-dredging data was obtained 2000-3, a gap of 2 years before the dredging, so it could be argued that the decline could have happened prior to the dredging and disposal. However the densities of maerl were stable 2000, 2002 and 2003. Maerl growth studies do not indicate any significant changes in growth rate over the period 2000-7. Thus loss due to increased siltation (to which maerl is acutely sensitive) over winter 2005/6 is the most likely cause of the decline.

The sedimentation studies and diver observations point to retention of silt from the dredging disposal within Poole Bay. Modelling (by HR Wallingford) of silt from the disposal ground suggested that it would be carried anti-clockwise around Poole Bay with some deposition during neap tides but re-suspension during spring tides. The extra silt remaining from the dredging and disposal is remobilised during storms and presumably largely re-settling in the Bay. An indication that sedimentation rates were returning to pre-dredging levels in autumn 2007 have not been borne out in 2008.

One of the concerns was that increased sediment levels would adversely affect reef biota. No impact on reef algal density was found (Collins, 2007). A range of established reef associated species was examined in each of the 3 years post-dredging. There was no evidence for loss of any of these.

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1. Introduction

This study includes the key areas for biological monitoring detailed in Section 5 of the Poole Harbour Approach Channel Deepening EIA: Proposed Monitoring Programme, Haskoning UK Ltd., Ref :9P07171/N/MAS/Exet, 5.3.05. The post-dredging studies undertaken in Poole Bay and Poole Harbour in 2006-7 were:

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Studies of the first 3 were continued into 2008. Each section describes the data collected and makes comparison with previous data.

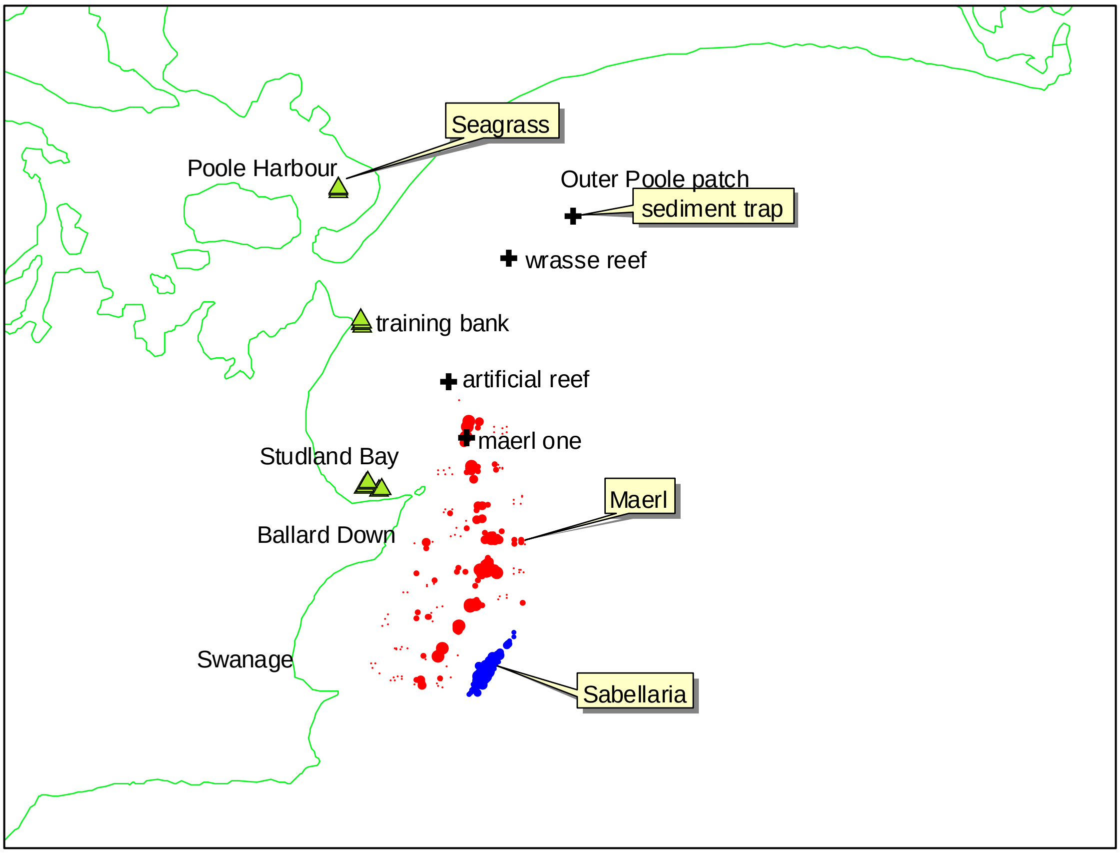

Figure 1 The main study sites described in this report. Sediment trap sites are indicated by a "+".

2. Methods

These are fully described in the previous reports (Collins, 2005, 2006, 2007). Maerl density studies were carried out by divers collecting material from within 0.5m^2 quadrats. Sedimentation studies were conducted with pairs of sediment traps (vertical tubes 40cm x 8cmID) at each of the 4 sites indicated in Fig.1 and replaced by divers at 1-2 monthly intervals. Reef associated species were recorded by divers using an underwater checklist on a slate backed up by underwater photography.

3. Maerl density studies

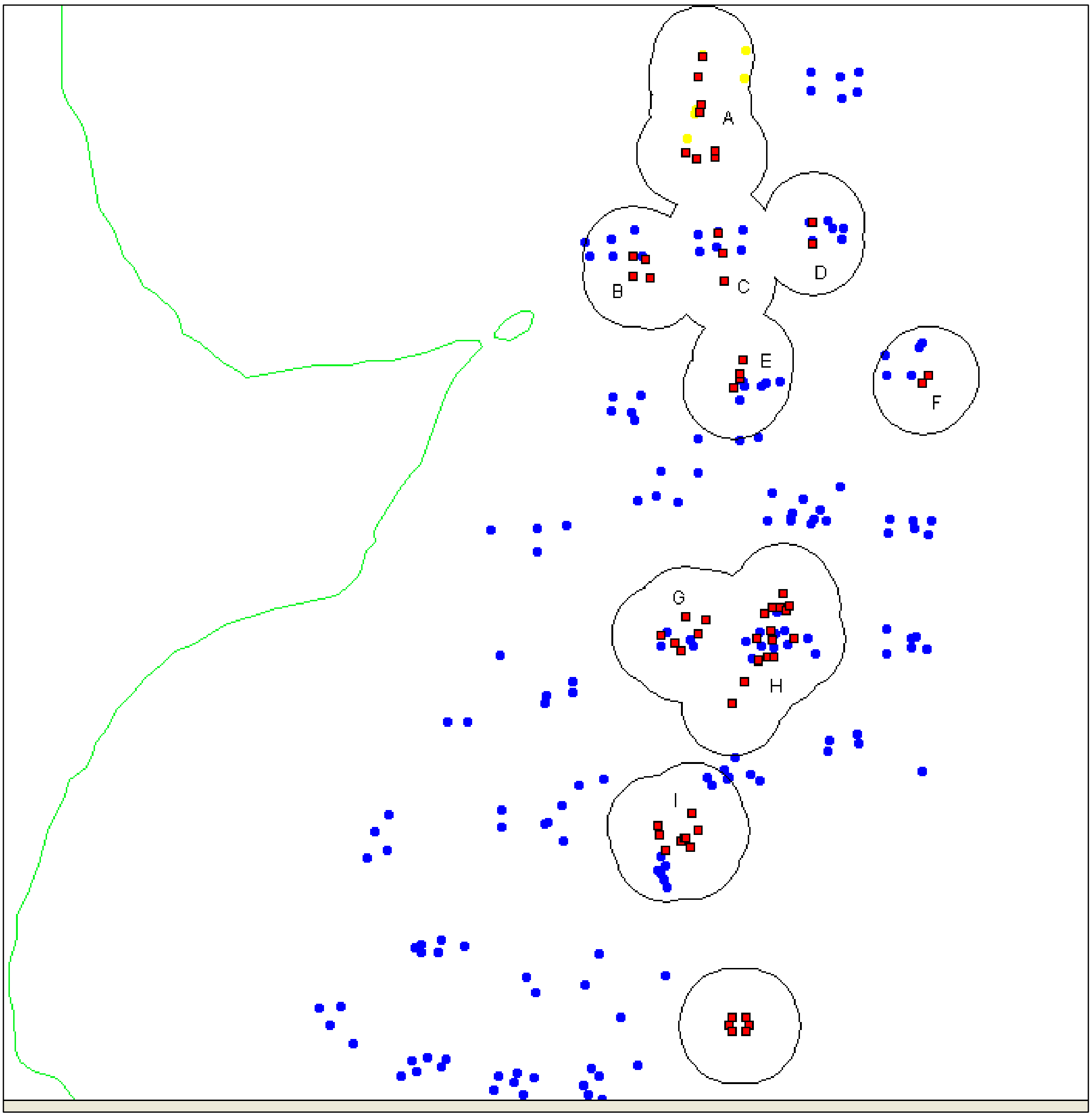

Figure 2 Maerl survey points, pre-dredging (2000-3, blue dots) and post dredging (2006-8, red squares). The labelled buffer zones A-I around the clusters of post-dredging surveys are used to select the pre-dredging data for direct comparison.

The results of maerl quadrat surveys (n=28 in 2006, n=94 in 2008) confirm the decline post-dredging reported previously (Collins, 2007). The densities have been analysed in clusters shown in Fig.2 above, the post dredging data being compared directly with pre-dredging sites within 125m or within 250m. Results are summarised in Table 1 below and statistical analyses are given in Appendix 1. It is difficult to closely replicate sampling sites whilst drift diving, the sampling method used. Pre-dredging data was identified as being within a fixed radius (250m and 125m) from post-dredging sampling sites. Whilst the 250m buffer zones yield larger comparative data sets than the 125m zones, the differences are small.

	Pre-dredging<125m			Pre-dredging<250m			Post-dredging		
Group	n	Avg	Std	n	Avg	std	n	Avg	Std
A	6	47.4	21.5	14	46.7	19.9	26	30.3	14.4
B	6	1.1	1.4	12	0.7	1.1	8	0.3	0.4
C	12	25.4	23.5	12	25.4	23.5	8	27.3	7.4
D	8	10.5	5.3	12	8.3	5.4	4	3.6	3.0
E	10	21.0	10.3	12	20.5	9.6	10	11.8	3.2
F	2	6.9	2.5	10	4.5	2.5	4	5.1	4.4
G	8	15.2	5.5	8	15.2	5.5	12	6.9	5.4
H	24	39.8	15.2	24	39.8	15.2	32	17.6	7.4
I	8	45.1	12.6	16	43.3	15.5	18	19.9	8.8

Table 1 Comparison of maerl densities (g m-2) average densities (and standard deviation) recorded in the areas indicated in Fig.1, within 125 and 250 m of the post-dredging survey.

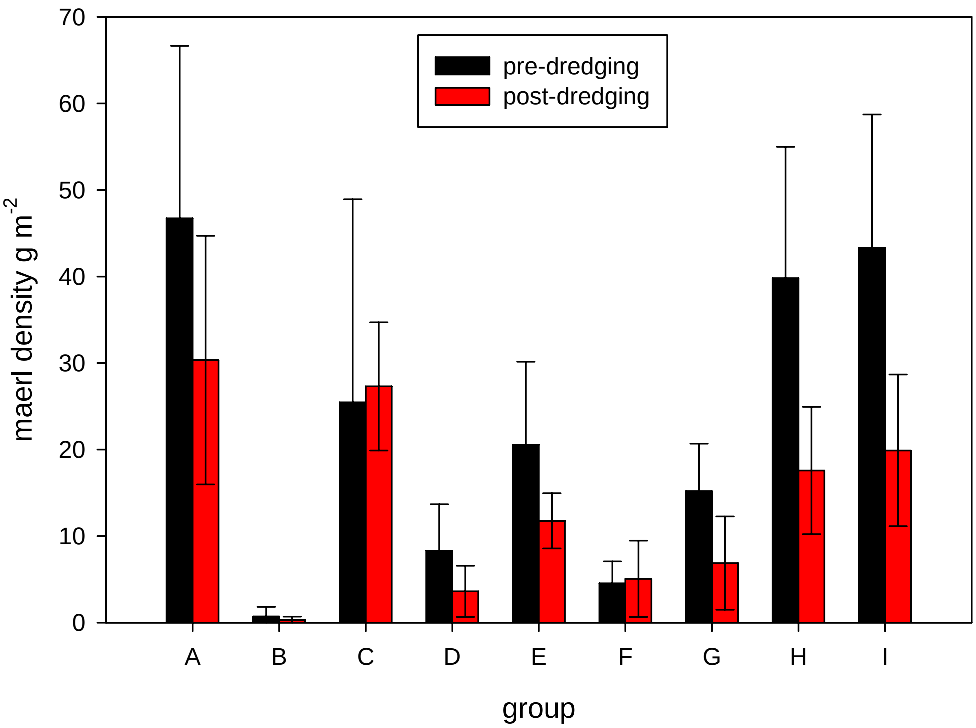

Figure 3 Comparison of average post-dredging data with pre-dredging sites within 250m, data from Table 1. The error bars indicate 1 standard deviation.

Significant declines are evident in groups A, G and I (t-Test p= 0.005, 0.003, <0.001 respectively) and E and H (Mann Whitney Rank Sum Test p=0.016 and <0.001 respectively). The apparent decline in group B, evident in Fig 3 is not statistically significant. Reducing the buffer zones to 125m, removes group E as having shown significant decline.

The average density post dredging is 60% of that pre-dredging (across the 9 areas, using both buffer zone radii).

Another method of representing the maerl density data is shown in Fig 4 below. Here the density data pre- and post-dredging have been interpolated (method IDW, 500m fixed radius) within ArcView 3.2 then the surfaces compared. The core band of denser maerl is very evident in the 2000-3 data (left Fig.4). Lower values in the 2006-8 (centre Fig.4) are evident simply from the common classification colour scale. This is confirmed by the extensive areas of loss (right Fig.4).

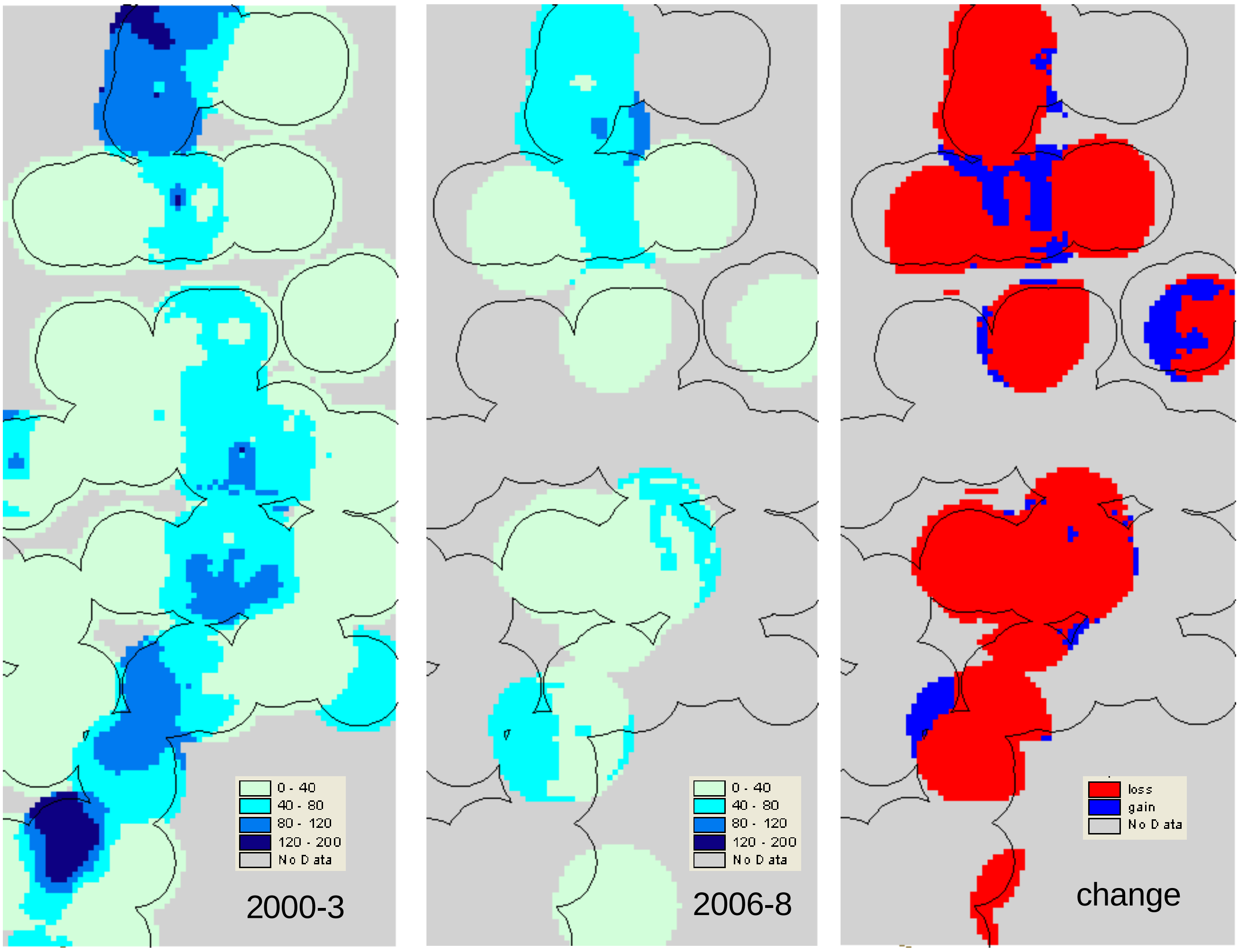

Figure 4 Interpolated maerl density 2000-3 (left), 2006-8 (centre) and net change (right).

3.1.Maerl growth studies

A novel environmental monitoring technique was explored in collaboration with Prof. Christine Maggs, Queens University Belfast. Studies by Buchan (2005) showed that the Poole Bay maerl rhodoliths contain both annual growth rings and monthly sub-rings representing growth during the summer. These were detected by electron microscope examination of sections. Prof. Maggs' team has been using micro CT scanning of whole specimens. Samples of maerl collected in August 2007 were similarly examined by electron microscopy at NOCS by Wright (2008). Analysis of these did not detect any change in maerl growth patterns in the years prior to and post the dredge spoil disposal campaign in the winter of 2005/2006.

Maerl is very sensitive to increase in fine sediment loading in suspension and deposition, even very small amounts will cause it to die (Wilson and Maggs, 2004). It is probable that increased sediment loading in Poole Bay as a result of the dredged spoil disposal in the winter of 2005/2006 may simply have killed maerl rhodoliths outright rather than impacting their growth rates.

4. Sedimentation rate studies

The sediment traps at the 4 sites indicated in Fig.1 were replaced at approximately 1-2 monthly intervals May 2005 to Nov 2008. It was not usually possible to replace all on the same day. A spreadsheet was set up with 1 day per row and columns for each of the 2 sediment traps at each of the 4 sites. Daily sedimentation (dry weight silt fraction <64µ) was assumed to be constant from the day of deployment to recovery. In this way average monthly sedimentation was calculated for the whole study period (Fig.5 below)

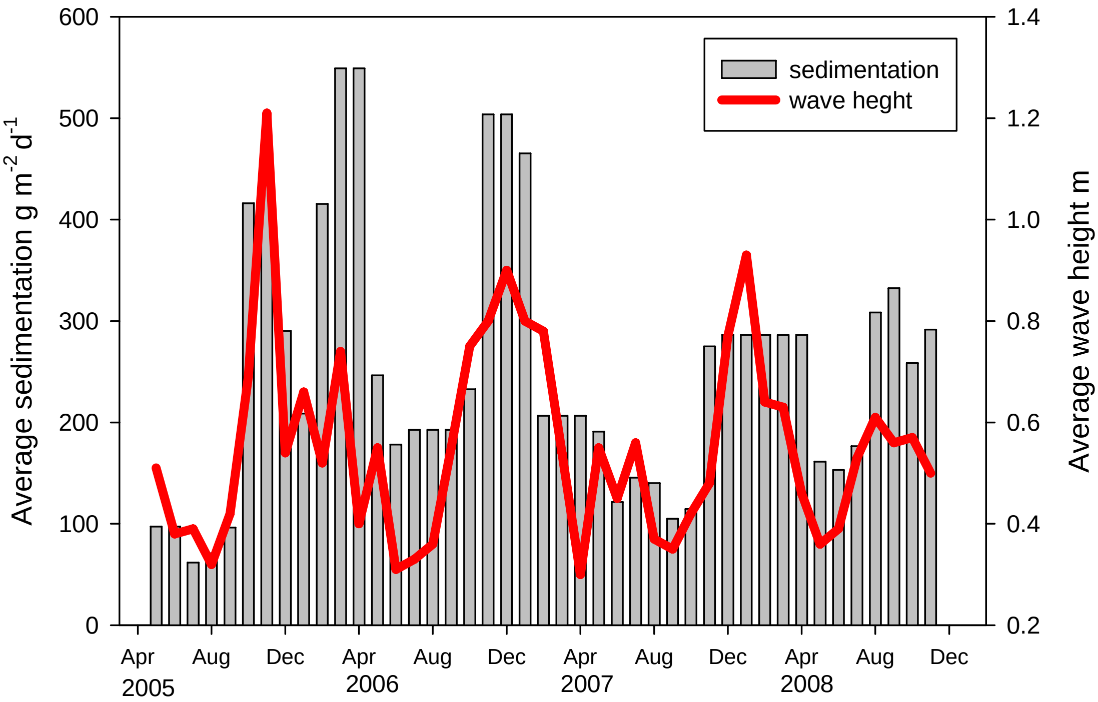

Figure 5 Average sedimentation rates May 2005-Nov.2008 from 4 sites in Poole Bay.

Storms re-suspend the seabed sediment in Poole Bay. It was very evident from this study that higher sediment accumulation coincided with winter storms. The second plot in Fig.4 above plots monthly average wave height calculated from the Boscombe Wave Rider Buoy data: (http://www.channelcoast.org/data_management/real_time_data/charts/?chart=66&tab=stats&disp_option) There is a trend in the relationship between average monthly wave height and sedimentation rate (Fig. 6, r^2 =0.38). Applying this relationship to the wave height predicts a sedimentation rate which is compared to the observed values in Fig.7. Notable periods of excess sedimentation are in spring 2006 following the dredging and disposal over winter 2006/7. This is interpreted as there having been deposition of fine sediment in Poole Bay carried in from the dumping site as predicted by the HR modelling. However this has remained in the Bay much longer than the predicted period, years rather than just a spring-neap interval. This reservoir of excess sediment observed by divers within the Bay is being re-suspended during storms. Observations in autumn 2007 suggested that the sedimentation levels were returning to pre-dredging levels, though this has not been evident in 2008 data.

The summer of 2005 shows much lower levels of sedimentation than predicted. Given that the relationship between wave height and sedimentation has largely been derived from post-dredging data and assuming that the there is a new reservoir of silt within the Bay, this is not surprising.

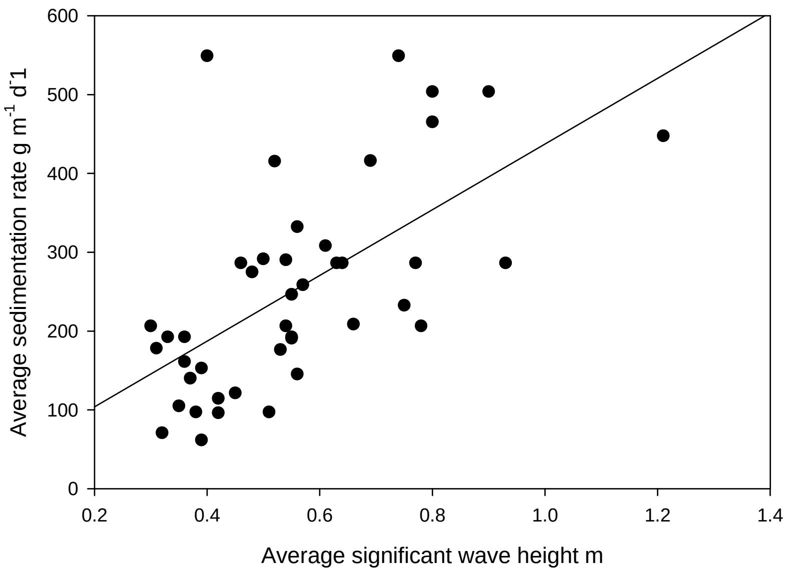

Figure 6 Plot of average monthly significant wave height (Boscombe) vs average monthly sedimentation rate.

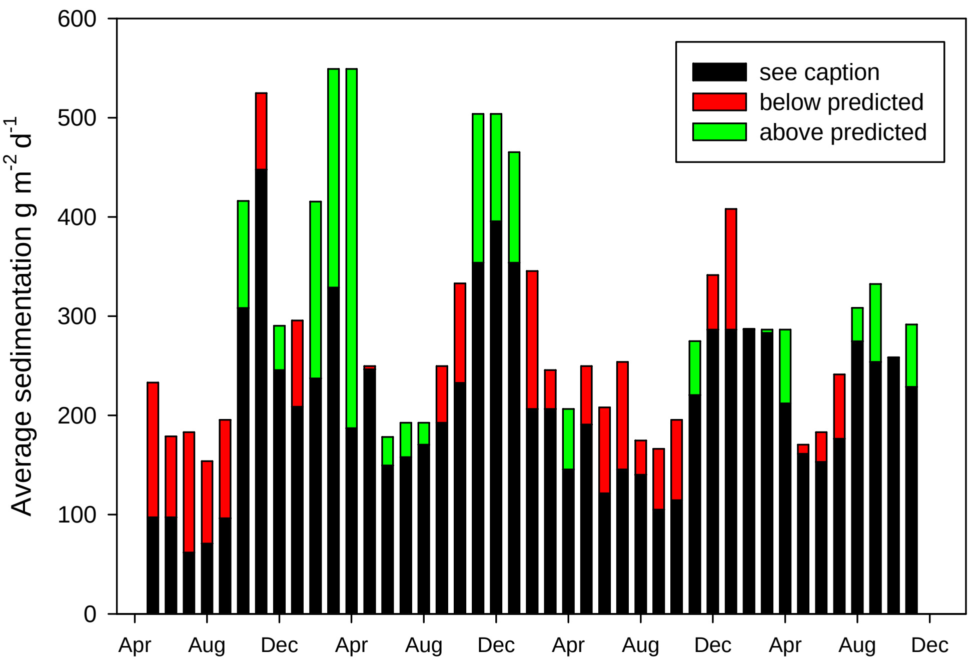

Figure 7 Comparison of predicted sedimentation rate (from wave height, Fig 6) compared to observed. If the predicted level is above observed then the difference is indicated by the red bar. If predicted is less than observed then the excess is indicated by the green bar .

5. Reef biota studies

Mallinson *et al.* (1999) documented the colonisation of the Poole Bay artificial reef since its deployment in 1989 alongside the biota of natural patch reefs in Poole Bay. This provides a baseline for comparison of species occurrence post-dredging. One of the potential impacts of increased sedimentation in Poole Bay could be increased silt thickness on reef surfaces which, in turn, may adversely affect sessile fauna and flora growth.

Table 2 below lists the species present before the dredging and post-dredging (2006 and 2008). There is no evidence for loss of any species.

Table 2 Species of reef fauna and flora present before and after dredging.

Taxon	Species	common names
PORIFERA	*Dysidea fragilis*	
	Esperiopsis fucorum	shredded carrot sponge
	Hemimycale columella	
	Hymeniacidon perleve	
	Leucosolenia complicata	
	Suberites carnosus	
CNIDARIA	*Aglaophenia parvula*	
	Halecium halecinum	
	Hydrallmania falcata	
	Laomedea flexuosa	
	Nemertesia antennina	antenna hydroid
	Plumularia setacea	
	Tubularia larynx	
ANNELIDA	*Bispira volutacornis*	twin spiral worm
	Pomatoceros triqueter	keel worm
CRUSTACEA	*Acasta spongites*	Barnacle
	Balanus crenatus	Barnacle
CRUSTACEA	*Cancer pagurus*	edible crab
	Carcinus maenas	green shore crab
	Galathea squamifera	squat lobster
	Galathea strigosa	squat lobster
	Homarus gammarus	European lobster
	Maja squinado	spiny spider crab
	Necora puber	velvet swimming crab
	Pagurus bernhardus	hermit crab
	Pagurus cuanensis	hermit crab
	Palaemon serratus	Prawn
MOLLUSCA	*Calliostoma zizyphinum*	painted topshell
	Crepidula fornicata	slipper limpet
	Gibbula cineraria	grey topshell
	Ocenebra erinacea	Tingle
	Ostrea edulis	European oyster

Table 2.cont. Species of reef fauna and flora present before and after dredging.

Taxon	Species	common names
BRYOZOA	*Bicellariella ciliata*	
	Bugula plumosa	
	Chartella papyracea	
	Flustra foliacea	Hornwrack
	Pentapora foliacea	Ross 'coral'
	Disporella hispida	
	Electra pilosa	
TUNICATA	*Aplidium punctum*	
	Ascidia mentula	
	Clavelina lepadiformis	Light bulb sea squirt
	Polycarpa sp.	
	Styela clava	
	Diplosoma listerianum	
ALGAE	*Bryopsis plumosa*	
Green	*Cladophora sp.*	
Brown	*Undaria pinnatifida*	
Red	*Calliblepharis ciliata*	
	Delesseria sanguinea	sea beech
	Gracilaria bursa-pastoris	
	Griffithsia corallinoides	
	Heterosiphonia plumosa	
	Lithothamnion type crust	coralline crust
	Phyllophora crispa	
	Phyllophora pseudoceranoides	
	Plocamium cartilagineum	
	Rhodymenia holmesii	
	Spyridia filamentosa	

6. Reef Algae

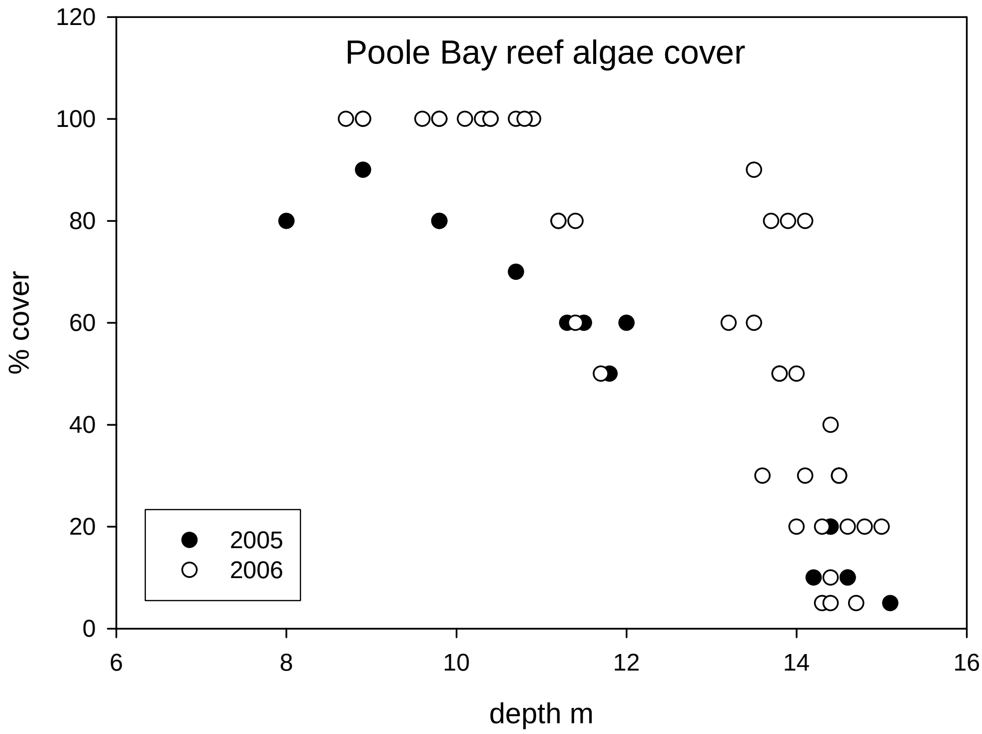

Figure 8. Poole Bay patch reef algae cover on horizontal surfaces determined in summer 2005 and 2006.

The small patch reefs within the Bay support typically a mixture of brown (*Dictyota dichotoma*) and red algae (*Calliblepharis ciliata*) species shallower than 10mCD and purely red algae below this depth. One of the potential impacts of increased sedimentation in Poole Bay could be increased silt thickness on horizontal reef surfaces which may adversely affect algal growth. To check this, algal coverage and maximum height were measured at a range of depths (8-15m) on several patch reefs in summer 2005 and again in summer 2006, post-dredging.

There is no evidence for any adverse impact post-dredging.

7. Pink sea fans, *Eunicella verrucosa*

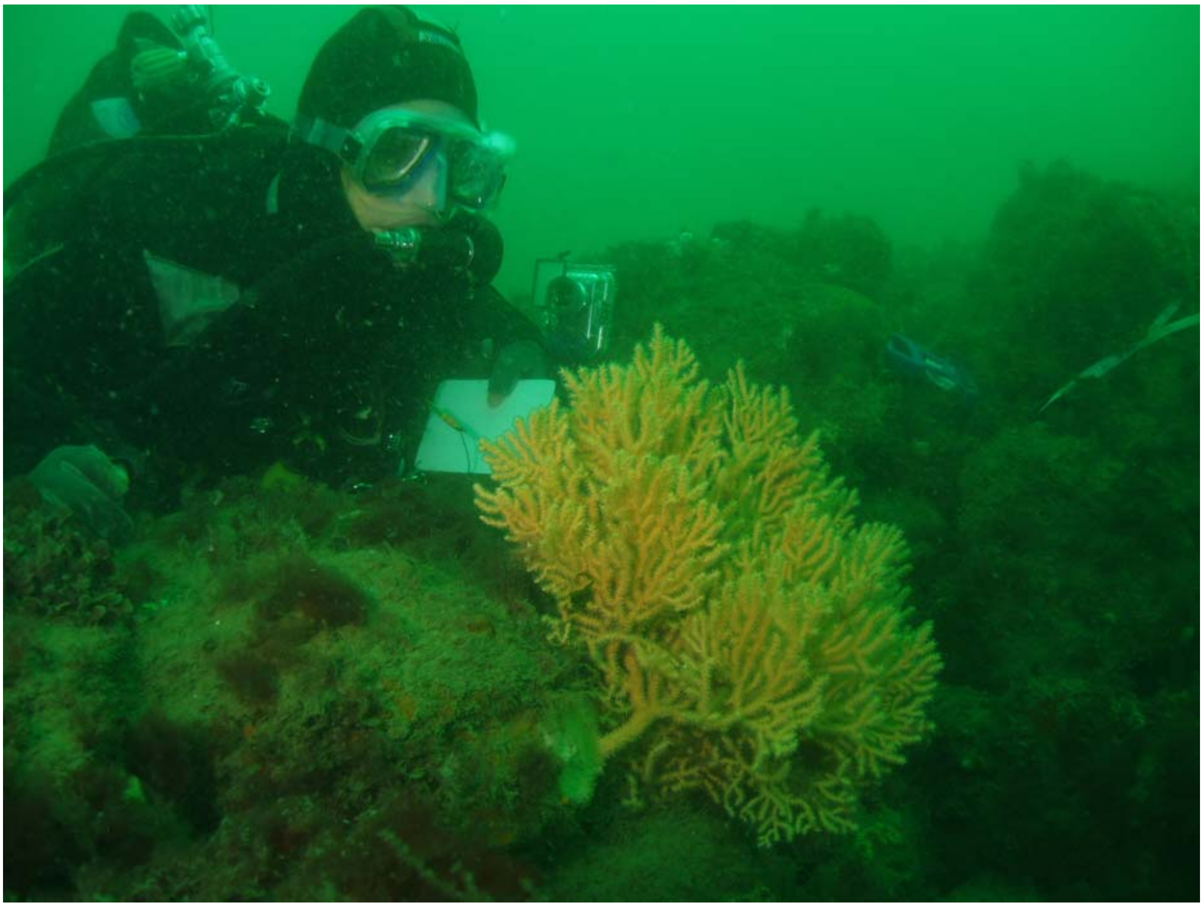

Figure 9. Healthy pink sea fan growing on a Poole Bay patch reef, photographed August 2006, post-dredging/disposal

Poole Bay represents the eastern-most extent of the pink sea fan, *Eunicella verrucosa*, along the English Channel. To date four specimens have been found on isolated patch reefs within Poole Bay. Of these, two were relocated in summer 2006. Fig.9 shows one which has clearly has not suffered from raised suspended matter levels during the previous winter . The second specimen was located attached beneath an overturned rock slab, presumably moved by recent hauling of pot lines. The rock was returned to its original position and the sea fan found to be remarkably unaffected by this event or the dredging/disposal.

8. Sabellaria spinulosa *reefs*

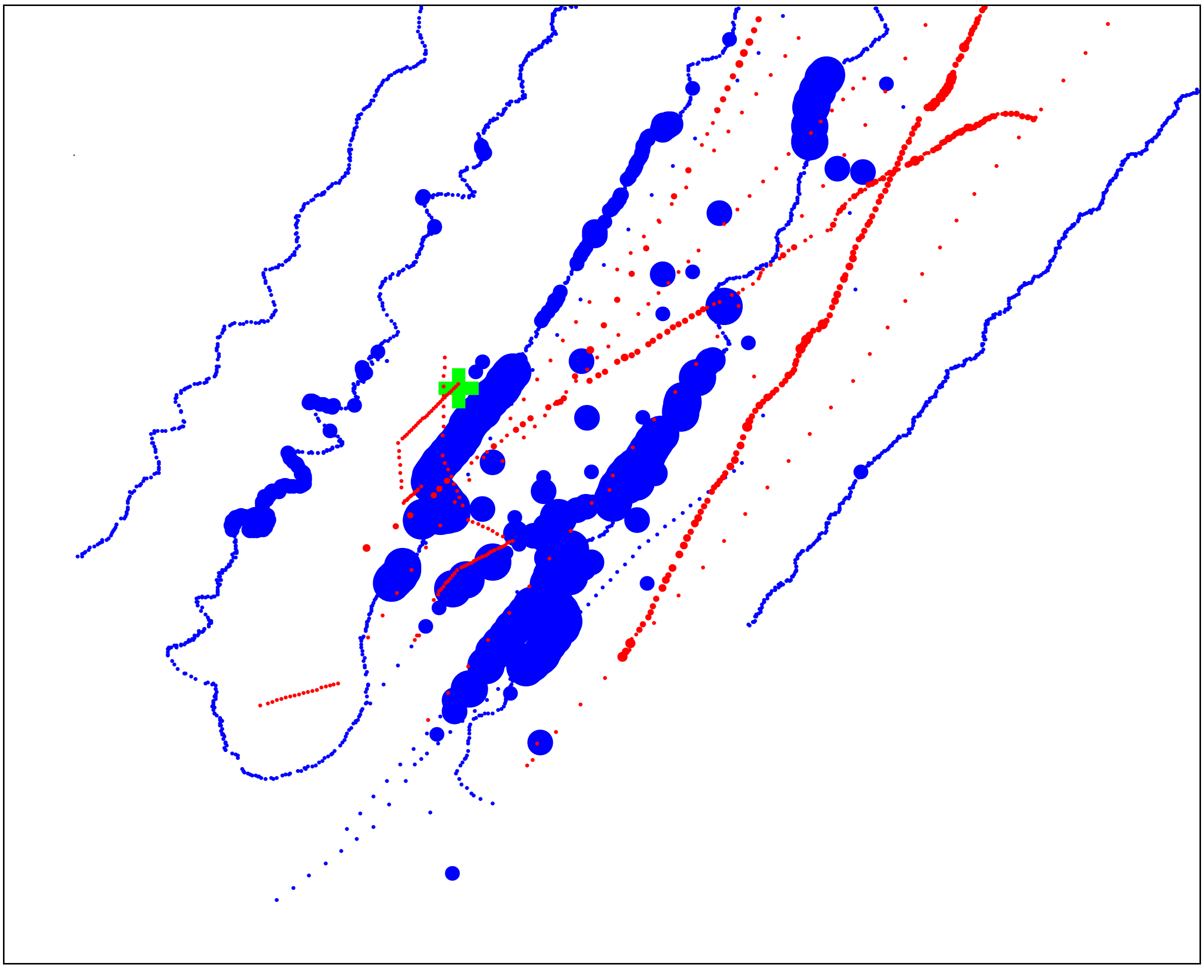

Figure 10. Core Sabellaria reef area off Swanage (see Fig.1) approximately 1 km2, showing results of surveys 2002-4 (blue dots) and 2005-6 (red dots). Dot size is proportional to density with the smallest dot size representing absence of Sabellaria reefs. The green cross marks the location the sediment depth monitoring site.

The extent and density of the *Sabellaria spinulosa* reefs off Swanage have been monitored by towed seabed video sledge and drift diving since 2002. In 2004 some indication of damage by trawling or dredging was first noticed within the core area shown in Fig.10 above. It was considered essential to carry out a thorough survey in 2005 prior to the Poole Harbour dredging and spoil disposal. It was very evident that no extensive areas of undisturbed reef remained in the core area. Typically the reefs existed (prior to 2004) as irregular mounds 2-10m across and 0.5 high. Surveys in 2005 and 2006 showed that these had almost universally been levelled with only a thin band of damaged tubes around their perimeter. Small clumps still remained in the lee of isolated rocks and reefs, plus a patch of small reef clumps to the north of the area enclosed by Fig.10.

No detrimental effects attributable to the spoil disposal were noted. The sediment depth monitoring site (a series of metal poles in the seabed) showed no new accumulation of sediment post disposal.

9. Seagrass, Studland Bay and Poole Harbour

Detailed quantitative studies of the seagrass were undertaken by divers in Studland Bay, adjacent to the Poole Harbour entrance Training Bank and at one bed within the Harbour (Fig.1). At each study site a pair of divers both measured the shoot density within a 30x30cm quadrat and measured the maximum blade length within that quadrat. Using a tape measure (and noting the direction of travel) these measurements were repeated at 5 m intervals over a 30m distance yielding 14 measurements at each site. At each of the three locations 5/6 replicate sites were surveyed. These surveys were undertaken pre-dredging in July 2005 and exactly repeated post-dredging in July 2006.

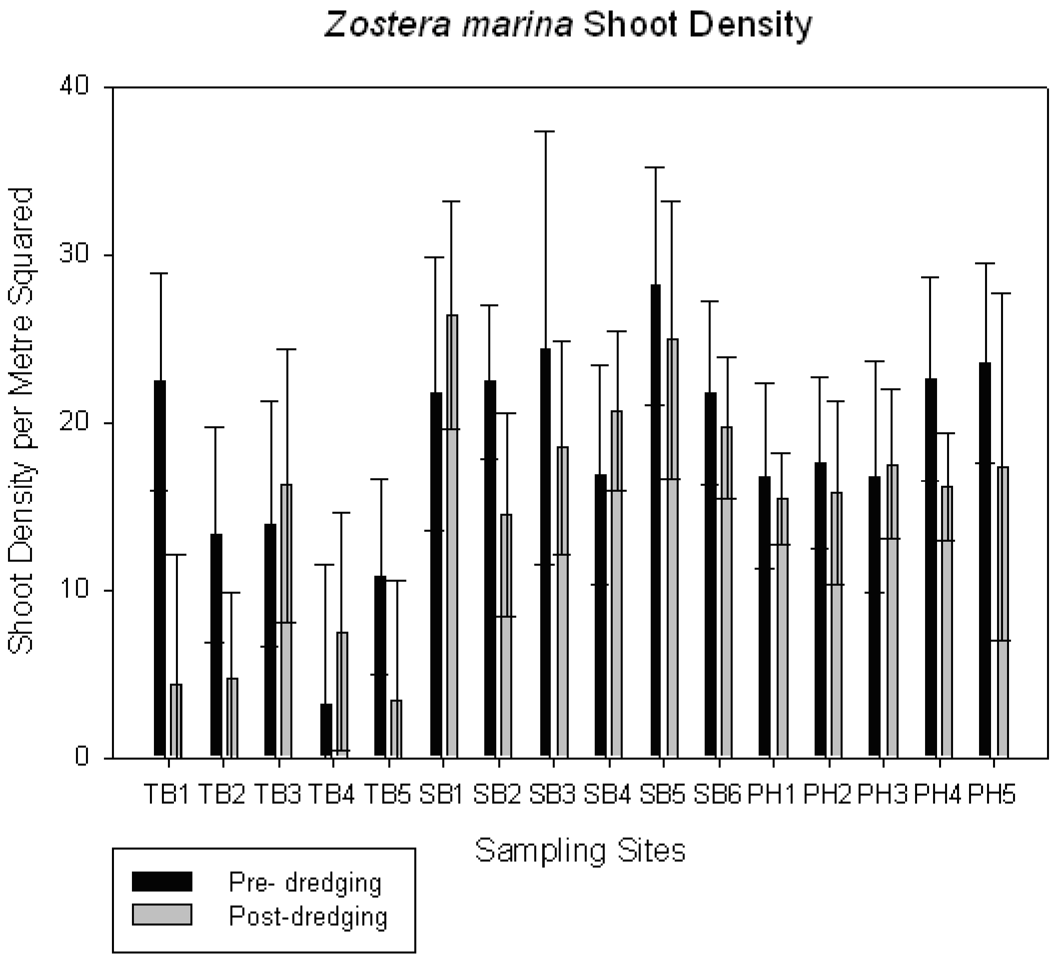

Figure 11. Average seagrass shoot densities (± 1 standard deviation) from before and after dredging (2005 and 2006, respectively). Site notation: TB=Training Bank, SB=Studland Bay and PH=Poole Harbour.

10. Conclusions

No significant changes post-dredging and spoil deposition were detected from the studies of Seagrass (*Zostera marina*), *Sabellaria spinulosa* reefs, reef biota, algal density on patch reefs and Pink seafans (*Eunicella verrucosa*).

The purpose of this continuation EIA study into 2008 was to obtain for longer term data on the maerl, sedimentation and reef biota.

The decline in maerl density post-dredging has been confirmed by more extensive studies in 2008. Average densities were found to be 60% of pre-dredging levels, a statistically significant change at the majority of sites. Pre-dredging data was obtained 2000-3, a gap of 2 years before the dredging, so it could be argued that the decline could have happened prior to the dredging and disposal. However the densities of maerl were stable 2000, 2002 and 2003. Maerl growth studies do not indicate any significant changes in growth rate over the period 2000-7. Thus loss due to increased siltation (to which maerl is acutely sensitive) over winter 2005/6 is the most likely cause of the decline.

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Appendix 1 Maerl density analyses of pre- (2000-3)and post-dredging (2006-8) data. Group refers to the areas denoted in Fig.2.
+ = post –dredging, - = pre-dredging, T = t-test, MW = Mannn Whitney Rank Sum Test

<125m separation between pre- and post sampling points

group	N	Mean	Std Dev	SEM	test	p	Significant
A+	26	30.33	14.36	2.82			
A -	6	47.37	21.49	8.77	t	0.024	Yes
B+	8	0.32	0.37	0.13			
B -	6	1.10	1.42	0.58	t	0.155	No
D+	4	3.62	2.96	1.48			
D -	4	3.62	2.96	1.48	t	1.000	No
G+	12	6.88	5.38	1.55			
G -	8	15.20	5.47	1.93	t	0.003	Yes
I+	18	19.90	8.78	2.07			
I -	8	45.09	12.58	4.45	t	<0.001	Yes

group	N	Median	25%	75%	test	p	Significant
C+	8	25.91	22.33	29.55			
C -	12	18.75	10.85	33.05	MW	0.203	No
E+	10	10.78	9.82	14.90			
E -	10	10.78	9.82	14.90	MW	0.970	no
F+	4	5.18	1.32	8.80			
F -	2	6.85	5.10	8.60	MW	0.800	no
H+	32	14.41	12.94	21.84			
H -	24	37.87	28.99	50.38	MW	<0.001	yes

<250m separation between pre- and post sampling points

group	N	mean	Std Dev	SEM	test	p	significant
A+	26	30.33	14.36	2.82			
A -	14	46.71	19.93	5.33	t	0.005	yes
D+	4	3.62	2.96	1.48			
D -	12	8.31	5.35	1.00	t	0.122	no
F+	4	5.06	4.41	2.21			
F -	10	4.54	2.52	0.80	t	0.783	no
G+	12	6.88	5.38	1.55			
G -	8	15.20	5.47	1.93	t	0.003	yes
I+	18	19.90	8.78	2.07			
I -	16	43.26	15.45	3.86	t	<0.001	yes

group	N	Median	25%	75%	test	p	significant
B+	8	0.14	0.00	0.73			
B -	12	0.18	0.00	0.95	MW	0.968	no
C+	8	25.91	22.33	29.55			
C -	12	18.75	10.85	33.05	MW	0.203	no
E+	10	10.78	9.82	14.90			
E -	12	18.60	12.45	28.68	MW	0.016	yes
H+	32	14.41	12.94	21.84			
H -	24	37.87	28.99	50.38	MW	<0.001	yes