



Impacts of large vessel anchoring on seabed habitats and Marine Protected Areas

A report by
Dorset Wildlife Trust



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Impacts of large vessel anchoring on seabed habitats and Marine Protected Areas

Since March 2020, a number of large cruise ships have been anchored in Poole Bay and Weymouth Bay

On 20 October, 23 cruise ships were visible in the English Channel, 15 of which were at anchor on the south coast and one in port in Southampton. These include some of the largest cruise ships in the world, such as the *Allure of the Seas*, at 360m length, a gross tonnage of 225,282t and capable of carrying over 6000 passengers. In January 2021 Dorset Wildlife Trust commissioned remote sensing surveys in Weymouth Bay and Poole Bay, with funding from Natural England, to understand and document the impact of large vessel anchoring on seabed features and Marine Protected Areas.



Figure 1 Screenshot from VesselFinder on 20 October 2020

The right to anchor.

Article 17 of the United Nations Convention on the Law of the Sea (UNCLOS) grants all ships the right of innocent passage – this includes stopping and anchoring, “but only in so far as the same are incidental to ordinary navigation or are rendered necessary by *force majeure* or distress or for the purpose of rendering assistance to persons, ships or aircraft in danger or distress.”

It is reasonable to accept that the global outbreak of Covid-19 constituted a *force majeure* for cruise ships, leaving them suddenly with no passengers and nowhere to go. That argument is less compelling after nearly a year.

Cruise ships were monitored using reported AIS positions as visible on VesselFinder.com. Hourly screenshots from VesselFinder were collected between October 2020 and early January 2021, centred on Weymouth Bay (50.56N, 2.28W) and Poole Bay (50.66N, 1.9W) zoom level 12.

Weymouth Bay

Between 8 October and 28 December 2020, the following cruise ships were recorded as apparently at anchor in Weymouth Bay:

Arcadia, Aurora, Britannia, Ventura (P&O Cruises), Marella Explorer, Marella Explorer 2, Marella Discovery (TUI UK), Norwegian Bliss, Norwegian Encore (Norwegian Cruise Line), Queen Elizabeth, Queen Mary 2, Queen Victoria (Cunard)

During this period the vessels either moved around or left and returned such that, between them, they appear to have dropped anchor at least 73 times (Appendix 4)

Anchoring during the ‘ordinary course of navigation’ is part of the Public Right of Navigation making it a highly complex issue (Griffiths, et al., 2017). There are 2 types of anchorages:

- 1) those identified by and positioned within harbour authority jurisdiction
- 2) those outside harbour limits which have historically been used and identified by navigational stakeholders led by the MCA.

Neither type of anchorage is formally recognised as being managed by any organisation and anchoring is considered a common law right.

Weymouth Bay is a recognised anchorage, sheltered from southwesterly weather by the Isle of Portland. There are a number of designated deepwater and hazardous cargo anchorages within the Outer Harbour of Portland Harbour, just outside the North-eastern Breakwater. These are under the control of Portland Harbour Authority. The east coast of Portland, from the East Ship Channel to Grove Point, also under the jurisdiction of Portland Harbour Authority, is a no-anchoring zone and inner Weymouth Bay, from the northern limit of Portland Harbour Authority to Redcliff Point, is under the control of Port of Weymouth.

To the east lies the Purbeck Coast MCZ/Studland to Portland SAC, in which it would be inappropriate to anchor a large vessel other than in an emergency – though there is no *de facto* restriction on anchoring in MPAs. Some anchoring has apparently occurred just over the border of the MPA – when this has happened, MMO/MCA have requested the vessel move – though by then any damage is already done.

Between these restricted areas, there is a box of about 280ha marked on the Admiralty chart as a designated anchorage. Some of the cruise ships have chosen to anchor within this area, but there is only room for about 4 vessels at one time – up to 8 cruise ships have been seen at one time at anchor. The presence of the cruise ships is also displacing the occasional commercial cargo vessels and tankers that traditionally use the anchorage.

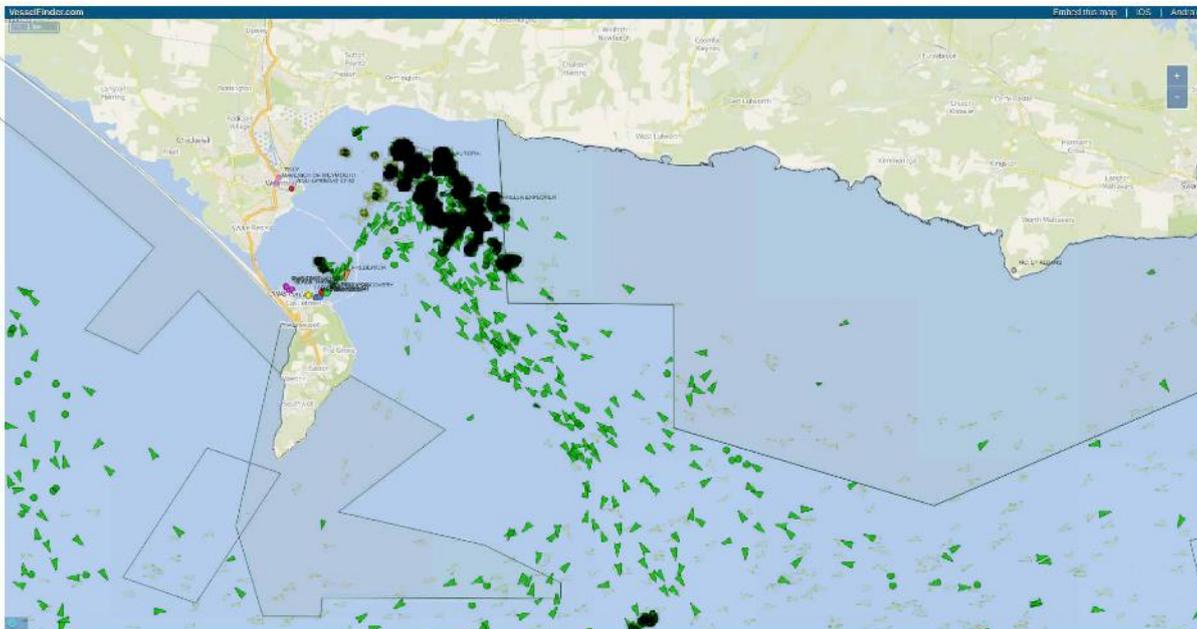


Figure 2 Cumulative image of cruise ship positions from VesselFinder.com between Oct and Dec 2020

Figure 2 is a composite image of all hourly Weymouth Bay screenshots between October and December – dark areas indicate the density of overlapping positions, showing likely anchoring locations.

Concern has been raised about the impact of this unprecedented level and duration of anchoring of such large vessels on the seabed. To better understand this impact and to discover if it is affecting the MPA, 3x 1km² blocks of multibeam sonar data were collected in early January 2021 (Appendix 6), with funding provided by Natural England. Block 1 is within the designated anchor zone, block 2 is to the south of this and partly overlaps the anchoring areas detected from Vesselfinder and Block 3 straddles the MPA boundary where one of the cruise ships (Marella Explorer) was seen anchoring in December.

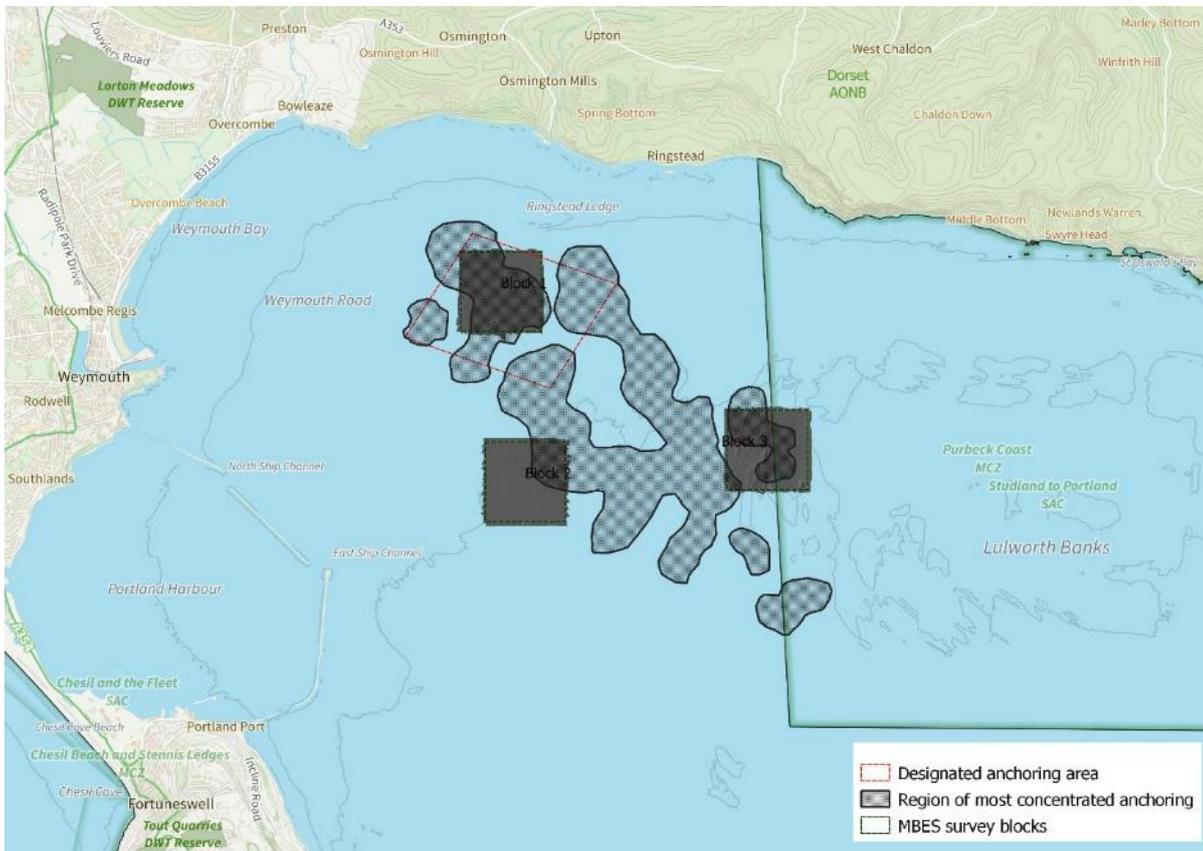


Figure 3 Details of designated anchorage and sites of Multibeam Echosounder (MBES) survey blocks

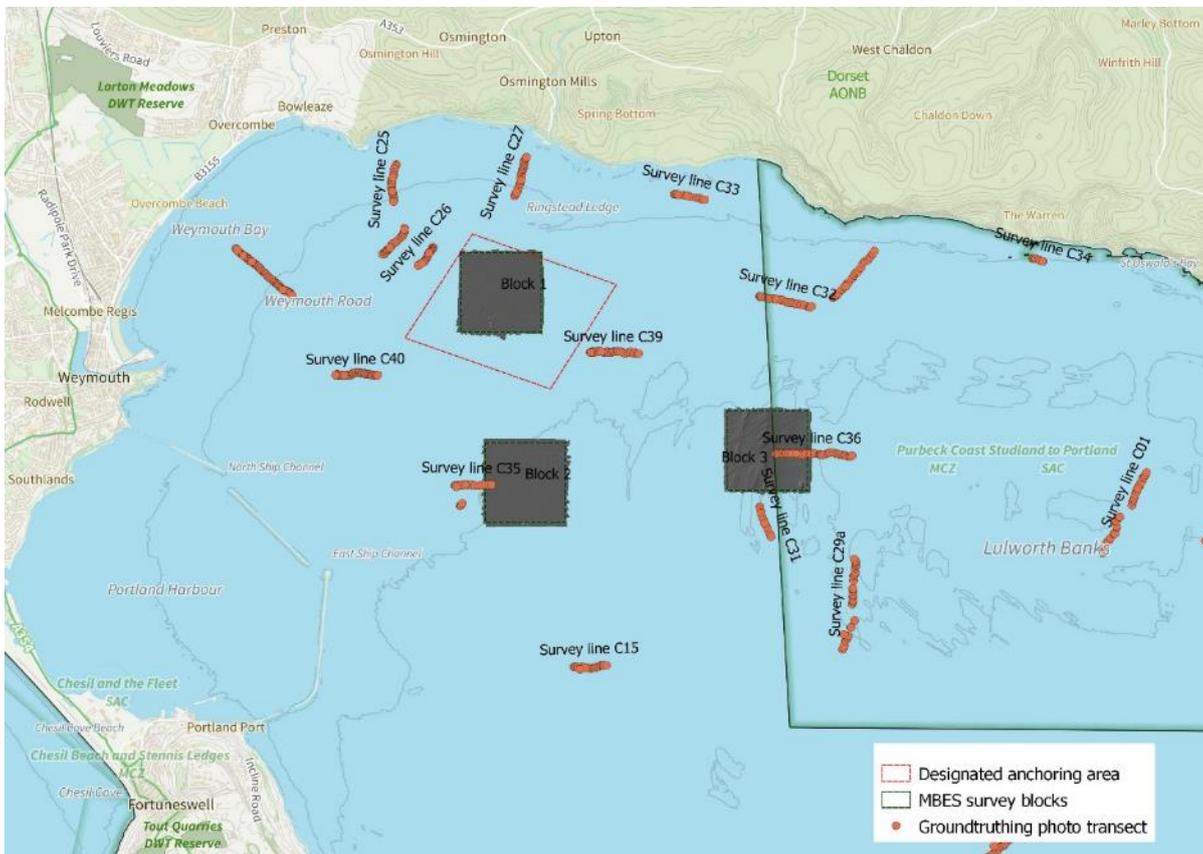


Figure 4 Location of ground-truthing photos from DORIS drop-down camera survey (Axelsson, et al., 2011) near survey blocks

Block 1

Block 1 is within the designated anchoring area. Depth ranges between 15 and 19m and the seabed is a fine muddy sand with a stiff clay and numerous burrows. Drop video tracks C39 and C26 (Appendix 1) show the seabed at the top and bottom of the slope. There are a number of anchor scars identifiable. Figure 5 shows a number of deep grooves, up to 60cm deep and about 5m wide, often with a lip of raised sediment on one side. These are most likely caused by an anchor being dragged across the seabed. A typical scar comprises a long groove where the chain lies on the seabed with a fan of fainter marks caused by the vessel moving around the end of the anchor chain and possibly a short (100m or so) deeper groove caused by the anchor dragging.

The extensive scar in Figure 8, radiating from a central anchoring point, covers over 6 hectares of seabed. This corresponds to the position of the cruise ship “Aurora”, which occupied this area between 27 December and mid January and would have been at anchor during the survey – the anchor and chain are visible in the multibeam image. It is not certain that all of this disturbance is from one anchoring event but it is consistent with the ship initially lying east of the anchor and shifting to a position to the south of the anchor.

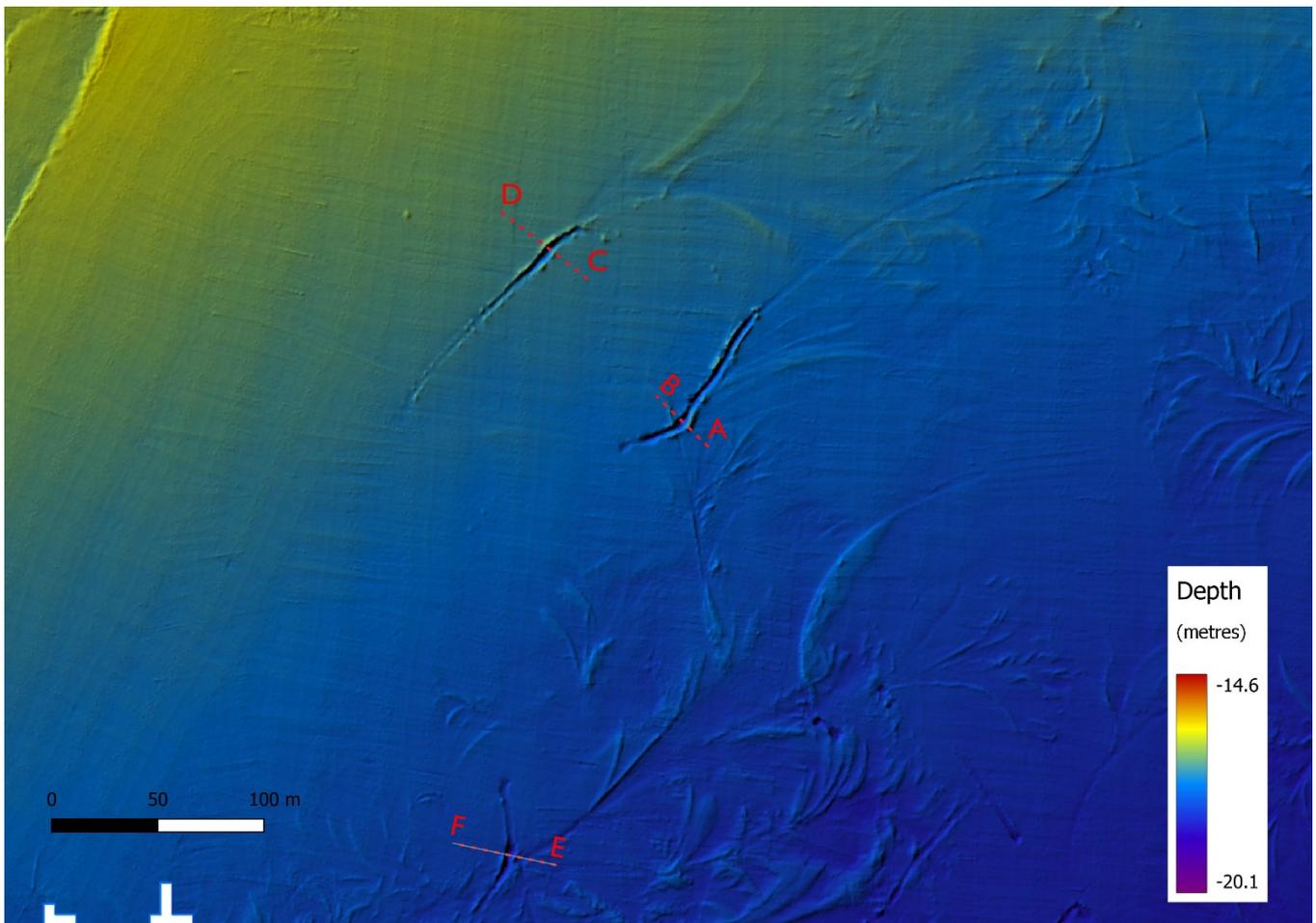


Figure 5 Deep scars in Block 1 – most likely from anchor drag

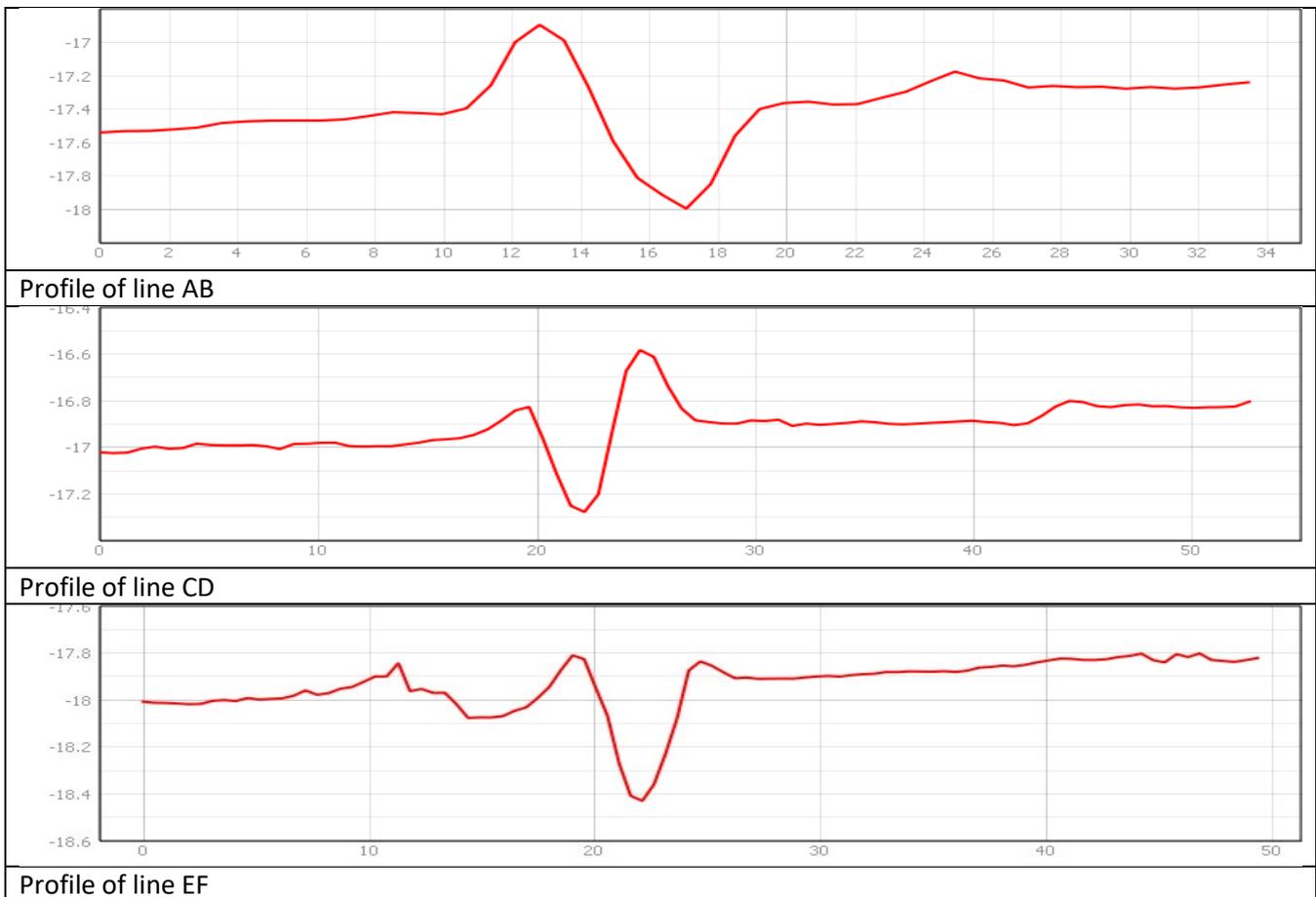


Figure 6 Profiles of lines AB, CD and EF across anchor scars. All measurements in metres

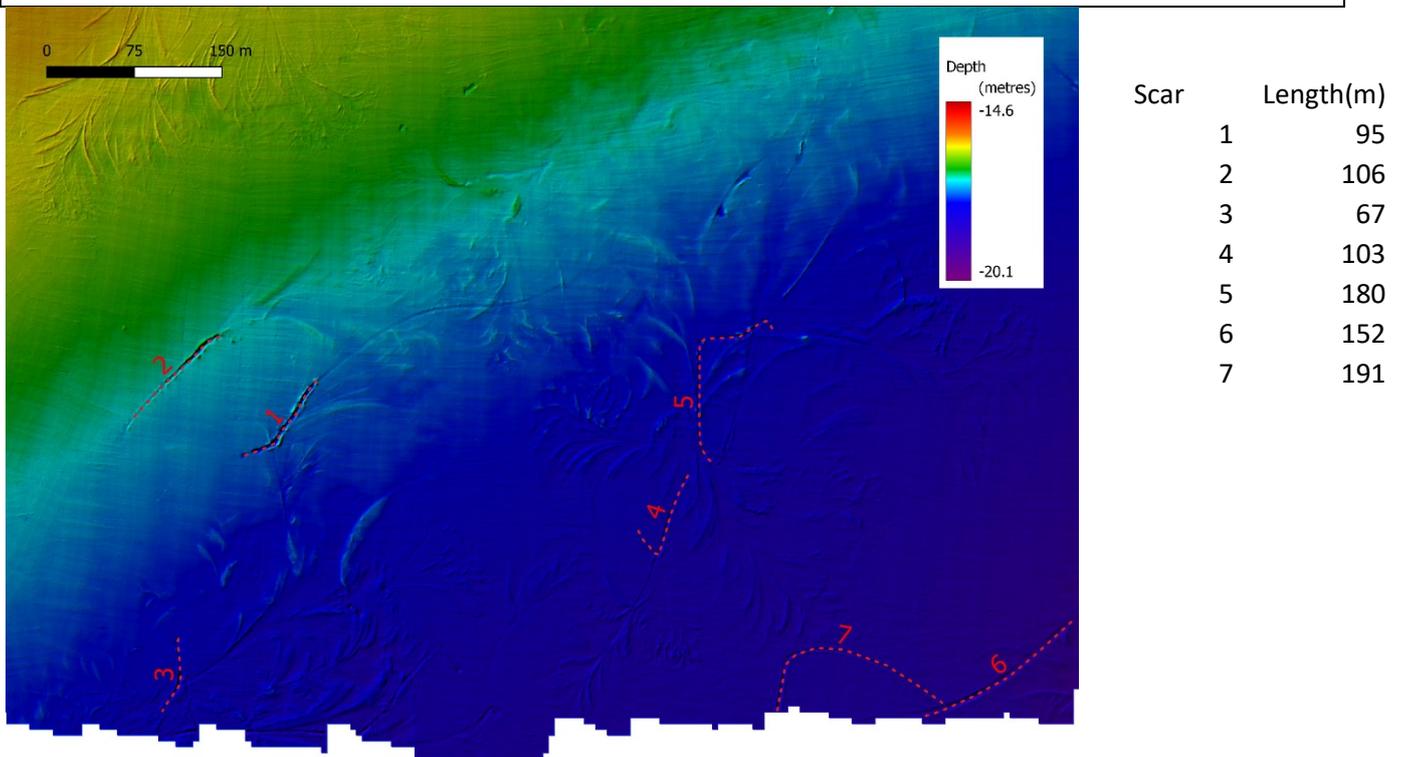


Figure 7 Traces of anchor drag furrows in Block 1

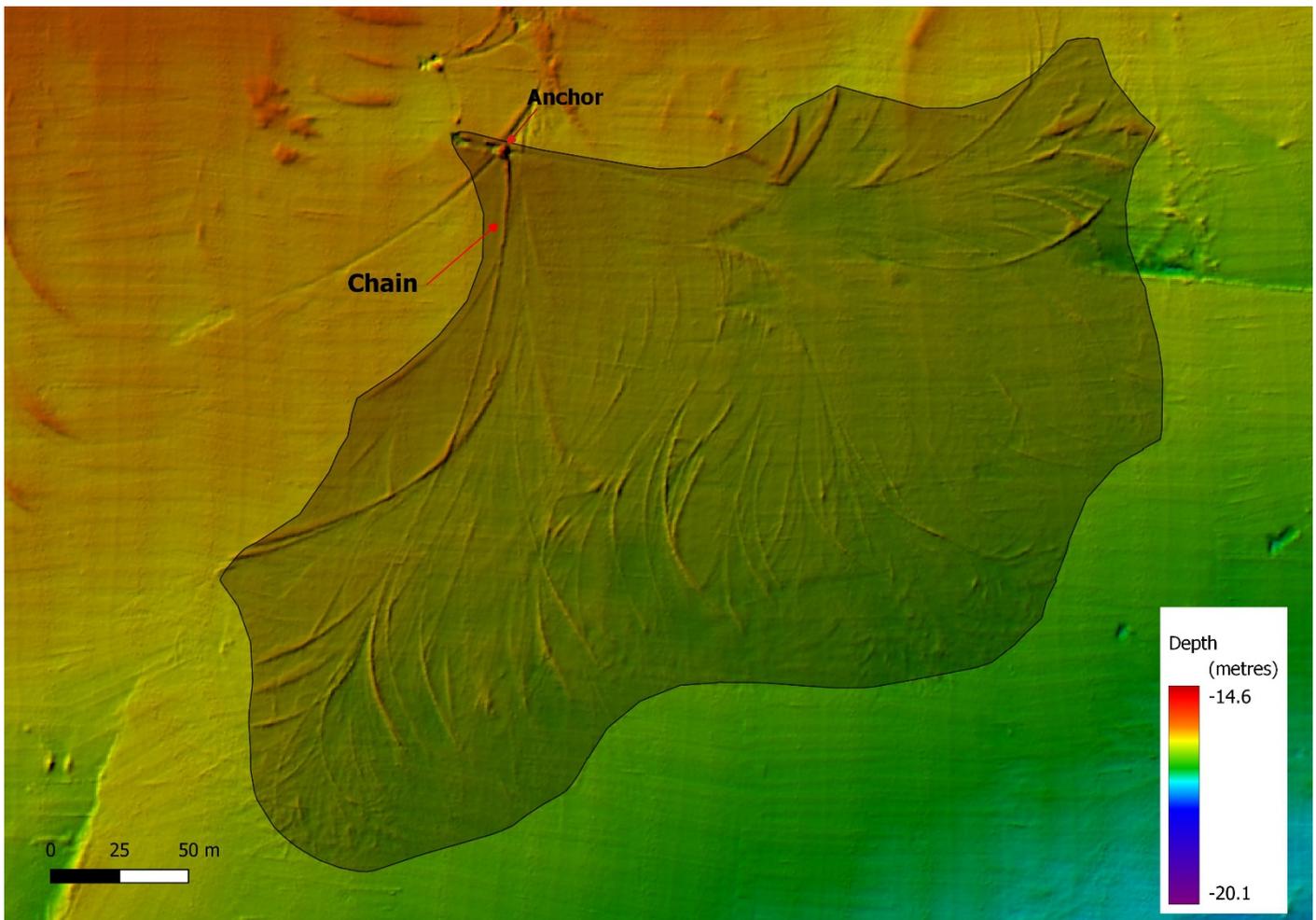


Figure 8 Extent of scarring around an anchoring location

Block 2

Block 2 is to the south of the designated anchoring area and is slightly deeper – between 20 and 22m. The seabed is similar to Area 1, with a greater abundance of slipper limpets – see images from transect C35 (Appendix 2)

The north-east corner of this block is almost entirely impacted by anchoring(Figure 9), which gives an indication of the cumulative effects of many anchoring events over a long period. There is little opportunity for any recovery. The same area was surveyed in 2008 – only two faint scars were visible at that time (Figure 10).

Figure 11 shows a different scarring pattern which could be from the use of two anchors and a shorter chain. Here, the “feathering” pattern is replaced with two almost symmetrical broad depressions and associated mounds.

Figure 12 shows a single anchor scar of 550m length, with an additional 200m of “feathering” caused by the vessel dragging the chain across the seabed as it moves with the wind and tide. This feathering pattern is visible along much of the length of the deeper scar, suggesting the vessel has dragged at anchor. This deeper scar is 5m wide and about 30cm deep. This is 4 times the length of the scar attributed to the dragging of a 1 tonne anchor from a cruise ship (Griffiths, et al., 2017).

In Figure 13 Length of anchor chain deduced from multibeam image, we can trace the full length of the chain in contact with the seabed – this totals 267m and all but the 30m nearest the anchor have dragged across the seabed, tracing an area out to approx. 200m from the anchor.

Figure 14 shows an attempt to calculate the area impacted by four individual anchoring events. These range from 0.9 ha to 2.7ha.

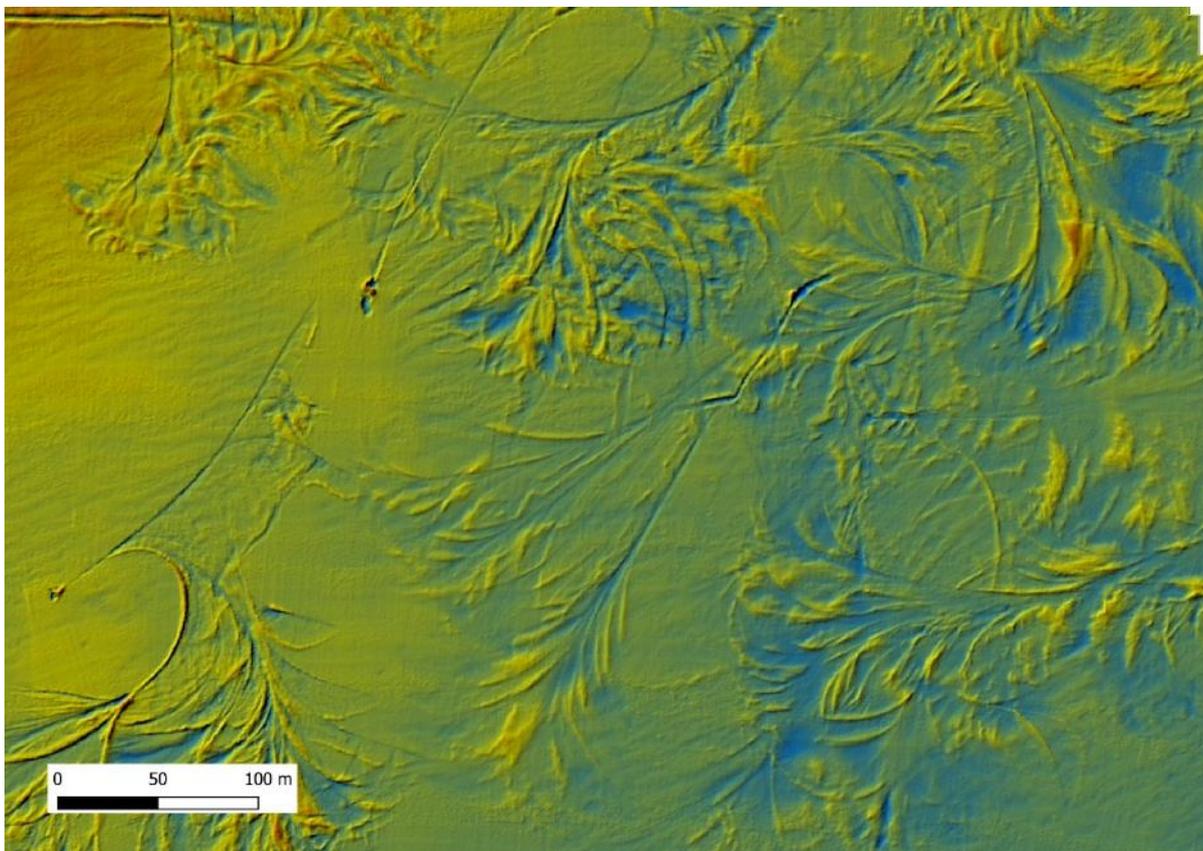


Figure 9 North-east corner of block 2, showing extensive anchor scars

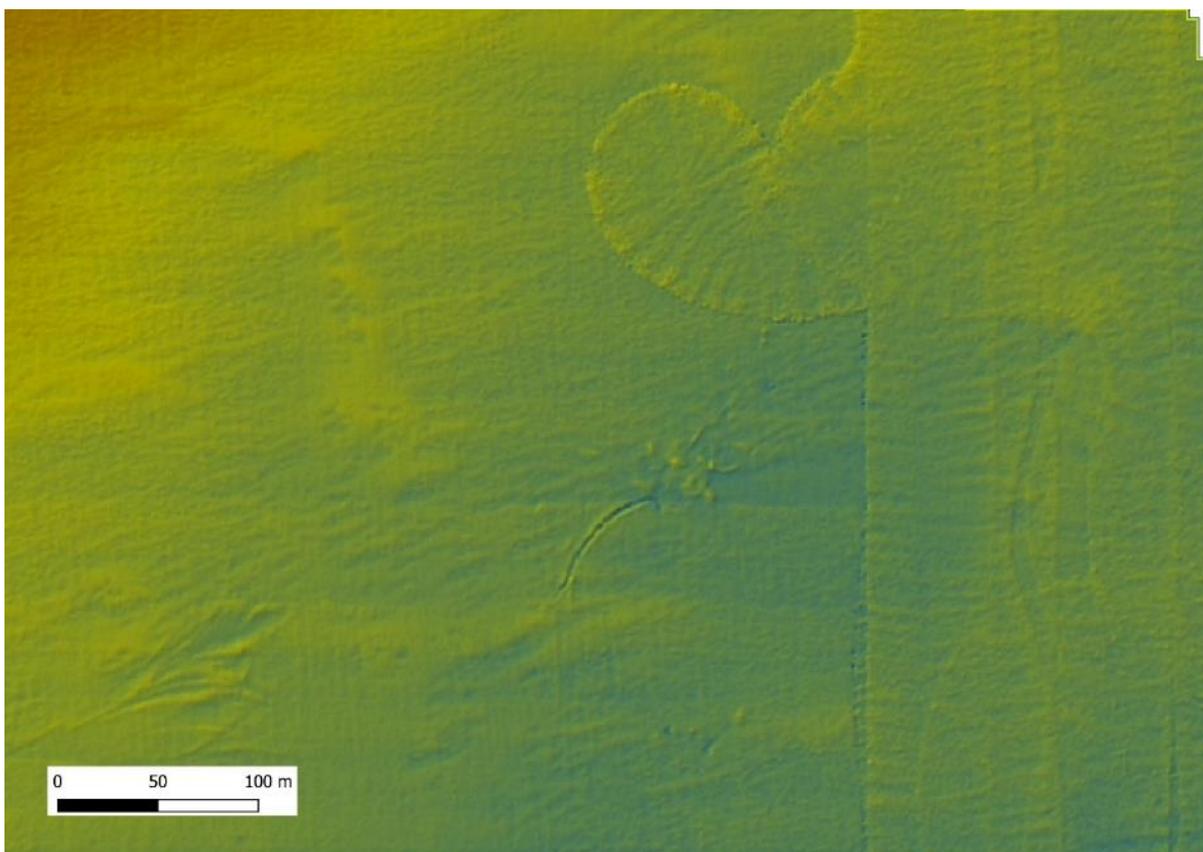


Figure 10 The same area as above, from 2008. The stripe down the right hand side and adjoining curve are survey artefacts, showing the survey vessel track.

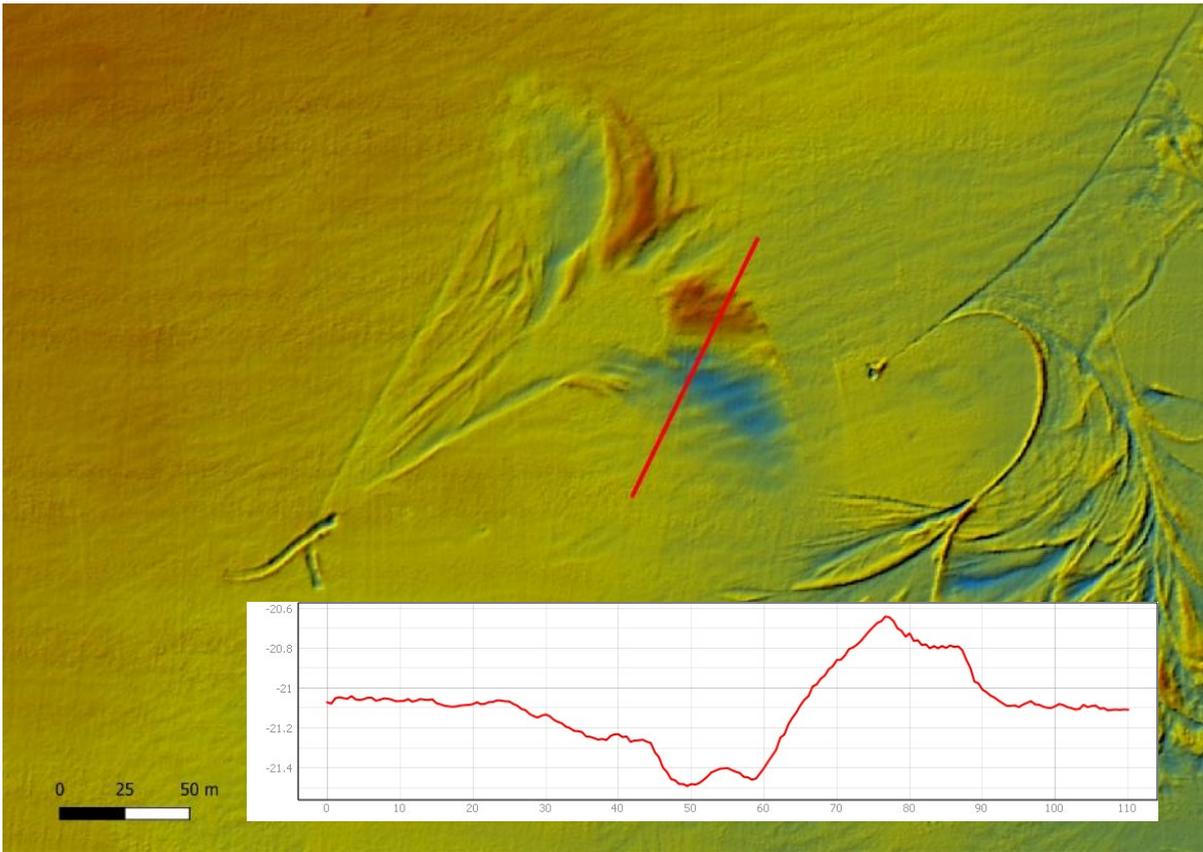


Figure 11 Twin anchor? scar alongside more typical scar

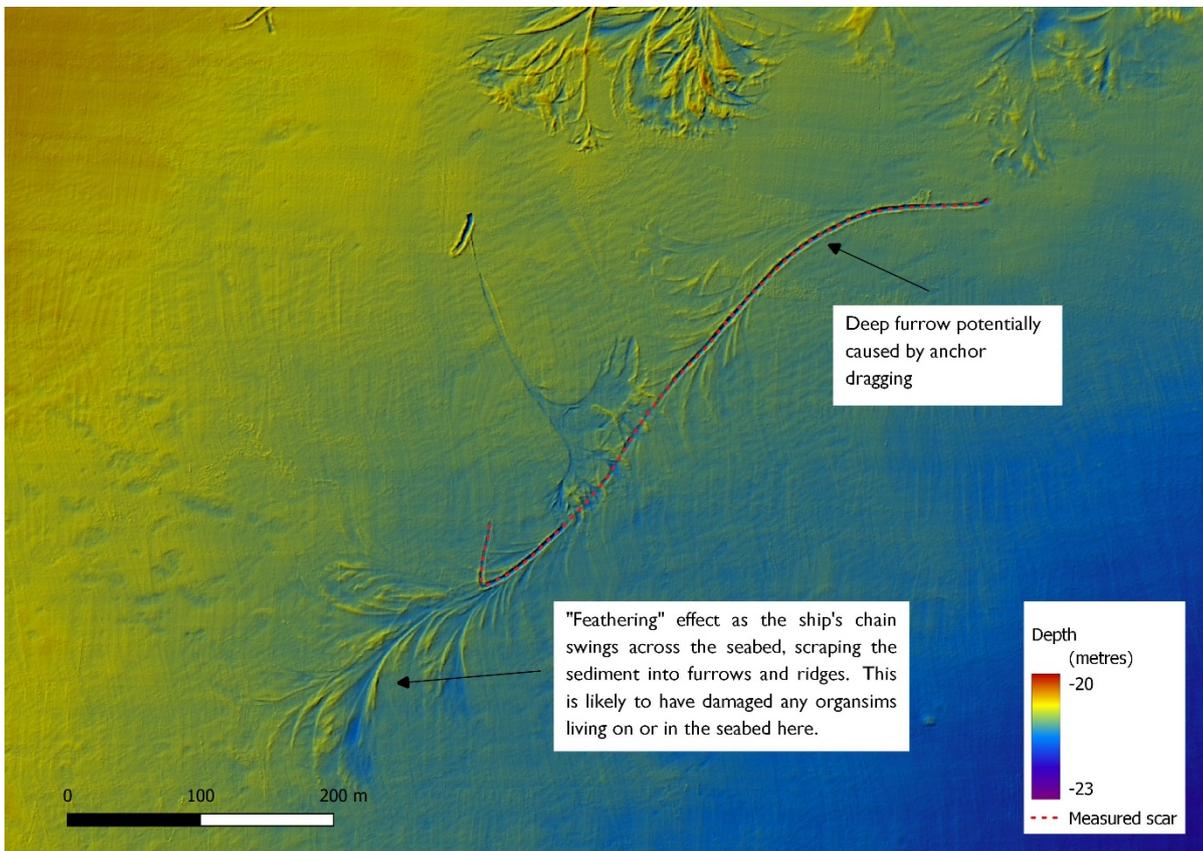


Figure 12 A single anchor drag scar measuring 550m

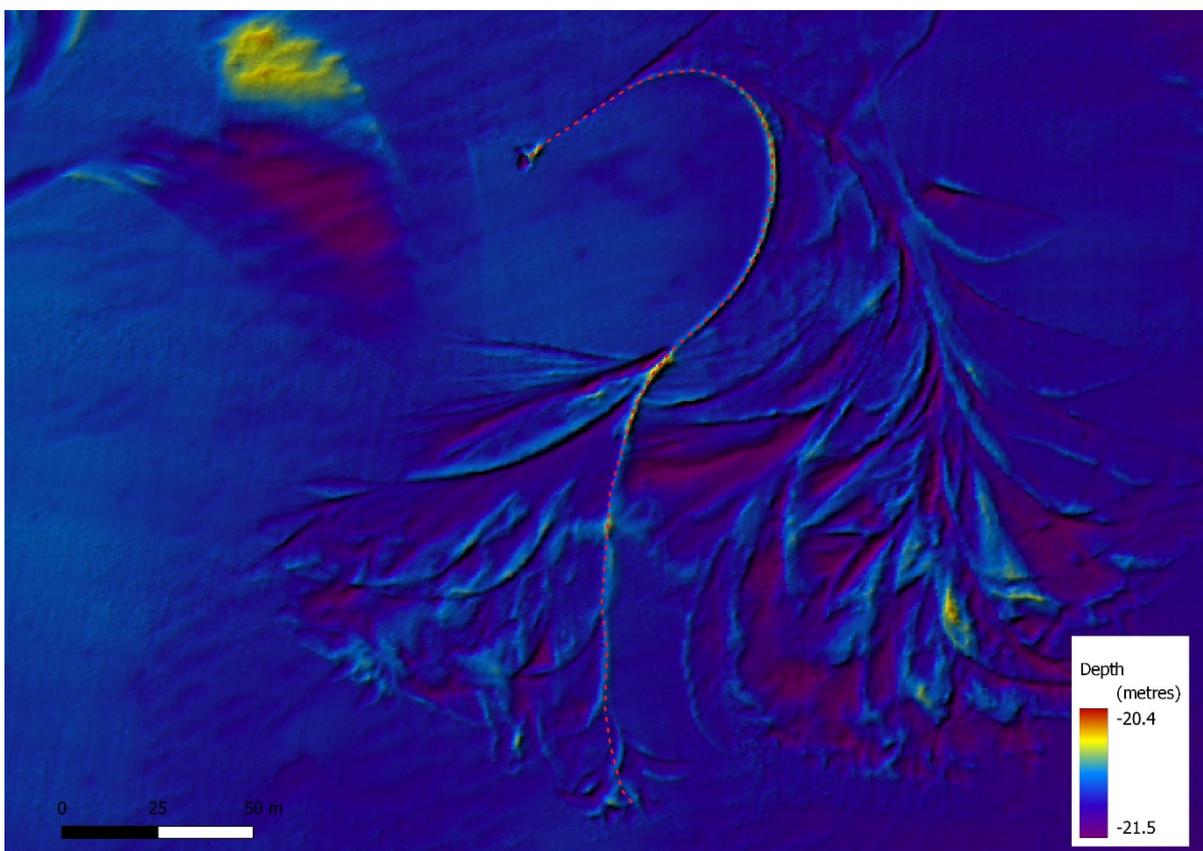


Figure 13 Length of anchor chain deduced from multibeam image

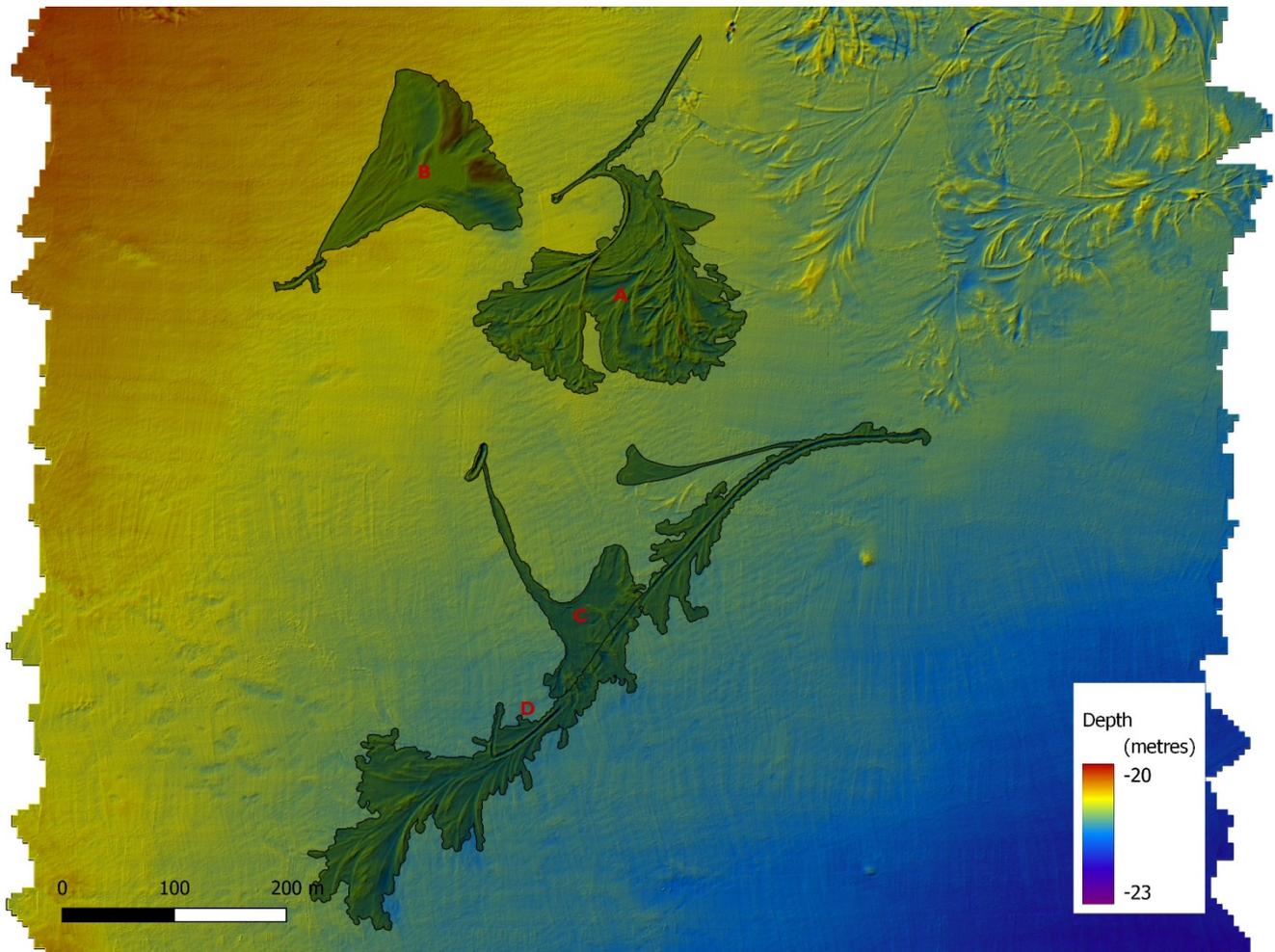


Figure 14 Attempt to calculate area of individual scars. Area A – 2.7ha, Area B – 1.5ha, Area C – 0.9ha, Area D – 2.7ha

Block 3

Block 3 straddles the boundary of the Studland to Portland SAC/Purbeck Coast MCZ. This site is between 18 and 23m deep and is a mix of sediment and exposed bedrock reefs. Ground-truthing survey tracks C36 and C31 (Appendix 3) give a good indication of the range of habitats here.

There were occasions where vessels appeared to be anchoring within, or very close to, the protected area. On these occasions, the vessels were requested to move. The Marella Explorer was recorded in Block 3 between from 10 to 12 October and between 8 and 11 December. There are three scars visible close to the MPA boundary - one just crossing the boundary, one about 100m inside, and a third scar just outside the boundary. A fourth scar in the northwest corner of the block corresponds to the recorded position of Marella Explorer between 10 and 12 October. The MPA is designated for Annex I reef and subtidal coarse and mixed sediment. The MBES data shows the impact on the sediment but the trail disappears where it crosses a corner of reef. This does not mean there is no impact, just that the survey method is not able to detect it. Without knowing precisely where the anchor went down, it would be very difficult to detect damage over reef habitat.

Marella Explorer also spent some time inside the MPA boundary about a kilometre further south, between 18 and 22 October, moving to just on the boundary for a further 2 days before moving closer to the designated anchorage. This area was not covered in this survey.

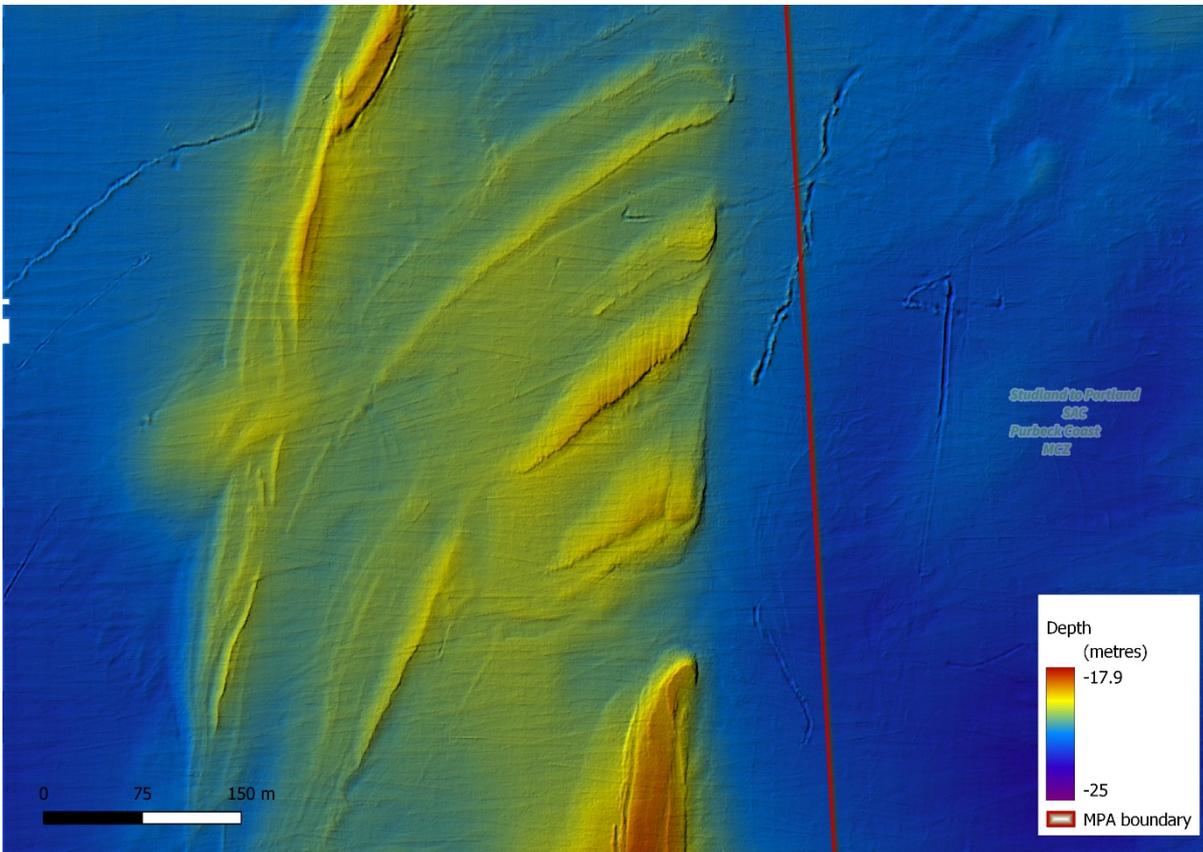


Figure 15 North-east corner of Block 3, showing scarring within MPA boundary

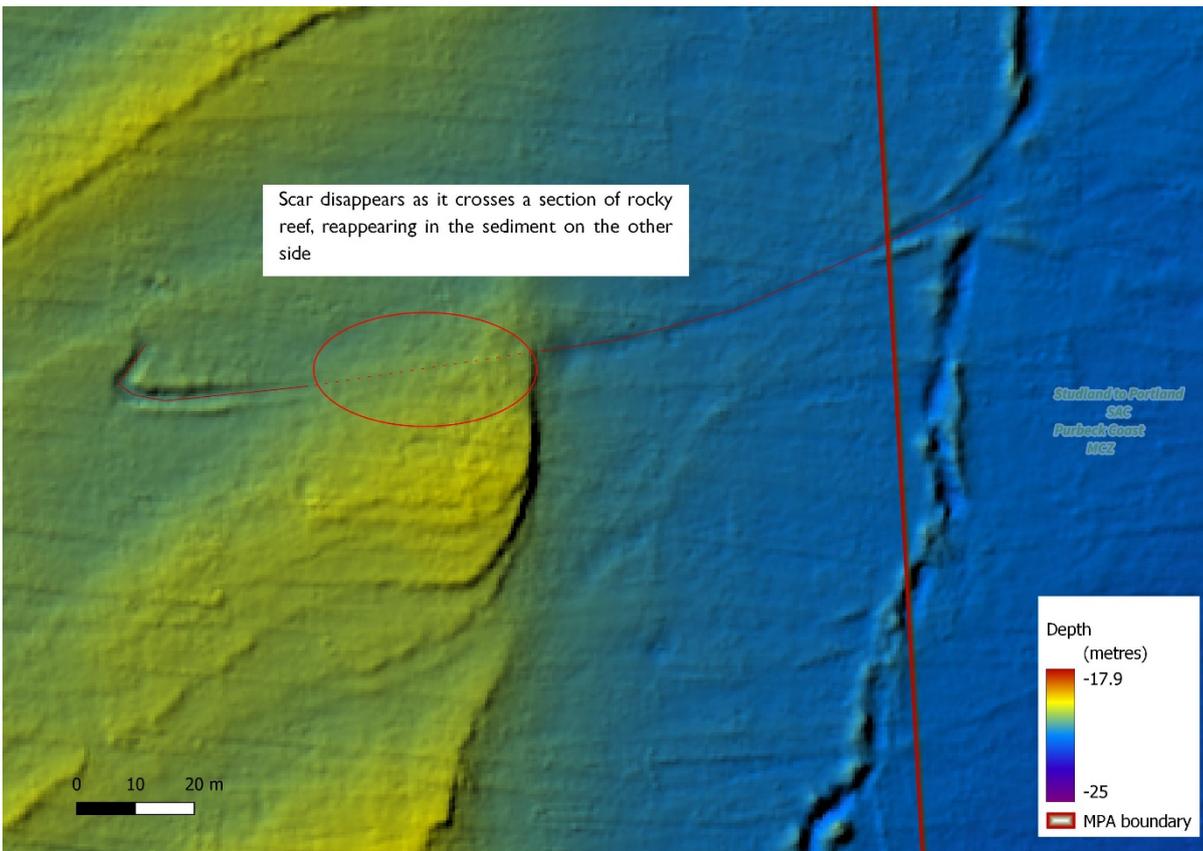


Figure 16 Showing difficulty in detecting a scar where it crosses a rocky outcrop

Recommendations



Figure 17 Screenshot from MarineTraffic on 9 Feb 2021

On 8 February, Marella Discovery moved into the Lyme Bay and Torbay SAC to anchor just south of Bridport. It was later joined the following day by Marella Explorer 2. This was quickly reported to MMO and a request to move was made by MCA. Both vessels moved on 10 February, after requesting the coordinates of the MPA boundary. Marella Discovery initially moved to a position right on the border of the Chesil Beach and Stennis Ledges MCZ.

This raises several issues:

Other than in an emergency, there should be no reason for these large vessels to drop anchor within a Marine Protected Area, but there seems to be no legal barrier to prevent them doing so. All MPAs designated for seabed features should have a strong legal protection from anchoring of large vessels, presuming a sensible size cut-off can be agreed that would not affect continuing routine use by small vessels. This would require a MMO byelaw.

Related to this is the inconsistency around the marking of MPA boundaries and sensitive features on navigational charts. Figure 17 shows the Navionics electronic chart from the MarineTraffic website. At first glance, this appears to prohibit anchoring and fishing in Lyme Bay, but this refers to a small area, only marked at lower zoom levels, off West Bexington, which is a submarine cable area, though no longer believed to be in use. There are a number of areas marked with red dashed lines – some of these are military areas, but some are MPAs. On closer inspection, it appears that Marine Conservation Zones are marked, but Special areas of Conservation are not. Based on their behaviour elsewhere, it is possible that Marella Discovery and Marella Explorer 2 would not have anchored so far inside the SAC, had the boundary been marked on the chart. This is something that could be easily addressed and should be done with some urgency.

While vessels do seem to be avoiding anchoring within MPAs, there have been a number of instances where anchoring takes place right on the border of a protected area. The multibeam data from the recent survey demonstrates that the seabed impact can extend 500m or more from the ships position. This would suggest at least a 500m buffer zone around any protected area or known sensitive feature. This should also be explicitly marked on the charts.

Poole Bay

Using hourly screengrabs from www.vesselfinder.com, we have tracked the arrivals and departures of cruise ships in Poole Bay between 08 October 2020 and 5 Jan 2021. In that period, the following vessels were recorded: –

Jewel of the Seas, Anthem of the Seas, Explorer of the Seas, Allure of the Seas (Royal Caribbean International) and Arcadia (P&O Cruises)

Each of these vessels spent most of the time at anchor but regularly left the bay, usually returning within a day or two. Each time an anchor is dropped or recovered, there is the possibility of an impact on the seabed. “Arcadia” arrived on 8 October and left within a week, without returning. The other 4 vessels weighed/dropped anchor 28 times between them over the 89 days (Appendix 5).

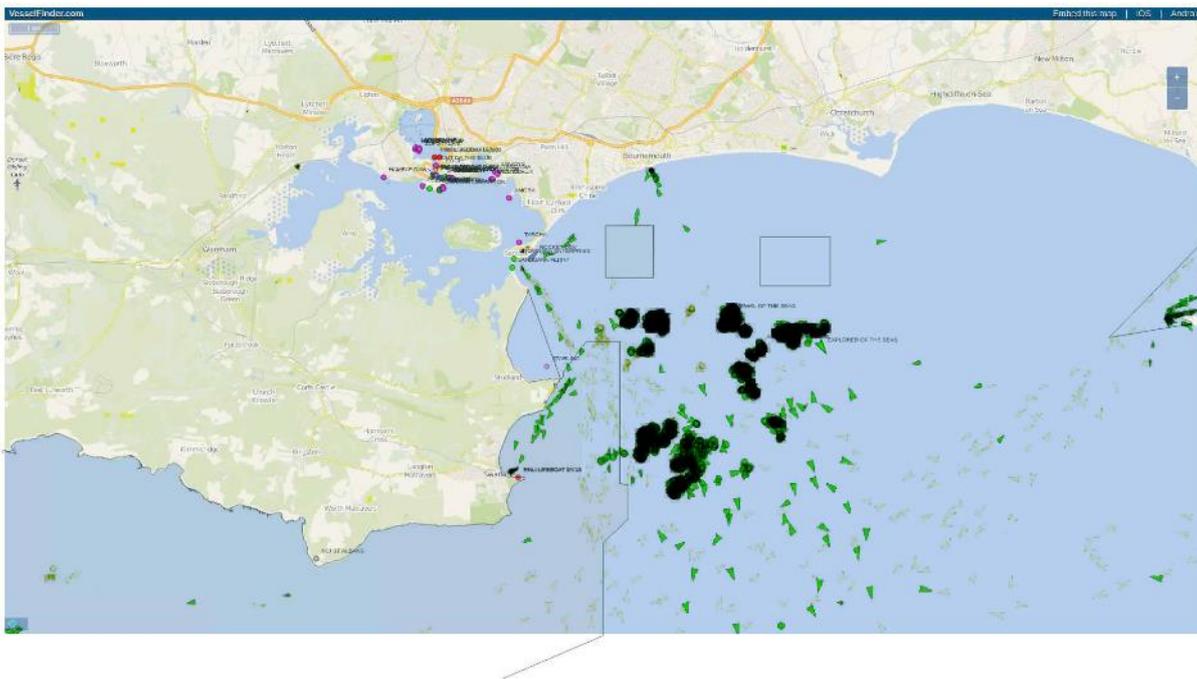


Figure 18 Composite image of hourly screengrabs from VesselFinder.com between October and December 2020

A composite of all of the hourly screengrabs shows where the vessels spend most of their time – see Figure 18. The larger patches indicate where a vessel has re-anchored in the same general location – “Explorer of the Seas” spent most of its time in the area to the south of Southbourne Rough MCZ, but other vessels were less faithful to any particular site.

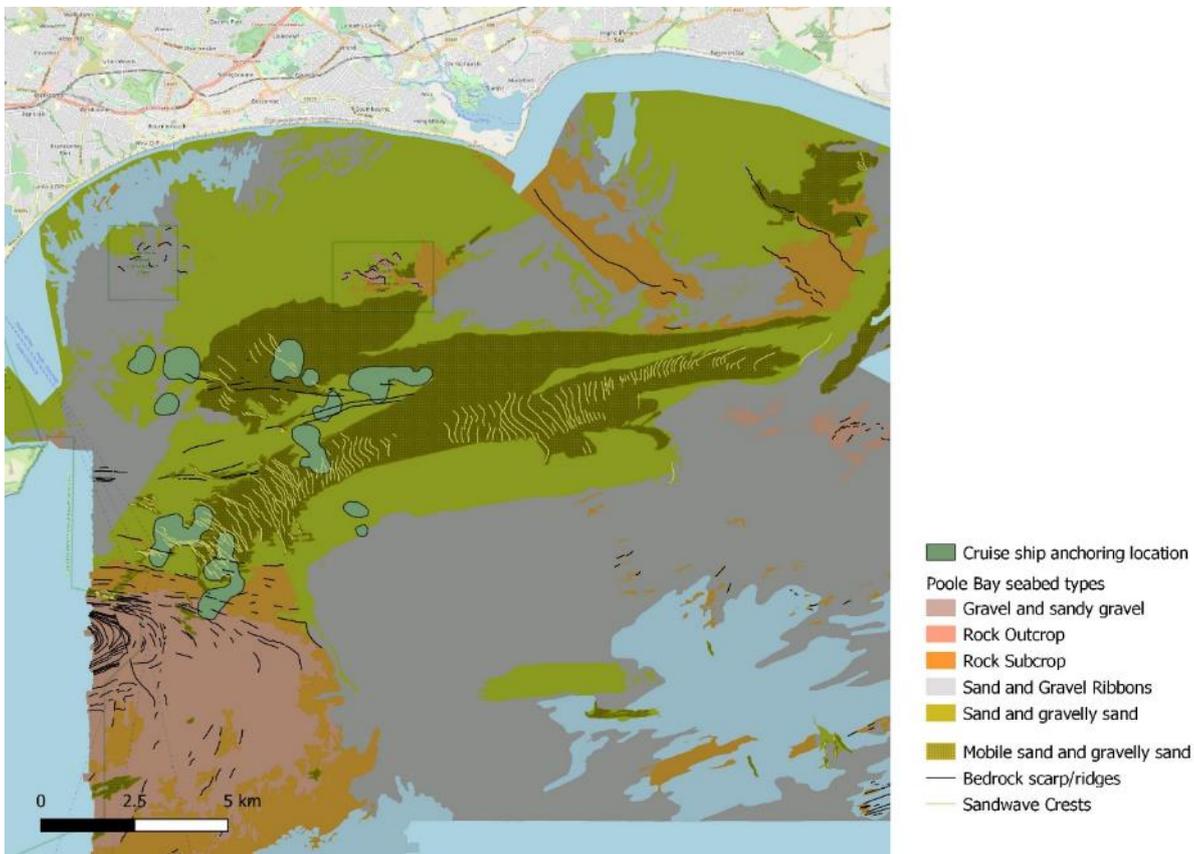


Figure 19 Anchoring locations shown against seabed type (from HI1366)

The severity of any impact from anchoring would depend on the sensitivity of the seabed and the frequency of anchoring. The majority of the anchoring sites seem to be associated with “Sand and gravelly sand”, which is widespread across the bay, but they do not entirely avoid outcropping or sub-cropping bedrock and seabed features such as rock scarps/ridges.

While most of Poole Bay has been covered by multibeam survey as recently as 2012, there is little in the way of ground-truthing data to help locate any more sensitive habitats. The Environmental Survey (Corallian Energy Ltd, 2017) carried out prior to the oil appraisal well drilled in Poole Bay in 2018 did identify and map some sensitive features, including *Sabellaria spinulosa* reefs. While *Sabellaria spinulosa* is widespread as an encrusting worm on rocks and pebbles, in the right conditions, aggregations of *Sabellaria* worm tubes can form boulder-like concretions up to 1m across and 30cm high. This is a Habitat of Principal Importance, listed in S41 of the NERC Act 2006.

Sabellaria spinulosa reefs were first discovered in Poole Bay in 1999 about 2 miles east of Swanage and these reefs were extensively surveyed in the early 2000s. This area is now within the Purbeck Coast Marine Conservation Zone, though there are no recent records of healthy *Sabellaria* reefs from this area.

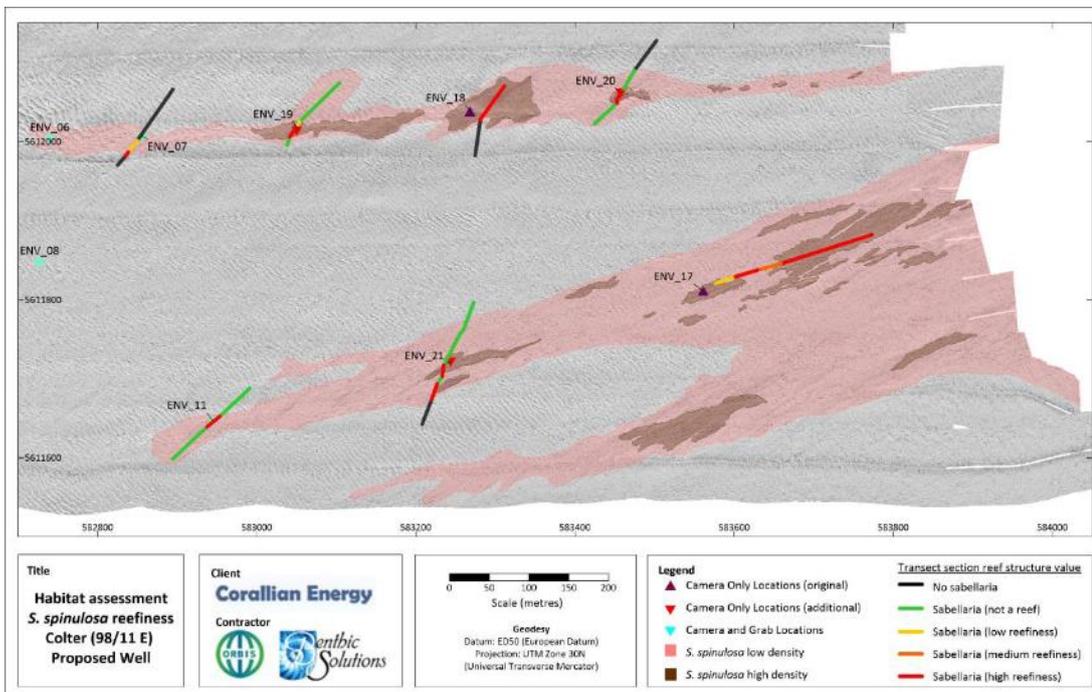
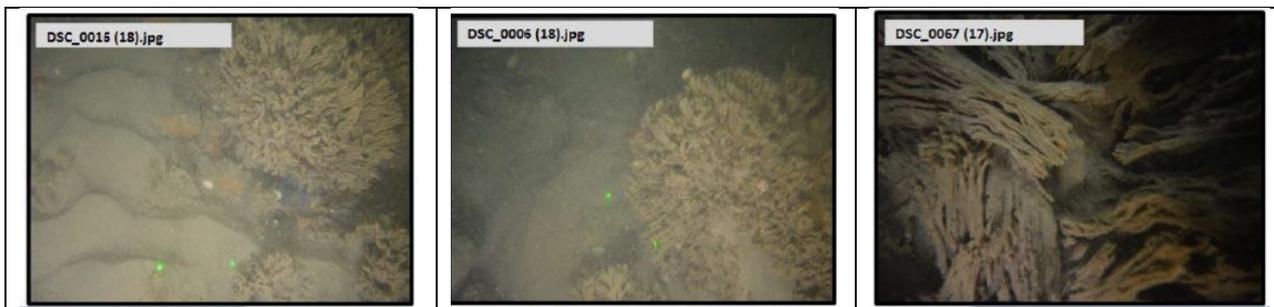


Figure 20 From Colter (98/11-E) Appraisal Well: Environmental Statement



The central Poole Bay *Sabellaria* reefs were discovered in the southeast corner of the Environmental Survey study area and it is highly likely that the feature extends further east, potentially for up to 2km, as the mapped areas of reef seem to be associated with a seabed features visible from existing multibeam data.

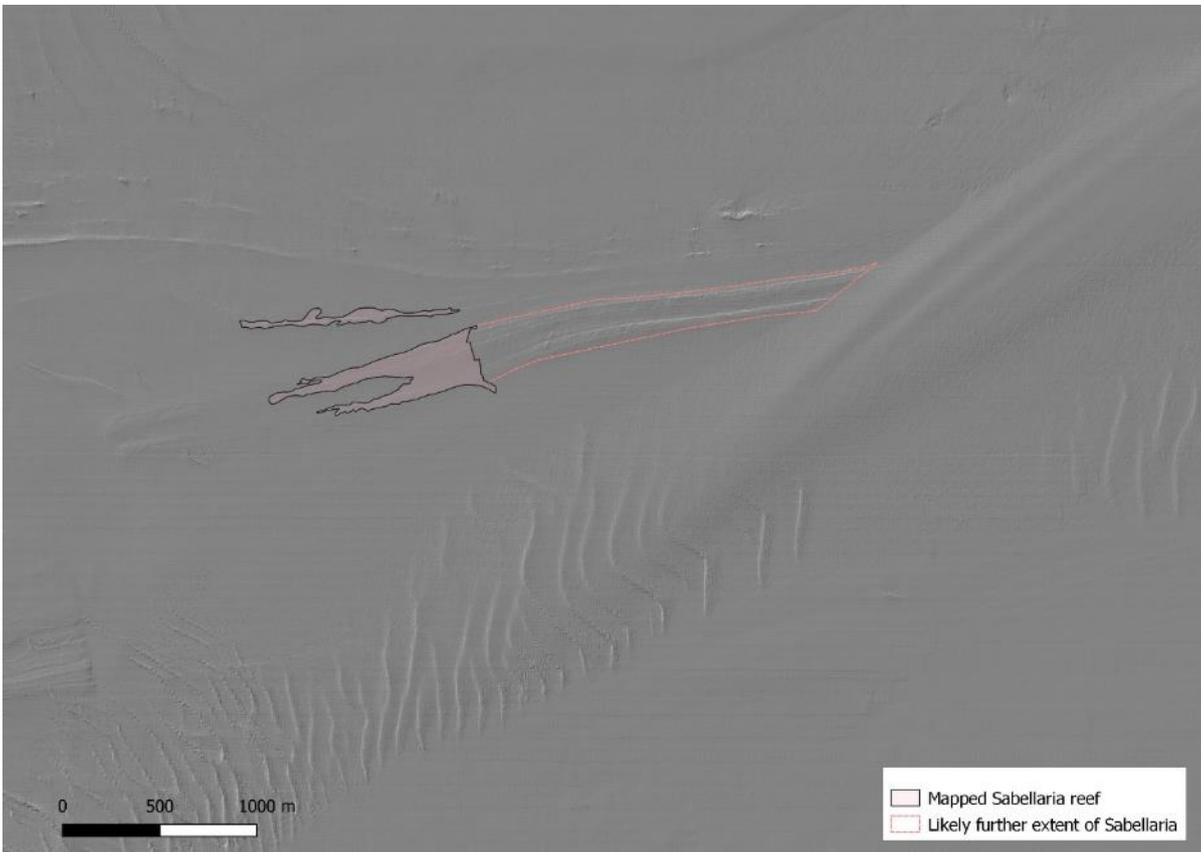


Figure 21 Mapped Sabellaria reef in relation to seabed features.

Intensity and distribution of anchoring in Poole Bay

Figure 22 shows that one anchoring cluster (“Anthem of the Seas”) coincides with the *Sabellaria* reef mapped by the Colter Appraisal ES survey. The “Anthem of the Seas” occupied this area from before 8 October 2020 to 16 October 2020, at which point it moved offshore. The vessel returned to Poole Bay on 18 October 2020 but took up a different anchoring position and has since occupied several other sites in the bay.

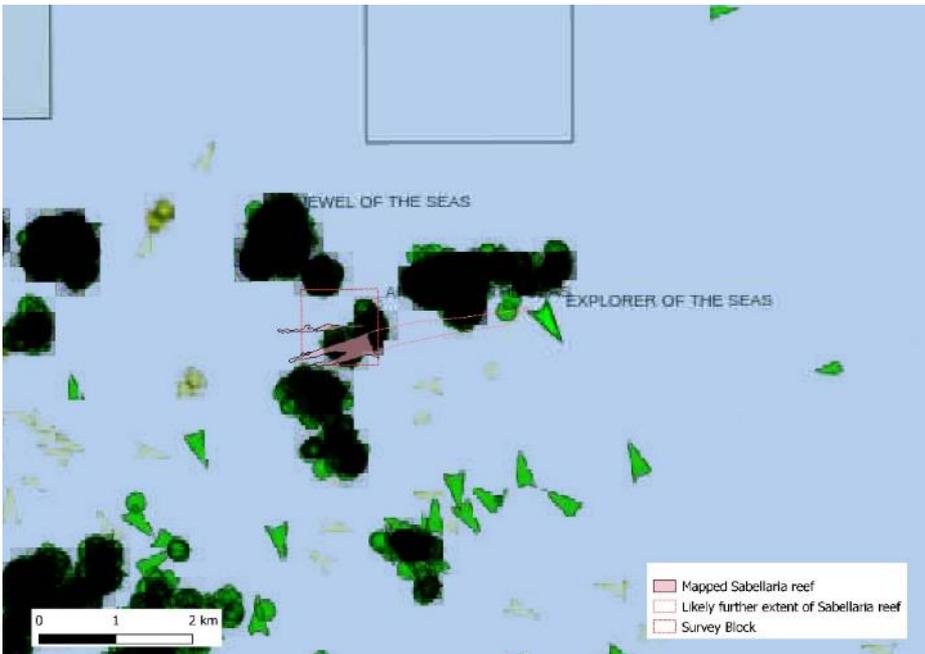


Figure 22 Extent of Sabellaria reef (from Colter 2018) shown over anchoring locations.

To better understand the impact of large anchors on *Sabellaria* reefs, 1km² of sidescan survey data was collected from this area on 8 Jan 2021. This was funded by Natural England.

Results

The sidescan from 2021 matches well with that collected from the same area in 2017. Darker patches in the 2021 data line up well with the areas identified as *Sabellaria* reef from the Colter study. No ground-truthing has yet been undertaken on the recent sidescan but the Colter survey results are backed up by drop-camera surveys, clearly showing well-developed *Sabellaria* reef. If anything, there appear to be more textured areas, suggesting *Sabellaria* reef, on the 2021 data than on the 2017, but this would need ground-truthing.

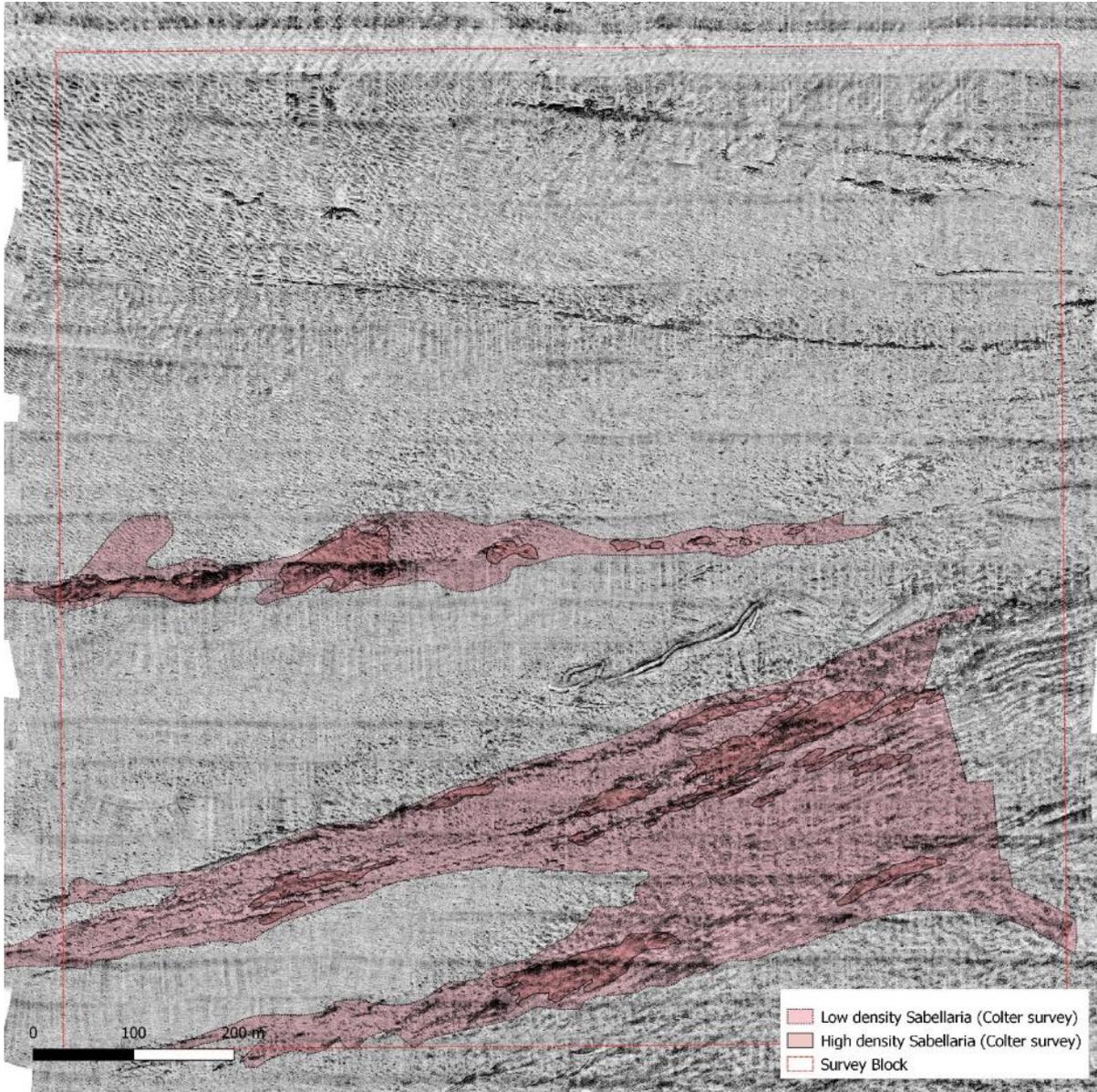


Figure 23 2021 sidescan mosaic with overlay of 2017 *Sabellaria* extent

A large scar, over 200m long and 5m wide, is clearly visible in the centre of the survey block. This is less than 100m from an area characterised as “high density” *Sabellaria* reef in the 2017 survey. A smaller and fainter scar is visible at the south of the survey area.

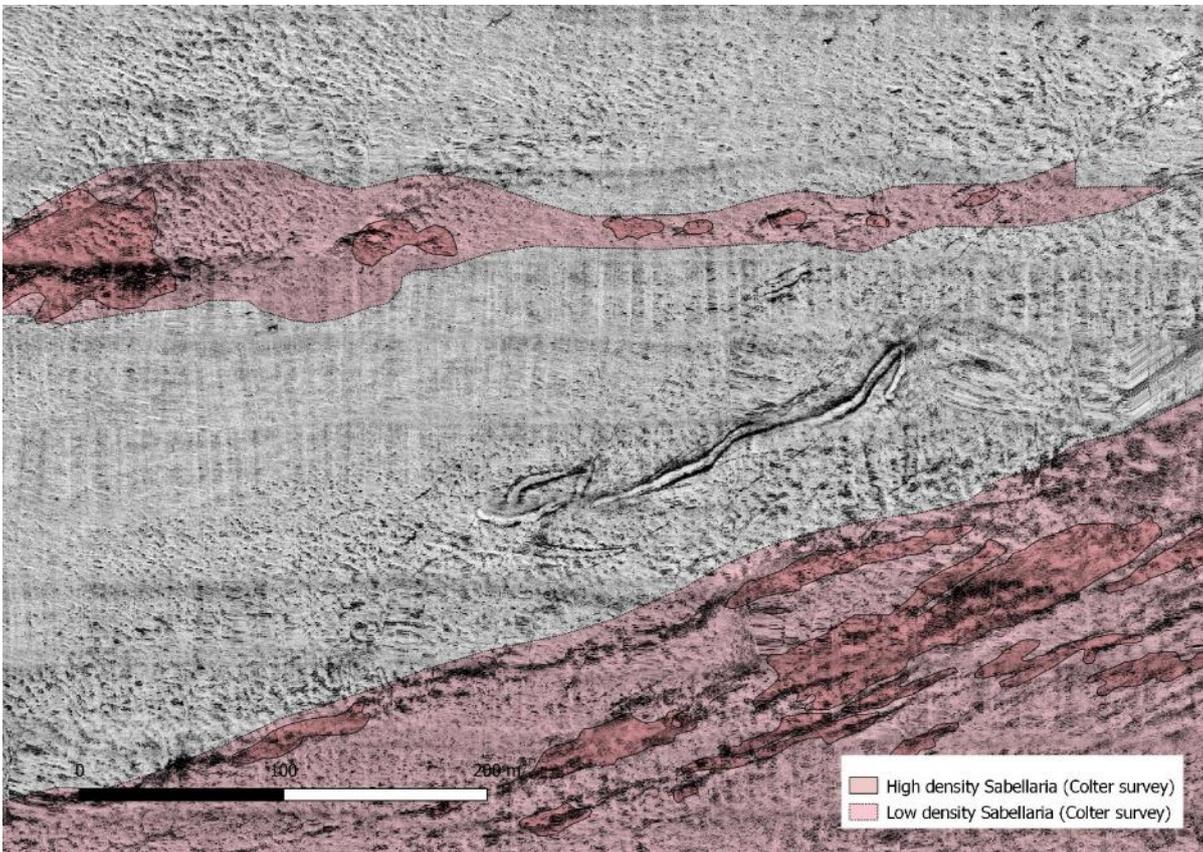


Figure 24 Section of sidescan mosaic showing visible seabed scar.

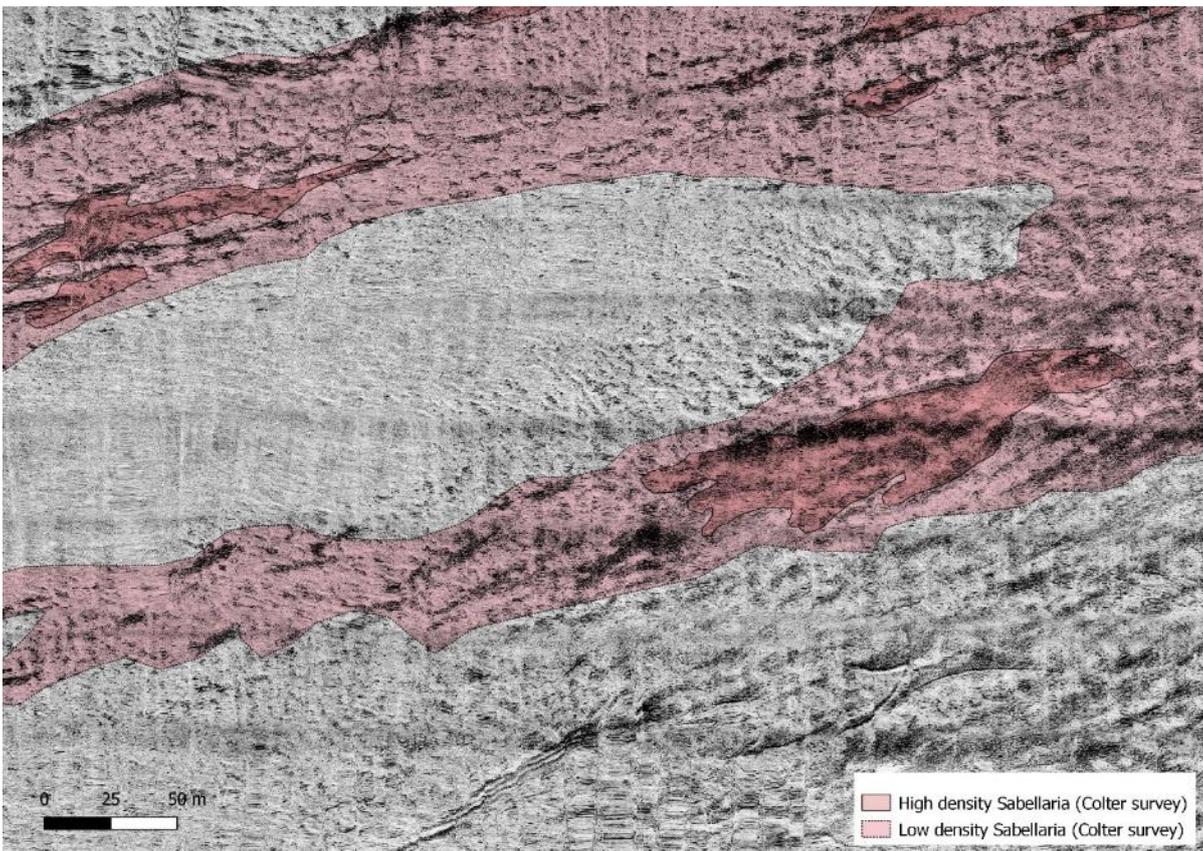


Figure 25 Fainter scar visible at southern edge of survey block

We can date the scar as we know the vessel moved on 84 days prior to the survey – it would seem likely that much of the scar was caused by dragging the anchor along the seabed as it was retrieved. Since that time there have been

a number of weather events, storm Bella on 26/27 Dec being the most significant, but none of these have erased the scar.

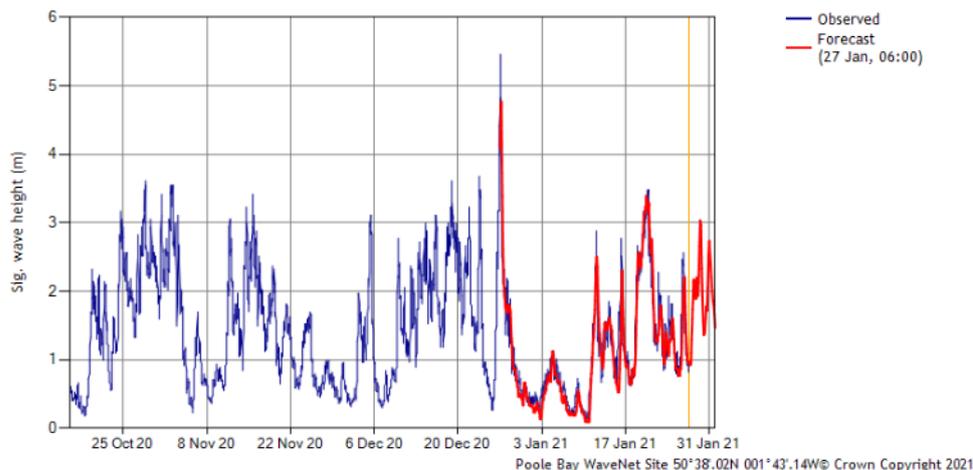


Figure 26 Significant wave height from Poole Bay WaveBuoy

Recommendations

The current situation is unusual and unprecedented and is happening at several sites along the south coast. Each time one of these large vessels drops and retrieves an anchor, it is making a noticeable impact on the seabed. The cumulative effect of this on sensitive habitats could be significant. Poole Bay seabed is generally described as largely mobile sediments but it is far from uniform. This study has shown that at least one sensitive habitat, *Sabellaria spinulosa* reef, is at risk and that scars created in what is considered coarse mobile sediment in a tidesswept area are able to persist for almost 3 months.

The arrival of these cruise ships along the south coast has brought with it an additional pressure on the marine environment. We do not know how typical this scar is, nor do we know the sensitivity of the habitats at the other anchoring sites. Data from multibeam survey around anchoring sites in soft mud in Weymouth Bay suggest that the impact of anchoring is wider than that detected by this sidescan survey – there is likely to be a fan of scraped seabed at one end of the chain scar caused by dragging of the chain at the vessel end. As the ship moves around the anchor in different weather/tide conditions, this could impact an area of several hectares – this could have a very significant impact on a delicate, highly localised habitat such as *Sabellaria* reef – the known mapped area is just over 20ha. An unlucky anchor drop could potentially destroy a third of this.

We are concerned that the currently unprecedented level of anchoring in Weymouth Bay and Poole Bay may have long-lasting impacts on a considerable area of seabed. While anchoring within the MPAs has mostly been limited, the seabed outside of the MPA boundaries should not be treated as a free-for-all. It is likely that significant impact has already occurred, this study helps indicate the potential scale of this.

We would like to see anchoring in Poole Bay restricted, at least until it is possible to better identify some sensitive areas to be avoided, such as the recently discovered *Sabellaria* reefs. Figure 27 shows a suggested 500m buffer zone around the known mapped area of *Sabellaria* plus the associated seabed feature.

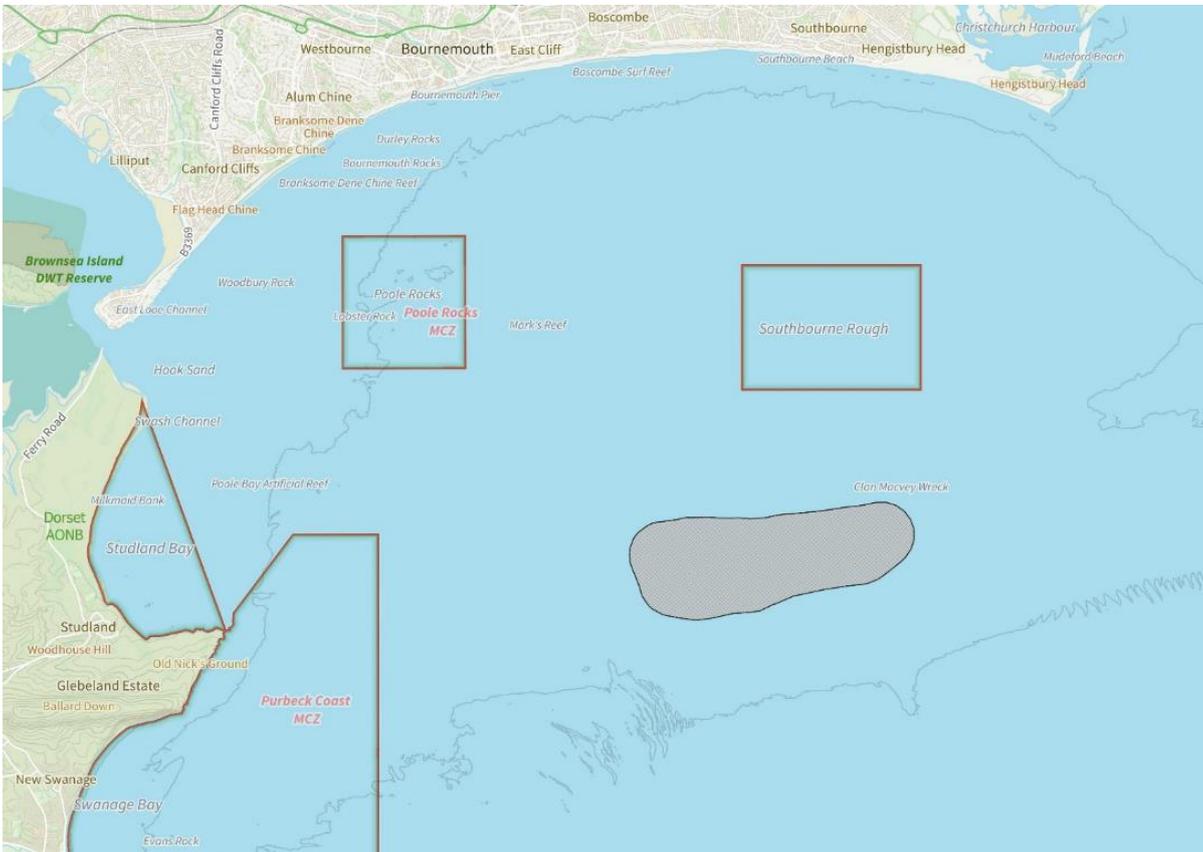


Figure 27 Suggested no-anchoring zone around recently discovered Sabellaria reef in Poole Bay

In the absence of more detailed survey work, the map below shows a suggested wider precautionary area to avoid, based on a 250m buffer around any rock outcrop, rock sub-crop, rock scarp or ridge identified in HI1366, or any MPA designated for seabed features.

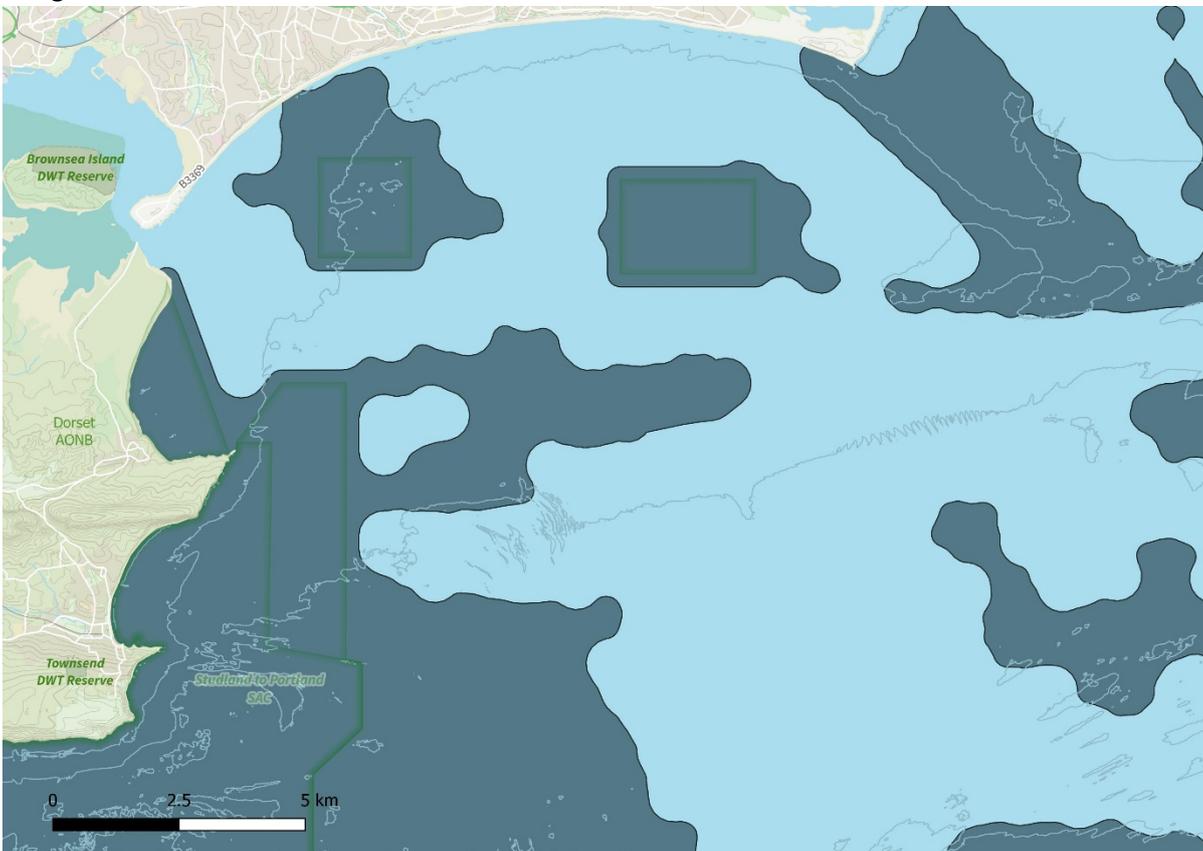


Figure 28 Suggested precautionary area to avoid anchoring

We would like to see underwater noise levels monitored and kept within yet-to-be agreed thresholds.

We would like to see night-time lighting reduced as much as possible.

We would be interested to hear of any opportunities for beneficial use of these vessels while they are tied up in Dorset's waters – environmental monitoring, observation, survey for example.

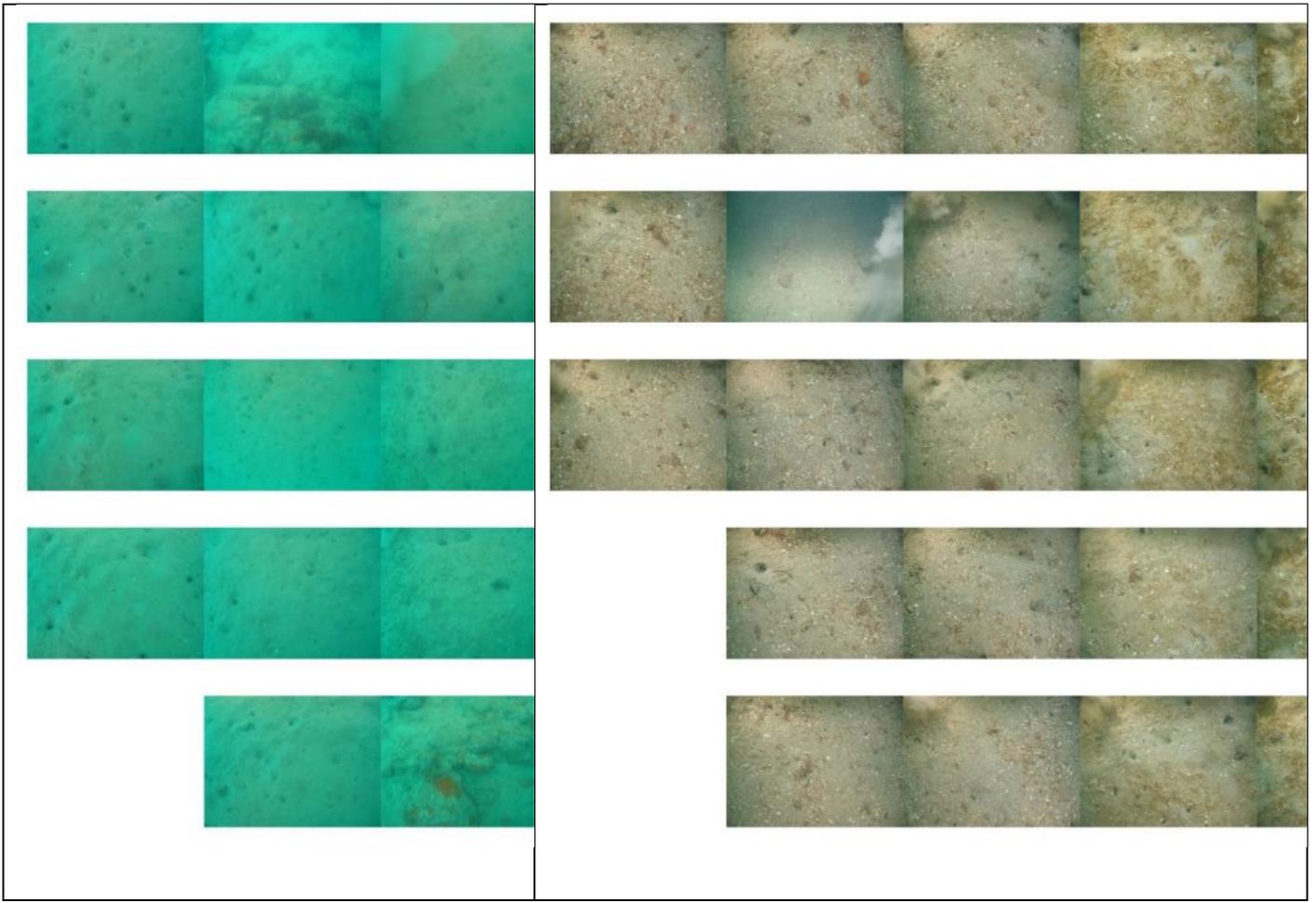
It should be possible to accurately date some of these scars, using AIS data. Future re-survey will help determine the longevity of such scars and the overall recovery of the site once the cruise ships resume normal operations. Diver survey of the reef in Figure 14 might shed some light on the impact of anchoring on reef habitat and drop camera survey of the *Sabellaria* reef site in Poole Bay would be useful to ascertain the continued existence of this feature.

Acknowledgements:

Multibeam and sidescan survey funded by Natural England

Maps contain data from Maritime and Coastguard Agency and Ordnance Survey, licenced under the Open Government Licence v3.0

Appendix I. DORIS Drop camera images near Block I



Appendix 2. DORIS drop camera images near Block 2



Appendix 3. DORIS drop camera images near Block 3



Figure 29 Drop video images - Track C31

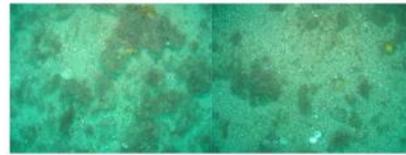


Figure 30 Drop video images - Track C36

Appendix 4. Log of arrivals and departures to Weymouth Bay between Oct and Dec 2020

Date	Movements	Anchor drops	Anchor hauls
08/10/2020	Aurora, Marella Explorer, Britannia present		
09/10/2020	Queen Elizabeth arrives	1	
10/10/2020	Marella Discovery and Norwegian Encore arrive	2	
12/10/2020	Aurora and Marella Discovery leave		2
14/10/2020	Aurora and Norwegian Bliss arrive, Marella Explorer leaves	2	1
14/10/2020	Marella Discovery arrives	1	
15/10/2020	Marella Explorer arrives	1	
16/10/2020	Arcadia arrives	1	
17/10/2020	Queen Victoria arrives, Marella Explorer and Norwegian Encore leave	2	1
18/10/2020	Marella Explorer arrives (in SAC), Norwegian Bliss moves	2	1
19/10/2020	Arcadia and Queen Victoria leave		2
20/10/2020	Marella Discovery leaves, Norwegian Bliss moves	1	2
21/10/2020	Britannia leaves		1
22/10/2020	Marella Explorer moves outside SAC, Marella Discovery and Queen Victoria arrive	3	1
23/10/2020	Norwegian Bliss and Queen Victoria leave		2
24/10/2020	Aurora, Queen Elizabeth and Marella Discovery leave		3
25/10/2020	Aurora, Britannia, Queen Elizabeth, Marella Discovery and Queen Victoria arrive		5
26/10/2020	Norwegian Bliss arrives, Queen Victoria leaves	1	1
27/10/2020	Marella Explorer moves to Portland Harbour, Britannia and Marella Discovery leave		3
28/10/2020	Marella Explorer arrives, Norwegian Bliss leaves	1	1

29/10/2020	Aurora and Britannia arrive	1	1
30/10/2020	Aurora, Britannia and Queen Elizabeth leave		3
31/10/2020	Marella Explorer leaves		1
04/11/2020	Aurora, Marella Explorer, Britannia, Queen Elizabeth, Marella Discovery and Queen Victoria arrive	6	
05/11/2020	Queen Elizabeth leaves		1
07/11/2020	Queen Elizabeth arrives	1	
08/11/2020	Marella Discovery moves to Portland Harbour		1
10/11/2020	Marella Discovery arrives, Marella Explorer leaves	1	1
10/11/2020	Marella Discovery leaves		1
11/11/2020	Norwegian Bliss arrives, Britannia and Queen Victoria leave	1	2
11/11/2020	Norwegian Bliss leaves		1
12/11/2020	Aurora, Britannia, Marella Discovery, Norwegian Bliss and Queen Victoria arrive	5	
13/11/2020	Arcadia arrives	1	
13/11/2020	Aurora and Arcadia leave		2
14/11/2020	Britannia, Queen Elizabeth, Marella Discovery, Norwegian Bliss and Queen Victoria leave		5
16/11/2020	Aurora, Marella Explorer, Britannia, Queen Elizabeth, Marella Discovery and Norwegian Bliss arrive	6	
17/11/2020	Norwegian Bliss moves to Portland Harbour		1
18/11/2020	Marella Explorer, Britannia, Queen Elizabeth and Marella Discovery leave		4
19/11/2020	Marella Explorer, Queen Elizabeth and Marella Discovery arrive	3	
20/11/2020	Britannia arrives	1	
22/11/2020	Queen Victoria arrives	1	

23/11/2020	Marella Explorer 2 arrives, Aurora leaves	1	1
25/11/2020	Marella Discovery leaves		1
27/11/2020	Aurora and Norwegian Bliss arrive	2	
30/11/2020	Marella Explorer leaves		1
02/12/2020	Marella Explorer 2 leaves		1
03/12/2020	Queen Elizabeth leaves		1
04/12/2020	Marella Explorer, Marella Explorer 2, Norwegian Bliss and Ventura arrive, Britannia leaves	4	1
05/12/2020	Aurora, Marella Explorer 2 and Norwegian Bliss leave		3
06/12/2020	Aurora, Queen Elizabeth, Marella Explorer 2 and Queen Victoria arrive	4	
06/12/2020	Queen Elizabeth leaves		1
07/12/2020	Marella Explorer 2 moves close to SAC boundary	1	1
08/12/2020	Britannia arrives	1	
09/12/2020	Queen Victoria leaves		1
10/12/2020	Queen Victoria arrives	1	
11/12/2020	Marella Explorer 2 leaves		1
12/12/2020	Queen Victoria leaves		1
15/12/2020	Britannia leaves		1
16/12/2020	Ventura leaves		1
16/12/2020	Queen Elizabeth and Ventura arrive	2	
17/12/2020	Queen Mary 2 arrives	1	
17/12/2020	Queen Elizabeth and Queen Mary 2 leave		2
18/12/2020	Ventura leaves		1
19/12/2020	Britannia, Queen Elizabeth and Ventura arrive	3	
21/12/2020	Ventura leaves		1
22/12/2020	Aurora arrives	1	
23/12/2020	Queen Victoria arrives	1	
25/12/2020	Norwegian Bliss arrives	1	

26/12/2020	Aurora, Britannia, Queen Elizabeth, Norwegian Bliss and Queen Victoria leave		5
27/12/2020	Aurora, Britannia, Queen Elizabeth and Queen Victoria arrive	4	
28/12/2020	Norwegian Bliss arrives	1	
	Total	73	75

Appendix 5. Log of arrivals and departures in Poole Bay between October 2020 and January 2021

Date	Movements	Anchor drops	Anchor hauls
08/10/2020	Jewel of the Seas, Anthem of the Seas and Explorer of the Seas present		
08/10/2020	Arcadia arrives, Explorer of the Seas leaves	1	1
09/10/2020	Explorer of the Seas arrives	1	
10/10/2020	Allure of the Seas arrives	1	
14/10/2020	Arcadia leaves		1
15/10/2020	Explorer of the Seas leaves		1
16/10/2020	Anthem of the Seas leaves		1
17/10/2020	Explorer of the Seas arrives	1	
18/10/2020	Anthem of the Seas arrives	1	
19/10/2020	Jewel of the Seas leaves		1
20/10/2020	Jewel of the Seas arrives	1	
23/10/2020	Anthem of the Seas leaves		1
24/10/2020	Anthem of the Seas arrives	1	
25/10/2020	Explorer of the Seas leaves and returns	1	1
26/10/2020	Explorer of the Seas moves close to Swanage then returns	2	1
28/10/2020	Allure of the Seas leaves, Anthem of the Seas moves	1	2
30/10/2020	Allure of the Seas arrives	1	
31/10/2020	Allure of the Seas leaves, Anthem of the Seas moves		1
01/11/2020	Jewel of the Seas and Anthem of the Seas leave		2
02/11/2020	Explorer of the Seas leaves		1
04/11/2020	Jewel of the Seas, Explorer of the Seas, Anthem of the Seas and Allure of the Seas arrive	4	
05/11/2020	Anthem of the Seas moves	1	1
13/11/2020	Explorer of the Seas leaves		1
14/11/2020	Allure of the Seas leaves		1
16/11/2020	Explorer of the Seas and Allure of the Seas arrive	2	

18/11/2020	Anthem of the Seas leaves		1
20/11/2020	Anthem of the Seas arrives	1	
21/11/2020	Jewel of the Seas leaves		1
22/11/2020	Jewel of the Seas arrives	1	
23/11/2020	Explorer of the Seas leaves and returns	1	1
26/11/2020	Allure of the Seas leaves		1
28/11/2020	Allure of the Seas arrives	1	
03/12/202	Explorer of the Seas leaves		1
04/12/2020	Explorer of the Seas arrives	1	
05/12/2020	Jewel of the Seas leaves		1
07/12/2020	Jewel of the Seas arrives	1	
09/12/2020	Explorer of the Seas leaves		1
15/12/2020	Allure of the Seas leaves		1
18/12/2020	Anthem of the Seas leaves		1
20/12/2020	Anthem of the Seas arrives	1	
26/12/2020	Anthem of the Seas and Jewel of the Seas leave		2
28/12/2020	Jewel of the Seas and Anthem of the Seas arrive	2	
04/01/2021	Jewel of the Seas leaves		1
05/01/2021	Jewel of the Seas arrives	1	
	Total	29	29

Appendix 6. Hydrographic Survey Data Collection Parameters

Software	Acquisition:	Hypack Survey (latest update)			
	Processing:	Hypack Survey (latest update)			
Positioning	Type:	Single beam: CEESCOPE GPS			
		Multibeam: Applanix POSMV Wavemaster 2			
	Correction service:	Trimble VRS NOW			
	Accuracy:	0.05 metre horizontal & vertical			
	Calibration:	Checked against digital background data			
	Frequency:	Static momentary position			
	Position:	Observed to be within survey tolerance			
Tides	Method:	RTK GPS using Trimble VRS NOW virtual tide gauge			
	Datum:	Ordnance Datum Newlyn			
	CD/ODN value:	-0.93 metres (Weymouth) n/a Poole (no soundings)			
	Presentation/XYZ	To Chart Datum using the above separation value			
	Calibration:	Checked against predicted values			
MBES	Type:	Norbit iWBMS			
	Frequency:	400			
	Beam width (deg):	0.9 x 0.9 @400 kHz			
	Swathe width (degrees):	Typically 130 (steered where necessary)			
	Resolution (metres):	0.01			
	Accuracy (metres):	~0.10			
	On-line smoothing:	None			
	Velocity of Sound				
		Water column:	Instrument:	Valeport Swift	
			Sample rate:	Pre, post and hourly intervals	
		Beam forming:	Instrument:	Valeport Mini SVS	
			Sampling rate:	1 Hz and applied in real time	
		Motion reference:	Instrument:	Applanix POSMV Wavemaster 2	
			Location:	Factory installed within the Sonar head	
		Heading reference	Instrument:	Applanix POSMV Wavemaster 2 Dual antenna heading reference	
		Calibration	Verified patch test and GAMS test Cross-referenced to single beam soundings for gross error		
	Processing				
	System:	Hypack Hysweep (latest update)			
	Smoothing:	None			
	Filter:	Minimum beam quality: 3			
	Read density (metres)	0.5x0.5			
	Output density (metres)	0.5x0.5	Shoal bias		
	Output definition:	One point per cell located on actual XY (where possible)			
	Presentation rounding:	IHO Rounding Rules			
	Post processing:	POSPac			
	Comment:	Data has been collected to determine bed levels only			
Sidescan Sonar (Poole only)	Type:	CMAX			
	Frequency(kHz):	325	Range (m):	75	
	Record type:	Digital			
	Resolution:	0.01 metres			

	Accuracy (horizontal)	+/- 5 metres
	Accuracy (vertical)	+/- 0.2m
	Interpretation:	None – Geotif line by line provided to client
	Calibration:	Opposing track target closure
Conditions and comments	Max wave height:	0.5 metres (both sites)
	Max swell height:	0.0 metres (both sites)
	Conditions were suitable for the duration of the surveys	

Bibliography

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