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Skomer Marine Conservation Zone. Distribution & Abundance of *Zostera marina* in North Haven 2014.

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Synopsis

Volunteer divers were used to survey the seagrass (*Zostera marina*) bed in North Haven within Skomer Marine Conservation Zone (formerly Skomer Marine Nature Reserve). The methods devised in 1997 and refined in 2006 (Lock *et al* 2006) were used to complete a map of extent and shoot density.

The area of extent had increased from 8044.0 m² ,in 2010, to 8224.6 m² in 2014. Comparisons with the first detailed survey in1997 shows an increase in extent to the north, west and east.

The shoot density had decreased from 41.1 shoots /m² from 2010 data to 35.1shoots /m² in 2014. This decrease was not significant (at 5% significance level) when tested with ANOVA. Most of the decreases occurred in the eastern area of the bed.

Two acoustic surveys have been completed by the NRW Fisheries Assessment Team (2013 & 2014) using a Biosonics DT-X split beam echo sounder. These surveys have proved valuable in assessing area of extent and providing an estimate of stand height (shoot length). The acoustic method is quick and gives comparable area estimates. As yet the acoustic method cannot estimate shoot density.

The North Haven *Z. marina* bed is currently within the specified limits as defined by the Skomer Marine Nature Reserve management plan 2000. There is a declining trend in shoot density over the past 8 years but area of extent has been increasing.

Crynodeb

Defnyddiwyd deifwyr gwirfoddol i gynnal arolwg o'r gwely o forwellt (*Zostera marina*) yn Hafan y Gogledd o fewn Parth Cadwraeth Morol Sgomer (yn flaenorol Gwarchodfa Natur Forol Sgomer). Defnyddiwyd y dulliau a ddyfeisiwyd ym 1997 ac a fireiniwyd yn 2006 (Lock *et al* 2006) i gwblhau map gwasgariad a dwysedd egin.

Mae ardal y gwasgariad wedi cynyddu o 8044.0 m², yn 2010, i 8224.6 m² yn 2014. Mae cymariaethau â'r arolwg manwl cyntaf yn 1997 yn dangos cynnydd yn y gwasgariad i'r gogledd, gorllewin a'r dwyrain.

Mae dwysedd yr egin wedi lleihau o 41.1 egin /m² o ddata 2010 i 35.1 egin /m² yn 2014. Nid oedd y gostyngiad hwn yn arwyddocaol (lefel arwyddocâd o 5%) pan brofwyd gydag ANOVA. Digwyddodd y rhan fwyaf o'r gostyngiadau yn ardal ddwyreiniol y gwely.

Cynhaliwyd dau arolwg acwstig gan Dîm Asesu Pysgodfeydd CNC (2013 a 2014) gan ddefnyddio seinblymiwr Biosonics DT-X pelydr hollt. Bu'r arolygon hyn yn werthfawr wrth asesu ardal gwasgariad a rhoi amcangyfrif o uchder y tyfiant (hyd yr egin). Mae'r dull acwstig yn gyflym ac yn rhoi amcangyfrifon cymaradwy o ardal. Hyd yma, ni all y dull acwstig amcangyfrif dwysedd egin.

Ar hyn o bryd mae gwely *Z. marina* Hafan y Gogledd o fewn y terfynau penodedig fel y'u diffinnir gan gynllun rheoli Gwarchodfa Natur Forol Sgomer 2000. Mae tuedd o ddirywiad yn nwysedd egin dros yr 8 mlynedd ddiwethaf ond mae ardal y gwasgariad wedi bod yn cynyddu.

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1 Introduction

1.1 Seagrass Beds

Zostera marina, Linnaeus, (1758) is one of two seagrass species which are listed as nationally scarce and are included as a key habitat for conservation in the UK Biodiversity Action Plan 1994. Key objectives of the action plan for this habitat, as outlined in “Action for Wildlife” Biodiversity in Wales (Contryside Council for Wales, 1997), are to maintain the current extent of seagrass habitats around the coast of Britain and to investigate the feasibility of restoring damaged and degraded examples.

Z. marina is the only flowering plant within the British Isles that grows and produces seed entirely submerged by seawater. *Z. marina* populations are highly productive habitats and they provide an important stabilising function for the mobile marine sediments (Bertelli 2013 & Unsworth 2013). The maintenance of *Z. marina* populations directly influences the associated algal and invertebrate communities that are supported by them. These communities are an important source of food for other marine animals and birds. The optimal growth conditions for *Z. marina* are in relatively shallow, sheltered and stable environments.

The *Z. marina* bed at North Haven, Skomer is one of 8 subtidal *Z. marina* beds in Wales .

1.2 Review of *Zostera Marina* Mapping Studies in North Haven 1946 - 2014

The occurrence of *Z. marina* in North Haven, Skomer was first recorded by Bassindale (1946 and 1950) and subsequently by Hunnam (1976). The extent and density of the *Z. marina* bed in North Haven was unknown. The first mapping studies were completed in 1979, 1980 (Jones, 1980 and Jones and Hodgson 1980) and 1981 (Jones et al 1983), however the surveys were less intensive than subsequent surveys and so comparison between years is difficult. In 1982 a more detailed method was devised based on a fixed grid area and used a defined abundance scale (Jones et al 1983), this method formed the basis of the Skomer Marine Nature Reserve (MNR) survey completed in 1997 (Lock 1998).

The method used in 1997 to map the distribution and abundance of *Z. marina* closely followed that used in 1982, which allowed for a comparison to be made. The main change in method was that actual counts of *Z. marina* shoots in a quadrat were made instead of using an abundance scale. This avoided discrepancies between recorders and had the advantage of providing numbers for comparison in future surveys (Lock 1998). The 1997 survey also established fixed corner markers for the survey plot. This method was successfully repeated in 2002. The method was then expanded in 2006 (Lock et al 2006) and repeated in 2010 and 2014.

In 1997 a basic map of the *Z. marina* bed boundary was produced using shore-based surveyors taking bearings on the divers’ surface marker buoys using digital hand held compasses. In 2000 a GPS (Geographic Positioning System) unit was used to electronically record the position of the divers and the boundary of the *Z. marina* bed. This has been repeated from 2002 onwards. In 2013 a Biosonics DT-X echo sounder was used to acoustically estimate the coverage of *Z. marina* in North Haven. This method was repeated in 2014 and ground-truthed against the diver survey data.

1.3 Current Management

Zostera marina population

Because of its conservation importance the *Z. marina* population was selected as a management plan feature of the Skomer MNR (now Skomer Marine Conservation Zone (MCZ)). As such it is ascribed “specified limits”, which contribute to “performance indicators” used to assess its conservation status (Alexander 2003).

The 1997 mapping results were used to establish “limits of acceptable change” (now referred to as upper and lower specified limits) for the *Z. marina* population at North Haven. These are defined in the Skomer MNR Management Plan 2000 and are as follows:

The extent of the *Z. marina* bed:

Upper Specified limit: No limit set

Lower Specified limit: 5500 m² (from 1982 level)

The mean density of the *Z. marina* bed:

Upper Specified limit: No limits set

Lower Specified limit: mean density \geq 36 shoots/ m² (from 1997 level)

Monitoring project: RF23/01 Monitor *Z. marina* - abundance mapping, every 4 years.

North Haven

North Haven is marked as an anchorage on Admiralty Charts and is the access to the Skomer Island landing. Many boats use the area especially during the summer months; these include yachts, motorboats, dive boats and fishing vessels.

From 1992 onwards “No anchoring” marker buoys, clearly defining the northern edge of the *Z. marina* bed, have been installed as part of management measures designed to protect the bed from damage from anchoring. A number of visitor moorings were established at the same time to the north side of the *Z. marina* bed and their use is encouraged. All vessels are requested to refrain from anchoring southwards of the marker buoys.

1.4 Study Objectives

The key objectives of this survey are:

- To determine distribution and abundance of *Z. marina*.
- To map the boundaries of the *Z. marina* bed with in-situ diver survey and acoustic sonar methods.
- To compare the results with previous surveys.
- To determine if the *Z. marina* bed is within specified limits for conservation assessment.
- Ground-truth acoustic survey methods against in-situ diver surveys.

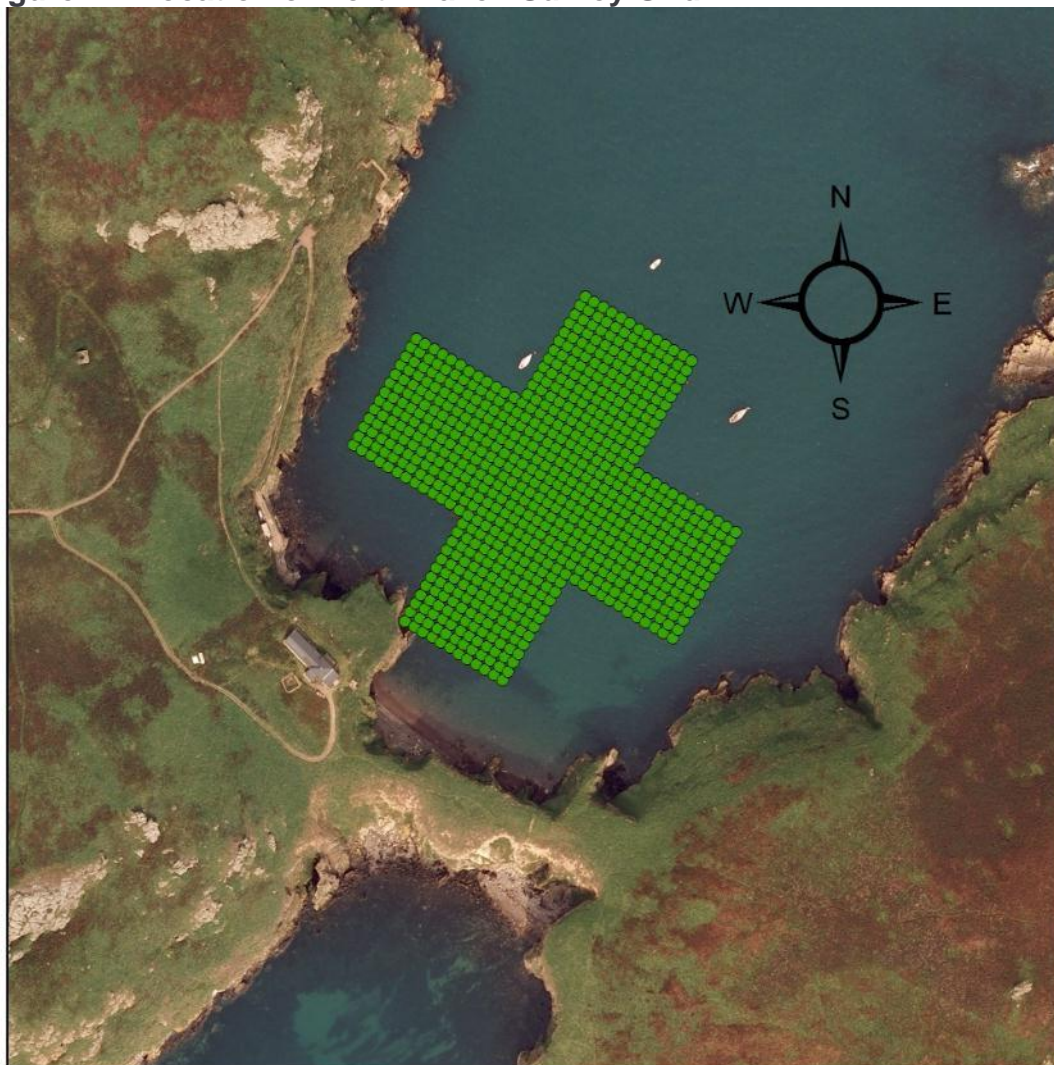
2 Methods

2.1 Establishment of Survey Plot

The survey plot used in the 2006 survey was re-established (see Fig 2.1). The fixed locations of the two “No Anchoring” marker buoys, a secured rock piton on the Loaf rock and a metal sinker with a surface buoy were relocated. Divers laid seven lead lines for the durations of the survey, two parallel between the markers in the west-east direction forming the south and north lines and one to mark the centre of the plot as shown in Figure 2.2. An east and a west line were laid to form a complete square around the main bed and 2 additional lines were laid parallel to the east & west lines 20m out (see Fig 2.4) these lines aid navigation and ensure the east & west transects are laid on the correct bearings. The lead lines were marked every 5m with fluorescent tape marked with the distance along the rope.

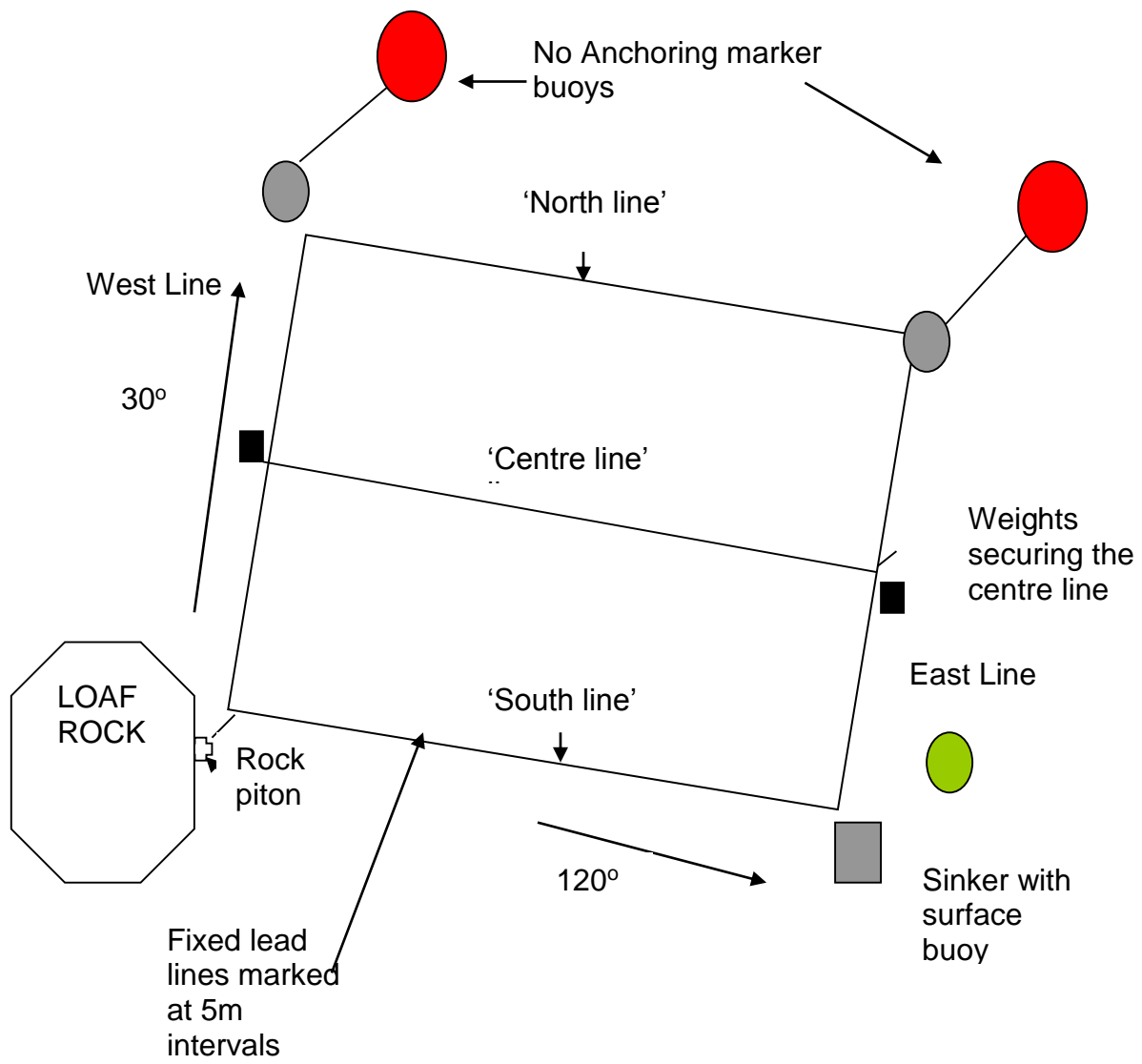
On completion of the survey divers retrieved the lead lines and secured the four corner markers as permanent markers for future surveys.

Figure 2.1 Location of North Haven Survey Grid.



Each green dot is 5M apart and represents a sampling station surveyed in 2014

Figure 2.2 Fixed markers and lines marking the *Z. marina* plot, North Haven, Skomer.



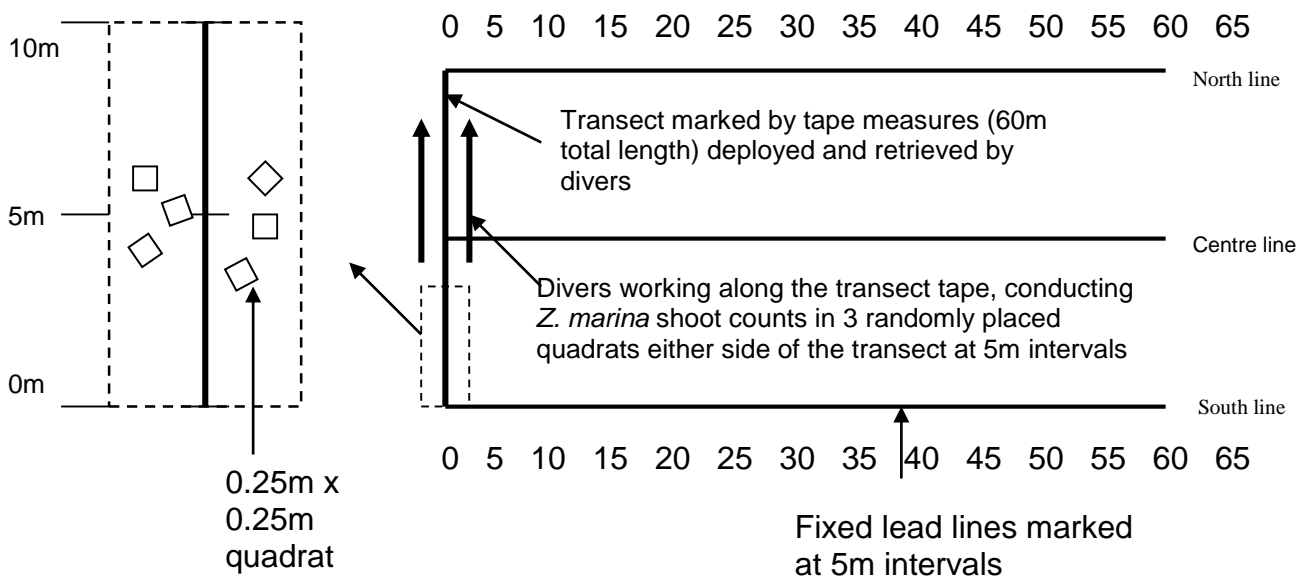
2.2 Distribution and Abundance of *Zostera Marina* Method

The survey method followed that used in 1997. The recording procedure was as follows:

Example for the 0m transect line

- Diver pair secures the end of a 30m tape measure using a diving weight to the south line 0m mark. Divers lay the 30m tape from the south line to the centre line 0m mark where the end is secured. This is repeated using a second 30m tape from the centre line 0m mark to the north line 0m mark. The tapes thus represent the 0m transect line of 60m length as shown in Figure 2.3.
- Divers swim back along the tapes checking that they have been laid and secured correctly.
- Diver pair work either side of the tape commencing from the south line at '0m' on the transect tape (called station 0). Each diver lays a 0.25m x 0.25m quadrat 'randomly' next to the station, then counts and records the total number of *Z. marina* shoots within the quadrat. Repeat so that each diver completes 3 quadrats (total of 6 quadrats completed by the diving pair) as shown in Figure 2.3.
- On completion divers move along the transect tape to '5m', Station 5, and complete quadrat counts. Divers repeat the process at 5m intervals between each station, Station 10, 15, 20 finishing at Station 60 on the north line.
- On completion of the transect divers retrieve the transect tapes and re-lay for the subsequent transect starting at the 5m mark on the south line for the '5m transect line'.
- The method is repeated for each transect, working at 5m intervals along the south line and finishing with the '65m transect' completing the survey plot.

Figure 2.3 Survey methods measuring the abundance of *Z. marina* in the fixed plot area.

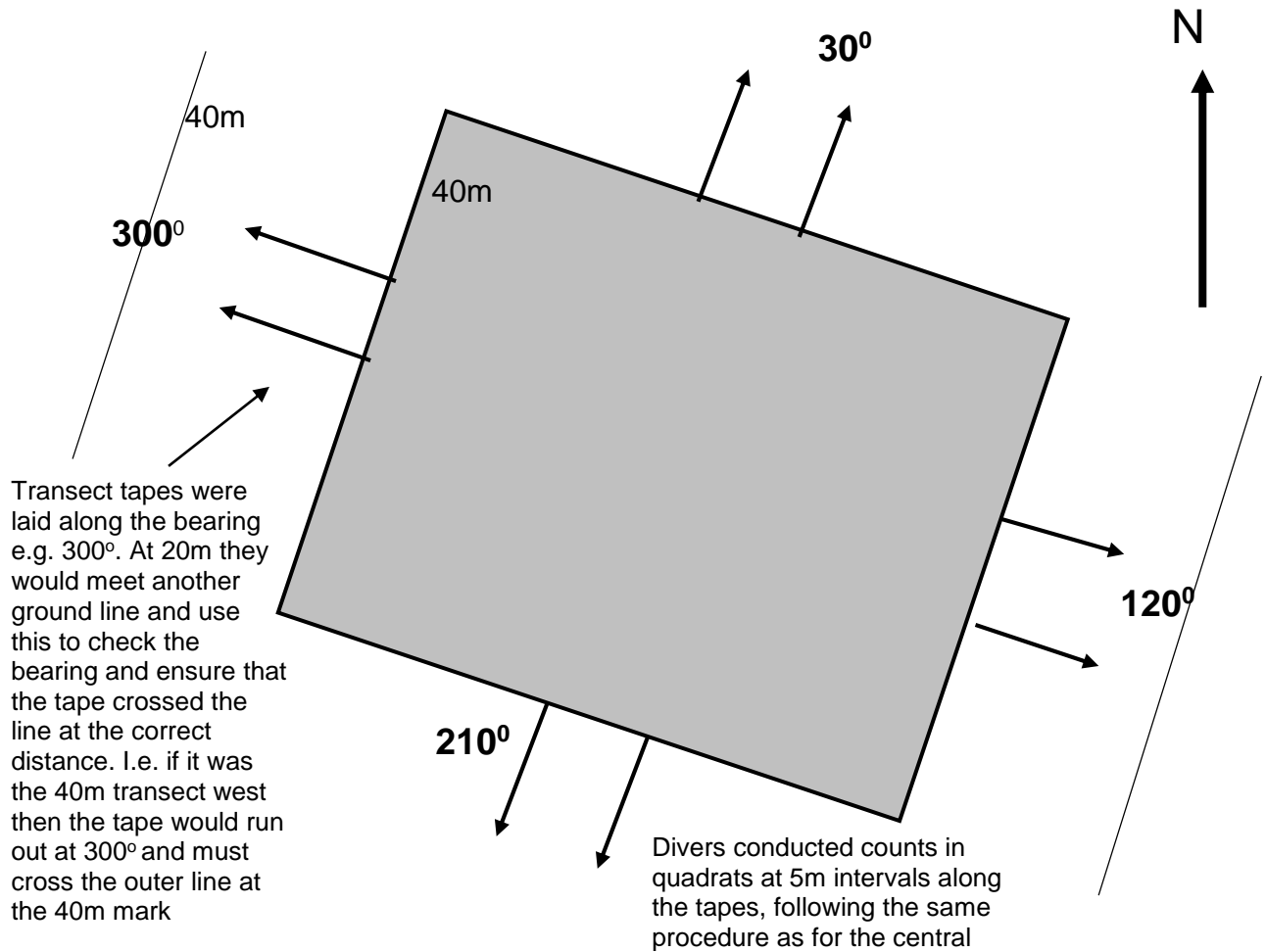


On completion of the survey within the central plot area the distribution and abundance of *Z. marina* outside the plot area was recorded:

- Two 30m tapes on reels are laid by divers in place of the '0m transect' forming the west line and two 30m tapes laid in place of the '65m transect' forming the east line, thus completing the sides of the study plot, see Figure 2.4.
- Divers attach the end of a 30m tape to the 0m mark at the corner of the south/west lines, lay the tape out on a bearing of 300° westwards. They will cross the outside line and check that the tape crosses at the correct distance for transect (see fig 2.3). In 2014 the full 60m East & West was surveyed for each transect (or until unsuitable habitat was encountered).
- Divers work either side of the tape completing quadrat counts every 5m along the tape as described in 3 and 4 above until 60m is reached.
- On completion divers retrieve the tape, re-lay and repeat the method at 5m intervals (*see note below) until all transects from the west line are complete.
- Divers repeat the method from 7-9 for each direction out from the study plot; the north line working 30' northwards, the east line 120' eastwards and the south line working 210' southwards, as shown in Figure 2.4.

*Note: In 1997 and 2002 tapes were laid at 10m intervals this was reduced to 5m intervals from 2006 onwards.

Figure 2.4 Establishing the distribution and abundance of *Z. marina* outside the central plot area



2.3 Estimating the Area of *Zostera marina* using a Split-Beam Acoustic survey. Natural Resources Wales Fisheries Assessment Team, Cardiff

The seagrass in North Haven was surveyed by the NRW Fisheries Assessment Team using a Biosonics DT-X split beam echo sounder, with a 7° circular 200kHz transducer, from the vessel “Skalmey”. The transducer was mounted vertically from the port side of the vessel and suspended 50cm below the water surface. The DT-X’s transmit power was set to -221.0dB, pulse width 0.1ms, ping rate 10 pings per second and raw data was collected at -130dB.

GPS data were logged using a Garmin 72 GPS, which was linked to the Biosonics system, and the boat speed for the survey was approximately 10kmh⁻¹.

The survey grid comprised 18 transects spaced at 20 metre intervals (see figure 2.5)

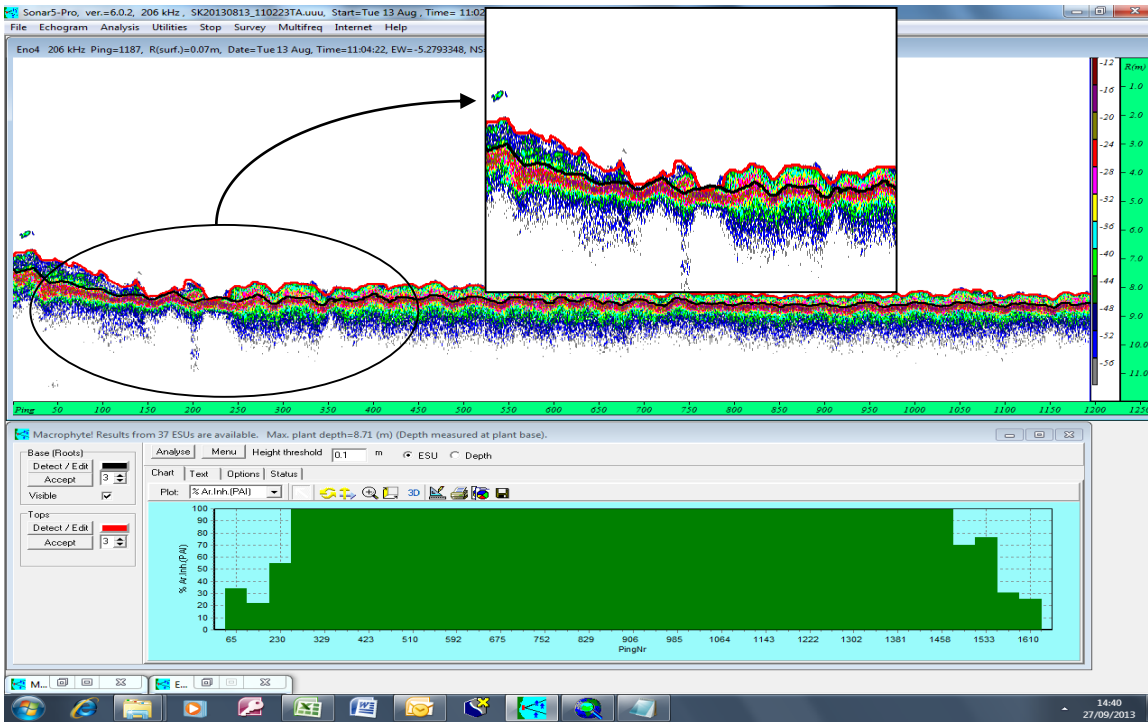
Figure 2.5 North Haven survey grid.



Analysis of the acoustic data was carried out using the macrophyte tool in Sonar 5-pro (Balk and Lindem, 2014). Analysis of macrophyte data involves defining the extent of the macrophyte roots (the sea bed) and the extent of the macrophyte tips. Algorithms in Sonar 5 pro then produce macrophyte metrics within these bounds for user defined Ecological Sample Units (ESU) along the transects. Due to the strong echo return from the seabed a base threshold of -30dB was used to define the base. A threshold of -60dB was used to define the tips.

The base and tip lines were subsequently visually inspected for any spurious echo inclusions and manually edited if required. Each transect was analysed in 5m ESU with a minimum height threshold of 10cm being used to exclude close cropping algae. The following metrics were outputted: Percentage Area Inhabited (PAI) and Bioheight (m). Each ESU has a geo reference, allowing presentation of these metrics in GIS, for easy interpretation of the results (see figure 2.6) . (Clabburn et al, 2014)

Figure 2.6 Screen shot from Sonar-5 analysis screen during acoustic survey.



Sonar-5 analysis screen of Skomer seagrass transect. Inset shows sea grass returns (right side) and non-sea grass returns (left side). Macrophyte bases are defined by the black line and tips by the red line.

The acoustic results were ground-truthed in 2013 with a drift over the survey area, using an underwater camera alongside the hydro acoustics. Video data suggested that the uniform areas were primarily seagrass and that the less uniform areas were comprised primarily of fucoids and Laminaria.

3 Results

All transects were completed by a team of volunteer divers over 3 weekends between 15th June to 20th July 2014.

On the 7th of July 2014 NRW Fisheries Assessment Team completed the Acoustic survey of North Haven *Z. marina* bed using a Biosonics DT-X echo sounder.

3.1 *Zostera marina* Shoot Density Results, In-situ Diver Survey

Figure 3.1 2014 Density (Shoots / m²) Results.

	Mainbed	South	North	East	West	Overall
Mean	41.09	8.39	2.98	28.08	8.59	18.8
Std Dev	18.6	19.7	12.1	26.9	14.0	24.1
Variance	344.5	386.2	147.1	721.9	194.8	579.4
Count	182	144	162	156	144	788
Std Error	1.38	1.64	0.95	2.15	1.16	0.86
Min	0.0	0.0	0.0	0.0	0.0	0.0
Max	86.7	85.3	82.0	104.7	57.3	104.7

Figure 3.2 2010 Density (Shoots / m²) Results.

	Mainbed	South	North	East	West	Overall
Mean	43.38	10.17	0.21	46.22	11.39	22.63
Std Dev	22.9	26.4	0.3	42.8	4.6	32.0
Variance	526.2	697.6	0.1	42.8	18.6	1027.2
Count	176	169	157	156	152	810
Std Error	1.7	2.0	0.0	3.4	0.4	0.4
Min	0.0	0.0	0.0	0.0	0.0	0.0
Max	122.0	152.7	0.7	182.7	72.7	182.7

Compared with 2010, the 2014 Density of *Zostera marina* shoots in the eastern area has significantly decreased ($t = 8.19$ sig @ $< P0.05$) while the shoot density in the north area has increased ($t = 2.89$ sig @ $< P0.05$). All other areas and the overall result are not significantly different ($P0.05$).

Figure 3.3 Graph Comparing 2010 Shoot Density Results with 2014.

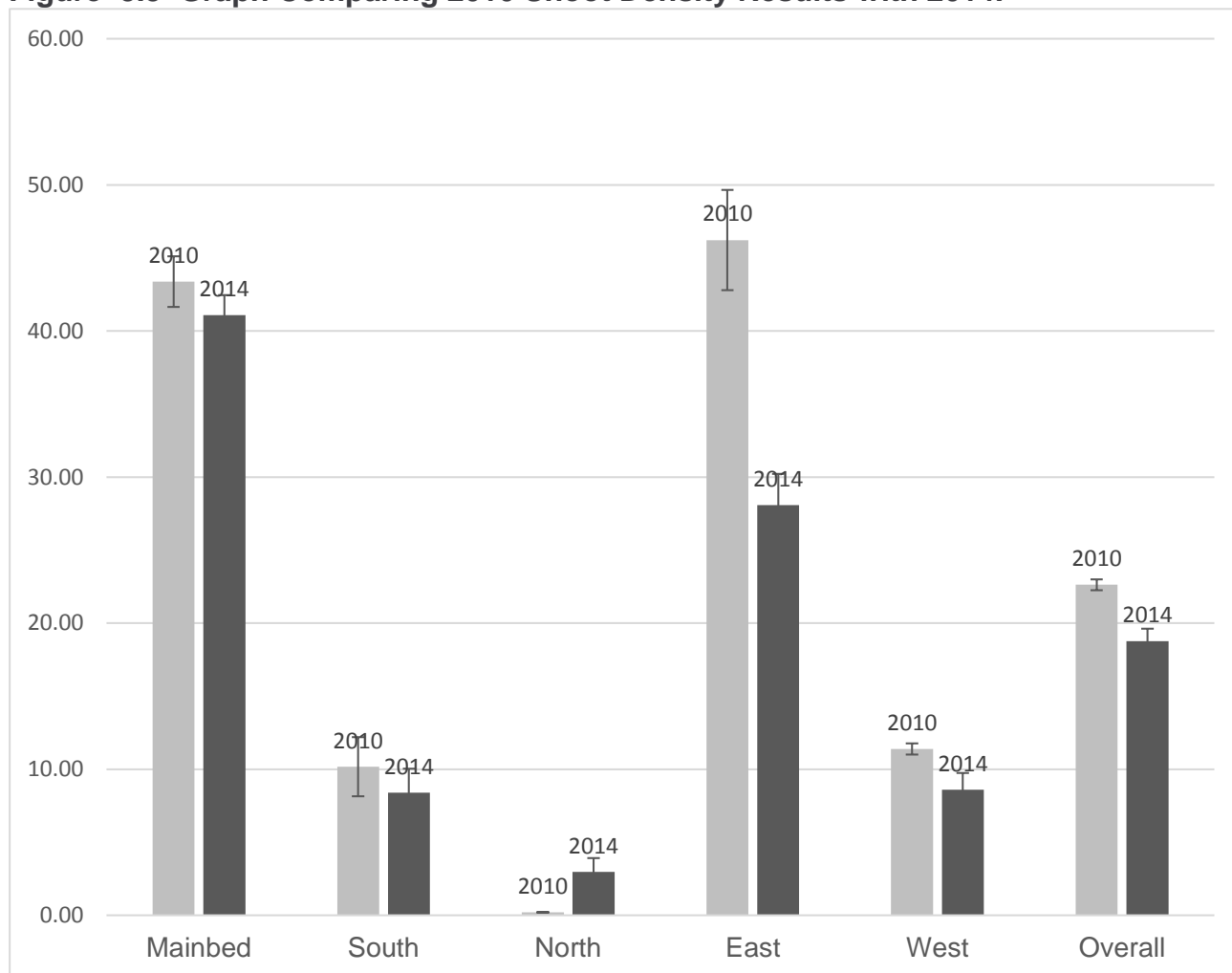


Figure 3.4 Comparison of Overall Shoot Density (per m²) for All Years 1997 - 2014 (Only using data from sample stations with replicates in every sampling year)

	1997	2002	2006	2010	2014
Mean	36.2	53.6	48.0	41.1	35.1
Std Dev	27.3	38.5	31.4	30.6	23.3
Variance	746.0	1478.4	987.8	933.6	544.4
Std error	1.6	2.3	1.8	1.8	1.4
n	289	288	289	289	289
min	0	0	0	0	0
max	104	156	128.7	182.7	104.7

Figure 3.5 Graph of Overall Shoot Density (per m²) for 1997 – 2014 (Shown with S.E of mean).

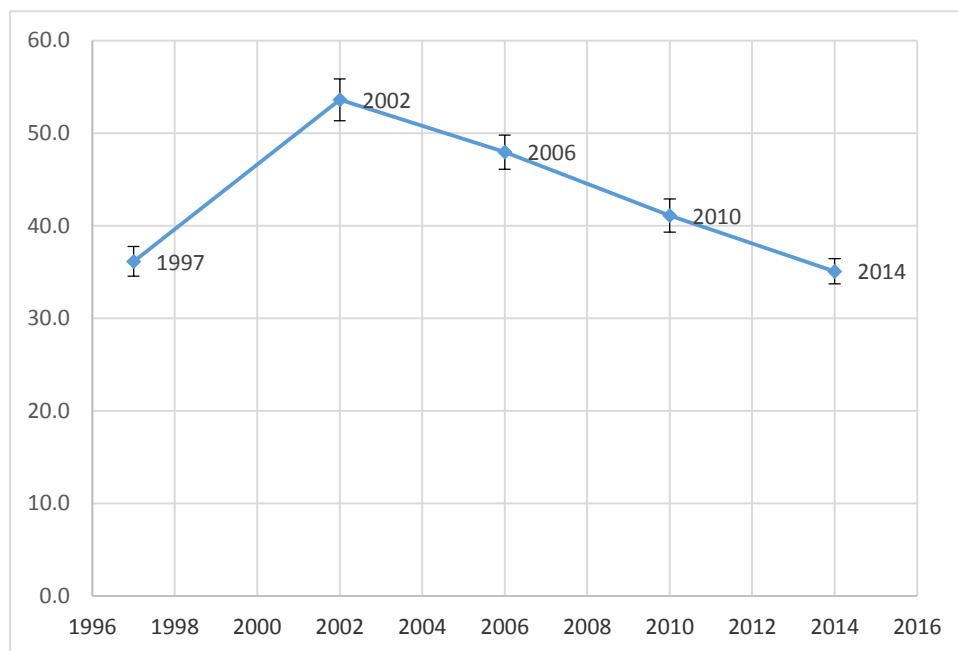


Figure 3.5 highlights the continued decline in overall shoot density since 2002.

One way ANOVA test on overall shoot density (Log₁₀(x+1) transformed) between the 5 survey years shows that there is a significant difference between the years (F 3.06 sig @ P 0.016)

A Tukey test (on untransformed data, P0.05) showed:

2002 mean shoot density was significantly greater than 1997, 2010 & 2014

2006 mean shoot density was significantly greater than 1997 & 2014

The other pairs of means were not significantly different to each other (P0.05)

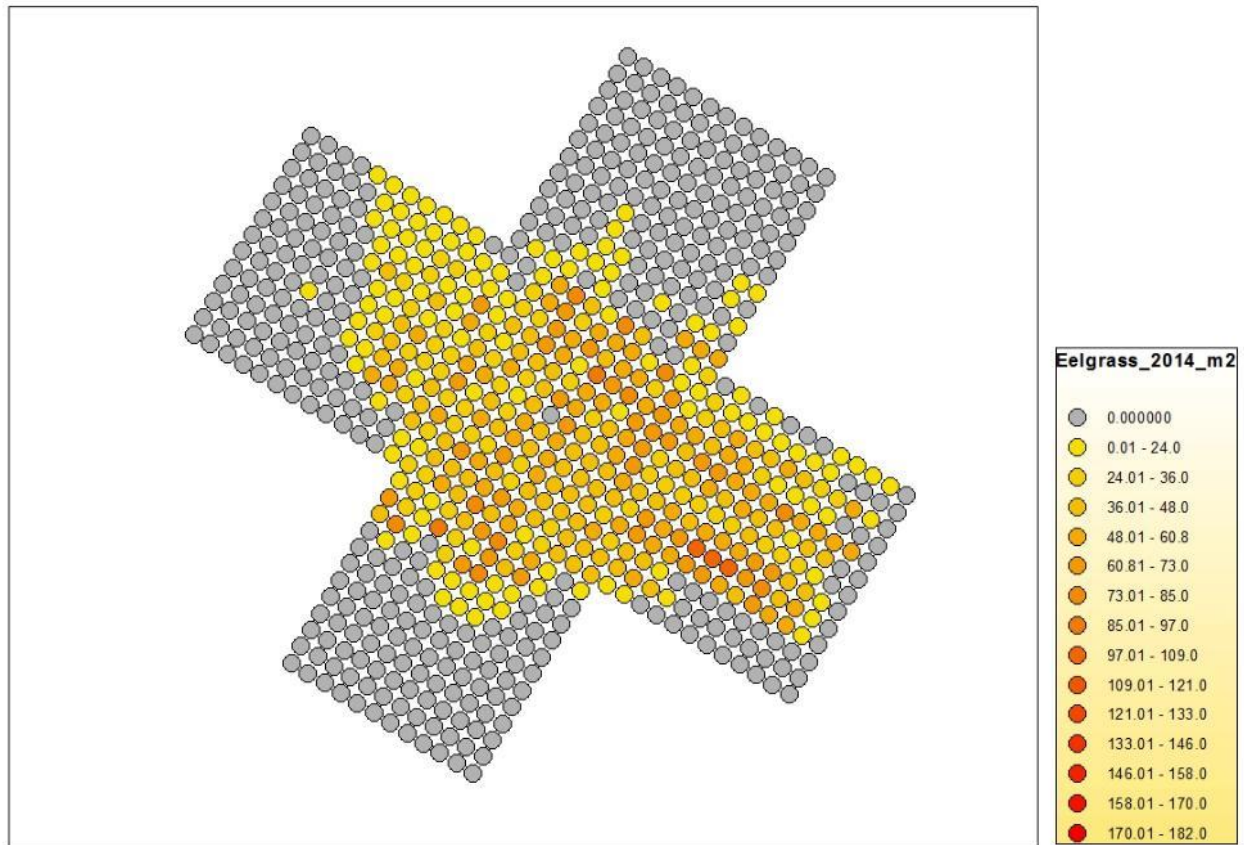
These results show that in 2014 the overall shoot density results are not significantly different to those in 2010 & 1997. It would appear that the *Z. marina* bed in North Haven had an increase in shoot density in 2002 & 2006 but since then the shoot density has decreased back to similar levels seen in 1997. The 2014 meanshoot density is 35.1 shoots/ m²., this is lower than but does not differ significantly from the Lower specified limit: mean density \geq 36 shoots/ m².

3.2 Spatial Analysis of Shoot Density Using G.I.S

Position data and mean shoot density from all the sampling stations from every survey year were entered into ArcMap (v10.2.2). Thematic maps were then produced showing the variation in shoot density across the whole seagrass bed for each year.

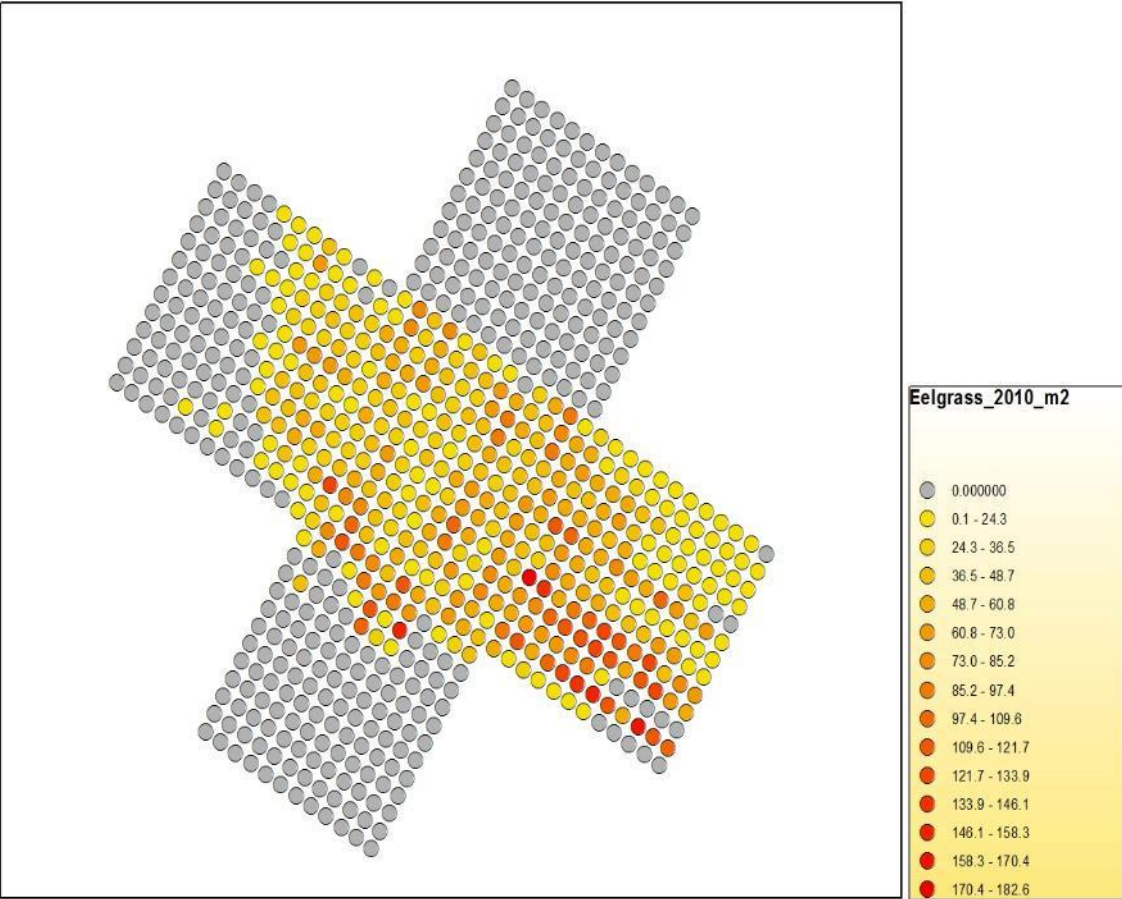
Fig 3.6 Thematic Shoot Density Maps 1997 - 2014

a) 2014 shoot density map (shoots / m²).

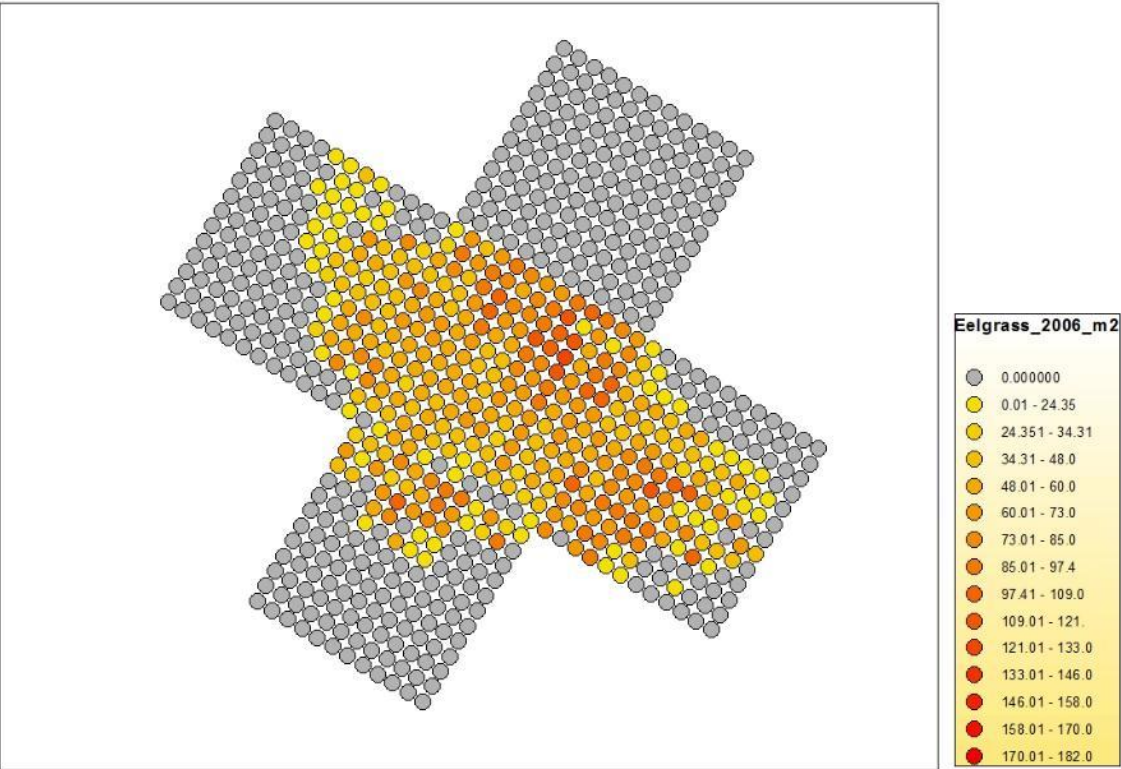


See legend: Grey = No shoots. The darker the colour the greater the shoot density.

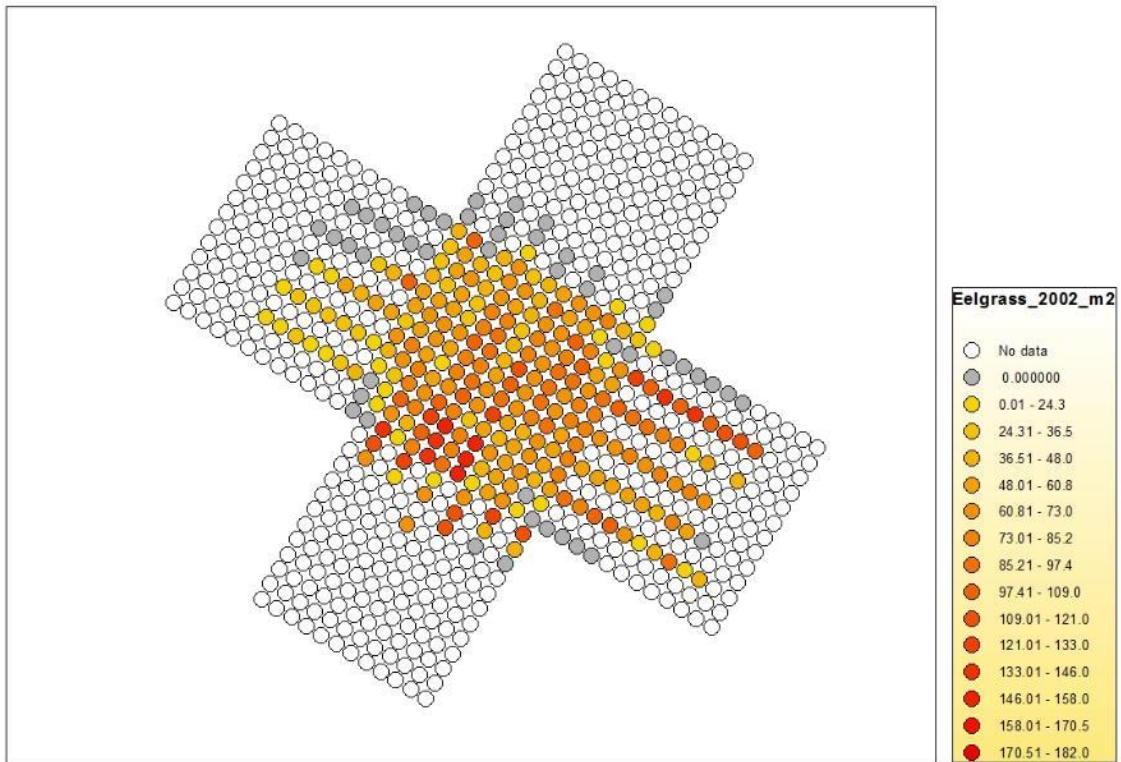
b) 2010 shoot density map (shoots / m²).



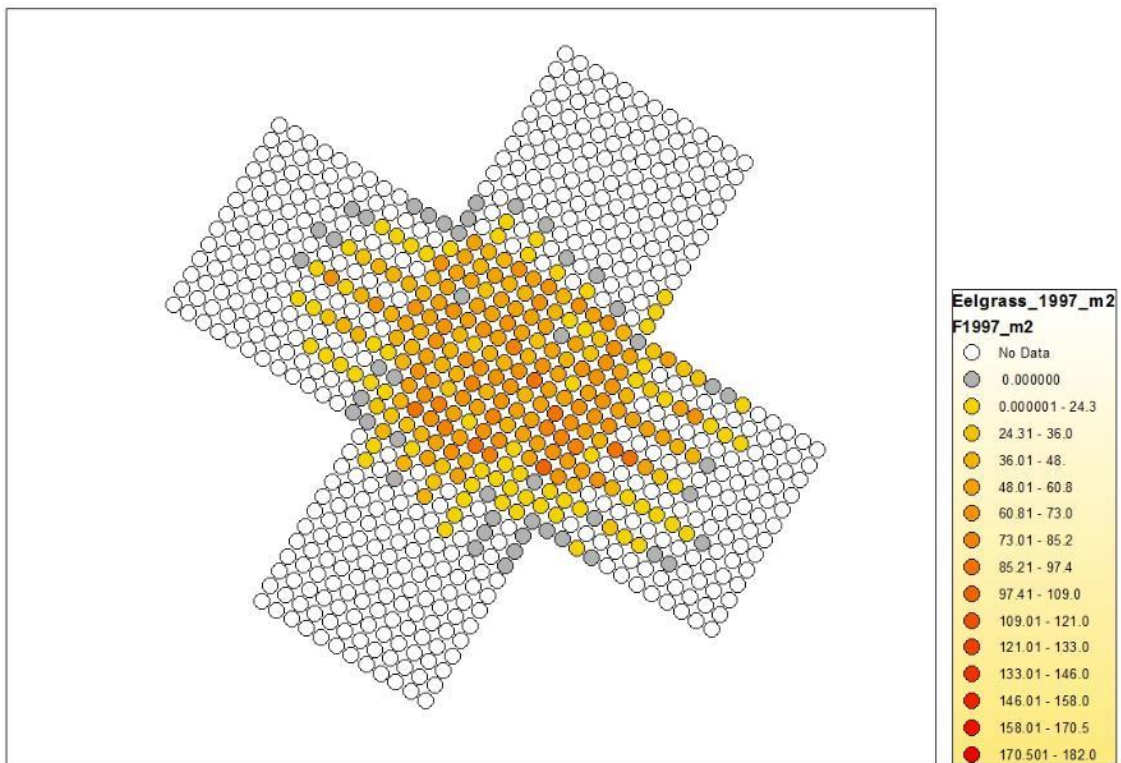
c) 2006 shoot density map (shoots / m²).



d) 2002 shoot density map (shoots / m²).



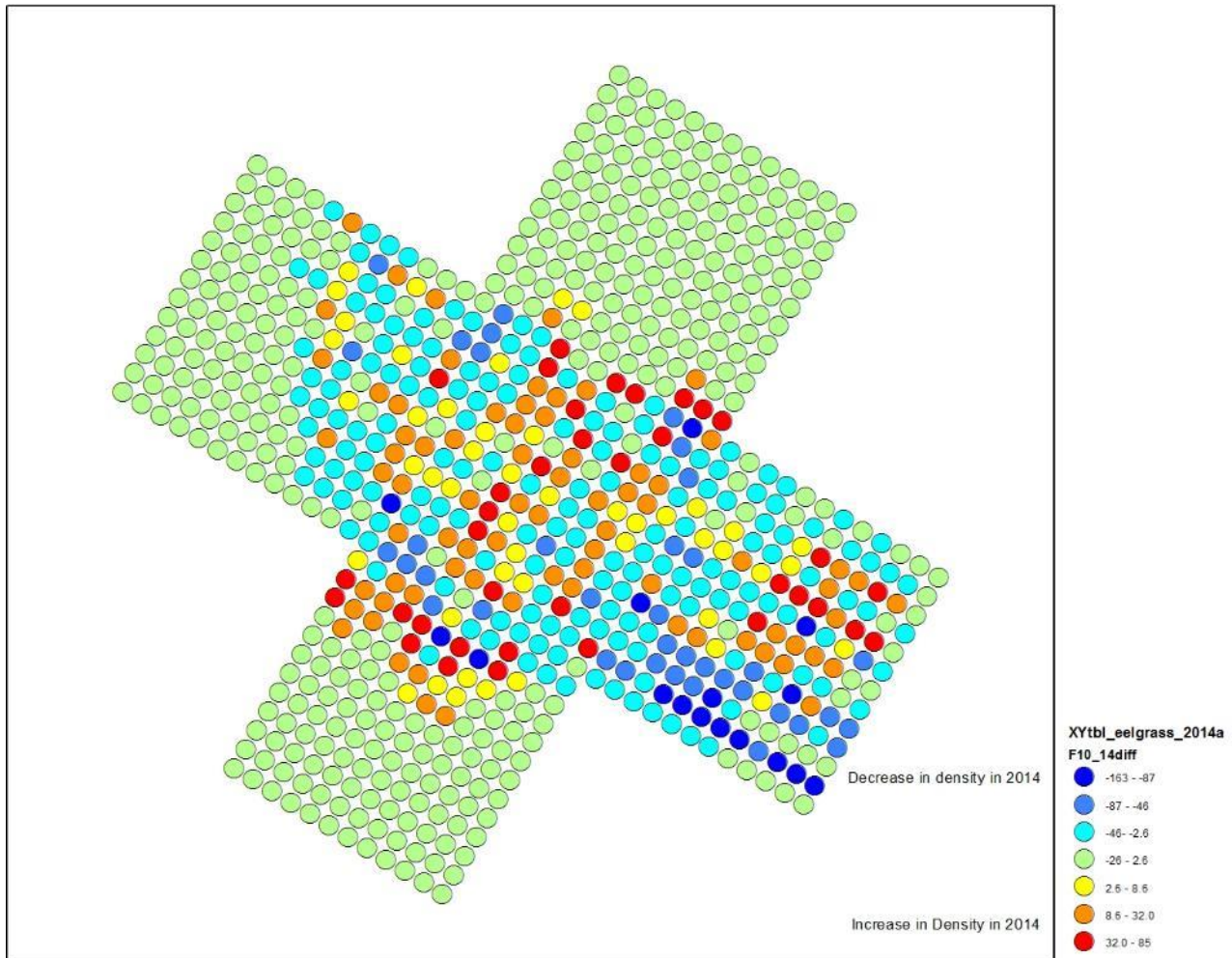
e) 1997 shoot density map (shoots / m²).



See Legend: white = Not surveyed that year i.e. no data

Differences between the last 2 surveys (2010 & 2014) can be mapped by plotting a function of; $\text{diff} = 2014 \text{ density} - 2010 \text{ density}$. A negative value means a decrease in density in 2014 compared to 2010 see Fig 3.7.

Figure 3.7 Comparison between 2014 and 2010 Shoot Density Data.



Blue areas show a decrease in density in 2014, compared with 2010. Red areas show an increase in density in 2014 & green highlights areas of little or no change.

This shows a mixed picture of losses and gains in 2014 compared to 2010 with the greatest loss found in the southeast corner.

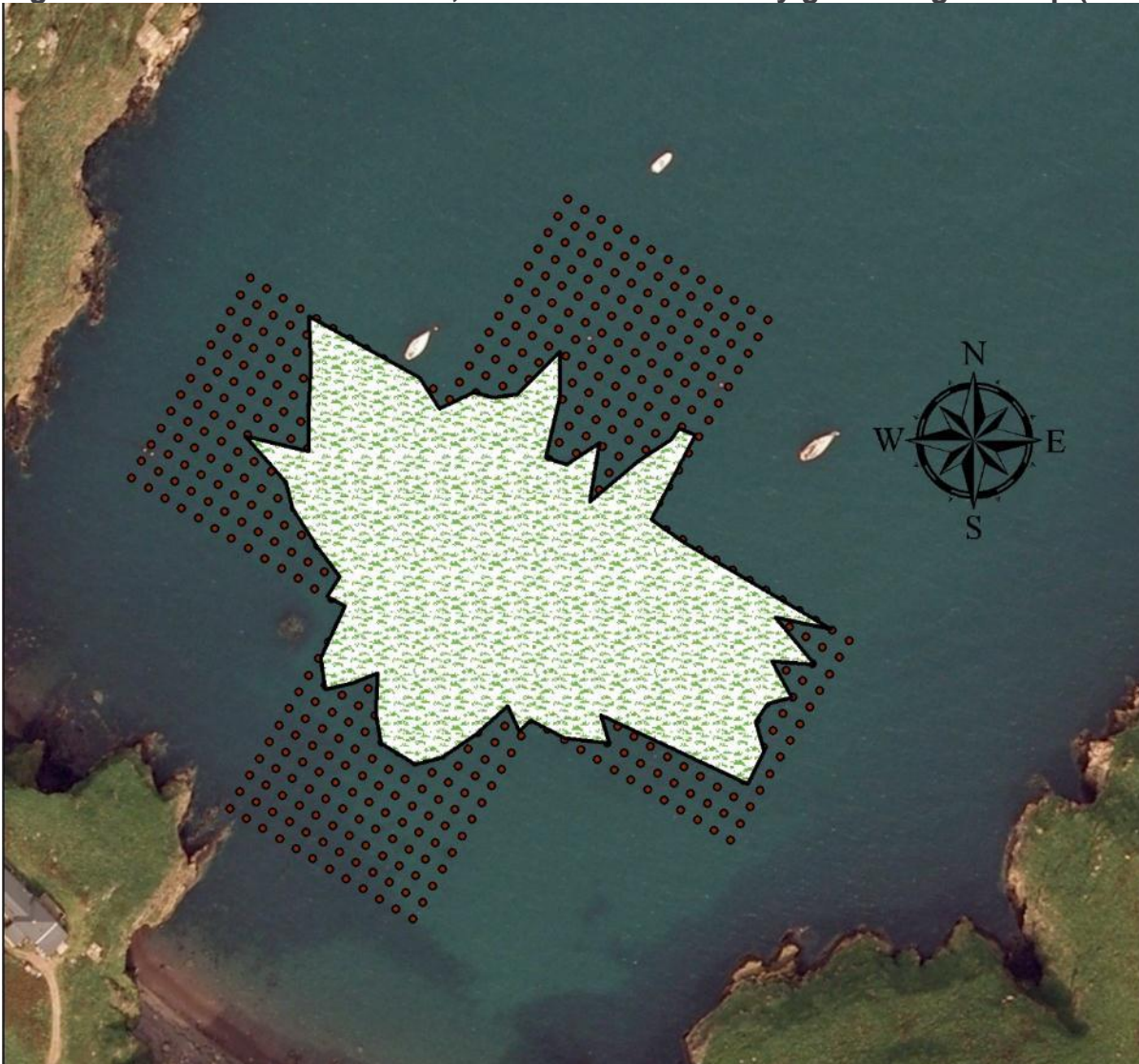
3.3 Area of Extent of the *Z. marina* Bed, In-situ Diver Survey

Since 1997 there have been 2 methods used to estimate the area of extent of the North Haven *Z.marina* bed using the diver survey:

- Diver swims of the boundary, giving a series of GPS waypoints around the edge of the bed. (these were completed in 2000, 2002 and 2004 (see figure 3.10).
- Polygons drawn in GIS software using the survey grid data. “MapInfo” was used with positions recorded using the WGS84 projection from 1997 to 2010. In 2014 the software was changed to “ArcMap 10.2” and British National Grid was used as the coordinate system. This was used to complete the 2014 map (see figure 3.8), and used to create the 1997 – 2010 maps for comparison (see figure 3.9).

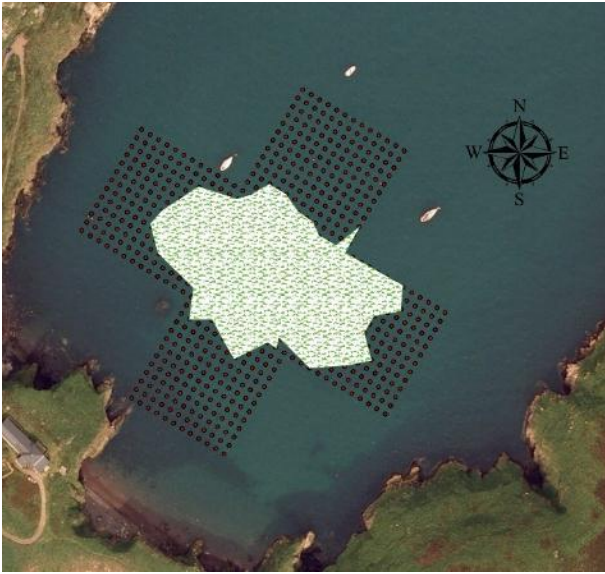
The areas estimates using each method is compared in figures 3.10 and 3.11.

Figure 3.8 2014 Area of extent, drawn from 5m survey grid using ArcMap (v10.2.2).

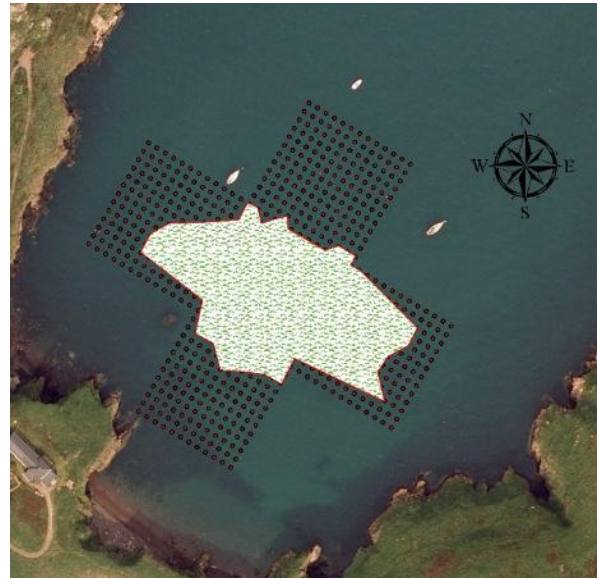


The estimated area of the whole *Z. marina* bed in 2014 is **8224.6 m²** compared to **8044m²** in 2010.

Figure 3.9 Area of Extent for 1997 – 2010



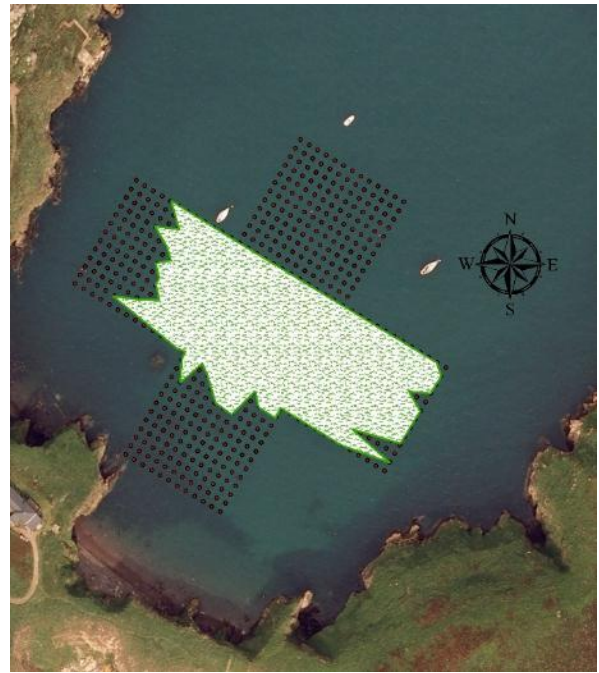
Area of extent 1997



Area of extent 2002



Area of extent 2006

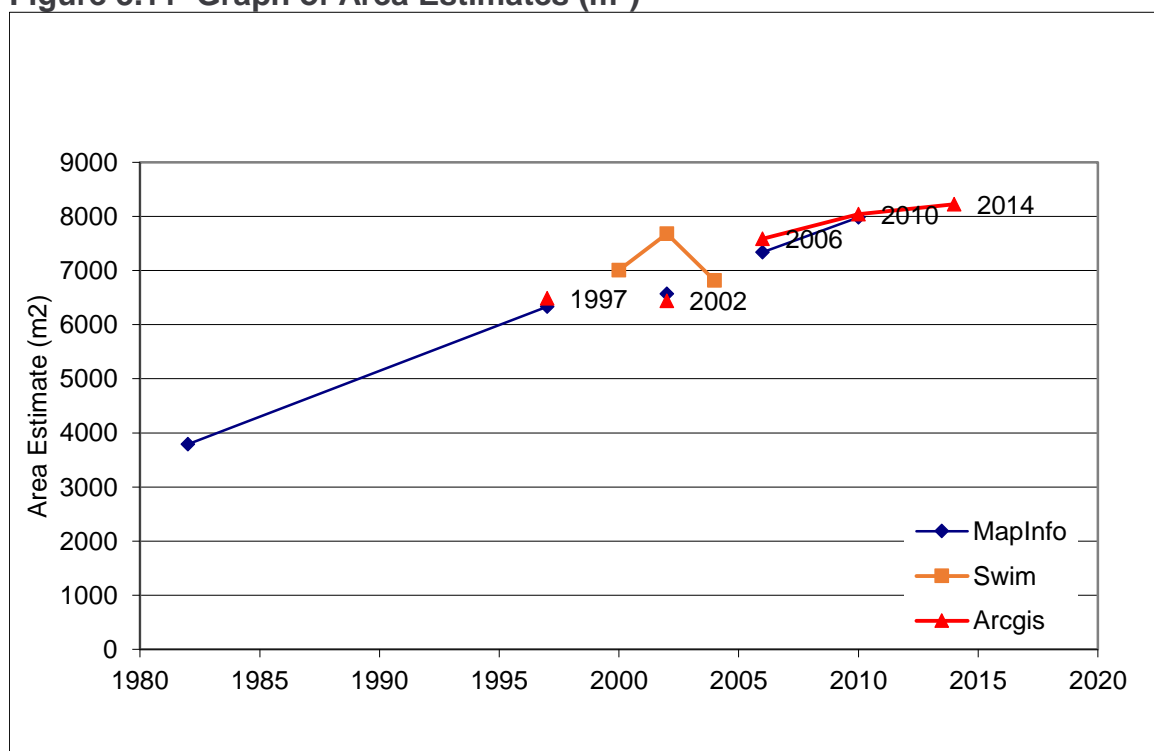


Area of extent 2010

Figure 3.10 Estimated Area of Extent 1982 – 2014 In-situ Diver Surveys

Year	Area Estimate m ² (from survey grid) MapInfo	Area Estimate m ² (from survey grid) ArcGIS	Area Estimate m ² (from swim)
1982	3788		
1997	6333.4	6484.2	
2000	No survey		7007.8
2002	6569.5	6439.6	7683.20
2004	No survey		6817.5
2006	7336.6	7587.2	
2010	7980.6	8044.0	
2014		8224.6	

Figure 3.11 Graph of Area Estimates (m²)

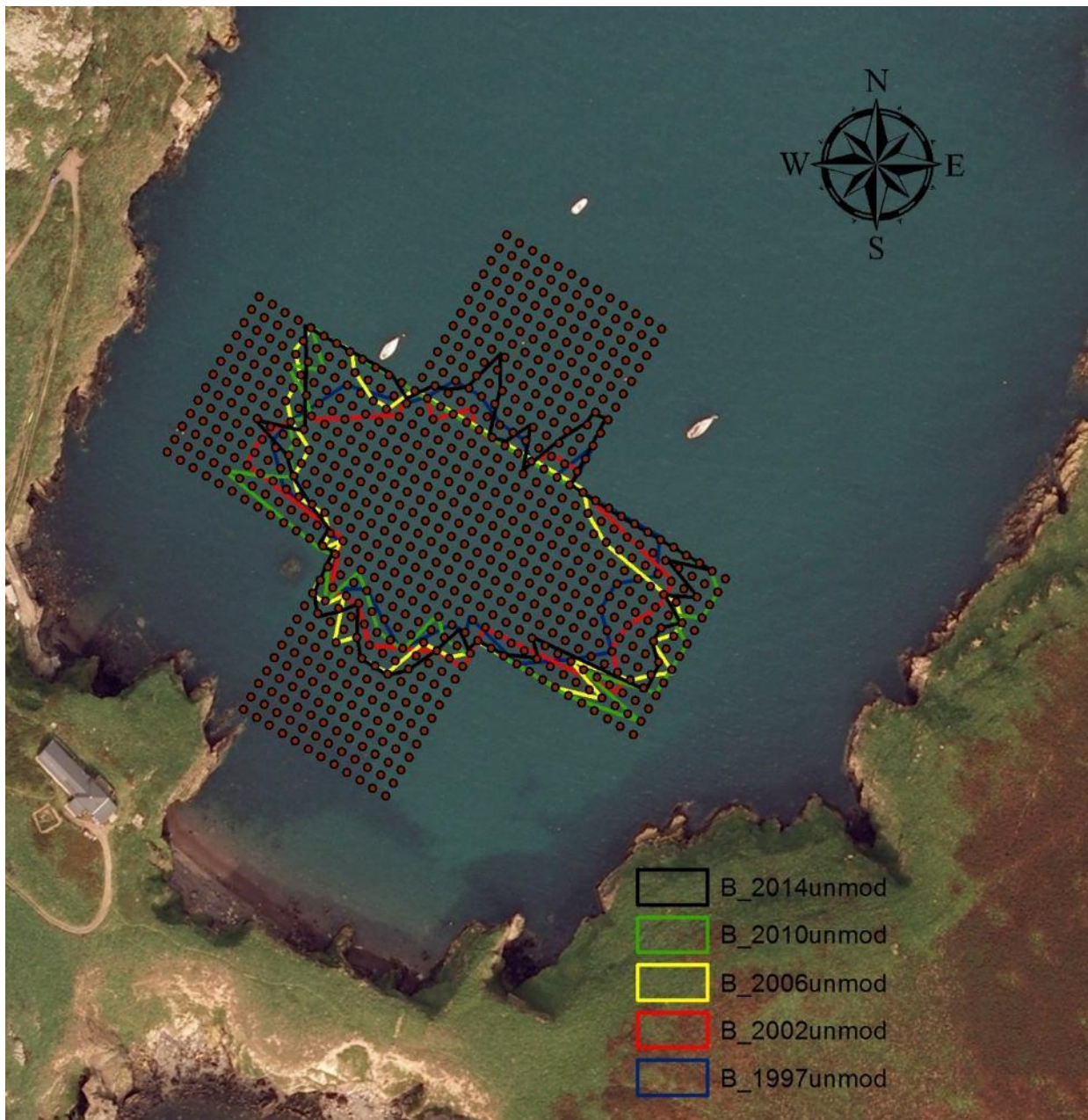


The two different GIS methods (MapInfo & ArcMap) using two different projections (WGS 84 & British National Grid) give similar results.

The area of extent appears to be increasing and in 2014 the area estimate of 8224.6m² is well above the Lower specified limit of 5500 m².

To directly compare the boundary of the *Z. marina* bed between surveys, the boundary outline for each survey has been overlaid. Figure 3.12 shows a comparison for surveys from 1997 to 2014, and figure 3.13 shows the changes between 2010 and 2014.

Figure 3.12 Area of Extent Polygons 1997 – 2014



From 1997 to 2010 the eastern boundary has increased in area but in 2014 there is a slight contraction. The northern boundary shows an increase in 2014.

Fig 3.13 Area of Extent Polygon for 2010 & 2014



A large area in the SE corner is missing in 2014 while the northern & southern extents have increased.

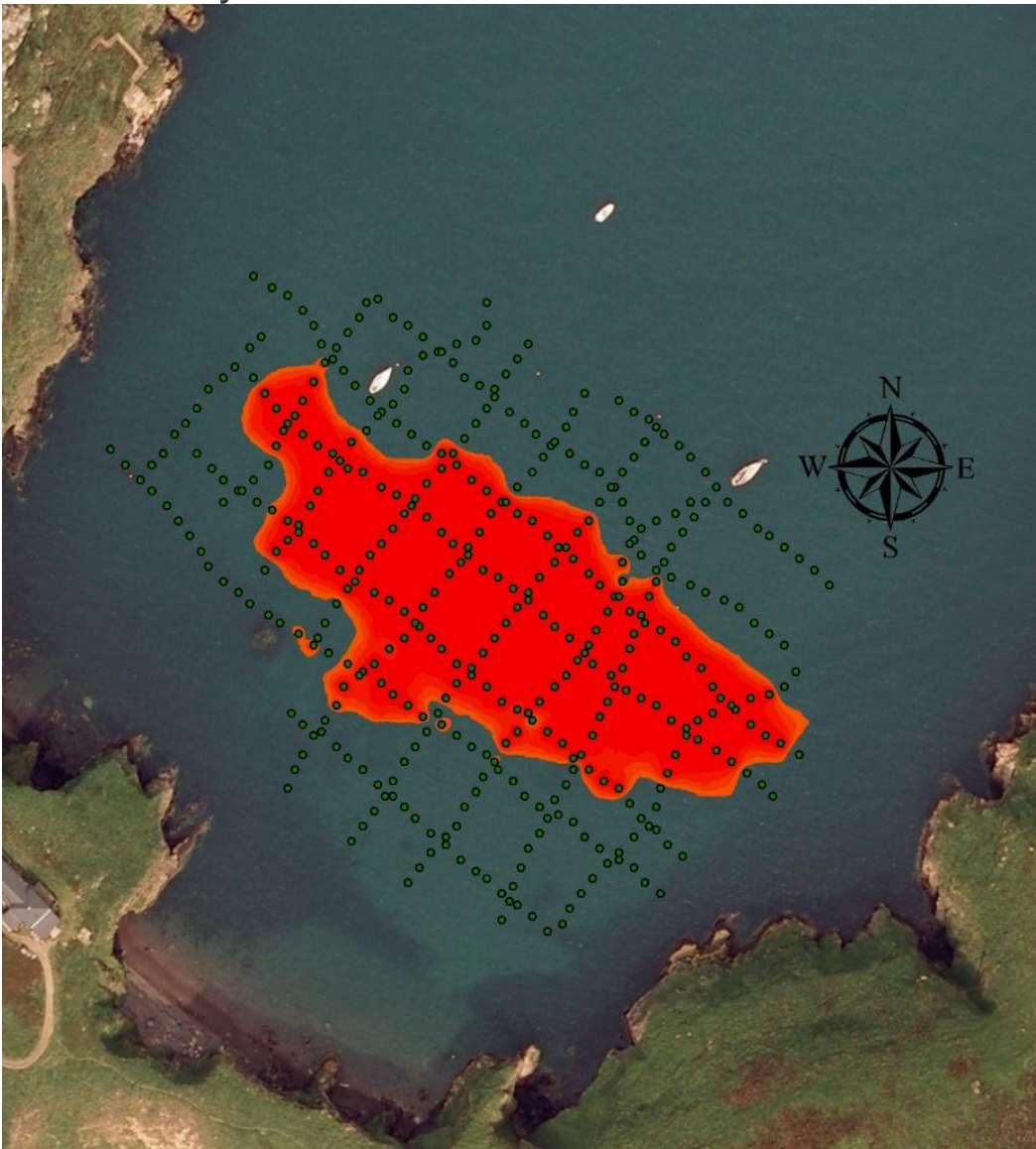
3.4 Acoustic Survey Results 2013 & 2014

The NRW Fisheries assessment team surveyed the North Haven *Z. marina* bed in 2013 and 2014 using the same Biosonics DT-X sonar equipment.

3.4.1 Area of extent

The 2013 & 2014 acoustic survey data was analysed in Sonar 5 Pro. Areas with acoustic returns not consistent with eelgrass were removed. The output was then put into Arc Map GIS software for visual analysis. The data was interpolated using Inverse Distance Weighting (IDW) to give an estimate of Percentage Area Inhabited (PAI) and height of the biomass.

Figure 3.14 2013 Interpolated Plot of Percentage Area inhabited (60-100%) Overlaid with the Survey Points.



Each green dot represents the mid point of a 5m Ecological Sample Units (ESU), for which different metrics can be calculated. The Interpolation model uses the values at each of these points to “fill in the gaps”. The Percentage Area Inhabited gives an estimate of the boundary of the *Z. marina* bed. At boundary areas where there are large spaces between the survey points the interpolation model will estimate where the edge lies between the surrounding sets of data. This will result in an artificial shape to the boundary.

Figure 3.15 2014 Interpolation Plot of Percentage Area Inhabited (60- 100 %) Overlaid with the Survey Points.



Figure 3.16 Estimated Area of extent from Acoustic survey data 2013 & 2014

% Area Inhabited Contour	2013 Area Estimate (m²)	2014 Area Estimate (m²)
90	6140.2	6282.1
80	7126.0	7329.4
70	7742.1	8041.8
60	8290.1	8621.1

Different cut off (contour) values can be used to set the edge of the *Z. marina* bed, the 60% contour appears to match up best with the in-situ diver area estimate (8224.6m²). These are mapped together for comparison in figure 3.17.

Figure 3.17 Comparison of Acoustic and In-situ Diver Survey Data 2014.



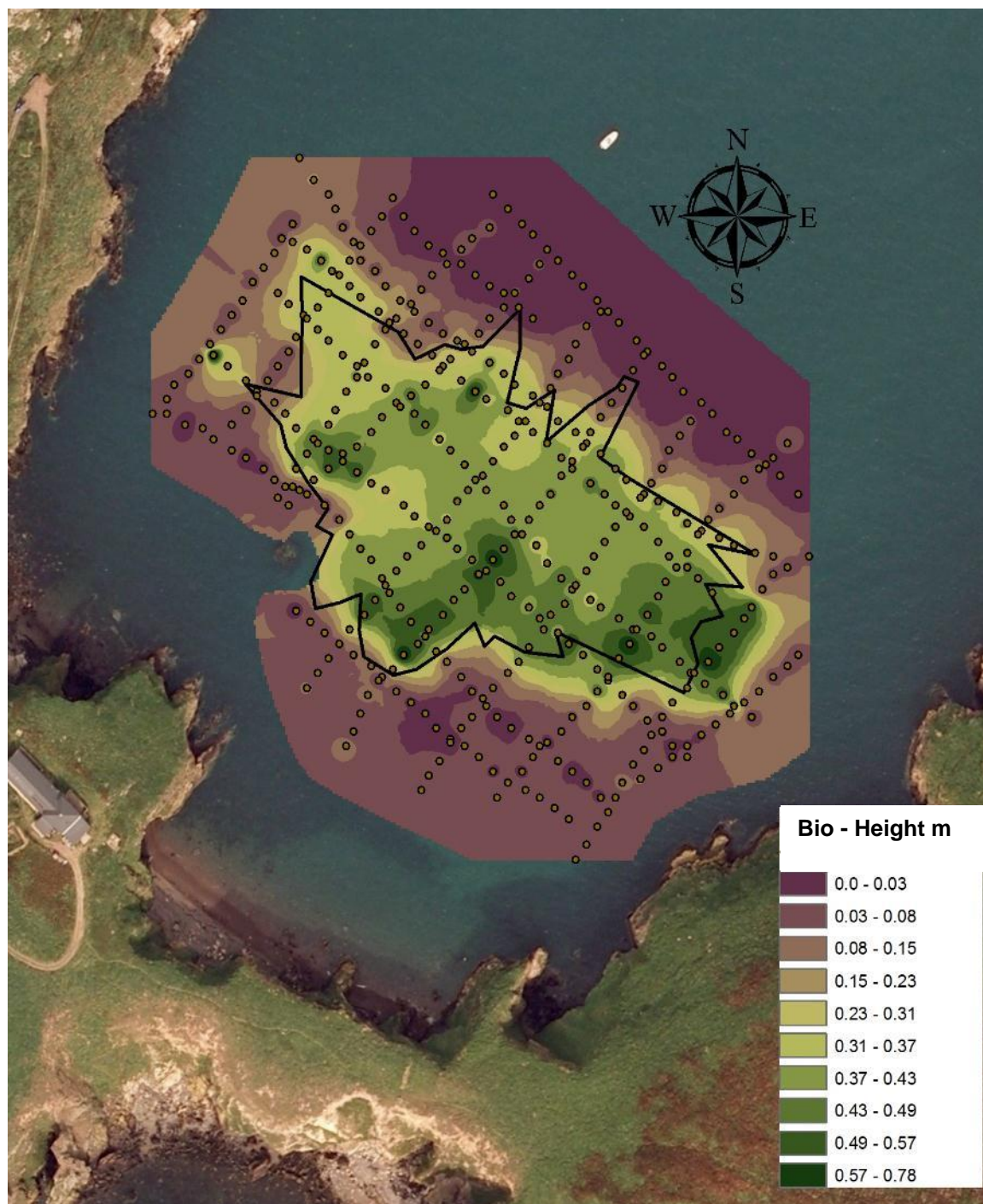
2014 Boundary Polygon (black) overlaid onto the 60% %AI contour boundary from the 2014 Acoustic survey.

The two areas match up very well. The acoustic survey will only ever be as good as the amount of data points used in the interpolation but the general shape is a good fit to the in-situ diver survey. The extended area out to the East, shown in the acoustic survey will need confirming as the diver survey recorded this area as kelp with no *Z. marina* present.

3.4.2 Stand Height of *Z. marina* 2014

The Sonar 5 Pro software also allows the user to estimate “bio-height” from the acoustic data. This measures the height of the eelgrass’s acoustic signal above the seabed which provides an estimate of stand height of the *Z. marina* fronds.

Figure 3.18 Bio- Height (m) of *Z. marina* , 2014



Estimated height of *Z. marina* above seabed (see legend) shown with the acoustic sampling points used to create the interpolation (brown dots) and the 2014 *Z. marina* boundary from the in-situ diver survey (black outline).

4 Discussion

4.1 Shoot Density

Shoot density was low in 2014 (35.1 shoots/m²). Only the northern area showed any increase which was due to an increase in extent out to the north. Shoot density is not significantly below the Lower Specified limit: Mean Density ≥ 36 shoots/ m².

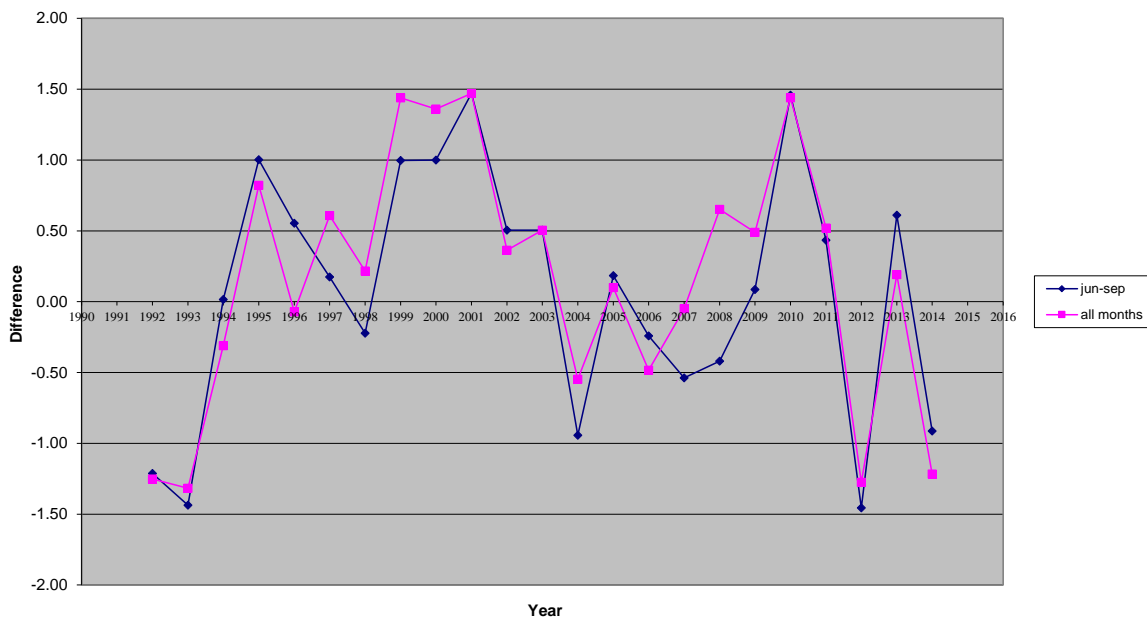
Shoot density is showing a declining trend since 2002. It would be worrying if this trend continues and further investigation may be required. Reasons for this decline are unclear but may include:

- Light availability – high turbidity in the water column above the bed will reduce photosynthetic activity and growth (Olsen 1993 & Unsworth 2014). Turbidity records are regularly taken within the Skomer MCZ (see figure 4.1). This data shows that the period from 1997 to 2002 was relatively clear. Since then water turbidity has been very variable with poor turbidity in 2004 to 2009, 2012 and 2014. This may account for the declining trend since 2002.
- Physical damage – this would tend to produce a localised effect. There have been very few instances of anchoring recorded within the bed and the results show a general decrease in shoot density across the whole bed rather than a large impact in a small area.
- Health of the eelgrass – epiphytes could be limiting growth and reproduction or water quality may be impacting on the *Z. marina* health (Burkholder 1992). No data is currently collected on these factors.

A survey once every 4 years does not give very detailed information about the dynamics of the shoot density or allow any conclusions to be drawn about why it is declining. Annual or seasonal surveys of small areas within the bed would allow a more in depth look at shoot density variation. It would make sense to also include the collection of environmental data (light & temperature) and physical measures of plant health e.g. frond length, carbon / nitrogen ratio & epiphyte cover. These tasks could be included into the annual work programme of the MCZ dive team but will require additional equipment and funds for chemical analysis (see McKenzie 2001 & Unsworth 2014 for proposed methods).

Fig 4.1 Secchi Disk Data for Skomer MNR

Annual Difference from Grand Overall Mean – negative results = cloudy water.



4.2 Area of Extent

The 2014 estimate of area of extent is the highest of all the survey years. The northern boundary has shown some extension since 2010.

The Biosonics acoustic method of surveying the estimated area of extent has worked very well and matches very closely to the in-situ diver survey results. This method is very quick and provides a practical way to get an annual estimate of area of extent. It also will pick up areas outside of the normal survey grid (e.g. to the northeast & northwest) which wouldn't normally be surveyed.

The method could be improved by:

- Decreasing the spacing between the transect lines.
- Surveying at low tide will increase the resolution of the acoustic system.
- Using a drop down video to confirm eelgrass readings at the edge of the bed.
- Currently the acoustic method does not allow for estimates of shoot density but other acoustic systems may be able to improve on this in the future.

4.3 Acoustic Estimate of Bio Height

Currently there is not any in-situ data to ground-truth the bio height estimates from the Biosonics echo sounder. This data could be collected by divers in the future. A survey could be designed to target areas highlighted by the acoustic survey of high, mid & low bio height. Actual heights and relative heights could then be ground-truthed.

4.4 Further Work

A study by Swansea university (Lawrence Jones 2014) investigated the use of *Z. Marina* in assessing ecological status. It suggested that measuring shoot length, width & area combined with tissue analysis for C:N:P ratios would be a better indicator of health than just shoot density. The study used samples of *Z. marina* from 14 sites in the UK. The samples from North Haven Skomer scored poorly with evidence of high nutrient enrichment limiting growth. The report recommends:

“C:N, C:P, leaf area, leaf length and leaf width as well as shoot density and shoot biomass are used for future monitoring of sea grass in the UK for a true representation of meadow status”.

It is unclear if the high nutrient levels are limiting growth directly or indirectly (e.g low light levels or high epiphyte loads) so turbidity levels (light availability) and epiphyte loads should also be monitored.

5 Recommendations

- Continue the 4 yearly in-situ diver survey and maintain the continuity of data.
- Continue with an annual acoustic survey of the eelgrass bed for area of extent.
- Check the boundary areas of the bed with a drop down video to confirm acoustic results.
- Ground-truth the bio height results from the acoustic survey with in-situ records.
- Develop a project to monitor shoot density, plant health and surveillance of environmental factors to allow some conclusions to be drawn about changes in shoot density. Ideally this would be an annual survey.
- Link in with other research and monitoring projects for eelgrass around Wales and the UK (see Unsworth 2014).
- Start monitoring C:N & C:P ratios along with measurements of leaf area.

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