Broads Annual Water Plant Monitoring Report 2014

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Autumn 2014

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1 EXECUTIVE SUMMARY

This report presents and discusses the findings from the annual water plant surveys carried out during 2014, which covered 24 waterbodies. 2014 saw a switch from the transect based method that has been used to complete surveys since 1983, to a point based method which has been developed since 2011. The newly implemented methodology and data analysis is detailed in Section 3 below.

The plant data for 2014 has been passed to Dr Nigel Wilby, University of Stirling, who is advising the BA on further revisions to the proposed methodology to allow continuation of long term trend analysis. Until we have received further feedback on the methodology and scoring mechanisms, direct comparison of abundance trends between 2014 and previous years have not been made.

Comparisons have been included regarding the numbers of species recorded from each site in 2014 and previous years, although it is important to note that the change in methodology may have impacted on the detection rates of species given the wider distribution of survey points. Generally speaking the results indicate that the number of species recorded have been broadly similar between years, suggesting that the change in method has not significantly effected this data, although the species composition may have altered.

Key Results for 2014 can be summarised as:

- An apparent trend across all the broads surveyed was a reduction in the presence of pondweed *Potamogeton* species. It is likely that this trend is linked to the climatic conditions over the previous winter 2013/2014 which the Met Office confirmed as being the wettest winter in the UK since records began in 1910. The wet weather, also meant it was very mild being 1.5^{o} warmer than average across the UK with southern England recording 12% more sunshine than average.
- Following the unusual winter weather, the spring was also subsequently very mild. As a result the growing season is likely to have started early with high levels of sunshine and rising water temperatures earlier on in the season. *Potamogeton* species often start growing in late spring and early summer from submerged rhizomes or overwintering buds called turions. Mild weather in early April and May 2014 would likely have triggered early growth, so that many of these species would have been dying back, or died-off completely, by the time the BA surveys started in late July, August and September.
- This is partly evidenced by staff reports from Whitlingham Great broad in May and June recording that *Potamogeton crispus*, which grows from overwintering leafy shoots, was growing to the surface over much of the western arm, however, by late July when the formal surveys were started, this species was not recorded from any of the 64 survey points.
- In the Thurne river valley, the number of species growing in Heigham Sound saw a continued increase from 9 species in 2013 to 12 species in 2014, including the vulnerable *Nitellopsis obtusa*, recorded for the 2^{nd} year running and the endangered *Chara intermedia* recorded at this site for the first time since 1983. Visual observations outside the point survey locations made by Emma Harris in July also

indicated the presence of *Najas marina* which was last formally recorded in 2008 at Heigham Sound.

- At Hickling, there was a slight reduction in the species richness in comparison to that recorded in 2013 with the transect survey. Despite the change in methodology the rare *Chara intermedia* was recorded as the second most dominant species for the 2nd year running. The distribution of the points at Hickling confirmed previous suppositions that much of the open water areas, in particular the navigation channel are currently devoid of plants, with the sheltered bays and inlets supporting the greatest abundance of growth.
- The Martham broads continued to support high numbers of different species, although a slight decrease was seen in comparison to 2013. As in recent years, the majority of biomass at both sites was comprised of a variety of *Charophyte* species. The *Chara* beds at both broads were dense and growing to the surface and macrophyte abundance levels continued to be high. The point based method was far easier to implement in comparison to the transect method which surveyors had previously struggled to replicate in the high plant density conditions.
- On the Ant valley, Barton Broad continued to exhibit low levels of species richness and low plant abundance with many of the survey points recording no plants. Following the Phoslock dosing project in Cromes Broad, the number of plant species recorded has increased with *Chara hispida* being recorded for the first time. A transect survey was also completed in Cromes Broad to enable consistent monitoring following the management work. Surveys at Reedham Water indicated a significant increase in the numbers and diversity of species growing here since the last survey was completed 2009 where one species was recorded. Ten species were found in 2014 including two *Chara* species.
- The Bure broads with high connectivity to the river, specifically Hoveton Great, Hoveton Little, Ranworth and Decoy broads, recorded very low levels of species richness and abundance. Those broads isolated from the river water in the Bure Valley continued the trend of supporting greater levels of species richness and biomass.
- In 2013, where transect surveys at certain sites were duplicated using the point survey method, there were a number of cases where additional species were recorded via the point methodology. It should be noted that some of the increases in species richness recorded in 2014, or cases where new species have been recorded for some sites, may be in part due to the changes to the survey method.

In general, the point based survey method was implemented successfully and in a much more consistent manner across all the broads surveyed when compared to the transect method. The data generated by the point survey methodology is more robust, in terms of repeatability and representativeness from each site. However, there were some factors that influenced the speed with which the new methodology could be completed, so the total number of broads that can be surveyed in any one year may be slightly reduced.

As a classification and assessment tool the water plant surveys inform ways in which lake restoration works can be targeted and allow the success of any management to be assessed. The water plant monitoring also provides an early means to identify possible sites of deterioration. The results of the water plant surveys contribute to the classification and

monitoring of SSSI waterbodies in partnership with Natural England. The detection of invasive, non-native plant species within the Broads is also important function of the annual survey if the risks posed by these plants are to be effectively managed.

Steady progress is being made through the Broads Biodiversity & Water Strategy, however much work remains to be done across the Broads to bring degraded broads back to health, in line with statutory drivers and to increase and subsequently maintain the diversity of those broads lacking in species richness. The annual water plant survey continues to be a valuable part of targeting and measuring the success of restoration efforts.

2 AIMS AND OBJECTIVES

The aim of the Broads annual survey in 2014 was to continue to monitor water plant growth within specified broads but using a new point based method. Following the analysis of data recorded in 2011 and 2013 whereby surveys were repeated on the same broads using both the historical transect method and the proposed point based method, Dr. Nigel Wilby , University of Stirling, has been advising the Broads Authority on the requirements of a point based method and a revised scoring mechanism to allow continuation of comparison of long term trends despite changes to methods used.

The method outlined in Section 3 below follows the most recent advice received. The data from 2014 will also be passed for analysis to further inform the proposed changes, although it is worth noting that during this transitional phase, further alterations to the methodology may be recommended.

Where broads have historically been sampled around a particular date, it is aimed that the survey takes place as near as possible to that date. The main objectives in the annual programme are to monitor key broads with long-term datasets, those that have had restoration measures put in place or those that are known to be experiencing a change in their macrophyte community. Broads that have not received restoration efforts or are stable and/or are generally without plants, are monitored on a less frequent basis. When resources allow, a rolling program of monitoring sites not previously surveyed is also an ongoing aim.

This report will collate the data collected since the last survey report in 2013 and will refer to the long-term data from 1983 to 2014, although direct comparisons of plant abundance levels collected using the different survey methods have not been attempted at this time.

3 POINT SURVEY METHODOLOGY

Following a number of years of increasing plant growth and abundance across many of the broads shallow lakes, it has been widely acknowledged that methodology employed for the broads annual macrophyte survey was becoming increasingly difficult to implement in a robust and consistent manner that would continue to allow accurate comparison and analysis of long term trends.

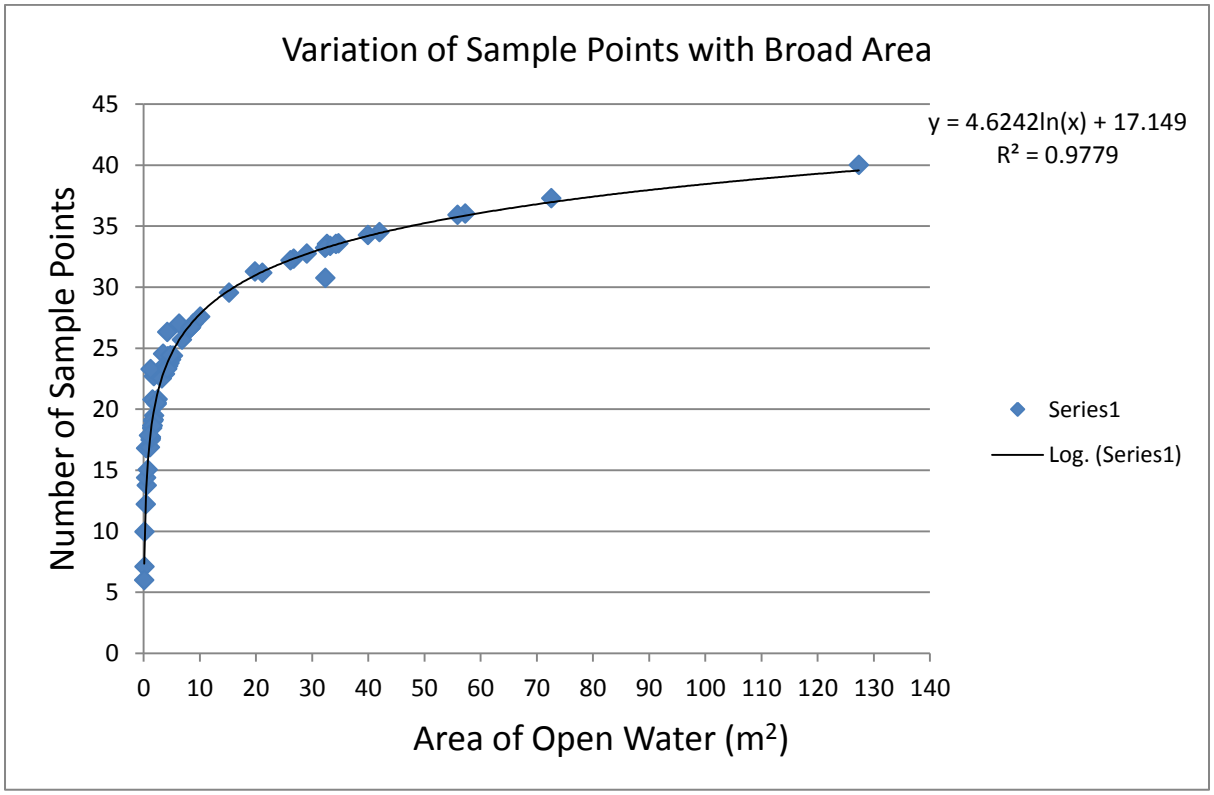
Following consultation with Natural England, Environment Agency, Dr Nigel Wilby and others, the decision was taken to adopt a point based survey methodology rather than the transect based method used since the annual macrophyte surveys' conception in 1982.

In 2011 and 2013 a number of sites were surveyed using both a point based and transect based method to enable analysis of the methods and to see if the data produced by the point based method could be directly comparable to the transect method.

The methodology set out below, is based on advice BA received that suggested that long term trend analysis would still be possible.

Point Survey Method

1. The area of open water of each broad surveyed was measured using the ArcGIS system.
2. Using a logarithm a grid system was applied and a set of points was plotted on to the open water areas of each broad. Points were located equidistant apart. The graph below illustrates the logarithm used to calculate the number of points per broad.



3. An aerial photograph of each broad was produced on which each of the numbered survey points was marked. On the reverse of each map was a list of the grid references of each numbered point.
4. In the field, surveyors used the grid references of each plotted point to identify the point's location. The survey boat navigated to each point using a GPS. Once within 10m of the plotted grid reference, 2 mud weights were deployed to keep the boat in the correct location.
5. At each point, a 5m survey throw was completed to the north and to the south using the aerial photographs for bearings.
6. A double headed survey rake was thrown a distance of 5m from the boat edge. The rake was left for 10 seconds to sink to the bottom after which the rake was pulled slowly and steadily back towards the boat. For points that were in deeper water, additional rope was thrown to allow the rake to sink and rest on the bed of the lake at a distance of 5m from the edge of the boat.
7. On retrieval of each rake, the plants attached to the rake head were collected in a white survey tray. If necessary, plants were washed to remove excess sediment to aid identification.
8. All the live plant material was identified to species level, or for some particularly difficult groups e.g. the starworts *Callitriche* sp, to genus level.
9. Any plant specimens where identification was uncertain were collected in plastic bags, labelled using the point number reference and taken for subsequent observation using a high powered microscope, or to be sent for expert identification.
10. To assign a level of abundance, each species collected was given a score of between 1 and 10. The score assigned should take into account the trapability of a particular species on the rake so that a score of 10 (91 to 100%) represents the maximum amount trappable on the rake for any particular species. As an example, a fine leaved species such as *Sparganium emersum*, would not be as trappable on the rake as a more structured species such as *Myriophyllum spicatum* and therefore for scoring a rake pull of these species of equal volume, the score for *S. emersum* would be higher than for *M. spicatum.*
    - 1 = 0 to 10%
    - 2 = 11 to 20%
    - 3 = 21 to 30%
    - 4 = 31 to 40%
    - 5 = 41 to 50%
    - 6 = 51 to 60%
    - 7 = 61 to 70%
    - 8 = 71 to 80%
    - 9 = 81 to 90%
    - 10 = 91 to 100%
11. For data comparison, the results have been calculated to show the species richness (number of species recorded) and the summary abundance score. Summary abundance is calculated by summing all the abundance scores for a particular species at each site and dividing by the number of points that were surveyed for that site. The results have been displayed in descending order so that the most abundant species in 2014 are listed at the top of each site table.
12. For the purposes of counting the number of points surveyed at each site, the results for the north and south throws have been separated as different points. The number of points where each species was recorded at each site is illustrated in the summary tables in Section 4.

Table 1. Sites surveyed for water plants from 1983 to 2014.

	# of years	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14
Alderfen	32	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Bargate	4																						■		■						■		■
Barnby	6																						■	■	■	■		■			■		
Barton	32	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Belaugh	20							■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■			■	■			
Blackfleet	3	■		■																					■								
Bridge	12														■	■	■	■	■	■	■	■	■	■	■	■					■		
Buckenham	8																						■	■	■	■		■	■	■		■	
Burntfen	6																■					■			■				■	■		■	
Calthorpe	4																												■	■	■		■
Catfield	2																						■					■					
Cockshoot	32	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Cockshoot Dyke	29	■	■	■	■	■	■	■	■	■	■	■	■	■			■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Cromes South	31	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Cromes North	29	■	■	■	■	■	■	■	■	■	■	■		■		■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■
Decoy	10				■												■						■	■	■	■	■	■				■	■
Filby	22	■	■	■	■	■		■	■	■	■			■	■	■	■	■	■		■	■	■	■	■	■			■				
Flixton Decoy	3																								■	■			■				
Hassingham	9																						■	■	■	■	■	■	■	■		■	
Heigham Sound	24	■	■	■	■	■	■	■	■	■	■	■	■		■	■								■	■	■	■	■	■	■	■	■	■
Hickling	32	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Horsey Mere	28	■	■	■	■	■		■	■	■	■			■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■
Hoveton Great	32	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Hoveton Little	14							■						■	■	■	■	■	■	■			■	■	■	■						■	■
Hudson's Bay	8	■	■	■		■		■							■											■					■		
Irstead	2																						■					■					
Lily	22	■	■	■	■	■		■	■	■	■			■	■	■	■	■	■		■	■	■	■	■	■		■					
Little	5																							■			■	■	■			■	

Malthouse	7																																
Martham North	31																																
Martham South	30																																
Mautby Decoy	4																																
Norton	4																																
Ormesby	25																																
Ormesby Little	24																																
Pound End	13																																
Ranworth	30																																
Reedham Water	3																																
Rockland	24																																
Rollesby	24																																
Round water	2																																
Salhouse Great	13																																
Salhouse Little	7																																
Spratts Water	3																																
Strumpshaw	9																																
Upton Great	32																																
Upton Little	8																																
Wheatfen	5																																
Whitlingham Great	11																																
Whitlingham Little	10																																
Woolners Carr	1																																
Wroxham	32																																
# per year		23	22	23	23	24	16	24	22	23	23	17	13	26	26	25	30	21	26	19	22	21	37	35	39	37	28	32	31	28	28	25	24

Table 2 Survey dates (2010-2014).

Broad	Survey Date				
	2010	2011	2012	2013	2014
Alderfen	03-Aug	09-Aug	14-Aug	14-Aug	14-Aug
Bargate	-	-	31-Aug	-	03-Sep
Barnby	-	-	19-Jul	-	
Barton	21-Jul	04-Aug	06-Aug	09-Aug	07-Aug
Belaugh	05-Aug	11-Aug	-	-	
Bridge Broad	-		03-Aug	-	
Buckenham Broad	30-Jul	20-Jul	-	26-Jul	
Burntfen	12-Aug	01-Sep	-	20-Aug	
Calthorpe	03-Sep	17-Aug	11-Sep	-	02-Sep
Cockshoot Broad	01-Sep	18-Aug	29-Aug	05-Sep	27-Aug
Catfield	-	-	-	-	
Crome's	03-Aug	08-Aug	14-Aug	08-Aug	06-Aug
Decoy Broad	-	-	-	23-Aug	01-Sep
Flixton Decoy	06-Aug	-	-	-	
Hassingham Broad	30-Jul	20-Jul	-	26-Jul	
Heigham Sound	23-Aug	29-Jul	26-Jul	02-Aug	22-Jul
Hickling	23-Jul	05-Aug	25-Jul	31-Jul	23-Jul
Horsey Mere	28-Jul	29-Jul	31-Jul	30-Jul	24-Jul
Hoveton Great	05-Aug	03-Aug	06-Sep	13-Aug	12-Aug
Hoveton Little	-	-	-	15-Aug	13-Aug
Hudsons Bay	-	-	06-Sep	-	
Irstead	-	-	-	-	
Little Broad				20-Aug	
Malthouse	17-Aug	-	-	-	
Martham Broad North	29-Jul	25-Jul	24-Jul	25-Jul	29-Jul
Martham Broad South	29-Jul	26-Jul	24-Jul	24-Jul	30-Jul
Mautby Decoy	02-Sep	-	-	-	
Mill Water	-	-	-	-	
Nortons	05-Aug	11-Aug	-	-	
Pound End	-	-	-	23-Aug	
Ranworth	31-Aug	16-Aug	02-Aug	28-Aug	02-Sep
Rockland	30-Aug	25-Aug	30-Aug	-	28-Aug
Reedham	-	-	-	-	31-Jul
Round Water	-	23-Aug	-	-	
Salhouse Great	-	-	08-Aug	-	
Salhouse Little	-	-	08-Aug	-	
Spratt's Water	-	23-Aug	-	-	
Strumpshaw	30-Jul	20-Jul	27-Jul	01-Aug	
Upton Great	13-Aug	10-Aug	22-Aug	21-Aug	19-Aug
Upton Little	13-Aug	-	22-Aug	22-Aug	20-Aug
Wheatfen	-	-	30-Aug	-	
Whitlingham Great	-	19-Jul	18-Jul	17-Jul	17-Jul
Whitlingham Little	30-Aug	19-Jul	18-Jul	17-Jul	17-Jul
Woolners Carr	-	23-Aug	-	-	
Wroxham	04-Aug	21-Jul	03-Aug	06-Aug	05-Aug

4 BROADS MACROPHYTE RESULTS.

Each broad that was surveyed in 2014 is reviewed in terms of species richness (the number of species recorded) and abundance (the amounts of each species recorded) according to the new point survey and scoring method (outlined in Section 3).

Due to the change of methodology, comparisons and analysis of recent trends of plant abundance have not been made. However, discussion around the species richness on sites has been included with summary tables displaying which species were recorded during the 2012 and 2013 surveys.

The abundance figures have been expressed as "Summary Abundance" whereby the abundance scores for each species at each site are summed and divided by the total number of survey points for that site. The results tables also illustrate how many points each species was recorded at giving an indication of the distribution.

The broads are grouped by the river catchment in which they are situated.

Appendix 1 classifies the plants into groups of similar form/structure. Appendix 2 lists the common and Latin names for all plants found to date during broads surveys.

4.1 Thurne Valley

The broads found in the Thurne valley contain one of the most diverse populations of stoneworts in the UK. Stoneworts are recorded in broads outside of the Thurne catchment but populations outside of the Thurne tend to comprise a suit of different species which also tend to be found in lower abundances.

Species present in the Thurne broads that are included in the Joint Nature Conservation Committee (JNCC) Red Data Book included, three 'Vulnerable' species: Baltic stonewort, Convergent stonewort and Starry stonewort, and one 'Rare' species: Intermediate stonewort (Stewart and Church, 1992). The Thurne broads also provide a stronghold for the rare BAP species holly-leaved naiad, as well as more common vascular plants such as spiked water milfoil and mare's tail.

4.11 Calthorpe

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Broad-leaved pondweed	Potamogeton natans	*	N/A	3.28	12
Filamentous algae		*		0.94	7
Blunt-leaved pondweed	Potamogeton obtusifolius			0.44	5
Common reed	Phragmites australis			0.17	2
Yellow water lily	Nuphar lutea	*		0.11	1
Common water-plantain	Alisma plantago-aquatica			0.06	1
Fragile/convergent stonewort	Chara globularis/connivens			0.06	1
Least duckweed	Lemna minuta			0.06	1
Bristly stonewort	Chara hispida	*			
Stonewort sp	Nitella sp	*			
White water lily	Nymphea alba	*			
Horned pondweed	Zanichellia palustris	*			
	Total species	**7**	**N/A**	**8**	**Total points surveyed 18**

Calthorpe Broad was not surveyed in 2013. Eight species were recorded in 2014, a very similar number to 2012, but as the results show the species recorded in 2014 were quite different from those in 2012. *Potamogeton natans* remained the most dominant species, there was no sign of *Chara hispida,* which was as abundant as *P. natans* in 2012. There were dense stands of *Nuphar lutea* around the margins of the broad as in 2012, but no sign of *Nymphea alba*. Five species were recorded this year which were not present in 2012, of note would be *Potamogeton obtusifolius*, *Alisma plantago-aquatica* and *Chara globularis/connivens*.

The change in species composition at Calthorpe could be a result of a number of factors or a combination of all of the following;

- The mild winter and spring may have caused early growth so that some species had gone over by the time the survey was carried out on 02/09/2014 and were not recorded.
- Following mud-pumping in 2009, the broad may still be undergoing transition towards a more stable macrophyte community, although the abundance of filamentous algae in the shallow areas is of concern. The presence of *Chara hispida* and *Nitella* sp. in 2012 was probably a response to the disruption of mudpumping.

From general observations, the western end of the broad was densely vegetated with a variety of species, whereas the eastern arm remained very shallow with little but filamentous algae growing. This corresponds with observations made in 2012 with the more diverse areas of plant growth broadly relating to those areas that were mud-pumped.

4.12 Heigham Sound

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points recorded
Spiked water milfoil	Myriophyllum spicatum	*	*	1.77	53
Mare's tail	Hippurus vulgaris	*	*	0.61	16
Rigid hornwort	Ceratophllum demsersum	*	*	0.35	18
Fan-leaved water crowfoot	Ranunculus circinatus		*	0.32	17
Curled pondweed	Potamogeton crispus	*	*	0.24	16
Starry stonewort	Nitellopsis obtusa		*	0.21	7
Intermediate stonewort	Chara intermedia			0.20	4
Canadian waterweed	Elodea canadensis		*	0.14	8
Lesser pondweed	Potamogeton pusillus		*	0.08	5
Filamentous algae				0.05	3
Nuttall's waterweed	Elodea nutallii		*	0.02	1
Common reed	Phragmites australis			0.02	1
	Total species	**4**	**9**	**12**	**Total points surveyed 66**

Following years of poor species richness in 2011 and 2012, 2014 saw a continuing upward trend in the number species recorded in Heigham Sound with 12 species, the greatest number since surveys started in 1983. Previously the highest number of species recorded was 10 in 1986, 1991 and 2005.

Of particular significance is the presence of the vulnerable *Nitellopsis obtusa* recorded for two years running, and the rare *Chara intermedia* formally recorded for the first time here since 1997 (this species was observed in 2013 but not as part of the official survey). In addition, during trials of the point survey methodology in July, rare *Najas marina* was also recorded in the sheltered northern bays of Heigham Sound. As has been the case since 2006, *Myriophyllum spicatum* remained the most abundant and widespread species, recorded from 53 of the total 66 points surveyed. *Potamogeton pusillus* was recorded for two years running, following last being recorded in 1997.

One note of caution in the interpretation is that the continuing increasing species richness in Heigham Sound may be linked to the change in methodology to point based surveys. This methodology covers a greater proportion of the broad area, including surveying in the sheltered bays where aquatic plant growth is favoured rather than the main navigation channel which was largely devoid of plants. However, improved water clarity has been recorded following the channel dredging and reconstruction of the Duck Broad spit. Future surveys will reveal if this improving trend continues

4.13 Hickling

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Spiked water milfoil	Myriophyllum spicatum	*	*	1.11	51
Intermediate stonewort	Chara intermedia	*	*	0.63	16
Fennel-leaved pondweed	Potamogeton pectinatus	*	*	0.19	10
Holly-leaved naiad	Najas marina	*	*	0.15	7
Baltic stonewort	Chara baltica		*	0.08	6
Opposite stonewort	Chara contraria		*	0.04	1
Fragile/Convergent stonewort	Chara globularis/connivens		*	0.03	2
Curled pondweed	Potamogeton crispus		*	0.01	1
Rigid hornwort	Ceratophyllum demersum	*	*		
Willow-leaved pondweed	Potamogeton x salicifolius		*		
Convergent stonewort	Chara connivens		*		
Stonewort sp	Chara sp	*			
Delicate stonewort	Chara virgata	*			
Mare's tail	Hippurus vulgaris	*			
	Total species	**8**	**11**	**8**	**Total points surveyed 80**

Macrophyte diversity in Hickling Broad has been declining since the early 2000s and over a three year period the species richness dropped dramatically from 11 in 2005 to 3 in 2008. The last few years have started to see a gradual recovery with 11 species recorded in 2013. Species richness in 2014 was slightly decreased with 8 species being recorded. *Myriophyllum spicatum* continued to be the most dominant species. Notably the rare *Chara intermedia* was the second most dominant species for the 2nd year running.

The vulnerable *Chara baltica* (first record in 2013 since 2005), *C. contraria* (first ever record from Hickling in 2013) and *C. globularis/connivens* were also recorded for the 2nd year running.

4.14 Horsey Mere

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Mare's tail	Hippurus vulgaris	*	*	0.71	14
Spiked water milfoil	Myriophyllum spicatum	*	*	0.52	23
Common reed	Phragmites australis			0.05	3
Willow-leaved pondweed	Potamogeon x salicifolius			0.03	2
Fennel-leaved pondweed	Potamogeton pectinatus		*		
Stonewort sp	Chara sp		*		
	Total species	**2**	**4**	**4**	**Total points surveyed 66**

Four species were recorded in Horsey Mere with *Hippurus vulgaris* and *Myriophyllum spicatum* remaining the two most constant and abundant species since 2004. However, overall plant abundance levels in Horsey Mere, in comparison to other Thurne broads, remains very low.

Martham North and South

For many years, the Martham Broads have been characterised by sustained clear water conditions, resulting from a supply of largely good quality freshwater draining from the area to the northeast of the broads. These conditions generally continue and are reflected in the high diversity of the plant communities found in the most recent surveys.

4.15 Martham North

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Bristly stonewort	Chara hispida	*	*	5.06	41
Starry stonewort	Nitellopsis obtusa	*	*	1.34	20
Filamentous algae			*	1.06	18
Intermediate stonewort	Chara intermedia	*	*	0.58	15
Holly-leaved naiad	Najas marina	*	*	0.26	6
Fennel-leaved pondweed	Potamogeton pectinatus	*	*	0.12	6
Baltic stonewort	Chara baltica	*	*	0.08	4
Rough stonewort	Chara aspera			0.02	1
Fragile/convergent stonewort	Chara globularis/connivens	*		0.02	1
Opposite stonewort	Chara contraria	*	*	0.02	1
Stonewort sp.	Chara sp.			0.02	1
Whorled water milfoil	Myriophyllum verticillatum		*	0.02	1
Yellow water lily	Nuphar lutea		*		
White water lily	Nymphea alba		*		
Horned pondweed	Zanichellia palustris	*	*		
Common water moss	Fontinalis antipyretica		*		

Common stonewort	Chara vulgaris	*			
Spiked water milfoil	Myriophyllum spicatum	*	*		
Starwort sp	Callitriche sp.		*		
Mare's tail	Hippurus vulgaris	*	*		
Stonewort sp	Nitella sp.	*			
	Total species	**13**	**16**	**12**	**Total points surveyed 50**

Between 1997 and 2010 surveys recorded a dominance of stonewort species compared to vascular plants comprised primarily of *Chara hispida* and *Nitellopsis obtusa*, the latter species classified as a "vulnerable" Red Data Book species. 2014 results appear to indicate a continuing trend since 2011 of the higher abundance of stoneworts compared to vascular macrophytes. *C. hispida* was the dominant species recorded at 41 of the 50 points surveyed in 2014.

The total number of species recorded in 2014 was the lowest since 2010, 7 species that were recorded in 2013 were not recorded this year. *Myriophyllum spicatum* has been recorded regularly at the site since the early 2000's but was not recorded in 2014. Similarly *Hippurus vulgaris* was not present in 2014. Visual observations noted that this species appeared to have died back by the time surveys were completed in late July, possibly as a result of the early start to the growing season.

4.16 Martham South

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Bristly stonewort	Chara hispida	*	*	5.37	36
Starry stonewort	Nitellopsis obtusa	*	*	1.67	14
Holly-leaved naiad	Najas marina	*	*	0.83	14
Hedgehog stonewort	Chara aculeolata			0.46	3
Filamentous algae			*	0.31	8
Intermediate stonewort	Chara intermedia	*	*	0.26	10
Baltic stonewort	Chara baltica	*	*	0.13	4
Spiked water milfoil	Myriophyllum spicatum	*	*	0.11	6
Fennel-leaved pondweed	Potamogeton pectinatus	*	*	0.11	6
Mare's tail	Hippurus vulgaris	*	*	0.09	3
Rough stonewort	Chara aspera			0.06	1
Delicate stonewort	Chara virgata			0.04	2
Convergent stonewort	Chara connivens			0.02	1
Common stonewort	Chara vulgaris			0.02	1
Common reed	Phragmites australis			0.02	1
Curled pondweed	Potamogeton crispus			0.02	1
Starwort sp	Callitriche sp	*	*		

Willow-leaved pondweed	Potamogeton x salicifolius	*	*		
Fan-leaved water crowfoot	Ranunculus circinatus		*		
Canadian waterweed	Elodea canadensis	*	*		
Yellow water lily	Nuphar lutea	*	*		
Opposite stonewort	Chara contraria		*		
Rigid hornwort	Ceratophyllum demersum		*		
Arrowhead	Saggitaria saggitifolia		*		
Pondweed sp	Potamogeton sp		*		
Whorled water milfoil	Myriophyllum verticillatum		*		
Horned pondweed	Zanichellia palustris	*			
Water crowfoot sp	Ranunculus sp	*			
Ivy-leaved duckweed	Lemna trisulca	*			
	Total species	**15**	**19**	**16**	**Total points surveyed 54**

Sixteen species were recorded from Martham South broad in 2014 compared to 19 species in 2013. *Chara hispida* was the most abundance species present in 2014 being recorded at 36 of the 54 points surveyed. *Nitellopsis obtusa* and *Najas marina* were both recorded from 14 of the 54 points but at a reduced abundance in comparison to *C. hispida.*

A total of 9 species of *Chara* were identified in 2014, 5 of which were not recorded in 2013, namely *C. aculeolata, C. aspera, C. virgata, C. connivens* and *C. vulgaris*. Nine of the vascular plants recorded in 2013 were not recorded in 2014.

The differences in species composition may be a result of the changed methodology. The distribution of the points may have resulted in greater coverage of the large *Chara*, particularly *C. hispida* beds, resulting in increased recording for presence and abundance of this species. Also the points may have missed the more nutrient tolerant species routinely present near the entrance to the main river.

4.2 Ant Valley

In the Ant Valley, Alderfen, Cromes and Barton broad have been regularly surveyed. These water bodies have been subject to extensive restoration effort over the last 25 years, and all have improved water quality and macrophyte populations as a result. Alderfen and Cromes have abundant and stable populations of rigid hornwort, although this species tends to be indicative of higher nutrient conditions.

4.21 Alderfen

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Filamentous algae		*	*	3.71	42
Rigid hornwort	Ceratophyllum demersum	*	*	2.33	43
Holly-leaved naiad	Najas marina	*	*	0.48	12
Fragile/Convergent stonewort	Chara globularis/ connivens	*		0.44	13
Ivy-leaved duckweed	Lemna trisulca	*	*	0.08	4
Water net algae	Hydrodiction sp.			0.02	1
Fragile stonewort	Chara globularis		*		
Lesser pondweed	Potamogeton pusillus		*		
Stonewort sp	Chara sp	*			
	Total species	**6**	**6**	6	**Total points surveyed 48**

As the table above indicates, the species richness at Alderfen has remained stable for the last 3 years although there have been some slight changes in the species composition. In 2014 filamentous algae and *Ceratophyllum demersum* were the dominant species recorded from more than 40 of the 48 survey points. *Najas marina* was the third commonest species in terms of abundance, but only recorded from 12 of the 48 total points. The situation in 2014 was largely reflective of the species composition and dominance recorded in 2012 and 2013. *Chara globularis/connivens* was recorded in 2014, the likelihood being given the confirmed records in 2013 that this would have been *C. globularis*.

There were large areas where voluminous clumps of filamentous algae formed large stands with other species scattered through. In addition, there were large bare patches of sediment scattered throughout and particularly around the shallow margins. These features have been present for many years.

4.22 Barton

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Fennel-leaved pondweed	Potamogeton pectinatus	*	*	0.43	18
Rigid hornwort	Ceratophyllum demersum	*	*	0.07	4
Canadian pondweed	Elodea canadensis		*	0.05	2
Greater reedmace	Tyhpha latifolia			0.05	2
Nuttall's pondweed	Elodea nutallii	*	*	0.05	3
Yellow water lily	Nuphar lutea	*	*	0.01	1
Curled pondweed	Potamogeton crispus	*	*		
Lesser pondweed	Potamogeton pusillus		*		
Frogbit	Hydrocharis morsus-ranae		*		
Water soldier	Stratiotes aloides	*			
	Total species	**6**	**8**	**6**	**Total points surveyed 74**

Barton Broad historically had a very low abundance and occasional complete absence of recorded aquatic macrophytes. Following a period of improving plant diversity between 2003 and 2008 where more than 10 macrophyte species were recorded each summer, the species richness and abundance of the broad in more recent years seems to be reducing.

Six species were recorded in 2014, as in recent years *Potamogeton pectinatus* was the most dominant species. *Elodea canadensis* was recorded for the 2nd year running since last being recorded in 2007. However, generally in 2014 the abundance levels of all plants were very low, best illustrated by the low number of points where plants were recorded given the total number of survey points was 74.

4.23 Cromes Broad

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Filamentous algae		*	*	2.73	30
Bladderwort	Utricularia vulgaris	*	*	2.61	29
Ivy-leaved duckweed	Lemna trisulca	*	*	0.61	22
Rigid hornwort	Ceratophyllum demersum	*	*	0.45	12
Greater reedmace	Typha latifolia			0.36	2
Nuttalls waterweed	Elodea nuttallii	*	*	0.34	10
Fragile/convergent stonewort	Chara globularis/connivens			0.25	7
Canadian waterweed	Elodea canadensis		*	0.25	9
Unbranched bur-reed	Sparganium emersum			0.11	3
Fragile stonewort	Chara globularis			0.02	1

Enteromorpha	Enteromorpha	*	*	0.02	1
Common duckweed	Lemna minor	*		0.02	1
Common reed	Phragmites australis			0.02	1
Small pondweed	Potamogeton berchtoldii			0.02	1
Water soldier	Stratoites aloides		*	0.02	1
Water net algae	Hydrodichtion sp		*		
Lesser pondweed	Potamogeton pusillus		*		
Common water moss	Fontinalis antipyretica		*		
Lesser duckweed	Lemna minuta	*			
Frogbit	Hydrocharis morsus-ranae	*			
Lesser reedmace	Typha angustifolia	*			
	Total species	**10**	**11**	**15**	**Total points surveyed 44**

Historical macrophyte surveys have split Cromes broad in to two areas north and south as Cromes Broad is divided into north and south basins by a reed strip on top of an old peat baulk. Both the basins have been dredged/mud pumped in the past and historically the south broad has had a greater diversity of plants than the north broad. However in the last few years, the positive effects of increased water depth as a result of the mud pumping have been reflected by increasing species richness in the north basin, whilst the southern broad has undergone a decline in species richness and abundance.

The point survey covered the broad as one water body. Cromes Broad has undergone recent restoration effort in winter 2012 with the application of Phoslock, a product designed to bind phosphates suspended in the water column which then sinks and is stored at the broad bed. This project aimed to reduce phosphate levels within the water column and improve local water quality.

The 2014 point surveys recorded a total of 15 plant species, the highest number recorded since at least 2012. Filamentous algae was the most dominant species, being recorded at 30 of the total 44 points. Interestingly, when looking at the distribution in the raw data, it is clear that the majority of the algae were recorded from points in the north broad, as has been the case over the last decade.

Utricularia vulgaris was the second commonest species present at similar levels of abundance to filamentous algae. *Sparganium emersum* was recorded for the first time since surveys began in 1983. *Stratoites aloides* was recorded for the 2nd year running since last being recorded from Cromes broad in 2007. *Chara globularis* was confirmed for the 2nd time in the history of the surveys at Cromes, having last been recorded in 2005, but *C. globularis/connivens* was recorded from 7 points with the likelihood that this was also *C. globularis*.

In order to maintain the consistency of monitoring methods in relation to the Phoslock project, a transect survey was also completed for Cromes broad. *Chara hispida* was recorded from one of the transects and this species has never been recorded from this site

before and has only been recorded once before from the Any Valley broads since surveys began in 1983.

4.24 Reedham Water

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Rigid hornwort	Ceratophyllum demersum	N/A	N/A	3.66	32
Ivy-leaved duckweed	Lemna trisulca			1.09	24
Common stonewort	Chara vulgaris			0.78	13
Filamentous algae				0.66	12
Nuttall's waterweed	Elodea nuttallii			0.5	9
Common duckweed	Lemna minor			0.16	5
Fragile stonewort	Chara globularis			0.09	3
Water net	Enteromorpha			0.09	3
Fragile/convergent stonewort	Chara globularis/connivens			0.06	2
Fennel-leaved duckweed	Potamogeton pectinatus			0.06	2
	Total species	**N/A**	**N/A**	**10**	**Total points surveyed 32**

The most recent previous survey at Reedham Water was completed in 2009 where one species, lesser pondweed *Potamogeton pusillus* was found in low abundance. Previous to that, the site was surveyed 2004 where rigid hornwort and algal species were present, also in low abundances.

However the diversity in the 2014 results implies that a dramatic shift in the water plant community has occurred in Reedham Water. Observations by the Broads Authority site manager throughout the season suggested that water levels were particularly low in the early spring of 2014 at this site, so this may have had a positive influence on the season's growth.

4.3 Bure Valley

The hydrological connection to the River and the position of the Bure Valley broads within the catchment affects both ecological condition and restoration potential of these waterbodies. In recent years Upton and Cockshoot Broads, both isolated from the river, have had the highest populations of aquatic plants present in the Bure Broads. Upton Great Broad is a stronghold for the rare holly-leaved naiad. Upton Little Broad was surveyed for the third time following mudpumping in 2011. Those broads directly connected to the river, such as Ranworth, tend to have minimal plant diversity.

4.31 Cockshoot

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Holly-leaved naiad	Najas marina	*	*	2.69	38
Filamentous algae		*	*	1.13	39
Rigid hornwort	Ceratophyllum demersum	*	*	0.22	8
Horned pondweed	Zanichellia palustris		*	0.09	4
Fragile/convergent stonewort	Chara glob/cons		*	0.07	4
Enteromorpha	Enteromorpha	*	*	0.07	4
Opposite stonewort	Chara contraria		*	0.02	1
Canadian pondweed	Elodea canadensis	*	*	0.02	1
Lesser pondweed	Potamogeton pusillus		*	0.02	1
Common duckweed	Lemna minor		*		
Common stonewort	Chara vulgaris		*		
Fragile stonewort	Chara globularis		*		
White water lily	Nymphaea alba	*			
Yellow water lily	Nuphar lutea	*			
	Total species	**7**	**12**	**9**	**Total points surveyed 54**

Holly-leaved naiad remains the dominant species in Cockshoot, being recorded from 38 of the total 54 points surveyed. Filamentous algae were also widespread and was recorded as the second most abundant species. A total of 9 species were recorded including one confirmed *Chara* species *C. contraria* recorded for the 2nd year running. This species had not been recorded at Cockshoot since surveys began in 1983, and then only from only one transect. The record for *C. globularis/connivens* is likely to have been *C. globularis* which was confirmed in 2013. After being recorded in 2013, *C. vulgaris* was not recorded in 2014.

4.32 Decoy

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Yellow water lily	Nuphar lutea	N/A	*	0.11	4
Filamentous algae				0.02	1
Rigid hornwort	Ceratophyllum demersum		*		
Nuttal's waterweed	Elodea nuttallii		*		
	Total species	**N/A**	**3**	**2**	**Total points surveyed 54**

Historically the overall abundance and species richness of plants at Decoy broad was very low. 2014 surveys indicated an apparent drop in the abundance of plants with only 5 of the 54 points supporting signs of aquatic macrophyte growth. There were signs of *Nuphar lutea* growth around the margins of the broad, particularly around the northern dyke entrance, but the distribution of points did not detect these areas of growth. The impact of changing to the point survey method may be pronounced at this site, especially if the previous transects were focussed on the areas containing visible water plants. More data in future years will help establish trends.

4.33 Hoveton Great

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Rigid hornwort	Ceratophyllum demersum	*	*	0.30	15
Filamentous algae		*	*	0.23	14
Yellow water lily	Nuphar lutea	*	*	0.08	2
Curled pondweed	Potamogeton crispus	*	*	0.03	1
Fennel-leaved pondweed	Potamogeton pectinatus	*	*	0.02	1
Nuttal's waterweed	Elodea nuttalli	*	*		
	Total species	**6**	**6**	**5**	**Total points surveyed 60**

Hoveton Great Broad generally exhibits low macrophyte abundance with remnant patches of water lilies in sheltered bays. The species richness of Hoveton Great broad continues to be stable, at a low level, with only very slight changes in species composition over the years. It is interesting to note that the change of methodology has not impacted on the list of species recorded, apart from the lack of *Elodea nuttalli*. However, the results clearly demonstrate how low plant abundance is generally within the broad, with the dominant *Ceratophyllum demersum* being recorded from only 15 of the total 60 points surveyed.

4.34 Hoveton Little

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Rigid hornwort	Ceratophyllum demersum	N/A	*	0.35	19
Fennel-leaved pondweed	Potamogeton pectinatus		*	0.12	7
Canadian waterweed	Elodea canadensis		*		
	Total species	**N/A**	**3**	**2**	**Total Points Surveyed 60**

Hoveton Little Broad has historically been a broad with low species diversity and low abundance levels. Rigid hornwort was recorded in 2013 and 2014 but had not been recorded previously since 2005. Abundance and diversity remains very low, with the dominant species *Ceratophyllum demersum* being recorded from only 19 of the total 60 survey points.

4.35 Ranworth

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Rigid hornwort	Ceratophyllum demersum	*	*	0.02	1
Fennel-leaved pondweed	Potamogeton pectinatus	*	*	0.02	1
Common water moss	Fontinalis antipyretica		*		
Curled pondweed	Potamogeton crispus	*			
	Total species	**3**	**3**	**2**	**Total points surveyed 66**

Following the historical trend, plant abundance and species diversity was very low in Ranworth Broad in 2014. *Ceratophyllum demersum* and *Potamogeton pectinatus* were recorded again in 2014 but from only 1 of the 66 total survey points. Curled pondweed has been frequently present but was not recorded in 2013 or 2014.

4.36 Upton Great

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Holly-leaved naiad	Najas marina	*	*	3.31	33
Opposite stonewort	Chara contraria	*	*	1.54	30
Common stonewort	Chara vulgaris	*	*	0.35	2
Filamentous algae			*	0.08	4
Fragile/convergent stonewort	Chara globularis/connivens			0.04	2

Bristly stonewort	Chara hispida			0.02	1
Stonewort sp	Chara sp			0.02	1
	Total species	**3**	**4**	**7**	**Total points surveyed 48**

Upton Great Broad continues to be a stable stronghold for *Najas marina*, where in 2014 it continued to occupy much of the water column being recorded from 33 of the 48 survey points. Although the summary abundance score for *Chara contraria* was lower than that of *N. marina* , both species were recorded from roughly the same number of survey points.

Four species of Charophyte were recorded in 2014 with new records for *Chara hispida* and *C. globularis/connivens*. *C. hispida* was previously recorded in 1991 from Upton Great. *C. globularis* has not been recorded from this site, whereas *C. connivens* was previously recorded in 2009.

As in previous years, the stonewort population is generally found around the shallower, marginal areas rather than the deeper, central basin where holly-leaved naiad dominates. *Chara vulgaris* was recorded again in 2014 following its identification in 2012 for the first time since 2003.

4.37 Upton Little

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Bristly hornwort	Chara hispida		*	6.69	30
Holly-leaved naiad	Najas marina			0.17	4
Fennel-leaved pondweed	Potamogeton pectinatus			0.03	1
Opposite stonewort	Chara contraria	*	*		
	Total species	**1**	**2**	**3**	**Total points surveyed 36**

Following the completion of mudpumping in autumn 2011, *Chara contraria* rapidly colonised the bare sediment in 2012, however 2013 saw a shift in the dominance of *C. contraria* to *Chara hispida*, a species which had not been present historically. In 2014, the dominance of *C. hispida* continued as it was recorded from 30 of the total 36 survey points apparently at the expense of *C. contraria* which was not recorded this year. Again, this may be a result of climatic factors or could be part of the stabilisation process following management works.

Again, *N. marina* plants were observed around the shallower margins of the broad where *C. hispida* was not present in such dense beds. This species was observed in 2013 but had not been recorded on the transect surveys so it is worth noting the wider coverage of the broad using the points method resulted in a greater number of species records for this site in 2014.

4.38 Wroxham

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Rigid hornwort	Ceratophyllum demersum	*	*	0.63	24
Fennel-leaved pondweed	Potamogeton pectinatus	*	*	0.31	14
Nuttall's waterweed	Elodea nutallii		*	0.26	11
Filamentous algae			*	0.16	5
Un-branched bur-reed	Sparganium emersum		*	0.06	1
Pointed stonewort	Nitella mucronata			0.06	2
Yellow water lily	Nuphar lutea		*	0.01	1
Starwort sp	Callitriche sp		*		
Common water moss	Fontinalis antipyretica		*		
	Total species	**2**	**8**	**7**	**Total points surveyed 68**

2013 was a good year for plant abundance and species richness in Wroxham broad. The species richness was largely maintained in 2014 with 7 species being recorded all of which were recorded in 2013 except for *Nitella mucronata* which has been recorded on 3 occasions in the past but not since 2007.

It is not possible to compare the 2014 abundance figures with the previous years, however *Ceratophyllum demersum* and *Potamogeton pectinatus* continued to be the most abundant species across the broad. The majority of the plant growth was identified in the northern bay of the broad as in 2013 with large areas of open water devoid of plant growth.

4.4 Yare Valley

Waterbodies surveyed in the Yare Valley are generally of good condition in terms of their submerged macrophyte populations; submerged plants are frequent in Rockland and Wheatfen Broads. Whitlingham Great and Little Broads originated from gravel extraction and despite their 'youth' have abundant submerged plant growth and a diverse species assemblage. The continued increase in species richness at Bargate broad was particularly encouraging from an improving water clarity and habitat quality perspective.

4.41 Bargate

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Rigid hornwort	Ceratophyllum demersum	*	N/A	1.07	18
Unbranched bur-reed	Sparganium emersum	*		0.98	25
Spiked water milfoil	Myriophyllum spicatum	*		0.43	8
Whorled water milfoil	Myriophyllum verticillatum	*		0.41	10
Starwort	Callitriche sp	*		0.39	12
Filamentous algae				0.36	9
Nuttall's waterweed	Elodea nuttallii			0.23	9
Yellow water lily	Nuphar lutea	*		0.23	9
Pointed stonewort	Nitella mucronata			0.2	5
Common watermoss	Fontinalis antipyretica			0.18	7
Fennel-leaved pondweed	Potamogeton pectinatus			0.07	2
Common duckweed	Lemna minor			0.05	2
Least duckweed	Lemna minuta			0.02	1
Small pondweed	Potamogeton berchtoldii			0.02	1
Stonewort sp	Nitella sp	*			
	Total species	**7**	**N/A**	**14**	**Total points surveyed 44**

As the table above shows, Bargate broad was last surveyed in 2012 and historically has recorded low species richness (3 species in 2004 & 2006), partly related to its close connectivity to the River Yare. Since the 2012 survey, the species richness has doubled from 7 to 14 species.

Notably *Myriophyllum verticillatum*, listed as vulnerable on the Vascular Plant Red Data List for Great Britain (2006 Cheffings and Farrell), was recorded for the second time and from ten points, generally located around the margins of the broad. Although the summary abundance scores indicated that *Ceratophyllum demersum* was the most abundant species, the species most widely recorded was *Sparganium emersum* recorded from over half the total 44 points surveyed.

In addition, *Nitella mucronata* was recorded from 5 points having never been recorded before as well as *Potamogeton pectinatus* and *P. berchtoldii.*

4.42 Rockland

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Spiked water milfoil	Myriophyllum spicatum	*	N/A	0.48	20
Rigid hornwort	Ceratophyllum demersum	*		0.35	21
Yellow water lily	Nuphar lutea	*		0.34	10
Filamentous algae		*		0.11	7
Common reed	Phragmites australis			0.08	2
Un-branched bur-reed	Sparganium emersum	*		0.06	4
Starwort	Callitriche sp	*		0.03	2
Nuttall's waterweed	Elodea nutalli			0.03	2
Common water moss	Fontinalis antipyretica			0.03	2
Flexible stonewort	Nitella flexilis agg			0.02	1
Fan-leaved water crowfoot	Ranunculus circinatus	*			
Water crowfoot sp	Ranunculus sp	*			
	Total species	**8**	**N/A**	**10**	**Total points surveyed 62**

Rockland was last surveyed in 2012 where 8 species were recorded. Surveys in 2014 recorded 10 species of which 3 were not recorded on the last survey; *Nitella flexilis* agg was recorded once previously in 2005, *Fontinalis antipyretica* was recorded once previously in 2010 and *Elodea nutalli* was last recorded in 2011.

Myriophyllum spicatum and *Ceratophyllum demersum* were the dominant species being recorded from nearly the same number of points, with *M. spicatum* recorded at slightly greater abundance levels.

4.43 Whitlingham Great

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Nuttall's waterweed	Elodea nuttallii	*	*	2.08	40
Common stonewort	Chara vulgaris	*	*	0.3	8
Lesser pondweed	Potamogeton pusillus	*	*	0.25	11
Rigid hornwort	Ceratophyllum demersum	*	*	0.25	13
Fragile stonewort	Chara globularis			0.22	2
Filamentous algae		*	*	0.22	13
Ivy-leaved duckweed	Lemna trisulca	*	*	0.17	10
Fragile/convergent stonewort	Chara globularis/connivens			0.06	4

Opposite stonewort	Chara contraria	*		0.05	1
Fan-leaved water-crowfoot	Ranunculus circinatus	*	*	0.05	3
Canadian waterweed	Elodea canadensis	*	*	0.03	2
Stonewort sp	Chara sp			0.02	1
Flat-stalked pondweed	Potamogeton friesii			0.02	1
Small pondweed	Potamogeton berchtoldii		*		
Curled pondweed	Potamogeton crispus	*	*		
Hair-like pondweed	Potamogeton trichiodes	*	*		
Unbranched bur-reed	Sparganium emersum		*		
Delicate stonewort	Chara virgata		*		
Amphibious bistort	Persicaria amphibia		*		
	Total species	**11**	**14**	**13**	**Total points surveyed 64**

Species richness remained high at Whitlingham Great broad with 13 species recorded this year. As in 2013 *Elodea nuttalli* was the most abundant species being recorded at 14 of the 64 points surveyed. One of the notable differences in the plant assemblage in comparison to 2013 was the reduction in the presence of pondweeds of which three species were not recorded; *Potamogeton crispus*, *P. trichiodes* and *P. berchtoldii*. Interestingly *P. friesii* was recorded for the first time in this broad from one point.

It is worth noting that there were reports from Broads Authority members of staff in May and June that there were extensive areas within the broad where *P. crispus* was growing to the surface. That there was no record of this species during the survey on 18th July may support the theory that *Potamogeton* growth may have peaked much earlier in the season due to the mild winter and spring. This may also explain the reduction in the number of other pondweed species in 2014.

Chara globularis was confirmed as a species on the Great broad for the first time since 2008, although *C. globularis/connivens* has been recorded on a couple of occasions since then. *C. contraria* was recorded again after being found for the first time in 2011.

In general Whitlingham Great broad continues to support a diverse and relatively stable plant community.

4.44 Whitlingham Little

Common Name	Scientific Name	Present 2012	Present 2013	Summary Abundance 2014	Number of points where recorded
Nuttall's waterweed	Elodea nuttallii	*	*	3.39	37
Ivy-leaved duckweed	Lemna trisulca	*	*	2.86	37
Rigid hornwort	Ceratophyllum demersum	*	*	2.36	29
Filamentous algae		*	*	1.48	29

Canadian waterweed	Elodea canadensis		*	0.32	9
Common duckweed	Lemna minor			0.05	1
Common water moss	Fontinalis antipyretica			0.02	1
Least duckweed	Lemna minuta			0.02	2
Fan-leaved water crowfoot	Ranunculus circinatus			0.02	1
Small pondweed	Potamogeton berchtoldii		*		
Unbranched bur-reed	Sparganium emersum		*		
Fennel-leaved pondweed	Potamogeton pectinatus		*		
Fragile/Convergent stonewort	Chara glob/cons		*		
Common stonewort	Chara vulgaris		*		
	Total species	**4**	**10**	**9**	**Total points surveyed 44**

Following a very poor year in 2012, 2014 survey saw a continuation of the recovery in the number of species present seen in 2013 with 9 species recorded. *Elodea nuttalli* was recorded as the most abundant species reflecting findings of recent transect surveys, with *Lemna trisulca* also found to be widespread across the broad; both species being recorded from 37 of the total 44 survey points. Historically *Ceratophyllum demersum* tended to be the most abundant species, however in 2014 it was the third most abundant species.

Four species were recorded in 2014 that were not present in 2013 or 2012. *Fontinalis antipyretica* is an aquatic moss that was recorded for the first time from Whitlingham Little Broad, albeit from only 1 survey point. Similarly *Ranunculus circinatus* was recorded for only the third time from this broad having most recently been recorded in 2008.

5 ACKNOWLEDGEMENTS

The Broads Authority wishes to thank all those individuals and organisations who assisted during the 2014 survey season by providing their time, boats, identification skills or permissions.

Thanks in particular go to Luke Harrison who signed up on a Broads Authority work experience placement and devoted the whole of his summer holidays to assist with every element of the water plant survey.

In no particular order, thanks are also due to the following Broads Authority volunteers: Sarah Houghton, Paul Blathwayte and Oliver Howlett.

As well as the volunteers, the survey program could not have been completed without the help of other Broads Authority staff, namely Dan Hoare, Sally McColl, Sue Stephenson, Hannah Gray, Erica Murray, John Hopes, Wyn Purdy, Jamie Hanger, Eddie Nicholls, Chris Glassel, Shaun Taylor, Polly King, Pip Noon, Steve Wright and Gavin Devaney. In addition, thanks to Elaine Green and Diane Monsey of Natural England.

Last but not least, many thanks to the landowners who kindly granted permission to access the privately owned & managed broads.

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7 APPENDICIES.

Appendix 1. Macrophyte groupings based on physical form.
Appendix 2a & b. Plant common and Latin names.
Appendix 3. Hydroacoustic Survey Results from Water Plants in Hickling Broad- August 2014

7.1 Appendix 1. Macrophyte groupings based on form

Stoneworts	**Free-floating or round floating-leaved**	**Vascular Macrophytes**	
Baltic stonewort	Amphibious bistort	Arrowhead	Lesser pondweed
Bristly stonewort	Common duckweed	Australian swamp stonecrop	Lesser reedmace
Common stonewort	Frogbit	Blunt-leaved pondweed	Mare's tail
Convergent stonewort	Greater duckweed	Branched bur-reed	Nuttall's waterweed
Delicate stonewort	Inflated duckweed	Broad –leaved pondweed	Perfoliate pondweed
Fragile stonewort	Ivy-leaved duckweed	Bulrush	Reed sweet grass
Hedgehog stonewort	Least duckweed	Canadian waterweed	Rigid hornwort
Intermediate stonewort	White water lily	Common reed	Sharp-leaved pondweed
Lesser bearded stonewort	Yellow water lily	Crowfoot sp.	Shining Pondweed
Opposite stonewort		Curled pondweed	Small pondweed
Pointed stonewort		Fan-leaved water crowfoot	Spiked water milfoil
Rough stonewort	**Macro-algae and mosses**	Fennel-leaved pondweed	Starwort sp.
Starry stonewort	*Enteromorpha*	Flat-stalked pondweed	Sweet flag
Translucent stonewort	Common water moss	Floating club-rush	Unbranched bur-reed
	Filamentous algae	Greater bladderwort	Water cress
	Stringy moss	Greater reedmace	Water-soldier
	Water net	Hair like pondweed	Whorled water milfoil
		Holly-leaved naiad	Willow-leaved pondweed
		Horned pondweed	

7.2 Appendix 2a. Latin to Common plant names.

Latin	Common
Acorus calamus	Sweet flag
Alisma plantago-aquatica	Common water-plantain
Chara aculeolata	Hedgehog stonewort
Callitriche stagnalis	Intermediate water-starwort
Callitriche sp	Starwort sp.
Ceratophyllum demersum	Rigid hornwort
Chara pedunculata	Hedgehog stonewort
Chara aspera	Rough stonewort
Chara baltica	Baltic stonewort
Chara connivens	Convergent stonewort
Chara contraria	Opposite stonewort
Chara curta	Lesser bearded stonewort
Chara globularis/connivens	Fragile/convergent stonewort
Chara globularis	Fragile stonewort
Chara hispida	Bristly stonewort
Chara intermedia	Intermediate stonewort
Chara sp.	Stonewort *(Chara)* species
Chara virgata	Delicate stonewort
Chara vulgaris	Common stonewort
Crassula helmsii	Swamp stonecrop
Elodea canadensis	Canadian waterweed
Eleogiton fluitans	Floating club-rush
Elodea nutalli	Nuttall's waterweed
Enteromorpha	*Enteromorpha*
Filamentous algae	Filamentous algae
Fontinalis antipyretica	Common water moss
Glyceria maxima	Reed sweet grass
Hippuris vulgaris	Mare's tail
Hydrocharis morsus-ranae	Frogbit
Hydrodictyon	Water net
Lemna gibba	Inflated duckweed
Lemna minor	Common duckweed
Lemna minuta	Least duckweed
Lemna trisulca	Ivy-leaved duckweed
Leptodictyum riparium	Stringy moss
Myriophyllum spicatum	Spiked water milfoil
Myriophyllum verticillatum	Whorled water milfoil
Najas marina	Holly-leaved naiad
Nitella flexilis	Smooth stonewort
Nitella mucronata	Pointed stonewort
Nitellopsis obtusa	Starry stonewort
Nitella translucens	Translucent stonewort
Nitella sp.	Stonewort *(Nitella)* species
Nuphar lutea	Yellow water lily
Nymphaea alba	White water lily
Persicaria amphibia	Amphibious bistort
Potamogeton acutifolius	Sharp-leaved pondweed
Potamogeton berchtoldii	Small pondweed
Potamogeton crsipus	Curled pondweed
Potamogeton friesii	Flat-stalked pondweed
Potamogeton lucens	Shining pondweed
Potamogeton natans	Broad –leaved pondweed
Potamogeton obtusifolius	Blunt-leaved pondweed
Potamogeton pectinatus	Fennel-leaved pondweed
Potamogeton perfoliatus	Perfoliate pondweed
Potamogeton pusillus	Lesser pondweed
Potamogeton x salicifolius	Willow-leaved pondweed
Potamogeton sp.	Pondweed sp.
Potamogeton trichoides	Hair like pondweed
Phragmites australis	Common reed
Ranunculus circinatus	Fan-leaved water crowfoot
Ranunculus fluitans	River water crowfoot
Ranunculus sp.	Crowfoot sp.
Rorippa nasturtium-aquaticum	Water cress
Saggitaria sagittifolia	Arrowhead
Schoenoplectus lacustris	Bulrush
Sparganium emersum	Unbranched bur-reed
Sparganium erectum	Branched bur-reed
Spirodela polyrhiza	Greater duckweed
Stratiotes aloides	Water-soldier
Typha angustifolia	Lesser reedmace
Typha latifollia	Greater reedmace
Utricularia vulgaris	Bladderwort
Veronica catenata	Pink water speedwell
Zanichellia palustris	Horned pondweed

7.3 Appendix 2b. Common to Latin plant names.

Common	*Latin*
Amphibious bistort	*Persicaria amphibia*
Arrowhead	*Saggitaria sagittifolia*
Baltic stonewort	*Chara baltica*
Bladderwort	*Utricularia vulgaris*
Blunt-leaved pondweed	*Potamogeton obtusifolius*
Branched bur-reed	*Sparganium erectum*
Bristly stonewort	*Chara hispida*
Broad –leaved pondweed	*Potamogeton natans*
Bulrush	*Schoenoplectus lacustris*
Canadian waterweed	*Elodea canadensis*
Common duckweed	*Lemna minor*
Common reed	*Phragmites australis*
Common stonewort	*Chara vulgaris*
Common water moss	*Fontinalis antipyretica*
Common water-plantain	*Alisma plantago-aquatica*
Convergent stonewort	*Chara connivens*
Crowfoot sp.	*Ranunculus sp.*
Curled pondweed	*Potamogeton crispus*
Delicate stonewort	*Chara virgata*
Enteromorpha	*Enteromorpha*
Fan-leaved water crowfoot	*Ranunculus circinatus*
Fennel-leaved pondweed	*Potamogeton pectinatus*
Filamentous algae	*Filamentous algae*
Flat-stalked pondweed	*Potamogeton friesii*
Floating club-rush	*Eleogiton fluitans*
Fragile stonewort	*Chara globularis*
Fragile/convergent stonewort	*Chara globularis/connivens*
Frogbit	*Hydrocharis morsus-ranae*
Greater duckweed	*Spirodela polyrhiza*
Greater reedmace	*Typha latifollia*
Hair like pondweed	*Potamogeton trichoides*
Hedgehog stonewort	*Chara aculeolata/pedunculata*
Holly-leaved naiad	*Najas marina*
Horned pondweed	*Zanichellia palustris*
Inflated duckweed	*Lemna gibba*
Intermediate stonewort	*Chara intermedia*
Intermediate water-starwort	*Callitriche stagnalis*
Ivy-leaved duckweed	*Lemna trisulca*
Least duckweed	*Lemna minuta*
Lesser bearded stonewort	*Chara curta*
Lesser pondweed	*Potamogeton pusillus*
Lesser reedmace	*Typha angustifolia*
Mare's tail	*Hippuris vulgaris*
Nuttall's waterweed	*Elodea nutalli*
Opposite stonewort	*Chara contraria*
Perfoliate pondweed	*Potamogeton perfoliatus*
Pink water speedwell	*Veronica catenata*
Pointed stonewort	*Nitella mucronata*
Pondweed sp.	*Potamogeton sp.*
Reed sweet grass	*Glyceria maxima*

Common	*Latin*
Rigid hornwort	*Ceratophyllum demersum*
River water crowfoot	*Ranunculus fluitans*
Rough stonewort	*Chara aspera*
Sharp-leaved pondweed	*Potamogeton acutifolius*
Shining pondweed	*Potamogeton lucens*
Small pondweed	*Potamogeton berchtoldii*
Smooth stonewort	*Nitella flexilis*
Spiked water milfoil	*Myriophyllum spicatum*
Starry stonewort	*Nitellopsis obtusa*
Starwort sp.	*Callitriche sp*
Stonewort *(Chara)* species	*Chara sp.*
Stonewort *(Nitella)* species	*Nitella sp.*
Stringy moss	*Leptodictyum riparium*
Swamp stonecrop	*Crassula helmsii*
Sweet flag	*Acorus calamus*
Translucent stonewort	*Nitella translucens*
Unbranched bur-reed	*Sparganium emersum*
Water cress	*Rorippa nasturtium-aquaticum*
Water net	*Hydrodictyon*
Water-soldier	*Stratiotes aloides*
White water lily	*Nymphaea alba*
Whorled water milfoil	*Myriophyllum verticillatum*
Willow-leaved pondweed	*Potamogeton x salicifolius*
Yellow water lily	*Nuphar lutea*

7.4 Appendix 3. Hydroacoustic Survey Results for Water Plants in Hickling Broad – August 2014

Hydroacoustic Survey Results for Water Plants in Hickling Broad – August 2014

Sally McColl
December 2014

1.0 Introduction

Hydroacoustics is a general term for the study and application of sound in water. Hydroacoustics, utilising sonar technology, is commonly used for detection, assessment, and monitoring of underwater physical and biological objects. Boat-mounted hydroacoustic equipment can be utilised to detect the depth of a water body (bathymetry), as well as the presence or absence, abundance, distribution and size of underwater plants.

Such survey equipment measures the range to an object and its relative size by producing a pulse of sound and measuring the time it takes for an echo to return from the object and the amplitude of the returned echo. The range is calculated as a function of the speed of sound and the time it takes for the echo to return.

2.0 Survey Methods

On 1st August 2014, the regular transect routes of the Broads Authority Annual Water Plant Survey were followed (see Figure 1). In 2014, the transect route for the annual macrophyte survey has been replaced with point survey, which are also depicted in Figure 1.

The equipment used in this survey included a BioSonics DT-X, single beam (10°), 420 KHz transducer, with an onboard control unit and operating laptop. All data recorded whilst mobile on the waterbody was georeferenced through connection to an external GPS system. This allowed subsequent quantitative analysis of the data using Sonar5-Pro post-processing software, developed specifically with a vegetation analysis component.

To assist with data processing and ground truthing the bathymetric measurements, a water depth was taken at the end of each transect with a measuring staff. Notes were made about the distribution of plants within each transect.

2.1 Data Analysis

Using the Sonar5-Pro software, the sediment surface of each transect file was identified, as well as the less intense return derived from the upper surface of the water plants. Each transect was divided into 10 m sections for ease of analysis and to provide workable units within which to generate values for the bathymetric and water plant parameters recorded. These were water depth (to sediment surface); plant height; area of lake bed covered by plants; and percent volume of lake inhabited by plants or PVI. Only features taller than 8 cm above the inferred sediment surface were recorded as water plants during the data processing, to reduce the likelihood of recording false positive results. This cut-off figure was calculated by selecting a transect with negligible plant growth, and adjusting the height threshold to determine the optimal (lowest) figure that minimised false reporting (Table 1).

Table 1 % of plant coverage, based on different height thresholds

Height threshold (m)	% of bed covered in plants
0.05	**74**
0.06	**74**
0.07	**74**
0.08	**23**
0.09	**23**
0.10	**23**

3.0 Results

Plant growth flourished in July and August 2014 following a cool spring, with observations of water plants growing up to the surface in sheltered bays.

Figure 1 below shows the transects throughout Hickling Broad in comparison to the points.

A typical screenshot of the post data processing showing transect length Q is depicted in Figure 2. The black line marks the sediment surface, and the red line the height of the aquatic macrophytes. The area between the red and black lines is the % bed covered in plants.

Table 2 shows the average figures for the whole broad. Average water depth 1.19m with an average plant height of 0.28m. Although in contrast maximum water depth is 1.54m with a maximum plant height of 0.97m. Average PVI is 16% but plant density varied considerably throughout the broad.

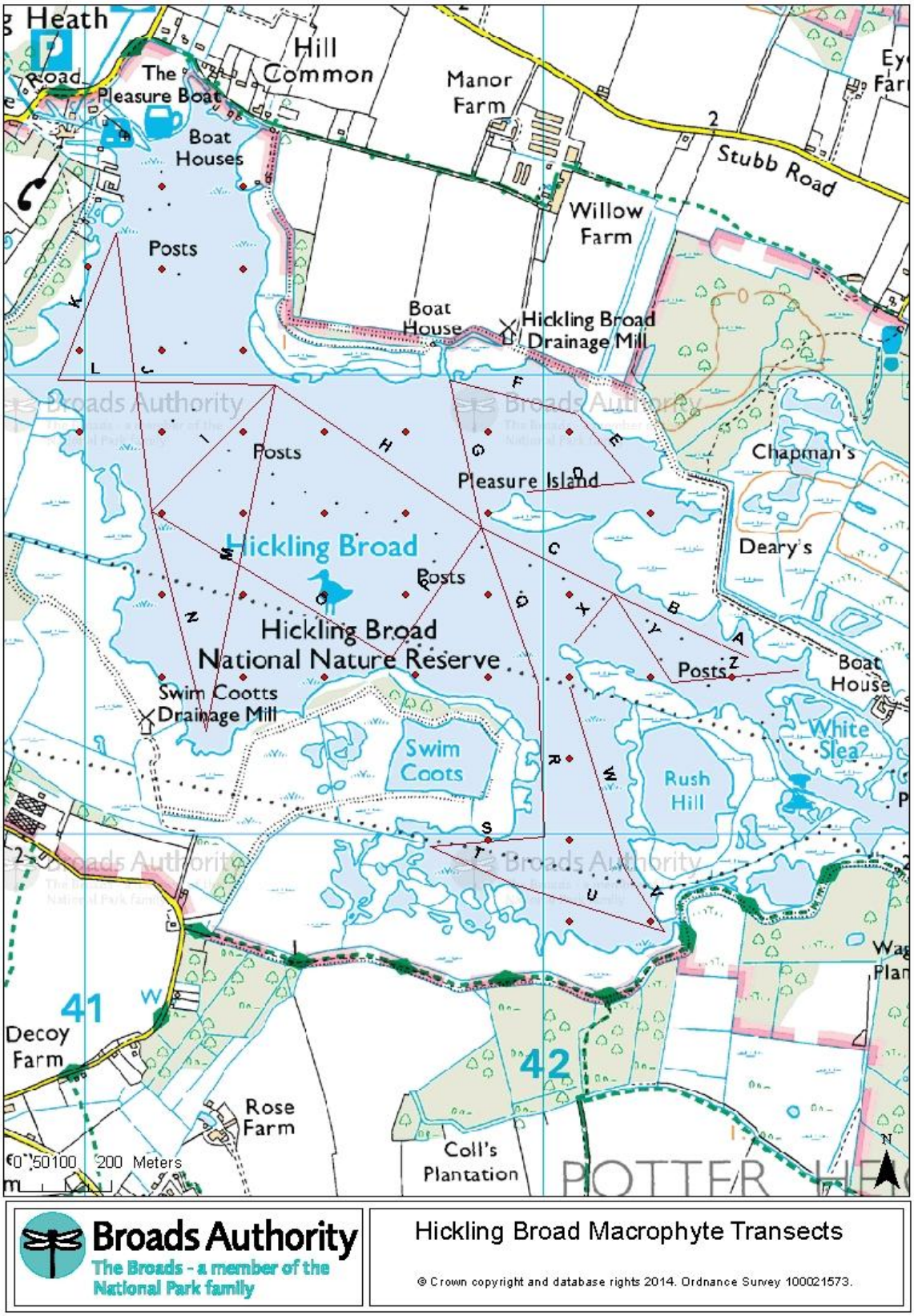
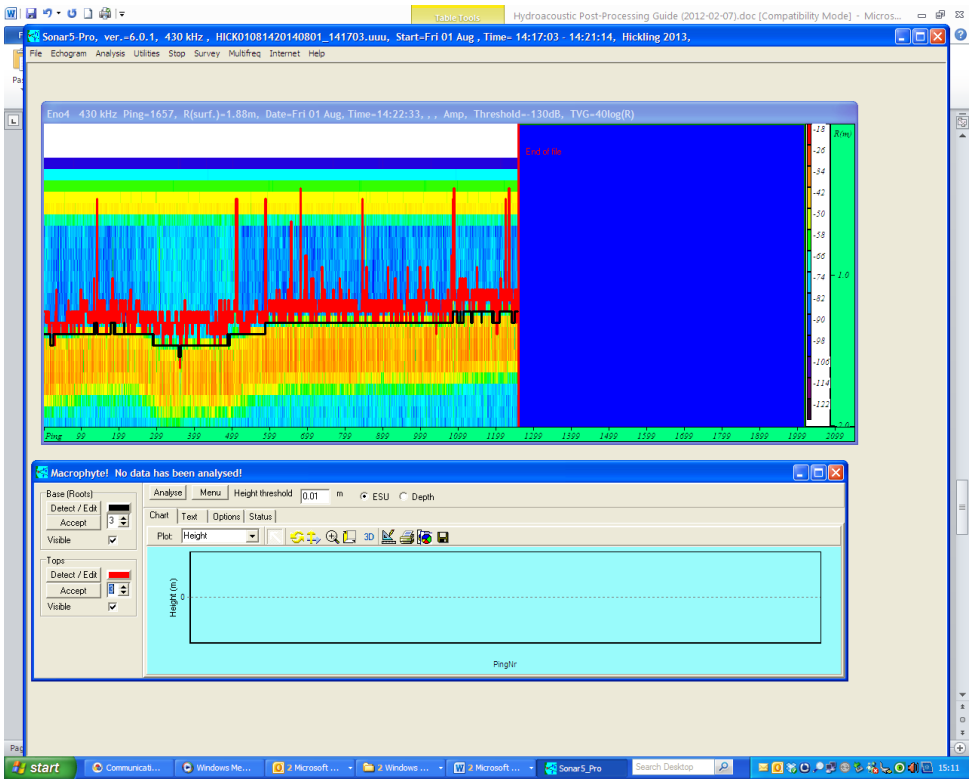


Figure 1. Hickling Broad with the hydroacoustic survey transects (red lines) and the locations of the sampling points for the macrophyte surveys (red dots).

Table 2 Hydroacoustic survey results from Hickling Broad

	Aug-14
Mean water depth (m)	1.19
Max. water depth (m)	1.54
Mean plant height (m)	0.28
Max. plant height (m)	0.97
% bed covered by plants (%)	52.09
% of plant volume (PVI) (%)	16.19

Figure 2 Typical screenshot on the hydroacoustics software



In Hickling Broad, there were lots of plants in transects D,E,F,R,S,W and Z which is reflected in more than 25% PVI for each of these transects. Around the bay to the north of Pleasure Island, plants were regularly seen growing to the surface, including some large beds of *Chara spp*. Transects E and F were particularly heavily vegetated with PVI recorded at over 50%. The bay between Swim Coots and Rush Hills, containing transects R-W, showed beds of *Najas marinas* to the surface, but unfortunately the transects seems to avoid most of these plants with only transects R, S and W recording more than 25% PVI.

As expected the transects crossing the navigation channel, and in the middle of the broad showed the least amount of plants.

4.0 Conclusion

The aquatic macrophyte survey has shown plant growth in Hickling Broad to be increasing over the past few years. The hydroacoustic data shows over 50% of the bed covered in plants, with an average PVI of 16%. No historic hydroacoustic data exists, so this data will act as a baseline for the coming years.