Broads Annual Water Plant Monitoring Report 2022

March 2023

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Contents

Cover photos of Hedgehog stonewort, Hickling Broad, taken by Hannah Southon

Executive Summary

The Broads Authority have surveyed the water plant communities within the Broads since 1983. The Broads Annual Water Plant monitoring programme provides information on the diversity of species and a measure of abundance. The programme has consistently surveyed key broads, such as Hickling Broad (a prime navigation site with high recreational value) and Cockshoot Broad (previously undergone restoration measures), providing long term datasets. Between 1983 and 2013, a transect-based technique was used for the monitoring programme. Due to limitations in the efficiency of the methodology along with the improvements in water plants generally across the Broads, a new point -based technique was developed and implemented. Point sample surveys have been conducted since 2014.

Macrophytes in the Broads are inherently highly variable in both abundance and species richness between years, so limited significance should be attached to variation in these parameters between one individual year and the next. However, to note the 40 years of data collected as of this year, the 2022 annual report also includes reflections regarding the entire dataset.

This report presents and discusses the findings from the annual water plant surveys carried out during 2022, which covered **25** Broads with a total of **596** survey points, in addition to looking back at the 40 years of the surveys history.

- Overall in 2022, 64% (16/25) of the Broads surveyed showed an increase in total species abundance. 24% (6/25) Broads showed a decrease and 8% (2/25) showed very little change. This continues the trend of increasing plant growth and overall species abundance recorded over the last few years.

- The Broads connected to the Bure River recorded an increase in abundance. All the Broads linked to the Bure which we surveyed (and have past survey data from 2014 onwards – Belaugh, Decoy, HGB, Hudson's, Hoveton little, Wroxham, Norton's and Pound End) all had an increase this year from the year(s) before. The depth of clarity of the water in the river and therefore the connected broads was also of note.

- Stonewort's were dominant in Hickling Broad, Martham North and Martham South and were also recorded in Alderfen Broad, Cromes Broad, Cockshoot Broad, Heigham Sound, Little Broad, Rockland Broad, Upton Great Broad, Upton Little Broad and Wroxham Broad. Abundance levels vary across the broads but 62% (8/13) showed an increase, 31% (4/13) a decrease and 7% (1/13) stayed the same from last year.

- Holly-leaved naiad saw higher abundance levels this year compared to 2021. Increases were seen in Alderfen, Cromes Broad, Hickling and Pound End and this Section 41 species was also recorded for the first time in Little Broad. In the Martham Broads, the overall abundance levels stayed similar to previous years.

Introduction

Background information

The Broads Authority (the Authority hereafter) has monitored aquatic macrophytes (water plants hereafter) annually at numerous broads within its Executive Area since 1983. The water plant monitoring programme has provided data on species richness (number of species) and a measure of abundance of the water plants present in each of the broads surveyed. The surveys have created long-term datasets, provided vital information in monitoring the response of a number of broads to restoration measures such as suction dredging and / or biomanipulation and are contributing to scientific reviews of key broads (http://www.broads-authority.gov.uk/__data/assets/pdf_file/0006/549114/Broads-Lake-Review.pdf).

Following increased water plant growth across many of the broads, it was acknowledged that the transect methodology (employed until 2013), was difficult to implement in a robust and consistent manner required for analysis of long-term trends. Following consultation with Natural England, Environment Agency, Dr Nigel Wilby (University of Stirling) and other researchers, a point-based survey methodology was developed. Between 2011 and 2013, the point sample survey was conducted alongside the transect surveys. The purposes of the concurrent surveys was to understand if the data gathered was directly comparable and would allow long-term trend analysis. Whilst research undertaken by Dr Nigel Wilby, revealed the data gathered by the two techniques was not directly comparable, the point-based technique was adopted as the method for the Broads Annual Water Plant Monitoring programme from 2014 onwards.

Aims & objectives

The main objectives of the annual programme are to monitor key broads with long-term datasets, those that have undergone restoration measures or those that are known to be experiencing a change in their water plant community. Broads that have not received restoration efforts or are stable (with or without water plants) are monitored on a less frequent basis. When resources allow, the monitoring of sites not previously surveyed is an ongoing objective. River stretches are also surveyed annually, focusing on the upper reaches where plant growth is concentrated.

The general aim of the monitoring programme is to monitor water plant growth and provide an assessment of the condition, or health, of the broads and waterways within the Broads. The monitoring programme also provides an assessment of Section 41 species, Species “of principal importance for the purpose of conserving biodiversity” covered under section 41 (England) of the NERC Act (2006) and therefore need to be taken into consideration by a public body when performing any of its functions.

Two types of surveys are undertaken as part of the monitoring programme, point sample surveys to assess species diversity and provide a measure of abundance within a broad or

stretch of river and hydroacoustic surveys, which use sonar technology to estimate cover and volume of water plants along transects.

The purpose of this report is to present the results of the 2022 survey season.

The data gathered through the water plant and hydroacoustic surveys and presented within these reports are used to:

- Report the status of conservation priority species, e.g. certain stoneworts and Holly-leaved naiad (Section 41 priority species)
- Assess the condition of designated sites (SSSIs) and WFD waterbodies in partnership with NE and EA respectively.
- Assess the success of restoration measures such as catchment or in-lake projects by managers and research scientists as well as assessing long-term trends
- Assess the impact of and ability to cut water plants to allow the safe passage of boats.

Methodology

Survey design

The point sample survey was designed in consultation with Dr Nigel Wilby using Broad's species accumulation data. The data generated a relationship (y = 4.6242ln(x) + 17.149) between the area of the open water of a broad and the required number of points to be sampled (see Figure 1). Using ArcGIS, the area of open water of each broad to be surveyed was measured in hectares (ha) and the number of sample points calculated. Once the required number of points was calculated, a grid system was applied over an aerial image of the open water areas of each broad. Sample points were set equidistant from each other and the co-ordinates generated (see Figure 2). The maps and sample point co-ordinates were loaded onto a Samsung tablet for the survey teams to use.

Figure 1

The relationship between the area of open water and the required number of points sampled.

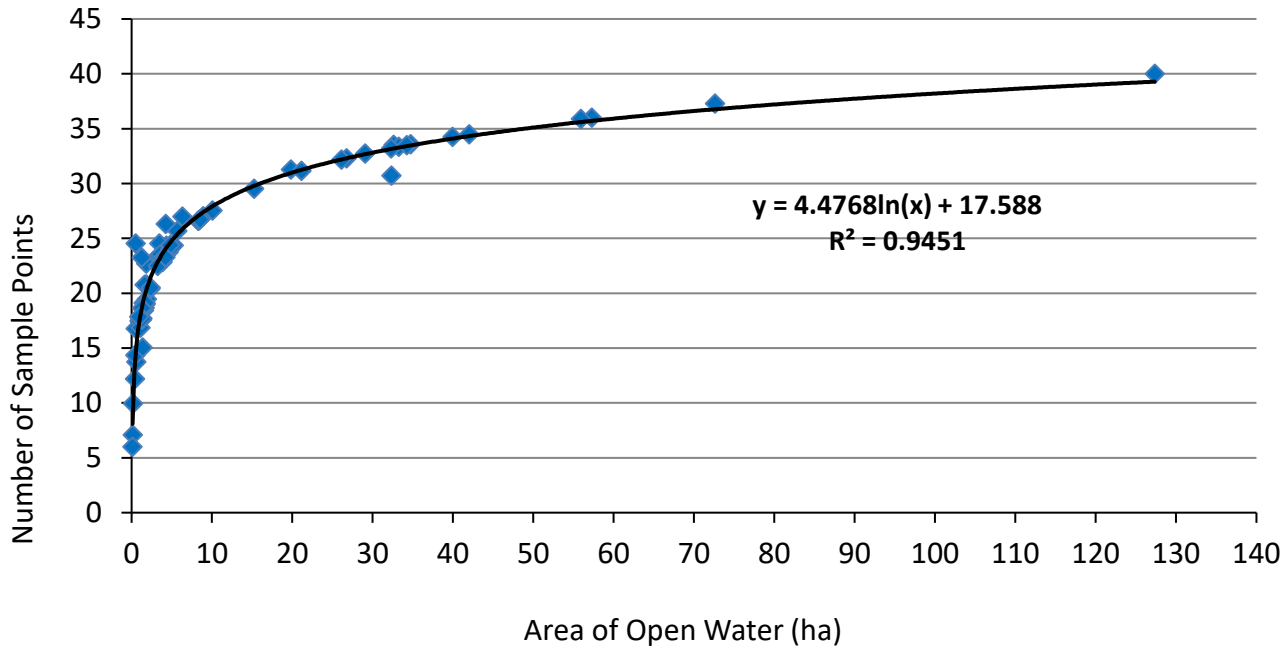
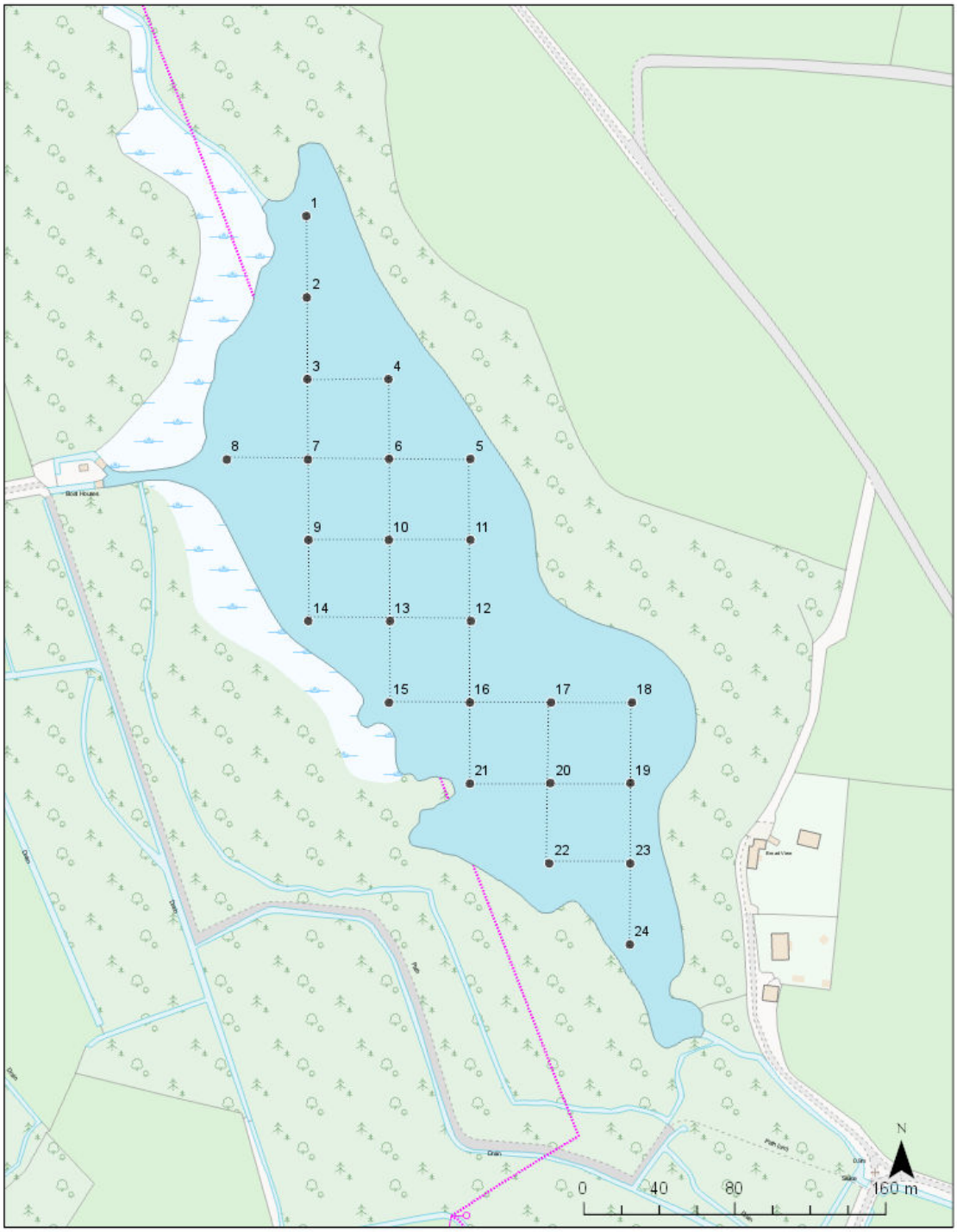


Figure 2

Map showing the sample points of Alderfen Broad



Sample points at Alderfen Broad

Point sample survey technique

At each broad, the surveyors used the maps and grid references on the Samsung tablet and GPS to navigate by boat to each of the sample points. Once within 5 m of the plotted grid reference, mud weights were deployed to keep the boat in the correct location.

At each sample point, a double headed survey rake was thrown north and south, at each sample point, at a distance of 5 m 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 known 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.

On retrieval of the 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. All the live plant material was identified to species level wherever possible. For example, some particularly difficult groups e.g. any non-fruiting starworts *Callitriche* sp. were only identified to genus level. Any unidentified plant specimens (or where identification was uncertain) were collected in plastic bags and labelled using the station number reference. These samples were then taken for subsequent observation using a high-powered microscope, or sent for expert identification. Wherever possible, voucher specimens were pressed and dried using standard herbarium techniques.

To assign a level of abundance for each species, the total volume of live water plant material was scored based on the maximum trap-ability on the rake. Scores attributed to each species present range from 10% (low abundance) and 100% (the maximum trappable) in increments of 10%. For example, if the maximum plant volume was present on the rake, but split equally between two species then each species would be scored 50%. In addition, scores of 1% were given to trace and very small amounts of identifiable plant material.

The ‘trap-ability’ of a particular species on the rake, was taken into account so that a score of 100% represents the maximum amount trappable on the rake. For example, a fine leaved species such as Unbranched bur-reed *Sparganium emersum* is not as ‘trappable’ on the rake as a more structured species such as Spiked water milfoil *Myriophyllum spicatum*. Surveyor experience and judgement is therefore important in scoring the less trappable species based on the likelihood of being retrieved in the rake and possibly other visual indications. The risk being that high abundances of less trappable species are routinely under-scored compared to more easily retrieved species. Other less trappable water plant families include duckweeds Lemna sp. and water lilies.

The maximum total of all species abundance scores on an individual rake sample cannot really be more than 100%, although ± 10% is considered acceptable to account for the varying trap-ability of different species.

The broads that have been sampled between 2014 and 2022 are presented in Table 1. Surveys are conducted during the summer period, July to September.

Table 1

Sites surveyed as part of the monitoring programme between 2014 and 2022.

Broad	2014	2015	2016	2017	2018	2019	2020	2021	2022
Alderfen Broad	X	X	X	X	X	X	X	X	X
Bargate Broad	X			X			X		
Barnby Broad		X							
Barton Broad	X	X	X	X	X	X	X	X	X
Belaugh Broad				X					X
Blackfleet broad			X						
Bridge Broad		X					X		
Buckenham Broad		X		X					
Burntfen Broad			X						X
Calthorpe Broad	X							X	
Catfield Broad		X							
Cockshoot Broad	X	X	X	X	X	X	X	X	X
Cromes Broad	X	X	X	X	X	X	X	X	X
Decoy Broad	X		X		X		X		X
Hassingham Broad		X		X					
Heigham Sound	X	X	X	X	X	X	X	X	X
Hickling Broad	X	X	X	X	X	X	X	X	X
Horsey Mere	X	X	X	X	X	X	X	X	X
Hoveton Great Broad	X	X	X	X	X	X	X	X	X
Hoveton Little Broad	X			X			X		X
Hudson's Bay		X			X		X	X	X
Little Broad			X						X
Malthouse Broad							X		
Martham Broad North	X	X	X	X	X	X	X	X	X
Martham Broad South	X	X	X	X	X	X	X	X	X
Mautby Decoy			X						
Norton's Broad			X						X
Oulton Broad			X						
Pound End		X					X		X
Ranworth Broad	X	X		X		X	X	X	
Reedham Water									
Rockland Broad	X	X	X	X	X	X	X	X	X

Broad	2014	2015	2016	2017	2018	2019	2020	2021	2022
Round Water Broad			X						X
Salhouse Great Broad									X
Sotshole Broad			X						
Sprat's Water			X						X
Strumpshaw broad		X			X			X	
Upton Broad	X	X	X	X	X	X	X	X	X
Upton Little Broad	X		X		X				X
Wheatfen Broad & Channels		X			X			X	
Whitlingham Great Broad	X	X	X	X	X				
Whitlingham Little Broad		X	X	X	X	X			
Woolner's Carr			X						X
Wroxham Broad	X	X	X	X	X	X	X	X	X

Data processing

For each sample point, an abundance score for each species was calculated, derived from the data from the north and south throws;

$$\frac{\text{(Score from north + Score from south)}}{2}$$

The abundance score for each species was then totalled to produce an abundance score for each sample point. An overall mean abundance for each species for the whole broad was then calculated by summing the scores from each sample point and dividing by the number of sample points. The overall mean abundance score for each species was then added together to give the overall total abundance score for the broad. Assuming maximum plant abundance on the site, the site abundance score should have a maximum of 100 (± 10%).

The water plants present in the surveys were also categorised into groups, such as stoneworts or macro-algae, and abundance scores were calculated for each group in each broad, as described above. The water plant groups and the species within them are presented in Appendix I.

Results

Section 41 Species

Species “of principal importance for the purpose of conserving biodiversity” covered under Section 41 (England) of the NERC Act (2006). These species need to be taken into consideration by a public body when performing any of its functions.

Table 2

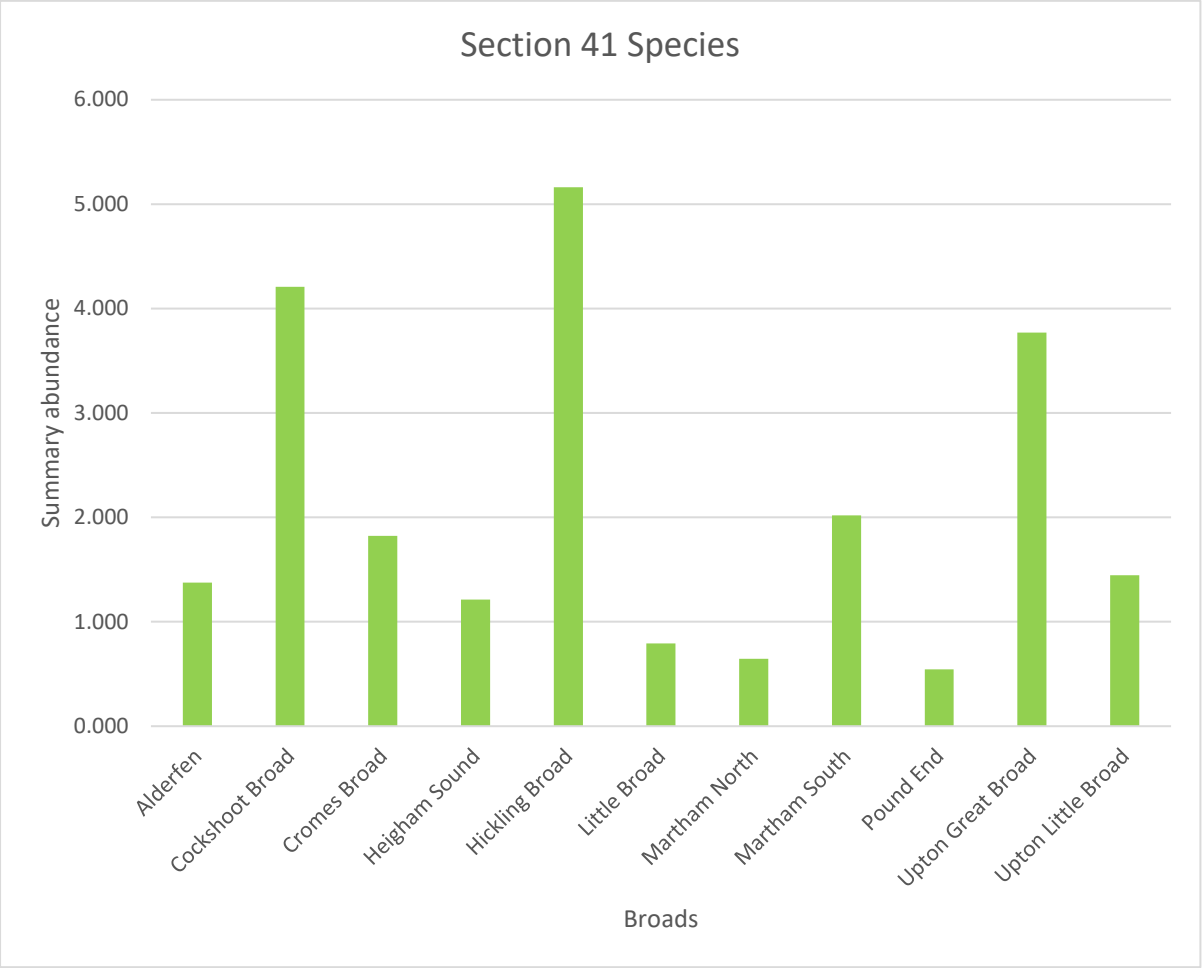
Ten Broads were found to have Section 41 species in 2022.

Species	**Broads**
Holly-leaved naiad- *Najas marina*	Alderfen Broad, Cockshoot Broad, Cromes Broad, Heigham Sound, Hickling Broad, Little Broad, Martham South, Martham North, Pound End, Upton Great Broad, Upton Little Broad
Baltic stonewort - *Chara baltica*	Cockshoot Broad, Heigham Sound, Hickling Broad, Martham North, Martham South
Intermediate stonewort - *Chara intermedia*	Heigham Sound, Hickling Broad, Martham North, Martham South, Upton Little
Convergent stonewort - Chara connivens	Heigham Sound, Hickling Broad, Martham South, Upton Great Broad
Starry stonewort *Nitellopsis obtusa*	Heigham Sound, Hickling Broad, Martham South

As can be seen from this table the broads in the Thurne are an important site for Section 41 species. In 2022, Holly-leaved naiad was recorded for the first time in Little Broad. Holly-leaved naiad saw some higher abundance levels this year compared to 2021. Increases were seen in Alderfen, Cromes Broad, Hickling and Pound End. In the Martham Broads, the overall abundance levels stayed similar to previous years.

Graph 1

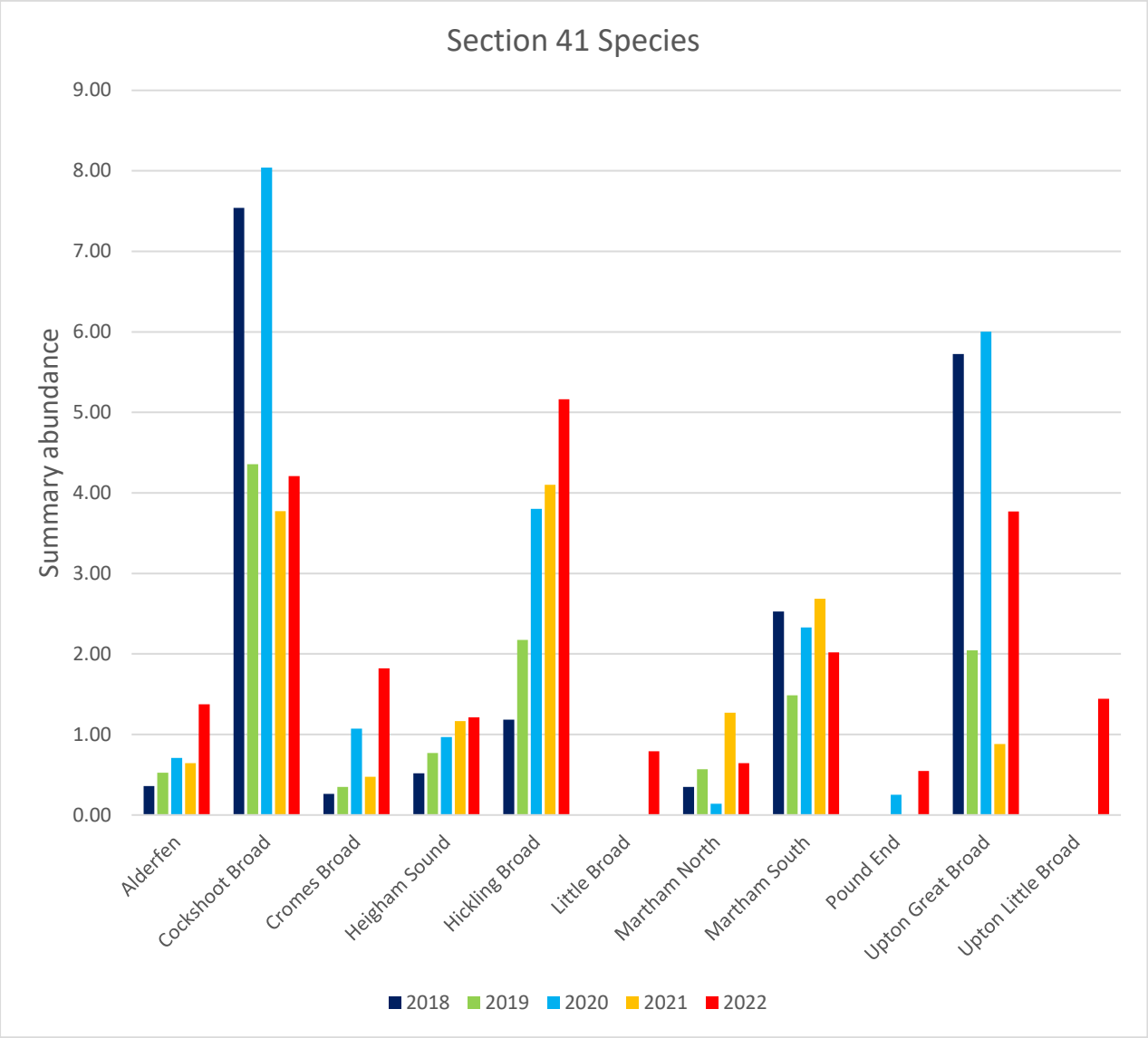
2022 abundance scores for Broads with Section 41 species



NB: Summary abundance axis usually sees ranges up to 10 in score, but to show the smaller values for section 41 species the axis has been reduced for this graph.

Graph 2

Section 41 species abundance between 2018 - 2022



Holly-leaved naiad abundance increased in many broads in 2022 which is reflected in the corresponding areas most prolific with the plant, Cockshoot Broad and Upton Great Broad. The Broads more dominant with stoneworts in the Upper Thurne Valley actually saw increases in the overall section 41 species this year. See main results for more details. There was also a first appearance for Holly-leaved naiad in Little Broad.

Table 3

Holly-leaved naiad distribution.

Broad	2020 Number of Points with Holly-leaved naiad	2020 Summary abundance	2021 Number of Points with Holly-leaved naiad	2021 Summary abundance	2022 Number of Points with Holly-leaved naiad	2022 Summary abundance
Alderfen	30/48	0.708	19/48	0.646	34/48	1.375
Cockshoot	47/48	7.958	36/48	3.773	44/48	4.167
Cromes	31/40	1.074	18/42	0.476	26/44	1.823
Heigham	2/66	0.045	2/66	0.030	4/66	0.061
Hickling	11/80	0.213	5/80	0.075	18/80	0.475
Martham North	/	/	10/52	0.231	7/48	0.146
Martham South	17/54	0.356	24/54	0.796	14/50	0.600
Upton	44/48	6.002	18/42	0.883	44/48	3.729
Little Broad	/	/	/	/	20/28	0.793
Pound End	11/44	0.250	/	/	8/44	0.545
Upton Little	/	/	/	/	6/36	0.250

Alderfen Broad has recorded a significant increase in Holly-leaved naiad, even though overall, the broad has seen a decrease in summary abundance. Cockshoot and Upton Great have increased following a poor year in 2021, however, abundance is not as high as seen in previous years. Increases in Hickling, Heigham and Pound End are notable and Little Broad recorded its first sighting of Holly-leave naiad which is encouraging.

Main Survey Results

The data collected from each broad is presented as species richness (the number of species recorded) and abundance (the amounts of each species recorded) according to the point survey and scoring method (outlined in Section 2.2).

The results tables also illustrate the number of points at which each species was recorded, giving an indication of the frequency of occurrence.

Appendix 1 lists the common and Latin names for all plants found to date during water plant surveys in the Broads.

Thurne Valley

The Thurne valley broads contain two Annex I open water habitats and form a key part of the Broads Special Area of Conservation (SAC) designation. (Hard oligo-mesotrophic waters with benthic vegetation of stonewort species (3140), and Natural eutrophic lakes with Magnopotamion or Hydrocharition - type vegetation (3150)).

These bodies of water are a sanctuary for vulnerable and rare species which are stated in the Joint Nature Conservation Committee (JNCC) Red Data Book, including three vulnerable species: Baltic stonewort, Convergent stonewort and Starry stonewort, and one Rare species: Intermediate stonewort (Stewart and Church, 1992). They also provide a safe haven for the rare Holly-leaved naiad, which is a Section 41 priority species, as well as more common vascular plants such as Spiked water milfoil and Mare's tail.

2022 Summary

This year there has been an assortment of results with increases, decreases and some broads remaining stable. Hickling and Heigham have increased in their overall abundances and they are the highest seen in the last 9 years. Martham North decreased in abundance and Martham South stayed very similar in abundance levels. Horsey saw an increase this year, back to a high only seen in 2019. The high variability of plant abundance between years highlights the importance of surveys carried out frequently and looking across multiple years to establish trends. Horsey Mere continues to show low macrophyte levels compared to the other broads in the Thurne Valley.

Heigham Sound

Table 4

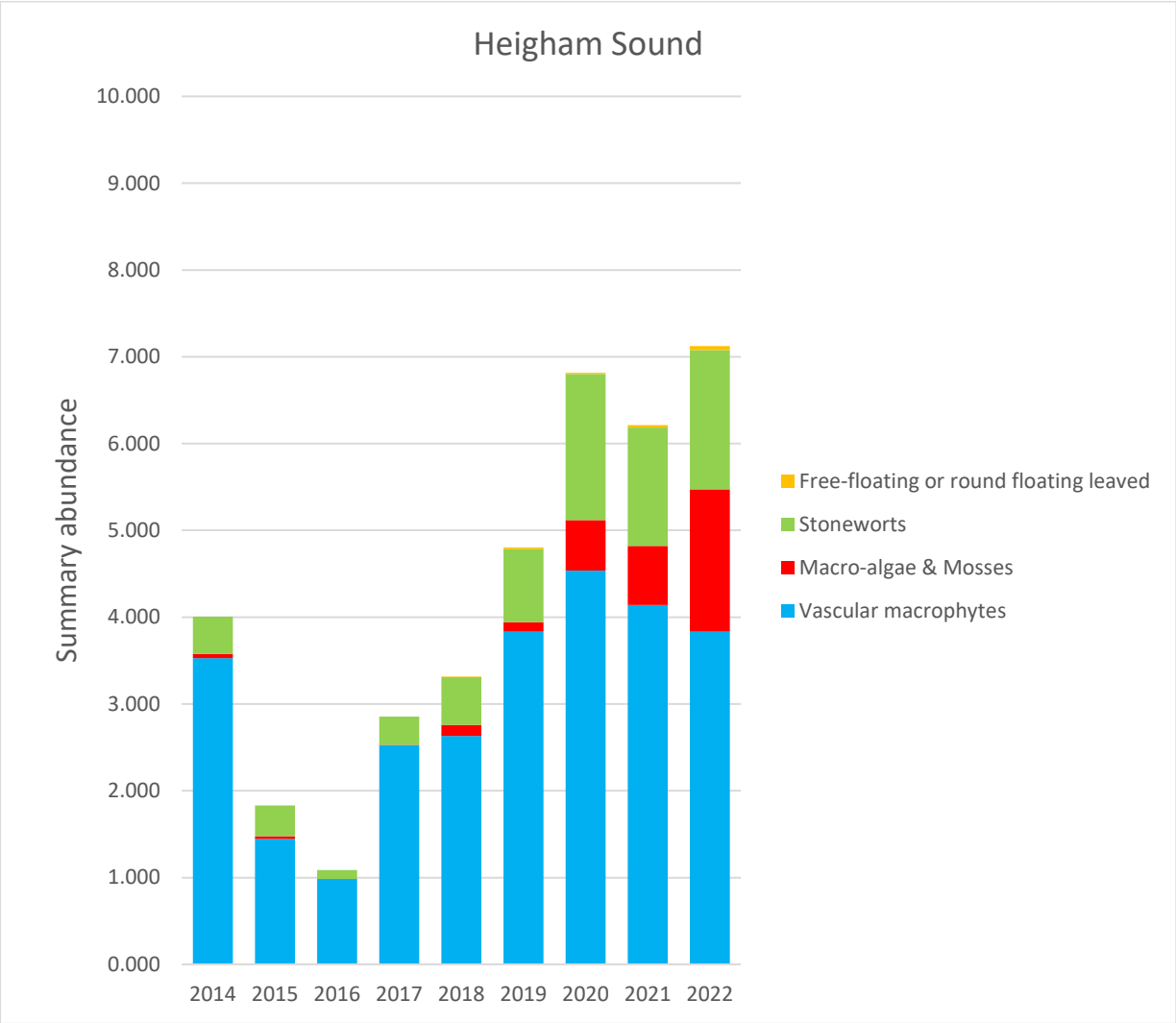
Common Name	Scientific Name	Summary Abundance	Occurrences
Filamentous algae	*Zygnematales*	1.638	29
Spiked water milfoil	*Myriophyllum spicatum*	1.000	48
Intermediate stonewort	*Chara intermedia*	0.818	16
Mare's tail	*Hippuris vulgaris*	0.727	21
Rigid hornwort	*Ceratophyllum demersum*	0.500	19
Bristly stonewort	*Chara hispida*	0.409	9
Nuttall's waterweed	*Elodea nuttallii*	0.409	17
Curled pondweed	*Potamogeton crispus*	0.364	16
Shining pondweed	*Potamogeton lucens*	0.348	5
Canadian waterweed	*Elodea canadensis*	0.258	9
Starry stonewort	*Nitellopsis obtusa*	0.167	6
Baltic stonewort	*Chara baltica*	0.121	3
Starwort species	*Callitriche sp*	0.076	5
Holly-leaved naiad	*Najas marina*	0.061	4
Convergent stonewort	*Chara connivens*	0.045	3
Fragile/convergent stonewort	*Chara globularis/connivens*	0.045	2
Fan-leaved water crowfoot	*Ranunculus circinatus*	0.045	3
Yellow water lily	*Nuphar lutea*	0.030	1
Perfoliate pondweed	*Potamogeton perfoliatus*	0.030	2
Ivy-leaved duckweed	*Lemna trisulca*	0.015	1
Whorled water milfoil	*Myriophyllum verticillatum*	0.015	1
No Plants	No plants	0.000	5
Total number of species recorded		**21**	**Total samples taken: 66**

This year has seen an increase for Heigham Sound, with the highest abundance recorded in the last 9 years and similar to 2020 levels. Species numbers also increased from 18 to 21. Filamentous algae increased from 0.682 to 1.638 with occurrences increasing from 20 to 29. Spiked water milfoil decreased 1.576 to 1.00, while Intermediate stonewort stayed the same

but increased in occurrences from 13 to 16. Bristly stonewort and Baltic stonewort increased along with Curled pondweed and Holly-leaved naiad.

Graph 3

Heigham Sound summary abundance shown in plant groups (see Appendix 1 for more detail)



Hickling Broad

Table 5

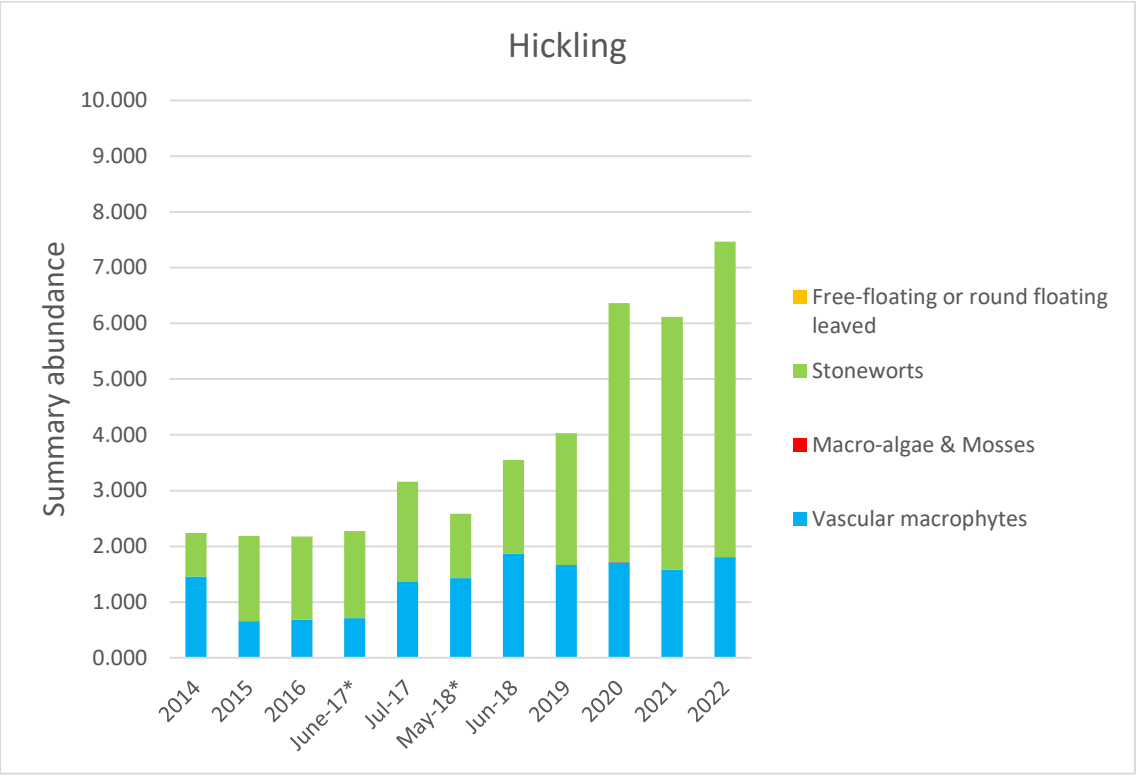
Common Name	Scientific Name	Summary Abundance	Occurrences
Intermediate stonewort	*Chara intermedia*	3.775	55
Spiked water milfoil	*Myriophyllum spicatum*	1.039	45
Baltic stonewort	*Chara baltica*	0.825	37
Bristly stonewort	*Chara hispida*	0.525	22
Holly-leaved naiad	*Najas marina*	0.475	18
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.413	27
Hedgehog stonewort	*Chara aculeolata*	0.238	2
Intermediate water-starwort	*Callitriche stagnalis*	0.175	4
Rough stonewort	*Chara aspera*	0.150	10
Convergent stonewort	*Chara connivens*	0.075	5
Whorled water milfoil	*Myriophyllum verticillatum*	0.063	4
Fragile/convergent stonewort	*Chara globularis/connivens*	0.050	4
Mare's tail	*Hippuris vulgaris*	0.025	1
Filamentous algae	*Zygnematales*	0.013	1
Starry stonewort	*Nitellopsis obtusa*	0.013	1
Curled pondweed	*Potamogeton crispus*	0.013	1
Lesser bearded stonewort	*Chara curta*	0.013	1
Stonewort (Chara) species	*Chara sp.*	0.004	3
Shining pondweed	*Potamogeton lucens*	0.001	1
No plants	*No plants*	0.000	1
Total number of species recorded		**19**	**Total samples taken: 80**

This year the summary abundance increased from 6.116 to 7.456 and there were six dominant species compared with four in 2021. Intermediate stonewort is the most dominant stonewort with other Stonewort (*Chara*) species this year having less dominance but still recording increases in abundance. There were 14 species found last year compared with 19 this year and only one survey point with no plants. The vascular macrophytes

increased slightly this year and only one occurrence of filamentous algae was seen. Holly-leaved naiad increased from 0.075 with five occurrences to 0.475 with 18 occurrences.

Graph 4

Hickling Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Horsey Mere

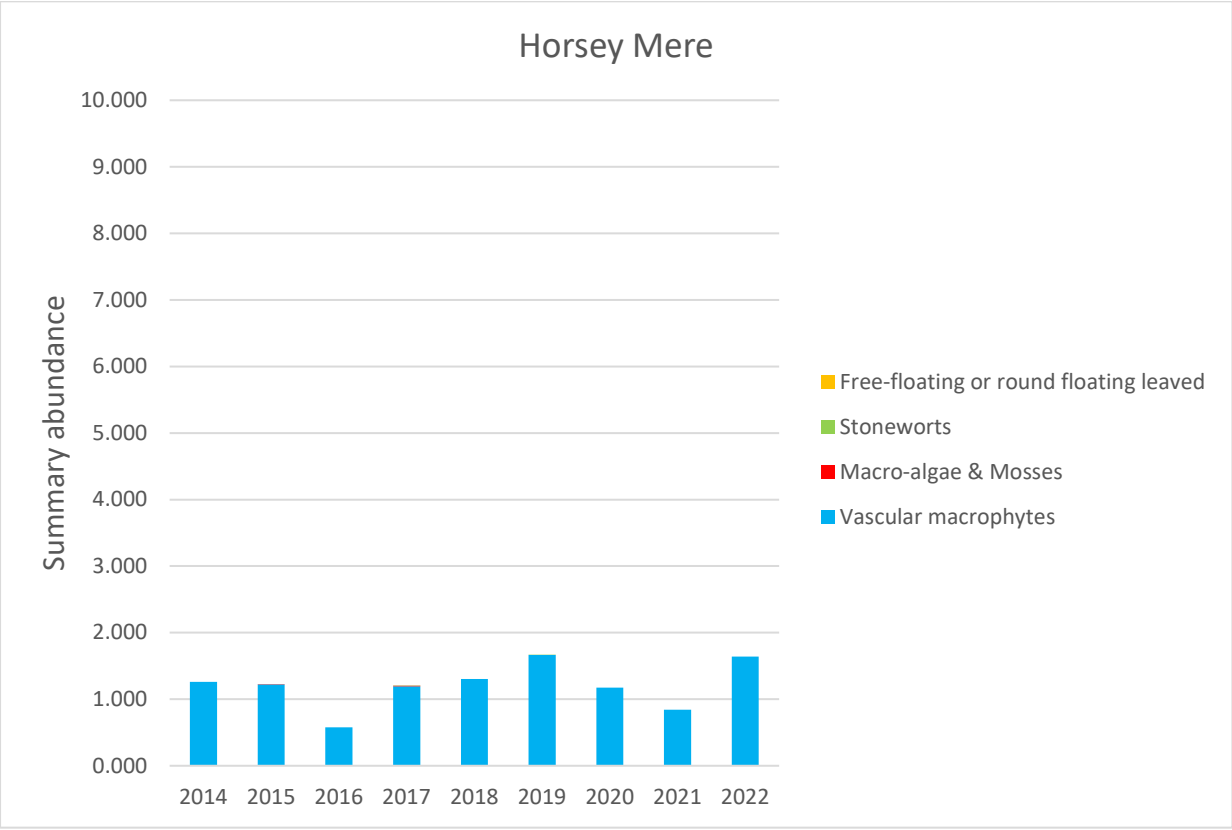
Table 6

Common Name	Scientific Name	Summary Abundance	Occurrences
Spiked water milfoil	*Myriophyllum spicatum*	1.291	29
Mare's tail	*Hippuris vulgaris*	0.333	11
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.015	1
No plants	*No plants*	0.000	37
Total number of species recorded		**3**	**Total samples taken: 66**

Species decreased from five to three this year. Spiked water milfoil increased in abundance from 0.294 to 1.291 and 20 to 29 occurrences. Mare's tail decreased in abundance from 0.486 to 0.333 and 17 to 11 occurrences. No plant occurrences were similar to last year.

Graph 5

Horsey Mere summary abundance shown in plant groups (see Appendix 1 for more detail)



Martham North

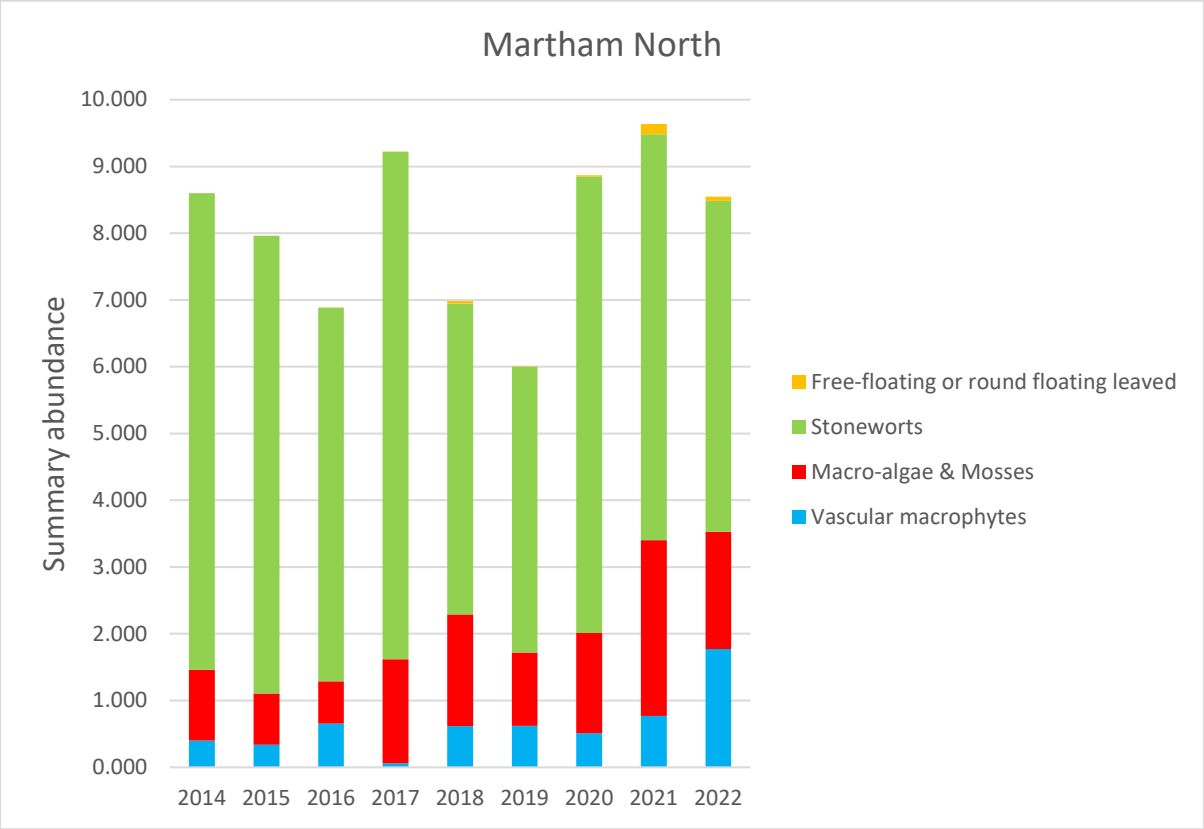
Table 7

Common Name	***Scientific Name***	**Summary Abundance**	**Occurrences**
Bristly stonewort	*Chara hispida*	4.458	36
Filamentous algae	*Zygnematales*	1.608	15
Fennel-leaved pondweed	*Potamogeton pectinatus*	1.396	19
Baltic stonewort	*Chara baltica*	0.271	8
Intermediate stonewort	*Chara intermedia*	0.229	6
Spiked water milfoil	*Myriophyllum spicatum*	0.188	1
Holly-leaved naiad	*Najas marina*	0.146	7
Common water moss	*Fontinalis antipyretica*	0.146	7
Ivy-leaved duckweed	Lemna trisulca	0.063	3
Canadian waterweed	Elodea canadensis	0.021	1
Whorled water milfoil	Myriophyllum verticillatum	0.021	1
Total number of species recorded		**11**	**Total samples taken: 48**

Species numbers decreased this year from 14 to 11. Decreases were seen in the abundance of Bristly stonewort and Filamentous algae with Bristly stonewort recording a decrease from 5.038 to 4.458. Interestingly, the southern end of the broad was difficult to access due to the large amount of Filamentous algae although this isn't reflected in the overall abundance drop from 2.519 to 1.608. Fennel-leaved pondweed and Baltic stonewort also saw a slight decrease. Despite individual decreases, overall, vascular macrophytes recorded an increase in summary abundance.

Graph 6

Martham North Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Martham South

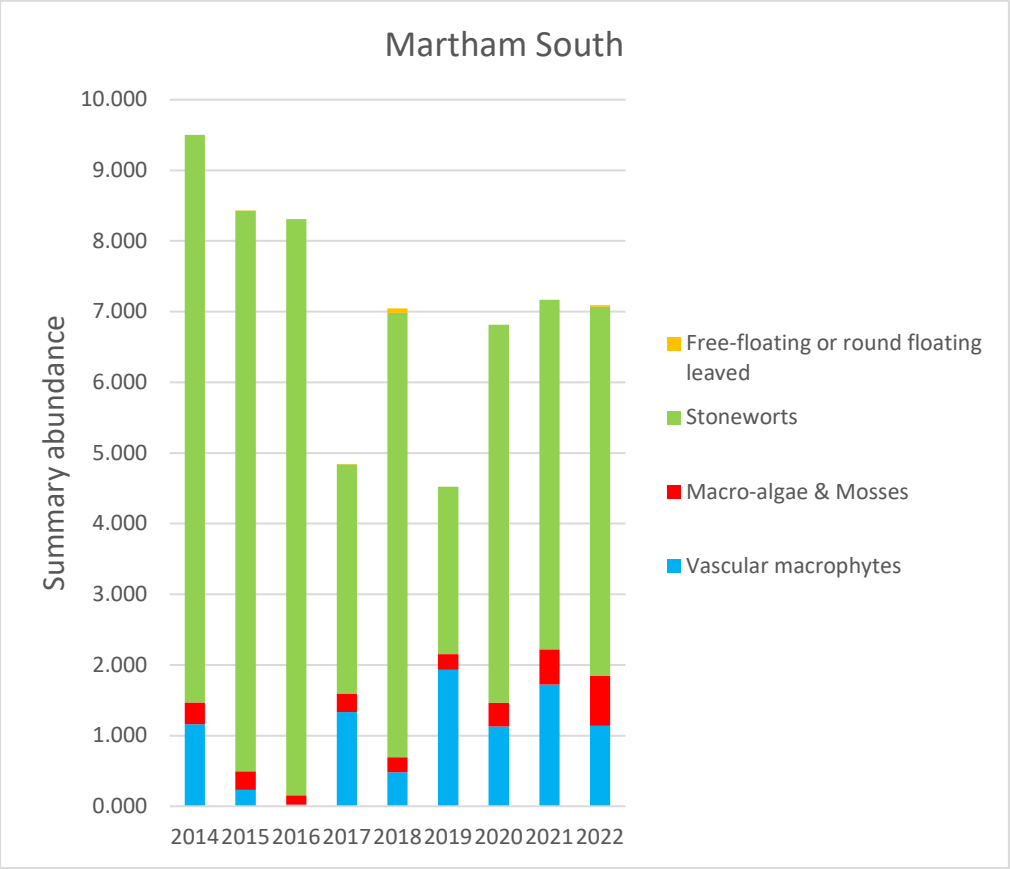
Table 8

Common Name	Scientific Name	Summary Abundance	Occurrences
Bristly stonewort	*Chara hispida*	3.540	32
Intermediate stonewort	*Chara intermedia*	0.680	16
Filamentous algae	*Zygnematales*	0.650	33
Holly-leaved naiad	*Najas marina*	0.600	14
Baltic stonewort	*Chara baltica*	0.560	15
Spiked water milfoil	*Myriophyllum spicatum*	0.340	15
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.280	5
Hedgehog stonewort	*Chara aculeolata*	0.200	1
Mare's tail	*Hippuris vulgaris*	0.180	5
Starry stonewort	*Nitellopsis obtusa*	0.160	8
Common water moss	*Fontinalis antipyretica*	0.060	3
Rough stonewort	*Chara aspera*	0.040	2
Delicate stonewort	*Chara virgata*	0.020	1
Ivy-leaved duckweed	*Lemna trisulca*	0.020	1
Convergent stonewort	*Chara connivens*	0.020	1
Willow-leaved pondweed	*Potamogeton x salicifolius*	0.020	1
Total number of species recorded		**16**	**Total samples taken: 50**

Martham South Broad has not seen much change this year. Bristly stonewort, Filamentous algae, Baltic stonewort and Spiked water milfoil all recorded increases in abundance. Overall, the proportion of vascular macrophytes decreased whereas stoneworts increased slightly. Stoneworts decreased in species number from 10 to 8 from 2021 but the abundance increased. Two points were not accessible this year due to low water levels and high plant growth. These points are likely to have had stoneworts present.

Graph 7

Martham South Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Ant Valley

In the Ant Valley, Alderfen, Cromes and Barton Broad were some of the first broads to be surveyed, starting in 1983 and have been regularly surveyed since. These water bodies have been subject to extensive restoration effort over the last 25 years and have all experienced improvements to water quality.

2022 Summary

2022 has seen Alderfen decrease in overall abundance whereas Barton and Cromes have increased.

Alderfen

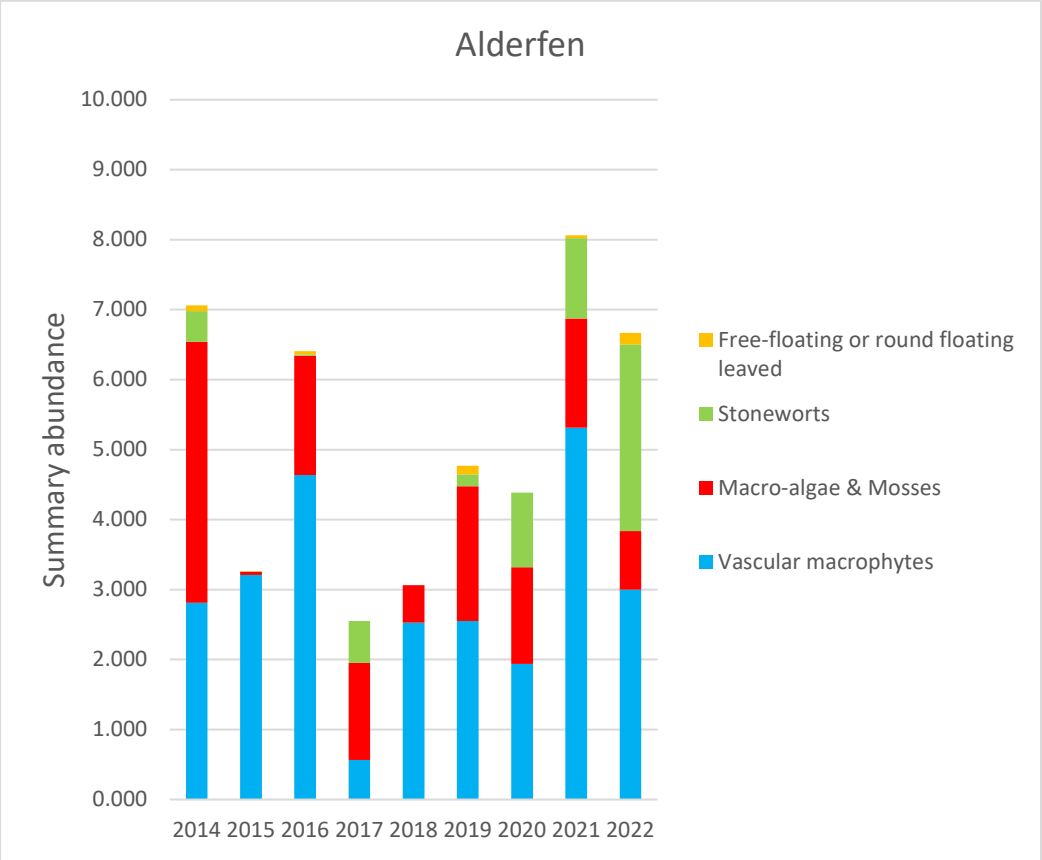
Table 9

Common Name	**Scientific Name**	**Summary Abundance**	**Occurrences**
Delicate stonewort	*Chara virgata*	2.667	27
Rigid hornwort	*Ceratophyllum demersum*	1.625	37
Holly-leaved naiad	*Najas marina*	1.375	34
Filamentous algae	*Zygnematales*	0.752	18
Ivy-leaved duckweed	*Lemna trisulca*	0.167	8
Jelly algae	*Nostoc*	0.063	3
Enteromorpha	*Enteromorpha*	0.021	1
No plants	*No plants*	0.000	2
Total number of species recorded		**10**	**Total samples taken: 48**

Alderfen has seen an overall decrease in summary abundance this year although water levels were very low. Delicate stonewort increased (1.085 to 2.667) along with Holly-leaved naiad, whereas Rigid hornwort and Filamentous algae decreased. The decrease in Rigid hornwort accounts for the overall drop in the vascular plant group and the increase in Delicate stonewort accounts for the up-turn in stoneworts. In addition, it is encouraging to see macro-algae and mosses decreasing. The overall species count increased from 8 to 10 this year and jelly algae was seen at three points.

Graph 8

Alderfen Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Barton Broad

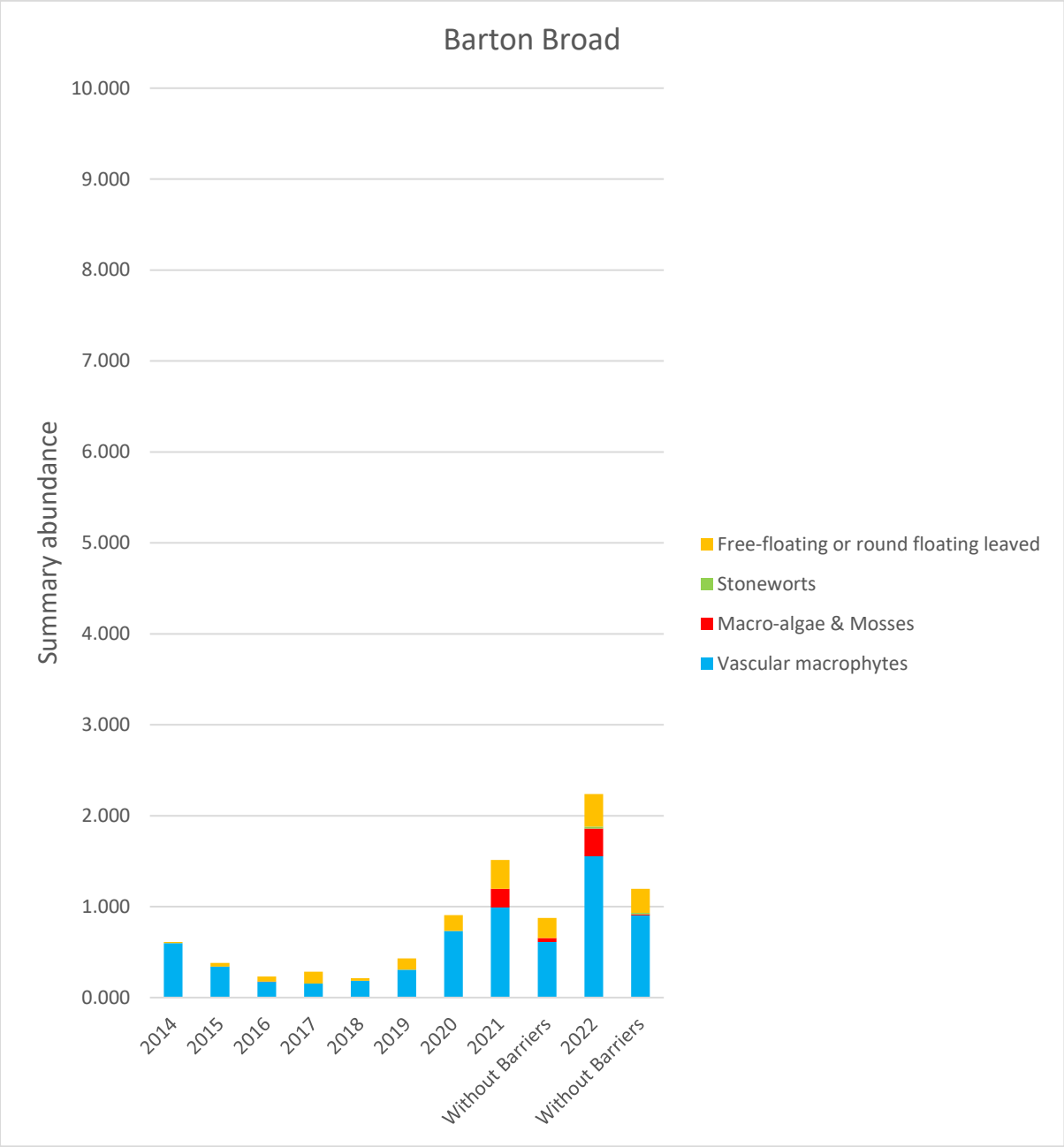
Table 10

Common Name	**Scientific Name**	**Summary Abundance**	**Occurrences**
Rigid hornwort	*Ceratophyllum demersum*	1.011	30
Nuttall's waterweed	*Elodea nuttallii*	0.359	15
Filamentous algae	*Zygnematales*	0.304	5
Yellow water lily	*Nuphar lutea*	0.217	7
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.163	15
Ivy-leaved duckweed	*Lemna trisulca*	0.054	2
White water lily	*Nymphaea alba*	0.054	1
Fragile/convergent stonewort	*Chara globularis/connivens*	0.022	2
Canadian waterweed	*Elodea canadensis*	0.011	1
Common duckweed	*Lemna minor*	0.011	1
Frogbit	*Hydrocharis morsus-ranae*	0.011	1
Shining pondweed	*Potamogeton lucens*	0.011	1
Greater duckweed	*Spirodela polyrhiza*	0.011	1
No plants	No plants	0.000	53
Total number of species recorded		**13**	**Total samples taken 72**

Barton Broad recorded all four major plant groups this year. Four freshwater mussel species were observed including duck, swan, painters and zebra mussels. Water crowfoot and Frogbit were also observed along with freshwater sponge. The increase seen this year can mostly be attributed to the plant growth found in the fish barriers which were installed in 2019. One of the barriers had clear water and there were 7 more plant species found this year than in 2020. The plants were found in the shallower areas and nearer the edges around the Broad. The species abundance level is the highest seen since the new survey method commenced, despite there also being 53 survey points with zero no plants. The graph shows the 2022 plant data with and without the survey points that are located within the barriers. The barriers were installed in 2019 after the plant survey was undertaken and in 2020, only outside the barriers was surveyed due to Covid limitations.

Graph 9

Barton Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Cromes Broad

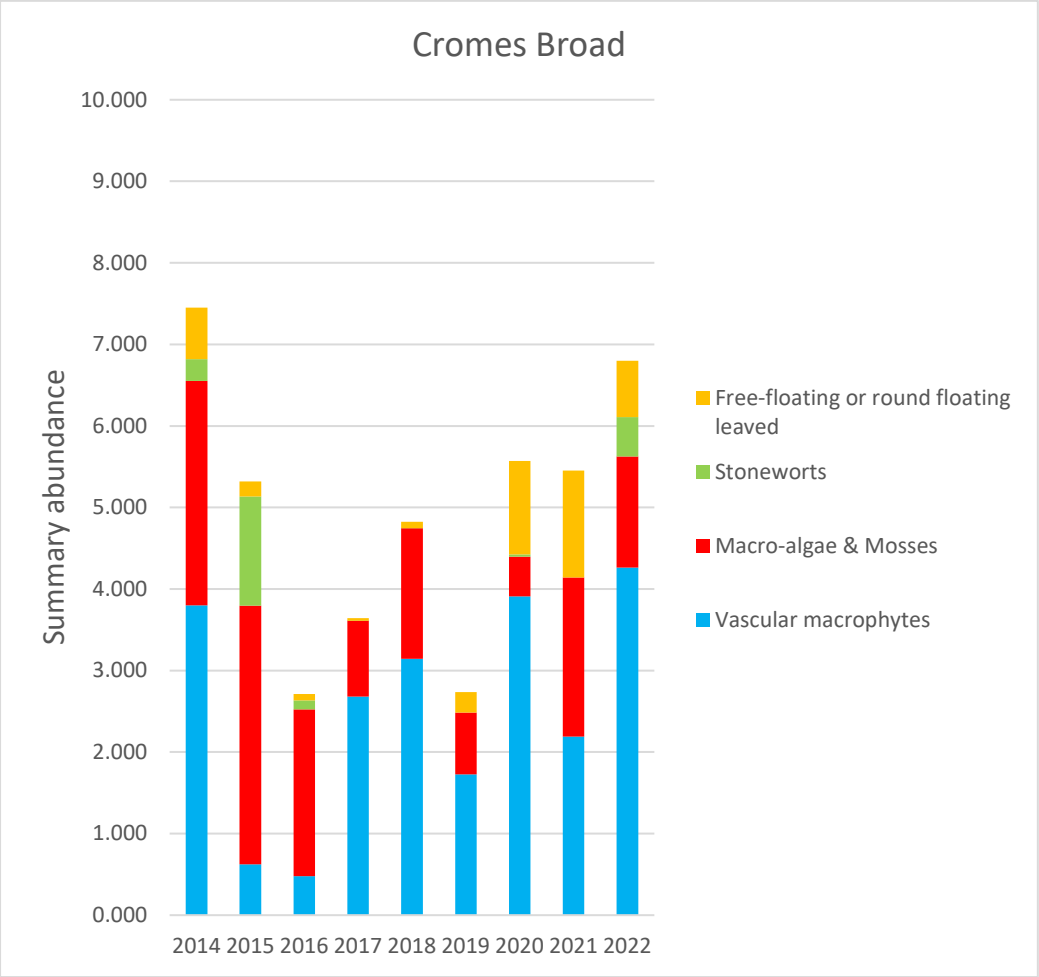
Table 11

Common Name	**Scientific Name**	**Summary Abundance**	**Occurrences**
Rigid hornwort	*Ceratophyllum demersum*	2.186	33
Holly-leaved naiad	*Najas marina*	1.823	26
Filamentous algae	*Zygnematales*	1.364	29
Delicate stonewort	*Chara virgata*	0.482	15
White water lily	*Nymphaea alba*	0.409	5
Bladderwort	*Utricularia vulgaris*	0.205	6
Yellow water lily	*Nuphar lutea*	0.182	1
Ivy-leaved duckweed	*Lemna trisulca*	0.045	2
Lesser reedmace	*Typha angustifolia*	0.045	1
Least duckweed	*Lemna minuta*	0.025	2
Common duckweed	*Lemna minor*	0.023	1
Greater duckweed	*Spirodela polyrhiza*	0.007	3
Jelly algae	*Nostoc*	0.005	2
Horned pondweed	*Zannichellia palustris*	0.002	1
No plants	No plants	0.000	1
Total number of species recorded		**16**	**Total samples taken: 44**

There was a noticeable increase in vascular plants this year mostly due to Rigid hornwort and Holly-leaved naiad. Rigid hornwort decreased in occurrences from 39 to 33, however, abundance went from 1.619 to 2.186. Holly-leaved naiad abundance increased from 0.476 to 1.823 and also increased in occurrence by 8. Filamentous algae decreased along with White water lily with the decrease in the latter seemingly at odds with observations of more plant stands this year than before. Of particular note was the decrease in Filamentous algae and access across the broad was simpler than in other years. Delicate stonewort was picked up this year at 15 points; this is a species that has not been seen since 2015. Bladderwort was also seen in six spots and a swan mussel was also found during the survey.

Graph 10

Cromes Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Bure Valley

In recent years Upton and Cockshoot Broads, both isolated from the river, have been a stronghold for the rare Holly-leaved naiad. Conversely, those broads directly connected to the river, such as Wroxham and Hoveton Great, have tended to have minimal plant diversity. However this year, all the broads connected to the Bure River (which we have past data for) have seen an increase in summary abundance..

Belaugh Broad

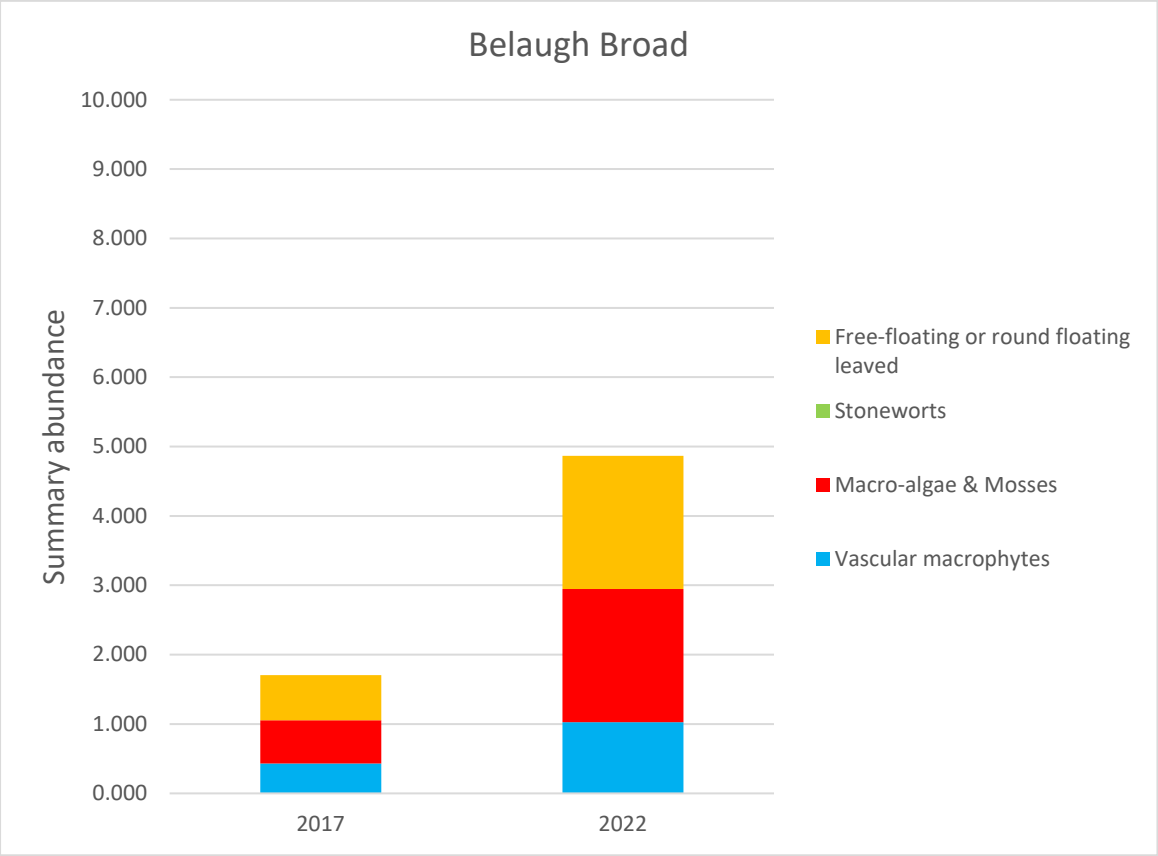
Table 12

Common Name	**Scientific Name**	**Summary Abundance**	**Occurrences**
Filamentous algae	*Zygnematales*	1.919	24
Rigid hornwort	*Ceratophyllum demersum*	0.972	18
Yellow water lily	*Nuphar lutea*	0.919	14
White water lily	*Nymphaea alba*	0.778	5
Greater duckweed	*Spirodela polyrhiza*	0.139	5
Common duckweed	*Lemna minor*	0.056	2
Nuttall's waterweed	*Elodea nuttallii*	0.028	1
Frogbit	*Hydrocharis morsus-ranae*	0.028	1
Branched bur-reed	*Sparganium erectum*	0.028	1
Total number of species recorded		**9**	**Total samples taken: 36**

The four main species in recorded from this broad in 2017 are still present and in the same order of abundance, all of which also recording increases in abundance levels. Filamentous algae increased from 0.619 to 1.919 but decreased in occurrences from 33 to 24. Free floating or round floating leaves and macro algae and mosses increased more than vascular plants and there were plants found at all points of the survey. Species number increased from seven to nine.

Graph 11

Belaugh Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Burntfen

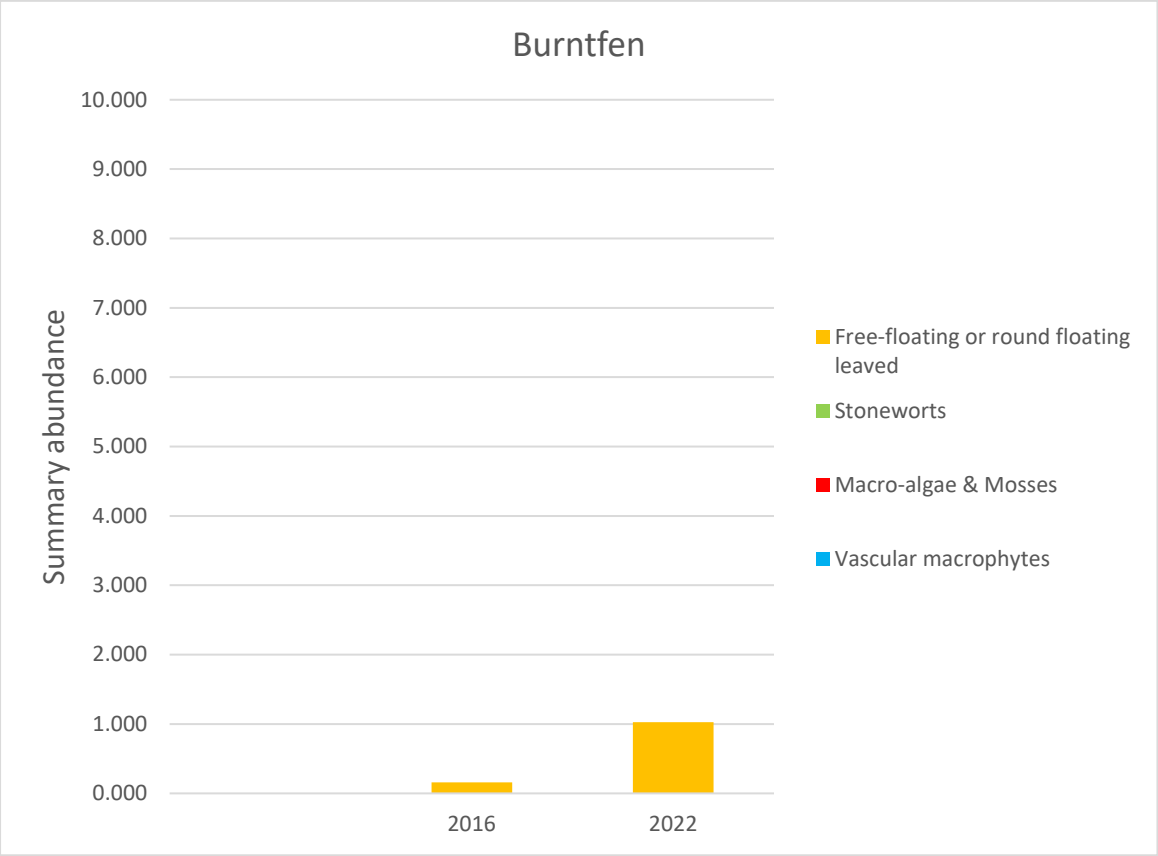
Table 13

Common Name	**Scientific Name**	**Summary Abundance**	**Occurrences**
Yellow water lily	*Nuphar lutea*	0.675	6
White water lily	*Nymphaea alba*	0.350	2
No plants	*No plants*	0	33
Total number of species recorded		**2**	**Total samples taken: 36**

A lovely isolated broad, however water lilies appear to be dominant and are the only plants which grow on the main water body. Both water lilies were also observed outside of the survey points.

Graph 12

Burntfen Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Cockshoot

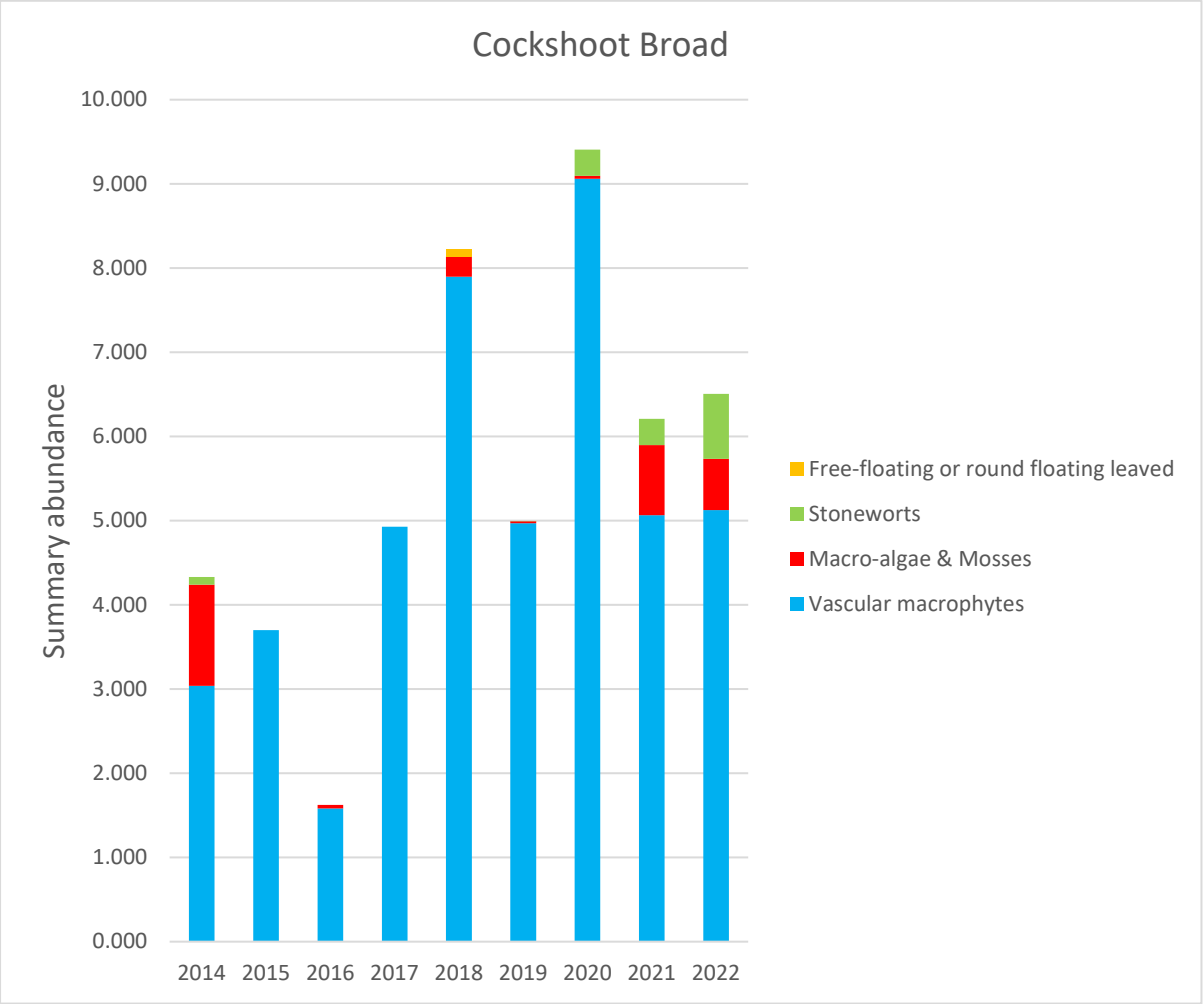
Table 14

Common Name	**Scientific Name**	**Summary Abundance**	**Occurrences**
Holly-leaved naiad	*Najas marina*	4.167	44
Rigid hornwort	*Ceratophyllum demersum*	0.917	35
Filamentous algae	*Zygnematales*	0.517	26
Common stonewort	*Chara vulgaris*	0.438	14
Fragile/convergent stonewort	*Chara globularis/connivens*	0.167	8
Delicate stonewort	*Chara virgata*	0.125	6
Enteromorpha	*Enteromorpha*	0.094	9
Baltic stonewort	*Chara baltica*	0.042	2
Canadian waterweed	*Elodea canadensis*	0.042	2
No plants	*No plants*	0.000	1
Total number of species recorded		**9**	**Total samples taken: 48**

This year has seen a some stability in plant abundance in the broad. Holly-leaved naiad increased from 3.773 to 4.167 and increased in occurrences from 36 to 44. Filamentous algae decreased from 0.708 to 0.517. Common stonewort also increased from 1 to 14 occurrences and overall stoneworts increased from 7 to 30 occurrences. Compared with 2017 when there were 2 species recorded it is good to see the diversity increasing within the broad.

Graph 13

Cockshoot Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Decoy Broad

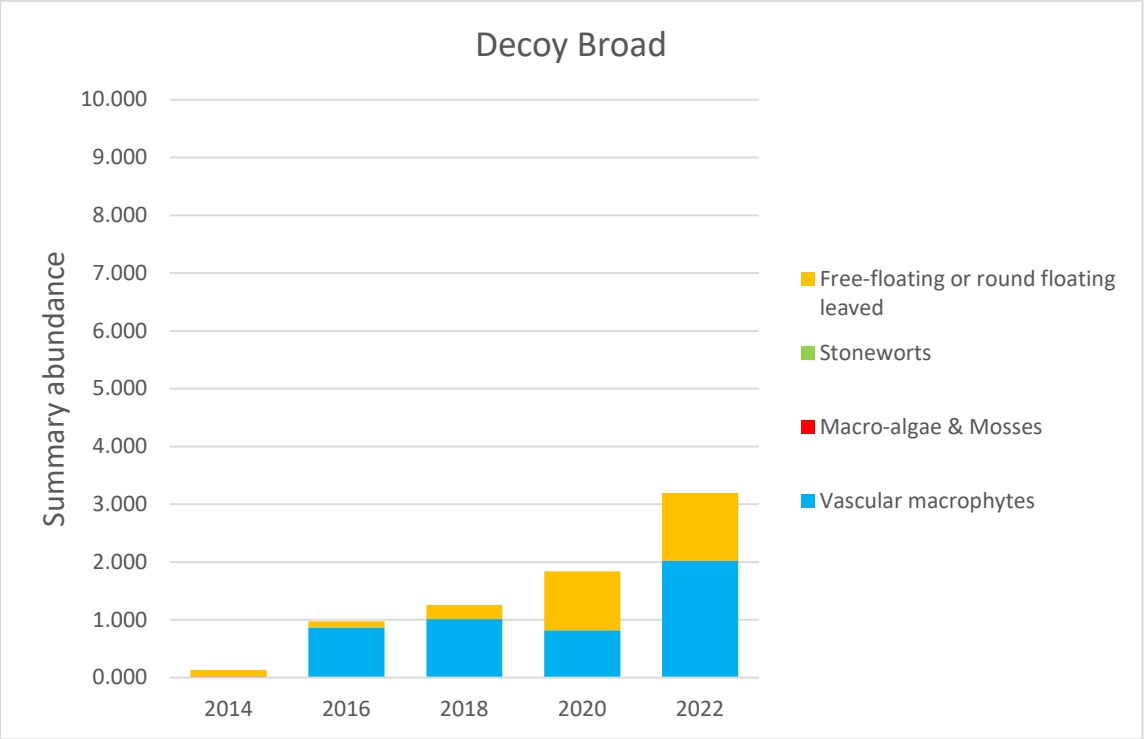
Table 15

Common Name	**Scientific Name**	**Summary Abundance**	**Occurrences**
Rigid hornwort	*Ceratophyllum demersum*	1.648	31
Yellow water lily	*Nuphar lutea*	1.167	16
Nuttall's waterweed	*Elodea nuttallii*	0.356	15
Fresh water sponge	*Spongillidae*	0.148	8
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.019	1
Filamentous algae	*Zygnematales*	0.006	3
No plants	*No plants*	0.00	21
Total number of species recorded		**9**	**Total samples taken: 54**

This year has been the best year to date for summary abundance in Decoy Broad. Vascular plants doubled in summary abundance and free floating or round floating leaved remained the same as 2 years ago. Three mussel species were present in the survey including Duck, Swan and Zebra mussel. Nuttall's waterweed increased from 2 occurrences to 15 this year.

Graph 14

Decoy Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Hoveton Great Broad

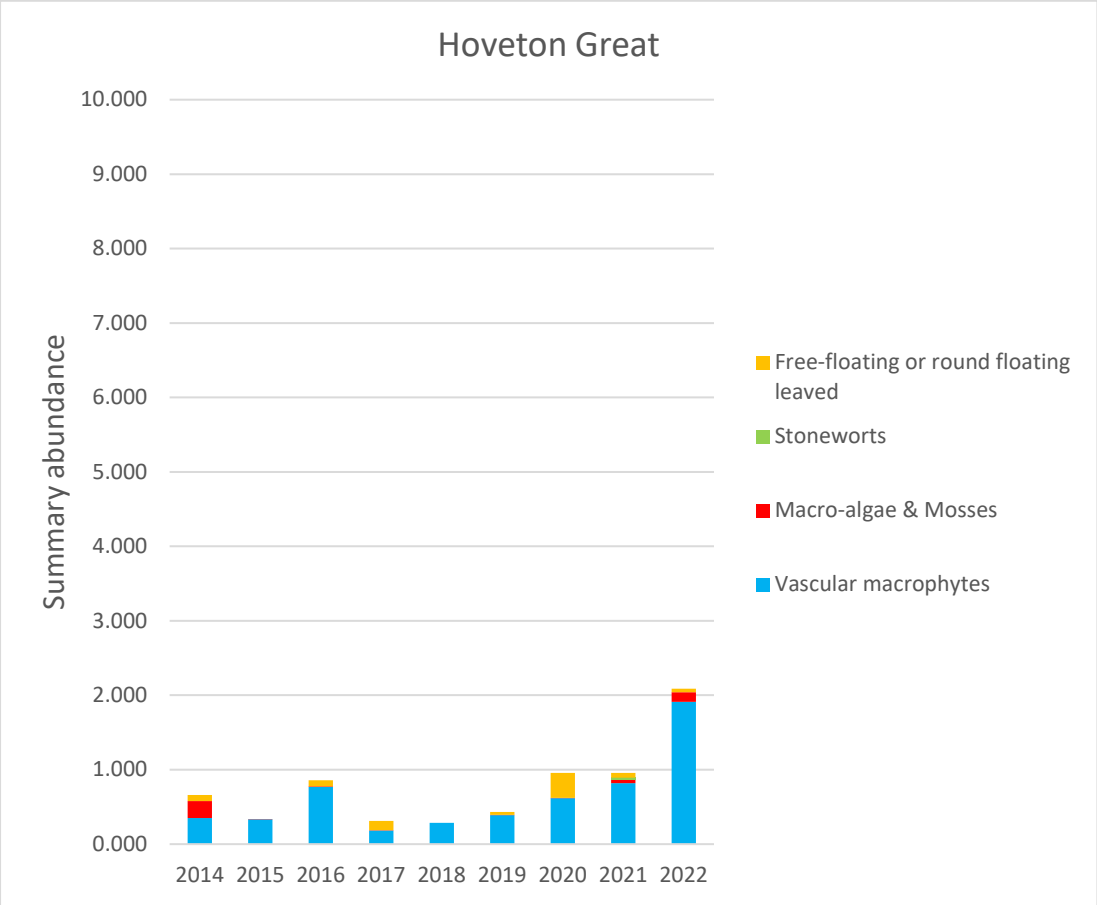
Table 16

Common Name	Scientific Name	Summary Abundance	Occurrences
Nuttall's waterweed	*Elodea nuttallii*	0.892	27
Rigid hornwort	*Ceratophyllum demersum*	0.659	38
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.173	10
Filamentous algae	*Zygnematales*	0.130	8
Yellow water lily	*Nuphar lutea*	0.109	2
Canadian waterweed	*Elodea canadensis*	0.063	4
Greater duckweed	*Spirodela polyrhiza*	0.031	2
Unbranched bur-reed	*Sparganium emersum*	0.016	1
Common duckweed	*Lemna minor*	0.016	1
No plants	*No plants*	0.000	20
Total number of species recorded		**14**	**Total samples taken: 64**

Vascular plants doubled this year with Nuttall's water weed and Rigid hornwort being the prominent species. This is the highest summary abundance seen in the last 9 years and follows the general improving trend of the broads connected to the River Bure. Four mussel species were found including Duck, Painters, Swan and Zebra throughout the survey and an Asiatic clam. Filamentous algae increased in abundance but decreased in occurrences. There are a few key places like the eastern edge of the Broad near one of the new reedbed installations which shows encouraging signs of plants establishing in the area. The edges are still where the plants are found the vast majority of the time and the centre points continue to remain plant free.

Graph 15

Hoveton Great Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Hudson's Bay

Table 17

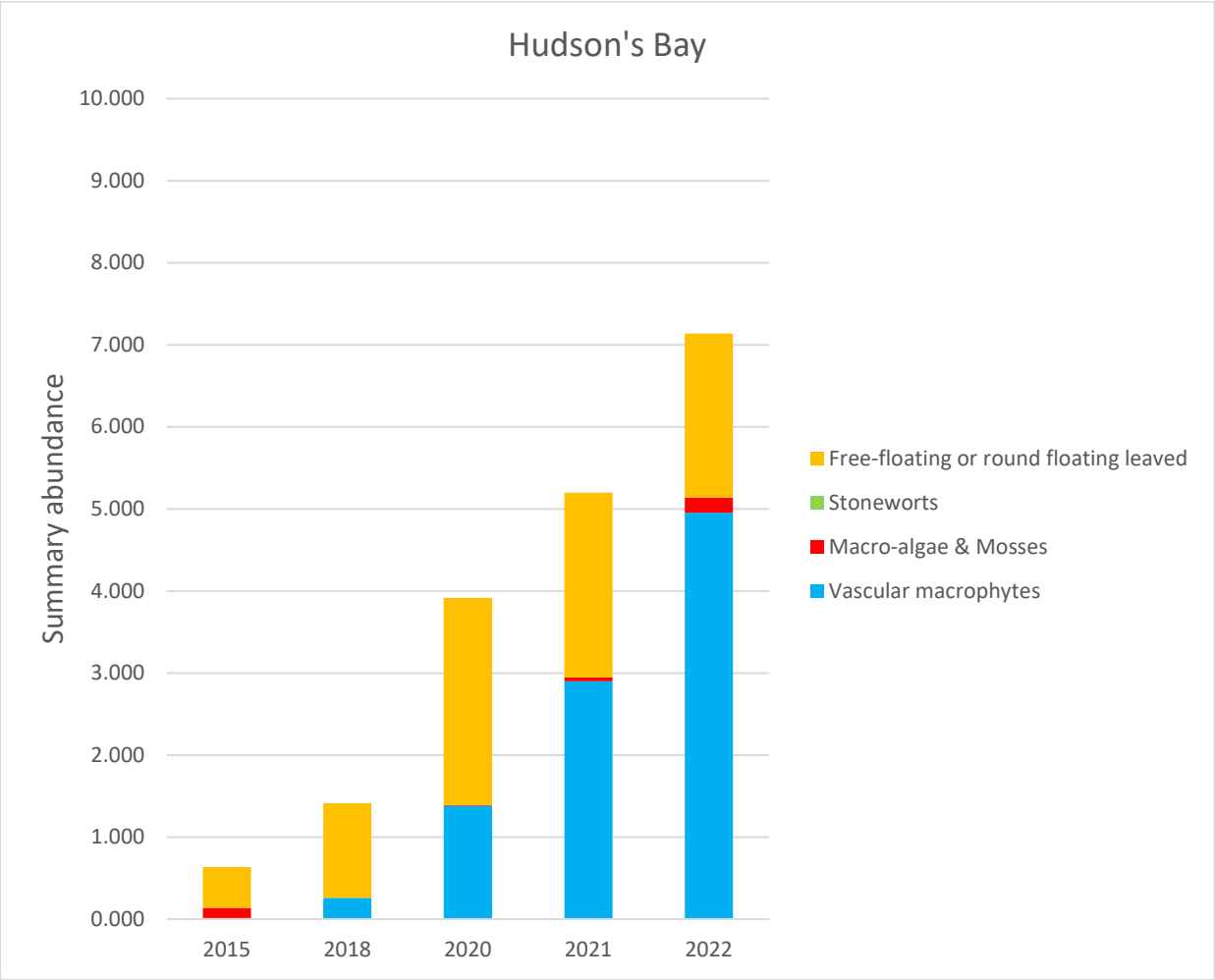
Common Name	Scientific Name	Summary Abundance	Occurrences
Rigid hornwort	*Ceratophyllum demersum*	4.953	39
Yellow water lily	*Nuphar lutea*	1.050	13
White water lily	*Nymphaea alba*	0.950	6
Filamentous algae	*Zygnematales*	0.183	17
Jelly algae	*Nostoc*	0.003	1
Total number of species recorded		**5**	**Total samples taken: 40**

Hudson's Bay has recorded another increase in 2022 with summary abundance from below one in 2015 to just above seven this year. Rigid hornwort and water lilies (yellow and white)

are the notable species for 2022. Rigid hornwort increased from 2.900 in summary abundance to 4.953 this year, which makes up the majority of the marked increase in vascular macrophytes. Four species of mussels were present in the survey including Duck, Painters, Swan and Zebra mussels. Freshwater sponge was also observed. There were plants at every survey point.

Graph 16

Hudson's Bay summary abundance shown in plant groups (see Appendix 1 for more detail)



Hoveton Little Broad

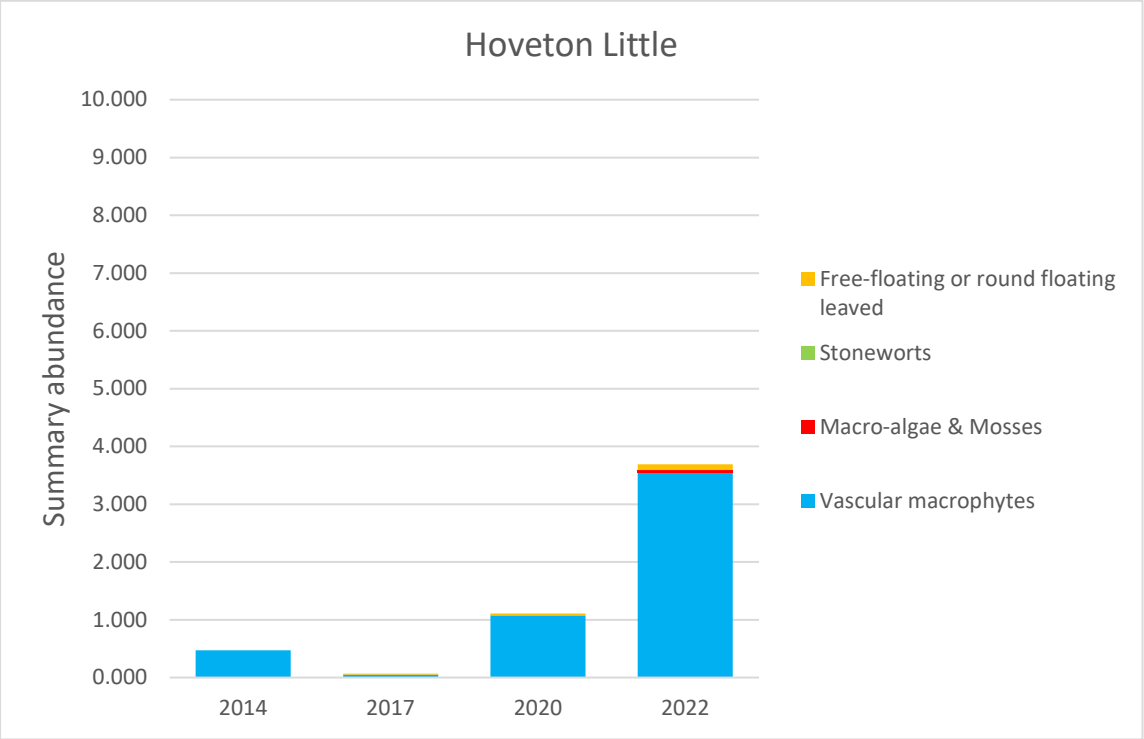
Table 18

Common Name	Scientific Name	Summary Abundance	Occurrences
Rigid hornwort	Ceratophyllum demersum	2.083	55
Fennel-leaved pondweed	Potamogeton pectinatus	0.952	35
Nuttall's waterweed	Elodea nuttallii	0.500	17
Yellow water lily	Nuphar lutea	0.100	4
Filamentous algae	Zygnematales	0.040	6
Spiked water milfoil	Myriophyllum spicatum	0.017	1
No plants	No plants	0.000	5
Total number of species recorded		**6**	**Total samples taken: 60**

This year has seen a great increase in Rigid hornwort with abundance going from 0.388 in 2021 to 2.083 this year. Fennel-leaved pondweed and Nuttall's waterweed were also among the main plants this year with Nuttall's waterweed featuring for the first time in 9 years alongside Filamentous algae.

Graph 17

Hoveton Little Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Little Broad

Table 19

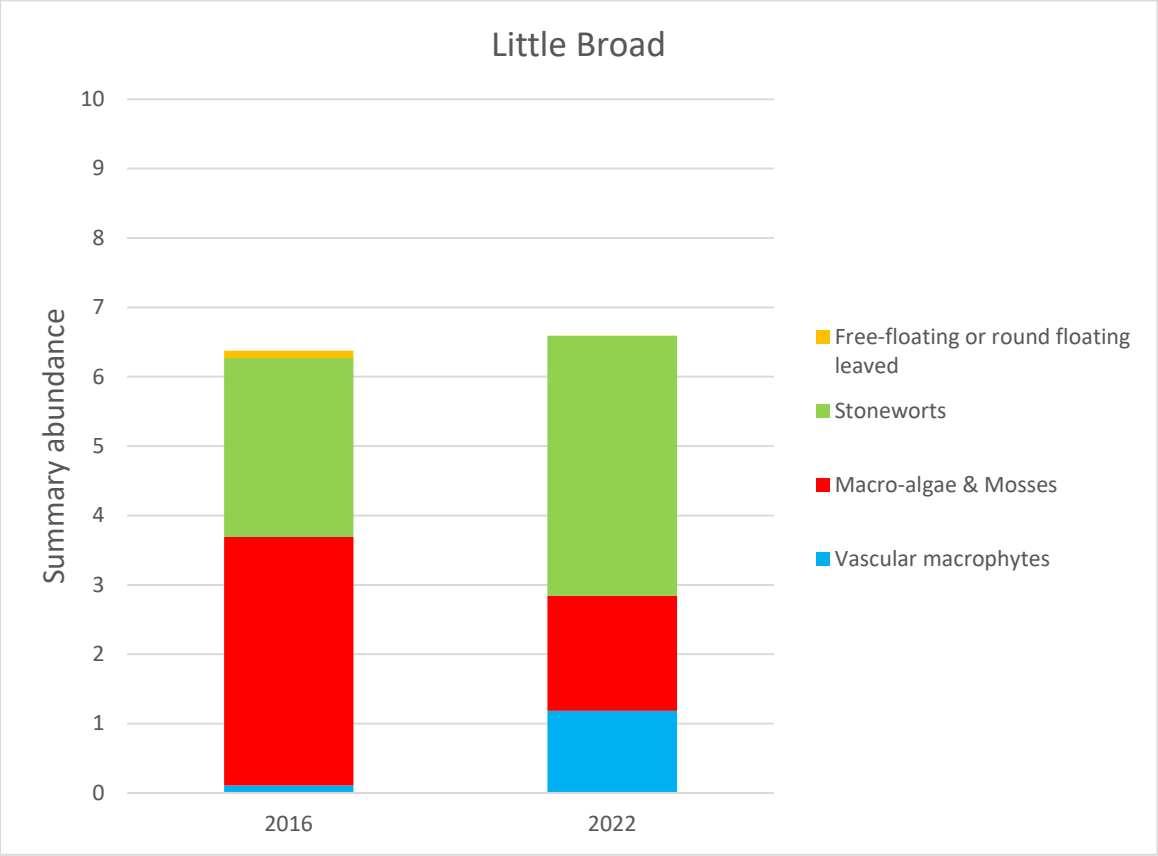
Common Name	**Scientific Name**	**Summary Abundance**	**Occurrences**
Bristly stonewort	*Chara hispida*	3.750	17
Filamentous algae	*Zygnematales*	1.654	19
Holly-leaved naiad	*Najas marina*	0.793	20
Bladderwort	*Utricularia vulgaris*	0.393	10
Fresh water sponge	*Spongillidae*	0.011	3
Ivy-leaved duckweed	*Lemna trisulca*	0.004	1
Total number of species recorded		**6**	**Total samples taken: 28**

Little Broad has summary abundance levels similar to 2016, however, instead of the broad being dominated by Macro-algae and mosses, stoneworts are more dominant. Vascular plants have also increased since the survey in 2016 and Holly-leaved naiad is now present

which has not been seen in the surveys since 2005. Bladderwort also increased in abundance from 0.107 in 2016 to 0.393.

Graph 18

Little Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Norton's Broad

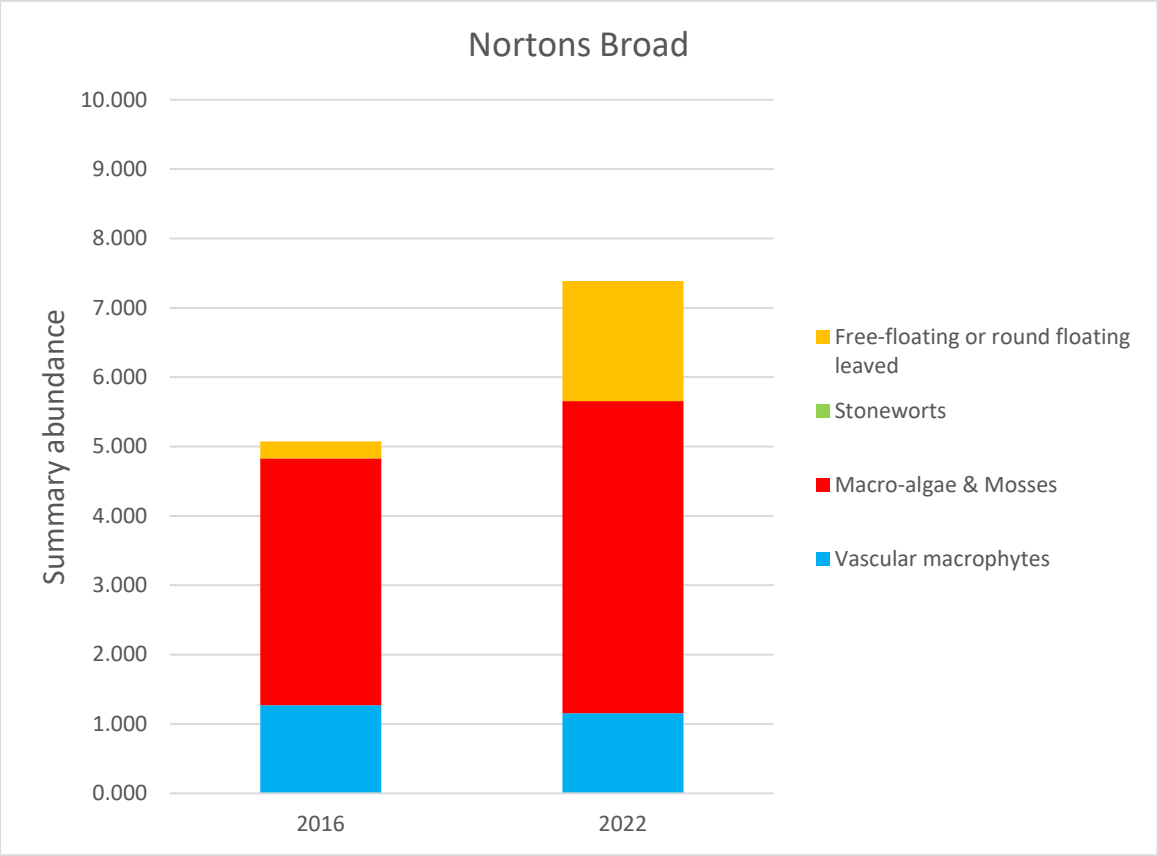
Table 20

Common Name	Scientific Name	Summary Abundance	Occurrences
Filamentous algae	*Zygnematales*	3.846	24
Rigid hornwort	*Ceratophyllum demersum*	0.731	15
Water net	*Hydrodictyon*	0.654	13
Frogbit	*Hydrocharis morsus-ranae*	0.654	4
Common duckweed	*Lemna minor*	0.577	15
Least duckweed	*Lemna minuta*	0.462	12
Canadian waterweed	*Elodea canadensis*	0.273	4
Nuttall's waterweed	*Elodea nuttallii*	0.115	3
Starwort species	*Callitriche sp*	0.038	1
Yellow water lily	*Nuphar lutea*	0.038	1
Total number of species recorded		**10**	**Total samples taken: 26**

There has been an increase in the number of species being recorded in this broad from six in 2016 to 10 this year. Rigid hornwort, Frogbit and Water net are also additions that were not recorded in 2016. It is felt the broad may be quite eutrophic and it is unclear how connected the broad is to the river. Vascular plants have stayed at similar overall abundance and free-floating or round floating leaved plants have increased.

Graph 19

Norton's broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Pound End

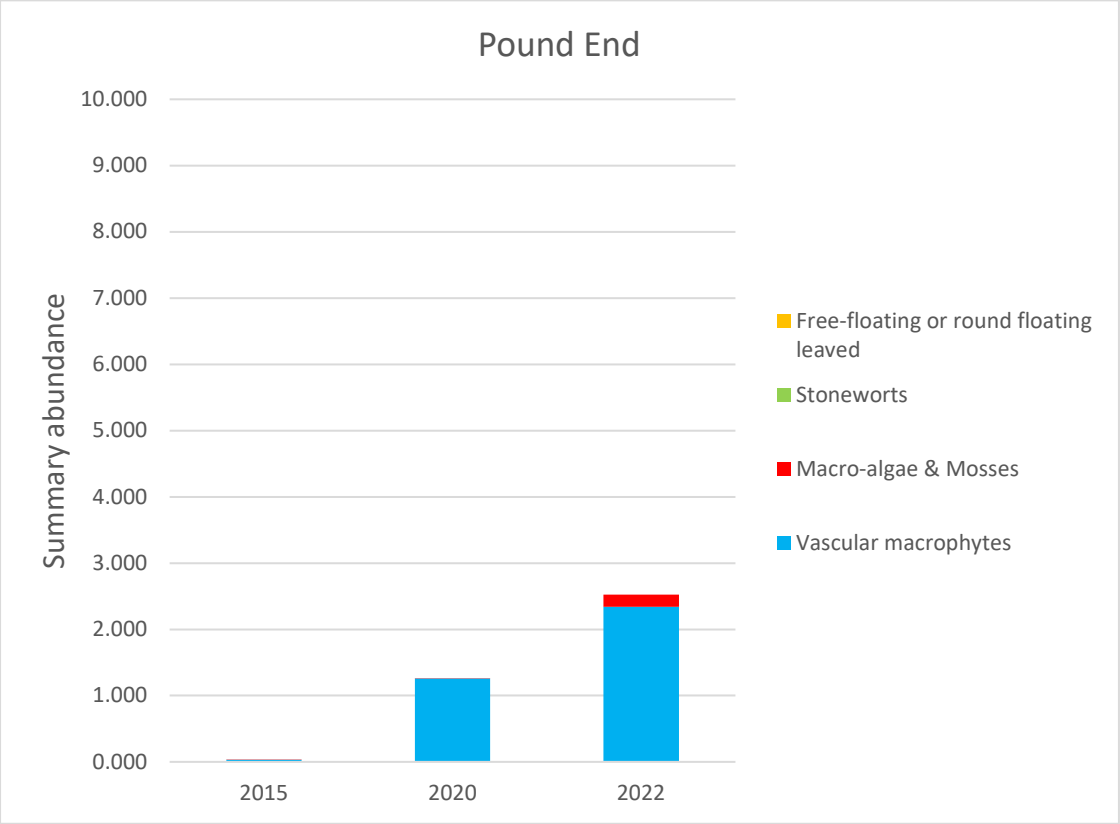
Table 21

Common Name	**Scientific Name**	**Summary Abundance**	**Occurrences**
Fennel-leaved pondweed	*Potamogeton pectinatus*	1.023	21
Rigid hornwort	*Ceratophyllum demersum*	0.750	20
Holly-leaved naiad	*Najas marina*	0.545	8
Filamentous algae	*Zygnematales*	0.184	8
Canadian waterweed	*Elodea canadensis*	0.023	1
No plants	No plants	0.000	8
Total number of species recorded		**5**	**Total samples taken: 44**

This year vascular plants have continued to increase and Macro-algae and mosses have increased slightly. Canadian waterweed appeared again for the first time since 1992.

Graph 20

Pound End summary abundance shown in plant groups (see Appendix 1 for more detail)



Salhouse Broad

Table 22

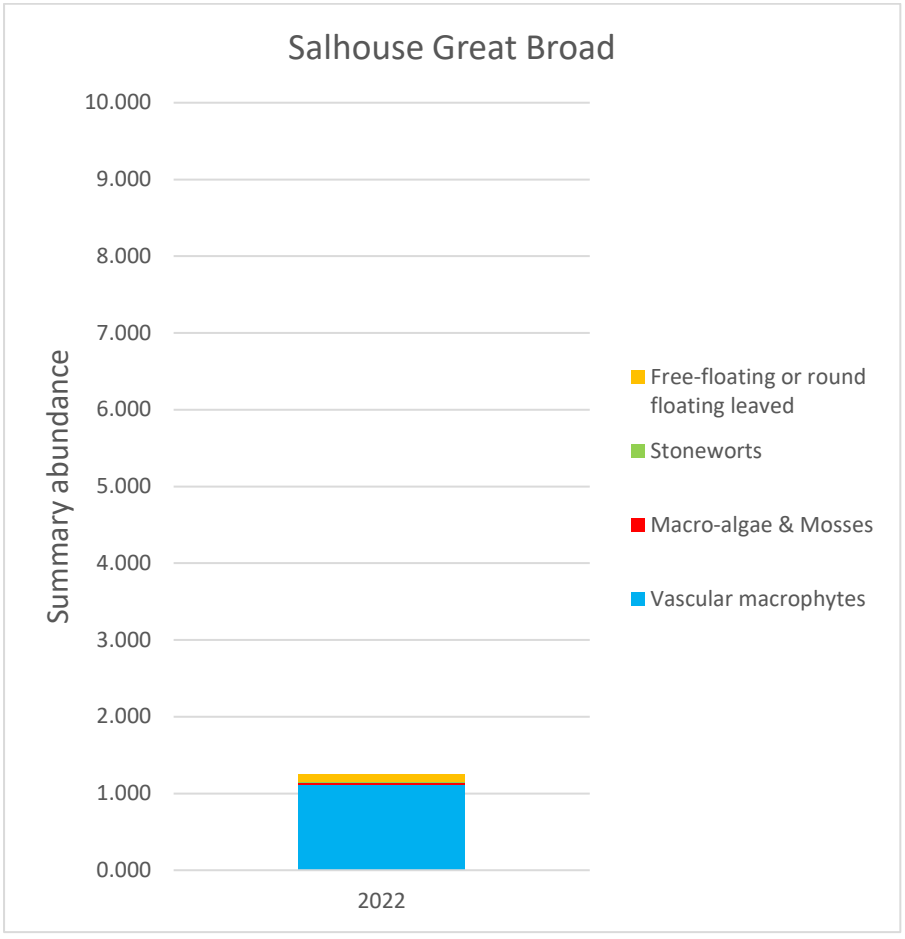
Common Name	Scientific Name	Summary Abundance	Occurrences
Rigid hornwort	Ceratophyllum demersum	0.673	23
Spiked water milfoil	Myriophyllum spicatum	0.192	8
Unbranched bur-reed	Sparganium emersum	0.115	2
Yellow water lily	Nuphar lutea	0.062	4
Fennel-leaved pondweed	Potamogeton pectinatus	0.058	3
Nuttall's waterweed	Elodea nuttallii	0.058	3
White water lily	Nymphaea alba	0.038	1
Filamentous algae	Zygnematales	0.023	3

Common Name	Scientific Name	Summary Abundance	Occurrences
Pointed stonewort	Nitella mucronata	0.019	1
Arrowhead	Saggitaria sagittifolia	0.019	1
No plants	No plants	0.000	22
Total number of species recorded		**16**	**Total samples taken: 52**

This is the first time since the new survey method started that Salhouse Broad has been surveyed. Spiked water milfoil, white water lily, fennel-leaved pondweed, unbranched bur-reed, arrowhead have all been recorded for the first time since 1986. Although levels are low it will be interesting to see how this broad develops as river health improves.

Graph 21

Salhouse Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Upton Great Broad

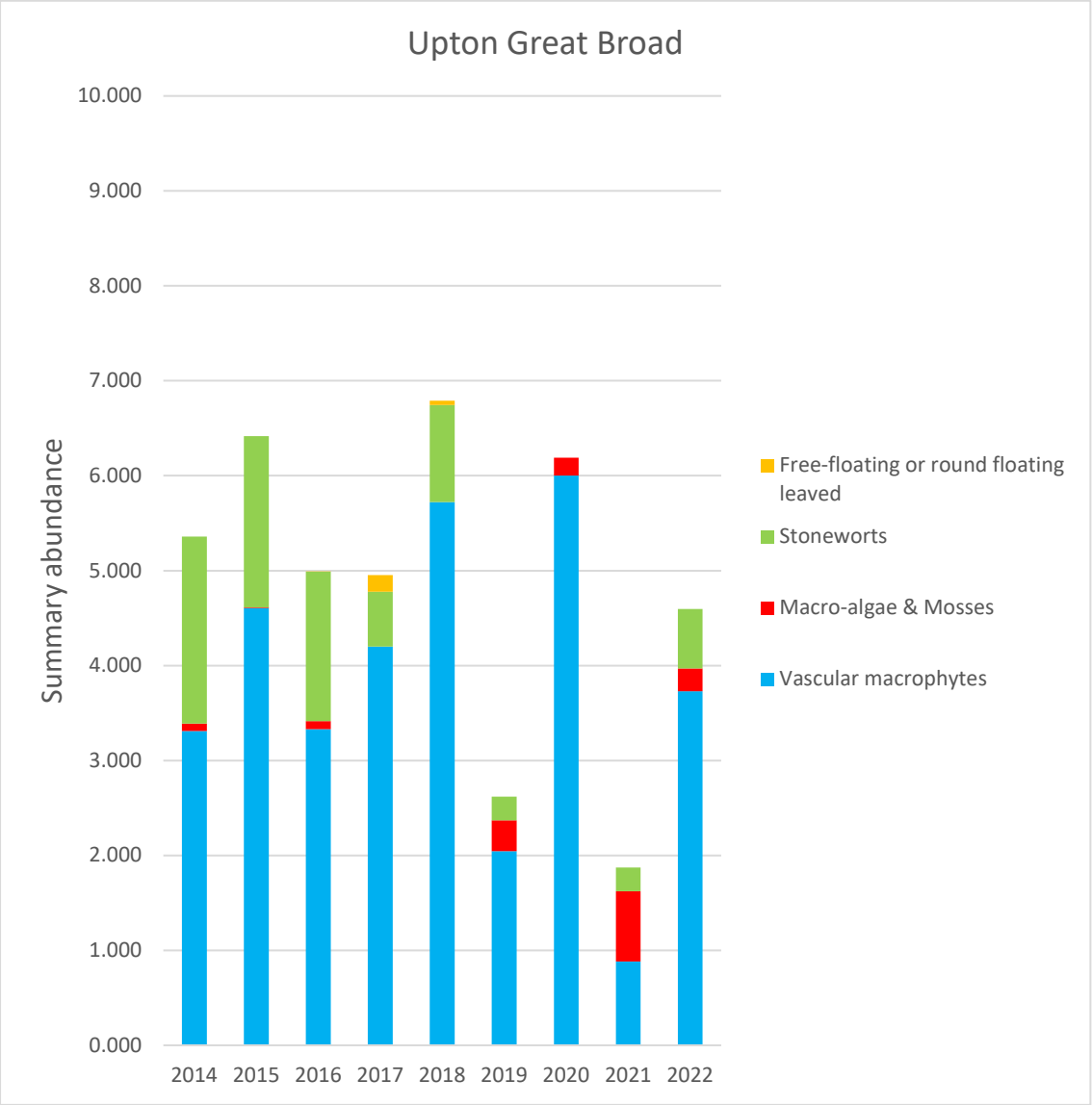
Table 23

Common Name	**Scientific Name**	**Summary Abundance**	**Occurrences**
Holly-leaved naiad	*Najas marina*	3.729	44
Bristly stonewort	*Chara hispida*	0.333	3
Filamentous algae	*Zygnematales*	0.242	17
Common stonewort	*Chara vulgaris*	0.229	7
Convergent stonewort	*Chara connivens*	0.042	2
Fragile/convergent stonewort	*Chara globularis/connivens*	0.021	1
No plants	No plants	0.000	1
Total number of species recorded		**6**	**Total samples taken: 48**

This year Holly-leaved naiad recovered to previous levels with an increase from 0.883 to 3.729. Bristly and Common stoneworts also increased whereas macro-algae and mosses decreased.

Graph 22

Upton Great Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Upton Little Broad

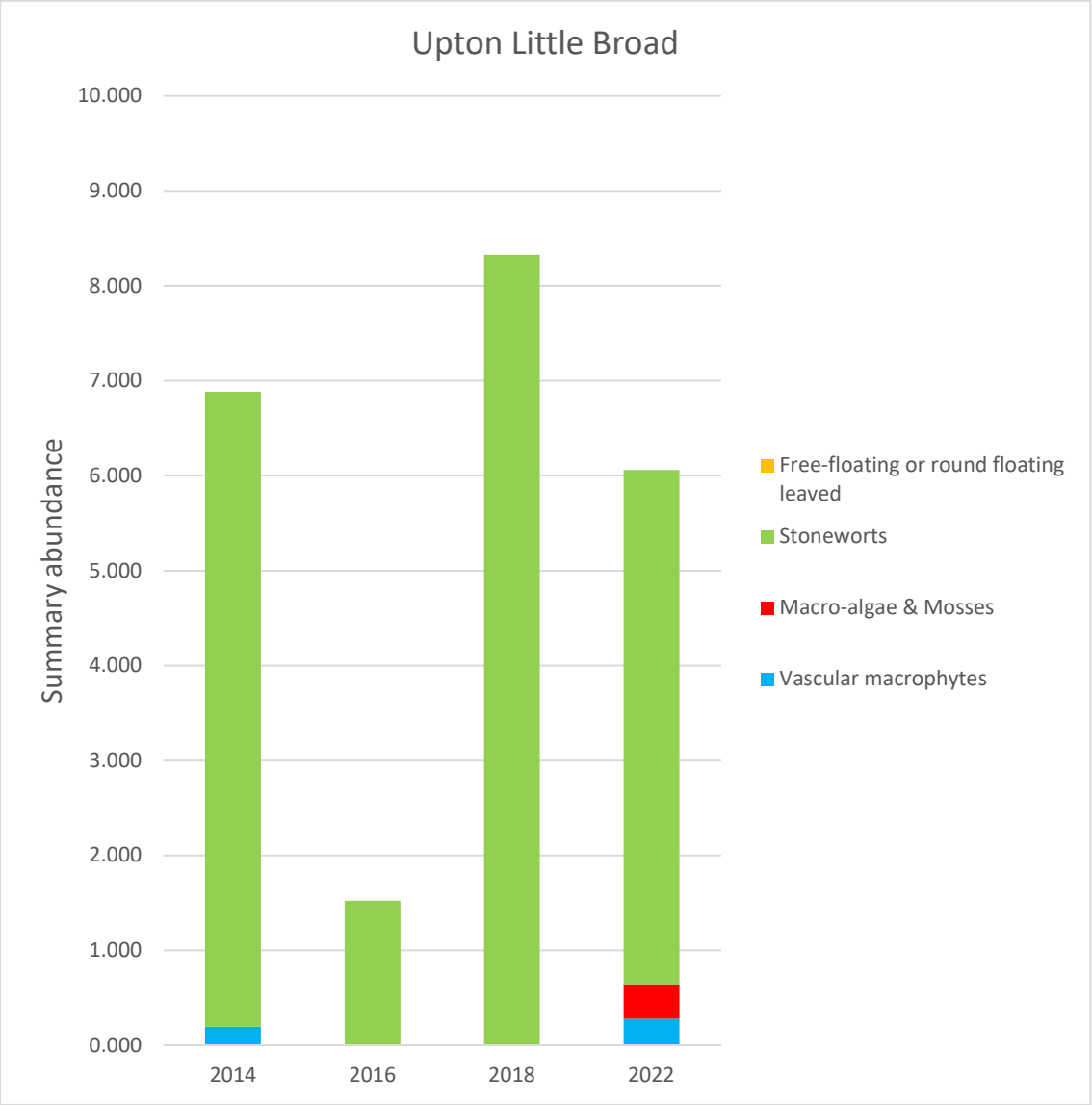
Table 24

Common Name	**Scientific Name**	**Summary Abundance**	**Occurrences**
Bristly stonewort	*Chara hispida*	4.167	34
Intermediate stonewort	*Chara intermedia*	1.194	20
Holly-leaved naiad	*Najas marina*	0.250	6
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.028	1
Fragile/convergent stonewort	*Chara globularis/connivens*	0.028	1
Common stonewort	*Chara vulgaris*	0.028	1
Filamentous algae	*Zygnematales*	0.003	1
Total number of species recorded		**7**	**Total samples taken: 36**

Vascular plants and macro-algae and mosses have made an appearance this year. Stoneworts are not as high as they have been in previous years but good abundance was seen in plant growth. Duck mussel, freshwater sponge and jelly algae also were recorded in the survey.

Graph 23

Upton Little Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Wroxham Broad

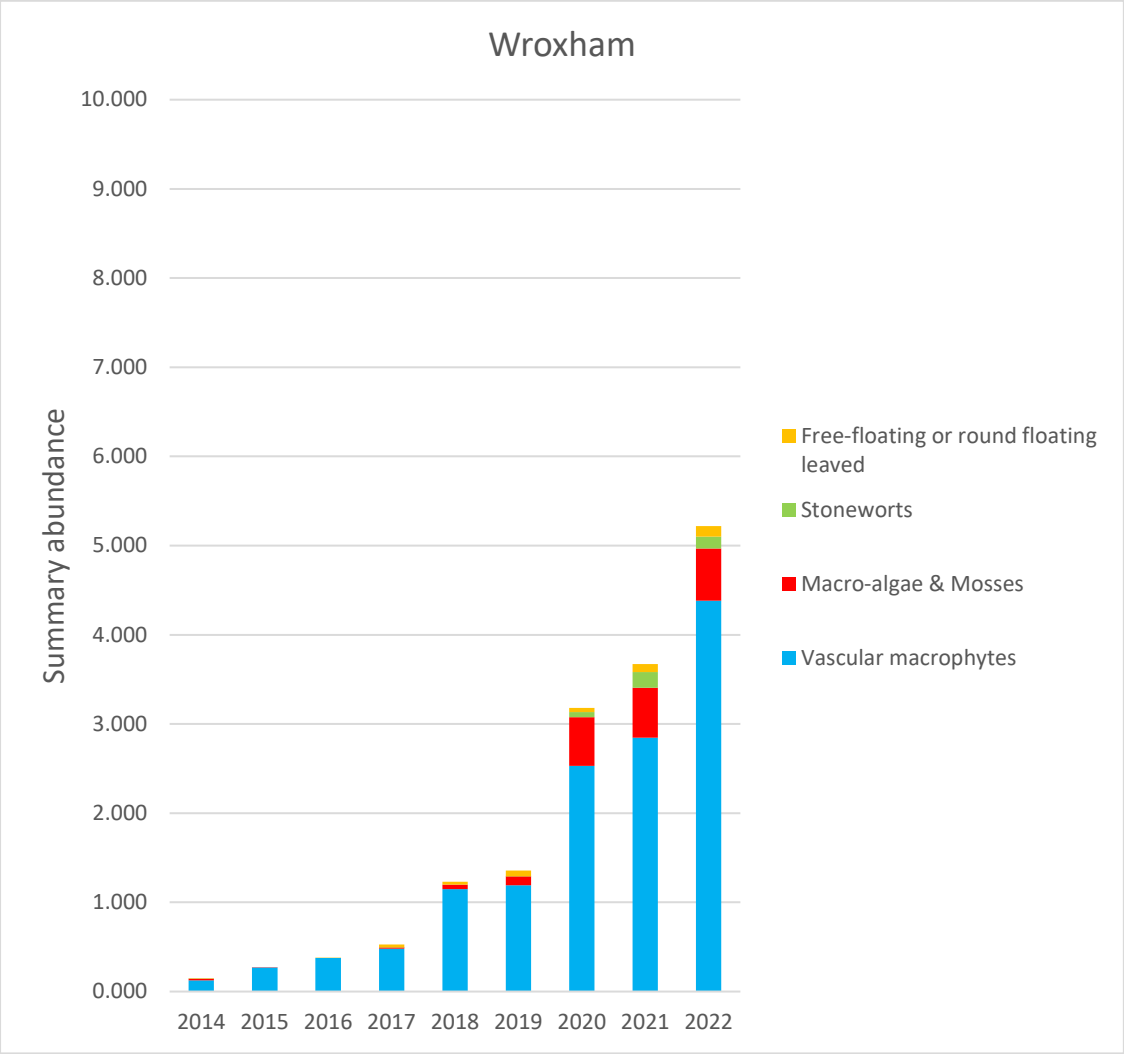
Table 25

Common Name	Scientific Name	Summary Abundance	Occurrences
Nuttall's waterweed	*Elodea nuttallii*	1.853	61
Rigid hornwort	*Ceratophyllum demersum*	1.765	61
Filamentous algae	*Zygnematales*	0.582	38
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.529	18
Pointed stonewort	*Nitella mucronata*	0.132	8
Spiked water milfoil	*Myriophyllum spicatum*	0.118	8
Yellow water lily	*Nuphar lutea*	0.118	7
Unbranched bur-reed	*Sparganium emersum*	0.104	6
Flat-stalked pondweed	*Potamogeton friesii*	0.015	1
Enteromorpha	*Enteromorpha*	0.001	1
Total number of species recorded		**12**	**Total samples taken: 68**

The water was very clear during the survey in 2022 and the overall water plant abundance is continuing to increase year on year, as it has done since 2014. There were two fewer species found in Wroxham Broad this year compared to last. Seven out of the 10 species increased this year, most of them being in the vascular plant group. Three mussels were found including Duck, Painters, Zebra and an Asiatic clam.

Graph 24

Wroxham Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Yare Valley

The majority of the broads within the Yare valley are isolated from the main river, with only Bargate, Rockland and Wheatfen having a direct hydrological connection. The Yare valley survey also includes two water bodies which are not a true ‘broad’, a manmade lake created from flooded peat diggings, or ‘decoy’, a lake created for wildfowl shooting. Whitlingham Great and Little are created from gravel extraction and are quite young compared to other open water bodies.

2022 Summary

Rockland was the only Broad surveyed this year which showed a slight decrease in overall abundance from previous years.

Rockland Broad

Table 26

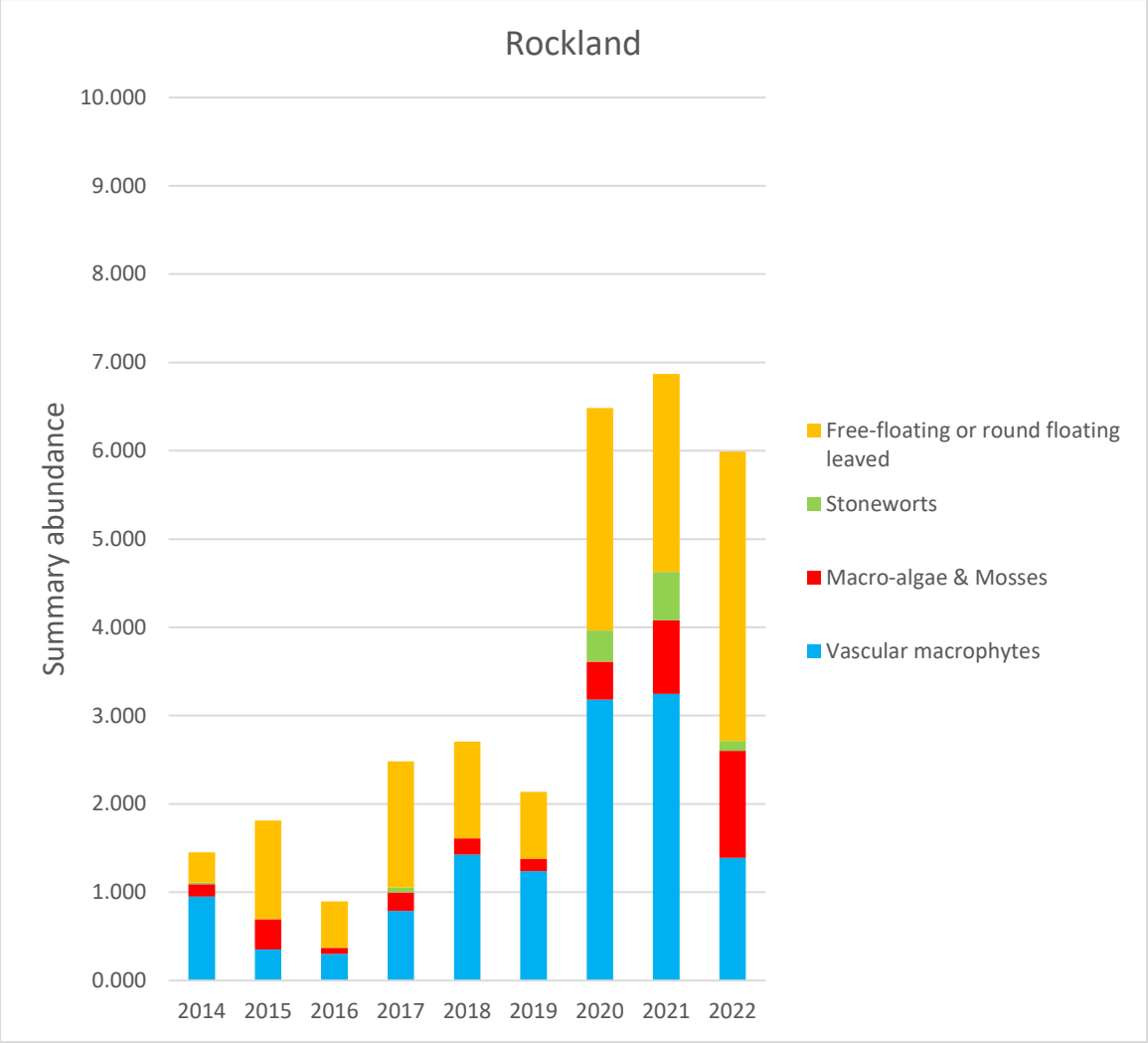
Common Name	Scientific Name	Summary Abundance	Occurrences
Yellow water lily	Nuphar lutea	3.129	29
Filamentous algae	Zygnematales	0.984	44
Unbranched bur-reed	Sparganium emersum	0.453	21
Rigid hornwort	Ceratophyllum demersum	0.258	16
Nuttall's waterweed	Elodea nuttallii	0.210	13
Common water moss	Fontinalis antipyretica	0.194	12
Starwort species	Callitriche sp	0.161	10
Frogbit	Hydrocharis morsus-ranae	0.129	1
Pointed stonewort	Nitella mucronata	0.113	7
Spiked water milfoil	Myriophyllum spicatum	0.082	6
Common duckweed	Lemna minor	0.081	5
Enteromorpha	Enteromorpha	0.034	3
Fennel-leaved pondweed	Potamogeton pectinatus	0.032	2
Inflated duckweed	Lemna gibba	0.032	2
Whorled water milfoil	Myriophyllum verticillatum	0.016	1
Least duckweed	Lemna minuta	0.016	1
Arrowhead	Saggitaria sagittifolia	0.016	1
Greater duckweed	Spirodela polyrhiza	0.016	1
Horned pondweed	Zannichellia palustris	0.016	1
Perfoliate pondweed	Potamogeton perfoliatus	0.016	1
No plants	No plants	0.000	3
Total number of species recorded		**24**	**Total samples taken: 62**

Rockland Broad has seen a slight decrease this year. Vascular plants decreased whereas floating leaved or round floating leaved increased along with macro-algae and mosses. The

increase in yellow water lily and Filamentous has made the drop in vascular plants less apparent. Two mussel species were found, duck and painters mussels along with an Asiatic clam. Freshwater sponge was also found during the survey. Stoneworts also decreased this year.

Graph 25

Rockland Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Waveney Valley

There are six broads within the Waveney valley: Barnby, Spratt's Water, Woolner's Carr, Round Water, Flixton Decoy and Oulton Broad. Some of these broads were surveyed in 2022 with Round Water, Spratt's Water and Woolner's Carr on the schedule. Unfortunately, Woolner's Carr was inaccessible and so could not be surveyed.

Round water

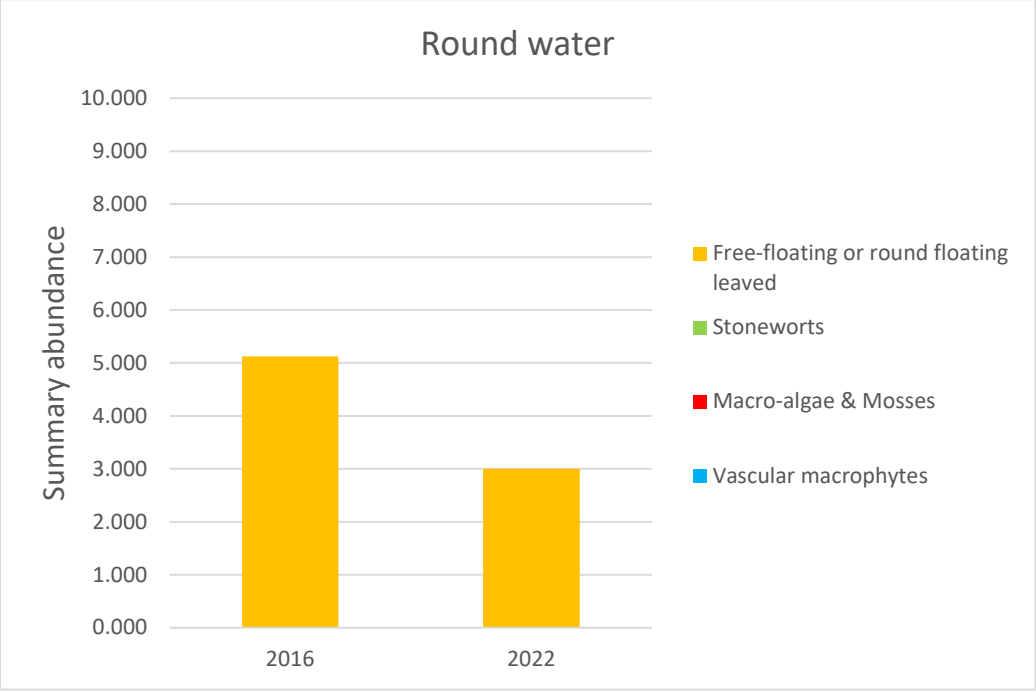
Table 27

Common Name	**Scientific Name**	**Summary Abundance**	**Occurrences**
Ivy-leaved duckweed	*Lemna trisulca*	1	8
Common duckweed	*Lemna minor*	1	8
Least duckweed	*Lemna minuta*	1	8
Total number of species recorded		**3**	**Total samples taken: 8**

Although small, this is a nice broad in an isolated location with only free-floating or round floating plants found.

Graph 26

Round Water summary abundance shown in plant groups (see Appendix 1 for more detail)



Spratt's water

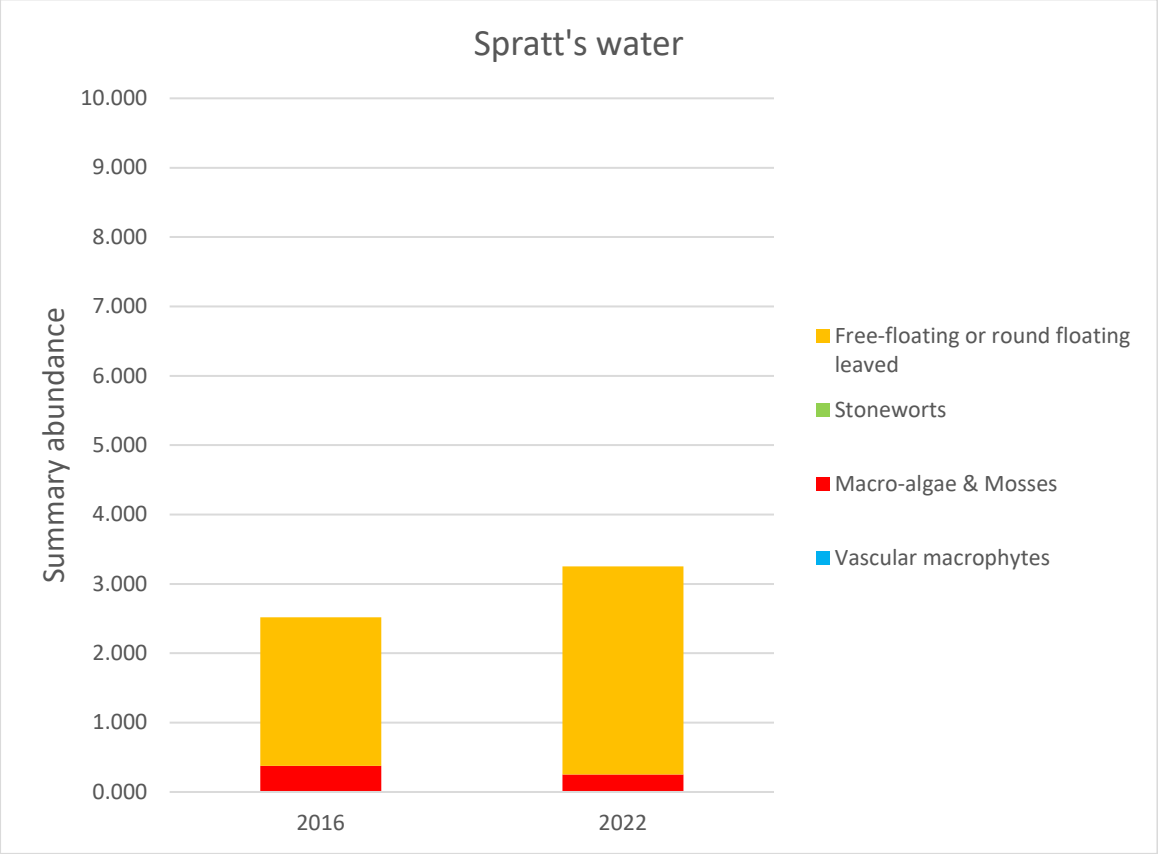
Table 28

Common Name	Scientific Name	Summary Abundance	Occurrences
Ivy-leaved duckweed	*Lemna trisulca*	1	16
Common duckweed	*Lemna minor*	1	16
Least duckweed	*Lemna minuta*	1	16
Filamentous algae	*Zygnematales*	0.25	4
Total number of species recorded		**3**	**Total samples taken: 8**

A slight increase was seen in the free-floating or round leaved plants, with Filamentous algae abundance remaining the same.

Graph 27

Spratt's Water summary abundance shown in plant groups (see Appendix 1 for more detail)



40-year review

2022 marks the 40th year that the annual macrophyte survey has been undertaken using repeatable methodologies by the Broads Authority and ecological researchers active in this field prior to the formation of the Authority in 1989. This extensive dataset of over 72,800 records contains a wealth of information regarding species, abundance and the inter-broad and inter-year variation experienced in this aquatic habitat.

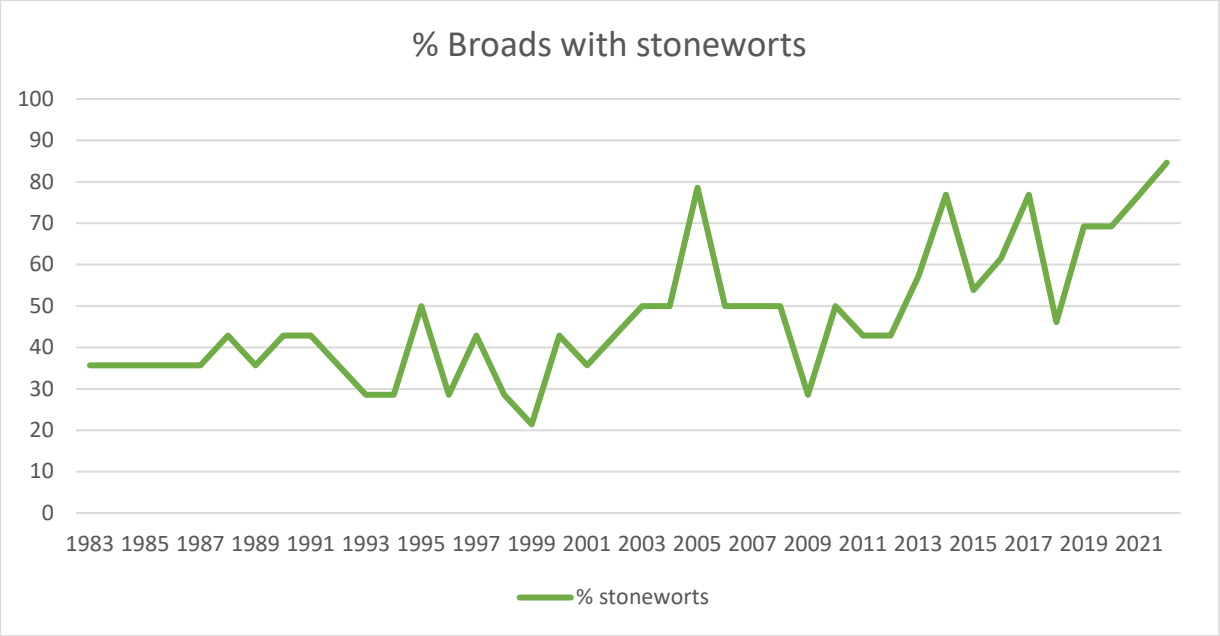
This section of the report briefly looks at the full dataset, from 1983 to 2022, drawing out some highlights and points of interest. It should be noted that owing to a change in survey methodology in 2014, direct comparisons across the entire dataset have not been attempted in this report. More in depth analysis would be needed and time does not permit this at present.

The focus of this review has been on common factors across the dataset that can be tracked and graphed. Using species number as a factor and concentrating on the thirteen broads that have been surveyed every year, the following graphs demonstrate the overall increase in species over the last 40 years. The 13 Broads are : Alderfen Broad, Barton Broad, Cockshoot Broad, Cromes Broad, Heigham Sound, Hickling Broad, Horsey Mere, Hoveton Great Broad, Martham North, Martham South, Rockland Broad, Upton Great Broad and Wroxham Broad

Figures 3 to 6 demonstrate this overall increase, as shown by species groups.

Figure 3

Percentage of broads with stonewort (*Charophyte*) species present



From the 13 Broads looked at stonewort presence has increased.

Figure 4

Percentage of broads with vascular macrophytes present

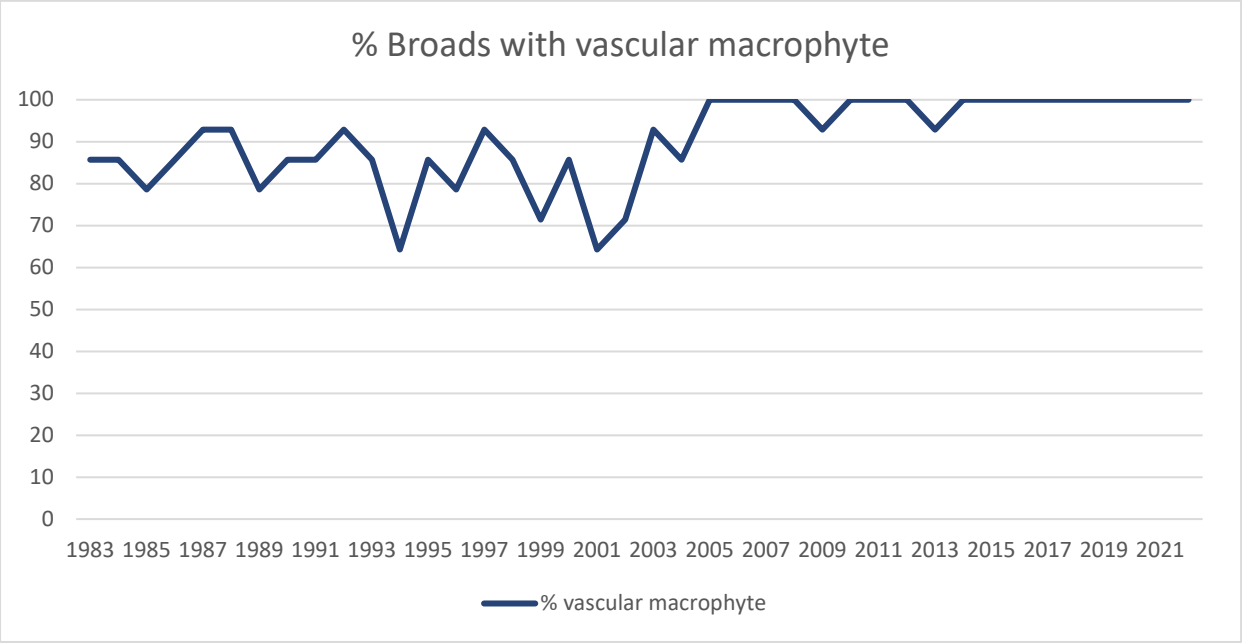


Figure 5

Percentage of broads with free-floating or round floating leaved plants present

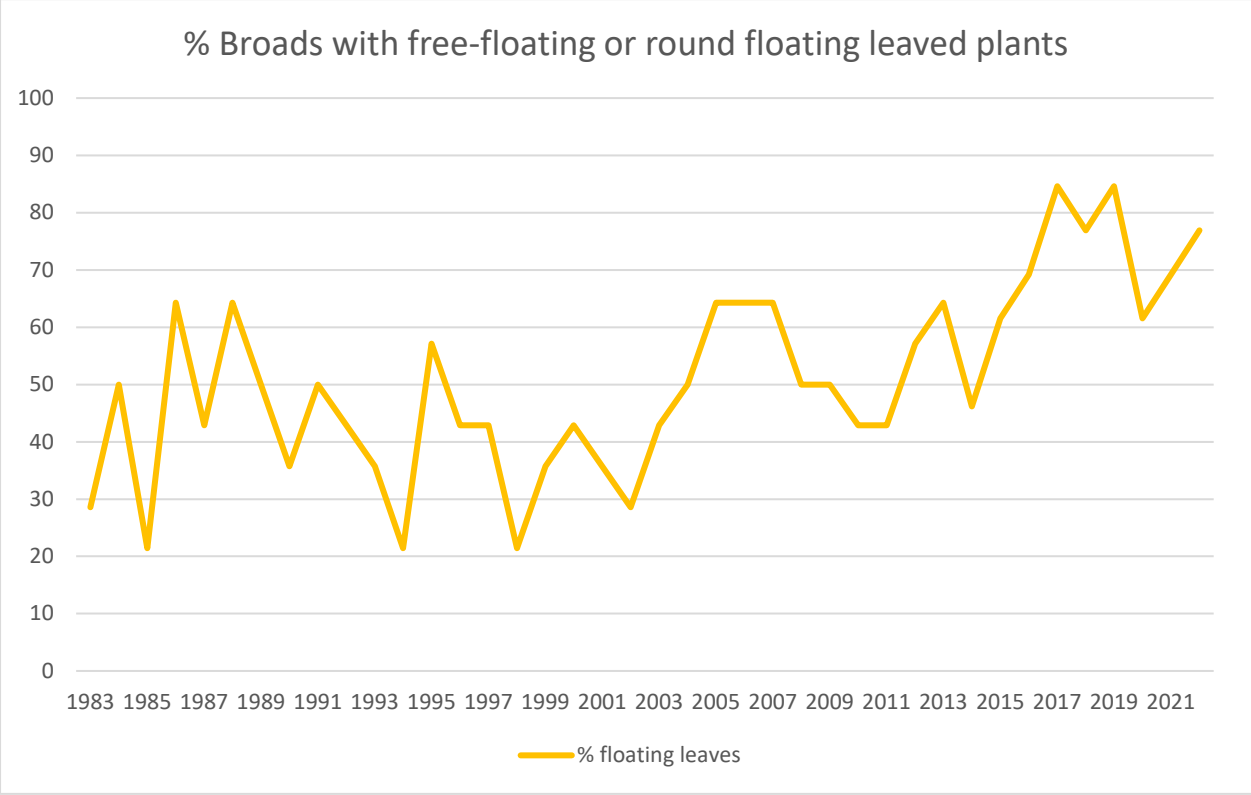


Figure 6

Percentage of broads with macro-algae & mosses

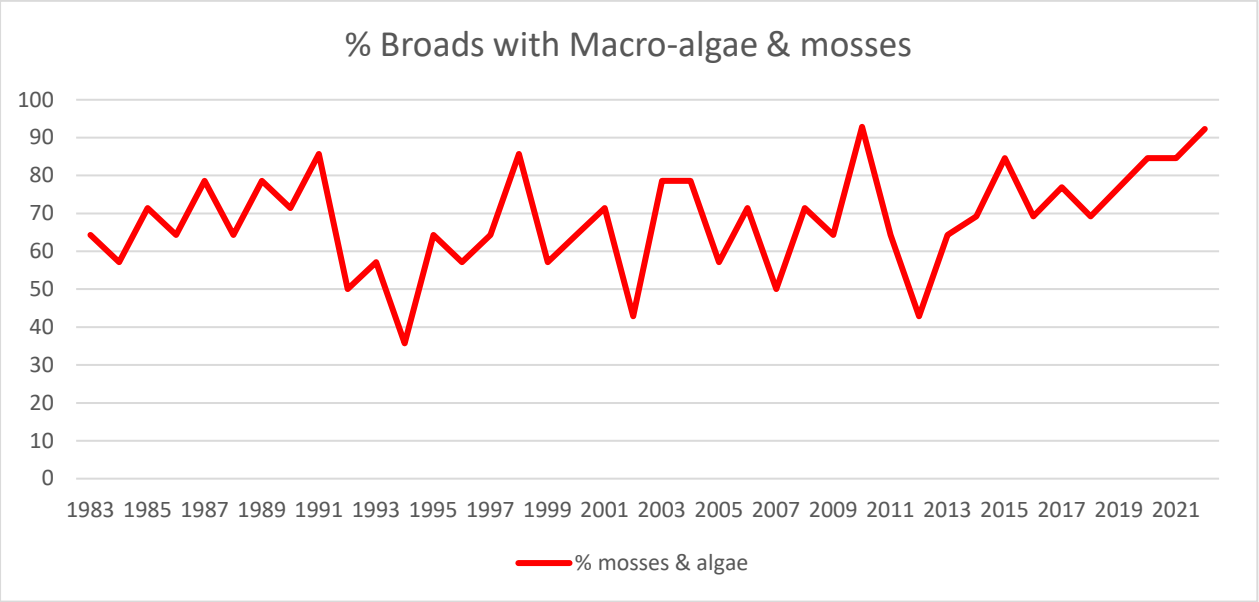


Figure 7

Number of broads with section 41 species recorded over the 40 years

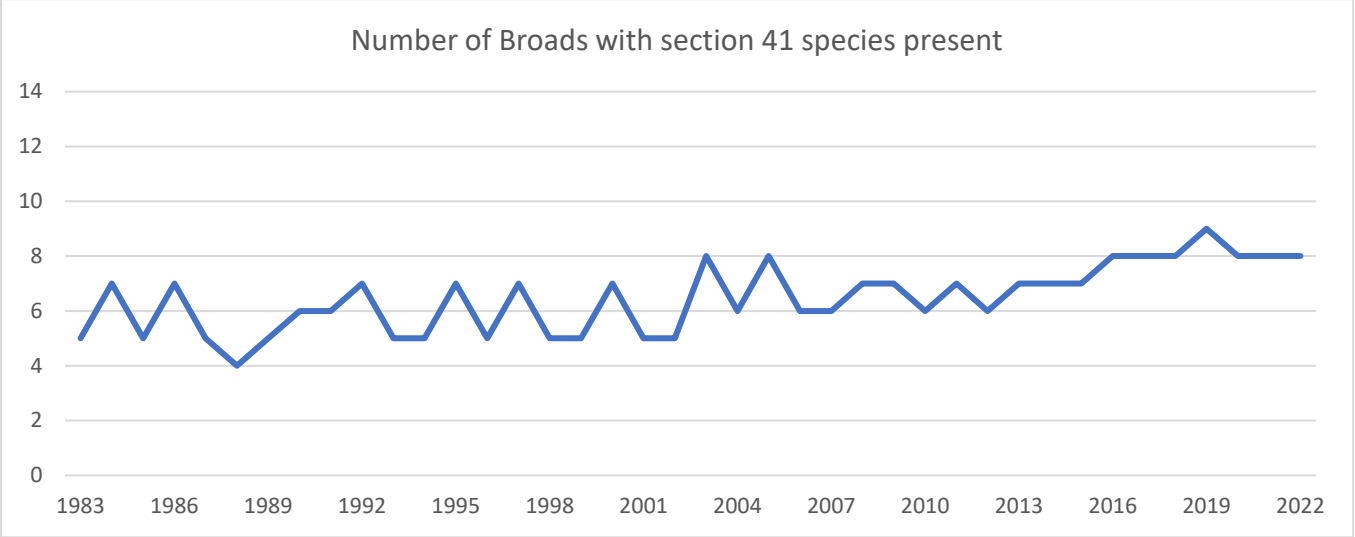
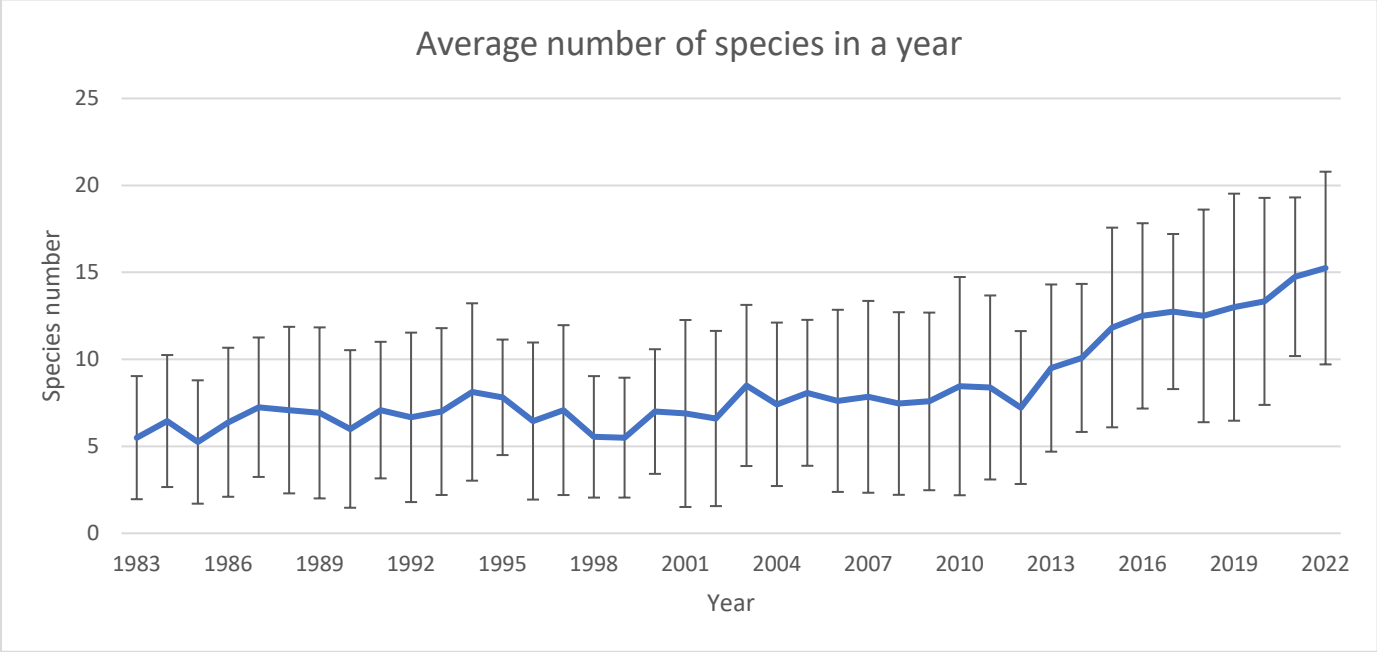


Figure 8

Average number of species per Broad per year



Taking the mean average number of species per year (Figure 8), this value has increased increase from around 5 in 1983 to 15 in 2022. Despite the variance present in the annual data, the recent trend of increased species number in the main Broads sites is clear. Of particular note is the relative increase in the past eight years, when the average number increased to above 10 species per broad.

The role of water clarity and nutrient concentrations invariably play a part in the explanation of these data. Further investigation is required to better understand the drivers influencing the increase in species number and from what is evident in the main results section of this report, the increase in water plant abundance throughout the Broads.

Table 29

Frequency of surveys over 40 years, blue/grey square shows survey taken place

Site	No. of yrs	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Alderfen	40																																								
Bargate	6																																								
Barnby	7																																								
Barton	40																																								
Belaugh	22																																								
Blackfleet	4																																								
Bridge	14																																								
Buckenham	10																																								
Burntfen	8																																								
Calthorpe	5																																								
Catfield	3																																								
Cockshoot	40																																								
Cockshoot Dyke	28																																								
Cromes South	30																																								
Cromes North	37																																								
Decoy	14																																								
Filby	22																																								
Flixton Decoy	3																																								
Fritton Lake	1																																								
Hassingham	11																																								
Heigham Sound	32																																								
Hickling	40																																								

Site	No. of yrs	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Horsey Mere	36																																								
Hopton 1 (Lound)	1																																								
Hopton 2 (Lound)	1																																								
Hopton 3 (Lound)	1																																								
Hopton 4 (Lound)	1																																								
Hoveton Great	40																																								
Hoveton Little	17																																								
Hudson's Bay	13																																								
Irstead	2																																								
Lily	22																																								
Little	7																																								
Malthouse	8																																								
Martham North	39																																								
Martham South	38																																								
Mautby Decoy	5																																								
Mill Water (Lound)	1																																								
Norton	6																																								
Ormesby	25																																								
Ormesby Little	24																																								
Oulton Broad																																									
Pound End	16																																								

Site	No. of yrs	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Ranworth	35																																								
Reedham Water	2																																								
Rockland	32																																								
Rollesby	24																																								
Round water	4																																								
Salhouse Great	14																																								
Salhouse Little	7																																								
Spratts Water	5																																								
Strumpshaw	12																																								
Upton Great	40																																								
Upton Little	11																																								
Wheatfen	8																																								
Whitlingham Great	15																																								
Whitlingham Little	14																																								
Woolners Carr	3																																								
Wroxham	40																																								
Number 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	40	42	28	32	31	28	28	25	20	25	27	21	20	15	21	18	26

River Plant Survey Methodology

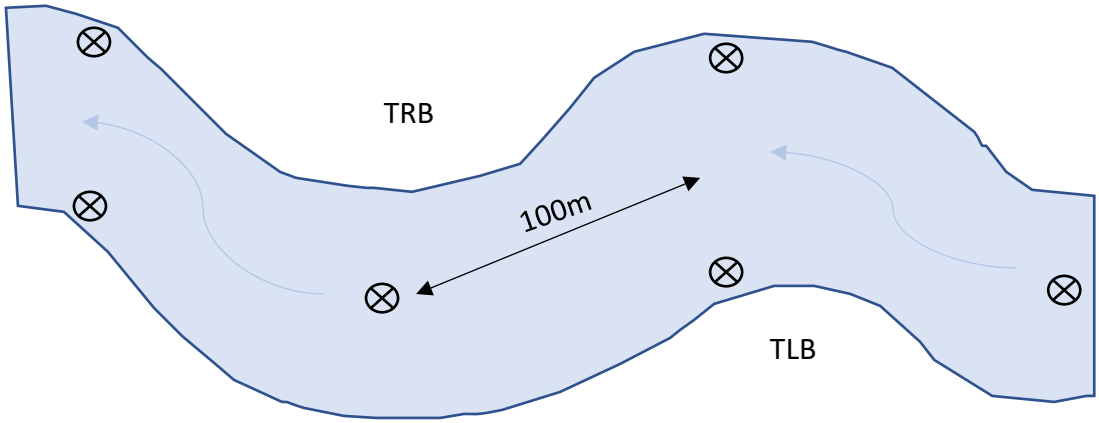
Point sample survey technique

The new survey design develops upon groundwork laid by earlier surveys of the Broads' river systems. Stretches where routine water plant cutting takes place annually were identified and the surveys have focused exclusively on these reaches (see Appendix 1).

Survey points were placed in a diamond formation along the reach to be surveyed, to account for differing plant communities at the margins compared to the centre of the channel (see figure 3). A sampling point was taken in the middle of the channel and then 100m downstream two sampling points were taken at the true left and true right banks. The maps and sample point co-ordinates were loaded onto a Samsung tablet for the survey teams to use.

Along each reach to be surveyed, the survey team used the maps and grid references, loaded onto the Samsung tablet, and GPS to navigate by boat to each sample point. Once within 5m of the plotted grid reference, mud weights were deployed to keep the boat in the correct location. At the sample point a double headed survey rake is thrown at a distance of 5m from the edge of the boat. In contrast to the broads' water plant survey, only one downstream throw is made at each point to mitigate against downstream drift of plant material. The rake is left for 10 seconds to allow it to sink to the bottom, after which it is pulled steadily back towards the boat.

Figure 3
Diagram illustrating river survey methodology



The plants accumulated on the rake head are collected in a white survey tray and washed to remove any excess sediment, as required. All live plant material is identified to species level wherever possible. However, some particularly difficult groups, such as the non-flowering starworts *Callitriche sp.*, can only be identified to genus level. Specimens that remain unidentified in the field, or where identification was uncertain, are collected in labelled

plastic bags and taken for closer inspection under a microscope or sent for expert identification. Specimens of interest are pressed and dried using standard herbarium techniques.

A level of abundance for each species is assigned based on the total volume of live water plant material, accounting for maximum trap-ability on the rake. Scores give each species present a range from 10% (low abundance) to 100% (the maximum trappable) in increments of 10%, with scores of 1% given to trace, or very small amounts, of identifiable plant material. A score of 100% represents the maximum amount trappable on the rake, to control for the 'trap-ability' of a given species. For instance, fine leaved species such as unbranched bur-reed, *Sparganium emersum,* are not as trappable with the rake as more structured species such as spiked water milfoil, *Myriophyllum spicatum.* This has the potential to result in under-recording of high abundances of less readily trapped species. Consequently, surveyor experience and judgement are important for scoring these less trappable species, such as duckweeds, *Lemna sp.* and water lilies. Scoring should consider the likelihood of a given species being retrieved on the rake and other visual indications of abundance.

The maximum total of all species abundance scores on an individual rake sample cannot really be more than 100%, although ± 10% is considered acceptable to account for the varying trap-ability of different species.

A preliminary survey is undertaken in April/May time, before the water plant cutter is mobilised, and where prioritised, a secondary survey is undertaken later in the season, in June or July. Due to the constraints introduced by the coronavirus pandemic in 2020, the river survey was confined to the River Thurne. In 2021, lifting restrictions allowed the survey to be extended to the other Broads river systems. However, in 2021 the River Ant was excluded from the survey programme due to an infestation of floating pennywort which is currently under management. In 2022 the river plant survey was extended to all survey reaches of all river systems in the Broads for the first time since 2014.

Results analysis

The data collected from each river transect is presented as abundance (the amounts of each species recorded) based on the Braun-Blanquet Scale[1]. The results tables illustrate the number of points at which each species was recorded to indicate frequency of occurrence. Historical records from past surveys are not presented here, different survey methodologies were used and therefore the results are not directly comparable.

[1] Braun-Blanquet (1932) *Plant Sociology. The study of plant communities.* First ed. Pp xviii – 439. McGraw-Hill Book Co. New York & London.

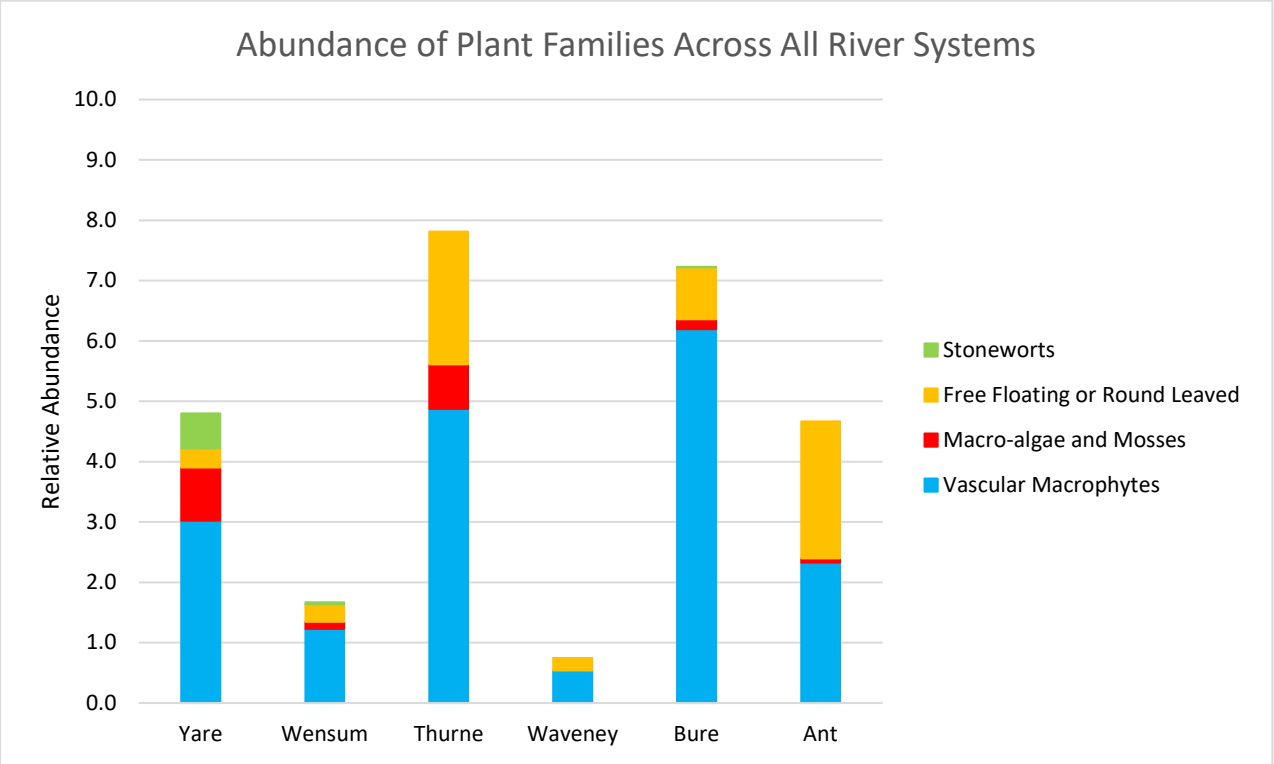
River Plant 2022 Survey Results

The data collected from each river transect is presented as abundance (the amounts of each species recorded) based on the Braun-Blanquet Scale, as outlined in the river survey methodology. The results tables illustrate the number of points at which each species was recorded to indicate frequency of occurrence. Historical records from past surveys are not presented here, different survey methodologies were used and therefore the results are not directly comparable.

Summary

Vascular plants were the most common group of plants recorded on all the river systems, followed by floating plants, whereas on the Ant there were similar abundances of floating and vascular plants this year. Pointed stonewort, *Nitella mucronata,* was recorded at nine separate points across the Bure, the Wensum and through the Thorpe Green reach of the Yare, in significant abundance. Otherwise stoneworts were not well represented in the river systems. The Bure and the Thurne were the most species rich river systems and carried the greatest abundance of plants, with the Thurne ultimately having the greatest species richness and abundance. Greater levels of macro-algae and mosses were recorded on the Thurne compared to the other river systems. Holly-leaved naiad, *Najas marina,* which is a Section 41 priority species, was only recorded on the Thurne.

The Waveney had the lowest species richness and abundance. The dominant species was unbranched bur-reed, *Sparganium emersum,* across both of the surveyed stretches. Notably, dredging had taken place through the Beccles reach the year previously. The Wensum showed moderate species abundance and richness.



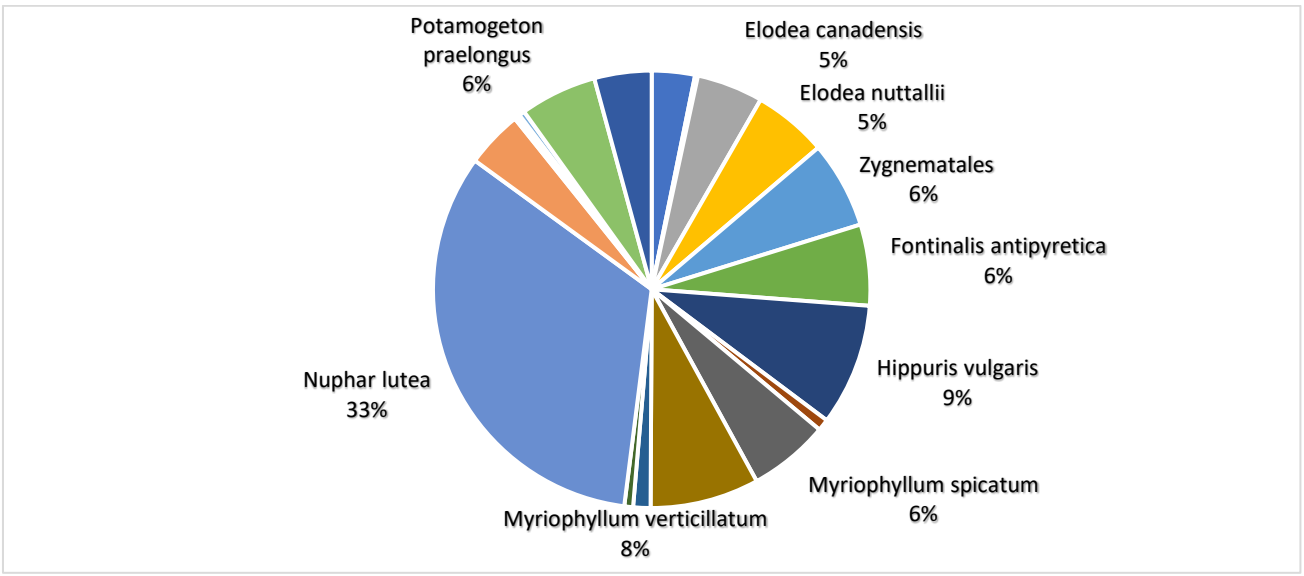
Thurne

Common Name	Scientific Name	Abundance	Occurrences
Yellow water lily	*Nuphar lutea*	1.96	30.5
Mare's tail	*Hippuris vulgaris*	0.54	16
Whorled water milfoil	*Myriophyllum verticillatum*	0.48	9.5
Filamentous algae	*Zygnematales*	0.38	19
Common water moss	*Fontinalis antipyretica*	0.36	15.5
Spiked water milfoil	*Myriophyllum spicatum*	0.35	14
Long-stalked pondweed	*Potamogeton praelongus*	0.34	7.5
Nuttall's waterweed	*Elodea nuttallii*	0.33	7.5
Canadian waterweed	*Elodea canadensis*	0.29	17
Arrowhead	*Saggitaria sagittifolia*	0.25	5.5
Curled pondweed	*P. crispus*	0.25	10
Starwort species	*Callitriche sp*	0.19	8.5
Holly-leaved naiad	Najas marina	0.08	1
Ivy-leaved duckweed	*Lemna trisulca*	0.05	4
Willow-leaved pondweed	*P. x salicifolius*	0.03	0.5
Rigid hornwort	Ceratophyllum demersum	0.01	0.5
Fennel-leaved pondweed	*P. pectinatus*	0.01	0.5
Perfoliate pondweed	*P. perfoliatus*	0.01	0.5
Total number of species recorded		**18**	**Total samples taken: 40**

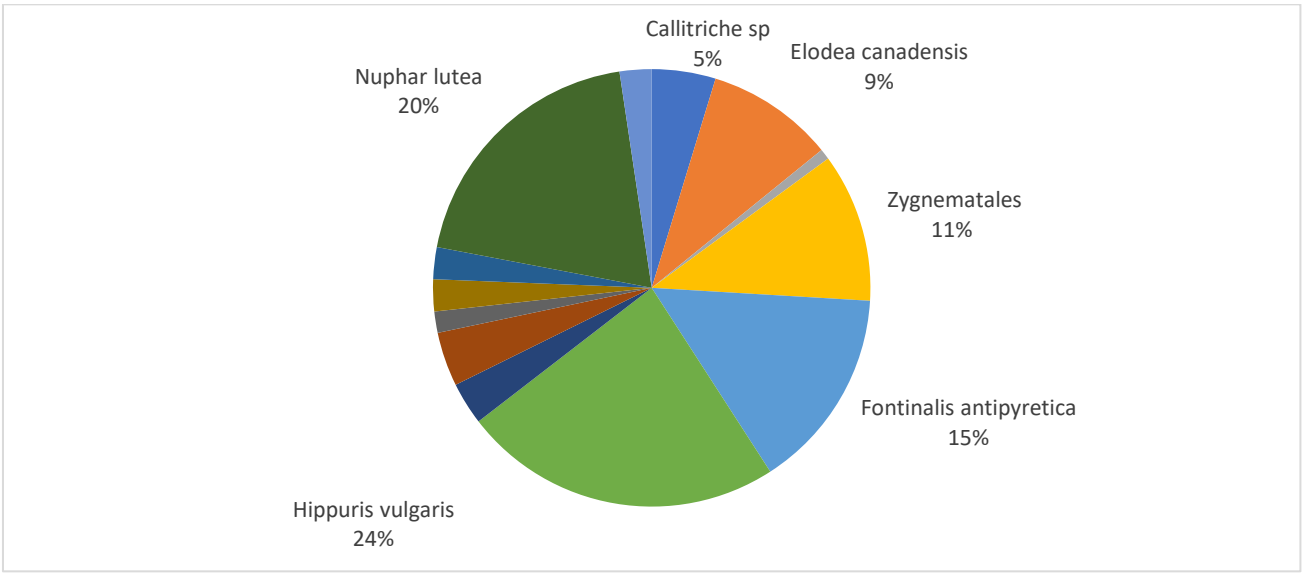
Yellow water lily, *Nuphar lutea,* was the most dominant species on the Thurne system followed by mare's tail, *Hippuris vulgaris.* Filamentous algae, *Zygnematales,* was abundant on the Thurne compared to the other river systems. Although in low abundance, there was greater species richness recorded on the Thurne than on any of the other surveyed river systems. There was an average of three occurrences of no plants across both surveys on the Thurne, giving a relative abundance of 0.04.

N. lutea increased in abundance through the season whereas *H. vulgaris* had negligible abundance later in the year. Overall, there was greater species richness in the later survey, with 17 species recorded, compared to 13 recorded in the early survey.

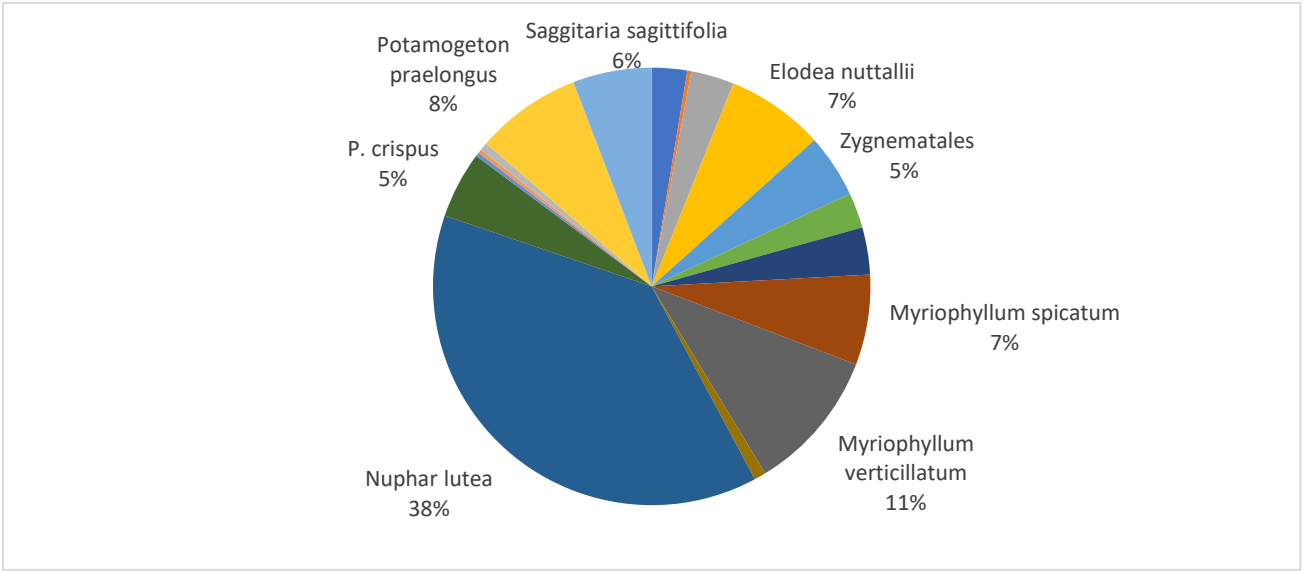
April & August Survey Results



April Survey Results



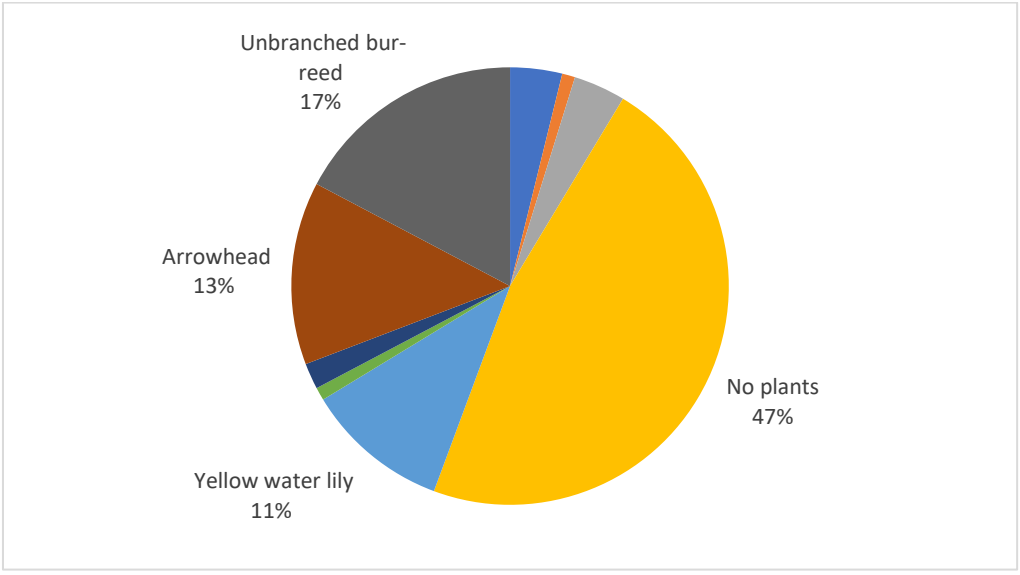
August Survey Results



Waveney

Common Name	Scientific Name	Abundance	Occurrence
Unbranched bur-reed	*Sparganium emersum*	0.24	15
Arrowhead	*Saggitaria sagittifolia*	0.19	15
Yellow water lily	*Nuphar lutea*	0.15	10
Starwort species	*Callitriche sp*	0.05	3
Canadian waterweed	*Elodea canadensis*	0.05	4
Lesser water-parsnip	*Berula erecta*	0.03	1
Rigid hornwort	*Ceratophyllum demersum*	0.01	1
Crowfoot species	*Ranunculus sp.*	0.01	1
Total number of species recorded		**8**	**Total number of samples taken: 74**

The Waveney had the lowest species richness and abundance of any of the river systems. The plant community was dominated by unbranched bur-reed, *Sparganium emersum.* There were ten occurrences of no plants, giving a relative abundance of 0.66, which was higher than on any of the other river systems. Unlike the other rivers surveyed, only an early survey was completed on the Waveney due to time and equipment constraints.



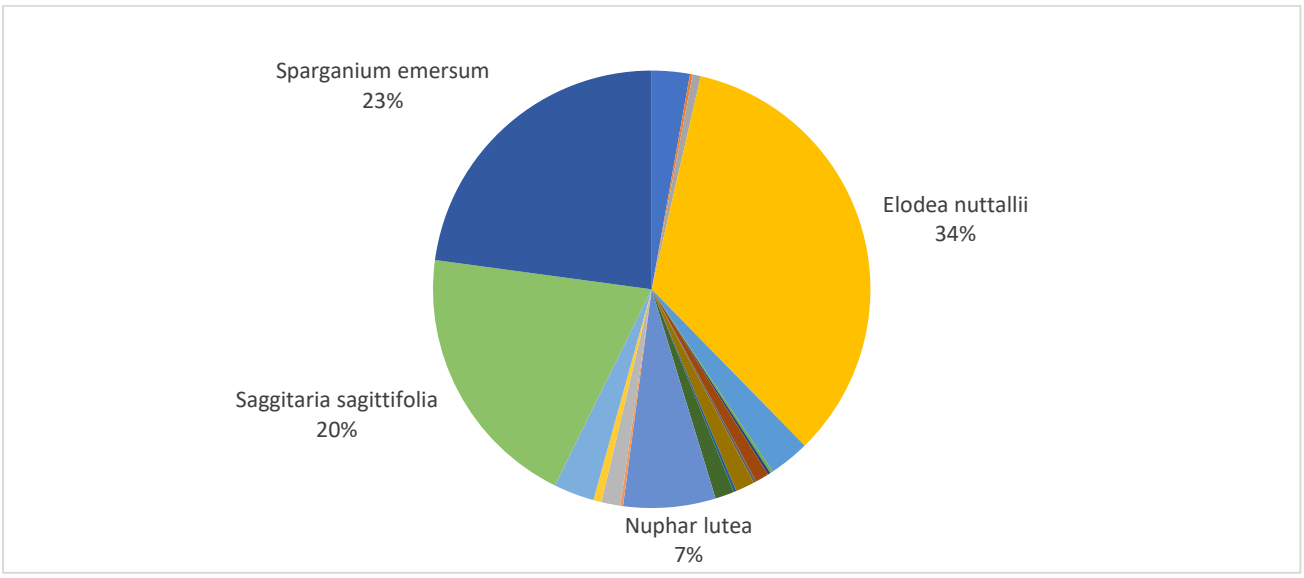
Bure

Common Name	Scientific Name	Abundance	Occurrence
Nuttall's waterweed	Elodea nuttallii	1.42	61
Unbranched bur reed	Sparganium emersum	0.95	56
Arrowhead	Saggitaria sagittifolia	0.83	34
Yellow water lily	Nuphar lutea	0.28	23
Zygnematales	Filamentous algae	0.13	4
Lesser water parsnip	Berula erecta	0.13	8
Starwort species	Callitriche sp	0.12	14
Ivy leaved duckweed	Lemna trisulca	0.06	7
Blunt leaved pondweed	P. obtusifolius	0.06	7
Common duckweed	Lemna minor	0.04	5
Canadian waterweed	Elodea canadensis	0.03	45
Long stalked Pondweed	Potamogeton praelongus	0.03	3
Rigid hornwort	Ceratophyllum demersum	0.01	1
Common water moss	Fontinalis antipyretica	0.01	1
Frogbit	Hydrocharis morsus ranae	0.01	1
Least duckweed	Lemna minuta	0.01	1
Pointed stonewort	Nitella mucronata	0.01	1
Shining pondweed	P. lucens	0.01	1
Total number of species recorded		**18**	**Total number of samples taken: 60**

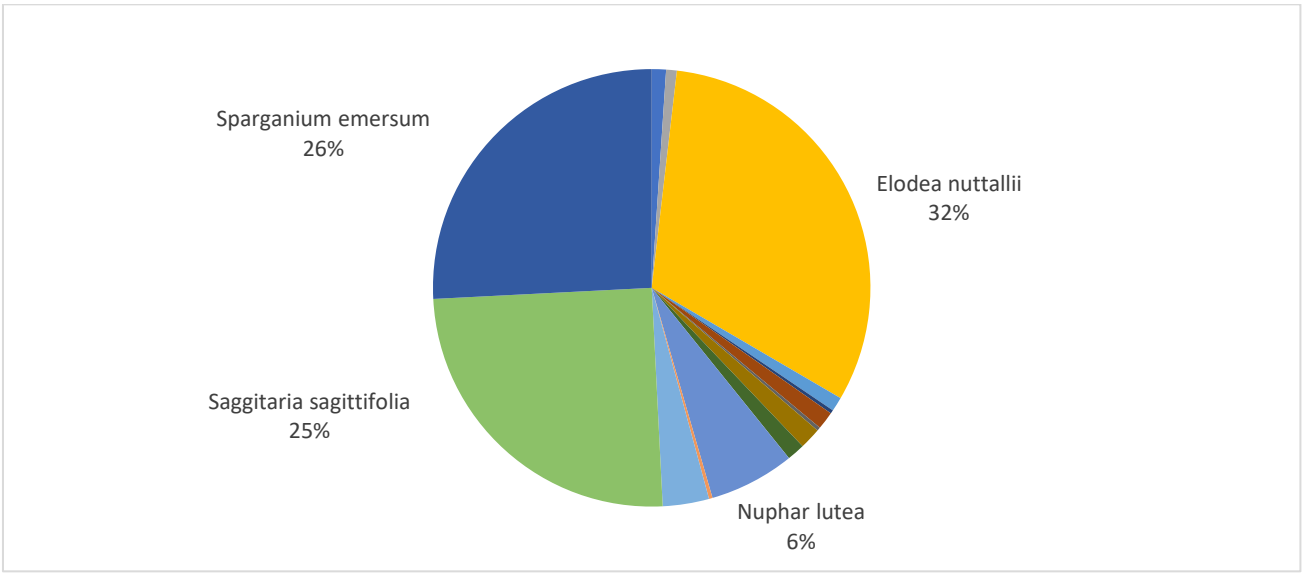
The Bure had the second highest species richness of all the rivers. The most dominant species was Nuttall's waterweed, *Elodea nuttallii,* followed by unbranched bur-reed, *Sparganium emersum* and arrowhead *Saggitaria sagittifolia.* Although the species recorded had good abundance, there was lower species richness recorded on the Bure compared to the Thurne. There was an average of seven occurrences of no plants across both surveys, giving a relative abundance of 0.06.

Species richness in the Bure was consistent through the year, with 14 species recorded during both surveys.

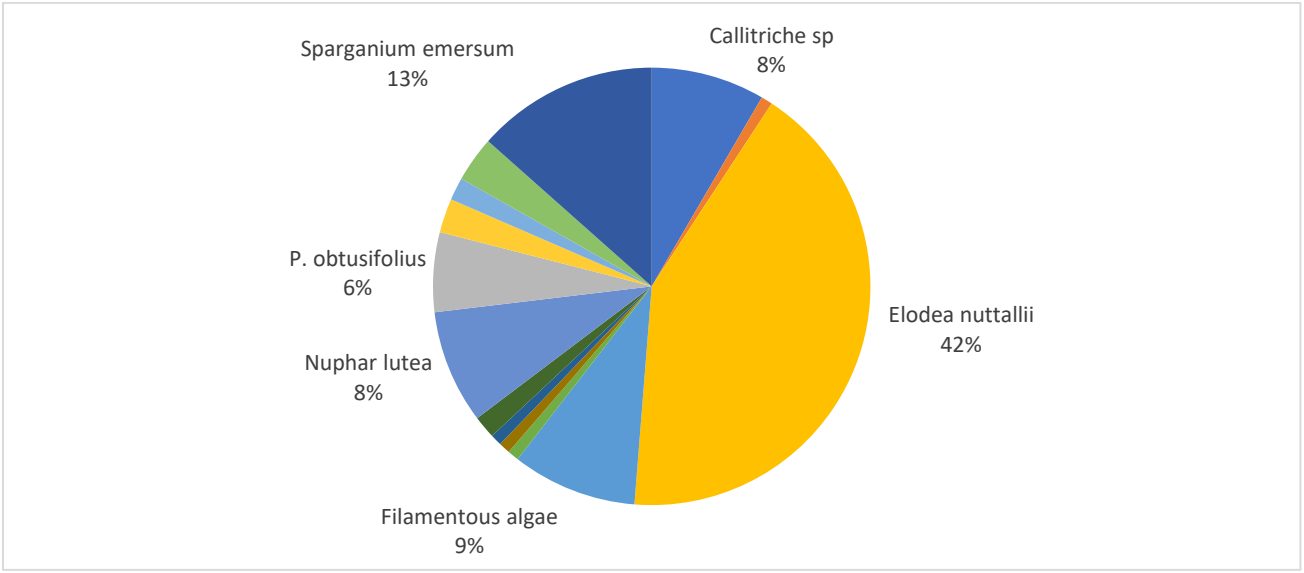
April and August Survey Results



April Survey Results



August Survey Results



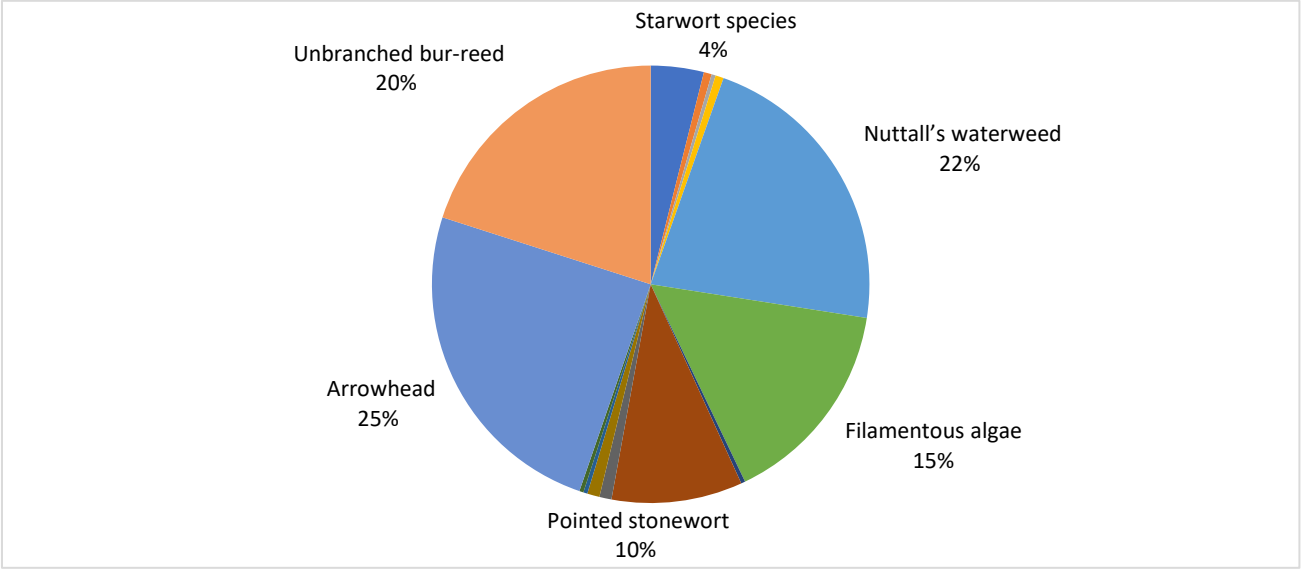
Yare

Common Name	Scientific Name	Abundance	Occurrences
Unbranched bur-reed	*Sparganium emersum*	1.04	16.5
Nuttall's waterweed	*Elodea nuttallii*	1.04	16
Filamentous algae	*Zygnematales*	0.86	3.5
Arrowhead	*Saggitaria sagittifolia*	0.84	12.5
Pointed stonewort	*Nitella mucronata*	0.56	7
Starwort species	*Callitriche sp*	0.26	6
Yellow water lily	*Nuphar lutea*	0.06	1
Canadian waterweed	*Elodea canadensis*	0.04	1
Rigid hornwort	*Ceratophylum demersum*	0.02	0.5
Stonewort (Chara) species	*Chara sp.*	0.02	0.5
Common water moss	*Fontinalis antipyretica*	0.02	0.5
Small pondweed	*P. berchtoldii*	0.02	0.5
Lesser water-parsnip	*Berula erecta*	0.02	0.5
Total number of species recorded		**14**	**Total number of samples taken: 25**

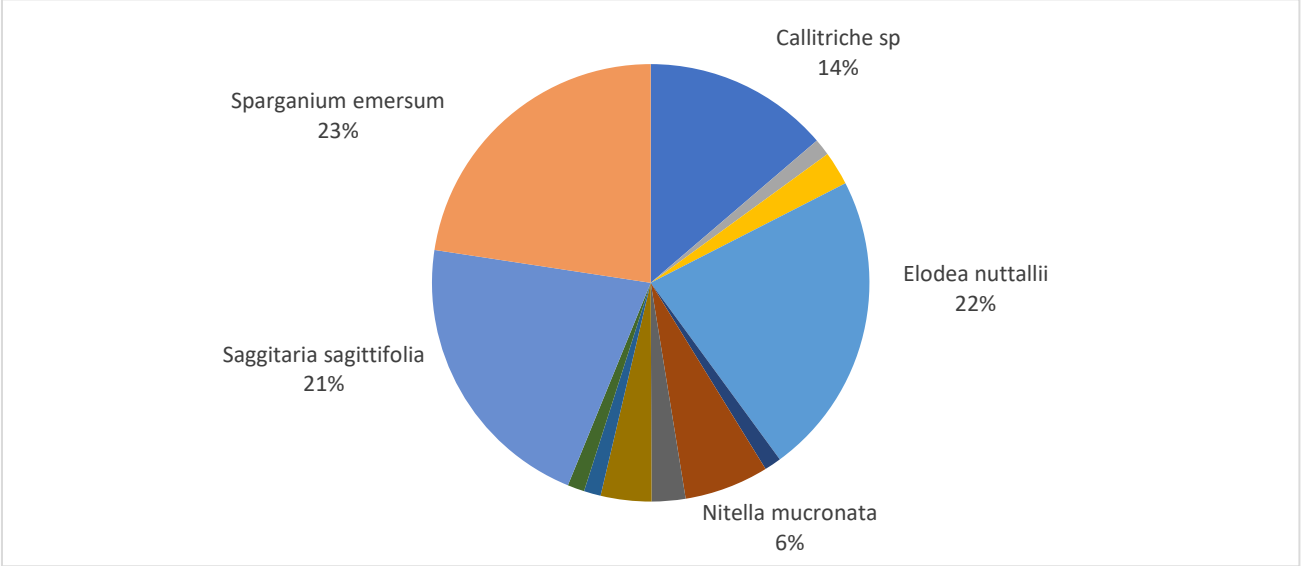
Unbranched bur-reed, *Sparganium emersum,* was the most dominant species on the section of the Yare surveyed, followed by Nuttall's waterweed, *Elodea nuttallii.* There was a good species richness in the stretch surveyed, with a total of 14 separate species recorded. Species richness and abundance was particularly good through the Thorpe Green reach. There was an average of one occurrence of no plants across the surveys. Given the difference in number of points, this gave a relative abundance of 0.04, as seen on the Thurne.

Species richness dropped between the two surveys, with 12 species recorded in the early survey and only 7 recorded in the later survey. Filamentous algae *Zygnematales* increased in abundance between the survey and had significantly higher abundance in the later survey than in the early survey.

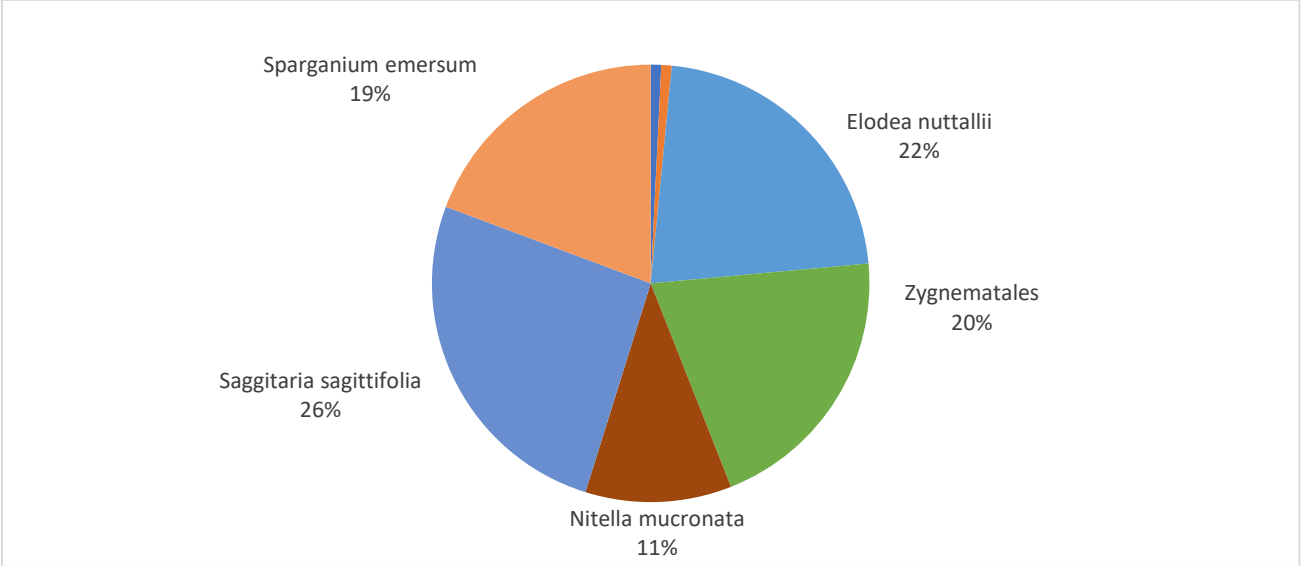
April and August Survey Results



April Survey Results



August Survey Results



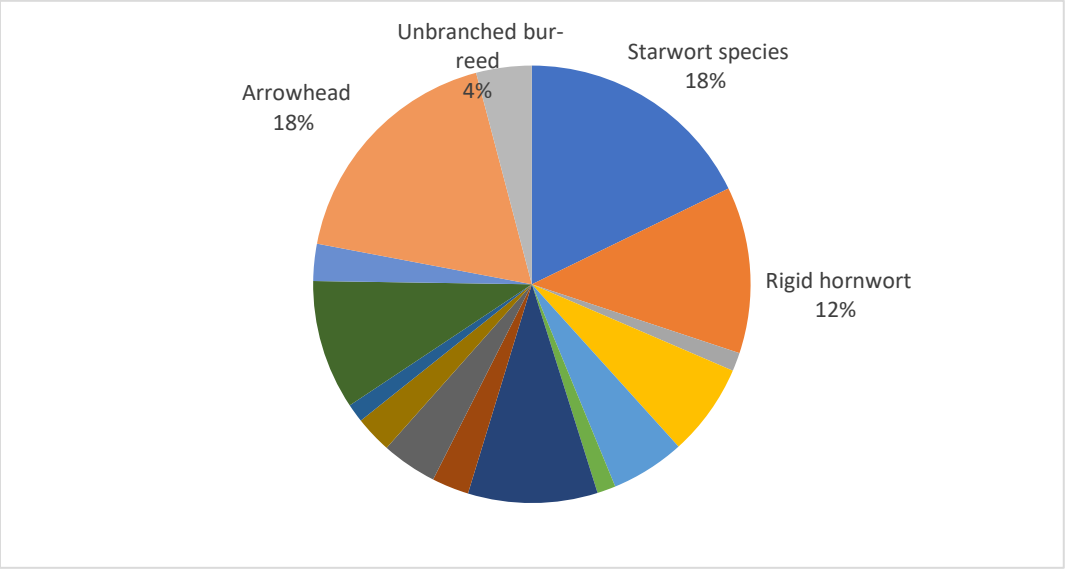
Wensum

Common name	Scientific name	Abundance	Occurrences
Arrowhead	*Saggitaria sagittifolia*	0.68	13.5
No plants	*No plants*	0.31	14
Starwort species	*Callitriche sp*	0.15	2.5
Unbranched bur-reed	*Sparganium emersum*	0.15	5.5
Yellow water lily	*Nuphar lutea*	0.13	2.5
Rigid hornwort	*Ceratophyllum demersum*	0.11	2.5
Nuttall's waterweed	*Elodea nuttallii*	0.08	3.5
Spiked water milfoil	*Myriophyllum spicatum*	0.08	1.5
Perfoliate pondweed	*P. perfoliatus*	0.08	0.5
Enteromorpha	*Enteromorpha*	0.06	1.5
Zygnematales	*Filamentous algae*	0.05	1
Pointed stonewort	*Nitella mucronata*	0.04	1.5
Fan-leaved water crowfoot	*Ranunculus circinatus*	0.02	1
Common water moss	*Fontinalis antipyretica*	0.01	0.5
Blunt-leaved pondweed	*P. obtusifolius*	0.01	0.5
Total number of species recorded		**14**	**Total number of samples taken: 42**

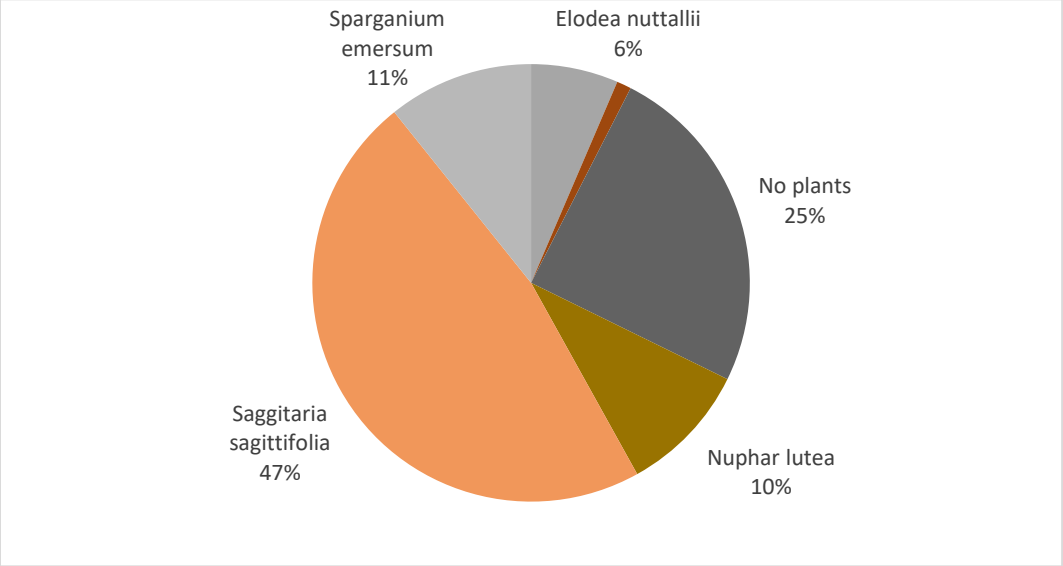
Arrowhead, *Saggitaria sagittifolia,* starwort, *Callitriche sp.* and unbranched bur-reed, *Sparganium emersum,* were the most dominant species on the Wensum. The species richness was similar to that recorded on the Yare but overall abundance was lower on the Wensum. The early survey showed poor species richness, although the species that were present were in relatively good abundance. However, there were fourteen occurrences of no plants, giving a relative abundance of 0.31.

By the time of the later survey, species richness had increased, although *S. sagittifolia* was still the most dominant species, it did not dominate the species composition as significantly as in the early survey. *Callitriche* was as abundant as *S. sagittifolia*, followed by *Ceratophyllum demersum.*

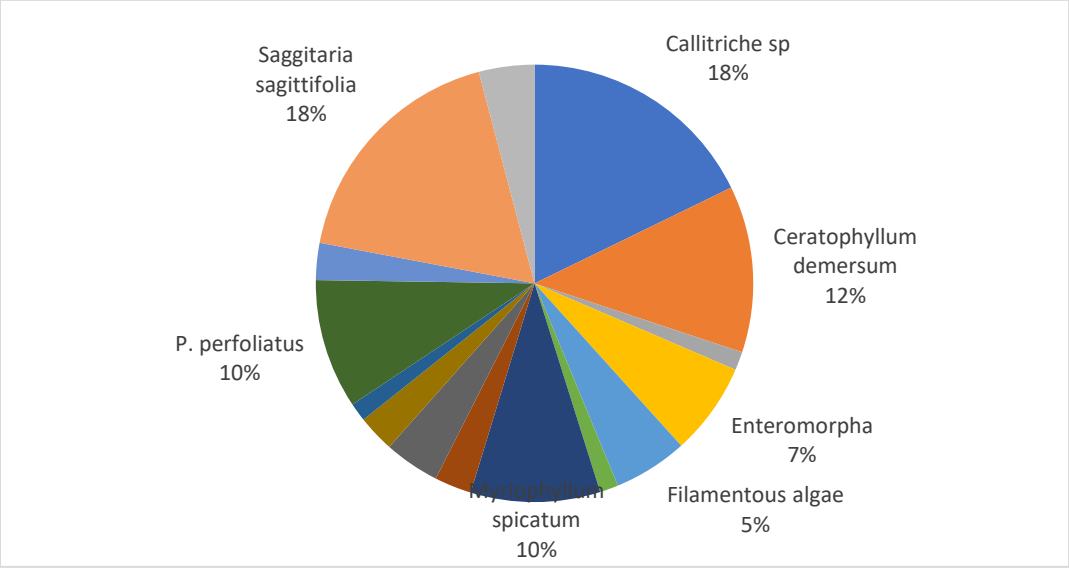
April and August Survey Results



April Survey Results



August Survey Results

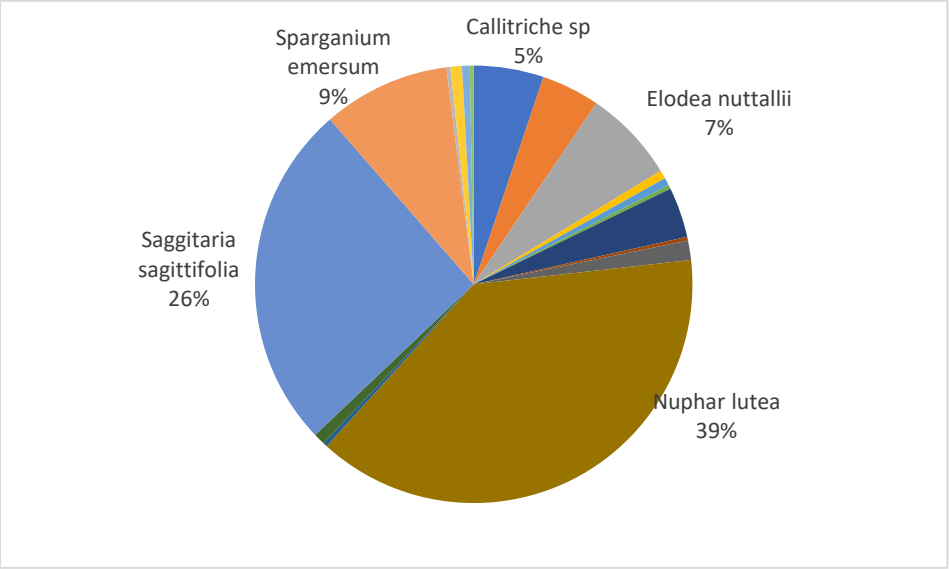


Ant

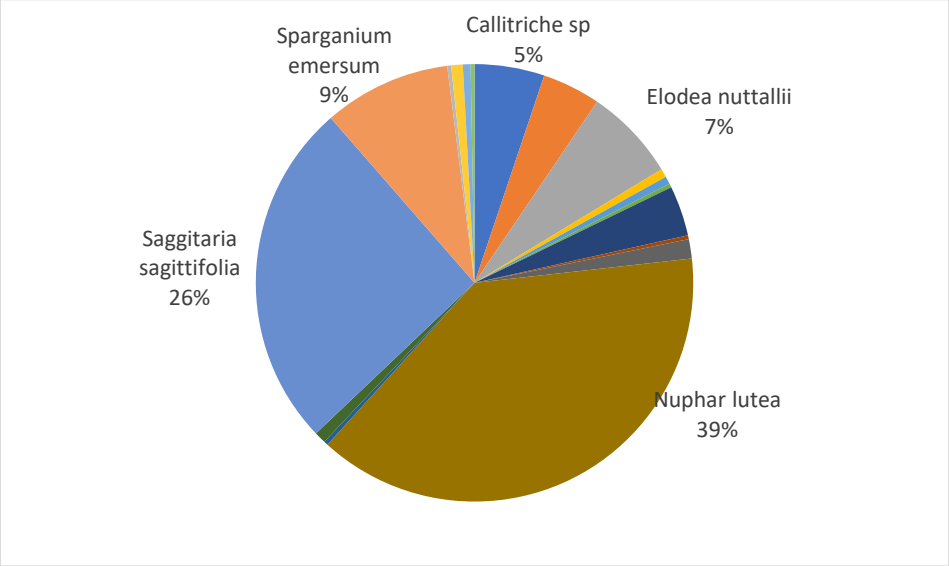
Common name	Scientific name	Abundance	Occurrence
Yellow water lily	*Nuphar lutea*	1.82	46
Arrowhead	*Saggitaria sagittifolia*	1.22	29
Unbranched bur-reed	*Sparganium emersum*	0.45	20
Nuttall's waterweed	*Elodea nuttallii*	0.32	10
Starwort species	*Callitriche sp*	0.24	18
Canadian waterweed	*Elodea canadensis*	0.20	16
Frogbit	*Hydrocharis morsus-ranae*	0.18	3
Fan leaved water crowfoot	*Ranunculus circinatus*	0.04	3
Water Soldier	*Stratiotes aloides*	0.04	3
Zygnematales	*Filamentous algae*	0.03	4
Common water moss	*Fontinalis antipyretica*	0.03	2
Bladderwort	*Utricularia vulgaris*	0.03	2
Common duckweed	*Lemna minor*	0.01	1
Fennel leaved pondweed	*P. pectinatus*	0.01	2
Greater duckweed	*Spirodela polyrhiza*	0.01	1
Water violet	*Hottonia palustris*	0.01	1
Total number of species recorded		**17**	**Total number of samples taken: 37**

The Ant was found to have average species abundance, although species richness was relatively high, with 17 species recorded across 37 survey points over both surveys. Yellow water lily *Nuphar lutea* was consistently the most dominant species, across both surveys. Arrowhead *Saggitaria sagittifolia* was the second most commonly recorded species. There were five occurrences of no plants, giving a relative abundance of 0.07.

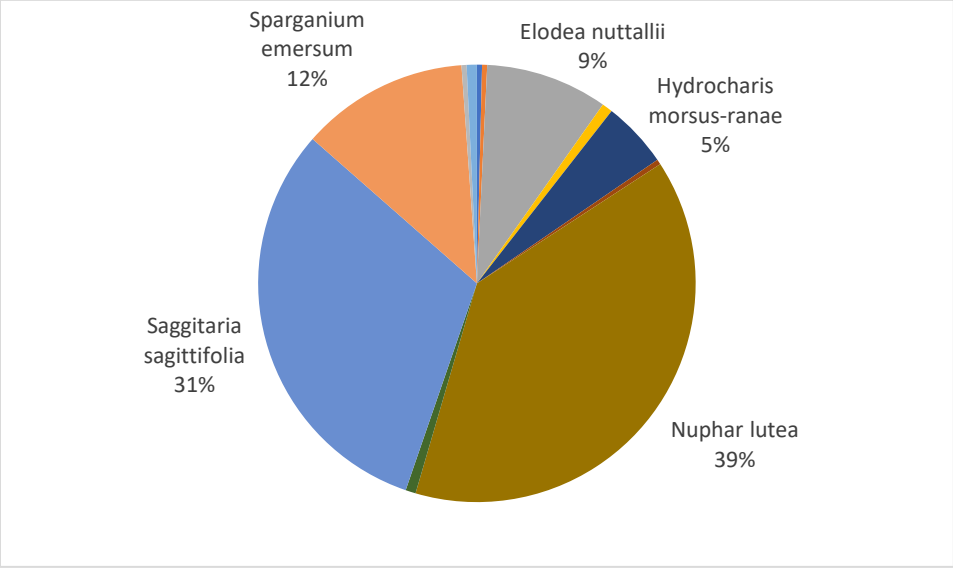
April and August Survey Results



April Survey Results

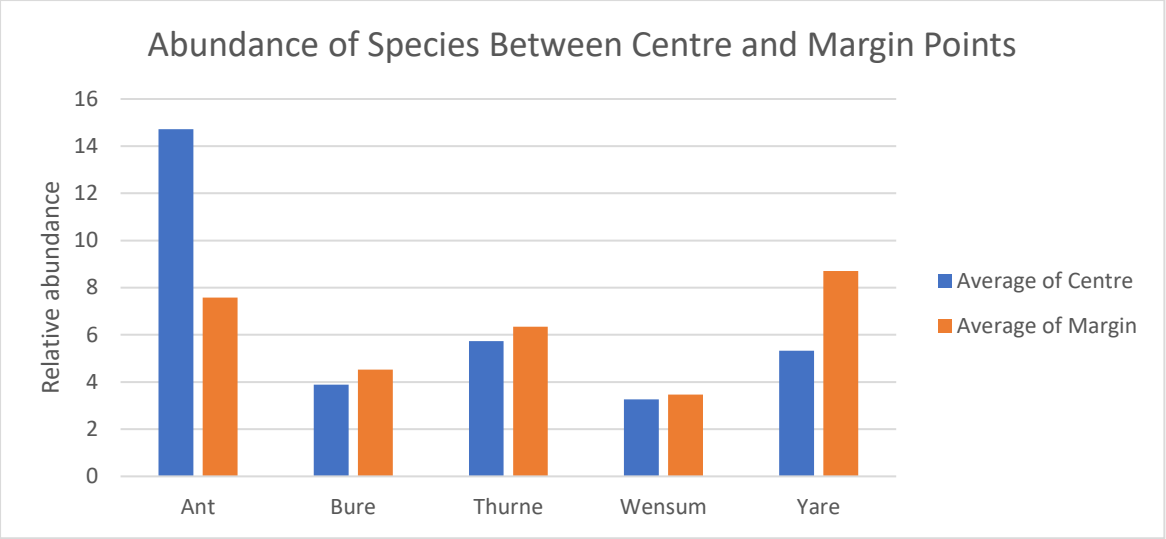


August Survey Results

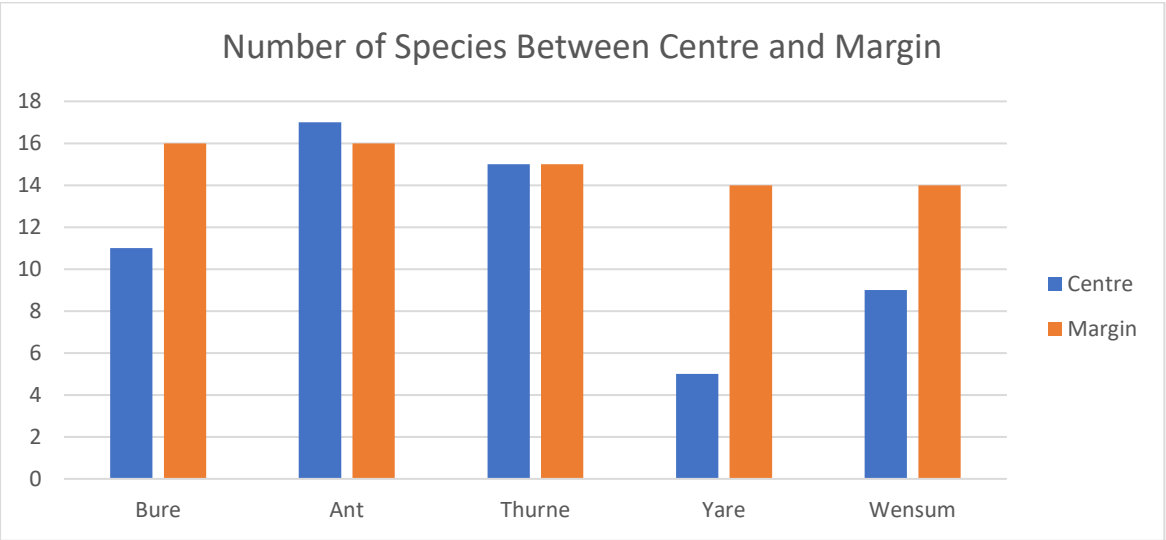


Variation in centre and margin points

It was hypothesised that plants would have a greater abundance at the river channel margins than in the centre. To an extent, this was found to be the case. There tended to be slightly greater abundance of plants in the marginal points on all the river systems except the Ant, where there was considerably greater abundance of plants in the centre of the channel. *Saggitaria sagittifolia* and *Sparganium emersum* which both grow more commonly in the middle of the channel rather than at the margins, were two of the most frequently recorded species on the Ant. There is only a small difference in abundance between central and marginal points on most of the other river systems surveyed.



The Ant also had greater species richness in the centre than in the margins, whilst most of the other river systems show considerably greater species richness at the channel margins than in the centre. The Thurne shows equal species richness between the channel margins and the centre. The areas of the rivers surveyed are all in the upper reaches of the river systems and tend to be narrow compared to downstream reaches which may have an impact on the relatively similar abundances between the channel margins and centres.



Annual comparison across all surveyed stretches

There was a slight decrease in the number of vascular plants recorded in 2022 compared to 2021. This slight decrease also occurred in the number of macro-algae and mosses recorded between 2021 and 2022. However, the number of free floating or round floating leaved plants and stoneworts recorded between 2021 and 2022 showed a marginal increase.

Acknowledgements

The Broads Authority, would like to thank all those individuals and organisations who assisted during the 2022 survey season by providing their time, boats, identification skills or permissions.

Many thanks must be expressed to the landowners who kindly granted permission to access the privately owned & managed broads: Norfolk Wildlife Trust, Natural England, the Horsey Estate and the National Trust. Trafford Estate, Hoveton Estate, Suffolk Wildlife Trust and the Trustees of Burgh of St Margaret and Billockby Poors Trust.

Many thanks to those individuals who facilitated access to the broads this year; John Blackburn, Steve Collin, Debs Kershaw, Adam Houlgate, Rick Southwood, Robin Buxton, Steve Prowse, Richard Starling, Simon Partridge and Chris Tubby from How Hill Trust, Tim Strudwick, Stephen Watts, Neil George, Richard Jordan and Jamie Nickerson.

Most of all many thanks all those who gave up their time to collect and assist with analysing the water plant data; Abigail Leach, Emily Leonard, Emily Chittenden, Sue Stephenson, Jonathan Cook, Emma Harris, Kylie Moos, Mike Whittaker, Erin Barber, Dan Hoare, Erica Murray, Natural England - Elizabeth Mitchell, Marc and Elaine Green, NWT - Bob Morgan, Elvie, John and Robert, James Addison, Olivia Coman, Evie Meale and James Gathergood.

A special thanks to Vicky Short for all the GIS work involved and Tom Waterfall for formatting the report and getting it published online.

Appendix I: Common water plants in the Broads

Table 27

Details of Broads water plants

Group	Scientific name	Common name	Section 41
Stoneworts	*Chara aspera*	Rough stonewort	
	C. baltica	Baltic stonewort	Y
	C. connivens	Convergent stonewort	Y
	C. contraria	Opposite stonewort	
	C. curta	Lesser bearded stonewort	
	C. globularis	Fragile stonewort	
	C. hispida	Bristly stonewort	
	C. intermedia	Intermediate stonewort	Y
	C. pedunculata	Hedgehog stonewort	
	C. virgata	Delicate stonewort	
	C. vulgaris	Common stonewort	
	Nitella flexilis	Starry stonewort	Y
	N. mucronata	Pointed stonewort	
	N. translucens	Translucent stonewort	
Vascular macrophytes	*Acorus calamus*	Sweet flag	
	Crassula helmsii	Australian swamp stonecrop	
	Callitriche sp.	Starwort sp.	
	Ceratophyllum demersum	Rigid hornwort	
	Elodea canadensis	Canadian waterweed	
	E. nuttallii	Nuttall's waterweed	
	Eleogiton fluitans	Floating club-rush	
	Glyceria maxima	Reed sweet grass	
	Hippuris vulgaris	Mare's tail	
	Myriophyllum spicatum	Spiked water milfoil	
	M. verticillatum	Whorled water milfoil	
	Najas marina	Holly-leaved naiad	Y
	Persicaria amphibia	Amphibious bistort	
	Potamogeton acutifolius	Sharp-leaved pondweed	
	P. berchtoldii	Small pondweed	
	P. crispus	Curled pondweed	
	P. friesii	Flat-stalked pondweed	
	P. lucens	Shining Pondweed	
	P. natans	Broad –leaved pondweed	
	P. obtusifolius	Blunt-leaved pondweed	
	P. pectinatus	Fennel-leaved pondweed	
	P. perfoliatus	Perfoliate pondweed	
	P. pusillus	Lesser pondweed	
	P. trichoides	Hair like pondweed	
	Potamogeton x Salicifolius	Willow-leaved pondweed	
	Ranunculus circinatus	Fan-leaved water crowfoot	
	Rorippa nasturtium-aquaticum	Water cress	
	Saggitaria sagittifolia	Arrowhead	
	Sparganium erectum	Branched bur-reed	
	S. emersum	Unbranched bur-reed	

	Stratiotes aloides	Water-soldier	
	Utricularia vulgaris	Greater bladderwort	
	Zannichellia palustris	Horned pondweed	
Free-floating or Round floating leaved macrophytes	*Hydrocharis morsus-ranae*	Frogbit	
	Lemna gibba	Inflated duckweed	
	L. minor	Common duckweed	
	L. minuta	Least duckweed	
	L. trisulca	Ivy-leaved duckweed	
	Nuphar lutea	Yellow water lily	
	Nymphaea alba	White water lily	
	Spirodela polyrhiza	Greater duckweed	
Macro-algae & Mosses	*Enteromorpha*		
	Fontinalis antipyretica	Common water moss	
	Hydrodictyon	Water net	
	Leptodictyum riparium	Stringy moss	
	Zygnematales	Filamentous algae	

Appendix II: Hydroacoustic report

Hydroacoustic surveys of Hickling Broad Annual Report 2022

Origination

Version	Author	Date	Detail	Approved by
1.0	JC		Initial Draft	
2.0	JC	14/2/23	Second Draft	Dan Hoare

Distribution

Name	Role	Organisation	For sign-off, information, or comment
Sue Stephenson	E&D Supervisor	BA	
Dan Hoare	Head of CME	BA	

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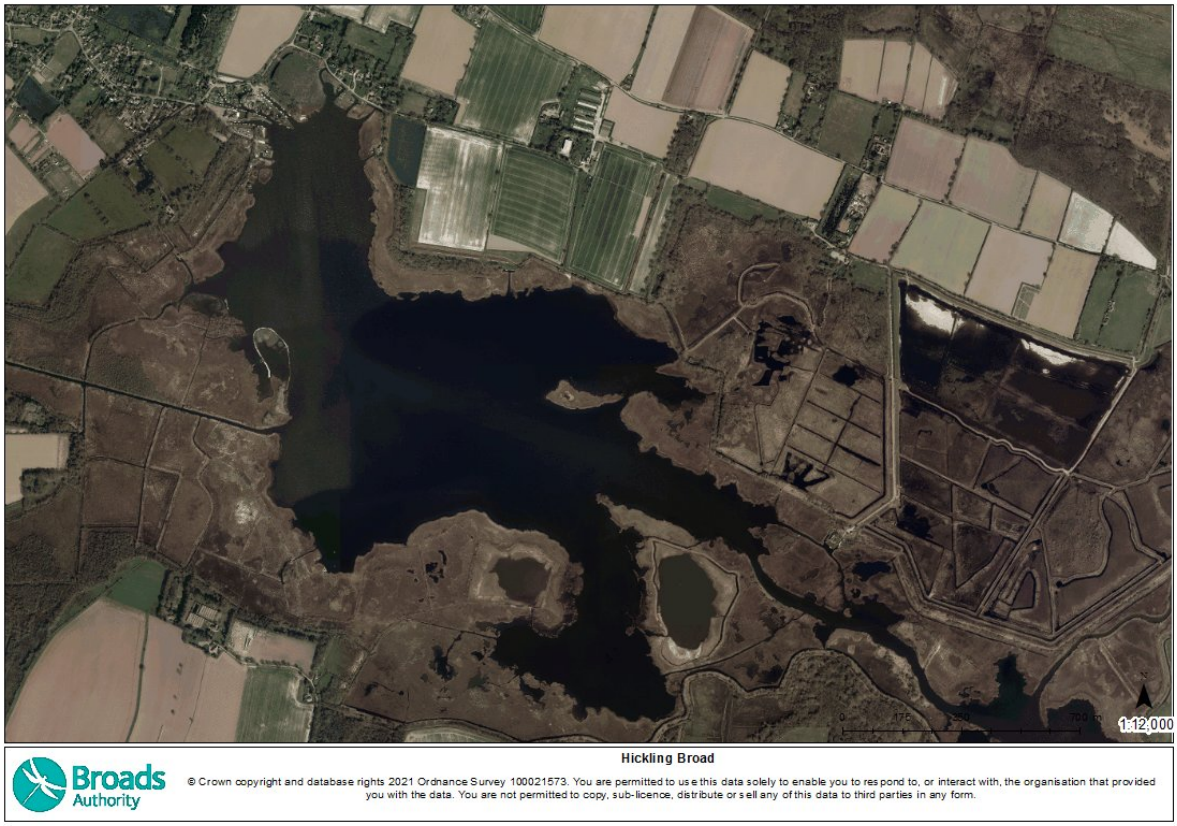
1 Background Information

1.1 Hickling Broad

Hickling Broad (Figure 1) is the largest body of water within the Norfolk & Suffolk Broads, comprising 128 hectares (ha) of open water. The broad has an average depth of between 0.68m to 1.86m and the bed is mostly comprised of soft mud with a layer of fluidised sediment on top. Hickling Broad contains species and habitats of high conservation importance, and is also a key navigation waterbody within the Broads executive area.

Figure 1
Aerial image of Hickling Broad from 2020



As the navigation authority, the Broads Authority (BA hereafter) is obliged to maintain navigable access within the Broads Executive Area. Within Hickling, the current water depth is below recommended guidelines in parts of the broad (1.3 m at MLW, Sediment Management Strategy, 2007) and water plant growth from the bed during summer months can further reduce accessibility for boats. For Hickling Broad, these recommended guidelines are assessed with consideration to the presence of protected water plant communities. Given the good water plant growth in Hickling Broad and the importance of the broad to navigation and recreation in the Norfolk Broads, the main channel has undergone management in the form of dredging during the winter months and water plant

cutting in the summer (assent from Natural England is currently in place to cut the submerged water plants within the marked channel to enable boat access to continue).

1.2 Hydroacoustic Survey

Hickling Broad is monitored to assess the condition and status of the water plant community and provide useful information to inform management decisions. Two complimentary survey techniques are conducted at Hickling Broad. Hydroacoustic surveys provide a measure of the height, cover and volume of water plants across the broad. Standard water plant surveys identify the species present at 39 sampling points and provide a score of their abundance. The purpose of this report is to present the findings of the hydroacoustic surveys of Hickling Broad.

Table 1

Details hydroacoustic survey conducted at Hickling Broad.

Year	Survey date	No. of transects	Distance surveyed (m)
2013	October	14	4,746
2014	August	26	8,120
2015	August	18	6,585
2016	June	19	12,468
	October	19	10,565
2017	May	19	12,204
	June	37	21,238
	August	37	22,148
	October	37	22,673
2018	May	19	11,943
	August	19	11,761
	October	19	11,975
2019	May	19	11,704
	August	19	11,981
	October	19	12,242
2020	June	19	10,092
	August	19	11,796
	October	19	11,964
2021	May	19	11,897
	August	19	11,717
	October	19	11,692
2022	May	19	11,496
	August	19	10,799
	October	19	11,290

Hydroacoustic surveys have been conducted annually at Hickling Broad since 2012 (Table 1). In 2016, the survey design was updated to incorporate the water plant survey points (see below), with the frequency of surveys also increased. In 2017, an additional 18 transects,

running parallel to the main transects were surveyed in June, August and October, to increase the coverage of the western section of the broad. The increased survey effort was in response to the expansion of water plants in 2016 with the aim of monitoring the growth of plants over the growing season. The schedule returned to the original number of surveys and transects in 2018.

2 Methodology

Hydroacoustic survey equipment, utilising sonar technology, is commonly used for detection, assessment, and monitoring of underwater physical and biological objects. Boat-mounted hydro-acoustic equipment can be utilised to detect the depth of a water body (bathymetry), as well as the presence or absence, distribution and size of underwater plants.

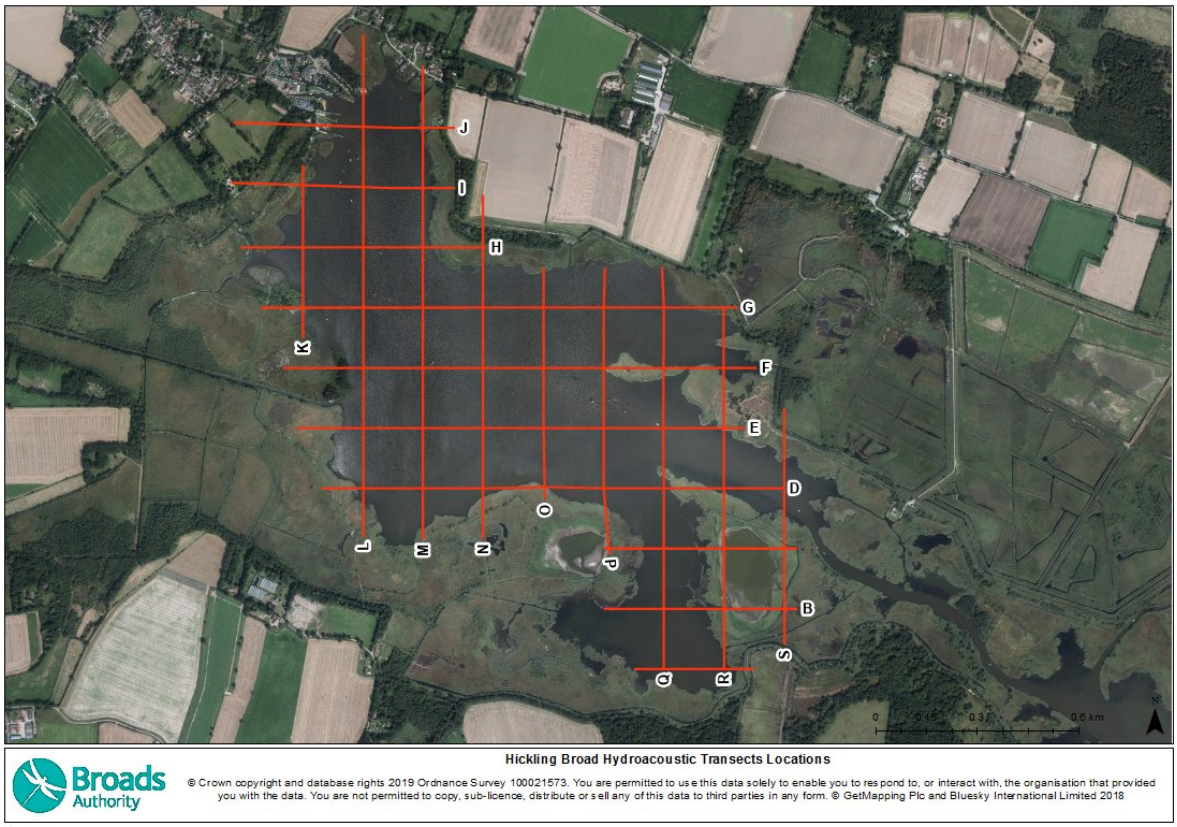
Such survey equipment measures the range to an object and its relative size by producing a pulse of sound and measuring the time it takes for an echo to return from the object and the amplitude of the returned echo. The range is calculated as a function of the speed of sound and the time it takes for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

The surveys were completed with updated hardware (BioSonics DT-X scientific echosounder) and software which was first used last year in the August survey. The older equipment (DTX biosonics) was replaced as the software was no longer being supported.

2.1 Survey design and programme

From 2018 onwards, the survey design reverted to the 19 transects (A to S) first surveyed in 2016. The length of the programmed transects are between 150 to 1020m and the survey consists of ten transects on an east – west axis and nine on a north – south axis (Figure 2). These parallel transects are 177 m apart and the location where transects intersect corresponds to the sample points for the annual water plant survey.

Figure 2
Location of the 19 hydroacoustic survey transects covering Hickling Broad.



Three surveys were programmed for 2022, in May, August and October. The programme was devised following the assessment of previous hydroacoustic surveys (see 1.2 above).

2.2 Survey Methodology

The hydroacoustic surveys were conducted by navigating a survey boat along the transects (see Figure 2), maintaining a constant speed of approximately 5 miles per hour (mph). The equipment used in this survey included a BioSonics DT-X, single beam (10°), 420 KHz transducer, with an on-board control unit and operating laptop. All data recorded was geo-referenced through connection to an internal GPS receiver. This allowed subsequent quantitative analysis of the data using Visual Aquatic post-processing software, developed specifically with a vegetation analysis component (see below).

The surveys were conducted by trained BA staff on 10th May, 10th August and 13th October 2022. Table 2 presents the total length of transects surveyed in each of the surveys conducted in 2022.

Table 1
Sampling details

Survey	Dates	Number of transects	Distance surveyed (m)
May	10th 2022	19	11,496
August	10th 2022	19	10,799
October	13th 2022	19	11,290

2.2 Data analysis

Using the Visual Aquatic 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. The sonar produces 5 pings per second and the transects were analysed every 10 pings. The programme produces a report on those 10 pings to get an average on depth, plant height and percentage cover.

The results derived from the processing of the hydroacoustic data were then used to calculate plant height, mean area of lake bed covered by water plants (PAI) and mean percent volume of the water column inhabited by water plants (PVI). Overall means were calculated for each survey for the entire broad and the individual transects (A to S). Water depth on the date of the survey is recorded and variability between surveys should be considered when interpreting results. Water depths are noted with the result tables and accompanying maps. The results of the three surveys of Hickling Broad are presented in Table 3, figures 1 to 3 are the mean results of the surveys since 2013.

Table 2
Results of the hydroacoustic surveys of Hickling Broad in 2022.

Metric	May 2022	August 2022	October 2022
Metres Above Ordnance Datum (mAOD)	0.17m	0.33m	0.50m
Maximum water depth (m)	1.51m	1.67m	1.96m
Mean water depth (m)	1.01 m	1.09m	1.36m
Maximum water plant height (m)	1.05m	1.08m	1.36m
Mean water plant height (m)	0.51m	0.57m	0.49m
PAI (%)	68.25	85.45	80.63
PVI (%)	41.91	50.30	30.22

Figure 4

Mean Plant Height in metres

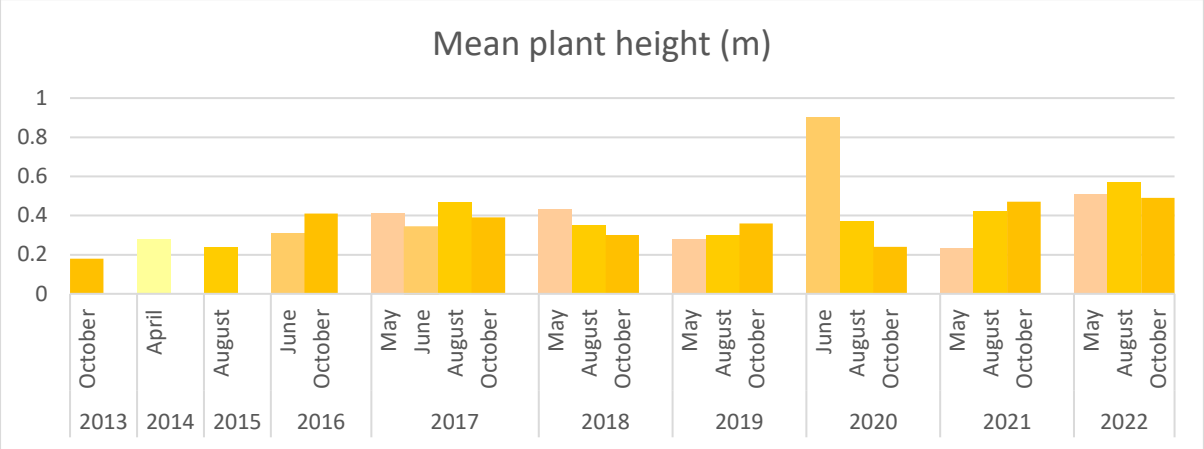


Figure 5

Mean PAI (plant area over bed)

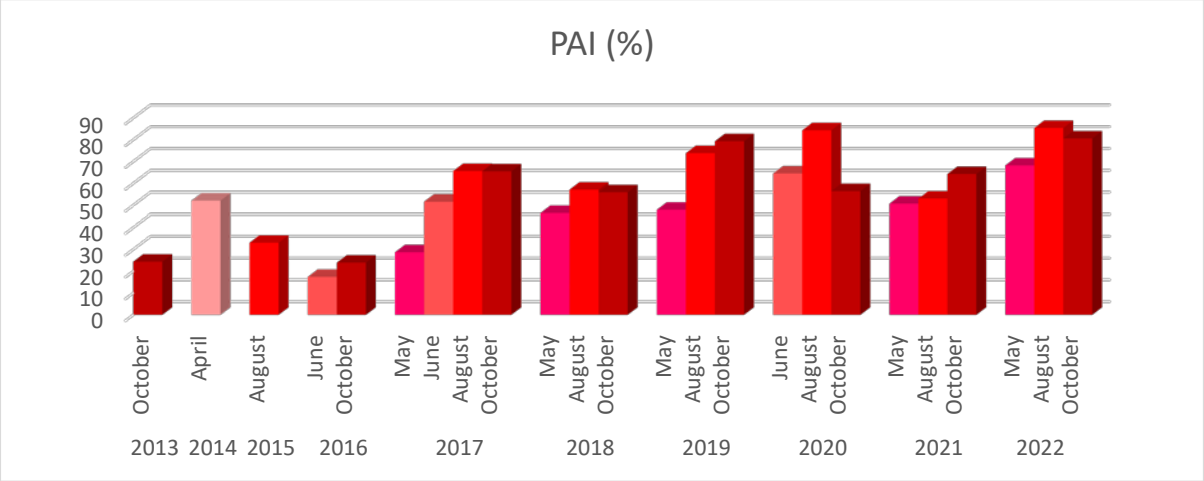
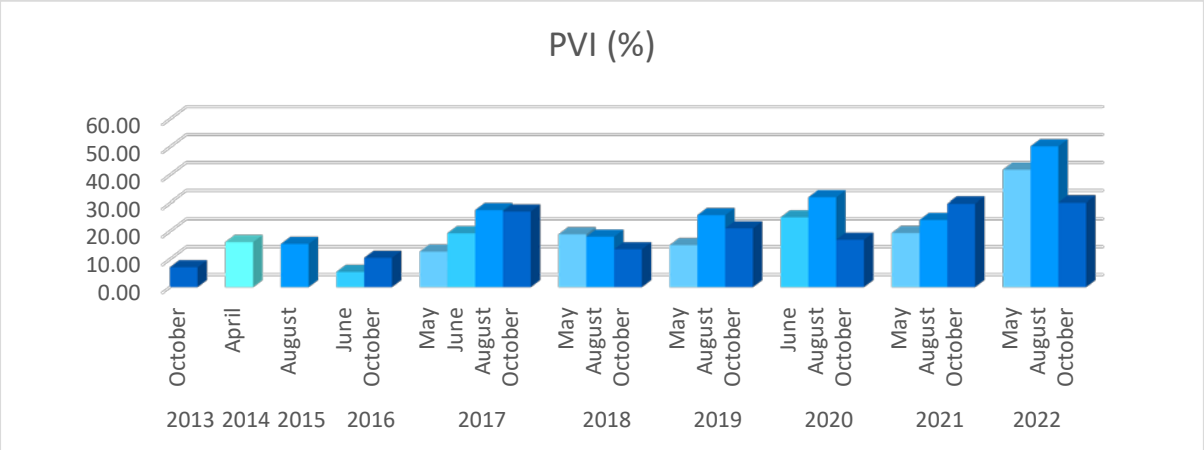


Figure 6

Mean PVI (Plants in water column)



The annual mean water level for Hickling Broad is 0.35m ***Meters above ordnance datum*** (mAOD). At the time of the survey in May 2022 the mAOD was 0.17m, during August, the mAOD during the survey was 0.33m and in October 0.50m. This considerable variation in actual water levels through the three months needs to be considered when interpreting the results as the percentage volume of plants in the water column (PVI) will read higher when water levels are low and lower when water levels are high.

In May, water plants reached a maximum height of 105cm in transect Q and an overall mean height of 51cm. Seven transects recorded plants reaching a maximum height of 81cm plus and ten transects had mean heights of at least between 50cm and 64cm. Transect C had the greatest mean cover of water plants (PAI) with 97%, which is one of the shortest transects. The second highest transect (B) containing 91% PAI and the lowest cover at just 30% PAI was transect H. Overall PVI was estimated at 41.91%, with values ranging from 16.01% (S) to 67.78% (C); all together eleven transects displayed a mean PVI figure of over 40%.

The maximum plant height recorded in August was 108cm, with twelve transects containing water plants in excess of 80cm in height, all the transects had a max plant height above 73cm. The mean heights ranged from 34cm to 86cm, with fourteen transects with a mean of at least 50cm in height. Overall, mean plant cover (PAI) was estimated at 85%, with a range of values from 52% (transect R) to 98% (transect B), with sixteen transects containing a minimum of 80% cover. The mean PVI ranged from 31% (transect C) to 77% (transect B), resulting in an overall mean of 50%. In total, eight transects contained PVI minimum values of 50% (transects A, B, C, D, I, N, P & Q).

The maximum height of the water plants in Hickling Broad increased by 28cm to 136cm in October, with nine transects containing plants greater than 100cm in height (transects A, E, F, G, N, O, P, Q & R). The mean height of water plants by transect ranged from 23cm (S) to 72cm (A), resulting in an overall mean of 49cm for the broad as a whole. Cover of plants ranged from 61% (R) to 97% (C), resulting in an overall mean cover for the broad of 81%. The mean PVI percentages ranged from 16% (S) to 59% (A), with an overall mean of 30%.

The result shows that transect B to the south contained highest plant cover from 91% to 98% over the duration of the survey period. The remaining Southern transects A, C & D through the survey period ranged from 66% to 97% plant cover. There was an average increase of 9% cover from May to October for the four transects. There was a 68% increase of cover in transect S from May to October, this was the largest increase in all the transects. Transect H had the second largest increase of 54% in cover over the period. Transect K indicates a decline of plant cover from May to October by 23%, this transect was not surveyed in August as plant growth was at a density that prevented navigation. Transect H & F had the lowest percentage cover over the 3 surveys both having an average 62%, while in comparison, transect B averaged 95%. Transects A, B, C and D are all particularly high.

In May, there were four transects with a percentage of plants in water column (PVI) greater than 50%; in August that increased to eight transects, then by October reduced to three transects. Transects B & G in May had a PVI of 60% and 67%, which is high compared to previous years when PVI has been recorded at 60% in the height of the growing season. Transect B had the highest PVI over the year with 76% recorded in August and ten transects had a minim of 49% in that month. Transect A increased 27% from May (35%) to August (74%). Over the three surveys, transect C was the highest averaging 61% with transect S being the lowest at 21% PVI. Over the three surveys, 11 transects averaged a minimum of 40%, of which 4 of these had an average of 50% or greater.

In Figure 3, the maps show the water depths of Hickling along the transects during the survey, in all three, the navigation channel can be identified from the dark blue points. It is also notable in October where the map shows deeper water over the broad which coincides with the highest water levels recorded during the survey period. During the survey the gauge depth averaged 0.50m mAOD compared to 0.33m in August and 0.17m in May.

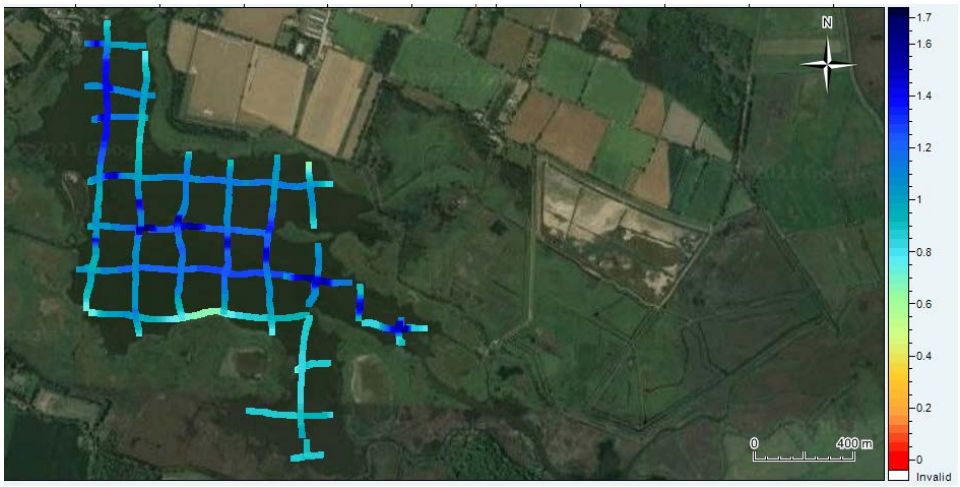
The average plant heights in August mapped in Figure 4 show that the plant growth was at its peak which also coincides with a PVI of 57cm. The south east corner of the broad had the most growth; this was also represented in the data from the PVI of transects A, B, C, and Q, these transects having some of the highest PVI, all between 62cm and 77cm.

The August map from Figure 5 shows the highest PVA which correlates with the 85.45% plant cover figures obtained from the data. The southeast corner again indicates vigorous growth which is represented from the data in those transects (A, B, C & D); 85% to 89% PVA. All the maps show the abundance of in the southeast part of the broad. The map for May indicates good plant coverage at the beginning of the year, though the water levels where low (17cm) and need to be considered as this will reduce the water column volume which is likely to skew the results. Transect K is not shown on the August map due to the density of the macrophytes and their height preventing the sonar gathering the data and issues with navigating through that section of the broad.

Figure 3
Water Depths

May

August



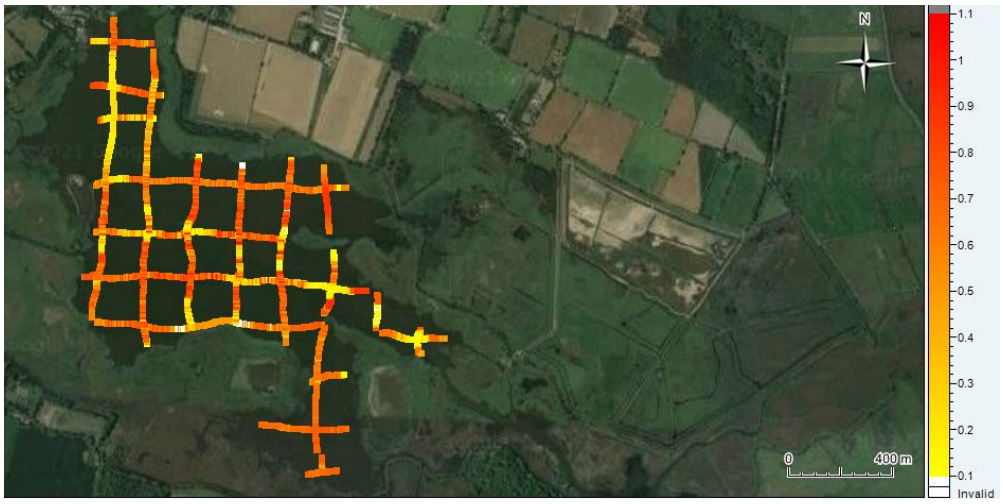
October

Figure 4

Average Plant Height

May

August



October

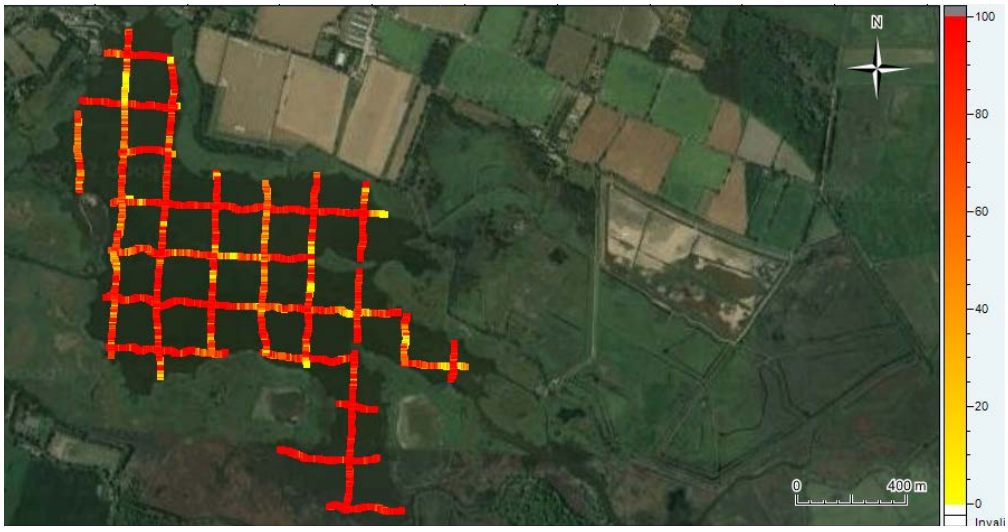
Figure 5

Average Plant Cover

May

August

October



4 Conclusions & Recommendations

- The hydroacoustic surveys of Hickling Broad reveal that water plant cover reached its highest value in August (85%) with lowest levels being measured in May, though this was high at 68% compared to previous years.
- The higher than usual plant cover in May is likely due to a couple of factors, these being the low level of water (gauge mean 0.17m) compared with the average 0.35m mAOD; and warm weather in April promoting early growth.
- The greatest value for mean plant height was recorded in August at 57cm compared to 48 cm the previous year, and the highest percentage volume of water plants was also recorded in August at 50%.
- Throughout the season, transects A, B, C & Q had a minim of 75% of plant cover, in October they were all above 91%.
- Transect K was difficult to survey and in August was not surveyed due to the density of macrophytes. It is one of shallower and sheltered parts of broad and has good a stonewort population. Taking these factors into consideration, it provides favourable conditions for macrophytes to grow and become established. Stoneworts also retain a core structure if not disturbed or over-grazed, therefore due to the sheltered conditions, the plant bed is likely to retain its biomass through the seasons.
- Sixteen transects out of the nineteen surveyed in August had plant cover greater than 81% the highest being 98% in transect B, contributing to the 85% mean for the period.
- Transect R recorded the lowest plant cover of 52%, this is most likely due to the short length of the transect with a significant proportion of the transect dissected by the navigation channel. Though it was noted high plant cover occurred near the broad edge.
- Mean PVI was highest in August at 50% at the peak of the growing season; it was lowest in October at 30%. In May it was 41% although the particularly low water levels in May and a warm April prompting early growth will have impacted this figure. October's results are likely to be skewed owing to particularly highwater levels.
- The new sonar equipment does seem to provide higher percentage results in comparison to the previous DTX biosonics sonar. Alterations to the software and the analysis criteria means that a direct comparison to previous survey data cannot be made; this will change as more surveys are completed. It should be noted however that changing weather patterns may continue to affect survey results by widening the variations of water levels throughout the survey season.