The Big Seaweed Search: evaluating a citizen science project for a difficult to identify group of organisms

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1. The Big Seaweed Search invites people to survey UK seashores for 14 conspicuous seaweeds. The science investigates i) impact of sea temperature rise, ii) spread of non-native species, and iii) impact of ocean acidification. Survey data submitted between June 2016 and May 2020 were analysed to evaluate and explore project directions in relation to citizen science project development.

2. Of the 378 surveys submitted, 1,414 people participated, contributing 1,531 person hours. Surveys were undertaken around the UK, with the highest proportion (46.7%) in the south west and the lowest (3.7%) in the north east.

3. After data verification, 1,007 (54%) records were accepted. *Fucus serratus* had the highest number of entries correctly identified (66%) and *Undaria pinnatifida* the lowest (5%), inferring that at least some seaweeds can be difficult to identify, although the overall misidentification rate was relatively low (c. 15%).

4. Apart from *Alaria esculenta*, *U. pinnatifida* and *Saccharina latissima*, the large brown seaweeds were abundant on at least some shores. Non-natives *Sargassum muticum* and *Asparagopsis armata*, were band-forming but in low numbers. Coralline algae, whilst band-forming on some shores, were most commonly patchy or sparse in abundance. Revisits, i.e. repeat surveys, at the same site with an interval of at least one year, are relatively low, with 18 sites revisited once and three sites revisited twice. Currently, data are insufficient to determine whether any changes in abundance could be detected.

5. This study highlights areas where project developments can enhance data quality and quantity, e.g. better identification resources, training programmes for dedicated volunteers, and an annual focus week of activities. The project framed around climate change impacts, aims to raise awareness of the ecological importance of, and threats faced by, this understudied habitat and introduce conservation concepts including the need to protect common species showing signs of decline.

KEYWORDS

citizen science, conservation, coralline algae, data verification, large brown seaweeds, non-native species, ocean acidification

1. INTRODUCTION

The seaweeds, red (Rhodophyta), green (Chlorophyta) and brown (Phaeophyceae) macroalgae, are vital components of marine ecosystems. The UK, with its long and varied coastline, is rich in seaweed biodiversity (Brodie et al., 2016). It is a stronghold for habitat-forming seaweeds, such as kelp forests, which are highly productive, capture and transfer carbon to the open ocean and deep sea, provide nurseries for fish, and support an immense diversity of organisms (Pessarodona et al., 2018 and references therein; Steneck et al., 2002). However, seaweeds are being profoundly impacted by environmental change brought about by accelerating CO_2 emissions, increasing pressures on coastlines associated with human population growth, and increased consumption of finite resources (Brodie et al., 2014). There is overwhelming evidence that seaweeds are being impacted as a consequence of recent ocean warming trends (Harley et al., 2012; Brodie et al., 2014; Yesson et al., 2015; Smale, 2020; Filbee-Dexter & Wernberg, 2022), pressures of coastal populations and ocean acidification, resulting in declines in species abundance or loss (e.g. Brodie et al., 2014,2018; Yesson et al., 2015). Such declines in or loss of species is an increasing cause for concern but a lack of consistent monitoring over time is a key impediment in obtaining reliable evidence of change. This lack of monitoring is compounded by the difficulty of assessing seaweed-dominated areas (Brodie et al., 2018). Aside from the logistics of accessing remote or submerged locations, there are very few professional seaweed scientists to undertake this work on a nationwide scale.

At the same time, given the number of people in the UK that live on the coast or visit the seashore, there is great potential to invite citizens to gather seaweed data from intertidal areas (Bennion et al., 2019). Indeed, citizen science has been recognized as an extremely valuable tool with which to investigate rocky shores (Cox et al., 2012; Earp et al., 2022 and references therein). Furthermore, with high quality citizen science project design and appropriate training provision, citizen science can benefit both the public and scientists as an interactive outreach tool and research method (Newman et al., 2012).

The Big Seaweed Search was originally conceived in 2006, launched in August 2009 and ran until 2015. People were invited to search the seashore around Britain for 12 conspicuous and what were considered to be easily identifiable seaweeds (Supplementary

Table 1). The choice of species at that time was based on general observations that the distribution of seaweeds around UK's shores was changing; non-native species such as *Sargassum muticum* were spreading north and many species were responding to climate change and rising sea levels. It was designed to be a simple, accessible, fun activity that anyone could take part in anywhere in the UK at any time of the year, that would contribute to real research whilst also raising awareness of the importance and diversity of seaweed. It also fitted well with the Natural History Museum's (NHM) definition of citizen science: "the involvement of volunteers in scientific projects that contribute to expanding our knowledge of the natural world, through the systematic collection, analysis or interpretation of environmental observations.".

In 2011, two years after the original launch in 2009, there had been 7,000 website hits and 99 completed surveys (c. 1.5% conversion rate), largely from England. Between 2011 and 2015, it became apparent that there were a number of inherent problems with the design of the project that limited its ability to achieve its research goals. It became clear that people were having trouble distinguishing between some species. A particular problem came to light when the species data were mapped. *Bifurcaria bifurcata*, a brown species confined to the south-west coast of England, had been recorded from the north-east coast of England and confused with another brown species, *Himanthalia elongata*, whose young fronds can be confused with those of *B. bifurcaria*. A project review in 2015 identified what had worked well and what was less successful. For example, feedback from participants indicated that they enjoyed the activity, but the method, which involved noting the seaweeds during a walk on the beach, needed to be more rigorous to ensure that the data were comparable and of sufficient quality to be used for scientific research. Species photos were also essential so that identifications could be verified. Confusion between species highlighted a need for basic training in identification beyond the provided ID guide. Also, whilst the project had been based on scientific reasoning, this needed to be strengthened. This led to a review, revision and relaunch of the project in July 2016 with an additional partner, the Marine Conservation Society (MCS), who were expanding their citizen science programmes at the time. The addition of MCS to the project, meant that they had the benefit of working with the established NHM citizen science team whilst the NHM benefitted from a large body of volunteers and marine presence with regional engagement officers.

The science behind the project is still framed around the same environmental impacts, but the research and monitoring foci, have been adjusted to reflect priorities. The rationale is based on three key environmental impacts on the marine environment: i) sea temperature rise,

ii) ocean acidification, and iii) the increase in the number of non-native species. There is increasing evidence of declines of kelp forests around the world (Wernberg et al., 2010; Moy & Christie, 2012; Koch et al., 2013; Smale et al., 2013, Brodie et al., 2014, Krumhansl et al., 2016, Flixbee-Dexter & Wernberg, 2022) and that ocean warming is a key driver (Smale, 2019). There is also evidence that several of the large brown kelps, wracks and related species around the UK are declining at their southern edge and/or moving northwards (Mieszkowska et al., 2006, Yesson et al., 2015). Whilst ocean acidification is predicted to impact calcified seaweeds over the next century (Brodie et al., 2014), it already can cause reduced abundance, and reduced rates of calcification and recruitment in most coralline algae (Cornwall et al., 2021). Furthermore, ocean acidification can affect structural integrity of the skeletons of maerl-forming species including *Phymatolithon calcareum* and *L. corallioides*, free living calcified rhodoliths that support unique communities (Melbourne et al., submitted). There are also an increasing number of reports of the arrival of non-native species with the potential to pose threats to native biodiversity (Roy et al., 2018).

For the redeveloped Big Seaweed Search launched in 2016, people are invited to search the seashore around the UK for 14 seaweeds whose distribution and abundance may be affected by the three environmental impacts given above. The seaweeds included in i) sea temperature rise are the large kelps and wracks *Alaria esculenta*, *Ascophyllum nodosum*, *Fucus serratus*, *F. spiralis*, *F. vesiculosus*, *H. elongata*, *Pelvetia canaliculata* and *Saccharina latissima* associated with changes in distribution noted above. For ii) the increase in the number of non-native species, the brown algae *Sargassum muticum* and *Undaria pinnatifida*, and the red algae *Asparagopsis armata* and *Bonnemaisonia hamifera* were included. The addition of *Undaria pinnatifida*, to *S. muticum* (which had been in the original survey), was made because although it had originally been found on floating pontoons in the Solent, southern England, 1994 (Fletcher & Manfredi, 1995), it is now increasingly found on shores and more widely around the UK (Bunker et al., 2020). The taxa for iii) ocean acidification are calcified coralline algae and are not identified to species level but grouped as calcified crusts (crustose) and coral weeds (upright).

Following the revision of the Big Seaweed Search, the aim of this paper is to: i) undertake an analysis of the survey data gathered between June 2016 and May 2020, ii) evaluate how the results can be used for scientific research, and iii) explore possible ways forward with a view to developing the next stages in the advancement of citizen science projects.

2. METHODS

Data collection

Field data used in this study were collected from Big Seaweed Search surveys undertaken by members of the public between 1st June 2016 and 31st May 2020 around the coast of the UK, and the Channel Islands. Participants were able to visit any seashore but those shores with hard structures were recommended. Participants were asked to ideally start their survey an hour before low tide. They were asked to search for about one hour and to record the time they started and finished surveying. Presence/absence and abundance was recorded for each species, and participants were encouraged to photograph each species. Each survey was undertaken from the low water mark at the bottom of the shore to the upper limit of the tide at the top of the shore, recording all of the target species within the 5 m belt of the transect, following the methodology given in the guide (Supplementary Figure 1; https://www.nhm.ac.uk/content/dam/nhmwww/take-part/Citizenscience/seaweed-survey/big-seaweed-search-guide.pdf). Data were uploaded by the participants in the online recording form at http://www.bigseaweedsearch.org/data-entry.

Data verification

Every record that was entered into the online recording system underwent a verification process, as shown in the flowchart in Figure 1, ensuring that every species record matched the uploaded image. All records that fulfilled the acceptance criteria were verified by being marked as accepted and those that did not were marked as rejected. Once this had been completed, the whole data set for the period of study was downloaded as an excel file. Any 'test' records (i.e. those set up initially to test the on-line recording system) and any records failing quality control checks were removed. Observations were put into biogeographic regions following Connor et al. (2004), with records from the Channel Islands grouped with the Western Channel region.

Analysis

Survey data: For each survey completed, the data analysed covered the following: i) survey effort, i.e. the number of people who took part and the time they took to complete each survey, ii) date and location of each survey, iii) photographic evidence, iv) presence or absence of the 14 target seaweeds, and v) abundance of each target seaweed, which was recorded as one of the following categories: “band-forming” (the seaweed grows as an uninterrupted band right across the width of the 5 m width of the transect); “patchy” the seaweed grows in large patches (greater than one metre across) but does not cover the whole 5 m width of the transect); or “sparse” (the seaweed grows in small patches (less than one metre across).

Individual seaweed records: These were assessed to determine how many records were verified or rejected. Individual seaweed records were rejected for the following reasons: i) part of the record was missing, i.e. no photos, ii) the seaweed was misidentified (based on expert inspection of the image), or iii) the photograph showed the target was drift or unattached in the hand of the observer.

Biogeographic analysis: The number of surveys per biogeographic region was analysed to determine where effort was concentrated. The number of seaweed records per biogeographic region was also analysed to act as a baseline from which to monitor change with time.

3. RESULTS

Between 1st June 2016 and 31st May 2020, 378 surveys were uploaded to the Big Seaweed Search website and 1,414 people took part with an overall effort of 1,531 person hours (Table 1). The number of people participating in individual surveys varied between 1 and 57, (mean=4, median=2, mode=2 participants, with 95% of surveys conducted by 12 or fewer people). Twenty-five per cent of surveys were by adult volunteer groups, 20% by adult friend & family groups, 12% by friends & family groups with children, 15% by school & college groups, and 28% by other groups.

The distribution of surveys (Figure 2) showed that whilst there was wide geographic coverage, some areas lacked surveys. Notable in this respect (where there are suitable shores with hard substrata), were the Outer Hebrides, the Orkney Islands, the north and east coasts of Scotland, south Wales and much of the Northern Irish coast. The number of surveys per biogeographic region (Table 2) showed that considerably more surveys were undertaken in some regions than in others. The highest number undertaken (165 - 43.7%) was in the Western Channel & Celtic Seas region, whereas the lowest (14 - 3.7%) was for the Scottish Continental Shelf region.

After data verification, including rejection of 12% of surveys where no photos were uploaded and correct identification assigned to misidentified photos, 1,876 species records remained (Table 3). Of those, the number of accepted records was 1,007 (54%) and rejected records 869 (46%). This left the number of surveys with accepted records at 275 (73% of total surveys). The species with the highest proportion of correctly identified records, (Table 3), was *Fucus serratus* (66%) and the lowest, *Undaria pinnatifida* with just one validated record (5%). *F. serratus* was the species identified correctly most often for those taxa selected for sea temperature rise, whereas *Alaria esculenta* was the least (8.7%). Of the non-native species, *Sargassum muticum* was identified correctly most often with (48%) and *U. pinnatifida* the least although *Bonnemaisonia hamifera* with fewer submitted records initially, was similarly only recorded correctly once after verification (6.5%). The results for the coralline algae representing ocean acidification showed that calcified crusts were identified correctly (62%), marginally more than coral weeds (including *Corallina* spp., *Ellisolandia elongata* and *Jania* spp.) (57%).

Seventy-three per cent of rejected records were due to lack of photographic evidence in the record. A summary of reasons for rejection of records where there were photos is shown in Table 3. Of the 46% of records rejected, c. 27% had photos associated (Table 3). A number of the rejected records were for correctly identified species, but as drift/dead specimens, e.g. *A. esculenta*, *Saccharina latissima*, *Himanthalia elongata* and *Sargassum muticum*. Records of all other species rejected with photos were misidentified as different attached species, those with the highest percentages being *Pelvetia canaliculata*, *F. spiralis* and *B. hamifera*. With the exception of calcified crusts, records of drift/dead specimens were submitted for all species, those with the highest percentages being *U. pinnatifida*, *Asparagopsis armata* and *F. serratus*.

The results indicate that *S. muticum* was the easiest to identify and *U. pinnatifida* was the hardest (Table 3). Of those with photos, the overall percentage of species that were misidentified, including those drift/dead specimens, was 15%. The misidentification rates of *U. pinnatifida*, *B. hamifera*, *A. armata* and *Alaria esculenta* were all over 50%, i.e. they were misidentified more often than they were correctly identified.

Distribution maps for the 14 taxa after data cleaning are shown in Figure 3. For the sea temperature rise category, *F. serratus*, *F. vesiculosus*, *Ascophyllum nodosum*, *F. spiralis* and *P. canaliculata* were widely recorded from around the UK. In contrast, distribution records for *S. latissima* and *H. elongata*, although present in the south west and the north east, were more limited overall, and *Alaria esculenta* was only represented by one record in the south west and one in the north east. For the non-native category, records for *Sargassum muticum* were mostly confined to the southern half of Britain, *Asparagopsis armata* to the south west, the one record of *B. hamifera* in Northern Ireland, and the one record of *U. pinnatifida* from the south west. For the ocean acidification category, calcified crusts and coral weeds were widespread around the UK.

The proportion of accepted seaweed records by biogeographic region (Figure 2, Supplementary Table 2) follows the same pattern as for the number of surveys for these regions (Table 1) with the Western Channel and Celtic Seas the highest and Scottish continental shelf the lowest.

In terms of the abundance of species (Figure 4), all the large brown seaweeds potentially affected by increasing sea surface temperatures, were recorded as band-forming on some shores except for *Alaria esculenta* and *Saccharina latissima*. *F. serratus*, *F. vesiculosus* and *A. nodosum* had the highest numbers of band-forming records. The coralline algae, i.e. coralline crusts and coral weeds, were also band-forming on some shores but were more often recorded as patchy or sparse. Of the non-native species, *Sargassum muticum* and *Asparagopsis armata* were recorded as band-forming but numbers were low. All species were recorded as patchy for at least one record except for the non-natives *B. hamifera* and *U. pinnatifida*.

4. DISCUSSION

Analysis of 2016-2020 Big Seaweed Search data has provided, georeferenced and correctly identified species information at specific times that can provide a baseline on the distribution of the seaweeds selected for study from which future comparisons can be made. At the same time, the results, where 54% of the data could be used after cleaning and verification, have raised a number of challenges particularly related to following methods fully (e.g. taking photos and not recording drift/dead specimens) and difficulties in species identification, for this citizen science project, the first of its kind focused on seaweeds. Furthermore, it is clear from the results that seaweed species can be difficult to distinguish, even for trained members of the general public.

Whilst surveys have been undertaken from around the UK coast, the high number undertaken in south-west England and the lack of surveys in parts of Scotland may in part reflect popular holiday areas, more populated regions and ease of access. For analysis, the uneven geographic distribution of surveys was mitigated by combining data by biogeographical region (Yesson et al., 2015). This regional aggregation can be a useful way of analysing broader spatial patterns, allowing the monitoring of regional distribution and abundance patterns for the target species.

Given a core objective of the Big Seaweed Search is to monitor changes in seaweed distribution over time, a key question is whether the data show any evidence of change over the period of study. The ideal framework for examining temporal trends is to revisit the same locations over multiple years to monitor change. To date, only 21 BSS sites have been visited in more than one year (Supplementary Figure 2). Of those 21 sites, the majority (18) have had just one revisit but not in consistent years. Only three sites had been visited in three different years and no sites more than that. There are very few long-term datasets of seaweeds for the UK and the wider north-eastern Atlantic (see Yesson et al., 2015 and references therein) and studies have tended to resurvey sites where there are historical data (e.g. Simkanin et al., 2005 (Ireland); Mieszkowska et al., 2006) or in the case of Yesson et al. (2015) analysed a combined 36 year data set between 1974 and 2010. Our results do provide a baseline from which change can be assessed over time and provided the project continues, it has the potential to be one of the very few long-term studies of its kind in the UK. However, there needs to be an understanding of how to assess change over time, including, for example, encouraging repeat visits to the same location at exactly the same site, at the same time of year and on a similar tide and combining data in a geographical context as we have done with the biogeographical regions (Yesson et al., 2015).

The distribution maps for most of the wrack species chosen in relation to sea temperature rise, i.e. *Ascophyllum nodosum*, *Fucus serratus*, *F. spiralis* and *F. vesiculosus*, present a useful baseline that match reasonably well with known historical distributions, albeit with huge gaps, when a qualitative comparison is made with published maps (Hardy & Guiry, 2006). However, compared with the published maps, the distribution of the other species in this category, *Pelvetia canaliculata*, *Alaria esculenta*, *Saccharina latissima*, *Himanthalia elongata*, are under-represented. The map for *Fucus spiralis* includes at least two species because it is an aggregate of morphologically similar species, including *F. guiryi*. It is possible to distinguish these two species from photos based on the morphology of the conceptacles, provided these are visible. An added complication which can lead to confusion is that these species can hybridize with *F. vesiculosus*.

Rejection of a considerable proportion of the Big Seaweed Search species records due to a lack of photos for verification or validation failure, may explain some of these results. In the case of *Saccharina latissima* (and others – see Table 3), the issue was not identification accuracy but a methodological error; 40% of records that were rejected were correctly identified but were of dead/drift specimens. Also,whether individuals were alive and originally attached but picked for photos is unknown. Seaweeds are generally unfamiliar and can be considered a difficult group to identify, especially for beginners, for reasons given above. However, the overall misidentification rate in this study of c. 15% was relatively low, and provides evidence for confidence that, in the main, the species chosen for the Big Seaweed Search can be correctly identified by beginners using the identification tools provided. Solutions to improve the identification rate, especially for those with low accuracy identified by this study such as *U. pinnatifida,* are discussed below.

A further factor that will affect the likelihood of a species being recorded is the difficulty of physical access due to their position on the shoreline. For example, *Alaria esculenta* occurs at the bottom of the shore on bedrock or low shore pools on exposed shores and therefore requires good low tides with calm weather.

For the species in the non-native category, the distribution of *Sargassum muticum* from the southern part of the UK, with the exception of a record from Northern Ireland, is less widespread than current records indicate. The species is widespread in the west of Scotland and has been reported from the Hebrides (e.g. Dipper, 2018) and the Outer Hebrides (Laura Bush, personal communication). This is a further reflection of where effort has been focused in the Big Seaweed Search and points to the need to develop a strategy to cover parts of the coast which have so far received very little attention. The strategy would include getting MCS volunteer engagement officers running surveys in less studied areas during the annual Big Seaweed Search focus week ,which began in 2021, and calling for and training volunteers from these areas. The strategy would also include consideration of monitoring a few sites once or twice a year where the transect would be marked so that people could go back to exactly the same place to repeat the survey. The lack of verifiable records for another non-native, *Undaria pinnatifida,* appears to be due to the difficulty of identifying this species. However, *U. pinnatifida* is becoming much more common on shores in southern England and is more widespread in the UK generally (pers. obs.; Epstein & Smale, 2017). The same problems of misidentification apply to the two red non-native species *Asparagopsis armata* and *Bonnemaisonia hamifera*, which will need to be rectified in order to find out more about their gametophyte distribution.

The calcified crusts in particular, and to a lesser extent the coral weeds, appeared to be generally easier to identify. For the calcified crusts, the rejected records were primarily due to the lack of photos.

While observation of the widespread large brown species creates a large foundational dataset (e.g. *Ascophyllum nodosum*, *Fucus serratus* and *F. vesiculosus*), the quantity (and value) of the data for some species is limited, such as *Undaria pinnatifida,* where the small number of verified records is not currently sufficient for research use. In the longer term, with more same site revisits recording absence as well as presence (now incorporated into the recording form), it should be possible to look for major trends in species distribution. The results will need to be distinguished from cyclical changes in the abundance of seaweeds (also affected by climate change) and from other impacts such as storm events and heat surges. Participants have a free text section and will be encouraged to note any such observations in their area.

In another part of this study, participants are asked to take a picture of the shore they are surveying from the bottom of the shore. These images are a source of additional information, particularly over the long term for repeated surveys at a site when, for example, an obvious reduction in the zone-forming species with time becomes apparent. These images and the identified species images are a valuable resource, particularly with the latter for possible Artificial Intelligence (AI) image recognition initiatives (e.g. Tonion & Pirotti, 2022). Analysis of the images will be the subject of a different study.

Future developments and recommendations

A secondary benefit of the research analysis of 4 years of the Big Seaweed Search data, has been the identification of opportunities to enhance the research data, in particular the potential to increase the proportion of submitted observations that are both correctly identified, and supported by a photo.

Photographic evidence: The decision to only use verifiable data (observations supported by a photo) in the research analysis meant that a considerable amount of data was not used, either due to no photo being uploaded, or the participant incorrectly uploading them against the wrong species, representing wasted effort amongst citizen scientists. To try to minimize this in the future, the instruction booklet has been redesigned to emphasize the need for photos, and a guide to taking good quality photos for research purposes was created. However, this research need must be balanced against the desire to encourage participation and lower barriers to doing so (such as having a smartphone or camera), and so photo upload is currently not mandatory. Technical improvements to the data entry system aim to provide greater opportunity for dialogue and feedback between researcher and participant, allowing the researcher to explain why data points were rejected or could not be verified, to create a richer training opportunity for participants and to further encourage photo upload in future. Percentage of records supported by a photo will be a key indicator of success going forward, to be analysed regularly throughout the project.

One of the valuable outcomes of the project is the growing bank of georeferenced photos of shorelines (participants photograph their whole survey plot as well as each individual species) with consent for research use and optional publicity use. These images provide a major resource for temporal comparisons of shores, particularly where there is a focus on revisiting sites. It may be possible in the long term to observe changes such as large increases and reductions in band-forming species as evidence, for example, of change due to increasing sea water temperature, provided these can be distinguished from natural fluctuations.

Volunteers and training programmes: The data have demonstrated accuracy rates for each species that can inform training design, with a goal of increasing identification accuracy. A training programme has been developed by the project team at the NHM and MCS for delivery online or in person at the coast. MCS Regional Community Engagement Managers are delivering training to committed volunteers in their region (in person and online) to enhance identification skills and confidence. This smaller pool of well-trained volunteers who repeat participate will enhance revisit rates and identification accuracy. This training aims to develop a deeper relationship with committed citizen scientists such that over time they may become more deeply involved in the project, and eventually steer the project and participate in multiple stages of the research process beyond data collection. This collaborative model of citizen science (Bonney et al., 2009) redistributes power within a project and delivers more equitable science research, enabling public audiences to play a role in defining research questions, developing projects, delivering training, participating in data analysis and/or disseminating findings.

Resources for identification and species information: This study identifies opportunities to enhance identification accuracy rates and methodological accuracy (not recording dead/drift specimens) through updated identification tools and further training. Further information has been incorporated into the training programme and more resources will be developed on where the species grow on the shore and the influence of the nature of the shore. The current guide includes images of near perfect seaweeds and their features, but this does not reflect the full variability of colour and morphology observed on the shore, especially if specimens are juveniles or old, chewed by grazers, trampled, battered by storms, and exposed to high light levels and high temperatures. Furthermore, as *Fucus spiralis* is an aggregate of morphologically similar species, including *F. guiryi*, and these can hybridize with *F. vesiculosus*, this is another reason for requiring photos for expert verification. Therefore, more resources, including images to illustrate the range of morphologies that might be encountered, need to be developed. There is scope for a sub-project to look specifically for *F. guiryi* and *F. spiralis*.

Annual focus week: An annual focus week for the Big Seaweed Search was introduced in July-August 2021 and continued in 2022 as a means of enhancing geographic spread of surveys around the UK, as well as providing a series of live and online events to raise awareness of the project, engage people with seaweeds and with the aim of attracting more volunteers. Here, the value of partnerships is evident with Marine Conservation Society Volunteer and Community Engagement Managers able to organize events in south-west, east and north-east England, and west Wales and Scotland. Forty-one surveys were undertaken during a single week, a third of the annual total to date of 121 (January to September 2022). A Welsh language version of the instruction leaflet was also produced to support participation in this region.

Future developments: In order to overcome the problem of very low numbers of observations of some target species, particularly the non-native taxa, a number of initiatives are being developed. These include the possibility of targeting specific species, for example *Undaria pinnatifida* to have a drive on getting a better indication of its distribution. Another initiative for species which tend to occur low down the shore, is to focus surveys on the lowest spring tides during the year. Development of Big Seaweed Search sub-projects in response to a particular need, e.g. Sussex kelp recovery project, are in discussion, and would involve searching for all the kelp and related brown species. To continue to maintain people's engagement, several additional species identified as a result of the Red Data project of British seaweeds (Brodie et al., 2018) are being reviewed for possible inclusion in a Big Seaweed Search project for people who would like a more advanced survey.

Feedback from volunteers: An online evaluation form gathers feedback from the volunteers, including aspects of photography, identification, and the general experience, both to encourage engagement and retention and to identify where changes need to be made to the project. Examples of feedback are given in Supplementary Table 2. This has enabled the iterative improvement of the survey and the supporting materials provided. It is also important to give feedback to the volunteers. Feedback so far has included a summary of the results on the Big Seaweed Search website, an annual report (https://media.mcsuk.org/documents/BSS_2021_annual_report.pdf), a 'meet the scientists' virtual meeting, and this paper forms an additional mode of sharing project outcomes.

Projects in the marine environment have been highly underrepresented in citizen science (Roy et al., 2012) and more specifically, whilst it is growing in importance both for scientists and the public, the number of projects focusing on seaweeds remains very low (Sandhal & Tøttrup, 2020). The Big Seaweed Search, an example of a contributory citizen science project, i.e. designed by scientists with members of the public contributing data (Bonney et al., 2009), adds to the number of marine citizen science projects and notably on seaweeds. . As recommended by the citizen science practitioner community (e.g. Catlin-Groves, 2012; Balázs et al., 2021), in recognition of the potential lack of trust in citizen-generated data from the scientific community, or the doubts caused by data of unknown quality, this project has taken a rigorous approach in order to quantify and maximize data quality both in the initial design of the method, and in the development of strict protocols for data cleaning and verification. The latter led to the flow diagram in Figure 1 which can be modified for alternative projects. Despite only accepting 54% of the survey results, the quality of those data is very high, being both verified and georeferenced. It should be recognized that this requires considerable effort of expert validation. This means that these records (1,007) have ongoing research value and indeed were included in the dataset used in a Red Data analysis of British Seaweeds (Brodie et al., 2021). They also represent a baseline at sites which can be revisited and compared over time and the photographic images are a major resource.

The Big Seaweed Search data have the potential to provide hitherto elusive and rare long term monitoring information. The results will give us insights into the spread of invasive species and the impacts of climate change on the abundance and distribution of sentinel species. At the same time it can develop knowledge, field skills and a sense of agency to take environmental action amongst public audiences (Ballard, Dixon & Harris, 2016; Wardlaw et al., in press). With recent expansions of this project to Mexico and the Falkland Islands, the lessons learned here will enhance the impact of citizen science research internationally.

Acknowledgements

We acknowledge the University of Plymouth's placement year scheme which enabled Sarah Kunzig to undertake the analysis of the data for this project. We are grateful for funding from Research England for Chris Yesson's contributions

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Table 1. Effort taken for the Big Seaweed Search surveys submitted between 1st June 2016 and 31st May 2020.

Survey information	**Numbers**
Number of surveys	387
Total number of participants	1414
Range of number of participants per survey	1-57
Mean number of participants per survey	4.24 (sd $\pm$6.12)
Total time for all surveys (h)	361
Range of time for all surveys (min)	5-300
Mean time per survey (min)	33
Total person hours	1,531

Table 2. Number of surveys per biogeographic region. Note that totals for 2016 and 2020 do not cover a full calendar year and the latter was impacted by the COVID pandemic. Biogeographic region source: Connor et al. (2004).

Biogeographic region	**2016**	**2017**	**2018**	**2019**	**2020**	**Total**
Scottish Continental Shelf	10	4	0	0	0	14 (3.7%)
Northern North Sea	16	4	5	24	3	52 (13.8%)
Southern North Sea	7	1	9	6	1	24 (6.4%)
Eastern English Channel	3	12	15	33	11	74 (19.6%)
Western Channel & Celtic Seas	21	45	53	34	12	165 (43.7%)
Irish Sea	8	5	3	4	0	20 (5.3%)
Minches & Western Scotland	12	5	5	6	1	29 (7.7%)
Total	77	76	90	107	28	378

Category	Species	Total records	Accepted (%)	Total rejected	Rejected					
					With photos					
					Rejected with photos	Reasons for rejection (%)[1]				
						Correct identification but drift/dead	Misidentified attached	Misidentified drift/dead	Photo problems	Total misiden-tified with photos (%)
Sea temperature rise	*Alaria esculenta*	21	2 (10)	19	9	11	56	22	11	70.0
	Ascophyllum nodosum	168	103 (61)	65	13	7.5	85	7.5	0	10.3
	Fucus serratus	306	201 (66)	105	20	0	47.5	42	10.5	8.2
	Fucus spiralis	196	97 (49)	99	35	0	74.5	17	8.5	24.8
	Fucus vesiculosus	295	188 (64)	107	19	0	56	22	22	7.4
	Himanthalia elongata	80	23 (29)	57	21	21	47.5	26.5	5.2	37.2
	Pelvetia canaliculata	152	73 (48)	79	20	0	82.5	17.5	0	21.5
	Saccharina latissima	73	23 (32)	50	21	46	38.5	15.5	0	25.0
Non-native species	*Asparagopsis armata*	45	8 (18)	37	17	0	37	52.5	10.5	65.2
	Bonnemaisonia hamifera	16	1 (6)	15	7	0	67	16.5	16.5	85.7
	Sargassum muticum	96	46 (48)	50	16	40	13.5	6.5	40	5.5
	Undaria pinnatifida	21	1 (5)	20	10	0	40	60	0	90.9
Ocean acidification	Calcified crusts	189	117 (62)	72	7	0	71.5	37	28.5	6.4
	Coral weeds	218	124 (57)	94	19	0	52.5	0	10.5	7.5
	Total	1,876	54%	869	234					15.1

TABLE 3. Total number of each seaweed taxon recorded and of those accepted. Summary of reasons for records rejected with photos.

Figure legends

Figure 1. Flow chart for seaweed data verification.

Figure 2. Geographic locations of all surveys. Points coloured by biogeographic region.

Figure 3. Distribution maps of individuals species in columns according to their sea temperature rise, category, non-native species and ocean acidification.

Figure 4. Abundance of species for accepted records. Less than 1% of records (n=8) did not contain abundance data.

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Minches & Western Scotland	12	5	5	6	1	29 (7.7%)
Total	77	76	90	107	28	378

TABLE 3. Total number of each seaweed taxon recorded and of those accepted. Summary of reasons for records rejected with photos

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						Correct identification but drift/dead	Misidentified attached	Misidentified drift/dead	Photo problems	Total misiden-tified with photos (%)
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	Sargassum muticum	96	46 (48)	50	16	40	13.5	6.5	40	5.5
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	Total	1876	54%	869	234					15.1

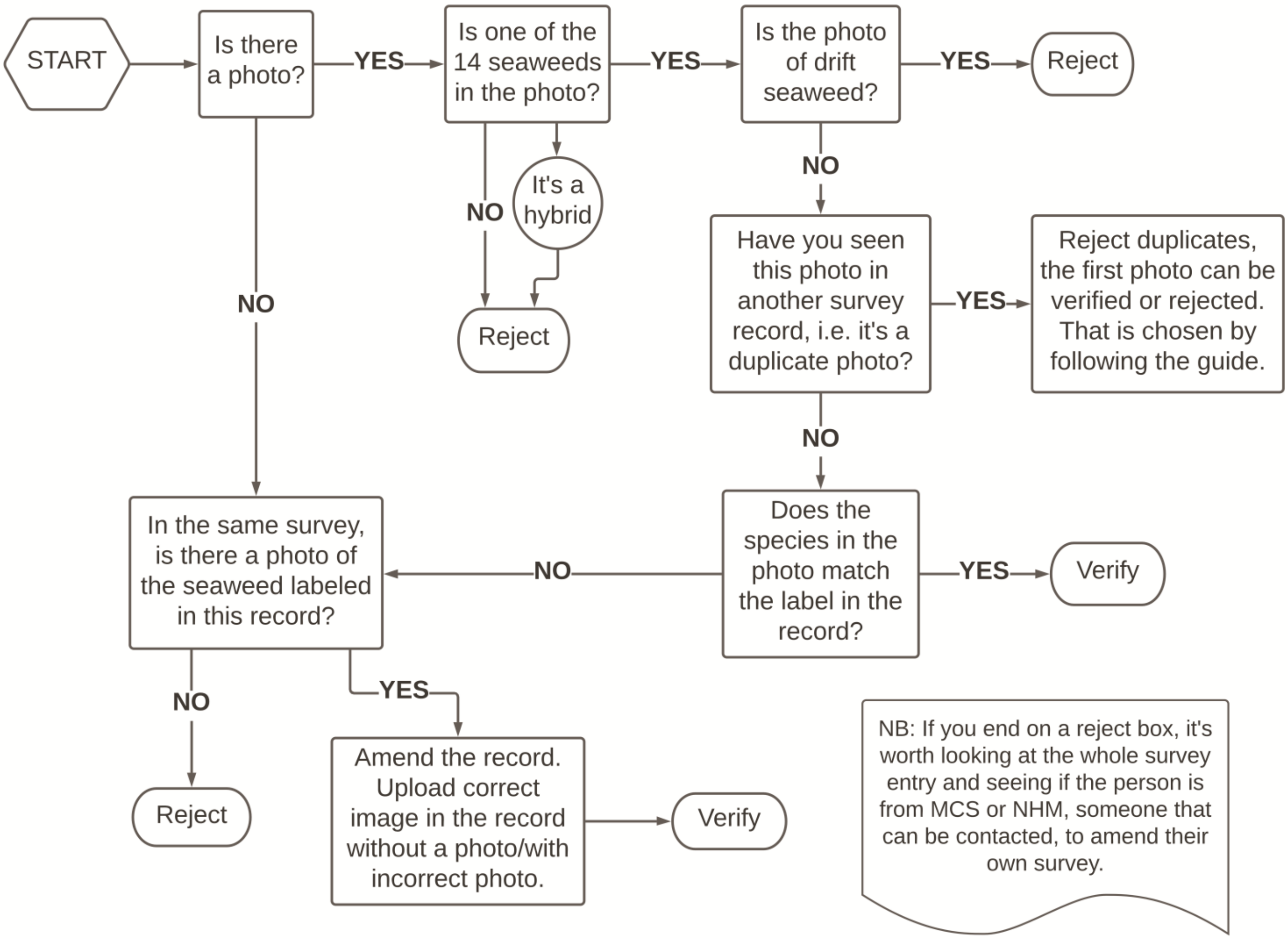
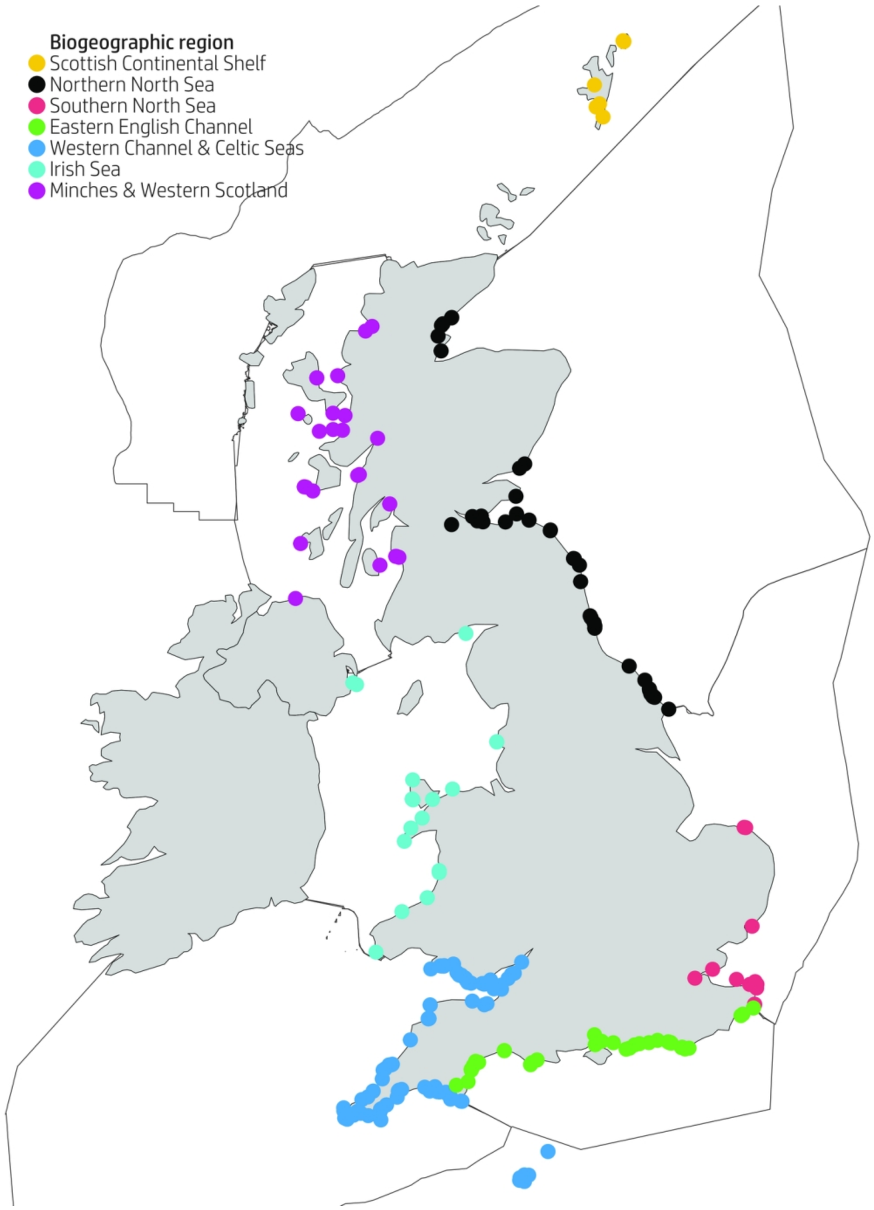
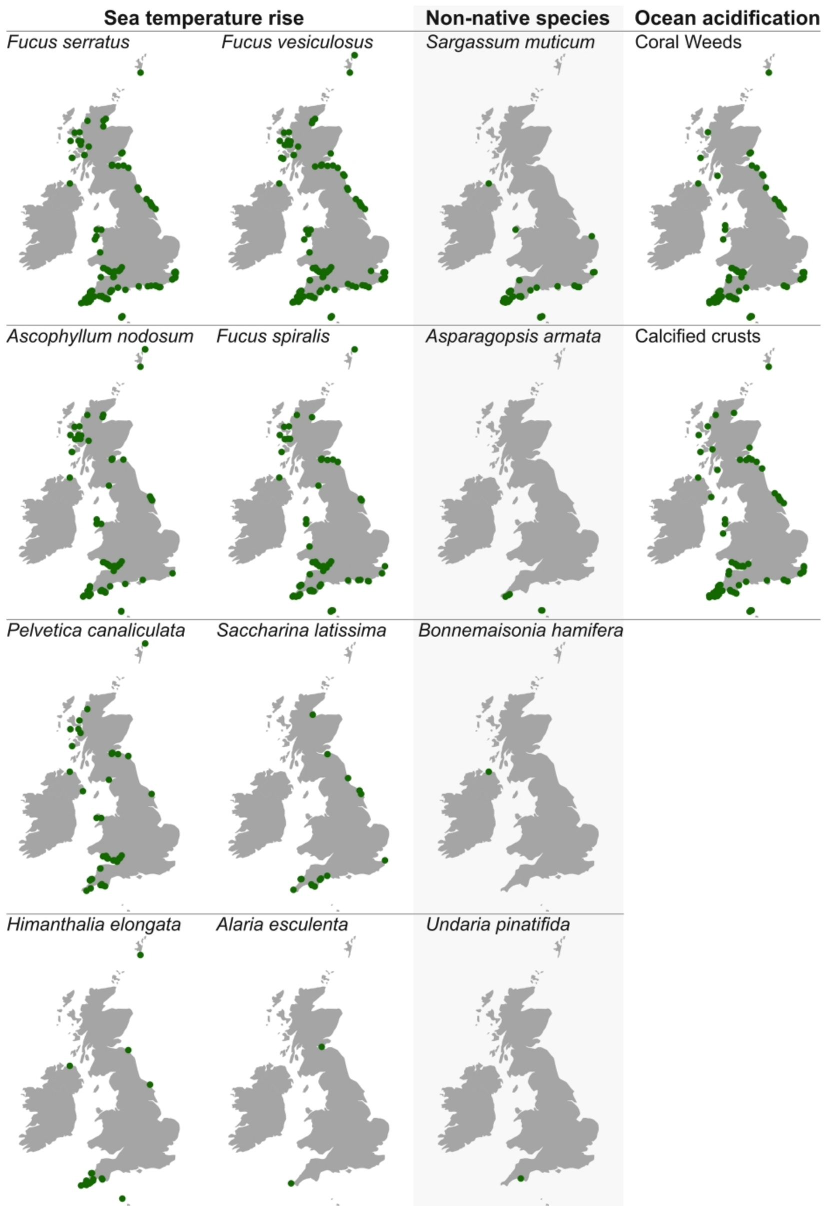

START
Is there a photo?
YES
NO
Is one of the 14 seaweeds in the photo?
YES
NO
It's a hybrid
Reject
Is the photo of drift seaweed?
YES
Reject
NO
Have you seen this photo in another survey record, i.e. it's a duplicate photo?
YES
Reject duplicates, the first photo can be verified or rejected. That is chosen by following the guide.
NO
Does the species in the photo match the label in the record?
YES
Verify
NO
In the same survey, is there a photo of the seaweed labeled in this record?
NO
Reject
YES
Amend the record. Upload correct image in the record without a photo/with incorrect photo.
Verify
NB: If you end on a reject box, it's worth looking at the whole survey entry and seeing if the person is from MCS or NHM, someone that can be contacted, to amend their own survey.

Figure 1



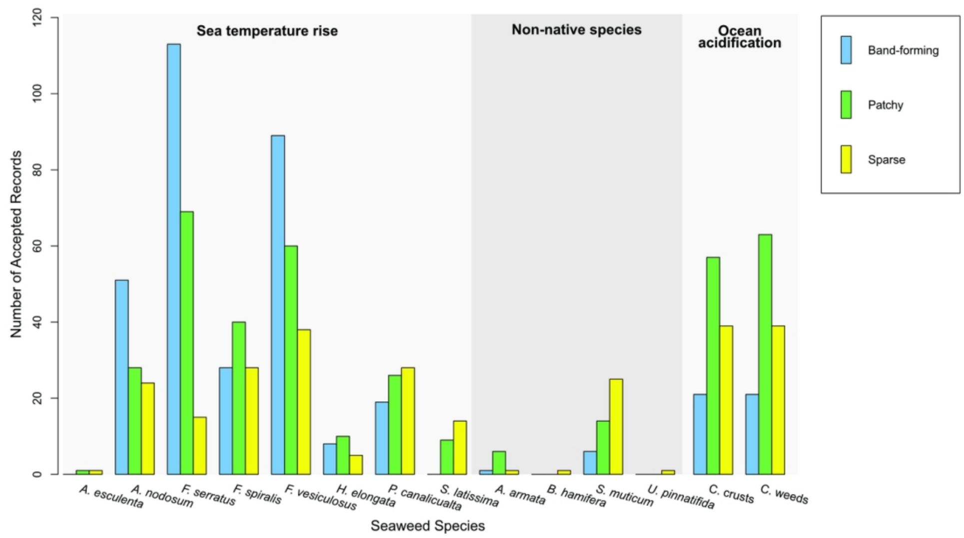
Geographic locations of all surveys. Points coloured by biogeographic region.

127x167mm (300 x 300 DPI)



Distribution maps of individuals species in columns according to their sea temperature rise, category, non-native species and ocean acidification.

190x280mm (300 x 300 DPI)



Abundance of species for accepted records. Less than 1% of records (n=8) did not contain abundance data.

127x74mm (300 x 300 DPI)

Supplementary Table 1. List of seaweed taxa in the original Big Seaweed Search.

Group	Scientific name	Common name
Brown seaweeds (native)	*Ascophyllum nodosum*	Egg Wrack
	Alaria esculenta	Dabberlocks
	Bifurcaria bifurcata	Brown Tuning Fork Weed
	Fucus serratus	Toothed Wrack
	Fucus spiralis	Spiral Wrack
	Fucus vesiculosus	Bladder Wrack
	Fucus vesiculosus	Toothed Wrack
	Himanthalia elongata	Thongweed
	Saccharina latissima	Sugar Kelp
Brown seaweed (non-native)	*Sargassum muticum*	Wire Weed
Red seaweed	*Corallina* species	
Green seaweed	*Ulva* species	

Supplementary Table 2. Number of accepted seaweed records by biogeographic region.

	Scottish continental shelf	Northern North Sea	Southern North Sea	Eastern English Channel	Western Channel & Celtic Seas	Irish Sea	Minches & Western Scotland
Alaria esculenta	0	1	0	0	1	0	0
Ascophyllum nodosum	6	16	0	4	56	5	16
Asparagopsis armata	0	0	0	0	8	0	0
Bonnemaisonia hamifera	0	0	0	0	0	0	1
Calcified crusts	1	21	6	15	60	6	8
Coral weeds	1	19	8	18	71	3	4
Fucus serratus	1	31	11	49	87	6	16
Fucus spiralis	1	14	1	8	59	4	10
Fucus vesiculosus	6	35	8	35	81	5	18
Himanthalia elongata	1	2	0	0	19	0	1
Pelvetia canaliculata	4	10	0	0	47	4	8
Saccharina latissima	0	7	1	5	10	0	0
Sargassum muticum	0	0	3	13	28	1	1
Undaria pinnatifida	0	0	0	0	1	0	0

Supplementary Table 3. Issues for analysis

1 Issues for analysis

Import-ance	Issue	Potential Solution
H	Lack of photos submitted 35-40% (we don't know if there was no photo taken, if observer forgot to submit, or if the site didn't upload it)	Website auto message if no photo added when record is positive record, asking if they have a photo and not allowing submission with no photo Update survey resources. Update training resources
L	Lack of photos means nothing is done with that data, despite survey effort	Can the submissions that we cannot verify (solely no photos) be separated into a different downloadable spreadsheet? Could make for interesting data analysis down the line
H	Drift included; a lot of records rejected due to being dead/drift/not clearly attached	New photo guide & website instructions New instructions in survey guide Update training resources.
M	Blurred photos submitted regularly	New photo guide & website ins New instructions in survey guide Update training resources
	Cannot tell observer skill level and hence measure skill bias	Incorporate self-skill rating function on website and record form
	No record as to whether survey was abandoned before being completed e.g. due to weather tide, waves; unsure if all species searched for or not	Enable recording of ABANDONED SURVEY as well as time
	Unable to record UNSURE if species are present/absent e.g. if could not access low shore to look. It defaults to absent unless tick 'present' So does ABSENT mean absent, or not seen or not looked for? It is unclear	Enable recording of ABANDONED SURVEY as well as time, Enable choice of' not looked for' as well as present/absent on survey form and website
	We do not know what is not there.	Potentially ground-truth verification work to thoroughly search the 5m to estimate how many times species are

		not recorded when there – build detectability index/likelihood models
	Lack of acknowledgement to observer submitting data. Does not encourage surveyors to do more, or repeat survey	Create auto message acknowledging submission, thanking and asking for survey to be repeated another time
	Lack of acknowledgement when submitting could also be causing duplicates, if people are unsure if results have been accepted or not	Auto message acknowledging submission as above
	Lack of detailed identification notes for each species causing misidentification	Expand identification guide, training materials, especially for most mis-identified species Training video
	We reject photos of hybrids submitted	May want to have a different selection process for these (not reject or accept but note it is hybrid)
	If observers consider they have found species but have misidentified (submitted incorrect photo) unknown if species there or not (unless find in another photo)	Better training in identification and clearer method resources to reduce misidentification and drift
	Instructions are to search for species WITHIN 5m only. Species not occurring in the 5m are not to be recorded even if there. Is this desirable? For example if NNS are present but outside of 5m presumably we want to know.	Ask key surveyors how they are interpreting? Discuss and potentially refine the protocol? Widen transect, or conduct an additional search?
	Difficult to change photos once uploaded therefore people will leave mistakes if it takes too long to rectify	Enable corrections. NB: can correct if signed in, so people need to be encouraged to set up account/sign in
	Gaps in surveys geographically especially NI, W and N Wales, N&E Scotland and IOW Also where substrate is mainly sand/mud. Also gaps in raining/support/engagement staff (none in Wales, only 1 person for Scotland)	Find gaps and work out if not a good substrate or another issue. Make it clearer that artificial structures can be surveyed (& how) Target training and promo to geo gaps with suitable substrate Work with partner orgs in gaps
	Errors in location lat/long: People can select where the survey site is as upload	Make it clear what site location means

	data, but this can be mistaken as map is difficult to manipulate and understand. Sites that are obviously wrong (e.g. not coastal) will be picked up in data cleaning, but others may remain erroneous Unclear whether location means state, town, beach, region etc	The map when trying to select where the site is (both on the recording part and in 'explore the data') is clunky. If use mouse to scroll in or out, it moves map & also the page at same time. Fix zoom, UK only Site look-up function (name or postcode)? Fix location search. Map legend & scale needed. More layers desirable to aid navigation, increase icon size Improve map function generally
	Not many repeat surveys as yet. Directions have been to choose any site. Weakened ability to say anything about change if lack repeat surveys	Directed, repeat surveys through training/comms/auto feedback etc Direct placement students/Sea Champions to re-survey sites
	Most repeat surveys are not on same day or even same month – often 1 month behind in subsequent year.	Directed, repeat surveys through training/comms etc. Placement students/Sea Champs as above to re-survey
	Most species are perennials, but not all (e.g. Bonnemaison's); time of year affects whether will be found for some species	Suggest optimal survey periods
	Duplications of site and survey	Pop up message on the site asks if survey could have been submitted before if same dates, time and location as a previous survey (pop up message that effectively asking 'this has been recorded before, are you sure you want to continue').
	Work out if the site logs incomplete survey entries when it times time out, thus creating duplicates on the spreadsheet.	Pop up saying 'do you want to continue this survey or start a new?'
	Duplications where people took part in groups; have similar site, same date/time but different observer. Groups sometimes share photos, but have not always shared ALL photos, so not a full duplicate. Difficult for verifier to work out which is 'correct' & which to remove.	Do not allow photos to be uploaded more than once (photos have tags). Could the site detect and indicate if same photo has been uploaded before and location where taken?

		When taking/training groups, assign one person per 5m to upload data.
	All repeated data points were found and collated into a list so the verifier could go online and check them off and work out which survey needed deleting or rejecting. But this is time consuming.	Identify repeated data points automatically Remove all deleted data automatically from all places
	Data-less surveys; There are some survey entries that are 'data-less' possibly from people half submitting surveys and the site just accepting them, or starting and then abandoning the process Surveys that are essentially a record of absence can be left in the data.	Have a submit button that flashes up notice saying you have not entered data/incomplete data entered, are you sure you want to submit and leave?
	There were at least 5 'no-data' repeat surveys that cannot be deleted as they have no evidence of them on the site, however they still appear on the spreadsheet.	'No-data' repeat surveys – amend website so that it doesn't accept survey submissions until completed. All deleted data needs to delete from all places
	Filters behind the scenes do not work and that affects data cleaning and manipulation	See below for details of three filters that need fixing (who/what/consents)
	Re-verifying is difficult. At present only way to change it is to re-upload the same photo, so the site thinks it's a new submission.	Allow for re-verification of a record
	Data spreadsheet does not allow biogeographic region data; makes analysis in terms of the BG regions difficult	Add biogeographic region to spreadsheet
	Tide levels likely affect species found and observer effort. If compare tide phase/height and survey time could predict likelihood of finding low shore species & evaluate relationships between species records, observers & tide	Add tides to spreadsheet for future analysis

Supplementary Table 4. Issues for observer

2. Issues for Observer		
Import-ance	Issue	Potential solution
	Drift; is it 100% clear that algae need to be attached from survey guide and that photo MUST show it? Guide says: "Take **A** clear photo showing the identification features." And: "Only record living seaweeds not dead ones washed up on the beach"	Amend guide to say Take up to 2 clear photos/species. One should show seaweed attachment and use other to show the identifying features of the seaweed species if needed. Add to guide to taking photos
	When uploading photos difficult to see if blurred or incorrect due to the small size.	Make uploading photo window bigger so people make less mistakes
	Difficult to tell if results have successfully submitted or not and therefore may be incomplete or duplicates. Does not encourage taking part again	Auto message acknowledging submission and thanking Acknowledge by email when records have been submitted, thank and suggest next steps Add help page to the website
	Unclear what to do if survey was abandoned (eg due to weather or waves) before all species were searched for and not able to indicate which species were NOT searched for NB: Can select abundance 'not recorded'	Enable recording of ABANDONED SURVEY Add species not looked for (which would happen if abandoned) as well as present/absent
	Very simple identification notes exist for each species within guide and one photo per species or species group; lacks information on similar species or hybrids likely to be misidentified eg *Cystoseira baccata* and *Sargassum muticum*, wakame and furbellows.	Expand survey guide, to include more than one identification feature/seaweed Make it clear that ALL i-d features should be present not just some and On website, under 'Meet the seaweeds' include more photo

		examples of each species than just those from the guide Add more training materials, training video, quizzes and possibly keys for observers to utilise (Patrick Martone?). Recommend/link to additional sites where can find identification tips and example photos (and books/keys)
	Hybrids are rejected but this is not made clear.	Advise that photos should be of 'classic' example not an 'odd' one. Create a guide to hybrids and 'odds' Feedback to observers why records are rejected
	Not obvious where to put in notes for example this *F vesiculosus* with no bladders is from an exposed shore; it could go in photo captions – but not obvious to observers to do this	Provide a clearer, searchable field on the website for specific notes about the species relating to photos
	Difficult to view data on current site for users Distribution map just produces a list and is not easy to interpret or use for re-survey purposes Filters are not user-friendly	And/Or improve map on BSS website and data visualisation Export to NBN so people can view records there and provide guidance on how to view.
H	Not clear in guide that 2 photos/species can be submitted and at least one should show it is attached. Currently says **a** photo should show i-d features, but if observers follow this and photograph i-d features close up, that often doesn't show it is attached and could be rejected; open to misinterpretation.	Make it clearer in survey guidance how to submit the photos. Explain that two photos can be submitted, at least one of which should show whole seaweed including attachment and other can show i-d features clearly/close up, that match the guide. Feedback to observers why records are rejected

	Guidance for abundance is clear but for what angle is gently sloping vs flat, what is almost all rock vs a mixture (percentage?) and 'very few, several and a lot' of rockpools (proportion/number) is missing and hence measurements are subjective. Could become important/interesting in future; need to standardise if recording these variables for analysis	Standardise the protocols for slope, shore features and substrate as for abundance
	Tick boxes when uploading data are EXTREMELY small for shore features like man made structures and no. of pools	Make a little larger as could cause mistakes in data
	Must load ALL survey data and photos in one go – cannot save as working through species. Likely that people will get interrupted and not finish upload	Allow to save and come back to data upload
	Unclear how to resolve problems/ask questions where observers are unsure	Add help page Add FAQs Add definition of scientific terms

Supplementary Table 5. Results and feedback; volunteer journey and experience issues

3 Results & feedback; Volunteer Journey and Experience issues		
Import-ance	Issue	Potential solution
	Measuring survey effort year on year	Collated total number of people that have taken part in all surveys, including duplicates and people doing survey more than once. Extracted average no. of people on surveys to find the average no. people participated. Not exact number of people taken part; have no way of knowing this.
	If successful engagement and/or training means a person has gone onto submit data, how can we track how many engaged/trained and how many went on to survey? Without this cannot measure effectiveness of strategies to boost participation	Need to track individual participation and link it to source by organisation/region/event Refine surveyor questions to track source of surveyor. Completed training tick box and/or menu to select how/who with
	Improve variety and inter-activity of learning methods to build skills for use in the survey, that are valued as can also be transferred to local recording work etc.	Create training video Creation of a ‘check your ID skills’ quiz on the site, so people can see what kind of photos are accepted as well as having a go at identification of the seaweeds. A training certificate?
	Enhance observer understanding of why taking part and the value of the survey (Learn Cit Sci identified this as a gap)	Create background to survey video Make sure previous surveyors have seen it Enhance aspects such as about the survey to include history and links to research
	Improve contact rates, consents and GDPR compliance	Ensure feedback from the analysis is put onto the website

	Ensure that we: Provide feedback to all participants so they feel included/valued That we can contact surveyors to verify records (ask for missing photos) That we can contact as many people as possible to ask to re-survey	Produce a feedback summary part 2 from four year results and decide who to/how to disseminate Update consents on website to include us contacting surveyors about re-surveying, verification etc – activities relating to • current surveys • future surveys
	Instance where one person submitted many, poor-quality duplicates. Unless person is known to the team or has ticked 'OK to get in touch' it is impossible to prevent same person from repeatedly uploading poor data.	Auto messages that prevent duplicates/no photos. Re-word consents so that we can get in touch with people not only to verify, but also to help them with survey and offer training
	Results to date cannot answer the three posed questions RE temp rise, acidification and NNS as some surveyors may expect	Explain why cannot yet answer those questions, when might be able to say something, and what can say in meantime
	Difficulty in attracting people to training or events due to negative pre- ideas of seaweed (smelly connotations)	Offer 'science on the shore' events rather than BSS Training'. Diversify activities Perhaps include foraging (everyone asks about eating it) and other fun activities
	Keep feedback up to date, relevant and make it feel inclusive and interactive	Seaweed/photo of the week/month*. Could share on social media On site have 'gallery' showing rolling gallery of recent ACCEPTED images. Volunteer stories and feedback on the website/emailed to those taken part that have given contact permission Update no. of surveys dynamically GDPR – update consents
	Difficulty getting people to re-survey sites that are not very interesting over 6-10 years	Add in more one-off or additional activities eg: grazers/crabwatch/marine invaders/seagrass/ stalked

		jellies/special seaweed species (IUCN red data) or life stage searches/phenology
	Enhance volunteering experience and build a satisfying volunteer 'journey' to encourage people to return & re-survey. Input resources, support and training to lift people to next level	Improve welcome process. Certificates/badges for returning volunteers. Downloadable certificate of participation available on the site with advanced level once completed 10-25-50-100 surveys? On social media, ask people to take pictures and share it to keep people coming back to the survey.
	Mapping why people end their volunteering	Contact people that never came back to ask why/ what would help Again need to update consents
	Lack of capacity for training 1: Develop super-surveyors that could share their knowledge	Contact individual surveyors that have done a lot of sites to thank and perhaps write their story up, ask if they want to help train others
	Lack of capacity for training 2: Render self-lead training resources accessible for individuals and groups	Training video Training webinars Downloadable resources
	Promoting widely via talks	Create a shareable talk that can be delivered by staff/volunteers And a few slides that can be slotted into any talk
	Promotion at events e.g. science fairs	Share the seaweed demo that has worked well
	Engagement resource gaps: Need photos of people doing the survey and not just the species to illustrate volunteer stories	Ask people to upload a photo of them doing the survey as well as survey site, and ask for permission to use
	Enable easier sign up and broaden routes for engagement	Enable sign up through social media Improve reciprocal links to partner websites and social media accounts
	Not clear how to join the survey/register from the website	Make this more obvious – join in now button?

	Sign in by user name, not email – can be difficult to remember and is not intuitive	Enable email as user name
	Delay in survey and upload as need PC to upload data	Enable data upload via mobile to facilitate result submission (including IOS)
	Website not IOS compatible – PC only & excludes some observers from taking part	Render IOS compatible

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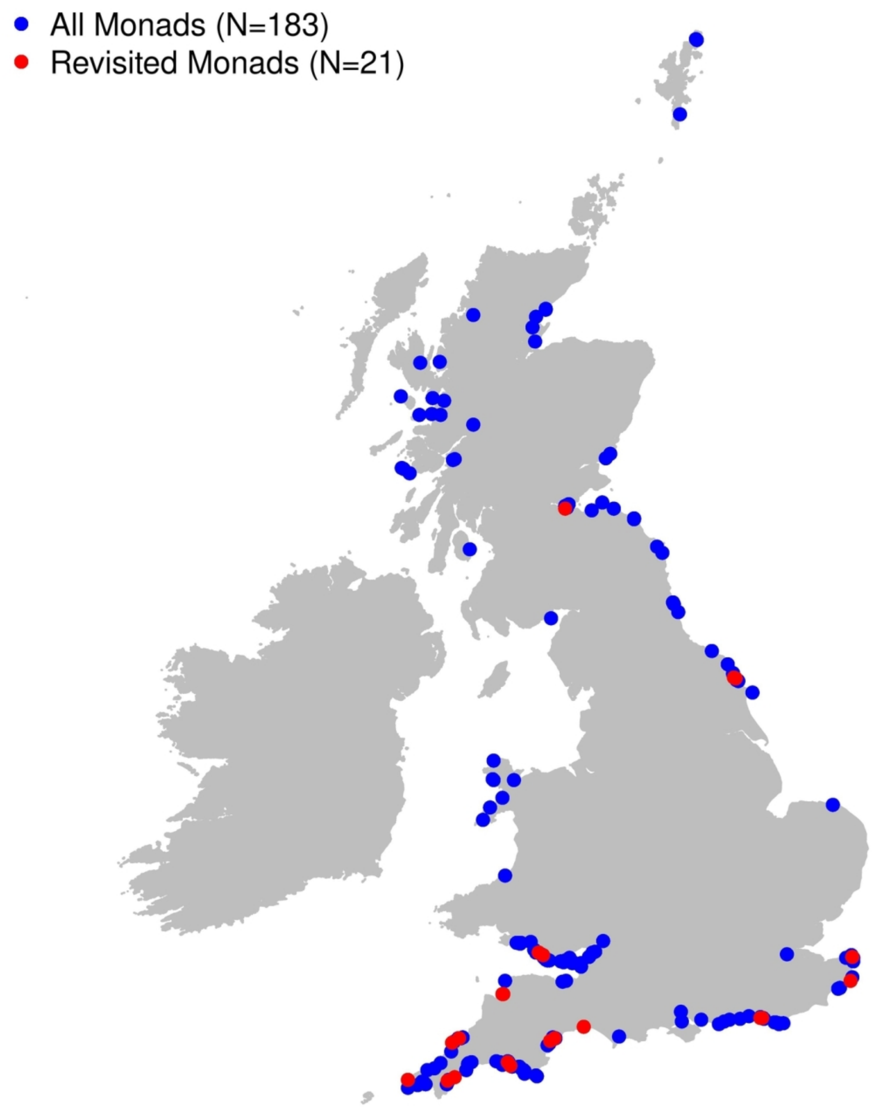

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