

Science 2.0: Bridging Science and the Public

Per Hetland

FAGFELLEVURDERT ARTIKKEL

Per Hetland

Director, InterMedia, University of Oslo, Norway.
per.hetland@intermedia.uio.no

English abstract

“Science 2.0” is still evolving; basically, it is an ongoing, “natural” experiment about a potentially novel way of participating in knowledge construction processes based on Internet applications. The topic of this article is scientific culture and organisation that interact with communities of interests outside of institutions, based on analyses of systematic biology and the mapping of biodiversity. The focus will be on the convergence of professionals and so-called amateurs involved in the production of new knowledge.

Keywords: Science 2.0, citizen science, apomediation, boundary infrastructures

Introduction

Collaborative technologies provide new possibilities for doing science and including amateurs in knowledge production. These possibilities may cause exaggerated expectations (Selwyn, 2009). Nevertheless, expectations are important for shaping the future (Brown, Rappert & Webster, 2000). Parallel with the development of collaboration technologies, policy is an important driver towards stronger emphasis on networking, sharing and communication. The participation principle is, for example, an important part of Norwegian science and technology policy. Web 2.0 and later Science 2.0 are now depicted as being novel modes of organisation and culture in scientific communities (Waldrop, 2008). Eysenbach suggests a framework of five major aspects or themes to describe Medicine 2.0 (Eysenbach, 2008): 1) Social Networking, 2) Participation, 3) Apomediation, 4) Collaboration and 5) Openness. Apomediation is a new socio-technological term that was coined to characterise the ‘third way’ for users to identify trustworthy and credible information and services. *Apo* comes from the Latin for ‘stand by’, and apomediation describes the fact that when you access information on the Internet, you can bypass the gatekeepers or any middlemen, and it allows you to go directly to the source of information, even if it is not a (previously considered) ‘expert’ source. The expert ‘stands by’ you.

This article aims to contribute to the understanding of scientific development, public participation and the possibilities for co-production of scientific knowledge, and to explore how collaborative technologies influence how we understand social networking, participation, quality assessment, collaboration and openness in science. This may be studied as a bottom-up process following in the footsteps of scientists and amateurs, or as a top-down process following the shaping of new boundary infrastructures for doing science. In order to have the possibility to include both strategies, I have chosen systematic biology and the mapping of biodiversity in Norway. Systematic biology and the mapping of biodiversity is a growing field in Science 2.0 (Hine, 2006, 2008). Over time, several constituencies of stakeholders have developed, and their activities have converged such that we may now have a new mode of knowledge production that can form the basis for an exploratory study of Science 2.0, possibly a paradigmatic case. At the same time, systematic biology and the mapping of biodiversity have engaged amateurs for as long as the disciplines have existed. Few branches of biology have felt the hand of amateurs like ornithology (Mayfield, 1979). Mayfield (1979) underlines that “Perhaps the most important contribution of the amateur, and assuredly one that will not dwindle in the years ahead, is the nurture of young scientists” (p. 170). Amateur activities among children and teenagers often lay the foundation for a later scientific career; and, of course, “Fieldwork is fun, and the public is not always able to distinguish what is purely recreational” (p. 168). The often symbiotic relationships between amateurs and professionals have also given us analytical concepts like boundary objects (Star & Griesemer, 1989). The word ‘amateur’ has its roots in Latin (*amator* – lover) and is used for persons practising an activity without having this as a livelihood. In everyday language, the concept is often applied to lay people or those who are self-taught. In keeping with the Latin origins of the amateur concept, amateurs may have training in the subject up to degree level. That which distinguishes them is the work that they undertake in connection with, for example, the natural history collections, and which is not their paid profession. An alternative concept can thus be ‘voluntary’. In this connection, it is important to be clear about the fact that the non-governmental organisations (NGOs) in natural history organise both amateurs without any formal schooling or work association, and those with a formal education and relevant employment. That the latter group can, nevertheless, play a particularly active role in the NGOs is related to the fact that they have frequently commenced their career as amateurs and where they later have not clearly defined the boundary between professional and hobby activities. The word

‘amateur’ also signals a certain passion and the strength of this passion is well described by Richard Conniff in his colourful history of the early naturalists (Conniff, 2011). Within natural history, there are both ‘broad’ and ‘narrow’ amateur communities in Norway. Concerning vascular plants, this may amount to several thousand individuals, while with lichens there are possibly only 30 or so. These interest groups are important within their field of natural history in three ways: first, they make a considerable contribution of new objects to natural history collections; second, they contribute new information and quality assessment of older information in the existing parts of the collections; and third, they are important contributors of new information through the newly established Species Observation.

The changes in the relationship between the expert and different publics, policy, administration and civil society mean that knowledge and values must be renegotiated, and that expertise is both real, substantive and relational (Callon, Lascoumes, & Barthe, 2009; Collins & Evans, 2007). The Internet is one of many new arenas in which this clearly comes to expression. For the university museums, this signifies that the relationship between science and the public is changing, and that the traditional authority of science must be legitimised in a different manner than hitherto. Collaborative technologies may be used to shape hybrid spaces with heterogeneous actors and agendas, and collaboration activities may be facilitated by the development of *boundary objects and boundary infrastructures* (Bowker, 2000; Bowker & Star, 1999; Star, 2010; Star & Griesemer, 1989). These terms help us to establish a theoretical process-oriented perspective on how negotiations and competition for different interpretations and practices within a given ‘hybrid space’ take place. Boundary objects refer to elements that link various groups and interests together. Star and Griesemer (1989) define boundary objects as temporary agreements by different actors and groups on how to relate to a given situation. They describe how a standardised method in natural history for collecting, conserving, marking and describing finds, functioned as a boundary object between amateurs and researchers in what was a research subject among researchers and a subject for hobby activity, exercise of an occupation or nature conservation among groups of the public. In other words, they establish agreement about what are points of contact in common. Boundary objects are negotiated agreements that contain different interests but, at the same time, open up for slightly different practices. In this way, boundary objects permeate borders at the same time as the established practice is continued. Scientific infrastructures represent “regimes and networks of boundary objects (and not unitary, well-defined objects), boundary infrastructures have sufficient play to allow for local variation together with sufficient consistent structure to allow for the full array of bureaucratic tools (forms, statistics, and so forth) to be applied” (Bowker & Star, 1999, pp. 313-314) and thereby help scientists, amateurs and administrators to cooperate across disciplines and organisational boundaries. Cyberscience, E-Science and Science 2.0, therefore, become a manifestation of scientific culture articulated in the face of a new technology (Hine, 2008, p. 34). Bowker argues that this layering of boundary objects creates a form of irreversibility or path dependency in the infrastructure for two reasons: “first because the infrastructure is *performative*; and second because the infrastructure is *diffuse*” (Bowker, 2000, p. 648). To analyse the processes that facilitate the building of boundary infrastructures, and thereby the scaffolding of Science 2.0, I will introduce the concept of bridging. Bridging activities and boundary objects are essential for understanding how Science 2.0 develops over time. The concept of bridging helps us to establish a theoretical process-oriented perspective on how negotiations and competition for boundary infrastructures take place.

Based on these concepts, the research problems can be formulated as follows:

What characterises participation in knowledge production and collaboration in respect of systematic biology and biodiversity in Internet-based hybrid spaces? How does apomediation play out to identify

trustworthy and credible information and services given multiple voices operating in Internet-based hybrid spaces? Finally, how do the interfaces used to stimulate collaboration function as bridging devices between different user groups and stakeholders?

Methods

On behalf of the University Museums Commission, appointed by the Norwegian Ministry of Education and Research, a colleague and I evaluated the university museums' work in digitalising their collections (Hetland & Borgen, 2005). Fifty people were interviewed, some of them several times. About half of them worked with natural history, while the other half worked with cultural history. More detailed references to the empirical material are given in Hetland & Borgen. Later in 2010, I conducted follow-up interviews with important natural history experts at the Global Biodiversity Information Facility (GBIF) both in Norway and at the international GBIF Secretariat at the Natural History Museum in Copenhagen, The Norwegian Biodiversity Network (SABIMA) and The Norwegian Biodiversity Information Centre (NBIC). The follow-up interviews have been selected for studying critical issues in the process of building boundary objects and boundary infrastructures and the role of apomediation in this respect.

Technoscience may be described as building networks and we have followed scientists, amateurs and policy actors at work; how do they enrol or exclude actors and resources building boundary objects and boundary infrastructures through problematisation, interesement and the definition of obligatory passage points (Latour, 1987). Latour call this the translation model. The translation model offers methods and concepts to open up the innovation process. The research questions were analyzed by following important and often controversial issues in the interviews combined with document studies of the same issues, what kind of transformations do these issues undergo later in the hands of others and finally how are these controversies resolved. During the process we have followed how various groups and interests are linked together, building boundary objects and boundary infrastructures while establishing routines for quality assessment.

Mapping of biodiversity: The Norwegian case

In Norway, natural history museum collections are the backbone of taxonomic and bio-geographical research. They comprise: a) documentation of previous scientific work and enable us to understand the current position of the subject; b) research material selected by a large number of individuals over a period of two hundred years, material that no individual short-term project could replace today; and c) they provide a large biological diversity database where the determination of species and related information may be revised when necessary or possible. Digitalisation of the museum collections was an important precondition for more flexible use of the same collections. Five approaches to digitalisation of the collections can be identified, facilitating Science 2.0: 1. *Digitalisation as a researcher-driven activity*. The first attempts to digitalise the collections commenced in the 1970s. What characterised the individual projects was the fact that they were supervised by researchers who recognised the great demand for digitalisation within their own field (Hetland & Borgen, 2005, pp. 15-16). 2. *Digitalisation as an employment-driven activity*. Early in the 1990s, unemployment in Norway was high, and in this connection, the University of Oslo launched a digitalisation project as a contribution for enhancing both employment and skills (Hetland & Borgen, 2005, pp. 16-30). Over time, more than 1,000 man-years have been used in the digitalisation of museum collections. 3. *Digitalisation as an administrative and dissemination-driven activity*. Administrative and dissemination-driven activities have been organised by adopting

two approaches: a. *The Museums Approach*. The challenges facing the university museums were first outlined in the Green Paper NOU 2006:8 entitled *Knowledge For Everybody*. This was followed by Parliamentary Report no. 15 for 2007-8, *Talking Artefacts – The University Museums*. Finally, this provided the basis for proposing the National Digital University Museum. b. *The Biodiversity Approach*. The NBIC was established in 2005 as a joint bank for biological diversity in Norway, and a national information source for natural species, varieties and populations. Several activities have commenced in close association with the NBIC, not least Species Observation in collaboration with the NGOs that have organised themselves into *The Norwegian Biodiversity Network (SABIMA)*. This is an umbrella organisation with the objective of working to strengthen the protection of biodiversity in Norway. With more than 18,500 members, the ten NGOs embrace both professionals and most skilled amateur biologists in Norway. However, among the approximately 8,000 information providers, over 60 per cent of the observations are made by the 100 most active observers. Other services provided by the NBIC include the Red List Database, the Alien Species Database, Species Maps, Species Names and the Habitat Database. 4. *Digitalisation as 'megascience'*. The Global Biodiversity Information Facility (GBIF) was an initiative introduced by the OECD Megascience Forum Working Group. The Norwegian GBIF-node was established in 2005. GBIF-Norway and the NBIC provide access to over 12 million records from almost 30 information providers, including all the important scientific institutions, NGOs and some private companies, through the service Species Map. More than 6.2 million of these records are registered through Species Observation, mostly carried out by amateurs (all figures are from September 2011).

All types of systematisation establish a form of path dependency. The potential for change is reduced and it becomes difficult to include new functions that require another form of systematisation without considerable extra resources. The need for new methods by which to systematise the museums' collections became manifest when changes and new subject traditions arose in the border zone with the old. A good example is the emergence of ecology as a new discipline. Other challenges are seen in the increased interest in interdisciplinary and multidisciplinary approaches. In retrospect, it may be said that the superior rationale of digitalisation processes is linked to the need to rapidly be able to use the collection for an increasing number of new purposes, many of which had not been previously considered. These new possibilities have also established a basis for formulating new needs within research, administration and dissemination and, not least, for identifying important gaps in our shared knowledge. In the following, I will look at how social networking, participation, apomediation, collaboration and openness influence how hybrid spaces are shaped and the importance of boundary objects in this respect.

Social networking and participation

Historically, the first attempts to digitalise collections arose from a tradition whereby the individual curator had a personal relationship with the collections, or as one of the curators stated: 'That which was the forerunner to the compilation of a database was to obtain an overview of one's own collection. You may indeed emphasise *own* – "They are my collections and I must know what I have in my own collections such that I can inform others who want to know what I have".' Increasingly, other actors were involved and the emphasis on "my collections" slowly changed. One of the curators was a role model for the amateur community, and they frequently used his databases as models reflecting how they prefer to see them. On occasions, they found that this did not work as expected, and that they required this or that particular function. They communicated this to the curator. The next day, he had worked throughout the night and changed the programme, and the new function was

incorporated. The amateur community were amazed at how concerned the curator was with user-friendliness and his ability to listen to others' suggestions.

Digitalisation, therefore, increased the amateur community's interest in participating in a major national project, and the emerging databases functioned as boundary objects between the museums and the amateur community. The aforementioned curator functioned as a broker between the museum and the amateur community, not least because of his central position in the network, and his willingness to devote time to the development of both solutions and relations. Later, this central position also made it possible for him to take an important role in the GBIF's activities. So, even if the different activities evolve around the boundary object, the different network relations are not symmetrical, but include both interactional as well as structural diversity, and strong as well as weak ties.

Collecting new objects is a central activity of the amateur community. For example, the vascular plant collection at the Natural History Museum in Oslo receives some ten thousand new objects each year, of which seven thousand come from amateurs. The fact that 'collecting' is central to the amateur community is associated with the fact that the 'discovery' aspect in the role of the researcher is that which initially arouses an interest in the natural sciences. The Swedish Species Information Centre coordinates the so-called "Swedish Taxonomy Initiative" and produces *The Encyclopaedia of the Swedish Flora and Fauna*. This encyclopaedia is also popular among Norwegian amateurs and when the first volumes of butterflies arrived, the number of members in the Norwegian Entomological Society increased 15 per cent during the first summer, and several ornithologists started to collect butterflies alongside bird watching. Digitalisation has provided the opportunity to discover 'new territory' and to develop one's own interests. One informant stated: 'The fact that data is accessible on the web is a strong motivation for collecting, and it is stimulating to make new finds, especially when one knows from the accessible information that a particular find is an important find. Many get a "kick" out of locating "unexplored terrain" by mapping existing finds and discovering areas where no previous finds have been made of a particular species.' Digitalisation has thus established a new arena for revealing the contribution of the amateur community. It is, nevertheless, important with this type of motivation that feedback is provided to the collectors. Should amateur individuals feel that the museums have appropriated their items and overlooked their origins, then much of the motivation is invalidated. This can also be a factor influencing which museum the collector comes to regard as 'his' or 'her' museum. There are several examples of collectors attaching themselves to a specific museum where they feel that they have established the best dialogue. This dialogue depends on mutual respect and trust; there are now examples of amateurs who both registered their specimens in Species Observation and thereafter handed the specimens over to the museum. On some occasions, amateurs have experienced a reluctant attitude towards their observations from the museum, an attitude that may extend the gap between the two communities. Boundary objects may be both abstract and concrete. Star and Griesemer first noticed that "specimens of dead birds had very different meanings for amateur bird watchers and professional biologists, but that "the same" bird was used by each group" (Bowker & Star, 1999, p. 297). I will claim that for a boundary object to work well, this presupposes that each group respects the different communities of practice.

At the outset, direct contact between the different curators and amateurs was an important element in both networking and participation. The NGOs aimed for a mutual database for both scientists and amateurs. However, they were not completely satisfied with the registration system chosen by scientists; they, therefore, argued that the NBIC should copy the very successful Swedish

Artportalen.se, which now has almost 30.4 million observations. Both before and simultaneously with this initiative, several other actors had identified similar needs. Artportalen.se is fairly easy to use, but does not cater for all the needs of the scientists. In 2007, the Minister of the Environment, Helen Bjørnøy, decided to implement a solution that “should increase public participation in biodiversity mapping”. The new service was launched in May 2008. The most important change that came with Species Observation was that the strong network between amateurs and scientists now also includes the conservation authorities. Species Observation has been a remarkable success and since May 2008, more than 6.2 million observations, made mostly by amateurs, have been registered. For the amateur community, administration and policy actors Species Observation is now an obligatory passage point. The NGOs consequently regard the NBIC as a very important measure, and they have also obtained a place on the board of management. For the individual observer, Species Observation also makes it possible to produce personal digital field notes. What distinguishes the Norwegian and Swedish solution from several other similar solutions is that the information providers have “ownership” of their own observations, and almost all information is accessible for everybody free of charge according to the EU Inspire Directive. Amateurs, NGOs, independent research institutes, researchers at museums and universities and, not least, planning authorities use the report possibilities. At present, Species Map is the most important report service and it is made an obligatory passage point for the planning authorities by Section 8 of the Norwegian Biodiversity Act, which states that the public authorities must base their planning decisions on scientific knowledge. The service is also an important learning resource at universities and schools. As an illustration; among those people accessing the Swedish Artportalen.se, about 15 per cent report observations, while 85 per cent only use the different services. Four 'moments' of translation are recognised in the attempts by these initiators to impose themselves and their definition of the situation on others: (a) problematisation: the initiators sought to be indispensable to other actors by defining the nature and the problems of the latter and then suggesting that these would be resolved if the actors negotiated Species Observation as the obligatory passage point; (b) interesement: a series of processes by which the initiators sought to lock the other actors into the roles that had been proposed for them in the shaping of Species Observation; (c) enrolment: a set of strategies in which the initiators sought to define and interrelate the various roles they had allocated to others; and (d) mobilisation: a set of methods used by the initiators to ensure that supposed spokespersons for various relevant collectivities were able to represent those collectivities properly.

The amateur communities are rather skewed when it comes to interests in natural history. Among the more than 6.2 million observations in Species Observation, one finds 87.8 per cent birds, 0.5 per cent other vertebrates, 2.1 per cent insects and invertebrates and 9.6 per cent plants. Skewing of data collection and management efforts is central to how we understand the world around us. Bowker discusses several reasons for skewing among scientists (and their financial supporters) like the species being very small (viruses); being the exotic other (Antarctic bryozoans); having been already studied (beetles); being disliked (parasites); being charismatic or non-charismatic species (pandas or weeds) (Bowker, 2000), and surely many more reasons may exist. When amateur communities form in natural history, it is reasonable to assume that skewing will grow out of interests linked to charismatic species; attractive species; species that are easy to observe; species being the exotic other, and I would add; species that live close to human habitats; species with a large variety; species with high aesthetic value (colourful); species with dramatic behaviour (like migration); species that are part of cultural history (useful or dangerous); and species that encourage community building and the display of social status in a community. Interestingly, the establishment of Species Observation has, over time, reduced the skewing of reported observations. Ornithology is an interesting example of community building, mostly consisting of boys and men. Professional

ornithologists long ago labelled ornithology the “*scientia amabilis*” (Mayfield, 1979, p. 168). Mayfield also describes how in 1888, teenagers’ interest was already instrumental in establishing The Wilson Ornithological Society. The original registration system in Artportalen.se is especially well suited to the registration system used by ornithologists since they were instrumental when constructing the registration system. The revised version of Species Observation, therefore, aims to cater for a larger number of needs to better mobilise all relevant collectivities.

Apomediation and collaboration

Right from the time when Carl von Linné established the Latin binomial nomenclature, researchers throughout the world have worked with the system of species. The work on giving species scientific names has, therefore, been carried out for more than 250 years. One consequence of this self-organised activity is that the same organism could have been described under different names, and that the understanding of these names varied over time and space. Tidying up and further development of this is taxonomic research. When the collection was digitalised, it was important to establish a structure that related the different names to each other. Thus, if a former name was used when registering, then this name is stored, but it is stored in relation to the modern name used today – the ‘correct’ name. As an example, it can be mentioned that in the species thesaurus for Norwegian vascular plants, some 19,000 names are registered for approximately 3,000 Norwegian vascular plants. Updated species thesauri and taxon registers are thus important for quality assessment of the digitalised material. Work on digitalisation has manifested the need for a national standard in this field, which the Global Biodiversity Information Facility and the NBIC are now following up, which, again, is part of the work conducted on international codes of biological nomenclature. The standard will be an important tool for the research community, administrative institutions and NGOs, and will contribute to increased collaboration and improved communication. One may claim that the “purpose of standards is to achieve orderings of practice at a distance” (Fenwick & Edwards, 2010, p. 85).

Quality assessment, however, has several facets whereby in this connection quality assessment may be regarded as a continual process involving problematisation, interessement, enrolment and mobilisation. Quality assessment of the scientific collections may be divided into three main aspects: 1) quality assessment of the actual digitalisation process, 2) quality assessment of the professional decisions and descriptions, and 3) quality assessment through new information. Regarding the first aspect of quality assessment, professionals with first-degree knowledge have read the proofs. Regarding the second aspect of quality assessment, curators have neither the capacity nor the possibility to assess everything included in the collections. First, the collections are very large, such that quality assessment at this level would scarcely be possible on account of the volume. It is emphasised that this would be a never-ending task. Second, possibly only a few individuals have the specialist knowledge required. The third form of quality assessment occurs when the material is subjected to taxonomic revisions or research projects, broadly understood (including those undertaken by the amateur community). In this event, the material will be quality assessed by those working on this, and where new information will normally be added. One example is the Red List project involving mosses. Those working on the project discovered that the most important thing that they could do was to assess the quality of the information in the collections. An assessment was made of the Red List mosses and it was revealed that the material had an error level of about 25 per cent. Assumedly, this is one of the highest levels of error frequency. A far lower error percentage is expected for lichens, but, at the same time, it is important to make users aware that errors do occur. At the bottom of the search page of the Lichen database, it is consequently stated: “We do not

guarantee a correct classification of the material, nor correct information on the labels. For a critical use of the database, please contact the person responsible for the database". Another important point in relation to material included in later research projects is associated with lending routines. Several museums have developed good lending routines such that 'first of all, you receive an overview of what we have; you determine what you will borrow; you are given a list of what you have borrowed; you are obliged to return the material by the agreed date; you are obliged to apply for and receive approval if you plan to do anything with an object (for example remove a leg from an insect); you will receive a reminder if the article is not returned by the agreed date' (Informant). Such routines are essential if one is to follow the history of the object, not least because this type of loan frequently results in systematic revision of the database when new information is included.

Errors may be checked manually and with the assistance of automatic assessment routines. As mentioned, the actual identification is registered manually, but some assessments may be undertaken automatically. For example, checking that the coordinates are placed within the rectangle, which encompasses the municipality, may test the location; second, investigating what appear to be logical inconsistencies or surprising locations. The amateur community can also contribute new information and quality assessment of older information relating to existing parts of the collections. For example, amateurs are involved in the registration of local flora in a number of geographical areas. In this connection, they have been granted access to the scientific databases. Through this activity, they are also contributors to the data. In the Vascular Plants Database, much geographical information is given, particularly that which is familiar to local residents who are thus best able to interpret and confirm and, at the same time, determine the coordinates of the localities. The amateur community thereby makes a major contribution to the database through an interpretation of the geography and coordinate determination. This information is subsequently quality assessed. The other area to which amateurs make an important contribution is related to time and the individual collector. Who has found the item and when? 'Amateurs can relate data from the individual localities. They know in detail where they have gone from day to day, and can immediately recognise inconsistencies. They know, for example, that an individual could scarcely have found items at two localities wide apart on the same day at the end of the 1800s' (Informant).

Quality assessment or validation of information in Species Observation differs somewhat from the scientific model. The different NGOs together with the NBIC have organised validation with the help of national coordinators and a network of experts, and the costs are shared between the different actors. Three coordinators handle the largest species groups. One coordinator handles birds, one all other zoological observations and one botanical observations. Red List observations are given priority. The validation activity has three levels. First, openness encourages self-control; people do not want to expose excessive ignorance. Second, they can ask for help from fellow observers to validate their observations and comment on pictures, etc. The third is the more formal validation. The coordinators validate some observations themselves; a network of experts validates the rest. The experts are mostly highly skilled amateurs with a high standing within the specific community, good performance and publishing activities in the NGOs' journals. In addition to biological skills, all experts have to have a certain level of digital literacy. Also, professionals like retired professors etc. are active as experts. For every observation, the experts will state if it is validated or if more information is needed. Pictures are important in this process. An observation that fails the quality assessment will not be removed, but will only be available for the owner. They try to avoid validating the observer, which is a strategy with a long history in some of the NGOs. If an observation is accepted, the owner cannot change or remove the observation without consent from the organisation. So far, no observations have been removed. A referee system by means of which at

least two experts shall validate the same observation, is used only for birds. One reason for this is the difficulty in finding enough experts in all species groups. Even the large community of bird watchers has problems finding enough experts. In this respect, Species Observation is a greater success than expected. There are some examples of assumed fraud; when one and the same person has an unlikely number of rare observations, that person will then be contacted for closer examination. Not only recent observations are included in the database; old diaries and inventory lists are also included. This is very interesting since historical data will make it possible to observe changes over time. Finally, quality assessment is also ensured by the educational activities of the NGOs and the NBIC.

One reason why the amateur community, for some species, might have a higher number of skilled experts than the scientific community is the fact that systematic biology in many respects has a higher standing among amateurs than among professional scientists. However, the rising concern for biodiversity is also positioning “systematics as a strategic science” and thereby increasing its status (Hine, 2008, p. 96). After this short span of time, Species Observation has already been made an obligatory passage point for nearly all reporting activities among the NGOs and the system of quality assessment is important, both for locking the actors into specific roles and for the enrolment of new users. The importance of digital literacy also concerns the observers, and some amateurs prefer to work in the traditional *modus operandi*; collecting specimens and handing them over to the museums. The different amateur communities also have different experiences with digital tools. Interestingly, Species Observation has made it easier for amateurs in rural areas to participate and to make them more visible. Some capitalise on this visibility since their activities may be turned into paid contracts later on, or they may receive payment for illustrations. Different ranking lists also encourage visibility. Increased visibility and user-friendliness are, without doubt, important. One species group increased its observations five-fold between the year before Species Observation and the year after. Rare findings are also made more visible, and contributions from the amateur community are made more visible for the scientific community. So far, Species Map is one of the most important bridging devices and, for some species, especially birds, the number of observations is so great that it is possible to study them with more advanced statistical models. Or as one stated when underlining the importance of Species Observation, “the proof is in the maths...”.

Openness

In our interviews, we have attempted to register attitudes towards the level of ‘openness’ concerning both scientific collections and Species Observation. In this connection, we have heard a number of stories concerning previous attitudes where certain curators have regarded the collections as being virtually their own private property. At the same time, our informants have emphasised the fact that digitalisation has established a new form of transparency and that ‘closing’ parts of the collection has become a far more visible action. Transparency is therefore important to ensure interest, enrolment and mobilisation. On the other hand, this question is not entirely unproblematic and has been the focus of much discussion. In some instances, the individual researcher or the research community has argued for limited access. One such argument has been the need to protect particularly rare species. Other arguments are associated with need: ‘It will never be realistic in my view to put absolutely everything on display. Who else, other than those who are occupied with research, needs to know if all the data from a station comes from Finnmark which has been visited six times in the last six years?’. And concerning ongoing research: ‘With regard to non-published material, it is the case that not everyone has access to absolutely everything contained there’ (Informant). The last point was also emphasised regarding motivating researchers to enter new

material into the databases while simultaneously not wishing to give away ‘large data sets free of charge’.

The question of ‘ownership’ is interesting. ‘We have a small in-house problem here – one which concerns “my collections”.’ For some of the collections, we have proceeded from a systematically structured collection where it was possible to find your animals at a specific location, to a numeric system. The fact that you can no longer find ‘your collection’ is something that is alien to the classical curator. One is concerned that a distance is established between the individual and the collection’ (Informant). Without saying that this applies to all museums in Norway, it is, nevertheless, emphasised by a number of individuals that this refers to cultural differences between different professional areas, and we hear comments such as: ‘There is not so much of this in botany; it is just that our collections are organised in a different manner to zoologists. It is here that there is a cultural difference.’ Without having systematically investigated these cultural differences, we find at one of the museums involved that, concerning botany, there is a clear difference when the material collected by the researcher is for personal use, and when it is part of the museum’s public collection. This boundary is seen in the publication of scientific work which refers to the material and is indicated by data registration, labelling and physical transfer from the researcher’s workplace to the herbarium. In addition to possible cultural differences, there are a number of instances where a certain amount of caution must be displayed in respect of researchers’ needs. The NBIC has, therefore, drawn up an agreement with the different primary data owners who are to deliver data to the NBIC. Since Norway is a member of the GBIF, there will be increased pressure on public collections to share their information more widely, although it will continue to be legitimate to protect certain information; for example, that relating to vulnerable species, data from ongoing projects and data of questionable quality. Increased acceptance of these underlying values is important for the intersement processes.

There is much to suggest that digitalisation has also resulted in new approaches and attitudes in the amateur community. According to other informants, this type of reporting was far less common previously and secrecy was widespread in many amateur groups. The reasons for this secrecy could be several: first, increased status and/or collector pride – ‘This is my place, I know it best; here I can slip away and study my species.’ The second reason is ‘the need for protection’. Both of these reasons have been discussed in SABIMA, where the current attitude is that ‘one desires to be a part of the joint effort in mapping our nation’ and that secrecy disenables the individual from playing this part. Secrecy is, however, ensured for some species by delaying observation or making the geographical location less accurate for fear of environmental crime. In this respect, it is important to remember that some of the active amateurs also hide reports because they are afraid of “environmental crimes” being committed by criminals as well as the public authorities. This especially concerns the large predators.

Bridging

One of the most important aspects of collaborative technologies is that the technology facilitates bridging activities and thereby co-exploration. Museum collections have, for many years, been important boundary objects between amateurs, professionals and conservation authorities. The collections have, however, been difficult to access for a growing number of new purposes. The digitalisation of collections has built bridges between a number of more or less well-structured boundary objects in local use. The ability to link boundary objects together into boundary infrastructures, therefore, depends on bridging activities between a heterogeneous set of actors and

repositories. In this article, we have identified four steps leading towards a new boundary infrastructure. First, the digitalisation of museum collections was an important premise for facilitating bridging activities. With such a start, the 'privatisation' of collecting activities was challenged, professionals and amateurs met in new arenas and the natural history collections of all Norwegian museums were bridged together. Second, the establishment of the Global Biodiversity Information Facility created a bridge between Norwegian collections and an increasing number of collections around the globe. This has also made standardisation an even more important precondition for scientific collaboration. Third, the establishment of Species Observation created a new opportunity for the amateur community to participate in national mapping activities, and has facilitated new ways of bridging activities between science and the public. With Species Observation, a successful boundary object has been established between the scientific community, the amateur communities and the conservation authorities. The mapping of biodiversity has been made into a huge collaborative enterprise. As Dickinson et al quite rightly emphasise, most large-scale citizen science projects provide long-term monitoring on a geographical scale beyond the reach of ordinary research methods (Dickinson, Zuckerberg, & Bonter, 2010). Fourth, bridging activity between the more science-driven museum collections and the more interest-driven Species Observation has facilitated new services as obligatory passage points for planning authorities.

In this article, we have identified some important processes in building boundary infrastructures. The most important element is to develop boundary objects that facilitate collaboration. Successful boundary infrastructures presuppose two levels of boundary objects. The first level facilitates communication and trust. At this level, one finds the standardisation of names or species thesauri, the EU Inspire Directive and the growing standardisation of assessment routines. These boundary objects are structured through more formal standardisation processes and more informal self-organised processes. This layer of boundary objects also facilitates the management of standardised forms like the Red List or The Alien Species List. The convergence of the aforementioned processes facilitates enhancing the level of trust in the information provided through the boundary infrastructures. The second level of boundary objects facilitates activities that reach out to the different communities or society at large. Important boundary objects are, so far, the Species Maps. Potential boundary objects, which have not yet succeeded, are parallel to the Swedish initiative being established at the National Encyclopaedia of the Swedish Flora and Fauna. As regards Science 2.0, establishing functional boundary objects will, for example, help a group of actors to identify collective needs, while simultaneously adjusting to individual needs and so forth. The boundary objects create a dialogue between various interests, and handle stability and ambiguity concurrently. Bridging different boundary objects then facilitates the building of boundary infrastructures that make Science 2.0 possible. One important aspect, bridging the amateur community and scientists and facilitating collaboration, is the move from the Model-Authoritative to the Model-Democratic (Fischer, 2009). While the Model-Authoritative has weak input filters and strong output filters, the Model-Democratic has weak input filters and strong output filters. Species Observation has a low threshold for contribution by the amateur community, but well organized quality assessment of critical content. So far the assessment routines focus on critical information, since this large information repository grows very fast. Fisher quite rightly points to the fact that large information repositories may be a mixed blessing unless we are able to develop new strong output filters. One of the possibilities he mentions is collaborative filtering, which is already in use for parts of the Species Observation-repository.

Boundary infrastructures, therefore, presuppose two bridging activities. First, standards are important bridging devices between different boundary objects. The standardisation of names or

species thesauri, data standards and agreed quality routines makes it possible to exchange information between different sources. Second, new services like the Red List or Species Maps have sufficient consistent structure to allow for the full array of bureaucratic tools (forms, statistics and so forth) to be applied. With this second bridging activity, the boundary infrastructure also opens up for a wide array of possible applications that producers and users might develop further.

Acknowledgments

The author thanks Jorunn Spord Borgen for her collaboration and contributions during the first stage of this study and the two reviewers for their helpful comments on an earlier draft of the manuscript.

References

- Bowker, G. (2000). Biodiversity Datadiversity. *Social Studies of Science*, 30(5), 643-684.
- Bowker, G., & Star, S. L. (1999). *Sorting Things Out: Classification and its Consequences*. Cambridge, Massachusetts: The MIT Press.
- Brown, N., Rappert, B., & Webster, A. (2000). *Contested Futures. A Sociology of Prospective Techno-Science*. Aldershot: Ashgate.
- Callon, M., Lascoumes, P., & Barthe, Y. (2009). *Acting in an Uncertain World: An Essay on Technical Democracy*. Cambridge, Massachusetts: The MIT Press.
- Collins, H., & Evans, R. (2007). *Rethinking Expertise*. Chicago: The University of Chicago Press.
- Conniff, R. (2011). *The Species Seekers: Heroes, Fools, and the Mad Pursuit of Life on Earth*. New York: W. W. Norton & Co.
- Dickinson, J. L., Zuckerberg, B., & Bonter, D. N. (2010). Citizen Science as a Ecological Research Tool: Challenges and Benefits *The Annual Review of Ecology, Evolution, and Systematics* (Vol. 41, pp. 149-172): Annual Reviews.
- Eysenbach, G. (2008). Medicine 2.0: Social Networking, collaboration, Participation, Apomediation, and Openness. *Journal of Medical Internet Research*, 10(3), 1-9.
- Fenwick, T., & Edwards, R. (2010). *Actor-Network Theory in Education*. London: Routledge.
- Fischer, G. (2009, June 8-13). *Democratizing Design: New Challenges and Opportunities for Computer-Supported Collaborative Learning*. Paper presented at the CSCL: 8th International Conference on Computer Supported Collaborative Learning.
- Hetland, P., & Borgen, J. (2005). *Evaluering av universitetsmuseenes digitaliseringsarbeid*. Oslo: NIFU STEP.
- Hine, C. (2006). *New infrastructures for knowledge production. Understanding e-science*. Hershey: Information Science Publishing.

Hine, C. (2008). *Systematics as Cyberscience. Computers, change, and continuity in science*. Cambridge, Massachusetts: The MIT Press.

Latour, B. (1987). *Science in Action: How to follow scientists and engineers through society*. Milton Keynes: Open University Press.

Mayfield, H. F. (1979). The Amateur in Ornithology. *The Auk*, 96(January), 168-171.

Selwyn, N. (2009). Challenging educational expectations of the social web: a web 2.0 far? *Nordic Journal of Digital Literacy*, 4(2), 72-85.

Star, S. L. (2010). This is Not a Boundary Object: Reflections on the Origin of a Concept. *Science, Technology & Human Values*, 35(5), 601-617.

Star, S. L., & Griesemer, J. R. (1989). Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology. *Social Studies of Science*, 19(3), 387-420.

Waldrop, M. M. (2008). Science 2.0: Great new tool, or great risk? Wikis, blogs and other collaborative technologies could usher in a new era of science. Or not., *Scientific American* (Vol. 2008).