Marine Pollution Bulletin 134 (2018) 145–151

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Seagrass ecosystem services – What's next?

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ABSTRACT

Seagrasses, marine flowering plants, provide a wide range of ecosystem services, defined here as natural processes and components that directly or indirectly benefit human needs. Recent research has shown that there are still many gaps in our comprehension of seagrass ecosystem service provision. Furthermore, there seems to be little public knowledge of seagrasses in general and the benefits they provide. This begs the questions: how do we move forward with the information we have? What other information do we need and what actions do we need to take in order to improve the situation and appreciation for seagrass? Based on the outcomes from an international expert knowledge eliciting workshop, three key areas to advance seagrass ecosystem service research were identified: 1) Variability of ecosystem services within seagrass meadows and among different meadows; 2) Seagrass ecosystem services in relation to, and their connection with, other coastal habitats; and 3) Improvement in the communication of seagrass ecosystem services to the public. Here we present ways forward to advance seagrass ecosystem service research in order to raise the profile of seagrass globally, as a means to establish more effective conservation and restoration of these important coastal habitats around the world.

1. Introduction

Seagrasses provide a wide range of ecosystem services (Campagne et al., 2015; Cullen-Unsworth et al., 2014; Nordlund et al., 2016), here defined as natural processes and components that directly or indirectly benefit human needs (De Groot et al., 2002). Seagrasses are marine flowering plants, which form extensive meadows in shallow coastal waters on all continents except Antarctica (Green and Short, 2003; Short et al., 2007). Even if the term ecosystem service is recent, seagrasses have benefited human needs for a very long time. For example, *Posidonia* litter has been used as filling for bedding since the 16th century (Terrados and Bodrum, 2004). In the early 18th century, seagrass in Orkney (Scotland) was being used by cottars as a substitute for straw in thatching the flagstoned roofs of Orcadian houses (Willis, 1983). A report from 1824 shows that storm cast seagrass was used in agriculture across the North Atlantic (Urquhart, 1824). In an article from 1951, there is a detailed description of the widespread loss of the seagrass *Zostera marina* across the Atlantic which impacted all associated species and negative effected humans due to declines in fish and Brant (*Branta bernicla* Linnaeus, 1758), a popular goose to hunt in the past (Milne and Milne, 1951). Although we have been aware of several benefits to humans of seagrass for a long time and there have been significant advances in ecosystem service related research over the last decade, and recent research has shown that there are still many gaps in our comprehension of seagrass ecosystem service provision (Nordlund et al., 2016). Furthermore, globally there seems to be little knowledge by the public of seagrasses in general and the benefits they provide. In comparison to many other ecosystems which also benefit society, seagrass receives little attention and it is often not considered in coastal management decisions (Duarte et al., 2008; Grech et al., 2012; Nordlund et al., 2014).

The intertidal-to-shallow-subtidal location of most seagrass meadows allows relatively easy access and multiple uses, which exposes seagrass ecosystems to both terrestrial and marine based threats (Cullen-Unsworth et al., 2014; Cullen-Unsworth and Unsworth, 2016; Grech et al., 2012; Nordlund et al., 2014). The many threats to seagrass are causing it to disappear rapidly around the world (Cullen-Unsworth and Unsworth, 2016; Nordlund et al., 2014; Short et al., 2011; Waycott

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http://dx.doi.org/10.1016/j.marpolbul.2017.09.014
Received 18 April 2017; Received in revised form 1 September 2017; Accepted 7 September 2017
Available online 20 September 2017

et al., 2009), with an estimated annual decline rate of 7% globally (Waycott et al., 2009). Arguably, the biggest threat to seagrass is public indifference and unfamiliarity. Successful conservation requires raising the profile of seagrasses. Seagrass beds do not look particularly different from terrestrial grassland habitats. Seagrass does not have the immediate appeal or charisma of other marine ecosystems, such as coral reefs and mangroves (Duarte et al., 2008; Orth et al., 2006), which puts them at a disadvantage regarding gaining awareness by the general public. This results in a lack of perceived importance of the services that seagrasses provide in the ocean despite the fact that seagrass services are vast and some quite unique. The identification of ecosystem services can increase focus on the importance of seagrasses for humans and not just seagrasses as simple "grass", thus driving conservation and management. However, poor communication of these values and a poor science base may compromise the message.

Scientific evidence exists from around the world that seagrasses provide a wide variety of ecosystem services (Nordlund et al., 2016), but service provision is often disparate and site specific. This begs the questions: how do we move forward with the information we have? What other information do we need and what actions do we need to take in order to improve the situation and appreciation for seagrass? Based on the outcomes from an international expert eliciting workshop, here we describe the main outcomes of the workshop and also include the authors' personal opinions of the three broad themes that emerged as research areas in urgent need of attention. We provide a roadmap of suggestions of how to move seagrass ecosystem service research forward in order to raise the profile of seagrass globally. We also present examples of the different themes to illustrate the current problems and potential solutions.

2. Methods

To address critical questions in where to go with regard to seagrass ecosystem services, an expert workshop was held. Expert knowledge is used widely in science and the practice of conservation, and eliciting opinions and information from experts is commonly used to fill knowledge gaps (Ban et al., 2015; Burgman, 2005; Grech et al., 2012; Krueger et al., 2012; Martin et al., 2012). We define an expert as "anyone with relevant and extensive or in-depth experience in relation to a topic of interest" (Krueger et al., 2012). Based on these criteria, experts included managers, practitioners, and researchers working with (a) questions related to the natural or social environment of seagrass, and/or (b) questions relevant to seagrass ecosystems. These experts may therefore not directly work with ecosystem services, yet ecosystem services are intrinsically a component of their work.

The expert workshop was entitled "Seagrass ecosystem services – what's next?" and was held during the 12th International Seagrass Biology Workshop (ISBW) - Securing a Future for Seagrass, on the 17th of October 2016 in Wales, United Kingdom (Hind-Ozan and Jones, 2017). The biennial ISBW is the largest seagrass meeting in the world and attracts participants from academic institutions, government agencies and non-government organizations with expertise in seagrass biology, ecology, management, monitoring and social aspects of seagrass research.

There were 38 workshop participants, which constituted approximately a quarter of the 160 ISBW attendees from 40 countries. The participation in the workshop was voluntary and before starting all participants were made aware that the results were intended for publication in a scientific journal. Following previous protocols for soliciting expert opinion we openly invited experts from a range of seagrass research fields, and across a wide range of countries and bioregions. Ahead of the workshop, invitees were provided with a summary of three key topics for discussion: 1) how can the seagrass research community move forward with the information we have about seagrass ecosystem services?; 2) can we identify interesting ideas and actions, and work together to develop new research to advance research based on seagrass ecosystem services?; and 3) can we find clever ways of using ecosystem service knowledge to increase the appreciation of seagrass, that goes beyond "simply" putting an economic value on them?

The participants worked in six groups based on haphazard grouping. Each group was asked to decide on what they considered to be two key priorities, and notes were taken of: a) background and context to those priorities; b) key research gaps in knowledge; and c) suggested ways forward, as specifically as possible. We provided a list with 12 examples of research areas to start the discussion (Supplementary Material 1). After 1.5 h of individual group discussions, a 45-min plenary group discussion was held, where each group presented their main outcomes and broader conclusions were made among the entire expert group. Individual group discussion responses were compiled into priority actions.

Following the workshop, we carried out a text analysis to create a word cloud in order to examine and highlight the main issues contained in the experts' texts. The original texts were prepared for analysis by compiling into one continuous text. Topic headings (the focus points the experts were asked to address) were removed and the text filtered for text congruency. We used an online word cloud generator (http://www.wordclouds.com/) to generate the wordlist (n = 310 words). This list was then filtered to exclude 118 non-specific words not previously excluded by the software and used to create a high definition word cloud in jpg format. The text, wordlist, and filtered wordlist are provided in Supplementary Material 2.

3. Results and discussion

To advance the current knowledge on seagrass ecosystem services three broad themes within in a wide range of topics were highlighted during the workshop. The three broad themes that are in urgent need of attention are:

1) Investigate variability of ecosystem services within seagrass meadows and among different meadows by investigating their variation among different factors, including seagrass species, meadow characteristics and environmental conditions in which they develop;
2) Investigate seagrass ecosystem services within the seascape by comparing delivery of services among the different coastal and marine habitats and investigate effects of connectivity, juxtaposition of habitats, configuration of habitat patches and seascape dynamics;
3) Improve communication of seagrass ecosystem services to the public, by analyzing which messages are most effective to communicate, how to reach broader levels of society, and the mechanisms by which to communicate.

The experts highlighted that the current knowledge in these three broad themes is still limited, and more basic knowledge is needed. For example, we do not even know how much seagrass we have around the world, with current estimates varying between 177,000–600,000 km^2 (Mcleod et al., 2011; Waycott et al., 2009), but with new mapping techniques, such as GIS or species distribution models, it may prove to be as much as 1,000,000 km^2, as large areas are still unmapped.

Fig. 1 presents the word cloud generated by the expert opinion notes. The most commonly mentioned words after services, seagrass and ecosystem were words related to the diversity of services [*different* (11), *important* (5), *specific* (5)], scale [*local* (10), *scale* (7), *variability* (4)] and communication [*communication* (7), *public* (6), *people* (5), *communicate* (4), *communicating* (3)] as well as seagrass attributes [*species* (7), *meadows* (5)] and management related words [*restoration* (4), *management* (3), *managers* (3)](Fig. 1).

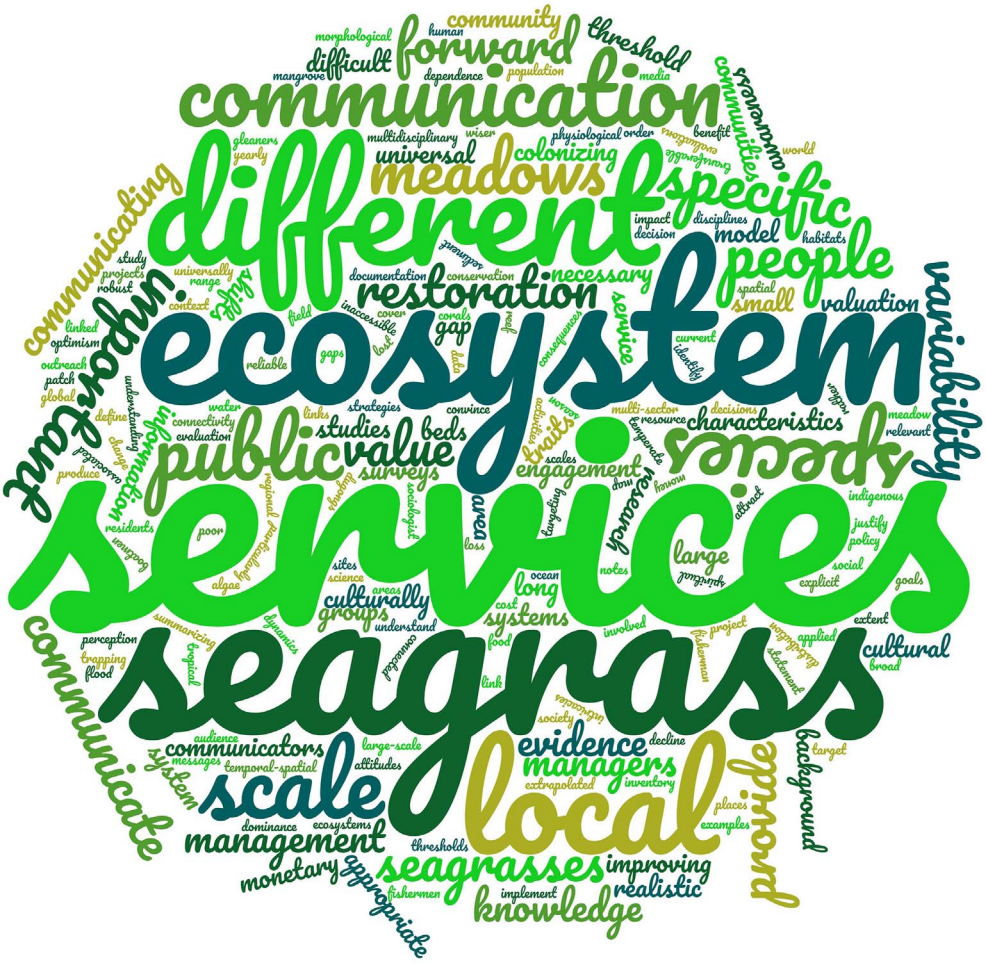

Fig. 1. Word cloud of text analysis of experts' priorities for seagrass ecosystem services research (including notes on background and context of those priorities, key research gaps and suggested ways forward). In the word cloud, the size of each word indicates its frequency or importance.

3.1. Theme 1. Variability in ecosystem services within and among seagrass meadows

3.1.1. What are the non-linearities in ecosystem service provision within and among seagrass meadows?

Recent research has shown that there is substantial variability in known seagrass ecosystem services among seagrass genera across the globe and that there are very large knowledge gaps (Lavery et al., 2013; Nordlund et al., 2016). This topic was investigated in previous ISBW workshops (Nakaoka et al., 2014; Nordlund et al., 2016), but was discussed in light of future research needs in the ISBW12 workshop. Large knowledge gaps were identified as to what extent different levels of services are provided by different seagrass genera and species. The composition of species in a meadow, and whether it is mono- or multi-specific may also have an effect on the ecosystem services (Duarte, 2000). Therefore, a priority for future research regarding service variability identified during the workshop was to investigate larger, long-lived species vs. small, faster growing colonizing species. Furthermore, we recommend that future research should investigate how ecosystem provision varies with plant and meadow physiological and morphological characteristics (e.g. shoot density, canopy height, root depth, and life history strategy). Another important aspect that requires further study is the effect of variation in climate conditions such as seasonal variation, geographical location, and weather, etc., on the amount and quality of ecosystem services provided.

Future research also needs to consider within-species variability in ecosystem services. To illustrate this a notable example comes from eelgrass (*Zostera marina*) where monospecific meadows develop all over the temperate Northern Hemisphere. Studies so far suggest that eelgrass meadows vary substantially in shoot size, shoot density, as well as genetic diversity and community composition of associated biota such as epiphytic algae and invertebrate animals (Duffy et al., 2015). The multiple ecosystem services from these varying eelgrass beds are expected to differ substantially, yet a comprehensive assessment of ecosystem services is still lacking for this very common and much-studied species of seagrass.

To illustrate this, carbon sequestration in meadows has been found to vary among species in different regions (Lavery et al., 2013) and within the meadow landscape (Gullström et al., 2017; Ricart et al., 2017). Whilst for some species of seagrass, for example, *Posidonia oceanica*, carbon sequestration estimates have been well studied, for other species our knowledge of their carbon sequestration capacity is rudimentary. Carbon sequestration has also been found to vary with depth, water turbidity, wave height, canopy complexity and bioturbators (Martinetto et al., 2016; Samper-Villarreal et al., 2016; Serrano et al., 2014).

Hydrodynamic damping by seagrass meadows is well known (Bradley and Houser, 2009; Fonseca and Cahalan, 1992; Koch et al., 2006; Paul, 2017). Another less well-known regulation services by seagrasses are indirect damping processes by beach cast seagrass. For example, beach cast of *P. oceanica* along extensive stretches of the shoreline alters its geomorphology over times scales up to years, playing an important role in protecting the coast from the effect of waves, currents and winds (Jeudy de Grissac and Audoly, 1985). Although these ecosystem functions of seagrass may result in coastal protection, it cannot be assumed that the pure presence of seagrass will lead to the full provision of this ecosystem service (Barbier et al., 2008; Koch et al., 2009). Wave attenuation and reduction in current velocity

are a function of density of the seagrass bed and the hydrodynamic conditions of the area (Hansen and Reidenbach, 2017; Koch and Gust, 1999), both of which can vary significantly among seagrass beds with different species compositions, under different geographical conditions. We are just starting to understand the complexity of this variability within and among seagrass meadows. The knowledge we have is mostly from a few ecosystem services which are more commonly recognized and researched, such as carbon sequestration and coastal protection, but what about all other ecosystem services seagrasses provide which may be equally important?

3.1.2. Does scale matter?

The spatial and temporal scale at which ecosystem services are evaluated was also a key point that was found to need further research. We suggest it is a necessity to establish a minimal threshold of the spatial scale for evaluating ecosystem services. For example, some commercially important decapods and juvenile fish prefer to inhabit the center of dense seagrass beds whereas larger carnivorous fish stay at the periphery (Connolly and Hindell, 2006; Nakaoka, 2005). In such cases, evaluating animal abundance at plot scale (e.g. m^2 level) leads to the underestimation of the provisioning services. Appropriate scale of observation and evaluation would be meadow or landscape level ($> 10–100\ m^2$ level) to quantify different types of animals utilizing seagrass meadows in a different manner. Regulating services like nutrient retention and carbon sequestration also depend on the size of seagrass beds. A recent study on carbon sequestration capacity of eelgrass meadows revealed that the capacity is meadow-size dependent, with larger eelgrass beds more effective in capturing and storing organic carbon (Miyajima et al., 2017). This suggests the presence of non-linear changes in seagrass ecosystem services, with biotic/abiotic factors having thresholds which need to be tested for various types of ecosystem services at multiple locations.

We suggest that there is a need to consider the temporal scales at which evaluation of seagrass ecosystem services should be made. Many seagrass meadows in the tropics consist of different species that vary not only in size and form but also in growth and turnover rates (colonizing, opportunistic or persistent), which makes meadows either enduring or transitory (Kilminster et al., 2015). The ecosystem services provided by different phases (successional stages) of seagrass beds varies greatly (see Table 1 of Kilminster et al., 2015), and their estimates can vary depending on the period contemplated. Even for monospecific eelgrass beds in temperate zones, the plants undergo large seasonal variation in biomass and productivity, with some beds completely annual (Meling-López and Ibarra-Obando, 1999; Olesen and Sand-Jensen, 1994; Sand-Jensen, 1975). The value of ecosystem services, of course, will vary greatly depending on whether we contemplate only the peak productivity season, or annual or longer term averages.

3.1.2.1. Scale tailored to demand. The issue of scale of research also depends on that required by the human communities. Government and international organizations may urgently need countrywide-scale data on the value of ecosystem services from seagrass beds for which broad-scale data may be necessary (with an aid of GIS). In contrast, local stakeholders (such as fishers, local agencies for water quality control, marine ecotourism sectors, etc.) may need fine-resolution information on the status of ecosystem services from each eelgrass meadow off their beach. We discuss this point further in the section of communication.

3.2. Theme 2. Seagrass ecosystem services within the seascape

3.2.1. How useful is comparing ecosystem service delivery among coastal habitats?

One approach to increasing our understanding of the relative importance of seagrasses is to compare ecosystem service delivery between seagrass and other coastal and marine habitats. There have been many attempts to contrast values (Costanza et al., 1997; Dewsbury et al., 2016; Koch et al., 2009; Rönnbäck et al., 2007), but with limited available information, estimates can be very unreliable and difficult to defend. For example, with increased attention on blue carbon, seagrass carbon stocks and burial rates have been successfully set side by side with other coastal habitats (Fourqurean et al., 2012; Luisetti et al., 2013; Mcleod et al., 2011). Discussions at the expert workshop highlighted that comparisons with other systems are usually only with other well-known habitats such as coral reefs, mangrove forests, and saltmarshes. One problem is that coral reefs and mangroves are better researched coastal systems when contrasted with seagrass meadows (Duarte et al., 2008; Orth et al., 2006), so the values of seagrass might be underrepresented. Similarly, other less “charismatic” habitats such as unvegetated mudflats are not included in such analyses but may make up a significant part of the seascape, and in some instances, may represent an alternate state for seagrass following disturbance. Another challenge is that not all ecosystem services are included in such studies. This is partly because we are still lacking information about some seagrass meadow ecosystem services and seagrass might therefore be undervalued. We propose that habitat comparisons made at local or regional scales are useful for management and public engagement purposes, but should be grounded by a strong science base. We suggest that further research on this topic is required and that contrasts at larger scales, with the inherent generalizations and data gaps, should be used with caution and be presented with advice of the limitations of the evidence.

3.2.2. How important is understanding the connectivity of seagrass ecosystem services in the seascape?

We need to consider and gain a better understanding of the ways in which different systems are connected, for example how the surrounding habitats (e.g. coral reef and mangrove with tropical seagrass beds, and kelp forest and saltmarsh with temperate beds) affect the provision of seagrass ecosystem services.

For instance, seagrasses stabilize the sediment, reducing sediment re-suspension and nutrients in the water column, improving water quality (Verweij et al., 2008), and thus, promote the health of coral reefs with benefits in biodiversity and productivity. Seagrasses also serve as a nursery habitat for some commercially important fish and invertebrates collected in other habitats (Honda et al., 2013; Jackson et al., 2001; Nagelkerken et al., 2002; Unsworth et al., 2008; Valentine and Heck, 2005). Recent studies have demonstrated that even adult fish undergo daily migrations between coral reefs and seagrasses (Honda et al., 2016). Seagrass beds support reef fish productivity and biodiversity of coral reef ecosystems (Unsworth and Cullen, 2010). Seagrasses also provide important regulating services, such as nutrient retention and recycling, water quality control and carbon sequestration. Furthermore, seagrasses can potentially buffer future ocean acidification on adjacent coral reefs (Unsworth et al., 2012). A very recent study revealed that they can even reduce bacterial pathogens in reef ecosystems that harm both marine organisms and humans (Lamb et al., 2017). Regarding carbon sequestration, there is a clear interchange of carbon among adjacent habitats such as coral reefs, seagrass beds, and mangroves via the water column, (Hemminga et al., 1994). Seagrass meadows are important autochthonous and allochthonous carbon sinks (Kennedy et al., 2010), and seagrass carbon can also be exported to adjacent beaches or even to the deep sea, the latter constituting a sink for long-term storage (Laruelle et al., 2010). Identifying the dynamic spatial effects at the seascape level for each ecosystem service is a key knowledge gap, which should be addressed in further studies for more effective conservation and management. Also, assessing the potential effects of seagrass ecosystem services if adjacent ecosystems are damaged or, in fact, protected, may be considered as a core research, but there may be a disproportionate response in ecosystem services under this scenario; where one service may strengthen, some may not change, while others may decline.

3.3. Theme 3. Communicating and linking ES to people/communities

The most highlighted outcome of the workshop was the need for improved communication of the value of seagrasses and their ecosystem services; underscoring the current need to identify the correct message for the right target group and the mechanisms/methods by which researchers and mangers can effectively communicate with people.

There is no clear research on whether seagrass ecosystem services are used worldwide to explain to the public the importance of conserving seagrass habitats. There is also no knowledge on which ecosystem services are more or less often mentioned by managers to local communities to justify seagrass conservation. A key research gap is a lack of knowledge, attitudes, and perception regarding seagrass ecosystem services in multi-sectoral groups in society e.g. managers, boatmen, fishers, gleaners, among others. Furthermore, if we are to communicate economic value of seagrass ecosystem services, there is a need to further research of economic valuation 'principles' as well as studies that provide the type of information to make more accurate estimates (Dewsbury et al., 2016). Particular ecosystem services that were identified as seldom being communicated are those related to culturally and spiritually related services, which require further research.

3.3.1. Identifying the right ecosystem service message for the target group

We suggest that specific information to communicate ecosystem services to the general public should be strongly evidence-based in order to maximize its potential impact. There is a great deal of general knowledge on seagrass ecosystems, however local studies of services are often lacking. Ecosystem services are a way to link people to their seagrass system. Local facts relating to local ecosystem services may potentially have the highest impact, given the relatability of local seagrass to that audience, area, context and human population. For instance, choosing ecosystem service messages relevant only to long lived large species, such as shoreline protection, in a community whose local seagrasses are small and ephemeral will not adequately convey the importance of seagrasses and could even lead to a questioning of the scientific facts being communicated versus local knowledge and experience. In contrast, noting the local importance of seagrass beds to fish stock replenishment, given their role as nursery habitats, would be of great impact to local fishers. The messages could also focus on the appeal and persuasiveness of the underlying fact, i.e. seagrass inhabitants such as dugongs, turtles, and seahorses, flagship species which hone conservation importance of certain seagrass services. Communicating the services influenced by human impact, with the aim of implementing change in management or with the end users are of key importance.

Cultural and spiritual seagrass ecosystem services have a high potential for communication impact, as where they are important people are intrinsically aware of them, yet clearly stipulating them and linking them to seagrass habitats would be of great benefit. For example, the value of enjoying a view of calm water near the coastline when we visit can be in part attributed to seagrasses slowing down water flow in many locations. Increased communication focused on local seagrass facts, facts to implement change in management or end users and of less tangible ecosystem services in seagrass ecosystems is considered to have high communication potential.

3.3.2. Identifying a target audience for communicating seagrass ecosystem services?

In order to communicate effectively, we suggest that first we need to identify the target audience and their current knowledge level of ecosystem services provided by seagrass. In the workshop it was highlighted that just because a lot of seagrass research has been done in a location, it does not necessarily follow that the local community is aware of the outcome of such research. Another aspect highlighted was that we do not know whether the intrinsic value of seagrass is recognized by the general public through one or some of the ecosystem services it provides. When developing a communication plan, not only the right message needs to be identified, but it has to be specially formulated to take into account of who the message is for. In general, it is considered that the diverse stakeholders need to be identified and taken into account in communication initiatives. Scientific knowledge can sometimes be inaccessible to seagrass stakeholders and communication specialists can be a powerful asset in translating complex scientific findings into effective information based on the stakeholder target profiles. In particular, it was noted that increased awareness of seagrass ecosystem services is important not only at the level of the general public but also should be targeted to include managers and policy makers.

3.3.3. What are the possible mechanisms for communication to build awareness

We have little-to-no idea of which media outlets have been most successfully used to communicate seagrass conservation through ecosystem services. These knowledge gaps, and synthetic studies to pinpoint them, were identified and suggested as a necessary basis for developing communication strategies. The traditional pathway is that scientists publish their results in specialized journals, conferences or workshops (Day and Gastel, 2012). This message is mainly restricted to academic and research areas, so its dissemination is poor and partly inefficient. In order to reach other levels of society and improve communication the message must have a greater impact in the mainstream media.

Another key question, in need of investigation, identified during the workshop is how to effectively communicate seagrass ecosystem services beyond direct stakeholders, such as to people living in cities far from seagrass beds who are indirectly benefiting from ecosystem services from seagrass beds (e.g., buying seafood collected from a remote seagrass bed in the local supermarket at the end of global supply chain). Communication through various types of media becomes desirable to improve the awareness of the seagrass ecosystem services to the diversity of potential target audiences. Social media, for example, is transforming the concept of how information is disseminated, with new tools being taken up by society (Boyd and Ellison, 2007). How effective and what benefits can be obtained from communicating seagrass ecosystem services using platforms such as Facebook, You Tube, Instagram and Twitter? It has been reported that the use of scientific blogs may be an influential tool to connect scientists with governing authorities and economist communities (Fox, 2012). We think developing an adequate networking strategy could be particularly powerful to transmit a more effective and clear message regarding seagrasses ecosystem services. Public engagement and outreach programs may also prove to be a very valuable tool for effectively communicating seagrass ecosystem services. If seagrasses receive more attention from the media, it will likely lead to a high impact in society, and may occupy a prominent place in public policy.

Usually, seagrasses are "free riders" in marine conservation, i.e. included in the protection or management but not specifically targeted. There are some programs that do have a focus on seagrasses, for example Chesapeake Bay—the largest estuary in the United States, and the Great Barrier Reef Marine Park in Australia and the Action plan for the conservation of marine vegetation in the Mediterranean Sea (Chesapeake Bay Program, 2017; Great Barrier Marine Park, 2017). We suggest analyzing and evaluating how such programs communicate about seagrass and its ecosystem services are one way to learn increase our understanding of how to conduct effective communication for the benefit of seagrass.

4. Conclusion

Based on the expert workshop we identified three broad themes that need urgent research attention to fill key knowledge gaps, these themes may serve as guidance as to how to move forward in seagrass ecosystem

service research. First, there is a lack of information on the variability of ecosystem services within and among seagrass meadows, particularly given the variability in seagrass life histories and in the seagrass seascape. This is a complex task but to increase our understanding of seagrasses and their provision of ecosystem services we need to explore this further. Secondly, there is very limited knowledge of the variability of ecosystem services among different habitats, and how variations in ecosystem services among the habitats will effect ecosystem service provision in other habitats. This is likely to require collaboration of researchers from different research fields and may become rather large studies. Third, it is clear that more research regarding the communication of seagrass ecosystem services will provide insight as to which messages and mechanisms may lead to most effective target based communication, with a clear lack of knowledge regarding emerging social media communication platforms. Seagrass researchers working together with communicators could probably make a big difference for improved and increased communication.

Future research on seagrass ecology and communication which fill these gaps will promote conservation and restoration of seagrass beds around the world. More comprehensive understanding of the variability in seagrass ecosystem services among species and sites, as well as on the interrelationship of its services with those of adjacent mangroves and coral reefs will help designate conservation areas and determine restoration programs. Continuous communication between scientists and stakeholders in an established, systematic manner will enhance the goals of conservation/restoration. We believe that a multidisciplinary approach by which seagrass scientists increasingly involve and collaborate with other areas will be key in advancing the 'What's next' agenda of seagrass ecosystem services.

Acknowledgements

We would like to acknowledge the ISBW12 organizers and the workshop participants: Agustin Moreira Saporiti, Alix Green, Amanda Cole, Kirsty Fraser, Maria Potouroglou, Len McKenzie, Arie Vonk, Diana Perry, Fred Short, Helen Horangic, Hugh Kirkman, Inés Viana, Jun Shoji, Jutta Meyer, Laura Yarbro, Leanne Cullen-Unsworth, Maike Paul, Mary Bernadette De Venecia, Masakazu Hori, Mathew Dring, Mirta Teichberg, Nick Higgs, Peter McCreadie, Rachel Cole, Rachel Manassa, Richard Preziosi, Richard Unsworth, Ruby Gartwin, Theodora Horangic and Xaoli O'Reilly-Berkeley.

LMN acknowledges funding from the Swedish Research Council Formas, grant number 2014-1288. JSV thanks the University of Costa Rica for travel funds. MN is supported by the Environment Research and Technology Development Fund (S-15 Predicting and Assessing Natural Capital and Ecosystem Services (PANCES)) of the Ministry of the Environment, Japan. JCC was supported by the Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro and Conselho Nacional de Desenvolvimento Científico e Tecnológico, Brazil.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.marpolbul.2017.09.014.

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