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Editorial

Translating seagrass science into action

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Seagrasses are flowering plants that live in coastal waters and comprise 72 species distributed worldwide (Duffy *et al.* 2019). They support a wide range of biological resources and ecosystem services but are also under tremendous threat. Seagrass meadows absorb nutrients, support foodwebs, are effective carbon sinks, and provide nursery habitats and breeding grounds for many other species (Barbier *et al.* 2011). They are economically valuable thanks to their contribution to fisheries and tourism, as well as their ability to reduce coastal erosion through binding sediments, trapping particulate matter, and attenuating wave energy (Ruiz-Frau *et al.* 2017). It is of great concern then that seagrass meadows are being lost worldwide due to local and global stressors, despite the clear need to conserve these communities (Orth *et al.* 2006; Waycott *et al.* 2009). Sediment and nutrient run-off are particularly pressing issues, leading to low light availability, smothering of seagrasses, and the creation of algal blooms (Orth *et al.* 2006; Yaakub *et al.* 2014*a*). Physical destruction of seagrass beds will increase as land is reclaimed, harbours are developed, fishing pressure intensifies, and aquaculture expands (Quiros *et al.* 2017). These stressors are expected to worsen in line with the growing number of people living on or near the coast around the world (Yaakub *et al.* 2014*b*). As the temperature of the oceans increases globally, the incidence of disease in seagrasses is also likely to rise (Duffy *et al.* 2019). Unfortunately, pressures on seagrass communities are often overlooked in media reporting and scientific publications in favour of other coastal ecosystems such as coral reefs (Unsworth *et al.* 2019), an oversight that exacerbates the risks to seagrass meadows and highlights a need to improve education and awareness.

As part of the ongoing effort to generate public interest and enhance knowledge exchange, the 13th International Seagrass Biology Workshop (ISBW13) and World Seagrass Conference 2018 (WSC) was held from 11 to 17 June 2018 in Singapore. A flagship event of the World Seagrass Association, ISBW13 and WSC were jointly organised and supported by the National University of Singapore, DHI Water & Environment, and the National Parks Board of Singapore. The theme of the event was 'Translating Science into Action', motivated by the ever-important need for effective communication of seagrass science amongst scientists, managers, and practitioners, to better develop and implement science-based seagrass conservation and restoration policies. The event was attended by 201 participants, the highest in the event's history, with 72 poster presentations and 118 oral presentations in the WSC component. During ISBW, there was a strong focus on training and knowledge sharing, with workshops on new technologies such as using drones for habitat mapping and the application of virtual reality, as well as discussions on key issues such as ecosystem resilience and new practices in habitat restoration and pulse amplitude modulated (PAM) fluorometry. The aim was for practitioners to be able to harness collective knowledge and skills for advancing seagrass science and management.

This 'Translating Seagrass Science into Action' research front arose from ISBW13 and we sought manuscripts from conference participants that emphasise the applicability of scientific research to management practices and policies for the conservation of seagrass meadows, from the local to global scale. All eight papers presented here examine the impacts of human activities or have a conservation perspective. Following strong regional representation at ISBW13, research and researchers from the tropics and South-east Asia are well represented, with many welcome contributions from students. The papers can be grouped into four thematic pairs, covering a range of critical topics.

In the first two papers, Rahman and Yaakub (2020) and Chuan *et al.* (2020) assess some of the ecosystem services provided by seagrass meadows. Rahman and Yaakub engage with the challenging task of determining both the ecosystem-service and socio-economic value of seagrass meadows at

Mukim Tanjung Kupang, Johor, Malaysia. They employ a benefit-transfer approach using anthropological and local-knowledge of their study location. Although they calculate the habitat value at US\$57 731.80 ha^{-1} $year^{-1}$, they consider this a substantial underestimate because of the large number of seagrass ecosystem-services for which there is currently no value available. Chuan *et al.* (2020) focus on blue carbon, testing current sequestration assumptions by 500-day anoxic decomposition and mineralisation experiments. Their data and models suggest that carbon sequestration may be lower than previously thought, and they highlight the need for greater certainty regarding model assumptions that are key to understanding how seagrasses can be part of a solution to climate change.

Sánchez *et al.* (2020) and Seng *et al.* (2020) investigate issues of environmental quality: a well-established pollution issue (nitrogen rich wastewater), and an emerging one (microplastic pollution). Sánchez *et al.* (2020) used $\delta^{15}N$ to determine the presence of nitrogenous nutrients of anthropogenic origin in *Thalassia testudinum* collected from two sites in the Mexican Caribbean (Cancún and Mahahual). They found strong evidence for tourism driven wastewater as a source of $\delta^{15}N$ at Cancún and encourage action to be taken to improve water treatment and disposal. Even though effects of plastic pollution on a wide variety of marine life is known (Law and Thompson 2014), seagrasses have been overlooked. Previous to the paper by Seng *et al.* (2020), only one study had documented microplastics encrusted within seagrass (*Thalassia testudinum*) epibionts (Goss *et al.* 2018). Seng *et al.* (2020) have expanded this knowledge to include microplastics presence data for *Cymodocea rotundata*, *Cymodocea serrulata* and *Thalassia hemprichii*. Even though the direct impact of microplastics remains unresolved, they have the potential to enter the food chain by herbivory.

The next pair of papers are also related to changes in environmental quality, in particular sediment-driven turbidity. Ow *et al.* (2020) and Kong *et al.* (2020) investigate the effects of low light on two seagrass species in Singapore, where high turbidity is a major conservation issue for all benthic photosynthesisers. Ow *et al.* show how high epiphyte load, by reducing light reaching seagrass blades, can compound the negative effects of chronic turbidity. They used a neat experimental design based on a modified spectrometer and clear polyethene strips as seagrass (*Cymodocea rotundata*) mimics for measuring the relationship between epiphyte load and light transmission. They conclude that high epiphyte load is unlikely to be an issue in clear waters, but it can play a much more important role in turbid conditions. They also provide useful threshold values to inform conservation managers. Kong *et al.* examine *Halophila ovalis* acclimatisation to low light and how this may affect the optimal temperature for photosynthesis. Although there was the potential for synergistic effects between water temperature and light level on productivity, this was not found, with light having little influence on the thermal requirement of *Halophila ovalis.*

The final two papers both look to sediments to answer key questions regarding how seagrasses may respond to environmental change. Ong *et al.* (2020) highlight the importance of viable seedbanks for seagrass meadow resilience while Foster *et al.* (2020) present an environmental DNA (eDNA) toolkit for long-term ecological reconstruction of coastal vegetated ecosystems. Seed banks in sediments provide some species (i.e. those that are fast-growing and so do not have extensive carbohydrate reserves) the chance to regenerate from major disturbances (Jarvis *et al.* 2014), but there are few reports from the tropics. Ong *et al.* found worryingly depauperate seed banks for *Halophila ovalis* and *Halodule uninervis*, and no *Cymodocea rotundata* seeds at all from their six study sites, suggesting seagrass meadows in Singapore may not have the capacity to recover from future impacts. Foster *et al.* argue that our understanding of how coastal vegetated ecosystems have changed in the past in response to human activity is important for identifying contemporary conservation strategies. They advocate using eDNA from dated sediments to reconstruct past seagrass communities and identify the appropriate emerging technologies and methodological approaches for doing this.

The papers in this research front reflect the expanding scope of seagrass research and the growing drive for actionable-science and evidence-based decision making in seagrass conservation. In order to safeguard seagrasses for future generations we need to be proactive in applying scientific knowledge to the management of these key coastal communities. Increasing recognition of seagrasses and their associated ecosystem services is required on a global scale in order to prompt policy makers to protect existing seagrass habitat. Further, we must also improve our understanding of the multiple stressors seagrasses face, as well as implement more consistent approaches to monitoring and improve data collection that can then be used to inform policy decisions (Griffiths *et al.* 2020). It is important to be both innovative and adaptive in the management of seagrass habitat, incorporating conservation goals that take into account future climate predications, but that also include human needs and presence (Unsworth *et al.* 2019). In doing so, we can begin to create a future where seagrass communities are not only surviving but thriving.

Conflicts of interest

Siti Maryam Yaakub, Nicole Foster, Michelle Waycott and Peter Todd are guest editors of the 'Translating Seagrass Science into Action' research front in *Marine and Freshwater Research*. Despite these relationships, they took no part in the review and acceptance of this or any other manuscript in this issue that they authored. The authors declare that they have no further conflicts of interest.

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