

Editorial

All for one and one for all: research from the 6th International Invasive Sea Squirt Conference and the 10th International Conference on Marine BioinvasionsP. Joana Dias^{1,2}, Mary R. Carman³ and Stephan G. Bullard⁴¹NOAA Northwest Fisheries Science Center, Seattle, WA, USA²School of Aquatic and Fisheries Sciences, University of Washington, Seattle, WA, USA³Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA, USA⁴University of Hartford, Hillyer College, West Hartford, Connecticut 06117, USAAuthor e-mails: jdias@uw.edu (JD), mcarman@whoi.edu (MC), bullard@hartford.edu (SB)

Citation: Dias PJ, Carman MR, Bullard SG (2019) All for one and one for all: research from the 6th International Invasive Sea Squirt Conference and the 10th International Conference on Marine Bioinvasions.

Management of Biological Invasions 10(4): 597–601, <https://doi.org/10.3391/mbi.2019.10.4.01>

Received: 5 December 2019

Accepted: 12 December 2019

Published: 14 December 2019

Handling editor: Vadim E. Panov

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It has been 20 years since the foundation of a dedicated International Conference on Marine Bioinvasions in 1999 (ICMB-I, Massachusetts Institute of Technology, Cambridge, MA, USA). Amongst the most prominent driving factors behind this were the invasion of the Great Lakes by the zebra mussel *Dreissena polymorpha* Pallas, 1771 in the 1980s and reports of an average of one new species invading San Francisco Bay every 14 weeks between 1961 to 1995 (Cohen and Carlton 1998). At this time, scientists were becoming well aware of the growing number of introductions worldwide and their impacts on marine communities (Minchin 1996; Reise et al. 1998; Hewitt et al. 1999; Sliwa et al. 2009). Ascidians, commonly known as sea squirts, were quickly flagged as one of the most notorious and diverse group of fouling species being transported and introduced around the world (Shenkar and Swalla 2011). Indeed, in the late 1990s and early 2000s, invasive ascidians were identified as important players causing significant ecological and economic impacts to marine systems (Coles et al. 2002; Lambert 2002). As the twenty-first century enters its third decade, invasive ascidians continue to affect ecosystems (Carman et al. 2011; Shenkar 2012; Zhan et al. 2015), create problems for aquaculture (Muñoz and McDonald 2014; McKenzie et al. 2017), and frequently dominate coastal fouling communities (López-Legentil et al. 2015).

The International Invasive Sea Squirt Conference (IISSC; <https://web.who.edu/sea-squirt-conference/>) began in 2005 to bring together diverse user groups concerned about invasive ascidians. The goal was to explore invasive ascidian biology, ecology, impacts and management options. The conference audience included marine biologists, shellfishery scientists and industry, governmental agencies concerned with coastal resources, representatives from sponsoring organizations and the media. The first IISSC was so successful that it became more or less a biennial event, with

four IISSC hosted by the Wood Hole Oceanographic Institution (WHOI), MA, USA and two at Prince Edward Island, Canada, and Nelson, New Zealand (IISSC-II and IISSC-IV respectively). Papers presented during the first five conferences were published in special issues of the *Journal of Experimental Marine Biology and Ecology* (2007, vol. 342: 1), *Aquatic Invasions* (2009, vol. 4: 1 and 2011 vol 6: 4), and *Management of Biological Invasions* (2016, vol. 7: 1). Together, these five IISSC's generated 95 scientific papers that have significantly contributed to our understanding of invasive ascidians. Overviews of past conferences can be found in Whitlatch and Bullard (2007), Locke and Carman (2009), Locke and Hanson (2011), and Bullard and Carman (2016). Longer term trends in invasive ascidian research have been examined by Bullard and Carman (2009).

The IISSC-VI was held on May 2–4, 2018 at Woods Hole Oceanographic Institution. The meeting attracted participating researchers from Canada, Ireland, Israel, Spain, and the United States. Nineteen talks and six posters were presented. Topics ranged from invasions dynamics of introduced species, natural and chemical control mechanisms, physiological changes in response to climate change, impacts on aquaculture, documentation of presence/absence in expected areas and alternative uses for harvested tunicates.

Four IISSC-VI papers are included in this special issue of *Management of Biological Invasions*. Carman and Grunden (2019) examined the potential of crabs to consume ascidian-covered eelgrass. They found that the spider crab *Libinia dubia* consumed eelgrass fouled by *Botryllus schlosseri* and *Molgula manhattensis*, while the green crab *Carcinus maenas* did not. They also observed *L. dubia* removing *M. manhattensis* from eelgrass and feeding on it separately. Thus, *L. dubia* may act to remove some epiphytes from eelgrass. Osborne and Poynton (2019) assessed whether pollution could affect interspecific competition between a native and an invasive ascidian. They found that the growth of the native ascidian *Aplidium glabrum* was significantly impacted at low copper levels (1 µg/L copper when in the presence of a competitor), while the growth of the invasive ascidian *Botrylloides violaceus* was only affected at high copper levels (37.1 µg/L copper when growing alone, 31.7 µg/L copper when in the presence of a competitor). These results suggest that invasive species are more tolerant to pollution which may give them an edge in interspecific competition. Zhang et al (2019) examined the metabolic rates for two invasive ascidians (*Didemnum vexillum* and *Botrylloides violaceus*) and one native ascidian (*Aplidium glabrum*). They found that *D. vexillum* regenerated NH_4^+ faster than *A. glabrum* and *B. violaceus*. Carman et al (2019) surveyed ascidians within eelgrass meadows at thirty-three sites from New Jersey, USA to Newfoundland, Canada. They found eight ascidian species colonizing eelgrass, of which four were non-native and one was cryptogenic. Ascidian diversity was highest in the southern part of

the survey area, and less diverse north of Cape Cod, USA. Ascidian density was generally low, usually ranging from 1–25% cover of eelgrass shoots.

The 10th International Conference on Marine Bioinvasions ICMB-X was held on October 16–19, 2018 in Puerto Madryn, Argentina, marking the fifth time that the conference was held outside of the USA (for details on the conference history see Dias et al. 2017a). This was the first time the conference was held in Latin America and although it played a remarkable role in highlighting the research being conducted throughout South America, it also attracted researchers from over 40 countries. The ICMB-X themes included advances through international networks, climate change, risk assessment and management, and special sessions on cutting-edge topics and tools such as the development and application of environmental DNA (eDNA) for improved marine biosecurity surveillance. Research from all sessions is represented by 14 papers that include 12 papers published in a parallel special issue of *Aquatic Invasions* (see editorial by Fowler et al. 2020) and two management focused papers published in this IISSC-VI / ICMB-X joint special issue. Here, Couton et al. (2019) shows how metabarcoding represents an efficient approach to the detection and study of reproduction cycle and establishment success of non-indigenous species at an early planktonic larval stage, when species-diagnostic morphological characters are still undeveloped. Further, the study highlights the importance of building local reference collections of DNA barcodes. Indeed, the lack of skilled taxonomists that can discern invaders from native species has made the assemblage of reference collections of DNA barcodes, ideally, linked to vouchered specimens, of utmost importance (Dias et al. 2017b; Carlton and Fowler 2018). Of utmost importance is also the adoption of precautionary and proactive approaches, particularly to areas of high value, which can often be remote as shown by Cunningham et al. (2019). These authors show the role that pathway management plans can have in mitigating the growing threat of marine bioinvasions, discussing challenges and successes, and inspiring governments and communities in other countries and regions to take on similar work.

We hope you enjoy reading this special joint issue that brings together research from a community of scientists dedicated to tackling one of the most notorious groups of introduced and invasive species across all seas and oceans, with research from the northern and southern hemispheres that can be reproduced to tackle marine bioinvasions of various taxonomic groups worldwide. Expanding national and international networks, the multidisciplinary of teams and projects, and exchanging know-how in engaging communities and governments has never been so relevant in an increasingly challenging world. We look forward to seeing you all in 2021 for the ICMB-XI hosted by Dr Greg Ruiz and the Smithsonian Environmental Research Center in Annapolis, MD, USA.

Acknowledgements

The ICMB-X was supported by CONICET, MINCYT, SCTeIP Chubut, Consejo Federal de Inversiones, Biodiversity Heritage Library, Administración Portuaria de Puerto Madryn (APPM), Office of Naval Research Global, Aluar Aluminio Argentino, Madryn Bureau, Ente Mixto Puerto Madryn, Municipalidad de Puerto Madryn, FAO-GEF-SAyDS. Special acknowledgement to Yagui (Instagram: @yaguiart) for allowing the use of his artistic paintings on the background of the ICMB-X logo in banners, conference program, abstract book, reports, social media, etc. Ale Bortolus designed the logo for the *Society for the Study of Marine Bioinvasions*.

The 6th IISSC was supported by sponsors Woods Hole Sea Grant and Oak Bluffs Shellfish Department and steering committee members Dr. Stephan Bullard, Dr. Jim Carlton, Dr. Phil Colarusso, Dr. Jeff Davidson, Dr. Cynthia McKenzie, Dr. Judith Pederson, and Dr. Page Valentine. Special gratitude is extended to Ellen Bailey who organized all IISSC conferences. Thank you too to Dr. Vadim Panov for his continued support in publishing papers from the conferences.

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