

Taking stock of Singapore's marine life: the Comprehensive Marine Biodiversity Survey Johor Straits International Workshop 2012

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Abstract. The Johor Straits International Biodiversity Workshop was held on Pulau Ubin from 15 October to 2 November 2012 as part of the Comprehensive Marine Biodiversity Survey (CMBS) led by the the National Parks Board (NParks) and the National University of Singapore (NUS). The purpose of the workshop was to engage interested overseas and local scientists to conduct systematic studies on the marine flora and fauna of the northern shores of Singapore. Basic laboratory facilities were provided and accommodation as well as meals arranged in the Outward Bound School. A total of 48 international and Singapore scientists, staff from NParks and NUS, as well as volunteers were involved in the workshop, during which some 17 intertidal and 14 subtidal locations in the East and West Johor Strait were sampled for marine organisms. Volunteers played a significant and critical role in collecting and sorting the thousands of specimens that were collected from different locations during the workshop. Participants carried out one or more research projects in their area of expertise during their stay, and their findings form the 24 peer-reviewed papers that comprise this workshop volume. Seventeen species of invertebrates new to science are described from the Johor Straits, comprising two nematodes, one polychaete, four marine mites, two parasitic copepods, a hermit crab, a brachyuran crab, three sacoglossan gastropods, one bryozoan and two sea cucumbers. More than 100 new records of marine organisms ranging from dinoflagellates to fish have also been established for Singapore, with additional taxonomic and behavioural observations on flatworms, tree-climbing crabs and a sap-sucking gastropod.

Key words. Marine biodiversity, Johor Straits, Singapore, Pulau Ubin.

INTRODUCTION

The Comprehensive Marine Biodiversity Survey (CMBS) of Singapore was launched in November 2010 as a national initiative to take stock of the state of marine biodiversity in Singapore waters. The five-year survey, led by the National Parks Board (NParks) in partnership with experts from National University of Singapore (NUS), non-governmental organisations and some 500 volunteers, was carried out in three overlapping phases between 2010 and 2015 to obtain specimen records from as many marine ecosystems as possible, with emphasis on poorly known habitats, including intertidal mudflats, the subtidal soft-bottom benthos, and coral reefs. As part of this survey, NParks and NUS organised a three-week international workshop between 15 October and 2 November 2012 on Pulau Ubin in the East Johor Strait. The purpose of the workshop was to engage interested overseas and local scientists to conduct systematic studies on the marine flora and fauna of the northern shores of Singapore. During the workshop, field trips were organised to various

parts of the Straits of Johor. Basic laboratory facilities were provided and accommodation and meals arranged at the Outward Bound School. Participants carried out one or more research projects in their area of expertise during their stay, and their findings form the 24 peer-reviewed papers that comprise this workshop volume.

The format of such international marine biology/biodiversity workshops is not new and has been previously applied elsewhere, notably in Hong Kong and in Australia (see e.g., Morton, 2000; Wells et al., 2005), and more recently in Thailand (Bieler et al., 2008) and Singapore (Tan et al., 2009). Over the last three decades, these activities have been very successful in generating new knowledge and stimulating interest in poorly studied marine environments.

Physical setting. The Straits of Johor separates Singapore Island from peninsular Malaysia. The narrow strait forms an irregular arc about 50 km long that is 2 km wide at its broadest, stretching from Tanjung Piai (Johor, Malaysia) and Tuas (Singapore) on the southwestern end to Pengerang (Johor, Malaysia) and Pulau Tekong (Singapore) on the easternmost end. The Johor Straits is divided into two halves by a land bridge (known as the Causeway) connecting Singapore and the city of Johor Bahru by road and rail, forming two deep cul-de-sacs on either side of the Causeway termed the East and West Johor Straits. The causeway was completed in 1923. Water exchange across the East and West Straits underneath the Causeway is minimal. Nonetheless,

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tidal influence is felt throughout the Johor Straits as the western and eastern inlets are contiguous with the Malacca Strait and South China Sea, respectively. At the same time, freshwater input from various rivers, principally from Johor (e.g., Sungei Pontian and S. Sekudai; major rivers draining Singapore Island, including S. Kranji, S. Seletar and S. Punggol have been closed off from the Strait to form freshwater reservoirs), is still a significant factor in maintaining estuarine conditions in the Straits of Johor (Lim, 1984a, b). A number of small islands are present in the Johor Strait, the two largest being Pulau Tekong and Pulau Ubin, both of which are located in the East Johor Strait and part of Singapore. Pulau Merambong, located near the mouth of the West Johor Strait is the third largest island and is part of Malaysia.

Due to the sheltered, estuarine nature of the environs, mangroves and mudflats, interspersed with occasional sandy and rocky shores, are common along both the Singapore and Malaysian coastlines defining the Johor Straits. Significant but narrow remnants of mangroves are present especially in the West Johor Strait (Lai et al., 2015), where the Sungei Buloh Wetland Reserve is located (Murphy & Sigurdsson, 1990). The Straits of Johor is also a major aquaculture area, with more than 50 floating fish farms located around Pulau Ubin, and a similar number off Lim Chu Kang. Vessels bound for shipyards at Loyang and Sembawang (Singapore), and for the container and ferry terminals at Pasir Gudang and Tanjung Belungkor (Johor, Malaysia) respectively can frequently be seen on the East Johor Strait, in addition to



Fig. 1. The workshop 'laboratory' at Outward Bound School on Pulau Ubin.

the smaller ferries that ply the smaller islands, fish farms and Changi Point.

Workshop venue. The modern facilities and sprawling grounds of the Outward Bound School (OBS) located next to the sea at the western end of Pulau Ubin proved conducive for workshop activities. Whilst we stretched the use of the air-conditioned 'Learning Rooms' (Fig. 1) to the limit as common laboratory, office and seminar hall all at once, we also occupied one of the boat (kayak) sheds as a wet sorting area where scientists, staff and volunteers mingled freely over specimen trays. The shared accommodation, though basic, was more than adequate, helped by generally pleasant weather and unexpectedly cool nights. The relatively undisturbed seashores of OBS proved to be a veritable source of interesting specimens.



Fig. 2. Participants of the Johor Straits biodiversity workshop, Outward Bound School, Pulau Ubin, Singapore. **Front (L–R):** Tan Kai-xin, Robert Lasley, Ong Joo Yong, Kevin Tilbrook, Poon Sze Wan, Daphne Fautin, Lim Phaik-Eem, Ilse Bartsch, Lee Yen-ling, Helen Larson, Lim Jiayi, Sumaitt Puchakarn, Joycelin Teo, Tipamat Upanoi, Vararin Vongpanich; **Back (L–R):** Nguyen Thanh Son, Valerie Phang, Zeehan Jaafar, Peter Ng, Jose Mendoza, William Ludt, Kathe Jensen, Daisuke Uyeno, Ng Poh Kheng, Prosanta Chakrabarty, Dwi Listyo Rahayu, Nicholas Yap, Helen Wong, Lee Bee Yan, Tay Ywee Chieh, Tan Chia Sing, Niel Bruce, Arthur Anker, Chen Cheng Ann, Rony Huys, Li Xinzheng, Tan Koh Siang

Participants, volunteers and guests. A total of 48 overseas and local scientists as well as staff from NParks and NUS were involved in the three-week long workshop on Pulau Ubin (see also Fig. 2):

Dr Arthur Anker (Tropical Marine Science Institute, NUS)
 Dr Ilse Bartsch (Forschungsinstitut Senckenberg, Hamburg, Germany)
 Dr Niel Bruce (Museum of Tropical Queensland, Brisbane, Australia)
 Dr Prosanta Chakrabarty (Louisiana State University, USA)
 Mr Chen Cheng Ann (Universiti Malaysia Sabah, Malaysia)
 Ms Chew Siew Moon (Tropical Marine Science Institute, NUS)
 Professor Daphne Fautin (University of Kansas, USA)
 Dr Toshihiko Fujita (National Museum of Nature and Science, Tokyo, Japan)
 Ms Linda Goh (National Biodiversity Centre, NParks)
 Dr Rony Huys (The Natural History Museum, London)
 Dr Kathe Jensen (Zoologisk Museum, Copenhagen, Denmark)
 Mr Koh Kwan Siong (National Biodiversity Centre, NParks)
 Dr Joelle Lai (Lee Kong Chian Natural History Museum, NUS)
 Dr Helen Larson (Museum and Art Gallery of the Northern Territory, Darwin, Australia)
 Mr Robert Lasley (Lee Kong Chian Natural History Museum, NUS)
 Ms Lee Bee Yan (Lee Kong Chian Natural History Museum, NUS)
 Ms Lee Yen-ling (Tropical Marine Science Institute, NUS)
 Dr Sandric Leong (Tropical Marine Science Institute, NUS)
 Dr Li Xinzheng (Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China)
 Mr Kelvin Lim (Lee Kong Chian Natural History Museum, NUS)
 Ms Lim Lay Peng (Tropical Marine Science Institute, NUS)
 Dr Lim Phaik Eem (Universiti Malaya, Kuala Lumpur, Malaysia)
 Mr Lim Swee Cheng (Tropical Marine Science Institute, NUS)
 Ms Lua Hui Kheng (Lee Kong Chian Natural History Museum, NUS)
 Mr William Ludt (Louisiana State University, Florida)
 Dr Jose C. Mendoza (Lee Kong Chian Natural History Museum, NUS)
 Dr Ng Heok Hee (Tropical Marine Science Institute, NUS)
 Prof Peter Ng (Lee Kong Chian Natural History Museum and Tropical Marine Science Institute, NUS)
 Ms Ng Poh Kheng (Universiti Malaya, Kuala Lumpur, Malaysia)
 Mr Nguyen Thanh Son (Lee Kong Chian Natural History Museum, NUS)
 Ms Ong Joo Yong (Tropical Marine Science Institute, NUS)
 Ms Poon Sze Wan (Universiti Malaya, Kuala Lumpur, Malaysia)
 Dr Sumaitt Putchakarn (Burapha University, Thailand)
 Dr Dwi Listyo Rahayu (Tropical Marine Science Institute, NUS and Indonesian Institute of Sciences, Indonesia)
 Mr Razali bin Mohd Duriat (Tropical Marine Science Institute, NUS)
 Dr Bertrand Richer de Forges (Institut de Recherche pour le Développement, New Caledonia, France)
 Dr Tan Heok Hui (Lee Kong Chian Natural History Museum, NUS)
 Ms Tan Kai-xin (Lee Kong Chian Natural History Museum, NUS)
 Dr Tan Koh Siang (Tropical Marine Science Institute, NUS)
 Mr Tan Siong Kiat (Lee Kong Chian Natural History Museum, NUS)
 Dr Tay Ywee Chieh (Tropical Marine Science Institute, NUS)
 Dr Kevin Tilbrook (Museum of Tropical Queensland, Brisbane, Australia)
 Ms Tipamat Upanoi (Phuket Marine Biological Center, Thailand)
 Dr Daisuke Uyeno (University of Ryukyus, Japan)
 Ms Vararin Vongpanich (Phuket Marine Biological Center, Thailand)
 Mr Wong Ann Kwang (Tropical Marine Science Institute, NUS)
 Ms Helen Wong (Tropical Marine Science Institute, NUS)
 Dr Zeehan Jaafar (Department of Biological Sciences, NUS)



Fig. 3. At the sorting station, Professor Peter Ng (in blue shirt) explaining the critical role of volunteers (seated) in support of the workshop to Minister Tan Chuan Jin (standing, in red shirt), as Dr Leong Chee Chew (centre) and Prof Leo Tan (in batik) look on.

Volunteers played a significant and critical role in collecting and sorting the thousands of specimens that were collected from different locations during the workshop. They also helped to contribute blogs that provided day-to-day accounts of the workshop on the internet (see megamarinesurvey.blogspot.sg). An estimated 270 volunteers participated over the three-week workshop period, and some of them continued to help with the sorting and curation after the workshop. Ms Ria Tan was particularly helpful in organising and leading the volunteers in search of interesting specimens.

Then Acting Minister of Manpower and then Senior Minister of State for National Development Mr Tan Chuan Jin visited the workshop on the morning of 23 October 2012 (Fig. 3), together with other VIPs including Dr Leong Chee Chiew (Deputy Chief Executive Officer and Commissioner of Parks & Recreation, National Parks Board), Professor Tan Eng Chye (Deputy President, Academic Affairs and Provost, National University of Singapore) and Professor Leo Tan (Special Duties, National University of Singapore and Chairman of Garden City Fund).

The workshop benefited in many ways from generous funding and support from Asia-Pacific Breweries Singapore, Hong Kong and Shanghai Banking Cooperation Care-for-Nature Trust Fund, Shell Eastern Petroleum in Singapore and Air Liquide Group, whose contributions were instrumental in the smooth-running of the workshop.

SURVEY SITES AND METHODS

Survey sites. Some 17 intertidal and 14 subtidal locations were sampled during the 20-day workshop (Fig. 4). About half (nine) of the intertidal locations were on Pulau Ubin, including relatively undisturbed mudflats, rocky shore and mangroves within the confines of the Outward Bound School on the western third of the island. Other sampling locations elsewhere in Singapore included Pulau Ketam, Changi, Pasir Ris and Punggol in the East Johor Strait, and Tuas, Lim Chu Kang and Sungei Buloh in the West Johor Strait. At each location, a number of discrete sites were

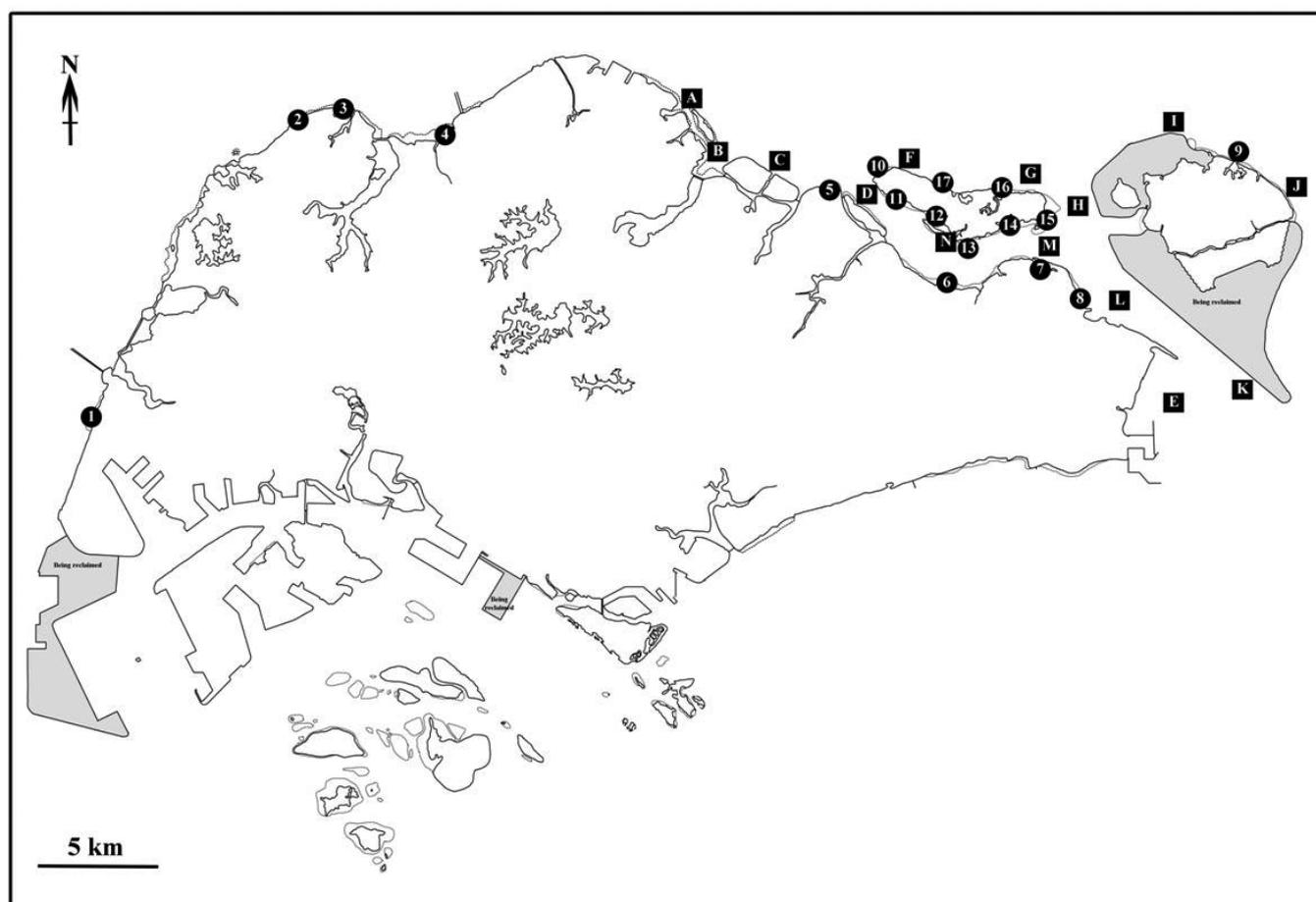


Fig. 4. Locations sampled during the Johor Straits workshop. Intertidal localities are numbered in black circles. Subtidal localities sampled by dredging and trawling are indicated alphabetically in black squares. 1. Tuas; 2. Lim Chu Kang; 3. Sungei Buloh; 4. Sungei Mandai Besar; 5. Punggol Marina; 6. Pasir Ris (Sg. Api-Api and Sg. Tampines); 7. Changi Creek; 8. Changi Beach (Car Park 7); 9. Lighthouse Oyster Farm; 10. Tanjung Tajam, Pulau Ubin; 11. Outward Bound School; 12. Pulau Ketam and Sungei Puaka; 13. Fish Farm between Sungei Jelutong and Sungei Tiga; 14. Kampung Melayu; 15. Chek Jawa and Pulau Sekudu; 16. Sungei Besar estuary; 17. Sungei Mamam and Kelong FC72E. A. Felkin Spit off Pulau Seletar; B. Alang Perimbi, off Pulau Seletar; C. off Pulau Punggol; D. off Tanjung Tajam, Pulau Ubin; E. Johor Shoal off Changi East; F. Fan Shoal, off Pulau Ubin; G. Henderson Shoal, off Pulau Ubin; H. off Chek Jawa, Pulau Ubin; I. off Beting Bronok, Pulau Tekong; J. off Tanjung Pasir, Pulau Tekong; K. Angler Bank, off Pulau Tekong; L. off Changi Ferry Terminal; M. off Pulau Sekudu; N. Squance Bank off Pulau Ubin.

selected for sampling. A total of 49 intertidal and 33 subtidal sites were sampled in the East and West Johor Straits. All subtidal locations were sampled from NUS research vessel *RV Galaxea* (Fig. 5).

Survey methods. A variety of basic methods were employed to sample different habitats. On the intertidal zone, apart from manual collection using hand tools and nets (Figs. 6, 7) as well as test sieves, ‘yabby pumps’ were also used to extract burrowing animals from muddy sand in the intertidal zone. The subtidal benthos was sampled using a 1 meter-wide beam trawl (Fig. 8) and a small rectangular dredge on the *RV Galaxea*. An epibenthic sled was employed to collect smaller specimens inhabiting the seabed surface. A small van Veen grab was used to obtain mud samples from the shallow subtidal seabed off Pulau Ubin from a dinghy.

RESULTS AND SUMMARY

A total of 24 original articles comprise this volume, based on the research efforts carried out at the workshop by

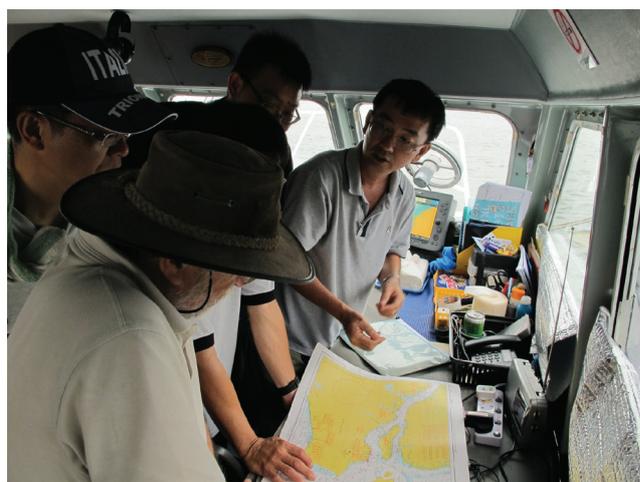


Fig. 5. Participants of the Johor Straits workshop discussing seabed sampling sites on onboard *RV Galaxea*.



Fig. 6. Participants and volunteers of the Johor Straits workshop helping to haul in a seine net at Changi Point.



Fig. 7. Dr Rony Huys sampling benthic copepods on a sandflat at Pulau Ubin.

the participants. The subjects of these research articles span a wide range of taxa that reflect the rich diversity of marine organisms found in the Johor Straits. These include dinoflagellates, macroalgae, sponges, flatworms, nematodes, polychaetes, marine mites, crustaceans, molluscs, bryozoans, echinoderms and fishes. Seventeen new species of invertebrates are described from the East Johor Strait, comprising two nematodes, one polychaete, four marine mites, two copepod symbionts on sea pens, an intertidal hermit crab, a brachyuran crab from a seagrass bed, three sacoglossan gastropods, one bryozoan and two sea cucumbers. More than 100 new records have also been established for Singapore: three species of dinoflagellates; a parasitic red alga *Gracilaria babae* growing on its host, another red alga and common congener *G. salicornia*; two species of sponges; five species of sea anemones; one species of a nereidid (ragworm) polychaete; eight species of marine mites; 17 species of amphipods; 44 species of isopods; five penaeid prawns; two hermit crab species; a species of tree-climbing crab confined to the nipah palm; four species of sap-sucking slugs living on algae; a leaf-encrusting bryozoan; 14 brittlestar species; 11 sea cucumber species; and four species



Fig. 8. Dr Bertrand Richer de Forges (left) and Mr Lim Swee Cheng getting ready to sample the seabed off Pulau Ubin with a beam trawl on board RV *Galaxea*.

of fish. Two additional studies have clarified the taxonomic status and relationships of a common red seaweed species (*Gracilaria tenuistipitata*) and five species of tree dwelling vinegar crabs living in the Johor Straits, and a further two papers describe for the first time the reproductive behaviour of a common marine flatworm and a sap-sucking gastropod. Many of these studies relied heavily on the availability of living specimens, which were observed both in the field and in captivity, photographed and, for some, their movements recorded on video almost immediately after they were collected. The importance of making observations on living organisms cannot be overemphasised, and this workshop has provided a wonderful opportunity to understand marine life in situ in the Johor Straits.

Apart from the results obtained from the Johor Straits international workshop, material obtained from the CMBS continues to be sorted, analysed and identified by local and overseas researchers. Over the last four years since the start of the CMBS in 2010, additional observations of marine organisms have been documented, which include descriptions of new species (e.g., Bartsch, 2013a; Chen & Long, 2014; Ng, 2014; Rahayu & Ng, 2014; Yap et al., 2014), documentation of plants and animals recorded for the first time in Singapore (e.g., Ng, 2012; Bartsch, 2013b; Tan & Low, 2013; Ng, 2014; Ng & Lim, 2014), as well as other pertinent natural history investigations (e.g., Su et al., 2013; Tan & Low, 2014). The companion proceedings to the present volume, which is due for publication by the end of 2015, will also contain the results of the Singapore Strait workshop held on St John's Island in June 2013.

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infectious enthusiasm, dynamism, patience and cheer during the conduct of the workshop. We are also indebted to the management and staff of Outward Bound School (OBS): Mr Yeo Ting Chuan, Mr Teo Beng Tiam, and Mr Foo Say Peng, for allowing unhindered access to their superb facilities and for so kindly accommodating our special needs. The compilation of this volume would not have been possible without the critical support provided by international reviewers who have generously lent their time and effort to ensure that the manuscripts are in line with existing standards of scientific publication. Finally we are grateful for the unstinting editorial support given by Jeremy Yeo Wei Liang (Lee Kong Chian Natural History Museum) during the final stages of the preparation of this volume.

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