

The Comprehensive Marine Biodiversity Survey Singapore Strait International Workshop 2013

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Abstract. The Singapore Strait International Marine Biodiversity Workshop was held on St John's Island from 20 May to 7 June 2013 as part of the Comprehensive Marine Biodiversity Survey (CMBS) led by the National Parks Board (NParks) and the National University of Singapore (NUS). The three-week event largely followed the structure of a previous workshop on Pulau Ubin in the Johor Straits held six months earlier from 15 October to 2 November 2012. Both workshops were organised with the same objective: facilitate interested overseas and local scientists to conduct systematic studies on the marine flora and fauna and take stock of Singapore's marine life. A total of 54 international and Singapore scientists, staff from NParks and NUS, together with more than 40 volunteers took part in the workshop. Some 35 intertidal and 18 subtidal locations across the Singapore Strait were sampled for marine organisms using a variety of techniques including SCUBA. The 'Singapore Deeps' were also explored using a dredge and beam trawl. Volunteers continued to play a critical supporting role in extracting, collecting and sorting the numerous specimens from the field. Participants carried out one or more research projects in their area of expertise during the workshop, and their findings are presented in this volume comprising 30 peer-reviewed papers. These include marine species checklists for algae, sponges, annelids, barnacles, caridean shrimps, cephalopods, bryozoans, ascidians, and gobioid fishes in Singapore and the South China Sea. In addition, seven species of marine invertebrates new to science are described from the Singapore Strait, comprising a sponge, an amphipod, a stomatopod, a hermit crab, a squat lobster, a porcellanid crab, and a coral rubble crab. More than 160 new records of marine organisms ranging from meiofauna, flatworms, sipunculans, isopods, amphipods, various decapod crustaceans, bivalves, bryozoans, brittlestars, featherstars, ascidians and gobies have also been documented in this volume.

Key words. Marine biodiversity, Singapore Strait, St John's Island

INTRODUCTION

The Comprehensive Marine Biodiversity Survey (CMBS) 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) and the National University of Singapore (NUS) that involved many non-governmental organisations, some 500 volunteers and scientists from 14 countries, was carried out in three overlapping phases between 2010 and 2015. The three phases involved sampling of three habitats: intertidal mudflats, subtidal soft-bottom benthos, and coral reefs. Specimen records were obtained from all accessible marine ecosystems as far as possible by systematic sampling. NParks and NUS also organised two international workshops as part of these efforts. The first workshop was held at Outward Bound School on Pulau Ubin in the Johor Straits in

October 2012 (see Tan et al., 2015). The second workshop, the subject of this volume, was held on St John's Island in May 2013. Participants carried out one or more research projects in their area of expertise over three weeks between 20 May and 6 June 2013.

During the conduct of CMBS, NUS and the Singapore Ministry of Foreign Affairs independently organised a 'Workshop on Marine Ecosystems and Biodiversity: Cooperative Project under the ASEAN-China Declaration on the Conduct of the Parties in the South China Sea', between 31 July and 4 August 2012. This was held to complement a similar workshop in 1997 (see Ng & Tan, 2000) as well as to take stock of developments that have happened since. A review of the progress of research concerning the marine flora and fauna of the South China Sea (which includes Singapore) was carried out by domain experts, some of whom were also participants in the CMBS Johor and Singapore Strait workshops. These reviews, in the form of annotated species checklists, provide a regional perspective on the state of knowledge of biodiversity in relation to Singapore. It was felt that their inclusion in this volume would be appropriate, given that many new records documented in the checklists are based on specimens obtained during CMBS.

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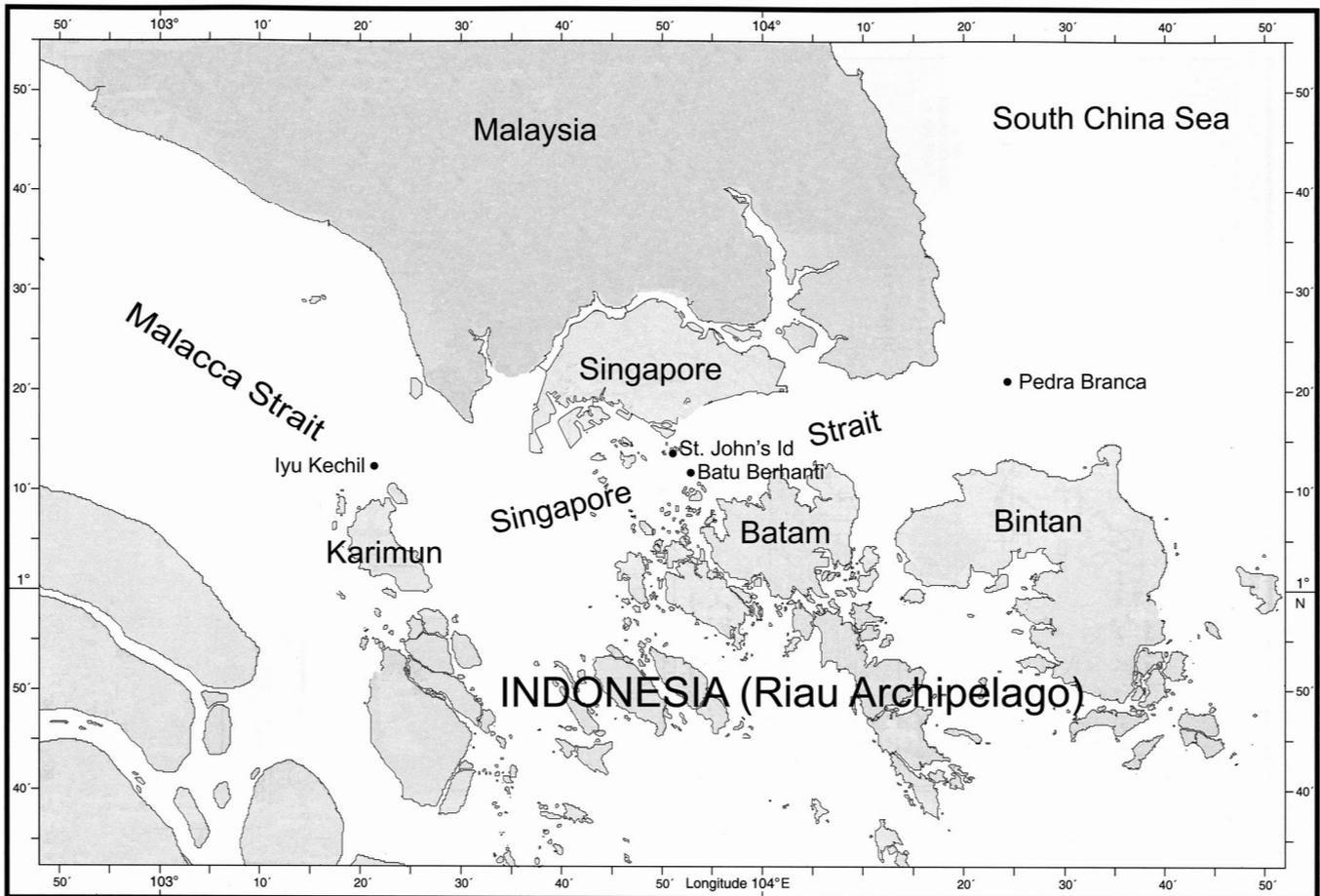


Fig. 1. Location of Singapore Strait. The distance between Pulau Iyu Kechil (Brothers Light) and Pedra Branca (Horsburgh Lighthouse, or Pulau Batu Puteh) is about 60 nautical miles. The two islands are generally considered to mark the western and eastern entrances respectively of the Singapore Strait.

Physical setting. Sandwiched between the main island of Singapore and the Indonesian islands of Karimun, Batam and Bintan (part of the Riau archipelago), the Singapore Strait is a narrow channel that connects the Malacca Strait to the South China Sea. It stretches for about 60 nautical miles approximately from Pulau Iyu Kechil (Brothers Light) off the northern tip of Pulau Karimun Kechil in the west to Pedra Branca (Pulau Batu Puteh; Horsburgh Light) to the east (Fig. 1). While the entrances on either side of the Strait are about 10 nautical miles wide each, it is constricted about midway and is narrowest between St John's Island and Batu Berhanti where the width of the Strait is reduced to less than five nautical miles. It is also in this vicinity where there are numerous small islands and patch reefs. These are immediately south of the main island of Singapore (e.g., Pulau Bukom, P. Semakau, P. Satumu) and also to the west of the Indonesian island of Batam (e.g., P. Nipa, P. Takong, Karang Banteng, P. Belakang Padang). Given the physically constrained nature of the Singapore Strait, tidal current flow can be strong, reaching 3.6 knots during spring tides in some areas (Thomas, 1991; Singapore Tide Tables, 2015). The tidal range at the western limit of the Strait is 2.6 m, about 1 m more than at the eastern limit (UKHO, 2006). The seafloor of the Singapore Strait is mostly shallow, typically ranging between 20 and 50 m in depth. However, between St John's Island and Batu Berhanti, there is an area about 2 nautical miles long and 1 nautical mile wide where

depths in excess of 100 m are found, and in particular, a depression with a maximum depth of 200 m, known as the 'Singapore Deeps' (Hill, 1968). The port limits of Malaysia, Singapore, and Indonesia about the Singapore Strait, but the areas surveyed by the workshop participants were all within the port limits of Singapore.

Shipping traffic in the Singapore Strait is one of the busiest in the world. Vessels traveling between the Indian and West Pacific oceans generally ply this short route through the Malacca Strait. As such, the port of Singapore has grown to be one of the largest container ports in the world, handling more than 1 million TEUs (ten-foot equivalent units) annually. Singapore is also an important bunkering and petrochemical port, where crude oil is received and processed. To accommodate these activities, as well as a growing population, large-scale reclamation in the last 50 years have straightened coastlines and joined reefs and islands together (e.g., Jurong Island, Seringat Island). Traditional fishing kelongs (artisanal fish trapping platforms) and island settlements have disappeared, and there are few natural coastal features remaining that have not been artificially modified in some way.

Despite such extensive coastal urbanisation and intense usage of the sea by vessels, many pockets and remnants of marine habitats are present in the Singapore Strait (see Tan et al.,



Fig. 2. Volunteers working on specimens. A part of the Cooper Channel and Lazarus Island can be seen in the background.

2016 for a review). These include existing patch and fringing coral reefs, mangroves, rocky shores, seagrass beds and the soft subtidal benthos that have not been reclaimed, but also new communities that have established on built seawalls and in swimming lagoons. Chronic and acute disturbances from reclamation activities, oil pollution, and urban runoff are likely to have caused significant changes to the original marine communities present in the Singapore Strait. However, the organisms that comprise these communities remain poorly known.

Workshop venue. The Singapore Strait Workshop was held at the eastern end of St John’s Island, facing the Cooper Channel that separates St John’s Island from Lazarus Island. The spacious boat shed (Fig. 2) was used as a wet sorting and equipment washing area, whilst the building immediately next to it was used as a laboratory. The other buildings within the facility were used for dining and accommodation for the duration of the workshop.

Participants, volunteers and guests. (Fig. 3) A total of 24 international scientists with various interests from 10 countries participated in the three-week workshop:

- Dr. Niel Bruce (Museum of Tropical Queensland, Brisbane, Australia) – marine isopods
- Prof. Daphne Fautin (University of Kansas, USA) – sea anemones
- Dr. Toshihiko Fujita (National Museum of Nature and Science, Tokyo, Japan) – brittlestars
- Dr. Emily Glover (Natural History Museum, London, UK) – bivalves
- Dr. Sammy De Grave (Oxford University Museum of Natural History, UK) – shrimps
- Ms. Catherine Head (Oxford University, UK) – shrimps and crabs
- Prof. Ronald Huys (The Natural History Museum, London, UK) – harpacticoid copepods
- Ms. Ismiliana Wirawati (Research Center for Oceanography, Indonesian Institute of Sciences, Indonesia) – sea cucumbers



Fig. 3. Participants and volunteers of the Singapore Strait international biodiversity workshop at St. John’s Island, Singapore. **Front row (L–R):** Marcus Ng, Ivan Kwan, Koh Kwan Siong, Ismiliana Wirawati, Teresa Tay, Ong Joo Yong, Lee Yen-ling, Iffah bte Iesa, Lim Jin Yi, Nur Soleha, Hoang Quoc Anh, Melissa Teo, Pearlynn Sim, Choo Le Min, Ng Juat Ying, Sabrina Tang, Gan Da, Mark Tan, Rene Ong. **Middle row (L–R):** Ria Tan, Paul Ng, Tri Ariyono Hadi, Daphne Fautin, Jose C. Mendoza, Lim Swee Cheng, Chim Chee Kong, Tan Kai-xin, Lee Bee Yen, Helen Wong, Charles Messing, Tan Koh Siang, Rony Huys, Joelle Lai, Sylvia Haliman, Tan Siong Kiat. **Back row (L–R):** Kenny Chua, Chiew Yong Seng, Dwi Listyo Rahayu, Lua Hui Kheng, Sofina Ng, Kitithorn Sanpanich, Henrietta Woo, Tay Ywee Chieh, Zeehan Jaafar, Daisuke Uyeno, Niel Bruce, Melissa Diagana, James Lowry, Sammy de Grave, Toshihiko Fujita, Kevin Tilbrook, Shane Ahyong, John Taylor, David Lane, Arthur Anker, Emily Glover, Nathaniel Evans, Lin Chia-wei, Leonard McKenzie. Photographer: Tan Heok Hui.

- Dr. Gretchen Lambert (University of Washington, USA) – ascidians
 Dr. David Lane (Universiti Brunei Darussalam, Brunei) – stars and sea cucumbers
 Dr. Lim Po Teen (Universiti Malaya, Malaysia, Malaysia) – dinoflagellates
 Dr. Lin Chia-wei (National Museum of Marine Biology and Aquarium, Republic of China) – crustaceans
 Dr. Leonard McKenzie (Seagrass Watch Program Leader, Australia) – seagrasses
 Prof. Charles Messing (Nova Southeastern University, Florida, USA) – crinoids
 Dr. Bertrand Richer de Forges (Institut de Recherche pour le Développement, New Caledonia, France) – crabs
 Mr. Tan Toh Hii (Universiti Malaysia Sarawak, Malaysia) – dinoflagellates
 Dr. John Taylor (Natural History Museum, London, UK) – bivalves
 Dr. Kevin Tilbrook (Museum of Tropical Queensland, Brisbane, Australia) – bryozoans
 Ms. Tri Arfianti (Research Center for Oceanography, Indonesian Institute of Sciences, Indonesia) – amphipods
 Mr. Tri Ariyono Hadi (Research Center for Oceanography, Indonesian Institute of Sciences, Indonesia) – sponges
 Dr. Daisuke Uyeno (University of Ryukyus, Japan) – parasitic copepods
 Dr. Kitithorn Sanpanich (Institute of Marine Science, Burapha University, Chon Buri, Thailand) – molluscs
 Dr. Shane Ahyong (The Australian Museum, Australia) – mantis shrimps
 Dr. James Lowry (The Australian Museum, Australia) – amphipods

Local scientists and staff

More than 30 scientists and staff from the National University of Singapore and the National Parks Board also participated and contributed towards the workshop:

- Dr. Arthur Anker (Tropical Marine Science Institute) – shrimps
 Ms. Chew Siew Moon (Tropical Marine Science Institute) – microalgae
 Mr. Chim Chee Kong (Tropical Marine Science Institute) – echinoderms; seabed survey
 Ms. Gan Bin Qi (Tropical Marine Science Institute) – flatworms
 Mr. Koh Kwan Siong (National Biodiversity Centre) – volunteer leader and logistics
 Dr. Joelle Lai (Lee Kong Chian Natural History Museum) – crabs; cryo-station
 Ms. Rene Ong (National Biodiversity Centre) – photography
 Ms. Lee Bee Yan (Lee Kong Chian Natural History Museum) – logistics
 Ms. Lee Yen-ling (Tropical Marine Science Institute) – polychaetes
 Ms. Serina Lee (Tropical Marine Science Institute) – ascidians
 Dr. Sandric Leong (Tropical Marine Science Institute) – microalgae
 Ms. Lim Jiayi (Tropical Marine Science Institute) – seabed survey

- Mr. Kelvin Lim (Lee Kong Chian Natural History Museum) – fishes
 Ms. Lim Lay Peng (Tropical Marine Science Institute) – microalgae
 Mr. Lim Swee Cheng (Tropical Marine Science Institute) – sponges
 Ms. Lua Hui Kheng (Lee Kong Chian Natural History Museum) – insects
 Dr. Jose C. Mendoza (Lee Kong Chian Natural History Museum) – crabs; photography
 Prof. Peter Ng (Lee Kong Chian Natural History Museum and Tropical Marine Science Institute) – crabs; co-organiser
 Ms. Ong Joo Yong (Tropical Marine Science Institute) – sea cucumbers
 Dr. Dwi Listyo Rahayu (Tropical Marine Science Institute Visiting Scientist) – hermit crabs
 Mr. Razali bin Mohd Duriat (Tropical Marine Science Institute) – logistics and steersman
 Ms. Tan Chia Sing (Tropical Marine Science Institute) – cephalopods; photography
 Dr. Tan Heok Hui (Lee Kong Chian Natural History Museum) – fishes; dive team leader
 Ms. Tan Kai-xin (Lee Kong Chian Natural History Museum and Tropical Marine Science Institute) – administration
 Dr. Tan Koh Siang (Tropical Marine Science Institute) – co-organiser
 Mr. Tan Siong Kiat (Lee Kong Chian Natural History Museum) – molluscs
 Ms. Teresa Tay (Tropical Marine Science Institute) – crinoids
 Dr. Tay Ywee Chieh (Department of Biological Sciences) – cephalopods; cryo-station
 Dr. Serena Teo (Tropical Marine Science Institute) – ascidians
 Ms. Helen Wong (Tropical Marine Science Institute) – isopods; logistics
 Mr. Wong Ann Kwang (Tropical Marine Science Institute) – steersman of R/V *Galaxea*
 Dr Zeehan Jaafar (Department of Biological Sciences) – fishes

Student helpers and volunteers

The Singapore Strait Workshop also benefitted significantly from the tireless efforts of many student helpers (both undergraduate and postgraduate) who contributed in various areas such as field trips, sorting and preservation of specimens, photography, and logistics.

Volunteers also played an important role in collecting specimens on field trips and in sorting out the thousands of specimens collected from different locations during the workshop. They also helped to contribute blogs (see megamarinesurvey.blogspot.sg) and social media updates (e.g., Facebook, Twitter) that documented day-to-day happenings over the workshop duration. More than 40 volunteers contributed their time during the Singapore Strait Workshop, and some of them continued to help with sorting and curation after the workshop. Ms Ria Tan was particularly helpful in organising and leading the volunteers in search of specimens, and in updating the public about interesting finds via the internet.

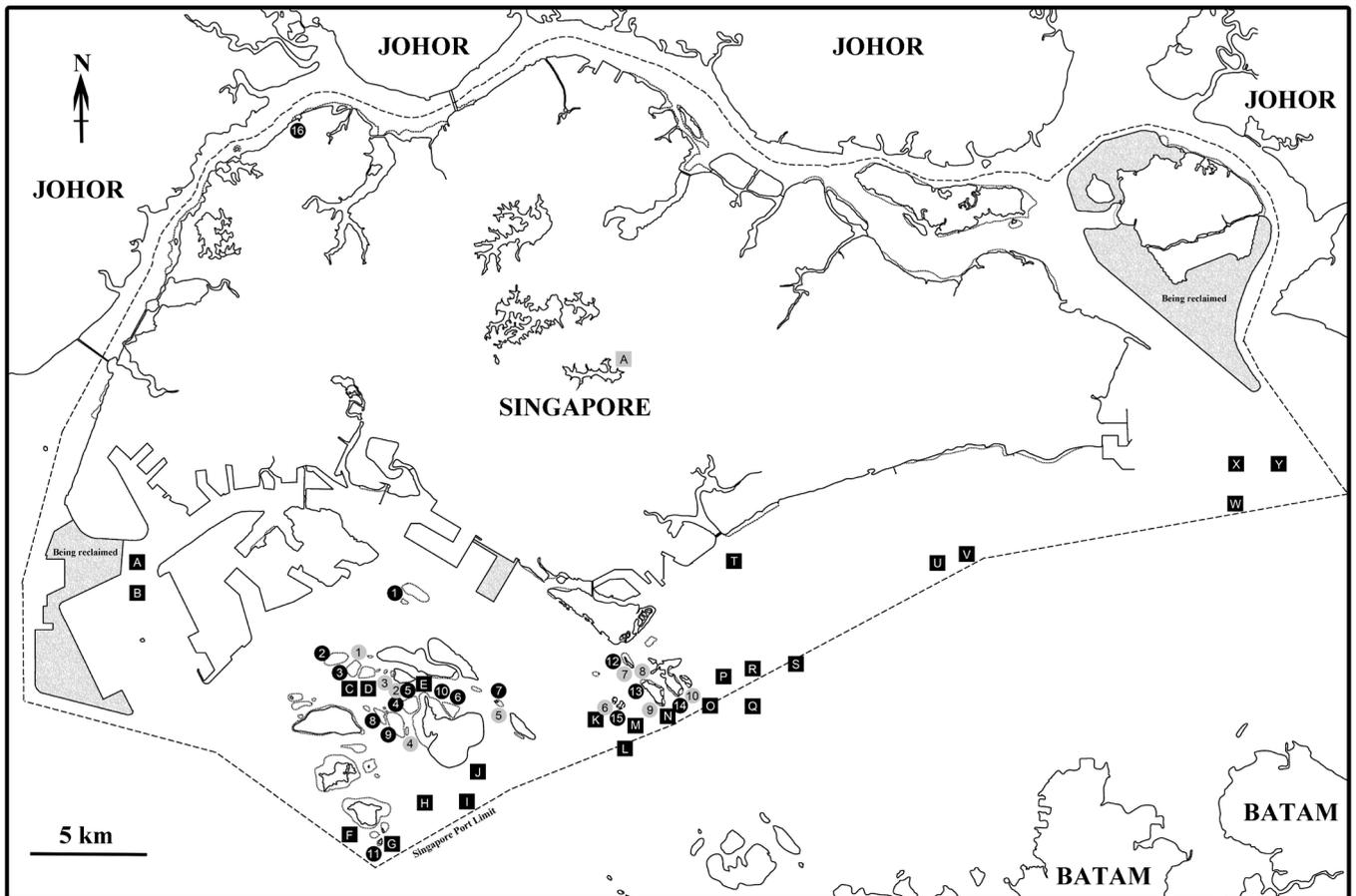


Fig. 4. Locations sampled during the Singapore Strait workshop from 20 May to 7 June 2013. Intertidal localities are numbered in black circles, subtidal localities are numbered in grey circles and black squares (alphabets). Grey circles denote samples collected by SCUBA diving, snorkelling, traps and nets, whereas black squares indicate collection using either a rectangular dredge or beam trawl. **Black circles:** 1. Cyrene Reef; 2. Terumbu Pempang Laut; 3. Terumbu Pempang Tengah; 4. Terumbu Raya; 5. Pulau Hantu; 6. Terumbu Semakau; 7. Pulau Jong; 8. Terumbu Bemban; 9. Beting Bemban Besar; 10. Pulau Semakau; 11. Raffles Lighthouse; 12. Pulau Tekukor; 13. St. John’s Island; 14. Lazarus Island; 15. Pulau Subar Laut (Sisters’ Islands); 16. Lim Chu Kang. **Grey circles:** 1. Terumbu Pempang Tengah; 2. Terumbu Raya; 3. Pulau Hantu; 4. Pulau Semakau; 5. Pulau Jong; 6. Pulau Subar Darat (Sisters’ Islands); 7. Pulau Tekukor; 8. Lazarus Island; 9. St. John’s Island; 10. Kusu Island. **Black squares:** A–Y. A freshwater/terrestrial locality is indicated alphabetically in a grey square. A. MacRitchie Reservoir.

Guests

Then Acting Minister for Manpower and Senior Minister of State for National Development Mr Tan Chuan Jin visited the workshop on the morning of 27 May 2013 together with other VIPs including Dr Leong Chee Chew (Dy CEO, National Parks Board), Mr Seah Kian Peng (CEO, National Trades Union Congress), Mr Lee Tzu Yang (Chairman, Shell Companies in Singapore) and Mr Sakata Kazuyuki (Managing Director, Singapore Oxygen Air Liquide Private Limited). The VIPs visited the workshop facilities and took a short tour of the Singapore Strait by boat. Minister Tan even joined researchers on a dive off Pulau Tekukor. Journalists from major public media agencies reported on the workshop.

SURVEY SITES AND METHODS

Survey sites. A total of 35 subtidal and 18 intertidal locations (Fig. 4) were sampled during the three-week workshop. Subtidal locations included 25 seabed sites sampled by dredge and trawl from the research vessel *Galaxea*. This included the ‘Singapore Deeps’ located just outside the

Singapore Port Limit but within the area where the Vessel Traffic Separation Scheme applied. Due to heavy ship traffic in the vicinity, we obtained permission from the Maritime and Port Authority of Singapore to work in the area in four 3-hour slots each morning (0900–1200 hrs) for four days on 22/5, 23/5, 4/6 and 5/6. These days were selected for their reduced tidal stream strength during the mornings when ship traffic was expected to be low in the area. Some 10 sites sampled by SCUBA, while reef flats, sand flats, and mangroves at 18 intertidal locations were sampled during low tide on foot. Snorkel surveys were also carried out at the intertidal areas and lagoons around the DRTech facility and at Lazarus Island.

Survey methods. A variety of methods were employed to sample different habitats. At intertidal sites, apart from manual collection using hand tools and nets (i.e., chisels, spades, trowels, cast nets, gill nets, line fishing, etc), yabby pumps were also used to extract burrowing organisms from muddy sand. SCUBA and snorkel were used to access subtidal sites up to a depth of 20 m. Rocks and dead coral were also

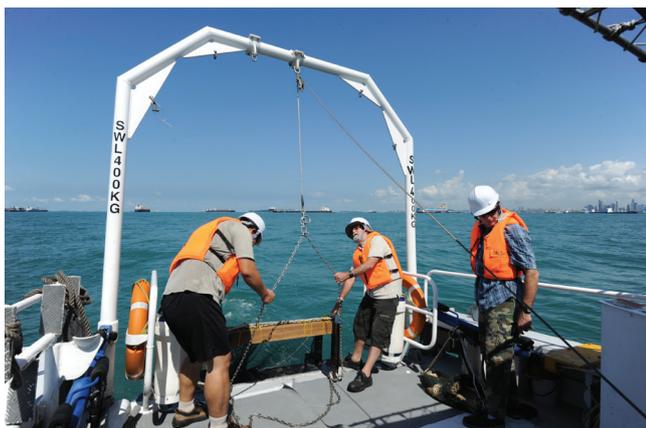


Fig. 5. Preparing to launch a beam trawl using the A-frame onboard R/V *Galaxea*.

collected and brushed for smaller organisms living on the surface and in crevices of these microhabitats. The subtidal benthos was sampled using a 1-metre-wide beam trawl and a similar-sized rectangular dredge on the NUS research vessel *Galaxea*. An epibenthic sled was used to collect smaller specimens inhabiting the surface of the seabed. ‘Bubu’ traps (artisanal fish traps) and gill nets were also deployed in the lagoons to collect fish.

Sampling the ‘Singapore Deeps’. During the workshop, we took the opportunity to dredge and trawl in the deeper part of the Singapore Strait (to 200 m) with the expert help of Dr Bertrand Richer de Forges and Captain Jean-Francois Barazer using a new winch on board R/V *Galaxea* (Fig. 5). Due to heavy ship traffic in the vicinity, we obtained permission from the Maritime and Port Authority of Singapore to work in the area in four 3-hour slots each morning (0900–1200 hrs) for four days on 22/5, 23/5, 4/6 and 5/6. These days were selected for their reduced tidal stream strength during the mornings when ship traffic was expected to be low in the area.

RESULTS AND SUMMARY

More than 10,000 specimens were collected and preserved over the duration of the workshop. This volume contains 30 articles reporting upon a wide range of marine organisms from meiofauna, phytoplankton, seagrass and sponges to fishes. Seven species new to science are described in this volume: *Theonella laena* Lim & Tan (Porifera); *Podocerus cyrenensis* Hughes (Crustacea); *Gonodactylus sentosa* Ahyong (Crustacea); *Galathea johnsoni* Lin & Osawa (Crustacea); *Coenobita lila* Rahayu, Shih & Ng (Crustacea); *Polyonyx heok* Osawa & Ng (Crustacea); and *Nursia tohae* Ng & Komatsu (Crustacea). In addition, more than 160 new records for Singapore are also recorded in this volume. These new records include four genera of interstitial tardigrades, 49 species of dinoflagellates and diatoms, 13 species of polyclad flatworms, seven species of sipunculans, a siliquariid gastropod, a cymothoid isopod, eight species of mantis shrimps, 47 species of caridean shrimps, a galatheid lobster, many species of bryozoans, eight sea cucumbers, two brittlestars, at least one species of feather star, 14 species



Fig. 6. The basket star *Euryale aspera* Lamarck was surprisingly common in the deeper waters of the Singapore Strait on sandy and rocky substrata. Disc diameter approx. 3 cm.

of ascidians, and eight species of gobies. An amphipod, *Cyrtophium orientale*, was rediscovered after a hiatus of more than 150 years. Interestingly, some 46 species of intertidal bivalves in 11 families were found in a small, reclaimed beach on Seringat Island, which is diverse by any standard. On the other hand, 17 species of crinoids previously recorded from Singapore in the 19th and early 20th centuries were absent from the survey, as were a number of lucinid bivalves. From deeper waters, perhaps the most interesting result from the sampling done was the prevalence of the basket star *Euryale aspera* (Fig. 6) on the seafloor. Basket stars were thought to be extremely rare in Singapore (see however, Yeo & Loh, 2014), but this survey has shown that it is a common benthic animal in the deeper waters (>40 m) of the Singapore Strait. The total number of specimens collected since the beginning of the Comprehensive Marine Biodiversity Survey exceeds 70,000 specimens, comprising nearly 1,300 species. The collected material continues to be examined in Singapore and elsewhere by workshop participants and other scientists.

Further to the works listed in Tan et al. (2015), three new species of kinorhynch (Sørensen et al., 2016), two new species of isopods (Sidabalok & Bruce, 2015), a new species of amphipod (Lowry & Springthorpe, 2015), and a new species of macrophthamid crab (Anker & Ng, 2014) have been described recently based on CMBS specimens. Additional new records of two kinorhynch (Sørensen et al., 2016), an amphipod (Azman & Ali, 2015), three polychaetes (Lee & Glasby, 2015; Lee & Ong, 2015), velutinid gastropods (Tan et al., 2015), a nudibranch (Toh, 2014) and a fish (Tan & Lim, 2014) have been documented, as well as rediscoveries of a hermit crab (Rahayu & Ong, 2015), rare epialtid and chasmocarcinid crabs (Ng & Richer de Forges, 2015; Ng & Castro, in press) and a cone snail (Toh et al., 2014). Many other new records of marine organisms continue to accrue based on other studies (e.g., Ng & Lim, 2015; Toh & Tan, 2015; Toh, 2016). A major output of the survey is the establishment of a database of marine invertebrates and their localities accompanied by well-preserved specimens. These data will form the basis for establishing the geographical distribution of each species in Singapore, which will in

turn be invaluable in the management and conservation of marine ecosystems, including the newly designated Sisters Islands Marine Park.

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