Appendix 10: Marine Living Fossils Report

Status, Trends and Recommendations on Protection of Selected Marine Invertebrates – Hong Kong's "Living Fossils"

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Introduction

In Hong Kong, there are numerous marine invertebrate species reported in various habitats from literature sources. For example, there are some 600 taxa (body-size >0.5 mm) recorded in the soft-bottom seabed within our territorial waters (Shin et al., 2004). To attempt assess the status and trends of all these taxa (or species) will be close to an impossible task. In this report, only three groups of marine invertebrates are reviewed, because of the few species involved and, more importantly, because of their key evolutionary importance. These are horseshoe crabs, amphioxus and lamp shells (brachiopods), Hong Kong's living fossils. Data related to these selected marine invertebrates were obtained from published literature and the authors' research materials. Information from government studies, environmental impact assessment (EIA) reports or other sources is not included in this review.

Horseshoe Crabs

Horseshoe crabs are an ancient animal group and often referred to as "living fossils". They belong to the Phylum Arthropoda, Subphylum Chelicerata, Class Merostomata. Despite their name, these animals are not true crabs but are more closely related to scorpions, spiders and extinct trilobites. Their fossil relatives are recognized as far back as the Late Ordovician Period (about 475 million years ago), and modern-day horseshoe crabs have a body structure that dates back to the Jurassic Period (200 million to 146 million years ago) (Rudkin and Young, 2009). At one time, there could have been many species of horseshoe crabs; however, only four species are present today. The four extant horseshoe crab species can be identified into three genera under two families: Limulidae, genus *Limulus* and Tachypleinae, genera *Tachypleus* and *Carcinoscorpius*.

In Hong Kong, two horseshoe crab species *Tachypleus tridentatus* and *Carcinoscorpius rotundicauda* are currently recorded along the northwestern coastline of Deep Bay, northeastern New Territories and some sandy-mudflats around Lantau Island (Shin et al., 2009; Morton and Lee, 2011). An updated survey in 2014 showed that both species co-exist at six shores, including Pak Nai, Ha Pak Nai, Yi O, Sham Wat, San Tau and Tung Chung Wan, whereas *T. tridentatus* is only found at Shui Hau Wan and *C. rotundicauda* at Tsim Bei Tsui, Tai Ho Wan and Luk Keng shores (unpublished data).

Status and Trends

From Mikkelsen (1988), there were records of three Asia-Pacific horseshoe crab species in Hong Kong, including *Tachypleus gigas, T. tridentatus* and *C. rotundicauda*. However, more recent population studies (Li, 2008; Shin et al., 2009; Morton and Lee, 2011) did not reveal any presence of *T. gigas* in Hong Kong waters and *T. gigas* was believed to be locally extinct (Chiu and Morton, 2003). A recent literature review suggested previous reports of the presence of *T. gigas* in Hong Kong are a case of mistaken identity, and because of this it has not and does not naturally occur here.

Historical distributions of horseshoe crab populations in Hong Kong were documented in Chiu and Morton (1999) by interviews with fishermen and rural villagers as well as information scattered in previous articles. The study concluded that horseshoe crabs were probably quite evenly distributed over all mudflats, beaches and waters in Hong Kong, at least until the 1980s. The historic widespread occurrence of horseshoe crabs in Hong Kong may be indicated indirectly from the names of some landmarks such as Hau Hok Wan (in Chinese "鱟殼灣" which literally means "Horseshoe Crab Carapace Bay") on northern Lantau Island and Hau Tei (in Chinese "鱟地" which literally means "Ground for Horseshoe Crabs") in Tsuen Wan. However, no juvenile horseshoe crabs have recently been observed at Hau Hok Wan and Hau Tei was reclaimed a long time ago and is now a local market. Both *T. tridentatus* and *C. rotundicauda* have also disappeared from other historic locations such as Lung Kwu Tan and Tolo Harbour, and only lesser numbers of individuals can be found in Deep Bay as compared with anecdotal records (Chiu and Morton, 1999; Chiu, 2003).

The first set of quantitative data on horseshoe crabs in Hong Kong was reported by Morton and Lee (2003) in a study along the northwestern coastline of Deep Bay from May to December 2002, and details of these data with more updated information from 2007 were published in 2011 (Morton and Lee, 2011). Adopting a similar survey methodology, further studies were conducted in 2004 at 17 potential spawning and nursery shores at the northeastern and northwestern coastlines of the New Territories as well as on Lantau and Lamma Islands (Shin et al., 2009). The same 17-shore survey was repeated in 2012, whereas another survey is being undertaken in 2014. A summary of these findings is as follows:

Tachypleus tridentatus

Pak Nai and Ha Pak Nai in Deep Bay are the localities with highest abundance of juvenile *T. tridentatus*. According to Morton and Lee (2011), the mean density recorded in 2002 was between 4 and 9 ind/100 m^2. In 2007, at some of the survey sites at Pak Nai the density had dropped to 0.27 and 0.17 ind/100 m^2, as compared to 1.33-3.7 ind/100 m^2 in 2002. At another site, numbers seemed to have increased from 0.33-1.5 ind/100 m^2 in 2002 to 2.42 ind/100 m^2 in 2007. In Shin et al. (2009), *T. tridentatus* juveniles were also found to have decreased from 0.10, 1.97, 1.55 and 1.14 ind/100 m^2 in 2002 (data from Morton and Lee, 2003) to 0, 0.08, 0.16 and 0.23 ind/100 m^2 in 2004 at Sheung Pak Nai, Pak Nai and two sites at Ha Pak Nai, respectively. The 2012 survey (unpublished data), however, showed higher densities in some of these areas: 0, 1.09, 0.47 and 1.17 ind/100 m^2.

Apart from Deep Bay, juvenile *T. tridentatus* were also found at other shores including Shui Hau Wan, San Tau, Sham Wat, Tung Chung Wan and Yi O on Lantau Island. Their densities varied from 0.08 to 0.31 ind/100 m^2 in 2004 to 0.16 to 2.19 ind/100 m^2 in 2012. It is also noted that no juveniles were recorded at Sok Kwu Wan on Lamma Island in both 2004 and 2012 surveys, as compared to that reported in Chiu (2003).

From the 2012 survey data, it is estimated that there are a total of some 4,500 juvenile *T. tridentatus* on the shores in Hong Kong. About 60% of these juveniles reside on the sandy mudflats of Pak Nai and Ha Pak Nai.

Carcinoscorpius rotundicauda

The quantitative survey in 2004 (Shin et al., 2009) did not record any juvenile *C. rotundicauda* for estimation of density data. However, a total of 30 individuals were reported from active walk-through search in the summer on Deep Bay shores, Tai Ho Wan, Yi O and Tung Chung Wan on Lantau Island, and Luk Keng and Lai Chi Wo in northwestern New Territories, and 4 individuals were noted from Luk Keng in the winter. The study by Morton and Lee (2011) also reported that only 4 *C. rotundicauda* juveniles were noted at Sheung Pak Nai and Long Chuk Hang of Deep Bay in 2002 and 2 individuals at Ha Pak Nai in 2007. The 2012 survey (unpublished data) showed that *C. rotundicauda* were present at Tsim Bei Tsui, Ha Pak Nai, San Tau, Tai Ho Wan, Yi O and Luk Keng with densities ranging from 0.16 to 1.80 ind/100 m^2. Based on such density data, it is estimated that there are a total of some 3,000 juvenile *C. rotundicauda* on the shores of Hong Kong. About 50% of these juveniles live at the Luk Keng mudflat. The 2014 survey also reported high abundance of juvenile *C. rotundicauda* on the mudflat at Sha Tau Kok.

General observations

Juvenile *T. tridentatus* and *C. rotundicauda* are still found at some shores in Hong Kong but the numbers are very low, as compared to data from mainland China (e.g., Hu et al., 2009). At present, quantitative data are still limited to establish any reliable trends on the population status of juvenile *T. tridentatus* and *C. rotundicauda* on Hong Kong sand-muddy shores. However, based on anecdotal records and the data at hand, there is no doubt that there has been a substantial decline in populations for both species in Hong Kong since the 1980s. In some areas, such as Tolo Harbour, Lung Kwu Tan and Sok Kwu Wan, no juvenile horseshoe crabs can be found now. Morton and Lee (2011) concluded that "Today, *Carcinoscorpius rotundicauda* appears close to extirpation locally and the remaining *Tachypleus tridentatus* individuals are not far behind them."

Major Threats

Lifestyle requirements

All four species of horseshoe crabs have specific spawning requirements related to a combination of factors including tides, substrate type and sand grain size.

T. tridentatus usually nests on the high tide mark of protected sandy beaches and appears to have very specific preferences as to the range of sand grain size for nesting. In areas where suitable beaches are not available, or have been diminished, *T. tridentatus* may spawn in the lower reaches of tidal streams. *C. rotundicauda* does not spawn on sandy beaches. It lays its eggs in muddy substrate in streams, rivers or mangrove stands.

Adult female horseshoe crabs carry thousands of eggs in a breeding season (April to September), which are laid in small batches over a period of time. Spawning is tied to the lunar cycles, taking place on high tides, so that the eggs can be laid specifically in the high

tide zone, where the correct microclimate involving a combination of temperature, moisture and oxygen content is critical to successful embryonic development and hatching (Brockman, 2003).

After spawning, eggs take up to 45 days to develop. Once hatched, small trilobite larvae are released, and according to the species, these develop in the spawning area, or very close to it. About one year after hatching, juveniles of both species move to a nursery area in the inter-tidal zone, where they will spend up to sixteen years, according to species, feeding and growing, and they regularly molt as they grow in size. Depending on the species, they may molt up to eighteen times before reaching maturity (Sekiguchi, 1988). Juvenile *T. tridentatus* may also have preferences for substrate type and sand grain size. After reaching maturity, the young adults move into deeper water (circa 10-20 m) to forage.

The close proximity of these three different habitats to meet the demands of their various stages of development is critical to their survival needs and from a conservation point of view, if either the spawning or juvenile development habitats fail, then all of them fail.

Adult horseshoe crabs of both species were vulnerable to bottom trawling, but since this was banned in Hong Kong in December 2012, this threat to adult horseshoe crabs no longer exists, which could result in a stabilization of adult populations.

The natural survival rate of juvenile horseshoe crabs, particularly in the first year of their life cycle, is very low. On the shores, juvenile horseshoe crabs are more vulnerable to predation because of their small body size and relatively softer carapace than the adults. From field data (unpublished), the mortality rate per instar (molting) stage is estimated to be 57-84% for *T. tridentatus* and 30-81% for *C. rotundicauda*.

Habitat loss or degradation

Habitat loss or degradation poses major threats to horseshoe crab populations in Hong Kong.

The slow growth of the juveniles and their long life span on the shores also make them highly susceptible to direct loss of habitat through construction of coastal defences (e.g., seawalls) and reclamation works and disturbances caused by urban developments in the vicinity of these spawning/nursery shores.

It is also noted that modifications of the hydrography of nearby waterways from coastal developments could adversely affect the return of adult horseshoe crabs to the shores for spawning, thus resulting in less recruitment and decrease in juvenile populations (Sekiguchi and Shuster, 2009).

Habitat disturbance

Most of Hong Kong's horseshoe crab spawning and nursery beaches are either situated next to population centres or are easily accessible and popular locations for a variety of activities including sunset viewing (Pak Nai/Ha Pak Nai), clam digging (Ha Pak Nai, Tung Chung Wan and Shui Hau Wan) and/or razor shell fishing with salt (Ha Pak Nai).

Clam digging in particular is an unregulated and out of control activity which is causing catastrophic damage to the intertidal areas at Tung Chung Wan and Shui Hau Wan, whilst razor shell fishing with salt is a new phenomenon, which has the potential to cause catastrophic damage to the *Halophila beccarii* seagrass beds and juvenile horseshoe crab foraging grounds at Ha Pak Nai (see report by Marine Impacts Focus Group).

Fisheries

Between 1980 and 2001, a Japanese pharmaceutical company set up a clandestine horseshoe crab bleeding facility in Hong Kong, to extract Tachypleus Amoebocyte Lysate (TAL) from local populations of the Chinese horseshoe crab *T. tridentatus*. This bleeding facility was set up in a shark fin warehouse in Sheung Wan District, Hong Kong and horseshoe crabs were delivered there on a daily basis from the local trawling fleet. The crabs were bled dry, then returned to the fishermen for disposal (Novitsky, 2012). In parallel with such bleeding activities, populations of *T. tridentatus* in Hong Kong collapsed, with conservative scientific estimates putting population declines at around 90%.

In Hong Kong, there is currently no target fishery on adult horseshoe crabs, although individuals of adults are sometimes caught entangling in fish nets erected across the coastline of some shores (e.g., in Deep Bay) by fishermen for harvesting fish, crabs or shrimp when the tide recedes. According to interviews with fishermen and fish stall owners in 2004 and 2005, there was an average monthly sale of 17 adult *T. tridentatus*, mostly females, in the markets, with about 10 (circa 60%) being sold for religious set-free ritual purposes and 7 (circa 40%) for human consumption (Shin et al., 2009). While such human exploitation data seem very insignificant in comparison to other seafood species, the sale of adult horseshoe crabs is not desirable because information on the adult horseshoe crab populations in Hong Kong is virtually unknown (see Knowledge Gaps).

International situation

T.tridentatus and *C. rotundicauda* are currently listed as Data Deficient on the IUCN Red List of Threatened Species, although the status of both species is currently under review by the IUCN Horseshoe Crab Specialist Group. Because of this, neither species is listed with CITES.

There is, however, international concern over the threats facing Asian horseshoe crabs, including both Hong Kong species. At the World Conservation Congress session in Jeju, Korea in 2012, a resolution was passed on the "Conservation of Asian horseshoe crabs" (WCC-2012-RES-030-EN), in which it was recognized that *T. tridentatus* and *C. rotundicauda* are facing a range of threats, including habitat destruction and degradation caused by land reclamation, coastal dredging and development, construction of coastal fortifications and shoreline modification, excavation and disturbance of seabed, habitat disturbance, and impacts of pollution. It is also noted that their habitats, such as seabed, intertidal sandy beaches and mudflats, mangroves, river inlets and seagrass beds, serve as important habitats for a wide variety of marine life and, where appropriate, horseshoe crabs should be used as "flagship species" for the conservation of such ecosystems.

Recommended approaches to conservation encompass identifying critical habitats that sustain horseshoe crabs and addressing through appropriate integrated marine and coastal management approaches, all threats to their habitats, including all activities and incentive

systems that support their destruction and unsustainable use. Sustainable development should be promoted in areas adjacent to horseshoe crab habitats with a view to protecting those habitats, to discourage activities that could adversely affect the connectivity between different habitats or alter natural processes, such as tidal flows, and to rehabilitate and restore degraded ecosystems, and re-stock populations to promote the recovery of their numbers.

Threats should also be addressed through the use of legislative, regulatory and policy instruments and alternative mechanisms, including incentive systems, financing structures and management strategies, in addressing their conservation and to support the introduction of provisions relating to them and the efforts of enforcement agencies in protecting them.

Lack of protection

Horseshoe crabs are currently not protected by local legislation, including Wild Animals Protection Ordinance (Cap. 170), Animals and Plants (Protection of Endangered Species) Ordinance (Cap. 187) or Fisheries Protection Ordinance (Cap. 171) as well as international regulations such as IUCN Red List (for Asian species) and CITES.

Knowledge Gaps

(1) The biology and ecology of both Hong Kong species are still poorly understood.

(2) The current population status and trends of horseshoe crabs are mainly based on data from *ad hoc* surveys of juveniles on their spawning/nursery shores.

(3) There is virtually no information on the population status of adult *T. tridentatus* and *C. rotundicauda* in Hong Kong waters.

(4) There is a possibility that horseshoe crabs exhibit beach fidelity, which if confirmed, will have profound implications for the conservation effort. Preliminary data on genetic diversity showed that there could be distinct "genetically different" populations of Chinese horseshoe crabs in Deep Bay and northern Lantau areas and the adults might return to the same shore for spawning.

Priority Actions

The following actions are deemed important to protect horseshoe crab species (*Tachypleus tridentatus* and *Carcinoscorpius rotundicauda*) in Hong Kong.

Priority (1) Habitat protection

Priority (1) Habitat protection – Designation of Marine Protected Areas to protect important spawning/nursery habitats of juvenile horseshoe crabs in Hong Kong. According to current population survey data and from a conservation perspective, the following sites should be accorded high priorities:

T. tridentatus and *C. rotundicauda* together – Pak Nai/Ha Pak Nai, Tung Chung Wan and Yi O.

T. tridentatus single occurrence – Shui Hau Wan

C. rotundicauda single occurrence – Tai Ho Wan and Luk Keng

Pak Nai and Ha Pak Nai on the Deep Bay coast are particularly important spawning/nursery grounds, supporting some 60% of the total juvenile *T. tridentatus* population in Hong Kong. Similar to Pak Nai, both horseshoe crab species *T. tridentatus* and *C. rotundicauda* are recorded at Ha Pak Nai, where extensive *Halophila beccarii* seagrass beds are present. Tung Chung Wan and Yi O, on the northwestern coast of Lantau Island, also have considerable juvenile populations of *T. tridentatus* and *C. rotundicauda.* In particular, *H. beccarii* seagrass beds and mangroves at Yi O (Tam and Wong, 2000) play an important role in maintaining the natural populations of both horseshoe crab species. The intertidal sand flat at Shui Hau Wan on southern Lantau Island supports a rich marine intertidal community not seen elsewhere in Hong Kong (Morton and Morton, 1983), and Shui Hau Wan appears to have the highest density of juvenile *T. tridentatus* according to the 2012 survey, with 2.17 ind/100 m^2. Tai Ho Wan on the northern shore of Lantau Island had a high density of juvenile *C. rotundicauda* at 0.39 ind/100 m^2 (2012 data), whereas the mudflat at Luk Keng supports about 50% of total juvenile *C. rotundicauda* population in Hong Kong.

Action also needs to be taken to address the mundane threats to some of these important habitats, including clam digging (Ha Pak Nai, Tung Chung Wan and Shui Hau Wan), razor shell fishing (Ha Pak Nai) and from development threats (Tai Ho Wan).

Priority (2) Species protection

Priority (2) Species protection – Designation of horseshoe crabs as protected species in Hong Kong, in view of the evolutionary significance of horseshoe crabs as marine "living fossils". Of the four extant species, two (50% of total species number) are still found in Hong Kong, and juvenilesof both species coexist on some local shores. While at present, the Asian horseshoe crab species are not on the IUCN Red List owing to deficiency of data for proper assessment, *T. tridentatus* and *C. rotundicauda* have already been listed as "EN (Endangered)" and "VU (Vulnerable)", respectively, under the China Species Red List (Wang and Xie, 2005). Within Asia, *T. tridentatus* (also known as the Japanese horseshoe crab) is regarded a national priority protection species whereas in mainland China, *T. tridentatus* is listed as a second priority protection species in some provinces, such as in Guangxi and Fujian. It is hoped that with the "protected status" in Hong Kong, catch and sale of both horseshoe crab species are prohibited.

Comments

Many activities threatening horseshoe crabs, including clam digging and razor shell fishing, could be regulated for under the Fisheries Protection Ordinance Regulations (Cap 171). Moreover, both species of horseshoe crabs could be designated as protected species under this ordinance.

Under Section 4 – Regulations, the Chief Executive in Council may by regulation provide for (c) the prohibition or restriction of the taking of any variety of fish, or fish of any size, from the waters of Hong Kong; (d) the prohibition or restriction of the use of any specified kinds of net or of nets having a mesh of any specified size for the purpose of fishing; (g) the protection of spawning areas; (ga) the prohibition or restriction of the use of any apparatus of a class or description specified under paragraph (gb), for the purpose of fishing; and (h)

generally, the protection or regulation of fishing. (Under the regulations, fish (魚類) includes all forms of aquatic life and turtles).

Under Section 4A – Orders, The Secretary (Secretary for Food and Health) may, by order published in the Gazette, (a) designate any area of the waters of Hong Kong to be a fisheries protection area to promote the conservation and management of marine and fisheries resources. It should be noted, use of marine resources is not limited to fishing. It includes such activities as science, education and ecotourism.

Priority (3) Research

Priority (3) Study of adult horseshoe crab populations – a territory-wide survey on adult horseshoe crabs should be conducted to ascertain current population status, which is essential for formulation of future conservation plan for these species.

Priority (4) Monitoring

Priority (4) Routine monitoring of juvenile and adult horseshoe crabs – resources have to be allocated to establish a routine monitoring programme for these species, so as to establish the long-term trend of population changes and devise appropriate management measures to cope with such changes.

Amphioxus

Amphioxus or lancelet is a marine invertebrate, with an adult body length of 5–7 cm depending on species. It is a primitive representative of the Phylum Chordata, and the only group which belongs to subphylum Cephalochordata. Amphioxus resembles a simple fish in appearance. The body is elongated and slightly flattened with segmented muscles, the notochord extends as far as both ends of the body, and the head is not well defined**.** Amphioxus may seem not distinct in external appearance, but it is recognized as the closest living invertebrate to the vertebrates by possessing the unique structures of notochord, hollow dorsal neural tube, segmented muscle blocks (myotome) and perforated pharyngeal (pharyngeal slits) region. The structure of amphioxus is crucial in understanding the morphology and evolution of chordates in general. It is also referred as a "living fossil", with the oldest fossil record from over 500 million years ago (Chen et al., 1995).

At present, there are 29 species of amphioxus in the world, comprising 22 species under the genus *Branchiostoma* and 7 species under *Epigonichthys* (Poss and Boschung, 1996). They have a global distribution in the shallow waters of the temperate and tropical regions. In Hong Kong, five species of amphioxus, including *Branchiostoma belcheri*, *B. japonicum* (*B. belcheri tsingtauense*), *B. malayanum*, *Epigonichthys lucayanus* and *E. culltellus* have been recorded on the eastern coast off Sai Kung Peninsula (Chen, 2007).

Status and Trends

Of the five species of amphioxus recorded in Hong Kong, only very few specimens of *E. lucayanus* and *E. culltellus* were found in Pak Lap Wan off the Sai Kung Peninsula coast. *E. culltellus* has been reported in Xiamen, China with a density up to 60 ind/m^2 (Fang and Lu, 1990), while both species have been recorded in Taiwan waters, especially *E. lucayanus* in

high abundance with a density up to 63 ind/m^2 (Lin, 2011). In recent studies, Nishikawa (2004) also collected several specimens of *E. lucayanus* from Kyushu Island, Japan. The Hong Kong records may indicate that these two species have a wider distribution than previously reported (Poss and Boschung, 1996). Indeed, Hong Kong has the highest species number of amphioxus compared with that reported in Taiwan (4 species; Lin, 2011) and mainland China (3 species, Fang and Lu, 1990; Zhang et al., 2006).

The three *Branchiostoma* species recorded in Hong Kong are mainly located in Tai Long Wan (also commonly known as Tai Long Sai Wan), Nam She Wan, Long Ke Wan and Pak Lap Wan off the Sai Kung Peninsula coast, with densities ranging from circa 10 to 400 ind/m^2 at sampling locations from surveys conducted in October 2003 and June 2004 (Chen, 2007). In particular, *B. belcheri* and *B. malayanum* are most abundant, with densities >100 ind/m^2 and contributing nearly 90% of the total number of amphioxus collected in the above-mentioned areas. Further population studies in June 2005 to June 2006 (Chen et al., 2008) confirmed the high abundance of both *B. belcheri* and *B. malayanum*, with some 400 and 120 ind/m^2, respectively, in Tai Long Wan and Pak Lap Wan.

B. belcheri was first identified living in Hong Kong in the mid 1970 by Shin (1977) and later reported in an updated territory-wide survey of the benthic communities in 2001-2002 (Shin et al., 2004), both in the same area as mentioned above. *B. belcheri* favours the seabed off the Sai Kung Peninsula coast, principally because of the unique sediment characteristics (i.e., very fine, well-sorted sand), stable environmental conditions especially low turbidity and high salinity, and less seabed disturbance from bottom trawling (due to shallow waters) in the area. There is also high diversity of benthic fauna associated with such Amphioxus Sand habitat (Chen et al., 2013).

The presence of *B. malayanum* has rarely been reported in the literature; only two specimens were recorded by Webb (1958) in Guinea, four by Gibbs and Wickstead (1969) in Solomon Islands, and few by Nohara et al. (2004) in Thailand. From the authors' knowledge, no type specimens can be found in museums from previous studies. These findings in Hong Kong therefore represent the first record of a significant *B. malayanum* population reported in the world.

B. japonicum, formerly named as *B. tsingtauense* or *B. belcheri tsingtauense*, has first been reported in Kiaochow Bay, Qingdao, northern China (Tchang and Koo, 1936) and recently recorded in Xiamen waters (Zhang et al., 2006). In China Seas, the population of *B. japonicum* in Hong Kong has the highest level of within-population genetic diversity as compared to that in Xiamen and Qingdao (Chen et al., 2007).

There are *ad hoc* reports from EIA and EM&A (Environmental Monitoring and Audit) studies on the presence of amphioxus (largely *B. belcheri*) on the seabed in other Hong Kong waters. However, details of these reports and the validity of the data have not been reviewed. The wider records in the distribution of amphioxus locally could possibly be due to the dispersal of the planktonic larvae of amphioxus and their subsequent settlement in appropriate sediments (Chen, 2007).

Major Threats

Habitat loss or degradation

While capable of swimming, adult amphioxus is a benthic animal, typically burrowing vertically in the surface layer of sand. It rests with only the front end exposed to the water and filter-feeds by means of a branchial ciliary current created by the movement of the oral cirri. When disturbed, they quickly leave their burrows and will swiftly swim a short distance, and then rapidly re-burrow again into the sand. Because amphioxus is not a good swimmer, it cannot travel far away. The most common habitats for amphioxus are shallow, subtidal fine sand flats, with fairly fast water flow.

In 2014, the Town Planning Board gave approval for village house development in Pak Lap (Draft Pak Lap Outline Zoning Plan No. S/SK-PL/1), which poses threats to the amphioxus communities in Pak Lap Wan on a number of fronts. Development in the area will include the diversion of streams, which could affect the deposition of sediments in Pak Lap Wan. The use of on-site septic tanks and soakaway (STS) systems to disperse untreated wastewater into the surrounding soil and the direct discharge of greywater into storm drains could lead to increased pollution in Pak Lap Wan, and development in Pak Lap will require excavation and exposure of the topsoil and underlying sediments, posing the risk of sediment discharge into Pak Lap Wan, which could smother the amphioxus communities (Laurie, 2014).

Any loss of such fine sand flats where present populations of amphioxus are found due to coastal reclamation or removal of seabed sediments by dredging could result in extirpation of the existing populations.

Habitat disturbance

Amphioxus requires specific sediment type and stable water quality conditions for their settlement, survival and growth (Chen, 2007). This is the reason why large populations are primarily confined to Tai Long Wan and Pak Lap Wan areas off the Sai Kung Peninsula. Hence, changes in sediment and water quality due to seabed dredging and sewage discharge could adversely affect the survival of these populations. In particular, reduction of salinity below 15‰ would result in 100% mortality and increase of suspended solids to 100 mg/L, or turbidity >5 NTU, would cause abrasions or loss of the oral cirri, which could, in turn, lead to infections around the wound and eventual death (Chen, 2007). The 'ideal' habitat of amphioxus in Hong Kong is characterized by shallow water depth (8-23 m), stable salinity (32-36‰), low turbidity (<5 NTU) or suspended solids level (<12 mg/L), sediment moisture content 17-38%, total organic matter 1.4-4.0%, median particle size 0.11-1.68 mm, and sand and granule fraction 73-100% (Shin et al., 2006).

The BSAP Sustainable Use of Marine Resources Focus Group has identified anchor damage from recreational vessels as a cause for concern in some of Hong Kong's more popular bays and specifically cites large numbers of leisure craft anchoring at Tai Long Sai Wan as an example. Neither the extent nor impacts of this type of activity on amphioxus habitats is known (Sustainable Use of Marine Resources Report. Section D – Non-fishing Uses).

Amphioxus has a life span of one to six years depending on species. *B. belcheri* can live between three to five years (Fang et al., 1990) whilst *B. malayanum* may have a shorter life span of up to 4 years only (Chen, 2007; Chen et al., 2008). Both *B. belcheri* and *B. malayanum* exhibit two peaks of spawning, in June and July and in April and August, respectively. There are no detailed data on life span and spawning for *B. japonicum* in Hong Kong. Planktonic larval life generally lasts about 4 weeks. Thus any significant deterioration

in water quality during the spawning periods will reduce spawning success and subsequent recruitment of juveniles.

Lack of protection

There is no specific local legislation to protect amphioxus at present. However, it is noted that *B. belcheri* is listed under "EN (Endangered)" and *B. tsingtauense* (now *B. japonicum*) under "VU (Vulnerable)" in the China Species Red List (Wang and Xie, 2005). *B. belcheri* is also listed under China Key List II (Protection Class II) in view of the significant decline in populations especially in Xiamen (Wang and Xie, 2005).

Information Gaps

(1) There is a lack of updated population status and trends of amphioxus in Hong Kong since the detailed survey off the Sai Kung Peninsula coast in 2003-4. A comprehensive database on amphioxus in Hong Kong's territorial waters should be established.

(2) Among the three *Branchiostoma* species recorded in Hong Kong, information on the biology and ecology of *B. japonicum* is less studied and poorly known locally.

Priority Actions

The following actions are deemed important to protect amphioxus species in Hong Kong.

Priority Action (1) Habitat protection

Priority action (1) Designation of Marine Protected Areas – to protect important Amphioxus Sand habitats in Hong Kong. According to data at hand, the following sites should be accorded high priority:

1. Tai Long Wan
2. Pak Lap Wan

Both areas have a high abundance of amphioxus, including the globally less reported *B. malayanum*.

Priority action (2) Species protection

Priority action (2) Designation of *B. belcheri* and *B. malayanum* as protected species, or consideration to protecting the whole "amphioxus" group – in view of its importance in the understanding of the morphology and evolution of chordates. In particular, Hong Kong is the first place where high abundance of *B. malayanum* has been recorded, whilst *B. belcheri* is a Class II Protection Species in mainland China.

Priority action (3) Research

Priority action (3) Further study on the biology and ecology of amphioxus – this should include the biology and ecology of *B. japonicum* as well as the within-population genetic diversity among *Branchiostoma* populations in Hong Kong waters. Research also needs to be

undertaken on the occurrence of, and impacts associated with, anchor damage from recreational vessels in amphioxus habitats.

Priority action (4) Monitoring

Priority action (4) Monitoring of amphioxus populations – continuous sampling and study of amphioxus should be conducted at 2-year intervals in Tai Long Wan and Pak Lap Wan, to ascertain the long-term viability of the populations (Shin et al., 2006).

Lamp Shells (Brachiopods)

Brachiopods are marine invertebrates under the Phylum Brachiopoda. They are a group of animals with two shell valves, but unlike the bivalve molluscs, these valves are hinged dorso-ventrally at the rear end with the front end opening for feeding with the characteristic lophophore (which is also used for respiration). The linguliformean brachiopods, under the Class Inarticulata, is regarded as the most primitive of the brachiopods and represents the first certain appearance of brachiopods in the fossil records, dating back to the Cambrian period of 530 million years ago (Zhang et al., 2005). Hence, linguliformean brachiopods are often cited as "living fossils" (Fortey, 2011), and their organophosphatic shell valves represent one of the first innovations in biomineralization by any animal (Davies, Natural History Museum, UK, 2014). Of the Family Lingulidae, there are nine species belonging to the genus *Lingula* (BrachNet, 2014), of which, one of them, *Lingula anatina* (formerly identified as *Lingula lingua* in Morton and Morton, 1983), is recorded in Hong Kong.

Status and Trends

In Hong Kong, Morton and Morton (1983) described the presence of *L. lingua* (now *L. anatina*) on protected intertidal shores, such as the sand flats of Shui Hau Wan on south Lantau Island and Starfish Bay (Hoi Sing Wan) in inner Tolo Channel, northeastern New Territories. A more detailed survey on 40 soft shores in 2000–2002 (Shin and Cheung, 2005; Tai, 2005) revealed that *L. anatina* was present in mid-shore areas of Tai Tan and Yung Shue O in Tolo Channel of northeastern New Territories, and Wong Yi Chau in Sai Kung waters of southeastern New Territories. A total of 10 specimens were collected from these shores from quadrat and core sampling. In a further survey at Tai Tan, Yung Shue O and Shui Hau Wan in 2012 (unpublished data), however, *L. anatina* was found at Tai Tan only, with circa 6 ind/m^2 from random quadrat sampling on the mid-shore. Using random core sampling along five transects between 0.5 and 1.3 m above CD (Chart Datum), a recent 2014 survey also recorded *L. anatina* at Tai Tan and Wong Yi Chau, but not at Starfish Bay (unpublished data), with 4 and 2 ind/m^2, respectively.

Based on the preliminary data of the sites where *L. anatina* was found, it seems that *Lingula* prefers sandy/muddy habitats associated with mangroves and freshwater input. It occurs in the middle shore from about 0.5 m to 1.1 m above CD. The data, however, are too few to draw any meaningful conclusion of their habitat requirements.

From the above data at hand, albeit limited, it thus appears that *L. anatina* might be very rarely found now (or possibly extirpated) on the mid-shores of Yung Shue O, Shiu Hau Wan

and Starfish Bay, whereas consistent populations are still present at Tai Tan and Wong Yi Chau.

Major Threats

Habitat loss or degradation

L. anatina has an infaunal lifestyle, living in burrows of sand with restricted movement. Hence, any destruction of the shore due to coastal reclamation and urban developments could cause extirpation of the population.

In 2014, the Town Planning Board gave approval for village house development in Tai Tan (Draft Tai Tan, Uk Tau, Ko Tong and Ko Tong Ha Yeung Development Permission Area Plan No: DPA/NE-TT/C), which poses threats to the *Lingula* communities in Tai Tan Bay on a number of fronts, as identified similarly to the case in Pak Lap Wan for impacting the amphioxus populations. In particular, the use of on-site septic tanks and soakaway (STS) systems to disperse untreated wastewater into the surrounding soil and the direct discharge of greywater into storm drains could lead to increased pollution in Tai Tan Bay, and development in Tai Tan will require excavation and exposure of the topsoil and underlying sediments, posing the risk of sediment discharge into Tai Tan Bay, which could smother the *Lingula* communities there.

Habitat disturbance

L. anatina is a suspension feeder using its lophophore to filter food particles. Hence, excessive level of suspended particles in the overlying waters may affect the function of the lophophore, reducing the feeding efficiency.

Because of the opening up of development in Tai Tan, increased residents and visitor numbers could lead to an increase in the use and exploitation of the intertidal mudflat at Tai Tan Bay, which could either directly or indirectly impact on the *Lingula* communities in the bay. Clam digging or the recent razor shell fishing with salt in particular could affect the burrows of *L. anatina*.

Lack of protection

Currently, there is no legislation to protect lamp shells locally or in mainland China. They are also not listed on the IUCN Red List.

Fisheries

There is no target fishery for lamp shells in Hong Kong. However, in SE Asia, lamp shells are dug up during low tides and the stalk (pedicle) of the animal is eaten as “sea bamboo shoot” (Davies, Natural History Museum, UK, 2014).

Information Gaps

(1) There is a lack of updated population status and trends of *L. anatina* in Hong Kong. A comprehensive database on *L. anatina* on our sandy shores should be established.

(2) Information on the biology and ecology of *L. anatina* is less studied and poorly known.

Priority Actions

The following actions are deemed important to protect *L. anatina* in Hong Kong.

Priority Action (1) Habitat protection

Priority action (1) Designation of Marine Protected Areas – to protect important *L. anatina* habitats in Hong Kong. According to data at hand, the following shores should be accorded high priorities:

1. Tai Tan
2. Wong Yi Chau

Both shores have consistent populations of *L. anatina* from data at hand.

Priority action (2) Species protection

Priority action (2) Designation of *L. anatina* as a protected species – because of its limited range and occurrence in Hong Kong, its key evolutionary importance and its status as a "living fossil".

Priority action (3) Research

Priority action (3) Study on the biology and ecology of *L. anatina* – this should include habitat requirements, eco-physiology, reproduction, behaviour and genetic diversity of the local populations.

Priority action (4) Monitoring

Priority action (4) Monitoring of *L. anatina* populations – an update of the presence of *L. anatina* on local shores should be conducted, supported by future continuous surveys to ascertain the health of the existing populations.

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