

**DISTRIBUTION, HABITAT UTILISATION AND CONSERVATION STATUS
OF THE FRESHWATER CRAB, *SOMANNIATHELPHUSA ZANKLON*
NG & DUDGEON, 1992 (CRUSTACEA: BRACHYURA: GECARCINUCIDAE)
ENDEMIC TO HONG KONG**



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Abstract: *Somanniathelphusa zanklon* Ng & Dudgeon, 1992 is a tropical freshwater crab currently considered endemic to Hong Kong. The present study shows that *S. zanklon* has been found in a variety of lotic and lentic habitats, mostly lowland, slow moving streams and marshes. The species is more widely distributed than previously known, and potentially occurs outside Hong Kong. However, its habitat is under threat from development and channelization of watercourses. The life cycle of the crab requires both slow moving streams and marshes for adults and adjacent terrestrial habitats for brooding females, highlighting the need for integrated conservation of lowland streams and their riparian corridors. It is hoped that understanding of the species habitat requirements will encourage others to further explore lowland watercourses in the Pearl River Delta and aid in habitat conservation.

Keywords: Crustacea, endemic, habitat loss, Hong Kong, marsh, tropical, watercourses.

Chinese abstract: 鎌刀束腰蟹是一種熱帶地區的淡水蟹，目前被列為香港的特有品種。本文研究發現此種淡水蟹生活於各種流水和靜水生境，主要包括位於低地的緩慢流動的溪流以及沼澤地。其分佈的地點較以往認知的更為廣泛，同時，亦可能在香港以外的地方出現。但是，牠的棲息地正在遭受渠道化及其他各種發展的威脅。鎌刀束腰蟹生命週期的成熟階段，需要緩慢流動的溪流和沼澤作為其生境，而雌性個體則需要在這些生境周邊的陸地生境中孵卵。這一生命週期特點反應了對低地溪流及其河岸走廊進行整體保育的重要性。本文希望通過對該物種對棲息地需求的了解，鼓勵其他人進一步研究珠三角地區的低地河流，並對生境保育工作起到幫助促進作用。

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Author Contribution: DJS and MRL both participated in the design of the study, acquisition of data, analysis and interpretation of data, and drafting of the manuscript. Both read and approved the final manuscript. Both the authors have contributed equally to this paper.

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INTRODUCTION

Somanniathelphusa zanklon Ng & Dudgeon, 1992 is a tropical freshwater crab (see Image 1a,b), which occurs in a variety of lotic and lentic habitats of Hong Kong (Ng & Dudgeon 1992; Esser & Cumberlidge 2008). *Somanniathelphusa zanklon* was confused with *S. sinensis* (H. Milne Edwards, 1953) until Ng & Dudgeon (1992) recognised them as distinct species. *S. zanklon* is currently considered an endemic freshwater crab of Hong Kong and is listed under the Endangered category of the IUCN Red List due to a limited extent of occurrence (less than 5,000km², known only from the lower course of the Lam Tsuen River and Su Kwun) and probable decline in habitat quality from application of pesticides in rice fields (Esser & Cumberlidge 2008). While the threat assessment made by IUCN must be viewed as hypothetical as there were no rice fields in Hong Kong when this assessment was made (Environmental Resources Management 2009), there is ongoing loss and channelization of lowland wetland habitats and watercourses within the species' known range in Hong Kong (Hyder-Mott Connell 2007; Hill 2011). Under a local conservation assessment, the species is listed as being of global concern (Fellowes et al. 2002).

Somanniathelphusa zanklon has a similar life cycle to other true freshwater crabs of Hong Kong, i.e., with a suppressed planktonic development and hatchlings that resemble the adult. Brooding female crabs are reclusive and their juveniles are released at the onset of wet season (Ng & Dudgeon 1992; Dudgeon & Corlett 1994). This species is considered to be omnivorous in the wild (Ng & Dudgeon 1992; Dudgeon & Corlett 1994, 2004), and an individual has been observed eating a seed of *Bauhinia variegata* (a common Hong Kong tree) (Philip Yip pers. comm. 20 October 2013). In laboratory conditions the species selectively prefers thin-shelled gastropod prey (Dudgeon & Cheung 1990), and there is evidence that the abundance of thin-shelled gastropods may be directly influenced by its presence, with populations of pulmonates being reduced where the crab is found (Dudgeon & Corlett 1994). This suggests that thin-shelled snails might be a preferred prey in the wild. As a corollary, the absence of thin-shelled gastropods in streams may affect distribution of *S. zanklon*, albeit it appears that the former are more widespread than the latter (Dudgeon & Corlett 1994). Therefore, pollution may be a more important limiting factor (either directly, or indirectly due to low dissolved oxygen levels in polluted waters) than prey availability for the distribution of *S. zanklon* (Dudgeon & Corlett



Image 1a. *Somanniathelphusa zanklon* Ng & Dudgeon, 1992 in its natural habitat



Image 1b. *Somanniathelphusa zanklon* Ng & Dudgeon, 1992 in its natural habitat

1994). However, the species is reported to be fairly tolerant to organic pollution (Ng & Dudgeon 1992). Ng & Dudgeon (1992) found the crab in irrigation ditches and flooded furrows and sometimes dwelling among the roots of floating plants such as the exotic water hyacinth, *Eichhornia crassipes* or the trailing roots and stems of riparian grasses and other plants.

Field observations by the authors indicated that this species actually uses a wider range of habitats than has been described previously, and is distributed quite widely in the northern and western New Territories and Lantau Island of Hong Kong. This study was implemented in order to fill gaps in the knowledge of the distribution of this species.

MATERIALS AND METHODS

Study area

The study area is the Hong Kong Special Administration Region, People's Republic of China (PRC), which lies on the south China coast between 22°09'–22°37'N to the east of the Pearl River (Zhujiang) estuary (113°50'–114°30'E) (Fig. 1). Hong Kong occupies an area of 1,100km² and is made up of a section of the Chinese Mainland (Kowloon and the New Territories, 793km²) and islands, of which Hong Kong and Lantau are the largest (78km² and 147km² respectively). The topography is generally rugged with little flat land; much of the flatter areas (c. 60km²) are a result of land reclamation (Dudgeon & Corlett 2004). The Shenzhen River to the north largely separates Hong Kong from the Shenzhen Special Economic Zone of the PRC.

The climate of Hong Kong is distinctly monsoonal and despite its subtropical nature has well-defined seasons associated with the cyclical advance and retreat of the east Asian monsoons (Carey et al. 2001). In winter,

the continental high-pressure region over Siberia and Mongolia results in north or north-easterly winds that bring cool, dry air to Hong Kong (Dudgeon & Corlett 2004).

Literature review

A detailed review of literature was undertaken to examine the known distribution of *S. zanklon*. Hong Kong SAR has a robust environmental impact assessment (EIA) process and numerous developments requiring EIA studies have taken place in lowland Hong Kong; potentially affecting streams where this crab occurs. Such EIA studies invariably require surveys of the streams that may be affected. Accordingly, desktop studies of EIA reports were made from the documents available at the Environmental Protection Departments website (<http://www.epd.gov.hk/eia/>) in order to comprehensively review the available ecological findings from these studies. Additional data was obtained from unpublished studies (Dudgeon & Chan 1996; Drainage Services Department 2014), communication with other



Figure 1. Study Area of Hong Kong Special Administrative Region, People's Republic of China and the distributional range of *Somaniathelphusa zanklon*. Green Circles indicate locations of *S. zanklon* as part of this review; red triangle indicate type locality (approximately).



Image 2. Examples of watercourses where *Somanniathelphusa zanklon* occurs. A - Ma Tso Lung; B - Chau Tau; C - Tong Fung; D - Ngong Ping

freshwater surveyors and the authors' own unpublished results of previous survey findings.

Field study

Among the localities surveyed during the previous EIA studies where *S. zanklon* was known to occur, five sites were selected to conduct water quality sampling during the present study (Image 2). Five sampling stations were chosen at each selected site. Five water quality parameters (turbidity, salinity, dissolved oxygen, pH and water temperature) were tested for each of the sites and the range of each water quality parameter calculated.

RESULTS

Distribution of *S. zanklon*

Previously, specimens of *S. zanklon* were collected from the main Lam Tsuen River and also from the irrigation ditches of the nearby Su Kwun village of New

Territories, Hong Kong (Ng & Dudgeon 1992). During the present review, no recent record of the species was found from these locations.

A review of 104 EIA reports, published between 2002 and 2015, was undertaken and these are listed in Appendix 1. The findings from this review, combined with additional data obtained from unpublished studies have revealed that *S. zanklon* is known from at least 43 sites in Hong Kong (Appendix 2). These sites are widely located in the northwestern as well as northeastern New Territories and Lantau Island (Fig. 1). The occurrence limit of the species is thus extended to 250km².

Habitat requirements of *S. zanklon*

Somanniathelphusa zanklon was mostly found either in lowland watercourses or wetlands/marsh, with all records below 220m. All the sites are characterised by slow flowing, low-gradient streams or wetland/marsh with varying degrees of water quality. All the sites have been subjected to anthropogenic influence, either through modification and channelization of

Table 1. Summary table to show range of water quality parameters from five selected sites in New Territories, Hong Kong

	Turbidity (NTU)	Salinity (ppt)	Dissolved Oxygen (mg.L ⁻¹)	pH	Temperature (°C)
Maximum	61.4	0.16	7.57	7.38	25.50
Minimum	0.10	0.01	0.75	4.77	21.80
Mean	7.35	0.05	4.53	6.57	23.07
SD	12.78	0.05	1.83	0.82	1.13

watercourses or by point pollution and water quality impacts. At none of the sites the crab was listed as, or found to be, abundant. Hence, it appears that *S. zanklon* occurs at a low population density.

Water quality

Among the localities surveyed during the previous EIA studies, five sites were selected to conduct water quality sampling during the present study. The range of each water quality parameter is shown in Table 1. Full results of water quality sampling can be seen in Appendix 3.

Potential predators and preys of *S. zanklon*

From the literature review and authors' knowledge, potential predatory fishes, from watercourses where *S. zanklon* occurs, include *Channa* spp., *Carassius auratus*, *Clarias* spp., *Oreochromis niloticus*, and *Hemiculter leucisculus* (Ove Arup & Partners 2002, 2007, 2009, 2013a,b; Mott MacDonald 2010; Meinhardt 2012). It is not clear whether *S. zanklon* forms a part of the diet of these fishes or not; however, in view of the nature of the known diet of these species, this is likely.

Gastropods typically recorded from watercourses and wetlands where *S. zanklon* occurred include, but are not limited to, *Sinotaia quadrata*, *Melanoides tuberculata*, *Radix* sp., *Pomacea lineata*, *Bellamya* sp., *Biomphalaria straminea*, *Gyraulus* sp., and *Physella acuta*.

DISCUSSION

Distribution and habitat requirements of *S. zanklon*

Esser & Cumberlidge (2008) stated that the crab occurred in less than five localities in Hong Kong; however from the present review, it is clear that the species is more widespread than previously thought with 43 identified sites in an area of occupancy of approximately 250km². Watercourses within this area are often fragmented, piped or channelized—modifications that are likely to inhibit movement of crabs, particularly upstream movements, both within

and between catchments. Hence it is likely that within this area of occupancy there are now a number of more or less isolated sub-populations.

The most important factor influencing the distribution of *S. zanklon* appears to be the physical features of the site, i.e., slow-flowing, low-gradient streams or wetland/marsh together with water quality parameters. Predation by fish does not appear to be a limiting factor though this may require further study. All the sites appeared to have a good assemblage of gastropods; thin-shelled gastropods are preferred prey for this species in laboratory conditions. Given the apparent suitability of other lowland watercourses of the New Territories, it is likely that the species is found more widely including areas, such as the eastern New Territories, where the developmental pressure (and hence the requirement to undertake surveys under the EIA process) is lower.

For the implementation of conservation actions, prior identification of potential sites of species occurrence is required. Misconceptions about its habitat requirements, notably the suggestion that it is associated with rice fields, and observer bias may have contributed to the species being overlooked at other sites. It is likely that the range of *S. zanklon* extends beyond Hong Kong, given its occurrence in the Hong Kong catchment of the Shenzhen River, and searches of lowland watercourses may result in the discovery of more populations. As such, it should be looked for more widely in the Pearl River Estuary and in other lowland river catchments in South China.

Influence of water quality parameters on *S. zanklon*

Testing of water quality was only made from five sites where *S. zanklon* occurs, as part of this review. These samples were made in order to provide an overview of water quality requirements for the species. From these limited findings, it is difficult to draw any firm conclusions on the water quality requirements of *S. zanklon*. Whilst it does appear that the species is tolerant of high turbidity and low dissolved oxygen levels, further work is required to investigate this in more detail.

Threats to global population

The use of pesticides in rice fields, which was described as a major threat to this species by Esser & Cumberlidge (2008), remains a hypothetical threat as *S. zanklon* has yet to be found in rice-growing areas. Instead, it is considered here that the development of lowland watercourses and wetland habitats is a serious threat to the species. Lowland habitats are under severe pressure from development or to reduce flood risk (Cheung et al. 2010; Hong Kong Birdwatching Society 2013). Watercourses are subject to modification, channelization, fragmentation or complete loss by placing them in underground pipes. Currently, there is no mechanism in place to protect the ecology of entire rivers and their catchments in Hong Kong (Dudgeon & Chan 1996; Cheung et al. 2010), and there is an urgent need for protection of the remaining rivers in their natural state (Hong Kong Birdwatching Society 2013); a similar situation is occurring in much of the rest Asia (Cumberlidge et al. 2009). Undiscovered populations of *S. zanklon* may be in danger of being totally lost or in a state of population decline, as a result.

Mitigation and Conservation

IUCN stated that no conservation measures were known to be in place for this species and it was not found in a protected area (Esser & Cumberlidge 2008); this remains largely correct, with only one site afforded protection through conservation designation. When mitigation is prescribed through the EIA process in Hong Kong, it is usually in the form of watercourse preservation and the inclusion of riparian buffers and/or translocation exercises. Currently, there are no stringent guidelines for implementation of habitat management, riparian buffer zones or conducting species translocation. However, projects for reducing habitat loss and fragmentation by watercourse restoration, recreation or enhancement and faunal conservation programs are in progress or are being studied (e.g., Cumberlidge et al. 2009; Drainage Service Department 2014) in Hong Kong and elsewhere in the southern China region.

Studies on other endangered freshwater crabs of this region showed that these crabs are able to readily colonize newly created habitats (Cumberlidge et al. 2009). Many of the sites in Hong Kong are isolated, fragmented by a combination of developed areas and physical topography, and have few ecological linkages suitable for a predominantly aquatic species to exploit. Protection of known sites is therefore important, so that these can ensure the continued survival of the species, and suitable habitat management would also

be beneficial either by providing increased habitat area or by providing corridors to link populations.

IUCN Red List Status

The present study is not intended to constitute a review of the IUCN listing of *S. zanklon*. Nevertheless, we suggest that the IUCN Red List status of *S. zanklon* should be revisited in the light of our findings: it is most unlikely that the population size or its rate of decline and the extent of species occurrence or area of occupancy meet the IUCN criteria for the listing of *S. zanklon* as 'Endangered'. Conversely, the species is still known only from Hong Kong and probably with a relatively small, fragmented and declining population.

CONCLUSIONS

Somanniathelphusa zanklon is widely distributed within Hong Kong, recorded from the northwestern and northeastern New Territories and Lantau Island. This species has so far not been recorded outside of Hong Kong. It appears that the species prefers low-gradient, slow-flowing tributaries and freshwater marshes as opposed to larger rivers or smaller fast-flowing watercourses. Watercourses in which this species occurs are of diverse ecological value and states of naturalness, and are under threat of loss and modification from urban development. Given the life cycle of the species, with suppressed planktonic development, adjacent terrestrial habitats within the riparian corridor or marsh-edges are as important as the aquatic water bodies; as such, channelization of watercourses can be detrimental to species recruitment. Watercourse restoration projects provide an opportunity to conserve habitat of this species', and its habitat requirements should be taken into account, when restoration measures are planned for potentially suitable watercourses.

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Appendix 1. List of Environmental Impact Assessment reports reviewed as part of this Study. All reports can be viewed online at <http://www.epd.gov.hk/eia/index.html>

Application No.	Environmental Impact Assessment Report
EIA-002/1998	Tsuen Wan Bay Further Reclamation, Area 35, Tsuen Wan Engineering, Planning and Environmental Investigation
EIA-013/1999	Tang Lung Chau Dangerous Goods Anchorage
EIA-014/1999	Main Drainage Channels and Poldered Village Protection Schemes for San Tin, NWNT EIA Study
EIA-017/1999	Essential Public Infrastructure Works associated with West Rail Stations in Yuen Long Tin Shui Wai and Tuen Mun Centre
EIA-020/1999	Route 16 Investigation Assignment from West Kowloon to Sha Tin
EIA-021/1999	Feasibility Study on the Alternative Alignment for the Western Coast Road, Tseung Kwan O
EIA-022/1999	Sha Tin Sewage Treatment Works, Stage III Extension - Environmental Impact Assessment Study
EIA-023/1999	Tseung Kwan O Development - Contract F: Grade Separated Interchange T1/P1/P2
EIA-026/1999	Essential Public Infrastructure Works with West Rail Stations (the Eastern Access Road)
EIA-027/1999	East Rail Extensions - Tai Wai to Ma On Shan
EIA-028/1999	Hebe Haven Yacht Club Development - Phase 2 Environmental Impact Assessment Study
EIA-029/1999	132 kV Overhead Pole Line & Underground Cable from the Existing Po Lam Substation to the Existing Tui Min Hoi Substation - Circuit No.2
EIA-030/1999	Tin Shui Wai Phase 4 Rail Extension
EIA-031/1999	Light Rail Transit (LRT) Extension in Tin Shui Wai Reserve Zone and Grade Separation of the LRT with Pui To Road and Tsing Lung Road in Tuen Mun
EIA-033/1999	Route 10 North Lantau to Yuen Long Highway Investigation and Preliminary Design (Southern Section)
EIA-039/2000	Shenzhen River Regulation Project Stage III - Environmental Impact Assessment
EIA-040/2000	Northshore Lantau Development Feasibility Study - Environmental Impact Assessment
EIA-041/2000	Construction of an International Theme Park in Penny's Bay of North Lantau together with its Essential Associated Infrastructures - Environmental Impact Assessment
EIA-043/2000	Agreement No. CE 73/98 Investigation Assignment for Widening of Tolo Highway/Fanling Highway between Island House Interchange and Fanling
EIA-061/2001	Tseung Kwan O Roads D1, D8 and D10
EIA-063/2001	Replacement of Cremators at Fu Shan Crematorium
EIA-066/2001	The Decommissioning of Underground Fuel Tanks at Tsuen Wan No.1 Pumping Station
EIA-067/2001	Widening of Yuen Long Highway between Lam Tei and Shap Pat Heung Interchange
EIA-068/2001	Planning and Engineering Feasibility Study for Sham Tseng Developmen
EIA-071/2001	Sheung Shui to Lok Ma Chau Spur Line
EIA-074/2002	Yuen Long and Kam Tin Sewerage and Sewage Disposal Stage 1 Packages 1A-1T and 1B-1T - Kam Tin Trunk Sewerage Phase I and II
EIA-075/2002	Tung chung road
EIA-076/2002	Fill Bank at Tseung Kwan O Area 137
EIA-078/2002	Deep Bay Link
EIA-079/2002	Ngong Ping Sewage Treatment Works and Sewerage. EIA report submitted to EPD.
EIA-082/2002	Shenzhen Western Corridor
EIA-083/2002	Feasibility Study for Housing Development at Whitehead & Lee On in Ma On Shan
EIA-086/2002	Upgrading and expansion of San Wai Sewage Treatment Works and expansion of Ha Tsuen Pumping Station
EIA-087/2002	Cement Silos Addition Work in Tai Po Cement Depot
EIA-089/2003	The Proposed Submarine Gas Pipelines from Cheng Tou Jiao Liquefied Natural Gas Receiving Terminal, Shenzhen to Tai Po Gas Production Plant, Hong Kong
EIA-093/2004	Improvements to San Tin Interchange
EIA-094/2004	Yuen Long and Kam Tin Sewerage and Sewage Disposal Stage 2
EIA-096/2004	Peng Chau Sewage Treatment Works Upgrade
EIA-097/2004	Tai Po Sewage Treatment Works Stage V
EIA-099/2004	Renewable Energy by a Wind Turbine System on Lamma Island
EIA-100/2004	Siu Ho Wan Water Treatment Works Extension
EIA-101/2004	Drainage Improvements in Sai Kung

Application No.	Environmental Impact Assessment Report
EIA-103/2004	Trunk Road T4 in Sha Ti
EIA-106/2005	New Contaminated Mud Marine Disposal Facility at Airport East / East Sha Chau Area
EIA-107/2005	Peng Chau Helipad
EIA-110/2005	Drainage Improvements in Southern Lantau
EIA-111/2005	Further Development of Tseung Kwan O Feasibility Study
EIA-112/2005	Proposed Extension of Public Golf Course at Kau Sai Chau Island, Sai Kung
EIA-114/2005	Helipad at Yung Shue Wan, Lamma Island
EIA-118/2005	Main Arena of the 2008 Olympic Equestrian Event
EIA-119/2005	Lamma Power Station Units L4 & L5 Flue Gas Desulphurization Plant Retrofit Project
EIA-122/2006	Yuen Long, Kam Tin, Ngau Tam Mei & Tin Shui Wai Drainage Improvement Stage 1, Phase 2B - Kam Tin Secondary Drainage Channel KT13
EIA-124/2006	A Commercial Scale Wind Turbine Pilot Demonstration at Hei Ling Chau
EIA-125/2006	Liquefied Natural Gas (LNG) Receiving Terminal and Associated Facilities
EIA-126/2006	Relocation of Yiu Lian Floating Dock No. 3
EIA-128/2007	Drainage Improvement in Northern New Territories - Package C
EIA-130/2007	Drainage Improvement in Sha Tin and Tai Po
EIA-133/2007	North East New Territories (NENT) Landfill Extension
EIA-143/2007	South East New Territories (SENT) Landfill Extension
EIA-144/2008	Proposed Comprehensive Development at Wo Shang Wai, Yuen Long
EIA-146/2008	Provision of Cremators at Wo Hop Shek Crematorium
EIA-148/2008	Harbour Area Treatment Scheme (HATS) Stage 2A
EIA-149/2008	Proposed Development at Fung Lok Wai, Yuen Long at Lot 1457 R.P. in D.D.123
EIA-156/2008	Development of a Biodiesel Plant at Tseung Kwan O Industrial Estate
EIA-159/2008	Construction of Cycle Tracks and the associated Supporting Facilities from Sha Po Tsuen to Shek Sheung River
EIA-159/2008	Construction of Cycle Tracks and the associated Supporting Facilities from Sha Po Tsuen to Shek Sheung River
EIA-160/2008	Improvement to Pok Oi Interchange
EIA-161/2008	Construction of a Secondary Boundary Fence and new sections of Primary Boundary Fence and Boundary Patrol Road
EIA-161/2008	Construction of a Secondary Boundary Fence and new sections of Primary Boundary Fence and Boundary Patrol Road
EIA-162/2008	Inter-reservoirs Transfer Scheme (IRTS) - Water Tunnel between Kowloon Byewash Reservoir and Lower Shing Mun Reservoir
EIA-163/2008	Hang Hau Tsuen Channel at Lau Fau Shan
EIA-164/2009	Upgrading of Remaining Sections of Kam Tin Road and Lam Kam Road
EIA-167/2009	Hong Kong Offshore Wind Farm in Southeastern Waters
EIA-169/2009	Hong Kong Section of Guangzhou - Shenzhen - Hong Kong Express Rail Link
EIA-170/2009	Provision of a Poultry Slaughtering Centre in Sheung Shui
EIA-172/2009	Hong Kong - Zhuhai - Macao Bridge Hong Kong Link Road
EIA-173/2009	Hong Kong - Zhuhai - Macao Bridge Hong Kong Boundary Crossing Facilities
EIA-174/2009	Tuen Mun - Chek Lap Kok Link
EIA-177/2009	Development of a 100MW Offshore Wind Farm in Hong Kong
EIA-178/2009	Black Point Gas Supply Project
EIA-180/2010	Improvement of Fresh Water Supply to Cheung Chau
EIA-186/2010	Integration of Siu Ho Wan and Silver Mine Bay Water Treatment Works
EIA-188/2010	Phase III Redevelopment of The Hong Kong Federation of Youth Groups Jockey Club Sai Kung Outdoor Training Camp
EIA-189/2010	Regulation of Shenzhen River Stage IV
EIA-190/2010	Liantang /Heung Yuen Wai Boundary Control Point and Associated Works
EIA-193/2011	Development of the Integrated Waste Management Facilities Phase 1
EIA-199/2011	Shatin to Central Link - Hung Hom to Admiralty Section

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EIA-200/2011	Shatin to Central Link - Tai Wai to Hung Hom Section
EIA-201/2011	Engineering Investigation and Environmental Studies for Integrated Waste Management Facilities Phase 1 – Feasibility Study
EIA-203/2012	Pilot Project for Public - Private Partnership Conservation Scheme, Sha Lo Tung Valley, Tai Po
EIA-206/2012	Drainage Improvement Works at Ngong Ping
EIA-209/2013	Cross Bay Link, Tseung Kwan O
EIA-210/2013	Tseung Kwan O – Lam Tin Tunnel and Associated Works
EIA-212/2013	Development of Lok Ma Chau Loop
EIA-213/2013	North East New Territories New Development Areas
EIA-218/2013	Development of Organic Waste Treatment Facilities, Phase 2
EIA-219/2013	Outlying Island Sewerage Stage 2 - Upgrading of Cheung Chau Sewage Collection, Treatment and Disposal Facilities
EIA-222/2014	Development of Anderson Road Quarry
EIA-224/2014	In-situ Re-provisioning of Sha Tin Water Treatment Works - South Works

Appendix 2. Locations where *S. zanklon* has been recorded in Hong Kong

Catchment/Location	Latitude (N) ¹	Longitude (E) ¹	Altitude (m)	Number of sites in catchment	Water Quality Grading ²	Source
Northern New Territories (watercourses)						
Yuen Long River	22°24'–22°25'	113°59'–114°01'	13–106	6	Bad–Fair	Authors' unpubl. data Philip Tang unpubl. data
Kam Tin River	22°25'–22°28'	114°03'–114°04'	10–17	2	Bad–Fair	Authors' unpubl. data
Sheung Yue River	22°29'–22°30'	114°05'–114°06'	9–27	6	Fair–Excellent	Authors' unpubl. data Ove Arup and Partners Ltd. 2013a, 2013b
Ma Tso Lung Stream	22°31'	114°06'	11–29	2	-	Ove Arup and Partners Ltd. 2013a, 2013b
Lok Ma Chau Village	22°30'53.35"	114°06'56.15"	15	1	-	Ove Arup and Partners Ltd. 2013a
Ping Yuen River (watercourses and a single freshwater marsh)	22°31'–22°32'	114°07'–114°10'	8–134	12	Fair–Excellent	Authors' unpubl. data Ove Arup and Partners Ltd. 2007 Mott Macdonald 2010
Ng Tung River	22°29'–22°30'	114°07'–114°08'	8–35	3	Good	Authors' unpubl. data
Freshwater marshes/ponds (north-east New Territories)						
Luk Keng Marsh	22°31'15.39"	114°13'04.21"	0	1	-	Dudgeon & Chan 1995
Kuk Po Marsh	22°31'51.19"	114°13'09.56"	0	1	-	Dudgeon & Chan 1995
Sheun Wan Marsh	22°28'09.80"	114°12'15.27"	2	1	-	Dudgeon & Chan 1995
Sha Lo Tung Marsh	22°28'50.36"	114°11'02.64"	220	1	-	Dudgeon & Chan 1995
Sheung Miu Tin Marsh	22°30'23.28"	114°15'31.00"	c. 140	1	-	Dudgeon & Chan 1995
Wu Kau Tang	22°30'19.13"	114°14'41.59"	98	1	-	Tommy Hui Unpubl. data
Fung Yuen	22°28'04.23"	114°10'48.74"	32	1	-	Tommy Hui Unpubl. data
Lai Shui Heung	22°29'47.10"	114°10'04.73"	111	1	-	Tommy Hui Unpubl. data
Lantau (Watercourses)						
Pak Ngan Heung, Mui Wo	22°16'15.99"	113°59'35.43"	c. 15	1	Excellent Good/ Excellent	Drainage Services Department 2014
Tong Fuk	22°13'39.27"	113°55'47.73"	c. 30	1	Good/ Excellent	Drainage Services Department 2014

Catchment/Location	Latitude (N) ¹	Longitude (E) ¹	Altitude (m)	Number of sites in catchment	Water Quality Grading ²	Source
Ngong Ping	22°15'24.69"	113°54'04.25"	430	1	Average/Good	Ove Arup and Partners Ltd. 2002 Meinhardt 2012 Drainage Services Department 2014
San Tau	22°17'30.74"	113°54'48.80"	8	1	-	Ove Arup and Partners Ltd. 2009

¹ - Latitudes and longitudes are approximate as exact locations could not always be sourced from literature.

² - Water Quality Grading taken from Environmental Protection Department (2014) or Drainage Services Department (2014) evaluations where applicable.

Appendix 3. Water Quality Data from all sites

Site	Sampling Station	Turbidity (NTU)	Salinity (ppt)	DO (mg/L)	pH	Temp (°C)
Chau Tau	1	23.0	0.14	1.44	7.07	23.1
Chau Tau	2	22.5	0.14	1.25	7.21	23.0
Chau Tau	3	19.9	0.14	1.55	7.25	23.0
Chau Tau	4	61.4	0.16	1.98	7.38	23.0
Chau Tau	5	8.9	0.13	0.75	7.20	23.0
Ma Tso Lung	1	1.6	0.05	5.28	7.27	22.7
Ma Tso Lung	2	0.4	0.04	4.93	7.14	22.8
Ma Tso Lung	3	0.9	0.04	5.25	7.08	22.8
Ma Tso Lung	4	0.8	0.04	4.6	7.05	22.8
Ma Tso Lung	5	1.5	0.04	5.11	7.01	22.8
LMC Village	1	3.2	0.06	7.57	7.24	25.5
LMC Village	2	4.6	0.06	5.91	7.28	25.4
LMC Village	3	3.0	0.06	6.51	7.19	25.2
LMC Village	4	1.8	0.06	6.08	7.21	25.2
LMC Village	5	7.1	0.04	3.15	6.64	24.4
Ping Hang	1	2.5	0.01	3.87	6.20	22.4
Ping Hang	2	3.8	0.01	6.06	6.37	22.7
Ping Hang	3	1.7	0.01	6.67	6.36	22.8
Ping Hang	4	1.7	0.01	5.78	6.41	22.9
Ping Hang	5	0.1	0.01	4.8	6.66	23.0
Pak Shek Au	1	3.4	0.03	4.4	6.00	22.0
Pak Shek Au	2	3.9	0.02	5.06	5.27	21.9
Pak Shek Au	3	3.4	0.02	4.39	5.20	21.9
Pak Shek Au	4	1.9	0.02	3.97	5.04	21.8
Pak Shek Au	5	5.0	0.02	5.57	4.77	21.9

