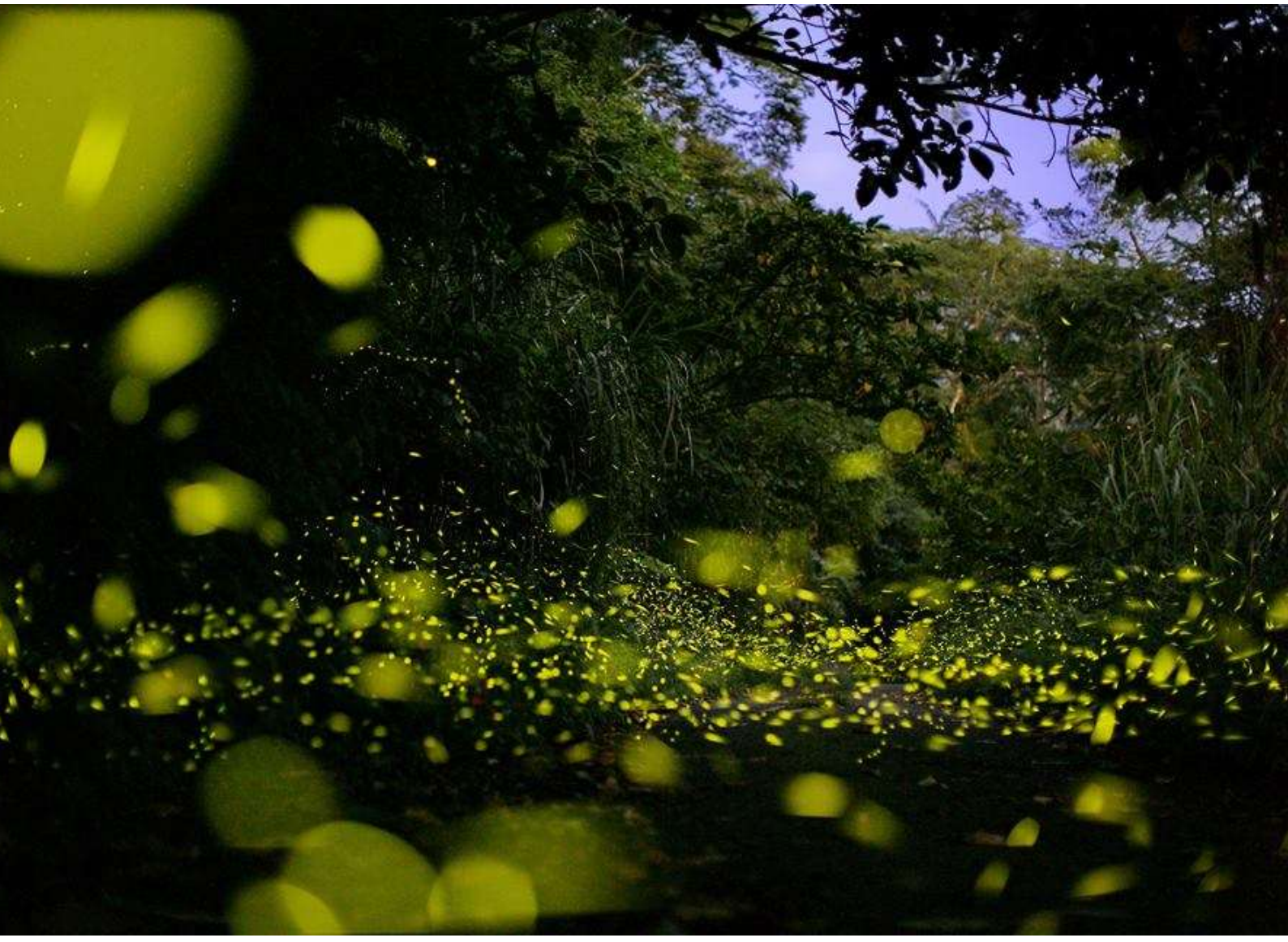
MNS Conservation Publication No. 20

Congregating Firefly Zones (CFZ) in Malaysia:

Conservation of mangrove congregating fireflies

MNS Firefly Conservation Initiative



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Congregating Firefly Zones (CFZ) in Malaysia:

Conservation of mangrove congregating fireflies

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Front cover	Firefly watching by boat, Sungai Selangor by Ian Shive
Back cover	Synchronous fireflies by Fletcher & Baylis
Inner front cover	Kampung Kuantan synchronous fireflies by Ohba Nobuyoshi and *Abscondita cerata*, seasonal fireflies in Taiwan by Hua Te Fang
Inner back cover	Firefly light trails and the synchronous fireflies, *Photinus carolinus* in the Great Smoky Mountain, USA by Radim Schreiber, FireflyExperience.org
Previous page	Rowing the firefly watching boat in Kampong Kuantan, Selangor by Ian Shive

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www.malaysianfireflies.wordpress.com

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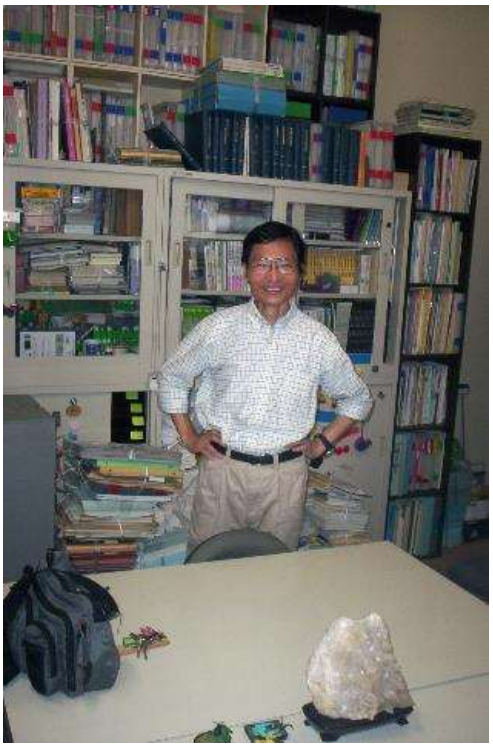
I dedicated this book to three fireflyers:

Dr Ivan Polunin (1920-2010).
Photograph is contributed by Olga Polunin of her father at his favourite playground-the mangroves



Dr Ohba Nobuyoshi (1945-2020).
His office In the Nagai Uminote Park, Soleil Hill Firefly Museum, Yokosuka City

Balu Perumal (1966-2021).
Wearing the first World Firefly Day T-shirt. His encouragement led to the inaugural World Firefly Day in 2018. Photo by MNS

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Foreword

Riparian reserves for the true mangrove and brackish water rivers act as a natural barrier to minimize the impact of erosion and serve as sanctuary for primates, small mammals, herpetofauna, birds, invertebrates and fishes. One of the invertebrates is the mangrove congregating fireflies on display at night as part of their daily mating ritual along the riverbank. The presence of these insects indicates a healthy riparian forest.

This publication highlights the special mangrove congregating fireflies in Malaysia which are also found in the mangroves of South East Asian countries and the New Guinea islands. This directory highlights these famous mangrove congregating fireflies lining the many mangrove rivers in Malaysia. It also highlights the significance and the threats faced by the mangrove congregating fireflies.

Conserving these congregating firefly zones (CFZ) would also help to protect the habitat for other wildlife and ensure the sustainability of the ecosystem services that are beneficial for the local communities. The information provided by this book will be useful for managers, planners and policy-makers to mainstream the key mangrove firefly sites in efforts to ensure the sustainable development of riparian habitats.

This book is published by the Research and Development Committee (JTRD) for the *National Mangrove and Other Suitable Coastal Species Replanting Programme* established since 2005 based on the work of MNS. I expect this publication to provide invaluable information about the mangrove congregating fireflies for the public and interested parties. I would like to take this opportunity to express my gratitude to the MNS for making this book possible. I look forward to more publications in the coming joint projects between FRIM and MNS.

Dr Ismail Hj. Parlan
Director General
Forest Research Institue of Malaysia

Foreword

I congratulate the author for taking the initiative to publish a book on Congregating Firefly Zones (CFZ) in Malaysia: Conservation of mangrove congregating fireflies. Many mangrove firefly habitats in Malaysia are still unexplored. There are 113 CFZ were listed in this book. Studies on firefly and their habitat is very important as they are important indicator to mangrove ecosystem health which in turn benefit human in general.

The book highlights that many of the better Congregating Firefly Zones (CFZ) are in the relatively undisturbed east coast river of Peninsular Malaysia, Sabah and Sarawak. However, a large portion of the CFZs are being challenge by developments at the riverbanks which are the fireflies' habitat, chemical pollution, the light pollution that comes with the development that affects the fireflies communication and even irresponsible tourism for short term profits.

Using these mangrove fireflies as an iconic flagship species to protect the riverbanks will be beneficial to nature and human's wellbeing. Hopefully, these valuable information will be a guide for the planners, decision makers and landowners before any developments to take place along the riverbanks. River banks as buffers are essential to prevent disasters like floods, erosion and loss of fisheries or aquatic ecosystem.

Malaysian Nature Society (MNS) encourage more publication on fireflies as a reference. More research on all aspects of biology, ecology, threat and human interactions need to be done. Keep up the good work, and I look forward for more support from FRIM in the future.

Prof Dr Ahmad Ismail
President
Malaysian Nature Society

Foreword

The decline in species numbers and habitats is becoming ever more apparent to us all, and in particular to those of us who pursue fireflies. The MNS and Sonny Wong are to be congratulated on this undertaking which so ably addresses the firefly problems. Our issue is conservation, but before we can conserve we need to establish just what is there, and then how we can go about identifying our priorities then it is necessary to exert the correct influences and determine where and how can we go about this. Wong has ably overviewed the situation with regard to Malaysia from a variety of angles, with copious information arising from his own extensive surveys. It is hoped that the volume of information here will be of use to researchers and decision makers, as well as appealing to many of other interested 'citizen scientists'. Importantly Wong has realized the need for continual updating of the information presented here and provided a clear mechanism by which this can be done.

Dr Lesley A. Ballantyne
Firefly Taxonomist/ Systematist
Charles Sturt University, Australia

Preface

Before 2009, we did not know how many congregating mangrove fireflies' habitat were left, while the riverine mangrove forest were disappearing at a rapid rate especially where the water was brackish. With a limited budget and timeframe, I did my first firefly river documentation and thereafter updating the firefly river directory from updated data. The first survey was a daily adventure, driving alone for 10 hours, going into tiny tracks along the river, documenting the land use in the firefly habitat; boating for hours in the dark along the mosquito and crocodiles infested river with the local fisher folks, listening to their stories and history of the area. "Why do you want to look at fireflies?' as they always asked me. My usual answer with a smile, 'To save them'. To the fisher folks, fireflies have always been there and they are so used to seeing them without noticing, but they could not understand the need to save them. Anyway, these wonderful fisher folks who are expert in handling their boats without lights on and showed me what I wanted to see. Putting all these into a book took sometime, lots of encouragement from my colleagues and finally here it is, a collection of *congregating firefly zones* around Malaysia. This directory is based on site visits, published data and, other reliable sources for site descriptions. This publication will be a suitable reference for decision makers, planners and, landowners along the riverbanks; including researchers, educators, conservationists, firefly tour operators and firefly enthusiasts. Conserving the mangrove fireflies, means saving the mangrove ecosystem from the pressures of development, all of which benefits both the environment and community wellbeing. The firefly is part of the ecosystem and provides ecosystem services like any other wildlife. Being a predator during the larva stage, the fireflies maintain the population of other invertebrates especially slugs and snails, both which are known pests to vegetable farmers. This mangrove superstar is an excellent performer at night, mesmerizing firefly lovers with its lights. I have included in the appendices some general facts about fireflies, firefly watching, conservation efforts, available legal instruments plus the global guiding principles for firefly conservation, *The Selangor Declaration on the Conservation of Fireflies;* a document hatched here in the city of Shah Alam, by firefly experts during the International Firefly Symposium 2010. And finally, we invite you to help update this directory if you have additiona or new information, so that the publication remains relevant for all times. Happy watching the sparkling winged wonders!

Sonny Wong C.H.
Conservation Division
Malaysian Nature Society

List of Acronyms and Abbreviations

a.s.l.	above sea level
ASEAN	Association of Southeast Asian Nations
CFZ	Congregating Firefly Zones
cm.	centimetre
d m s	degree minutes seconds
E	east
ECER	East Coast Economic Region (development corridor)
ESA	Environmentally Sensitive Area
FRIM	Forest Research Institute of Malaysia
GPS	Global Positioning System
Ha.	hectares
IBA	Important Bird and Biodiversity Area
IUCN	International Union for Conservationof Nature
Jln.	jalan (road)
JPS	Jabatan Pengairan dan Saliran or Department of Irrigation nd Drainage
Kg.	kampung (village)
km^2	square kilometer
LUAS	Lembaga Urusan Air Selangor or Selangor Water Management Board
MARDI	Malaysian Agriculture Research and Development Institute
MDKS	Majlis Daerah District Council
mm	millimeter
MNS	Malaysian Nature Society
N	north
NGO	non-governmental organisations
SCORE	Sarawak Corridor of Renewable Energy (development corridor)
SDC	Sabah Development Corridor
SSC	Species Survival Commission
Sg.	sungai (river)
UiTM	Universiti Teknologi MARA
UKM	University Kebangsaan Malaysia
UMS	Universiti Malaysia Sabah
UMT	Universiti Malaysia Terengganu
UPM	Universiti Putra Malaysia
USM	Universiti Sains Malaysia

1. Introduction

In the tropical Southeast Asia and Australopacific region, (including Hong Kong and west India coast) are locations known for populations of congregating mangrove fireflies. One particular genus of fireflies is *Pteroptyx* (Ballantyne & McLean 1970, Ballantyne 2001, Ballantyne & Lambkin 2013, Ballantyne et al 2011, 2015, 2019; Jusoh et al. 2018) which dominates mangroves in Southeast Asia, and has attracted the attention of scientists as well as tourists. However, these congregating firefly habitats, which are distributed along riverine mangrove forests remain largely undocumented (Wong & Yeap 2012).

Home of the congregating mangrove firefly (in green): Portion mangrove map of the South East Asian and Oceania region (much of the northern coast of Western Australia may have fireflies but there are no records - pers. comm. Lesley). Credit: Giri et al. 2011. Map credit: NASA Earth Observatory

In the estuaries, the intertidal wetlands consist of salt water riverine mangrove forests towards the sea (estuarine mangroves) and brackish water nipah-rasau (*Nipa* palm and *Pandanus*) tidal swamps more inland. These wetlands are being changed by human activities, especially in the more accessible brackish water regions. Indiscriminate clearing, many unregulated and some illegal, for flood mitigation, infrastructure construction, aquaculture, plantations, sand mining, swiftlet farms (for their nest as traditional Chinese medicine) and even tourism. Strong directional light sources like security spotlights along ports, aquaculture ponds and swiftlet farms affect the firefly communications (Lloyd 2006). Water and solid waste pollution from various sources upstream or from the sea during high tide may affect the firefly display trees, firefly larvae and their prey.

Riverine forests which are not gazetted as Protected Areas or Environmentally Sensitive Areas (ESA) face the complex process for freshwater resources management which the Intergrated River Basin Management is in place to resolve this matter.

Mangroves provide critical ecological services, such as nurseries for fisheries, unique biodiversity (Chong et al., 1990; Sasekumar et al., 1992), water filtration, erosion prevention, and present a buffer against a tsunami. Socio-economic benefits accessible to the local communities include charcoal, erosion-resistant foundation poles, tannins, other forest products and firefly watching tourism. The

firefly in itself is not a pest, but a friend to farmers. Presence of fireflies indicates a healthy environment.

The lack of awareness, of the need for conservation, underscores the urgency to highlight the congregating fireflies' existence. Although some species of congregating fireflies are protected in forest reserves where the true mangrove forests are found, however the upper brackish waters, which is home to other species of congregating fireflies are not protected, unless the whole river is in a protected area. A healthy river ecosystem is directly related to livelihood sources for the local community.

The Malaysian Nature Society under the Firefly Conservation Initiative started this compilation of the mangrove firefly habitat or congregating firefly zones (CFZ) in Malaysia from 2009 to 2010 funded by the MBZ Species Conservation Fund. These surveys identified key CFZs for conservation in Malaysia to ensure the species survival.

This publication includes the CFZ data according to each state, the status (current, past and data deficient), challenges and firefly watching activities. The data will be continuously updated with help from the public. The findings from the initial survey revealed that there are very few non degraded CFZ sites in the west coast compared to the east coast of the Peninsula and to those in Sabah and Sarawak. Pressures from economic activities remain a challenge, but the economic loss of biodiversity, ecosystem services, loss from natural disasters, loss of human lives and properties may be underestimated. The recommendation for conserving the CFZ is that a buffer zone of between 50 to 100 meters of vegetation be prescribed along the length of the river where the congregating fireflies and their prey are found. The State government may need to buy back private land or restrict activities by law. This firefly sanctuary was done in Sungai Selangor through the state enactment. . The other proposed firefly sanctuary is in Sungai Sepetang. Both locations were the result of public pressure.

This direcory will be useful for land use planners and decision makers, especially those within the Economic Planning Unit, the Town and Country Planning Department, Department of Irrigation and Drainage, Agriculture Department, other relevant agencies, local authorities and private landowners who have land use practices or operations that have an impact on these river reserves. Habitat restoration is a slow and costly process as experienced in Sungai Selangor since 2005.

The *Selangor Declaration on conservation of fireflies*, is a document to which governments around the world can refer on firefly conservation. This was a result from the Second International Firefly Symposium co-hosted by FRIM and MNS in 2010 and was subsequently revised in 2014 during the Firefly Symposium in Florida. The document is a collection of inputs from world firefly experts, who urged governments to increase conservation and restoration efforts, provide funding for research, education and awareness, reduce light pollution and pesticides, prevent live collections and trade and also encourage eco-friendly firefly watching. Firefly watching is an annual million ringgit business as exhibited on Sungai Selangor. The nation blessed with more than 105 'firefly estuaries', many of which are still pristine but unprotected, may find this activity financially rewarding.

Basic understanding of the firefly biology and ecology is important towards conservation and rehabilitation work. Local communities monitoring the firefly habitat, and involved in conducting tours for firefly watching can be motivated to protect the fireflies.

The appendices include fact sheets about the firefly, the display trees, and the congregating fireflies' light show, a map of Singapore CFZ and firefly watching sites in ASEAN countries and the ethics of firefly watching. Also included are the objectives of the *MNS firefly conservation initiative* together with the available legal instruments, conservation efforts in other countries, and a document of the *Selangor Declaration on firefly conservation.*

2. Setting the Stage

2.1 Background

Malaysia is known to support populations of mangrove congregating fireflies, particularly from the genus *Pteroptyx.* However, many of these congregating firefly populations distributed along riverine mangrove forests, remain undocumented.

The move to document these congregating fireflies came about on awareness that more of the mangroves have been decimated, and The *MNS Firefly Conservation Initiative* was conceived and further inspired during the first International Firefly Symposium 2008 in Thailand. Support came from the *MBZ Species Conservation Fund* to document the Congregating Firefly Zones (CFZ)[1] in 2009-2010 under the *Initiative.* The perceived urgency to document these zones provides one of the main objectives of this publication. Post project findings until 2017 are included in this book. For data updates, readers are encouraged to send in their observations for future editions.

MNS hopes that this book will be useful for planners, decision makers, and land managers who are suitably positioned to make a positive impact on these riverine mangroves. Researchers, educators and firefly enthusiast or 'fireflyers' (short for *firefly chasers* coined by the late Dr Jim Lloyd, a foremost firefly researcher from USA) will hopefully find this book useful, and together make concerted efforts to help conserve the congregating firefly zones in Malaysia.

2.2 Aim and Objectives

The aim of this book is to promote the conservation of congregating firefly zones (CFZ) which are located in the banks of estuarine mangrove.

The objectives of this book are to:

- Identify and document the CFZs in a standardized format
- Inform decision makers at local, national and international levels of the CFZs' biodiversity and ecotourism values and their challenges
- Identify clear priorities for site-based conservation action and to encourage government, institutions, and non-State actors to address them
- Encourage development of CFZ for ecotourism by local communities.
- Stimulate the study and generate awareness about the CFZ and fireflies in general

Dispelling the myths and misconceptions

There is a lack of awareness and misconceptions about the firefly in most countries. Many locals believed that all fireflies are the same species as the ones in Sungai Selangor. A common myth is that only Sungai Selangor has 'firefly Christmas trees' (synchronous flashing) and also one of only two places in the world, the other being in Brazil! The Selangor fireflies are always present on the *berembang (Sonneratia caseolaris),* many believed that the fireflies must need a *berembang* tree and chewed holes on the leaves or fruits of these trees are thought to be the work of the fireflies. The other congregating fireflies besides the *Pteroptyx* was observed to exhibit this behavior, is a species of *Colophotia* firefly in Kuala Selangor Nature Park (Wong, C.H. 2013a). Many locals generalised that there are only two types of fireflies, the big glowing one called *kunang-kunang* and the small flashing one called *kelip-kelip* depending on which area they are found. In Indonesia, they use the word *kunang-kunang* for fireflies. Some locals called them *api-api* probably due to their lights or their presence on the *Avicennia* tree (local name *api-api*) or the *Sonneratia alba.* Surprisingly, many youths living nearby these rivers have not even seen the 'firefly trees'. Many villagers and anglers who don't go fishing at night have not seen fireflies. Many local authorities did not know about fireflies in their

[1] *The author chose to keep the word 'congregating' instead of 'aggregating'.*

own district. Fisher folks are so used to the fireflies and did not think of them until they were asked. They will always ask 'why do you want to see them?' Importantly they will also mention that the fireflies are getting fewer nowadays

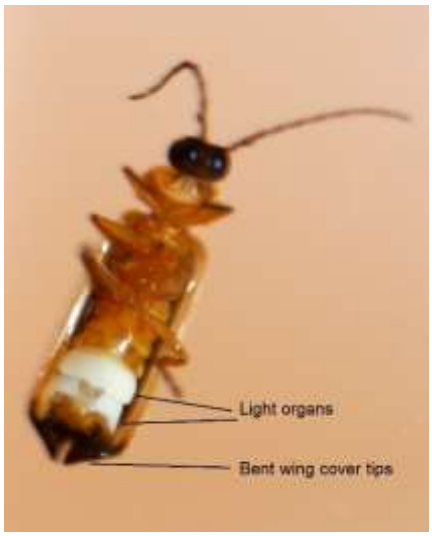
2.3 Mangrove congregating fireflies

Worldwide, there are over 2000 species of fireflies (McDermott 1966), with a diversity of life histories and sexual communications (light signals). Most fireflies will be found singly or in a small group flying about flashing or glowing to attract the female fireflies. In the mangrove congregating fireflies, male fireflies aggregate together to perform courtship displays (or *lekking),* using light signals to attract the females. The male fireflies perform it while perched on the leaves of the mangrove 'display trees' and the females will choose their mates subsequently.

In Malaysia, *Pteroptyx* fireflies are commonly found along the banks of mangrove estuaries. The density of firefly coverage varies, with only one or two fireflies on a single tree, patches to rarely a whole coverage of a single medium sized mangrove tree. The fireflies can be found on whole stretch of trees usually separated by unoccupied trees or single trees in between. In cases of cleared riverbanks, resulting in a few mangrove trees far in between having fireflies on them, and sometimes these trees will be fully occupied with fireflies (as observed by the author along Sungai Perak). Different species of congregating fireflies will have different light signal systems. The basic types of light signals for congregating fireflies, will be the spectacular quick rhythmic synchronous flashing and the slow hypnotic non- synchronous flashing (Wong & Yeap 2012). Based on the high densities or population of fireflies observed, the synchronous fireflies are actually 'quite rare', in terms of species number, but they are the most successful and advanced in terms of their evolution (Branham & Wenzel 2003). One of the earliest studies here were those of Sungai Benut congregating fireflies observed by Bassot & Polunin (1967).

2.4 Pteroptyx – *the bent-winged firefly*

In 1902, Ernest Olivier, an entomology curator from the Paris Museum, named the firefly species as *Pteroptyx* (figure 1), derived from the deflexed apices of the elytra (or 'bent tips of the wing shield) in the adult male firefly. This is one of the main external characteristics of males of *Pteroptyx* firefly besides the bipartite (split into two) light organs, and little bristles on the hind femur[2] (Ballantyne & McLean 1970, Ballantyne 2001, Ballantyne & Lambkin 2013, Ballantyne *et al*. 2015; Jusoh et al. 2018, 2020).



Two main charactersitics of a male*Pteroptyx,* which in this case, *P. gelasina* (Chey Vun Khen) with the two segments of light organs, the second segment consist of a bipartite light organs. The second feature is the wing shield tip which is bent inwards.

Eighteen species of *Pteroptyx* fireflies) have been recorded from East India, Myanmar, Thailand, Indo China (Cambodia, *old Cochin China/ Tonkin* possibly modern day Vietnam and/or Laos), Malaysia, Singapore, Indonesia (Borneo, Java, Sulawesi, Bali and Sumatra), Philippines and Hong Kong (Ballantyne *et. al.*, 2011; Ballantyne & Lambkin, 2013, Ballantyne *et al.*, 2015; Jusoh et al. 2018, 2020).

[2] *Metathoracic femoral comb*

Currently in Malaysia, there are eleven recorded species as per Table 1 below:

Pteroptyx firefly in Malaysia[3]

***Pteroptyx* firefly**	**Location**	**Light signals**
Pteroptyx asymmetria	Peninsular Malaysia	Unknown
P. bearni	Peninsular Malaysia, Sabah and Sarawak	Non-synchronous
P. decolor	Sarawak	Unknown
P. galbina	Sarawak	Unknown
P. gelasina	Sabah and Sarawak	Non-synchronous
P. gombakia	Peninsular Malaysia (Selangor)	Unknown
P. malaccae	Peninsular Malaysia, Sabah and Sarawak	Synchronous
P. sayangia	Malaysia	Unknown
P. tener	Peninsular Malaysia, Sabah and Sarawak	Synchronous
P. testacea	Peninsular Malaysia (Melaka), Sarawak	Unknown
P. valida	Peninsular Malaysia, Sabah and Sarawak	Non-synchronous

Common *Pteroptyx* firefly in Malaysia
Clockwise from the upper left : *Pteroptyx malaccae* from Thailand (Anchana Tancharoen)
Ventral and dorsal view of *Pteroptyx tener* from Sungai Selangor (Ohba Nobuyoshi)
Pteroptyx valida from Kuala Selangor Nature Park (Ohba Nobuyoshi)
Pteroptyx gelasina from Sabah (Chey Vun Khen)

[3] *Ballantyne et. al., 2011; Ballantyne & Lambkin 2013, Ballantyne et al 2015, Mahadimenakhbar et all 2003, Mahadimenakhbar 2011, 2014, (Chey 2006, 2008, 2009, 2010, 2011), MNS Miri 2012; Jusoh et al 2018, 2020.*

Pteroptyx bearni from Sungai Cherating

Note: For positve identification of all the Pteroptyx fireflies based on the male genitalia, please refer to Ballantyne & Lambkin 2013, Ballantyne et al. 2015.

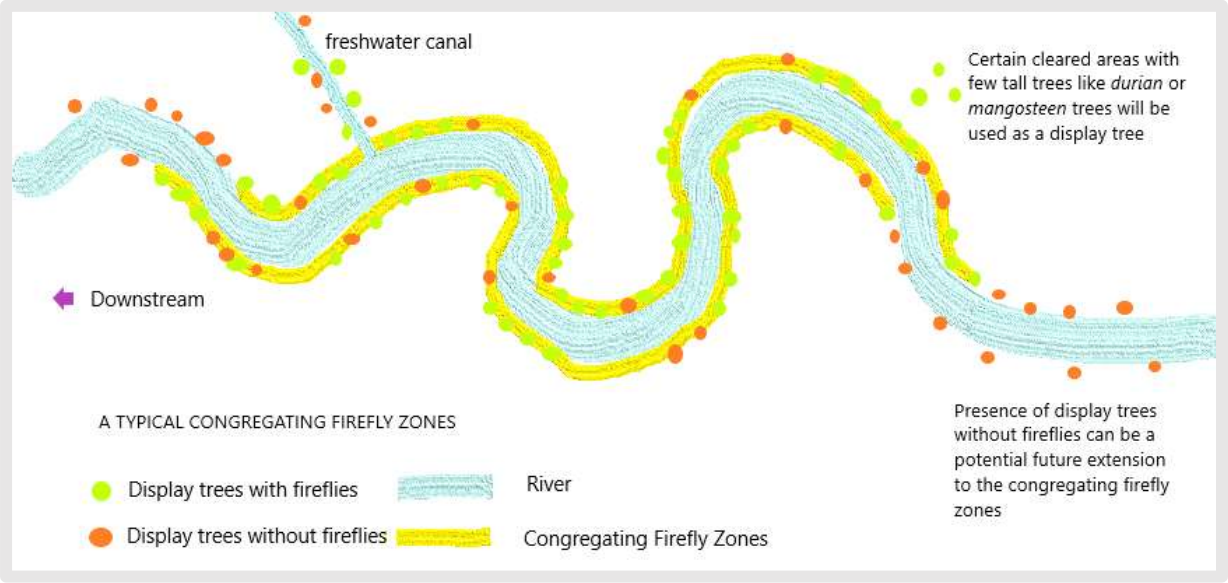
2.5 Congregating Firefly Zones

This main objective of the 2009-2010 study was to identify and document the congregating firefly habitat or the congregating firefly zones (CFZ) in the estuarine mangrove forests (Wong & Yeap 2012). The main features of the mangrove congregating firefly habitat are:

i) Riverine margins of vegetation: these are the stretch(es) of display trees, or individual display tree(s) along the estuarine banks of the mangrove forests at the intertidal zone ranging from brackish to saline waters. At the river edge female fireflies will have an unobstructed view of the males. Firefly congregations were observed to move around different trees. Fireflies will either rest on the display trees or on other vegetation, during the day (Ohba & Wong 2004).

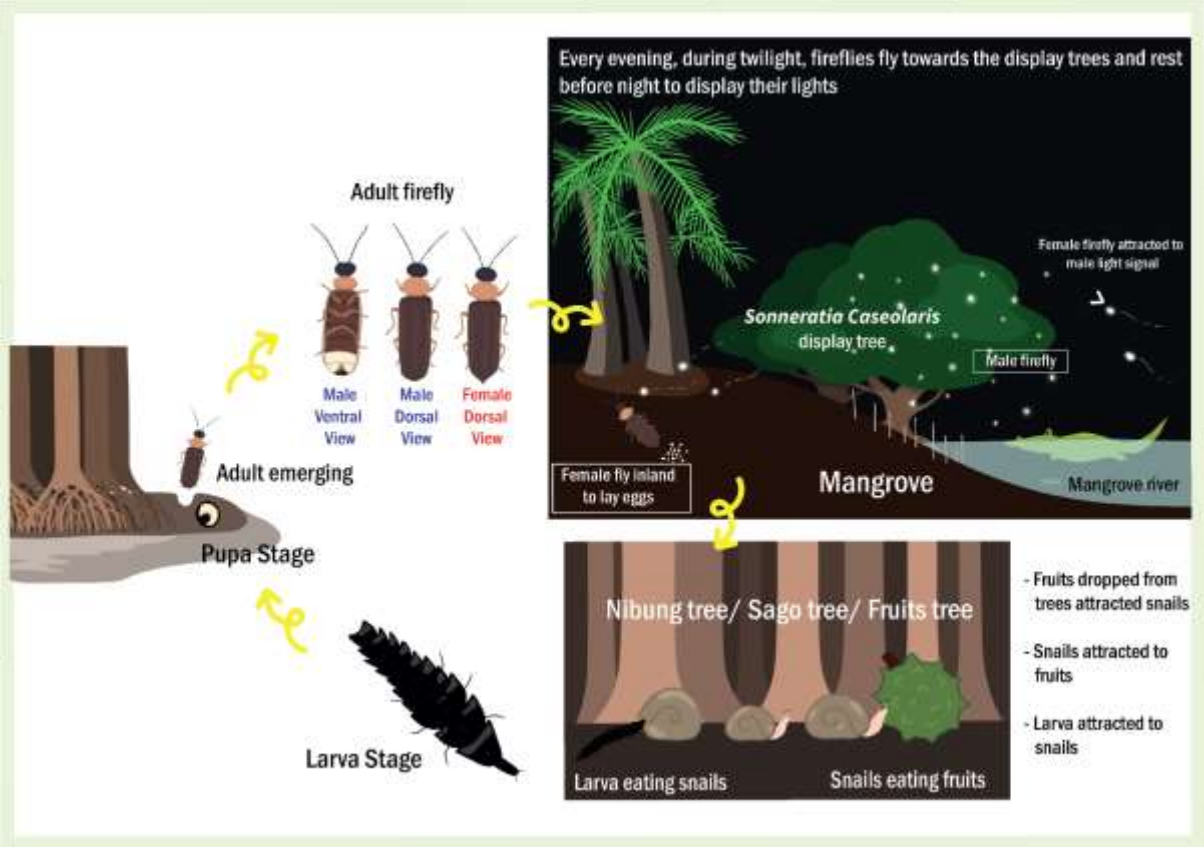
ii) Behind the river margins: This is where the fireflies spend most in their life-cycle. After mating the female fireflies will fly to and lay their eggs on the muddy substrates. The firefly larvae will hatch, feed, grow and pupate into adults. This habitat will provide food for the larva, e.g. tiny snails (gastropods) or other invertebrates. Research done in Sungai Selangor has shown that at the base of the sago palms (near the river banks) a higher firefly larvae abundance is observed compared to heavy land usage by human activities which made it less habitable by the larvae and sanils. These landuse areas are low in humidity, higher temperature presence of light intrusions (Kirton et al. 2007).

A variety of firefly display trees along Sungai Kerteh in the East Coast of Peninsular Malaysia



A typical Congregating Firefly Zones along the mangrove river, sketched by Sonny Wong/MNS

Firefly larvae feeding on a snail at the base of sago palms by Veronica Khoo Swee Imm



Life cycle and habitat of *Pteroptyx tener,* Sungai Selangor, infographic by Lim Jia Yeng

Pteroptyx tener have been observed to congregate on single tall trees beside small canals inland from the Sungai Selangor forming a beacon of light. In Papua New Guinea, the *Medeopteryx effulgens* formerly known as *Pteroptyx effulgens*, shows such behaviour (Ohba 1999). The CFZ or firefly habitat is the area surrounding the tree crown.

Medeopteryx effulgens, from New Britain by Ohba Nobuyoshi

2.6 Wetlands and congregating fireflies

There are various types of wetlands in Malaysia (DWNP 1987). This includes the human- made wetlands like seasonal wet rice fields, dams, mining pools, irrigation canals and aquaculture ponds. Which of these wetlands support congregating fireflies?

River systems: There are 189 major river basins in Malaysia as per Table 2 (DID 2010). The largest is the Rajang River in Sarawak. There are roughly six river types in Malaysia: montane streams, upland *Saraca* streams, lowland *Neram* rivers, lowland slow-flowing streams, freshwater tidal *Rasau* rivers and brackish water or mangrove estuaries (DWNP 1987). The last two river systems support the congregating fireflies, *Pteroptyx* spp., especially along mangrove estuaries (figure 8). The fireflies are also found along man-made canals in the estuaries (Wong & Yeap 2012). In many of the west coast's rivers in Peninsular Malaysia the mangroves suffered from clearing and fragmentation, however, currently in the east coast mangroves are less disturbed and old mangrove trees were observed.

A typical *Pteroptyx* firefly habitat, with *Berembang-Nipah* vegetation along Sungai Sepetang

The number of river basins in Malaysia.

	River basin	Main river basin (>80 km^2)	Small river basins (<80 km^2)
Peninsular Malaysia	1,235	74	1,161
Sarawak	283	40	243
Sabah	1,468	75	1,393
TOTAL	**2,986**	**189**	**2,797**

Source: Modified from River Basin and Coastal Zone Management Division, Dept. of Irrigation and Drainage presentation at the MAP Malaysia Geospatial Forum 2011 (except islands other than Langkawi and Penang Island)

Mangroves: *Pteroptyx* fireflies were observed to be closely associated with the riverine margins of the mangrove forest. Over 50 mangrove plant species occur here where some mangrove vegetation will be used as display trees by the fireflies. Coastal mangroves are found in large areas in Perak, Selangor and Johor in Peninsular Malaysia, along the east coast of Sabah and in northern and south-western Sarawak (DWNP 1987). The mangroves support specialized plants and animals.

Nipah Swamps: These are tidally influenced monospecific stands of Nipah palms (*Nypa fruticans*) (DWNP 1987). Nipah occurs in association with mangroves and lines the tidal rivers and forming Nipah swamps in delta like areas in Klias Peninsula, Sabah. The *Pteroptyx* fireflies were observed during the author's survey on Nipah palms in Klias, but are not common.

Peat Swamp Forest: An extreme environment of acidic and poor nutrient soil. The occurrence of congregating fireflies was observed during the author's survey along the river (in Klias Peninsula) and forest edge. Other types of congregating fireflies, *Colophotia* sp. were personally observed on the individual trees in a burnt area of Raja Musa peat swamp forest, Selangor during the 2013 expedition (Wong 2013b).

Ox-bow lakes: Occur mainly in East Malaysia along major rivers. Congregating fireflies were observed along the riverine mangroves e.g. in Danau Pitas, Sungai Kinabatangan (Mahadimenakbar et. al. 2003).

Freshwater Swamp forest: Occurs on permanently or seasonally flooded soils in the upper estuarine areas. They can occur in lakes like Tasik Bera and Tasik Chini. The forest is species rich compared to mangroves. Congregating fireflies were reported to occur along the river and in Tasik Chini.

Lakes: There are very few natural lakes and many are reservoirs for dams and abandoned tin mines. Currently, there are no published accounts from these habitats.

Marshes: There are very few open marsh areas in Malaysia. An example is Kota Belud Bird Sanctuary which consists of freshwater marshes and a complex of other wetlands habitats. The occurrence of congregating firefly is reported from several new tour operator's websites at the Sg. Nanamun and Kawa-Kawa, Kota Belud in Sabah.

Mudflats: Mudflats by definition do not have trees, but may have seedlings. Eventually seedlings grow and form the accreting shore. So far no reports from the vegetation fringes.

Seasonally wet rice fields: This is a major, localised and constructed wetland. There are anecdotal accounts of firefly congregations from Kedah (unpublished MNS firefly survey done in 1999/2000). The author observed congregation of fireflies of an unidentified firefly species on a mango tree beside a rice field in Sri Lanka.

3. In the Field

Data gathering

The survey: For some Peninsular Malaysia's rivers, data was sourced from primary and secondary data (published and unpublished reports e.g. unpublished MNS members' firefly survey 1999/2000), journals, magazines, theses, media, websites and interviews with the locals and tour operators) for site verification. In Sarawak, the survey was along the north Sarawak coast. There was no survey done for Sabah, compiled data was from published accounts and from tour operator websites. Local fisher folks were normally hired for their navigation skills in the dark. The last firefly display tree observed indicated unnavigable channels.

Period: An earlier recce was done in 2008 for a few selected rivers, before this project (MNS survey 2008). The Peninsular Malaysia surveys took place from June 2009 to May 2010 (MNS survey 2009/10). The Sarawak surveys took place from October 2010 to March 2011 (MNS survey 2010/11). Surveys were conducted when the moon was below the horizon, which is roughly over a 10-day period per month. The surveys took place between 6pm to 10pm.

Documentation: Two datasheets jointly developed with UPM, (Hashim et. al., 2009), one of which is the daytime datasheet which documents the land use and threats, flora and fauna, habitat requirement and ecotourism. The night datasheet documents the environmental conditions, display trees, GPS coordinates, time, light signals and colour, larva site, and light pollution. Other documentation included photographs and interviews.

GPS marking for firefly colonies: For narrow rivers, the display trees on either side of the river were marked at the same time with a GPS, with the left or right bank noted down. For wider rivers, both the banks surveyed separately. As a guideline, for high firefly abundance, if a single tree had less than 10 fireflies then it may not be marked. If there is a continuous stretch of firefly display trees, either significant or not, it will be noted as a 'stretch'. If the river has very low firefly abundance, even a single firefly is marked.

Compilation

The site accounts were compiled according to political subdivisions, together with CFZ maps. Unvisited or unverified sites or historical usually listed in a table format due to lack of information. Later surveys are also included for record purpose. The firefly occurrence coordinates are Universal Transverse Mercator (UTM) using the WGS84 datum (zone-easting-northing) UTM coordinates.

Survey limitations

1. Weather, tides, navigation hazards like solid waste, aquatic plants, logs and unseen barge cables; possible effects of nightglow on the fireflies.
2. Time and budget limited the number of sites and number of visits to a site (especially for big rivers with many tributaries like the Perak River, which required many visits).
3. Human factors include the boatmen's knowledge and temperament
4. Firefly specimens were not collected in this study.

4. Findings and Discussion

4.1 CFZ in Malaysia

Until 2015, a total of 114 CFZs were documented: 71 CFZ in Peninsular Malaysia, 16 CFZ from Sabah and 27 CFZ in Sarawak. There were many remaining areas not verified or surveyed. Unreliable sources were not included. Please go to section 6 for the site accounts.

Note:
n = non-synchronous fireflies
s = synchronous fireflies
u = unverified/ unsurveyed/ unconfirmed /unpublished /website
x = extinct, habitat destroyed

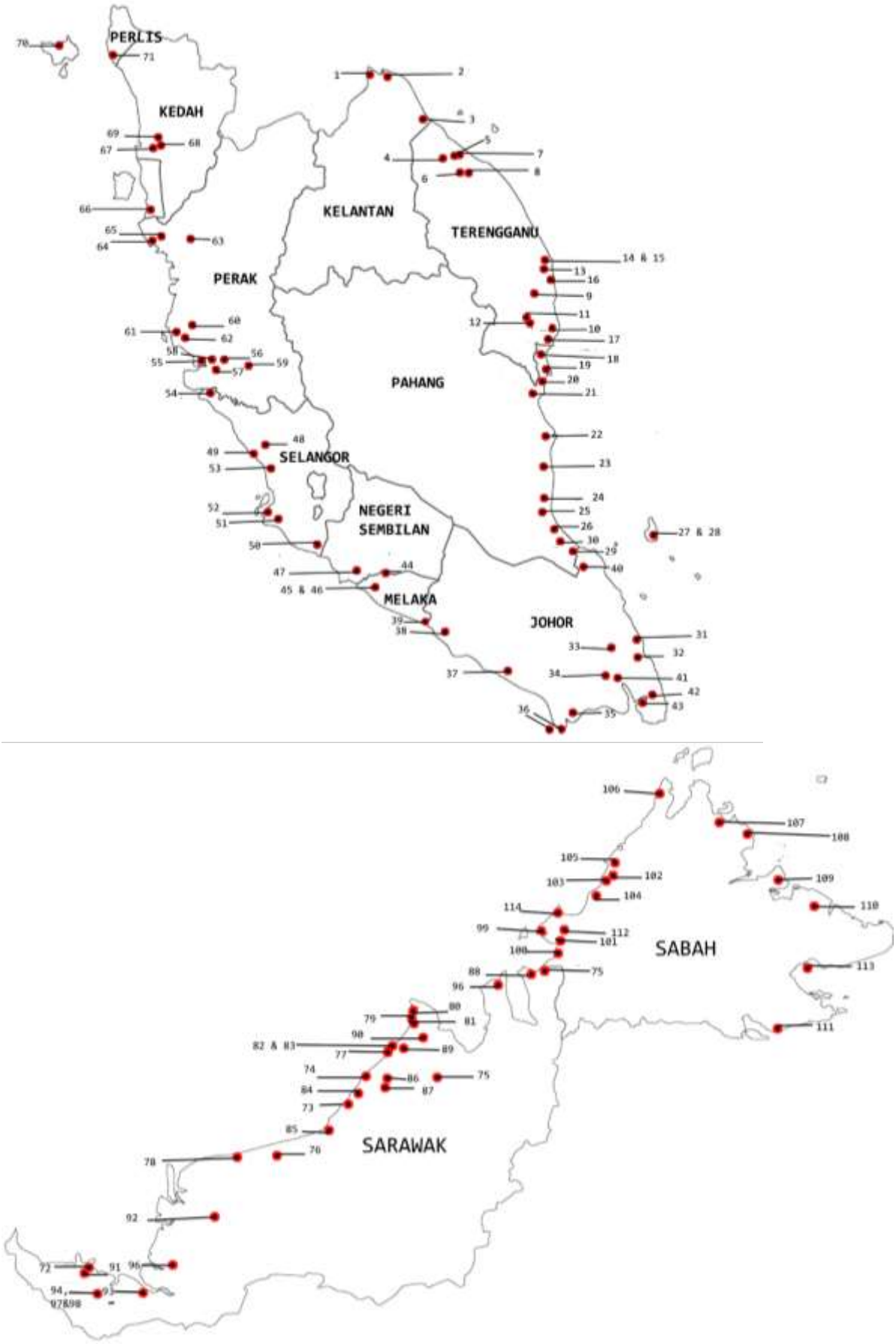
Location of CFZ in Malaysia

No	CFZ Code	State	River/ Area	Note
1	Kt01	Kelantan	Tumpat Lagoon	x, u
2	Kt02	Kelantan	Kampung Pulau	u
3	Kt03	Kelantan	Semerak Lagoon	s
4	Tr01	Terengganu	Sungai Setiu (Setiu-Chalok Lagoon)	s, n, u
5	T1	Terengganu	Sungai Nyatoh	u
6	T2	Terengganu	Sungai Chalok	s
7	T3	Terengganu	Sungai Penarik	u
8	T4	Terengganu	Sungai Merang	U
9	Tr02	Terengganu	Sungai Kerteh	s, n
10	Tr03	Terengganu	Sungai Chukai	s, n
11	T1	Terengganu	Sugai Ibok	s
12	T2	Terengganu	Sungai Yakyah / Bungkus	s
12	Tr04	Terengganu	Sungai Dungun	u
13	T1	Terengganu	Sungai Rajawali	u
14	T2	Terengganu	Sungai Pimpin	u
15	Tr05	Pahang	Sungai Paka	u
16	Tr06	Pahang	Sungai Kemaman	u
17	Ph01	Pahang	Sungai Cherating	n
18	Ph02	Pahang	Sungai Balok	n
19	Ph03	Pahang	Sungai Kuantan	u
20	T1	Pahang	Sungai Belat	s
21	Ph04	Pahang	Kuala Sungai Pahang	s, n
22	Ph05	Pahang	Sungai Bebar	s, n
23	Ph06	Pahang	Sungai Merchong	s, n
24	Ph07	Pahang	Sungai Rompin	s, n
25	Ph08	Pahang	Sungai Pontian	s, n
26	Ph09	Pahang	Sungai Mentawak, Tioman	u
27	Ph10	Pahang	Sungai Barok, Tioman	u
28	Ph11	Pahang	Sungai Endau	n
29	Ph-Jh	Pahang-Johor	Sungai Endau	s, n
30	T1	Pahang	Sungai Anak Endau	s, n
31	Jh01	Johor	Sungai Sedili Besar	u

32	Jh02	Johor	Sungai Sedili Kecil/ Sungai Kangkar	u
33	Jh03	Johor	Sungai Mawai	s, u
34	Jh04	Johor	Bukit Berangan	s, u
35	Jh05	Johor	Sungai Pulai	u
36	Jh06	Johor	Tanjung Piai and Pulau Kukup	n, u
37	Jh07	Johor	Sungai Benut	n, u
38	Jh08	Johor	Sungai Muar	u
39	Jh09	Johor	Sungai Kesang	u
40	Jh10	Johor	Kupia Labong	s, u
41	Jh11	Johor	Sungai Johor (Nam Heng estate)	s, n
42	T1	Johor	Sungai Lebam	s, n
43	T2	Johor	Sungai Raya (tributary of Sg Belungkor)	n
44	Mk-Ns	Melaka-Negeri Sembilan	Sungai Rembau/Timun	n, s
45	T1	Melaka	Sungai Ramuan Cina Besar	n, s
46	T2	Melaka	Sungai Ramuan Cina Kecil	n, s
47	Ns01	Negeri Sembilan	Sungai Linggi	s
48	Se01	Selangor	Sungai Selangor	s, n
49	Se02	Selangor	Kuala Selangor Nature Park	n
50	Se03	Selangor	Sungai Sepang Kecil	u
51	Se04	Selangor	Sungai Langat, Bukit Jugra	u
52	Se05	Selangor	Sungai Rambai, Kampong Kurau Pulau Carey	u
53	Se06	Selangor	Sungai Buloh	u
54	Se-Pk	Selangor-Perak	Sungai Bernam	s, n
55	Pk01	Perak	Sungai Perak	s, n
56	T1	Perak	Sungai Sumum	u
57	T2	Perak	Sungai Rebana	u
58	T3	Perak	Sungai Dedap	s
59	T4	Perak	Sungai Bidor	s, n
60	Pk02	Perak	Sungai Dindings, Kampong Sitiawan	x, u
61	T1	Perak	Sungai Sitiawan	u
62	T2	Perak	Sungai Deralik	x
63	Pk03	Perak	Sungai Sepetang	s, n
64	Pk04	Perak	Bund Choo Keang, Kuala Gula	n
65	Pk05	Perak	Sungai Kurau	s, n
66	Pp01	Pulau Pinang	Sungai Kurau	s
67	Kd01	Kedah	Sungai Merbok	n
68	T1	Kedah	Sungai Lallang	n
69	T2	Kedah	Sungai Bedong	n
70	Kd02	Kedah	Sungai Kubang Badak, Langkawi	u
71	Ps01	Perlis	Kuala Perlis	u
72	Sw01	Sarawak	Sungai Buntal	n(u)
73	Sw02	Sarawak	Sungai Similajau	s, n(u)
74	Sw03	Sarawak	Sugai Suai	s (u)
75	Sw04	Sarawak	Sungai Teru	s
76	Sw05	Sarawak	Sungai Balingian	u
77	Sw06	Sarawak	Sungai Sibuti	s

78	Sw07	Sarawak	Sungai Mukah	n(u)
79	Sw08	Sarawak	Sungai Miri	s
80	T1	Sarawak	Sungai Adong	u
81	T2	Sarawak	Sungai Maloi	u
82	Sw09	Sarawak	Sungai Raan	u
83	Sw10	Sarawak	Sungai Bakam	u
84	Sw11	Sarawak	Sungai Nyalau	u
85	Sw12	Sarawak	Sungai Likau	u
86	Sw13	Sarawak	Sungai Niah	u
87	T1	Sarawak	Sungai Sepupuk	u
88	Sw14	Sarawak	Sungai Punang	u
89	Sw15	Sarawak	Sungai Satap	u
90	Sw16	Sarawak	Sungai Bakong	u
91	Sw17	Sarawak	Sungai Santubong	s, u
92	Sw18	Sarawak	Sungai Rejang-Sibu, Sarikei	s, u
93	Sw19	Sarawak	Sungai Sebuyau/Lupar	u
94	Sw20	Sarawak	Paya Paloh	s, n, u
95	Sw21	Sarawak	Saratok	s, u
96	Sw22	Sarawak	Limbang	s, u
97	Sw23	Sarawak	Pending (Pendang)	s, u
98	Sw34	Sarawak	Kuching	s, x
99	Sb01	Sabah	Sungai Klias, Binsulok, Garama	s, n
100	Sb02	Sabah	Sungai Sipitang	s, n, u
101	Sb03	Sabah	Sungai Padas	u
102	Sb04	Sabah	Likas	s, u
103	Sb05	Sabah	KK Wetlands Center	s,u
104	Sb06	Sabah	Sungai Kinarut/ Kawang	u
105	Sb07	Sabah	Sungai Mengkabong	n, u
106	Sb08	Sabah	Kudat Bay	n, u
107	Sb09	Sabah	Sungai Paitan	n, u
108	Sb10	Sabah	Sugut, Sabang Estate	u
109	Sb11	Sabah	Sungai Sepilok Kecil, Sg. Sepilok Besar, Sg. Cina, Sg. Sepilok Laut	n, u
110	Sb12	Sabah	Danau Pitas, Sungai Kinabatangan	s, u
111	Sb13	Sabah	Semporna-Pegagau-Tawau	u
112	Sb14	Sabah	Sungai Teratak, Beaufort	s, n
113	Sb15	Sabah	Pulau Sakar	n
114	Sb16	Sabah	Kampong Binsulok, Membakut	u

There are few mangrove rivers with good stretches of firefly colony on the west coast of Peninsular Malaysia due to the more mangrove disturbances compared to the east coast. There may be more undiscovered CFZ in Sabah and Sarawak, as seen from the growing number of websites featuring new firefly watching sites. It is crucial that these major CFZ need to be highlighted for protection especially in the East Coast Economic Region (ECER) development corridor or the Sarawak Corridor of Renewable Energy (SCORE) and Sabah Development Corridor (SDC) (RCDA 2009).



Location of CFZ in Peninsular Malaysia, Sarawak and Sabah.

4.2 Pressures

More than forty years ago, Malaysia (based on villagers' reports from Sg Selangor and other mangrove estuaries) and Thailand (Buck 1966, 1968) had a high density of congregating fireflies. These firefly habitats were degraded gradually through human activities. In some cases light pollution hampered firefly communications.

Civilization has always flourished where there is a constant supply of water for drinking, cleaning, transport, trade, irrigation, energy and industry. Agriculture flourished on fertile soils in flood plains and this followed the growth of human population. The biggest pressure on estuarine mangroves came from human socio-economic activities, and land use changes apart from natural disasters. Additionally are the issues of illegal activities, light pollution and irresponsible tourism.

Flooding is natural in floodplains, and mitigation measures sacrificed the mangrove and riparian forest with flood protection or agriculture weirs, bunds/dykes and drainage canals. Rivers are constantly deepened and straightened by cutting the curves creating ox-bow lakes for fast channeling of water to the sea in order to protect the agricultural and urban areas. These activities will clear the river reserves and disrupt the natural river flow and thus threaten the aquatic ecosystems, with direct loss in specialized faunal and floral diversity including endangered species and the fireflies.

Land ownership along the river occurred during pre-independence days. Over time, the river course changes result in private lands beside the river either going further from the river or even being eroded into the river. Therefore land opening activities takes place close to the river.

Conversion or even temporary occupation of permanent forest reserves or river reserves for agriculture, aquaculture activities, or sand mining poses such challenges to nature conservation. Aquaculture ponds, sand mining and plantations beside the rivers promoted erosion of river banks and firefly habitat destruction. Sand mining also disrupts the river bed ecosystem as well as depositing mined sand on the river banks. This is visible in the sandy rivers of the east coast e.g. Sungai Pahang and Sungai Johor.

Major infrastructures like ports, weirs, highway bridges, railway lines, roads, jetties, tourism facilities and urbanization are taking a toll on river banks. These challenges are more significant in the brackish water regions, unlike many estuarine mangroves are legally protected by the Forestry Department as mangrove forest reserves.

Further issues accompanying these socio-economic activities are water pollution and increased turbidity of the river water. The main sources are unregulated or illegal dumping of solid waste, sullage, sewage or animal waste, industrial waste, fertilizer, herbicide and non-silt traps runoffs. All this becomes a threat to the vegetation and wildlife, and even to humans living there. Solid waste or trash is a hazard to navigation and an eyesore for tourists. Pet escapees or accidental releases of invasive species like tilapias and water hyacinth affect local fish species and will also affect navigation in slow moving rivers or lakes. Over extraction of river water may exacerbate the problem like the drying up in sections of the rivers as seen in Sungai Selangor in February 2002 (Fig 11).

One major issue from human activities is the ecological consequence of light pollution which affects the firefly's light communication through noise, illumination and misinformation by the high intensity directional lights (Lloyd 2006). Sea turtles, migratory birds and other insects that navigate at night are also affected. These lights observed were from infrastructures like the electric lights from street lamps, jetty, port, bridges, buildings, advertising boards, sand mining barges, aquaculture security spot lights, swiftlet houses, oil and gas industries (gas flare); vehicles lights; and non-eco-friendly tourism activities (riverfront restaurant and unsustainable practices during firefly watching). Another phenomenon is night or sky glow resulting from urban lights reflected from low clouds creating a background light (Christopher et al., 2015). Areas observed along the mangrove river bank with such strong illumination were reduced or devoid of fireflies.

Land use challenges: Top row: Aquaculture ponds and plantations along Sungai Selangor (MNS). Second row: Flood mitigation measures at Sungai Sedili Kecil destroyed the mangroves and freshwater swamp; weir at Sungai Pontian. Third row: sand mining activities along the river banks of Sungai Pahang destroyed firefly habitats (panorama view). Bottom row: Water Pollution: solid waste affecting tourism and navigation in Sg Selangor (MNS); port and fish industries along Sungai Bernam.

(top row) The canal built to transfer water from Sungai Kemaman and the straightening of Sungai Chukai to reduce flood in Kemaman in 2015 damaged the firefly habitat in Sungai Chukai. (middle row) Water plants like water hyacinths affecting navigation in Sungai Kurau; In February 2002, over extraction of water caused parts of Sungai Selangor to dry up (GEC photo). (bottom row) Light pollution: from swiftlet house security lights along Sungai Perak; gas flares along Sungai Kerteh.


Boat wakes erode the river banks; clearing of mangroves for jetties at Tanjung Bukit Mentok, Sungai Kemaman.

Wakes from big fishing boats or fast motor boats will erode the riverbanks. Earlier in 2002, the Selangor government banned motor boats from the firefly watching area for the safety of tourists and to prevent erosion and noise.

Other issues include irresponsible firefly watching, houseboats, seafood restaurants, jetties and riverfront resorts together with fish cages, all of which are affecting the firefly colonies from the lights, water pollution, and destruction of river bank. An example is in Sungai Cherating, where the riverbanks are slowly being 'opened up' for fish cages and Sungai Lebam with too many houseboats.

Another major factor is the increased salt water intrusion further upstream as a consequence of reduced freshwater flow following dam construction. This may affect the vegetation growing on the estuarine banks like in Sungai Selangor (MNS 2002).

4.3 Congregating Firefly Zones

The synchronous fireflies, *Pteroptyx tener* and *P. malaccae*, were always observed to be associated with the Mangrove Apple Tree (*Sonneratia caseolaris*) locally known as berembang (MNS 2002, Jusoh et al, 2010a, b, Nallakumar 2003, Ohba & Wong 2004 , Jusoh et al 2011, 2012). The locals tend to agree that the congregating fireflies seem to prefer this tree. Similarly both the Thais (the Lamphoo tree) (Buck and Buck 1966; Loomboot 2008), and the Indonesians mentioned this tree.

Whether it is berembang or other display trees, they play a role in the life cycle of these mangrove fireflies. During mating it was observed that the male fireflies perch on leaves above tidal waters to perform the light flashing displays.

The survey indicated that habitat requirements of the non-synchronous and synchronous fireflies can be distinguished. Non-synchronous fireflies like *Pteroptyx bearni*, *P. valida* and *P. gelasina*, tend to be observed at the higher salinity waters, where the 'true mangroves' like the *Rhizophora*, *Aviccenia, Sonneratia alba* or *Excoecaria* are found. Synchronous fireflies like *P. tener* and *P. malaccae* occur at the lower salinity waters (brackish) where mangroves like *Sonneratia caseolaris* (*berembang*), *Gluta renghas*, *Talipariti* or *Barringtonia* are found. Sometimes the habitats of the two types of fireflies overlap, like in Sungai Kerteh (Jusoh et al 2011), probably due to rapid salinity changes, either upstream or downstream. In Sungai Teratak, synchronous fireflies *(P. tener*) were found in small numbers in a non-synchronous firefly habitat (*P. bearni*) (Foo & Mahadimenakhbar in press). Non synchronous *P valida* was found amongst the synchronous fireflies in Sungai Selangor (MNS 2002).

Why is there an apparent preference for the berembang tree? Suggestions ranged from coincidental locations, firefly feeding on exudates (sugary substances) from the leaves stipules (Nallakumar 2003),

and freedom from weaver ants and scale insects (Hogarth 2015) (Foo & Mahadimenakhbar in press) to a healthy tree (Jusoh et al 2010 a, b).

There is a larger diversity of tree species observed along the brackish waters particularly rivers in the east coast of the Peninsular Malaysia. Here the berembang is one of the display trees for *P. tener* among other trees like the Sea Hibiscus (*Taliparitì tiliaceum*), *Putat* (*Barringtonia sp.), Buta-buta* (*Excoecaria sp*.) and *Rengas Laut (Gluta velutina*). In Sungai Kerteh, there were 27 types of display trees with more berembang trees counted (Jusoh et al 2011).

Rivers observed especially in the west coast are *berembang* dominant rivers. There are other types of display trees in smaller numbers like in Sungai Rembau (Jusoh *et al*, 2010a), and Sg Sepetang (Jusoh *et al* 2010b). This appears to indicate that other trees can be good substitutes.

Younger berembang trees with smaller leaves were observed to have more fireflies, occasionally they are observed on some big old berembang trees with sparse leaves, and even other big leaf trees. Contrary to what Dr Buck observed in Thailand (Buck & Buck 1966), on some rare occasions the author observed fireflies on nipah palms in Sungai Belat and Sungai Klias (Wong & Yeap 2012), However the loose pinnate (feathery) leaves and the scissor-like movement when blown by the wind will disturb the fireflies

4.4 Benefits of firefly

Benefits of fireflies to the mangrove ecosystem and local communities

Fireflies are not pests, they do not damage padi crops or parasitise little shrimps, in fact fireflies control pests (Fu & Meyer-Rochow, 2012) like snails in a padi field. The firefly larvae help keep in check the invertebrates population in the mangrove ecosystem.

Saving the mangrove habitat will help save the fireflies, indirectly saving the fish and prawn nursery grounds, the mangrove wildlife and plants, the natural water filtration system and prevent coastal erosion especially the mudflats. Local communities depending on the mudflats will benefit. Cockle beds on the extensive mudflats on the west coast of the Peninsula apart from inshore fishing are a main source of livelihood for the local communities (Broom. 1982). Bats from inland caves like Batu Caves in Kuala Lumpur are known to fly to the Sungai Selangor mangroves and pollinate the flowers like the berembang. Bats from Batu Caves believed to pollinate durian and other fruit trees (Jacobs, 1988, Watzke 2006). Internationally, the significance of the coastal mangroves and extensive mudflats for example in the north central Selangor coast, lie along the East Asian-Australasian Flyway, which is a roosting and resting site for tens of thousands of migratory waterbirds flying south to escape the northern winter (Bamford et al., 2008).

Socio-economic benefits of firefly watching

During the study period, there were about 15 active firefly watching sites in Malaysia. More new sites are being discovered, some leading to new CFZ being identified like the Sungai Nanamun in Kota Belud, Sabah. Most are managed by local communities either through the fisherman's association, informal groups or registered societies. For most of these groups, there is no fixed schedule or properly licensed boat and certified guides. Most earn a supplementary income by taking people to watch fireflies. Private enterprises also contributed like the hotels or resort operators, travel agencies, tour guides, boat rental companies who will take the customers directly to the sites, or passed to the earlier mentioned groups. Sungai Selangor (at Kampong Kuantan) is the only firefly watching site managed by the government. Sungai Selangor currently has two other private tour boat operators.

The downside of these tours is the lack of emphasis on environmental education elements other than watching the fireflies. Information boards and appropriate briefings at the sites before the actual tour are needed. Only one operator, Hafiz Tour in Sungai Cherating has briefing and debriefing included in

the tour. The responsibility or sustainable side of firefly watching needs to be included (Appendix 7) as well as the safety aspects for both the environment and the participants.

Culturally, firefly watching has been a favourite summer social activity for generations in Japan. There are numerous firefly clubs all over Japan promoting firefly awareness, restoration of firefly habitats and their conservation. In Korea, the Muju Firefly Festival is a popular event for the appreciation of fireflies, with lots of activities; similarly firefly festivals occur in Taiwan and Hong Kong. In 2011, the first Malaysian firefly festival was in Kg Dew, Perak organized MNS with the villagers (MNS 2013, unpublished). Since 2018, World Firefly Day (Appendix 7) is gaining popularity worldwide.

In some European countries and USA, nature trails and protected areas that have firefly species will require a minimum payment for private parking fees, or be part of hiking or night walk activity in a tour package. These firefly seasons are very short in the temperate regions. The adults will emerge either all together or only a few individuals spread over a few days to a few weeks in summer and it depends on the day length which determines the temperature (Faust & Weston 2009). The firefly awareness activities may be organized by firefly enthusiast groups, nature groups, institutions or even individuals. Examples of these are found in Taiwan, USA, Hong Kong, and Europe. The groups will organize firefly awareness tours, produce educational materials, even field guides, firefly festivals, produce media articles, short videos, and web pages and hold exhibits in shopping malls. Some groups may have study groups and use citizen science for firefly monitoring. Some groups go into the art form and drama in expressing the firefly movements.

However, in ASEAN countries especially in Malaysia, Indonesia, Philippines, Thailand, Cambodia and Laos due to the constant temperature all year round, humidity and almost equal day/night length, the emergence of the congregating fireflies occurs almost daily. Therefore firefly watching is itself a lucrative ecotourism industry. The spillover benefits flow onto other sectors like hospitality, boat hire, restaurants, local produce, handicrafts, local transport, souvenirs, and other local attractions. In Kuala Selangor, it was estimated about RM7.3 million of revenue was accrued in 2000. Using a multiplier of 1.5, it can be assumed that the average for ecotourism in the firefly business is worth about RM11 million per annum at an active site such as the Sungai Selangor firefly watching area (MNS, 2002).

4.5 Firefly conservation in Malaysia

Malaysia, is a party to various biodiversity related multilateral agreements and conventions such as the Convention of Biological Diversity, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Convention on Wetlands of International Importance especially the Waterfowl Habitat (Ramsar Convention), the World Heritage Convention, the East Asian-Australasian Flyway Partnership amongst other multilateral environmental agreements. From these conventions, Malaysia has developed national policies and action plans for their implementation.

Only in recent years, some local authorities, local communities and entrepreneurs have awakened to the potential of firefly watching. Thus, there is a need to guide new enterprises into more eco-friendly and educational tours. This may require local authorities to monitor their activities.

During the worst haze and drought episode in the El-Nino year of 1997, of reduced river water level reducing the firefly population in Sungai Selangor, came pressures from the public, media, MNS, other NGOs and even the Royal family. This further aggravated by land clearances at several places including the firefly watching areas by landowners in 2009 and 2010. The Selangor state government, through the Selangor Water Management Board (LUAS) Enactment 1999 (s.48) (Government of Selangor Gazette, 2 July 2009) gazetted a river reserve in July 2009 to protect the firefly habitat along the banks of the Sungai Selangor at Kampung Kuantan (SWMA 2009). The 1,108 ha of river reserve ranges from 150m to 400m from the left and right banks of Sungai Selangor, and 20km upstream and 20km downstream from the Kampung Kuantan firefly jetty. The Sungai Selangor finally became the

first Special Protection Zone for Fireflies (with restricted activities) in Malaysia. However, villagers report further clearings in the area.

On the 6 November 2013, a second CFZ was proposed , a 152.98 ha of riverine mangrove forest along the Sungai Sepetang, in Perak State, the gazettement as a forest reserve under the National Forestry Act 1984, for firefly protection has not materialised at the time of writing (The Star, 2017)[4]. Although some gazettement of protected areas like State Parks, Nature Reserves, Wildlife Reserves and Permanent Forest Reserves or even public parks like the Kuala Selangor Nature Park (Wong, 2013a), are not solely for firefly conservation. Most of the coastal mangroves are protected to provide protection against coastal erosion and protection of the fish nursery grounds. In 2015, the conservation of 432 hectares Setiu Wetlands in Terengganu State (another 1,088 hectares will be gazetted in phase two), will protect outstanding wetlands features, wildlife, plants, and the fireflies.

However, the status of the upper estuarine (brackish) or river reserves has some 'protection' from guidelines as they are under the jurisdiction from various State government bodies (e.g. JPS, District Office or Council, LUAS), it will be better if it is made legal to protect the river reserves. Some of the river reserves are privately owned.

The justification for saving a firefly habitat based on scientific information is a challenge for decision-makers or politicians to decide on reserving the land for conservation at the expense of revenue generation. With a potential revenue justification in the firefly watching industry, the value of ecosystem services, cost of health and property loss and carbon credits, the value of protecting this humble insect and its habitat is therefore easier to justify. The priority is to protect the congregating fireflies' habitat by the provision of ecosystem services and their economic benefits. In order to do this, the fireflies need to be assessed for their global threat status under the IUCN Red Data List for decision makers to protect the fireflies' habitat. This matter will be address soon with the setting up of a IUCN SSC Firefly Specialist Group in 2018. If the fireflies were assessed to fall within the globally threatened categiories, there will be a better justification for the protection of the fireflies' habitats.

There are several Federal laws governing the socio-economic activities along the river reserves and water usage. However, the use of land, forest and water resources is under the jurisdiction of the State Government and governed by the respective State Government enactments e.g. the Selangor Water Supply Enactment 1997, Selangor Water Management Authority (LUAS) 1999 and the other different States Water Resources Enactment. The Forestry Department of Peninsular Malaysia manages the Permanent Forest Reserve which includes the coastal mangroves. Many river reserves have been gazetted by the main government body which is the Department of Irrigation and Drainage (JPS), but the river reserves are not exclusively for biodiversity conservation.

The rest of the unprotected riverine mangroves will either be State land which has plans for development, or under private ownership which falls under the National Land Code 1965 or the Waters Act 1920 (rev. 1989). Various guidelines like the Guidelines for the Development of Rivers and River Resources by JPS; the Aquaculture's Code of Practice and Good Aquaculture Practice have been developed by the Department of Fisheries in 2008, which can be revised to include the fireflies habitat conservation.

Note: Readers should consult other relevant materials: Managing Biodiversity in the Riparian Zone-Guideline for Planners, Decision-Makers & Practitioners (NRE, 2009), Guidelines for Development of Rivers and River Reserves (JPS, 2001), and Urban Storm Water Manual for Malaysia (MASMA)-Chapters 42 and 43 (JPS, 2000).

[4] https://www.thestar.com.my/metro/metro-news/2017/09/23/deforestation-in-kg-dew-destroys-firefly-habitat/

5. Recommendations

The government are encouraged to refer to the *Selangor Declaration on firefly conservation (revised 2014)* as a guiding principal (Appendix 6). The conservation of CFZ will require the concerted efforts of both Federal and State governments together with the non-State actors. Below are some recommended firefly conservation measures for every stakeholders to work together.

Mainstreaming CFZ into spatial planning

The Important Bird and Biodiversity Areas (IBA) (Yeap et al, 2007) compiled by MNS has been included into the National Physical Plan by the government to be taken into consideration in the State Structural and Local Plans. Similarly, the CFZ can be embedded for future revisions in the Plans.

The river reserves should take into account of the land use and for river course changes in the area. The current maximum 50 meters (depending on the river width) needs to be revised and extended to 100 meters based on observations of the presence of larva and female fireflies depositing eggs. The 100 meters buffer was suggested in the Fireflies of Sungai Selangor Studies (MNS, 2002) based on the extrapolation from studies of *Medeopteryx (Pteroptyx) effulgens* from Papua New Guinea (Ohba, 1999). This inland congregating species has a CFZ radius of 100 meters of a solitary tall display tree.

The CFZ should be frequently updated to reflect the current situation of the CFZ. More work is needed for verifying other CFZ, firefly identification in each CFZs, areas not covered which includes Johor, central Perak, north Terengganu, south and central Sarawak, Sabah; tributaries, islands including isolated inland and highland firefly colonies.

Reducing light pollution

The modern issue of electric lights (for safety and beauty) ranging from car headlights, LED street lights to reflected city lights from the clouds (night glow) are affecting the light communications among fireflies. Ways to reduce these lights either by switching off the unnecessary lights, redirecting, blocking, reducing the intensity or using wavelengths that do not affect the fireflies.

Funding for firefly research and conservation

There is a need for an understanding of the ecology, biology and taxonomy of fireflies in order to conserve them. Governments and the business community should set up a funding mechanism for firefly research and conservation especially for the local institutions. From the global firefly researchers' survey conducted in 2014, most firefly research are self-funded. Joint research should be encouraged with international firefly experts. Areas to look at are:

- Studies on the biology and ecology for *Pteroptyx* fireflies (some work has been on *P. tener, P. valida, P. bearni. P. malaccae, P. assymetria).*
- Firefly taxonomy especially the firefly female and larva. The Luciolinae sub family taxonomist is Dr Lesley Ballantyne, (retired).
- Studies on the mangrove ecosystems in relation to the firefly, predators, prey and mimics.
- CFZ monitoring should be long-term to look at the trend and firefly abundance.
- Investigaet the time for regeneration of forest and recolonization by fireflies.

Inclusion of firefly education in the education co-curriculum

Firefly education should be a co-curriculum subject for the primary, secondary and tertiary level. The school co-curriculum may help strengthen the youth involvement in firefly conservation.

Public education, awareness and involvement

This is to develop the awareness and support for firefly conservation. World Firefly Day or firefly festivals with the public and local communities promotes firefly appreciation in terms of science, culture, history, and art. Citizen science involving local communities can help monitor the firefly

habitat (CFZ). Similar studies in Thailand recommend constant public awareness activities based on biology, ecology and ethnology of the firefly (Nurancha 2013).

Local community involvement and firefly watching best practices

The aim is for each state having one or more protected CFZ and firefly watching activities with the local community involvement. Developing the local communities to run activities will be socially and economically viable. The villagers will look after the river as they derive supplementary income from tourists. Currently MNS is forming a network of Firefly Komuniti as part of the firefly conservation efforts.

Similarly, the impact of non-sustainable tourism has been highlighted in the study on firefly watching tour management guidelines in Thailand (Nurancha 2013). The study suggested a change from mainstream tour management to an 'eco-friendly tour' with tourist participation in conservation activities. The tour agent should have an understanding of the environment and with a stakeholder's approach involving the tour/ company, local community and government in monitoring. Income generation thus comes about through nature based rather than man-made which means minimal infrastructure.

6. Congregating firefly zone (CFZ) site accounts in Malaysia

This chapter is a compilation of CFZ site accounts from the 2009/2010 surveys, and a few from later periods, usually accompanied by a map of the CFZ. The compilation also includes references made from published and unpublished literature; personal communications from reliable sources from MNS members, researchers and local communities; and reliable websites of local and international travel agencies, social media and trave bloggers. Each CFZ will have a site description where information is available. Many of these CFZ were from personal communications and from websites. Readers do take note that these data are considered 'unverified' until an actual survey is conducted in the future. Those without information will only have a locaton name only. The CFZs will include historical sites, which may still have very small and probably unviable population or considered 'extinct'. The arrangement will be group by political subdivisions. Please refer to the map in Chapter 4 for their location.

Guide to the site accounts.

STATE: arranged in accordance to the states of Peninsular Malaysia (from the east coast to the west coast), Sarawak and Sabah. For sites with few data will be put in a table format.
CFZ CODE: Each CFZ is assign a State initials followed by a serial number starting from number 01, , followed by annotations, and CFZ status.

- **State initials**: Kelantan (Kt), Terengganu (Tr), Pahang (Ph), Johor (Jh), Melaka (Mk), Negeri Sembilan (Ns), Selangor (Se), Perak (Pk), Pulau Pinang (Pp), Kedah (Kd) and Perlis (Ps), Sarawak (Sw), Sabah (Sb) and including Federal Territories, Labuan (Lb).
- **Annotations**: T=tributary, s = synchronous flashing, n= non-synchronous flashing
- **CFZ status:** x=historical/extinct, u = unknown/unvisited/unverified

e.g. Pk01 , T1, s, u = Sungai Dedap (T1), tributary of Sungai Perak (Pk01) , with synchronous fireflies (s), and status unknown (u).
e.g. Pk-Se = Sungai Bernam, a transboundary river between Perak and Selangor.
CFZ NAME: Name of the river name and / or the nearest place name.
MAP: displaying the firefly occurrence along the river (available for surveyed rivers) and a location map for 'unverified' site, where possible.
CFZ DESCRIPTION: (Where information is lacking, the categories are indicated as 'N.a.')

- **Firefly habitat:** brief descriotion of the habitat where the fireflies occured
- **Firefly occurence**: Coordinates for both ends of the firefly occurrence along the river. For 'unverified' rivers, only one point coordinate to indicate the river location
- e.g. 6d12m35.9s N, 102d12m07.6s E where d=degree, m=minutes, s=seconds, N= North, E=East,
- **Firefly species**: decriptions of flash behaviour: synchronous or non-synchronous or unknown. Fireflies were sampled, checked for the bent wing tips (*Pteroptyx* firefly) and photographed.
- **Display trees**: Only the major display trees are noted
- **Other firefly:** non-congregating fireflies at the CFZ
- **Land use and Threats:** current and future threats
- **Conservation measures**: Habitat protection status (present or future efforts or none).
- **Firefly watching:** Presence or absence of firefly watching activities

OTHER BIODIVERSITY: Presence of any threatened flora and fauna
NOTES: Other relevant data like wildlife or tourists attractions nearby
REFERENCES: Published accounts or personal communications

6.1. Update the CFZ

This book will eventually provide a comprehensive catalogue of CFZs in Malaysia, and maybe regionally in the future. You can help in the updating process by informing your firefly sightings to the Malaysian Nature Society at conservation2@mns.org.my

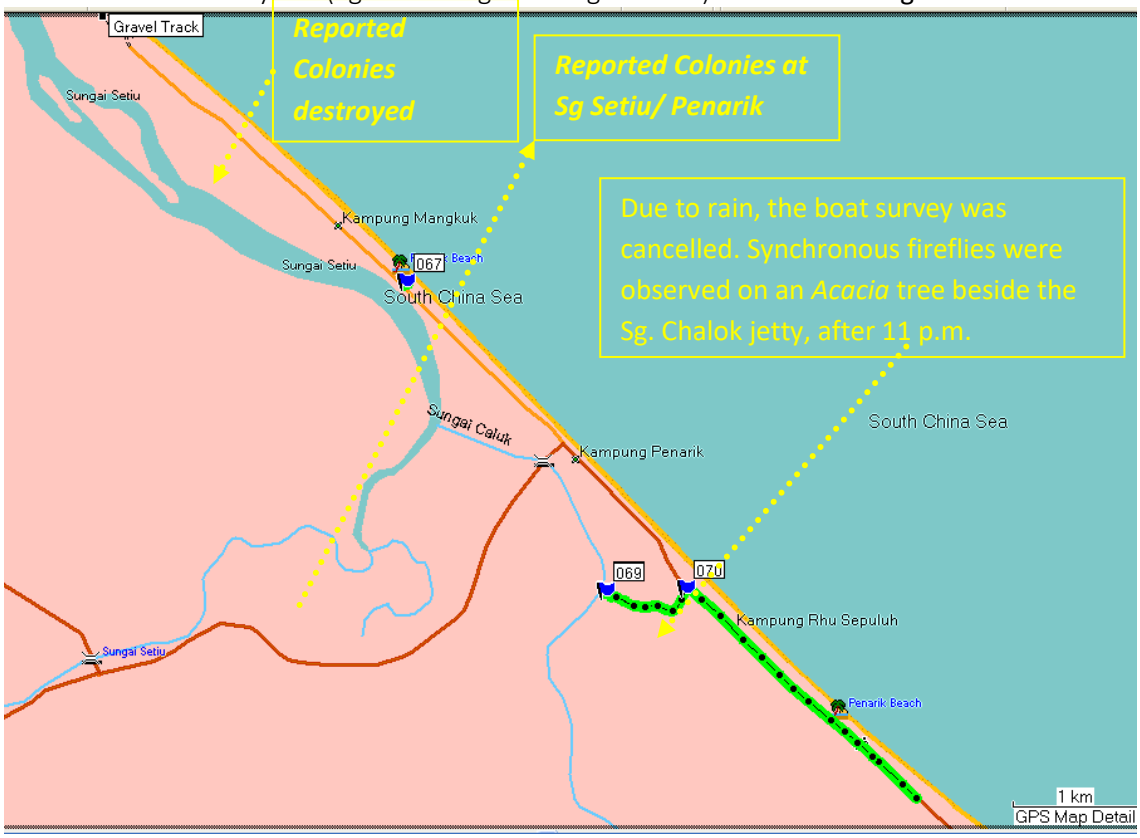
KELANTAN

Congregating Firefly Zones CFZ NAME	Sungai Kelantan	Sungai Pengkalan Datu
CODE	Kt01, x, u	Kt02, u
LOCATION MAP	Tumpat Lagoon	Kampung Pulau
DESCRIPTION		
Firefly habitat	Estuarine and island mangroves	Mangrove island and riverine,
Firefly occurrence	6d12m35s N, 102d12m7s E; historical	6d5m24s N 102d17m37s E Sungai Lubuk Dalam, Kampung Pulau, Sungai Pengkalan Datu
Firefly species	N.a.	N.a.
Display trees	N.a.	N.a.
Other firefly	N.a.	N.a.
Land use and threats	N.a.	N.a.
Conservation measures	N.a.	N.a.
Firefly watching	N.a.	By Min House Camp
OTHER BIODIVERSITY	N.a.	N.a.
NOTES	N.a.	Sungai Lubuk Durian is located between Kampung Pulau Tengah and Kampung Pulau Hilir
REFERENCES	Pers, comm. : Leong SC, Nik Maseri (MNS)	http://dwaliman.blogspot.com/2018/05/dfx.html

CFZ CODE: Kt03, s
CFZ NAME: Semerak Lagoon; Pasir Puteh District
CFZ DESCRIPTION:
Firefly habitat: riverine mangrove forests through estuarine mangroves and *Melaleuca* forest
Firefly occurence: N.a.
Firefly species: Pteroptyx mallacae (identified by FRIM)
Display trees: *Avicennia alba*, *Sonneratia alba, Rhizophora apiculata*
Other firefly: *Pyrocoelia* sp. at Kampung Tandak
Land use and Threats: future development
Conservation measures: Tok Bali Mangrove Reserve
Firefly watching: Absence
OTHER BIODIVERSITY: N.a.
NOTES: Other attractiona include *Melaleuca* forest, lagoon, beach, fishing village.
REFERENCES: Zainuddin, A. (2006); Department of Wildlife and National Parks (1987)

TERENGGANU

CFZ CODE: Tr01 s, n, u
Tr01, u Sg Setiu rivermouth, sand spit area
Tr01, T1, u Sg Nyatoh, tributary of Sg Setiu;
Tr01, T2, s Sg Chalok, tributary of Sg Setiu
Tr01, T3, u Sg Penarik, tributary of Sg Setiu
Tr01, T4, u Sg Merang, main and link to Sg Bari then Sg Chalok
CFZ NAME: Setiu-Chalok Lagoon
(Kg Mangkok, Kg Penarik, Kg Bkt Chalok, Pengkalan Bkt Chalok, and Kg Merang)
MAP: Unverified firefly site (Sg. Chalok-Sg. Setiu-Sg. Penarik) **Setiu-Chalok Lagoon**

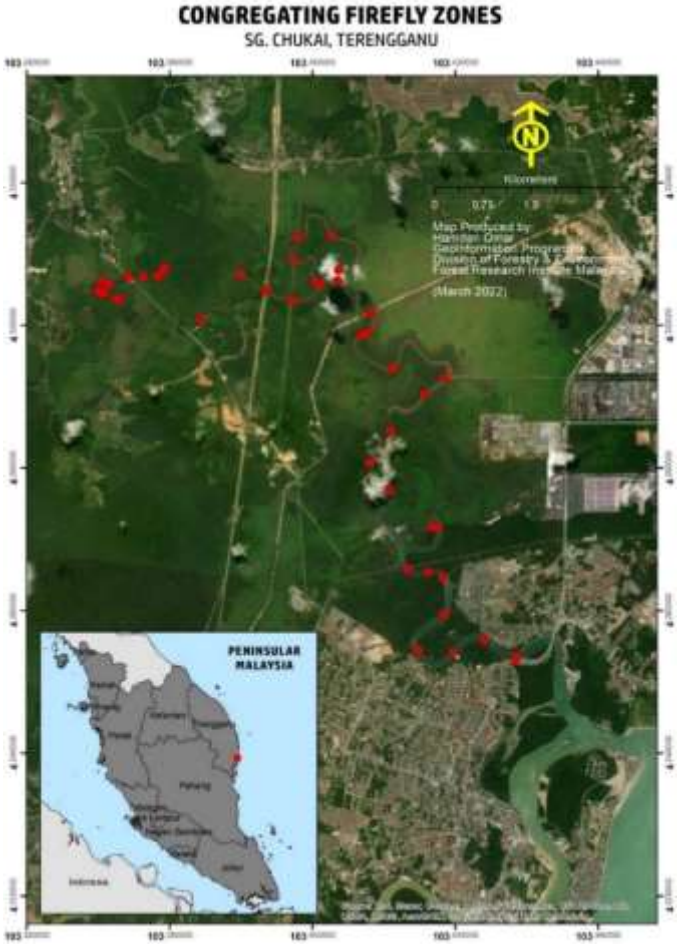


CFZ DESCRIPTION:
Firefly habitat:
1). elongated sand spit, with mangrove forest and beach, still relatively untouched.
2). not surveyed
3). villages behind degraded peat swamp forest river reserves (MNS survey 2009/10)
4). sandy spit, bunded, sandy beach vegetation
5). not surveyed
Firefly occurence: Sungai Setiu-Chalok and tributaries;
1). In the old days, there are more on the Berembang on the sand spit, now shifted to the other side and patchy (Dino, WWFM, 1992). Did not survey due to rain, so localities is unknown. (MNS 2009)
2). Bridge site, where the TNB high tension pylons are are the best site in the area (anectdotal)
3). Sg Chalok River (5°35'41.5"N, 102°49'10"E)–3 *Acacia mangium* trees with 20-30 fireflies at the jetty area. After 11pm, the fireflies did not seem to synchronise. (MNS survey 2009/10)
4). Sg. Penarik (5 37'39.2"N, 102 47'33.5"E)- none observed (21/07/2009). Penarik Inn operator mentioned due to land clearing of *Melaleuca* Forest (MNS survey 2009/10)

5). not surveyed
Firefly species: non synchronous and synchronous
For 3). *Pteroptyx malaccae* (Jamal A, UMT thesis, 2007); looks darker, a bit similar to *P. tener* (MNS survey (2009/10))
Display trees: (*Api2 menjalar, nipah, bebaru-Talipariti, jambu air, Berembang*) patches (pers. Comm.)
For 3). *Acacia mangium/ Melaleuca*.
Other firefly: N.a.
Land use and Threats Weirs for flood mitigation and for water supply, cutting of channel at the spit to build jetty for berthing at the Setiu lagoon, fishing boats create wave erosion, chalets on the spit, pollution, fish farm, river deposit at channel; 1,000 ha integrated Shrimp Aquaculture Park (I-Sharp Aquaculture) at Sg Chalok
Conservation measures: Setiu Wetlands State Park in December 2017, turtle sanctuary With the size of 23,000 hectares, Setiu Wetlands is the largest natural wetlands in the East Coast. 432 hectares has been declared as Setiu Wetlands State Park (another 1,088 hectares will be gazetted in phase two).
Firefly watching: Fishermen; as and when needed through
1. Ping Anchorage with a Kg Mangkok chalet; 2. Mayang Sutera Beach Resort, Marang (Fishing boat Class A to Sg Nyatoh); 3. JourneyMalaysia at the jetty or walk along the Sungai Penarik to Penarik Inn
OTHER BIODIVERSITY: Painted and River Terrapin and Green Turtle
NOTES: - Due to rain, only get to observe the fireflies at the Sungai Chalok fishing jetty at around 11pm. None at Sg Penarik (MNS 2009); Influenced by North East monsoon
Other attractions: Lagoon, fishing village, beach, culture, mangroves;
https://www.terengganutourism.com/setiu_wetlands_state_park/experience.htm
REFERENCES: pers. comm: WWFM, Yad from Penarik Inn and Mohd Shahril & Pak Wan (MNS survey (2009/10); Temblyn et. al., (2006))

CFZ CODE: Tr02, s, n,
CFZ NAME: Sg Kerteh, (Sg Betul); Kg Gelugur
CFZ DESCRIPTION:
Firefly habitat: Riverine mangroves, *Melaleuca* Forest and Peat Swamp Forest. Mangroves (*Rhizophora, Aviccenia, Bruguiera* near the estuarine, *Xylocarpus-Nypa,* then *Nypa-Sonneratia-Taliparita- Excoecaria-Renghas*, narrows as it reached the rassau area upstream. Peat, *Melaleuca* and heath forest along the inter-tidal river. Old growths of *Sonneratia* and *Nypa* are relatively undisturbed.
Firefly occurence:
4 31'27.52"N, 103 26'43.9" to 4°33'40.5"N, 103°24'31.8"E (4 31'27.52"N, 103 26'43.9" E to approx. 4 32.40'N, 103 26'25.9"E) *P bearni* begin near the rail bridge and overlaps with (4° 32'58"N, 103°26"E to 4°33'40.5"N, 103°24'31.8"E) *P tener;* ends just after Kg Ranggun at the junction of Sg Batu Puteh.

Further upstream is Kg Batu Puteh upstream and very few fireflies. (pers. comm. with Razali Muda, boatman, MNS survey 2009/10).
Firefly species: *Pteroptyx tener, P. bearni (?) females with faster flashing yellowish lights),,* slow flashing bright whitish blue light- possible *P. valida(*?) Firefly larvae (*P. tener*) at Kampung Ranggun.
Display trees: 27 species (tree preference *Sonneartia caseolaris, Gluta renghas, Taliparíti tiliaceum* (*P tener*), *Xylocarpus granatum* (*P bearni*)) (MNS survey 2009/10)
Other firefly: N.a.
Land use and Threats
Major land use is the Petronas oil refinery area, railway line, Kerteh airfield, disused oil palm and other plantation, villages, canals, jetties, fish farm, and fishing activities.
Erosion on the sand mining banks, high tide, and fast water, which can be more than 10 feet; drainage of peat for development with canals (2009 clearance at Kg Ranggun); Gas flares (light pollution causing night glow) and helicopter flights with wind disturbing the foliage.
Conservation measures: Mangrove Forest Reserve at estuarine, estuarine mangrove replanting by EcoCare community group formed by MNS in 2006.
Firefly watching: during MNS educational activities by EcoCare
OTHER BIODIVERSITY: Otters, Southern pied hornbills, fish owl, dusky leaf monkey, long tail macaque, raptor, kingfisher, river terrapin, mangrove cat snake, phyton, coacal, duck, monitor lizard, cicada season (March 2007),
NOTES: Rare plant *Brownlowia argentata*; coastal hill forest, Bukit Labuhan, beach, fishing villages; firefly population influenced by the North East Monsoon. During March 2007 half moon, fireflies ended up low with few on top.
REFERENCES: (MNS survey 2007,2008, 2009/10), (Jamaludin, R. M. et al, 2007), (Ohba, N & Wong C.H., 2012 in prep); Razali Muda, boatman- MNS survey (2009/10)



CFZ CODE: Tr M3 s,n ; T1 s; T2 s
CFZ NAME: Sg Chukai, Chukai jetty
T1). Sg Ibok, T2). Sg Yakyah, Kg Yakyah jetty area
CFZ DESCRIPTION:
Firefly habitat: Inter tidal mangrove river flowing through nipah swamp forest and fresh water swamp forest. Successions are more distinct, relatively undisturbed. True mangroves at the estuarine. Old growth *Sonneratia* & *Barringtonia* (putat) with *Gluta renghas* and sago palm presence.
Firefly occurence: 4d18mN 103d26m E - 4d34m N, 103d24m E
presence of a blocked channel (nearly ox bow lake) called the Wall (MNS survey 2007, 2008, 2009/10)
Monsoon effects – March 2007 most-abnormal (more fireflies early & mid year.
Firefly species:
Pteroptyx tener (dense colonies), *P. bearni,* a few *P. valida* may be on tall trees
Display trees*: Sonneratia caseolaris, Xylocarpus, Barringtonia, Taliparíti, Gluta*
Other firefly: N a.

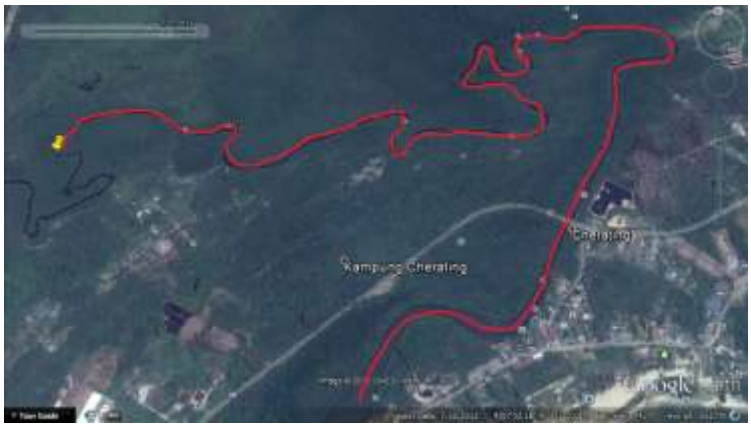
Land use and Threats: The mangroves largely undisturbed except for extraction of mangroves for fuel in an old factory. A canal was dug at a loop reducing the distance travel for delivering products. Remnants of the hand dug canal and factory still around.
During March 2007 visit, the new tourist site at Kg. Ibok beside the bridge is cleared for parking, amenities, water monitoring tower, office, jetty and boat skid. Boats parked under bridge. No electricity and water. Sign board beside the road. During the 2009 visit, infrastructure under renovation and bigger bus parking lot.
Conservation measures: Kemaman Mangrove Forest Reserve
Firefly watching: The Ministry of Tourism (Trengganu) promoted the area together with the Chukai Town Council, Kampung Ibok and Kampung Yakyah JKKK. Ping Anchorage also brings in visitors.
OTHER BIODIVERSITY: Hornbills, long tailed macaque, annual emergence of cicada (greenish in colour) on a long stretch of Melaleuca trees
NOTES: Historical, mining, fishing village, beach; a 1921 settlement after the Orang Asli were resettled
REFERENCES: MNS survey (2009/10)

CFZ NAME	Sungai Dungun and T1 Sg. Rajawali, T2 Sungai Pimpin	Sungai Paka, Kampong Durian Mentangau	Sungai Kemaman, Kg Durian Mentangau
CODE	Tr04, T1,T2, u	Tr05, u	Tr06, u
LOCATION MAP			
DESCRIPTION			
Firefly habitat	Estuarine mangroves	Riverine mangroves	Riverine mangroves
Firefly occurrence	4d39m27sN, 103d24m16sE	4d39m27sN, 103d24m16sE	N.a.
Firefly species	N.a.	N.a.	Much reduced (pers.comms. with village fishermen)
Display trees	N.a.	N.a.	N.a.
Other firefly	N.a.	N.a.	N.a.
Land use and threats	N.a.	Much river reserves cleared for plantation and village expansion.	much river reserves cleared for plantation and village expansion.
Conservation measures	N.a.	Riverbank rehabilitation	Riverbank rehabilitation
Firefly watching	N.a.	N.a.	N.a.
OTHER BIODIVERSITY	N.a.	N.a.	N.a.
NOTES	Future survey	Did not survey.	Did not survey.
REFERENCES	pers. comm. with locals. MNS survey (2009/10)	Pers.comms. with Pak Yop, Kg Paka fisherman (MNS survey (2009/10); and www.myadha.blogspot.com/ 2008/09/khazanah-sungai-paka	Pers. comm.with locals MNS survey (2009/10)

Tr04 Sungai Dungun

Tr05 Sungai Paka

PAHANG



CFZ CODE: Ph01, n
CFZ NAME: Sungai: Cherating, Kg Cherating
MAP: CFZ map of Sungai Cherating by Sonny Wong/MNS
CFZ DESCRIPTION:
Firefly habitat: Intertidal mangrove river and estuarine. Relatively undisturbed sheltered by Tanjung Cherating. Predominantly *Rhizophora-Bruguiera*, few nipah, no *Sonneratia.* Firefly colonies: From the estuarine to the big bend of the river.
Firefly occurrence: 4d07m38s N, 103d23m28.2s E -4d07m56.1s N, 103d22m45.3s E
Firefly species: .*Pteroptyx bearni*
Firefly display trees*: Bruguiera, Rhizophora, Ceriops, Aviccenia, Xylocarpus.Lumnitzera, Achanthus*
Other firefly: N.a.
Land use and Threats: coastal highway cuts through the mangrove forest reserve. Expansion of Kampung Cherating and agriculture plantations. Firefly guides using torch to call fireflies.
Conservation measures: Sungai Cherating Mangrove Reserve
Firefly watching: managed by Hafiz Cherating
OTHER BIODIVERSITY: Oriental pied hornbill, monitor lizards, kingfisher, mangrove cat snake and recticulated pythons coiled around the trees
NOTES*:* A good non-synchronous firefly site. More fireflies in January after the monsoon (pers. comm. with Hafiz).
REFERENCES: MNS survey (2008, 2009/10)

CFZ code: Ph02, n
CFZ NAME: Sungai Balok, Kg Balok Lama
CFZ DESCRIPTION:
Firefly Habitat: intertidal mangrove river.
Firefly occurence: 3d56m59.9s N, 103d21m54s E - 3d56m42.8s N, 103d22m16s E (patchy colonies, fallen trees prevented from going upstream).
Firefly species: non synchronous fireflies
Firefly display trees:N.a.
Other firefly: N.a.
Land use and Threats: housing projects.
Conservation measures: N.a.
Firefly watching: N.a.
OTHER BIODIVERSITY: N.a.

NOTES: N.a.
REFERENCES: MNS survey (2009/10)
CFZ CODE: Ph03, u; T1, s
CFZ NAME: Sungai Kuantan, Majlis Perbandaran Kuantan jetty (main)
T1). Sungai Belat, upper tributary, in the sub urban of Kuantan, from the Pekan highway bridge

CFZ DESCRIPTION.

Firefly habitat: Intertidal mangrove river. Sungai Belat, one of the main tributary of Sungai Kuantan, has more firefly colonies than the main river. Nipah-*Sonneratia-Taliparitii* vegetation

Firefly occurrence: Sungai Kuantan: patchy colonies after the jetty to Sg Belat (pers comm.).

Sungai Belat: 3d45m43.4s N, 103d16m17.1s E -3d45m47s N, 103d16m23.4s E (one kilometer)

Firefly species: Sungai Kuantan: (Pers. comms. with Veronica Khoo), *P tener , P malaccae*

Sungai Belat: *Pteroptyx tener*, *P malaccae, P bearni* (pers comms Veronica)

Firefly display trees: Sungai Belat: Fireflies on many *Nipah* palms which is uncommon.

Other firefly: N.a.

Land use and Threats: Sungai Kuantan:expansion of Kuantan sub urban and agriculture.

Sungai Belat: Fishermen cutting *berembang* to make *unjam (fish trap)*, oil spill; Illegal housing, rubbish

Conservation measures: N.a.

Firefly watching: Sungai Kuantan: Managed by local tours and promoted by Majlis Perbandaran Kuantan; Sungai Belat: Managed and promoted by Majlis Bandaraya Kuantan..

OTHER BIODIVERSITY: Sungai Belat: Estuarine crocodile

NOTES: Sungai Kuantan: from website, newspaper and heard from MNS Pahang members
Sungai Belat: FRIM, UKM; other foreigners did come and study (pers comm..boatman)

REFERENCES: Sungai Belat: MNS survey (2009/2010)

CFZ CODE: Ph04, s, n
CFZ NAME: Kuala Sungai Pahang (Pulau Miseh and Pulau Bijeh; UMP Lake), Kampong Bahrum
CFZ DESCRIPTION

Firefly habitat: estuary, coastal brackish, mudflats (islands). The river mouth of Sungai Pahang and mangrove islands. The river mouth is brackish due to the volume of freshwater from the biggest river in the Peninsular Malaysia. It is shallow with depositions of sand. The are mangroves *Avicennia-Rhizophora,* a small patch found near the river mouth at the and at Tanjung Agas South of the river. Islands are thick with *Sonneratia.* Most of the river bank has a thin layer of mangroves or riparian forest or none. According to the villagers most of the islands are relatively untouched. Only one island was planted with coconuts including a coconut factory now abandoned and mangroves regrown back.

Firefly occurrence: 3d31m00.7s, 103d26m47.5s) (Islands); 3d31m02.7s N, 103d26m25s E (UMP Lake).; and bridge of Pekan town to the rivermouth mangrove islands.

Firefly species: synchronous and non-sychronous *Pteroptyx* fireflies and two unknown species.

Firefly display trees: *Sonneratia* sp.

Other firefly: N.a.

Land use and Threats: Possible threats from the dredging of sand at the river mouth. There are during the survey 11 sand mining barges along the river, with their bright spotlight working 24 hours a day disturbing many parts of the firefly area. The riverbanks are cleared in most places except for the Sungai Miang Forest Reserve is being developed now. Shrimp farm with its spotlight on the northern banks at the river mouth. Lights from the Pahang bridge and buildings all along the river side. Island development. Bunding of Pekan town area.

Conservation measures: N.a.

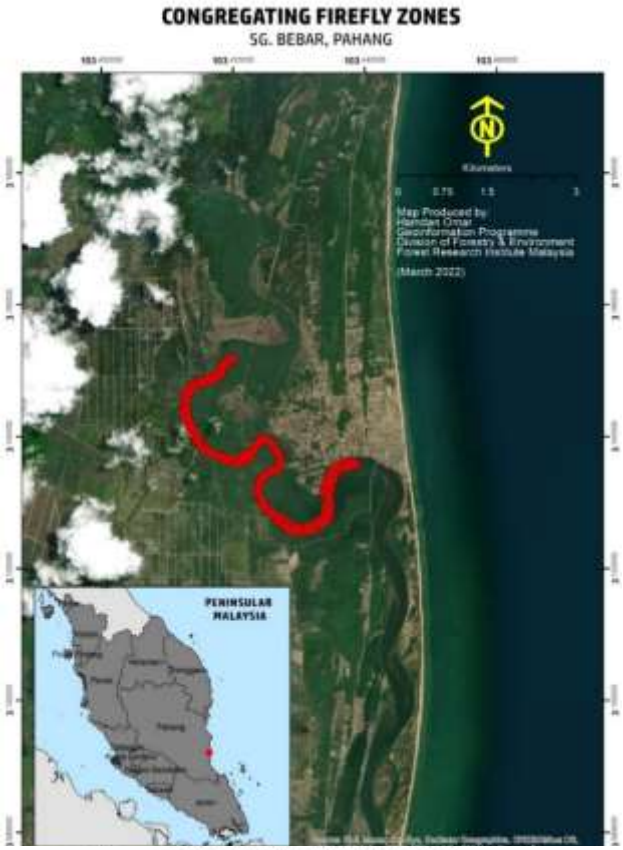
Firefly watching: N.a.

OTHER BIODIVERSITY: heronry on one mangrove island (Pulau Bangau), abandoned factories on the mangrove islands.

NOTES: Endemic *Aviccenia lanata* (DWNP,1987)

REFERENCES: MNS survey (2009/10)

CFZ CODE: Ph05,s, n,
CFZ NAME: Sungai Bebar, Kampong Nenasi
CFZ DESCRIPTION
Firefly habitat: intertidal river going through lowland peat swamp forest.
Firefly occurrence: 3d09m05s N, 103d25m11.8s E - 3d08m01.8s N, 103d26m07.1s E (survey cut short due to thunderstorm approaching)
Firefly species: synchronous and non-synchronous *Pteroptyx* sp.
Firefly display trees: *Excoecaria agallocha, Avicenia* sp.*, Sonneratia* sp.
Other firefly: N.a.
Land use and Threats: oil palm plantations upstream, logging, flood mitigation, aquaculture ponds, solid waste, lights
Conservation measures: relatively undisturbed
Firefly watching: rarely, used to be by Summerset Resort (closed down)
OTHER BIODIVERSITY: N.a.
NOTES: orang asli villages, beach, peat swamp forest, fishing
REFRENCES: MNS survey (2009/10)



CFZ CODE: Ph06, s, n
CFZ NAME: Sungai Merchong, Kampong Merchong
CFZ DESCRIPTION
Firefly habitat: intertidal river going through lowland peat swamp forest
Firefly occurrence: 3d1m37.3s N, 103d25m14.7s E – 3d0m21s N, 103d25.m59.4s E (more after the bridge)
Firefly species: synchronous and non-synchronous *Pteroptyx* firefly
Firefly display trees: *Sonneratia ovata*
Other firefly: N.a.
Land use and Threats: aquaculture farms and light pollution, padi fields, oil palm plantations and logging upstream
Conservation measures: N.a.
Firefly watching: Summerset Resort (closed)
OTHER BIODIVERSITY: estuarine crocodiles
NOTES: good synchronous firefly displays at Sungai Jong nearby (pers.comm. with Kuala Pontian fosherman); off road ATVs; fishing
REFRENCES: MNS survey (2009/10)

CFZ CODE: Ph07 s , n

CFZ NAME: Sungai Rompin, KampongLeban Chondong, Kampong Samak, Kuala Rompin

CFZ DESCRIPTION

Firefly habitat: intertidal mangrove river. *Rhizophora-Bruguiera-Taliparíti-Nypa-Sonneratia*

Firefly occurrence: 2d54m29.8s N, 103d24m14.7s E – 2d51m36.1s N, 103d25m46.8s E

Fireflies before the bridge to (MNS, 2009)

Firefly species: non-synchronous and synchronous *Pteroptyx* firefly

Firefly display trees: *Thespesia* sp., *Sonneratia, Taliparíti, Acanthus, Aviccenia.*

Other firefly: N.a.

Land use and Threats. Bank erosion, intensive water usage and pesticides from padi fields, lights from roadside, bridge and buildings

Conservation measures: Mangrove reserve

Firefly watching: Summerset (closed) & Lanjut Golf and Beach Resort. Contracted out to local boatmen at Sg Merchang and Sg Rompin

OTHER BIODIVERSITY: southern pied hornbills, cicadas, crocodiles

NOTES: Attractions include- Resort, beach, peat swamp, birding, fishing village. Pers.comm. with boatman the CFZ ends at Kampung Tanjung Tengku and Pantai Bernas but according to Wong Foot Jaw, MNS, it ends at Lanjut Resort

REFERENCES: MNS survey (2009/10)

CFZ CODE: Ph08, s, n

CFZ NAME: Sungai Pontian, Kuala Pontian

CFZ DESCRIPTION

Firefly habitat: intertidal mangrove river going through swamp forest

Firefly occurrence: 2d45m9.4s N, 103d27m55.6s E –2d45m53.1s N, 103d31m24.2s E (estuarine to weir)

Firefly species: synchronous and non synchronous *Pteroptyx* firefly

Firefly display trees: *mengkadang or Api-Api, Sonneratia caseolaris, Excoecaria, Taliparíti, Nipah*

Other firefly: N.a.

Land use and Threats: dam, fishing, expansion of villages, plantations, rice fields, forest produce, lights from buildings and bridge.

Conservation measures: mangrove forest reserve

Firefly watching: N.a.
OTHER BIODIVERSITY southern pied hornbills, egrets, herons, kingfisher, patin, siakap, prawns, crocodiles, empangan Pontian/ Manong (weir)
NOTES: the wier destroyed part of the firefly habitat
REFERENCES: MNS survey (2009/10)

CFZ CODE: Ph09; and Ph10, u
CFZ NAME: Sungai Mentawak and Sungai Barok, Pulau Tioman
MAP: N.a.
CFZ DESCRIPTION
Firefly habitat: mangrove on fallen boulders
Firefly occurrence: N.a.
Firefly species: N.a.**Firefly display trees**: N.a.
Other firefly: four adults and one flightless female from the Luciolinae and Lampyrinae sub-families along the Juara-Tekek road
Land use and Threats: N.a.
Conservation measures: Wildlife Reserve and Forest Reserve
Firefly watching: N.a.
OTHER BIODIVERSITY: *Rafflesia,* greater mousedeer
NOTES: pers. comms from Raoof, a former Kampong Juara cook
REFERENCES: the author did not find any congregating fireflies in July 2013

PAHANG-JOHOR

CFZ CODE Ph-Jh, s, n, T1, s, n
CFZ NAME: Sungai Endau Sungai Endau, Kampong Pianggu, Pahang (Pahang / Johor) T1 Sungai Anak Endau, Kampung Sungai Tiong Basah, Pahang (tributary)
MAP: Sungai Anak Endau (left), Sungai Endau (right)
CFZ DESCRIPTION
Firefly habitat: Sungai Endau: intertidal mangrove river. Deep and wide river at the estuary. *Rhizophora, Sonneratia, Bruguiera.* More mangroves on the Johor side than the Pahang side.
Sungai Anak Endau: iintertidal mangrove river; *Sonneratia* dominance, *Taliparitі*
Firefly occurrence: Sungai Endau: 2d38m2.6s N, 103d36m0.6s E – 2d38m35s N, 103d35m39.6s E (extensive upstream, pers comm. with villager)
Sungai Anak Endau: 2d41m15.8s N, 103d35m06s E – 2d 38m59.7s N, 103d35m29.6s E

Firefly species: Sungai Endau:. *P tener* (Ivan Polunin), non-synchronous *Pteroptyx* at the lower stretch; Sungai Anak Endau: synchronous and non-synchronous *Pteroptyx* firefly
Firefly display trees: Sungai Endau: *Sonneratia caseolaris;* Sungai Anak Endau: *S. caseolaris, Talipariti*
Other firefly: N.a.
Land use and Threats: Sungai Endau: padi fields, town and village expansion, shrimp farms, oil palm plantation. Light from factory, jetty, port, town, and buildings. Fisheries, coconut plantation. More land clearance for factories at the Johor side near Endau town (MNS, 2009)
Sungai Anak Endau:power lines, bridge, port, plantation, fishing, lights from buildings, ports, fish farm, aquaculture ponds, and swiftlet house.
Conservation measures: Sungai Endau: upper streams are the Labis Forest Reserve, Endau Rompin National Park; Sungai Anak Endau: N.a.
Firefly watching: Sungai Endau: no longer active due to extensive clearing downstream
Sungai Anak Endau: N.a.
OTHER BIODIVERSITY: Sungai Endau: hornbills, crocodiles; Sungai Anak Endau: N.a.
NOTES: Sungai Endau:historical Kampong Denai; (Pers. comm. with Tok Pak Awang (2010)) land clearings affected the fireflies downstream. The upper stream firefly colonies are extensive reaching Kampong Peta. Survey may take a few days. The survey found that the forested areas have less fireflies than the disturbed forest. The berembang stretches are extensive as Sungai Pahang. Other Pahang rivers are less extensive. Sungai Anak Endau: Crabs and ox bow lakes.
REFERENCES: MNS survey (2009/10)

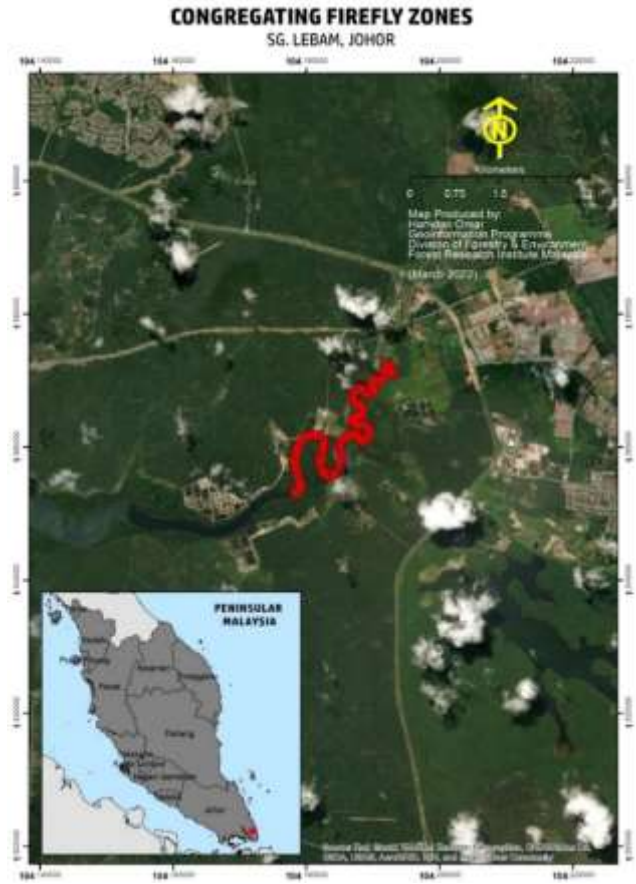
JOHOR

(table overleaf)

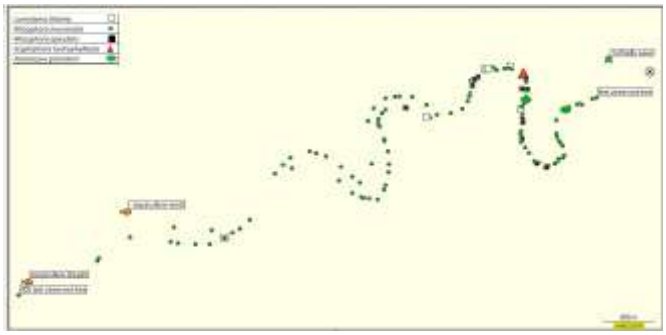
CFZ CODE	CFZ NAME	JOHOR - CFZ DESCRIPTION								OTHER BIODIVERSITY	NOTES	REFERE
		Firefly habitat	Firefly occurence	Firefly species	Firefly display trees	Other firefly	Landuse and Threats	Conservation measures	Firefly watching			
Jh01, u	Sungai Sedili Besar	mangrove river-swamp forest.	N.a.	N.a.	N.a.	N.a.	bunding for flood mitigation	N.a	presence	N.a.	N.a.	MNS s (2009/10
Jh02, u	Sungai Sedili Kecil, Sg. Kangkar	mangrove river-swamp forest.	N.a.	N.a.	N.a.	N.a.	Bunding for flood mitigation; shrimp farms, oil palm	N.a.	Presence	N.a.	N.a.	MNS s (2009/10
Jh03, s, u	Sungai Mawai	N.a.	N.a.	*Pteroptyx tener*	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	Ivan Polu
Jh04, s,u	Bukit Berangan, tributary	N.a.	N.a.	*P malaccae*	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	Ivan Polu
Jh05, u	Sungai Pulai	mangrove estuary	N. a.	N.a.	N.a.	N.a.	N.a.	Ramsar Site	N.a.	N.a.	sea grass, seahorse,S eletar orang asli,	(pers. co late Dr UMT)
Jh06, n, u	Tanjung Piai and Pulau Kukup	Promontory, mangrove island, mangrove fringed coastal flats and canals.	Tanjung Piai-Trail and bund; Pulau Kukup-stream and canals near Kampong Kukup Laut	Non synchronous *Pteroptyx* firefly (re: Johor National Parks)	N.a.	N.a.	Pollution, illegal felling, coastal erosion from ship waves and coastal developments nearby	Ramsar site and State Park	presence	rare and endangered birds; crab eating monkey	Southern most tip of Asia, birding, gula melaka, honey bee	PERHILIT Johor National Parks (MNRE
Jh07, s, n, u	Sungai Benut	Mangrove river	N.a.	*Pteroptyx tener, P. valida (Ivan Polunin)*	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	Pers. co with Tokiman,
Jh08, u	Sungai Muar	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.
Jh09, u	Sg. Kesang	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	presence	N.a.	N.a.	LUAS we
Jh10, s, u	Kupia Labong	N.a.	N.a.	*Pteroptyx tener*	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	Ivan Polu

CFZ CODE: Jh11, s, n
CFZ NAME Sungai Johor (Nam Heng Estate)
CFZ DESCRIPTION
Firefly habitat: Intertidal mangrove river. Upperstream *Sonneratia*. Downstream *Rhizophora, Sonneratia.*
Firefly occurrence: 1d40m49.9s N, 103d56m25.9s E - 1d43m22s N, 103d54m28.9s E (After the highway bridge from Kota Tinggi towards the rivermouth)
Firefly species: Synchronous and non synchronous *Pteroptyx* fireflies (*P. malaccae, P. tener*, Nam Heng (Ivan Polunin))
Firefly display trees: *Taliparitiliaceum, Gluta renghas, Pandanus, Ficus tinctonia* (preference), *Sonneratia,*
Other firefly: N.a.
Land use and threats: Sand mining, flood mitigation, agriculture, light pollution
Conservation measures: Forest Reserve
Firefly watching: Private tourrs, tour agents
OTHER BIODIVERSITY: N.a.
NOTE: Gunung Panti Forest Reserve, prawns
REFERENCES: MNS survey (2008, 2009/10)

CFZ CODE : Jh11, T1, s, n
CFZ NAME: Sungai Lebam
CFZ DESCRIPTION
Firefly habitat: Intertidal mangrove river.
Firefly occurrence: 1d34m16.4s N, 104d11m35.2s E – 1d33m11.1s N, 104d10m41.9s E
Firefly species: synchronous and non synchronous *Pteroptyx* firefly
Firefly display trees: *Sonneratia ovata, S. caseolaris, S. alba*
Other firefly: N.a.
Land use and Threats: . Aquaculture ponds, factory ash, *rumah rakits* lining riverbank.
Conservation measures: Forest Reserve
Firefly watching: Presence of private operators
OTHER BIODIVERSITY: dugong, grey heron, lesser adjutant, milky stork, white bellied sea eagle, common sandpiper, mangrove pitta, mangrove blue fly catcher, water monitor, oyster, otter, leaf monkey, pig tailed macaque, hornbill, and mullet.
NOTES: Tangkol fishing, fishing, prawns, double decker boat, blue tears.
REFERENCES: MNS survey (2008, 2009/10)



CFZ CODE : Jh11, T2, n
CFZ NAME: Sungai Raya, tributary of Sungai Belungkor
MAP a display tree map by Sonny Wong
CFZ DESCRIPTION
Firefly habitat: Intertidal mangrove river.
Firefly occurrence: 1d28.688m N, 104d04.679m E – 1d29.115m N, 104d05.928m E; 124 trees



Firefly species: non synchronous *Pteroptyx* firefly, probably *P. bearni;* a few firefly colonies in Sg. Belungkor. Pers. comm. with Linting villager, Sg. Ambat with firefly colonies.
Firefly display trees: *Rhizophora mucronata (preference) Lumintzera littoral, R. apiculata, Scyphiphora hydrophyllacea. and Xylocarpus granatum*
Other firefly: N.a.
Land use and Threats:. mangrove thinning, agriculture, quarry expansion at Belungkor.
Conservation measures: Belungkor mangrove Forest Reserve
Firefly watching: N.a.
OTHER BIODIVERSITY: N.a.
NOTES: relatively undisturbed narrow river
REFERENCES: MNS survey (2014)

MELAKA –NEGERI SEMBILAN

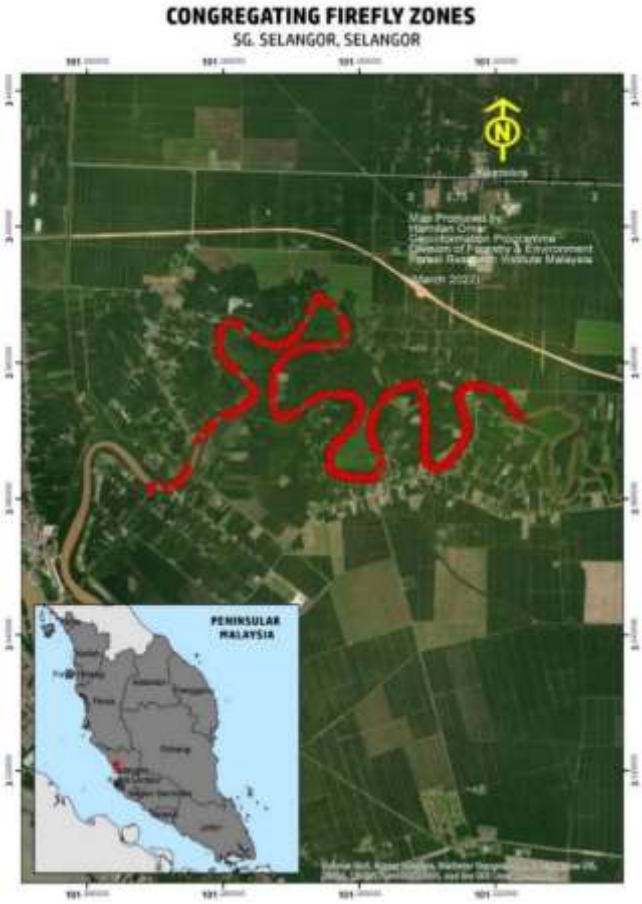
FZ CODE: Mk-Ns n, s ; T1, T2
CFZ NAME: Sungai Rembau (Negeri Sembilan (NS)/ Melaka border) Called Sungai Rembau in Melaka & Sungai Timun in Negeri Sembilan. Tributary: Ramuan China Besar (T1) (Melaka); Ramuan China Kecil (T2) (Melaka)
CFZ DESCRIPTION
Firefly habitat: *Rhizophora apiculata, Sonneratia caseolaris, S. alba, nipah, Oncosperma* sp, palms, ferns (Melaka / NS). Wide river, tall matured berembang, broken up by nipah or behind nipah stretches; R*hizophora* sp (NS)
Firefly occurrence: 2d26m05.8s N, 102d03m14.3s E – 2d25m45.1s N, 102d3m1.41s E

Sungai Rembau (9km, 87 trees, NS / Melaka); Sungai Ramuan Cina Besar(3km, 13 trees, Melaka); Sg Ramuan Cina Kecil (0.7km, 20 trees, Melaka).
Firefly species: *Pteroptyx tener, P.valida*
(Melaka / NS); *P. tener, P. malaccae (*voucher- -FRIM) (NS)
Firefly display trees: *Sonneratia caseolaris, Hibiscus tiliaceus, Rhizophora* sp (display trees) 130 trees
Other firefly: N.a.
Land use and Threats: dam upstream, river deepening damaged Sungai Rembau Melaka side
Conservation measures: Proposed Linggi Mangrove park (Melaka)
Firefly watching: Kampong Sungai Timun firefly komuniti (Negeri Sembilan)
OTHER BIODIVERSITY: Estuarine Crocodile, intermediate egret, seafish, ray, jellyfish
NOTES: Pengkalan Kempas museum, old historical port 1940-50s, Kuala Linggi, udang galah
REFERENCES: UPM(2009), MNS survey (2009/2010)

NEGERI SEMBILAN

CFZ CODE: Ns01, s
CFZ NAME: Sungai Linggi
MAP: N.a.
CFZ DESCRIPTION
Firefly habitat: inter-tidal mangrove river
Firefly occurrence: Sungai Linggi (3km) 10trees (NS)
Firefly species: *P. tener, P malaccae* (voucher-FRIM) (NS)
Firefly display trees: *Sonneratia caseolaris, Hibiscus tiliaceus, Rhizophora* sp (display trees)
Other firefly: N.a.
Land use and Threats: Solid waste pollution, Deepening river destroyed Sungai Linggi (NS)
Conservation measures:Wildlife reserve for estuarine crocodile in 2003 , Forest Department to gazette buffer zone.
Firefly watching: N.a.
OTHER BIODIVERSITY: Estuarine Crocodile, udang galah
NOTES: Pengkalan Kempas museum, old historical port 1940-50s Kuala Linggi
REFERENCES: UPM(2009), MNS survey (2009/10)

SELANGOR



CFZ CODE: Se01, s,n
CFZ NAME: Sungai Selangor
Firefly colonies: Long stretch 12-18km of young mature trees, good density in stretches from Kg Sepakat to Pulau Derhaka (MNS 1996, 2001, survey 2009/10)
CFZ DESCRIPTION
Firefly habitat: Mangrove River- *Sonneratia caseolaris, nipah, Metroxylon (sago)*
Firefly occurrence: 3d22m19.1s N, 101d19m25.6s E – 3d21m41s N, 101d6m09.9s E (did not go upstream to Kg Asahan for the firefly colony). Firefly larvae site: Sago palm- nipah area (main area((FRIM) and durian and mangosteen. *Cyclotropis carinata* snail, prey for the firefly larvae
Firefly species: Synchronous firefly: *Pteroptyx tener, P malaccae* (very few) (MNS 2001). Non-synchronous firefly
Firefly display trees: *Sonneratia caseolaris* (main); Durian, Mangosteen (others) (MNS 2001)
Other firefly: *Pyrocoelia* sp. (MNS,2001) in oil palm estates
Land use and Threats Core area destroyed in November 2008 and early 2009; Tanjung Beluntas and Tanjung Kg Nyior (2007). In 2010 latest land clearing at Kg Sarang Lang (70% cleared); pollution, tourism practices, salt intrusion upstream
Conservation measures: Zone of Protection (Section 48) LUAS Enactment 1999 Selangor Gazette 2 July 2009 for fireflies protection
Firefly watching:
1. Kampong Kuantan; Promotion by Ministry of Tourism. Well known locally & oversea
Old management:-1971- Klip Klip Trading, MNS helped formed
New Management : Majlis Daerah Kuala Selangor (1996); Villagers uses traditional row boats
2. Bukit Belimbing : BB Firefly Park Resort uses electric engine boats
OTHER BIODIVERSITY: starworm *Diplocladon* sp, crocodile, pangolin, leaf monkeys, otters
NOTES:KSNP, historical town, seafood, padi fields, IBA site, Malay village, Peat swamp, agriculture park, fishing village, oil palm
REFERENCES 1960s James Case, Ivan Polunin, MNS (1996/7), MNS (2000/01), MNS survey (2009), FRIM

CFZ CODE: Se02, n,
CFZ NAME: Kuala Selangor Nature Park (KSNP), estuarine of Sungai Selangor (south bank)
CFZ DESCRIPTION
Firefly habitat: Secondary forest, scrub and mangrove ferns and introduced species
Firefly occurrence: Around the lagoon 3d20m13.3s N, 101d14m16.4s E

Colophotia sp. and *Pteroptyx valida* fireflies displayed on trees around the KSNP brackish lake (Wong (2012)). After the lake turned ino a lagoon, the fireflies vanished. Remnant population are found in
other areas around KSNP.

MAP: fireflies displayed on trees around the lake by Sonny Wong/MNS 2011)
Firefly species: .Non-synchronous: *Pteroptyx valida*; *Colophotia* sp.
Firefly display trees: *Acacia mangium* (main); *Bintangor* (main); *Ficus sp* (others) emerged from grass to the trees, larva on grass and tree trunks.
Other firefly : *Pyrocoelia* sp. (entrance trail)
Land use and Threats: Yearly canal clearing; freshwater lake became a lagoon
Conservation measures: Forest Reserve, IBA, part of Banjar Selatan Mangrove Reserve (proposed to be regazetted), Proposed as a Ramsar site.
Firefly watching: N.a.
OTHER BIODIVERSITY: Starworm *Diplocladon*, glowing snail (*Quantula striata);* glowing mushrooms, glowing zooplanktons*,* smooth otter, hairy nose otter, small clawed otter, silvery langur, long tailed macaque, wild boar, pangolin
NOTES: Birdwatching, historical town, Sg Selangor firefly watchng, seafood, rice field, fishing village
REFERENCES: Wong (2013)

CFZ NAME	Sungai Sepang Kecil	Sungai Langat, Bukit Jugra	Rambai, Kg Kurau, Pulau Carey	Sungai Buloh
CODE	Se03, u	Se04, u	Se05, u	Se06, u
LOCATION MAP	N.a.	N.a.	N.a.	N.a.
DESCRIPTION				
Firefly habitat	Mangrove river	Mangrove River. *Taliparititiliaceum,*	Mangrove river	Mangrove river
Firefly occurrence	Small area	few at Kg Jugra	N.a.	N.a.
Firefly species	N.a.	*P asymmetria* (Ivan Polunin)	N.a.	N.a.
Display trees	N.a.	N.a.	N.a.	*Sonneratia*
Other firefly	N.a.	N.a.	N.a.	N.a.
Land use and threats	cleared in 2009 by DID for flood mitigation	land clearance, mangrove thinning especially on the Pulau Carey. Factories and land use after Kg. Jugra.	Plantation expansion	Solid waste
Conservation measures	**N.a.**	**N.a.**	N.a.	N.a.
Firefly watching	**N.a.**	N.a.	N.a.	N.a.
OTHER BIODIVERSITY	**N.a.**	N.a.	N.a.	Heronry, waterbirds
NOTES	N.a.	Bukit Jugra historical site	MahMeri people.	Sky mirror, cockle spat
REFERENCES	MNS survey (2009/10)	MNS survey (2009/10)	Pers. comm. with villager	Local media

SELANGOR-PERAK

CFZ CODE: Se-Pk , s, n
CFZ NAME: Sungai Bernam
MAP: this may be the best firefly stretch
CFZ DESCRIPTION
Firefly habitat: Intertidal Mangrove River/ Riparian/ Plantation. *Rhizophora-Sonneratia* stretches near the estuarine, then nipah; then *Sonneratia* followed by mixed *Nipah-sonneratia* patches then *Nipah.*
Firefly occurrence: 3d52m06s N, 100d, 56m46.7s E –3d51m59.2s N, 100d56m13.3s E Fragemented mangroves from the estuarine to Sabak Bernam (MNS survey (2009/10)
Firefly species: Synchronous Firefly: *Pteroptyx tener* and *P malaccae* (Rasaintharan); and possibly two different non-synchronous fireflies observed (estuarine at Perak side)
Firefly display trees: *Sonneratia caseolaris* (preference tree),
Other firefly: N.a.
Land use and Threats Land clearing, oil palm estates, light pollution
Conservation measures: N.a.
Firefly watching : Kg Sungai Air Manis homestay
OTHER BIODIVERSITY: Otters
NOTES: the author has observed fireflies on *Sonneratia* trees along the riverside in Sabak Bernam town
REFRENCES MNS survey (2009, 2010)

PERAK

CFZ CODE: Pk01 s, n ; T1,u ; T2, u; T3, s; T4, s, n;
CFZ NAME: Sungai Perak
T1 Sungai Sumum and T2 Sungai Rebana (not surveyed)
T3 Sungai Dedap
T4 Sungai Bidor
CFZ DESCRIPTION
Firefly habitat: Intertidal Mangrove River/ Riparian/ Oil palm plantation right up to the banks with sometimes a single mangrove tree full of fireflies
Firefly occurence:
Sungai Perak 3d59m27.3s N, 100d45m25.7s E - 4d03m17.6s N, 101d01m00.8s E
A very wide river reaching over a kilometre from each banks at the rivermouth where the fireflies are Sparse with other type of fireflies. The mangroves are discontinuous in many parts. The firefly stretches are found along the 66.44 km from the rivermouth at Bagan Datuk to Teluk Intan suburbs.

The mangroves layers are thicker at the lower stream, compared to single mangrove layer or even single mangrove trees in broken stretches upstream, the fireflies dwindled due to loss of vegetation, mainly due to erosion and oil palm plantations. However, surprises of getting a whole mangrove tree covered with fireflies occurred in the badly degraded mangroves at the upperstream.

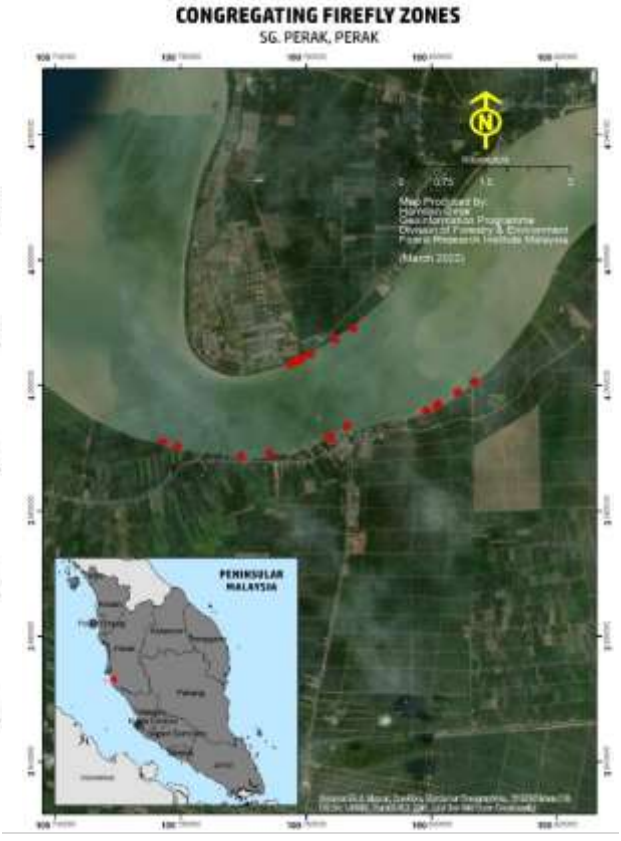
T3) Sungai Dedap 3d20m13.29s N, 101d14m16.37s E – 3d57m55.89s N, 100d52m51.57s E

The boatman is afraid of the crocodile infested tributary and turned back.

T4) Sungai Bidor 4d00m37.73 N, 101d04m35.74s E – 4d01m31.85s N, 101d01m31.85s E

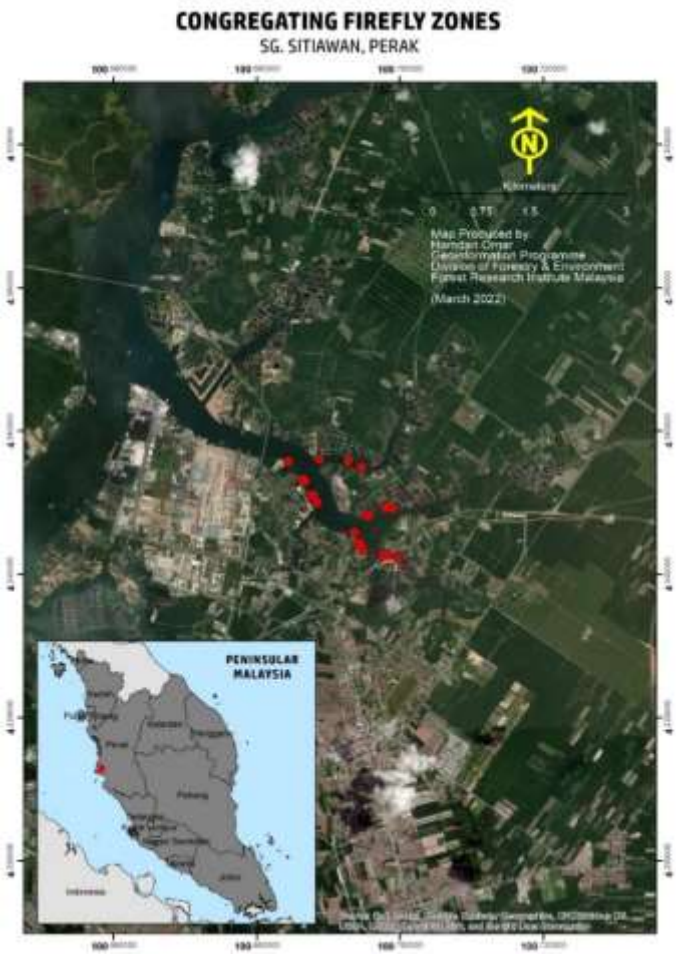
Very good firefly colonies and did not go furtherdue to navigation difficulty.

There are many tributaries with firefly colonies. The 2009 survey are sampled 6 km from Teluk Intan, Bagan Datuk river mouth and the tributaries of Sungai Dedap and Sungai Bidor. In 2019, the author visited around Teluk Intan and a canal with good firefly stretches.



Firefly species: Sungai Perak - Synchronous (*Pteroptyx tener, P. malaccae* in very small population) and non-synchronous *Pteroptyx* firefly
T1) and T2) used to be firefly watching area
T3). Synchronous firefly
T4). Synchronous and non-synchronous firefly
Firefly display trees: Sonneratia caseolaris (mainly)
Other firefly at the rivermouth mangroves
Land use and Threats
Sungai Perak - Broken stretches of mangroves;Oil palm plantations right up to the river bank; Discharges from palm oil factory, land clearing, urban lights
Sungai Dedap – did not have much disturbances
Sungai Bidor – relative undisturbed, but flood mitigation measures are quite frequent
Conservation measures: Beting Nature Society, Bagan Datuk for local outreach
Firefly watching: Kota Setia, Hujung Rentis (old site); latest in-Teluk Intan (Firefly Marvels)
OTHER BIODIVERSITY: large henronry (Pulau Bangau,Teluk Intan), crcodiles, waterbirds high tide roost.
NOTES : Historical royal Beting Bras Basah jetty, traditional villages, leaning tower (Teluk Intan), largest river in Perak
REFERENCES: MNS survey (2009/10)

CFZ CODE: Pk02 x, u; T1 u;, T2 x;
CFZ NAME: Sungai Dindings, Kampong Sitiawan
T1). Tributary: Sungai Sitiawan
T2). Deralik
CFZ DESCRIPTION
Firefly habitat: Mangrove River –high salinity/ riparian/ expanse ofoil palm plantation and prawn farms); *Sonneratia alba, Aviccenia* trees,
Firefly occurrence: 4d14.886m N, 100d41.723m E
The survey found two individual fireflies in Sungai Sitiawan only. Locals mentioned that the 20 years ago, the fireflies were abundant.
Firefly species: *Pteroptyx asymmetria* and *P. valida* (Ivan Polunin), 2 individual spotted with -yellow light at 2-3 second per flash.
MAP: Please note that the red dots are not the fireflies but survey waypoints.



Firefly display trees: *Avicennia; Sonneratia*
Other firefly:N.a.
Land use and Threats One thin layer of mangroves along the prawn farms and oil palm plantations bordering the remaining mangroves. There are, agriculture, villages, swift houses, light pollution, shooting of wildlife by prawn farrners, pollution discharged by prawn farmers and vegetable growers. The awareness is low. All the rivers are silted up.
Conservation measures: N.a.

Firefly watching: N.a..
OTHER BIODIVERSITY: Large heronrys,
NOTES: Mosquito infested rivers, tremendous decline of firefly and will be extinct soon. There are other tributaries unsurveyed, which can be surveyed in the future. The Kampong Sitiawan is historical. There are beach, wildlife, and recreational fishing.
REFERENCES: MNS survey (2009/10)

CFZ CODE: Pk03, s, n,
CFZ NAME: Sungai Sepetang
CFZ DESCRIPTION:
Firefly habitat: Intertidal Mangrove River/ Riparian vegetation: *Sonneratia caseolaris, Rhizophora* sp; *Bruigueria Nypa fruicans; Acrostichum aureum;* mangrove tree still intact, good thick stretch upstream more than 10 years ago.
Firefly occurrence: 4d52m45.38s N, 100d38m02.05s E – 4d54m27.72s N, 100d39m44.76s E
300m downstream from Kg Dew bridge and 8km downstream near the pylons
Firefly species: . Synchronous and non synchronous firefly; *Pteroptyx tener, P. assymetria*
Firefly display trees: *Sonneratia caseolaris* (about 60% of the vegetation)
Other firefly: N.a.
Land use and Threats: illegal clearing of mangroves, prawn farm expansion, factorriesand oil palm factory discharge, waves from boat
Conservation measures: IBA, Mangrove Forest Reserve along the river bank proposed by the Forestry Department of Peninsular Malaysia to protect the firefly habitat

Firefly watching: . KECAP fromKampong Dew village; Kuala Sepetang Eco Tourism Association
OTHER BIODIVERSITY: Crocodiles, dolphins
NOTES:wildlife watching, mangrove cruise, fishing village, charcoal kiln, birding, historical town of Kuala Sepetang and Taiping, Eco-education Center, Matang, museums, seafood
REFERENCES: USM, UPM, UKM, MNS (2013)

CFZ CODE:PK04, n
CFZ NAMEi: Bund Choo Keang, Kuala Gula
CFZ DESCRIPTION
Habitat: Mangrove forest, canals, plantation- Oil Palm
Firefly occurrence: 4d55m38s N, 100d27m07s E. mangrove river and canals
Firefly species: . Non-synchronous firefly:

Firefly display trees: Rhizophora
Other firefly: *Pyrocoelia*
Land use and Threats: Annual canal cleaning
Conservation measures: IBA, Mangrove Reserve, Wildlife Reserve
Firefly watching: KALAM and CETA group, Kuala Gula
OTHER BIODIVERSITY: waterbirds, Dinoflagellates; crocodiles (heresay)
NOTES: Kuala Gula; Nature activites, guided tour, fishing village, belacan factory, charcoal factory, cockle farm, birding, oil palm, boat ride, mangrove, coast, Hindu civilisation archaeological site
REFERENCES: MNS survey (2009/10)

CFZ CODE: Pk05, s, n
CFZ NAME: Sungai Kurau
CFZ DESCRIPTION
Firefly habitat: Mangrove Forest (thin buffer) backed by oil palm
Firefly occurrence: 5d00m30.4s N, 100d26m02.3s E – 4d59m23.5s N, 100d27m09.1s E.
Site closer to bridge are no longer there due to bright lights; colony may go up to Lean Seng Estate or more before the new road to Kampung Masjid Tinggi.Most of the upper stretch unsurveyed due to water hyacinths and rain made unnavigable
Firefly species: . Synchronous and non-synchronous: fireflies
Firefly display trees: *Sonneratia caseolaris*
Other firefly: N.a.
Land use and Threats Buffer zones thinning, water hyacinths made unavigable, riverbank encroachment
Conservation measures: Forest Reserve;
Firefly watching: . Potential
OTHER BIODIVERSITY: Crocodiles (hearsay)
NOTES: fishing village, dry fish, fish farm, oil palm, mangrove boat ride, fishing
REFERENCES: MNS survey (2009/10)

<u>Potential CFZs:</u>
Pulau Pasir Hitam, Bagan Cina and Kuala Terong mangrove reserve;
(Pers. comm.wiith Kuala Terong Forest Ranger. and from a website).

PULAU PINANG

CFZ CODE:Pp01, s
CFZ NAME: Sungai Krian, Nibong Tebal, (Byram Estate), Seberang Prai (mainland)
CFZ DESCRIPTION
Firefly habitat: About half a kilometer upstream from Nibong Tebal the vegetation becomes sparse until the the barrage. Longer stretches of *Sonneratia* are found downstream. *Sonneratia caseolaris, S ovata, S alba, Nypa patches, and Taliparti* backed by oil palm plantations and aquaculture ponds. Old *Aviccenia* found along the rivermouth.
Firefly occurrence: 5d09m33.6s N, 100d26m39s E – 5d09m06.3s N, 100d30m01.2s E
The best CFZ in Pulau Pinang.
Firefly species: . *Pteroptyx tener* (MNS survey (2009/10), Pot, (2009))
Firefly display trees*: Sonneratia,Taliparit*i
Other firefly: present
Land use and Threats: Discharge from oil palm factory, solid waste, land clearing, low awareness, opportunist, non responsible tourism; light pollution from swift house. prawn farm, village, and town.
Conservation measures: N.a.
Firefly watching: few local entrepreneur
OTHER BIODIVERSITY: octopus
NOTES: Mangrove, fishing village, seafood, swift house, octopus watching, prewar houses in Nibung Tebal , Penang island, only roundabout with an art deco firefly sculptor
REFERENCES: MNS survey (2009/10)

Potential CFZs:
Balik Pulau: west coast of Penang island (Pers. comm with Heng, local Kerian firefly guide);
Batu Maung: south east coast of Penang Island (historically with *Pteroptyx asymmetria* (Ivan Polunin) most probably extinct);
Sungai Tembus: Seberang Prai (historically with fireflies, since the flood mitigation the fireflies suffered) The author surveyed in 2021 and found small population of fireflies, probably the non-synchronous *Pteroptyx valida*, perched high on a few tall trees.

KEDAH

CFZ CODE: Kd01, n T1, n T2, n
CFZ NAME: Sungai Merbok
T1 Sungai Lallang; T2 Sungai Bedong
CFZ DESCRIPTION
Firefly habitat: mangrove river, tributaries runs into sub-urban area.
Firefly occurrence:
Sg Merbok 5d41m56.9s N, 100d30m17.57s E – 5d41m21.17s N, 100d29m19.51s E
T1) Sungai Lallang 5d41m58.71s N, 100d30m26.55s E (low tide, cannot go upstream)
T2) Sungai Bedong 5d42m37.44s N, 100d30m27.08s E - 5d41m56.9s N, 100d30m17.57s E
very few in Sungai Lallang and along Sungai Merbok, more in Sungai Bedong
Firefly species: . Possible two species of non synchronous firefly
Firefly display trees: *Sonneratia ovata, S caseolaris, Ficus, Rhizophora*;
Other firefly: N.a.
Land use and Threats: Land clearing, villages, oil palm, prawn farm , swift houses
Conservation measures: Mangrove Forest Reserve/ River reserve
Firefly watching: from Sungai Petani Jeti (near Semeling Bridge)
OTHER BIODIVERSITY: monitor lizard, heron, long tailed macaque
NOTES: Mangrove, Merbok Archaeology Museum, Beach
REFERENCES: MNS survey (2009/10)

CFZ CODE:Kd02 , u
CFZ NAME: Sungai Kubang Badak Mangrove Reserve, Pulau Langkawi, Kedah
MAP: N.a.
Firefly occurence: 6d24m09.52s N, 99d43m37.31s E
Not spotted at Sungai Kubang Badak during the survey
Firefly species: . N.a.
Firefly display trees: N.a.
Other firefly: N.a.
Land use and Threats: N.a.
Conservation measures: N.a.
Firefly watching: N.a.
OTHER BIODIVERSITY: N.a.
NOTES: Other unverified spots from pers. comm. with Irshad, MNS): Pulau Jemurok, Jalan Datai lamp posts, Ibrahim Hussein home (no more), Teluk Berembang, Sungai Kilim)
REFERENCES: MNS survey (2009/10), (pers.comm. with Irshad, MNS)

PERLIS

CFZ CODE:Ps01, u
CFZ NAMEi: Kuala Perlis
6d24m26.27s N, 100d08m20.18s E; Not surveyed (pers. comm. with Hymeir, MNS)

SARAWAK

CFZ CODE: Sw01, n (u)
CFZ NAME: Sungai Buntal; Bako-Buntal Bay
CFZ DESCRIPTION
Firefl habitat: riverine mangroves *Rhizophora, Brugueria, Sonneratia, Avicinnea, Nypa*
Firefly occurrence: 1d40m12.91s N, 110d22m20.88s E – 1d38m43.57s N, 110d21m12.45s E
Firefly species: *Pteroptyx bearni*
Firefly display trees: *Sonneratia alba, Avicinnea, Brugueria*
Other firefly: N.a.
Land use and Threats shrimp ponds,
Conservation measures: IBA, EAAFP Flyway Network Site
Firefly watching: Batang Salak jetty, Kg. Semaring Batu
OTHER BIODIVERSITY: Dolphin, waterbirds, proboscis monkey
NOTES: Bako National Park, Mout Santubong, Sejingkat power plant ash ponds waterbird roosting site
REFERENCES: MNS survey (2009/10)

CFZ CODE: Sw2, s, n (u)
CFZ NAME: Sungai Similajau
CFZ DESCRIPTION
Firefl habitat: riverine mangroves on the Similajau National Park side, opposite is oil palm plantation. *Brugueria, Nibong, Nypa, Medang, Nyireh, Bakau, Talipariti*
Firefly occurrence: 3d29m20.5s N, 113d20m31.7s E – 3d30m52.2s, 113d18m21.1s E
Firefly species: *Pteroptyx malaccae, P. tener, possible P. bearni*
Firefly display trees: *Nypa* (many), *bakau, Talipariti,* 54 display trees (MNS survey 2010/11)
Other firefly: N.a.
Land use and Threats: plantation expansion, heavy industry (SCORE), port

MAP: GPS survey map of Sungai Similajau CFZ by Sonny Wong

Conservation measures: Similajau National Park on one river bank, Lambaga Sungai enforcer

Firefly watching: absent (no interst by local fisherman)

OTHER BIODIVERSITY: crocodiles

NOTES: something uncommon fireflies on *Nipah* palm. Fireflies mostly seen on the disturbed side of the river banks,

REFERENCES: MNS survey (2010/11)

Potential CFZs:

Kg Sibu Laut/ Santin, off Telaga Air;
Sungai Hunai (Jangalas);
Sg. Kedulit;
Punang, Kg Punang Jaya (presence of Sonneratia trees); and
Sg. Awat-Awat and Sg. Sundor have more fireflies (pers comm villagers)

Next page in table format

CFZ CODE	CFZ NAME	SARAWAK -CFZ DESCRIPTION								OTHER BIODIVERSITY	NOTES	REFERENCE
		Firefly habitat	Firefly occurence	Firefly species	Firefly display trees	Other firefly	Landuse and Threats	Conservation measures	Firefly watching			
Sw03, s (u)	Sungai Suai (lower)	Intertidal mangrove	3d46m06.4s N, 112d32m14.7s E – 3d47m25.7s N, 113d30m06.1s E	N.a.	29 trees *Sonneratia, bakau, nipah*	N.a.	Oil palm expansion	N.a.	N.a.	crocodile, Black Hornbill	N.a.	MNS survey (2010/11)
	Sungai Suai (upper)	Intertidal mangrove	3d45.374m N, 113d32.092m E – 3d45.992m, 113d36.226m E	N.a.	*Nipah (more)*	N.a.	Oil palm expansion	N.a.	N.a.	Crocodile, Black hornbill	N.a.	MNS survey (2010/11)
Sw04, s	Sungai Teru	Intertidal mangrove, freshwater swamp	N.a.	N.a.	N.a.	N.a.	N.a.	Loagan Benut National Park	N.a.	N.a.	N.a.	MNS survey (2020/11)
Sw05	Sungai Balingian	Intertidal mangrove	2d59m34.6s N, 112d35m21.0s E – 2d55m29.8s N, 112d32m42.8s E	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	MNS survey (2010/11)
Sw06, s	Sungai Sibuti (upper), Kg. Kuala Sibuti	Intertidal mangrove	4d00.414m N, 113d45.581m E – 3d59.679 N, 113d44.117m E	N.a.	19 trees, 3 km *Nipah (more)*	N.a.	N.a.	Sibuti Wildlife Sanctuary	N.a.	crocodile	N.a.	MNS survey (2010/11)
Sw07, n (u)	Sungai Mukah	Intertidal mangrove	2d54m23.4s N, 112d06m12.6s E – 2d53m20.3s N, 112d07m43.1s E	*Pteroptyx valida*	*Sonneratia, nipah*	N.a.	Oil palm expnsion	N.a.	N.a.	Egret heronry	N.a.	MNS survey (2010/11)

Sw08, s, T1, T2	Sungai Miri, T1 Sungai Adong, T2 Sungai Maloi Tributaries not surveyed: Sg.Dalam, Sg. Kebali, , Sg. Kabala,	Intertidal mangrove	4d24.267 N, 114d03.201 E, 4d27/906m N, 4d27.906m N, 114d00.556m E; T1 4d25.558 N, 114d01.582 E – 2d6.027m N, 114d02.112m E; T2 4d24.194m N, 114d02.940m E, 4d24.187m N, 114d02.942 E	N.a.	15 trees (Sg. Miri)	N.a.	Oil palm, urban expansion, light pollution	N.a.	N.a.	Crocodile, egret heronry	N.a.	MNS survey (2010/11)
Sw09	Sungai Raan	Intertidal mangrove	4d14.952m N, 113d55.517m E – 4d15.001 N, 113d55.517m E	N.a.	*18 trees, 2.2km pedada, Nipah, Sonneratia, bakau*	Seen	N.a.	N.a.	N.a.	crocodile	N.a.	MNS survey (2010/11)
Sw10	Sungai Bakam	Intertidal mangrove	4d14.728m N, 113d55.644m E – 4d14.552m N, 113d55.848m E	N.a.	*2 Bamboo tree, 1.2km*	seen	N.a.	N.a.	N.a.	crocodile	N.a.	MNS survey (2010/11)
Sw11	Sungai Nyalau	Intertidal mangrove	3d38.417m N, 113d23.274m E – 3d36.792m N, 113d25.093m E	N.a.		N.a.	N.a.	N.a.	N.a.	crocodile	N.a.	MNS survey (2010/11)
Sw12	Sungai Likau	Intertidal mangrove	11d9.907 N, 113d9.835m E – 2d0.875 N, 113d09.485m E	N.a.	12 trees, 3km	N.a.	N.a.	N.a.	N.a.	crocodile	N.a.	MNS survey (2010/11)

Sw13, T1 , u	Sungai Niah, Kampung Sepupuk T1 Sungai. Sepupuk – not surveyed	Intertidal mangrove	3d51.819 N, 113d45.100m E, 3d52.538m N, 113d42.212m E	N.a.	56 trees T1 (more fireflies, pers. comm. with villager.	N.a.	Riverbanks cleared	N.a.	N.a.	Crocodile, giant prawns	N.a.	MNS survey (2010/11)
Sw14	Sungai Punang	Intertidal mangrove	4d52.357m N, 115d20.951m E – 4d53.129m N, 115d20.760m E	N.a.	26 trees *Sonneratia caseolaris*	N.a.	Logging, oil palm plantation	N.a.	N.a.	N.a.	N.a.	MNS survey (2010/11)
Sw15	Sungai Satap	Intertidal mangrove	N.a.	N.a.	1 tree	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	MNS survey (2010/11)
Sw16	Sungai Bakong	Intertidal mangrove	N.a.	N.a.	None	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	MNS survey (2010/11)
Sw17, s, u	Santubong	N.a.	N.a.	*Pteroptyx malaccae*	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	Ivan Polunin
Sw18, s, u	Rejang-Sibu, Sarikei	N.a.	N.a.	*Pteroptyx malaccae*	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	Ivan Polunin
Sw19, u	Sebuyau / Lupar; Kg Sebuyau	N.a.	N.a.		N.a.	N.a.	N.a.	N.a.	Presence	N.a.	N.a.	N.a.
Sw20, s, n, u	Paya Paloh	N.a.	N.a.	*Pteroptyx malaccae P. bearni, P. tener, P.decolor*	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	Ivan Polunin
Sw21, s, u	Saratok	N.a.	N.a.	*Pteroptyx decolor , P. tener*	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	Ivan Polunin
Sw22, s, u	Limbang	N.a.	N.a.	*Pteroptyx malaccae, P. tener*	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	Ivan Polunin
Sw23, s, u	Pending (Pendang)	N.a.	N.a.	*Pteroptyx tener*	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	Ivan Polunin
Sw24, s, x	Kuching	N.a.	Probably extinct	*Pteroptyx tener*	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	Nobuyoshi Ohba

SABAH

CFZ CODE: Sb01, s, n
CFZ NAME:Sungai Klias, Binsulok, Garama (Beaufort); Kg Garama, Kota Klias jetty, Klias Peninsula
MAP: N.a.
CFZ DESCRIPTION
Firefly habitat: Peat swamp forest and mangrove forest with abundant Sago palm *and Sonneratia caseolaris* is uncommon
Firefly occurrence: a firefly watching hotspot in Sabah due to the firefly diversity
Firefly species: *Pteroptyx malaccae, P. bearni, P. valida, P. tener*
Firefly display trees: *Sonneratia alba, Excoecaria agallocha, Excoecaria indica* (preferred tree), *Rhizophora apiculate (Bangkita), Aviccenia alba, Taliparoti tiliaceum, Glochidion littorale Clerodendrum inerme, Nypa fruticans, Ficus microcarpa, Heritiera littoralis (Dungun)* dominant tree (display tree);
Other firefly : N.a.
Land use and Threats: Timber, mining, agriculture expansion
Conservation measures: Forest Reserve and Stateland, IBA, Klias Peninsula Wetland Reserve
OTHER BIODIVERSITY: proboscis monkey, Borneon gibbon, crocodile , silver langur
NOTES: ,Birding, catch prawn the Bisayah way.
REFERENCES: Kevin Foo, et al (2017), Chey (2004, 2010), The author did a short recce survey in 2013.

Next page in table format

CFZ CODE	CFZ NAME	SABAH -CFZ DESCRIPTION								OTHER BIODIVERSITY	NOTES	REFERENCE
		Firefly habitat	Firefly occurence	Firefly species	Firefly display trees	Other firefly	Landuse and Threats	Conservation measures	Firefly watching			
Sb02, s, n, u	Sipitang	N.a.	N.a.	*Pteroptx tener, P.gelasina, P. gelasin*	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	Ivan Polunin
Sb03, u	Sungai Padas, Weston	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	Weston Nature Park	Presence	N.a.	N.a.	Keong
Sb04, s, u	Likas	N.a.	N.a.	*P. bearni (similis)*	N.a.	N.a.	N.a.		N.a.	N.a.	N.a.	Ivan Polunin
Sb05, x, u	KK Wetlands Center	N.a.	N.a.	1950s extinct	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.
Sb06, u	Sungai Kinarut/ Kawang (20 minutes from Kota Kinablau)	N.a.	N.a.	*Pteroptyx bearni (similis)*	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.
Sb07, n, u	Sungai Mengkabong 45 minute from Kota Kinabalu, Kg. Trayong, Kg. Sebandar, Tuaran	Mangrove river	N.a.	*Pteroptyx gelasina, P. bearni (similis),* an unidentified species	*Scyphiphora hydrophyllacea, Lumitzera littorea, Rhizophora apiculate*	N.a.	Light pollution, , fragmented forest	N.a.	Presence	Otters, long-tailed macaques, civet, slow loris, Lesser frigatebird		Chey (2009)
Sb08, n, u	Kudat Bay	N.a.	N.a.	*Pteroptyx bearni (similis)*	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	Rungus culture	Ivan Polunin

Sb09 n, u	Sg Paitan, Kg Paitan	Mangrove estuarine, banana and coconut groves, Nipa palms	N.a.	*Pteroptyx bearni (similis) (more abundant), P. gelasina*	*Avicennia alba (preferred); Rhizophora apiculate, Scyphiphora, Xylocarpus granatum*	N.a.	N.a.	N.a.	N.a.	Snake infested river	N.a.	Chey (2006).
Sb10	Sugut, Sabang Estate	*Lumintzera littorea*, beside main road	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.
Sb11, n, u	Sungai Sepilok Kecil, Sepilok Besar, Sungai Cina; Sepilok Laut	N.a.	N.a.	*Pteroptyx bearni (similis)* (more abundant); *P. gelasina*		N.a.	N.a.	Sepilok Forest Reserve (1,235ha)	Presence	water birds, mangrove snake, mudskippers, orang utan, Malayan sunbear	N.a.	Chey (2008)
Sb12 s, u	Danau Pitas, Sungai Kinabatangan , Kg Abai	N.a.	N.a.	*Pteroptyx tener* (Ivan Polunin)	*Excoecaria indica* – kelapa hutan (danau Pitas preferred tree) Kampung Abai riverside- *Sonneratia caseolaris Ficus* sp, *Taliparíti* sp	N.a.	Land clearing	N.a.	Presence	N.a.	N.a.	Mahadimenakbar (2003)
Sb13	Semporna-Pegagau-Tawau	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	Ivan Polunin
Sb14, s, n	Sungai Teratak, Beaufort	N.a.	5d19m38.9s N, 115d31m06.7s	*Pteroptyx bearni (dominant), P. malaccae, P.tener*	*Aviccenia* (abundant)	N.a.	N.a.	N.a.	Presence	N.a.	N.a.	Foo (2015)

Sb15, n	Pulau Sakar, off the coast of Lahad Datu	N.a.	Fringing the coast mangrove	*Pteroptyx bearni (smilis), P. gelasina*	*Rhizophora apiculata, Scyphiphora hydrophyllacea R mucronata, R. stylosa*	N.a.	Oil palm expansion, chemical runoff down hill to the mangroves	.N.a.	N.a.	N.a.	.N.a.	Chey (2011)
Sb16, u	Kg. Binsulok, Membakut	N.a	N.a.	N.a.	N.a.	N.a.	N.a.	N.a.	Presence	N.a.	N.a.	Mahadimenakbar

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Appendices

Appendix 1. Watching mangrove fireflies in ASEAN countries

There are many firefly watching sites around this ASEAN region where the congregating mangrove fireflies are found. Map by Sonny Wong,

Historical sites and new sites of mangrove congregation fireflies in Singapore. *Pteroptyx* and *Colophotia* fireflies are found in Singapore. Map by Sonny Wong.

Appendix 2: Watching fireflies responsibly

Like bird watching, there are ethics in firefly watching too. True blue birders do not playback bird songs continuously to attract, catch or trap a lifer bird for photography. So what about fireflyers? Below are some tips on firefly watching along a river, in the forest, parks or fields. Included here are some guidelines on how you be a responsible firefly watching guide.

Gerneral tips on how to enjoy firefly watching whether in a boat or on land :

- Be quiet and not disturb others. Enjoy the fireflies.
- Please do harass, handle or collect the fireflies. Let them produce the next generation of fireflies.
- No smoking, eating and littering while watching fireflies.
- Try not to use mosquito repellant if possible. This chemical may harm the firefly.
- For safety reasons, use a red/blue light torch, or place a piece of blue/red plastic as filter for your torch. Blue/red light normally do not disturb fireflies.
- Watch where you step, always keep to the trail/platform. There may be firefly larva or flightless females or female fireflies laying their egss in the undergrowths.
- For photography, use a digital SLR camera/ smartphone with low light settings for taking firefly light shows. Use a tripod and a self-timer. If on a boat, make sure it is stationary. For macro shots of the firefly, this needs patience and can be very tricky on a boat. Do not take too long to photograph, as it will stress the fireflies.
- Do not be disappointed if you see a few or do not see a firefly especially the non congregating fireflies or solitary fireflies. Some fireflies are seasonal, or come out in specific hours.
- Please do report to the relevant authorities if you see any disturbances to a firefly habitat. E.g. if it is a forest reserve, you refer to the Forestry Department, if it is state land, you refer to the District Officer or District Council.

If you are a firefly watching guide.

These are some guidelines on how to be a responsible firefly watching tour:

- Give a 10-15 minutes briefing before a trip (on fireflies, safetydos and donts, what to bring and not to bring, the time period and what to expectp, and answer questions). A post briefing for discussion and feedback about the trip.
- Practice the safety rules- e.g. wear a 'life jacket' if using a boat. Tell the visitors to stick to the trail or platform, and not walk unguided. Bring a blue/red torchlight and first aid kit.Always place a staff at the back and middle of the group if walking in the forest. Be aware of the surrondings while guiding
- Remind the visitors not to litter, or smoke. Teach them to enjoy the serenity and do not disturb others by making a lot of noise.
- Try not to catch and show the visitors the firefly.
- Teach your visitors the proper way of photographing the fireflies.
- Have good knowledge of other natural phenomenon especially wildlife at night
- Do not smoke during a guiding session

Please do report any disturbances to a firefly habitat to the relevant authorities.

Appendix 3. MNS Firefly Conservation Initiative

The Initiative aims:

- Documentation of key biodiversity areas for fireflies
- Engaging the local communities in responsible firefly watching
- Develop a platform for firefly habitat intrusion reporting and monitoring
- Develop educational and awareness materials and events
- Lobby for firefly conservation
- Network with other firefly groups locally and internationally

When MNS was involved with fireflies?

MNS has been associated with the fireflies since 1970 when the Sungai Selangor congregating fireflies was 'discovered' by our member, the late medical doctor Ivan Polunin. Since then, firefly watching has been a popular nature activity for MNS members in Sungai Selangor.

In 1980s, MNS helped set up a local enterprise called Klip-Klip Trading in Kampong Kuantan, the 'first' firefly watching managed by local community (mainly fishermen), which is now a world famous tourist destination.

Study of the Selangor fireflies by MNS began, when the Selangor State Government consulted us on the potential ecotourism of Sungai Selangor in 1995/96 (MNS, 1996). Between the years 1998-2001, a DEIA requirement on the effects of the Sungai Selangor dam to the fireflies (MNS, 2001).

MNS also involved the local communities e.g. the Sg Selangor communities and the Kampung Dew, Sungai Sepetang, Perak. For promotion and awareness, the first annual firefly festival was held in August 2011 (Wong, 2011).

The important work to recognise firefly sites and diversity started and a firefly sightings by MNS members during their hikes were collected in 1999- 2000 (unpublished). In 2009, the CFZ documentation began. For Sabah and Sarawak, CFZ workshops for MNS Sabah, Miri and Kuching branch together with local institution and government were conducted to create the awareness and help in the firefly surveys. MNS Miri Branch was actively involved in surveying the Northern Sarawak CFZ (MNS Miri Branch, 2011).

Basic research continues with the *Pteroptyx bearni* was conducted in Sg. Kerteh and Cherating, Terengganu in 2010. Habitat mapping and research on three species of fireflies (*Colophotia, Pteroptyx and Pyrocoelia*) in Kuala Selangor Nature Park started in 2011. Other then the congregating fireflies, work started on the other more diverse soilitary fireflies continues like the urban fireflies of Bukit Kiara.

MNS first attended the first 2008 International Firefly Symposium in Thailand. Networking with other countries on firefly conservation were during the IFS. The Second International Firefly Symposium co-organised with FRIM was held in Subang Jaya, Selangor State on the2nd-5th August 2010. Here *the Selangor Declaration* was born. A training course on identification and taxonomy of SEA fireflies was part of the Symposium organized by FRIM to spur firefly research in Malaysia.

In 2017, MNS helped formed the Fireflyers International Network and became the honorary secretary for the network. With the formation of the IUCN SSC Firefly Specialist Group, MNS became the co-chair in 2018.

To learn more about firefly:

www.malaysianfireflies.wordpress.com

www.sarawakfireflies.blogspot.com

Appendix 4: Legal instruments that may help protect the CFZ

- National Land Code (1965), Section 62- river reserves establishment and prescription/conditions in land development by State Authority (Peninsular Malaysia); section 13-..reserves of 50 meter from river bank
- National Water Resources Council – State governments are to gazette river reserves
- Land acquisition Act 1960- acquire private land in the river reserves
- National Forestry Act 1984- protection of water courses and water resources in Permanent Forest Reserves
- Town and Country Planning Act 1976, Section 8- statutory spatial plans for river reserves, river frontage development and flood levels, etc.
- Street, Drainage and Building Act 1974 (1994) - provides Local Authorities (Peninsular Malaysia) with powers pertaining to the management of drains and water courses.
- Local Government Act 1976, s.69, 70, and 71; 73(a); 101 (ee) - provides local authorities in Peninsular Malaysia with various powers pertaining to watercourses.
- Various Water Act, Ordinance and Enactment for State and Federal Territory of Kuala Lumpur Agencies- responsibility of all the waterways e.g. Water Act 1920, s.14 …reserves is 50 feet from any river bank.
- Sabah Water Resources Enactment 1998, s. 40-
- Fisheries Act 1985- implementation of aquaculture development zone
- Environmental Quality Act 1974 (1987), Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987 - aquaculture projects (Peninsular Malaysia)
- Natural Resources and Environment (Prescribed Activities) (Amendment) Order 1997- aquaculture projects (Sarawak)
- Environment Protection Enactment (Prescribed Activities) (Environmental Impact Assessment) Order 2005- aquaculture projects (Sabah)
- Sabah Inland Fisheries and Aquaculture Enactment 2003- implementation of aquaculture development plan
- Selangor Waters Management Authority Enactment 1999 (Government of Selangor Gazette, 2 July 2009) - protection of important wildlife habitats in the riparian zone which in this case the congregating fireflies along the Sungai Selangor. The river reserve ranges from 150m to 400m from the left and right bank of Sungai Selangor and 20km to the upstream and 20km downstream from the Kg Kuantan firefly watching jetty.

<u>Soft law</u>

- River Sand Mining Guideline, 2009 (DID)
- Guidelines for Rivers and River Reserves (DID) - specify widths of river reserves to a maximum of 50m, based on the width of the river.

<u>Policy</u>

- Integrated Coastal Zone Management Policy ("ICZM") for reconciling conflicting uses and ensure sustainability of coastal resources, plus identify and provide for uniformity and minimum standards to be adopted in Malaysia
- Integrated river basin management is essential to establish inter-agency coordination in the management of water resources and environmental.

Appendix 5. Firefly conservation in other countries

Japan may have done the most effort in firefly habitat restoration and conservation then any country from continuous efforts for more than 40 years. Due to rapid post war development, population expansion and industrialisation, most of the firefly habitats especially the popular Genji firefly together with other native wildlife and plant species, were very much reduced or destroyed, and polluted. Lots of research and experimentation work has been done for decades to restore back the firefly habitat and reintroduced back the local firefly. Today, there are many restored firefly conservation sites protected by law (National Natural Monument in cities and towns all over the country. Schoolchildren working with the elderly are the main force in the restoration under the guidance of firefly clubs, firefly museums and experts. Activities include annual firefly surveys, recreate firefly habitats, breed and reintroduced the local firefly. As a result, local native wildlife and plants returned when the restored habitat recovered.

Re-engineered drainage which was once a natural stream, now a protected firefly habitat of the aquatic Genji firefly, *Luciola cruciate*, in Kitakyushu, Japan.

In Taiwan, China, Hong Kong, South Korea similar efforts in setting up firefly protected areas firefly research, awareness days like the Korean Muju Firefly Festival, citizen involvements and guided tours by firefly societies or other nature NGOs, firefly forums on websites, and protected areas are getting more active. Monitoring and survey part of citizen science has been done in USA under the Firefly Watch website; similar ongoing public survey is done in UK, Portugal and Belgium. And not forgetting the annual World Firefly Day will be a day to celebrate the bright and tiny fireflies.

Appendix 6. The Selangor Declaration on the Conservation of Fireflies (revised 2014)

From the Proceedings of the Second International Firefly Symposium, Selangor, Malaysia 2010:

Participants from 13 countries met at the Second International Firefly Symposium in Selangor, Malaysia from 2nd to 5th August 2010. They included experts in the fields of taxonomy, genetics, biology, behaviour, ecology and conservation of fireflies as well as members of government agencies, non-governmental organisations, educational institutions, corporations and the public. The theme of the symposium was 'Firefly Conservation: From Science to Practice.' The following declaration was made in conjunction with the symposium at the Third International Firefly Research Network Meeting on 5th August 2010 and updated by the same body on the 25th November 2014

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THE ABILITY OF FIREFLIES to produce light has inspired wonder and benefited mankind through biomedical research, yet little is known of the diversity of fireflies in many regions of the world because firefly research has not been sufficiently emphasised or adequately funded. As a result, in-depth research has focused on a limited number of species. At the same time, firefly populations are declining across the world, and there is an urgent need for conservation of their habitats. This reflects a decline in the health of the environment and a global trend of increasing biodiversity loss.

Governments, local authorities and government agencies need to take measures to preserve the habitats of fireflies and support research, which ultimately provides valuable information to aid in conservation. Protection of the habitats of fireflies contributes to the conservation of many other species of wildlife and a better quality of life for human beings. Fireflies have the potential to be used in education to enhance environmental and conservation awareness. Fireflies have also in recent years become ecotourism icons.

Ecotourism needs to be managed sustainably with good, ecologically sound guidelines. Local communities should be involved in the ecotourism industry, be beneficiaries of its economic returns and be involved in conservation.
WE, the participants of the Second International Firefly Symposium and Third International Firefly Research Network Meeting recognise and advocate that:

1.1 Fireflies are a part of our biodiversity heritage and are iconic insects that have been the subject of much investigation in the sciences, an inspiration in the arts and a part of local cultures, folklores and traditions because of their ability to produce light. This ability has also enabled their genes and enzymes to be used in biomedical research for the benefit of mankind.
1.2 The world's firefly diversity is still poorly understood, and studies on their physiology and behaviour have focused on only a small number of species. Taxonomic research on fireflies has been poorly funded and given insufficient priority, but is greatly needed since it forms the basis for our understanding of their diversity and is crucial for the development of other aspects of firefly research.
1.3 Fireflies have been a source of ecotourism revenue for many communities in different parts of the world and have the potential to bring similar benefits to other local communities. Fireflies and their natural habitats also enhance quality of life and contribute to economies through the promotion of aesthetically pleasing landscapes that have greater appeal.
1.4 Fireflies are bio-indicators of the health of the environment and are declining across the world as a result of degradation and loss of suitable habitat, pollution of river and water systems, increased use of pesticides in agro-ecosystems, non-regulated commercial harvesting and increased ecological light pollution in areas of human habitation. The decline of fireflies is a cause for concern and reflects the global trend of increasing biodiversity loss.
1.5 Intervention is greatly needed from governments to provide guidelines for preserving existing habitats and restoring degraded habitats for the conservation of fireflies.
1.6 The habitats of fireflies are a refuge for many forms of wildlife including mammals, birds, reptiles, amphibians and numerous species of invertebrates and flora. Recognizing that habitat conservation and/or restoration is a long-term commitment, we believe this to be a worthwhile goal with the potential to conserve a wide range of flora and fauna.

WE urge governments, local authorities and government agencies worldwide to take decisive and concrete action at the regional, national and local level to:

2.1 First and foremost, protect the habitats of fireflies so as to preserve these iconic creatures and other fauna and flora for the enjoyment of future generations.
2.2 Undertake rehabilitation of degraded firefly habitats to enable gradual recovery of populations.
2.3 Develop management plans for firefly ecotourism sites that enable them to be managed sustainably and in a manner that is ecologically sound.
2.4 Promote the involvement of local communities in firefly ecotourism and ensure they are beneficiaries of the economic returns.
2.5 Ensure local communities are equipped with knowledge of the habitats, life cycle and ecology of fireflies and are fully involved in conservation efforts.
2.6 Develop guidelines prohibiting commercial harvesting of wild fireflies for biochemical extraction, as synthetic alternatives are now widely available. Similarly, harvesting of wild fireflies for public or private entertainment, hobby trade or social functions should be discouraged.
2.7 Protect the genetic integrity of current firefly populations by discouraging/prohibiting release of non-native or captive-bred fireflies outside their natural range.
2.8 To recognize that pesticides uses and release of biochemical controls in agricultural, urban or residential areas may impact firefly larval or adult, locally, regionally or in nearby ecologically sensitive habitats.
2.9 Promote environmental education about firefly conservation in schools, and create awareness among the public on the natural history and conservation of fireflies.

WE strongly recommend that governments, local authorities, agencies and corporations support the allocation of human and financial resources for:

3.1 Inventory and documentation of firefly species in highly diverse, under-researched areas such as Asia, Africa and tropical America.
3.2 Taxonomic research on firefly diversity at both the morphological and molecular level, which forms a basis for our understanding of the world's poorly-documented firefly fauna.
3.3 Research on fireflies that provides key information on all aspects of their classification, genetics, biology, ecology, behaviour, physiology, conservation and utilization in biomedical research.
3.4 The development and application of low environmental impact techniques that minimize degradation of firefly habitats together with environmental impact assessment yet enable the development of infrastructure for the benefit of human communities.
3.5 Collaboration and the sharing of research findings among researchers, and communication of research findings to government authorities and agencies to aid the cause of firefly conservation.
3.6 Environmental education on the ecology and conservation of fireflies at the level of schools, local communities and the public, as a tool for inculcating environmental responsibility.

Dated this 5th day of August, 2010, by the participants of the Second International Firefly Symposium and Third International Firefly Research Network Meeting in Subang, Selangor, Malaysia

Revised: 25th day of November, 2014, by the participants of the Third International Firefly Symposium and Fourth International Firefly Research Network Meeting in Gainesville, Florida, U.S.A.

A Brief History of the International Firefly Symposium

By Dr. Raphaël De Cock and Dr. Marc Branham

Summarised from the Fireflyers International Network webiste https://fireflyersinternational.net/historyInternational

The philosophy behind organizing the first Firefly Meeting was to bring together people from around the world with an interest in fireflies (and other bioluminescent beetles) at a venue open to not only scientists, but educators, naturalists and artists. Artistic activities involving fireflies represent an essential link in promoting these insects and their conservation to a wider audience, especially those works combining art, science and education. By providing a venue for an international meeting, the organizers hoped to foster collaborative partnerships between those interested in many different aspects of fireflies.

The series of meetings that has become the International Firefly Symposium arose from the Firefly Network Meeting hosted in 2007 in Portugal. The meeting, was hosted and organized by Mr. Nuno Gomes Oliveira and Dr. Raphaël De Cock. In 2008, Thailand organized the 1st International Firefly Symposium. In 2010, the Forest Research Institute Malaysia (FRIM) and the Malaysian Nature Society organized the 2nd International Firefly Symposium in Selangor. At the 2010 symposium, the Selangor Declaration for the Conservation of Fireflies was made.

In 2014, the University of Florida hosted the 2014 International Firefly Symposium in Gainesville, Florida. The Selangor Declaration was revised to reflect the current situation of the fireflies and habitats.

Acknowledgement: We would like to thank Ricoh for the opportunity to be present and discuss in the 2014 International Firefly Symposium. The revision of the Selangor Declaration is one of the result of the support.

Appendix 7. Fireflyers International Network (FIN) and Firefly Specialist Group (IUCN SSC FSG)

FIN is an international group of firefly scientists and enthusiasts. The Network have more than 200 members representing over 20 countries, including ecologists, chemists, geneticists, artists, and naturalists, brought together by a shared sense of wonder and delight in these bioluminescent beetles. FIN wants to learn more about the fireflies' unique biology, and work together to protect threatened species.

The origin of FIN, started in the 90s, by Dr. Raphael De Cock and Dr. Nuno Gomes Oliveira, who organized the Firefly Network Meeting in 2007, which gathered about 40 scientists from all over the world and was the first international meeting about the firefly. The philosophy behind organizing the first Firefly Meeting was to bring together people from around the world with an interest in fireflies (and other bioluminescent beetles) at a venue open to not only scientists, but educators, naturalists and artists. Artistic activities involving fireflies represent an essential link in promoting these insects and their conservation to a wider audience, especially those works combining art, science and education. By providing a venue for an international meeting, the organizers hoped to foster collaborative partnerships between those interested in many different aspects of fireflies. Following that, the first International Firefly Symposium (IFS) was held in Chieng Mai, Thailand (2008), subsequently in Shah Alam, Malaysia (2010), Florida, USA (2014), and Taipeh (2017) with the formation of FIN, currently registered in Hong Kong. The FIN general meeting and election of committee is held during the IFS. The IFS2022 will be held in Portugal, scheduled for 2020 but was delayed due to the Covid19 pandemic.

Mission and Values of FIN

MISSION: To serve as a leader and catalyst for the conservation of fireflies and their habitats through research, education and advocacy.
VISION: A biologically diverse world where fireflies (and other bioluminescent beetles) can thrive, and where people understand and respect the ecosystems that sustain life on Earth.
AIMS:

- To bring together people involved in firefly conservation and research around the world to exchange knowledge and form collaborative partnerships
- To raise awareness and advance a public conservation ethic by sharing information about fireflies and their habitat requirements
- To foster delight and appreciation of fireflies across different cultures by blending artistic and scientific perspectives

Annual public awareness event on fireflies

The World Firefly Day (WffD) was conceptualized by the Malaysian Nature Society. It was first announced during the IFS 2017 in Taipeh, as a public awareness event and a conservation action day to celebrate the iconic firefly around the world. The WffD will be celebrated on the first weekend of July. The inaugural WffD was celebrated in 2018.

To join FIN, please go to the website https://fireflyersinternational.net/

Co-chairs Sara Lewis and Sonny Wong formed the IUCN Firefly Specialist Group (FSG) in 2018. The group's mission is to identify and work to conserve threatened firefly species around the world. Specific goals are to: (1) assess Red List status for 2,200+ species (2) prioritize key threats and conservation issues facing fireflies in different geographic regions (3) identify knowledge gaps for future biodiversity research, and (4) advocate for threatened species at regional and global levels.. This group now has 41 members in 6 regions, and it continues to grow. For more information, please visit https://www.iucn.org/ssc-groups/invertebrates

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