HARMFUL JELLYFISH

Country Report in Western Pacific

Bangladesh • Indonesia • Malaysia • Phillipines • Singapore • Thailand • Vietnam

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Contents

Foreword I

Wenxi Zhu
IOC Sub-Commission for the Western Pacific (WESTPAC)
Intergovernmental Oceanographic Commission of UNESCO

The world is entering a new era of crucial focus on achieving sustainable development, as demonstrated by the universal agreement on the 2030 Agenda for Sustainable Development. Our ocean is the central to achieving this goal as it regulates the earth and climate system, supplies living and non-living resources, and provides social and economic goods and services.

Marine science, technology and innovations essentially underpin the conservation and sustainable use of oceans, seas and marine resources. The Western Pacific and its adjacent waters are of vast environmental, social and economic importance, thus vital to humans' survival and prosperity not only in the region, but in the whole world. The Intergovernmental Oceanographic Commission of UNESCO (IOC/UNESCO), through its Sub-Commission for the Western Pacific (WESTPAC), has been committed to promoting international cooperation on marine research, sustained observations and services in order to support both sustainable use and stewardship of our blue planet.

Deeply rooted in the most populous region, WESTPAC recognizes that marine science must respond to societal needs and global challenges, and thus endeavors to advance ocean knowledge, foster science-policy interface, and build new partnerships with various ocean stakeholders in order to further connect science to society. Given the increasing concerns on the harmful jellyfish blooms and their undesirable impacts to socio-economic and human health in the region, it is critical to examine the state of our knowledge, identify gaps, and map priorities to collectively address this issue. In this light, WESTPAC established, at its 11th Session (21-23 April 2017, Qingdao, China), a regional programme with a view to assisting countries to sustainably enhance harmful jellyfish research and network in the region and provide scientific guidance for remediation measures.

We would extend our sincere appreciation to Prof. Dr. Aileen Tan Shau Hwai, Universiti Sains Malaysia, for her instrumental role in setting up the commendable multi-disciplinary collaboration among researchers, healthcare providers, private sectors, local communities and public. Despite at an early stage, it provides a valuable model for the broad scientific communities to aspire for real changes, whether that be in the level of knowledge, or in the way we manage cooperation and partnerships in support of a healthy ocean. I considered it is exactly the transformative change that the international communities expect to achieve through the UN Decade of Ocean Science (2021-2030) for Sustainable Development, a ten-year and large scale cooperative programme to seek urgently needed scientific solution for better management of ocean and coastal zone resources and reducing maritime risks.

The book serves as a key output from the WESTPAC Inception workshop entitled "Harmful Jellyfish Sampling Protocol & Data Analysis in the Western Pacific" (Penang, Malaysia, 5-7 December 2017). It is intended to present the latest scientific findings and remedial measures that countries take to address harmful jellyfish issues. I hope it would be a good reference material for researchers, healthcare providers, and even tourists. My sincerest thanks to the Centre for Marine and Coastal Studies (CEMACS), USM, Prof. Dr. Aileen Tan Shau Hwai and her efficient team, and all contributors. I expect more achievements could be made and more good practices could be replicated in the near future!

Foreword II

Aileen Tan Shau Hwai
(Principle Investigator of IOC-WESTPAC Project)
Centre for Marine and Coastal Studies (CEMACS)
Universiti Sains Malaysia (USM)

Invasions and blooms of jellyfish had caused negative impacts to public health, tourism, fisheries, and the health of the marine ecosystem. Historically the bloom is a rare event but at recent times, many incidents have been recorded across the WESTPAC countries and some very classified disaster as they involved human lives. Damages ranged from thousands to millions of dollars loses and causing many livelihoods interrupted or terminated. Such blooms or invasions of the jellyfish are still relatively unknown and further studies are needed to understand causative factors behind the phenomena in order to device preventives and mitigation strategies.

The publication of the 'Harmful Jellyfish County Report in Western Pacific' is the culmination of a tri-national collaborative effort to better understand and report on the Harmful Jellyfish. It presents results from work relating to harmful jellyfish studies carried out by universities and research centres in all participating countries.

The aim of this publication is to share knowledge regarding their behaviour, dynamics of the bloom and to raise awareness among the communities impacted by the bloom. Secondly, various ways of preventions have been discussed.

The project under the support of IOC-WESTPAC entitled "*Enhancement of Sustainable Harmful Jellyfish Research and Networking in Western Pacific Region*" aims to:

- Improve the understanding and develop regional collaborative research and monitoring abilities in the WESTPAC regions
- Standardise monitoring efforts and research network among various institutions and agencies in the regions
- Sharing of information of jellyfish invasion, hazard awareness and studies in each participating country
- Explore the possibility of building a joint research of jellyfish diversity, distribution and abundance

This publication is an outstanding example of sub-regional collaboration among scientists. I would like to take this opportunity to thank the IOC Sub-Commission for the Western Pacific (WESTPAC) for making this effort possible and entire staff of Centre for Marine and Coastal Studies (CEMACS), Universiti Sains Malaysia (USM) for their continued support.

On behalf of the editorial team, we would like to thank all country contributors in making this publication possible.

Contributing Authors and Institutions

This report was compiled from seven countries, produced in partnership with the Centre for Marine and Coastal Studies (CEMACS), Universiti Sains Malaysia (USM) and IOC Sub-Commission for the Western Pacific (WESTPAC). Many other international organizations, research institutions, universities contributed data, reviewed results, scientific guidance and images for these reports, including:

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Special thanks to Mr. Sim Yee Kwang for compiling the information on jellyfish country report during the infancy stage of the project. In that content, we are grateful to him for providing many of the photographs used in this publication. Special appreciation is dedicated to Mr. Nirmaryadi Rashid (Graphic Designer) for designing the cover of this publication.

We would like to express our gratitude to the following organizations that provided assistance and individuals who helped us in many ways throughout the course of our field activities: The entire staff of Centre for Marine and Coastal Studies (CEMACS), WESTPAC officers Ms. Nachapa Sarantuth and Ms. Orathai Pongruktham.

List of Figures

Figure	Caption	Page

List of Tables

List of Abbreviation and Acronyms

AP	Asia-Pacific
CEMACS	Centre for Marine and Coastal Studies
COI	Cytochrome C oxidase subunit I
CPR	Cardiopulmonary resuscitation
DAN	Divers Alert Network
DMCR	Department of Marine Coastal and Resources
DNA	Deoxyribonucleic acid
DO	Dissolved Oxygen
DOH	Department of Health
DOI	Digital Object Identifier
EAF	Ecosystem Approach to Fisheries
ECG	Electrocardiogram
ERT	Emergency Response Team
FAO	Food and Agriculture Organization
FIO	First Institute of Oceanography
IEC	Information Education Campaign
IOC	Intergovernmental Oceanographic Commission
LIPI	Indonesian Institute of Sciences
LKCNHM	Lee Kong Chian Natural History Museum
MAH	Malaysian Association of Hotels
MCCRC	Marine and Coastal Resources Research and Development Center in Center Gulf of Thailand
MCCRE	Marine and Coastal Resources Research and Development Center in Eastern Gulf of Thailand
MCCRL	Marine and Coastal Resources Research and Development Center in Lower Gulf of Thailand
MCCRU	Marine and Coastal Resources Research and Development Center in Upper Gulf of Thailand
MEWR	Ministry of the Environment and Water Resources
MST	Malaysian Society Toxinology
MOU	Memorandum of Understanding
NEA	National Environment Agency
NUS	National University of Singapore
O_2	Oxygen
PDRRMO	Provincial Disaster Risk Reduction and Management Office
RECS	Remote Envenomation Consultancy Services
RV	Research Vessel
SASPS	Sultan Azlan Shah Power Station
SD	Standard Deviation
SDC	Sentosa Development Corporation
SIPS	Sultan Ismail Power Station
TJPS	Tuanku Ja'afar Power Station
TNB	Tenaga Nasional Berhad
US	United State
USM	Universiti Sains Malaysia
WESTPAC	Western Pacific
WHO	World Health Organization

Chapter 1. Introduction

1.1 What is Harmful Jellyfish?

Harmful jellyfish typically refers to the medusae of class Scyphozoa (predominantly order Rhizostomeae and order Semaestomeae) and class Cubozoa which able to cause or likely to cause harm or negative impacts to human, ecosystem and socio-economic.

Scyphozoans are common jellyfish, as known by public, that possess umbrella-like, hemispherical or dome-shaped bells. Scyphozoans of order Rhizostomeae has eight oral arms with no marginal tentacles whilst jellyfish of order Semaestomeae has only four oral arms with marginal tentacles in converse (Kramp, 1961). Scyphozoa may interfere with tourism by stinging swimmers, affect fishing activities by clogging nets, disrupts aquaculture by killing fish in net-pens and blocking cooling-water intake screens at coastal power plants.

Cubozoans or more commonly known as box jellyfish, as its name suggests, have cuboidal or box-shaped bells. They are characterized by uncleft bell margins and four single (interradial) or groups of tentacles (Rizman *et al.*, 2016). Cubozoans in Malaysia are of two orders (Carybdeida and Chirodropida) which comprise one species each (Rizman *et al.*, 2016). Cubozoans or box jellyfish are infamous for their fatal stings of Irukandji and *Chironex fleckeri* jellyfish (Fenner & Harrison, 2000). Box jellyfish such as *Carukia barnesi* are responsible for severe systemic symptoms known as Irukandji syndrome after an average of 30 minutes of the stings (Fenner & Carney, 1999). However, box jellyfish blooms and their risk to humans tend to happen in a small spatial scale (Kingsford *et al.*, 2012).

1.2 Effects of Harmful Jellyfish

Harmful jellyfish blooms are common occurrences in many marine habitats and are important events (factors) controlling plankton dynamics in these systems (Purcell *et al.,* 2007). The increasing of reports on human problems with jellyfish within coastal marine systems has led to much public attention regarding the ecological role of jellyfish (more specifically medusa of the Phylum Cnidaria: Orders Rhizostomeae and Semaeostomeae) (Whiteman, 2002; Carpenter, 2004).

The jellyfish existence has caused ecological and socio-economic problems. Ecologically, they will disturb the food web of the ecosystem of the invaded area since they feed on zooplankton and ichthyoplankton that are also the food source for other aquatic animals i.e. fish (Purcell *et al.,* 2007). Furthermore, they might also cause algae blooming due to the decreasing of zooplankton that they feed on.

In the socio-economic area, rise in biomass of jellyfish has caused a lot of trouble to human activities and also exerted significant predation pressure. Numerous cases have been reported which involved impeding fishing trawling (Uye & Ueta, 2004), causing decreased catch in artisanal and industrial fisheries (Lynam *et al.*, 2005; Purcell and Sturdevant, 2001), damage to fishing gears, interrupted operation of desalination plants (Daryanabard & Dawson, 2008), and damage to the seawater cooling systems of coastal power plants (Mills, 2001). Since jellyfish feed on zooplankton and ichthyoplankton, jellyfish also have indirect effects on fisheries by becoming the competitors of fish and eventually decreasing the fish population (Purcell *et al.*, 2007).

According to Purcell *et al.* (2007), increased jellyfish and ctenophore populations are often associated with warming caused by climate change and possibly power plant thermal effluents. In short, the propensity of jellyfish in forming extensive nuisance blooms and their associated socioeconomic effects have largely driven the interest on jellyfish study (CIESM, 2001).

As large jellyfish blooms have detriment impacts on fishery resources and ecosystem functioning, it is desirable to understand the factors leading to jellyfish blooms. Speculations on possible factors are stimulated including climate change, eutrophication, over fishing and invasions (Hay, 2006; Graham & Bayha, 2008).

1.3 Causes of Harmful Jellyfish Bloom

Jellyfish are major pelagic predators, but their importance to the marine ecosystems remains to a large degree unknown (Mills, 1995). In many part of the world, jellyfish form "blooms", with exceptionally high in numbers and becomes a treat to the marine ecosystem (Mills, 2001). The reasons for such outbreak are still not fully understood, and a range of factors may be involved, including natural variations (Mills, 2001).

According to Purcell *et al.* (2007) and Mills (2001), the jellyfish blooms may be triggered by the warming of sea temperature due to global climate change or power plant effluent. In temperate area, the jellyfish usually increase their asexual reproduction of polyps and new jellyfish during warm temperature while in tropical area, the jellyfish reproduction may occur all year (Lucas, 2001). Thus, the jellyfish blooms may occur all the time in the tropic area despite of the season. Furthermore, the ability of medusae to tolerate with low dissolved oxygen (DO) compared to other aquatic organism also gives advantage to their survival (Purcell *et al.*, 2007). For example, predation by *Chrysaora quinquecirrha* medusae on fish larvae was greater at low DO, presumably because the larvae escaped poorly in stressed condition. Dissolved oxygen amount and distribution are affected by atmospheric exchange, the physical circulation, turbulence, and water temperature, as well as organic activity such as primary production, decomposition of organic matter, and other biological processes.

Eutrophication may also increase the abundance of jellyfish in that area. The eutrophication occurs as a result of increased mineral nutrients concentration (primarily nitrogen and phosphorus), change in nutrients ratio and increase in turbidity, where there are human activities at the coastal area (Arai, 2001). Eutrophication can also occur because of natural processes such as river inflow and upwelling, but anthropogenic cause has become the present concern (Arai, 2001). Nutrients are increasing in water bodies as the result from the addition of sewage, deforestation, fertilizer usage on adjacent land and reactive nitrogen emitted to the atmosphere during fossil fuel combustion. The increasing of nutrients in water column may lead to greater biomass at all trophic levels and increase the food source for jellyfish polyps (Daskalov, 2002; Purcell *et al.*, 1999). Moreover, the jellyfish will also increase their asexual reproduction as well as sexual reproduction (Stibor & Tokle, 2003; Lucas, 2001; Purcell *et al.*, 2007). Eutrophication can also cause complex changes in the food web. It may change the food path of an ecosystem towards a flagellate-based path that ends with 'low energy' consumers, which favours the jellyfish. This condition may occur when N:P ratios is high and could shift the phytoplankton community away from diatoms toward flagellates and jellyfish (Purcell *et al.*, 2007). Furthermore, nutrient enrichment may reduce the size of zooplankton community which can be harmful to fish. This is because they are visual predators that prefer large zooplanktons (Purcell *et al.*, 2007). Therefore, this will benefit the jellyfish which are not visual predators and they can consume on small or large prey.

1.4 Knowledge Gaps in the WESTPAC Region

The status of jellyfish invasion in WESTPAC countries is still not a serious threat yet but soon it will be looking at the increasing cases of jellyfish stung reported in particularly Thailand and Malaysia. Although there is no formal report or scientific research describing the relationship between the fishery and jellyfish bloom, jellyfish has brought havoc on tourism industry, in particular those countries, which promote beaches as their tourism attraction. With all these concerns, clarification of the mechanism of jellyfish blooms and effects of environmental conditions on jellyfish abundance are indispensable for forecasting and regulation of the bloom.

Figure 1.1 shows the jellyfish population trends across the world. However, although there have been jellyfish stung cases in the WESTPAC region but no official records been reported. Therefore, there is an urgent need to have collaborations among the WESTPAC countries or partners to look into the jellyfish research and aim to fill up the knowledge gaps in term of research, capacity building and awareness.

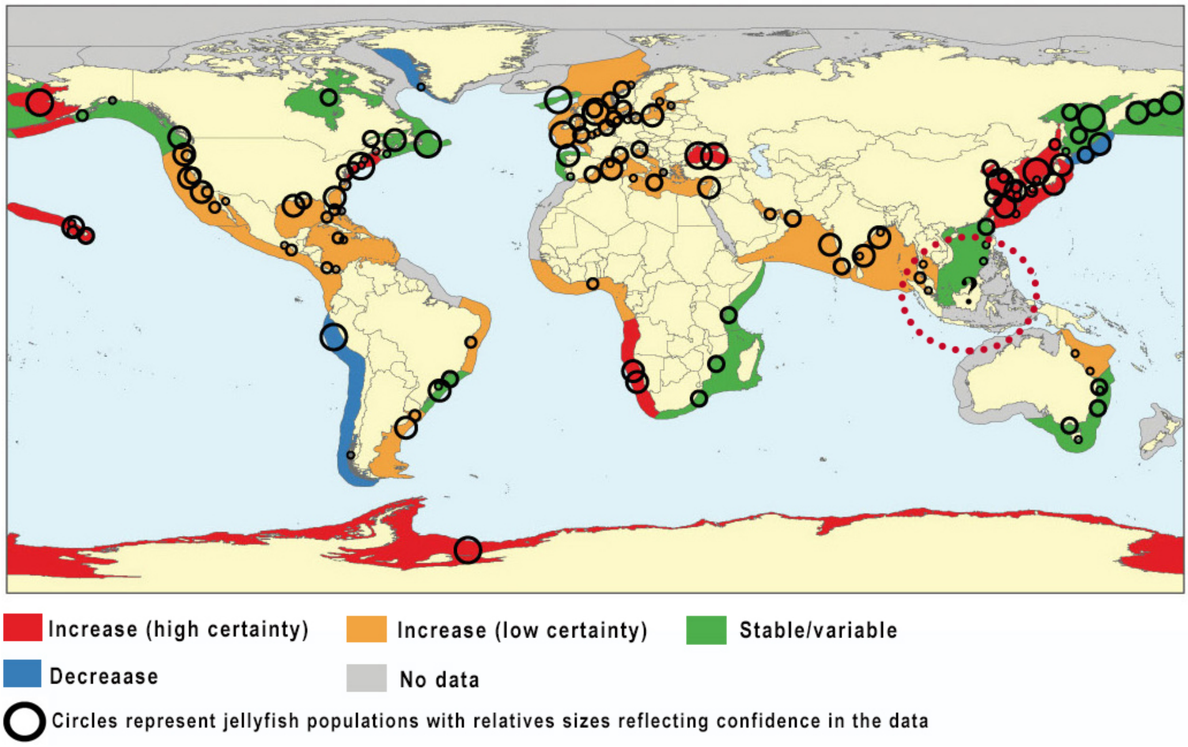

Fig 1.1 The knowledge gaps of the jellyfish studies in the WESTPAC region (Brotz *et al.*, 2012).

Chapter 2. Country Summaries

2.1 BANGLADESH

I. Status and Background

Bangladesh, with a coastline of 710 km and a broad shallow continental shelf in the northern Bay of Bengal, is home to a variety of marine life and ecosystem, including the coral reefs of St. Martin's island and the world's largest continuous mangrove forests, the Sundarbans. Despite being a hotspot of rich biodiversity, general interest in the discovery of marine organisms has not yet garnered the attention of biologists (Chowdhury *et al.,* 2016). In particular, little is known about the natural history, taxonomy and distribution of jellyfish, which are gelatinous zooplankton organisms of the class Scyphozoa, Cubozoa and Hydrozoa under the phylum Cnidaria. To date, four species of scyphozoan jellyfish (Das, 2007) and three species of hydrozoan jellyfish (Das, 2007; Chowdhury *et al.,* 2016) are reported from the marine/brackishwater environments of Bangladesh.

Jellyfish are important both from ecological and societal point of view. For example, jellyfish involve in the ocean food chain as they are often eaten by small crabs, large crustaceans, small/large fish and turtles. Importantly, dead jellyfish is found to contribute to the food chain of deep-sea ecosystem, where food sources may be decreasing as the ocean warms. Even people eat jellyfish in some countries of East and Southeast Asia. So, there is a bright prospect of edible jellyfish fishing and aquaculture in the future.

On the contrary, some jellyfish (scyphomedusae, hydromedusae, siphonophores and ctenophores) can negatively impact the aquaculture industry by causing fish gill disorders, and by fouling net of cages and pens. In addition, increasing frequency of jellyfish blooms and jellyfish stings may have far-reaching socioeconomic implications, including human fatalities. The later issues, therefore, have prompted a fresh look at the role of jellyfish all over the world, including Bangladesh.

II. Diversity, Distribution and Abundance

A review study by Das (2007) documented four scyphozoan species such as *Rhizostoma pulmo*, *Rhizostoma* sp., *Cephea cephea* and *Cassiopea xamachana* from the estuarine river, Sundarbans and Cox's Bzara coastal areas. This study also mentioned two hydrozoan jellyfish, *Aequorea pensilis* and *Physalia physalis* from Cox's Bazar (Das 2007). Recently, a floating hydrozoan *Porpita porpita* is added to the list which was collected from the coral island of St. Martin's; (Fig 2.1.1) (Chowdhury *et al.,* 2016). In contrast, a work by Kabir *et al.* (2008) listed 22 species of scyphozoan jellyfish and a hydrozoan *Physalia physalis*, but the occurrence data for each species was not discussed in local context. Therefore, it is not conclusive whether those species of jellyfish are actually occurring in the aquatic ecosystems of Bangladesh. All the jellyfish species are listed in Table 2.1. Also, photograph of *Porpita porpita* is given in Fig 2.1.2.

Table 2.1 Species of jellyfish documented from Bangladesh.

FAMILY/Genus/Species	Habitat (location)	Reference
Class: Scyphozoa		
ALATINIDAE Gershwin, 2005		
Alatina Gershwin, 2005	Marine (–)	Kabir *et al. (*2008)
1. [a]*Alatina alata* (Reynaud, 1830)		
CASSIOPEIDAE Agassiz, 1862		
Cassiopea Péron & Lesueur, 1810	Coastal, marine (Cox's Bazar)	Das (2007)
2. *Cassiopea xamachana* (Bigelow, 1892)		
3. *Cassiopea andromeda* (Forsskål, 1775)	Marine (–)	Kabir *et al.* (2008)
CATOSTYLIDAE Gegenbaur, 1857		
Acromitus Light, 1914	Marine (–)	Kabir *et al.* (2008)
4. *Acromitus flagellatus* (Haeckel)		
5. *Acromitus rabanchatu* (Annandale, 1915)	Marine (–)	Kabir *et al.* (2008)
Crambione 6. *Crambione mastigophora* (Maas, 1903)	Marine (–)	Kabir *et al.* (2008)
Crambionella Stiasny, 1921 7. *Crambionella orsini* (Vanhöffen)	Marine (–)	Kabir *et al.* (2008)
CEPHEIDAE Agassiz, 1862		
Cephea Péron & Lesueur, 1810	Estuarine, marine (Sundarbans)	Das (2007)
8. [b]*Cephea cephea* (Forskål, 1775)		
Netrostoma 9. *Netrostoma coerulescens* (Maas, 1903)	Marine (–)	Kabir *et al.* (2008)
CHIROPSALMIDAE Thiel, 1936		
Chiropsoides Southcott, 1956	Marine (–)	Kabir *et al.* (2008)
10. [c]*Chiropsoides buitendijki* (van der Horst, 1907)		
11.[*d]*Chiropsoides quadrigatus* (Haeckel, 1880)	Marine (–)	Kabir *et al.* (2008)
CYANEIDAE L. Agassiz, 1862		
Cyanea Péron & Lesueur, 1810	Marine (–)	Kabir *et al.* (2008)
12. *Cyanea nozakii* (Kishinouye, 1891)		
LYCHNORHIZIDAE Haeckel, 1880		
Lychnorhiza	Marine (–)	Kabir *et al.* (2008)
13. *Lychnorhiza malayensis* (Stiasny, 1920)		
MASTIGIIDAE Stiasny, 1921		
Mastigias Agassiz, 1862	Marine (–)	Kabir *et al.* (2008)
14. *Mastigias papua* (Lesson)		
Versuriga 15. *Versuriga anadyomene* (Maas)	Marine (–)	Kabir *et al.* (2008)
PELAGIIDAE Gegenbaur, 1856		
Chrysaora Péron & Lesueur, 1810	Marine (–)	Kabir *et al.* (2008)
16. *Chrysaora helvola* (Brandt, 1838)		
17. *Chrysaora melanaster* (Brandt, 1838)	Marine (–)	Kabir *et al.* (2008)
18. *Chrysaora quinquecirrha* (Desor, 1848)	Marine (–)	Kabir *et al.* (2008)
Pelagia Péron & Lesueur, 1810 19. *Pelagia noctiluca* (Forsskål, 1775)	Marine (–)	Kabir *et al.* (2008)
20.[*]*Pelagia panopyra* (Péron & Lesueur)	Marine (–)	Kabir *et al.* (2008)
RHIZOSTOMATIDAE Cuvier, 1799		
Rhizostoma Cuvier, 1799	Coastal, marine (Cox's Bazar)	Das (2007)
21. *Rhizostoma pulmo* (Macri, 1778)		
22. *Rhizostoma* sp.	Coastal, marine (Cox's Bazar)	Das (2007)
Rhopilema Haeckel, 1880 23. *Rhopilema hispidum*	Marine (–)	Kabir *et al.* (2008)
TAMOYIDAE Haeckel, 1880		
Tamoya Mueller, 1859	Marine (–)	Kabir *et al.* (2008)
24. *Tamoya gargantua* (Haeckel, 1880)		
ULMARIDAE Haeckel, 1879		
Aurelia Lamarck, 1816	Marine (–)	Kabir *et al.* (2008)
25. *Aurelia aurita* (Linnaeus, 1758)		
26. *Aurelia maldivensis*	Marine (–)	Kabir *et al.* (2008)
Class: Hydrozoa		
AEQUOREIDAE Eschscholtz, 1829		
Aequorea Péron & Lesueur, 1810	Coastal, marine (Cox's Bazar)	Das (2007)
1. *Aequorea pensilis* (Haeckel, 1879)		
PHYSALIIDAE Brandt, 1835		
Physalia Lamarck, 1801	Coastal, marine (Cox's Bazar)	Das (2007); Kabir *et al.* (2008)
2. *Physalia physalis* (Linnaeus, 1758)		
PORPITIDAE Goldfuss, 1818		
Porpita Lamarck, 1801	Marine (Saint Martin's Island)	Chowdhury *et al.* (2016)
3. *Porpita porpita* (Linnaeus, 1758)		

(–): location is unknown; [*]nomen dubium; Reported as [a]*Carybdea alata* (Kabir *et al.*, 2008), [b]*Cephea conifer* (Das, 2007), [c]*Chiropsalmus buitendijki* (Kabir *et al.*, 2008), [d]*Chiropsalmus quadrigatus* (Kabir *et al.*, 2008).

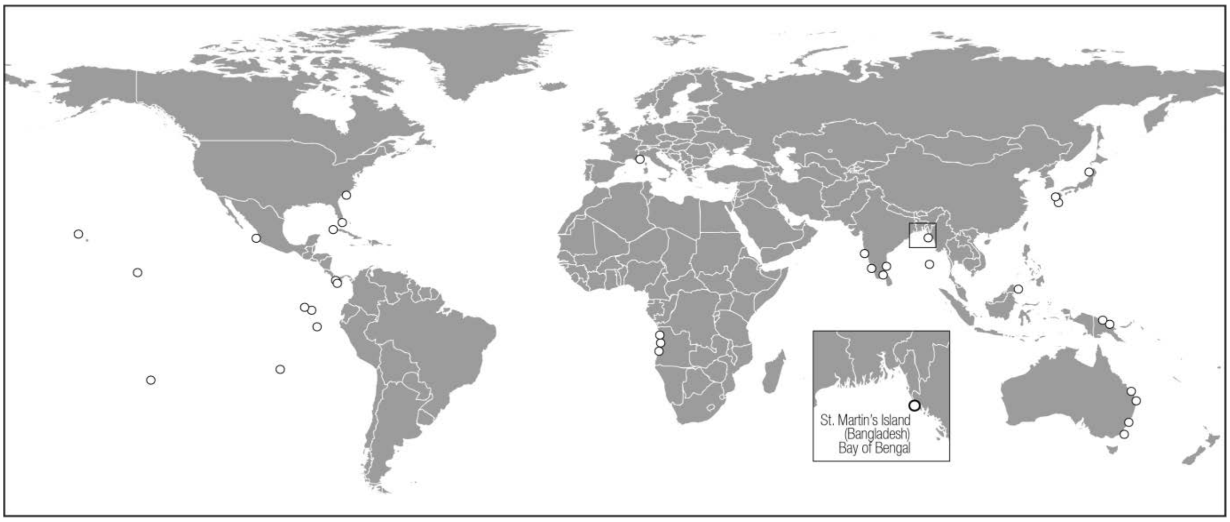

Fig 2.1.1 Occurrence of *Porpita porpita* in the St. Martin's Island, Bangladesh (inset) on its global distribution map (source: Chowdhury *et al.,* 2016).

Fig 2.1.2 *Porpita porpita* from the St. Martin's Island, Bangladesh – a free-floating specimen in shallow water (left), and a stranded specimen on the sandy beach (right).

III. Monitoring and Management

Some of the recent concerns such as jellyfish disruption of fisheries, tourism and other coastal activities are not known to occur in Bangladesh. Even the cases of jellyfish stings and sudden death following jellyfish envenomation are uncommon (Uddin *et al.*, 2014). Therefore, jellyfish have not drawn public interest and remains a neglected issue in Bangladesh. At present, there is no monitoring of jellyfish in the northern Bay of Bengal.

IV. Impacts of Harmful Jellyfish on Human

There is no report of human fatality from jellyfish stings in Bangladesh. Although, unpredictable encounter with painful stings can be a problem in the coastal areas including Cox's Bazar, Teknaf, St. Martin's Island and similar geographical settings. Uddin *et al.* (2014) described a case of jellyfish contact illness in a 30-year old male, who was stung while fishing in the Teknaf coast of Cox's Bazar. Symptoms of jellyfish stings included urticaria formation in the contact area along with a burning and sore sensation. Few minutes later, the patient reported to suffer from severe abdominal pain, body ache and paresthesia. Routine laboratory investigations of the patient had no abnormality, except non-significant ST elevation in ECG (electrocardiogram). The patient was treated conservatively with antihistamine, corticosteroids and antibiotics, and recovered completely within four days (Uddin *et al.*, 2014). While the species belonging to the stinger group yet to be identified, this is the only case report of jellyfish sting-induced illness in Bangladesh.

V. Economic and Socio-cultural Impacts

Neither ecological nor socioeconomic impacts of jellyfish are studied in Bangladesh, but the jellyfish nuisance can be severe as climate change intensifies. Thus, there is an urgent need to generate baseline data on the socioeconomic consequences of jellyfish in this region.

VI. Challenges and Gaps of the Monitoring Harmful Jellyfish Bloom

As jellyfish-human interactions is increasing, it is necessary to provide science-based management plan to control the negative outcome of jellyfish blooms and to use the benefits of their ecosystem services. For this, knowledge and capacity building on the following issues is essential:

1) Jellyfish sampling/surveying know-how and their taxonomy,
2) Aspects of jellyfish life cycles and ecology including fish-jellyfish interactions, and
3) Jellyfish outbreaks and envenomation management.

VII. Current Research of Harmful Jellyfish

Harmful jellyfish research in Bangladesh is just in the initial stage and mostly focused on species diversity and distribution mapping. For collecting jellyfish samples from the northern Bay of Bengal, possible collaboration with "FAO EAF-Nansen Programme" and "RV Meen Sandhani", a survey and research vessel operated by the Department of Fisheries (Government of Bangladesh), is in progress. A successful collaboration of this kind would be useful to understand the jellyfish diversity and their distribution in Bangladesh. Moreover, to serve the greater interest, a joint research on population genetic studies of harmful jellyfish and their distribution mapping across the WESTPAC region should be developed.

2.2 INDONESIA

I. Status and Background

The incidents of jellyfish stings on human have been reported worldwide, including throughout the coastal areas of Southeast Asia such as Malaysia (Lippmann *et al.,* 2011; Mohd *et al.,* 2016), Philippines (Williamson *et al.,* 1996), Thailand (Fenner *et al.,* 2010; Suntrarachun *et al.,* 2001), Timor Leste and northern Australia (Little *et al.,* 2006). Unfortunately, the published scientific data from Indonesia is very limited due to the lack of research. Therefore the current state of knowledge is based on sting reports from the media. The only scientific publication would be by Mujiono (2012) where the data were mainly derived from the local and on-line newspapers. It described three fatalities during 2005 to 2009, two cases at Situbondo district (East Java Province) in June and July 2008 and one case on Bangka island in October 2008, Bangka Belitung Province. The victims from Situbondo district were 19 and 10-year-old and they got stung while swimming, meanwhile the victim from Bangka Island was a 4-years-old boy who was playing by the beach when he got stung by jellyfish (Anonymous, 2008a & b; Bangka Pos, 2008). All of them died on the way to the nearest local health facility. These reports were the worst jellyfish envenomation to human that occurred in Indonesia from 2005 – 2018 according to the media (Table 2.2).

Among the reported jellyfish sting incidents that mainly comes from the southern coastal areas of Indonesia, the species of suspected jellyfish was *Physalia* or commonly known as fire jellyfish in Indonesia (Aksawa, 2018; Deni, 2018; Redaksi, 2018). However, the presence of *Physalia* (Fig 2.2.1) and other species were only based on the witnesses and syndromes (Fig 2.2.2).

The annual bloom of *Physalia* in some southern coastal areas of Indonesia might be related to the southeast monsoon winds and ocean currents between June and September is further influenced by the Australian continental air masses. This stinger's occurrence have been an annual phenomenon in certain areas, for instances June to August in the southern waters of Bantul district (Special Region of Yogyakarta Province) (Marzuki, 2018; Anonymous, 2018; Viva, 2018; Hasanudin, 2018). They usually appear from August to September on the southern waters of Malang district (East Java Province) (Malangpost, 2017; Memo-x, 2017; Nana, 2018). Meanwhile, other jellyfish species appears during dry season (June to September) in Probolinggo district (East Java Province) (Priyasidharta, 2012; Dewanto, 2016; Yoenianto, 2016) when the seawater temperature lower due to southeast monsoon.

Despite the high number of stung victims report, death from the jellyfish stings in Indonesia is uncommon, thus jellyfish stings have not considered as a national potential threat by the government authorities yet. Perhaps, it might be due to the lower fatality cases compared to the neighboring countries. Several local governments that are annually affected has started to develop awareness such as warning signs at the beach, provide lifeguards and collaborate with local health facilities and the policeman.

Fig 2.2.1 SAR team picked the poisonous jellyfish from Parangtritis Beach (Aksawa, 2018).

Fig 2.2.2 Jellyfish bloom in Probolinggo Beach become an educational awareness (Yoenianto, 2016).

Table 2.2 Record of jellyfish stung cases in Indonesia from 2005 – 2018.

Date	Location	No. of victims	Fatality	Species	References
July 27, 2005	Sanur Beach, Denpasar city, Bali Province	-	-	*Physalia utriculus*	Bali Post, 2005
July 8, 2007	Depok beach	2 in 2009, 50 in 2004	Stomach ache	*Physalia utriculus*	Werdiono, 2007
July 20, 2007	Teleng Ria beach, Pacitan	10	Severe cold, asphyxia	-	Adi, 2007
August 12, 2007	Parangtritis beach, Bantul	10	Itchy and burnt on skin	*Physalia utriculus*	Utantoro, 2007
June 5, 2008	Mlandingan beach, Situbondo District, East Java Province	1	19-year-old man die	*Physalia utriculus*	Anonymous, 2008b
July 4, 2008	Banyuputih beach, Situbondo District, East Java Province	1	10-year-old boy die	*Physalia utriculus*	Anonymous, 2008a
October 5, 2008	Bembang beach, Bangka island, Bangka Belitung Province	1	4-year-old boy die	*Chrysaora quinquecirrha*	Bangka Post, 2008
July 19, 2009	Parangtritis and Samas beach, Bantul District, Special region of Yogyakarta Province	10	Severe pain, unconscious	*Physalia utriculus*	Waskita, 2009
September 22, 2009	Parangtritis beach, Bantul District, Special region of Yogyakarta Province	100	Severe pain, unconscious	*Physalia utriculus*	Heru, 2009
September 22, 2009	Widrapayung beach, Cilacap District, Central Java Province	10	Severe cold, choke	*Physalia utriculus*	Anonymous, 2009
September 23, 2009	Glagah Indah and Trisik beach, Kulonprogo District, Special region of Yogyakarta Province	10	Asphyxia, unconscious	*Chrysaora quinquecirrha*	Kuntadi, 2009
September 26, 2009	Kukup beach, Gunung Kidul Special region of Yogyakarta Province	64	-	Unknown	Wulan, 2009
October 2, 2009	Pangandaran beach, Ciamis district, West Java Province	1	Almost unconscious	Unknown	PikiranRakyat, 2009
August 17, 2014	Krakal, Sepanjang, Kukup beaches, Bantul District, Special region of Yogyakarta Province	>10	Asphyxia, cramp, severe pain, nausea, shivering	*Physalia*	Maryanto, 2014
2014-2015	Balekambang beach, Malang district, East Java Province	10	Itchy and burnt on skin, severe pain	Unknown	Memo-x, 2017
July 19-20, 2015	Parangtritis beach, Bantul District, Special region of Yogyakarta Province	378	Itchy and burnt on skin, severe pain	Unknown	Viva, 2018
August 21, 2016	Parangtritis beach, Bantul district, Special region of Yogyakarta Province	5	Asphyxia, Itchy and burnt on skin, Severe pain	Unknown	Viva, 2018
August 13, 2017	Sepanjang beach, Bantul District, Special region of Yogyakarta Province	20	Asphyxia, stomachache, Itchy and burnt on skin	Unknown	Widuri, 2017
2017	Balekambang beach, Malang district, East Java Province	10	Itchy and burnt on skin, severe pain	Unknown	Malangpost, 2017
June 13 – July 3, 2018	Southern beaches of Bantul district, Special Region of Yogyakarta Province	92	Asphyxia, Itchy and burnt on skin, Severe pain	*Physalia*	Hasanudin, 2018
June 20, 2018	Southern beaches of Purworejo district, Cental Java Province	10	Itchy and burnt on skin, severe pain	Unknown	TribrataNews, 2018
2018	Balekambang beach, Malang district, East Java Province	13	Itchy and burnt on skin	Unknown	Nana, 2018

II. Diversity, Distribution and Abundance

The limited scientific data of the harmful jellyfish in Indonesia caused the difficulty to identify the species diversity, distribution and abundance. Regardless to that, there were several scientific data reported on the presence and abundance of jellyfish that were collected throughout the Indonesia's coastal areas such as *Acromitus, Catostylus, Rhopilema, Cyanea* and *Chrysaora* in the eastern coastal area of Surabaya, East Java Province (Hayati, 2011), *Crambionella* in Kebumen district, Central Java Province (Nishikawa *et al.,* 2015), *Crambione mastigophora* in Prigi Bay and Muncar, East Java Province (Omori and Nakano, 2001) and Saleh Bay, Sumbawa island (Asrial *et al.,* 2015), *Aurelia aurita* in Batu Kalang Tarusan beach, West Sumatra (Rahmah and Zakaria, 2017). The sampling period of the collected species were varied with each location; the eastern coastal area of Surabaya was conducted from November to December (Hayati, 2011), Batu Kalang Tarusan beach from May to October (Rahmah and Zakaria, 2017), Sumbawa island from September to December (Asrial *et al.,* 2015) and Kebumen district in September (Nishikawa *et al.,* 2015).

III. Monitoring and Management

There is no monitoring system established so far regarding the presence of harmful jellyfish in Indonesia. However, the annual occurrence of harmful jellyfish in some coastal areas has initiated some local governments to build safety signs, provide a standby lifeguards and collaborate with the nearest local health facilities to treat the stung patients, in particular during the holiday peak season (Antara, 2015; Nana, 2018; Aksawa, 2018; Anonymous, 2018).

In addition, the policeman also participate to warn the tourists to stay out from the beach during the blooming season of harmful jellyfish (TribrataNews, 2018; Marzuki, 2018). The lifeguards are not only preparing the first aid kits and O_2 tank, but also provide a traditional formula which consist of a liquid of chilli, spice and salt, or a combination of chili, vinegar and alcohol or soda (Sudjatmiko, 2017; Setyawan, 2017). They believe that this formula could warm the stung wound so that it would reduce the pain. The traditional medicine will be applied after the stung wound is cleaned up with seawater, baking soda or warm water then packed with vinegar. It takes approximately 15 minutes to 2 hours for the victims to recovery, depends on the fatalities after the application of that traditional medicine.

IV. Impacts of Harmful Jellyfish on Human

Regarding the *Physalia* stinging cases, mainly the stung victims are young children who are attracted to touch the tiny blue balloon like jellyfish which got stranded on the beach (Fig 2.2.3; Fig 2.2.4; Fig 2.2.5). They usually play or swim along the shoreline where jellyfish are washed up on the beach, meanwhile the adult victims get sting when they are swimming.

Fig 2.2.3 Visitors who were get stung by poisonous jellyfish (Setyawan, 2017).

Fig 2.2.4 Police are appealing the crying boy who was stung by jellyfish (Sudjatmiko, 2017).

Fig 2.2.5 Officers dealing with the boy who was stung by jellyfish (Anonymous, 2018).

According to the online newspaper, there were a high number of stung victims in the last three years. It presumably related to Eid Al-Fitr, a big Muslim holiday in Indonesia where mostly people spend their holiday by going to the beach with the families and relatives. The *Physalia* stung victims admitted that they suffered from itchy and burnt on skin, which followed by severe pain in young children (Marzuki, 2018; Deni, 2018). At this stage, the lifeguards will treat the victim with the traditional formula (Marzuki, 2018; Anonymous, 2018; Setyawan, 2017). The following severe symptoms are muscle cramping, nausea, vomiting and breathing difficulties. When the victims get breathing difficulties and those severe symptoms, the lifeguards will apply the O_2 mask and immediately take the victim to the nearest local health facility and hospital for further treatment (Sudjatmiko, 2017; Memo-x, 2017; Maryanto, 2014; Aryono, 2018).

V. Economic and Socio-cultural Impacts

The first jellyfish economic impact in Indonesia was reported on 26th April 2016 where this delicate marine species massively entered the cooling system of Paiton 9 Power Plant in Probolinggo district, East Java Province. (Fig 2.2.6 and Fig 2.2.7) (Dewanto, 2016; Faisol, 2016; Rofiq, 2016; Rosyadi, 2016).

The management team of the Paiton power plant has actually set up the jellyfish net in order to anticipate the occurrence of jellyfish that occur every May since 2012. Nonetheless, they did not expect the huge number of jellyfish that bloomed earlier than predicted (Dewanto, 2016). As this power plant is the main electricity supply for Java and Bali island, the central of economy, industrial and main governmental offices located, the impact was devastated. The electricity supply for some big cities in Jakarta and West Java Province had to be shut down (Rosyadi, 2016). It took more human resources and time to totally clean up along the main cooling system, and they put more permanent jellyfish net around the intake canal in order to prevent this incident in the future (Dewanto, 2016; Faisol, 2016; Rofiq, 2016; Rosyadi, 2016).

The jellyfish stinging had also ruined the 19th Indonesian national sports week (PON) that is celebrated every four years and attended by athletes from all Indonesian provinces. They reported that several swimming athletes in Tirtamaya beach, Indramayu district, West Java Province were stung by jellyfish, thus the athletes could not continue the race due to severe pain and breathing difficulties (Anggara, 2016; Adisubrata, 2016) (Fig 2.2.8 & Fig 2.2.9).

Fig 2.2.6 Jellyfish invading the cooling machine (Rofiq, 2016).

Fig 2.2.7 Workers cleaning the jellyfish in the cooling machine (Rofiq, 2016).

Fig 2.2.8 Athlete Johanes Joni Harbelubun got exposed to jellyfish sting (Adisubrata, 2016).

Fig 2.2.9 Medical officers treating an athlete who was stung by jellyfish (Anggara, 2016).

Besides the jellyfish stinging cases, the impacts of blooming jellyfish in Indonesia's fisheries are not widely reported. Some fishermen in Java north coast, particularly Port of Tanjung Tembaga and Perikanan Pantai, Probolinggo city (East Jawa) admitted that the annual blooming of jellyfish reduced their catch and clogged the fish net (Priyasidharta, 2012) (Fig 2.2.10). Furthermore, this blooming jellyfish affected the mangrove nursery area in Probolinggo district, since they swim into this area during high tide, then stranded, died and covered the mangrove seedling. According to the farmers, the dead body of jellyfish caused a fungi-like disease to the seedling (Yoenianto, 2016) (Fig 2.2.11).

VI. Challenges and Gaps of the Monitoring Harmful Jellyfish Bloom

The vast area of Indonesia with various oceanography characters brings monitoring and management of harmful jellyfish to a challenging task. Awareness of the impact of harmful jellyfish only exist in the tourist destination areas or during the holiday peak season by few local governments (e.g. Bantul district and Malang district). The prevention and monitoring of harmful jellyfish are basically during their annual occurrences, thus when it happens out of the predicted months, the impact will be large as shown in Paiton Power Plant in Probolinggo district (Faisol, 2016; Rofiq, 2016; Rosyadi, 2016).

According to the incidents reported by media, it showed that the management of harmful jellyfish in Indonesia is mainly based on the countermeasure acts which is costly. It is suggested that the impact of harmful jellyfish may be reduced by regularly monitoring of the seawater quality as the bloom of this animal is induced by increased of some nutrients in seawater (Purcell *et al.*, 2007; Purcell, 2012). Moreover, the application of satellite images could mitigate the status of the wind direction, sea surface temperatures and concentration of chlorophyll that promote the outbreaks of this animal in real time, therefore the prevention of the affected areas could be conducted earlier (Xu *et al.*, 2013; Keesing *et al.*, 2016). Also, in order to minimize the number of stung victims every year, the warning signs should be added more at the beaches that are affected. Education on how to treat the stung victims is needed, since there are different methods developed by the lifeguards beside the recommended application of vinegar.

VII. Current Research of Harmful Jellyfish

To our knowledge, Mujiono (2012) is the only scientific publication of harmful jellyfish in Indonesia. Since Indonesia has been productively in exported edible jellyfish, therefore currently many studies has been focusing in identification and abundance of edible jellyfish such as Nishikawa *et al.* (2014), Asrial *et al.* (2015), Rahmah and Zakaria (2017) and Yusuf *et al.* (2018).

Fig 2.2.10 Jellyfish at Harbor Tanjung Tembaga and Fishing Port, Probolinggo (Priyasidharta, 2012).

Fig 2.2.11 Magrove seeds attacked by jellyfish in the north coast of Probolinggo (Yoenianto, 2016).

2.3 MALAYSIA

I. Status and Background

Recent studies on jellyfish are dwelling into the ecological niches of the jellyfish within coastal ecosystems (Doyle *et al.*, 2006). The number of studies on jellyfish skyrocketed in 1980's after *Pelagia noctiluca* bloomed in the Mediterranean and Adriatic Seas (Maretic *et al.,* 1991). Jellyfish blooms pose tremendous threats to the sustainability of fisheries and jeopardize human health (Uye, 2008). The causes of jellyfish blooms and the direct and indirect implications were then being intensely studied (Dong *et al.,* 2010; Purcell *et al.,* 2007).

A study by Chuah *et al.* (2010) proposed that Straits of Malacca is prone to the invasions of alien jellyfish species attributing to its buzzling ports and harbours. On top of that, there is likely no signs before the bloom of the invasive jellyfish as seen in the bloom of *Phyllorhiza punctata* at the Gulf of Mexico in 2000. This infers that a tendency of an alien jellyfish bloom in Malaysian waters is likely (Graham & Bayha, 2008).

Jellyfish has provoked a chaos in Malaysia this decade due to their notoriously painful and possibly fatal stings. The death of a Swedish woman in early February 2010 in Langkawi due to an unknown jellyfish sting (suspected to be a deadly box jellyfish sting) had wracked a havoc on headlines of international news (Ibrahim, 2013). Since early 2017, Malaysians were worried after the news of a twelve-year-old boy fell into coma after being stung by jellyfish at Teluk Bahang (The Star; Jellyfish victim out of coma; 7th March 2017) and Swedish tourist who was enjoying his holiday in Langkawi sadly passed away after getting stung by a jellyfish near Tanjung Rhu beach (New Straits Times; Swedish tourist stung to death by jellyfish in Langkawi; 28th June 2018).

In order to have a better understanding of jellyfish roles in our ecosystem; efforts on jellyfish research in Malaysia has been carried out by several institutes. Centre for Marine and Coastal Studies (CEMACS), Universiti Sains Malaysia (USM) pioneering the jellyfish ecological research to provide a full insight of the diversity and abundance of jellyfish in the northern Peninsular Malaysia waters. Jellyfish study was carried from the month of March 2018 in Sabah, East Malaysia after a training and workshop of harmful jellyfish at CEMACS, USM, Penang. Jellyfish bloom was started in March and it was high in April and May, 2018 and slowly declined in June. However, still sporadically, moon jellyfish and box jellyfish have been noticed in Sabah.

The outcomes of this project are useful for the management of jellyfish and prevention of severe jellyfish stings to both locals and tourists. Species identification of jellyfish in Malaysia using DNA sequencing and phylogeny analysis was carried out by Institute of Ocean and Earth Sciences, University of Malaya aimed to document and resolves the uncertainty of earlier identified species in the region and gives valuable information for the future generation which has same interest and inspired the budding scientist to carry out further research on it. Remote Envenomation Consultancy Services (RECS) by Malaysian Society on Toxinology (MST) has played their role to assist healthcare providers at various levels of clinical management for stings and envenoming jellyfish.

II. Diversity, Distribution and Abundance

A total of twenty one species were recorded in the previous jellyfish studies in Malaysia. However, some species were misidentified and given the wrong taxa due to the lack of knowledge and information back then. Precise identification of jellyfish in Malaysia was done by Rizman *et al.* (2016) using DNA sequencing. The first species identification of jellyfish in Malaysia using DNA sequencing is carried out by Rizman *et al.* (2016) and twelve jellyfish species representing eleven genera were identified. The species identified were *Acromitus flagellatus, Cephea cephea, Rhopilema hispidum, Mastigias sp., Phyllorhiza punctata, Cyanea* sp., *Chrysaora chinensis*, *Lobonemoides robustus*, *Rhopilema esculentum*, *Catostylus townsendi*, *Morbakka* sp., and *Chiropsoides buitendijki* (Fig 2.3.1).

Jellyfish diversity, distribution are high in Sabah waters seasonally (March-June), in addition some species of jellyfish are abundant. We found number of jellyfish samples such as *Acromitus flagellatus*, *Aurilia* sp., *Catostylus townsendi*, *Lobonemoides robustus*, *Mastigia papua, Netrostoma* sp., *Thysanostoma* sp. (Cnidaria, Scyphozoa) and investigated their biodiversity. The jellyfish *Anamalorhiza shawi* (Scyphozoa, Rhizostomae) is considered as a new record to Malaysia. Many associated fauna such as crabs, fish, shrimps, ophiruoids, etc. were found and preserved for our association study.

A research by Tulasiramana (2007) found seven jellyfish species off Kota Kinabalu namely *Aurelia aurita*, *Mastigias papua*, *Thysanostoma thysanura*, *Drymonema dalmatinum*, *Acromitus flagellatus*, *Chrysaora* sp. and *Chiropsalmus quadrigatus* (cubozoan). In his study, jellyfish of species *Mastigias papua* was recorded. However, study using DNA sequencing could only identify the jellyfish to genus level which is *Mastigias*. The record of *Thysanostoma thysanura* was another misidentification to the species *Phyllorhiza punctata* due to the similarity of the morphological features. Furthermore, *Cyanea* sp. is also believed to be misidentified as *Drymonema dalmatinum* as the later was only recorded in Atlantic Seas such as Caribbean Sea (Larson, 1987) and Adriatic Sea (Malej *et al.,* 2014) and there was no literature of its occurrence in South China Sea. Besides, *Chiropsalmus quadrigatus* was recorded in the study is in a status of nomen dubium and is suspected to be the species *Chiropsoides buitendijki* which is commonly found in Malaysia. All these errors were because the study in 2007 was merely based on physical examinations and morphological identification.

A study of jellyfish species at the Straits of Malacca (specifically Penang National Park, Manjung and Port Dickson) had discovered seven species (representing five genera) namely *Chrysaora* spp. (three species), *Phyllorhiza punctata*, *Chiropsoidis buitendijki*, Carybdeid- *Morbakka* sp. and *Stomolophus* sp. (Chuah *et al.,* 2010).

The jellyfish *Chrysaora* spp. could only be identified until genus level and were categorized using their colour variations and patterns which are *Chrysaora* sp.1 (whitish to brownish with white dots), *Chrysaora* sp.2 (reddish-orange dots) and *Chrysaora* sp.3 (reddish-brown petaloid bell edge). All three species were then identified as the same species as *Chrysaora chinensis* by Rizman *et al.* (2016). Cannonball jellyfish or *Stomolophus* sp. was described as having "inconspicuous brown papillae distributed unevenly on both upper and lower halves of the umbrella" in the study, which this is actually a morphological characteristic of *Rhopilema hispidum* which has a similar considerably large bell and colour. This is believed to be a misidentification of the species *Rhopilema hispidum* which is described as "sand type" jellyfish by Rizman *et al.* (2016). This is further supported by the descriptions and pictures of *Rhopilema hispidum* by Gul and Morandini (2015).

Fig 2.3.1 Twelve jellyfish species found in Malaysian waters. Cubozoan jellyfish: (a) *Morbakka* sp.; (b) *Chiropsoides buitendijki*; Scyphozoan jellyfish: (c) *Acromitus flagellatus*; (d) *Catostylus townsendi*; (e) *Cephea cephea*; (f) *Chrysaora chinensis*; (g) *Cyanea* sp.; (h) *Lobonemoides robustus*; (i) *Mastigias* sp.; (j) *Phyllorhiza punctata*; (k) *Rhopilema hispidum*; and (l) *Rhopilema esculentum*. (Source: Rizman *et al.*, 2016).

A recent study by Low (2017) described nine scyphozoan jellyfish species found in Peninsular Malaysia, i.e., *Chrysaora chinensis*, *Cyanea* sp., *Versuriga anadyomene*, *Rhopilema hispidum*, *Rhopilema esculentum*, *Phyllorhiza punctata*, *Acromitus flagellatus*, *Lobonemoides robustus*, and *Lychnorhiza malayensis*. *Lychnorhiza malayensis* was first reported in Malaysian waters.

In short, a total of fifteen species of jellyfish comprising fourteen genera is found in Malaysian waters. There are thirteen species of scyphozoan which are namely *Acromitus flagellatus*, *Cephea cephea*, *Rhopilema hispidum*, *Mastigias* sp., *Phyllorhiza punctata*, *Cyanea* sp., *Chrysaora chinensis*, *Lobonemoides robustus*, *Rhopilema esculentum*, *Catostylus townsendi*, *Aurelia aurita*, *Lychnorhiza malayensis* and *Versuriga anadyomene*. However, the identity and occurrence of *Aurelia aurita* in Malaysia is yet to be determined. Two species of cubozoan found in Malaysian waters were *Morbakka* sp. and *Chiropsoides buitendijki*.

III. Monitoring and Management

Centre for Marine and Coastal Studies (CEMACS), Universiti Sains Malaysia (USM) pioneering the jellyfish ecological research in Penang Island in studying the monthly distribution and abundance of jellyfish species in the coastal waters of Penang National Park which was conducted for 12 months started from November 2009 to October 2010.

Jellyfish species abundance does not fluctuate much according to this study. There is no significant trend that allows the fluctuation to be predicted. Excessive nutrient input might be the major factor to be blamed on for the increase abundance of jellyfish and followed by climate change (global warming) and human activities (development).

CEMACS was appointed by Tenaga Nasional Berhad (TNB) from September 2009 until February 2011 as consultant to provide useful information for proper management strategies to overcome jellyfish ingression in TNB power plants (Fig 2.3.2). The Tenaga Nasional Berhad (TNB) power plants i.e. the Sultan Ismail Power Station (SIPS), located in Paka, Terengganu; the Tuanku Ja'afar Power Station (TJPS), located in Port Dickson, Negeri Sembilan; and the Sultan Azlan Shah Power Station (SASPS) located in Manjung, Perak, were facing with jellyfish infestation problem that could interrupt their operation. The jellyfish abundance is considered as a serious problem when the cooling-water intake screens are being clogged up by jellyfish. This has incurred a huge amount of cost and effort in order to get rid of the jellyfish when they are trapped in the filter system(s). This research was undertaken to understand the dynamic and occurrence of jellyfish as well as to determine what environmental factors that triggered jellyfish outbreak.

Several parameters were studied to determine the factors that cause the jellyfish occurrence and abundance at the coastal water of the power plants. The parameters studied were jellyfish, phytoplankton, zooplankton and water quality. The species and distribution of phytoplankton and zooplankton together with water quality data were used to correlate with the jellyfish abundance. From the data analysis, a management framework (model) was proposed in order to control the jellyfish infestation problem (Fig 2.3.3). Recently (September 2017 - current) CEMACS received funding from the Penang State Government to monitor the jellyfish (medusae) species in the coastal waters of Penang, Malaysia. This project will be carried out for 24 months period at five tourist hotspots (Teluk Bahang, Batu Ferringghi, Tanjung Bungah, Tanjung Tokong, Georgetown and Pantai Bersih/Robina) around the coastal waters of Penang as monitoring and study sites. The main objective was to assess the monthly distribution, abundance and species of jellyfish (Medusae) present in the coastal waters of Penang (Fig 2.3.4 & Fig 2.3.5). Our team hope to study the monthly water quality (physical and chemical) patterns and analyse the effects of monthly water quality on the distribution and abundance of jellyfish species in the coastal waters of Penang. Our final aim is understanding the ecological processes determining the outbreaks of jellyfish population in the coastal waters of Penang.

In term of promoting the public awareness of jellyfish sting in Penang Island, CEMACS organized the first public awareness talk in 4th December 2017 to enhance multi-disciplinary collaborations among researchers, healthcare providers, private sectors, local communities and public. This event received great attention from mass media as the public event was published in several local news. There were more than 60 participants took part in this public talk. The first vinegar pool and 'first aids steps' sign board was set up in front of the centre (Fig 2.3.6).

The half-day workshop was organised by the Malaysian Association of Hotels (MAH) Penang Chapter, together with CEMACS, USM as part of its ongoing Jellyfish Awareness Campaign to educate all those involved in the hospitality industry in Penang. About 50 participants from various hotels, comprising mainly Emergency Response Team (ERT) members, security personnel, recreation and front office staff attended the workshop that was held at the Golden Sands Resort Penang on 27th April 2018 (Fig 2.3.7).

Fig 2.3.2 Sampling activity for jellyfish research at the Sultan Azlan Shah Power Station (SASPS) located in Manjung, Perak.

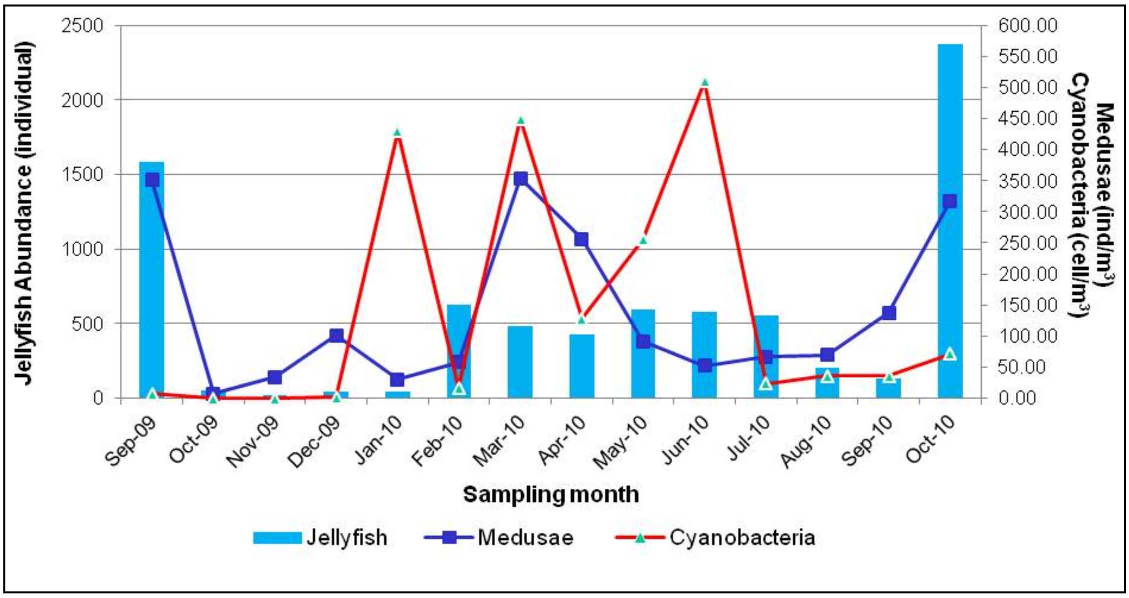

Fig 2.3.3 The abundance of jellyfish, zooplankton (Medusae) and phytoplankton (Cyanobacteria) at the Sultan Azlan Shah Power Station (SASPS) located in Manjung, Perak from September 2009 to October 2010.

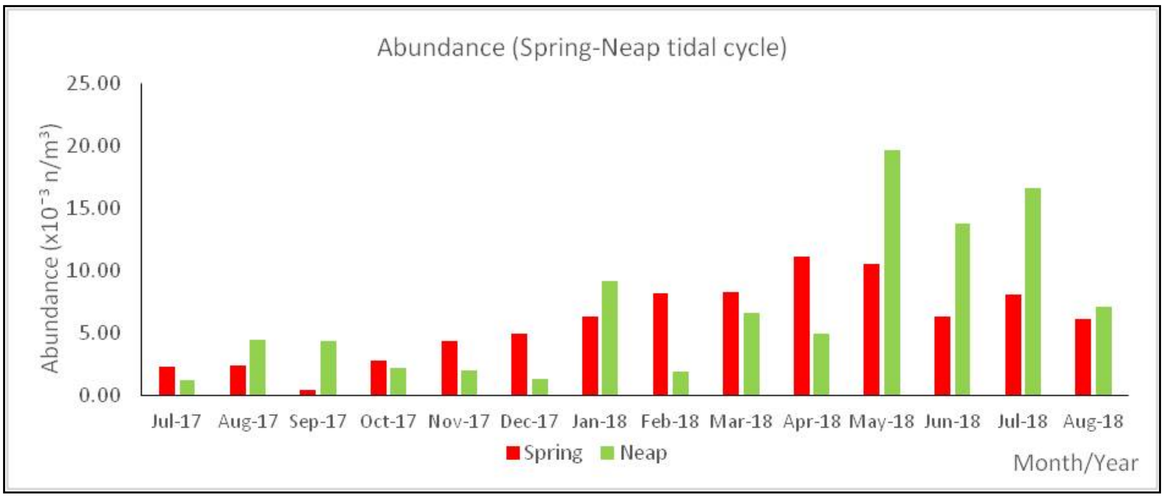

Fig 2.3.4 Monthly abundance of total jellyfish around the coastal waters of Penang, Malaysia (July 17 – August 18).

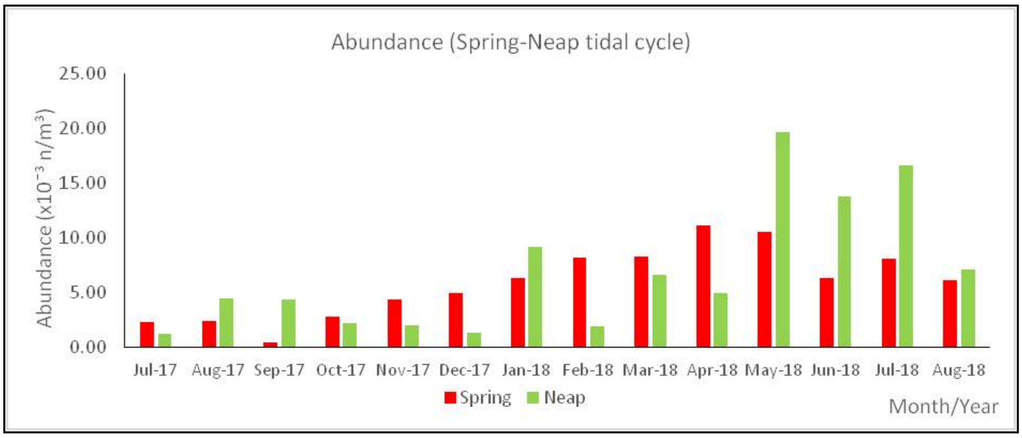

Fig 2.3.5 Monthly abundance of total jellyfish (Spring – Neap tidal cycle) around the coastal waters of Penang, Malaysia (July 17 – August 18).

Fig 2.3.6 The first vinegar pool and 'first aid steps' sign board in Penang Island in front of Centre for Marine and Coastal Studies (CEMACS), Universiti Sains Malaysia.

Fig 2.3.7 Malaysian Association of Hotels (MAH) Penang Chapter & Centre For Marine & Coastal Studies (CEMACS), Universiti Sains Malaysia Jellyfish Awareness Campaign; 27th April 2018, Golden Sands Resort, Penang.

The workshop was also part of CEMACS's commitment to the Jellyfish Awareness Programme under the United Nations Intergovernmental Oceanographic Commission (IOC) for the Western Pacific (WESTPAC). The box jellyfish is considered to be among the top ten deadliest animals on Earth, containing toxins that would cause paralysis to the heart, nervous system, and skin cells when in contact with the tentacles. It is deemed highly hazardous to unsuspecting swimmers in the sea.

This highly informative and educational workshop covered all aspects of the threat posed by venomous sea creatures along with guidance on the dos and don'ts when a person is stung. The session included scientific facts on the box jellyfish and a video presentation of first aid treatment for victims. First responders from St. John Ambulance were also present to demonstrate emergency first aid treatment for victims stung by jellyfish on the beach in front of the resort. It is hoped that through this workshop, all participants would be equipped with the vital knowledge and practical know-how in the event of an actual emergency involving jellyfish sting victims. In Sabah, monitoring is carried out often, but lack of fund and information lead to missing some precious specimens.

IV. Impacts of Harmful Jellyfish on Human

Recently, jellyfish (or suspected box jellyfish species) sting cases in Malaysia have captured the public's attention which caused 12 years old boy pain for over a week before falling into a coma in Teluk Bahang, Penang (The Star; Jellyfish victim out of coma; 7th March 2017) (Fig 2.3.8 & Fig 2.3.9); swarms of stinging jellyfish proved to be an added obstacle for participants of the Penang International Cross Channel Swim (The Star; Swimmers brave jellyfish stings to cross Penang Strait; 27th March 2015); In Sabah, a total of 22 people have suffered jellyfish stings in popular Tanjung Aru beach, Kota Kinabalu (The Star; Stinging threat for beachgoers; 2nd February 2016) and a nine-years-old girl became the victim of jellyfish sting in Tanjung Aru beach; bringing the total known 22 cases in January 2016 (The Star; Jellyfish invasion at Tanjung Aru; 31st January 2016 / The Star; Girl stung by poisonous jellyfish at Tanjung Aru beach; 30th January 2016).

Meanwhile in Langkawi, Swedish tourist who was enjoying his holiday sadly passed away after getting stung by a jellyfish. This tragic incident happened near Tanjung Rhu beach on 27th June 2018 (New Straits Times; Swedish tourist stung to death by jellyfish in Langkawi; 28th June 2018). In early February 2010, a Swedish woman vacationing with her family in Langkawi was also killed by a jellyfish while bathing off Pantai Cenang. According to media reports, the victim was on her way back to the beach when she encountered the dangerous jellyfish just a few meters from the shore (Astro Awani; Stings from jellyfish can be fatal; 24th August 2013). Records from Langkawi Hospital between January 2012 and December 2014 showed that a total of 759 patients presented with jellyfish stings during the three years study period, with highest number of visits in July, October, November, and December. The mean patient age was 26.7 years (SD: 12.14), 59.4% were men, 68.1% were foreigners or international tourists, and 40.4% were stung between 12.00 p.m. and 6.59 p.m. At least 90 patients presented with mild Irukandji or Irukandji-like syndromes. Most of the jellyfish stings occurred at Pantai Cenang (590 reported cases), followed by Pantai Tengah and Kok Beach. Most patients were treated symptomatically, and no deaths following a jellyfish sting was reported during the study period (Mohd *et al.*, 2016).

Fig 2.3.8 Scars from jellyfish stings.

Nation 17

Jellyfish victim out of coma

Boy unconscious for three days by slow-acting toxin that shrinks veins

By LO TERN CHERN
andylo@thestar.com.my

BUTTERWORTH: A Year Six schoolboy fell into a coma for three days after being stung by a jellyfish while swimming in Teluk Bahang.

Ahmad Azfar Hakim, 12, was in pain for over a week before falling into a coma on Thursday after he was admitted to the Seberang Jaya Hospital.

His father Zainudin Zakaria, 48, said the family was having a picnic in Teluk Bahang when his son was stung at about 3.30pm on Feb 26.

"I was preparing food on the beach when Azfar suddenly ran out of the water screaming in pain. His arms and legs were covered in swollen welts.

"We took him to a nearby toilet to wash and left an hour later. We then took him to two clinics where he was given an injection at about 10pm that day," he said when met outside the hospital's intensive care unit yesterday.

Zainuddin said they thought that Azfar was now fine but at 2am, he complained that he was still in pain.

"I then took him to the Bukit Mertajam Hospital but the doctors told me that there was no cure for jellyfish sting and advised me to apply a soothing cream on my son.

"On Wednesday, my son's condition turned critical when he had difficulty breathing and his vision turned blurry.

"I rushed him to the Bukit Mertajam Hospital's emergency unit and they later transferred him to the Seberang Jaya Hospital where he fell into a coma," he said.

Zainudin added that Azfar came out of his coma on Saturday and is recovering.

"Doctors told me the symptoms showed that he was stung by a jellyfish which has a slow reacting toxin that shrinks the veins.

"Azfar is expected to be discharged in a few days," he said.

Back from beyond: Azfar before he woke up from his coma at Seberang Jaya Hospital in Butterworth.

Brave teenage girl conquers channel

Swimmer endures jellyfish stings and murky waters to win gold

Fig 2.3.9 Recent newspaper reports regarding jellyfish attacks in the year 2017.

V. Economic and Socio-cultural Impacts

Edible jellyfish fishery is going on in Malaysia. In hotels and some restaurants, they serve jellyfish delicacy. Awareness on harmful jellyfish in schools and also to local people about what to do and don't were introduced.

Publication or report by Lippmann *et al.* (2011) had been applied the model of internet-based retrospective health data aggregation, through the Divers Alert Network Asia-Pacific (DAN AP), together with more conventional methods of literature and media searches, to document the health significance, and clinical spectrum, of box jellyfish stings in Malaysia for the period 1st January 2000 to 30th July 2010. Results showed that three fatalities, consistent with chirodropid (box jellyfish) envenomation, were identified for the period - all tourists to Malaysia. Non-fatal chirodropid stings were also documented. During 2010, seven cases consistent with moderately severe Irukandji syndrome were reported to DAN and two representative cases are discussed here. Photographs of chirodropid (multi-tentacled), carybdeid (four-tentacle) box jellyfish, and of severe sting lesions were also submitted to DAN during this period.

This study suggests that the frequency and severity of jellyfish stings affecting tourists in Malaysia have been significantly underestimated. An increasing in fatal of tourists cause by jellyfish in Malaysia waters, while without proper and timely management, can cause a great impact on tourism.

VI. Challenges and Gaps of the Monitoring Harmful Jellyfish Bloom

Collaboration and networking between institutes within country needed to standardize and synchronize the method on monitoring and management system of harmful jellyfish bloom in Malaysia.

Gaps and capacities needed for harmful jellyfish research, monitoring and management to be addressed via WESTPAC; Jellyfish species/taxonomy; jellyfish species geolocation/distribution; jellyfish ecology/ bloom predictions; role as parasite vectors/host-symbionts; training for healthcare providers; public awareness programs; local government involvement in efforts and tourism/hospitality industries support.

VII. Current Research of Harmful Jellyfish

No.	Institutes	Research Niche Areas	Target Locations
1	Centre for Marine and Costal Studies (CEMACS), Universiti Sains Malaysia (USM)	• Long term monitoring • Jellyfish ecological research - species diversity & distribution	Northern Peninsular Malaysia
2	Institute of Ocean and Earth Sciences (IOES), University of Malaya (UM)	• Species identification using DNA sequencing and phylogeny analysis	Malaysia
3	Universiti Malaysia Sabah (UMS)	• Jellyfish ecological research - species diversity & distribution • Molecular research- new species found in Sabah • Symbiotic copepods associated with box jellyfish	Sabah
4	Remote Envenomation Consultancy Services (RECS) by Malaysian Society on Toxinology (MST)	• Clinical toxinology; research toxinology; networking of experts in the field	Malaysia

2.4 PHILIPPINES

I. Status and Background

The term 'jellyfish' in this chapter refers to planktonic, gelatinous and medusoid animals belonging to the phylum Cnidaria. The Philippines is rich in jellyfish diversity, and different species have been recorded in coastal waters as early as the 1900s (Light, 1914 and 1921; Mayer, 1910 and 1915). Taxonomic descriptions were later explored by Heeger (1998) and Gershwin (2003). These past studies provide valuable taxonomic information, but no accurate estimate of species diversity.

Recent studies on Philippines jellyfish focus mainly on aspects of biology including population dynamics (Boco, 2014; Boco *et al.*, 2014; Geson and Ongluico, 2013), jellyfish-commensal association (Boco & Metillo, 2018; Kondo *et al.*, 2014; Ohtsuka *et al.*, 2015), and reproduction (Geson, 2018). There is a lack of information on jellyfish biology and ecology, especially on harmful effects of jellyfish to humans and the marine ecosystem in the Philippines are few. This review focuses on the status, diversity and management of Philippines harmful jellyfish.

II. Diversity, Distribution and Abundance

There are about 2,000 species of jellyfish globally and only 10-15 species are considered to be life-threatening (Fenner 1998; Williamson *et al.* 1996). In the Philippines, there are about 38 species of Scyphomedusae and seven species of Cubomedusae from past estimates (Light, 1921; Mayer, 1915) (Table 2.4). These numbers could be greater after a thorough nationwide research. For instance, a recent study in Malampaya Sound, Northern Palawan has rediscovered the mangrove panther jellyfish, *Acromitus maculatus*, almost a century later since it was first described (Kondo *et al.*, 2014).

Despite having a vast coastal area, the country does not have accurate information on jellyfish distribution and abundance. Blooms often occur during warm months of March to April (e.g., Boco et *al.,* 2014). However, the tropical upside-down jellyfish, *Cassiopea andromeda* is abundant year round with peak over the warmer months from May to June (Fig 2.4.1) in certain areas of the country (Geson, 2018).

Further research is necessary to answer questions on the driving factors that cause the increase of *C. andromeda* population over the 'summer'. A bloom of the common moon jellyfish, *Aurelia aurita*, in Sogod Bay, Southern Leyte was reported last April 2018. Stranding of the scyphomedusae *Cephea cephea* is also more common on beaches of Balamban, Cebu after the summer months (Geson 2017, pers. obs.). *Pelagia* sp. was observed to peak in abundance in December 2017 at a Central Philippines island (Fig 2.4.2). Harmful jellyfish species such as the cubomedusa *Chironex* sp. (Fig 2.4.3) is reported by local fishermen to be more common in July to September following the warmer months (Metillo *et al.,* 2015b). The highly lethal cubomedusae *Malo* sp. and *Morbakka* sp. have been respectively recorded in Taytay, Palawan (Metillo *et al.,* 2015b) and Moalboal, Cebu (Sipalay, 2017 personal observation). Proper assessment and monitoring of these species will certainly establish the seasonality and regularity of summer blooms.

Fig 2.4.1 Abundant upside-down jellyfish *Cassiopea andromeda* found in Mactan, Cebu.

Fig 2.4.2 Bloom of *Pelagia* sp. off the coast of Daram Island, Samar on December 2017.

Fig 2.4.3 *In situ* picture of the lethal box jellyfish, *Chironex* sp. from Eastern Visayas, Philippines.

Table 2.4 List of reported jellyfish species based on Light (1914 & 1921)[1], Heeger (1998)[2] and other reported sightings[3].

Class	Order	Family	Species	Location
Hydrozoa	Anthoathecata	Porpitidae	*Porpita porpita*	Leyte[2], Luzon[2], Cebu[1,3]
			Velella velella	Batanes[2]
	Leptothecata	Aequoreidae	*Aequorea* sp.	Palawan[2]
Schyphozoa	Coronata	Atollidae	*Atolla parva*	Philippines[1]
		Linuchidae	*Linuche unguiculata*	Philippines[1]
			Linuche aquila	Davao Gulf[3]
		Periphyllidae	*Periphylla hyacinthina*	Philippines[1,3]
	Semaeostomeae	Pelagiidae	*Chrysaora helvola*	Bantayan Is.(Cebu)[2]
			Chrysaora quinquecirrha	Leyte[1,2]
			Chrysaora melanaster	Philippines[1]
			Pelagia panopyra	Bantayan Is.[2] ; Samar[2,3]
			Sanderia malayensis	Philippines[1]
		Cyaneidae	*Cyanea nozakii*	Philippines[2]
			Aurelia aurita	Philippines[1,2,3]
			Aurelia labiata/limbata	Philippines[1,2,3]
	Rhizostomeae	Lynchnorhizidae	*Anomalorhiza shawi*	Visayas Seas[2]
		Mastigiidae	*Mastigias papua*	Tawi-Tawi[1,2], Panay Is. [1,2], Bohol[1,2,3]
			Mastigias ocellatus	Philippines[1,2]
			Versuriga anadyomene	Visayas Seas[1,2], Bantayan Is.(Cebu)[1,2], Mindanao[1,2], Bohol[1,2]
			Phyllorhiza punctata	Cebu[1,2], Mindoro[1,2], Visayas Sea[1,2]
			Phyllorhiza luzoni	Philippines[1]
		Thysanostomatidae	*Thysanostoma loriferum*	Cebu[1,2]
		Cepheidae	*Cephea cephea*	Bohol[1,2,3], Cebu[1,2,3]
			Cotylorhiza pacifica	Phhilippines[1]
		Catostylidae	*Catostylus townsendi*	Palawan[2]
			Catostylus purpurus	Philippines exclusive[1,2]
			Catostylus mosaicus	Philippines[1,2]
			Catostylus sp.	Paguil Bay, Mindanao[3]
			Acromitus maculosus	Palawan[1,2]
		Lobonematidae	*Lobonema smithii*	Palawan[1,2,3]
			Lobonemoides robustus	Malampaya Sound[3], Carigara Bay, Leyte[3]
		Cassiopeidae	*Cassiopea andromeda*	Mindanao[1,2,3], Leyte[1,2,3], Cebu[1,2,3], Negros[3]
			Cassiopea ndrosia	Mindanao[2], Cebu[2]
			Cassiopea ornate	Philippines[1]
		Rhizostomatidae	*Rhopilema hispidum*	Palawan [2]
			Rhizostoma sp.	Visayas Seas[2]
Cubozoa	Chirodropida	Chiropsalmidae	*Chiropsalmus quadrigatus*	Mindanao[2], Palawan[2], Cebu[2,3]
		Chirodropidae	*Chironex fleckeri*	Mindanao[2]
	Carybdeida	Carybdeidae	*Carybdea rastoni*	Mindanao[2]
			Carybdea alata	Philippines[2]
			Carybdea marsupialis	Philippines[2]
			Carybdea sp.	Luzon[2]
			Carybdea sivickisi	Mindoro[3]

III. Monitoring and Management

Although awareness of the presence of harmful jellyfish in coastal waters is high, there is no formal nationwide management and monitoring of toxic and bloom jellyfish species. With the exception of the Provincial Disaster Risk Reduction and Management Office (PDRRMO) of Pangasinan, Northwestern Philippines which has been actively monitoring jellyfish cases in their coastal waters (Visperas, 2017). Dr. Angel Yanagihara of University of Hawaii in Manoa and her team from Tacloban City have been involved in workshops and campaigns to promote awareness of jellyfish stings and to prevent sting-related fatalities in Pangasinan; Eastern Visayas; and Lucena, Quezon, Southern Luzon. Some media and regional offices of the Department of Health broadcast jellyfish sting warnings to beach goers particularly during the warm months of March to May (Fig 2.4.4).

In the medical field, the Remote Envenomation Consultancy Services (RECS) has expanded its network to the country through Dr. Khaldun Ismail from Malaysia. The organization is composed of Medical Emergency Response Doctors specially trained to handle marine and terrestrial envenomation cases but are based in different parts of the country.

Recently a social media group called “Philippines Jellyfish Stings” was created as a “citizen science” tool that is primarily aimed at increasing the awareness among Filipinos on the impacts of harmful jellyfish, and identifying possible envenomation hotspots (https://www.facebook.com/phjellyfishsting/).
Through this platform, anyone in the country can report harmful jellyfish sightings and sting cases.

IV. Impacts of Harmful Jellyfish on Human

With highest frequency during the warm season from March to early June, jellyfish sting incidents in the country have been increasing in recent years (Guevara *et al.*, 2017). It remains unconfirmed whether the increasing rates of jellyfish stings during warm months are due to the high numbers of beachgoers, the occurrence of jellyfish bloom or both.

Regarded as a major global hotspot of jellyfish envenomation, the country registers the highest morbidity and mortality among fishermen and children, with a conservative estimate of 20 to 50 deaths annually (Fenner and Williamson, 1996; Heeger *et al.*, 1992). These numbers, however, may be low since many deaths caused by jellyfish are usually unreported and improperly catalogued by hospitals and health agencies because the cause of death in the death certificate is not required for burial especially in public cemeteries (Fenner and Williamson, 1996).

Majority of the Filipinos seem to treat jellyfish envenomation lightly, but awareness may have heightened when, a local celebrity was stung by a box-jellyfish last April 2014 (Fig 2.4.5), and was sensationalized by local and the social media.

V. Economic and Socio-cultural Impacts

Impacts of jellyfish in the country is not only limited to stings. An emergency shutdown of the Sual Power Plant in Pangasinan in December 1999 was caused by the clogging of the cooling intake pipes by a massive bloom of *Aurelia* sp. resulting to power loss to nearly half of the Luzon area (Anonymous, 1999). In June 2017, the famous Nacpan Beach in El Nido, Palawan was temporarily closed due to a mass stranding of an unidentified jellyfish as posted in Facebook (Fig 2.4.6). No quantification was made on the impacts of such event to the tourism industry.

On the positive note, a boost in local tourism industry can be attributed to initiatives in showcasing the beauty of jellyfish species. In Sohoton Cove, located off the coast of Surigao City, Eastern Mindanao a jellyfish lake is very popular among local and foreign tourists taking a chance to see the “golden stingless jellyfish” which is identified as *Mastigias papua* (Metillo, 2017). Also, the local government of Zamboanga City, located in the southwestern part of the country has been showcasing thousands of the upside-down jellyfishes in Sta. Cruz Island to tourists through their boat-riding activity within a mangrove forest.

Pangasinan beachgoers warned vs jellyfish

Philippine Daily Inquirer / 10:12 AM April 16, 2014

DAGUPAN CITY, Philippines—The provincial disaster risk reduction and management council (PDRRMC) on Tuesday warned beachgoers to stay close to the shore when swimming in the Lingayen Gulf to avoid being stung by jellyfish.

The warning was issued in anticipation of the influx of thousands of tourists heading for the different public beaches in Pangasinan province during the Holy Week.

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Filtered By: News

2 dead, 19 jellyfish attacks recorded in Pangasinan during Holy Week

Published April 6, 2015 2:43pm

(Updated 3:45 p.m.) Two people drowned while 19 people were attacked by jellyfish in beaches in Pangasinan during the Holy Week, the Provincial Disaster Risk Reduction and Management Council said.

One of the fatalities drowned in Lingayen while another drowned in Hundred Islands, GMA Dagupan reported Monday.

Fig 2.4.4 Articles from different newspapers reporting lethal jellyfish monitoring and management in the Province of Pangasinan, Northwestern, Philippines.

Fig 2.4.5 Local actress, Anne Curtis-Smith, after she was stung by unknown jellyfish while on a movie shoot in Batangas. Source: ABS-CBN Broadcasting Company.

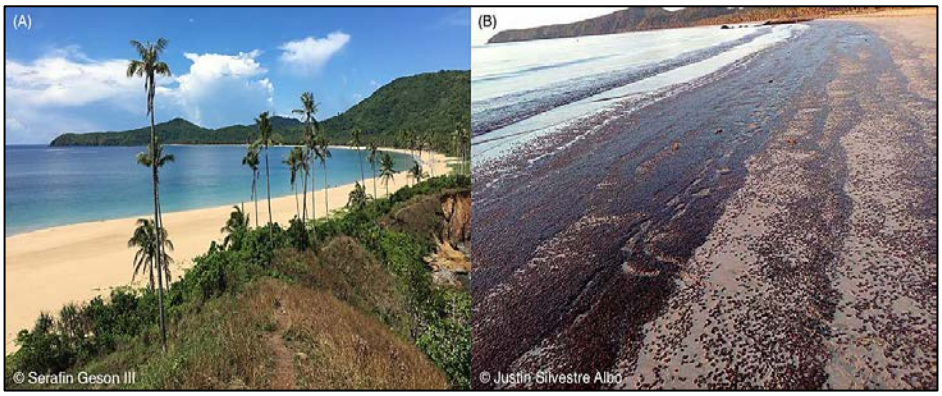


Fig 2.4.6 Nacpan Beach, El Nido, Northern Palawan, Philippines. (A) June 2016 and (B) June 2017 during the mass stranding of an unknown jellyfish bloom.

In addition, a diverse collection of jellyfish is displayed at the Manila Ocean Park for visitors. All of these may increase awareness to the public on the diversity of Philippines jellyfish.

A seasonal fishery of the commercially important jellyfish *Lobonemoides robustus* (Fig 2.4.7) is operational at a small to medium scale in Bicol, Palawan, Samar and Leyte (Omori and Nakano, 2001; Camacho and Sotto, 2007; Kondo *et al.,* 2014) and contributes to about 0.8% of the 5,400-10,000 tons of jellyfish imported to Japan with an annual market value of about $25.5M (Omori and Nakano, 2001). However, inter-annual variability in catch exists in Malampaya Sound and Bacuit Bay, Northern Palawan in the past 15 years as there are years with zero harvest (Metillo *et al.,* 2015b).

The bell of species of *Cassiopea* (Genson, 2017, pers. obs.), *Acromitoides*, other edible scyphozoans, and even the lethal box jellyfish *Chironex* can be eaten raw with vinegar and salt and sold in markets (Metillo, 2017 pers. obs.). Dehydrated scyphomedusae are being served as delectable dish in Chinese restaurants (Heeger, 1998) (Fig 2.4.8). Two edible species from Mindanao coastal waters, *Acromitoides purpurus* from Panguil Bay and the large type *Mastigias papua* from Zamboanga del Sur showed high levels of protein based on proximate analysis (Metillo *et al.,* 2015a).

There are no information on the impact of jellyfish blooms on the fishing industry in the country. However, very recently, one of us (EB Metillo) in August 2018 received a report of a bloom of *Cassiopaea* sp. in fish ponds of Botong, Batangas.

Fig 2.4.7 Dehydrated jellyfish bell of *Lobonemoides robustus* processed at Bacuit Bay, El Nido, Palawan, Philippines. Triple A means the largest bell size category.

Fig 2.4.8 Stir-fried jellyfish (dotted circle) served as part of a cold appetizer platter at a Chinese restaurant in Cebu, Philippines.

VI. Challenges and Gaps of the Monitoring Harmful Jellyfish Bloom

The main challenge of monitoring the blooms of harmful jellyfish is investment on a proper research and development framework including the implementation of science-based policies by concerned government institutions. Despite the looming threat of stinging jellyfish to coastal tourism, no proper assessment of species diversity and factors that determine spatial and temporal variations is conducted. The participation of the private sector also needs to be exhorted. What is immediately needed is to assess, manage and monitor jellyfish stings which are often lethal

VII. Current Research of Harmful Jellyfish

At present, there is a collaborative effort between Filipino and Japanese scientists together with the funding agencies (e.g. Nagao Natural Environment Foundation and the Japan Society for the Promotion of Science) in the re-examination of gelatinous zooplankton biodiversity which includes harmful jellyfish in the entire country (Metillo, 2017; Metillo *et al.,* 2015a). Also, Dr. Angel Yanagihara of the University of Hawaii in Manoa has proposed to the US National Institute of Health a program entitled "Improving Outcomes of Life Threatening Box Jellyfish Sting Injuries in the Philippines". Academic institutions like the University of San Carlos in Cebu, Central Philippines are into fisheries assessment and surveying and document both harmful and non-harmful jellyfish in Carigara Bay, Leyte, which is also a possible hotspot area with numerous marine envenomation cases. Mindanao State University-Iligan Institute of Technology and Western Philippines University are looking at dynamics and fisheries of *L. robustus* in Malampaya Sound and Taytay, Northern Palawan and the biology of *Acromitoides purpurus* in Panguil Bay, Northern Mindanao.

Also, through the concerted efforts of scientists and medical doctors from RECS Philippines, a proposed plan to report all marine envenomation cases to the Department of Health (DOH) was formulated. Information Education Campaign (IEC) will be heightened so as to increase the awareness of locals especially those residing in coastal communities on the harmful effects of jellyfish. In addition, funding for research will be requested from the Philippines government and other concerned sectors for a better understanding on the biology and ecology of jellyfish especially the harmful species.

Acknowledgement

We deeply thank the information shared by Mr. Sheldon Rey Boco, PhD student at the Griffith School of Environment, Griffith University at Gold Coast, Queensland, Australia. (Facebook: *Philippines Jellyfish* Stings or Twitter: @phjellyfishsting)

2.5 SINGAPORE

I. Status and Background

Singapore's location at the southern tip of the Malay Peninsula has served it well in areas of trade and commerce through the 19th and 20th century, putting it on the map of explorations in the 'Orient'. Even then, Singapore was noted to be resourceful albeit expensive its supplies were pricier than what European explorers could get from their homeland (Zangger, 2013). From the 1890 visit by Swiss naturalists Pictet and Bédot searching for jellyfish (Zangger, 2013), to the 1907 fisheries expedition conducted by the American steamer "Albatross" (Mayer, 1915), Singapore has been a point of transit with some medusozoan findings reported. In historical records, the local jellyfish found since 1890 (namely from the classes Scyphozoa and Hydrozoa) were mediocre: many, if not all, gelatinous zooplankton observed were already described; producing nothing taxonomically exciting at that time (Zangger, 2013). Upon entering the 21st century, Singapore's presence in the global economic scene and its geographical position as a significant transit point still maintains - so has the status quo in jellyfish interest in Singapore. Scientific mediocrity in the pelagic cnidarian community carried on over to the modern years with local publications of medusae few and sparse.

In order to understand observations of jellyfish around Singapore, one would have to scrutinise the temporally changing currents, bearing nutrients and current-driven creatures, through annual north-east and south-west monsoon seasons (experienced during November-February and June-August respectively) which affect the regional winds and local tides. Hydrodynamic studies in the Singapore Strait reveal the formation of at least three large-scale eddies at slack phase of tides around several of the Southern islands and Kármán vortex streets between a couple more islets off Singapore (Behera *et al.,* 2012) - potential pathways that drive jellyfish movements.

Longitudinal data of environmental parameters such as temperature, salinity and prey (in the planktonic community) would supplement this understanding of the natural climate cycles that affect jellyfish asexual production of new medusae from polyps (Purcell, 2005). A multi-pronged study of the aforementioned factors, coupled with long-term jellyfish surveys, would shed some insight on species-specific bloom occurrences around Singapore.

II. Diversity, Distribution and Abundance

A survey of jellyfish around Saint John's Island (one of Singapore's Southern islands) was conducted from January 2006 to August 2012 and its findings published in the Contributions of Marine Science, a National University of Singapore (NUS) publication. The authors provided a preliminary taxonomic account of seven species of jellyfish, of which five were new records (Yap & Ong, 2012). Voucher specimens were deposited in the Lee Kong Chian Natural History Museum (LKCNHM), in NUS, for future studies and reference. A list of published literature reporting jellyfishes encountered around Singapore accompanied Yap & Ong's paper (Table 2.5). Reference types range from primary scientific literature to field guide entries.

Since Haeckel's description of *Thamnostoma macrostomum* found in Singapore (Haeckel, 1879), a total of nine families (10 genera) of Hydrozoan medusae, 10 families (14 genera) of Scyphozoan medusae and four families (four genera) of Cubozoan medusae have been locally recorded. There still lacks comprehensive taxonomic and ecological research on pelagic cnidarians found around Singapore. Not to mention, erroneous identification and brief descriptions (such as from field guide entries and book chapters) may not be diagnostic for positive identification to species (see Yap & Ong, 2012). Distribution and abundance studies in the jellyfish occurring around Singapore are also lacking.

Table 2.5 List of known medusae reported from Singapore - classes Hydrozoa, Scyphozoa and Cubozoa (Yap & Ong, 2012).

Class HYDROZOA Owen, 1843			
Family	**Species**	**References**	**Reference type**
Subclass ANTHOMEDUSAE Haeckel, 1879 **Order ANTHOATHECATA Cornelius, 1992 ****			
Bougainvilliidae	*Thamnostoma macrostomum*	Haeckel, 1879	Primary scientific literature
Subclass LEPTOMEDUSAE Haeckel, 1879 **Order LEPTOTHECATA Cornelius, 1992 ****			
Aequoreidae	*Aequorea conica*	Stiasny, 1928	Primary scientific literature
	Aequorea parva	Stiasny, 1928	Primary scientific literature
	Aequorea pensilis	Yap & Ong, 2012	Primary scientific literature
Eirenidae	*Eirene hexanemalis*	Stiasny, 1928	Primary scientific literature
Malagazziidae	*Malagazzia carolinae*	Stiasny, 1928	Primary scientific literature
Subclass HYDROIDOLINA Collins, 2000 ** **Order SIPHONOPHORAE Eschscholtz, 1829 ****			
Diphyidae	*Diphyes bojani*	Yap & Ong, 2012	Primary scientific literature
	Diphyes chamissonis	Wickstead, 1958	Primary scientific literature
		Chuang, 1961	Book chapter
		Ng *et al.*, 2011	Encyclopedic entry
	Diphyes spp.	Ng *et al.*, 2011	Encyclopedic entry
	Lensia spp.	Ng *et al.*, 2011	Encyclopedic entry
Physaliidae **	*Physalia* sp.	Sharma, 1973	Book chapter
	Physalia utriculus	Sharma, 1973	Book chapter
Subclass TRACHYLINAE Haeckel, 1879 ** **Order TRACHYMEDUSAE Haeckel, 1879**			
Geryoniidae	*Liriope tetraphylla*	Wickstead, 1958	Primary scientific literature
		Yap & Ong, 2012	Primary scientific literature
Order NARCOMEDUSAE Haeckel, 1879			
Aeginidae	*Solmundella* spp.	Wickstead, 1958	Primary scientific literature
Cuninidae	*Cunina duplicata*	Haeckel, 1879	Primary scientific literature
Class SCYPHOZOA Goette, 1887			
Order CORONATAE Vanöffen, 1892			
Nausithoidae	*Nausithoe punctata*	Searle, 1957	Primary scientific literature
Linuchidae	*Linuche unguiculata*	Mayer, 1917	Primary scientific literature
		Searle, 1957	Primary scientific literature
		Ng *et al.*, 2011	Encyclopedic entry
Order SEMAEOSTOMEAE Agassiz, 1862			
Pelagiidae	*Chrysaora chinensis*	Yap & Ong, 2012	Primary scientific literature
	Chrysaora melanaster	Chuang, 1963	Book chapter
		Chou,1993	Field guide entry
	Sanderia malayensis	Goette, 1886	Primary scientific literature
		Mayer, 1917	Primary scientific literature
		Searle, 1957	Primary scientific literature
		Ng *et al.*, 2011	Encyclopedic entry
Cyaneidae	*Cyanea lamarcki*	Chou,1993	Field guide entry
		Ng *et al.*, 2011	Encyclopedic entry
Ulmaridae	*Aurelia aurita*	Searle, 1957	Primary scientific literature
		Sharma, 1973	Book chapter
		Chou, 1993	Field guide entry
		Yap & Ong, 2012	Primary scientific literature

Table 2.5 Continued: List of known medusae reported from Singapore - classes Hydrozoa, Scyphozoa and Cubozoa (Yap & Ong, 2012).

Order RHIZOSTOMEAE Cuvier, 1817			
Suborder KOLPOPHORAE Stiasny, 1921			
Cassiopeidae	*Cassiopea andromeda*	Searle, 1957	Primary scientific literature
		Chuang, 1961	Book chapter
	Cassiopea xamachana	Lee, 2009	Honours thesis
	Cassiopea sp.	Chuang, 1961	Book chapter
		Chou, 1993	Field guide entry
		Wang and Yeo, 2011	Field guide entry
		Ng *et al.*, 2011	Encyclopedic entry
Cepheidae	*Cephea octostyla*	Haeckel, 1880	Primary scientific literature
	Netrostoma dumokuroa	Yap & Ong, 2012	Primary scientific literature
Mastigiidae	*Mastigias ocellatus*	Ng *et al.*, 2011	Encyclopedic entry
	Mastigias papua	Searle, 1957	Primary scientific literature
		Chuang, 1961	Book chapter
		Ng *et al.*, 2011	Encyclopedic entry
	Mastigias siderea	Stiasny, 1920, 1921	Primary scientific literature
	Phyllorhiza punctata	Chou, 1993	Field guide entry
		Yap & Ong, 2012	Primary scientific literature
Thysanostomatidae	*Thysanostoma* spp.	Tan, 2008	Primary scientific literature
Suborder DAKTYLIOPHORAE Stiasny, 1921			
Catostylidae	*Acromitus hardenbergi*	Iesa and Will, 2017 *****	Biodiversity record
	Acromitus spp.	Chuang, 1961	Field guide entry
		Ng *et al.*, 2011	Encyclopedic entry
	Catostylus spp.	Chuang, 1961	Book chapter
		Ng *et al.*, 2011	Encyclopedic entry
Class CUBOZOA Werner, 1973			
Order CARYBDEIDA Gegenbaur, 1856			
Carukiidae	*Morbakka* sp.	Iesa and Yap, 2018 *****	Biodiversity record
Carybdeidae	*Carybdea* sp.	Sharma, 1973	Book chapter
Tripedaliidae	*Tripedalia cystophora*	Iesa, 2017 *****	Biodiversity record
Order CHIRODROPIDA Haeckel, 1880			
Chiropsalmidae	*Chiropsoides quadrigatus*	Searle, 1957	Primary scientific literature
		Sharma, 1973	Book chapter

Single asterisk '*****' indicate entries added, while double asterisks '******' indicate edits made to Yap & Ong 2012's list

III. Monitoring and Management

There are currently no monitoring efforts for jellyfish in Singapore simply because there is no explicit need for one. There has been neither known fatalities nor near-death experiences triggered by jellyfish stings from local shores that warrants resources to be directed to any systematic long-term monitoring efforts. However, some stakeholders of accessible beaches along Singapore's coastline such as the Sentosa Development Corporation (SDC) which manages the resort island Sentosa, nested at the southern tip of Singapore's mainland, and nature enthusiasts (such as the author of WildSingapore.com) have been accumulating observable data of jellyfishes encountered. From their information, Singapore experienced at least two jellyfish "blooms" in the past seven years: Once in March-April 2010, when an abnormal number of beachgoers were stung by unidentified Semaestomae jellyfishes and sought first aid on Sentosa's beaches, and another event of many individuals of the mangrove jellyfish *Acromitus* sp. seen in Pasir Ris mangroves, one of Singapore's mangrove patches, during a high tide in March 2017 (WildSingapore, 2017). It was not observed whether the events extended for a significant enough period of time to be classified as a "bloom".

On a governmental level, the Ministry of the Environment and Water Resources (MEWR) has a statutory board (National Environment Agency (NEA)) conducting weekly water quality monitoring on Singapore's recreational beaches, following the World Health Organisation's (WHO) guidelines for safe recreational water environments (NEA, 2018). However, this is only for the purpose of monitoring levels of the bacteria *Enterococcus*. The recreational beaches cover stretches of the north-eastern and south-eastern coastlines of Singapore's mainland, and the south-western artificial beaches of Sentosa Island (Fig 2.5.1).

It is unclear what the other environmental parameters that were measured are (like surface water temperature, pH, salinity, dissolved oxygen content) for coastal surveys as the data is not publicly available. Such longitudinal data could give insight to the trends and variations of conditions crucial to jellyfish occurrence and blooms around Singapore.

No vinegar poles or public notices of jellyfish are currently erected anywhere in Singapore. General management of jellyfish stings, however, exists in the form of scattered first aid hubs along recreational beaches, especially around Sentosa. Group water activities conducted by facilities along Singapore's mainland beaches are managed by trainers or coaches who have undergone standard industrial first aid training (with brief coverage on marine envenomation). Management staff of the aforementioned first aid hubs and recreational facilities indicated knowledge and employment of the most effective treatment known for general jellyfish stings using hot water and vinegar.

Detailed first aid accounts of marine envenoming by Sentosa Development Corporation (SDC) include:

- Victim information such as gender, race and age,
- Environmental information (tide and zone of beach),
- Description and location of the sting injuries on body,
- Photograph of injury (Fig 2.5.2) and;
- Treatment given by responder.

Education and outreach efforts that raise awareness on general marine envenomation are present in the form of "Beach and Water Safety" presentations by SDC staff every week at a children's water playground feature on Sentosa, and through a regular beach safety outreach programme to the citizens living on Singapore's mainland. The efficacy of such efforts have yet to be accessed.

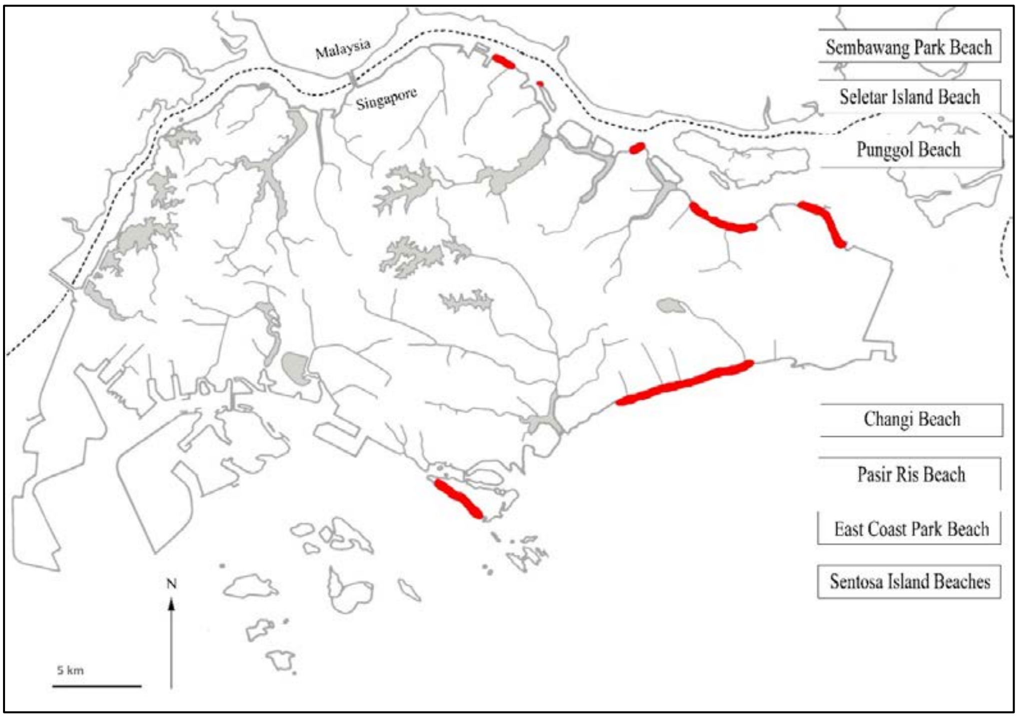


Fig 2.5.1 Map indicating the seven recreational beaches (lined in red) with weekly water quality monitoring activities conducted by NEA.

Fig 2.5.2 Trailing welts from unidentified jellyfish on lower torso of victim. Photograph taken by Sentosa Resilience Department, a division of Sentosa Development Corporation in 2010.

IV. Impacts of Harmful Jellyfish on Humans

Historically, it was recorded by Sharma in 1973 that the highly venomous cubozoan medusa *Chiropsalmus quadrigatus* was found to occur locally, and Searle (1957) reported a serious injury from *C. quadrigatus* encountered in local waters. No diagnostic photographs or taxonomic description was published thereafter to provide evidence of its continued presence in Singapore. Voucher specimens are also not available for examination. A damaged box jellyfish *Morbakka* sp., however, was found dead on a recreational beach in 2016 (Iesa and Yap, 2018) and deposited at LKCNHM.

Due to the lack of a centralised platform to consolidate jellyfish encounters and sting incidents around Singapore, this section presents first aid accounts of stings recorded over seven years (from the year 2010) by the Sentosa Resilience Department, a division under SDC.

A year-round entertainment hotspot, Sentosa Island houses its own Universal Studios™, Resorts World Sentosa's S.E.A. Aquarium™ and Adventure Cove Waterpark™, attracting tourists from all over the world and receives 19 million visitors a year (Post Magazine, 2015). Boasting three artificial beaches stretching over 2 km along Sentosa's south-western coast (see Fig 2.5.3), Sentosa also hosts an annual New Year's Eve beach party on one of its largest and more popular beach, Siloso Beach. The other two beaches are Palawan Beach and Tanjong Beach. According to staff from SDC, the beaches vary in popularity among visitors and there exists seasonality of visitor footfall.

All three beaches have a history of jellyfish envenoming cases but to varying degrees since 2010. A total of 101 stings were recorded from Sentosa in 2010 (Fig 2.5.4), a significant number of cases for the response team. Palawan Beach reported the highest number of incidents (57% of total cases in 2010), followed by Siloso Beach (34%) and Tanjong Beach (9%) that year.

The smallest of the three beaches, Tanjong Beach, presented a consistently low sting incident count (less than ten incidents per year) over the seven years, possibly because of its relatively low visitor footfall compared to the other two beaches. Factors that determine popularity of a beach would include, for example, distance to nearest transport hub, presence of family-friendly entertainment facilities and other amenities. Demographics of visitors to beaches also differ; Tanjong beach, for example, is more popular for dog owners and their furry companions.

Out of the 101 sting incidents in 2010, 43% of the total number of cases occurred in March and 39% of cases in April, forming the 'peak' of sting incidents that year (Fig 2.5.5). The 'peaks' appear to shift in the following years, most notably to April-May of 2011 (making up 55% of incident count that year) and subsequently June of 2016 (75% of incident count that year), although lower in absolute quantities of sting records compared to that of 2010.

Further analyses should be conducted in relation to fluctuations in visitor footfall on individual beaches throughout the year before any conclusions can be reasonably made to interannual or intra-annual variability in jellyfish encounters and risks of stings on Sentosa beaches. Considering significance of diurnal patterns in daylight and tides, along with other environmental parameters corresponding to the jellyfish encounters would give better understanding of the data presented in this section.

Variations in annual nutrient content (particularly phosphate and nitrate) patterns, salinity and plankton distribution and abundance are known to occur in the Singapore Strait, with species-to-species plankton dominance at different times of the year (Chou and Chia, 1991). To what extent each of these factors play in harmful jellyfish proliferation and occurrence around Singapore, and ultimate impact on humans, has yet to be determined.

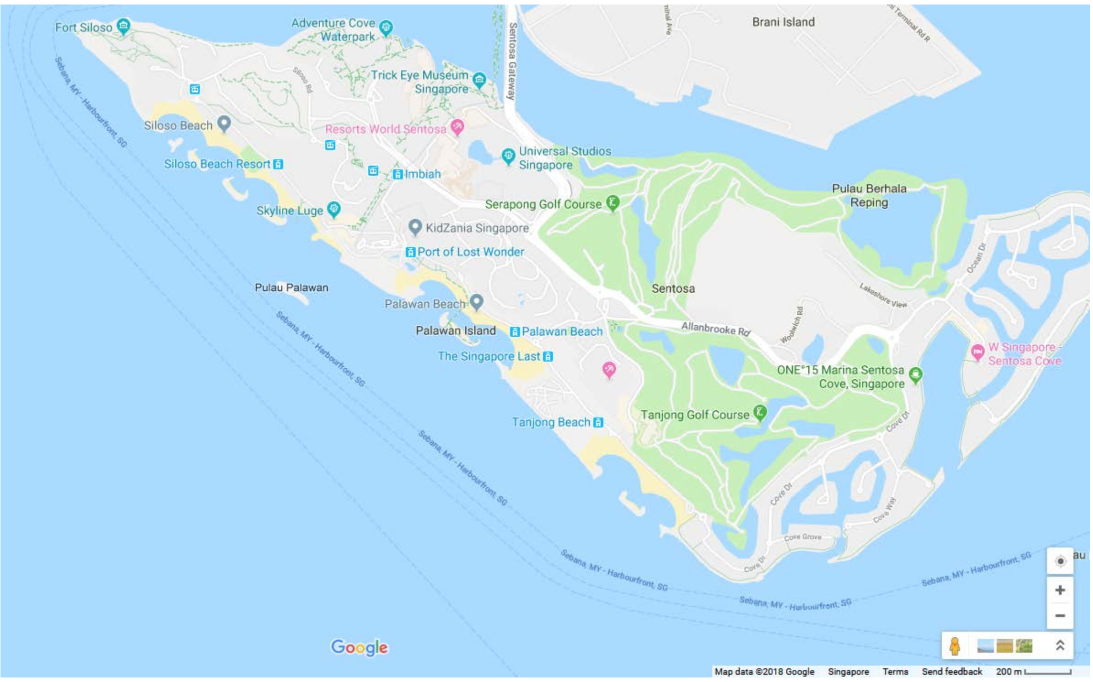
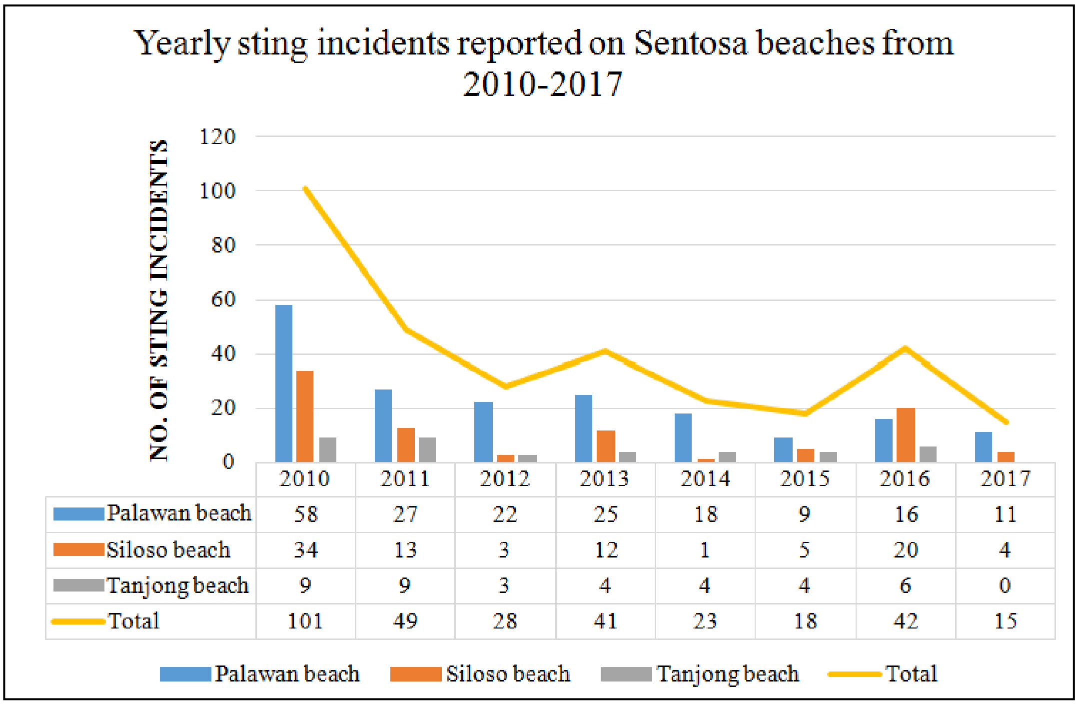


Fig 2.5.3 Screenshot of Sentosa Island's beaches (Google Maps, accessed on 30th July 2018).



	2010	2011	2012	2013	2014	2015	2016	2017
Palawan beach	58	27	22	25	18	9	16	11
Siloso beach	34	13	3	12	1	5	20	4
Tanjong beach	9	9	3	4	4	4	6	0
Total	101	49	28	41	23	18	42	15

Fig 2.5.4 Breakdown of sting incidents across Palawan, Siloso and Tanjong beaches from 2010-2017.

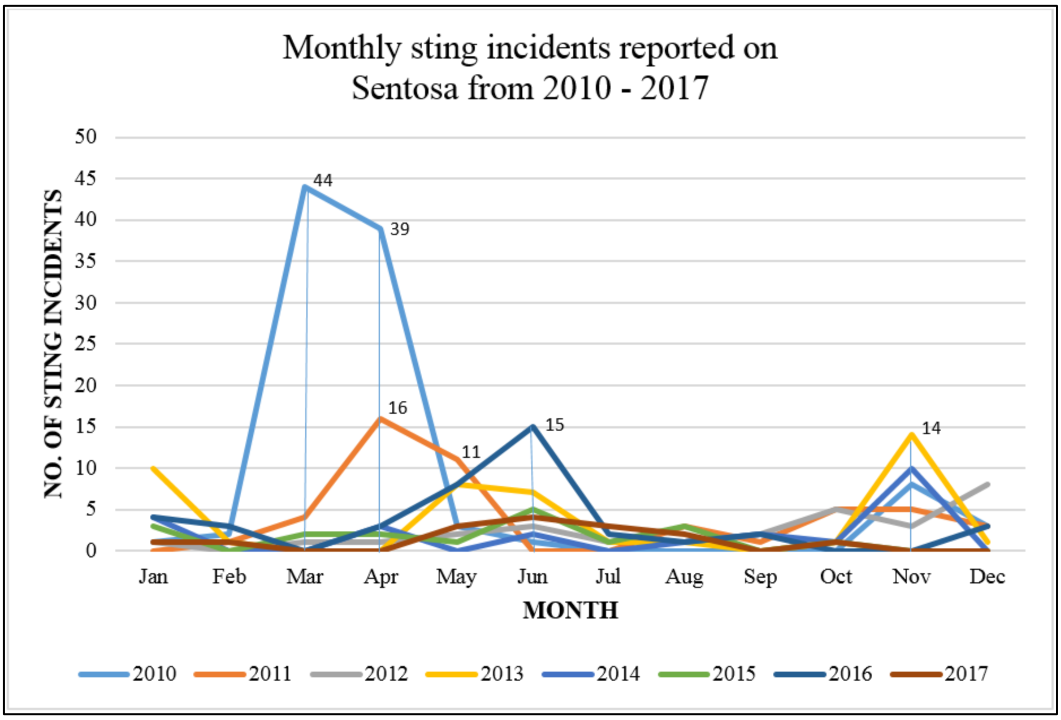


Fig 2.5.5 Monthly sting incidents by jellyfishes reported from years 2010-2017 on Sentosa Island.

V. Economic and Socio-cultural Impacts

Singapore's geographical and ethnological landscape hosts a rich history of past villages across its 63 islands. In the 1960s and 1970s, rapid and intense development activities across the peripheral islands relocated the indigenous inhabitants to Singapore's mainland, many of whom were fishermen (The Straits Times (ST), 1966). There were also established communities of fishermen on the mainland at the time (ST, 1965). Today, fishermen activities still continue, under government control, such as having an allocated boat docking facility and requirement of boat licenses (ST, 2018). It is still uncertain how this population of sea-dependent citizens have been - or would be - affected by local jellyfish blooms and the resultant socio-cultural impacts that follow.

As of 2017, Singapore has 125 fish farms, of which seven are land-based (ST, 2017a). While only 10% of Singapore's fish consumption are of local origins (in 2016), it is hoped that productivity of local fish farms improve, through regulated aquaculture research, to serve as a buffer in the mist of any disruptions in global supply (ST, 2017a).

Current explorations of "vertical farming" in urban settings (such as in parks and on rooftops of buildings) are underway, with efforts currently in the prototyping stage (ST, 2017b). Coastal fish farms, meanwhile, are vulnerable to regional harmful algae blooms and oil spills (ST, 2017a). There is a lack of evidence suggesting jellyfish directly impacting local fish production. Further on-site investigations are required into (1) fish farms' relative locations to any significant, repeated jellyfish occurrence around Singapore (if applicable), (2) containment unit designs' vulnerability to regionally-occurring jellyfish and (3) fish farmers' level of understanding and resilience to jellyfish blooms, before any comments can be made to extrapolate economic impacts of harmful pelagic cnidarian blooms on Singapore's coastal fish farming industry.

VI. Challenges and Gaps of the Monitoring Harmful Jellyfish Bloom

Due to the lack of knowledge of species-specific conditions for jellyfish proliferation in the region, seasonal abundance patterns and spawning aggregations (if relevant to local waters) are difficult to determine. To undertake a comprehensive study in predicting harmful jellyfish occurrence around Singapore, one would have to consider longitudinal environmental parameter monitoring as well as defining relevant factors involved in oceanic fluxes that affect sea level variabilities in the Singapore Strait due to annual monsoon-driven sea level anomalies and interannual El Niño and La Niña episodes (Tkalich *et al.,* 2013). All in addition to systematic survey efforts for pelagic cnidarians, which are lacking. Comparable data from the South China Sea and along the Straits of Malacca would aid in supplementing local observations of jellyfish and shed insight on general areas of polyp settlement and jellyfish movement in the region.

Visibility of waters around Singapore are also notoriously low (lesser than two meters), despite local reefs successfully hosting over 250 species of corals (Chou *et al.,* 2012). Regular dredging of sea beds to maintain heavily utilized shipping routes and ongoing reclamation works along mainland Singapore's coastlines (Chou *et al.,* 2012) keep sedimentation levels up to as high as 44.64 $mg/cm^2/day$ (Low and Chou, 1994).

Faced with year-long turbid waters, visual non-capture methods (such as aerial and ship surveys) could be deemed unproductive for baseline species composition and distribution studies. Acoustic methods to study abundance of jellyfish using echo sounders and sonar can only be effectively employed upon understanding: (1) the species occurring around Singapore's waters, (2) their vertical ranges (how shallow or deep they travel along the water column), (3) possible zonations of jellyfish around Singapore (defined by oceanic physicochemical attributes and prey availability) and (4) temporal specificity, if applicable.

VI. Current Research of Harmful Jellyfish

There are currently no formal research projects ongoing specific to gelatinous zooplankton that confers negative impacts to Singapore's priorities. Jellyfish observations remain opportunistic: from stakeholders of recreational beaches who sweep clean the occasional beached jellyfish carcasses, to nature enthusiasts and recreational divers chancing upon jellyfish in local sites on days of reasonable visibility.

2.6 THAILAND

I. Status and Background

There are eight fatal cases and 14 unconscious cases from jellyfish sting in Thailand; up to now, five cases in Krabi and Satun provinces (Andaman Sea), and 17 cases in Trat, Phetburi and Surat Thani provinces (Gulf of Thailand).

Thailand have 23 provinces along the coast. The Department of Marine Coastal and Resources (DMCR) classified coastal areas in accordance with the risk. Krabi, Satun (located on the coast of Andaman Sea), Trat, Phetburi, and Surat Thani provinces (located on the coast of Gulf of Thailand) are classified as area of prevention from venomous jellyfish, while the remaining 18 provinces are classified as area of surveillance from venomous jellyfish. Box jellyfish is also found in those 18 provinces, but there is no fatal and unconscious cases. Both areas have the same management system, *e.g.*, set up warning sign with first aid instruction and vinegar pole, educate first aid and CPR training to the local, rescue officer, nurse, and doctors. However, stinger net will only be set up on high risk beaches during bloom season as prevention.

II. Diversity, Distribution and Abundance

The knowledge on box jellyfish in this region are limited. A number of species in the Andaman Sea was investigated during the national workshop in June and August 2015. With the support of DMCR, Thailand-China Joint Laboratory for Climate and Marine Ecosystem, and WESTPAC, a WESTPAC Training Workshop on the Identification of Box Jellyfish in the Eastern Indian Ocean and the Gulf of Thailand was held at PMBC in June 2016.

Recently, there are about 11 species of box jellyfish, four species in the Class Hydrozoa in Thai waters, and about 16 species in the class Scyphozoa in Thai waters (Fig 2.6.1, Table 2.6a).

With regard to cubozoan species, most of them could not be identified to species level, which appears to contain several undescribed species and may be a new species. A few scyphozoans and hydrozoans species could not be identified as same as cubozoan. However, the venomous hydrozoan jellyfish includes the Portuguese man of war, *Physalia* cf. *urticulus*.

III. Monitoring and Management

DMCR is national agency who is responsible on the monitoring of venomous jellyfish, taxonomic study, and management. Monitoring of venomous jellyfish are mainly done by five centers under DMCR, *i.e.,* Phuket Marine Biological Center at Phuket province (PMBC), and four other Marine and Coastal Resources Research and Development Centers in Eastern Gulf of Thailand (MCCRE) at Rayong province, Upper Gulf of Thailand (MCCRU) at Samut Sakorn province, Center Gulf of Thailand (MCCRC) at Surat Thani province, and Lower Gulf of Thailand (MCCRL) at Songkhla province. All centers started their monitoring in 2009. Spatial and seasonal distribution of venomous jellyfish would be the main objective of the monitoring effort in order to give warning, via application mobile, *i.e.*, Line, Facebook etc., and manage the prevention system at the right time (social media or application such as Line and Facebook are very effective and rapid way).

Normal surveys on venomous jellyfish are carried out once a month in target areas by using shrimp trammel net (length 400 m. x height 1.5 m.) and hand net. Observations at night are carried out occasionally by snorkelling. Three percent formalin were used for jellyfish specimens' fixation and preservation (the pedalium and other important characters that use for identification may degraded at higher percent of formalin).

Occasionally, jellyfish stranding on the shore are collected as well. Beach seines (1.20 x 20 m) is used to drag parallel to the beach for approximately 200 m, to catch organisms from the bottom and water mass profile, while drag, supported by Marine Stinger Safety and Education in Thailand Programme, is drag parallel to the beach for approximately 200 m to gather organisms in near the surface.

DMCR has four strategies under the surveillance and prevention of venomous jellyfish plans, *i.e.*, enhancing knowledge, development of methodology and processes for the surveillance and prevention of venomous jellyfish, development of management system, and research.

With regard to the strengths, those strategies have been work out by DMCR officer and our partners under the committee on venomous marine animal and marine pollution. The committee is under the National Marine and Coastal Resources Sub-Committee.

Web page with regard to jellyfish in Thai waters was established on DMCR web site, https://km.dmcr.go.th/th/c_247, which include basic knowledge about venomous jellyfish, taxonomic study of those species, distribution and seasonal, situation in all coastal provinces, first aid Instruction, guidelines for DMCR officer, the instruction for reporting, guideline for investigation once stinging, a report form, medical treatment for jellyfish stings for nurse and doctor, warning signs or brochures in Thai, Chinese, and English can be downloaded from the web page (Chinese are the highest number among foreigner's tourists according to Ministry of Tourism and Sports), etc.

DMCR is also working in progress on database system for the occurrence of venomous jellyfish and position of vinegar pole. DMCR promoted MOU with relevant agencies, we have MOU between DMCR and Department of Epidemiology firstly in 2011 for two years, and continues again during 2014 until 2018. The stinger net prototypes are designed to prevent box jellyfish. In 2017, DMCR and local parties set it up in two areas, Mark Island in Trat province and Samui Island in Surat Thani province.

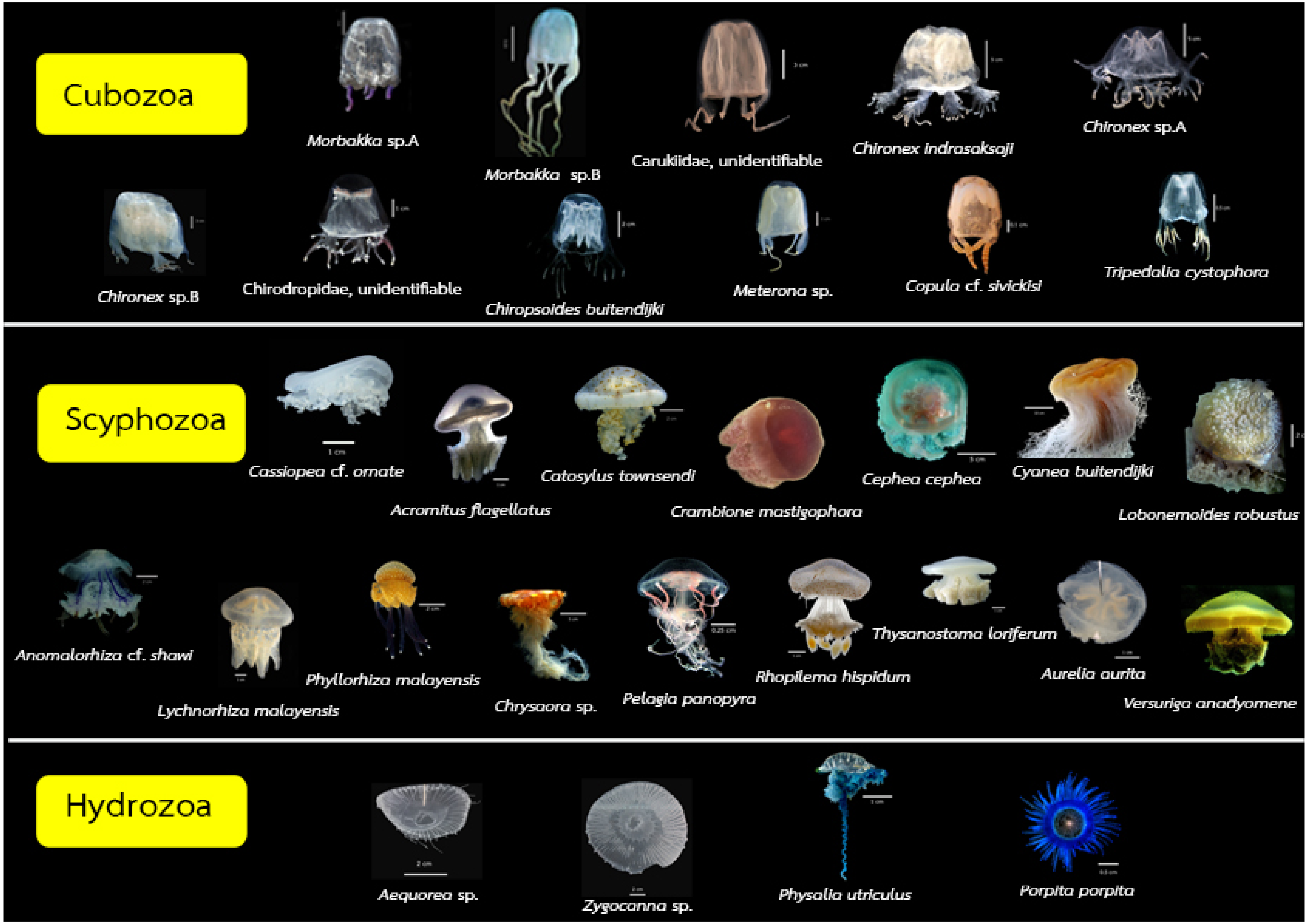


Fig 2.6.1 Jellyfish species found in Thai waters.

Table 2.6a Checklist of jellyfish species found in Thai waters (* indicate venomous jellyfish and ** indicate edible jellyfish).

Family	species	Ranong	Phang nag	Phuket	Krabi	Trang	Satul	Trat	Chanthaburi	Rayong	Chonburi	Chacheng-sao	SamutPrakan	SamutSakon	SamutSongkhram	Phetchaburi	PrachuapKhirikhan	Chumphon	Surat Thani	Nakhon Sri Thammarat	Songkhla	Pattani
Cubozoa																						
Carukiidae	*Morbakka* sp. A*													√	√	√	√	√	√	√	√	
	Morbakka sp. B*	√	√	√	√	√	√	√		√	√	√				√	√	√	√	√	√	√
	Carukiidae, unidentifiable	√	√	√	√	√	√									√			√		√	
Chirodropidae	*Chironex indrasaksajiae**								√	√									√			
	Chironex sp. A*		√	√	√			√	√	√												
	Chirodropidae, unidentifiable		√		√					√									√			
Chiropsalmidae	*Chiropsoides buitendijki**	√	√	√	√	√	√												√	√	√	√
Chiropsellidae	*Meterona* sp.							√	√													
Tripedaliidae	*Copula* cf. *sivickisi*							√														
	Tripedalia cystophora			√																		
Scyphozoa																						
Cassiopeidae	*Cassiopea cf.ornata*				√																	
Catostylidae	*Acromitus flagellatus*			√	√			√				√	√	√	√	√	√	√	√	√	√	√
	Catostylus townsendi	√	√		√			√	√	√	√	√	√	√	√	√	√	√	√	√	√	
	Crambione sp.**			√	√																	
Cepheidae	*Cephea cephea*			√	√				√	√											√	
Cyaneidae	*Cyanea buitendijki*			√	√													√	√	√	√	
Lobonematidae	*Lobonemoides* sp. **	√	√	√	√	√	√	√		√	√				√	√	√	√	√	√	√	
Lychnorhizidae	*Anomalorhiza cf. shawi*								√	√									√			
	Lychnorhiza malayensis	√	√		√	√														√	√	√
Mastigiidae	*Phyllorhiza punctata*		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
Nausithoidae	*Nausithoe punctata*																			√		
Pelagiidae	*Chrysaora* sp. *	√	√	√	√	√	√	√	√	√	√				√	√	√	√	√	√	√	√
	Pelagia sp. *			√	√			√									√	√	√	√	√	
Rhizostomatidae	*Rhopilema hispidum***				√		√	√	√	√	√				√	√	√	√	√	√	√	√
Thysanostomatidae	*Thysanostoma loriferum*			√	√																	
Ulmaridae	*Aurelia aurita*				√		√															
Versurigidae	*Versuriga anadyomene*				√		√			√	√	√				√	√	√	√	√	√	
Hydrozoa																						
Aequoreidae	*Aequorea* sp.					√	√														√	
	Zygocanna sp.	√			√	√			√	√		√	√			√		√	√		√	
Physaliidae	*Physalia* cf. *utriculus**			√	√														√		√	
Porpitidae	*Porpita porpita*		√	√				√	√								√	√	√	√	√	

IV. Impacts of Harmful Jellyfish on Human

Not all members of box jellyfish are harmful jellyfish. Even though more than half of box jellyfish could not be identified, but their relative are well known as venomous jellyfish. The venomous jellyfish in Thai waters comprised of about seven species of box jellyfish, two species of Scyphozoa and one species of Hydrozoa (Table 2.6b). Species identification and their toxic are study in progress.

V. Economic and Socio-cultural Impacts

An increase in fatal cases of tourists cause by jellyfish in Thai waters, while without proper and timely management, can cause a great impact on tourism.

VI. Challenges and Gaps of the Monitoring Harmful Jellyfish Bloom

Lack of collaboration and networking with neighbouring countries would be the main challenge to further understanding on the distribution and/or movement of venomous jellyfish. Knowledge on monitoring methods and management system practiced by other countries in the region are also important.

VII. Current Research of Harmful Jellyfish

Morphological studies of venomous jellyfish are mainly the done by five Centers under DMCR, while genetic analysis will be carried out by other institutes and universities, such as, Ramathibodi Hospital, Mahidol University, First Institute of Oceanography (FIO, China), and Department of Biology, Faculty of Science, Chiang Mai University. DMCR has collaborated with Department of Epidemiology & Faculty of Medicine, Chiang Mai University for knowledge of public health and prevention. With the Ramathibodi Hospital, Mahidol University for toxicology. Apart from these, DMCR have collaboration project with FIO, in China, to establish DNA barcoding of jellyfish in Thai waters.

DMCR will also encourage other collaborative projects, such as, population genetic, life cycle, and the environmental factors that influence the distribution of box jellyfish. Up to present, four papers were published as below:

1. Sucharitakul, P., C. Aungtonya and S. Chomdej. 2016. DNA sequencing complements morphological identification of *Chiropsoides* from Nam Bor Bay, Phuket, Thailand. *Phuket Marine Biological Center Research Bulletin.* no. 73: 7–14.
2. Liu, R., J. Xiao, X. Zhang and C. Aungtonya. 2016. Genetic analysis of common venomous Cubozoa and Scyphozoa in Thailand waters. DOI : 10.3969/j.issn.0253-4193.2016.06.006. (in Chinese).
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Table 2.6b Patient's symptoms.

Family	Scientific Name	Patient's symptoms
Cubozoa		
Carukiidae	*Morbakka* sp. A *Morbakka* sp. B	Although, the research of these species and their toxin in this family are in progress, two species, *Morbakka virulenta* (Kishinouye, 1910), described from Japan and *M. fenneri* (Gershwin, 2008) described from Australia, cause the Irukandji syndrome, which induces excruciating muscle cramps in the arms and legs, severe pain in the back and kidneys, a burning sensation of the skin and face, headaches, nausea, restlessness, sweating, vomiting, an increase in heart rate and blood pressure, and psychological phenomena such as the feeling of impending doom. The severe syndrome is delayed for 5–120 minutes (30 minutes on average) (Cegolon *et al*., 2013).
Chirodropidae	*Chironex indrasaksajiae* *Chironex* sp. A *Chironex* sp. B	Same as the upper family. At least two species, *Chironex fleckeri* Southcott, 1956, *C. yamaguchii* Lewis & Bentlage, 2009 causes human fatality. A sting cause sudden severe skin pain, obvious severe whip-like skin marks, rapid reduction of consciousness, and life-threatening breathing and/or cardiac problems (Fenner *et al*., 2010).
Scyphozoa		
Pelagiidae	*Chrysaora* sp. *Pelagia* sp.	Their toxic cause local symptoms, such as pain, pink skin rash, edema and vesicles (Cegolon *et al*., 2013; and observation).
Hydrozoa		
Physaliidae	*Physalia* cf. *utriculus*	Although toxic of *Physalia physalis* can cause human fatality, but that of *P. utriculus* usually causes local pain only and patients may have headache, drowsiness, fainting, confusion and cardio-respiratory syndromes (dyspnea) (Cegolon *et al*., 2013; and observation).

2.7 VIETNAM

I. Status and Background

Viet Nam is located in Southeast Asia with a coast line of approximately 3,200 kilometers and more than 3,000 islands which concentrate mostly in North-West area. There are more than 11,000 marine species were recognized belong to 20 marine ecosystems include benthic (6,000 species), fish (2,000 species), zooplankton (657 species), phytoplankton (537 species) and mega fauna (12 species), Jellyfish play an important roles in the oceanic such as: transferring carbon from surface waters to the seabed (Lebrato *et al.,* 2012), food chain (Pauly *et al.*, 2009). Jellyfish are a form of plankton, which means that their delicate bodies have a hard time resisting currents in the ocean. Jellyfish are carnivorous and feed mostly on plankton for example: Mass appearances of salps that feed on small phytoplankton can serve as vectors of carbon from the surface to the ocean depths through the production of faecal pellets, which have high organic content (Madin 1982; Turner 2002). There are very few examples of jellyfish that feed exclusively on other jellyfish: the ctenophore *Beroe cucumis* is known to feed the ctenophore *Bolinopsis infundibulum*.

While jellyfish bloom sometimes have negative impacts on human activities, such as damage to fishing gear and/or fishery products (Omori 1978, Kawahara *et al.*, 2006) and stinging swimmers at the beach (Purcell *et al.,* 2007), some species have been beneficial to humans because they have been utilized as food, especially in Chinese cuisine (Omori 1978, Omori and Nakano 2001).

II. Diversity, Distribution and Abundance

Jellyfish in Viet Nam were first collected by Shirota (1966) with a list and monographs of 53 species belong to subphylum Cnidaria and Ctenophora. Late research was focus on economic jellyfish (8 species belong to the order Rhizostomeae, class Scyphozoa) (Jun *et al.*, 2008).

From year 2000 until now, plankton works from Institute of Oceanography were mainly focus on small organisms such as copepod, tunicate, chaetognath and included small jellyfish belong to ctenophore and hydrozoa. From year 2000 until now, the monitoring program in southern Viet Nam to collect the data of environment and plankton diversity in May and August each year. In these samples, we only identified jellyfish species without counting and we had a list of jellyfish species.

Samples were collected from eight stations from the middle-south to southern of Vietnam (Fig 2.7.1). At each station, sample was collected by Juday net (mouth diameter: 37cm, mesh size: 200µm) from bottom to surface water. Quantitative samples were fixed by formaldehyde 5% and identified at lab by using MPC-1 stereo microscope.

There were 47 species of jellyfish were recognized belong to two phylum Ctenophora (eight species) and Cnidaria (39 species). During 18 years of monitoring program, Phan Thiet station had a highest number of jellyfish species (26) followed by Nha Trang station (25), Rach Gia station (23) and Vung Tau (20). Stations in southern Vietnam (Dinh An and Ca Mau) had a lower number of species (10 and 18, respectively) (Table 2.7). Some species such as *Pleurobrachia pileus*, *Liriope tetraphylla*, *Obelia* sp. occurred at most stations, while *Nausithoe punctate* and *Nausithoe* sp. only showed in the middle-south of Viet Nam (Nha Trang, Phan Thiet and Vung Tau station) (Table 2.7).

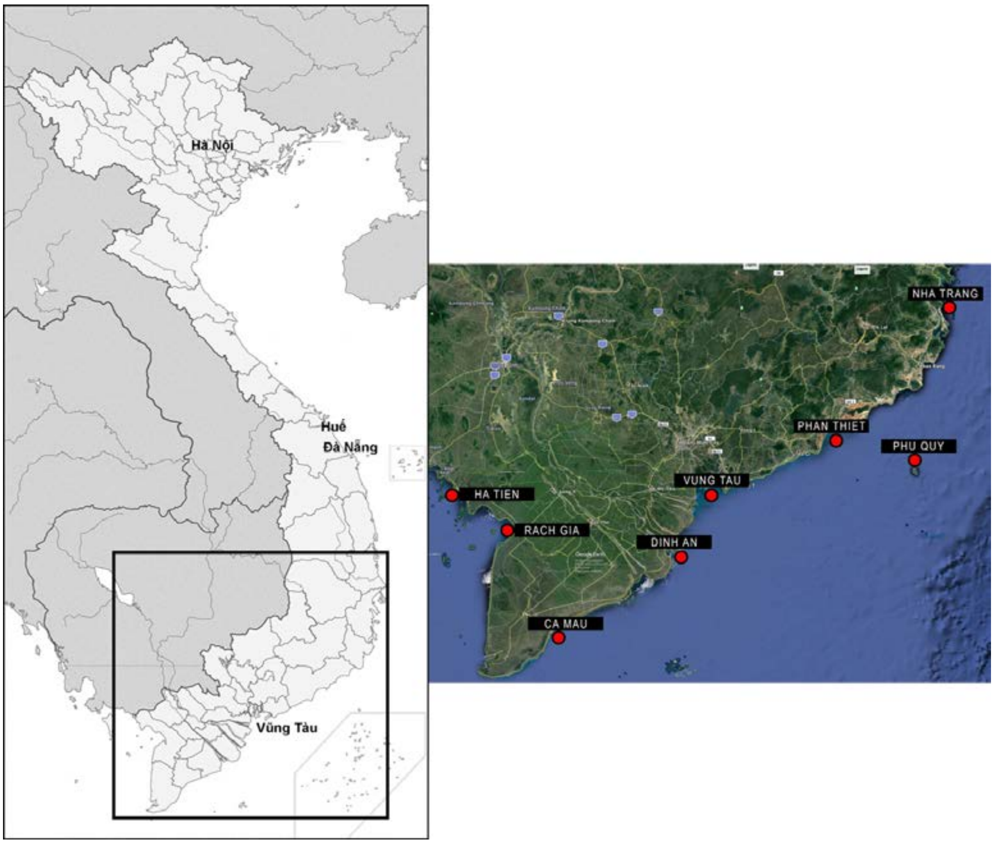


Fig 2.7.1 Monitoring stations in Southern Viet Nam from 2000 – 2018.

III. Monitoring and Management

In Vietnam, jellyfish fisheries started after 1970s in three main areas, the Gulf of Tonkin area, Cam Ranh in the South China Sea, and Phu Quoc Island in the Gulf of Thailand (Omori & Nakano 2001). *Rhopilema hispidum* and *Rhopilema esculentum* were confirmed as commercially exploited in Nothern Viet Nam. The number of Rhopilema jellyfish collected by fishermen is estimated as 800,000–1,200,000 inds. per fishery season (Jun Nishikawa et al, 2008).

IV. Impacts of Harmful Jellyfish on Human

There were few cases of people who got stung by jellyfish during summer from Middle (Da Nang city: http://goo.gl/9xnEkj) to Southern of Viet Nam (Phu Quoc Island: https://goo.gl/CjErgT). According to these reports, these jellyfish which harmfully to people named "fire-jellyfish" in local and we still do not have the identification of these jellyfish.

V. Challenges and Gaps of the Monitoring Harmful Jellyfish Bloom

Officially, there were lacking research related to jellyfish such as taxonomy, monitoring program for harmful jellyfish in Viet Nam. More studies on that will improve our knowledge and understand the important of jellyfish in our ocean as well as how to manage the damaged of jellyfish to human. Furthermore, we need to have:

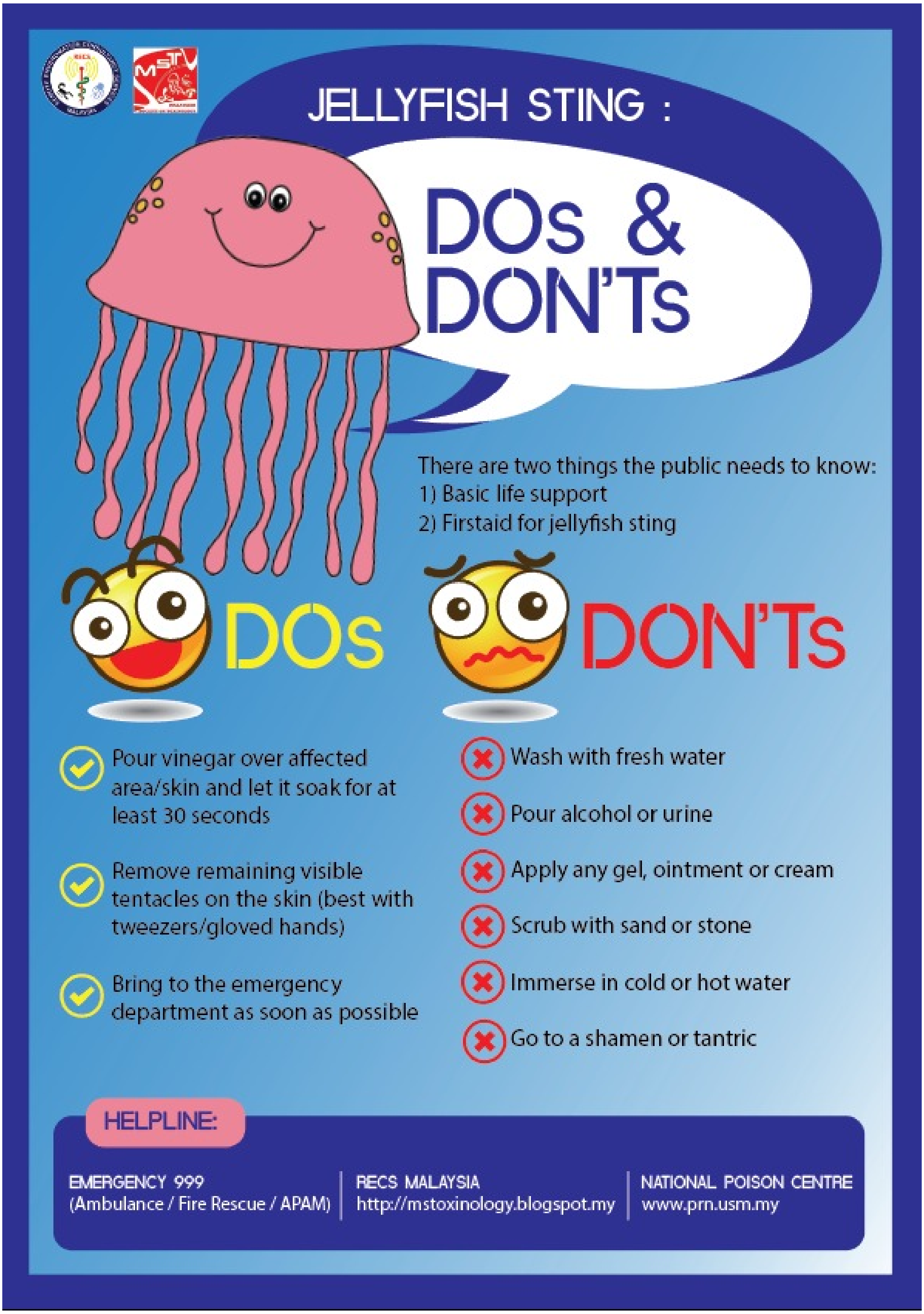
- Training/Workshop based on jellyfish identification as well as jellyfish biology.
- Sampling and Observation for harmful jellyfish program.
- Media program for harmful jellyfish attack.

Table 2.7 Number of jellyfish species in 8 monitoring stations in Southern Viet Nam (2000-2018).

No	Species	Monitoring stations								
		Nha Trang	Phan Thiet	Phu Quy	Vung Tau	Dinh An	Ha Tien	Rach Gia	Ca Mau	Total
	Ctenophora									
1	*Beroe forskalii* Milne Edwards, 1841	+	+	+	+			+	+	+
2	*Beroe* sp.	+	+		+	+				+
3	*Haeckelia rubra* (Kölliker, 1853)					+				+
4	*Hormiphora plumosa* M. Sars, 1859	+	+	+	+			+	+	+
5	*Hormiphora* sp.	+				+				+
6	*Leucothoe* sp.	+								+
7	*Pleurobrachia pileus* (O. F. Müller, 1776)	+	+	+	+	+	+	+	+	+
8	*Pleurobrachia rhodopis* Chun, 1879				+					+
	Cnidaria									
	Hydrozoa									
9	*Aequorea* sp.					+				+
10	*Aglaura hemistoma* Péron & Lesueur, 1810	+	+	+	+	+		+		+
11	*Auphysa* sp.		+							+
12	*Blackfordia* sp.							+		+
13	*Bougainvillia muscus* (Allman, 1863)		+					+	+	+
14	*Bougainvillia principis* (Steenstrup, 1850)							+		+
15	*Bougainvillia* sp.	+	+	+			+	+		+
16	*Clytia noliformis* (McCrady, 1859) sensu Calder, 1991		+	+		+			+	+
17	*Clytia simplex* (Browne, 1902)							+		+
18	*Clytia* sp.						+	+	+	+
19	*Corymorpha nutans* M. Sars, 1835		+		+			+	+	+
20	*Cunina* sp.	+	+	+						+
21	*Ectopleura* sp.		+							+
22	*Eirene* sp.	+	+		+		+	+	+	+
23	*Eirene viridula* (Péron & Lesueur, 1810)	+	+		+			+	+	+
24	*Euphysa aurata* Forbes, 1848		+							+
25	*Euphysa* sp.								+	+
26	*Eutima gegenbauri* (Haeckel, 1864)							+		+
27	*Geryonia proboscidalis* (Forsskål, 1775)		+		+			+		+
28	*Hormiphora* sp.	+								+
29	*Liriope* sp.							+		+

Table 2.7 Continued: Number of jellyfish species in 8 monitoring stations in Southern Viet Nam (2000-2018).

30	*Liriope tetraphylla* (Chamisso & Eysenhardt, 1821)	+	+	+	+		+	+	+	+
31	*Obelia geniculata* (Linnaeus, 1758)	+	+		+					+
32	*Obelia* sp.	+	+	+	+	+		+	+	+
33	*Octocanna* sp.								+	+
34	*Phialella* sp.				+					+
35	*Phialidium* sp.	+	+		+	+	+	+		+
36	*Podocoryna carnea* M. Sars, 1846	+	+	+	+				+	+
37	*Podocoryne* sp.	+	+		+				+	+
38	*Porpita sp*.	+							+	+
39	*Rhopalonema* sp.							+		+
40	*Sarsia* sp.	+	+	+	+	+	+	+	+	+
41	*Solmaris solmaris* (Gegenbaur, 1857)							+		+
42	*Solmundella bitentaculata* (Quoy & Gaimard, 1833)	+	+	+	+			+	+	+
43	*Sulculeolaria* sp.	+								+
44	*Tiaropsis multicirrata* (M. Sars, 1835)				+					+
45	*Zanclea* sp.	+		+						+
46	**Scyphozoa** *Nausithoe punctata* Kölliker, 1853	+	+	+						+
47	*Nausithoe* sp.	+	+							+
	Total	**25**	**26**	**14**	**20**	**10**	**7**	**23**	**18**	**47**


JELLYFISH STING :
DOs &
DON'Ts
There are two things the public needs to know:
1) Basic life support
2) Firstaid for jellyfish sting
DOs
DON'Ts
Pour vinegar over affected area/skin and let it soak for at least 30 seconds
Remove remaining visible tentacles on the skin (best with tweezers/gloved hands)
Bring to the emergency department as soon as possible
Wash with fresh water
Pour alcohol or urine
Apply any gel, ointment or cream
Scrub with sand or stone
Immerse in cold or hot water
Go to a shamen or tantric
HELPLINE:
EMERGENCY 999
(Ambulance / Fire Rescue / APAM)
RECS MALAYSIA
http://mstoxinology.blogspot.my
NATIONAL POISON CENTRE
www.prn.usm.my

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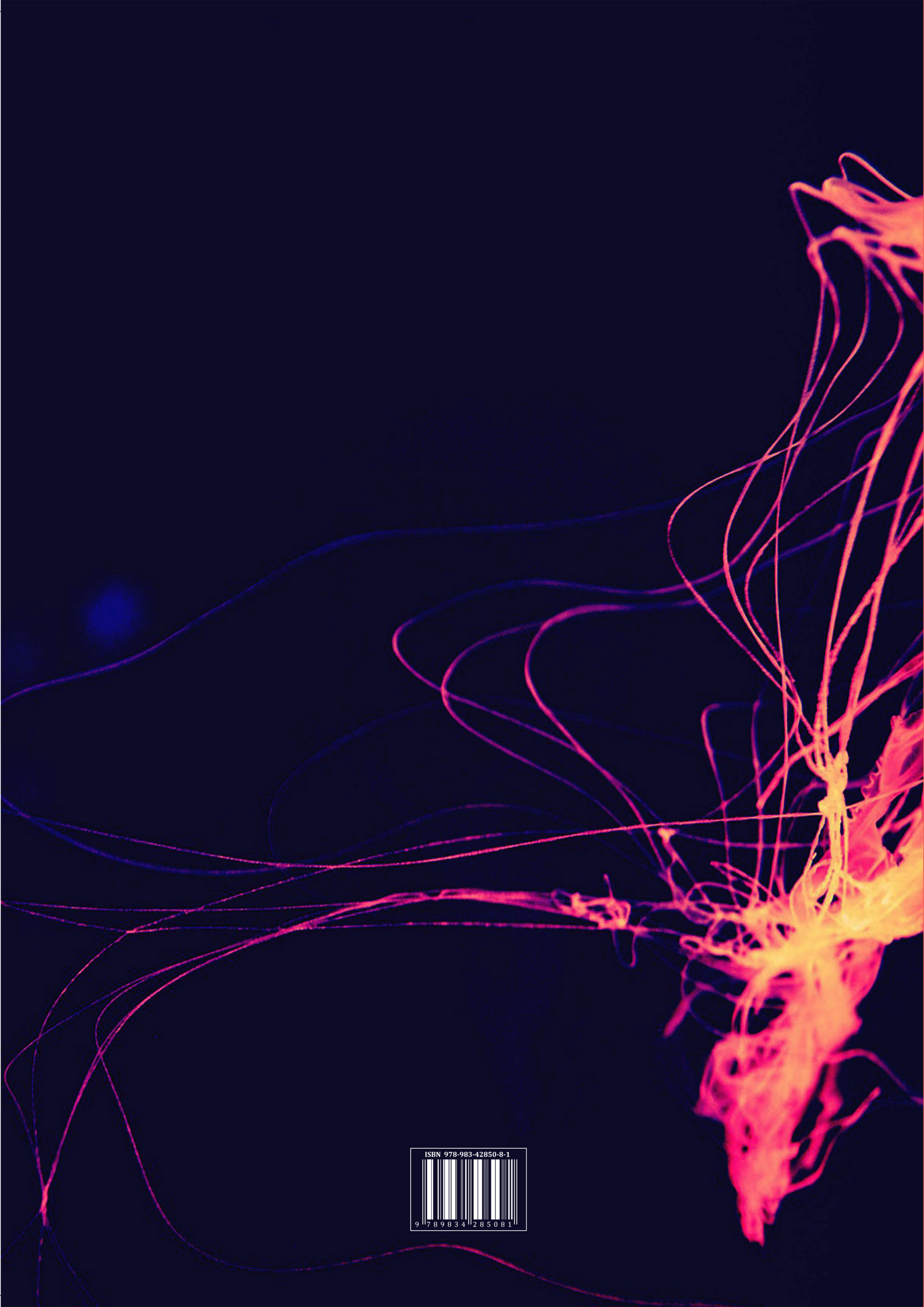

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