POLICY BRIEF

Harmful Jellyfishes are Manageable

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KEY POINTS

- Very little is known about harmful jellyfish species in the Philippines, much less about their impacts on society (e.g., fishing and tourism sectors, local community).
- The Department of Agriculture - Bureau of Fisheries and Aquatic Resources (DA-BFAR), Department of Environment and Natural Resources (DENR), Departments of Health (DOH) and Tourism (DOT) together with the Department of Science and Technology – Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (DOST-PCAARRD), other research institutions and academe, should conduct more research related to harmful jellyfish species to address the paucity in information.
- To reduce injuries and deaths resulting from harmful jellyfish envenomation, DA, DENR, DOH, and DOT, and their counterparts in local governments must strengthen their information and education campaigns, preventive measures, emergency response, and treatment of jellyfish-related injuries and stings.
- DA-BFAR should monitor box and other harmful jellyfishes in collaboration with the local governments with high coastal tourism traffic. This monitoring should be made participatory in high tourism-traffic areas, involving members of the public, the fisheries, tourism, and health sectors of the local governments in coordination with local academic institutions.
- DA-BFAR and DENR should also maintain a publicly available database of jellyfish envenomation dates, times, and locations. Health workers and law enforcement officials should be taught to recognize the stings and record casualties for the DA-BFAR and DENR databases. This database and monitoring could be the basis for a national risk map and calendar and, eventually, an advisory and warning system.

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1. What are harmful jellyfishes?

Jellyfishes are gelatinous and semi-transparent marine animals with an umbrella-like structure (i.e., the bell) and tentacles (see Figure 1; CEMACS 2019). Jellyfishes belong to Phylum Cnidaria, a taxon known for their stinging cells (Daly et al. 2007). Jellyfishes are consumed as food, and their toxins have been found to have pharmaceutical applications (Hodgson and Isbister 2009; Escoubas and King 2014; CEMACS 2019; Nisa et al. 2021). But jellyfishes also negatively impact human health and the economy, particularly when jellyfish populations bloom, reaching abnormally high numbers. Jellyfish

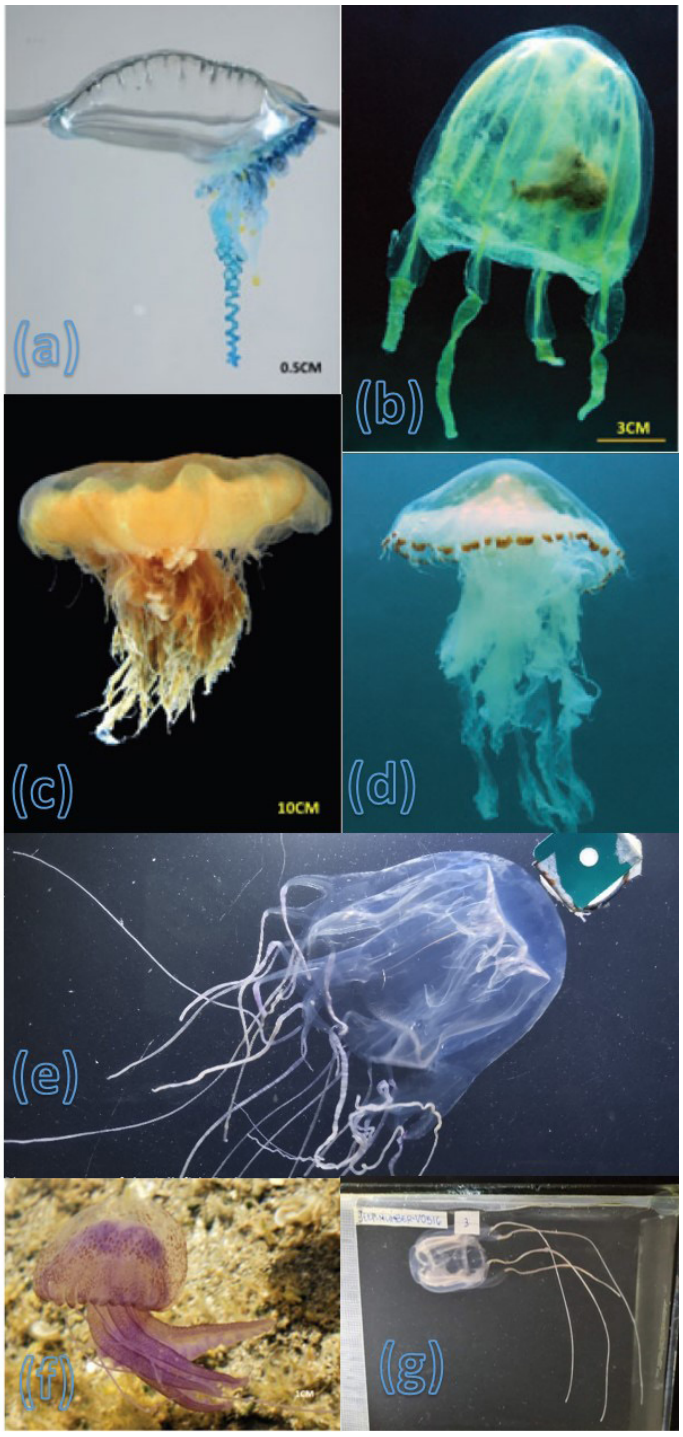

Figure 1. Representative photos of some of the harmful jellyfish species in the Philippines: (a) Physalia sp., (b) Morbakka sp., (c) Cyanea sp., (d) Chrysaora sp., (e) Chironex sp., (f) Pelagia noctiluca, (g) Carybdea sp.

Note. The photos used in panels (a)-(d), & (f) are from the *Field Guide to the Jellyfish of Western Pacific.* (2021). Center for Marine and Coastal Studies, Universiti Sains Malaysia, Penang, Malaysia, pp. 34, 45, 47, 51, 115. Reproduction for educational or other noncommercial purpose is authorized.

Panels (e) and (g) are original photos from the ongoing Jellyfish Ecology and Envenomations Project funded by the Department of Science and Technology – Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development.

blooms negatively affect fishing, tourism, and electrical power generation (Quinones et al. 2012; Chiaverano et al. 2013; CEMACS 2019). In addition, stings of some species of jellyfish are fatal to humans (CEMACS 2019). Moreover, it has been documented that jellyfishes are "able to cause or likely to cause harm or negative impacts" to ecological and socio-economic systems (CEMACS 2019). However, very little is known about harmful jellyfish species in the country, let alone their impacts on the environment and society (Licuanan et al. 2021). Therefore, this policy brief aims to highlight the issue of harmful jellyfish species and make recommendations on how existing government agencies and policies should be organized to address said issue.

2. What is known about harmful jellyfishes in the country?

Harmful jellyfishes belong to Class Scyphozoa and Cubozoa (CEMACS 2019). It is reported that 38 species from Class Scyphozoa and seven from Class Cubozoa can be found in the Philippines (Gershwin 2003). Jellyfishes belonging to Class Cubozoa are commonly known as box jellyfish because of their box or cuboidal-shaped bells. The presence of the lethal box jellyfish Chironex sp., Malo sp., and Morbakka sp. has been reported (Metillo et al. 2015). Annually, 20-40 people are stung and killed by harmful jellyfishes (Fenner 2005). Although awareness of harmful jellyfish in coastal waters is high, there is no formal nationwide management and monitoring of toxic and bloom jellyfish species (Metillo et al. 2019). Hence, the annual jellyfish-related fatality in the country is believed to be grossly underestimated (CEMACS 2019; Licuanan et al. 2021). Furthermore, evidence suggests that the incidence of stinging from harmful jellyfishes is increasing (Guevara et al. 2017).

In the Philippines, jellyfish populations bloom during the warm months of March to July (Boco et al. 2014; Guevara et al. 2017). These are the same months when beachgoers flock to coastal areas. Licuanan et al. (2021) found that the population of a box jellyfish species in Caramoan, Camarines Sur blooms from April to June and is blown to shore by the northeast monsoon (or amihan). During a bloom, the number of box jellyfish counts could easily reach > 100 individuals in a 100-meter stretch of the intertidal zone over a 5- to 9-day sampling period. Whereas in other months (January-March and July-December), box jellyfish numbers drastically drop to 0-2 (see Table 1 of Licuanan et al. 2021). The species of the box jellyfish there is yet to be confirmed via genetic analysis. The typical circumstances believed to lead to a greater risk of encountering box jellyfishes in Caramoan and the municipalities of Lagonoy and Del Gallego (where deaths were recorded) were the proximity (≤ 5 km) of sites to rivers and the timing of high tides during spring tides.

3. How can we reduce injuries and death due to harmful jellyfish?

Four government agencies could form an inter-agency committee to manage harmful jellyfish species and related injuries and deaths. These are the Department of Agriculture (DA), Department of Environment and Natural Resources (DENR), Department of Health (DOH), and the Department of Tourism (DOT). DENR has the broadest scope of responsibility and level of coordination among the four agencies – usually serving as the lead coordinating agency as prescribed by Presidential Executive Order No. 192 (1987). The laws and policies where there are intersections between the respective mandates and functions of the four agencies are summarized in Table 1 and illustrated in Figure 2. However, the primary laws or policies that could serve as the initial legal framework for the formation of an inter-agency committee between DA-BFAR, DENR, DOH, and DOT that will manage harmful jellyfish species and related injuries and death are the following: Republic Act 7160 or the Local Government Code of 1991, the Integrated Coastal Management Policy of DENR (Executive Order No. 533), DOH Administrative Order 2014-002, DOH Circular 2014-0149, and the Marine Wildlife Tourism Interactions in the Philippines (DOT-DA-DILG-DENR Joint Memorandum Circular No. 01 series of 2019). The inter-agency committee could concretize four significant courses of action, which are discussed below:

A. Further research

DA, DENR, DOH, and DOT have respective functions in conducting research. However, academic and research institutions should assist in initiating and implementing the research and developing a participatory monitoring system (EO 533, and DOT-DA-DILG-DENR JMC No.01 s 2019). For example, basic research on the biology and ecology of different jellyfish species is a huge knowledge gap in the Philippines (CEMACS 2019; Licuanan et al. 2021). The information generated in these basic researches could contribute to DA and DENR's would-be database. Similarly, research on the biology of harmful jellyfishes could guide biochemical and pharmacological studies to characterize jellyfish toxins. With sufficient knowledge of jellyfish toxins, specific medical treatments could be prescribed, or anti-venoms could be developed. More research could also be done on how jellyfish species could be utilized economically. For example, the jellyfish species Aurelia aurita, with a documented bloom in Sogod Bay, Southern Leyte, is rich in collagen and other nutrients and can be processed as feedstock (Purcell et al. 2013; Doyle et al. 2014; Arguello-Esparza et al. 2019). Furthermore, since jellyfishes are collagen-rich, they can be processed to create gelatin (Egloso and Urboda 2017). Another jellyfish species, Rhopilema hispidum, found in Palawan, is edible and commercially important (Khong et al. 2016). A. aurita and R. hispidum are not harmful jellyfish species, but the experimental studies conducted on them could be replicated to those that are harmful or lethal.

B. Information and education campaign (IEC)

All four agencies have functions and capacities for information and education campaigns. The urgent pieces of information that must be made known to the general public are the high-risk areas and times for encountering harmful jellyfish species. DOH Circular 2014-0149 also alerts health workers of the possibility of increased incidence of jellyfish stings to beachgoers during the summertime. Another urgent piece of information that must be broadcasted to the general public is the preventive measures for jellyfish envenomation and the appropriate first aid. DOH Circular 2014-0149 outlines preventive measures and

Table 1. Summary of laws and policies that supports the present brief's recommendations

Law/policy	Short description	Relevance to recommendations of the policy brief
P.E.O. 288 (1958)	Establishment and reorganization of DOH	promotion of Filipino health and well-being, adequacy of municipal/rural health units (sections 4, 17-25, 43-50)
P.E.O. 116 (1987)	Establishment and reorganization of DA	creation of regional offices of DA, as well as BFAR (section 13)
P.E.O. 192 (1987)	Establishment and reorganization of DENR	creation of DENR with a mandate to manage the environment (section 4), creation of Protected Areas and Wildlife Bureau, which is now the Biodiversity Management Bureau, which in turn, has the Coastal Management Division (section 18)
R.A. 7160 (1991)	Decentralization of governmental powers giving local government units autonomy	the local government unit is the main stakeholder and key player in any management plan
R.A. 8550 (1998) as amended by R.A. 10654	The Philippine Fisheries Code	The National Fisheries Research and Development Institute can play an important role in the monitoring of harmful jellyfish species (section 82)
DENR E.O. 533 (2006)	The integrated coastal management policy of the country	DENR has the jurisdiction over managing watersheds which includes the coasts (section 3-11)
R.A. 9593 (2009)	Establishment of DOT	creation of DOT, sustainable coastal tourism is anchored on the national integrated coastal management policy (section 2), and local government units have jurisdiction over locally managed tourism activities (section 37)
DOH A.O. 2013-005	Establishment of a unified registry system involving injuries	creation of a monitoring system and online database for all types of injuries, including stings from animals
DOH A.O. 2014-002	Amendment to the national policy on violence and injury	strengthening of DOH programs to prevent premature deaths due to injuries
DOH Circular 2014-0149	Advisory on jellyfish sting prevention and management	the only policy created specifically for jellyfish sting prevention and first aid
DOT-DA-DILG-DENR JMC 01 (2020)	Implementing rules and regulations for marine wildlife tourism interactions	outlines the governmental framework and system that could potentially operationalize the recommendations of this policy brief (e.g., safety – section 3, IEC and research – section 5, monitoring – section 10)

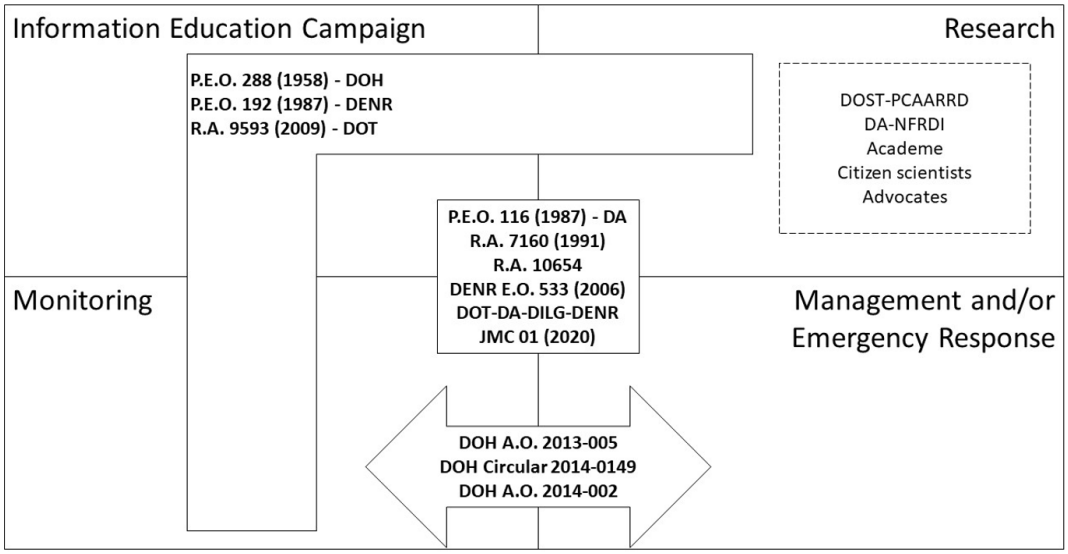

Figure 2. The four major recommendations of the policy brief occupying different quadrants. The polygons occupying multiple quadrants indicate intersections or commonalities between the goals and objectives of the laws/policies and this policy brief.

first aid for jellyfish envenomation, but these must be updated and made more comprehensive since stings from different species of harmful jellyfish have differing first aid, management, and treatment (Verdadero et al. in prep). In addition, various traditional and local remedies (e.g., rubbing sand on stung areas; urination; use of soft drinks, petrol or gasoline, coconut milk; rubbing with beach plants; drinking chicken blood or mangrove extract; washing with seawater) are found ineffective (or could even worsen the envenomation) as first aid or treatment for jellyfish stings should also be included in IEC materials.

C. Management and emergency response

DOH is committed to "health and well-being for every Filipino" and lowering injury-related mortality (DOH Administrative Order 2014-002). Similarly, the Tourism Act (RA 9593) and the Marine Wildlife Tourism Interactions in the Philippines (DOT-DA-DILG-DENR Joint Memorandum Circular No. 01 series of 2019) ensure the safety of both local and foreign tourists. Therefore, the inter-agency committee could make policies and guidelines for the formation of local management and emergency response teams in high-risk areas. Furthermore, the local components of DA-BFAR, DENR, DOH, and DOT could collaborate with local government units (LGU), as prescribed by the LGU Code (RA 7160), to take preventive measures, develop emergency response systems, and procure adequate treatment facilities.

Preventive measures for harmful jellyfish envenomation could be any of the following: issuance of warning bulletins, installation of signages and barrier nets, identification of no-swim zones (especially during jellyfish blooming seasons), and mandating of proper attire (e.g., long-sleeved rash guards and leggings). In addition, the development of emergency response systems could be in the forms of trained fishers and boat-operators, tour guides, and resort staff in conducting first aid and management of jellyfish stings (Pirkle and Yanagihara 2019); publicly available first aid kits in coastal areas with a high risk of harmful jellyfish stings; and predetermination of an emergency vehicle, response team, and route to the nearest healthcare facility. Furthermore, DOT could enhance its accreditation process to require local tourist operators situated at high-risk areas for harmful jellyfish envenomation to have adequately trained personnel and facilities for emergency cases (RA 9593; DOT-DA-DILG-DENR Joint Memorandum Circular No. 01 series of 2019). Lastly, DOH should ensure that seaside towns are adequately equipped with the facilities needed to treat victims of jellyfish stings. This may include oxygen tanks, cold packs, analgesics, and anti-venom (Fenner 2005).

D. Monitoring

DA-BFAR and DENR could establish a national monitoring system for harmful jellyfish blooms with representative pilot sites in any of the locations in Figure 3. With a monitoring system, BFAR can identify areas with high risks for harmful jellyfish envenomation and relay this information to local governments, DOH, DOT, and the general public. Furthermore, a well-designed, nationally standardized monitoring system could allow DA-BFAR to investigate if jellyfish blooms affect the country's fisheries and by how much. This is particularly relevant because currently, there are no data from the academic literature on the impact of jellyfish blooms on the country's fishing industry. However, Purcell et al. (2013), Clinton et al. (2021), and Bosch-Belmar et al. (2021) have reported that jellyfish blooms reduce the salmon aquaculture harvest by 12% in several countries in the northern hemisphere. The Philippines is a top exporter of aquaculture-raised fish food (Clinton et al. 2021). According to the DA-BFAR website, fisheries contribute to 1.2% of the country's Gross Domestic Product, with the aquaculture sector having the second largest number of actively engaged fisherfolk (https://www.bfar.da.gov.ph/).

Jellyfish blooms or swarms generally affect marine aquaculture in two ways. First, dense jellyfish populations get entangled in the cages or other related structures of marine aquaculture, which leads to biofouling. Furthermore, cages clogged with jellyfish have reduced water flow and flushing, leading to changes in the water's physicochemical properties, which is detrimental to the fishes being cultured. Second, blooms or swarms of jellyfish increase the likelihood of direct envenomation to the cultured fishes resulting in injuries, diseases, or death (Purcell et al. 2013; Clinton et al. 2021; Bosh-Belmar et al. 2021). These observations are similar to the experience of DA-NFRDI grow-out ponds in Butong, Batangas, where blooms of the upside-down jellyfish (Cassiopaeia spp.) are infesting at Caranx ignobilis or Maliputo aquaculture facilities (Mutia pers comm. 2019).

Some regional offices of DA-BFAR are monitoring harmful jellyfish blooms. Still, the monitoring needs to be nationally standardized and concerted (CEMACS 2019) and made participatory through the involvement of citizen scientists and advocates. The local jellyfish monitoring team in Lian, Batangas, could serve as a model for participatory monitoring (Licuanan et al. 2021). With the support of the Management Association of the Philippines, De La Salle University initiated jellyfish monitoring by fishers' and women's organizations in Lian, Batangas. The monitoring teams perform regular and standardized sampling, data collection, and storage. The team also collects weather and oceanographic data. In any case, the local monitoring team must be fully capacitated by the local management and emergency response team to ensure that the local monitoring team must have the proper knowledge and skills on identifying and handling harmful jellyfish species, personal equipment for protection (e.g., long-sleeved rash guards with hoods and leggings), and be supported by an adequate emergency response system. The costs for monitoring harmful jellyfish blooms could be incorporated into sustainable coastal tourism plans as prescribed by the DOT-DA-DILG-DENR Joint Memorandum Circular No. 01 series of 2019.

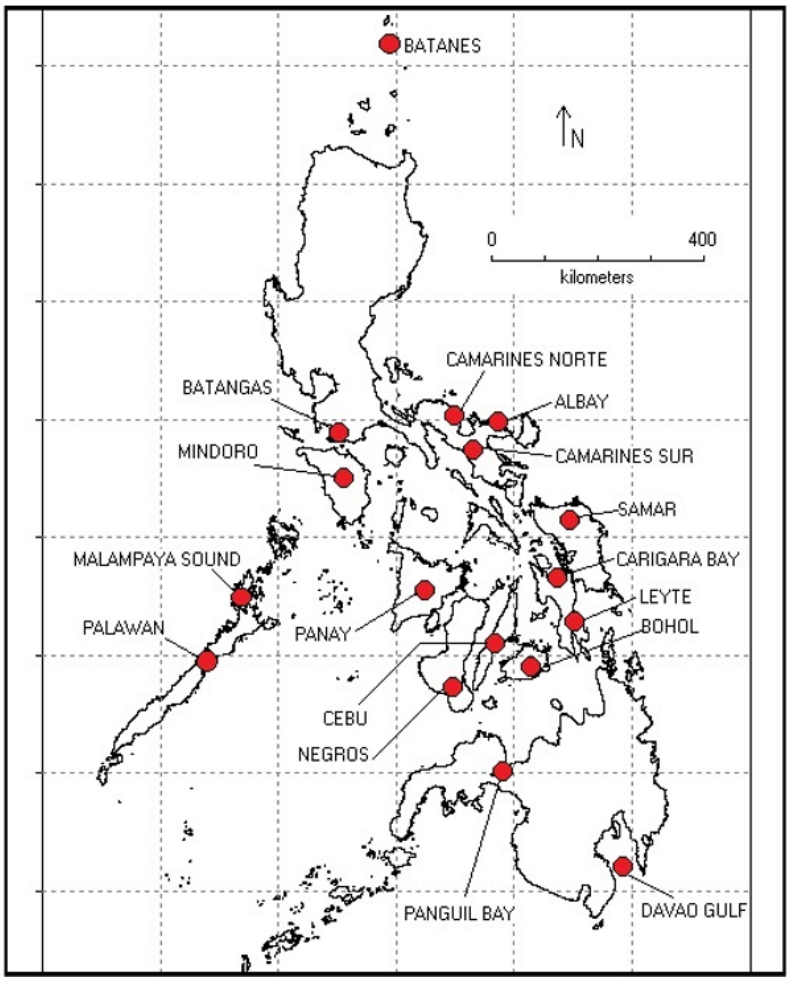

Figure 3. A map of the country with red dots corresponding to locations known to have harmful jellyfish species (CEMACS, 2019).

DA-BFAR, DA-NFRDI (the research arm of DA on fisheries and aquatic resources under RA 8550 as amended in RA 10654), and DENR's monitoring system will require a shared database. The database could contain the following information: where and when jellyfish populations bloom; the species of jellyfish in bloom; a distribution of jellyfish species; fish catch following a jellyfish bloom; and incidences of harmful jellyfish envenomation. The monitoring systems' database could also contain a repository of images of different jellyfish species and the appearance of jellyfish stings on human skin. DOH can use these to develop a handbook on managing and treating varying jellyfish stings. Once sufficient information is available on jellyfish blooms, the inter-agency committee could also coordinate with the National Telecommunication Commission to develop a national warning system, similar to the warning systems of the National Disaster Risk Reduction and Management Council and the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (Licuanan et al. 2021).

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AUTHOR CONTRIBUTIONS

Verdadero FXD: Conceptualizing, Data gathering, Writing. Licuanan WY: Conceptualizing, Data gathering, Writing, Editing. Ang JL: Data gathering, Technical support. de los Santos B: Data gathering, Technical support. Metillo EB: Conceptualizing, Data gathering, Writing.

CONFLICTS OF INTEREST

This article has no conflict of interest whatsoever.

ETHICS STATEMENT

The authors carried out no animal or human studies.

REFERENCES

Arguello-Esparza DG, Ruiz HA, Aguilar CN, De Rodriguez DJ, Souza B, Rodriguez-Jasso RM. 2019. Relevant marine biomass as feedstock for application in the food industry: An overview. In: Chávez-González ML, Buenrostro-Figueroa JJ, Aguilar CN, editors. Handbook of Research on Food Science and Technology Volume 3. p. 197–225. New York: Apple Academic Press.

Boco S, Metillo E, Papa R. 2014. Abundance, size and symbionts of Catostylus sp. medusae Scyphozoa, Rhizostomeae) in Panguil Bay, Northern Mindanao, Philippines. Phillip J Syst Biol. 8:63–81.

Bosch-Belmar M, Milisenda G, Basso L, Doyle TK, Leone A. 2021. Jellyfish impacts on marine aquaculture and fisheries. Reviews in Fisheries Science & Aquaculture. 29(2):242–259. https://doi.org/10.1080/23308249.2020.1806201

CEMACS. 2019. Harmful Jellyfish Country Report in Western Pacific. Penang, Malaysia: Center for Marine and Coastal Studies, Universiti Sains Malaysia.

Chiaverano L, Holland B, Crow G, Blair L, Yanagihara A. 2013. Long-term fluctuations in circalunar beach aggregations of the box jellyfish Alatina mosei in Hawaii, with links to environmental variability. PloS one. e77039. https://doi.org/10.1371/journal.pone.0077039

Clinton M, Ferrier DEK, Martin SAM, Brierley AS. 2021. Impacts of jellyfish on marine cage aquaculture: an overview of existing knowledge and the challenges to finfish health. ICES Journal of Marine Science. 78(5):1557–1573. https://doi.org/10.1093/icesjms/fsaa254

Daly M, Brugler M, Cartwright P, Collins A, Dawson M, Fautin, D, France S, McFadden C, Opresko D, Rodriguez E, Romano S, Stake J. 2007. The phylum Cnidaria: a review of phylogenetic patterns and diversity 300 years after Linnaeus. Zootaxa. 1668:127–182. https://doi.org/10.11646/zootaxa.1668.1.11

Doyle TK, Hayc GC, Harrod C, Houghton JDR. 2014. Ecological and Societal Benefits of Jellyfish. In: Pitt K, Lucas C, editors. Jellyfish Blooms. Springer, Dordrecht: Springer. p. 105–127. https://doi.org/10.1007/978-94-007-7015-7_5

Elgoso NL, Urboda EM. 2017. Utilization of Spotted Jellyfish (Mastigias Papua) for Gelatin Production in Palompon, Leyte Phils.: Basis for Product Commercialization. International Conference on Chemical, Agricultural, Biological and Medical Sciences (CABMS-17). http://uruae.org/siteadmin/upload/AE0117613.pdf

Escoubas P, King G. 2014. Venomics as a drug discovery platform. Expert Rev Proteom. 6(3):221–224. https://doi.org/10.1586epr.09.45

Fenner P. 2005. Venomous jellyfish of the world. SPUMS J. 35(3): 131–138.

Field Guide to the Jellyfish of Western Pacific. 2021. Center for Marine and Coastal Studies, Universiti Sains Malaysia, Penang, Malaysia.

Gershwin L. 2003. Scyphozoa and Cubozoa of Guam. Micronesica. 35(36):156–158.

Guevara B, Dayrit J, Haddad V. 2017. Sea bather's eruption caused by the thimble jellyfish (Linuche aquila) in the Philippines. Clin Exp Dermatol. 42(7):808–810. https://doi.org/10.1111/ced.13196

Hodgson W, Isbister G. 2009. The application of toxins and venoms to cardiovascular drug discovery. Curr Opin Pharmacol. 9(2):173–176. https://doi.org/10.1016/j.coph.2008.11.007

Khong NMH, Yusoff FM, Jamilah B, Basri M, Maznah I, Chan KW, Nishikawa J. 2016. Nutritional composition and total collagen content of three commercially important edible jellyfish. Food Chemistry. 196:953–960. https://doi.org/10.1016/j.foodchem.2015.09.094

Licuanan W, Verdadero F, Ang J, De Los Santos B, Metillo E. 2021. Initial findings suggest box jellyfish encounters along shallow Philippine coastlines are predictable. Phil J Sci. 150(6B): 1641–1645. https://philjournalsci.dost.gov.ph/images/pdf/pjs_pdf/vol150no6B/initial_findings_suggest_box_jellyfish_encounters_along_Phil_coastline_are_predictable_.pdf

Metillo E, Geson S, Sotto F. 2019. Country summaries: Philippines. Harmful Jellyfish Country Report in Western Pacific. Centre for Marine and Coastal Studies, Universiti Sains Malaysia, Penang, Malaysia.

Metillo E, Pagliawan H, Ohtsuka S, Miyake H, Nishikawa J. 2015. Philippines jellyfish biodiversity, fisheries, and ecophysiological and life-history responses to climate change and global warming parameters. 13th National Symposium on Marine Science. p. 73. General Santos: Philippine Association of Marine Science.

Nisa S, Vinu D, Krupakar P, Govindaraju K, Sharma D, Vivek R. 2021. Jellyfish venom proteins and their pharmacological potentials: A review. Int J Biol Mol. 176:424–436. https://doi.org/10.1016/j.ijbiomac.2021.02.074

Pirkle CM, Yanagihara AA. 2019. Insights in Public Health: Trapped in a Sea of Uncertainty: Limitations in Unintentional Injury Research in the Philippines and Interdisciplinary Solutions to Reduce Fatal Box Jellyfish Stings. Hawaii J Med Public Health. 78(1):30–34. PMID: 30697473; PMCID: PMC6333957.