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Pollution Status of the North-Central Selangor Coast as an Important Shorebirds Area

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The North-central Selangor (NCSC) is one of the important IBA in Malaysia that holds over 50,000 migratory shorebirds including globally threatened and near-threatened species. Nonetheless, the NCSC is currently under a very high pressure or threat. For instance, heavy metal levels have been reported to increase significantly along the west coast of Malaysia. However, little studies have been done to highlight this issue in NCSC. Moreover, the lack of studies on emerging and new pollutants in the area is also concerning. Micro-plastics pollution should also be addressed as they are abundant during high tide, exposing the shorebirds as 70% of their foraging activity occurs at that time. The increase in pressure is mostly attributed to the anthropogenic activity and development along the NCSC area. Other issues faced by the shorebirds population in the area include coastal erosion, exposure to coal-by-product, land management and climate change. Similar challenges also occur within the region as such, understanding and solving the issues in NCSC would help improve conservation works in nearby areas too. Hence, suggestions to mitigate and improve the current issues are also presented.

Keywords: migratory shorebirds; North-central Selangor Coast; important bird and biodiversity area; East-Asian Australian flyway; conservation area

I. INTRODUCTION

The current biodiversity crisis has led to the most dramatic declines of shorebirds population around the world (WHSRN, 2025). Hence, the Important Bird and Biodiversity Area (IBA) Program was created, where selected sites are known to have true significance for the international conservation of bird populations (BirdLife International, 2025a). Malaysia alone has a total number of 55 IBAs with an area of 5,135,645 ha; 18 in Peninsular Malaysia, 14 in Sabah, 22 in Sarawak and one oceanic island. Additionally, Malaysia became the 28th Partner of East-Asian Australian Flyway (EAAF) Partnership, further acknowledging the importance of these IBAs to the global shore bird population (EAAF Secretariat, 2025). The EAAF is an important route for more than 95% of the population of certain endangered species (Kim *et al.*, 2018), which is one of the nine major routes used by migratory birds. Stretching from Siberia and Alaska in the north and going southward passing through east and south-east Asia and ends in Australia and New Zealand (Figure 1). In general, it crosses three continents and 22 countries and is considered to be one of the largest and most species-rich migration corridors (Turrin & Watts, 2016). According to EAAF Secretariat (2025), the flyway is home to over 50 million migratory birds, from over 250 different populations, which include 36 Globally Threatened species and 19 Near Threatened species.

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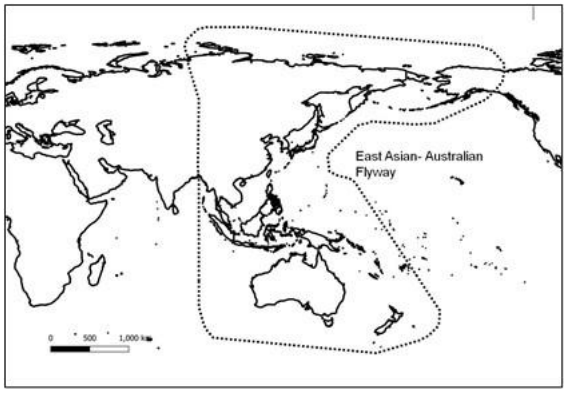

Figure 1. The East-Asian Australian Flyway (EAAF)

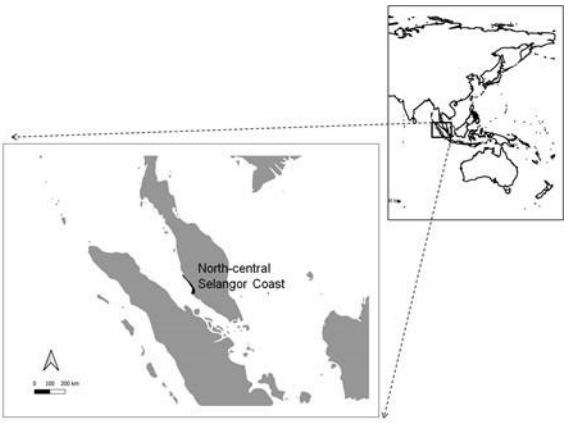

Figure 2. North-central Selangor Coast as part of the EAAF network

II. THE NORTH-CENTRAL SELANGOR COAST

The North-central Selangor Coast (NCSC) is both part of the IBA and East-Asian Australian Flyway networks (Figure 2). A coastal area stretching from Sungai Besar in the north until Pulau Indah in the south, with an area of approximately 28,000 ha. It consists of intertidal mudflats, sandflats, mangrove forest patches and mangrove islands. The mangrove belt of NCSC is known for being highly productive and has significant social and economic importance (BirdLife International, 2025b). The average annual rainfall in the area is less than 2,000 mm with a mean annual temperature of 26.6°C and it experiences both the north-east and south-west monsoons. The NCSC is one of the key wintering and staging sites for migratory waterbirds, predominantly waders, based on their abundance and diversity. Moreover, several globally threatened and near-threatened species including Spotted Greenshanks, Far Eastern Curlew, Great Knot, Black-tailed Godwit and Bar-tailed Godwit have been recorded in the area. Additionally, it is also home to the globally threatened Lesser Adjutant and believe to support one of the largest remaining populations in Malaysia.

Although IBAs are considered as priority conservation areas, many are not legally protected (BirdLife International, 2025c) such as in the NCSC case. This makes the coverage of biodiversity by protected areas inadequate and incomplete. Furthermore, continuous development and anthropogenic activities in the area further degrade and disturbed existing habitats. Therefore, this article aims to provide a comprehensive review of the current state of the NCSC, focusing on the main issues it faces to evaluate and synthesise existing knowledge, identify gaps, and highlight the implications for conservation and management of the area. It is a hope that this review will help related stakeholders to understand more about the challenges and allow them to work together effectively to conserve the area in the future.

III. MAIN ISSUES AND CHALLENGES

According to Birdlife International (2025b), currently the North-central Selangor coast (NCSC) is under a very high pressure or threat with unfavourable state of condition. To aggravate this issue, shorebirds population are also subjected to continuous exposure from various toxic pollutants in the coast (Ismail & Rahman, 2016; Rahman *et al.*, 2017). As such, we will try to highlight pollution studies and other issues (or the lack thereof), that focus on the NCSC and their significant impact onto the subject. These include inorganic and persistent organic pollutants, micro-plastic pollution, coastal erosion, coal burning by-products, governance and management issues and climate change.

A. Inorganic Pollution (Heavy Metals)

Heavy metals pollution has long been an issue particularly along the west coast of Malaysia. Lead (Pb) in particular has shown high accumulation in the sediment (Rahman *et al*., 2013; Buhari & Ismail, 2020) and biological samples (Arai *et al*., 2012; Rahman *et al*., 2019; Salam *et al*., 2021) through the years. Heavy metals are known to induce behavioural changes, increased susceptibility to diseases and reproductive dysfunction even in sub-lethal dose to shorebirds (Martin *et al*., 2003; Fry, 1995; Ludwig *et al*., 1995). The metals are also highly nephrotoxic to newly born chicks (Burger & Gochfeld, 2009) affecting embryonic development (Kertész *et al*., 2006) and causing renal and haematological toxicity (Mateo *et al*., 2003). Other than that, the thinning of eggshells, premature hatching and deformities in the young has also been reported (De Luca-Abbot *et al*., 2004; Kim & Koo, 2007). According to ECU (2023), the main sources in Malaysia are mostly caused by sewage and effluent discharge from agro-based and manufacturing industries, irresponsible earthworks, land-clearing activity and waste disposal. Evidently, there is an increasing trend of heavy metals accumulation in the marine environment in the peninsular. However, the lack of study of heavy metals focusing on shorebirds habitats in NCSC is concerning despite the trend. Even if one exists, the data are too scattered and most likely outdated to reflect its current status.

B. Persistent Organic Pollution

Persistent-organic pollutants (POPs) are highly toxic, persistent and mobile. Even though many of the sources of POPs have been banned, they are still largely present in the environment due to their persistency. DDT, PCB, and dioxins are some of the well-known examples. Under the Stockholm Convention Treaty, more than 90 countries worldwide agreed to reduce or eliminate the use, production and/ or release of 12 key POPs (USEPA, 2025). Nonetheless, in Malaysia, reports as early as 1981 has found high levels of POPs contaminating river water, sediments and fish (Abdullah, 1995). A study done to look into organochlorine pollutant (OCP) a part of POPs, found out that their levels in the west coast are comparatively similar with studies in the same region and other parts of the world (Hossain, 2001). However, the constant levels of POPs pesticides in the Malaysian environment suggested continuous input have been occurring even though they have been banned from import (CAP, 2005). The lack of study focusing on POPs along the NCSC should be addressed urgently too. Persistent organic pollutants exert a broad-spectrum of side effects on birds, interfering with their endocrine, immune and neural system, reproduction, and development, and growth (Hao *et al*., 2021). Shorebirds in particular, are susceptible to embryotoxicity, reduced reproduction performance as well as reduced refuelling and flight performances (Ma *et al*., 2022).

C. Micro-plastic Pollution

Plastic or macro-plastic (>10mm) breaks down under into smaller particles, becoming widespread and ubiquitous in the marine environment. Hence, they are readily consuming throughout the food chains and are toxic to fauna (Sridharan *et al*., 2022). Plastics ingestion by shorebirds is increasingly common and it is estimated that at least 44% of the marine birds have ingested them (Rios & Moore, 2007). In Malaysia, both macro and micro-plastics can be found in abundance along the high tide lines particularly in the west-coast area (Ismail *et al*., 2009; Vin *et al*., 2020; Mohamed *et al*., 2023). The high tide lines or upper tidal flats was found to contributes to more than 70% of the birds' cumulative foraging time, twofold greater than their proportional area (Mu & Wilcove, 2020). This demonstrated the significance plastic pollution and the impact it could have on foraging shorebirds. Moreover, the widespread of plastic in fish or shorebirds preys along the west-coast of peninsular Malaysia are also common; commercial fish species in a local market in Selangor were found to be contaminated by plastics from 0.2 mm to 34.9 mm in size (Karbalei *et al*., 2019), while another study found out more plastics in 16 commercial species from the west coast (Jaafar *et al*., 2021). Clearly, there is a grave concern over the consumption of fish not only for the shorebirds, but also the human population in the west-coast region.

D. Coastal Erosion

In Malaysia, at least 15% of its area is threatened by coastal erosion (ECU, 2023). Moreover, erosion is believed to be one of the serious and dangerous issues along the Selangor's coastal area (Zecchin *et al.*, 2019; Asmawi & Ibrahim, 2013). The average erosion rate along Selangor coastline was said to be more than 2m/ year and it can vary from 4.81 to 6.39 m every year (Ahmad *et al.*, 2021). The highest erosion rate was recorded in Kuala Selangor district coast with 18.61 m/yr (Daud *et al.*, 2021). Furthermore, it was found that the Selangor's shoreline is exposed to more erosion activity (77.3%) than accretion activity (22.7%) (Maulud *et al.*, 2022), which covers at least 151 km area. They added that, apart from natural phenomenon, anthropogenic activity along the coast has been attributed to the observed erosion activity. Prone areas were also found to lack mitigation or structure to prevent such erosion. Moreover, land use such as development, land reclamation and aquaculture further accelerate erosion activity in already vulnerable locations.

The rising sea level has been causing erosion and submergence of shorebirds feeding areas (Galbraith *et al.*, 2002; Nicholls & Cazenave, 2010). Several IBAs along the East-Asian Australian Flyway have also shown striking tidal flat losses (Santos *et al.*, 2023). When combine with the already aggressive erosion activity from anthropogenic sources, the NCSC coastal erosion is expected to accelerate in near future. In addition, due to the compound effect of both anthropogenic activity as well as shorebirds abundance, there is a need to assess the severity of erosion activity in all key sites along the NCSC to better understand the risk.

E. Exposure to Coal-burning By-products

The shorebirds in the North-central Selangor Coast (NCSC) area are also exposed to coal-mining by products. The Kapar Power station (KPS) in Klang has several man-made ponds to contain the waste or by-product of coal burning and usually covered by shallow level of water (Chin & Khoo, 2018). These by-products i.e., coal ash ponds of which 70% of it is still being disposed of in landfills (Haynes, 2009), create a high tide roosting site for migratory shorebirds wintering in the area. However, these coal ash ponds are still an unstable form of containment, as coal is burned, trace amounts of arsenic, lead, cadmium, mercury, and other metals remain in the ash (Delbridge, 2019). The lack of study to assess the level of heavy metals along the vicinity of the power station and its potential impact to the migratory shorebirds needs to be looked into. Although the immediate danger of death to the population or individual species may not be a concern, prolong exposure to the heavy metals could affect their survival in the long run. In addition, the decommissioning of KPS is well-underway as it will be replaced by a gas-fired power plant (TNB, 2022). The development of new power plants and reclamation of the existing one will surely affect the shorebirds activity in the area, most likely displacing them somewhere else. As such, there is really a need to identify new potential key sites as an alternative to the current KPS's location. In the meantime, understanding the shorebirds habitat preference as well as strengthening conservation efforts on the remaining sites should be prioritised.

F. Governance and Management Issues

Although Malaysia has a clear policy and planning to the extent of including ecological corridors in its land-use process (Rameli, 2022), they cannot be the sole solution to prevent global biodiversity decline from development, as different categories of countries need contrasting conservation strategies (Huang *et al.*, 2018). In some part of the country, shared governance practice has been seen to yield positive result particularly in Marine Protected Area (Islam *et al.*, 2017). Such case is most likely viable due to the inter-dependency of the local's livelihoods with the government's agenda. However, in the case of the country's IBAs, some are not only under different jurisdiction, but they could also be spatially and temporally inaccessible to many due to their location and nature. Nonetheless, they are still at the receiving end of pollution input from anthropogenic activity. Hence, conservation interest particularly from the local community perspective is low. Conversely, some areas may have gained the interest of both the local community and industrial players (Ismail & Rahman, 2016). Such case is not rare in the region due to continuous demand of coastal land for economic development (Amir, 2020). The destruction occurred mainly due to poor coordination among the stakeholders as well as

conflicting interest. Apart from poor coordination between government agencies in conservation planning (Gopinath & Puvanesuri, 2006), overlapping and complex jurisdiction between federal and state governments in Malaysia is also an on-going challenge that has been acknowledged (Islam *et al.*, 2017). According to KBAP (2025), these conflicts further lead to the lack of enforcement and increasing pressure for land-grab for the state development. Furthermore, this lack of jurisdictional coordination and integration among the agencies not only slow down on-going conservation effort but also make it fail to achieve its intended objective. The Economic Planning Unit (ECU, 2023) also added that enforcement capacity, inadequate monitoring and research and development need to be addressed. In addition, limited financing, the lack of ownership and shared responsibility among stakeholders have already caused numerous efforts undertaken to be less effective. Nonetheless, Malaysia has committed itself to achieve all the 17 Sustainable Development Goals (SDG) by integrating them into the 12th National Plans and so on.

G. Climate Change

In Malaysia, the characteristic features of the climate are uniform temperature (26°C to 28°C), high humidity and copious rainfall (MET Malaysia, 2025). According to Rahman (2018), Malaysia could be considered as a free zone from climate related disaster although mild climate related disasters are quite frequent to happen. Nonetheless, by 2050, it is projected that the overall temperature will rise of up to 1.5°C with higher rainfall activity particularly in the southern part of the peninsular. There are growing studies that show how climate can have tremendous impact on shorebirds population but only a few in Malaysia. A comprehensive review by Seri and Rahman (2021) suggested that about 169 migratory species in Asia area affected severely by weather and climate changes. Although the statuses of many other species are still unknown due to data scarcity, it can be assumed that they are also directly or indirectly affected by the changing of climate. Studies have shown that shorebirds were first affected by the weather conditions during migration and wintering (Saether *et al.*, 2006) and after arriving at their breeding ground (Tryjanowski *et al.*, 2004). According to Stutzman and Fontaine (2015), a close relationship between migrants and invertebrates' phenology indicates that shorebirds may be vulnerable to changes in seasonality driven by climate change. Evidently, protecting and conserving important habitats related to the shorebirds are vital in the long run. The ecosystem-based adaptation or approach to mitigate climate-induced changes by maintaining existing natural ecosystem structures and improving ecosystem services (Huq *et al.*, 2013) could very well benefits both people and nature such as in the case in Europe (Doswald & Osti, 2011). These include but not limited to protecting and restoring wetlands, riverbanks and mangrove re-planting in key areas.

IV. SUGGESTIONS AND FUTURE POSSIBILITIES

Considering the challenges and accelerated impact of anthropogenic activity on key habitats in the North-central Selangor coast, there is a need to develop an integrated and sustainable framework or approach to address the current issues. One way to mitigate the current habitat deterioration issue is to increase the resilient of key habitats and adjacent areas. In addition, improving ecological connectivity between key sites should also be considered in the long-term mitigation planning. For governance issues or conflicts, the involvement of various stakeholders, through shared responsibility and commitment should be considered. Furthermore, a steering committee or intra-agency task force consisting of key stakeholders are needed to ensure every action taken are on track and align with the strategic goals set up. There are also urgent needs for multi-disciplines research to be conducted to determine the actual status of the key habitats in NCSC and their impact onto the shorebird's populations. In the meantime, urgent action should be taken to:

1. Reduce the current loss of habitat and biodiversity in NCSC to the lowest level.
2. Identify new potential key areas to support both existing and future shorebirds population in NCSC.
3. Develop and strengthen the committee consisting of key agencies and related stakeholders.
4. Identify future alternative to increase resilience and promote adaptation.

V. CONCLUSION

The North-central Selangor Coast (NCSC) as an important IBA and network along the East-Asian Australian Flyway, is under increasing challenges to maintain its status. Despite the regular and updated reviews on Malaysia's biodiversity policies and frameworks, as well as the recent move to promote the IBA into Malaysia's new RAMSAR site, there is plenty of groundwork and action needed at the ground level addressing fundamental issues. The review further shows increasing and accelerating patterns of deterioration of the NCSC's ecosystem and its components despite all the efforts undertaken. Evidently, there is a need for a well-planned and systematic action be taken urgently, backed by a scientific consensus. As such, urgent multi-stakeholder collaboration is needed to mitigate the highlighted issues.

VI. CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

VII. REFERENCES

Abdullah, AR 1995, 'Environmental pollution in Malaysia: Trends and prospects', *Trends in Analytical Chemistry*, vol.14, no. 5, pp. 191–198.

Ahmad, H Maulud, KNA Karim, OA & Mohd, FA 2021, 'Assessment of erosion and hazard in the coastal areas of Selangor' *Geografia-Malaysian Journal of Society and Space*, vol. 17, no. 1, pp. 14-31.

Amir, AA 2020, 'The going gets tough for mangroves', *CHEC Human Ecology Journal*, vol. 30, pp. 16-18.

Arai, T Rahman, F Chino, N & Ismail, A 2012, 'Heavy metal concentration in a tropical eel *Anguilla bicolor bicolor* in Peninsular Malaysia, Malaysia', *Malaysian Applied Biology*, vol. 41, no. 1, pp. 43-46.

Asmawi, MZ & Ibrahim, AN 2013, 'The perception of community on coastal erosion issue in Selangor, Malaysia', *Journal of Clean Energy Technologies*, vol. 1, no. 3, pp. 164-168.

BirdLife International, 2025a, *Why apply criteria?* Viewed 15 January 2025, <http://datazone.birdlife.org/site/ibacriteria>.

BirdLife International, 2025b, *Important Bird Area factsheet: North-central Selangor coast*, viewed 15 January 2025, <http://datazone.birdlife.org/site/factsheet/north-central-selangor-coast-iba-malaysia>.

BirdLife International, 2025c, *Many IBAs are in an unfavourable state*, viewed 15 January 2025, <http://datazone.birdlife.org/sowb/state/theme5>.

Buhari, TR & Ismail, A 2020, 'Pollution status of heavy metals in surface sediments collected from west coast of Peninsular Malaysia' *Open Access Library Journal*, vol. 7, no. 6829.

Burger, J & Gochfeld, M 2009, 'Mercury and other metals in feathers of common eider (*Somateria mollissima*) and tufted puffin (*Fratercula cirrhata*) from the Aleutian chain of Alaska', *Archives of Environmental Contamination and Toxicology*, vol. 56, pp. 596–606.

Chin, CL & Khoo, SS 2018, *Kapar Waterbirds Survey 2015/16 and Kapar Waterbirds Survey 2016/17 (a supplementary)*, MNS Conservation Publication No 19, MNS, Kuala Lumpur, Malaysia.

Consumer's Association of Penang (CAP), 2005, *International POPs elimination Project: Malaysia country situation report*, The International POPs Elimination Network (IPEN), viewed 25 Aug 2024, < https://ipen.org/documents/malaysia-country-situation-report>.

Daud S, Milow, P & Zakaria, RM, 2021, 'Analysis of shoreline change trends and adaptation of Selangor Coastline, using Landsat satellite data', *Journal of the Indian Society of Remote Sensing*, vol. 49, pp. 1869–1878.

De Luca-Abbot, SB Wong, BSF Peakell, DB Lam, PKS Young, L Lam, MHW & Richardson, BJ 2004, 'Review of effects of water pollution on the breeding success of waterbirds', *Ecotoxicology*, vol. 10, no. 6, pp. 327-349.

Delbridge, L 2019, 'Coal ash wastescapes: The byproduct of our coal-fired power dependency', eds N Pevzner & S Carlisle, in *Scenario 07 (Power) Scenario Journal*, University of Pennsylvania School of Design, Philadelphia, USA.

Doswald, N & Osti, M 2011, *Ecosystem-based approaches to adaptation and mitigation – good practice examples and lessons learned in Europe, Bonn*, Federal Agency for Nature Conservation, Germany.

EAAF Secretariat, 2025, *The flyway*, viewed 5 March 2025, <https://www.eaaflyway.net/the-flyway/>.

Economic Planning Unit (ECU), 2023, *Twelfth Malaysia Plan: 2021-2025 a prosperous, inclusive, sustainable Malaysia*, Federal Government Administrative Centre, 62502 Putrajaya, Malaysia

Fry, DM 1995, 'Reproductive effects in birds exposed to pesticides and industrial chemicals', *Environmental Health Perspectives*, vol. 103, no. 7, pp. 165–171.

Galbraith, H Jones, R Park, R Clough, J Herrod-Julius, S Harrington, B & Page, G 2002, 'Global climate change and sea level rise: potential losses of intertidal habitat for shorebirds', *Waterbirds*, vol. 25, no. 2, pp. 173-183.

Gopinath, N & Puvanesuri, SS 2006, 'Marine capture fisheries', *Aquatic Ecosystem Health & Management*, vol. 9, no. 2, pp. 215-226.

Hao, Y Zheng, S Wang, P Sun, H Matsiko, J Li, W Li, Y Zhang, Q & Jiang, Z 2021, 'Ecotoxicology of persistent organic pollutants in birds', *Environmetal Science: Process & Impacts*, vol. 23, no. 3, pp. 400-416.

Haynes, RJ 2009, 'Reclamation and re-vegetation of fly ash disposal sites-challenges and research needs', *Journal of Environmental Management*, vol.90, no. 1, pp. 43–53.

Hossain, MM 2001, 'Fate of organochlorine pesticide (OCPs) residues in sediment and in the marine food chain, PhD thesis, Universiti Sains Malaysia.

Huang, C-W McDonald, RI & Seto, KC 2018, 'The importance of land governance for biodiversity conservation in an era of global urban expansion', *Landscape and Urban Planning*, vol. 173, pp. 44-50.

Huq, N Renaud, FG & Sebesvari, Z 2013, 'Ecosystem based adaptation (EbA) to climate change - integrating actions to sustainable adaptation' in *Impacts World 2013 Conference at Potsdam*, Potsdam Institute for Climate Impact Research, Postdam, Germany.

Islam, GMN Tai, SY Kusairi, MN Ahmad, S Aswani, FMN Senan, MKAM & Ahmad, A 2017, 'Community perspectives of governance for effective management of marine protected areas in Malaysia', *Ocean and Coastal Management*, vol. 135, pp. 43-42.

Ismail, A Adilah, NMB & Nurulhudha, MJ, 2009, 'Plastic pellets along Kuala Selangor-Sepang coastline', *Malaysian Applied Biology*, vol. 38, no. 1, pp. 85-88.

Ismail, A & Rahman, F 2016, 'Current Status of the Milky Stork Re-introduction Programme in Malaysia and Its Challenges', *Tropical Life Sciences Research*, vol. 27, no. 2, pp. 13-24.

Ismail, A & Yusof, S 2011, 'Effect of mercury and cadmium on early life stages of Java medaka (*Oryzias javanicus*): a potential tropical test fish', *Marine Pollution Bulletin*, vol. 63, no. 5-12, pp. 347-349.

Jaafar H, Azfaralariff, A Musa, SM Mohamed, M Yusoff, AH & Lazim, AM 2021, 'Occurrence, distribution and characteristics of micro-plastics in gastrointestinal tract and gills of commercial marine fish from Malaysia', *Science of the Total Environment*, vol. 799, pp. 149457.

Karbalei, S Golieskardi, A Hamzah, H Abdulwahid, S Hanachi, P Walker, TR & Karami, F 2019, 'Abundance and characteristics of microplastics in commercial marine fish from Malaysia', *Marine Pollution Bulletin*, vol. 148, pp. 5-15.

Kertész, V Bakonyi, G & Farkas, B 2006, 'Water pollution by Cu and Pb can adversely affect mallard embryonic development', *Ecotoxicology and Environmental Safety*, vol. 65, pp. 67–73.

Key Biodiversity Areas Partnership (KBAP), 2025, *Key Biodiversity Areas factsheet: North-central Selangor coast*, viewed 5 March 2025, <http://www.keybiodiversityareas.org/>.

Kim, J & Koo, TH 2007, 'Heavy metal concentrations in diet and livers of Black-crowned Night Heron *Nycticorax nycticorax* and Grey Heron *Ardea cinerea* chicks from Pyeongtaek, Korea', *Ecotoxicology*, vol. 16, no. 5, pp. 411-416.

Kim, M Choi, YE & Chon, J 2018, 'Key coastal landscape structures for resilient coastal green infrastructure to enhance the abundance of migratory birds on the Yellow Sea', *Environmental Pollution*, vol. 243, pp. 1617-1628.

Ludwig, JP Auman, HJ Weseloh, DV Fox, GA Giesy, JP & Ludwig, ME 1995, 'Evaluation of the effects of toxic chemicals in Great Lakes cormorants: has causality been established?', *Colonial Waterbirds*, vol. 18, no. 1, pp. 60–69.

Ma, Y Choi, C-Y Thomas, A & Gibson, L 2022, 'Review of contaminant levels and effects in shorebirds: Knowledge gaps and conservation priorities', *Ecotoxicology and Environmental Safety*, vol. 242, no. 113868.

Martin, MB Reiter, R Pham, T Avellanet, YR Camara, J Lahm, M Pentecost, E Pratap, K Gilmore, BA Divekar, S Dagata, RS Bull, JA & Stoica, A 2003, 'Estrogen-like activity of metals in Mcf-7 breast cancer cells', *Endocrinology*, vol. 144, no. 6, pp. 2425–2436.

Mateo, R Beyer, WN Spann, JW Hoffman, DJ & Ramis, A 2003, 'Relationship between oxidative stress, pathology,

and behavioral signs of lead poisoning in mallards', *Journal of Toxicology and Environmental Health (Part A)*, vol. 66, no. 14, pp. 1371–1389.

Maulud, KNA Selamat, SN Mohd, FA Md Noor, N Jaafar, WSWM Kamarudin, MKA Ariffin, EH Adnan, NA & Ahmad, A 2022, 'Assessment of shoreline changes for the Selangor Coast, Malaysia, using the Digital Shoreline Analysis System Technique', *Urban Science,* vol. 6, no. 4, pp. 71.

MET Malaysia, 2025, *Malaysia's Climate*, viewed 5 March 2025, < https://www.met.gov.my>.

Mohamed, CAR Shahruddin, AN Pradit, S Loh, PS Nitiratsuwan, T Kobkeatthawin, T Noppradit, P *et al*., Wang, J 2023, 'Depth profiles of microplastic in sediment cores in the mangrove area of Kuala Gula Mangrove, Malaysia', *Journal of Marine Science and Engineering*, vol. 11, no. 6, pp. 1223.

Mu, T & Wilcove, DS 2020, 'Upper tidal flats are disproportionately important for the conservation of migratory shorebirds', *Proceedings: Biological Sciences*, vol. 287, no. 20200278.

Nicholls, RJ, & Cazenave, A 2010, 'Sea-level rise and its impact on coastal zones', *Science*, vol. 328, no. 5985, pp. 1517-1520.

Rahman, F Ismail, A Omar, H & Hussin, MZ 2017, 'Exposure of the endangered Milky stork population to cadmium and lead via food and water intake in Kuala Gula Bird Sanctuary, Perak, Malaysia', *Toxicology Reports*, vol. 4, pp. 502-506.

Rahman, F Ismail, A Yusof, S Mazlan, N Engku-Ahmad-Khairi, EA 2019, 'Evaluation of Glyphosate Levels in Sediments of Milky Stork Foraging Areas in Kuala Gula Bird Sanctuary, Perak, Malaysia', *Pertanika Journal of Tropical Agricultural Science*, vol. 42, no. 3, pp. 995–1007.

Rahman, F Ismail, A & Yusof, S 2013, 'Metals contamination in the foraging area of Milky stork: Evidence of anthropogenic input in the aquatic environment of Kuala Gula', *Toxicological and Environmental Chemistry*, vol. 95, no. 9, pp. 1499-1505.

Rahman, HA 2018, 'Climate Change Scenarios in Malaysia: Engaging the Public', *International Journal of Malay-Nusantara Studies*, vol. 1, no. 2, pp. 55-77.

Rameli, A 2022, 'Incorporating ecological corridors into land use planning process', in *4th Asia Ministral conference on tiger conservation (AMC)*, 19-21 Jan 2022, Kuala Lumpur, Malaysia.

Rios, LM & Moore, C 2007, 'Persistent organic pollutants carried by synthetic polymers in the ocean environment', *Marine Pollution Bulletin*, vol. 54, no. 8, 1230-1237.

Saether, BE Grotan, V Tryjanowski, P Barbraud, C Engen, S & Fulin, M 2006, 'Climate and spatio-temporal variation in the population dynamics of a long-distance migrant, the White Stork', *Journal of Animal Ecology*, vol. 75, no. 1, pp. 80–90.

Salam, MA Dayal, SR Siddiqua, SA Muhib, MI Bhowmik, S Kabir, MM Eh-Rak, A & Srzednicki, G 2021, 'Risk assessment of heavy metals in marine fish and seafood from Kedah and Selangor coastal regions of Malaysia: a high-risk health concern for consumers', '*Environmental Science and Pollution Research*, vol. 28, no. 39, pp. 55166-55175.

Santos, CD Catry, T Dias, MP & Granadeiro, JP 2023, 'Global changes in coastal wetlands of importance for non-breeding shorebirds', *Science of the Total Environment*, vol. 858, no. 159707.

Seri, NA Rahman, AA 2021, 'Impact of climate change on Migratory birds in Asia', *Pertanika Journal of Science & Technology*, vol. 29, pp. 2937-2965.

Sridharan, S Kumar, M Saha, M Kirkham, MB Singh, L & Bolan, NS 2022, 'The polymers and their additives in particulate plastics: What makes them hazardous to the fauna?' *Science of the Total Environment*, vol. 824, no. 153828.

Stutzman, RJ & Fontaine, JJ, *Shorebird Migration in the Face of Climate Change*, Nebraska Cooperative Fish and Wildlife Research Unit, viewed 30 Aug 2024, <http://digitalcommons.unl.edu/ncfwrustaff/161.>

Tenaga Nasional Berhad, 2022, *TNB new 2,100 mw Kapar Power Plant, fortifies energy transition agenda*, viewed 30 Aug 2024, <https://www.tnb.com.my/>.

Tryjanowski, P Sparks, TH Ptaszyk, J & Kosicki, J 2004, 'Do White Storks *Ciconia ciconia* always profit from an early return to their breeding grounds?', *Bird Study*, vol. 51, no. 3, pp. 222–227.

Turrin, C & Watts, BD 2016, 'Sustainable mortality limits for migratory shorebird populations within the East Asian-Australian Flyway', Stilt, vol. 68, pp. 2-17.

United States Environmental Protection Agency (USEPA), 2025, *Persistent Organic Pollutants: A global issue, a global response*, viewed 12 February 2025, <http://www.epa.gov>.

Vin, LE Izam, NII Nilamani, N Razali, NM Zanuri, NM Yasin, Z, Hwai, ATS Shoufeng, Z & Hongjun, L 2020, 'Abundance

and distribution of macro-and micro-plastics at three different habitats along the Penang Coastline in the Northern Straits of Malacca', *Ramkhamhaeng International Journal of Science & Technology*, vol. 3, no. 2, pp. 1-15.

WHSRN (Western Hemisphere Shorebird Reserve Network), 2025, *Shorebird status*, viewed 12 February 2025, <http://www.whsrn.org>.

Yurimoto, T Kassim, FM Fuseya, R & Man, A 2014, 'Mass mortality event of the blood cockle, *Anadara granosa*, in aquaculture ground along Selangor coast, Peninsular Malaysia', *International Aquatic Research*, vol. 6, pp. 177-186.

Zecchin, M Catuneanu, O & Caffau, M 2019, 'Wave-ravinement surfaces: Classification and key characteristics', *Earth Science Reviews*, vol. 188, pp. 210–239.