



A REVIEW: DISTRIBUTION, STATUS AND CONSERVATION OF MARINE TURTLES IN COASTAL AREAS OF PAKISTAN

*Uzma Manzoor¹, Muhammad Moazzam², Salman Zubair³, M. Zaheer Khan¹ and Babar Hussain⁴

¹Department of Zoology, Faculty of Science, University of Karachi, Karachi-75270

²World Wide Funds for Nature (WWF) Pakistan, 46-K, PECHS, Block 6, Karachi- 75400

³Department of Geography, University of Karachi, Karachi-75270, Pakistan

⁴International Union for Conservation of Nature (IUCN), F-17/B/2 Clifton, Block 7, Karachi.

ABSTRACT

Green turtle (*Chelonia mydas*) is common in the entire coastal belt of Pakistan, shared by two provinces, Sindh and Balochistan. No record of nesting of Hawksbill turtle (*Eretmochelys imbricata*) and Olive ridley turtle (*Lepidochelys olivacea*) found since 2003 and 2004, respectively, however, distributed in off shore waters of Pakistan, similarly nesting of Loggerhead (*Caretta caretta*) and Leather back turtles (*Dermochelys coriacea*) was not identified in coastal areas. Gill netting and bycatch are the major threats to marine turtle species. Alteration of nesting habitat, harvesting of eggs, plastic and photo pollution, solid waste, oil spillage, developmental and anthropogenic activities could be the main causes of non-nesting behaviour of marine turtle species. Impact of lockdown since March 2020 is positive on nesting behaviour of Green turtle as public is not allowed to visit sea sites, hence disturbance not faced by female turtles. Climate change impact on nesting is not drastic but sex ratio is affected. Sindh Wildlife Department, Coastal Association for Research and Development (CARD) Balochistan and other non-governmental organizations such as International Union for Conservation of Nature (IUCN), World Wide Funds for Nature (WWF-Pakistan) and Scientific and Cultural Society of Pakistan (SCSP) are playing important role for the conservation of marine turtles in Pakistan.

Keywords: Pakistan coast, turtles, nesting, legal protection, marine protected area.

INTRODUCTION

In Arabian Sea the coastline of Pakistan is about 1050 km long (250 km Sindh province and approximately 800 km Balochistan province). An area of 350 nautical miles comprises of different maritime zones; distinguished as 12 nautical miles (22.22 km) off shore region, between 12 to 20 nautical miles buffer zone and up to 200 nautical miles Exclusive Economic Zone (EEZ) which covers an area of 240,000 km² approximately. An addition of 50,000 km² area in EEZ is also taken place under the article 76 of United Nations Conference on the Laws of Sea by recognizing Pakistan's continental shelf claim (Mangrove for Future Pakistan, 2016).

Being highly valuable, both commercially as well as economically, Karachi coast (Sindh province) situated between Gharo Creek and Hub River, supports a large biodiversity due to its sandy beaches, rocky, muddy sites and mangrove forests. An extensive creek system, mudflats, sand dunes, estuaries and mangroves are the characteristic features of Indus Delta. Thatta (from Korangi Creek to Indian border Sir Creek) and Runn of Kutch (from Badin to Tharparkar District) are also important coastal sites of Sindh.

The coastal belt of Balochistan is extended from Hub River in east to Iranian border in west with prominent sites; Ormara, Pasni, Astola Island (First Marine Protected Area in Pakistan), Makran, Gwadar and Jiwani (Fig. 1).

Marine Turtles

Marine turtles live in neritic as well as low-lying sandy beaches for foraging and nesting respectively (Boltan, 2003). They are distributed in tropical, sub-tropical and temperate areas including Indo Gangetic Plains, Southeast Asia, South China and New Guinea as main habitats (Van Dijk and Palasuwan, 2000). Table 1 shows globally distributed species of marine turtles, listed in Appendix-I of Convention on International Trade of Endangered Species of Wild Fauna and Flora - CITES (WWFPak, 2021).

Indian Ocean South East Asia (IOSEA) is a suitable habitat of six species of marine turtles except Kemp's ridley which is only found in Mexico Gulf, while five species have been reported from Pakistan except Flatback and Kemp's ridley turtles (Asrar, 1999, Firdous, 1986, 1988; Ghalib and Zaidi, 1976; Groombridge, 1982, 1987a, 1987b, 1989; Groombridge *et al.*, 1988; Iffat, 2009; Kabraji and Firdous, 1984; Khan *et al.*, 2005, 2010a; Khan and Ghalib, 2006a,b).

*Corresponding author e-mail: uxmamanxoor10@gmail.com



Fig. 1. Location of Pakistan Coast in Arabian Sea.

Table 1. Marine Turtle Species.

S. No.	Scientific name	Common name	CITES status
1.	<i>Eretmochelys imbricata</i>	Hawksbill turtle	Appendix I
2.	<i>Natator depressus</i>	Flatback turtle	Appendix I
3.	<i>Lepidochelys olivacea</i>	Olive ridley turtle	Appendix I
4.	<i>Lepidochelys kempii</i>	Kemp's ridley turtle	Appendix I
5.	<i>Dermochelys coriacea</i>	Leatherback turtle	Appendix I
6.	<i>Caretta caretta</i>	Loggerhead turtle	Appendix I
7.	<i>Chelonia mydas</i>	Green turtle	Appendix I

The present study is mainly focused on a review of distribution, status and conservation of marine turtles in coastal areas of Pakistan. Habitat searching, nesting pits along with tracks count and direct sighting were used in this work. Coastal sites viz. Sandspit, Hawkesbay and Cape Monze (Karachi coast, Sindh) were visited along with information about distribution, population and nesting of marine turtles in coastal belt of Balochistan collected from WWF-Pakistan, Coastal Association for Research and Development (CARD) Balochistan and IUCN regional office (Fig. 2a and 2b).

DISCUSSION

Research on marine turtles published between 1988 to 2020 mainly focused on climate change impacts on habitat, global distribution and threats (temperature, Sea Surface Temperature (SST), Sea Level Rise (SLR) (Patricio *et al.*, 2020) with a conclusion that all species of marine turtles have been affected with varying degree in geographical distribution, temporal habitat and population status (Hawkes *et al.*, 2009; Poloczansk *et al.*, 2009; Hamann *et al.*, 2013; Fuentes and Saba, 2016). Figure 3

describes population of marine turtles according to the study (1988-2020) and extracted that this species of marine mega fauna found in beaches, while few observed

in Oceans. *Caretta caretta* is distributed in large numbers (Patricio *et al.*, 2020).



Fig. 2a. Green turtle track in Sandspit Karachi coast.



Fig. 2b. Green turtle track at Jiwani.

Climate change study has usually been focused on terrestrial species due to easy accessibility and availability of baseline data (Feelay *et al.*, 2017). However, in recent years impact on marine biodiversity was also studied and documented (Poloczansk *et al.*, 2016; Worm and Lotze, 2016; Crespo *et al.*, 2019). Fish and plankton have been concentrated for long-term (Worm and Lotze, 2016), while current studies assessing mega fauna of marine ecosystem (Erauskin-Extramiana *et al.*, 2019; Albouy *et al.*, 2020), corals (Hughes *et al.*, 2018), sea grasses (Chefaoui *et al.*, 2018) and seaweeds (Martins *et al.*, 2019).

Due to arid and semiarid environment, climatic condition of Pakistan is varied, temperature ranges from extreme cold to extreme hot with varied degree of rainfall round the year (Khan, 1999). Its marine and coastal resources are not only vital economically but a strategic gateway with three sea ports including Karachi Sea Port (KPT), Port Muhammad Bin Qasim (Bin Qasim Port) and Gawadar Port (Mangrove for Future-MFF Pakistan, 2016).

The baseline data of coastal biodiversity of Pakistan has been provided by UNSECAP (1996). Several species of invertebrates and vertebrates including leeches, prawns, shrimps, lobsters, snails, unio, star fishes, brittle stars, sea cucumbers, sea urchins, patches of corals, fishes, sea snakes, marine turtles, migratory birds, dolphins etc. are inhabited in coastal ecosystem of Pakistan. Mangrove forests, an important part of coastal ecosystem, provide nursery for different sea animals, habitat for native and migratory birds, fuel wood for local community, fodder for cattles and acted as barrier against storms and tornadoes.

Several earlier studies (Groombridge, 1982, 1987a, 1987b, 1989; Kabraji and Firdous, 1984; Firdous, 1986, 1988; 2000, 2001, 2005, Groombridge *et al.*, 1988; Khan *et al.*, 2005) reported that two nesting species *Chelonia mydas* and *Lepidochelys olivacea* inhabited at Hawkesbay and Sandspit Karachi coast and Ormara and Jiwani along Balochistan coast. Another study Khan *et al.* (2010b) surveyed Mubarak village (Karachi coast), Gwadar (West Bay), Pushukan, Ganz, Sonmiani, and Hingol National Park (Balochistan coast) and discovered six new nesting beaches in Pakistan.

Current Study reveals that Green turtle has been commonly recorded from Sindh and Balochistan coast of Pakistan. Table 2 Indicates that out of five marine turtle species, three were investigated in different study periods, while limited information is available about Leatherback and Loggerhead turtles nesting sites, genetic stock and migratory patterns. Nesting and population trends of Green and Olive ridley turtles have been studied (1979-1997) in Karachi coast (Anwar, 2013), while same species

along with Hawksbill turtle were investigated (2001-2009) in Karachi coastal areas viz. Manora, Sandspit, Hawkesbay and Cape Monze (Khan *et al.*, 2010a) and distribution, status and conservation of Green turtle has also been studied (2014-2017) in Karachi coastal sites; Sandspit, Hawkesbay and Cape Monze (Manzoor *et al.*, 2019).

Threats to Marine Turtles

Changing temperature, particularly human induced climate change, is one of the severe threats to nature and has long lasting impact (Pecl *et al.*, 2017; Lenton *et al.*, 2019) particularly on biodiversity of different areas of the world (Newson *et al.*, 2009; Walther, 2010). Under the effects of climate change Green turtle, Leatherback turtle and Loggerhead turtle were reported threatened in the Mediterranean area (WWF, 2018; Sehrish *et al.*, 2021). In addition pollution, plastic materials, polythene bags, development of coastal land, sea debris, boat strikes and most important, bycatch in fishing activities are the priority threats to in-water populations of marine turtles.

Vehicles traffic on nesting beaches compacts sand and makes it difficult for female turtles to dig nests. Beaches of Karachi are heavily used for construction of large huts or houses which alters nesting habitat of marine turtles (Manzoor *et al.*, 2019). Incidental mortality in gill netting, long-line fisheries and shrimp trawl netting are one of the major causes of marine turtle mortality (Firdous, 1998).

Nine specimens of Hawksbill turtle entangled from March 2013 to December 2018. Out of 28,800 entangled species ~4,200 were Green turtles with highest number of 900 in November. There was no report of shrimp trawl entanglement during 2010-2014, while 24,600 Olive ridley turtles caught in Tuna gill netting operations with a peak of 4,500 in November. Juveniles and sub adults are seldom caught in gill netting. From 2012-2017 altogether 17 Leatherback turtles were caught, out of these, 4 stranded on the coast, one found dead and floating on sea surface at Miani Hor, Sonmiani while remaining were entangled in fishing operations except one which died in the net; all entangled turtles were released into the sea safely (Moazzam and Nawaz, 2014, 2015, 2017, 2019) (Table 3).

Predators such as feral dogs, crows, seagulls, crabs destroy eggs and kill hatchlings of marine turtles. Lightening at night disorientate hatchlings to move towards sea thus wander inland and mostly die of dehydration. Transportation of petroleum products in jarry cans and tankers is another threat to nesting beaches (Daran, Balochistan). After offloading from boats, pickup trucks and motorcycles carrying jarry cans or tankers cause compaction of sand and decrease nesting success of turtles (Crain *et al.*, 1995; Brinn, 2008; Shahid, 2020). Being vulnerable to oil spillage, nesting is stopped in

contaminated ground (Camacho *et al.*, 2013) meanwhile if eggs are exposed to oil spilled area during incubation, reduction in hatching success is observed; even if hatchlings survived, they tend to have developmental abnormalities (Wallace *et al.*, 2020).

Debris from crumbling huts, garbage thrown by picnickers and solid wastes create obstruction for nesting activity of turtles. In addition, interaction of people with turtles also disrupts nesting.

Table 2. Marine turtle Species studied in Coastal sites of Pakistan.

S. No.	Scientific name	Common name	1979-1997	2001-2009	2014-2017	2017-2020
1.	<i>Eretmochelys imbricata</i>	Hawksbill turtle	N/E	2003	N/E	N/E
2.	<i>Lepidochelys olivacea</i>	Olive ridley turtle	1979-1997	2003 – 2004	N/E	N/E
3.	<i>Dermochelys coriacea</i>	Leatherback turtle	N/E	N/E	N/E	N/E
4.	<i>Caretta caretta</i>	Loggerhead turtle	N/E	N/E	N/E	N/E
5.	<i>Chelonia mydas</i>	Green turtle	1979-1997	2001-2009	2014-2017	2017-2020

Not Evaluated= N/E

Table 3. Distribution, Nesting sites and Threats to Marine turtle Species in Pakistan.

S. No.	Scientific Name	Common Name	Distribution	Nesting Sites	Threats	Remarks
1.	<i>Eretmochelys imbricata</i>	Hawksbill turtle	Widely observed along coastline of Sindh and Balochistan (specific area has not been identified)	Cape Monze, Sindh (2003), Astola Island, Balochistan (2006) Balochistan; No nesting is reported since 2006	Entanglement in Tuna fishing operations, ghost gears, oil spillage.	study is required to identify reasons of loss of nesting in Pakistan
2.	<i>Lepidochelys olivacea</i>	Olive ridley turtle	Widely distributed in Northern Arabian Sea, off shore waters of Pakistan	Sandspit and Hawkesbay (Sindh), Taq (Ormara) and Astola Island (Balochistan), No nesting is reported since 2004	Entanglement in tuna gill netting and shrimp trawl fishing, oil spillage	Research is needed to find out major cause of disappearance of nesting in Pakistan
3.	<i>Dermochelys coriacea</i>	Leatherback turtle	Coastal and off shore waters of Gwadar and Jiwani (Balochistan), Karachi Great Khori Bank Indus Canyon (Sindh)	No nesting site is reported	Gill netting entanglement	Studies are required to evaluate feeding and nesting habitats
4.	<i>Caretta caretta</i>	Loggerhead turtle	Widely distributed in coastline of Sindh and Balochistan (specifically, areas closed to Masirah Island, Oman)	No reported nesting sites	Feral dogs, crabs and sea gulls	Investigation is required to evaluate feeding and nesting habitats
5.	<i>Chelonia mydas</i>	Green turtle	Coastal and off shore waters of Sindh and Balochistan	Sandspit, Hawkesbay, Kapaysee, Cape Monze (Sindh), Taq (Ormara), Astola Island, Pasni, Gawadar, Daran (Balochistan)	Oil spillage, compaction of sand, predators like; dogs, crabs, crows, sea gulls, kites destroy eggs and hatchlings, gill netting, habitat degradation, garbage, picnickers, alteration of nesting ground by constructional activities.	Hatcheries must be increased to protect eggs and hatchlings of turtles.

Brief description of different marine turtle species found in coastal and off shore waters of Pakistan are as follows:

1. Hawksbill Turtle (*Eretmochelys imbricata*)

This species has been observed in Sindh and Balochistan coast during October and March but no specific area of concentration is identified. Nesting was observed in 2004 and 2007 in Karachi coast (Cape Monze and Mubarak village) from July–December 2006 in Balochistan (Astola Island) (Moazzam and Nawaz, 2019) (Fig. 4).

2. Olive ridley Turtle (*Lepidochelys olivacea*)

During 1980 to 1997 nesting has been reported in Sandspit and Hawkesbay (Karachi coast) from June–September with highest rate in August, small scale from Taq (Ormara) and Astola Island (Balochistan).

There was a drastic decline in nesting after 1987. Only two nests were reported in each year of 1996 and 1997 with no nesting from 1998–2000 (Firdous, 1999, 2015). Tagging experiment was conducted by Sindh Wildlife Department, Government of Sindh to study migration and

spatial data. In 1982 and 2013, a total of 46 turtles were tagged. Among these, 7 were recovered after 1 year, 4 after 2 years and 1 after 5 years (Firdous, 2015). Out of 9 specimens tagged with satellite transmitters in Oman, only 1 travelled to Pakistan (Rees *et al.*, 2012).

Although large number found in off shore water but no specific reason is identified for disappearance of nesting, no commercial exploitation, poaching or harvesting of eggs, local community disturbance were reported. Climate is also not effectively and suddenly changing to influence nesting behaviour (Fig. 5).

3. Leatherback Turtle (*Dermochelys coriacea*)

From 2004-2007 nesting has been reported from Mubarak village Karachi (June and July), Pushukan (February) and Jiwani (January and February), but methods used to identify nests were not described and no hatchling was observed (Khan *et al.*, 2010b) however live specimens were reported in Great Khori Bank Indus Canyon, Sindh and Balochistan (Gawadar, Jiwani, Surbundar, Malan and Sonmiani) (Firdous, 1989; Moazzam and Nawaz, 2017, 2019). Detailed surveys between Bundal Island and Sir Creek for last 3 decades showed no nesting.

A dead specimen found in Miani Hor lagoon near Sonmiani (Balochistan) on November 17, 2016. A live specimen entangled in fishing net safely released into the water on January 4, 2017 (Fig. 6).

4. Loggerhead Turtle (*Caretta caretta*)

This species has been observed round the year in coastal waters of Balochistan, particularly near Masirah Island, Oman except June-August when there is a closure for Tuna fishing (Moazzam and Nawaz, 2016, 2019). Study is required for foraging habitat and migratory route. Meanwhile no record of nesting found on the entire coastline of Pakistan (Fig. 7).

From December 2015 to April 2018, 11 specimens entangled (Moazzam and Nawaz, 2019) while two specimens were entangled in 2019. A specimen caught by a fisherman from off shore water on December 15, 2015 which was released into the water.

5. Green Turtle (*Chelonia mydas*)

Large number is found in coastal and off shore waters of Pakistan. Nesting spreads between Manora (Sindh) to Jiwani (Balochistan) throughout the year, with a peak in September (Firdous, 2015). In Sindh coastline Sandspit, Hawkesbay, Kapaysee, Cape Monze while in Balochistan Taq (Ormara), Astola Island, Pasni (Ras Zarrien), Gawadar, Daran (Jiwani) are the important nesting sites (Anwar, 2005, 2013; Firdous, 1986, 1998; Butler, 1877).

A total of 17,008 nesting pits were observed in Sandspit and Hawkesbay since 1980-1997 and 1,208 nests from November 2011 to June 2012 (Firdous, 1999, 2015). WWF Pakistan under Wetlands Program, observed daily movement of Green turtle by tagging (Firdous *et al.*, 2010). Two turtles were tagged in Astola Island and Daran (Jiwani) which covered a distance as far as UAE and recovered at Um -al- Quain, tracked a route westwards to Iran, Qatar and UAE. Two more tagged turtles moved eastward and ended on west coast of India (Fig. 8).

Sindh Wildlife Department has successfully placed flipper tagging which revealed the movement of turtle to Bhaidar Island, Gulf of Kutch, India in September, 1989, Beralsole village South Central Eritrea in December 1995, and Lengeh and Dayyar (Persian Gulf, Iran) in August 1995 (Firdous, 2015).

Steps for Conservation of Marine Turtles in Pakistan

The Balochistan government declared Astola Island (Fig. 9) as Marine Protected Area (MPA) on June 15, 2017 for protection of *Chelonia mydas* (Kanwal *et al.*, 2018).

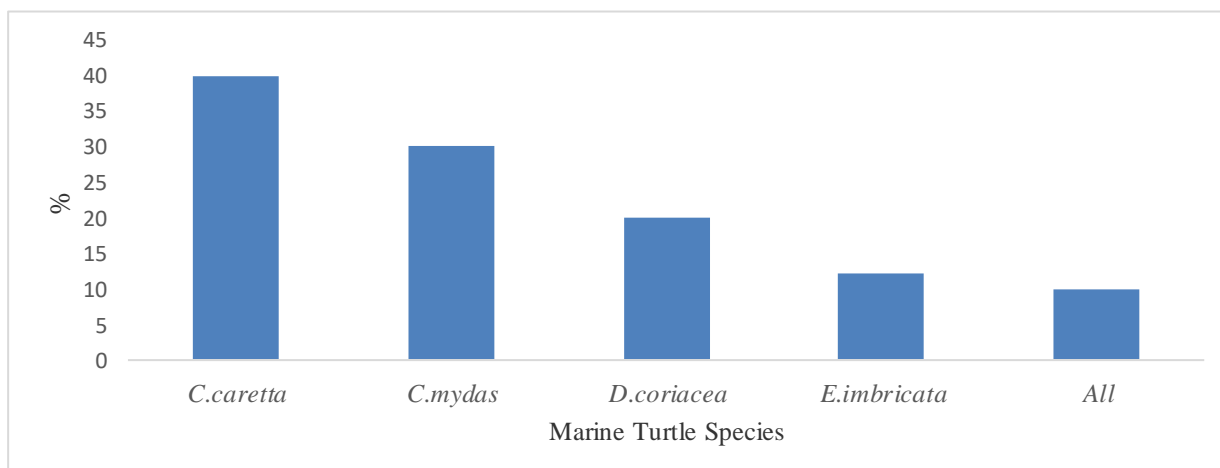


Fig. 3. Percentage of Marine turtle Species Distributed Globally (1988-2020).



Fig. 4. Hawksbill turtle caught by fishermen on December 12, 2018 Sapat, Balochistan.



Fig. 5. Olive ridley turtle caught by fishermen on Jan 03, 2020 off Ghora Bari, Sindh.



Fig. 6. Leatherback turtle caught by fishermen on April 07, 2019 in Ras Mauri, Balochistan.



Fig. 7. Loggerhead turtle caught by fishermen on November 2019 in Jiwani, Balochistan.



Fig. 8. Green turtle caught by fishermen on November 12, 2019 off Gawadar Balochistan.



Fig. 9. A view of first Marine Protected Area Astola Island (source: Kanwal *et al.*, 2018).

Marine turtles are protected in Pakistan under international treaties. Following measures have been taken for the conservation of marine turtle species:

- Being a signatory of Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) Pakistan is liable in protecting marine turtles species (Table 4).
- Sindh Wildlife Protection Ordinance 1972 included protection of marine turtle species.
- Sindh Fisheries Ordinance 1970, Schedule I, Rule 2016, included all marine turtle species and prohibited their fishing (catching, marketing and trade) (Government of Sindh, Livestock and Fisheries Department. Notification No. 5 (3) SO (FISH)/L&F 16 dated May 18, 2016) (Government of Sindh, 2016).
- Balochistan Protection, Preservation, Conservation and Management Act 2014, Schedule III (Protected Animals) included all marine turtle species.
- Catching, retention, marketing and trade of all marine turtles are prohibited under Balochistan Sea Fisheries Ordinance 1971, Rule, 2016 (Government of Balochistan, Coastal Development and Fisheries Department. Notification No. SO (COORD) FISH/2-1/2013/3148-54 dated September 8, 2016. (Government of Balochistan, 2016).
- Pakistan Fish Inspection and Quality Control Act 1997, Rules (1998) Clause 5 (3) explicitly prohibited export of all aquatic turtles.
- WWF-Pakistan developed the use of sub-surface operation of gillnets in order to minimize entanglement of Endangered, Threatened and Protected (ETP) species which substantially reduced entanglement and mortality of marine turtles.
- Turtle Excluder Device (TED) is a low cost solution of marine turtle entanglement. Pakistan is registered in (TED) user with USA Department of States however implementation found scarce.
- Hatcheries have been set up in nesting grounds (Karachi coast) by Sindh Wildlife Department, Government of Sindh for the protection of eggs and hatchlings of marine turtles from predators (Figs. 10 - 13).
- A laboratory is also set up at Hawkesbay Karachi by Sindh Wildlife Department for basic research work on different aspects of marine turtle species.
- Different awareness programs, training workshops and field visits have been conducted by IUCN, WWF-Pakistan, and Scientific and Cultural Society of Pakistan.
- Department of Zoology (Wildlife and Fisheries Section), University of Karachi successfully conducted research for M.Phil. and Ph.D. thesis on marine turtle.
- Coastal dwellers are also playing significant role for the conservation of marine turtle species.

RECOMMENDATIONS

- Research is needed to find out main causes of declining population and non-nesting behaviour of Hawksbill and Olive ridley turtles in Pakistan.
- Sindh Wildlife Department, Government of Sindh and Ministry of Climate Change, Government of Pakistan could play more significant role for the protection and conservation of marine turtles by involving local communities in large scale with attractive remuneration.
- Transportation of petroleum products through creek system should be strictly monitored and stopped as marine turtles avoid nesting in oil spilled beaches.
- Small and simple huts should be built to minimize disturbance and alteration of nesting habitat.
- Regular training workshops/ programs on protection and conservation of marine turtle should be organized even in COVID-19 period as well through virtual connectivity.
- Trash bins should be kept in excess for picnickers to throw litter.
- Sign boards should be used with clear instructions, symbols and directions such as use litterbins for trash and avoid lightening at night.
- Training programs for local fishermen must be regularly arranged for save fishing activities.
- Research studies on marine turtle should be regularly shared with academia as well as policy makers to take required steps or actions for the conservation of marine turtles.
- Print, electronic and social media should play more effective role for the conservation of marine turtles.

Table 4. International Conventions signed by Pakistan for the Protection and Conservation of Marine Turtles.

S. No.	International Conventions	Year	Marine Turtle Species	Measures for Conservation
1.	Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES)	1976	Hawksbill, Olive ridley, Leatherback, Loggerhead and Green turtles	Trade of all marine turtle species, shell, carapace and any part of the body is prohibited
2.	Convention on Migratory Species (CMS)	1987	Hawksbill, Olive ridley, Leatherback, Loggerhead and Green turtles	Marine turtle species found in Indo-Pacific areas are protected and conserved on priority basis
3.	Memorandum of Understanding on Conservation and Management of Marine Turtles and Their Habitats in Indian Ocean South-East Asia (MoU) (IOSEA).		Hawksbill, Olive ridley, Leatherback, Loggerhead and Green turtles.	Trans boundary actions taken for the conservation of marine turtle species found in IOSEA.



Fig. 10. Hatchery for Marine Turtles at Hawkesbay (Karachi coast).



Fig. 11. Fishing Activities at Karachi coast.



Fig. 12. Hatchlings of Green turtle at Karachi coast.



Fig. 13. Another view of Green turtle hatchlings at Karachi coast.

REFERENCES

- Albouy, C., Delattre, V., Donati, G., Frölicher, TL., *et al.* 2020. Global vulnerability of marine mammals to global warming. *Sci. Rep.* 10:548.
- Anwar, F. 2005. Habitat Management Plan for the Proposed Turtle Beach Protected Area: A Framework for Action. Unpublished Report. pp 59.
- Anwar, F. 2013. Assessing the Habitat Suitability for Species Habitation Case Study: Sandspit/ Hawkesbay Coastal Ecosystem as a Turtle Habitat. Unpublished Report. pp17.
- Asrar, F. 1999. Decline of Marine Turtle Nesting Population in Pakistan. *Marine Turtle Newsletter.* 83:13-14.
- Boltan, AB. 2003. Variation in Sea Turtle Life History Patterns: Neritic Vs. Oceanic Developmental Stages. In: *The Biology of Sea Turtles.* Eds. Lutz, PL., Musick, JA. and Wyneken, J. (vol. 2). CRC Press, Boca Raton, FL, USA. 163-197.
- Brinn, LA. 2008. Assessment of Differences in Physical Properties of Sand Associated with Beach Nourishment and Effects on Loggerhead Sea Turtle (*Caretta caretta*) Nesting in Northwest Florida. M.Sc. Thesis. University of Florida, USA.
- Butler, EA., 1877. Astola, a summer cruise in the Gulf of Oman. *Stray Feathers (Calcutta)* 5: 293-304.
- Camacho, MP., Calabuig, O., Luzardo, LD., Boada, M., Zumbado. and Orós, J. 2013. Crude Oil as a Stranding Cause Among Loggerhead Sea Turtles (*Caretta caretta*) in the Canary Islands, Spain (1998-2011). *Journal of Wildlife Diseases* 49:637-640.
- Chefaoui, RM., Duarte, CM. and Serrão, EA. 2018. Dramatic loss of sea grass habitat under projected climate change in the Mediterranean Sea. *Glob. Change Biol.* 24: 4919-4928.
- Crain, DA., Bolten, AB. and Bjorndal, KA. 1995. Effects of Beach Nourishment on Sea Turtles: Review and Research Initiatives. *Restoration Ecology.* 3:95-104.
- Crespo, GO., Dunn, DC., Gianni, M., Gjerde, K., Wright, G. and Halpin, PN. 2019. High-seas fish biodiversity is slipping through the governance net. *Nat Ecol Evol.* 3: 1273-127.
- Erauskin-Extramiana, Arrizabalaga, H., Hobday, AJ., Cabré, A., *et al.* 2019. Large-scale distribution of Tuna species in a warming ocean. *Glob. Change Biol.* 25: 2043–2060.
- Feeley, KJ., Stroud, JT. and Perez, TM. 2017. Most ‘global’ reviews of species’ responses to climate change are not truly global. *Divers Distrib.* 23:231-23.
- Firdous, F. 1986. Marine turtles. Proceedings of International Conference on Marine Sciences of the Arabian Sea Institute of Marine Sciences. University of Karachi, Karachi.
- Firdous, F. 1988. Conservation of turtles at Sandspit and Hawkesbay, Karachi. In: Proceedings of International Conference on Marine Sciences of the Arabian Sea. Eds. Thompson, MF. and Tirmizi, NM. American Institute of Biological Sciences. Washington, DC, USA. 217-222.
- Firdous, F. 1989. Male Leatherback Turtle Strands in Karachi. *Marine Turtle Newsletter.* 47:14-15.
- Firdous, F. 1998. Marine Turtle Conservation in Pakistan, Proceedings of the Northern Indian Ocean Sea. Turtle Workshop and Strategic Planning Session Bhubaneswar, Orissa, India. 13-18 January 1997.
- Firdous, F. 2000. Sea Turtle Conservation and Education Program in Karachi, Pakistan. In: *Sea Turtles of Indo Pacific: Research, Management and Conservation.* Eds. Pilcher, N. and Ismial, G. ASEAN Academic Press, London. 45-59.
- Firdous, F. 2001. Sea Turtle Conservation and Education in Karachi, Pakistan. ASEAN Review of Biodiversity and Environmental Conservation (ARBEC). 1-10.
- Firdous, F. 2005. Turtles Conservation and Education in Karachi, Pakistan. pp1-8 (Unpublished report).
- Firdous, F. 2009. Conservation of Marine Turtles at Sandspit and Hawkesbay, Karachi. Proc. Sem. Trans-Boundary Coastal and Marine Protected Areas with Special Priorities for Spawning Grounds, Karachi. Zoological Survey Department and Ministry of Environment, Govt. of Pakistan. 61-66.
- Firdous, F., Barkati, S. and Rehman, S. 2010. Studies on nesting and Tagging of two species of turtles of Karachi coast. *Pak. Jour. of Oceanography.* 6(1):1-14.
- Firdous, F. 2015. Marine Turtle Conservation in Pakistan with Special Reference to Measures Taken by Sindh Wildlife Department. In: Anonymous Proceedings of the Regional Symposium on Sea Turtle Conservation in Asia 24-25 March, 2015 Karachi, Pakistan. IUCN, Karachi, Pakistan. 94-104.

- Fuentes, MMPB. and Saba, V. 2016. Impacts and Effects of Ocean Warming on Marine Turtles. In: Explaining Ocean Warming: Causes, Scale, Effects and Consequences. Eds. Laffoley, D. and Baxter, JM. IUCN, Gland. 289-302.
- Ghalib, SA. and Zaidi, SSH. 1976. Observations on the Survey and Breeding of Marine Turtle on Karachi Coast. *Agricultural Pakistan*. 27(1):87-96.
- Government of Balochistan. 2016. Coastal Development and Fisheries Department. Notification No. SO (COORD) FISH/2-1/2013/3148-54 dated 8 September 2016.
- Government of Sindh. 2016. Livestock and Fisheries Department. Notification No.5 (3) SO (FISH)/L&F 16 dated 18 May 2016.
- Groombridge, B. 1982. The IUCN Amphibia-Reptilia Red Data Book, Part I, Testudines, Crocodylia, Rhynchocephalia. IUCN, Gland, Switzerland.
- Groombridge, B. 1987^a. A Preliminary Marine Turtle Survey on the Makran Coast, Balochistan, Pakistan with notes on Birds and Mammals. IUCN Conservation Monitoring Centre, Cambridge. pp 25 (Unpublished Report).
- Groombridge, B. 1987^b. Makran Coast: A Newly Explored Habitat for Marine Turtle. WWF-Pakistan Newsletter 6(2):1-5.
- Groombridge, B. 1988. Marine Turtles in Balochistan. Report on an Aerial Survey (with notes on wetland sites and a proposed marine turtle conservation project). IUCN Conservation Monitoring Centre, Cambridge. pp 25. (Unpublished Report).
- Groombridge, B., Firdous, AM. and Rao, AL. 1988. Marine Turtles in Balochistan. (Pakistan). *Marine Turtle Newsletter*. 42:1-3.
- Groombridge, B. 1989. Marine Turtles in Balochistan. Report on an aerial survey, 9-11 September 1988. Cambridge: World Conservation Monitoring Centre.
- Hughes, TP., Kerry, JT. and Simpson, T. 2018. Large-scale bleaching of corals on the Great Barrier Reef. *Ecology*. 99: 501.
- Hamann, M., Fuentes, MMPB., Ban, NC. and Mocellin, VJL. 2013. Climate Change and Marine Turtles. In: *The Biology of Sea Turtles*. Eds. Wyneken, J., Lohmann, KJ. and Musick, JA. Book 3. CRC Press, Boca Raton, FL, USA. 353-378.
- Hawkes, LA., Broderick, AC., Godfrey, MH. and Godley, BJ. 2009. Climate Change and Marine Turtles. *Endang. Species Res.* 7:137-154.
- Iffat, F. 2009. Marine Turtles. Zoological Survey Department, Govt. of Pakistan, Islamabad. pp.33.
- Kabraji, AM. and Firdous, F. 1984. Conservation of Turtles, Hawkesbay and Sandspit, Pakistan. World Wildlife Fund Project 1451. WWF International and Sindh Wildlife Management Board Karachi. pp 52.
- Kanwal, R., Ubaid Ullah., Hussain, B., Yasmeen, G., Zehra, A., Siddqui, S., Manzoor, U., Raza, N., Imdad, U., Hussain, SE., Khan, AR. and Ghalib, SA. 2018. First Marine Protected Area of Pakistan: Astola Island. *CJPAS*. 12(1):4423-4432.
- Khan, MS. 1999. Herpetology of Habitat Types of Pakistan. *Pakistan J. Zool.* 31:275-289.
- Khan, MZ., Hussain, B. and Ghalib, SA. 2005. Current Status of the Reptilian Fauna along Karachi Coast with special reference to Marine Turtles. *Journal of Natural History and Wildlife*. 4(2):127-130.
- Khan, MZ. and Ghalib, SA. 2006^a. Marine Ramsar Sites in Pakistan with special reference to Biodiversity of Astola Island and Jiwani Coastal Wetland. *Journal of Natural History and Wildlife*. 5(1):165-168.
- Khan, MZ. and Ghalib, SA. 2006^b. Status, Distribution and Conservation of Marine Turtles in Pakistan. *Journal of Natural History and Wildlife*. 5(2):195-201.
- Khan, MZ., Hussain, B., Ghalib, SA., Zehra, A. and Mehmood, N. 2010^a. Distribution, Population Status and Environmental Impacts on Reptiles in Manora, Sandspit and Cape Monze areas of Karachi Coast. *CJPAS*. 4(1):1053-1071.
- Khan, MZ., Ghalib, SA. and Hussain, B. 2010^b. Status and New Nesting Sites of Sea Turtles in Pakistan. *Chelonian Conservation and Biology*. 9:119-123.
- Lenton, TM., Rockström, J., Gaffney, O., Rahmstorf, S., Richardson, K., Steffen, W. and Schellnhuber, HJ. 2019. Climate Tipping points too Risky to Bet Against. *Nature*. 575:592-595.
- Manzoor, U., Khan, MZ. and Iqbal, MA. 2019. Distribution, Status and Conservation of Reptilian Fauna in the Coastal areas of Karachi with Special Reference to Marine Turtles. *J. Anim. Plant Sci.* 29:1748-1760.

- Mangrove for Future Pakistan (MFFP). 2016. A Handbook on Pakistan's Coastal and Marine Resources.
- Martins, GM., Harley, CDG., Faria, J., Vale, M., Hawkins, SJ., Neto, AI. and Arenas, F. 2019. Direct and indirect effects of climate change squeeze the local distribution of a habitat-forming seaweed. *Mar. Ecol. Prog. Ser.* 626:43-52.
- Moazzam, M. and Nawaz, R. 2014. By-catch of Tuna Gillnet Fisheries of Pakistan: A serious threat to non-target, endangered and threatened species. *J. Mar. Biol. Ass. India.* 56:85-90.
- Moazzam, M. and Nawaz, R. 2015. Turtle Mortality in Fishing Operations in Pakistan. In: Proceedings of the Regional Symposium on Sea Turtle Conservation in Asia 24-25 March 2015, Karachi, Pakistan. IUCN, Karachi. 52-65.
- Moazzam, M., Khan, MW. and Nawaz, R. 2016. Bycatch of Commercially Important Species of the Tuna Gillnet Fisheries of Pakistan. IOTC-2016-WPEB12-40. 1-16. (IOTC-2016-WPEB12-40_Pakistan.pdf).
- Moazzam, M. and Nawaz, R. 2017. Occurrence and Distribution of Leatherback turtle (*Dermochelys coriacea*) in the Coastal and off shore waters of Pakistan. *Rec. Zool. Surv. Pakistan.* 23:4-8.
- Moazzam, M. and Nawaz, R. 2019. Distribution and abundance of Hawksbill turtle (*Eretmochelys imbricata Ruppell*, 1835) from Pakistan. *International Biology and Biotechnology.* 16:983-990.
- Newson, SE., Mendes, S., Crick, HQP., Dulvy, NK., *et al.* 2009. Indicators of The Impact of Climate Change on Migratory Species. *Endang. Species Res.* 7:101-113.
- Patrício, AR., Hawkes, LA., Monsinjons, JR. Godley, BJ. and Fuentes, MMPB. 2020. Climate Change and Marine Turtles: Recent advances and future directions (Review). *Endang. Species Res.* 44:363-395.
- Pecl, GT., Araújo, MB., Bell, JD., Blanchard, J., *et al.* 2017. Biodiversity Redistribution under Climate Change: Impacts on Ecosystems and Human Well-Being. *Science.* 355:9214.
- Poloczanska, ES., Limpus, CJ. and Hays, GC. 2009. Vulnerability of Marine Turtles to Climate Change. *Adv. Mar. Biol.* 56:151-211.
- Poloczanska, ES., Burrows, MT., Brown, CJ., García Molinos, J., *et al.* 2016. Responses of marine organisms to climate change across oceans. *Front. Mar. Sci.* 3:62.
- Rees, AF., Al-Kiyumi, A., Broderick, AC., Papathanasopoulou, N. and Godley, BJ. 2012. *Lepidochelys olivacea* Nesting in Oman. *Mar. Ecol. Progr. Ser.* 450:195-205.
- Sehrish, K., Saima, S., Iqbal, MA. , Yasmeen, G., Ubaid Ullah, Zehra, A., Tahira, AL., Shaista, A. and Naseem Samreen, N. 2021. Review of Climate Change and its Effects on Biodiversity. *Canadian Journal of Pure and Applied Sciences.* 15(3):5345-5352.
- Shahid, A. 2020. As Iranian Petrol Smuggling Threatens to Cause another Shortage, PSO turns its head. <https://profit.pakistantoday.com.pk/2020/10/17/as-iranian-petrolsmuggling-threatens-to-cause-another-shortage-psy-turns-itshead/>. Accessed on June 10, 2021.
- UNESCAP. 1996. Coastal Environmental Management Plan for Pakistan.
- Van Dijk, PP. and Palasuwan, T. 2000. Conservation, status, trade and management of tortoises and freshwater turtles in Thailand. *Chelonia Research Monograph.* 2.
- Wallace, BP., Stacy, BA., Cuevas, E., Holyoake, C., Lara, PH., Marcondes, ACJ., Miller, JD., *et al.* 2020. Oil Spills and Sea Turtles: Documented Effects and Considerations for Response and Assessment Efforts. *Endangered Species Research.* 41:17-37.
- Walther, GR. 2010. Community and Ecosystem Responses to Recent Climate Change. *Philos. Trans. R. Soc. B.* 365:2019-2024.
- Worm, B. and Lotze, HK. 2016. Marine biodiversity and climate change. In: *Climate and global change: Observed impacts on planet Earth.* Ed. Letcher, T. (2nd edi.). Elsevier, Amsterdam. 195-121.
- WWFPak. 2021. Three of the Seven Exiting of Marine turtle are Critically Endangered. https://www.wwfpak.org/our_work_/wildlife_2/marine_turtles/#:~:text=All%207%20species%20of%20marine,3%20are%20classified%20as%20endangered. Accessed on June 10, 2021.
- WWF. 2018. Wildlife in a Warming World: The Effects of Climate Change on Biodiversity. www.worldwildlife.org/publications. Accessed on June 10, 2021.

Received: Nov 16, 2021; Revised: Dec 22, 2021;

Accepted: Jan 3, 2022

Copyright©2022, Uzma *et al.* This is an open access article distributed under the Creative Commons Attribution Non Commercial License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

