

## Early users of monsoon winds for navigation

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*The maritime history of India can be traced back to the Harappan Civilization. Studies suggest that even at that time, monsoon winds and currents assisted in navigation. Recent archaeological exploration and excavations along the Indian margin, Persian Gulf, Red Sea, and coasts of Southeast Asia provide convincing evidence about a maritime network and connections between mariners of India and other parts of the world in ancient times. The author of Periplus of the Erythraean Sea (PES) (60–100 CE) has credited Hippalus (~45 CE), the Greek mariner, with the discovery of monsoon winds and the mid-ocean route to the Indian ports from the Mediterranean. However, archaeological findings of Harappan Civilization, as well as the Vedic and Sangam period texts, suggest that the mariners of India who were trading in the Indian Ocean and adjoining seas had knowledge about monsoon winds much before Hippalus. In this paper, an attempt has been made to demonstrate the fact that knowledge of the monsoon winds was familiar to Indian mariners during the Harappan Civilization as well as in the later period.*

The ‘monsoon’ refers to the seasonal wind; in other words, a seasonal reversal in the direction of the wind is characteristic of the Indian monsoon<sup>1,2</sup>. The word ‘monsoon’ originates from the Arabic word ‘*mausim*’ or ‘*mausam*’ meaning seasonal winds<sup>3–5</sup>. Monsoon winds blow from the southwest during June to September (summer monsoons) and from the northeast from October–November to February–March (winter monsoon and trade winds) (the months of the season are based on the current calendar; it would have been 55 days later in 2000 BC due to axial precession). Heavy rain accompanies the former in the entire Indian subcontinent and Southeast Asia. The latter is dry and cold and flows out of the interior of Asia from the northeast. Until the early historical period, Indian literature mentioned the use of monsoon wind and currents in maritime trade<sup>6</sup>. However, Schoff<sup>7</sup> and Hariharan<sup>8</sup> referred to the Greek mariner, Hippalus (~45 CE) who discovered the monsoon wind system in the early centuries of the Christian era. Subsequently, sailors of Rome, Greece, Arabia and Portugal used monsoon wind and currents for their voyages to India in different periods<sup>9–11</sup>. Therefore, it is necessary to trace the origin of navigation in India with the aid of archaeological findings and literary sources that deal with monsoon wind and currents, which forms the objective of this paper.

### Reference to wind and currents in Indian literature

The text, *Satapatha Brahmana* (9th–8th century BCE) furnishes the first recorded

information on the circulation of oceanic water; ‘The ocean flows round this world on all sides’, to which Eggeling’s commentary adds, ‘accordingly turning to the right (south) whence the ocean flows round this world (from the east) southwards’. The review of the passage indicates that it refers to the southwest monsoon which lasts from May to September<sup>12</sup>. The *Baudhayana Dharmasutra* explicitly mentions maritime navigation<sup>13</sup>. The *Buddhist Jataka* stories and the *Jain Canonical* mention ships moving by force of wind ‘*Pavanabalasamahaya*’<sup>14</sup>. The Sangam period (3rd century BCE to 3rd century CE) texts, namely *Akananuru*, *Purananuru*, *Mathuraikanchi* or *Madurraikanchi* mention that Tamil mariners sailed with the help of wind and sails<sup>15</sup>. The Sangam texts also refer to four types of wind blowing from different directions, viz. *kontal* (east wind), *kotal* (west wind), *vatai* (north wind) and *tenral* (south wind) and the movement of various sizes of vessels with the help of wind in the mid sea and landing at the shore<sup>4</sup>. The extensive maritime activity during the Mauryan Empire as outlined in the *Arthashastra* is a clear indication of the depth of knowledge of winds and currents of that period. Further, the *Arthashastra* mentions the administration of ports, navy and provides a set of rules and regulations for navigation<sup>16</sup>. Besides the above references, in the *Meghdoot* Kalidas (4th century CE) has elaborately accounted the arrival of monsoons in India<sup>17</sup>. Aryasura in the *Jatakamala* (4th century CE) mentions waves and currents with currents being termed as *salila*. Three physical

phenomena of the ocean, namely tides, currents and waves were known to the seafarers of India<sup>18,19</sup>.

As evident from the above, ancient Indian literature describes the phenomena of winds and oceanic circulations vividly. Even the ship motif punch marked coins (PMC) (6th–5th centuries BCE) have masts with criss-cross riggings which suggest that sails were used during those days. Thus, the ship motif coins with mast(s) of the Satavahanas (2nd century BCE to 3rd century AD), Salankayanas (300–440 CE) and Pallavas (6th to 9th century CE) are unambiguous evidences of the knowledge of open sea navigation and understanding of wind patterns<sup>20,21</sup>.

In addition to Indian literature, the author of *Periplus Maris Erythraei* (60–100 CE) mentioned ports, anchorages, along with the *Erythraean Sea* which includes the Red Sea, Persian Gulf, Arabian Sea, Bay of Bengal and above all, also refers to the Southwest (summer) monsoon<sup>7</sup>. Similarly, in the *Natural History*, Pliny (77 CE) has also mentioned the southwest monsoon<sup>10</sup>. However, neither *Periplus* nor Pliny has referred to the currents of the Indian Ocean. In the ‘Record of Buddhist Kingdoms’, Fa-Hien, the Chinese traveller (414 CE) referred to his voyage from Tamralipti to Ceylon and mentioned the favourable Northeast (winter) monsoon wind and currents along the east coast of India which enabled him to reach Ceylon in just fourteen days<sup>22</sup>.

### Hippalus and monsoon winds

*Periplus* acclaimed Hippalus (Greek mariner) as the ‘discoverer’ of the

monsoon winds and direct monsoon route to India<sup>7,8</sup>. Thus the credit of discovery of monsoon winds was bestowed upon Hippalus. Wheeler<sup>23</sup> has applauded Hippalus and states, 'Hippalus is one of the great names in the history of navigation'. Further, Casson<sup>24</sup> and Warming-ton<sup>10</sup> have suggested that during the reign of Claudius (41–56 CE), Hippalus discovered the mid-ocean route to the Indian ports and sailed with the aid of monsoon winds. This route was considered to be the shortest between the Mediterranean or Arabian ports and the Indian coast. But Posidonius recorded that during Ptolemy Lathyros, Eudoxos of Cyzicos (Eudoxos of Cyzicus) (116 CE) made two overseas trips to India by the end of the second century BCE<sup>10</sup>, which indicates that monsoon winds were known to Eudoxos of Cyzicos earlier than Hippalus. Ptolemy VII was keen on developing the Red Sea maritime trade. As a result, direct sailing between India and Egypt was started by Eudoxus of Cyzicus in 120–110 BCE (ref. 25). Eudoxus of Cyzicus followed the directions of an Indian and sailed to India following the monsoon winds<sup>26</sup> and that Indian is believed to be a surviving sailor of a shipwreck<sup>4</sup>. Monsoon was known to all mariners who sailed along the Arabian and African coast from the time much before Hippalus<sup>27</sup>. The Indian and Arab sailors exploited monsoon winds to sail between their countries much before the westerners<sup>24</sup>. McCrindle<sup>28</sup> had described that incidental knowledge suggests that there were regular voyages from the ports of the east coast of Africa to India with the help of monsoon winds, long before Hippalus discovered the winds and introduced the knowledge to the Roman world. *Periplus* and Pliny differ in their accounts about the voyages to India using monsoon winds. *Periplus* mentioned that, before heading out towards the open sea, ships stop either at Qana or Aromata, whereas Pliny states that crossing of the Indian Ocean developed through various stages and it was possible at last to sail directly from Ocellis to the west coast of India without any stopover<sup>29</sup>.

Even the historiography of the navigator has questioned the very existence of Hippalus<sup>30</sup> and scholars believed that Hippalus was the name given to the wind<sup>31</sup>. Villiers<sup>32</sup> mentioned that Hippalus gave his name to monsoon winds and it continued afterwards. Strabo did

not refer to any information about Hippalus in his writings, whereas Pliny stated that nothing of any individual (navigator) named Hippalus is known; he knew Hippalus, the name of the wind, obviously the southwest monsoon<sup>10,33,34</sup>.

Mazzarino<sup>26</sup> remarked that Pliny was ignorant of the tradition adopted by *Periplus*, who initially suggested that Hippalus had discovered the monsoon. This tradition originated among Egyptian sailors. Many scholars have questioned on this content, and the argument must be rejected. The discovery of monsoon winds was made in successive stages; it was basically because merchants preferred new markets, that the new requirements of trade and commerce determined changes in navigational techniques<sup>35</sup>. During monsoon, inclement weather does not continue all through the whole season. Hence the ships sailing from the Red Sea coast set sail before the Southwest monsoon and return during the Northeast monsoon. The use of winds for navigation made it easy for seamen and traders from Egypt to stay a short while on the Indian coast before returning to their Red Sea ports thus increasing contacts with local Indians.

### **Rig Veda and monsoon winds**

Though there are diverse opinions on the *Rig Veda* (*Rg Veda*) (1700 and 1100 BCE) and its period, it is believed that *Rig Veda* is the oldest literary work of the Indian subcontinent. There are several hymns that have referred to the wind, waves, tides, water, thunder and rain, rivers, sea, etc.<sup>4,36,37</sup>. Similarly, many verses praise *Parjanya* (the thunder and rain), which shows that the *Rig Vedic* people were aware of the rainy season which comes in a certain period every year<sup>3</sup>. Monsoon winds are termed as *maruts* in the *Rig Veda*, whereas in the later Vedic texts, monsoon was referred to as *salila vada* (*sahla vada*) (the wind from the ocean, especially SW monsoon)<sup>38</sup> and the Buddhist texts mentioned *kalamegha* (dark clouds) and *varshavalshaga* (heavy rains)<sup>5,39</sup>. Despite the available information on monsoon, rain, and wind in the *Rig Veda*, the following questions were often asked: was the sea known to the *Rig Vedic* people? Were the *Rig Vedic* people familiar with seafaring? Numerous statements can be found in the *Rig Veda* concerning *Samudra* for sea, *Nau*,

*Nava*, *Ratha* being the general terms for boat or ship and *Navya* for navigation or sailor<sup>38</sup>. Among all these types of water crafts, *nau* was the sea vessel in which oars, sails, masts and anchors were carried. During favourable wind, sails were used so that *nau* could float and move with speed<sup>40,41</sup>.

### **Evidence of use of monsoon winds during the Harappan Civilization**

The discovery of vestiges of the Harappan Civilization from the northwest region of the Indian subcontinent obviously indicates the existence of highly advanced urban civilization. The Mesopotamian cuneiform texts suggest maritime contacts and exchange of goods between the Harappan and Mesopotamian civilizations (Figure 1). Moreover, the excavations at Harappa (Figure 2), Mohenjo-Daro (Figure 3) and Lothal (Figure 4) have yielded evidence of boats on seals, incised on pottery and terracotta models that shed more light on the maritime contacts of the Harappan Civilization<sup>42–48</sup>. Regarding the maritime knowledge of the people of the Harappan Civilization, it is suggested that the efficiency of boats not only depended on their size and design, but also on the knowledge of mariners of the sea, weather conditions and awareness of landmarks. Harbour facilities were equally important. There was every possibility that a marine connection existed from the mouth of the River Indus to shores of Gulf of Khambhat and Kutch region where smaller vessels were plied to cater to the requirements of Bagasra, Kuntasi, Kanmer, Juni Kuran including Dholavira. Moreover the route was shorter<sup>49</sup>. In an inscription, Sargon of Agade (2300 BCE) stated that he built ships from Meluhha, Magan, and Dilmun and tied those ships at the quay of Agade. Similarly, Gudea of Lagash asserted that ships along with timber came to Lagash from Meluhha, Magan, and Dilmun as a tribute. The above information shows that sailors involved in long distance trade crossed the Persian Gulf and must have observed the changes in the seasonal winds<sup>50,51</sup>. Moreover, some merchant records suggest that seasonality in maritime trade may have been because of monsoon winds<sup>52</sup>.

The southwest (summer) monsoon first reaches the Konkan coast, then Porbandar and after a month it hits Kachchh,

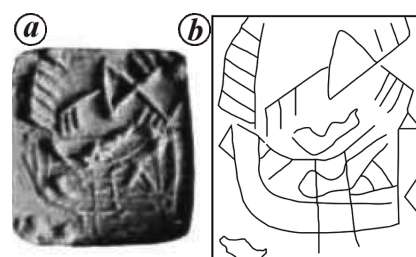
## HISTORICAL NOTES

Sind and Makran coasts. The seafarers of the Harappan Civilization might have faced violent and stormy monsoons in the Arabian Sea and other winds in the Gulf. But it is clear that the inclement weather of the monsoon did not prevail throughout the whole monsoon period<sup>53</sup>. During the southwest monsoon, except off the Makran coast for an eastward journey, there was no sailing in other regions. Probably sailors sailed either before or after the southwest monsoon. Sailing in the Gulf throughout the year<sup>54</sup> was possible. The withdrawal of summer monsoon starts from September after reaching Sind. Therefore the impact of summer monsoon is very minimal along the coast of Pakistan, and no cyclonic activities take place along the Makran coast and weather conditions remain sunny. The monsoon does not reach Gwadar and sailing can continue between Muscat, Oman, Gwadar and India except in May and July. This implies that Indian ships were able to sail in the Arabian Sea before the beginning of the winds. This indicates that shipping in the Harappan waters was restricted to the Makran coast for three months until the end of winter monsoon and the return voyage was made with the westerly monsoon winds in the month of May<sup>53</sup>. The settlement of the Harappan Civilization at Makran coast was remarkable because the sea was free from danger in the vicinity of anchorage. The monsoon weather does not bring strong winds and currents at Sutkagen-Dor as it does on the west coast of India<sup>49</sup>. Moreover, vessels sail-

ing from the west coast of India were not required to moor during July and August at Sutkagen-Dor<sup>55</sup>. If the vessels of the Mesopotamia or Gulf sailed in May, they would have to anchor or dock during the rough monsoon months. In order to avoid the stormy monsoon weather, the boats of the Gulf and Mesopotamia sailed from the Gulf in September with the assistance of westerly wind and made use of northeast monsoon wind and currents in mid November for the return journey<sup>53,54</sup>. During the winter season (October and November) and in later months, the northeast monsoon winds head towards the Arabian Peninsula from India (Figure 5). The finding of the seal, ivory comb, etc. at Ra's al-Hadd, suggests that the people of the Harappan Civilization appear to have sailed directly between Gujarat and Oman, and today, it is the natural landfall for ships using the monsoon winds<sup>56</sup>.

During the ancient period, maritime trade and shipping were based on knowledge of ship building, monsoon winds and use of celestial bodies for navigation. It is believed that the people of Harappan Civilization were aware of these aspects and used them meticulously. *Periplus* and Pliny have stated that for safe sailing, mariners had followed one latitude to cross the Arabian coast (Ocelis) and reach Muziris, west coast of India. Further, Tchernia<sup>33</sup> observed that crossing of high seas was possible if a sailor could stay on one parallel following the stars. Taking this into account, in her recent work Ratnagar<sup>49</sup>

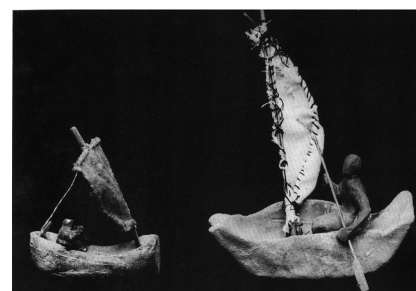
proposed that following the same degree north latitude, sailors could travel from Muscat to Lakhpat (the Great Rann). Following 23°30' parallel they could travel from Ras al Hadd to the Gulf of Kutch. Along the coast of the Gulf of Kutch, the Harappan Civilization sites namely Bagasra, Kuntasi, Shikarpur are located in bays and estuaries and experience severe monsoon. Under such conditions, small seagoing vessels were probably used for maritime trade which could ply throughout the year between Oman and the west coast of India except during May and July<sup>49</sup>.



**Figure 2.** a, b, The Harappan seal depicts a ship with mast and sail recovered from the excavations of Harappa.



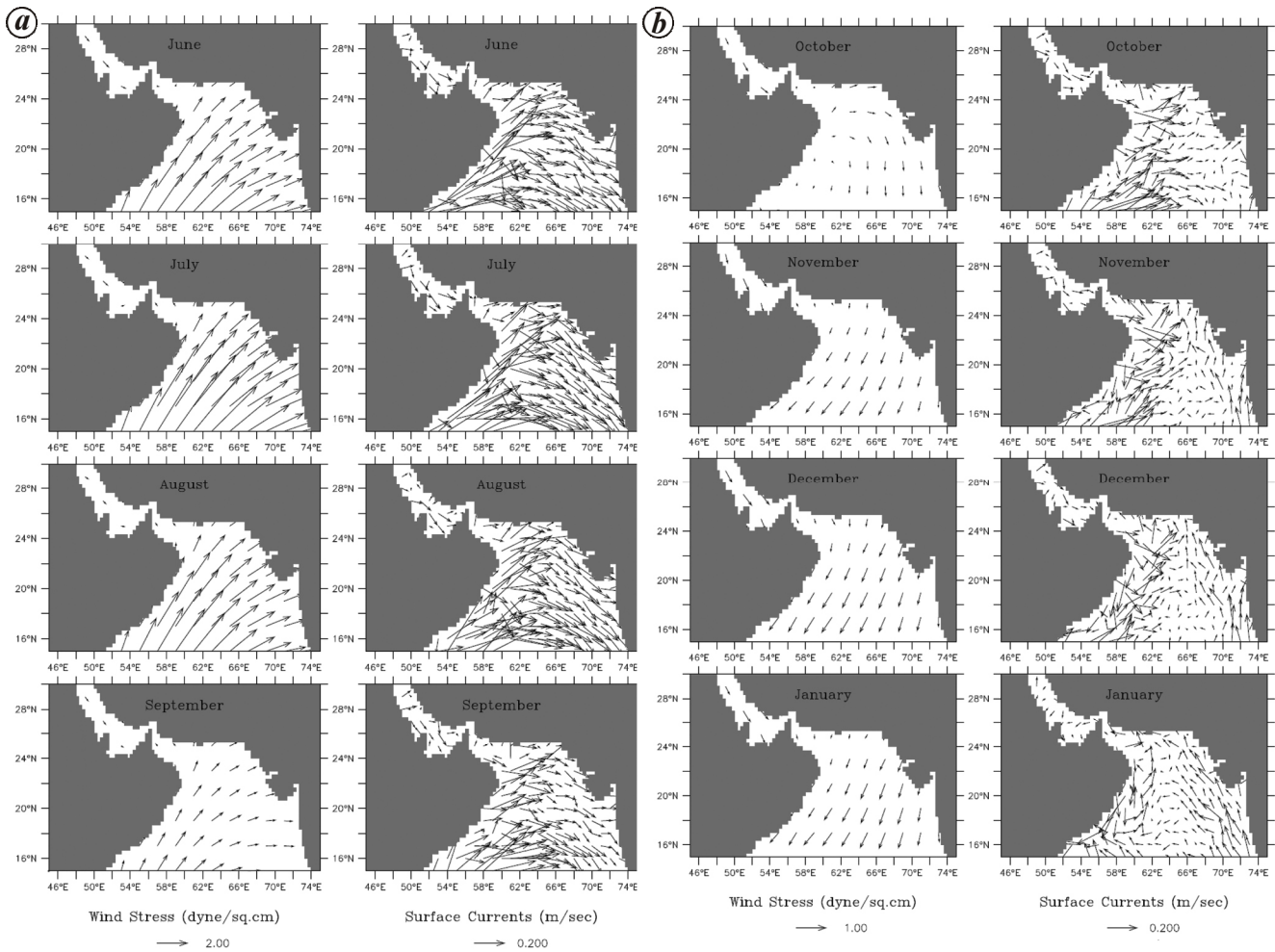
**Figure 3 a, b.** A seal and a terracotta amulet from Mohenjo-Daro depict ship with cabin and birds.



**Figure 4.** Clay model boats have been found from Lothal excavations.



**Figure 1.** Figure showing the sites mentioned in the text.



**Figure 5 a, b.** Surface winds and currents during Northeast monsoon and Southwest monsoon over the Arabian Sea and Persian Gulf regions (Hellerman and Rosenstein and OSCAR data sets).

The above information suggests that sailors of Harappan Civilization were aware of monsoon winds and followed both coastal and mid-sea voyages. It was not necessary that boats covered the entire distance at a stretch from the mouth of the Tigris and Euphrates to Sind or Gujarat. The Ur III period findings suggest that Mesopotamian boats sailed to Magan, then to Dilmun. Most of the cargo acquired was certainly of Indian origin. It establishes the fact that the Mesopotamian and the Harappan Civilization boats have sailed in the Tigris and Euphrates and Gujarat regions. Sutkagen-Dor, the coastal and farthest western Harappan site, served as an end point for the boats coming from the Gulf outside monsoon point. The frequent trips of different vessels, transshipment, and storage of cargo would have increased sea transport. In addition, archaeological evidence and textual sources suggest

direct contact between the Mesopotamians and the Harappan Civilization<sup>53,54,57</sup>. Bowen<sup>42</sup> and McGrail<sup>58</sup> have suggested that boats sailed, keeping the coast in sight because frequent repairs, maintenance and replenishment were required, even though the coastal route lacked sheltered places. The northeast monsoon wind facilitated sailing from Sutkagen-Dor to the coast of Oman. Without the northeast monsoon wind, a coastal route may not have been convenient. There were several coastal sites which served as safe anchorages and refuelling stations, but they were not ports. The northeast monsoon winds and currents were suitable for voyaging along the Makran coast. A vessel could turn south of Oman or north western for Musandam or beyond after reaching Jask<sup>59</sup>. Further, there is no evidence of the use of lateen sail during this period. As a result, in all probability, square

sails were designed to utilize monsoon wind force, and boats could sail with the aid of winds blowing from behind at an angle less than 30° from the dead astern<sup>60,61</sup>. With the help of square sails, it might have been possible for a vessel to sail from Gujarat or the Makran coast to Ra's al-Junayz in three months with the support of surface current and wind pressure, either by coastal or deep sea route. Moreover, square sails are suitable for windward navigation, and their use is evidenced from the Harappan Civilization seal (Figure 2)<sup>43,62</sup>. It would be interesting to know whether the stitched boats of the Harappan Civilization were able to resist the weather conditions of the southwest monsoon or not. It depended on the strength of construction of stitched boats and quality of sails used; besides, the mariners of Harappan Civilization had traditional knowledge to ascertain the coast from the colour of the

sea, landmarks and birds. The discovery of a terracotta amulet at Mohenjo-Daro by Dales<sup>45</sup> corroborates that the people of Harappan Civilization used birds for finding directions in mid-sea (Figure 3 b). The above evidence delineates the acquaintance with coastal navigation, but it cannot be ruled out that the people of Harappan Civilization had no knowledge of sailing across the seas. The recovery of a large barbed copper/bronze fish hook, 14 cm long along with fish bones of different sizes from the excavations of Padri, the Harappan Civilization site near the Gulf of Khambhat in Bhavnagar District and recovery of another copper fish hook, 7 cm long from the excavations of Bet Dwarka (Figure 6), Gulf of Kachchh, Gujarat, suggests that these hooks could be used for deep sea fishing<sup>63,64</sup>. It implies that the people of Harappan Civilization were familiar with deep sea navigation.

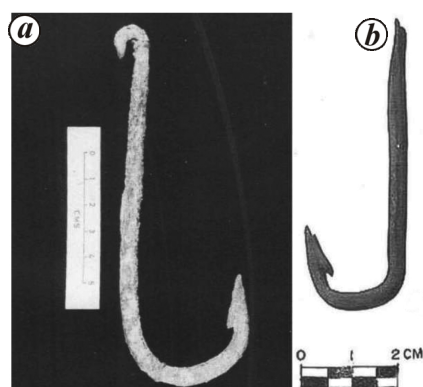
**Discussion and conclusion**

Monsoon is the lifeline of Indian subcontinent, and the society and economy of South Asia are dependent on monsoons. Numerous publications have appeared on the monsoon system, but only limited number deal with the historical aspects of monsoon winds in maritime trade, commerce, navigation including the discovery of monsoon winds, etc. From the existing sources, it could be established that Hippalus is a myth. Moreover, Pliny ignores Hippalus as a man and names Hippalus as the monsoon wind. Other than the *Periplus of the Erythraean Sea*

(PES) or the *Periplus Maris Erythraei* (PME), in which a single passage that has dealt with Hippalus, has undergone many revisions, and cannot be precisely dated, there is no reference to Hippalus. Therefore the theory of Hippalus can be completely ignored. The Indian literature of the pre- and post-Hippalus period clearly describes the Indians' knowledge of monsoon wind and currents and their use in maritime trade and navigation. Similarly, Casson<sup>24</sup>, Mazzarino<sup>26</sup> and Rao and Griffiths<sup>4</sup> have mentioned that Hippalus is not the discoverer of monsoon winds which was known to Indians much before him. Though there are many varied opinions about the *Rig Vedic* people and their homeland, the *Rig Veda* itself, as well as the later Vedic period texts, mention the monsoon winds, knowledge of sea and terms related to ships and shipping. Similarly, the archaeological findings from Harappa, Mohenjo-Daro and Lothal suggest that maritime trade existed between the Mesopotamian and Harappan Civilizations, and this is further substantiated by the cuneiform texts of Mesopotamia. Undoubtedly, people of the Harappan Civilization sailed across Arabian Sea probably from Sutkagen-Dor to Ras al Junayz and Ras al Hadd.

It appears that the mariners of Harappan Civilization who sailed towards the Gulf from Gujarat and Makran coast, used the north-easterlies and returned during the south-westerlies. The north-easterlies and south-westerlies wind could quickly push the vessels of the Harappan using square sails. Moreover, the representation of mast and square sail on the ships of Harappa, Mohenjo-Daro and Lothal clearly signifies that the people of Harappan had knowledge of harnessing monsoon winds for navigation, and it could be stated that the people of Harappan Civilization were already using monsoon wind and currents for maritime trade and navigation in 2500 BCE. Kostman<sup>65</sup> mentioned that collapse of maritime trade was one of the causes of the decline of Harappan Civilization. This further supports the theme of this paper, that the people of Harappan Civilization were aware of navigation by wind and currents.

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**Figure 6 a, b.** Copper fish hooks have been discovered during excavations at Padri and Bet Dwarka (Photo sources: Shinde et al., Padri; and Gaur et al., Bet Dwarka).

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