

**Template for Submission of Scientific Information  
to Describe Areas Meeting Scientific Criteria for  
Ecologically or Biologically Significant Marine Areas**

**Title/Name of the area: Indus delta and Indus Canyon**

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**Abstract** (*in less than 150 words*)

The Indus Fan with its 1500 Km length, 960 Km maximum width, and  $1.1 \times 10^6$  sq. Km. area, is the most extensive physiographical province of the Arabian Sea in the north-west Indian Ocean. It is bounded by the continental margin of India-Pakistan and Chagos-Laccadive ridge on the east, by the Owen and Murray ridges on the west and north and by the Carlsberg ridge in the south. The shelf-break occurs at about 100 m depth along the India-Pakistan margin. The Indus River system has been the dominant supplier of sediments in the Indus Fan. The Indus Canyon or the Swatch area is productive in its nature and lacks qualifying data. However through observer program reports run by WWF-Pakistan it has been reported that the area is rich in Tuna, Billfish, forage fish, Cetaceans and Sharks.

**Introduction**

*(To include: feature type(s) presented, geographic description, depth range, oceanography, general information data reported, availability of models)*

The patterns of sedimentation and morphologic development of a delta result primarily from the interaction of fluvial and marine processes. Historically, the Indus River delta has formed in an arid climate under conditions of high river discharge ( $400 \times 10^6$  metric tons of sediment/year), moderate tide range (2.6m), extremely high wave energy ( $14 \times 10^6$  ergs/sec) and strong monsoon winds from the southwest in summer and from the northeast in the winter. The resulting sandy, lobate delta, lacking in luxuriant vegetation and dissected by numerous tidal channels, has prograded seaward during the last 5000 years at an average rate of perhaps 30m/year. Morphology of the Indus Delta lies midway between that of a fluvially dominated delta (elongate, protruding distributaries) and a high energy wave dominated delta (beach beachridge, and downdrift deposits) (Wells and Coleman, 1983).

The Indus Fan with its 1500 Km length, 960 Km maximum width, and  $1.1 \times 10^6$  sq. Km. area, is the most extensive physiographical province of the Arabian Sea in the north-west Indian Ocean. It is bounded by the continental margin of India-Pakistan and Chagos-Laccadive ridge on the east, by the Owen and Murray ridges on the west and north and by the Carlsberg ridge in the south. The shelf-break occurs at about 100 m depth along the India-Pakistan margin. The Indus River system has been the dominant supplier of sediments in the Indus Fan. The Pakistan-India margin and the adjacent Arabian sea have evolved through a two stage evolutionary process, rifting and sea floor spreading (V. Kolla and F. Coumes, 1985).

High-resolution seismic (*Parasound*) profiles, multibeam bathymetry (*Hydrosweep*), underwater photography and sediment cores are used to map the morphology and echo-facies distribution, and to describe the late Quaternary sedimentation on the outer shelf and slope off the Indus delta (Pakistan).

The morphology and origin of the Indus Canyon were studied in detail. The upper and middle canyon (from 20- to 1350-m axial depth) is an erosional (degradational) canyon or delta-front trough with steep erosional walls and a meandering axial channel without levees. The lower Indus Canyon (1350- to 1500-m axial depth) is a transitional type between a degradational canyon and the aggradational channel-levee system of the upper Indus Fan. The late Quaternary sedimentation is influenced by fluctuations of fluvial input, delta progradation, canyon erosion and fan aggradation. It is especially controlled by sea-level changes. Four episodes can be distinguished:

- (1) During interglacial (?Eemian) times and a relatively high sea-level position, a layered sequence of V-shaped, channel-like erosional features were formed below the shelfbreak (135 m) down to an upper slope scarp by slumping or erosion as delta-front or prodelta gullies.
- (2) During the Last Glacial Maximum, the sea-level lowstand caused the Indus delta to advance across the present shelfbreak and shed fluvial silty clays directly onto the upper slope. This is indicated by layered, gently seaward dipping subparallel reflectors which are interpreted as being prograded prodelta mud units. At this time the Indus Canyon experienced maximum erosion and funnelled turbidity currents to the aggradational channel-levee system on the Indus Fan. Major slumps and debris flows were triggered at the continental slope.
- (3) During deglaciation and the beginning of the Holocene transgression, several sea-level stillstands are indicated by the formation of biogenic sediments on the outer shelf and the build-up of shallow-water algal bioherms around 9–12 ka BP (presently at a water depth of ~90–100 m).
- (4) During the late Holocene sea-level highstand, the shelf was flooded and the delta-front sediments of the Indus River were deposited on the innermost shelf. The outer shelf is characterized by a lack of deposition and erosion. The Indus Canyon experienced ongoing (but much decreased) activity of low-density turbidity currents with overbank spilling. The middle and lower continental slope down to ~ 2000 m is covered by hemipelagic sediments showing a layered sequence of distinct subbottom reflectors explained as hemipelagic drape interbedded with turbid layer sediments and/or thin mud turbidites from spillover along natural levees bordering the Indus Canyon. For the past 50 ka, the continental slope (outside the canyon and channels) experienced no turbidite sedimentation (Ulrich and Tahir)

The genus *Gromia* includes large marine protists ('gromiids') with filose pseudopodia and sack-like organic tests. The first deep-water species were discovered in the 1990s on the Oman Margin of the Arabian Sea and subsequently found on the Pakistan Margin. In addition to the two species (*Gromia sphaerica* and *Gromia pyriformis*) already described from this area, at least eight undescribed gromiid species were present. Most gromiids lived on the sediment surface with their apertures facing down and their pseudopodia presumably deployed into the sediment to feed on surficial material and associated bacteria. We conclude that these large protists may play an important ecological role in the bathyal Arabian Sea, particularly in carbon cycling but also in structuring the surficial sediments. In addition, their tests, particularly those of *G. sphaerica*, provide substrates for attached Foraminifera (Silva and Gooday, 2009).

The international Indian Ocean expedition (IIOE) has revealed that the Arabian Sea, particularly on its western side is a region of high basic production (Kabanova, 1964, Ryther et al, 1966). The most productive area of the ichthyoplankton was the waters south of Karachi, covered during the “Machera Cruise”, where 828 to 1262 larvae haul<sup>-1</sup> were obtained. The larvae were identified to species, genera or family. *Sardinella sindensis* (specific identification uncertain) larvae dominated in abundance. The other abundant larvae belonged to *Benthoosema* spp., *Amentum commersonii*, *Vinciguerria* spp. and *Diaphus* spp. Presumably, the waters south of Karachi represent good feeding grounds for *s. (sindensis)* larvae. Displacement volume, length and weight relationships of various larval size groups have been studied and a high rate of larval mortality (at a length of 5.0 to 8.5 mm) observed.(A. Khan, 1976).

### **Location**

*(Indicate the geographic location of the area/feature. This should include a location map. It should state if the area is within or outside national jurisdiction, or straddling both.)*

Much of the Indus Fan lies outside the 200nm limits around Pakistan and India. (Kolla, Coumes, 1983-1984).

### **Feature description of the proposed area**

*(This should include information about the characteristics of the feature to be proposed, e.g. in terms of physical description (water column feature, benthic feature, or both), biological communities, role in ecosystem function, and then refer to the data/information that is available to support the proposal and whether models are available in the absence of data. This needs to be supported where possible with maps, models, reference to analysis, or the level of research in the area)*

The upper fan has large channel-levee complexes with channels up to 350 nm deep. The banks of these channels have scalloped rims that are believed to be due to rotational slumping into the channels. The channel fed by Indus Canyon is different from others. (RRS Charles Darwin Cruise 20, 1987). The Indus Canyon also has possible presence of hydrothermal vents.

The Indus Canyon or the Swatch area is productive in its nature and lacks qualifying data. However through observer program reports run by WWF-Pakistan it has been reported that the area is rich in Tuna, Billfish, forage fish, Cetaceans and Sharks. Many fishers travel to the swatch area in search of these species. There is little documented evidence however, please see figure 10. *Kajikia audax* reported to be caught in swatch area (M. Moazzam, 2013, WWF-Pakistan report to IOTC).

A live sighting of 2-3 striped dolphins was recorded by a captain of a tuna fishing vessel (Gule- Muhammad No. 14623-B) off the Indus delta in the Swatch area (23°18.750'N 67°12.566'E) on 20 December, 2012 at 1350 PM. An animal of the same species became entangled and died in a tuna gillnet in deep waters off the Indus delta well beyond the shelf (GPS coordinates: 20° 49.172'N 65°16.150'E) on 16 January 2013 (Kiani et al, 2004).

The area from where the skull of a striped dolphin was retrieved is very near to a famous deep water area “the Swatch” along the Sindh coast. This area is very interesting as it spans over

the Indus river delta with a total length of about 117 km, having depth ranging from ca. 41 to 727 m. The Swatch starts ca. 12 km from the coast. This area attracts deep-water species of fish, cetaceans and other large marine vertebrates (Ahmed, 1985; Mikhaley, 1997 and 2000; Aziz Agha, a local game fisher, pers. comm.). Large whales such as the famous but endangered Arabian Sea humpback whale (*Megaptera novaeangliae*) are well known from this area, specifically from Russian illegal whaling data (Mikhaley, 1997 and 2000). It is possible that the striped dolphins may be using “the Swatch” area for their nearshore incursions in order to benefit from the rich food resources offered by rich mangrove ecosystem of the Indus delta. This is in agreement with Archer (2002) who states that the habitat of the striped dolphin is mainly oceanic but some occurrences over the continental shelf are also recorded throughout the range of the species. Moreover, the depths found in the Swatch area fall in the preferred foraging and diving range of the striped dolphin *i.e.* 200-700m. However, species’ diving and foraging behaviour has not been extensively studied (Archer, 2002). Its distribution also seems to be associated with areas where seasonal changes in thermocline depth occur, as reported from the eastern tropical Pacific (Reilly and Fiedler, 1993).

The literature also indicates that striped dolphins are commonly recorded from riverine mouth areas, which is in line with findings of the present study (Perrin, 1975 and references therein). Striped dolphins are known to feed on a wide variety of small, midwater and pelagic or benthopelagic fish, especially lanternfish (*Myctophidae*), cod (*Gadus morhua*) and cephalopods (Archer, 2002). Lanternfish and squids are present in the Pakistani EEZ (FAO, 2011) and thus can support a striped dolphin population. The pattern of wind driven circulation in the Indus delta favours deposition of dead cetaceans, and their remains, on the beaches just before the start of the turbulent southwest monsoon (mid June to September) which is thought to wash these specimens from the beaches. Fishing activities also decrease considerably during this period, which reduces the chances of cetaceans and other large marine vertebrate entanglements in fishing gear. The present specimen was found before the onset of the SW monsoon in the spring intermonsoonal period (March to May). Salm (1991) states that many beaches are swept clean during the annual SW monsoonal period and the peak abundances of dead dolphins and other taxa on the Arabian Sea coasts are just before the onset of the SW monsoon. The skull measurements were compared with those in MeFee *et al.* (1998) and were found to be within the reported range. Though it is difficult to establish the cause of death of this dolphin, a series of serrations on rostrum are visible which may be an indication of negative interaction with fisheries (e.g. entanglement and/or a propeller strike). This pattern of injuries is similar to those found in some other dead dolphins found during beach surveys (Kiani, M.S. and Pervaiz, I., unpublished data). The Swatch area is one of the most important fishing grounds along the Pakistan coastline, being very productive due to its close proximity to the nursery grounds found in the world’s largest arid mangrove ecosystem. Due to this reason fishers come from several different locations to this area, *e.g.* from Karachi to Keti Bunder (Indus delta) and from India as well.

This results in concentration of more fishing activities in a small area during the peak fishing season, *i.e.* predominantly during the northeast monsoon (November to February) and increases the chances of entanglement of cetaceans and other large marine vertebrates in fishing gear. Some commonly practiced fishing methods in this area include gillnets of various kinds/sizes and trawling. There is no or little information that shrimp trawling is associated with cetacean by-catch in Pakistan (Niazi, 1990; M. Moazzam Khan, ex- Director General Marine Fisheries Department of Pakistan MFD, pers. comm.). The gillnets are the most harmful fishing gear for cetaceans in Pakistani waters, as reported from other parts of the world (Jefferson and Curry, 1994; Perrin *et al.*, 1994). The lengths of medium (100-

120mm) and large mesh (150-240mm) sized gillnets, used for catching pomfrets, groupers, snappers, grunts, queenfish, seabreams, shads, catfish, croakers, tuna and other scombrids respectively in shelf and high seas, exceed the limits set by the United Nations General Assembly Resolution 44/225 1991 (M. Moazzam Khan, pers. comm.).

### **Feature condition and future outlook of the proposed area**

*(Description of the current condition of the area – is this static, declining, improving, what are the particular vulnerabilities? Any planned research/programmes/investigations?)*

According to the resolution, the length of gillnets should not exceed 2.5km on the high seas. However, the nets being used in Pakistan range from 7 to 10 km in length and can be up to 26 km long (M. Moazzam Khan, pers. comm.). These nets are functioning as “walls of death” and causing mortality of cetaceans of all sizes, turtles and other non-target species. Striped dolphins are not frequently associated with tuna and thus small numbers are killed in tuna fisheries (DeMaster *et al.*, 1992; Perryman and Lynn, 1994). The live sighting reported in this paper and a dead specimen that died as a result of entanglement were recorded by a captain of a boat catching large pelagic fish, including tuna. This demonstrates that the species may get entangled in the large gillnets being used by such boats in Pakistani waters and that striped dolphins are getting affected by tuna fishing operations in Pakistan. The extent of this issue is still to be studied.

Strict implementation of relevant laws to disperse the concentration of fishing activities, particularly in the Swatch, is important for conservation of cetaceans in Pakistan. Data on bycatch have not been accumulated by any of the relevant departments, and observer programmes by the Marine Fisheries department are not effective in recording cetacean interactions, being focused only on monitoring illegal fish catch and enforcement of fishing area restrictions. Detailed observations on the status, diversity, distribution of marine mammals, especially offshore cetaceans should be done extensively with the collaboration of relevant departments of the country and regionally active research groups, and it is only recently that WWF-Pakistan has initiated a dedicated observer program to monitor gillnet fisheries.

### **Assessment of the area against CBD EBSA Criteria**

*(Discuss the area in relation to each of the CBD criteria and relate the best available science. Note that a proposed area for EBSA description may qualify on the basis of one or more of the criteria, and that the polygons of the EBSA need not be defined with exact precision. And modeling may be used to estimate the presence of EBSA attributes. Please note where there are significant information gaps)*

<b>CBD EBSA Criteria</b> (Annex I to decision IX/20)	<b>Description</b> (Annex I to decision IX/20)	<b>Ranking of criterion relevance</b> (please mark one column with an X)			
		<b>No information</b>	<b>Low</b>	<b>Medium</b>	<b>High</b>
<b>Uniqueness or rarity</b>	Area contains either (i) unique (“the only one of its kind”), rare (occurs only in few locations) or endemic species, populations or communities, and/or (ii) unique, rare or distinct, habitats or ecosystems; and/or (iii) unique or				<b>X</b>

	unusual geomorphological or oceanographic features.				
<i>Explanation for ranking</i>					
<p>The genus <i>Gromia</i> includes large marine protists ('gromiids') with filose pseudopodia and sack-like organic tests. The first deep-water species were discovered in the 1990s on the Oman Margin of the Arabian Sea and subsequently found on the Pakistan Margin. In addition to the two species (<i>Gromia sphaerica</i> and <i>Gromia pyriformis</i>) already described from this area, at least eight undescribed gromiid species were present</p> <p>The international Indian Ocean expedition (IIOE) has revealed that the Arabian Sea, particularly on its western side is a region of high basic production (Kabanova, 1964, Ryther et al, 1966).</p> <p>The Indus Canyon also has possible presence of hydrothermal vents.</p> <p>Moreover, the depths found in the Swatch area fall in the preferred foraging and diving range of the striped dolphin <i>i.e.</i> 200-700m. However, species' diving and foraging behaviour has not been extensively studied (Archer, 2002).</p>					
<b>Special importance for life-history stages of species</b>	Areas that are required for a population to survive and thrive.				<b>X</b>
<i>Explanation for ranking</i>					
<p>This area attracts deep-water species of fish, cetaceans and other large marine vertebrates (Ahmed, 1985; Mikhalev, 1997 and 2000; Aziz Agha, a local game fisher, pers. comm.). Large whales such as the famous but endangered Arabian Sea humpback whale (<i>Megaptera novaeangliae</i>) are well known from this area, specifically from Russian illegal whaling data (Mikhalev, 1997 and 2000).</p> <p>Recently WWF-Pakistan observers released a longbill Cuvier beaked whale caught in Tuna gillnet vessel.</p>					
<b>Importance for threatened, endangered or declining species and/or habitats</b>	Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.				<b>X</b>
<i>Explanation for ranking</i>					
<p>The Indus Canyon or the Swatch area is productive in its nature and lacks qualifying data. However through observer program reports run by WWF-Pakistan it has been reported that the area is rich in Tuna, Billfish, forage fish, Cetaceans and Sharks. Many fishers travel to the swatch area in search of these species. There is little documented evidence however, please see figure 10. <i>Kajikia audax</i> reported to be caught in swatch area (M. Moazzam, 2013, WWF-</p>					

Pakistan report to IOTC).					
<b>Vulnerability, fragility, sensitivity, or slow recovery</b>	Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.				<b>X</b>
<i>Explanation for ranking</i>					
<p>The length of gillnets should not exceed 2.5km on the high seas. However, the nets being used in Pakistan range from 7 to 10 km in length and can be up to 26 km long (M. Moazzam Khan, pers. comm.). These nets are functioning as “walls of death” and causing mortality of cetaceans of all sizes, turtles and other non-target species. Striped dolphins are not frequently associated with tuna and thus small numbers are killed in tuna fisheries (DeMaster <i>et al.</i>, 1992; Perryman and Lynn, 1994). The live sighting reported in this paper and a dead specimen that died as a result of entanglement were recorded by a captain of a boat catching large pelagic fish, including tuna. This demonstrates that the species may get entangled in the large gillnets being used by such boats in Pakistani waters and that striped dolphins are getting affected by tuna fishing operations in Pakistan. The extent of this issue is still to be studied.</p>					
<b>Biological productivity</b>	Area containing species, populations or communities with comparatively higher natural biological productivity.				<b>X</b>
<i>Explanation for ranking</i>					
<p>It is possible that the striped dolphins may be using “the Swatch” area for their nearshore incursions in order to benefit from the rich food resources offered by rich mangrove ecosystem of the Indus delta.</p> <p>The Swatch area is one of the most important fishing grounds along the Pakistan coastline, being very productive due to its close proximity to the nursery grounds found in the world’s largest arid mangrove ecosystem. Due to this reason fishers come from several different locations to this area, <i>e.g.</i> from Karachi to Keti Bunder (Indus delta) and from India as well. (Kiani et al, 2013).</p>					
<b>Biological diversity</b>	Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.				<b>X</b>
<i>Explanation for ranking</i>					
<p>A live sighting of 2-3 striped dolphins was recorded by a captain of a tuna fishing vessel (Gule- Muhammad No. 14623-B) off the Indus delta in the Swatch area (23°18.750’N 67°12.566E) on 20 December, 2012 at 1350 PM. An animal of the same species became entangled and died in a tuna gillnet in deep waters off the Indus delta well beyond the shelf (GPS coordinates: 20° 49.172’N 65°16.150E) on 16 January 2013 (Kiani et al, 2004).</p> <p>Striped dolphins are known to feed on a wide variety of small, midwater and pelagic or</p>					

benthopelagic fish, especially lanternfish ( <i>Myctophidae</i> ), cod ( <i>Gadus morhua</i> ) and cephalopods (Archer, 2002). Lanternfish and squids are present in the Pakistani EEZ (FAO, 2011) and thus can support a striped dolphin population.					
<b>Naturalness</b>	Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.				
<i>Explanation for ranking</i>					

### Sharing experiences and information applying other criteria (Optional)

<b>Other Criteria</b>	<b>Description</b>	<b>Ranking of criterion relevance</b> (please mark one column with an X)			
		<b>Don't Know</b>	<b>Low</b>	<b>Medium</b>	<b>High</b>
<i>Add relevant criteria</i>					
<i>Explanation for ranking</i>					

### References

(e.g. relevant documents and publications, including URL where available; relevant data sets, including where these are located; information pertaining to relevant audio/visual material, video, models, etc.)

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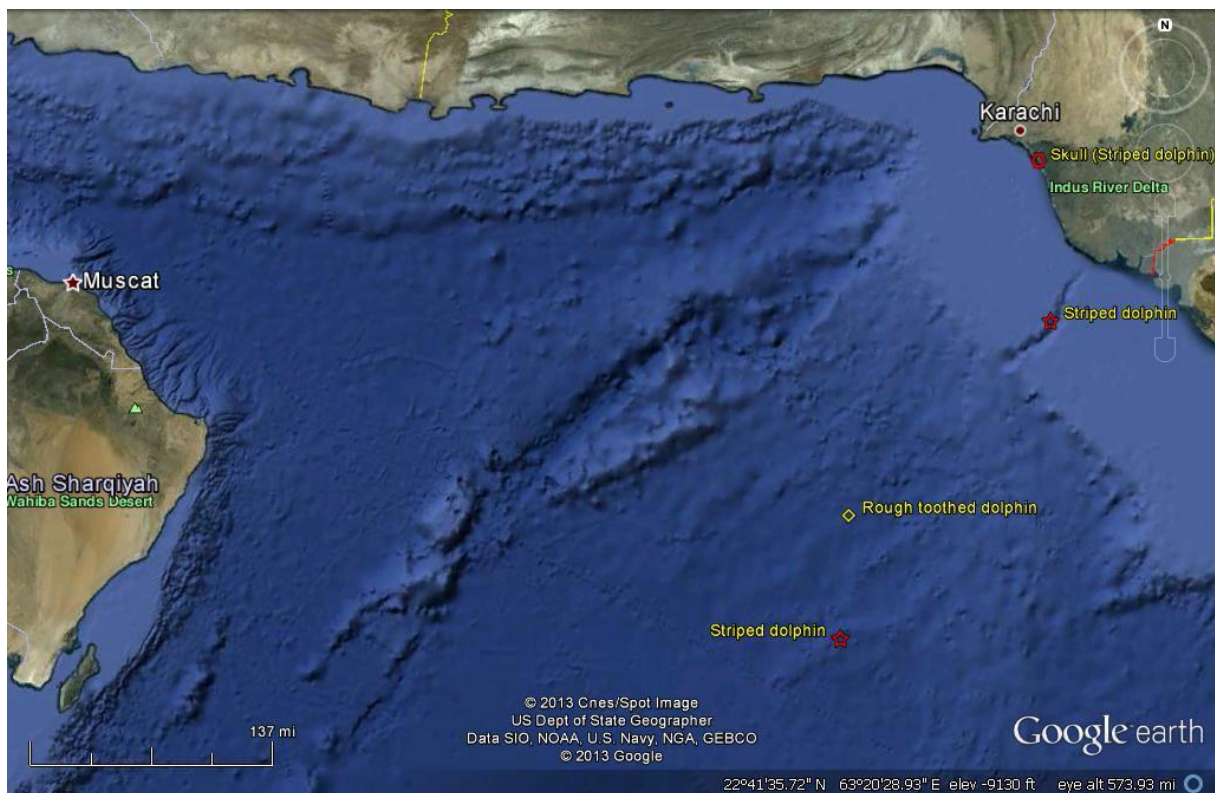
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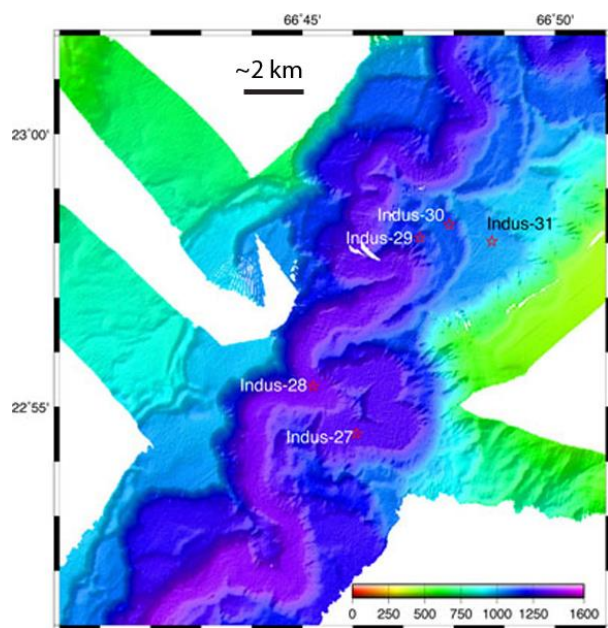
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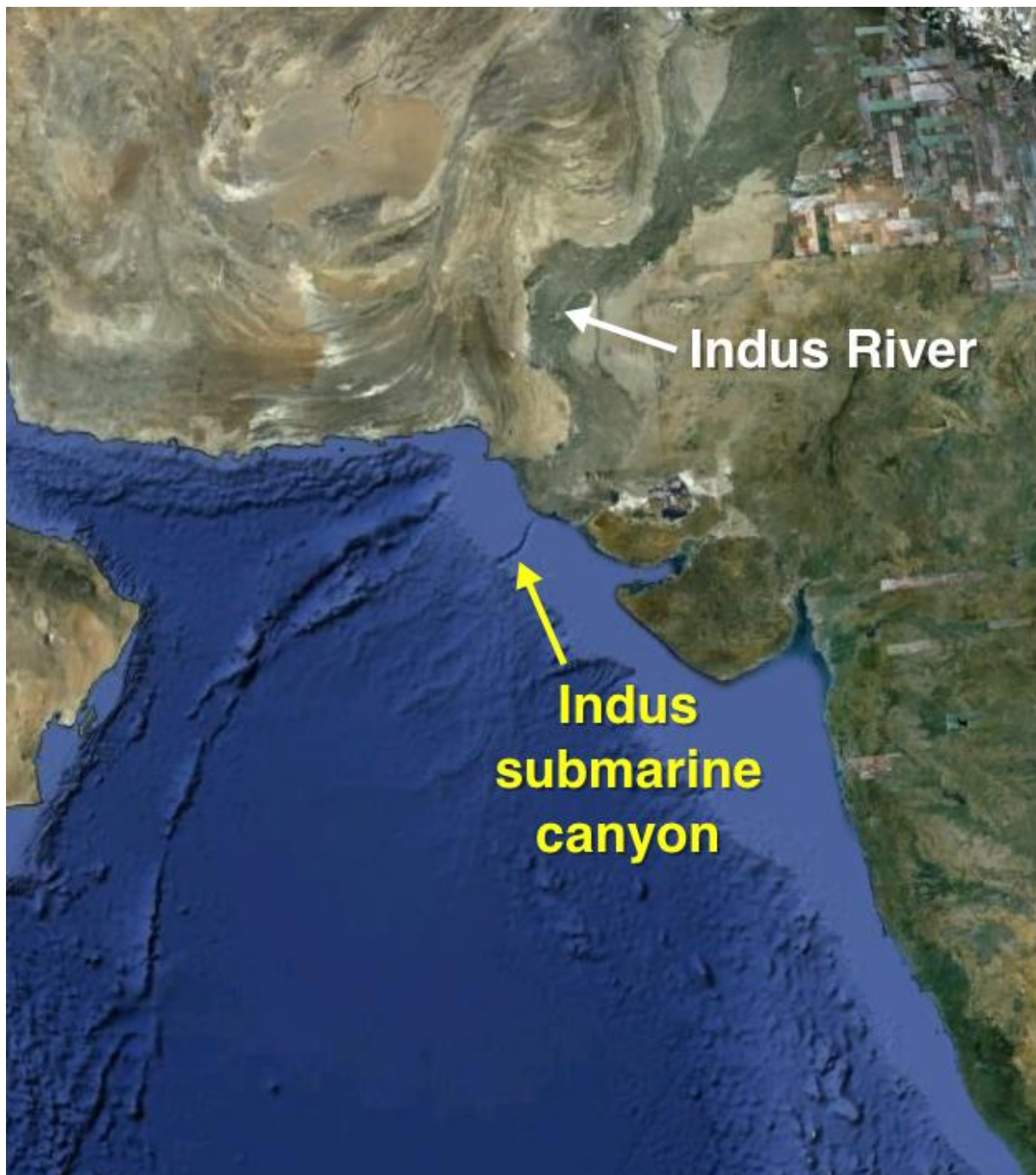
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## Maps and Figures







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Rights and permission is provided for use of data. All data is published presented in this proposal. For further queries Rab Nawaz (Director WWF-Pakistan) may be contacted at [mawaz@wwf.org.pk](mailto:mawaz@wwf.org.pk).