4 Broad-scale Biophysical Drivers

The Bay of Bengal Large Marine Ecosystem sits within the Indian Ocean Basin. The India ocean basin is geographically bound by land masses to the North and East, to the west by the countries and islands of South-east Asia and the Australian West Coast. The southern boundary is an oceanographic one and driven by the global circulation and oceanographic boundaries. However, these are fluid due to their seasonal and longer-term cyclical patterns. The resulting circulation is particularly complicated due to the seasonal reversal of the monsoons.

The biophysical drivers of marine systems play a critical role in determining the habitats that are available for marine ecological communities and warrant some detailed description in order to understand the range of different ecological systems that occur within the Bay of Bengal Large Marine Ecosystem. The major large scale (Indian Ocean) ecosystem drivers include ocean circulation, climate, water masses, tectonics, continental drift and basin evolution.

At the finer scale of the Bay of Bengal most of these remain important. However, additional more local drivers such as bathymetry, geomorphology, riverine input and productivity are also critical. These drivers create a wide range of unique biophysical conditions that support different and unique ecological communities. The following sections describe these features in order to help provide an understanding of the functioning of the ecological systems within the Bay of Bengal Large Marine Ecosystem.

4.1 Bathymetry

The Bay of Bengal is characterised by a narrow continental shelf and slope, a central basin (Bengal Basin) ranging between 2000 m and 4000 m depth and the Andaman Basin (Figure 4.1, 4.4). Exceptions to the narrow shelf include the extensive sediment fans that extend well beyond the mouths of the Ganges, Meghna, Brahmaputra, Ayeyawady/Irrawaddy delta system. These extend up to 250 km in the centre of the Gulf of Maratban, Andaman Sea (Rao et al., 2005). The Palk Strait, separating India and Sri Lanka is 53-80 km wide and the Strait of Malacca varies from about 50 to 150 km in width.

The continental slope is also narrow through most of the Bay of Bengal with exceptions in the southern Andaman Sea to the east and on either side of the Palk Strait. In the northern Andaman Sea the shelf break is at the 110 m isobath and depth increases rapidly beyond this to approximately 2000 m.

The Bengal Basin environments vary from <500 m to >4000 m depth. The western and central Andaman Sea are characterised by basin environments between 900 and 3000 m depth. This region includes a system of submarine valleys to the east of the Andaman-Nicobar Ridge which exceed 4000 m depth and the sea bed is characterised by relatively coarse sediments (see section X).

The bathymetry of within the Bay of Bengal region is highly variable as described above. Depth is one of the major drivers of species distribution, indicating that this LME is a region of relatively high habitat and ecosystem diversity. These features are further described in the sections below.
Figure 4.1. Bathymetry of the Bay of Bengal Large Marine Ecosystem

Figure 4.2. Bathymetry demarkations as described by Tomczak and Godfrey (2003).
4.2 Climate and Oceanography

The Bay of Bengal is situated almost entirely within the tropical zone and is dominated by a monsoonal climate. This is characterised by the northeast, or winter monsoon when cold, dry air flows over the region from the Asian interior (Figure 4.3, 4.5) and the southwest, or summer monsoon when warm, moist air flows into the region from the Indian Ocean (Figure 4.4, 4.5). This climate also generates tropical cyclones, usually in Summer and Autumn (Figure 4.6). This monsoonal regime governs the sea’s climate and water chemistry. In the winter the regional humidity is low, the sea receives little rainfall or runoff, and hence its surface salinities are high. During the summer monsoon, huge volumes of runoff water from river flows form a marked pattern of low surface salinity in the northern third of the Bay of Bengal.

The oceanography in the Bay of Bengal Large Marine Ecosystem is influenced mainly by the Indian Ocean currents system and its seasonal and cyclical patterns. The onset of the Northeast Monsoon (Winter) is characterised initially by the Equatorial Jet concentrating eastward equatorial flow above the thermocline, forming the North Equatorial Current which then drives a narrow current from the Malacca Strait to southern Sri Lanka and a clockwise East Indian Current in the Bay of Bengal (Figure 4.5). The Somali Current then strengthens quickly with the onset of the Southwest monsoon in April. This flow joins the Equatorial Jet around southern India and Sri Lanka. The east flowing South West Monsoon Current then dominates for 4-5 months during the Southwest Monsoon (Figures 4.4, 4.5). This current sets up the anti-clockwise East Indian Winter Jet within the Bay of Bengal, before reforming as the Equatorial Jet.

The opposition of current and wind patterns within the Bay of Bengal can produce sub-surface eddies which either pump cold, nutrient rich water to the surface productive zone or surface water below the thermocline. Figures 4.4 and 4.7 depict sub-surface cold-core eddies that support enhanced biological production during the Summer Southwest Monsoon (also see section 4.4).

*More detail to follow in future drafts and in province sections.*
Figure 4-3. Wind and ocean circulation patterns of the Bay of Bengal that characterise the Winter, north-east monsoon period.

Figure 4-4. Wind and ocean circulation patterns of the Bay of Bengal that characterise the late Summer, South-west monsoon period.
Figure 4-5. The annual evolution of surface currents within the northern Indian Ocean, SEC - South Equatorial Current, NEC - North Equatorial Current, ECC - Equatorial Countercurrent, SWMC - Southwest Monsoon Current, EAC – East Arabian Current, EIC – East Indian Current. Adapted from Tomczak and Godfrey (2003) and Cutler and Swallow (1984).
Figure 4-6. Northern Bay of Bengal showing pathways of selected cyclone tracks.

Figure 4-7. Sub-surface, cold-core eddies caused by opposing wind and current forces during the Summer Southwest Monsoon (reproduced from XXXX).
4.3 Characterisation of Water Masses

Application of the ecosystems characterisation framework (Lyne et al. 2006; Brewer et al. 2007) to the Bay of Bengal requires understanding the structure and dynamics of both the water masses (the pelagic environment) and the seafloor (the demersal environment) and how they interact with each other. As a start in applying this framework, characterisations of the structure of the demersal and pelagic environments need to be derived as components of the ecosystems. The joint CSIRO-BoBLME workshop conducted in Thailand in February 2014 focussed primarily upon characterisations of the demersal environment of the Bay of Bengal, and it is necessary that the pelagic structure be resolved in order to a more holistic view of the ecosystem characterisation.

A basic understanding of pelagic systems can be gleaned from the Figure 4.8. However, in order to resolve ecosystem differentiators specifically within the Bay of Bengal Large Marine Ecosystem we describe a more detailed structure of the deep ocean water masses offshore of the continental shelves in the Bay of Bengal, following methodology developed for the oceans around Australia by Lyne and Hayes (2005). We defer the reader to that report for technical explanations of the approach used.

A global water mass characterisation using the World Ocean Atlas (Version 1A), previously reported by Lyne et al. (2006) is used as the basis of the water mass descriptions and characterisations for the Bay of Bengal. In brief, this characterisation is a hierarchical set of classifications that describe increasing levels of structuring in the world oceans in 3D (using the standard depth levels in the World Ocean Atlas). We used the 30-level water mass characterisation (corresponding approximately to Level 2 in the classification hierarchy) to describe the water masses in the Bay of Bengal (Figure 4.9). This is the finest level of classification developed by Lyne et al. (2006).

For this report, we present below, in a tabular format, sections of the water masses taken at various latitude and longitudes - noted in the first column of the table below (Table 4.1). For reference to the sections, a gridded map of the Bay is also presented in Figure 4-10. In each of the sectional water mass plots below, the 30 characterised water masses used in the global classification are uniquely identified by the colours shown in the legend in the plot. Note that the colours have no meaning other than to identify the water mass.

The 500m sections are meant to identify the structures seen in the near-surface water masses, whereas the 3000m sections show the changes in the deep water masses and the contrast in these structures across the Basins in the Bay of Bengal. These Basins comprise: 1) The core of the Bay of Bengal - the Bengal Basin; 2) The Andaman Sea - Andaman Basin, and 3) The Cocos Basin. There is also an element of the Arabian Sea in the BoBLME region. Of interest in the deeper section are changes due to topographic structures and changes in the topography of the seafloor.

What we are trying to decipher and establish with the water mass characterisations is the location of the major changes in water masses across, and by depth, in the Bay of Bengal. We first describe the changes in water mass structure and we then attempt to define preliminary demarcations of changes in the water masses.
Figure 4-8. Depth Zonation diagram describing the basic features of pelagic ecosystems

Figure 4-9. Plots of the 30-class classification of global water masses at four depth levels (identified by the heading above each plot). Note that the colouring scheme does not imply any explicit changes in water properties such as temperature.
ZONAL SECTIONS (ALONG CONSTANT LATITUDE)

Table 4-1. Characterisation of zonal sections of water masses across the Bay of Bengal along a constant latitude. The 500m sections reflect the near-surface water masses whereas the 3000m sections show the deep water masses.

<table>
<thead>
<tr>
<th>Location</th>
<th>Description: 500m Sections</th>
<th>Description: 3000m Sections</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5N</td>
<td>Towards Maldives and Sri Lanka, the top 100m contains mixed water masses compared to the rest of the section. Just to the east of Sri Lanka, there is a “wedge” of water mass that extends right across the basin indicating strong mixing and possible subduction of mixed waters below the surface – ideal conditions for enhanced productivity. Mixed layer is shallower than 100m</td>
<td>Apart from the changes noted in the 500m sections, the 3000m section is relatively uniform but with a deepening of the water mass boundary at about 1000m as the Maldives ridge is approached from the east.</td>
</tr>
</tbody>
</table>
4.5N

Similar to 2.5N but mixed layer deepens to just over 100m. Additional mixed waters are evident in the top 100m. The “wedge” now extends to about two-thirds of the way across. A new water mass (deep blue) is now seen to extend over the top of the Cocos Basin indicating the influence of deep oceanographic processes and circulation on the near-surface features. This new water mass potentially may also provide enhanced nutrients into the nutricline below the mixed layer.

As above but now with a hint of a distinct water mass at about 2000m in the Andaman Basin.

6.5N

Sri Lanka now forms a barrier and there is a distinct separation in the surface water mass features to the east and west of the island. The new water mass that appeared over Cocos now extends across to Sri Lanka (indicating that it is a part of the Bengal Basin) in a domed shaped feature that could be due to an eddying process. The mixed layer of water masses now also extends slightly deeper.

In the Andaman Basin, the water masses are distinct to those in the Bengal Basin from about 1600m and deeper. There is a strong change in water masses at about this level (1600m) which extends right across the section. The water mass above this extends to 1000m with disturbances at either end of the section indicating potential interactions of currents/mixing with bathymetry.
To the west of Sri Lanka, a mixed collection of water masses in a relatively shallow “mixed layer” is distinct from the deeper mixed layer to the east. This layer contains the more of the new (deep blue) water mass now extending further in depth, and deepening, to the east of the Bengal Basin. Unfortunately, data in the Andaman Basin appears not to be available.

The distinctions noted above are reinforced. Now, the water mass at about 1000m in the Bengal Basin appears to fill the depths of the Andaman Basin from a sill located at about 1000m in the Andaman Ridge system. A slight disturbance is also noted at the Indian continental slope at this level.

To the west of India, the water mass wedge profile reverses. To the east, the pattern seen in previous sections is repeated but with further deepening of the water masses below the surface.

Clearly shows that the Andaman Ridge system plays a major role in the structuring of the deeper water masses as well as the sub-surface water masses extending across the Andaman Basin. The 1000m water mass boundary in the Bengal Basin is now seen to shallow to about 750m in the Andaman Basin.
As above but now the mixed layer in the Bengal Basin is relatively uniform across the width of the basin with further activity confined below the top 100m. In the Andaman Basin, the same water masses are deeper compared to the Bengal Basin.

A clear demonstration of the distinct water mass structures in the Arabian Sea, the Bengal Basin and the Andaman Basin. Continues the pattern of a missing water masses deeper than about 1600m seen in both the Arabian Sea and the Bengal Basin – an indication that the Andaman Sea is closed to mixing with the Bengal Basin below about 1600m.

As above but now with a weak indication of a sub-surface slope current as reflected by the inclined water masses to the east of the Indian continental shelf. Also a slight disturbance is evident to the north of the Andaman Island and the connection between the Bengal Basin and the Andaman Basin.

A distinct deepening of the deep water masses in the Arabian Sea compared to the Bengal Basin as seen for example in the deep water change at 1900m in the Arabian Sea compared to the same change at about 1700m in the Bengal Basin. Surface water mass structures are also different.
16.5N

The distinct nature of water masses to the east and west of India is evident from the evenness of the top 100m to the east compared to the diversity to the west of India. The thermocline/nutricline is stronger in the Bengal Basin. To the west of Myanmar, the water masses below the thermocline are deeper indicating either subduction or mixing of the deeper water masses with an associated sub-surface current.

18.5N

This section is offshore of the Ganges Delta system and shows some disturbance offshore of the Indian continental slope.

Relatively uniform across the Bengal Basin apart from slight disturbances at the near-surface off Myanmar, and at about 1200m off India.

Apart from the near-surface features, the deeper water mass structures are relatively uniform across the Bengal Basin.
### MERIDIONAL SECTIONS (ALONG CONSTANT LONGITUDE)

Table 4-2. Characterisation of zonal sections of water masses across the Bay of Bengal along a constant latitude. The 500m sections reflect the near-surface water masses whereas the 3000m sections show the deep water masses.

<table>
<thead>
<tr>
<th>Location</th>
<th>Description: 500m Sections</th>
<th>Description: 3000m Sections</th>
</tr>
</thead>
<tbody>
<tr>
<td>77.5E</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td>Surface water masses extend to about 130m in the south of the section, compared to 100m south of India.</td>
<td>Relatively consistent deep water structures.</td>
</tr>
<tr>
<td>81.5E</td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td>This section cuts across the eastern Sri Lanka and shows distinctions in water masses at about 100m. The wedge of water mass (green) in the top 20m in the south is seen as an extension of a more extensive water mass to the north. This indicates that Sri Lanka may be a barrier to water masses but at the same time causing some mixing. Below 100m the water mass seen in the Bengal Basin is missing to the south (indicating that it may be confined to the Bengal Basin).</td>
<td>Relatively consistent deep water structures apart from an upward sloping water mass boundary at about 1000m on the India – Sri Lanka continental slope.</td>
</tr>
</tbody>
</table>
Past the southern tip of Sri Lanka at about 5°N, a surface front shallows from about 100m to the surface and the thermocline at about 100m deepens. North of this point, the water masses at about 100m are also different and extend down to about 150m.

Deepening of the 1000m water mass boundary to the north of about 13°N – potentially a result of the meeting of the Bengal and Andaman Basins (main connection about 15°N).

The front south of 5°N is there still but not as obvious. There is now a hint of changes in the near surface at about 15°N at about the location where the Bengal Basin and the Andaman Basin connect (south of western Myanmar). North of this point, there are water masses at about 100m that are not seen in the southern part of the Bengal Basin.

As above.
The southern front has moved further south to about 3°N and marks a distinct change in the deeper waters below about 100m which extend as a deepening and thickening wedge to 200m to the north.

An instructive section contrasting the different water mass structures in the Bengal and Andaman Basin. The effect of the sill at about 1000m is also evident. The deep topographic structures appear to be influencing the structure near the surface noted to the left.

95.5E

Section across the Andaman Basin showing distinct deeper water masses below 100m and a possible deeper current system causing the sloping water masses to the north of the section.

Continues the patterns noted for the section to the east (above). The Andaman Basin appears to be cut-off from the Bengal Basin at about 1500m depth. The 1000m water mass surface in the Andaman Basin is also irregular compared to the Bengal Basin.

ANALYSIS OF CHANGES IN NEODYMIUM DISTRIBUTION

Partly to confirm, and partly to extend, the analyses of water masses described above, we undertook an analysis of the distribution of Neodymium (Nd) and other water properties reported by Singh et al. (2012) for a transect along the Bay of Bengal. The data from Singh et al. (2012) was manually transcribed from their paper and analysed to classify the samples against Depth, Nd, Potential Temperature (PT) and Salinity (S). The data used in the analyses are appended to this report.

Technically, we used the HOPACH classification algorithm in the R software package with only one main level of classification (HOPACH implements a hierarchical classification scheme) and the "cosangle" distance metric after all variables were histogram scaled. For an explanation of the techniques used, please refer to Lyne and Hayes (2005). This yielded 8 classes which were plotted against latitude of the transect as shown in Figure 4-11. Error! Reference source not found.
Figure 4.11. Water sampling stations from the Singh et al. (2012) study are classified into 8 classes (colour coded in the plot) as described in the text, and plotted against the latitude of the transect. Two vertical dashed lines are drawn at approximate locations that we visually demarcated to be locations showing significant changes in the composition of water mass classes by latitude.

Bearing in mind that this analysis is for a transect, the two main demarcations identified are:

1. At approximately 16.5°N: this boundary appears to be the offshore expression of the boundary emanating from the “opening” between Myanmar and the Andaman Ridge (at about 15°N) identified in the previous 3D water mass analyses. There may also be "contortions" in the boundary as it spans across the width of the Bay of Bengal, so we don’t expect precise matchups with the 3D analyses. The approximate match lends support to the hypothesis that there is a major boundary separating the northern waters of the Bay of Bengal from those located south of about 16.5°N in the "core" of the Bay of Bengal.

2. At approximately 10°N: this appears to be the front that separates the core waters of the Bay of Bengal from the more open ocean water masses south of the BoBLME study area. North of this boundary, the water properties would appear to be influenced by constraints on the circulation and mixing of water masses in the Bay of Bengal, whereas south of this boundary are equatorial water masses of the Indian Ocean.

In summary:

1. Changes in surface and deeper waters are intimately linked to changes in bathymetry.
2. The Andaman Basin surface and water deeper than about 1000m are distinct to those in the Bengal Basin.
3. Waters to the east and west of the Sri Lanka have different features shallower than about 100m.
4. The connection between the Bengal Basin and the Andaman Basin at the “opening” between Myanmar and the Andaman Ridge (at about 15°N) affects the surface water mass structures differences between the basin.
5. The Andaman Basin appears to have very different water mass formation and structures as compared to the Bengal Basin.
6. Surface water masses in the Cocos Basin appear to be different compared to the Bengal Basin.
7. Disturbances in the water mass boundaries are seen when water masses meet up with the continental slope.
8. Two separate analyses of water mass classifications were carried out to identify the structure of water masses in the Bay of Bengal and the location of major frontal boundaries.
9. The 3D analysis was able to identify key features of the structures and how they related to the topographic boundaries and links between the Basins in the Bay of Bengal (and the Arabian Sea).
10. Two major frontal boundaries identified from the Neodymium data appear to correspond to boundaries between the core waters of the Bay of Bengal and the fresher waters in the northern sector (with source waters from the Ganges), and in the southern boundary, between the core waters and the equatorial waters of the Indian Ocean.

### 4.4 Primary productivity

Primary productivity (proliferation of plants) is influenced strongly by levels of sunshine, nutrients and oxygen. In the worlds oceans primary productivity is mostly produced in the surface waters due to the limitations of sunshine penetration in other areas and planktonic plants (usually phyto and pico-plankton) produce most of the primary productivity in this zone. In most tropical seas, a thermocline separates warm surface waters from cool deeper and acts as a density barrier to the upward cycling of deeper nutrient-rich water into the surface water. Normally, nutrients are lost from the surface as organic detritus sinks into colder deeper water and do not get recycled. And although sunshine is plentiful, nutrients are often not, and plant productivity remains relatively low. The Bay of Bengal basin, like many other tropical seas is a biologically low productive basin (Figure 4.11). This is largely due to the strong stratification driven by the immense fresh water flux and in parts due to the shallow, oxygen-poor, euphotic zone, especially in the northern Bay due to immense suspended sediment load.

Sub-surface cold-core eddies in play an important role in supporting enhanced biological production in the Bay of Bengal basin (Section 4.2, Figure 4.7). These eddies produce due up-ward pumping of nutrients across the thermocline allowing pico- and phytoplankton to proliferate where sunlight penetration is adequate. Cyclones and storms can produce the same effect, but usually for much less sustained periods.

On coastal shelf and slope habitats upwelling of deep, nutrient-rich water occurs. This results when currents persist at 90 degree to the right of the coastline due to a process called Ekman transport. Some limited upwelling occurs along the southern coast of Sri Lanka in Summer due to the
Southwest Monsoon Current (Figure 4.4, 4.5) (check???) and along the east Indian coastline during the Winter Northeast Monsoon due to the East Indian Current (Figure 4.3, 4.5) (check???).

The coastal boundary layers do, however, support high primary productivity due to the enormous amount of dissolved and particulate material that enters the Bay of Bengal with the river water and shallow seas. River run off can provide sustained nutrient and oxygen rich water for long periods during the Summer monsoons and high primary productivity in the coastal surface waters. During the Winter NE Monsoon the North Equatorial Current and the East Indian Current (Figures 4.3 and 4.5) help draw nutrient rich water from the Strait of Malacca into Andaman Sea creating an annual productivity bloom.

A highly productive benthic boundary layer with these characteristics is also described in a limited area the western Bay of Bengal by (Edmond et al. 1979 and Broecker et al. 1980). This occurs along much of the east Indian coast where a nutrient rich benthic environment occurs within the mixed photic zone (e.g. <100 m depth). Nutrient input from river systems along this coast also provide additional nutrients and subsequent high productivity into this shelf zone.

Other areas in the Bay of Bengal that support high primary productivity are where coral reefs and raised sea bed features occur. Coral reefs occur in the photic zone and are abundant in a range of provinces (See Section 8). The symbiotic algae within corals (Zooxanthellae) are a critical source of primary productivity in these habitats and form the basis of diverse and productive coral reef systems. Raised seabed features such as seamounts force deeper, nutrient-rich currents to the closer to the surface (Figure 4-13). Where these currents reach the photic zone productivity hot spots can occur.

4.5 Geomorphology

The geomorphology of the Bay of Bengal Large Marine Ecosystem is depicted in Figures 4.12 to 4.15. The region is dominated by a large central deep water basin which deepens from north to south to >4000 m (Figures 4.1, 4.2). This basin is characterised by a sediment fan being deposited from the large river systems in the north. This is the world’s largest submarine sediment fan with an area of 2.8-3.0 x 106 km2 (Sarma et al, 2000). It extends from the Ganges/Brahmaputra delta, around 20° N latitude to south of 7° S, with a maximum width of about 1000 km around 15° N latitude (Figure 4.1, 4.3) and a maximum thickness of about 6 km (Figure 4.14).
The continental shelf is narrow in most areas with exceptions where large river basins form broader areas of sloping sediment. Continental shelf habitats are also narrow and relatively steep (Figure 4.13, 4.15), dropping from less that 100 m depth to greater than 500 m depth is a relatively short distance. An exception is the Andaman Sea and around the Andaman-Nicobar Ridge where a more complex configuration of Geomorphological features has developed. These included ridges a unique complex of habitats types such as ridges, canyons, abyssal hills and plains, plateaus and terraces. This heterogeneity in geomorphology supports a complex array of habitats by way of depth zones, current patterns, sediment grain sizes, as well as different temperature and oxygen zones (Figures 4.16, 4.17).

More detail to follow in future drafts and in province sections.

4.6 Terrestrial and riverine input

The Bay of Bengal is characterised by large river systems along much of its coastline (Figure 4.18). These include the large iconic delta systems of the Ganges, Meghna, Brahmaputra, and Irrawaddy Rivers. Describe more in next draft. These systems have a major influence on ecological habitats by their influence on depth and salinity characteristics, as well as suspended sediment concentrations, oxygen levels, sunlight penetration depth and nutrient concentrations. Each of these have critical defining influences on a range of important habitats types including mangrove, seagrass, coral reef, estuarine and open ocean environments. More detail to follow in future drafts and in province sections.
Figure 4-13. Geomorphological features of the Bay of Bengal Large Marine Ecosystem
Figure 4-14. Bay Bengal Sea bed Slope was extracted from Seabed Slope (degrees) developed by Harris and Whiteway (2009) originally derived from the ETOP-2 bathymetry grid (ETOPO-2, 2006).

Figure 4-15. Total Sediment thickness (km) was extracted from a dataset compiled for the Worlds Oceans and Marginal Seas by the National Geophysical Data Centre. The Smin grid was derived from a number of sources by Divins (1998).
Figure 4-16. Bay of Bengal Shelf (0-200m), Slope (200-2000m) and Abyss <2000m depth derived from ETOPO-2 (2006).

Figure 4-17. Bay of Bengal Bottom Ocean water temperature from the NOAA World Ocean Atlas (2005).
Figure 4-18. Bay of Bengal Bottom Dissolved Oxygen from the NOAA World Ocean Atlas (2005).

Figure 4-19. Bay of Bengal Region River Network (Lehner, B. et al., 2006) and Topology (ETOPO-2, 2006)