Observed Seasonal Variability of Barrier Layer in the Bay of Bengal

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Extended Abstract

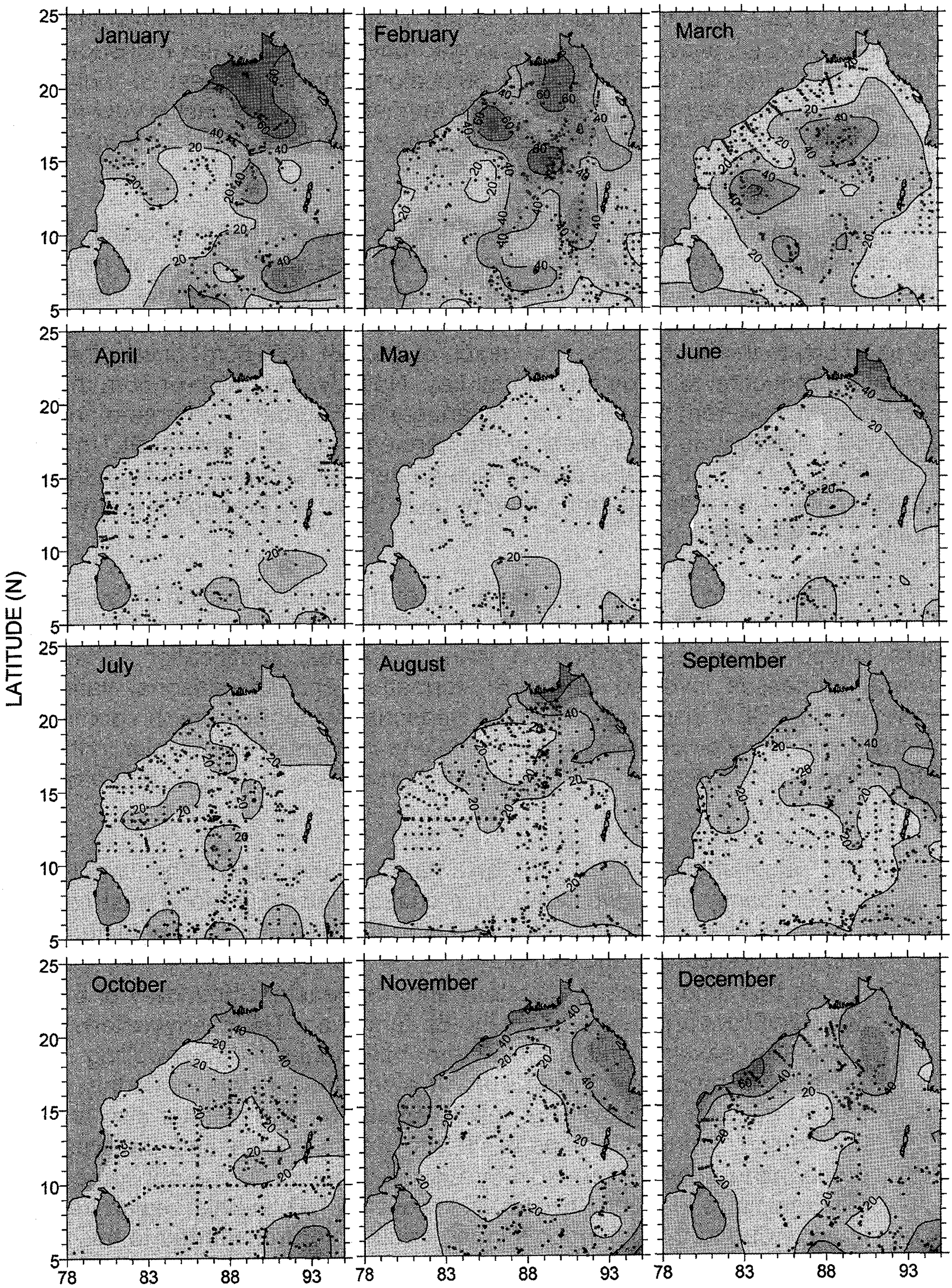
The objective of this study is first to resolve the spatial and seasonal variability of BL in the bay using 'the most comprehensive' data set available for the bay and then to understand the formation mechanisms and variability in the light of the known dynamical and thermodynamical processes. The most recent study [Masson et al., 2002] on the BL variability in the bay was based on the World Ocean Atlas (WOA98) of Levitus [1998]. The temperature and salinity profiles in the bay have increased considerably after the release of WOA98. The WOA98, itself has been updated to WOA01 in 2001. Further, the deployment of ARGO profiling floats in the bay since 2002 has generated many additional profiles. In addition to the ARGO data and the updated WOA01, the hydrographic data collected from the bay under several Indian national programs and archived in the Indian Oceanographic Data Centre (IODC) was also considered in the present study. The WOA98 and WOA01 consist of only limited data from the IODC archive, especially from the Exclusive Economic Zone of India. Therefore, the combination of these data from the three different sources (WOA01, ARGO and IODC) provides 'the most comprehensive data set' for the bay to resolve the BLT structure and its variability in a much better scale than in the past.

The seasonal evolution of BLT shows large variability with rich spatial structure (figure 1). The annual minimum (10 – 20 m) covering almost the entire bay is observed during April-May. By June, when the summer monsoon sets in, thick BL (~ 40 m) occurs in the northeastern bay. By August, the BL formed in the northeastern bay gets more organized in space and spreads westward. BLT about 30m is found all along the eastern bay, with the thickness increasing towards the coast. Although the data coverage is sparse very close to the head and northeastern bay during June and July, it is reasonable to presume that the extrapolated contours are realistic as the sea water becomes more and more fresh towards the head and northeastern bay (where the major rivers of Ganges, Brahmaputra and Irravadi dump large volume of fresh water). By September, the region of thick BL extends further westward from the northeastern bay and reaches the central bay. This westward spread of thick BL to the central bay is seen from June to October as a distinct feature of the summer monsoon variability of BL. With the beginning of the winter monsoon in November, the distribution of BLT shows a distinct change from that of summer monsoon. For the first time, the BL thickens up to 50m along the east coast of India. The offshore extent of the patch of the thick BL formed along the coast is very narrow, comparable to the width of the EICC that hugs the east coast of India during November .

In December, while the 50m thick BL is seen along the east coast, BLT of 30m spreads offshore. In January, the thick BL that was present all along the east coast of India and in the eastern bay during November gets weakened. Instead, the BLT becomes more organized in the northern bay extending from the head bay to the central bay. The region of thick BL (50–60m) covers the head bay with a reduction towards the central bay. Notably, the patch of 60m thick BL is found detached from the head bay in January. In February, the area of thick BL (30m) gets enlarged to cover most of the northern bay. The annual BLT maxima in amplitude (60m) and spatial extent, is seen during February. Although the BLT and its spatial extent decrease by March, thick BL is still present in a large area confined to the central bay.

The BL formation is essentially the result of haline stratification in the surface layer caused by excessive fresh water flux (E-P+R). In this case, the MLD is more limited by haline stratification than by thermal stratification. There are several processes involved in the BL formation and its seasonal variability. However, the BLT distribution and its seasonal variability are predominantly controlled by the two contrasting monsoons, the carriers of fresh water to the bay. Summer monsoon sets in the following major processes in the bay that affect the distribution of BLT.

- The alongshore winds of the summer monsoon (the winds are predominantly south westerly) drive coastal upwelling along east coast of India causing divergence in this region to cause for the shoaling of ILD and MLD resulting in the thin BL.
- During this time along the eastern and northeastern boundary of the bay two significant processes affect the BL formation. The southwesterly winds along the eastern and northeastern bay generate downwelling Kelvin waves that propagate towards north along the eastern boundary of the bay. In addition, downwelling Kelvin waves from the equator also arrive in this region during this season. These Kelvin waves and the westward propagating downwelling Rossby waves, together cause convergence in this region to deepen the ILD. However, MLD in this region remains shallow due to the presence surface fresh water transported to this region through the Ekman drift.


January
February
March
April
May
June
July
August
September
October
November
December
LATITUDE (N)
LONGITUDE (E)
25
20
15
10
5
78
83
88
93

- During summer monsoon high saline 'monsoon drift current' enters the bay reducing the haline stratification that results in deepening of MLD and shoaling of the BL.

During winter monsoon (November–February), the winds reverse from southwesterly to northeasterly. The EICC flows equatorward during November-December. During January, the EICC reverses to flow poleward as the western branch of the SAG that matures during February-March.

- The northeasterly winds force upwelling along the eastern boundary of the bay and the Ekman drift moves the surface water towards the east coast of India. Therefore, along the eastern boundary of the bay the divergence associated with the upwelling shoals the ILD and MLD, where as the movement of the surface freshwater towards the east coast of India forces convergence to deepen the ILD. However, the MLD shoals here due to the presence of low saline water at the surface.
- Another significant process in the bay during November-December is the presence of the cyclonic gyre. The cyclonic gyre shoals the MLD and ILD to form thin BL.
- During January the northern bay experiences negative wind stress curl that drives the SAG. The interior Ekman pumping associated with the SAG deepens the ILD. However, MLD in the gyre remains shallow due to the presence of low saline surface water. The thick BL during February is spatially coherent with the SAG.

The BLT is minimum during April-May. The seasonal buildup of warm water in the bay during April-May (spring warming) is a distinct feature of the north Indian Ocean. The SAG redistributes the fresh water received in the northern bay to the southern bay. Subsequently, during April-May the SSS increases due to mixing by the prevailing moderate winds. The increase in SSS results in reduction of stratification that results in deepening of MLD and weakening of BLT during this period.

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