### 8.2. Velocity

The velocities during the Spring Intermonsoon are generally much weaker than those found in either of the two monsoon seasons (see Fig. 7). The record is marked by inertial and tidal period variability, as well as two lower-frequency events. The first occurs around April 1, when the velocities observed beneath the mixed layer are stronger than those within it. The second occurs in the first half of May, and is accompanied by slow turning of velocities from southwestward to northwestward. Both of the velocity events are concurrent with temporary cooling noticed in the subsurface temperature record.

## 9. Discussion and summary

Time-series collected at the moored array are dominated by the twice-yearly cycle of mixed layer deepening and cooling that characterizes the monsoonally forced Arabian Sea. Concurrent meteorological observations and fluxes, detailed in Weller et al. (1998), showed that the surface forcing of the NE and SW Monsoon seasons differed dramatically. During the NE Monsoon, surface forcing was characterized by moderate wind stress with synoptic (5–7 day) variability and a strong net buoyancy loss at the sea surface. The buoyancy flux was due to net heat loss and to the flux of density associated with evaporation, which dominated over the nearly negligible precipitation. The SW Monsoon was characterized by strong, sustained wind stress; initially, the buoyancy flux was near-neutral and later there were strong net buoyancy gains by the ocean.

Despite the difference in the surface forcing, the essential upper-ocean response—a deepening and cooling of the mixed layer—was the same in both monsoon seasons. However, because of the difference in the forcing, many aspects of the response, and thus of the observed upper-ocean variability, were different. Diurnal variability of the sea-surface temperature was noticeable throughout the NE Monsoon, and the diurnal variations in the mixed layer depth were very pronounced. The moderate wind stress, combined with strong diurnal variability in the mixed layer depth, suggests that the primary local mechanism driving the entrainment and deepening of the mixed layer during the NE Monsoon was convective overturning. The oceanic response confirmed this, with low vertical shear and a generally stable gradient Richardson number during mixed-layer deepening. The NE Monsoon mixed layers were the deepest in the record.

Convective entrainment during the NE Monsoon in the Arabian Sea has been noted before. Warren (1994) comments that convective overturning in the winter in the Arabian Sea had been inferred to penetrate to depths of about 100–150 m. Banse (1984) noted that the central Arabian Sea had higher phytoplankton productivity than other subtropical gyres and speculated that in the winter convective deepening brought nutrients into the surface layer. Shetye et al. (1992) discuss wintertime convection in the Arabian Sea and focus on that process off the coast of Pakistan and India, where they believe that sinking of relatively fresh coastal water may contribute to maintaining a salinity minimum at depths of about 150 m. In our case, the convection occurs within a salty surface layer resting on top of a fresher seasonal thermocline. As the NE Monsoon progresses, the surface layer becomes saltier, roughly by the amount corresponding to the salt left behind by evaporation at the surface. Restratification during the Spring Intermonsoon is achieved by surface heating, and the approximately 100-m-deep surface layer created during the NE Monsoon is then capped over by a shallow, warm mixed layer.

The diurnal cycling in mixed layer depth during the NE Monsoon may be one reason for the weak signal of wind-driven flow found in the observed velocities. During the heating phase of the day, momentum from the wind stress would be trapped in a shallow layer and result in higher wind-driven flows than at night, when the momentum is distributed over much greater depth and a much weaker wind-driven flow would be present. Some downwind shear is evident in the progressive vector diagrams from the NE Monsoon. This also could provide for effective horizontal homogenization, as the shallow daytime surface layer is advected horizontally relative to deeper layers by