Blue carbon is defined as the carbon captured and stored by global coastal ecosystems (mangroves, saltmarsh and seagrass). Blue carbon research has expeditiously over the last decade, following the 2009 UNEP report on the efficiency of these habitats to act as carbon sinks. Mangroves have particularly been prioritized in atmospheric carbon mitigation strategies as they have been recognized for their significant role as carbon sinks. Despite research efforts, there is still a notable knowledge gap on the potential of various mangrove species to store carbon within different geographical regions. Currently scientific literature provides snapshots of carbon storage by coastal ecosystems in Africa, Southeast Asia and South America. This study provides the first comprehensive assessment on carbon storage for a mangrove forest in a warm-temperate estuary in South Africa. Carbon storage was quantified for *Avicennia marina* mangrove species at the Nxaxo Estuary, on aboveground carbon pools (wood, leaf litter, pneumatophores) and sediment carbon pools, using both elemental analysis and loss on ignition techniques. The results from the two aforementioned techniques were found to be weakly correlated. No carbon variability was found at an estuary level however, the results indicate that the carbon storage here is considerably lower than the carbon storage recorded for other regions. The total carbon storage for the (9.5 ha) mangrove area was quantified to be 1140.25 Mg C. Mangroves in warm-temperate regions of the South African coastline occur at one of the southernmost limits globally and the high-energy nature of this coast restricts these habitats to sheltered estuarine areas. As a result, the growth and productivity of mangroves in these regions can be influenced by estuarine and climatic dynamics. This study shows that the capacity for storage by mangroves is variable and that blue carbon studies in different geographic areas should provide estimates from direct quantification and allometric equation approaches. Carbon storage has been recognized as a valuable ecosystem service therefore an accurate estimation of the carbon storage potential for different regions is essential for climate change mitigation and emission offset projects.