The Weddell Sea is the largest Southern Ocean embayment. Its well developed gyre plays host to a ribbon-like pattern of bands of thicker ice separated by thinner ice. Such patterns are possible due to the vast size of the gyre as well as the year-round presence of sea ice. A stand-alone implementation of the CICE4 model was used to investigate the structure of the sea ice thickness in the Weddell Sea from 1998 to 2008. Processes that contribute to the sea ice thickness structure such as thermodynamic ice growth / decay, differential ice advection and ridging / rafting were examined. Ridging was greatest where sea ice, moving with the predominantly easterly winds and the westward coastal current, impacted the coastal promontories or protruding ice shelves, such as Vestkapp. By intercepting the drifting pack, first-year sea ice in these locations quickly thickens to a mean winter thicknesses of about 3 m. Under favourable wind regimes this thick ice moved away from the coast towards the centre of the Weddell Gyre. It was then distorted into bands of area-averaged thick ice that were separated by thinner, largely thermodynamically grown ice. The thinner ice, typically less than 1.5 m, originally formed in the shelf front polynyas in the southern Weddell Sea, such as the western Ronne Ice Shelf, and then drifts into the gyre. For the Weddell Sea our model suggests that the volume of thermodynamically grown ice dominates the volume grown by deformation.