Relative Countably Compact

Let $X$ be a topological space and $M$ a subset of $X$. $M$ is called relative countably compact if every infinite subset of $M$ has a limit point in $X$.

The following example shows that if $M$ is relative countably compact, then $\overline{M}$, the closure of $M$, need not be countably compact (in its relative topology).

Let $\omega$ be the first countable (infinite) ordinal, and $\Omega$ the first uncountable ordinal. Let $X = [0, \omega) \times [0, \Omega) - \{(\omega, \Omega)\}$ and $M = \{[0, \omega) \times [0, \Omega)\}$. Any infinite subset of $M$ contains a countably infinite subset $S$ which is contained in $T = [0, \omega) \times [0, \nu]$ for some countable ordinal $\nu$. Since $T$ is compact, it contains a limit point of $S$. This shows that $M$ is relative countably compact, and in fact, countably compact.

But the subset $[0, \omega) \times \{\Omega\}$ of $\overline{M} = X$ does not have any limit point in $\overline{M} = X$.

Another example (in a non-$T_1$ space): Let $X$ be any infinite set and $x_0 \in X$. Let the open sets be empty set and any set containing $x_0$. Let $M = \{x_0\}$. $M$ is relative countably compact. $\overline{M} = X$ and $X$ is not countably compact since $X$ is an infinite set that does not have limit point.