Unintentional mortality of higher trophic-level species in commercial fisheries (bycatch) represents a major conservation concern as it may influence the long-term persistence of populations. An increasingly common strategy to mitigate bycatch of harbor porpoises (Phocoena phocoena), a small and protected marine top predator, involves the use of pingers (acoustic alarms that emit underwater noise) and time-area fishing closures. Although these mitigation measures can reduce harbor porpoise bycatch in gillnet fisheries considerably, inference about the long-term population-level consequences is currently lacking. We developed a spatially explicit individual-based simulation model (IBM) with the aim to evaluate the effectiveness of these two bycatch mitigation measures. We quantified both the direct positive effects (i.e., reduced bycatch) and any indirect negative effects (i.e., reduced foraging efficiency) on the population size using the inner Danish waters as a biological system. The model incorporated empirical data on gillnet fishing effort and noise avoidance behavior by free-ranging harbor porpoises exposed to randomized high-frequency (20- to 160-kHz) pinger signals. The IBM simulations revealed a synergistic relationship between the implementation of time-area fishing closures and pinger deployment. Time-area fishing closures reduced bycatch rates substantially but not completely. In contrast, widespread pinger deployment resulted in total mitigation of bycatch but frequent and recurrent noise avoidance behavior in high-quality foraging habitat negatively affected individual survival and the total population size. When both bycatch mitigation measures were implemented simultaneously, the negative impact of pinger noise-induced sub-lethal behavioral effects on the population was largely eliminated with a positive effect on the population size that was larger than when the mitigation measures were used independently. Our study highlights that conservationists and policy makers need to consider and balance both the direct and indirect effects of harbor porpoise bycatch mitigation measures before enforcing their widespread implementation. Individual-based simulation models, such as the one presented here, offer an efficient and dynamic framework to evaluate the impact of human activities on the long-term survival of marine populations and can serve as a basis to design adaptive management strategies that satisfy both ecological and socioeconomic demands on marine ecosystems.