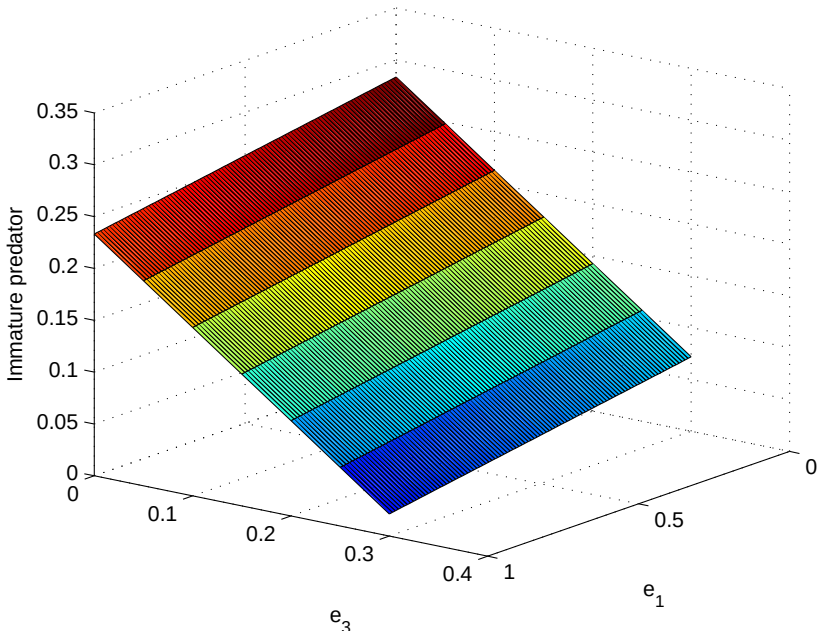

Fig.12. Immature predator biomass extinct to reach MSTY at $e_1 = 1.003$ and $e_3 = 0.33$.

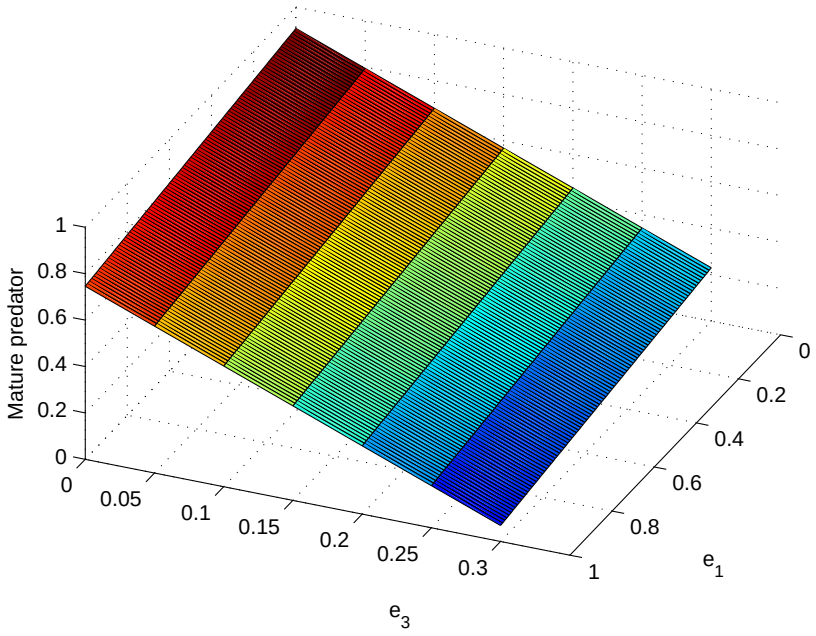

Fig.13. Mature predator biomass extinct to reach MSTY at $e_1 = 1.003$ and $e_3 = 0.33$.

6 Conclusion

This article describes the impacts of harvesting to reach the MSY or MSTY level in a stage structured population model. Some of the results are derived analytically and some others are shown numerically using the simulated parameter sets. It is observed that if prey is the only target species for harvesting, then MSY always exists. In this situation prey biomass reduces to exactly half of its value

in compared to unexploited system. Legovic et al. (2010) showed that in traditional prey predator systems, fishing to reach MSY of the prey population only will cause the extinction of predator population but in this case it is a sustainable policy (see Fig.1). It is also shown that harvesting the mature predator to reach MSY is a sustainable policy but predator biomass reduces exactly half of the unexploited system. One of our important investigation is to reach MSTY when combined harvesting effort is imposed to the prey and the mature predator. We have analyzed the impacts of common harvesting effort analytically and also illustrated numerically. It is observed that MSTY may exist (see Fig.3), and if it dose not exist then it is due to extinction of either the predator (see Fig.4.), or prey species (see Fig.5).

Lastly, we have discussed about the global MSTY taking independent harvesting efforts. It is seen that if global MSTY exists, it is independent of cachability coefficients. This result is a great achievement for a stage structured population model. Fig. 3 shows that MSTY under combined harvesting effort exists and is equal to 1.399 where as the same system exhibits the result that the global MSTY if exists is equal to 1.42 which is larger than MSTY under combined harvesting effort. In another simulation it is proved that though Hessian Matrix with respect to the selective harvesting effort is negative definite i.e., necessary condition for global MSTY is satisfied but due to extinction of predators species global MSTY does not occur for harvesting the prey and mature predator.

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