A preliminary effort to evaluate the effectiveness of the National Marine Protected Area of Alonissos, Northern Sporades (NMPANS)

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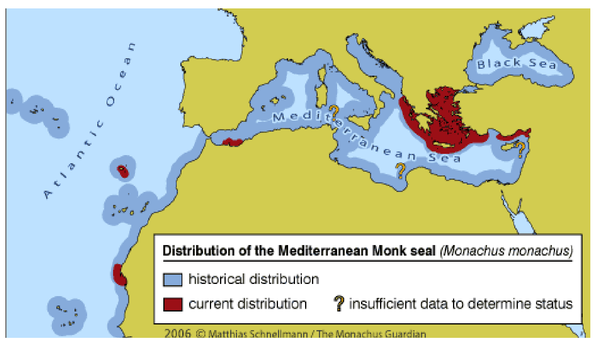
National marine park of Alonissos

Marine protected areas (MPAs) have been established to conserve biodiversity and protect vulnerable species and ecosystems; in case their conservation objective is the protection of highly mobile marine mammals, larger boundaries are usually set.

An important marine mammal area (IMMA) covering more than 10,000 km^2 is the National Marine Park of Alonnisos, Northern Sporades (NMPANS) established in Greece in 1992 for the protection of the endangered Mediterranean monk seal (*Monachus monachus*) and its natural habitat (Karamanlidis et al. 2004).



Monk Seal

In the case of the NMPANS, a systematic monitoring of annual monk seal pup production has been performed since 1990 by the NGO MOm in collaboration with the management body of the NMPANS.

The main threats of monk seal are deliberate killing, human disturbance, and the low population number. It has a 11-12 months gestation period and no natural predators.

Logistic equation with delay

In this study, the population dynamics of the Mediterranean monk seal has been explored using annual recordings of pups during 1990-2017.

The population dynamics of the Mediterranean monk seal in the NMPANS was studied using the modeling approach developed by Politikos & Tzanetis (2009). Further to the data on monk seal pups from 1990 to 2004 used in the frame of the latter assessment, the time series was extended up to 2017. The theta logistic-type with delay model was rerun and recalibrated. The main assumptions of the model are:

- Density dependence within the population is taken into account.
- The NMPANS has a spatial capacity of supporting the seal population.
- There is a delay in the growth rate of the population (~12 months).
- An intraspecific competition is considered implicitly between members of the population through the parameter θ.
- The model is described through the following differential equation:

$$\frac{dN}{dt} = rN(t)\left(1-\frac{N(t)}{K}\right)^{\theta}, r>0, K>0, \theta>1$$

$$N(t) = \varphi(t), t \in [-\tau, 0]$$

$$\tau = 1$$

where N=N(t) is the size of the population at time t, r=0.79 is the intrinsic growth rate, K=46.6 is the environmental average carrying capacity, τ=1 is the delay of one year for pups to become adults, and θ=3.2 is a term that may encompass different types of intraspecific competition among the members of a population. For the case of monk seal, an increased territorial competition may appear because of limited space for breeding and avoid bad weather during winter (Status report, 2005).

Results

The inclusion of delay and intraspecific competition has given the possibility to the model to produce cycles, a characteristic that is being rather clearly noticed in the fluctuations of the number of pups (Fig. 1). As there are no estimates of the abundance of adult seals, the latter was assessed considering that the ratio of the adult population to pups in Sporades was mentioned to be around 6.2:1 (see Politikos & Tzanetis, 2009), suggesting an inherent uncertainty in those estimates.

Model outputs have showed interannual fluctuations of fixed frequency throughout the years, the amount of time between peaks being four years (Fig. 1), which may be related, partly at least, to reproductive traits of the species. Moreover, during the period under study an overall stable trend for the Sporades monk seal population seemed to exist.

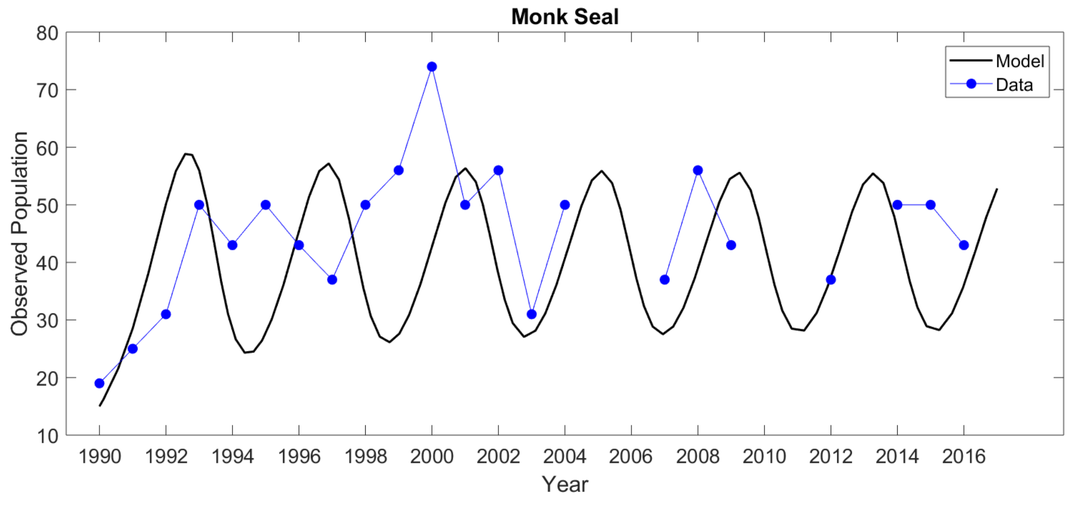


Fig. 1. Prediction of the delay model (black line) against data (blue dots) using a logistic type model with delay.

Discussion

Our findings based on monk seal pups' records suggest that the NMPANS appears to be successful in keeping the local Mediterranean monk seal population at rather stable levels, at least during the study period.

The observed and simulated stability, however, may indicate that the marine park has reached its spatial limits for supporting a further increase of the population, a point that should be considered and further explored while setting updated conservation objectives and respective targets for this iconic species.

What is more, certain marine caves, a crucial habitat in the life cycle of the Mediterranean monk seal, may be impacted by climate change. Hence, it is important to address points related to their ecological quality through suitable monitoring activities, such as those conducted under the Marine Strategy Framework Directive D1 and D6, as they may also affect the observed population stability.

The application of economic valuation to inform the management of natural resources in the NMPANS has showed that the willingness-to-pay (WTP) for the preservation of seals was quite higher than for other conservation priority components, underlining the public interest in contributing to the conservation of the emblematic monk seals (Vassilopoulos *et al.*, 2019).

The adoption of an integrated approach aiming at the sustainable management of the NMPANS, should be linked to the Programmes of Measures (PoMs) of the MSFD (e.g. related to monk seal habitat restoration), and may be supported by suitable economic arrangements (e.g. entrance fees) within the NMPANS.

References

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