Using seasonal variation in individual energetic requirements to simulate energy use in a population of harbor seals (Phoca vitulina)

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ABSTRACT

Harbor seals are a large-bodied and abundant marine predator in the ecosystem of the San Juan Islands, USA, and therefore may impact the success of marine protected areas by preying on recovering fish species. Understanding prey consumption first requires an understanding of individual energetics and their potential seasonal variation to simulate population energetics. We used time-depth recorder data to quantify activity budgets of harbor seals to build a population-level bioenergetics model that considered breeding (15 June - 15 Sept) and non-breeding (16 Sept - 14 June) periods. A total of 11 female and 8 male seals were tagged at rocky habitat sites. Females increased energetic requirements can be combined with diet data in future models that estimate harbor seal consumption rates.

METHODS

A bioenergetics model was developed using regional data on activity budgets and abundance as well as data from other studies. Time-depth recorders were attached to harbor seals in spring and fall-winter 2007-2008 to estimate percent of time spent in three behavioral classes: diving, shallow-water activity, and hauled-out. These time budgets were used to calculate a proxy for field metabolic rate. A compared seasonal energy use between harbor seal sex and age classes. Sex- and age-specific gross energy requirements in each season (EGR) were calculated by Boyd (2002):

\[ EGR = \frac{\text{Watts} \times \text{Breeding Season Days}}{100} \]

Data were assigned probability distributions and Monte Carlo simulations were performed to calculate a distribution of outputs (Winship 2002). Variables were also systematically held at fixed values in sensitivity analyses to pinpoint factors that drive model outputs (Figure 2).

RESULTS

Body mass had the largest effect on model outputs, and estimates shifted in a roughly equal proportion to the shift in input body mass (Figure 4a). Most other variables (including fertility rates, Figure 4b) had smaller effects, and estimates were not shifted significantly by changing the input values. Body mass accounted for > 80% of variance in outputs when other values were fixed (Figure 5).

RESULTS, CON.

The prey consumption model was most sensitive to the input values of seal body mass, suggesting that body size alone was the greatest predictor of energy use in harbor seals. Prey consumption estimates based on energy use estimates should focus on taking this source of variation into account. Future models can use this seasonal energy budget as the basis for estimating consumption rates based on bioenergetics principles. These estimates can then be used to evaluate the potential contribution of harbor seal predation to mortality rates of recovering fish species in the Puget Sound Georgia Basin marine ecosystem.

CONCLUSIONS

The harbor seal population has recovered since the 1970s after passage of the Marine Mammal Protection Act and the cessation of sealing (Jeffries 2003). Although there are many depressed fish stocks of concern in the Puget Sound Georgia Basin marine ecosystem, little is known on how this large predator population may impact the recovery of fish stocks in candidate marine protected areas that are being considered for groundfish recovery (Figure 1).

LITERATURE CITED

