Comparison of modeling approaches using ESAS data for estimating Abundance patterns of seabirds in the North Aegean Sea

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Introduction
Systematic efforts to determine Important Bird Areas for the Mediterranean began in 2004 but have so far been limited to areas around Portugal and Spain. Our aim is to extend this effort to the Aegean, where our knowledge of seabird populations has been more limited. In this work we estimate the population of seabirds in the North Aegean Sea for four species and find the associated confidence intervals and distribution patterns. In addition we use and compare different models to find the most important parameters determining the abundance and distribution of the birds.

Survey at sea
Survey supervised by the Hellenic Ornithological Society (HOS) using ESAS methodology.
Survey period: May, July–August and September 2009.
Transect width: 300m for each side of the boat (for ferry boats we observed only one side).
Total area covered: 1337 km², 1.2% of N. Aegean area (381 km² in May, 540 km² in July–August and 418 km² in September).
Most of the time there were two observers on the deck (multiple observers reduce bias). Birds were counted in clusters. As a cluster we consider every gathering of birds of the same species observed at a certain moment. During the surveys in the sea, all species observed were recorded. Before analyzing the data, cluster sizes of flying birds were corrected for movement bias.

Data analysis
We focus on the four most abundant species of seabirds: (left to right below) Calonectris diomedea (CD), Hymenopus cristatus (PY), Phalacrocorax aristotelis (PA) and Lulus michaelli (LM).

Population estimates:

\[ N(\text{total}) = \frac{\text{Number of observed} \times A}{\text{Area(Transect)}} \]

'Simple' estimates using the above formula are compared with Distance Sampling estimates (using the CDS engine)².

Uncertainty estimates:
Jackknife and bootstrap

Covariates: We examined which covariates affect the distribution and abundance with both Maximum Entropy (Maxent) and Generalized Additive models (GAMs)³. Oceanographic data were downloaded from the Ocean color Web⁴, Combi Maps⁵, IMBE⁶ and NGDC Coastline Extraction⁷. Data on colony positions were provided by the HOS.

Population Estimates
'Simple' calculations seem to result in bigger numbers of individuals than the Distance estimation (see box-plot below). Bootstrap revealed wide range of values for \( N \), though the median was close to the other two estimates.

Aggregation in populations

Coefficient of aggregation

\[ D = \frac{\text{Variance of numbers per cell}}{\text{Average numbers per cell}} \]

Calculated over grids of 300x300 m squares for each day.

Factors influencing distribution and density

The influence of five groups of covariates on populations in May calculated with Maxent and GAMs (PA excluded from analysis due to insufficiency of data). Maxent results are % contribution to the distribution while GAM results are \( p \)-values for each group of covariates.

Discussion
Based on a survey of 1.2% of the area of the N. Aegean we estimated the total population of birds (for the four most abundant species) to be between 316,000 and 418,000, that is between 2.87 and 3.80 birds/km². The most abundant species are \( P. \) yelkouan and \( L. \) michaelli. For \( C. \) diomedea the results of the two methods were similar, while for \( P. \) yelkouan Distance estimated a larger population size. Distance takes into account several parameters to reduce detection bias. \( P. \) aristotelis and \( L. \) michaelli didn't seem to meet the criteria for distance sampling as they were not evenly distributed in the sample area and were strongly correlated to land. For these species the model fit might be incorrect.

On average, distributions of \( P. \) yelkouan and \( L. \) michaelli are strongly aggregated while \( P. \) aristotelis and \( C. \) diomedea are randomly distributed.

In identifying the important covariates, Maxent and GAMs do not always agree (see Phillips et al 2006). For our system, though the within-group rankings of covariate importance may differ we find overall agreement on the ranking of each group's importance. The most important factor affecting the abundance of \( C. \) diomedea seems to be weather, turbidity for \( L. \) michaelli and optical thickness for \( P. \) yelkouan.

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References