Comparison of modeling approaches using ESAS data for estimating

Abundance patterns of seabirds in the North Aegean Sea

Sylvia Zakkak[1], Maria Panagiotopoulou[2] & John M Halley[3]

1. Aristotle University of Thessaloniki, Department of Ecology, 54124 Thessaloniki, Greece, zak.sylvia@gmail.com
2. Hellenic Ornithological Society, Kastritsiou 8, 54623 Thessaloniki, Greece, buru97@gmail.com
3. University of Ioannina, Department of Biological Applications and Technology, 45110 Ioannina, Greece, jhalley@cc.uoi.gr

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 N. Aegean Sea for four species and find the associated confidence intervals and distributional 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

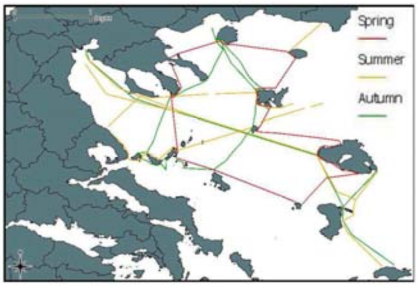
Survey supervised by the Hellenic Ornithological Society (HOS) using ESAS methodology[7]

Survey periods: 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: 1337km^2 – 1.2% of N. Aegean area (381km^2 in May, 540km^2 in July-August and 416km^2 in September)

Most of the time there were two observers on the deck (multiple observers reduce bias[6]). 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[5]



Data analysis

We focus on the four most abundant species of seabirds: (left to right below) *Calonectris diomedia* (CD), *Puffinus yelkouan* (PY), *Phalacrocorax aristotelis* (PA) *and Larus michahellis* (LM).

Population estimates:

$$N(\text{total}) \cong \frac{N(\text{observed}) \times \text{Area(total)}}{\text{Area(transect)}}$$

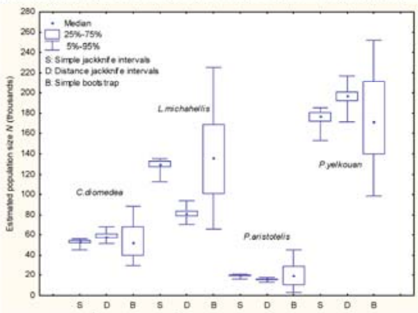
'Simple' estimates using the above formula are compared with Distance Sampling estimates (using the CDS engine)[1].

Uncertainty estimates: Jackknife and bootstrap.

Covariates: We examined which covariates affect the distribution and abundance with both Maximum Entropy (Maxent)[4] and Generalized Additive models (GAMs)[2,3]. Oceanographic data were downloaded from the Oceancolor Web[8], Coml Maps[9], IMBC[10] and NGDC Coastline Extractor[11]. 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.



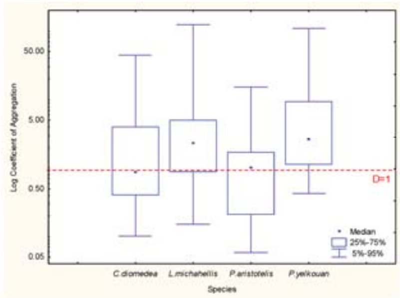
Estimate	CD	LM	PA	PY
Simple	53,000	128,000	20,000	175,000
Distance	57,000	78,000	15,000	194,000

Aggregation in populations

Coefficient of aggregation

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

Calculated over grids of 300×300m squares for each day



Factors influencing distribution and density

The influence of five groups of covariates on populations in May estimated with Maxent and GAM (*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.

	C.diomedia		*L. michahellis*		*P. yelkouan*	
Covariate group	**Maxent**	**GAM**	**Maxent**	**GAM**	**Maxent**	**GAM**
Weather	**89.1**	**0.000**	8.6	0.219	11.6	0.001
Organic matter	10.9	0.160	5.1	0.168	12.2	**0.000**
Turbidity	0	**0.000**	**76.0**	0.001	29.3	**0.000**
Time-place	0	0.410	6.5	**0.000**	1.2	0.277
Optical thickness	0	0.967	3.7	0.627	**45.7**	**0.000**

The two models generally agree on the rank of importance between the groups (except for turbidity for CD) but ranking of covariates within each group may differ.

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/km^2. The most abundant species are *P. yelkouan* and *L.michahellis*. 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. michahellis* 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. michahellis* 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.diomedia* seems to be weather, turbidity for *L. michahellis* and optical thickness for *P. yelkouan*.

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