



# SPERM WHALE ABUNDANCE ESTIMATES FROM ACOUSTIC SURVEYS OF THE IONIAN SEA AND STRAITS OF SICILY IN 2003

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## Abstract

Acoustic line-transect surveys for sperm whales were carried out in the Ionian Sea and Straits of Sicily, Mediterranean Sea, in 2003. A total of 17 whales were detected along 3846 km of designed survey track in the Ionian Sea, and 0 whales along 892 km in the Straits of Sicily. This total was insufficient to estimate a detection function, so further data were obtained from pseudo-random passages made elsewhere in the western Mediterranean in the same year. A detection function for dispersed animals (inter-animal spacing less than 1km) was calculated. The effective strip half-width was 10.0 km ( $n=40$ ). Assuming  $g(0)=1$ , the resulting abundance estimates for the Ionian Sea were 62 (with 95% lognormal confidence limits of [24,165]), and 0 for the Straits of Sicily. The low abundance estimate for the Ionian Sea indicates that careful monitoring of the population is needed in the future. During passages along the Hellenic Trench that were not part of the survey, several sperm whales including two aggregations were detected, suggesting that this may be a higher density area and ought to be considered as a separate stratum when designing future surveys.

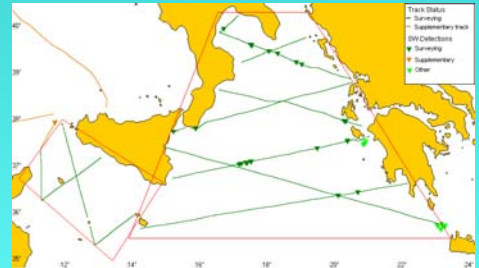


Figure 1. Survey track lines (green) and acoustic detections of sperm whales while surveying (dark green triangles) and off-effort (light green triangles). The Straits of Sicily block is on the left (0 detections), and the Ionian Sea block is on the right (17 detections).

## Introduction and Aims

- No population estimates of sperm whales in the Mediterranean at present; population may be isolated.
- Limited historical data from whaling records; status 'unknown' (Notarbartolo di Sciarra, 2002).
- Mediterranean sperm whales impacted by a number of anthropogenic threats.
- ACCOBAMS calling for Mediterranean basin-wide sperm whale survey.
- IFAW invited to trial acoustic survey methodology.
- This study provides abundance estimates of sperm whales for Ionian Sea and Straits of Sicily based on acoustic line-transect surveys between Aug and Oct 2003.

## Survey Design

- Acoustic line-transect survey.
- 2 survey blocks enclosed the areas of interest (figure 1).
- Ionian Sea block 271500 km<sup>2</sup> & Straits of Sicily 62100 km<sup>2</sup>.
- Track lines designed to provide even coverage of blocks.

## Field Methodology

- 6 knots survey speed along track lines.
- Dual-element hydrophone towed 200 m astern.
- RainbowClick software (Gillespie, 1997) used to:
  1. Scan for candidate clicks; clicks displayed real time & stored.
  2. Calculate bearings to clicks by comparing arrival times at elements.
  3. Trigger automated recordings (WAVs) of potential sperm whales.

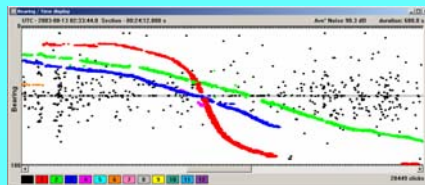


Figure 2. Tracks of four sperm whales over 10 minutes as the boat passes. The red whale is passed quickly as it is closest to the track.

## Post-survey Analysis

- RainbowClick used to assign clicks to individual whales based on bearings, inter-click intervals & spectral characteristics (figure 2).
- Matlab routine used each whale's clicks to calculate best position for whale by least-squares minimisation (figure 3).
- Perpendicular distances from whale to track calculated for Distance analysis.

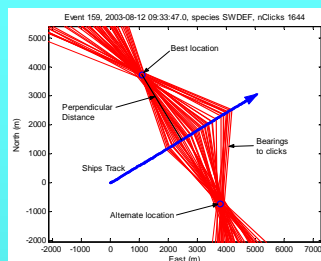


Figure 3. Reconstruction of a whale's position to estimate perpendicular distance from track line.

## Detection Function Estimation

- 17 detections made in the 2 survey blocks (Ionian 17, Straits of Sicily 0).
- Insufficient for detection function estimation.
- Supplemented by detections from pseudo-random passages across the western Mediterranean to give a total of 63 detections.

## Aggregations

- Nearest-neighbour analysis showed animals could be classified into 'clustered' and 'dispersed' strata based on a threshold distance of 1 km (figure 4).
- Histograms of perpendicular distances for these strata differed enough to warrant estimating detection functions for the strata separately (figure 4 inset).
- No animals classified as 'clustered' were detected within either survey block therefore only needed to estimate the 'dispersed' detection function.

## Detection Function Estimation

- Truncation width set at 20 km – two whales excluded.
- 40 'dispersed' detections used for detection function estimation.
- Fourier-series model fitted to truncated distance data (figure 5).
- Estimated strip half-width  $\hat{u} = 10.0$  km with  $\text{var}(\hat{u}) = 1.466$

## Density & Abundance Estimation

- Assume for this survey method  $g(0) = 1$ .
- Assumption supported by studies (Leaper et al, 2000; Barlow & Taylor, 2005).
- Only 8 transects in Ionian block - variance estimation in abundance estimates used Satterthwaite approximation.
- Straits of Sicily: 0 whales in 892 km of survey, so  $\hat{N} = 0$ .
- Ionian Sea: 17 whales in 3846 km of survey, so  $\hat{N} = 62$
- For the Ionian Sea:  $\text{var}(\hat{N}) = 751$ , lognormal 95% confidence limits of [24, 165] using the Satterthwaite approximation, density estimate is  $= 0.23 \times 10^{-3}$  with 95% confidence limits of  $[0.869 \times 10^{-4}, 0.606 \times 10^{-3}]$ .

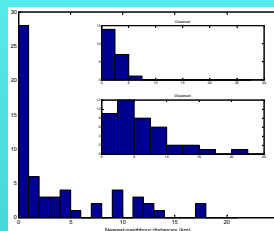


Figure 4. Nearest-neighbour distances. Insets show distance data stratified as 'clustered' (above) or 'dispersed' (below). No animals classified as 'clustered' were detected within either survey block; therefore only the 'dispersed' detection function was estimated.

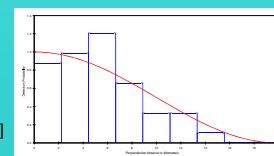


Figure 5. Perpendicular distances to dispersed sperm whales and fitted detection function.

## Discussion

- This analysis provides the first sperm whale abundance estimates for parts of the Mediterranean Sea.
- Abundance estimate for Ionian = 62; Sicilian Channel = 0 sperm whales.
- 'Dispersed' / 'Clustered' stratification probably a crude over-simplification of sperm whale behaviour (known to aggregate over range of spatial scales).
- Some degree of spatial dependence between 'dispersed' animals will result in possible underestimation of abundance confidence limits.
- Analysis assumes  $g(0) = 1$ , though  $g(0)$  may be slightly less.
- Two potential sources of error:
  1. Manual mis-assignment of clicks.
  2. Calculation of nearest-neighbour distances for stratification depends on least-squares fit; this can be ambiguous when travelling in a straight line.
- Larger groups may occupy East Ionian and future survey designs may need to treat this as a separate stratum.
- Sperm whale density is very low in the Ionian and Sicilian Channels compared to other regions of sperm whale habitat (summarised by Whitehead, 2003).
- Further surveys should be carried out in the future to monitor the status of sperm whales in this area.
- Further research required to establish if low densities due to human induced mortality – if so measures to reduce threats may be urgently required.

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