Fin whales (*Balaenoptera physalus*) summering in the Ligurian Sea: distribution, encounter rate, mean group size and relation to physiographic variables

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ABSTRACT

This paper investigates the distribution of Mediterranean fin whales (*Balaenoptera physalus*) between 1990-99 in the recently-established Pelagos Sanctuary for the Conservation of Mediterranean Marine Mammals. During the study period, 870 days were spent at sea, surveying a total of 73,046km, totalling 540 sightings of fin whales. Mean yearly whale encounter rates showed no significant differences in the first five years, but then steadily decreased between 1995-99. The highest encounter rates and largest mean aggregation size (mean=2.12; SD=1.32; SE=1.15) were in summer 1995 and the mean aggregation size throughout the study period was 1.75 (mode=1; SD=1.11; SE=0.05). Differences in mean aggregation size were significant between years, but not months. This is likely to be related to prey availability and to patchiness of plankton distribution. Generalised Linear Models were used to relate fin whale distribution to physiographic variables (mean, range and standard deviation of depth and slope, and distance from the nearest coast). Water depth was the most significant variable in describing fin whale distribution, with more than 90% of sightings occurring in waters deeper than 2,000m. This study demonstrates the deep water preference of fin whales in this area, emphasises the crucial role that this part of the western Ligurian Sea plays in the ecology of Mediterranean fin whales and provides recommendations for conservation and management measures in the area.

KEYWORDS: FIN WHALE; DISTRIBUTION; HABITAT; INDEX OF ABUNDANCE; CONSERVATION; EUROPE; MEDITERRANEAN SEA

INTRODUCTION

The fin whale (*Balaenoptera physalus*) is the only mysticete regularly occurring in the Mediterranean Sea (e.g. Duguy, 1990). Genetic analyses performed on Mediterranean specimens revealed the existence of a recently-diverged population, characterised by limited gene flow with North Atlantic conspecifics (Bérubé *et al.*, 1998). During the summer months, the species is known to concentrate in high numbers in the Corso-Ligurian Basin, described as one of the principal feeding grounds for fin whales in the Mediterranean Sea (Notarbartolo di Sciara *et al.*, 2003). Line-transect surveys, conducted in the western Ligurian Sea in August 1992 in order to assess the absolute abundance of cetaceans in the Basin during the summer months, yielded an estimate of 901 fin whales (SE=196.1, %CV 21.77, 95% CI 591-1,374), with a mean fin whale density ranging from 0.024 to 0.015 individuals km^{-2} (Forcada *et al.*, 1995; Gannier, 1997a; b). For a more detailed overview of the fin whale in the Mediterranean Sea see Notarbartolo di Sciara *et al.* (2003).

The oceanographic features of the Corso-Ligurian Basin result in an area of enhanced productivity (Jacques, 1990; Astraldi *et al.*, 1994) that hosts a richer cetacean fauna than bordering regions which are characterised by lower primary productivity (Notarbartolo di Sciara *et al.*, 1993). On 25 November 1999, in consideration of the local abundance of cetaceans, Italy, France and Monaco signed an Agreement for the establishment of an International Sanctuary for the Protection of Marine Mammals, which entered into force in 2002. The Sanctuary was listed among the Specially Protected Areas of Mediterranean Importance (SPAMIs) within the framework of the Barcelona Convention. The area encompassed by the Sanctuary lies between the French coast, northern Sardinia, and the coasts of Liguria and Tuscany in Italy (Fig. 1).

Mediterranean fin whales face a number of actual and potential anthropogenic threats, including collisions with vessels, chemical and acoustic pollution, entanglement in fishing gear (Notarbartolo di Sciara *et al.*, 2003) and disturbance by boats (Jahoda *et al.*, 2003). Collision events are common in Mediterranean waters (Anon., 1997; Pesante *et al.*, 2000) and may represent a major cause of non-natural mortality for fin whales. In fact, fin whales are the species most commonly struck by vessels worldwide (Laist *et al.*, 2001). Given the increasing number of ferries crossing the Pelagos Sanctuary, collisions are a growing source of concern for fin whales concentrating in this area during the summer months. Appropriate habitat use and distribution studies, to describe fin whales' habitat preferences and to investigate the existence of critical habitats for this species, are therefore urgently needed to aid implementation of management measures to regulate naval traffic, fishing and whalewatching within the Sanctuary.

This paper presents data collected in the waters of the Sanctuary during the summers of 1990-99. Dedicated cruises were organised to gather data on fin whale presence, distribution, encounter rate and aggregation size. The relationships with physiographic parameters such as water depth, slope and distance from the nearest coast were also investigated, as well as inter-annual patterns in mean aggregation size and encounter rate. The relevance of the results to the conservation of this species in the western Mediterranean Sea is presented at the end of the paper.

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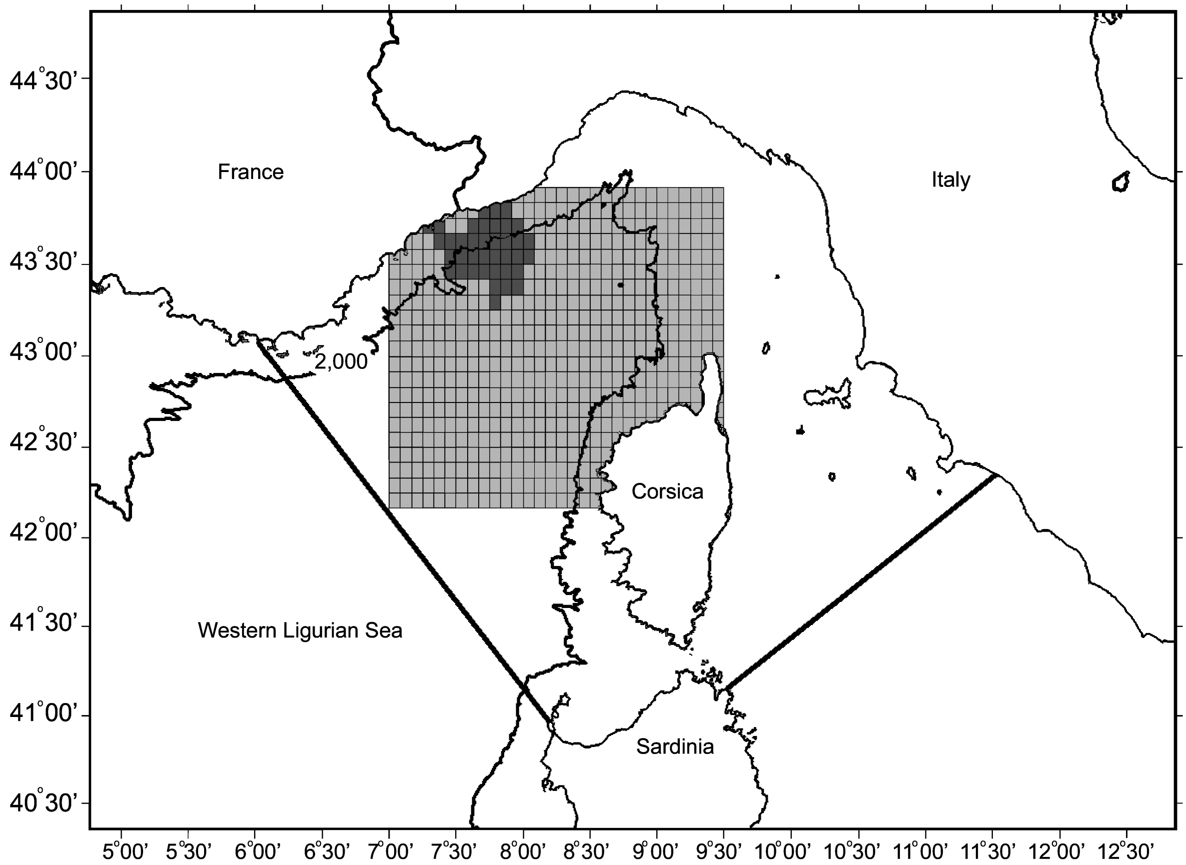

Fig. 1. The study area showing the 2,000m isobath, Sanctuary borders, 5' X 5' grid and in darker shading the sub-area.

MATERIALS AND METHODS

Study area

The study area included the continental shelf and offshore waters of the western Ligurian and Corsican Seas. Specifically, the study area was delimited by Saint Raphael (43°25'N, 6°50'E) on the French coast, Cape Mele (43°55'N, 8°10'E) on the Italian coast and Cape Corse (43°00'N, 9°25'E) and Girolata (42°20'N, 8°35'E) on the island of Corsica (Fig. 1). This area of approximately 24,000km² has a mean depth of 2,300m. The area is characterised by a narrow continental shelf, a marked cyclonic circulation present throughout the year, and strong upwelling currents (Jacques, 1994; Astraldi *et al.*, 1995).

Data collection methods and effort

This research was carried out between 1990 and 1999. Within each single year, effort varied in terms of length of field season and number of vessels used. The research platforms used in this study were auxiliary sailing vessels, equipped with inflatable craft, ranging in length from 15-20m, with a mean cruising speed ranging from 9-11km h^{-1}.

The tracks of the cruises were not designed to obtain an even coverage of the study area but rather to maximise encounters with whales (based on previous experience and available information), therefore increasing the number of sightings and the time spent with cetaceans.

During the searching effort, a minimum of one observer was positioned at each side of the vessel. Observations were made preferentially in flat seas and calm weather, defined as 'favourable conditions', and ceased when wind exceeded 3 on the Beaufort scale (wind speed = 5.4m s^{-1}). Searching effort start and end times were determined by departure and arrival times, start and end times of a sighting, sunrise and sunset, or major changes in weather conditions.

Whales were spotted by naked eye and were usually approached at short-distance to determine aggregation size, assess the presence or absence of sub-adults, and take pictures for photo-identification purposes (Agler *et al.*, 1990). In some cases the collection of biopsy samples for genetic (Bérubé *et al.*, 1998) and toxicological analyses (Marsili *et al.*, 1998; Fossi *et al.*, 2003), the assessment of possible disturbance caused by vessel approaches (Jahoda *et al.*, 2003) and tagging with time-depth-recorders (Panigada *et al.*, 1999; 2003) were also undertaken. Aggregation size was defined as the number of whales sighted within a radius of 1.5-2km of the research vessel. Whale sizes were compared visually to the sizes of nearby vessels of known length (i.e. the research or inflatable vessel), and all individuals <15m long were considered to be sub-adults; in accordance with data from the North Atlantic presented by Lockyer (1984) these whales were categorised as immature individuals and classified as suckling calves or weaning individuals following the criteria proposed by Orsi Relini (2000). Suckling and weaning whales were always accompanied by at least one adult (⩾16m long). Sighting co-ordinates were recorded using a Global Positioning System (GPS) and plotted on a digital map in *ArcView 3.2*. The distance from the nearest coast and the water depth for each sighting location were determined from this. Environmental data, such as visibility, Beaufort wind force and sea state were recorded every 60 minutes, or more frequently if changes in conditions occurred.

Data analysis

To provide detailed information on the relative abundance of fin whales, the study area was divided into 5' squares with a surface area of approximately 62.5km² each (Fig. 1).

To calculate encounter rates, 38 squares that were surveyed every year from 1990 to 1999 were selected, and treated as a sub-sample of the study area (Fig. 1). This sub-area, covering a total of 2,375km², including coastal, slope and pelagic habitats and encompassing water depths up to 2,400m, was treated as representative of the entire study area.

Sighting effort was measured by computing the length of the track line surveyed under 'favourable conditions' in each 5' square. Encounter rates were then calculated by dividing the number of fin whale sightings in each square by the total distance covered under favourable conditions in the same square. These single values provided an index of fin whale sightings per unit effort. In order to avoid small sample biases, all the grids containing a sighting with less than 10km surveyed were eliminated from the dataset. Encounter rates for each year were obtained by averaging all the squares sampled in that year. The sampling variance of the encounter rate was then calculated using the following formula (Buckland *et al.*, 1993):

$$\frac{\sum_{i=1}^{k} \frac{l_i}{L}\left(\frac{n_i}{l_i} - \frac{n}{L}\right)^2}{k-1}$$

where l_i = length of transect in each square, n_i = number of sightings in each square, n = total number of sightings, L = total transect length, k = number of squares.

Encounter rates of individuals were calculated by multiplying yearly encounter rates by mean aggregation sizes.

In this study only whales sighted while searching under 'favourable conditions' and occurring within the sub-sample of the study area have been used for encounter rate calculations, while all sightings, including those off effort and those in unfavourable conditions, have been used for the analyses of aggregation size and for the measurements of depths and distances from the coast.

Clarke (1982) calculated an 'index of sighting conditions for surveys of whales and dolphins' and estimated that fin whales could be seen by the naked eye at a distance of one nautical mile, up to sea state 7 on the Beaufort scale with a heavy swell. In addition, Gunnlaugsson *et al.* (2002) while estimating fin whale abundance in the North Atlantic, found that Beaufort sea state did not affect estimation of the detection function. Therefore, when pooling all the sightings made under 'favourable conditions' it was assumed that detection rates were consistent for sea state conditions 0-3 on the Beaufort scale.

Group size is also known to affect detection rates (Buckland *et al.*, 2001). However, since fin whales in the Mediterranean tend to form aggregations of mainly 1-2 animals (D'Amico *et al.*, 2003; Notarbartolo di Sciara *et al.*, 2003; this dataset) and previous surveys in the same area demonstrated that encounter rates did not significantly differ between school size categories (Forcada *et al.*, 1996), the data were not stratified by group size.

Generalised Linear Models (GLMs)

GLMs were used to model the distribution of fin whales in relation to physiographic variables.

The response variable was the number of fin whale sightings in each square in each year. The survey effort, expressed in number of km searched in each square under favourable conditions, was treated as an offset. The explanatory variables were year treated as a factor, mean and range of depth, mean and range of slope and distance from the coast. These covariates were calculated for each square using *ArcView 3.2*. Depth and distance from the coast were measured in meters, while slope, calculated with the function 'derive slope' in *ArcView*, was measured in degrees.

Models were fitted assuming either a Poisson or Quasi Poisson distribution, both with the log link function; these distributions assume linearity on the scale of the link function rather than linearity between the covariates and the response on the raw scale. Linearity on the scale of the link function was checked using partial regression plots to ensure this assumption was reasonable. Before any models were fitted, variance inflation factors (VIFs) were calculated to ensure collinearity between covariates was not prohibitively high. A Poisson distribution was assumed when the dispersion parameter for the Quasi Poisson family was close to unity; in this case the Akaike Information Criterion (AIC) was used to select the best models performing backward and forward stepwise selection. A Quasi Poisson distribution was assumed when the dispersion parameter was ≠1; in this case the models were first fitted with all candidate variables and those with *p*-values greater than 0.05 were dropped from the model one by one. Models were fitted to data from the whole study area and from the selected sub-area. Year was treated both individually and as two five-year intervals (1990-94 and 1995-99). However, when fitting the models with data from the whole study area, neither single year nor year intervals were significant, therefore years were pooled in all further GLM analyses.

RESULTS

The duration of the field season, the number of days spent at sea each year and the number of km surveyed are shown in Table 1. In 1992 and 1993 two vessels operated, while in the remaining years only one boat was used for the data collection. A total of 540 fin whale sightings were made during the study period, comprising 942 individuals.

Table 1

Study period, number of days worked, total number of km surveyed, number of sightings and whales, referred to the whole study area.

Year	First date	Last date	No. of days worked	km surveyed	No. of sightings	No. of whales
1990	6 Jun.	4 Oct.	77	6,096	36	43
1991	2 Jun.	3 Oct.	99	10,960	70	110
1992	6 Jul.	25 Sept.	104	9,967	69	125
1993	16 Jun.	4 Oct.	137	10,709	78	153
1994	21 Jun.	29 Sept.	70	6,500	74	146
1995	3 Jun.	1 Oct.	85	6,849	73	155
1996	6 Jun.	12 Sept.	65	4,315	37	49
1997	12 Jun.	9 Oct.	82	6,604	36	52
1998	20 Jun.	24 Sept.	72	5,026	33	59
1999	20 Jun.	24 Sept.	79	6,290	34	50
Total			**870**	**73,046**	**540**	**942**

The sub-sample of the study area appeared to be homogeneously covered throughout the study period, as shown in Fig. 2.

Distribution

The research effort, in terms of km surveyed, during the 10-year research period covered 55.6% of the whole study area, but was mainly concentrated in the region closest to the Italian-French coasts and in the shipping lane between the mainland and Calvi, on the island of Corsica (Fig. 3a). The

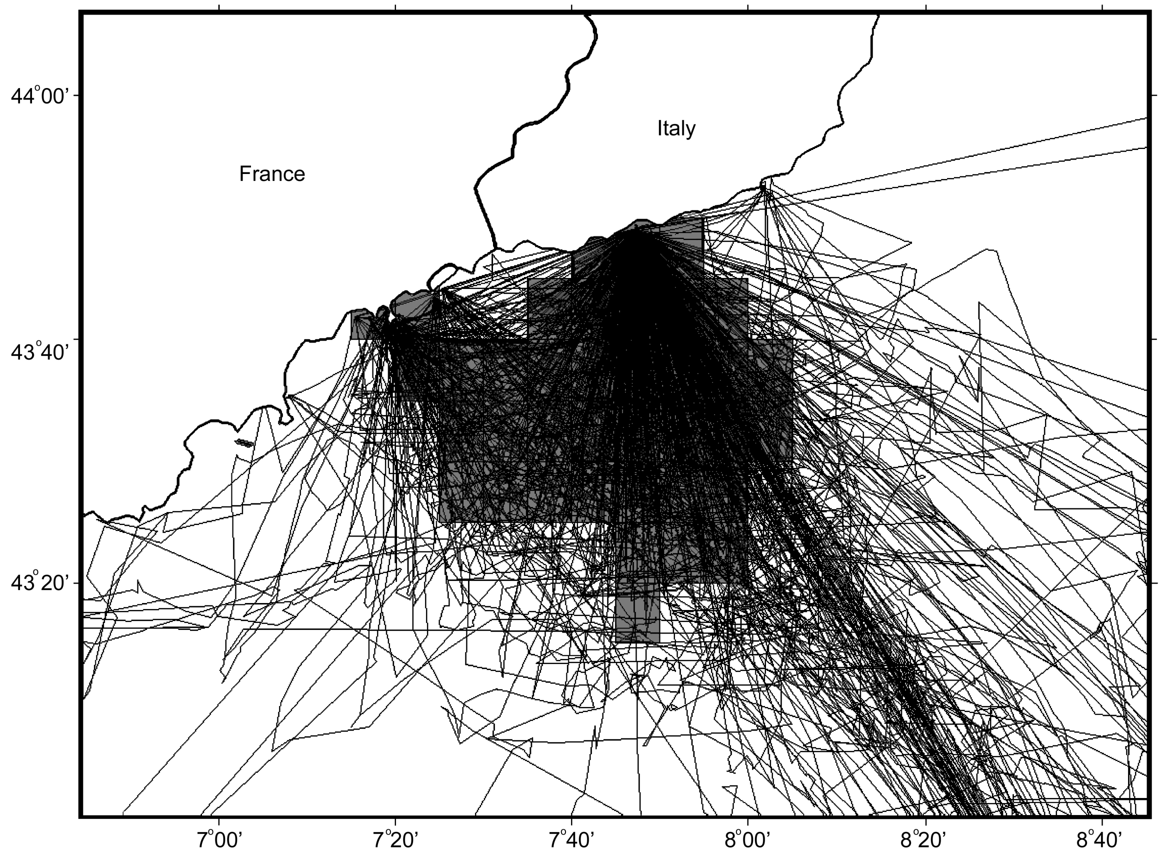

Fig. 2. The sub-sample of the study area showing the shipboard transects carried out in 1990-99.

540 fin whale sightings made from 1990-99 appeared to be concentrated in the central portion of the study area, in the zone between Nice, San Remo and the north-western coast of Corsica (Fig. 3b). The number of sightings in each 5' square is shown in Fig. 3c. The fin whale sightings generally reflected the distribution of effort, with a higher number of sightings close to the continental coast of Italy and France, in the centre of the study area and along the western coast of Corsica. The encounter rate values tended to be higher in the south-western portion of this area (Fig. 3d).

Whales were found predominantly in offshore waters, beyond the 2,000m isobath, with a relatively small number of sightings in shallower waters. More than 90% of sightings occurred in waters deeper than 2,000m and more than 23km from the nearest coast (Fig. 4). The mean water depth at sighting locations was 2,317m (SD=380, *n*=540, range 65-2,690), with a mean distance from the coast of 45.6km (SD=18.6, *n*=540, range 1.9-99.1). Distance from the nearest coast and sighting depth did not differ significantly throughout the study period.

Mean aggregation size, relative encounter rates of sightings and individuals in the sub-area surveyed each year are presented in Fig. 5. Encounter rates were stable for the years 1990-94, peaked in 1995 and steadily decreased in all successive years studied. The same trend could be seen for both aggregation and individual sightings.

An inverse variance-weighted linear regression was applied to the two time intervals. The first time interval (1990-94) did not show any particular trend (F-statistic = 0.064, p= 0.8171), while the second one, 1995-99, showed a significant decline (F-statistic = 185.5, p= 0.0008561).

GLM analysis

Two different data sets were used for the GLM analysis: one from the whole study area and one from the selected sub-area. The GLM analysis from the whole area revealed that mean depth was the most significant explanatory variable, with distance from the nearest coastline less significant, but still selected by the model (Quasi Poisson family, log link function) (Table 2). Bottom slope was never selected by the fitted models. Similar results were obtained when fitting the model for the sub-area (Poisson family, log link function) (Table 3); in that case, however, mean depth and depth range were highly significant, as well as year −treated as a factor.

The fit of each model was assessed using a pseudo-R² measure, calculated using the following formula (Hardin and Hilbe, 2001):

$$\text{Pseudo-R}^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y}_i)^2}$$

Where y_i = the response variable, $\hat{y}_i$ = the fitted value and $\bar{y}_i$ = the mean of the observed response.

The model for the pooled data returned a pseudo-R² of 0.665, while the sub-area model gave a pseudo-R² of 0.413. Although the largest values for sightings per unit effort were under-predicted by the model, no systematic patterns were found in model residuals.

Aggregation size and composition

Fin whales were sighted mostly as singles or pairs (Fig. 6); these made up 81% of the sightings. Mean aggregation size in the overall study area over the study period was 1.74 individuals (mode=1, SD=1.11, *n*=540, range 1-7). Mean annual aggregation sizes ranged from 1.19 in 1990 to 2.12 in 1995, showing significant differences between years (ANOVA, F=4.14, p<0.01) (Fig. 7a).

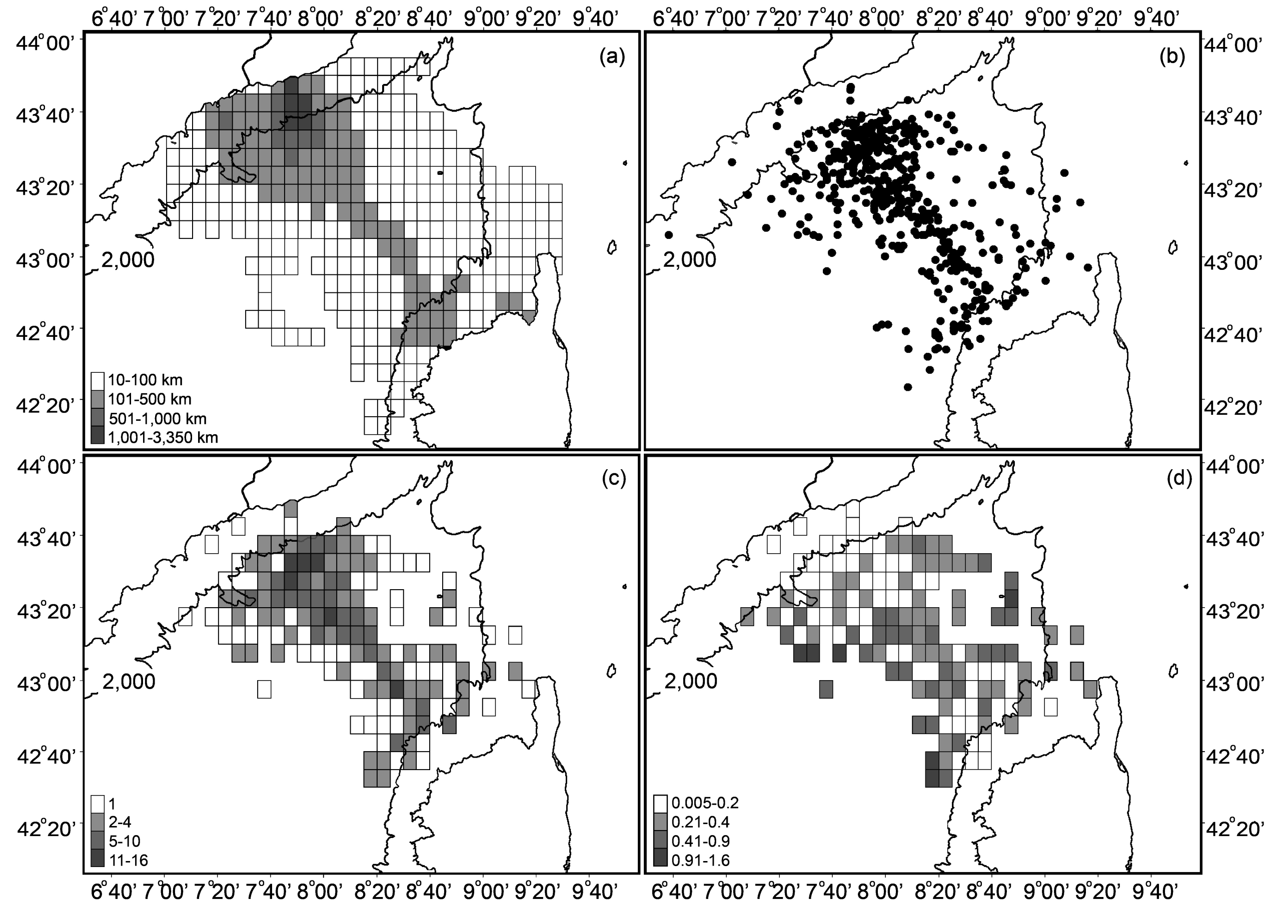

Fig. 3. (a) Research effort (km surveyed); (b) Fin whale sightings; (c) Number of sightings in each cell; (d) Encounter rate.

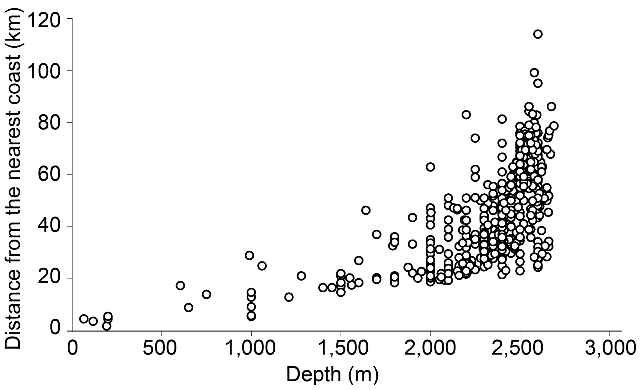

Fig. 4. Depth and distance from the nearest coast for all sightings.

Mean monthly aggregation size declined from 1.86 in June to 1.53 in September (Fig. 7b); however, this variation was not significant (ANOVA, F=1.02, p=0.349).

During the study period, 29 fin whales <15m long were recorded, representing 3.1% of the total. Following the age/size categories proposed by Orsi Relini (2000), these 'immature' whales were categorised as 13 suckling calves (6-11m long) and 16 weaning individuals (12-14m long).

DISCUSSION

This work summarises ten years (1990-99) of fin whale effort-weighed sightings in western Ligurian Sea waters. This area plays a key role for the ecology of cetaceans, particularly for whales, representing what is considered to be one of the most important feeding grounds in the Mediterranean Basin (Notarbartolo di Sciara *et al.*, 2003).

Considering that food is the driving force that influences cetacean distribution while in their feeding grounds (e.g. Sergeant, 1977), it can be assumed that Mediterranean fin whales summering in the Ligurian Sea strongly correlate their distribution and relative abundance with prey availability (Relini *et al.*, 1994; Orsi Relini *et al.*, 1992).

Fin whales in the Ligurian Sea were found predominantly in deep offshore waters, seldom occurring at depths less than 2,000m, which is in agreement with previous studies conducted both in the Mediterranean and the North Atlantic Ocean (Aguilar *et al.*, 1983; Sanpera *et al.*, 1984; Sigurjónsson *et al.*, 1989; Notarbartolo di Sciara *et al.*, 2003). However, in several locations within the species' known range, such as the Sicily Channel shelf near Lampedusa (Simone Canese, pers. comm.), or the continental shelf off the northeastern coast of the United States and Canada (Hain *et al.*, 1992) fin whales are mostly observed in shallow waters. These observations support the idea that habitat choice of fin whales when at their feeding grounds most likely depends upon the distribution of their prey (Woodley and Gaskin, 1996). In addition to prey distribution, depth preference is a widely used parameter to describe habitat choice by cetaceans (Davis *et al.*, 2001). Our results show that depth is the most important physiographic parameter that can be used to describe the distribution of fin whales in this study area. This underlines the offshore preferences of fin whales in the Ligurian Sea, which coincides with the presence of a large dome of cold water in the centre of the basin, characterised by high levels of nutrients and upwelling currents (Gostan and Nival, 1967; Pinca and Dallot, 1995). Such a pelagic distribution

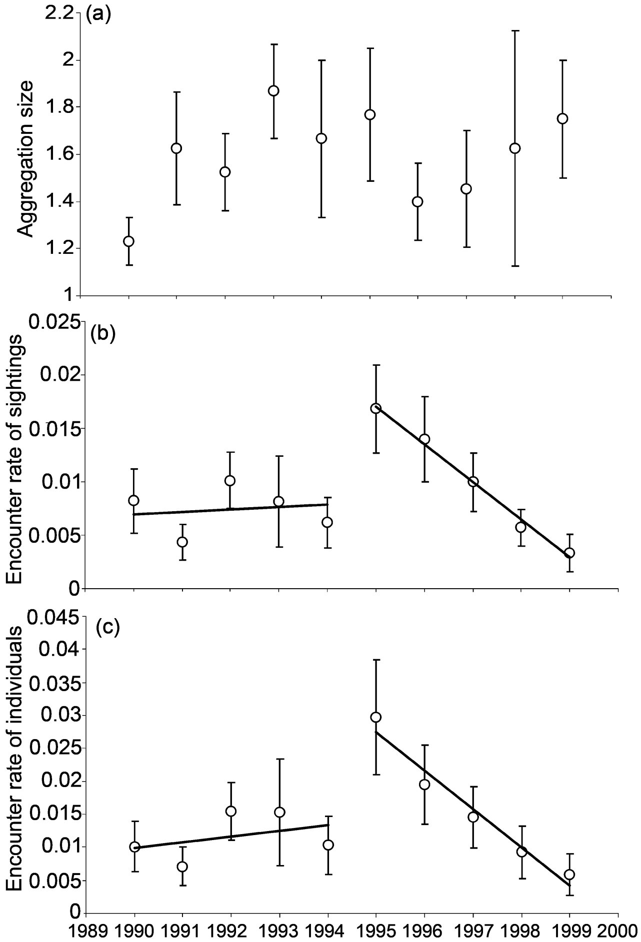

Fig. 5. Mean aggregation size and encounter rates for the sub-area, error bars represent ± one SE. (a) Mean aggregation size; (b) encounter rates of sightings; (c) encounter rates of individuals.

Table 2

Summary results of the GLM analyses, considering all data over the 10-year period and the whole study area (Quasi Poisson family, log link function).

	Estimate	SE	T	Pr (> | t |)
Intercept	-15.01	0.470	-32.1	< 0.001
Mean depth	-0.00154	0.000254	-6.05	< 0.001
Distance	0.0120	0.00503	2.39	0.0174

Table 3

Summary results of the GLM analyses, considering data over the 10-year period within the sub area (Poisson family, log link function). Year was considered as a factor.

	Estimate	SE	T	Pr (> | t |)
Intercept	-13.7500	0.9196	-14.9520	< 0.001
1991	-1.0220	0.3186	-3.2090	< 0.01
1992	-0.3285	0.2938	-1.1180	0.2635
1993	-0.5262	0.2681	-1.9630	< 0.05
1994	-1.6340	0.6048	-2.7020	< 0.01
1995	-0.2044	0.3396	-0.6020	0.547
1996	-0.2689	0.3721	-0.7230	0.469
1997	-0.4087	0.3597	-1.1360	0.256
1998	-1.1010	0.4044	-2.7210	< 0.01
1999	-1.5950	0.5374	-2.9680	< 0.01
Mean depth	-0.0015	0.0004	-3.9740	< 0.001
Depth range	-0.0013	0.0004	-3.3400	< 0.001

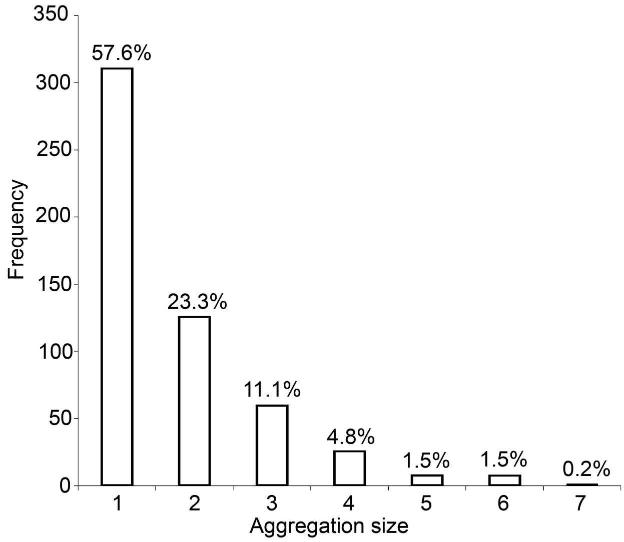

Fig. 6. Frequency distribution of aggregation sizes for all sightings.

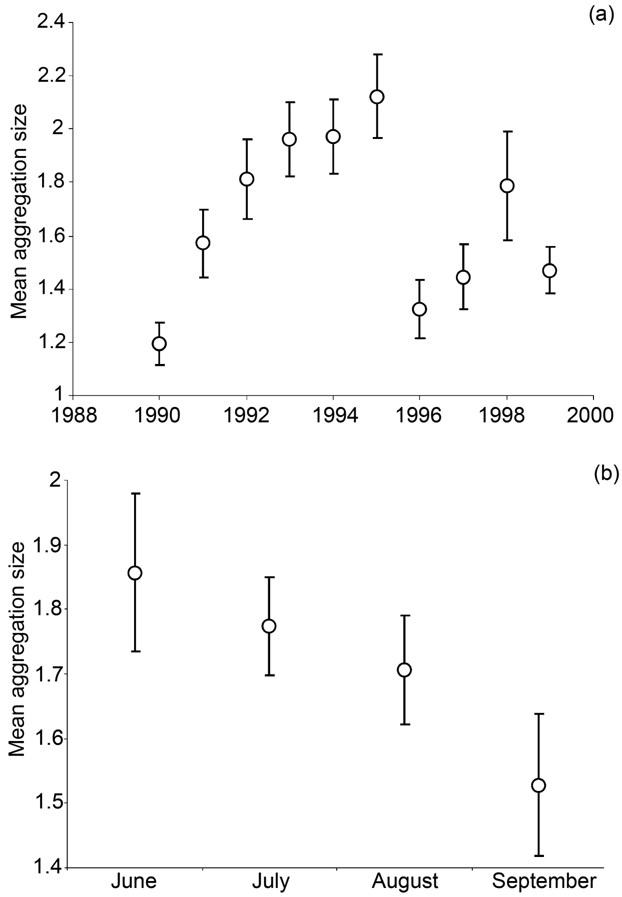

Fig. 7. (a) mean annual aggregation size for the whole study area; (b) mean monthly aggregation size for the whole study area. Error bars represent ± one SE.

most likely reflects the distribution of Northern krill (*Meganyctiphanes norvegica*), thus emphasising the strong link between habitat choice and prey distribution.

However, in the Mediterranean, there have been some years when fin whales were sighted close to the coast, over the continental shelf, as a possible consequence of coastal food aggregation (Notarbartolo di Sciara *et al.*, 2003). Airoldi *et al.* (1999) and Beaubrun *et al.* (1999) observed this unusual situation during summer 1997 in the Ligurian Sea and in the Gulf of Lions respectively, with whales observed less than 2km from shore, and often entering small bays and harbours. Our dataset did not show significant differences in mean depth and distance from the coast of sightings over the study period. An *ad hoc* GLM was fitted to test this hypothesis, considering the single year 1997 and testing it against all other years; GLM analysis again selected the model with mean depth, however year was not selected as an explanatory variable. The likely reason the coastal preference showed by fin whales during 1997 went undetected is that our effort was dedicated mainly to the offshore portion of the Ligurian Sea, with limited time spent in the coastal areas. Our results show that during summer 1997, fin whales were also present in offshore waters.

The steady decrease observed in the encounter rates from 1995-99 is cause for concern and stresses the need for further investigations. This decrease may be related to a geographical shift in the whales' distribution, perhaps induced by shifting oceanographic conditions, or to an altered prey distribution. However, the effects of a combination of human-induced threats, including naval traffic, anthropogenic noise and disturbance, habitat degradation and depletion of natural resources (Notarbartolo di Sciara and Gordon, 1997), cannot be disregarded. Nevertheless, although encounter rates varied considerably throughout the 10-year study period, they showed no overall trend. These results are in agreement with the GLM analysis for the sub-area, which selected year −treated as a factor −as a significant explanatory variable. This stresses the need for long term studies such as this which present natural fluctuations in encounter rate or distribution, that could be easily misunderstood if presented in a different time frame. Further investigations in the same area, including the repetition of surveys over wider areas and possibly encompassing the entire extent of the western Mediterranean summer feeding grounds, will help understanding of the reasons underlying such fluctuations across years, and provide better insight into fin whale relative abundance, and whether management measures are indeed required.

It has been hypothesised that cetacean group sizes largely depend on the distribution of their prey (Nemoto, 1964; Avocedo-Gutiérrez, 2002). Our data showed low mean aggregation size (1.74) compared with those (2.9) observed on the continental shelf off the northeastern coast of the United States and Canada (Hain *et al.*, 1992), but are consistent with data from the Gulf of Maine (Phil Clapham, pers. comm.). Forcada *et al.* (1996), also noted that mean aggregation sizes for Mediterranean fin whales were lower than that in other feeding grounds and proposed that aggregation sizes may be correlated with prey density. There may be a relationship between small mean aggregation size of fin whales and patchy distribution of *M. norvegica* −documented both in the Ligurian Sea (Labat and Cuzin-Roudy, 1996) and in other areas (Sameoto, 1983; Nicol, 1986) −as well as with the peculiar ecology in the Ligurian Sea of this euphausiid, which spends most of its time at considerable depth. The data presented here do not show a significant decrease in mean aggregation size from June-September, indicating that food may be evenly available throughout the season. These results match the seasonal abundance of *M. norvegica*, which is described as having two peaks of abundance, a major one in January/February and a less pronounced one during August-October (Sardou *et al.*, 1996). The recorded differences in yearly mean aggregation sizes indicate that prey availability or distribution might vary (e.g. with different patch size) across years. Inter-annual differences in prey biomass (Franqueville, 1971) may be related to different Beaufort states across winters; during calmer winter seasons low circulation may reduce the phytoplankton spring bloom and relative zooplankton high concentrations during the summer months.

The use of GLMs has provided valuable information regarding the distribution of fin whales in relation to physiographic variables. Future work will include the construction of cetacean habitat prediction models (Forney, 2000; Gregr and Trites, 2001), exploring the relationships between oceanographic conditions and cetacean distribution. In particular the relationship between biological parameters, including prey abundance and remotely sensed physical parameters (i.e. sea-surface temperature, ocean colour, wind speed), will contribute to the identification of particular areas that could be considered as critical habitats for this and other cetacean species in the Western Ligurian Sea.

Mediterranean fin whales are exposed to a number of threats, including direct human disturbance, anthropogenic noise, pollution and collisions with vessels. The latter represents a considerable source of concern in the study area (Laist *et al.*, 2001), due to the large and increasing number of ferries and commercial ships crossing the waters of the Ligurian Sea Sanctuary daily. Evidence of collisions has been reported both for stranded and free-ranging fin whales (data not shown), presenting high percentages of specimens struck by ships. The marked offshore distribution displayed by fin whales in the Ligurian Sea may serve to encourage, insofar as it is possible, the adoption of shipping lanes closer to coasts, thus reducing commercial traffic volume in offshore waters. Cetacean distributional differences throughout the study area should be further investigated to clearly determine whether zones of lower density exist, where ship crossings should occur to minimise their impact.

Throughout the study period 29 immature individuals (3% of the total) smaller than 15m were sighted. These whales were never seen alone, but always associated with at least one individual >16m, most likely representing a cow-calf association; nevertheless, given the difficulty in estimating length at sea, caution should be taken when dealing with these measurements. These data show that, even with a seasonal peak in births between September and January (Viale, 1985), Mediterranean fin whales may have adapted to the Mediterranean environment −which guarantees prey availability throughout the year and warm waters −by extending and overlapping both their calving and feeding seasons (Notarbartolo di Sciara *et al.*, 2003). Moreover, the observed immature individuals in the Pelagos Sanctuary during the summer months may also indicate that fin whales remain in the area year-round, suggesting that this area could represent also a significant breeding ground for them (Orsi Relini, 2000). This hypothesis is supported by the major peak in *M. norvegica* abundance described in the Ligurian Sea during January/February (Sardou *et al.*, 1996). Additionally, recent acoustic data, collected during autumn in the Corso-Ligurian Basin, confirmed the presence of vocally active fin whales during this period (Clark *et al.*, 2002), and analyses in progress of the same data set seem to demonstrate that fin whales are also present in the Western Ligurian Sea in winter and spring (Fabrizio Borsani, unpublished data).

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