Résumé

Activité estivale du Rorqual commun (*Balaenoptera physalus*) dans le sanctuaire pélagique nord ouest méditerranéen.

Nous avons étudié l'activité des Rorquals communs en Méditerranée nord-occidentale à l'aide des données de 274 observations obtenues au cours de prospections d'une longueur totale de 12 755 kilomètres entre 1991 et 2000. Le type d'activité a été déterminé à 184 reprises sur le terrain à partir de quatre possibilités: le repos, la prédation, la socialisation et le voyage. Les paramètres pris en considération ont été principalement la durée des sondes, le nombre de souffle, la vitesse et la variabilité de la direction du déplacement. L'analyse a été réalisée pour quatre périodes de la journée: le matin (avant 10h), le midi (10-14h), l'après-midi (14h-18h) et la soirée (après 18h). Il apparaît que durant la journée, l'occupation majoritaire est le repos (40,6% des cas) suivie par la prédation (36,1%). Mais la prédation est majoritaire le matin (52%) et en soirée (74%), alors que le repos est majoritaire en milieu de journée (51% des cas). On observe une variation concomitante de la durée des sondes, ainsi que du nombre de souffles entre deux sondes, entre le matin (durée moyenne 8,4 minutes), le midi (5,5 minutes) et la soirée (8,2 minutes). Ces résultats sont totalement en accord avec les connaissances acquises sur l'écologie de la proie préférentielle du Rorqual commun à cette saison, l'euphausiacé *Meganyctiphanes norvegica*, notamment avec les migrations nycthémérales verticales de ces crustacés. Ils correspondent également bien aux résultats sur les profils de plongée du Rorqual commun en Méditerranée, obtenus grâce à des balises enregistreuses. Les sondes de longue durée exposent les baleines à un risque de collision plus élevé, car elles doivent alors être détectées à une distance d'autant plus élevée que le navire avance vite.

Mots-clés:
Rorqual commun; Méditerranée; activité diurne; temps de sonde; collision.

Abstract

The summer activity pattern of fin whales in the north-western Mediterranean Sea was investigated with data from sighting surveys during the period 1991-2000. The effective visual effort totalled 12,755 kilometres obtained during which a total of 274 on-effort fin whale sightings was obtained and behaviour study could be carried on in 230 cases. Parameters such as dive duration, blow count and movement pattern were noted on the field and activity type was determined on 184 occasions. There is a clear decrease in both dive duration and blow count from the morning (dive duration = 8.4 minutes) to the midday (d.d. = 5.5mn), and both parameters increase again from afternoon to evening (d.d. = 8.2mn). Feeding is recorded during the majority of morning and evening sightings (respectively 52% and 74% of cases) and resting occurs in majority during midday and afternoon (51% of sightings). The present findings are consistent with existing knowledge on the ecology of the fin whale main prey, the krill *Meganyctiphanes norvegica*. Extended dives expose whales to a higher collision risk, since they remain visually undetectable at longer distances, especially in the case of fast cruising vessels.

Keywords:
fin whale; Mediterranean; sightings; activity pattern; diel variation; collisions.

Summer activity pattern of fin whales (*Balaenoptera physalus*) in the northwerstern mediterranean pelagos sanctuary.

Alexandre Gannier*

*Groupe de Recherche sur les Cétacés, 741 chemin des Moyennes Bréguières, Aurelia 13, 06600 Antibes, France

email : a_o.gannier@club-internet.fr

In February 2002, the Pelagos International Sanctuary for Marine Mammals was formally created in the liguro-provençal basin and the northern Tyrrhenian Sea. This marine area was shelters abundant populations of cetaceans, particularly of fin whales, *Balaenoptera physalus*, **(Forcada *et al.*, 1995; Gannier, 1999)** and striped dolphins, *Stenella coeruleoalba*. Summer densities of fin whales estimates reach consistent values of 0.015 to 0.019 whale/km^2 on the liguro-provençal basin **(Forcada *et al.*, 1996; Gannier, 1997; 1998a; 1999)**. The spring to autumn period is favourable to fin whale feeding in the north-western Mediterranean **(Gannier, 1998b; 2002)**, the main prey species being the euphausiid *Meganyctiphanes norvegica* **(Orsi-Relini & Giordano, 1992; Relini *et al.*, 1992; Orsi-Relini *et al.*, 1994)**. While much study effort was dedicated to fin whales distribution and abundance **(Notarbartolo Di Sciara *et al.*, 1993, 2003; Littaye *et al.*, 2004, Gannier *et al.*, 2003)**, the species summer activity pattern remains poorly known, including its dive and surfacing behaviour. Ship collisions pose a severe threat to the long term conservation of fin whale in the Mediterranean, an average of 1-5 collisions being reported yearly **(Laist *et al.*, 2001)**, especially because the population is largely isolated from that of the Atlantic Ocean **(Bérubé *et al.*, 1998)**. Collision risk derives from the dive pattern of whales, individuals being not visually detectable while they are below the surface. Consequently, fast vessels run higher risk because they cover a greater distance during the dive duration: a whale may therefore remain undetected over an entire dive cycle, upon surfacing right ahead of the ship bow. **Zanardelli *et al.* (1992)** recorded an average diving duration of 8.1 minutes with a limited data set. Recent results on fin whale dive profiles **(Panigada *et al.*, 1999)** suggest a high temporal variability in dive cycles, probably because whale activity is linked to the diel migration of its principal prey, *M. norvegica* **(Andersen *et al.*, 1992; Sardou & Andersen, 1993)**. Our research attempted to determine the daily variation of activity and dive patterns in the north-western Mediterranean Pelagos Sanctuary and adjacent waters. This was carried on by analysing sighting data from summer surveys held in the area from 1991 to 2000.

Study area and survey protocol

The study area encompasses Pelagos Marine Mammals Sanctuary and waters immediately adjacent, from 5°E to 11°30E longitude and North of 40°50 latitude. Large oceanic areas (water deeper than 2000 m) are found in the liguro-provençal basin, but not in the northern Tyrrhenian Sea, whose open sea waters are of intermediate depth (1000 m to 2000 m) (figure 1). The Ligurian Front and the associated water circulation form one of the most productive areas in the Mediterranean Sea, with a superficial primary biomass peaking in March-April and a summer primary production maximum located close to the pycnocline, 30 to 60m deep **(Jacques *et al.*, 1976; Prieur, 1981)**.

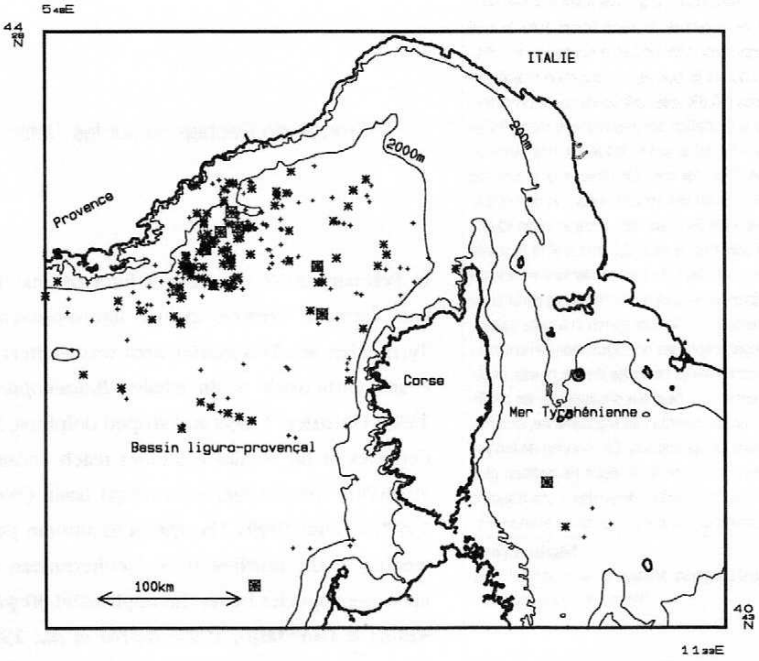


Figure 1
Study area and sightings of fin whales
Cross = 1 individual, star = 2-3 ind.,
square = 4-7 ind.
(200 and 2000 m isobath are drawn)

Although our dedicated small boat surveys began in 1988, only data collected from July 1991 to August 2000 were considered here to ensure a better consistency in field protocols, in such aspects as the use of satellite positioning devices, the number of on-duty observers. The determination of whales activity from observed behaviours may be considered as consistent throughout the period of study. A 9.50 m sloop was used up until 1994 (mean speed of 9 km/h) and surveys were carried on with a 12.0 m motor-sailer boat from 1995 onwards (mean speed of 11 km/h). The sampling strategy involved random sampling when the sighting conditions were good to excellent (basically Beaufort 0-3). The visual survey consisted of continuous, naked eye observation by shifts of three observers rotating every two hours and covering the 180° frontal sector. An index of sighting conditions was recorded every 20 minutes : the index varied from 0 (null) to 6 (excellent) and was derived from wind speed, sea-state, residual swell and light conditions **(Gannier, 1997)**. With wind speed equal to Beaufort 3, good light conditions and no conspicuous swell the sighting conditions index value was 4.

Sightings

When cetaceans were detected various sighting parameters were recorded (bearing and radial distance to the boat, position,..) and fin whales were usually approached at a distance of 100-200 meter to determine the school size and structure, and various behaviour parameters such as dive type and duration, number of blows and surfacing duration, swimming direction, velocity (estimated in relation to boat's speed) and variation. Two observers were in charge of counting blows and measuring dive and surfacing time of individual whales. One important aspect was the determination of activity type from a choice of four possibilities : resting, travelling, feeding and socialising. If behaviour and activity types have been studied in detail for delphinids such as spinner dolphins **(Norris *et al.*, 1994)**, there is no precise methodology for fin whales. The activity type was directly recorded on the field from the observation of behavioural factors (velocity and directionality of movement) and dive-surfacing cycles (dive type, dive time, blows count) (Table I). In some cases, two options were

example, travelling-feeding), and in several other cases it was not possible to determine activity at all. Sighting duration was variable, ranging from one minute to over 2 hours, however in 60% of the cases it was comprised between 5 and 60 minutes.

Activity type	swimming velocity	swimming directivity	Dive type	Dive time	Blow count
Resting	slow <2kts constant	weakly variable	sub-surface short distance	1 to 10 mn consistent	1 to 10 consistent
Travelling	fast >4kts constant	constant	sub-surface long distance	2 to 8 mn consistent	2 to 15 consistent
Feeding	3-5kts constant or variable	very variable	deep short distance	3 to 20 mn consistent	3 to 30 consistent
Socializing	3-10kts very variable	very variable	surface or sub-surface	0 to 7 mn variable	1 to 15 variable

Tableau I
Field determination of activity pattern for Mediterranean fin whales

Data analysis

Data was loaded into a database and exported to the geographic software *Oedipe* **(Massé & Cadiou, 1994)**, which was used for mapping of the sampling track and sightings. Analyses of activity patterns were carried out for a subset of sighting data : sightings had to be over 5 minutes in duration and observation distance was to be less than 800 meters. The field determination of activity was confirmed by a posteriori analysis of dive times and blows counts. The activity pattern was defined as the relative frequency of each activity category (resting, socialising, travelling, feeding) :

$$Fi = n_i / n_d$$

with n_d the number of sightings for which activity was determined on the field and n_i the number of cases for which activity i was recorded. When two possible activity categories were retained for a given sighting, a value of $^1/_2$ was affected to each activity category. The activity pattern was first determined globally and then by splitting data into four day time periods : from 6am to 10am (morning), from 10am to 2pm (midday), from 2pm to 6pm (afternoon) and from 6pm to 10pm (evening).

RESULT

Effort and sightings distribution

The effective visual effort amounts to a total of 12,755 km (6,887 nautical miles) during the survey period. A total of 274 fin whales sightings were obtained on-effort with Beaufort 3 or less sea-conditions (Figure 1). School sizes varied between unity (61.2% of sightings) and 7 individuals (one sighting), with 28.8% of pair of whales and 6.0% of sightings on schools of 3 individuals. A mean school size of 1.55 ind./group was obtained (SE=0.87).

Sightings were obtained in water 70 m to 3100 m deep, with a mean depth of 2295 meter; 86.8% of the sightings were obtained in water deeper than 2000 m, and 7.5% in water shallower than 1500 m. The average distance from sighting to shore was 45.3 km, with a minimum of 2.8 km and a maximum of 133 km; 50% of sightings were obtained between 30 and 60 km from shore.

Activity patterns

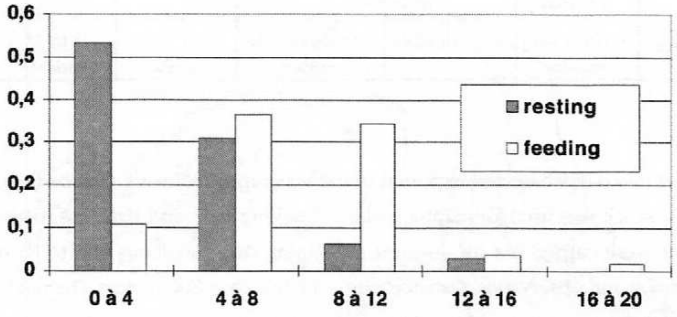
A total of 230 sightings were selected for analysis of activity patterns, including 184 cases for which activity could be determined (80% of the data subset). Dive time was measured in 136 cases and an average of 6.9 minutes was obtained, but with a significant temporal variation : durations were shown to decrease from 8.4 mn (SD=4.4) during the morning to 5.5 mn (SD=3.3) for the 10am-2pm period, and than to slightly increase to 6.9 mn (SD=3.6) from 2pm to 6pm and to 8.2 mn (SD=3.8) for the evening (Table II). Dive duration proved to be a good parameter to discriminate between different field-recorded activity categories : the average dive duration was of 4.4 mn for resting (SD=3.6), 5.3 mn for socialising (SD=3.1), 6.3 mn for travelling (SD=3.3) and reached 8.6 mn (SD=3.8) for feeding activity (maximum 19.5 minu

tes). When whales were determined as " resting ", a majority (78%) of dives were less than 4 mn in duration, compared to 55% of dives between 4 and 12 mn duration for the feeding activity (Figure 2).

Tableau II
Dive durations and blow counts for different periods of the day

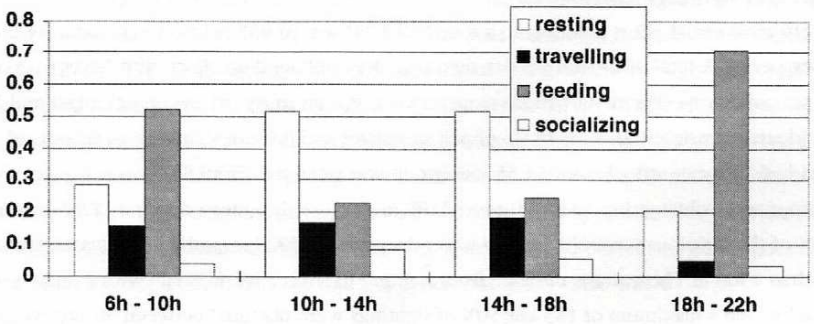
Period of the day	Dive duration average	Dive duration (n, SD)	Blow count average	Blow count (n, SD)
6am to 10am	8.4 mn	19 , 4.4	11.9	18 , 7.1
10am to 2pm	5.5 mn	47 , 3.3	7.2	42 , 6.3
2pm to 6pm	6.9 mn	45 , 3.9	8.0	45 , 6.3
6pm to 10pm	8.2 mn	24 , 3.8	11.1	29 , 6.2

Figure 2
Dive durations for resting and feeding activities



During our study, activity category could be determined in 184 cases. Fin whales were predominantly observed in " resting " (40.6% of cases) or " feeding " activity (36.1% of cases). Travelling was recorded in only 17% of sightings and socialising was the least represented activity category, with 6.3% of the cases. The diurnal variation of the activity type was very interesting (Figure 3): feeding activity was recorded in 52% of the case during the morning and its proportion decreased to 24% during the afternoon, before increasing to 71% of cases during the evening period. The proportion of " resting " cases followed a reverse trend, increasing from 28% during the morning to 51% during midday and afternoon, before decreasing to 21% for the evening period. This clear diurnal shift between the two principal activity categories might better be understood by keeping in mind that fin whales are also feeding during night time, in agreement with the migration habits of their preys.

Figure 3
Blow counts for resting and feeding activities



Blow counts were measured in 134 cases : an average of 9.1 blows per surfacing was obtained. In agreement with dive durations, there is a clear temporal variation of blow counts, which decreased from 11.9 blows during the morning to 7.2 blows per surfacing for the 10am-2pm period, and than to slightly increase to 8 blows (2pm-6pm) and to 11.1 blows for the evening (Table II). Blows counts were also determinant since in 80% of the "resting" cases, whales blew less than 4 times between successive dives. For the feeding category, blow counts were very variable between 3 and 20, average values between 11.7 and 14.5 blows per surfacing being obtained depending of the period of the day (Figure 4). Hence, dive durations and blow counts were related: long dive duration (in the morning) corresponded to higher blow counts, when short dives were related to low blow counts (midday and afternoon).

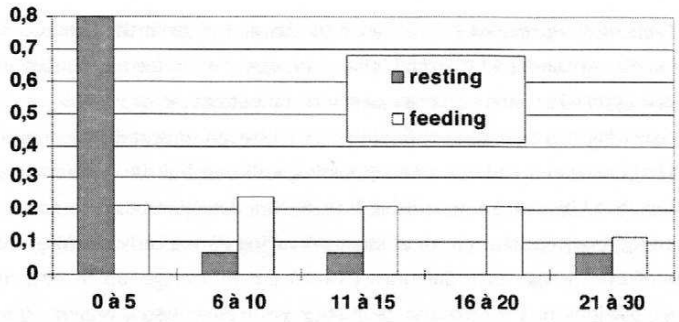


Figure 4
Activity patterns
and periods of the day

Estimated velocities were also useful in differentiating activity types : an average velocity of 1.1 m/s was estimated for " resting " cases, against 2.3 m/s in " feeding " cases. Discrimination between socialising and travelling activity types relied mostly upon movement patterns : on one hand, average velocities were not significantly different (1.85 m/s for socialising against 2.05 m/s for travelling), on the other hand, movement directionality was determinant : a constant direction was recorded in 83% of the " travelling " cases and a variable direction in 86% of the "socialising" cases.

DICUSSION

A dichotomy existed between activity patterns obtained during the morning and evening periods on one hand, when feeding is recorded in 52-71% of the cases respectively and resting occurs less frequently, and the activity recorded during the middle of the day, with about 24% of whales recorded as feeding and over 51% observed as resting (Figure 4). This diurnal variation of activity is clearly supported by dive durations and blow counts, with much longer dives associated to longer blowing sequences during the morning and the evening (Table II). This result is in agreement with **Panigada *et al.* (1999)**, who obtained dive profiles from time-depth-recorder deployments tags : one whale displayed shallow dives between 9 :45am and 5pm (mean depth 24.5 m), before starting a sequence of very deep dives (in excess of 470 m) of long durations (11.7 and 12.6 minutes). The authors related deep dive profile to active foraging, starting late in the afternoon. The daily variation of activity pattern is well in agreement with existing paradigm on fin whale nocturnal feeding habits, in the Mediterranean : the high proportion of whales recorded as feeding during the morning and the evening supported the opinion that fin whales spend most night time in feeding activity. **Zanardelli *et al.* (1992)** reported on 17 fin whale dive cycles in the Ligurian Sea and found an average duration of 8.1 minutes and a mean blow count of 7.3, both figures being in reasonable agreement with the results presented here (respectively 6.9 minutes dive duration and 9.1 blows). But **Jahoda *et al.* (2003)** obtained lower average dive time of 3.7 minutes and blow counts of 5.2 : these figures were estimated during a study of whale response to biopsy darting, hence a possibility of shorter dives and surfacing due to the close presence of the scientific boat. In the St.Lawrence estuary, dive cycles of fin whales have been studied in detail with TDR transmitters **(Giard *et al.*, 1999)** : dive were lasting 4.9 mn in average when whales were engaged in active feeding (between 5am and 3pm) and 3.9 mn when they were not. Maybe due to a different topography (depth <200 m) and variety of prey items (euphausiids and capelin *Mallotus villosus*), dives are significantly shorter than those obtained during the present study.

The diving behaviour of fin whales is well correlated to the temporal variation of the distribution of potential preys in the Ligurian Sea, in particular of the krill *M. norvegica*. This euphausiid is found in abundance in the north-western Mediterranean **(Casanova, 1974)**, where reproduction occurs from late winter to late spring **(Cuzin-Roudy, 1993; Labat & Cuzin-Roudy, 1996)**. Vertical upwards migration of this crustacean has been shown to occur from 2 hours before sunset **(Andersen *et al.*, 1992)**, after the swarms leave their deep daytime residency level **(Sardou & Andersen, 1993; Sardou *et al.*, 1996)**. The downwards migration seems to start less than one hour before sunrise and to be completed about 15 minutes after sunrise **(Andersen *et al.*, 1992)**. The same authors have also observed that

juvenile fractions of *M. norvegica* population stays day and night in the superficial 0-75 m layer, thus possibly explaining why several whales are observed in feeding activity even between 10am and 2pm, when larger crustacean should be out of reach.

With an average whale dive duration of 6.9 minutes, a boat cruising at 20 knots must detect a fin whale 4200 m ahead in order to avoid a possible collision, but the same whale must be sighted 8400 m ahead by a 40 knots cruising boat. Such a detection performance is unlikely with mediocre sighting conditions, such as those prevailing during early morning of late evening, periods of even longer dive durations (8.4-8.6 mn in average, up to 19.5 mn). This explains why collisions may increase in frequency with more faster vessels crossing the Pelagos Sanctuary during summer time.

CONCLUSION

The fin whales summer activity pattern was observed to vary substantially during the day, whales being observed either resting or feeding, depending on the time. Feeding, associated to longer dives, was in majority during the morning and the evening, while resting was the principal activity during midday and afternoon. Fin whales obviously adapt their diving activity to prey availability. Present findings clearly suggest why whales are highly vulnerable to collisions with fast vessels during long dives, calling for urgent precaution measures. Whales are exposed to other human-originated disturbance during their daily resting time: unregulated whale-watching may also be detrimental to the fin whale long term conservation.

REFERENCES

Andersen V., Sardou J, & Nival P., 1992. The diel migrations and vertical distributions of zooplancton and micronecton in the North-western Mediterranean Sea. 1. Euphausiids, Mysids, Decapods and Fishes. *Journal of Plankton Research*, **14** (8) : 1129-1154.

Bérubé M., Aguilar A., Dendanto D., Larsen F., Notarbartolo Di Sciara G., Sears R., Sigurjonsson J., Urban-Ramirez J., & Palsboll P., 1998. Population genetic structure of North Atlantic, Mediterranean Sea and Sea of Cortez fin whales, *Balaenoptera physalus* (Linnaeus 1758) : analysis of mitochondrial and nuclear loci. *Mol. Ecol.*, **7** : 585-599.

Casanova B., 1974. *Les Euphausiacés de Méditerranée (Systématique et développement larvaire. Biogéographie et Biologie)*. Thèse de Doctorat ès Sciences Naturelles, Université d'Aix-Marseille I, 360 pp.

Cuzin-Roudy J., 1993. Reproductive strategies of the Mediterranean krill, *M. norvegic*a and the Antarctic krill, *E. superba. Invertebrate Reproduction and Development*, **23** (2) : 105-114.

Duguy R., Casinos A., Di Natale A., Filella S., Ktari Chakroun F., Lloze R. & Marchessaux D., 1983. Répartition et fréquence des Mammifères marins en Méditerranée. *Rapp. Comm. int. Mer Médit.*, **28** (5) : 223-230.

Forcada J., Notarbartolo Di Sciara G. & Fabbri F., 1995. Abundance of the fin whales and the striped dolphin summering in the corso-ligurian basin. *Mammalia*, **59** : 127-140.

Forcada J., Aguilar A., Hammond P., Pastor X. & Aguilar R., 1996. Distribution and abundance of fin whales (*Balaenoptera physalus*) in the Western Mediterranean during summer. *Jour. of Zool. London*, **238** : 23-31.

Gannier A., 1997. Estimation de l'abondance estivale du Rorqual commun *Balaenoptera physalus* (Linné, 1758) dans le bassin liguro-provençal (Méditerranée nord-occidentale). *Rev. Ecol.* (Terre Vie), **52** : 69-86.

Gannier A., 1998a. Estimating the summer abundance of striped dolphins and fin whales in the North-western Mediterranean with a small boat survey. Report SC/49/0 1 to the 39th Annual meeting of the Scientific Committee, *International Whaling Commission*.

Gannier A., 1998b. Variation saisonnière de l'affinité bathymétrique des Cétacés dans le bassin liguro-provençal. *Vie et Milieu*, **48** (1) : 25-34.

Gannier A., 1999. Les cétacés de Méditerranée nord-occidentale, nouveaux résultats sur leur distribution, la structure de leur peuplement et l'abondance relative des différentes espèces. *Mésogée*, **56** : 3-19.

Gannier A., 2002. Summer distribution of fin whales (*Balaenoptera physalus*) in the northwestern Mediterranean Marine Mammals Sanctuary. *Rev. Ecol. (Terre Vie)*, **57** : 135-150.

Gannier A., Bourreau S., Drouot V., Gannier O. & Laran S., 2003. Summer distribution of fin whales (*Balaenoptera physalus*) in the Mediterranean Sea. *Mésogée*, **60** : 17-25.

Giard J., Michaud R. & Goodyear J.D., 1999. The day and nights of fin whales : a VHF tracking study of their behaviour and use of habitat in the St Lawrence estuary, Canada. *13th Biennial Conference on the Biology of Marine Mammals*, Maui, Hawaii (28 Nov.-3 Dec.) : *Abstracts* p.53.

Jacques G., Minas M., Neveux J., Nival P. & Slawik G., 1976. Conditions estivales dans la divergence de Méditerranée Nord-occidentale : III. Phytoplancton. *Ann. Inst. océanogr.*, Paris, **52** (2) : 141-152.

Jahoda M., Lafortuna C., Biassoni N., Almirante C., Azzelino A., Panigada S., Zanardelli M. & Notarbartolo di Sciara G., 2003. Mediterranean fin whales (*Balaenoptera physalus*) response to small vessels and biopsy sampling assessed trough passive tracking and timing of respiration. *Marine Mammal Science* **19** (1) : 96-110.

Labat J.-P., Cuzin-Roudy J., 1996. Population dynamics of the krill *Meganyctiphanes norvegica* (M.Sars, 1857) (Crustacea : Euphausiacea) in the Ligurian Sea (NW Mediterranean Sea) Size structure, growth and mortality modelling. *Journal of Plankton Research*, **18** (12) : 2295-2312.

Laist D.W., Knowlton A.R., Mead J.G., Collet A.S. & Podestà M., 2001. Collisions between ships and whales. *Marine Mammal Science*, **17** (1) : 35-75.

Littaye A., Gannier A., Laran S. & Wilson J.P.F, 2004. The relationship between summer aggregation of fin whales and satellite-derived environmental conditions in the northwestern Mediterranean Sea. R*emote Sensing of Environment* **90** (1) : 44-52.

Massé J. & Cadiou Y., 1994. *Oedipe: Manuel Utilisateur*. IFREMER (Nantes) : 38pp.

Norris K.S., Würsig B., Wells R.S. & Würsig M., 1994. *The Hawaiian Spinner dolphin*. University of California Press, Berkeley, Los Angeles, London.

Notarbartolo di Sciara G., Venturino M.C., Zanardelli M., Bearzi G., Borsani F. & Cavalloni B. 1993. Cetaceans in the central Mediterranean Sea: distribution and sighting frequencies. *Boll. Zool.*, **60** : 131-138.

Notarbartolo di Sciara G., Zanardelli M., Jahoda M., Panigada S. & Airoldi S., 2003. The fin whale *Balaenoptera physalus* in the Mediterranean Sea. *Mammal Review*, **33** (2) : 105-150.

Orsi-Relini L. & Giordano A., 1992. Summer feeding of the fin whale, *Balaenoptera physalus*, in the Liguro-Provençal basin. *European Research on Cetaceans*, **6** : 138-141.

Orsi Relini L., Relini G., Cima C., Palandri G., Relini M. & Torchia G., 1994. *Meganyctiphanes norvegica* and Fin Whales in the Ligurian sea : new seasonal patterns. *European Research on Cetaceans*, **8** : 179-182.

Panigada S., Zanardelli M., Canese S. & Jahoda M., 1999. How deep can baleen whales dive. *Marine Ecology Progress Series*, **187** : 309-311.

Prieur L., 1981. Hétérogénéité temporelle dans le bassin liguro-provençal. *Rapp. Comm. Int. Mer Médit.*, **27** : 177-179.

Relini G., Orsi-Relini L., Cima C., Fasciana C., Fiorentino F., Palandri G., Relini M., Tartaglia M., Torchia G. & Zamboni A. 1992. Macroplancton, *Meganyctiphanes norvegica*, and fin whales, *B. physalus*, along some transects in the Ligurian Sea. *European Research on Cetaceans*, **6** : 134-137.

Sardou J. & Andersen V. , 1993. Micronecton et macroplancton en Mer Ligure (Méditerranée) : migrations nycthémérales et distributions verticales. *Oceanologica Acta*, **16** (4) : 1-12.

Sardou J., Etienne M. & Andersen V. 1996. Seasonal abundance and vertical distributions of micronekton et macroplankton in the north-western Mediterranean Sea *Oceanologica Acta*, **19** (6) : 645-656.

Zanardelli M., Notarbartolo di Sciara G. A Jahoda M., 1992. Photo-identification and behavioural observations of fin whales summering in the Ligurian Sea. *European Research on Cetaceans*, **6** : 86-89.

Acknowledgements
I thank the GREC ground staff who efficiently contributed to the survey logistics and numerous experienced observers who greatly contributed to survey data collection.