SUMMER ACTIVITY PATTERNS OF THE STRIPED DOLPHIN IN THE NORTHWESTERN MEDITERRANEAN SEA

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INTRODUCTION The striped dolphin (*Stenella coeruleoalaba*) is the more abundant species in the Western Mediterranean sea and the liguro-provençal basin (Forcada *et al*., 1994; 1995; Gannier, 1998a). The Northwestern basin has been described primarily as a summer feeding area, although breeding and calving although occur during that season (Aguilar, 1990; Gannier, 1999). The striped dolphin shows a migratory pattern, although a proportion of the summer population is still found in the northwestern basin during the winter (Gannier and Gannier, 1997; Gannier, 1998b).

Few results exist to describe the summer activity patterns of the striped dolphin, although evidence of night feeding associated to a nycthemeral distribution shift exists (Gannier and David, 1997). It has also been suggested that day time is mainly devoted to resting and socializing activities (Gannier, 1997). From 1988 to 1996, informations on the activity were recorded during the summer surveys of the GREC, including surface behavior, dive and surfacing cycles, movements. We present here analyses conducted on a very large set of data available from these surveys.

METHODS The field surveys took place between 15 June and 15 September from a 9 meter sloop (1988-1994) and a 12 meter motorsailer (1995-1996). Observation protocoles remained similar, although the number of observers varied from 2-3 (1988-94) to 3-4 (1995-96). Boats moved off the 100 meters isobath on random linear tracks, either on pre-determined or weather-dependent routes. The area of study was restricted to the Western Mediterranean, north of the 40° parallel. The sighting conditions were defined on a 0-6 scale from wind, sea state and light. A mean speed of 5kts (prior to 1995) or 6kts was obtained by cruising mainly on diesel engine. Three observers in average were in duty, searching with naked eyes. Upon detection, measurements of relative position of cetaceans were made with reticuled binoculars. The animals were then generally approached (excepted during one month in 1996) to collect data on group structure, behaviour and activity. From 1994 onwards, systematic acoustic sampling was simultanaously conducted, with a rate of 0.5 listening per mille. Listenings were performed in the presence of dolphins to provide informations on activity. Sighting informations were recorded manually on a standard form shortly after the observation and were later loaded onto a Dbase4 data base. The sighting form varied little during the period of study.

We only kept for analysis the records featuring: a sighting conditions index of over 4, wind speed inferior or equal to Beaufort 3, records with a sighting duration of over two minutes. A total of 490 sightings were then selected: 3 in 1988, 39 in 1989, 29 in 1990, 43 in 1991, 67 in 1992, 78 in 1993, 58 in 1994, 77 in 1995, 96 in 1996.

Two types of variables were retained for the analysis: activity-related variables and environment/time-related variables. Activity related variables included group structure (GRP), group size (EST), activity (COM) and the frequency of juveniles (JEU) and calves (NOU) in the school. Environment/time-related variables included year (ANN), month (MOI), hour (HEU), distance to the coast (COT), depth (PRO) and sighting duration (DUR).

The activity was analysed as a function of the bottom depth. The activity was sorted into 4 classes (columns): socializing, travelling, feeding and resting. The bottom depth was sorted into 4 strata (rows): 200-1100m, 1100-1700m, 1700-2300m, 2300-3000m. This 4x4 distribution was analysed with *StatXact* ® by performing a Pearson Chi-2 test for independence of rows.
For the purpose of the multivariate analysis, every variable was sorted into 6 to 8 classes, trying to have an approximately equal sample size for each category (table 1). The group structure was sorted into 7 categories, including the « unknown » class. The activity variable was sorted into 8 categories, including 3 for which the activity could not be determined with certainty. Frequency of juveniles and calves variables include a category (NOU5 or JEU5) describing schools where only mother-calves (-juveniles) pairs could be seen.
A contingency table was formed with environmental variables as rows and activity-related variables as columns. A factorial analysis was run with *Statos* ® software. Taking account of the first results, several categories were pooled for a similar and improved analysis.

RESULTS During the period of study, the feeding activity is the most frequent, with 37.0% of the 319 cases. Travelling represents 29.8% of the cases recorded and socializing 20.3%. Resting is apparent the less frequent, with 12.9%. However, this activity pattern shows significant variations across the different depth strata (table 2). The feeding activity is predominant in the 200-1100m depth stratum (56.7%), when the travelling is more frequent in the 1100-1700m stratum (36.1%). Resting is very uncommon inshore (3.3%) and relatively more frequent offshore, with a maximal frequency in the deeper stratum (15.3%). The Monte Carlo estimate of the Chi-2 probability was 0.090 when all rows were considered (differences across rows unsignificant). When the second row (the less populated) was omitted from the comparison: the activity pattern was then found to be significantly dependent from the bottom depth, with a Chi-2 probability of 0.035.
The results of the Factorial Analysis are plotted on a two axis schematic diagram (Fig. 1). These two axis represent about 38% of the total inertia. The first axis contains much information on time and bottom depth. The second axis contains much information on group size and structure. The most significant variables (in term of contribution to the analysis) have been displayed together with the time and activity variables. We traced a path between the successive time periods. The following results became apparent:
- early morning and late evening periods are well grouped with the plots of feeding activity, shallow water and scattered groups,
- on the contrary, the socialisation activity is close to the plots of the afternoon period and offshore area,
- the late afternoon is associated with grouped structure, resting and presence of numerous calves and young.

This time path suggests a cyclic activity pattern with feeding occuring between evening and early morning (including night) and socializing and resting activities taking place during the middle of the day. The activity cycle appears to be coupled to a spatial distribution shift. A simultaneaous variation of school structure is apparent with small and scattered subgroups during the morning and more important schools with calves and juveniles during the afternoon.

DISCUSSION The complex overall picture given by the factorial analysis can be supported by simpler analysis already available. In a study undertaken during the summer 1997, within 30 miles of the french continental coast (Gannier, 1997), the temporal variation of the activity of 81 striped dolphins schools was shown: feeding was recorded in 93% of the determined cases during the early morning period. This proportion fell to 40% and 0% for the late morning and afternoon, respectively, before rising to 57% during the evening. The travelling activity took 27% of the share during the late morning and the resting was the most often recorded activity during the afternoon. Socialising was the less frequent activity, culminating at 14% during the afternoon.

It must however be added that activity patterns (as observed on the field) are not easily sorted into one of the 4 adopted categories. Nevertheless, the description from the survey in 1997 fits well within the schematic cycle depicted above (Fig. 1).
From the same field study, an offshore movement of the dolphins was shown during the late morning, and an inshore movement during the evening (Gannier and David, 1997). In the same paper, sighting rates estimates also clearly suggested a distribution shift, with a steep decrease in the nearshore area from the morning to the afternoon and an increase of sighting rate over the shelf break, from the afternoon to the evening.

CONCLUSIONS This study gives new information on the habitat use of the striped dolphin in an area where numerous human-induced perturbations might affect the dolphins long-term status. This aspect of the dolphin ecology needs more research when commercial and recreational dolphin-watching develops, particularly in areas close to the populated and popular Riviera shore.

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Table 1 Multivariates analysis: variables classification.

variables	cat	cat	cat	cat	cat	cat	cat	cat
group structure (GRP)	GRP0 unknown	GRP1 tight	GRP2 in line	GRP3 grouped	GRP4 spread	GRP5 scattered	GRP6 subgroups	
group size (EST)	EST1 1 to 5	EST2 6 to 10	EST3 11 to 15	EST4 16 to 20	EST5 21 to 35	EST6 36 to150		
activity (COM)	COM1 feeding	COM2 traveling	COM3 resting	COM4 socializin g	COM5 rest-/soc	COM6 rest-/trav.	COM7 trav/soc.	COM8 breeding
freq. juveniles (JEU)	JEUO unknown	JEU1 none	JEU2 less 25%	JEU3 25-50%	JEU4 over 50%	JEU5 w/mother		
freq. calves (NOU)	NOUO un-known	NOU1 none	NOU2 less 25%	NOU3 25-50%	NOU4 over 50%	NOU5 w/mother		
hour (HEU)	HEU1 500- 925	HEU2 925-1140	HEU3 1141-1400	HEU4 1401-1615	HEU5 1616-1830	HEU6 1831-2115		
dist. to coast (COT) (n. miles)	COT1 0-8	COT2 8.1-14	COT3 14.1-18.7	COT4 18.8-24	COT5 24.1-34	COT6 34.1-76		
depth (PRO) (meter)	PRO1 <1140	PRO2 1150-2000	PRO3 2010-2200	PRO4 2210-2450	PRO5 2460-2550	PRO6 2560-3200		
duration (DUR) (minutes)	DUR1 0-3	DUR2 4-5	DUR3 6-9	DUR4 10-13	DUR5 14-21	DUR6 22-330		

Table 2 Depth related activity patterns (number of sightings).

depth	socializing	travelling	feeding	resting
200-1100m	8	13	34	2
1100-1700m	8	13	10	5
1700-2300m	16	30	30	10
2300-3000m	33	39	44	21

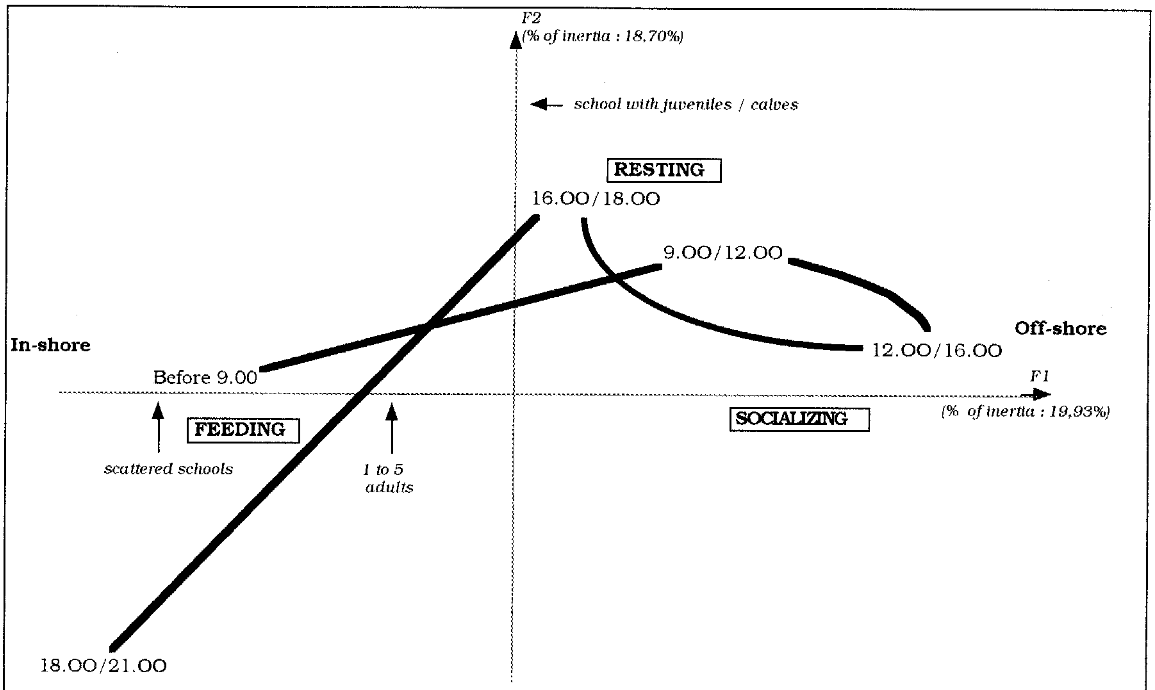

Figure 1 : Schématic description of main activity distribution with caracteristics of the group and environmental factor (from AFC).

Fig. 1 Schematic graph of the factorial analysis.