DISTRIBUTION OF CETACEANS IN THE MARQUESAS ISLANDS (FRENCH POLYNESIA)

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INTRODUCTION The Marquesas Archipelago is located between 7°30S and 10°30S south at a longitude of 140°W. These islands are not surrounded by a coral reef, contrary to most other islands of French Polynesia. No information on cetaceans local distribution was available for the Marquesas islands before a survey was held in December 1998 and January 1999 (Gannier, 1999). Marine environment is poorly known in this area, however local primary production enhancement is known from direct observation and the interpretation of satellite imagery (Signorini *et al*., 1999). The aim of our study was to assess the cetacean population in Marquesas at the end of cold season (October) and to compare new results with those obtained during the warm season.

MATERIAL AND METHODS Between 29 September and 2 November 2000, we conducted survey in the whole archipelago of Marquesas. During sampling, the ship, a 14 meter catamaran, was cruising at an average speed of 6 knots and at least 3 observers were on duty with the naked eyes (Gannier, 1999 and 2000). Position (GPS) and environmental parameters (sea state, wind, nebulosity, …) were recorded every half-an-hour and a listening session was performed with a towed hydrophone. For each sighting school size, species, activity pattern, presence of new-born calves were recorded as well as other information.
Result were plotted with ŒDIPE®IFREMER software (Massé & Cadiou, 1994). The diversity was expressed as the relative frequency, ***Fi***, ratio of the number of observed individuals belonging to the species *i* on the total number of cetaceans sighted on-effort; the Shannon-Weaver index was also used to describe the diversity. We determined a relative abundance index, ***R***, only in inshore area (within 5 milles from coast) and from visual sampling obtained with good sighting condition (Beaufort 3 or less). This index was obtained from the line transect density estimator (Buckland *et al*., 1993), and estimates were computed with DISTANCE 2.2 software (Laake *et al*., 1994).

$$\underline{\mathbf{R}} = \left(\frac{n}{L}\right) \cdot \underline{E(s)}$$

Variance and confidence intervals were estimated with the delta method (Buckland *et al.*, 1993).

RESULTS
Sampling and sighting results : A total of 2,555km of effort was logged, most of which (2,105km) covered with good sighting condition (4 Beaufort or less) including 924km with less than Beaufort 3. A total of 63 sightings were recorded, 57 being on-effort sightings including one unidentified dolphin school. Only delphinids belonging to 7 different species were sighted : pantropical spotted dolphin (*Stenella attenuata*, 23 sightings), spinner dolphin (*Stenella longirostris*, 17 sightings), bottlenose dolphin (*Tursiops truncatus*, 6 sightings), rough-toothed dolphin (*Steno bredanensis*, 4 sightings), melon-headed whale (*Peponocephala electra*, 3 sightings), short-finned pilot-whale (*Globicephala macrorhynchus*, 2 sightings*)* and pygmy killer whale (*Feresa attenuata*, 1 sighting). Results show the dominance of spotted and spinner dolphin, with 40% and 30% of sightings respectively (tab.1).
Mean school size varied according to the species (tab.1): melon-headed whale was always observed in large schools (30-120), spotted dolphin and spinner dolphin showed mean school sizes of 31.9

and 29.8 respectively, and bottlenose dolphin and rough-toothed dolphin schools were more limited with mean sizes of 11.8 and 8 individuals respectively.
When proportions of individuals were considered, pantropical spotted and spinner dolphins were also dominant, with 44.4% and 30.6 % respectively. However, melon-headed whales took some importance (16% of the total effective). Due to smaller school sizes, the 3 other species were less represented. We obtained a Shannon diversity index of 1.91.
Acoustic sampling : Out of 265 acoustic samples made during transect, 28 gave positive results and showed delphinid presence, from which only 6 were synchronised with visual sightings.
Species association *:* On nine occasions schools of different species were recorded simultaneously. The most abundant association inshore was pantropical spotted dolphin-spinner dolphin (5 times); a mixed school of 200 animals was also observed 45 km offshore. Pantropical spotted dolphin were also observed twice with bottlenose dolphins and once with short-finned pilot-whale. Spinner dolphin was also seen with melon-headed whale.
We have noticed calves on 35% of pantropical spotted dolphin's sightings, 53% for spinner dolphin and 100% for melon-headed whale.
Bathymetric affinity : 53 sightings of six species were represented on three bottom depth strata : neritic area (coastline to 100m of depth), slope area (101 to 2000 m) and oceanic area (> 2000 m).
Spinner dolphin showed a significant preference for neritic area (80% of spinner dolphins sighted), like melon-headed whale (100%) and bottlenose dolphin (88%). In contrast, pilot whales and rough-toothed dolphins showed a preference for slope areas (28% of rough-toothed dolphins) and for oceanic area. The spotted dolphin was the only species to be met over the three habitats, with a preference for slope (47%).
Relative abundance : For analysis, an effective search half-width of 600 m was adopted arbitrarily. From a total of 993km on 23 transect segments, 37 sightings featured a mean group size of 29.94 individuals, a detection rate of 0.037 individual per kilometre (CV=16.5%) and a relative abundance index of 0.93 delphinid per kilometre (CV=24.6%).

DISCUSSION Comparison with the previous survey was possible because both crew followed a similar protocol (tab. 2), and three observers participated to both programs. To minimise effect of sampling biases, we have compared only inshore sightings for both years, with 65 sightings for 1998-99 and 39 for 2000, on five different species. Sightings frequency ranks were conserved for all species. We noticed that 3 additional species were observed once in the previous study : the Risso's dolphin, the killer whale and the false killer whale. Proportions of individuals $\boldsymbol{F_i}$ showed some variations between years (fig.2), mainly because melon-headed whales share decreased from 52% to 24.6%, and spinner dolphin's increased from 7.8% to 24.6% of delphinid sighted between 98-99 and 2000. Thus, a seasonal variation of presence is apparent between October and December-January, when melon-headed whales are more frequent, this might be caused by reproduction activity or trophic conditions.
A Mann-Whitney Test, on the 4 main species, did not reveal any significant difference between both years for school size series of bottlenose dolphin (*p=0,7630*), spotted dolphin (*p=0,3609*), and melon-headed whales (*p= 0,4835*); but this difference was significant for spinner dolphins (*p=0,0015*).
Results on relative abundance inshore were slightly inferior for 2000 with 0.93 delphinid per kilometre, compared to the mean value of 1.2 obtained in 1998-99. This could result from the melon headed whale lesser presence. However, the relative abundance is still much higher than elsewhere in French Polynesia: Gannier (2000) evaluated a relative abundance of 0.28 dolphin per kilometre in the inshore area of the Society archipelago. The higher delphinid abundance in the Marquesas is clearly related to mesotrophic ecological conditions (Signorini *et al*., 1999).No sperm whale and no humpback whale were sighted during this cold season survey (Bourreau and Gannier, 2001).

Bathymetric affinity (for all sightings: inshore and offshore) were conserved for six common species : (1) spinner dolphin, melon-headed whale and bottlenose dolphin were always neritic species, (2) pilot whale and rough-toothed dolphin were deep water species and (3) spotted dolphin was present in the three habitats. This distribution is certainly due to ecological factors (reproduction, prey distribution,…) because anthropic impact is negligible.

CONCLUSION This 35 day survey in the Marquesas permitted to confirm results of the first study (Gannier, 1999) noticeably on cetacean diversity and abundance: (1) the Archipelago features a high diversity (2) large species such as sperm whale or humpback whale are apparently rare (3) relative abundance is higher than in other areas in French Polynesia.
This area is ecologically complex and unfortunately not well-known. Complementary studies with other methodologies, such as hydrology and satellite imagery will be necessary to understand this ecosystem.

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Table 1. Results of sightings in for 6 species (take in account the school of 12 pygmy killer whales).

Species	*S. attenuata*	*S. longirostris*	*P. electra*	*T. truncatus*	*S. bredanensis*	*G. macrorhynchus*
Number of sightings (and %)	23 (*40.4%*)	17 (*29.8%*)	3 (*5.3%*)	6 (*10.5%*)	4 (*7%*)	2 (*3.5%*)
Mean school size *	31.9	29.8	90	11.8	8	11.5
School size range *	2-150	2-100	30-120	1-35	5-12	9-14
CV(%)	23.8	19.3	33.3	43.8	19.8	-
Total * (and F_i in %)	**733** (*44.4%*)	**506** (*30.6%*)	**270** (*16.3%*)	**71**(*4.3%*)	**32** (*1.9%*)	**23** (*1.4%*)

*: in individuals

Table 2. Main characteristics of both field studies in Marquesas islands: 1998-99 et 2000.

	1998-99	2000
Plateform	ketch 15m	catamaran 14m
Period of year and duration (in days)	December-January / 52	October / 35
Duration of effective sampling (h.)	118,5	205
Sampling (km) with Beaufort < 4	2791	2105
Beaufort < 3	1928	924
Total of sightings (on-effort)	101	57
Number of common species	7	
Relative abundance (delphinid per kilometre)	1.2	0.93

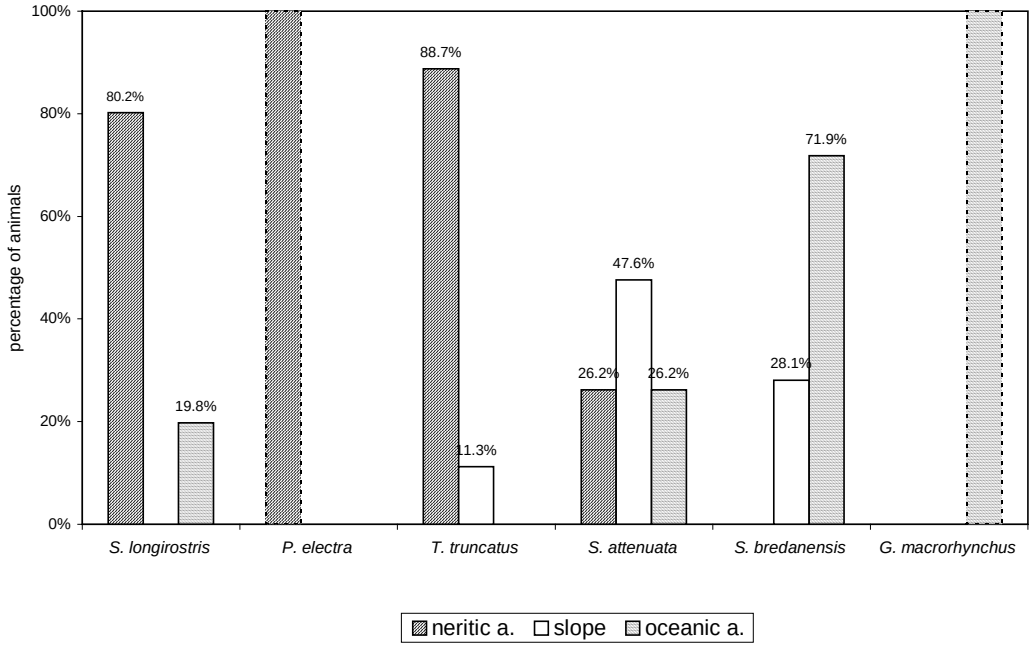

Fig. 1. Distribution of animals (by species) on 3 bathymetric classes.

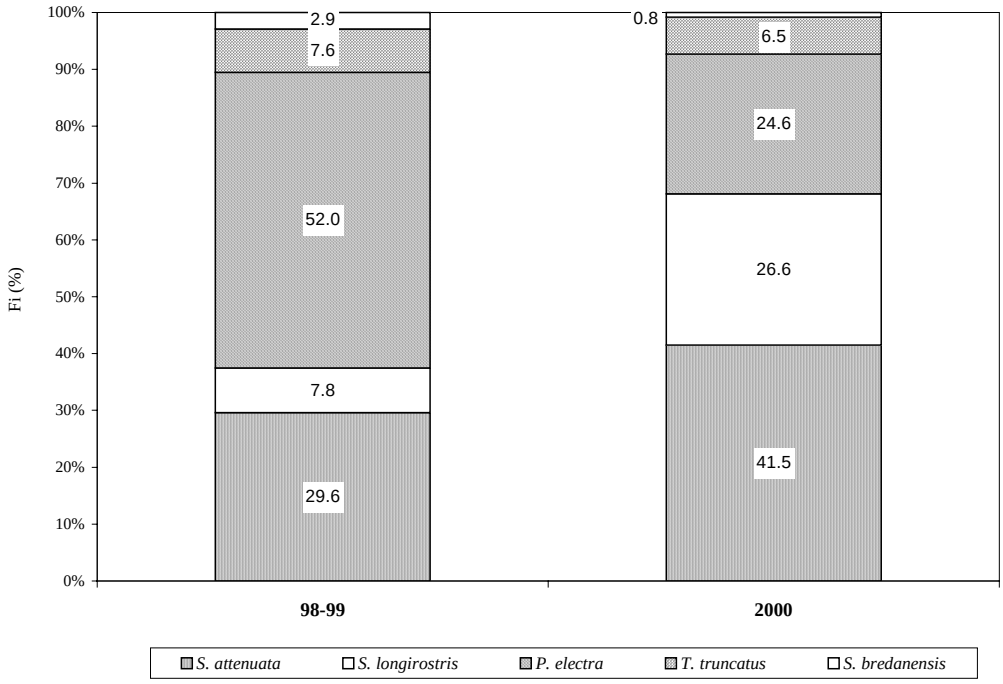

Fig. 2. Percentage of inshore cetaceans sightings for both periods (within 5 milles from coast).