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Behavioral description on surface and characterization of humpback whales population (*Megaptera novaeangliae*) during the breeding season 2006 in Colombian Pacific coast

Descripción del comportamiento en superficie y caracterización de la población de ballenas jorobadas (*Megaptera novaeangliae*) durante la temporada de reproducción y cría 2006, en la costa del Pacífico colombiano

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Abstract

Humpback whales arrive to Colombian Pacific Ocean for breeding and rearing its calves; from 20 m high shore platforms, 115 groups were observed during 44.8 effective sample hours during the 2006 breeding season. Using the group-follow method and incidental sampling were evaluated the group structure, displacement patterns and surface behavior frequency (flippering, lobtailing, breaching, arching, surface turns and spy hoping). Results showed that 26.1% of the groups were formed mainly by one adult, following by groups formed by two adults (22.6%), female, its calf and one escort (21.7%), female and its calf (20%), female, its calf and more than one escort (7%), by three adults (1.7%), and by two females, two calves and two escorts (0.9%). Whales swam with an average speed of 7.3 km/h, and there were not significant differences in speed between the groups (H6=4.9, p=0.5). 69.6% of the whales swam north, 27.8% south, and the rest did not show a clear course; the average time diving was about 4.9 min. Surface behaviors were short, it occurred during 2.5% of the registered time, and the group formed by two adults was the most active (H6=19.9, p=0.02). Humpback whales passing by Bahia Solano, in July and August, principally alone and in groups with one calf, course north, with a moderate speed, with diving intervals about 5 minutes; and that the aerial behavior is not frequent.

Keywords: *Megaptera novaeangliae*; Cetacean; Behavior; Colombian Pacific coast.

Resumen

Las ballenas jorobadas llegan al océano Pacífico colombiano para la reproducción y la crianza; desde plataformas marinas de 20 m de altura, se observaron 115 grupos durante 44.8 horas de muestreos efectivos, durante la temporada de cría 2006. Utilizando el método de muestreo de seguimiento grupal-incidental, se evaluó la estructura grupal, los patrones de desplazamiento y la frecuencia de la conducta sobre la superficie marina (aleteos, coletazos, exhalaciones, arqueos, saltos y espionajes). Los resultados mostraron que el 26.1% de los grupos estuvieron formados principalmente por un adulto, seguidos por grupos de dos adultos (22.6%), hembra con cría y un escolta (21.7%), hembra con cría (20%), hembra con cría y más de un escolta (7%), tres adultos (1.7%), dos hembras, dos crías y dos escoltas (0.9%). La velocidad media fue de 7.3 km/h, y no hubo diferencias significativas en la velocidad entre los grupos de ballenas (H6=4.9, p=0,5). El 69.6% de las ballenas nadaron hacia el norte, 27.8% al sur y el resto no mostró un rumbo claro; el tiempo promedio de inmersión fue de 4.9 min. Los comportamientos superficiales fueron cortos, se produjeron durante el 2.5% del tiempo registrado y el grupo formado por dos adultos fue la agrupación más activa (H6=19.9, p=0.02). Las ballenas jorobadas que pasan por Bahía Solano, en julio y agosto, se encuentran principalmente solas y en grupos con cría, llevan rumbo norte con una velocidad moderada, con intervalos de buceo alrededor de cinco minutos y el comportamiento aéreo no es muy frecuente.

Palabras clave: *Megaptera novaeangliae*; Cetáceos; Comportamiento animal; Costa pacífica colombiana.

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The Panamá, Colombia, Ecuador and Chile shore is well-known as the zone of the Southeastern Pacific. Is habitat between many subpopulations of humpback whales, which spend part of their time in areas of feeding in high latitudes of the south of the American continent and Antarctica, and the zones of coastal water reproduction lukewarm of the tropic, of which some populations cross up to 10 degrees to the north of the equatorial line crossing a distance of 8500 km (Stevick *et al.* 2004, Rasmussen *et al.* 2004, Acevedo *et al.* datos sin publicar).

The world-wide humpback whales population oscillates in 10% and 20% of their original size, and it has been catalogued by the International Union for Conservation of Nature (IUCN) as vulnerable status (Reeves and Leatherwood 1994, Reeves *et al*. 2003). In Colombia it also has been classified as vulnerable, (i.e. that at the moment is threatened in wild populations), (Flórez-González *et al*. 2006). The species has been reported annually in the colombian Pacific north, the area of Bahía Solano and surroundings, however there have been only some preliminary studies about its presence in the area (Alberico *et al.* 2000, Muñoz-Saba and Alberico 2004, García *et al.* 2006).

The behavioral patterns of this specie, show social functions, competitive demands, and necessities of feeding and availability of prey (Helweg and Herman 1994). When beginning the period of migration towards the zones of reproduction they appear typical conducts, like the competition between individuals, some events that denote aggression and the emission of songs (Herman and Antinoja 1977, Ávila 2000).

In Colombia, humpback whales have been studied on Gorgona island (Cauca department), and around Malaga Bay, Malpelo island (Valle del Cauca department), which comes to sites between June and November with the aim of breeding and rearing (Flórez-González and Capella 1993, Flórez-González *et al.* 1998, Avila 2000, Bonilla 2000). Although this specie has been reported annually in the northern of Colombian Pacific in Bahía Solano and its environs, only there has been some preliminary studies of its presence in the area (Alberico *et al*. 2000, Muñoz-Saba and Alberico 2004, García *et al.* 2006). Except Ávila´s study in 2006, in this country the majority of investigations based on the study of humpback whales behavior have been conducted from boats or under the direct influence anthropic, therefore there is a general way to a degree ethology unknown of these individuals in their natural state, this means without influence of boats that condition or influence the normal activity of the humpback whales (Avila 2006).

The regular presence of humpback whales in this area of Colombia, accentuates the need to know the ethology dynamics of these marine mammals, as well as being a kind of economic importance and cultural identification for the inhabitants of these localities ago Part of marine biodiversity possessing the waters of Chocó department. Therefore this study is timely and of great importance for the conservation of humpback whales in the Chocó and in Colombia, which have been little studied and deserve attention to promote subsequently to carry out conservation plans, management of wildlife and determination of natural conservation areas (Rocha 2007).

Materials and methods

The data was compiled during the humpback whales reproductive season, comprising from 1 of July to 31 of August 2006. The *M. novaeangliae* activity was registered based on Mann (1999) through of incidental samplings and continuous records from two land platforms of 20 meters of height; the samplings were made by two observers, while an observer described the activity, the other recorded the sequence of the same one in registry squares, which included beginning and ending sampling time and the time in which they were made each one of the events, each hour this job was intercalated to avoid errors in taking of data by visual fatigue; binoculars 7x50 offshore equipped with a horizontal direction component «azimuth» were used together with a chronometer that, allowed us to measure the speed expressed in degrees/total observation in seconds and a range scale which allowed to have certainty and trustworthiness that data registered already this scale establishes the distance in kilometers between the platform and observed group.

Groups were defined based in Ávila (2006) where a grouping appears when between the individuals is a distance smaller to 100 meters during a minimum

time of 10 minutes and the stability of such according to the changes in the group structure during the period of observation; in addition they must display coordinated movements and take same direction and speed of swimming (Whitehead 1981). The determination of the type of grouping was made visually having in account the corporal length and size of the fin dorsal and of body volume (Ávila 2006). From the terrestrial platforms whales can be detected by their exhalations which in their majority present display propulsion of water spurt of two to three meters of height on water surface, dorsal fin and peduncles exposure or surface and aerial displays (Rocha 2007). Humpback whales not conform stable groupings in time, except mother and you calve, which remain together by an approximated period of a year, during the lactation (Baker 1984).

According to distribution and based on previous studies, we determined the following types of social groupings: (A) an adult, (2A) two adults, (3A) three adults, (H+B) female and its calve, (H+B+E) female, calve and an escort, (H+B+Es) female, calve and more than one escort, (2H+2B+Es) two females, two calves and more than one escort. During each sample total observation, diving and on surface times, displacement degrees (azimuth) and swimming course according to direction taken for each group was recorded. For behavioral events determination on surface, some were taken from the activities that prioritize in the groupings of *M. novaeangliae* during the breeding season in Colombian Pacific. These types of recorded activities are very showy and therefore are reliable for identification from land platforms because are highly distinguishable over long distances (Ávila 2006). Flippering, lobtailing, breaching, arching, turns in surface and spy hoping settled down like surface events. As superficial activity all the other events are understood, including the water exhalations. Only the follow events were taken such as respiratory activity: Rotating, back and stomach breachs, because present their spiracles (nostrils) to the surface, simultaneously recorded as an event of respiratory activity.

Data analysis

Data was filtered to order them chronologically and by groupings types to obtain groups and total averages, standard deviations, and rates of occurrence as far as the items of superficial activity there. Time observation was made by subtracting the final time from the initial observation time. Dives and on the surface times, were obtained by subtracting the total time of observation time immersion, and it evaluated the respiratory behavior, displacement courses and speed. Photographic records obtained during part of 2005 and 2006 seasons were compared with each other in order to avoid errors in overestimating individuals registered, it was noted whether there were recaptured and thus established a preliminary list for the area through photoidentification method. For quantify events frequency of occurrence on surface, we used the method described by Helweg and Herman (1994), Corkeron (1995) and Ávila (2006), with an amendment, the rate was calculated for each event for each the 115 groups and then averaged by type of grouping, as a fee for each individual type of grouping as follow:

$$\text{Rate} = \frac{\text{N° of observed events by grouping}}{\text{Observation time (minutes)} \times \text{N° individuals of group}}$$

Speed obtaining

For each registry speed was determined as follow:

Total time observation = final time - initial time

$$\text{Distance} = \sqrt{(D1^2+D^2-2) * (D1*D2) * \cos(A\text{-}rad)}$$

Where D1 is the distance from the viewpoint to the starting point, D2 the distance of the viewpoint to final point observation and *Arad* is the angle transformed into radians (formulates of cosine); and the angle A= A1 - A2 ((1) angle at the beginning, (2) the end of observation).

Results

Sampling effort and registry success. During focal samplings from earth, made in the months of July and August of 2006, a total of 480 hours during 60 days was accumulated, the samplings were made from the 8 to 12 and from 14 to 18 hours, period subject to environmental and oceanic conditions; this one threw a success of capture or obtaining of registries, of 162,348 seconds equivalent to 2705.8 minutes or 45.09 hours (Table 1).

The samplings made from the terrestrial platform, was recorded 115 groups, which distributed themselves in seven type groupings. Altogether 250

Table 1. Sampling effort and registry success from earth

Total sampling hours = %	Recorded hours = %	Exit daily average %
480 h. = 100	45.09 h. = 9.39375	0.0939375 h

individuals were observed, of which 192 they were adult (72.8%) and 58 calves (28.2%) (Figure 1). The time average of observation of these 115 groupings was of 23.52 minutes. The type of grouping with greater observation numbers was the conformed one by an adult (A) 26.1%. The grouping constituted by three adults (3A) with (1.7%) was less frequent.

Total observation time of each type of grouping, corresponded directly with the number of observed groups in A, H+B, H+B+Es. 2A and 3A, respectively displayed a smaller number of groups (Figure 1) but greater observation time with respect to H+B+E and 2H+2B+Es (Figure 2). The frequency in the times of observation, varied according to conformation group.

The mean in observation time for each group do not retained relationship (R2=0.2) with the observed frequency of each one of the 7 groupings; that is to say, not evidence that groups with greater number of observations, have the greater mean of observation and vice versa; which is demonstrated in addition which the groupings of adults with young display a greater observation time, suggests greater activity of events in the surface of the water.

The sampling was divided in 4 phases (biweekly), with the aim of to identify if variations in the observation frequency of groupings existed during the total period of sampling (Table 2). The grouping 2A although obtained the greater frequency in phases 1 and 2, decreased substantially during the last phases; H+B+E and H+B diminished their frequency with respect to 2A, but they maintained the same tendency with this one grouping in the four phases. 3A and 2H+2B+Es, were those of smaller frequency and they only appeared in second and first phase, respectively. Most groupings were observed during two first phases with a frequency of the 66.1% and the third and fourth phase obtained the 33.9%, in second month the observation frequency decreased in a 50%.

Surface activity. The time percentage in which each one of the type groupings showed surface activity of the total time observed, total of aerial activities and events on surface (except respiratory events) happened in 0.8% of the total of the observed time. The greater activity in surface was observed in the groupings conformed by a greater number of individuals: H+B+Es and 3A, 2H+2B+Es although this one complete sample the greater frequency of activity in surface, does not provide representative

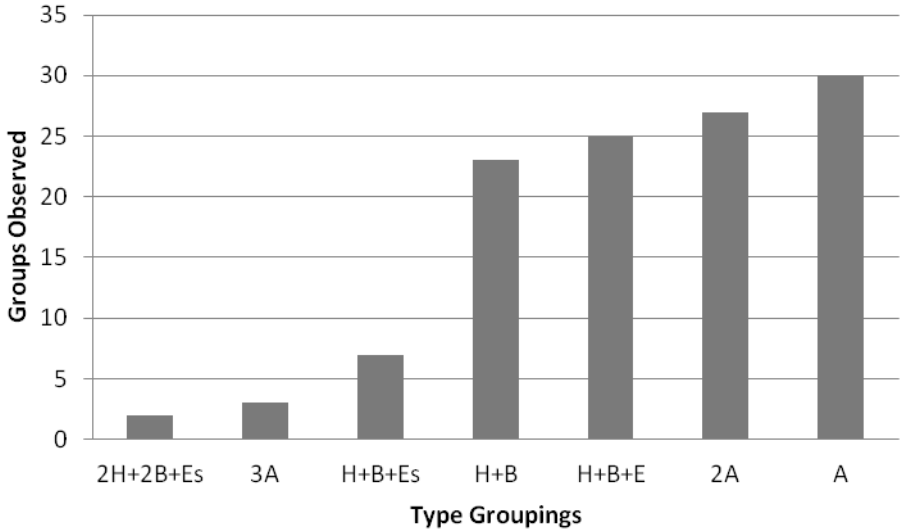

Figure 1. Number of groups observed during July and August of 2006 according to type of grouping.

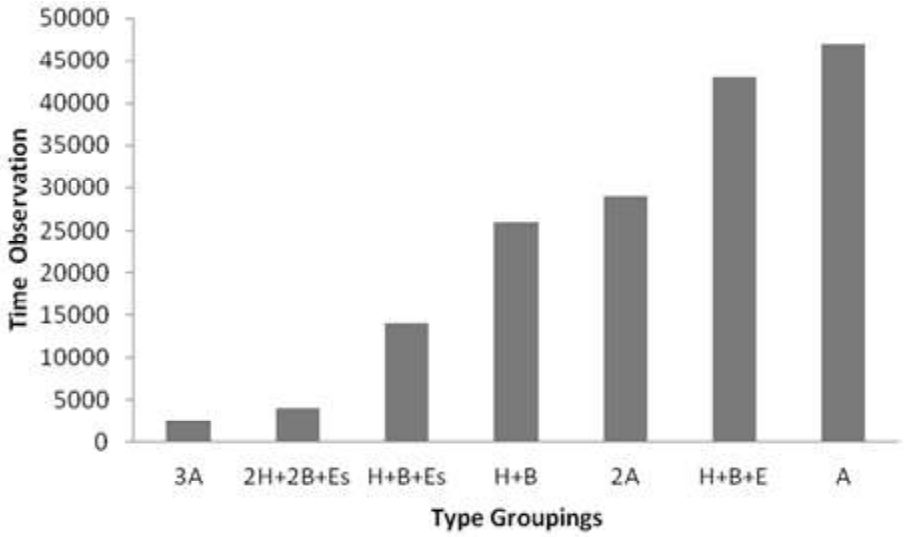

Figure 2. Total observation time in seconds, according to type of groupings.

Table 2. Sightings groupings frequency during four observation phases

Type grouping	Phase (%) 1 (30 Jun-15 Jul)	2 (16 Jul-31 Jul)	3 (1 Aug-15 Aug)	4 (16 Aug-30 Aug)	Total sightings
A	8 (21.05%)	3 (7.89%)	8 (42.10%)	11 (55.0%)	**30**
2A	10 (26.31%)	11(28.94%)	1 (5.26%)	4 (20.0%)	**26**
H+B+E	6 (15.78%)	13(28.94%)	3 (15.78%)	3 (15.0%)	**25**
H+B	9 (23.68%)	7 (18.42%)	6 (31.57)	1 (5.0%)	**23**
H+B+Es	4(10.52%)	2 (5.26%)	1 (5.26%)	1 (5.0%)	**8**
3A	——	2 (5.26%)	——	——	**2**
2H+2B+Es	1 (2.63%)	——	——	——	**1**
Total	38	38	19	20	115

information because single a registry of this one type of grouping was obtained, nevertheless bears relation to mentioned previously. The groupings that displayed greater number of events on surface were H+B+E, H+B, 2A, and A (Figure 3), which presented the greater observed frequency.

H+B obtained the greater average in the flippering rate, lobtailing, spy hoping and arching; A obtained the greater average in the rate of surface turns and 2A obtained the greater average in the rate of breaches (Table 3).

The surface time (ST) was obtained indirectly, reducing the diving time of the total time of record of each group. Therefore, obtained values correspond to events duration displayed on surface (flippering, lobtailing, breaches, spy hoping, arching and surface turns), but also to lapse among an event and other that does not correspond to one diving lower to 60 seconds. Spearman correlation analysis among events number and surface time of the groups observed showed a coefficient r=0.3929, which indicates that the relationship between the surface events number and surface time was positive but not significant (r <0.5). The value of R2 notes that the number of surface events hardly explains the 15.4% of the variation in surface time (Figure 4).

Respiratory behavior. A total of 3386 respiratory events were recorded such as: Expulsions of a water spurt, head exposition and spiracle, spy hoping, breach of turn, back breach. More greater respiratory activity was recorded in H+B+E (25 groups) with 1265 breathings (exhalations) 50.1 breathings average by group; the smaller amount breathings were recorded in follow groups: 2H+2B+Es (1 group) with 49 and 3A (2 groups) with 120 breathings, but to the being groups with low

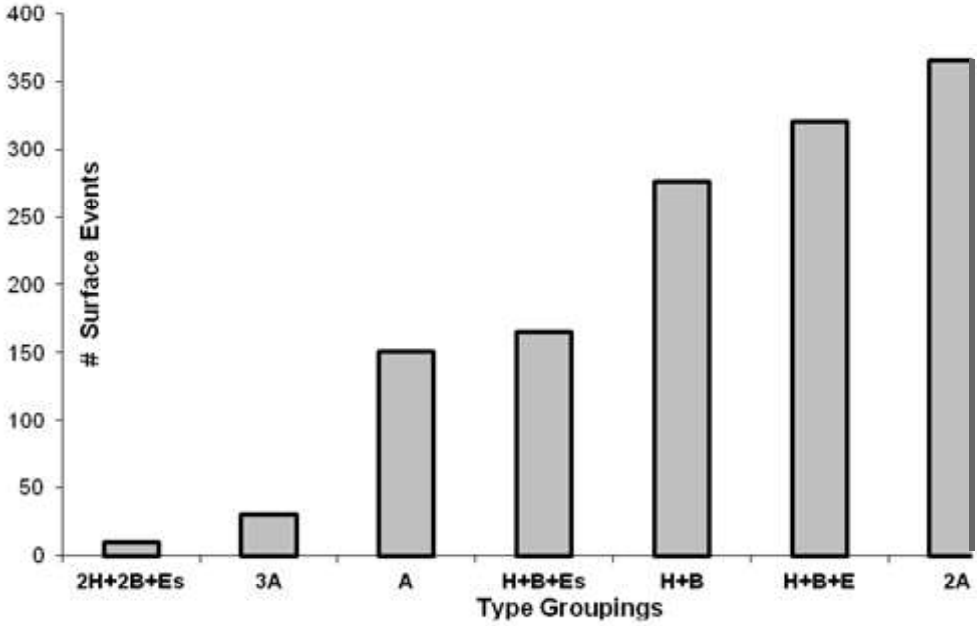

Figure 3. Number of events in surface.

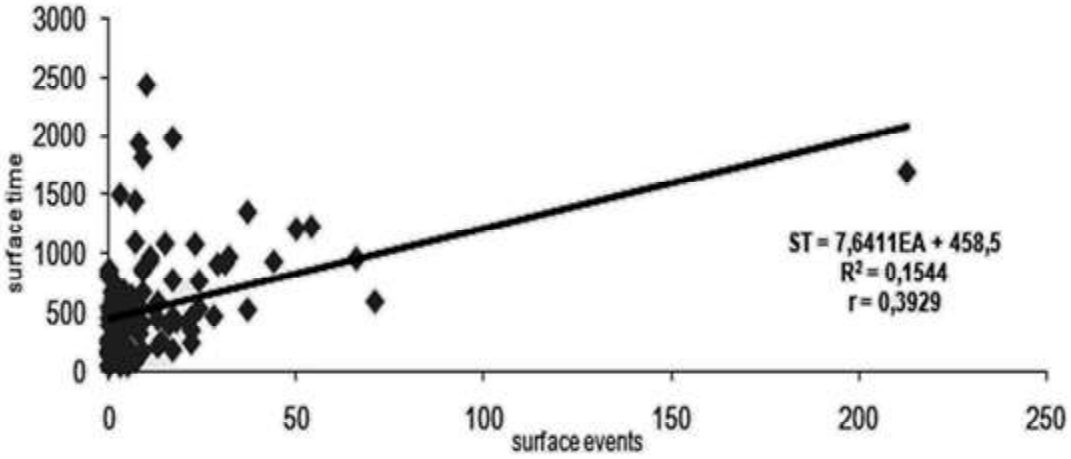

Figure 4. Correlation analysis among events number and surface time.

registries cannot be considered significant, by this was determined H+B (23 registries), as smaller breathings records (532) 23.13 group average (Table 4).

490 immersion events (time under water longer than 60 seconds as Avila *et al.* (2004) were recorded, with a total of 121,079 seconds under water along all observations; groupings with greater diving activity were H+B+E (25 groups) with 118 dives and 4.7 dives averaging per group, A (30 groups) with 118 dives and also averaged 3.93 dives per group: on the other hand, and the group of lesser activity in dives was 2H+2B+Es (1 group) with 7 events registered, but to have a single record was taken by the group H+B+Es It's like that of the lowest number of dives (49), but in the same manner that was presented the highest average with 6.12 per group dives (Table 5).

According to 4 and 5 tables, these showed that there are strong links in the averages higher breaths and dives into groups composed by female with calve and escort/s; however there are close linkages

Table 3. Rates average and standard deviation (SD) of surface events displayed by the groupings of *M. novaeangliae*

Rates	2A	2H+2B+Es	3A	A	H+B	H+B+E	H+B+Es
Flippering average	0,001674	0,000292	0,001516	0,001020	0,001996	0,001355	0,001043
Flippering SD	0,004597	*	0,002144	0,002673	0,003196	0,002791	0,001006
Lobtailing average	0,001800	0,000175	0,000962	0,002235	0,002577	0,000214	0,000525
Lobtailing SD	0,003942	*	0,000289	0,006180	0,004364	0,000332	0,000719
Breanches average	0,002158	0	0,001341	0,001716	0,002147	0,000844	0,000557
Breanches SD	0,002866	*	0,000247	0,004066	0,003324	0,001371	0,000626
Spyhoping average	0,000041	0	0	0,000067	0,000241	0,000112	0,000084
Spyhoping SD	0,000116	*	0	0,000261	0,000472	0,000519	0,000239
Arching average	0,000274	0,000058	0,000306	0,000311	0,000710	0,000132	0,000805
Arching SD	0,000497	*	0,000103	0,000954	0,001611	0,000185	0,001938
Surface Turns average	0,000095	0,000058	0	0,000097	0,000140	0,000125	0,000157
Surface Turns SD	0,000296	*	0	0,000337	0,000317	0,000251	0,000328

SD: Standard deviation * Without standard deviation because the single grouping was registered once

Table 4. Breathings events

Group	N° records	N° breathings	Average	% general
H+B+E	25	1265	50.06	37.3
H+B+Es	8	740	92.50	21.8
2A	26	629	24.19	16.2
A	30	551	18.36	16.3
H+B	23	532	23.13	13.7
3A	2	120	60.00	3.1
2H+2B+Es	1	49	49.00	1.3
Total	115	3886		100.0

between these groups, as were groups with the highest average time on the surface. The dives average in seconds were highest that the reported by Avila *et al*. (2004) which would confrontation with the directions and speeds of swimming suggest a short time spent in the area and that Bahía Solano waters would be a passage zone in its migratory route northward along sampling months (Tables 6 and 7).

The Figure 5 shows the number of breathings and dives of each one of the groupings (excepting 2H+2B+Es), this way the groups that have a greater number of individuals in their proportional structure and to the number of observations, display greater frequency breathings the groups with a minimum group structure.

Groupings such as A and 2A were in diving state on 75% and 60% respectively, of the total of monitoring, which indicates that were little active. On the other hand groupings as 2H+2B+Es and H+B+Es only had immersions in 15 and 40% respectively, of monitoring total time. This indicates that the groups of females with calve and escourt/s, again are most active in the zone, since the time of the remaining percentage would indicate respiratory and superficial activity, and diving smaller to 60 seconds (Figure 6). The Figure 7 indicates a close relationship (r=0.76) between the superficial breathing and events exists, since the number of breathings explains 59% of the variation in the number of events in surface, nevertheless 41% rest corresponds to those superficial events that do not correspond to a breathing, that is to say, not whenever the whales go to surface make it to breathe; this analysis allows to show quantitatively what as much of the activity in surface corresponds to the respiratory activity.

Displacement speed and swimming course. This one parameter was measured in degrees (azimuth)/observation seconds (total pursuit). The view field on which the platform was counted was of 168º. The amount of total displacement was 4.357º, an average of 37.88º of displacement for each group

Table 5. Diving events

Group	N° records	N° breathings	Average	% general
H+B+E	25	118	4.72	24.1
A	8	118	3.93	24.1
H+B	26	98	4.26	20.0
2A	30	91	3.5	18.6
H+B+Es	23	49	6.12	10.0
3A	2	9	4.5	1.8
2H+2B+Es	1	7	7	1.4
Total	115	490		100.0

Table 6. Swimming speed

Grouping	Azimuth º average	km/h average	Pursuit average (seconds)
2H+2B+Es	129.0	9.1	2855.0
H+B+Es	56.6	7.1	1813.12
A	44.4	6.0	1534.46
H+B+E	38.5	7.9	1673.96
2A	32.8	7.8	1106.07
H+B	26.3	7.6	1130.34
3A	9.0	2.1	1174.5
Total		7.2	100.0

Table 7. Number and occurrence percentage of course or displacement direction

Grouping	N	S	NO	SO	EC	O	E
A	22	4	1	2	1	0	0
H+B+E	10	6	2	3	3	0	1
2A	14	7	1	2	1	1	0
H+B	16	2	3	0	2	0	0
H+B+Es	7	0	0	0	0	1	0
3A	0	0	1	1	0	0	0
2H+2B+Es	1	0	0	0	0	0	0
Total	70	19	8	8	7	2	1
% (115 groupings)	**60.8**	**16.5**	**6.9**	**6.9**	**6.0**	**1.7**	**0.8**

was obtained. The group that obtained greater displacement average was H+B+Es (56.62º) and as one of smaller average to H+B (26.39º).

Humpback whales developed a average speed of 7.2 km/h. The speeds are found within the ranges reported by Kaufman and Forestell (2003), which reported that these cetaceans develop an average speed of movement between 4.8 and 12.9 km/h, however different from what found by Noad and Cato (2007) to migration zones where whales had an average speed of 4.0 km/h. The results suggest that the grouping was faster 2H+2B+Es and the slowest was 3A (Table 6).

As much the data of greater, as the smaller displacement were obtained by the groupings with one (1) and two (2) observation logs respectively in degrees azimuth, like in km/h (Table 6); as the data are minimum for these two groupings, it was chosen to take care of the results in sequence consecutive; this way the grouping with greater speed of displacement in km/h was H+B+E and the contrary the one of smaller speed in swimming was A.

Below notes the number that each grouping took a direction from displacement during every observation time. From top to bottom they appear the groupings with greater amount of observations and left to right the directional courses: N=North, S=South, E=East, O=West, NO=Northwest,

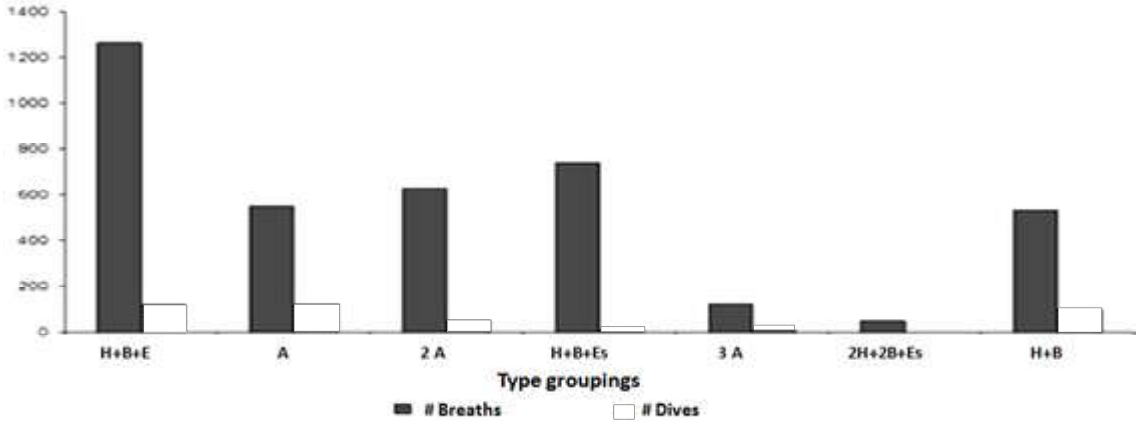

Figure 5. Number of breathings and dives in each group type.

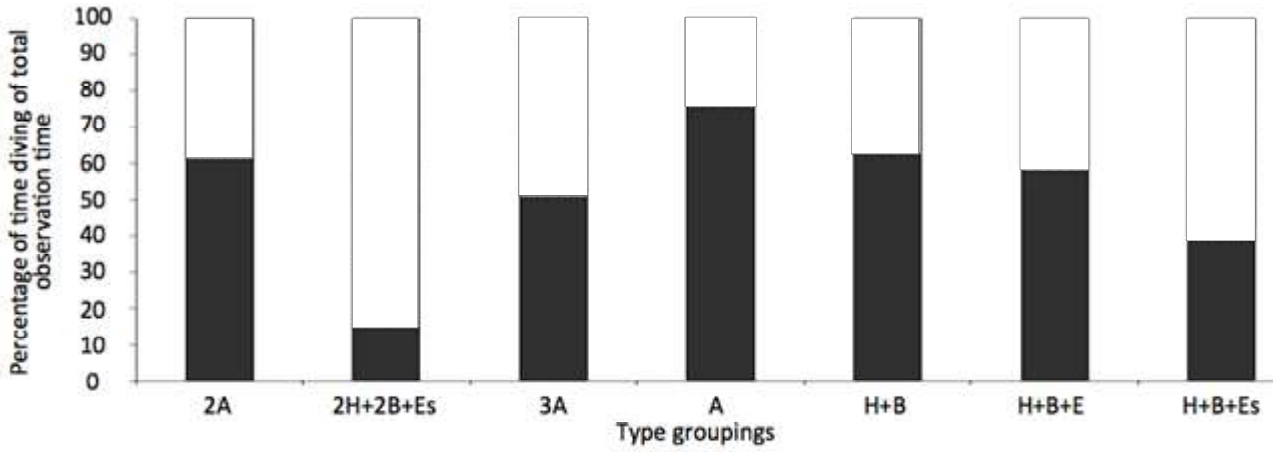

Figure 6. Percentage of iving time during the total time recorded of different type groupings of *M. novaeangliae.*

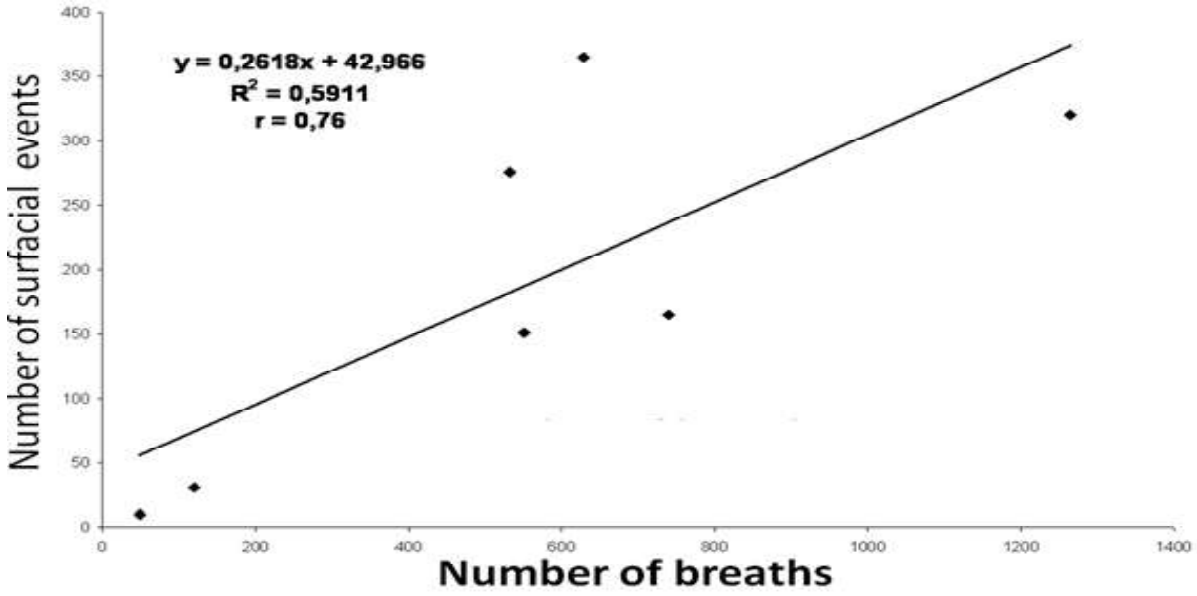

Figure 7. Correlation coefficient between the number of breathings *vs.* number of surface events.

SO=Southwest, EC=erratic Course (without defined direction). The direction that obtained a greater regularity in the registries was N, with the 60.8% and the smaller regularity it was and with as soon as the 0.8% (Table 7).

Contrary to reported by Avila (2000), the erratic courses «travel without defined direction», did not submitted a representative frequency in their observation and their percentage in relation to the other courses in all samplings are very low; according to Flórez-González *et al*. (2001) this behavior would indicate an influence of boats dedicated to whales watching tourism, in evasion of swimming normal course and although in the zone if they are carried out east type of activities, are very sporadic in comparison with other zones in where the industry of whales watching is greater. This suggests them marine waters of this area would be a zone of step and not of permanence, at least in these four biweekly periods of sampling and that during July and August months, whales possibly have a course defined towards the north of Colombia, arriving at waters of Panamá and South of Costa Rica (Rasmussen *et al*. 2004).

Megaptera novaeangliae behavior and the presence and/or abundance of deployments behavioral showed marked and several differences of behaviors evaluated in this study. The distribution of the formation of clusters of the humpback whale feeding areas is clearly related to the distribution of their prey (Tyack and Whitehead 1983), however in breeding areas where the availability of prey is not an important or decisive factor, causes of concentrations of this species and carry out certain activities of these animals in this area, do not seem to be so obvious (Rocha 2007).

Marine waters of El Valle and its environs were constituted as an optimal area for the accomplishment of the present study, registries of 115 groupings we obtained from land, 250 individuals, distributed in seven type of groupings; contrary to reported by Avila (2006) none group displayed changes in its structure during observation time, this suggests a stable structure at least while they happen through this zone. The observation group most frequently was A; this result differs with the reports made for Bay Malaga and Isla Gorgona, where the most abundant grouping is the constituted one by the mother and its littlest young and is the solitary adult (Flórez-González 1989, Celis 1995, to be accustomed to 1997, Londoño 2002, Ávila 2006).

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