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Humpback Whales in the Western Indian Ocean

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Editorial Note

Humpback whales are well known especially for their very long migration routes and also because of the songs that males emit during the breeding season. In 1971, in their famous article published in the journal 'Science', Payne and McVay describe these songs as "a series of surprisingly beautiful sounds"! Since 1971, more acoustic data have been collected and more knowledge generated; we now know that the song 'leitmotiv' is different from one geographic area to another, and from one year to the next. We also now know how they produce these sounds from their respiratory system.

In the last two decades, different techniques have been deployed to observe humpback whales in all the oceans. Not only have passive acoustic monitoring techniques been used, but also visual observations, electronic devices, and genetics. The objectives of these studies have been to better understand whale activities, behaviors, and also the underwater environment in which they live, and the potential effects of anthropogenic activities on their societies. This has involved many different research teams, with their own skills, methods and programmes. Results have been published in the scientific literature and presented at different international conferences.

However, three things have recently become apparent: Firstly, the study of humpback whales is a wide subject requiring people with complementary skills. It was apparent that it was necessary to bring these people together to discuss this species of whale for several reasons: a) because it would highlight the major results obtained thus far; b) because it would be interesting to share experiences (especially on the data and methods used, but also on common challenges); c) to co-design future projects and identify priorities; and d) because it would provide an opportunity to start new collaborations.

Secondly, before 2015, no international scientific conference or workshop existed with regular annual sessions especially dedicated to this species of Mysticeti whales. In order to address this, we initiated the creation of the Humpback Whale World Congress (HWWC, <http://www.hwwc.mg/>). The first session was held in Madagascar in 2015 and the second in La Réunion Island in 2017. Our idea was to bring together researchers and technicians from universities, research institutes, government organizations, and industry, dealing with all aspects of the biology, ethology, genetics, ecology, acoustics, signal processing, pattern recognition, mathematics, and computer sciences applied to the study of the humpback whales and their environment, and the potential effects of anthropogenic activities on the species. The goal of the HWWC is to provide a forum for exchange of new results obtained from the latest advances in instrumentation and methods.

Thirdly, during the BaoBaB project I led from 2012 to 2014, it became apparent that the extensive movement of humpback whales, even during the breeding season (with more than 100 km being covered per day), resulted in the same individuals being observed from the east coast of Africa to the Mascarene Islands. Because of this remarkable characteristic of this baleen whale species, it was obvious that we needed to encourage collaboration at a regional level, and we envisaged a consortium of people who work collaboratively on the Southwestern Indian Ocean humpback whale population.

During the international HWWC we were very pleased by the quality of the work shared by different teams, and the strong motivation to exchange information and work together. For this reason, we requested some colleagues to describe their projects in full papers, to put them together, and publish this unique special issue.

I would like to thank all the authors and co-authors, all the persons who contributed to this special issue, and more strongly the Cetamada Team who currently does such amazing work on these humpback whales!

Enjoy reading!

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Do the new-born calves of humpback whales (*Megaptera novaeangliae*) have a preference to position themselves at the side of their mother?

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Abstract

Spatial proximity to mothers is a key factor in offspring survival in group-living mammals. In humpback whales (*Megaptera novaeangliae*), an extreme migrating species, new-born calves stay close to their mothers. This proximity can be modified by the presence of other congeners or other species. The spatial relationship between mother and calf can therefore vary with social contexts. The position of the calf relative to its mother was investigated in different social contexts: alone, with one or several escorts; and in the presence of free divers. The positions of the calves in the 3D space surrounding their mothers were recorded using video footage of mother-calf pairs in 3 breeding sites located in the Indian and Pacific oceans, with the space methodically divided into ten positions. Calves mainly preferred positions above their mother, either on the right or the left; a strategy allowing the calf to be in an optimal position to breathe and to benefit from the hydrodynamic aspiration flow of its mother. A position below the mother was significantly related to resting behaviour, involving physical contacts with the mother and thus reinforcing their social bond. Finally, calves in the presence of free divers neither approached nor moved away from them, suggesting limited direct impact on their behaviour.

Keywords: humpback whale, calf, laterality, behaviour, preferred position.

Introduction

For large marine mammals that bear a single offspring every two to three years, calf survival is critical for the perpetuation of the species, and this depends on the mother's ability to both feed and protect the new-born, as well as on the calf's abilities to stay close enough to the mother for protection and care. Only females provide care to the young with no paternal care after conception recorded (Barlow and Clapham, 1997). Humpback whales are born in sub-tropical areas where they

spend their first months surrounded by males displaying aggressive behaviour, which occur within "competitive groups" composed of multiple males competing for proximity to a female, with or without calf (Baker and Herman, 1984; Tyack, 1981; Tyack and Whitehead, 1982). Mother-calf pairs must deal with the presence of other individuals surrounding them, calves must be able to follow their mother, and their schedules vary according to the number of males associated with the group (Cartwright and Sullivan, 2009a).

Spatial relationship and behaviour between mother-calf pairs in mysticetes present three distinctive phases that have also been observed in the southern right whale, *Eubalaena australis* (Taber and Thomas, 1982). The youngest calves spend most of their time travelling and breathing while maintaining proximity to their mothers. This spatial relationship becomes more distant as calves get older and allocate most of their time to playing and circling at the surface, while mothers stay a few meters underneath (Cartwright and Sullivan, 2009b; Zoidis, 2014). During movement, the young reduce their proximity to the mother and synchronize their movements and breathing, especially for long journeys such as on migration routes (Zoidis, 2014). As they grow, calves acquire new skills but still remain energetically-dependent on their mother (Cartwright and Sullivan, 2009b; Zoidis, 2014).

Depending on the social and maternal context, different sensory modalities are used to maintain such spatial proximity between mothers and new-borns, and the initiative can come either from mothers or

calves. In a wide variety of vertebrates including odontocetes, the right-hemisphere of the brain, which is dedicated to social interactions, obtains information from the left eye, resulting in a right-side social lateralization pattern being observed in mother and infant positioning (Damerose and Vauclair, 2002; Manning and Chamberlain, 1990). In belugas, continuous visual contact is more important in mother-calf interactions than tactile contacts, and these are initiated by calves (Karenina *et al.*, 2010). In wild belugas, calves present a highly significant right-side swimming position preference with their mothers (Hill *et al.*, 2017; Karenina *et al.*, 2010; Yeater *et al.*, 2014). Much like in belugas, dolphin mother-calf pairs maintain right-side visual contact and the mothers seem to be partially responsible for maintaining proximity to their calves (Lyamin *et al.*, 2007). The same right-side infant position preference has been observed in wild orcas (Karenina *et al.*, 2013). All these examples of cetaceans include only odontocetes species, but nothing is known for mysticetes.

In the present study, we quantify the prevalent spatial positions chosen by humpback whale calves

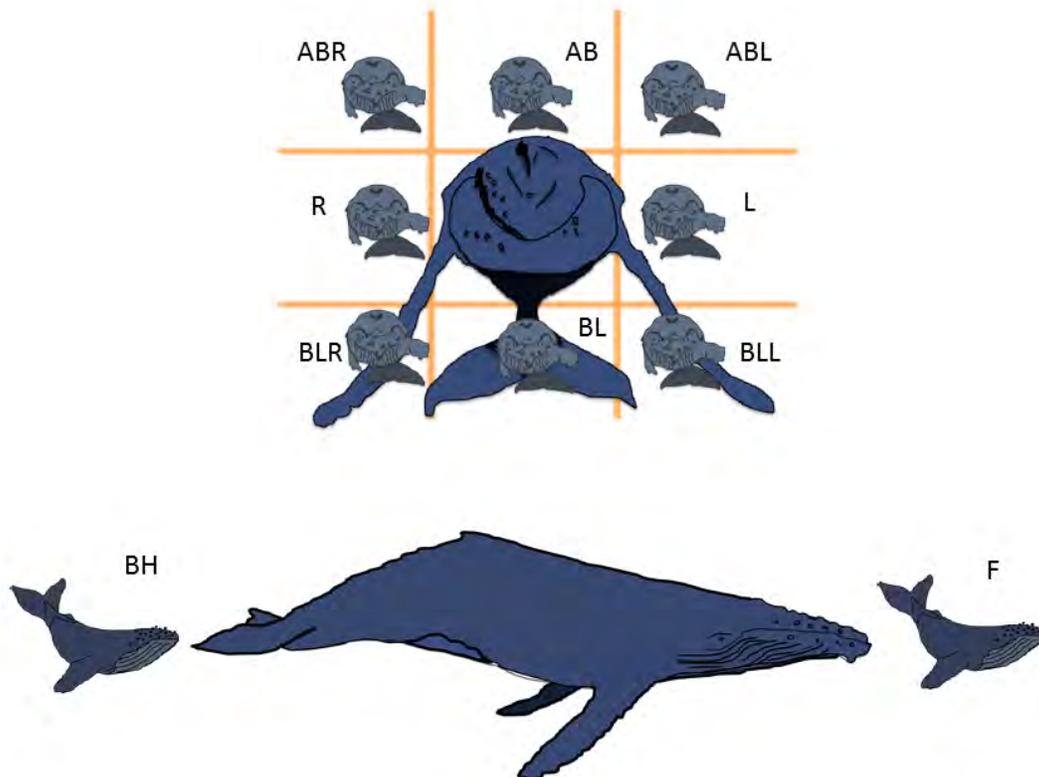


Figure 1. Schematic presentation of calf position (AB - above, ABR - above right, ABL - above left, R - right, L - left, BL - below, BLR - below right, BLL - below left, BH - behind, F - in front)

(a mysticetes species) around their mother, considering static and travelling behaviours, and their behaviour in the presence of free divers.

Methods

Video recordings

Opportunistic video data were obtained from different sources: 186 videos from snorkelers (using a GOPRO Hero 3 cameras); 2 videos from a drone (DJI Phantom 3 model); and 26 videos from immersed GOPRO Hero 4 cameras using a one-meter rigid pole from a boat or kayak. Videos were obtained from different geographic areas in the Indian Ocean (149 videos from Reunion Island, France, and 64 from Sainte Marie Island, Madagascar) and in the Pacific Ocean (1 video from Polynesia). From these 214 video files, a total of 91 mother-calf pairs were scored, representing a total observation time of 4 hours and 56 minutes. The mean duration of video files was $00:01:28 \pm 00:00:06$. The sex of the calves was identified when possible, and resulted in a sample of 20 female calves, 9 male calves, and 62 sex-undetermined calves.

Determination of calf position

For consistent interpretation of the results, only spatial positions initiated by calves were considered in the analysis, performed in two different ways. First, at a group level, all 91 mother-calf pairs were considered and the duration of each calf's position around the mother was noted, and average values for each position and for each calf was obtained. Secondly, all video files (214 videos) were considered without focussing on individual mother-calf pairs, and the average duration for each position of the calves was obtained. The position of calves was defined by using 8 grid positions around the mother, in addition to the position "in front (F)" and "behind (BH)" the mother. These were: above (AB); above right (ABR); above left (ABL); right (R); left (L); below (BL); below right (BLR); and below left (BLL) (Fig. 1). To compare the duration of each position among the 10 possible positions of the calf around its mother, Wilcoxon tests were used, and the p-values were correlated for multiple comparisons using Bonferroni correction. To detect any possible effect of side preference by the calves, the positions AR, R, and BR were pooled

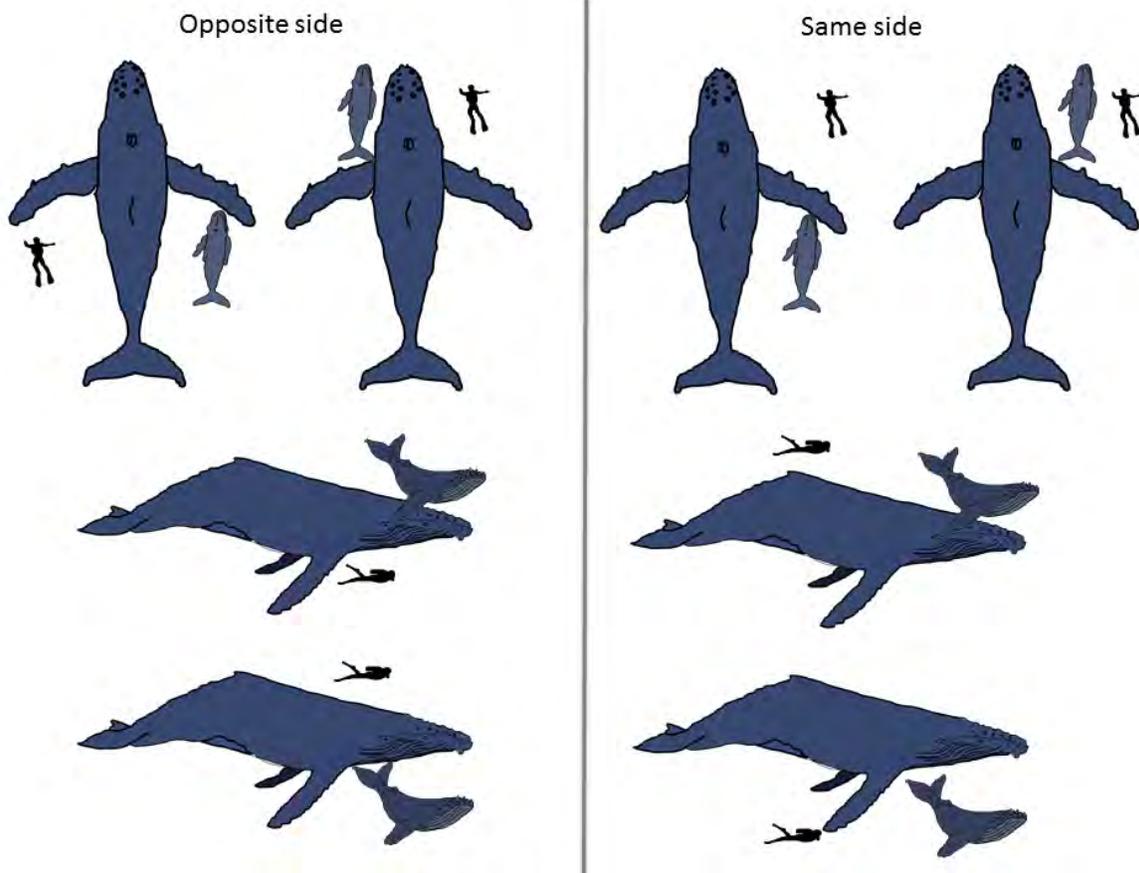


Figure 2. A schematic representation of free diver position in relation to calf position.

as “Right side”, and AL, L, and BL as “Left side”. Chi-squared tests were then carried out to compare the distribution of positions. Comparison between male and female calves could not be investigated due to the low number of sex-identified calves and an unbalanced number (9 males versus 20 females). Finally, to ensure that the position of the free divers’ underwater video recording did not influence the calf’s choices, the impact of the free divers’ position on the calf’s position was also assessed. The lateral position of calves compared to the free divers’ positions were observed and categorized as “opposite” side, “same” side, or “others” when calves and divers were not in a lateral position (Fig. 2). In this analysis, only the position initiated by the calf itself was considered. Moreover, as the free divers did not behave in the same manner on each occasion when interacting with the calf, their behaviour was divided into two categories: “interaction behaviour”, when the free divers aimed at interacting with the calf (e.g. proximity, or an attempt of physical contact); and “neutral”, when free divers kept their distance from the calf.

Results

Calf position

Analysis of all groups pooled together

The analysis performed on 91 mother-calf pairs showed that the positions that accumulated the longest durations were “Above Right” (ABR=01:16:48) and “Above Left” (ABL=01:21:52). Wilcoxon tests performed for each category showed that the durations for “Above” positions were significantly different from all others (Table 1). However, there was

no significant difference between “Above Right” and “Above Left” positions (test χ^2 , ddl=1, $\chi^2=0.16$, $p=0.68$) (Fig. 3).

Positions “Above” (AB= 00:37:22) and “Below” (BL= 00:49:50) were the second most important positions chosen by calves. No significance difference between these 2 categories was found (test χ^2 , ddl=1, $\chi^2=1.74$, $p=0.18$).

Right and left positions showed similar average durations and there was no significant difference between the two (test χ^2 , ddl=1, $\chi^2=3.39$, $p=0.06$) (Fig. 4).

Analysis at the group level

At a group level, 91 different pairs were considered. When a given group presented on several videos, an average of the position duration was calculated (Table 2). Considering the mean per group of the position durations, the main calf position choices around the mother were “Above left” (00:47:30) and “Above right” (00:44:27), followed by “Below” (00:30:36) and “Above” positions (00:18:41).

However, as for the summation of all groups, the main position durations “Above left” vs. “Above right” were not significantly different. This was also true for the second choices “Below” vs. “Above” (respectively, test χ^2 , ddl=1, $\chi^2=0.10$, $p=0.75$ and test χ^2 , ddl=1, $\chi^2=2.93$, $p=0.08$). Similarly, when pooling all right positions together, as well as all left positions, no significant difference was found in their durations (test χ^2 , ddl=1, $\chi^2=1.32$, $p=0.24$) (Fig. 5).

Table 1. Comparison of sum durations for each of the 10 calf positions around the mother. P values were assessed using pairwise Wilcoxon tests and a Bonferroni correction for multiple comparisons was applied.

	AB	ABR	ABL	R	L	BL	BLR	BLL	F	BH
AB										
ABR	4.75E-06									
ABL	6.48E-05	1.65E+01								
R	1.27E-02	< 9.90E-15	< 9.90E-15							
L	5.24E+00	4.23E-11	1.68E-09	1.16E+00						
BL	1.46E+01	4.59E-04	4.03E-03	2.04E-04	4.01E-01					
BLR	3.00E-02	9.90E-15	1.09E-13	4.18E+01	1.97E+00	6.61E-04				
BLL	2.99E-01	1.60E-13	< 9.90E-15	1.47E+01	1.04E+01	1.08E-02	1.85E+01			
F	3.00E-02	3.30E-13	1.22E-11	1.75E+01	9.98E+00	7.61E-03	2.37E+01	4.25E+01		
BH	2.02E-06	< 9.90E-15	< 9.90E-15	3.05E-01	4.43E-04	1.30E-08	2.89E-01	3.12E-02	5.41E-02	

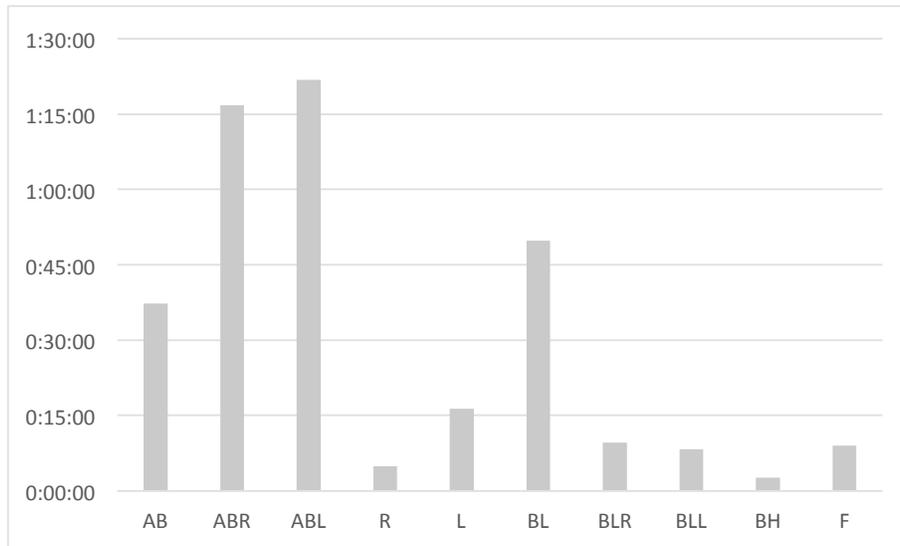


Figure 3. Sum durations for each of the 10 positions for all groups (AB - above, ABR - above right, ABL - above left, R - right, L - left, BL - below, BLR - below right, BLL - below left, BH - behind, F - in front).

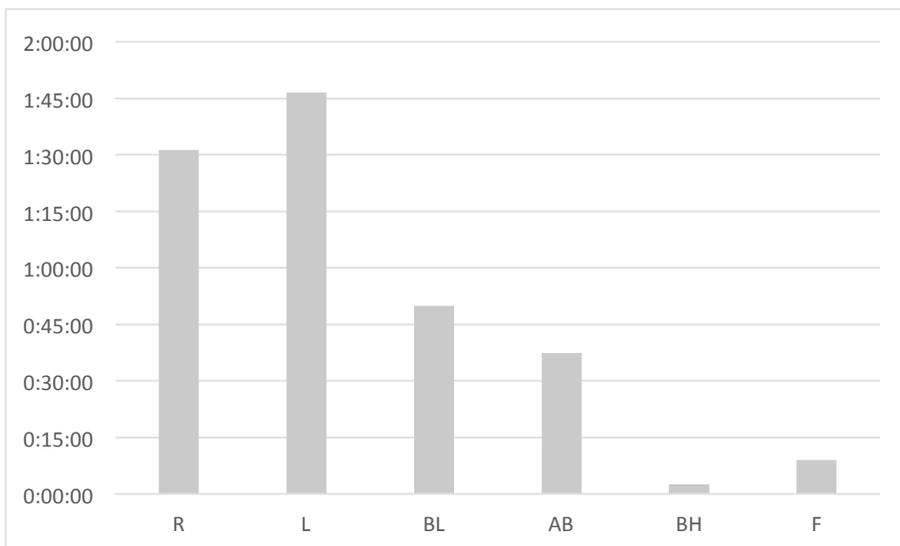


Figure 4. Sum durations for the 6 main positions: pooled right positions (R), pooled left (L), below (BL), Above (AB), behind (BH) and in front (F) for all groups together.

Impact of diver position on calf positioning

Results show that the position of free divers did not influence the position of the calf. The position durations where calves and free divers were on the same side of the mother (“Same Side” = 01:13:07) and those where the mother was between them (“Opposite Side” = 00:55:17) did not show any significant difference (test χ^2 , $ddl=1$, $\chi^2=2.50$, $p=0.11$). Calf-diver configurations that placed them on the same axis (“Same Side” and “Opposite Side”) were significantly less frequent than all the other configurations (test χ^2 , $ddl=2$, $\chi^2=74.72$, $p=5.93E-17$). No effect of the position of the free diver on the calf positioning around the mother was found. Indeed, whatever the behaviour of the free diver, either

attempting to interact with the calf or keeping a distance from the calf, no significant differences between the position durations between “Same side” and “Opposite Side” were found (test χ^2 , $ddl=1$, $\chi^2=0.00053$, $p=0.98$ and test χ^2 , $ddl=1$, $\chi^2=3.43$, $p=0.06$, for interaction or neutral behaviour, respectively) (Fig. 4). Regarding the behaviour of free divers towards the calves, most attempted to interact with the calf (test χ^2 , $ddl=1$, $\chi^2=101.57$, $p=6.87E-24$).

Discussion

This study investigated initiative and preferential position of young calves (i.e. less than 3-month old) around the mother during surface activities. Only two

Table 2. Comparison of mean durations for each of the 10 calf positions around the mother. P values were assessed using Wilcoxon tests and a Bonferroni correction for multiple comparisons.

	AB	ABR	ABL	R	L	BL	BLR	BLL	F	BH
AB										
ABR	3.92E-06									
ABL	2.78E-04	1.39E+01								
R	4.22E-03	< 9.90E-15	< 9.90E-15							
L	4.14E+00	6.05E-11	1.43E-08	9.06E-01						
BL	1.22E+01	1.53E-03	3.16E-02	6.56E-05	2.76E-01					
BLR	1.66E-02	< 9.90E-15	4.62E-13	4.18E+01	1.66E+00	3.31E-04				
BLL	1.65E-01	2.36E-13	4.09E-11	1.68E+01	8.22E+00	4.83E-03	2.23E+01			
F	3.28E-01	4.77E-12	5.18E-10	1.48E+01	1.17E+01	7.70E-03	2.07E+01	4.06E+01		
BH	1.10E-06	< 9.90E-15	< 9.90E-15	3.17E-01	4.73E-04	6.74E-09	2.84E-01	5.51E-02	4.90E-02	

calves were new-borns with one being 2-hours old. Mother-calf dyad position is critical when the calf is young, as proximity must be maintained during travelling, surfacing and diving activities. In other cetacean species such as bottlenose dolphins, it has been demonstrated that some calf positions provide locomotor advantages (Noren and Edwards, 2011). In this study, the prevailing positions of calves were “Above Right” and “Above Left” during static and travelling behaviour. Being above the mother near the rostrum allowed the mother-calf pair to keep visual contact during static behaviour. While travelling, these positions could be explained as a strategy used to benefit

from aspiration flow or “drafting effect of swimming” (Chatard and Wilson 2003) produced by the movement of the mother, which creates a pressure wave around her while diving or travelling. This drafting effect is beneficial to the calves only if they stay close to their mother. Back-riding by calves has been reported recently in blue, fin and grey whales, and this supports the hypothesis of adaptive benefits of locomotion energy savings for calves (Smultea *et al.*, 2017). For humpback whales that have a large and mobile lek mating system (Clapham 1996), females accompanied by their calves are exposed to breeding males. Association with groups of multiple males

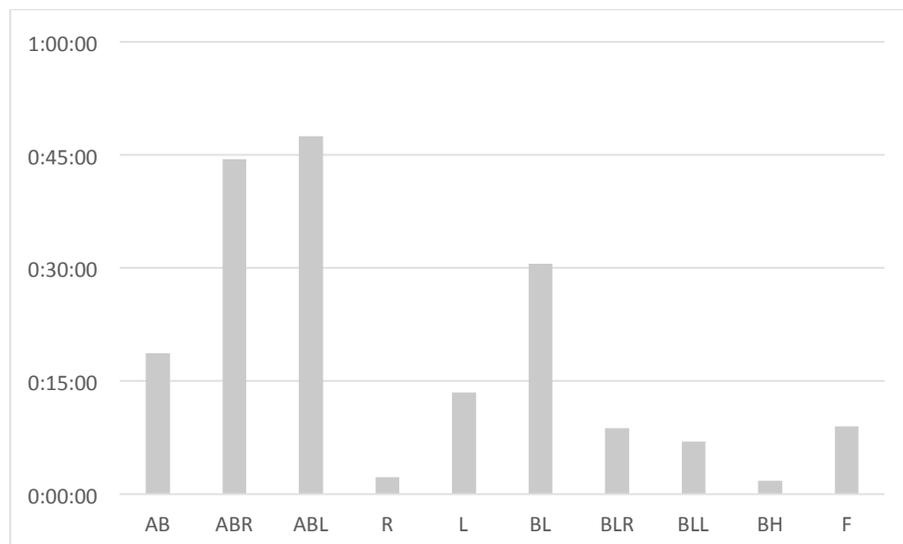


Figure 5. Average durations per observed group for the 10 studied positions (AB - above, ABR - above right, ABL - above left, R - right, L - left, BL - below, BLR - below right, BLL - below left, BH - behind, F - in front).

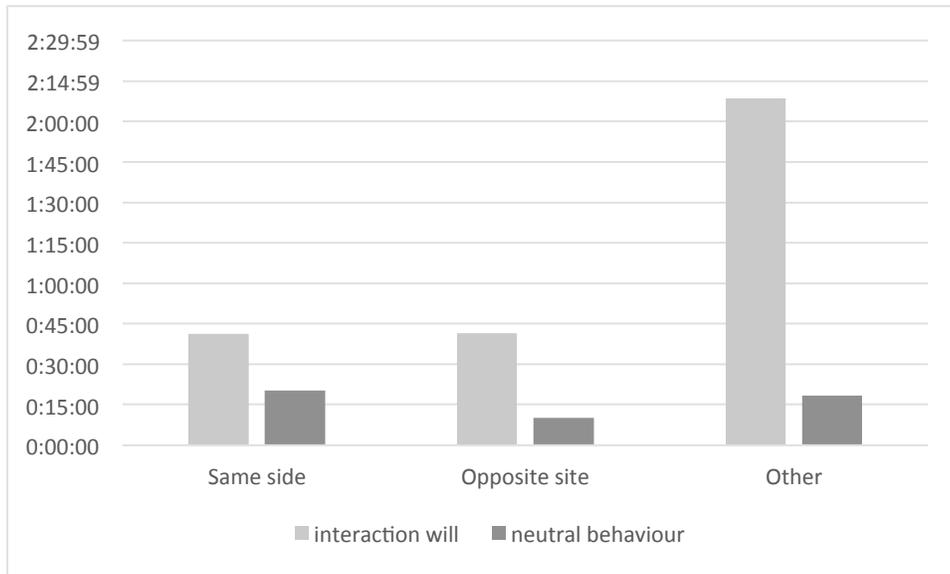


Figure 6. Position durations of the diver-calf dyad in 2 different free diver contexts (i.e. the free diver willing to interact with the calf - “interaction will”, or the free diver keeping distant from the calf - “neutral behaviour”).

encourages mother-calf travelling behaviour and thus energy expenditure (Cartwright and Sullivan, 2009a). In the case of a very large lek such as the population in the breeding area off Madagascar (Cerchio *et al.*, 2016), humpback whales travel long distances during the breeding season and females accompanied by their young calves can travel up to 100 km in 24 hours (Dulau *et al.*, 2017; Trudelle *et al.*, 2016). Keeping a position above and close to the mother allows calves to move securely, controlling their space orientation and reducing energetic expenditure, while having the same swimming performance as their mother.

The second most common position observed is “below” the mother (below the rostrum and flipper) that corresponds mostly to resting behaviour of calves, or occasionally below the caudal peduncle (when nursing), although there was no nursing behaviour observed in the present study. Humpback whales are well known for their ability to maintain neutral buoyancy in a head-down position during resting and singing behaviours (Adam *et al.*, 2013). Controlling their buoyancy is one of the skills that calves must acquire early on in life. Staying below the mother provides a secure place to rest and pause when the buoyancy of the calf is not yet well controlled, and this position also allows the pair to maintain physical contact.

In contrast to what has been described in the literature for odontocetes species, calf lateralization with regard to their position around the mother appears

to be absent in humpback whales. Even though lateralization has been observed in humpback whales for some active surface behaviours such as flippering (Clapham *et al.*, 1995), and potentially for nursing (Zoidis and Lomac-MacNair, 2017), these results should be considered with caution as further work with a larger sample size is required. Further investigations are needed to explore laterality in humpback whale mother-calf interactions.

The assessment of simultaneous calf and free diver positions revealed no significant impact on calf positioning. The presence of free divers did not seem to have an attraction or repulsion effect on the calf. However, it is possible that other non-behavioural impacts such as physiological stress could result from these interactions (e.g. an increase in heart rate, or increased stress hormone levels such as cortisol) (Martin and Réale, 2008; Ropert-Coudert *et al.*, 2009). Furthermore, it has been shown that during interaction with divers, the mother often moves closer to her calf when the calf produces a series of grunts, considered to be an alarm signal (Zoidis *et al.*, 2008). In the present study, only one scream (a mid-frequency harmonic sound) was heard while free divers were very close to the calf. The behaviour of the mother after this call could not be assessed, as the mother was not in the visual field of the camera. This was the only such alarm call encountered in the sample from the present study, suggesting that in general, free divers do not have a direct impact on the behaviour of humpback whale calves.

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