



The Influence of Dolphin Offspring to a Social Group

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Abstract – Managed care facilities are confronted with many challenges when caring for animals. One of them is balancing the possibility for a species to express its natural behavioral repertoire, and being able to reproduce, with the constraint of available space for the social group. Recent reproductive bans for cetaceans in managed care have been implemented without considering the effects of a calf birth to a social group. Our goal was to investigate whether the presence of pre-weaned calves in a social group influenced activity level and engagement among group members, including but not limited to the mother(s). When pre-weaned calves were present, larger dolphin groups were observed with spacing among members dependent upon calf age; groups with younger calves exhibited tighter clusters whereas groups with older calves were loosely spaced. Also, more diverse behaviors, inter-individual contacts, intensity of exchange(s), and number of individuals involved were documented for groups with pre-weaned calves. These results support the notion that presence of one or more pre-weaned calves enhances the overall well-being and welfare of a dolphin social group as not only mothers but also other individuals in the group join calves to engage in behavioral exchanges that increases group size and diversity and intensity in activity level(s).

Keywords – Offspring, Calf, Social Group, Dolphins, Influence, *Tursiops truncatus*

When we have animals in human care, how can we assure that we meet their needs such that they are in receipt of positive welfare? In other words, how much of animals' natural behavioral repertoire(s) must they be able to express to confirm receipt of positive welfare when in our care? For example, social species in managed care will vary in the degree to which sociality is expressed at the species or group levels (Dawkins, 2006; Veasey, 2022; Veasey et al., 1996; Whitham & Wielebnowski, 2013; Wolfensohn et al., 2018). For carnivores, is it better to have a lion pride with a male and multiple females or just have a male/female lion dyad (e.g., African lion, *Panthera leo*, Bauer et al., 2003; Sogbohossou et al., 2014)? For primates, like gorillas, is it better to have a social group comprised of all males or all females or a structure that mirrors that of wild groups with a silverback and several females with their offspring of various ages (e.g., Western Gorillas, *Gorilla gorilla gorilla*, Maestriperi & Ross, 2004; Robbins et al., 2004; mountain gorillas, *Gorilla gorilla beringei*, Schaller & Emlen, 2017)? Each type of social structure depends on the species and the number of individuals present in their social groups when in managed care, as well as in the wild. The lion pride and gorilla harem social structures are what would be experienced in a natural habitat and could provide each species opportunities in a managed care setting to express their natural suite of behaviors (Veasey et al., 1996; Whitham & Wielebnowski, 2013). These different types of social structures can be supported by managed care, but they come potentially at a cost, which is how much behavioral diversity or life history parameters would be expressed given the limitations of the selected social structure. The social structure dictates what aspects of each species life history traits can be expressed in managed care. Same-sex groups would be limited in the functionality of behaviors that would normally be shared

with the opposite sex even though they could display those actions with same-sex peers. Socio-sexual behavior might have similar functions in mixed-sex and same-sex dyads; however, copulation is functionally different in these dyads because in the former it can lead to reproductive success whereas in the latter it can only be used to build or strengthen social bonds between individuals.

These different social structures are built upon the inter-individual interactions and sociability for each animal within a group (e.g., Asian elephants, *Elephas maximus*, Veasey, 2022; gorillas, Maestripieri & Ross, 2004; Robbins et al., 2004; Schaller & Emlen, 2017; African lions, Bauer et al., 2003; Sogbohossou et al., 2014). Thus, it is not simply each individual as a silo, but how each possible dyad within a social group interacts (e.g., for chimpanzees, *Pan troglodytes*, Fraser et al., 2008; ravens, *Corvus corax*, Fraser & Bugnyar, 2010; dolphins, Themelin et al., 2020). Whether a dyadic, individual, or group level assessment is selected, group and individual welfare could be impacted for individuals within the group (Silk, 2007), but also these interactions could influence the well-being of neighboring groups (e.g., bonobos, *Pan paniscus*, Lucchesi et al., 2021).

In a managed care situation, does the individual require opportunities to engage in actions that their wild counterparts display in their efforts to survive to experience positive welfare? For example, must the former be offered options to roam long distances, to forage for their diet (partial or all), to care for offspring, to defend territories, to hunt, to fight for mates, to resolve conflict(s), and to reconcile with conspecifics? There is a debate about what is necessary for best practices to facilitate positive welfare for the animals in managed care (for supporting views, see Mellor et al., 2020; Veasey et al., 1996; Veasey, 2022; for opposing views, see Bandeli et al., 2023; Mason, 2010). This debate is not within the scope of this paper but potentially impacts the interpretation of different behaviors that might be considered necessary for animals in managed care to experience optimal welfare.

Individuals in social species often play different, if not critical, roles in their social groups and societies. For example, meerkats (*Suricata suricatta*) have sentinels for community protection and defense strategies but also, as community breeders, have communal offspring care (Bell et al., 2014). The dominant meerkat pair reproduces and receives support from subordinate members who have suppressed reproduction (Bell et al., 2014). In addition to providing group defense and direct care of offspring, non-parental adult and subadult individual roles may also include food provisioning (to offspring and/or parents), safety, socialization, and play. The presence of offspring has multiple benefits for the social group (with the recognition that offspring also represent a cost, e.g., increased visibility and susceptibility to predators, etc., Garcia, 2014). Aside from the genetic benefit of passing genes to the next generation (Dawkins, 2016), offspring are cognitively stimulating to the parent(s) (Uomini et al., 2020). Offspring also interact with other group members, providing opportunities for other adults, subadults, and even juveniles, to practice certain tasks and “roles” within their society. For example, alloparenting provides offspring care practice for young adult females (e.g., Dudzinski et al., 2022; Hrdy, 1976; Mota-Rojas et al., 2021; Riedman, 1982), multiple offspring offer numerous play opportunities for behavior and social development (Kuczaj et al., 2006), as well as a safe space in which to practice skills that will be required in adulthood (Bekoff & Byers, 1998). Having young animals in a social group enhances the lives of most, if not all, members of the society.

The presence of offspring (calves and juveniles) diversifies the behavioral lives of conspecifics in social species, which appears to be true of all settings in which the influence of offspring has been studied. Hill et al. (2015) found that mixed age and sex social groups with calves in belugas (*Delphinapterus leucas*) resulted in decreased solo swims by adult individuals and increased social interactions and play as compared to when social groups included only adults. For wild killer whales (*Orcinus orca*), as reviewed by Baird (2000), pre-weaned offspring increased the amount of time they spent interacting with other members of their pod as they age, including adult males and females, as well as playing with other same-aged individuals. Similarly, Kuczaj et al. (2006) and Mackey et al. (2014) showed that calves in groups with multiple peers were more social and engaged in more complex play than calves with no or few same-aged individuals in their social group. Wild bottlenose dolphins (*Tursiops aduncus*) in Shark Bay, Monkey Mia, Australia, show many similar patterns of behavior for maternal care and offspring development (reviewed by Mann, 2019). Levenson (2019) confirmed that not only do calves develop social relationships similar

to their mothers, but they also share avoidances of the same conspecifics. Thus, calves develop their social tendencies following the individuals with whom they most interact before weaning.

While maternal styles have been confirmed for belugas (Hill, 2009; Hill et al., 2013) and bottlenose dolphins (*Tursiops* sp.) (Duda et al., 2024; Dudzinski et al., 2021a; Hill et al., 2007; Mann & Smuts, 1999), the literature is sparse with respect to how bottlenose dolphin calves might impact their social group. A few exceptions are available. For both bottlenose dolphins and killer whales, the presence of neonates increases vigilance and overall activity for not just the mother but for all individuals in the social group (Eskelinen et al., 2017; Hill et al., 2008, 2017). Guarino et al. (2016) found that a killer whale calf socialized more frequently with all members of the social group as she matured over the first three years of life. Looking at calf-initiated contacts with mother and other group members, Dudzinski et al. (2021b) showed that calves shared more contacts with the mother when younger but diversified to other conspecifics, both kin and non-kin, as they aged toward weaning.

Our research into the potential impact and influence of common bottlenose dolphin (*Tursiops truncatus*) calves on a social group focuses on two questions: 1) does the presence of one or more pre-weaned calves impact a social group, and 2) do interactions between group members change when one or more pre-weaned calves are present in a group? We hypothesize that groups with pre-weaned calves available will be larger than groups with no calves, will exhibit more inter-individual interactions and more social behaviors, and be in groups with underwater activity levels involving more individuals and greater action/interaction between dolphins. We also hypothesize that closer proximity between dolphins will be observed in groups with pre-weaned calves. That is, groups with pre-weaned calves will have a tighter, more cohesive structure as compared to groups with older or no calves. Also, older ages of pre-weaned calves in a group will be correlated with more social behavioral contexts, higher activity levels, and looser group spreading. Our objectives to examine these hypotheses were to 1) examine observation sessions with young calves available to the group in comparison to sessions with only older calves or without calves present, 2) document spreading and proximity between individuals in all dolphin groups present, and 3) identify and code general behavior activity and underwater activity levels for all groups observed within the camera's field of view on all video records per session. We also recorded the total number of individuals (including calves) in each group as well as the number of pre-weaned calves in each group. Our underlying goal was to investigate whether the presence of pre-weaned bottlenose dolphin calves influenced the group's activity and engagement among members, including but not limited to the mother(s).

Methods

Ethics Statement

Methods were observational. Our observational research and data collection at the Roatan Institute for Marine Sciences (RIMS), Roatan, Honduras, was conducted with permission from the facility, which holds permits from the Honduran government.

Study Animals and Site

Underwater video data were collected in ~30 min sessions at The Roatan Institute for Marine Sciences (RIMS) as part of an ongoing, longitudinal study of dolphin communication and social behavior (e.g., Duda et al., 2024; Dudzinski et al., 2010; Dudzinski & Ribic, 2017; Themelin et al., 2020). A subset of 595 min (9.92 h) of video data from 2021, 2022, and 2023 (Table 1) were analyzed to investigate the influence of calves on social behavior and group dynamics of these dolphins. There were 18-20 common bottlenose dolphins (*Tursiops truncatus*) in this group ranging in age from neonate to 40+ years during this study (Table 1). This group's general social dynamic was similar to that observed for wild bottlenose dolphins (*Tursiops* sp., e.g., Kogi et al., 2004).

This group is housed in coastal sea pens along the east to southwest fringes of Bailey's Key, which is on the NW side of Roatan, Honduras. The sea pens, located inside Roatan's fringing reef, include one

large enclosure (~8,000 m² in surface area, where all video data were collected) and several smaller areas for training, research, and medical procedures.

Table 1

Video Data Analyzed for this Study, with Corresponding Group Size and Composition (Age/Sex) for each Session per Year

Session-Year	Duration	Group Composition A, S, J, C by sex	Calves C1, C2, C3 by sex
November 2021	~210 min	N = 20	N = 6
A42143	37:50		
A42144	35:24	AF = 8, AM = 2	C3F = 1
A42145	33:57	SF = 0, SM = 2	C1F = 2
A42146	34:30	JF = 0, JM = 2	C2M = 2
A42147	33:23	CF = 3; CM = 3	C1M = 1
A42148	36:16		
January 2022	~226 min	N = 20	N = 6
A42201	28:43		
A42202	32:06	AF = 8, AM = 4	C3F = 1
A42203	33:31	SF = 0, SM = 0	C1F = 2
A42204	34:49	JF = 0, JM = 2	C2M = 2
A42205	33:48	CF = 3; CM = 3	C1M = 1
A42206	30:27		
May 2023	~159 min	N = 18	N = 5
A42339	30:12		
A42340	29:44	AF = 6, AM = 4	
A42341	31:05	SF = 0, SM = 1	C2F = 2
A42342	31:08	JF = 1, JM = 1	C1F = 1
A42343	17:35	CF = 3; CM = 2	C3M = 2
A42344	18:45		

Note. C1 - one-year old, C2 - two-year old, C3 - three-year old. A is adult, S is subadult, J is juvenile, and C is calf. The six-digit code represents the 30-min session ID (e.g., A42143) for each month-year trip.

Data Collection

Dolphin interactions and behavior were video recorded with concurrent stereo audio via a mobile video/acoustic system while underwater (Dudzinski et al., 1995). All video data were collected with an all occurrence, focal follow protocol; see Dudzinski et al. (2009) and Dudzinski and Ribic (2017) for protocol details. Video records were coded using BORIS (v. 7.13.9, Friard & Gamba, 2016) via an event sampling protocol focusing on “social group” (see below). Each social group in-view of the camera’s viewfinder were coded using a behavior with several modifiers that accounted for dolphin(s) ID, number of dolphins, calf present or not and ID if present, proximity, group spreading, activity level, and group behaviors. Individual(s) age and sex were added to the data file after coding. Solo dolphins were also recorded using the same modifiers, though proximity and group spreading were coded as not applicable.

Definitions

Social Group – All individuals in spatial proximity to one another (within an adult dolphin body length of each other, 10 m chain rule), moving in a similar direction, and engaged in similar activities, for more than 5 s (based on Shane, 1990; Kogi et al., 2004; Themelin et al., 2020).

Proximity – Considers spacing between individuals such that “0” is ≤ 50 cm and individuals could touch each other easily with minor movement; “1” is between 50 cm and 1.5 m between individuals (i.e., to touch each other they must get closer); and “2” is ≥ 1.5 m between individuals. This parameter considers each pair of individuals within a social group.

Group Spreading – This is based on the proximities of the different pairs in a social group. If proximity is only 0 or 0 and 1, spreading is coded as Sp1, then spreading is low and the group has a tight formation. If proximity runs from 0 to 2 between different pairs, then spreading is considered medium (Sp2). If proximity is 1 and 2, or only 2, then spreading is considered high and the group has a loose formation (Sp3).

Group behaviors & Underwater activity levels – Behaviors for solo dolphins and behavioral interactions between individuals observed for this dolphin group from the underwater perspective were categorized into four behavioral categories (Table 2) (see original use of these categories in Dudzinski, 1998). Each category was defined by individual behaviors and/or behavioral exchanges between dolphins. Behaviors were not tallied but identified as present or not to define group behaviors. Each group's underwater activity (also simply referred to as activity levels) was also divided into five levels (Table 2), which were based on swim speed, social interactions, and vocal behavior.

Table 2

Group Behaviors and Underwater Activity Levels

Group Behaviors	
Swim	Slow swimming, usually a solo dolphin, no apparent goal activity.
Affiliative	Social affiliation included pair swims, presence of tactile contact, socio-sexual behavior that included body rubs, some low-level chase behaviors.
Agonistic	Social agonism between individuals involved behavioral exchanges initiated by one dolphin's rostrum (jawing, jaw claps) or fluke (tail slaps, kicks), with right or direct angles of approach. No affiliative rubbing or other contact was shared in agonistic activity.
Underwater Activity Levels	
U1	One dolphin solo swimming, maybe exploring, or immobile with slow movement. Could also be two dolphins in very slow pair swim or immobile observing another dolphin or object, no rubbing between individuals.
U2	Two dolphins or more in any pair swimming position (duos, triples, quads, etc.), with some physical contact, some orienting. Slow movements usually exhibited by the dolphins.
U3	Two dolphins or more interacting, much physical contact and rubbing between individuals, medium-speed chase behaviors, maybe some jawing or jaw claps exchanged. Direction changes evident in swim movements. Investigation by one or more dolphins of the environment, other dolphins, researcher.
U4	Two dolphins or more interacting, lots of physical contact and rubs shared. Individuals chase each other with more than medium speeds that can include some aerial behavior and loud vocalizations. There could also be object, social, and motor play.
U5	Three dolphins or more interacting with very close proximity, rubbing and rolling all over each other. There are usually high-speed chases or swims, including jumps and aerial behaviors (above water surface), and loud vocalizations. Social-sexual 'balls' with 3+ dolphins mounting each other and rolling over one another are often observed in this level.

Statistical Analyses

Data were reviewed descriptively to create graphs and tables using Microsoft Excel to assess trends in groups with and without a calf, as well as number of calves and calf age, potentially associated with activity levels, behavioral categories, and group spreading (see Dudzinski (1998), Dudzinski et al. (2009, 2010), for similar methodological approach). Using SPSS and Microsoft Excel, Spearman's rho was applied to assess correlations between ordinal and interval data, e.g., for the number of calves present versus activity level or group spreading. Pearson's chi-square tests were used to assess significance of calf presence or not with social group size, activity levels, behavioral categories, and group spreading. Pearson's chi-square tests were also used for number of calves and calf age with activity levels, behavioral categories, and group spreading. We also looked at social group size compared to number of calves present (including no calf) as well as behavioral category using the same test. Adjusted standardized residuals for all chi-square test results were interpreted for significant relationships and Cramer's V was examined for effect size.

Results

From three data collection trips (in November/December 2021, January 2022, May 2023, see Table 1), 914 dolphin social groups, 634 groups with a calf and 280 without a calf, were documented from underwater video data of the dolphins at RIMS. Among the 634 groups with a calf, 83.7% ($N = 530$) contained a single calf, 14.0% ($N = 89$) included two calves, 2.0% ($N = 13$) had three calves, and two groups each (0.2%) contained 4 or 5 calves.

With Calf vs. Without Calf

Group sizes ranged from a single individual to more than seven dolphins in a social group (Table 3, Table S1). When calves were present, they were more likely to be observed in groups of 2, 3, and 4 individuals ($\chi^2(6, N = 914) = 317.780, p < .001$, Cramer's $V = .590$, Table 3, Figure 1a). Solo individuals were observed more often to not be a calf (Table 3, Table S1), though two-year and three-year old pre-weaned calves were observed alone (see calf age section). Groups of 2 with a calf were more likely to be mother/calf pairs, while groups of three usually included an adult or juvenile female with a mother/calf pair. Groups of 4 were characterized as two mother/calf pairs or an adult female with her calf and other calves or juveniles.

Table 3

Adjusted Standardized Residuals of Chi-Square Test Results for Group with (Yes) vs. Without (No) Calf Compared to Group Size, Activity Level, Behavioral Category, and Group Spreading

Calf Present	Group Size						
	1	2	3	4	5	6	7+
Yes	-17.6	9.9	7.1	3.9	2.4	1.5	2.0
No	17.6	-9.9	-7.1	-3.9	-2.4	-1.5	-2.0
Calf Present	Activity Level						
	U1	U2	U3	U4			
Yes	-15.7	3.5	10.3	1.8			
No	15.7	-3.5	-10.3	-1.8			
Calf Present	Behavioral Category						
	Affiliative	Agonistic	Play	Swim			
Yes	14.2	1.1	1.1	-15.3			
No	-14.2	-1.1	-1.1	15.3			
Calf Present	Group Spreading						
	Tight	Medium	Loose	Single			
Yes	12.3	4.0	4.7	-17.6			
No	-12.3	-4.0	-4.7	17.6			

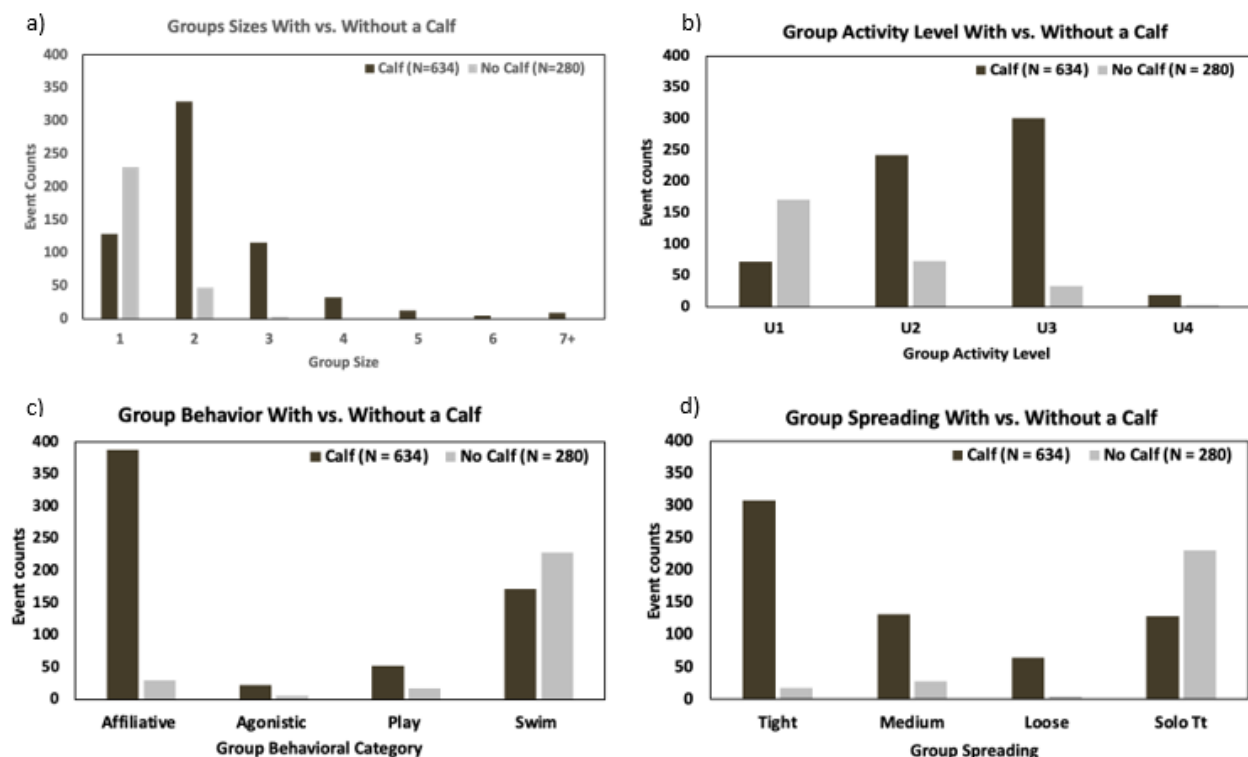
Note. U5 not included as this activity level was not observed in our data. Near 0 is as expected by chance, exceeding +/- 2 is considered significantly deviating from chance. ASR values in bold font indicate significance. For definitions, see Methods – Definitions and Table 2. See Table S1 for sample sizes. Grey-shaded cells intentionally left blank.

Social groups with a calf engaged in higher activity levels than groups with no calf ($\chi^2(3, N = 914) = 259.502, p < .001$, Cramer's $V = .533$; Table 3, Figure 1b, Table S3). Calves were observed in groups engaged in activity levels (e.g., U3) involving more rubbing, direction changes in swims, and vocal activity, whereas groups without a calf exhibited primarily low levels of activity (rest or slow swims, e.g., U1) (Table 3, Figure 1b). Groups with a calf exhibited more affiliative social behaviors whereas groups with no calf engaged in more (solo) swim activity and exhibited fewer social interactions (Table 3, Figure 1c); patterns that were supported by the analysis in which the addition of calves to a group saw a greater diversity in inter-individual exchanges as is often observed in affiliative social behavior categories ($\chi^2(3, N = 914) = 243.175, p < .001$, Cramer's $V = .516$; Table 3, Figure 1c). The presence of calves in a group was related to a tighter spreading – individuals in closer proximity to each other – when compared with no calf present

($\chi^2(3, N = 914) = 318.604, p < .001$, Cramer's $V = .590$; Table 3, Figure 1d). Indeed, groups with calves showed more of all three spreading categories (tight, medium, loose) as compared to when no calf was present, which were groups usually characterized as singletons (Table 3, Figure 1d).

Figure 1

Observed Frequencies of a) Group Sizes, b) Underwater Activity Levels, c) Behavioral Categories, and d) Group Spreading for Groups with a Calf (Calf) or without a Calf (No Calf)



Note. U5 not included as this activity level was not observed in our data. For definitions, see *Methods – Definitions* and Table 2.

Number of Calves Present

The number of calves present in a group was positively and significantly correlated with activity level (Spearman's rho (912) = .538, $p < .001$) and group spreading (Spearman's rho (553) = .119, $p = .005$). When more calves were present, groups activity levels were higher, displaying greater levels of social interactions (Table 2, Table S2). Also, when more calves were present the overall distance between individuals in a group increased (i.e., group spreading was loose).

To examine specific relationships between number of calves present with activity level, behavioral categories, or group spreading, three Pearson chi-square tests of independence were calculated. The presence of one to three calves was associated with significantly more diverse levels of social interaction, or higher underwater activity levels ($\chi^2(15, N = 914) = 350.038, p < .001$, Cramer's $V = .357$; Table 4, Figure 2a), more social behavioral activities versus solo activity ($\chi^2(15, N = 914) = 288.982, p < .001$, Cramer's $V = .325$; Table 4, Figure 2b), and more tighter spacing between individuals when at least 1 calf was present and looser spacing when more calves were part of a group ($\chi^2(15, N = 914) = 409.671, p < .001$, Cramer's $V = .387$; Table 4, Figure 2c).

None or fewer calves were in groups involved in low-level activity (resting, slow, and unidirectional swimming (U1), Table 4, Figure 2a) whereas groups with 2 or 3 calves were engaged in activity levels featuring more contact, more direction changes, and greater social interaction between

individuals, i.e., higher activity levels (U3, U4, Table 4, Figure 2a). Similarly, groups with no calves were observed in more swim behavioral categories, and groups with 1-3 calves showed more affiliative and agonistic behaviors (Table 4, Figure 2b, Table S3). Groups with none and 1-3 calves were equally likely to be observed in groups that were playing (Table 4, Figure 2b). For group cohesiveness (i.e., spreading among individuals), groups with 1 calf showed tight spreading with less space between individuals whereas groups with 2 calves had medium spreading and groups of 2-5 calves were observed with loose spreading between individuals (Figure 2c). This loose spreading with more than 2 calves in a group could be reflective of the distance between two mother/calf pairs while the space between a mother and her calf remained tight (i.e., < 50 cm).

Table 4

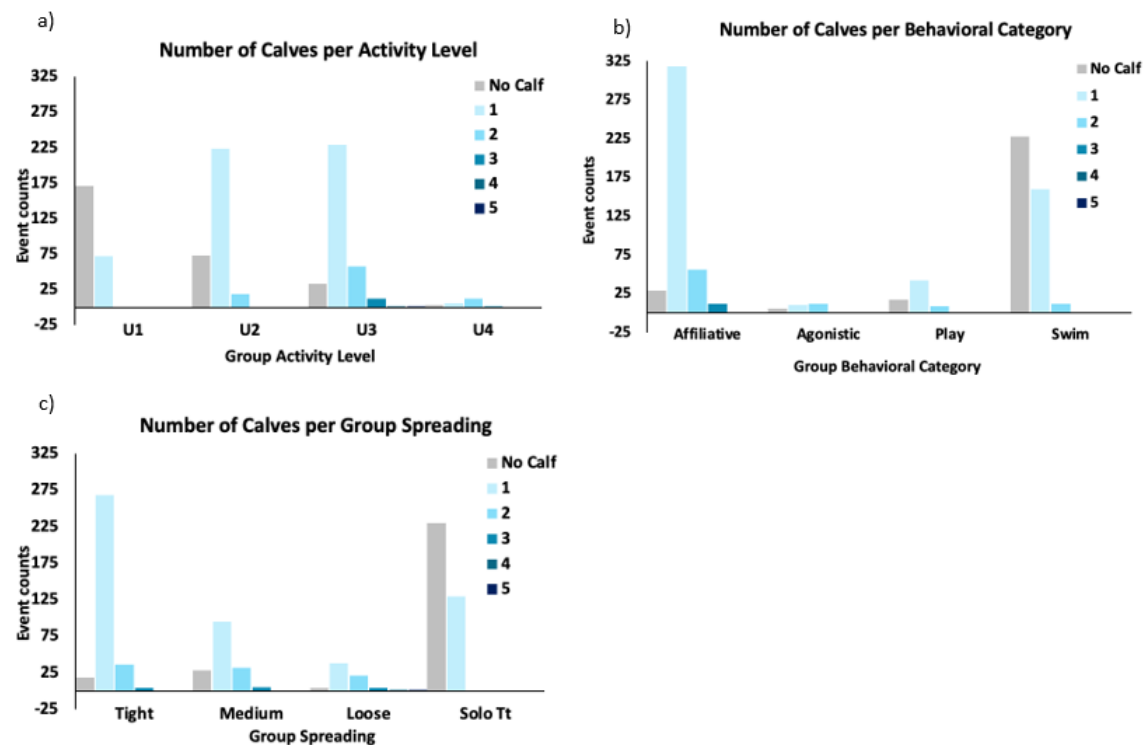
Adjusted Standardized Residuals of Chi-square Test Results for Number of Calves in a Group Compared to Underwater Activity Level, Behavioral Category, and Group Spreading

No. of Calves	Activity Level				Behavioral Category				Group Spreading			
	U1	U2	U3	U4	Affiliative	Agonistic	Play	Swim	Tight	Medium	Loose	
0	15.7	-3.5	-10.3	-1.8	-14.2	-1.1	-1.1	15.3	-12.3	-4.0	-4.7	
1	-10.5	5.7	4.9	-3.0	10.3	-2.4	.5	-9.7	11.0	.4	-.5	
2	-6.0	-2.7	5.9	7.2	3.4	6.0	1.0	-6.1	1.0	4.8	6.0	
3	-2.2	-2.6	4.2	1.3	3.4	-.6	.0	-3.2	-.4	2.0	3.2	
4	-.6	-.7	1.3	-.2	1.1	-.2	-.3	-.9	-.7	-.5	3.5	
5	-.6	-.7	1.3	-.2	1.1	-.2	-.3	-.9	-.7	-.5	3.5	

Note. U5 not included as this activity level was not observed in our data. Near 0 is as expected by chance, exceeding +/- 2 is considered significantly deviating from chance. ASR values in bold font indicate significance. For definitions, see *Methods – Definitions* and Table 2.

Figure 2

Observed Number of Calves per Group for a) Activity Levels, in b) Behavioral Categories, and c) Group Spreading



Note. U5 not included as this activity level was not observed in our data. For definitions, see *Methods – Definitions* and Table 2.

When multiple calves were present, group size was larger; the number of calves present varied significantly with group size ($\chi^2(30, N = 914) = 980.876, p < .001$, Cramer’s $V = .463$). Groups with no calves present were smaller, usually comprised of 1 dolphin, with group sizes of 2 or more dolphins less represented. Groups of 2 individuals contained a single calf significantly more than expected by chance, which could be explained as a mother/calf pair. Groups ranging in size from 3-6 individuals contained 2 calves more than expected by chance and groups of 5-7 dolphins had 3 calves more than expected. For this study group and years of data, two groups of more than 7 dolphins were confirmed to have 4 and 5 calves each.

Group size also varied significantly with behavioral category ($\chi^2(18, N = 914) = 550.994, p < .001$, Cramer’s $V = .448$; Table 5, Figure 3). Groups of 2-4 individuals were shown to be the most observed with a calf (Table 3) and also showed the most affiliative activity (Table 5, Figure 3). Smaller groups, of 1 or 2 dolphins, engaged in the most solo, slow swims of all groups (Table 5, Figure 3), which also were groups with no or rarely 1 calf (Table 3).

Table 5

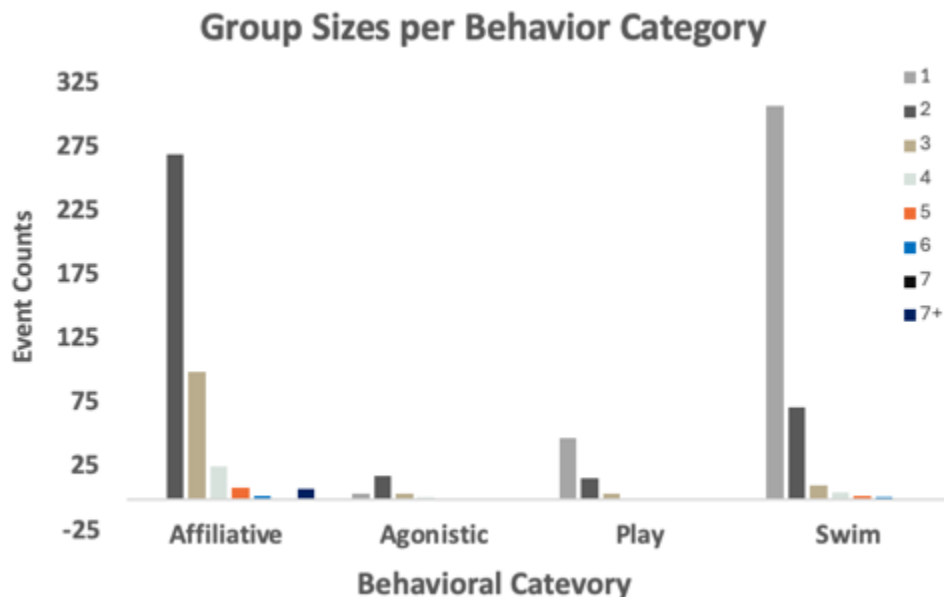
Observed Social Group Sizes Varied by Behavioral Category

Behavioral Category	Group Size						
	1	2	3	4	5	6	7+
Affiliative	-22.3	13.3	9.0	3.9	1.7	.6	3.3
Agonistic	-2.8	2.5	.2	1.0	-.6	-.4	-.5
Play	5.4	-3.2	-1.9	-1.7	.0	-.6	-.9
Swim	20.5	-12.5	-8.1	-3.4	-1.5	-.2	-2.7

Note. Near 0 is as expected by chance, exceeding +/- 2 is considered significantly deviating from chance. ASR values in bold font indicate significance. For definitions, see *Methods – Definitions* and Table 2.

Figure 3

Observed Social Group Sizes per Behavioral Category



Note. For definitions, see *Methods – Definitions* and Table 2.

Calf Age

Pre-weaned calves were examined according to their presence in social groups by age: one-year-old (C1), two-year-old (C2), and three-year-old (C3) calves, with a category denoted as “0” for groups with no calf present, which we used as a control. A group’s activity level varied significantly depending on calf age(s) when present in the group ($\chi^2(9, N = 914) = 278.240, p < .001$, Cramer’s $V = .319$; Table 6, Table S4). No calf (0) in a group was correlated with the lowest activity level (U1, Table 6, Figure 4a). When a C1 was present, the group was observed more in activity levels involving greater inter-individual exchanges (U3), e.g., body and pectoral fin contacts, direction changes, vocal activity (Table 6, Figure 4a). Groups with even greater activity were observed with older calves (C2, C3, Table 6, Table S4).

Calf age varied significantly with behavioral category ($\chi^2(9, N = 914) = 341.957, p < .001$, Cramer’s $V = .353$; Table 6, Table S4) with groups with no calf engaged in more solo swims. The youngest calves were observed in more affiliative categories but fewer swims, play, and agonistic categories (Table 6, Figure 4b). Two-year-old calves engaged in more play followed by agonistic interactions; both C2 and C3 calves used significantly fewer swims whereas the latter showed more affiliative than agonistic or play behaviors (Table 6, Figure 4).

Calf age was significantly related to group spreading ($\chi^2(6, N = 555) = 42.29, p < .001$, Cramer’s $V = .195$; Table 6); the youngest calves were observed in more tightly spaced groups but not in medium-spaced groups whereas the C2 calves were opposite and observed more in the medium-spaced groups, not the tight groups (Table 6, Figure 4c). The oldest calves (C3) were not observed with significance in any particularly spaced group. Groups with no calves were not tight but showed more medium spacing among group members (Table 6, Figure 4c).

Table 6

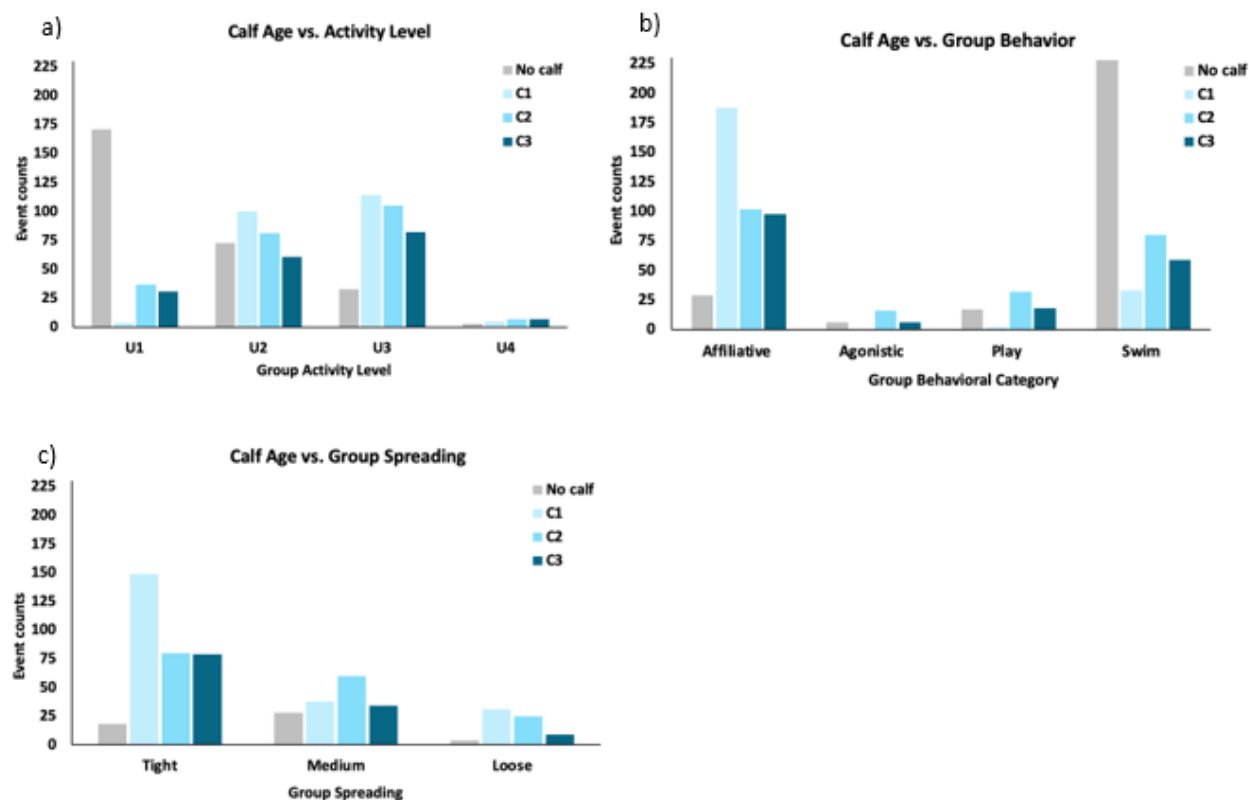
Adjusted Standardized Residuals of Chi-Square Test Results for Calf Age Compared to Activity Level, Behavioral Category, and Group Spreading

Calf Age	Activity Level				Behavioral Category				Group Spreading		
	U1	U2	U3	U4	Affiliative	Agonistic	Play	Swim	Tight	Medium	Loose
0	15.7	-3.5	-10.3	-1.8	-14.2	-1.1	-1.1	15.3	-3.4	4.4	-1.0
C1	-9.6	3.8	5.2	-.2	13.3	-3.1	-4.3	-10.0	3.7	-4.8	1.0
C2	-4.2	.3	3.3	.7	-.4	4.0	4.2	-3.2	-3.2	2.5	1.3
C3	-3.2	-.2	2.7	1.4	2.6	.2	1.4	-3.4	1.5	-.3	-1.9

Note. U5 not included as this activity level was not observed in our data. 0 equates to no calf present, which was used as a control for groups with pre-weaned calves. Near 0 is as expected by chance, exceeding +/- 2 is considered significantly deviating from chance. ASR values in bold font indicate significance. For definitions, see *Methods – Definitions* and Table 2.

Figure 4

Variability in Occurrence of Pre-Weaned Calf Ages in Groups with Different a) Activity Levels, b) Behavioral Categories, and c) Group Spreading



Note. U5 not included as this activity level was not observed in our data. For definitions, see *Methods – Definitions* and Table 2.

Discussion

When calves were present, we observed larger dolphin groups with spacing among group members dependent upon calf age with groups including younger calves in tighter clusters whereas groups with older calves were in loosely spaced groups. Also, groups with calves generally were more diverse in their behaviors as measured by activity level, which involved contacts, spacing, intensity of exchange, and number of individuals involved in shared interactions. These results support the notion that the presence of one or more pre-weaned calves positively impacts a social group, likely offering more positive well-being for all group members, and that interactions between group members change when one or more pre-weaned calves are present.

As we found in our study, other dolphin group sizes tend to be larger when calves, especially neonates, were present and clustering within groups was tighter for several populations of wild dolphins; for example, bottlenose dolphins in Shark Bay, Monkey Mia (Gibson & Mann, 2008; Mann et al., 2000) and Sarasota Bay (Wells et al., 1987), Indo-Pacific humpback dolphins (*Sousa chinensis*) along the coastlines of Taiwan, Hong Kong, and China (Karczmarski, 1999), and, including freshwater river dolphins, the tucuxi (*Sotalia fluviatilis*) in the Amazon and Orinoco River basins, South America (Azevedo et al., 2005). Closer proximity between individuals in a social group and larger group sizes also have been confirmed as anti-predator defense strategies (Gowans et al., 2007; Heithaus & Gill, 2002, 2007), which would be beneficial in groups with young calves. Mothers with young calves are likely to be distracted by their calf's needs and care and so benefit from a larger social grouping in response to potential predators.

Also, these larger groups allow increased babysitting opportunities such that a mother may forage as needed with support in calf care (Mann & Smuts, 1998; Mann, 2019; Riedman, 1982).

Diversity in behavior and inter-individual interactions is founded in the mother-calf bond but also in who and what a calf is exposed to for various behaviors from other social group members. Younger calves are exposed to their mother's foraging traditions and practices and often engage in those behaviors post-weaning (e.g., Sargeant & Mann, 2009), though some of the behaviors might require years of observation, physical and social maturity, and rehearsal and practice before implementation (e.g., intentional strand feeding by killer whales, Guinet, 1991; Guinet & Bouvier, 1995). For calves, development of their social interactions and behavioral exchanges with others also relies on exposure to their mother's social network and companion preferences (Krzyszczuk et al., 2017; Levensgood, 2019; Levensgood & Dudzinski, 2015; Mann, 2019; Mann & Smuts, 1998), though these resulting associations may be impacted by calf sex because, for some populations, females will return to their natal distribution whereas males tend to disperse from their natal habitat (Mann, 2019; Wells et al., 1987). These social differences are not as apparent when calves have shifted post-weaning to their juvenile stage (Krzyszczuk et al., 2017) during which both sexes of juveniles are more associated with one another. These observations suggest both sexes have different social developmental requirements at their different ages. That said, play is important for all social group members and is evident in elevated activity levels and behavioral exchanges, which were observed more for older pre-weaned calves in this study. Kuczaj et al. (2006) and Mackey et al. (2014) both showed that calf conspecifics benefited when multiple individuals were present, i.e., they gained more social coordination via social learning, modeling, and mentoring of conspecifics and similar-aged individuals.

Our findings confirm that pre-weaned calves increase overall well-being of a social group and the individuals in that group. Still, the question remains whether the ability to copulate for reproductive success, gestate an offspring, and/or raise an offspring are required for individual and group positive welfare. In the case of reproductive pathologies resulting in short- or long-term infertility (e.g., leiomyomas observed in various species, Penfold et al., 2014; Abegglen et al., 2022), these conditions could not only impact female health but also the overall social wellbeing of their groups by suppressing all group members' ability to care for young individuals. Though the social consequences of infertility or the incapacity for a female to produce offspring have not been explored, they should be investigated in the light of social group welfare rather than just conservation perspectives. Additionally, copulation (i.e., intercourse, sex) is used by dolphins (and bonobos and humans) to strengthen social bonds, not only for reproductive functions (Furuichi et al., 2014; Ham et al., 2023, Hohmann & Fruth, 2000), which suggests that the act of copulation (or genital stimulation) outside of reproduction is used by these individuals and availability of this behavior to these individuals likely elevates their welfare. The topics of copulation, gestation, and reproductive pathologies are outside the scope of this paper, but we raise these issues to stimulate additional discourse on these elements of welfare.

Theoretically, gestating an offspring, at least for a primiparous individual, should elevate that female's welfare because she would be able to shunt toxins to the calf (e.g., Borrell & Aguilar, 2005), which would likely cause decreased welfare of the calf, if it survived. That said, confirmation of elevated welfare of an adult female based on pregnancy and gestation also is outside the scope of this study but is an interesting philosophical query if the ability to express natural behaviors is a requirement for positive welfare of animals in managed care (Bandeli et al., 2023; Veasey, 2022). That is, would an adult female suffer negative welfare if she was never allowed to experience a pregnancy? Our results support the suggestion that raising an offspring, being able to provide maternal care to a genetically related calf or surrogate calf, allows an individual female to express a behavioral system that is biologically programmed (to some degree) within the natural repertoire (Bowlby, 1969/1982; Hinde, 1982). We also know that system is highly dependent on experience and available models with much individual variability between adult females (i.e., maternal styles; Dudzinski et al., 2021a; Hill et al., 2007) and calf-initiated behaviors (for dolphins, Dudzinski et al., 2021b; for belugas, Hill, 2009; Hill et al., 2013).

If calves are highly enriching to a social group, what happens when offspring are not available or present in a group? What are the implications for behavioral diversity and sociability of animals in groups

with no calves? Positively oriented social lives are possible in managed care, but humans must work harder to provide cognitive stimulation and enrichment and variable daily activities (sessions, pool changes, conspecific changes to simulate the fission-fusion social structure, e.g., Lauderdale & Miller, 2021). The presence of one or more pre-weaned calves enhances the overall well-being of a dolphin social group as not only mothers, but also other individuals join calves to engage in behavioral exchanges that increases group size and diversity and intensity in activity level(s).

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Supplementary Materials

Table S1

Observed Frequency for Group Sizes, Activity Levels, Behavioral Categories, and Group Spreading for Groups with and without a Calf

Calf Present	Group Size						
	1	2	3	4	5	6	7+
Yes	129	329	116	33	13	5	9
No	230	47	3	0	0	0	0
Calf Present	Activity Level						
	U1	U2	U3	U4			
Yes	72	242	301	19			
No	171	73	33	3			
Calf Present	Behavioral Category						
	Affiliative	Agonistic	Play	Swim			
Yes	388	22	52	172			
No	29	6	17	228			
Calf Present	Group Spreading						
	Tight	Medium	Loose	Single			
Yes	308	132	65	129 [‡]			
No	18	28	4	230			

Note. U5 not included as this activity level was not observed in our data. Grey-shaded cells intentionally left blank

Table S2

The Observed Number of Calves (from 0 to 5) in Groups Engaged in Varying Activity Levels (U1-U4), Behavioral Categories, and Spreading Configurations

No. of Calves	Activity Level				Behavioral Category				Group Spreading		
	U1	U2	U3	U4	Affiliative	Agonistic	Play	Swim	Tight	Medium	Loose
0	171	73	33	3	29	6	17	228	-12.3	18	28
1	72	233	229	6	318	10	42	160	11.0	268	95
2	0	19	58	12	58	12	9	12	1.0	36	32
3	0	0	12	1	12	0	1	0	-.4	4	5
4	0	0	1	0	1	0	0	0	-.7	0	0
5	0	0	1	0	1	0	0	0	-.7	0	0

Table S3

Observed Social Group Sizes Varied by Behavioral Category

Behavior category	Group Size						
	1	2	3	4	5	6	7+
Affiliative	0	270	100	26	9	3	9
Agonistic	4	18	4	2	0	0	0
Play	48	16	4	0	1	0	0
Swim	307	72	11	5	3	2	0

Table S4

Activity Levels, Behavioral Categories, and Group Spreading Showed Variability when Different Pre-Weaned Calf Ages were Present in Social Groups

Calf Age	Activity Level				Behavioral Category				Group Spreading		
	U1	U2	U3	U4	Affiliative	Agonistic	Play	Swim	Tight	Medium	Loose
0	171	73	33	3	29	6	17	228	18	28	4
C1	4	100	114	5	188	0	2	33	149	38	31
C2	37	81	105	7	102	16	32	80	80	60	25
C3	31	61	82	7	98	6	18	59	79	34	9