5. Impact of different kinds of humans in Swim-With-The-Dolphin Programs

Abstract

In recent years dolphin-assisted therapy has become very popular and an increasing number of facilities worldwide offer therapy programs with dolphins. We observed 83 sessions with five dolphins at "Dolphins Plus", Florida, and 37 sessions with 13 dolphins at "Dolphin Reef", Israel, in unstructured swim programs. Both facilities are fenced sea pans with ocean water. Our detailed observations at "Dolphins Plus" of contact and distance behavior between dolphins influenced by different groups of swimmers adults, children and children with mental and physical disabilities show that the dolphins at this site were stressed if humans were in the water, and that adult swimmers had the greatest impact. Furthermore, the dolphins tried to avoid close interaction with adults. The findings at "Dolphins Plus" were compared with the behavior of dolphins at "Dolphin Reef". In contrast to the behavior of the dolphins at "Dolphins Plus", the dolphins found adult humans to be very attractive at "Dolphin Reef". Finally, we discuss how the different living conditions may be responsible for this different behavior. Based on the high publicity of dolphin-assisted therapy we expect to see a continued growth in the number of oceanariums which offer these services. However, our observations show that limited space results in a reduction of the self-motivated attraction of dolphins toward humans.

Introduction

In 1985 the National Marine Fisheries Service authorised the use of dolphins in swim programs with humans (NMFS 1990). The first facility offering that kind of program was "Dolphins Plus", Key Largo, Florida. Since 1989, four more facilities have been authorised in the United States: the "Dolphin Research Center", "Dolphin Cove" and the "Theater of the Sea" at Florida Keys and the "Hyatt Regency Waikoloa" Hawaii (NMFS 1990). On average, 40000 humans have swum with dolphins annually since these programs were established (NMFS 1990). In the meantime, other swim-with-dolphins programs have been established elsewhere in the world, for instance in Israel ("Dolphin Reef", Eilat), in the Bahamas ("Dolphins Experience", Grand Bahama Island) and in Honduras ("Institute of Marine Science"). All these facilities offer recreation and entertainment (NMFS 1990; Simonds 1991). There are still not many quantitative studies about the impact of humans on the social behavior of dolphins (Spitz, 1993, Frohoff and Packard 1995; Frohoff 1996; Kyngdon, Minot, and Stafford. 2003). Samuels and Spradlin (1995) showed that the behavior of dolphins is more agonistic and sexual in programs where the dolphins interact independently of their trainers than in programs where they were always under their trainers' control. Agonistic and sexual behavior of dolphins in interaction with humans has also been observed in the wild (Webb 1978; Lockyer and Morris 1986; Bloom 1991).

A special kind of swim-with-dolphin program is dolphin-assisted therapy (DAT). Dolphins are used to assist therapists to help mentally or physically disabled or terminally ill people. In contrast to knowledge about swim-with-dolphin programs with healthy humans, there are virtually no publications concerned with the behavior of dolphins in swim programs with disabled children or adults. Since 1981 there have been a small number of publications about dolphin-assisted therapy by several psychologists. The first piece of research was a case study in which dolphins were used to motivate an autistic child to communicate (Smith 1981). A further experiment indicated that children learned two to ten times faster and with greater retention when working with dolphins (Nathanson 1989). Also significant improvements in hierarchical cognitive responses occurred when interacting with dolphins in mentally disabled children (Nathanson & de Faria 1993). An improvement in the social situation in families with disabled children was also observed (Voorhees 1995). Analysis of EEGs has shown that interaction with dolphins has a relaxing influence on humans (Cole 1996; Birch 1997). The effectiveness of short-term (Nathanson, de Castro and McMahon 1997) and long-term (Nathanson 1998) dolphin-assisted therapy for children with severe disabilities has been presented. Based on a study with approximately 1500 patients, a positive influence on child's autonomic homeostasis and psychoemotional status could be observed (Lukina 1999). Furthermore, the presence of the dolphins seemed to alleviate the pain atopic dermatitis patients experienced while bathing in seawater. It could be shown that the skin condition improved dramatically, and immunologically, while serum IL-8 levels decreased (Iikura et al. 2001). A reduction of anxiety in organized tourists swimming groups in the wild was also observed (Webb and Drummond 2001).

However, it is important to note that there also exists severe criticism that some of the studies used flawed data resulting in flawed conclusions (Marino & Lilienfeld 1998). Many common and uncommon effects of the DAT and also some future outlooks which represented the therapy in a very promising light have been discussed (McKinney, Dustin & Wolff 2001). Curtis points out that all publications were focused on humans but not on dolphins and possible disadvantages for these animals (Curtis 2000). Additionally, there is still an open discussion about the ethical and safety concerns of using free-ranging animals (Iannuzzi and Rowan 1991). Finally, Smith described the discovery and development of dolphin-assisted therapy based on her experience of more than 20 years as a scientist (Smith 2003).

However, to this date no studies exist about the behavior of dolphins during the dolphin-assisted therapy, except our publications (Brensing et. al. 2003; Brensing and Linke in press). In contrast to common assisted therapies with domestic animals, dolphins are not pets, they are predators and mostly captured from the sea. Nevertheless, people are willing to pay much more for dolphin programs than for other animal assisted therapy programs, mainly due to the greater publicity of dolphin therapy in the media. This resulted in a growth of this type of business over the last 10 years, and it is very likely that many oceanariums will follow the trend of offering this service.

In view of the growth in dolphin-assisted therapy and swim-with-dolphin programs in general, we believe that it is necessary to observe these programs and to determine the impact on these animals and, in particular, if they are stressed. This means that data have to be collected from different living conditions in different facilities (e.g. "Dolphins Plus", Florida; "Dolphin Reef", Israel) and with different kinds of humans.

For this purpose it would be useful to be able to measure hormone levels in the dolphins, but this was not feasible in our study. Taking blood samples itself causes stress and disturbance (Thompson and Geraci, 1986; St. Aubin and Geraci, 1988) and is therefore prohibited by the owners of the facilities. We therefore focused on less invasive methods, like observation of contact and distance behavior between the animals, of speed, depth of diving, breathing frequency and strategies of distribution in space. These parameters can be indicators of stress levels (Pryor and Schallenberger 1991).

At "Dolphins Plus", swim-with-dolphin programs were executed using trained and untrained dolphins. In the structured programs with the trained dolphins, there was no difference in the behavior of the dolphins towards healthy and disabled people. The dolphins were always under their trainers´ control and performed the same procedures; for instance, making noises, bringing toys, swimming and pushing the swimmers. This means that potential effects of humans on the behavior and social structure of the group of dolphins can only be observed in the unstructured programs. For this reason, our focus was on the unstructured swim programs at "Dolphins Plus". The group consisted of four adult females and one sub-adult male. Additionally, we observed the behavior of a group of 13 dolphins at "Dolphin Reef", Israel. All dolphins (in "Dolphin Reef" and "Dolphins Plus") were accustomed to being fed by the trainers; they did not have to do anything to receive fish which made all observed behavior self-motivated behavior. Based on the fact that all dolphins had been living together for years, it was very probable that they had developed a complex social structure (Samuels and Spradlin 1995). We set out to test the hypotheses:

- Different kinds of swimmers such as adults, children or disabled children have a different impact on the social structure of the interacting group of dolphins at "Dolphins Plus".
- Dolphins are repelled by humans and, furthermore, the interaction with humans can be a burden or stress for some animals.

Also we will discuss the different living conditions at the two facilities and the resulting behavior towards human swimmers.

Materials and Methods

Observations and Participants

The observations were part of a research project about communication among dolphins and interaction with humans which was carried out between April and December 1998 at "Dolphins Plus" Florida, USA and in March, April and September 2002 at "Dolphin Reef", Eilat, Israel. Both are fenced sea pans with ocean water. The primary difference between these facilities is the size of the enclosures. The largest pool we observed at "Dolphins Plus" was 20 X 30 m and covers an area of about 600 m^2 with no refuge area where the dolphins were undisturbed. "Dolphin Reef" covers an area of about 14000 m^2 (D. Todt and Hultsch 1995), and a very large section to which (approximately 30 percent) the dolphins can retreat and be undisturbed.

The situations we observed at "Dolphins Plus" included swim programs with different kinds of humans, and breaks in which the dolphins were undisturbed. The only disabled people included in our study were children under 12 years old; these children are referred to as *patients*. They had several mental and physical disabilities such as spasticity, apallic syndrome, epilepsy, ADHD, autism, Louis- Bar-Syndrome and other disabilities. There were no special requirements for taking part in this therapy, except that patients had to have head control. The other swimmers were divided into two groups: adults and children under 12 years. This differentiation was used to analyze whether dolphins have a preference for bigger or smaller humans.

Two different groups of dolphins (*Tursiops truncatus*) were used in swim and therapy programs at "Dolphins Plus". One group was trained and always under the control of the trainers; correct behavior was rewarded by the feeding of fish. The other group was untrained and could interact spontaneously with the swimmers with no control from the trainers. This group was fed three times a day independently of correct behavior. These dolphins were not used to being touched; all interactions with humans were initiated by the dolphins themselves.

As described in past research, trainers have a very high impact on the dolphins especially in the controlled programs (Frohoff and Packard 1993; Samuels and Spradlin, 1995; Kyngdon, D.J., E.O. Minot, K.J. Stafford. 2003). It is therefore very unlikely that the trained dolphins in the controlled programs act in a self-motivated manner. For this reason we decided to observe only the behavior of the untrained dolphins, where the trainers do not reinforce the behavior of dolphins. There was a group of four adult females between 13 and 16 years which were caught in the Gulf of Mexico and one sub adult male of four years, born at the Dolphin Plus. These dolphins could interact with adults or with children in the public swim sessions. These swim sessions took place approximately 4 times a day with an average of five human swimmers, either adults or children. In contrast to these swim sessions, the patients in the therapy sessions were assisted by a therapist. These dolphins have the choice of deciding if and for how long they want to interact with different swimmers.

The dolphins were identified by natural marks (Würsig and Würsig 1977, 1979; Würsig 1978). To get representative data for the control condition with no interaction with humans, observations were always made at the same time every day in the morning after the swim sessions and without humans close to the pool. The recording period was 30 minutes – the same duration as the swimming sessions and therapy programs. Altogether 83 sessions were recorded: 30 undisturbed with no humans in the water, 30 in swim-with-the-dolphin programs with tourists, and 23 in therapy programs.

At "Dolphin Reef" there were 13 bottlenose dolphins. These dolphins were able to leave the enclosure through a gate to the open sea. The gate was located in shallow water and open 24 hours a day. We observed 16 groups of swimmers with a minimum of two and a maximum of 5 adult humans per group (average= 3.2) including the guide. In addition, we observed 21 separate sessions which mainly took place in the pool entry area, where the humans get in and out of the pool. The swimmers were instructed not to force body contact or to put any pressure on the animals (such as chasing them). All groups were guided by an experienced guide employed at "Dolphin Reef". The swimmers entered the enclosure from the beach and followed the guide through the area. The swimming session ended when the group returned to the starting point. An average swimming session lasted between 20 and 30 minutes.

Materials and Apparatus

The pool was monitored with two Sony cameras (CCD–107P) with a resolution of 752x582 pixels. One camera with a wide-angle lens captured the entire pool area and was mounted above the pool on a wooden construction to the side of the pool. The second camera recorded only a highly frequented area. This area was used to identify the dolphins. Both cameras were equipped with polarized lenses. Two VCRs (GV 690 S HiFi) were used to record the video streams synchronized by the rapid time code on tapes. This arrangement makes it possible to use the focal animal sampling technique (Martin and Bateson 1986) for each dolphin simultaneously. In this way, we were able to analyze the data for all five dolphins and all swimmers at the same time. After identifying an individual in the highly frequented area, a special mouse-based computer program on the video screen (covering the entire pool), was used to identify the position of the dolphins and humans over time. To do so, the analogue video stream was digitized and displayed on a computer screen. Every individual was followed manually by the observer with the computer cursor pointed on the head of humans or on the melon of dolphins, and the position of the cursor was recorded once every second. Furthermore, it was possible to add notes about each individual (dolphin or human) at any particular time; describing, for instance, depth of diving, or the color of swimming gear.

Unfortunately, it was not possible to map the cursor position directly onto the video view. All photo and video sources have a distortion of perspective, depending on the angle of the camera. This distortion must be taken into account in every case to calculate the exact positions. In this study, an exact formula complex was empirically developed for this purpose (Brensing et. al. 2001). This high precision of the position data allowed us to correlate the position of every swimmer or dolphin to each other at any given time. Based on known positions in a three dimensional coordinate system it is possible to calculate different parameters like speed, depth of diving, distance, frequency of contact, and duration of contact. Knowing speed and distance, we were able to calculate another essential parameter that we will call the <u>speed-difference</u>. This parameter is an equal to adjusted behavior between individuals. Furthermore we analyzed the frequency of breathing. All these parameters were the basis for the statistical examinations of individual behavior as well as the group-dynamic in the different situations. These situations were: (1) undisturbed (no human in the water or close to the pool), (2) adults (swimmers over 12 years old), (3) children (swimmers of 12 years old and under) and (4) patients (children with unspecific mental or physical disability under 12 years old).

Our recordings at "Dolphin Reef" were executed between 9:30am and 1:00pm as at "Dolphins Plus" but also between 1:00pm and 4:00pm. Two settings were used one with a focus on the entry area and the other with a focus on the moving group of humans.

Observations of the entry area: A fix mounted camera (Video Hi8 Sony Handy Cam) observed the entry (128 m^2) of the swimming area. Every time a dolphin was present in this area, it was recorded.

Observations of moving groups: Every group was continuously recorded by one observer during the entire swim session using a Video Hi8 Sony Handy Cam. The camera zoom was adjusted to film the area around the focus group within a diameter of 15m to 20m, estimated from the length of the dolphins or humans. The observers filmed from the platform of a research tower 8m above sea level, thus having a good view over the whole area of the pen. All behaviors and distances between swimmers and dolphins were identified in slow motion by visually inspecting the screen. The swimmers were usually floating on the water surface and were easy to observe continuously. The dolphins had to be directly beneath or on the surface to be visible. The distance between the swimmers with their guide and the dolphins was estimated from the lengths of the dolphins. The duration of contacts to humans and the time spent with humans in an area with a diameter of 10m was estimated from the time code on the tape.

Calculation of individual parameters of single dolphins at "Dolphins Plus"

The speed between two coordinates (successive coordinates separated by a time interval of one second) in a two-dimensional coordinate system can be calculated using formula 5.1. The diving depth was estimated from depth horizons and computed into metres (formula 5.2). The breathing frequency was defined as the numbers of breakthroughs of the water surface by the dolphins per minute.

$$V = \sqrt{a^2 + b^2} * 3.6 = \sqrt{|x_1 - x_2|^2 + |y_1 - y_2|^2} * 3.6$$

Formula 5.1: Calculation of the speed (V) between two coordinates in two dimensions (x_1/y_1 and x_2/y_2) in km/h.

$$T = 2 * \text{Depth horizon} - 1.5$$

Formula 5.2: Calculation of the diving depth in m based on the observed value of depth horizons.

Calculation of group-specific parameters between two dolphins at the "Dolphins Plus"

For five animals there are ten possible combinations of pairs (figure 5.1).

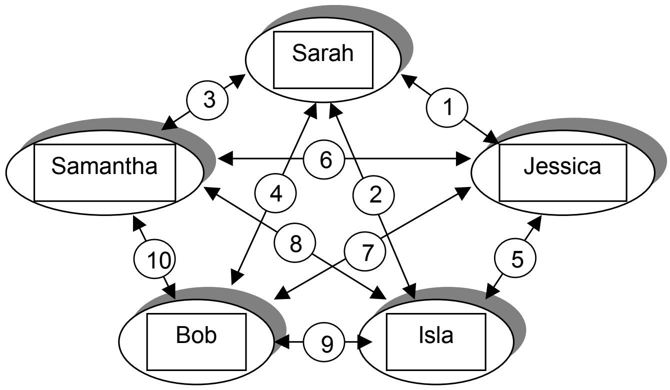

Figure 5.1: The 10 possible pairs of dolphins at "Dolphins Plus". The numbers in the circles correspond to the pair numbering used in the text.

The <u>distances</u> between two coordinates (dolphins) in a two-dimensional coordinate system can be calculated using formula 5.3.

$$D = \sqrt{a^2 + b^2} = \sqrt{|x_1 - x_2|^2 + |y_1 - y_2|^2}$$

Formula 5.3: Calculation of the distance (D) in m between two coordinates in two dimensions (x_1/y_1 and x_2/y_2).

The <u>speed-difference</u> was calculated from the difference of the speeds of the two individuals in an interacting pair (formula 5.4). For instance, if in a certain moment one individual has a speed of 3.2km/h and another individual has a speed of 2.4km/h the speed-difference is 0.8km/h.

$$dV = |V_1 - V_2|$$

Formula 5.4: Calculation of the difference of speed in km/h. The speed for each interaction partner was calculated using formula 5.1.

A small average of the mean value indicates whether they swim at a similar speed (independently of whether they swim close together or far away). In this case the behavior must be adjusted because of the restricted area in the pool of "Dolphins Plus". The contact frequency was for the purpose of this study defined as the frequency of decreases in distance to less than two metres. Consequently, each event of entering into an area with a radius of two metres around an individual represents a contact. Observations at Brookfield Zoo used a distance of one metre (Samuel and Gifford 1997), but this distance was only estimated. Furthermore, the observation basin was approximately half as wide as the one at "Dolphins Plus". All contacts were recorded in contacts per minute (formula 5.5).

$$\mathrm{Cf/min} = (\mathrm{contacts/20s}) * 3$$

Formula 5.5: Calculation of contact frequency (Cf) per minute.

The contact-duration (close contact) was the time during which two individuals swim at a distance of less than two metres.

Calculation of the distribution of dolphins compared to humans at "Dolphins Plus"

The distribution of dolphins in interaction with humans depends on the position of the humans. To evaluate if dolphins were attracted by humans we need to calculate randomized positions for of every dolphin as if humans were absent. These positions were computed by randomising every dolphin's trail over time in each session. This random position was used to determine a new randomized distance to every human. This distance was compared to the observed distance. If the observed distance was smaller than the randomized distance, the dolphin was attracted by the human and the value was set to 0. On the other hand, if the observed distance was larger than the randomized distance the dolphin was not attracted or may have been repelled, and the value was set to 1. One thousand permutations were computed. The expected range of values was between 0 (dolphins are always attracted) and 1000 (dolphins are always not attracted). The results were transformed into *P*-values (formula 5.6). This procedure was performed for different ranges of distance, i.e. a circle with a radius of 1m, annuli with inner-outer radii of 1-2m, 2-3m, 3-4m and so on. The results indicate how much distance dolphins prefer to keep between themselves and humans.

$$P = \frac{\text{Number of permutations, if OS} > \text{RS}}{1000}$$

Formula 5.6: Calculation of the *P*- value based on the permutations (RS = random separation and OS = observed separation).

Calculation of the presence, reemergence and retention of dolphins in absence and presence of humans at the entry area at the "Dolphin Reef"

The value of the presence was calculated as the accumulation of the presence of different dolphins. For instance, if in the same minute one dolphin was in the entry area for 45 seconds and another dolphin for 35 seconds, this would result in an accumulated presence of dolphins of 80 seconds per min. The average reemergence of individual dolphins was set at the recorded number of times they came into the entry area for every individual while the average retention period was the average time they spent per entrance into this area.

Calculation of the distance between humans and dolphins at the "Dolphin Reef"

The distance between dolphins and humans was estimated by the average length of the dolphins (2.70m), the distance between swimmers and the guide was estimated by the average length of the humans (1.80m). Dolphins were deemed to be "present" if the distance to a swimmer or to the guide was less than one dolphin length. Given that the group of humans could be somewhat spread out, its centre could be at least one human length from its edge. Therefore a circle with the same centre, drawn to extend to the dolphin, would have a diameter of about 10m, i.e. a radius of just over one dolphin length and one human length. The presence of dolphins in this circle of about 78m^2 was compared to the average distribution of dolphins in the whole area of about 14000m^2 (Todt and Hultsch 1995).

Statistics

Both the descriptive and the inferential statistics were calculated with SPSS version 8. The influence of different kinds of people at "Dolphins Plus" was determined by comparison with the reference behavior where the dolphins were undisturbed by humans. The reference values in each case were the averages of the parameters speed, depth of diving and breathing frequency for each dolphin and distance, speed-difference, contact-frequency and contact-duration for each dolphin in relation to every other dolphin. The group structure is illustrated in figure 5.1. A one-way ANOVA was used to determine whether the differences in dolphins' behavior observed with different kinds of humans were statistically significant. Before each analysis, variance homogeneity was tested. In some cases the data had to be square root transformed. Another condition was that the data had to be independent. However, position data of moving animals cannot be independent because successive positions are always dependent upon the previous position. The prerequisite of independence is met if the correlation coefficient is smaller than 0.16 with an n of 100 (formula 5.7, Köhler, 1983). To determine the independence of the parameters speed, diving depth, distance and speed-difference, the average of 15 single values was calculated so that the correlation coefficient was below 0.15. The other parameters, breathing frequency, contact-frequency and contact-duration, are independent. Significant results were further analyzed using the Tukey post-hoc method. It is a common problem that there is an increase of the probability for Type I errors if there are multiple tests. We tested this probability with the binominal distribution (Cross and Chaffin, 1982).

$$t = \frac{|n|}{\sqrt{1 - r^2}} * \sqrt{n - 2}$$

Formula 5.7: Calculation of the correlation coefficient to prove the independence of the parameters distance (figure 5.1) and difference of speed (figure 5.2) (Köhler, 1984).

At "Dolphins Plus", the data on the randomized and observed distribution of dolphins and humans, expressed in terms of distance (separation) ranges, were analysed for the probability that the randomized distance range was likely to be less than the observed distance range. The distance ranges on either side of the crossover from "more likely" to "less likely" as separation increased up to about 18m were called A and B. To determine the statistical significance of the difference between the distributions falling into these separation categories we calculated their *P*-values using the Mann Whitney U-Test.

At "Dolphin Reef", the comparisons between the two situations where humans were present in the entry area or not, were tested for significance for all three parameters (presence, reemergence and retention period) by the Wilcoxon Test. Also, the difference between the observed presence of dolphins in a circle of 78 m^2 surrounding a group of human swimmers and the expected presence based on an average distribution was tested for significance by the Wilcoxon Test.

Results

Speed, depth of diving, frequency of breathing, distance, speed difference, contact frequency and contact duration were analysed to describe the individual and group dynamical behavior of dolphins towards different kinds of human. Reference behavior was that in absence of humans.

Figure 5.2 presents the speed, depth of diving and frequency of breathing of each dolphin as influenced by adults, children and disabled children at "Dolphins Plus". These data were normalised, i.e., they are expressed relative to the reference behavior (where the dolphins interacted with each other without disturbance by humans) which was set to 100 per cent. This was done to simplify the interpretation. **All dolphins showed increases in speed, depth of diving and frequency of breathing when interacting with humans,** although some increases were not significant.

All female dolphins swam when undisturbed at a speed of between 3 and 3.5 km/h. The youngster Bob swam at about 4 km/h. All dolphins showed significant increases in speed when interacting with humans and the greatest increase, of up to 80 percent, occurred with adults. The undisturbed depth of diving range was from 1.8 to 2.2m. All dolphins increased their depth of diving significantly in the presence of adults. One dolphin (Sarah) increased her depth of diving by about 40 percent, the other dolphins by between 20 and 25 percent. Children and patients did not influence the depth of diving significantly. All female dolphins had an undisturbed frequency of breathing of between 1.5 and 2 breaths per minute. Bob was again an exception to the rule, with a frequency of breathing of about 2.3 breaths per minute. Two dolphins (Isla, Jessica) increased their frequency of breathing significantly when interacting with all kinds of humans, the increase ranging from 25 to 60 percent.

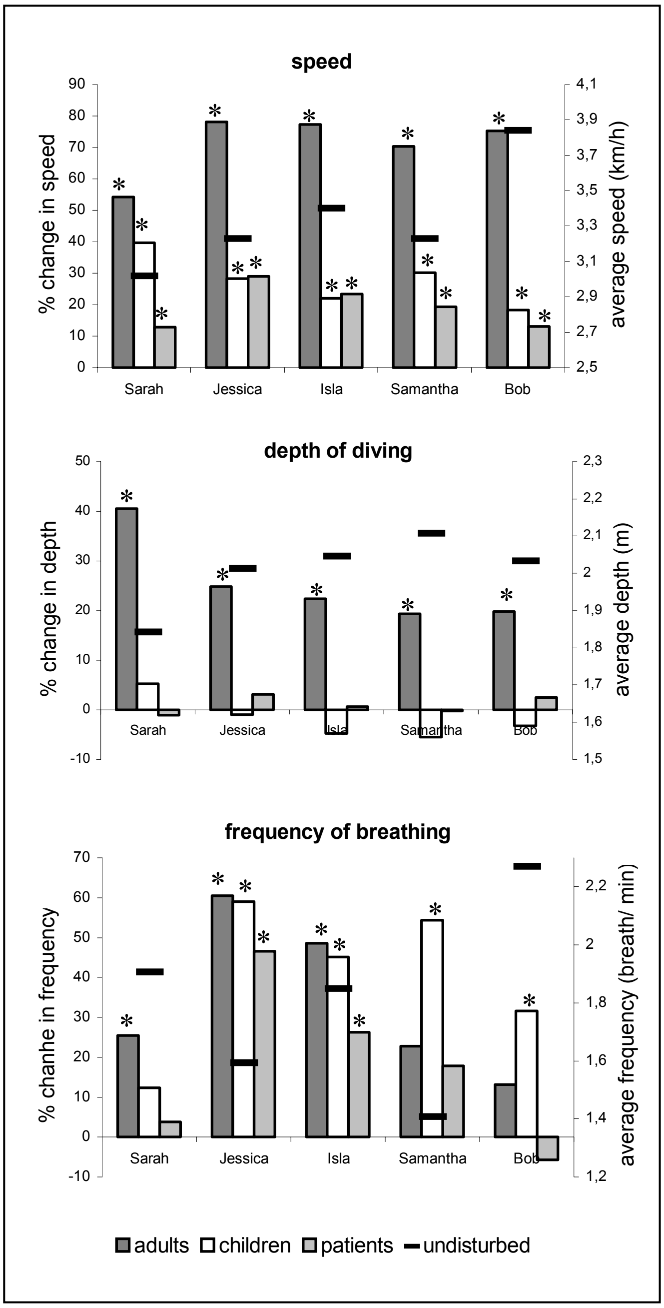

Figure 5.2: The individual parameters of each dolphin at "Dolphins Plus". The right axis shows the average of the mean values (▬) for each dolphin in the absence of humans. This absolute value is set to zero on the left axis, with the relative values in percent. The influence of the different kinds of human on the dolphins is recognisable as the variation in percent.

* Significant influence (level of p=0.05).

One dolphin (Sarah) was significantly influenced only by adults, and increased her frequency of breathing by about 25 percent. Two dolphins (Samantha, Bob) were significantly influenced only by children and increased their frequency of breathing by between 30 and 60 percent.

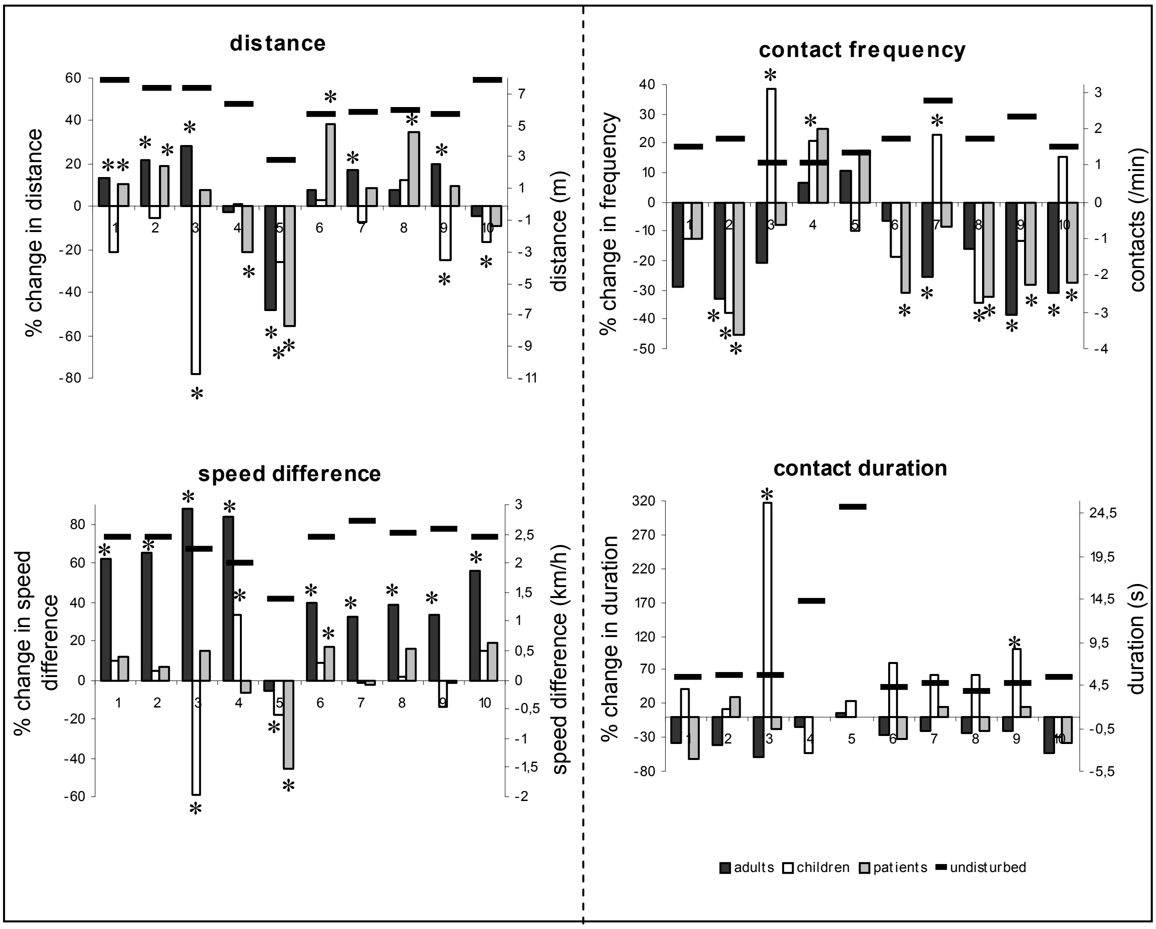

Figure 5.3: Illustration of the group dynamical parameters of all pairs of dolphins at "Dolphins Plus". The right axis shows the average of the mean values (▬) for all dolphin pairs in the absence of humans. This absolute value is set to zero on the left axis, with the relative values in percent. The influence of the different kinds of humans on the dolphin pairs is recognisable as the variation in percent. The names of the dolphin pairs are shown in figure 5.1.
* Significant influence (level of p=0.05).

Distance, speed difference, contact frequency and contact duration were analysed to describe the group dynamical behavior of dolphins influenced by different kinds of human. Figure 5.3 presents the distance, speed difference, contact frequency and contact duration of the 10 dolphin pairs at "Dolphins Plus" as influenced by humans. The data were normalised, i.e. the reference behavior (where the dolphins interacted with each other without disturbance by humans) was set to 100 percent. This was done to simplify the interpretation. The average distance between the dolphins of each pair ranged between 5.7m and nearly 8m, with the exception of pair 5 (Isla, Jessica) where it was 2.8 m. Every pair of dolphins reacted significantly to at least one group of humans. The change in distance was not consistent: there were nine significant increases and seven significant decreases in distance between the dolphins in their pairs. Only pair 5 (Isla, Jessica) reacted significantly to all kinds of humans, showing a decrease of up to 60 percent. The most impressive change was a decrease of nearly 80 percent in pair 3 (Sarah, Samantha) in reaction to the presence of children. Seven of the 10 pairs showed a decrease in distance in the presence of children, four of them significantly. In contrast most pairs increased their separation in response to adults and patients. The average difference of speed, in the dolphin pairs ranged from 2 to 2.7 km/h, with the exception of pair 5 (Isla, Jessica), at about 1.4 km/h. Speed difference tended to increase in the presence of humans. However, speed difference decreased in pair 3 (Sarah, Samantha) in the presence of children and in pair 5 (Isla, Jessica) in the presence of all kinds of human. Adults caused a very strong and significant increase in the difference of speed in all pairs with the exception of pair 5 (Isla, Jessica). The increase ranged from 30 to over 80 percent. Pair 3 (Sarah, Samantha) showed the greatest variation with a decrease of nearly 60 percent in the presence of children and an increase of nearly 90 percent in the presence of adults. The average contact frequency ranged from one to two contacts per minute, with the exception of pair 7 (Jessica, Bob) and 9 (Isla, Bob) at more than 2 contacts per minute. Pairs 3 (Sarah, Samantha) and 4 (Sarah, Bob) showed the lowest contact frequency at about one contact per minute. Figure 5.3 shows that most dolphins reduced the frequency of contact with their pool mates if humans were in the water. Pair 2 (Sarah, Isla) was influenced significantly by all kinds of human. This pair reduced contact frequency by about 30 percent in the presence of adults, 40 percent in the presence of children and about 45 percent in the presence of patients. Pairs 8 (Samantha, Isla), 9 (Isla, Bob) and 10 (Samantha/Bob) were significantly influenced only by two kinds of human, namely by patients and either adults or children, and they reduced the contact frequency by between 30 and 40 percent. In contrast, pair 3 (Sarah, Samantha), 4 (Sarah, Bob) and 7 (Jessica, Bob) were particularly influenced by children and increased their contact frequency in response. It is interesting that the only significant increase in contact frequency occurred in response to children; all other significant influences of humans resulted in a reduction in contact frequency. Pairs 1 (Jessica, Sarah) and 5 (Jessica, Isla) were not significantly influenced by the presence of humans. The duration of contacts was mostly in the range from four to six seconds, but there were two impressive exceptions: pair 5 (Jessica, Isla) at 25s and pair 4 (Sarah, Bob) at 14s. Children seemed to have the most important influence on the duration of contacts. In most cases the dolphins prolonged the duration. The standard deviation was very high, thus there were only two significant increases. Both were caused by the presence of children. Pair 9 (Isla, Bob) increased the duration by nearly 100 percent, but the very impressive value of over 300 percent was reached by pair 3 (Sarah, Samantha). Adults and patients seemed to reduce the duration of contacts, but in no case significantly.

To estimate the probability, to make a Type I error, we compared the distribution between all our tests and the significant tests with the binominal distribution (Cross and Chaffin, 1982). To describe the individual behavior we performed 45 tests and 29 were significant. The probability to make a Type I error, was *P*: 2.7E-15 (exact binominal test two –tailed). To describe the group dynamic behavior we performed 120 tests and 46 were significant. The probability to make a Type I error, was *P*: 1.1E-14 (exact binominal test two –tailed).

The distribution of dolphins in relation to humans at "Dolphins Plus" is based on observed behavior compared to randomized behavior. Randomized behavior would be expected if dolphins had no preferences (probability = 0.5). Therefore, there are three possibilities:

- dolphins prefer a distance range (the probability of being in this range is <0,5)
- dolphins ignore distance ranges (the probability of being in this range is 0,5)
- dolphins avoid a distance range (the probability of being in this range is >0,5)

As shown in figure 5.4, it is clear that dolphins avoid close proximity to humans. This statement is based on the fact that the range A (between 0m and 9m) is avoided whereas the range B (between 9m and 18m) is preferred. There is a clear trend of dolphins going from range A to range B with the crossover in probability occurring at approximately 9m. Beyond 18m dolphins again tend to maintain a greater separation than expected. This means dolphins do not prefer this distance of separation, rather that they were limited in space by the fences and walls. In this way, they were not able to be in the range of more than 18 m. The different distributions represented by the distance range categories A and B was compared using the Mann Whitney U-Test. Significant effects on dolphin distribution were demonstrated for female and male adults and for children. The effect of patients was not significant but followed the same trend.

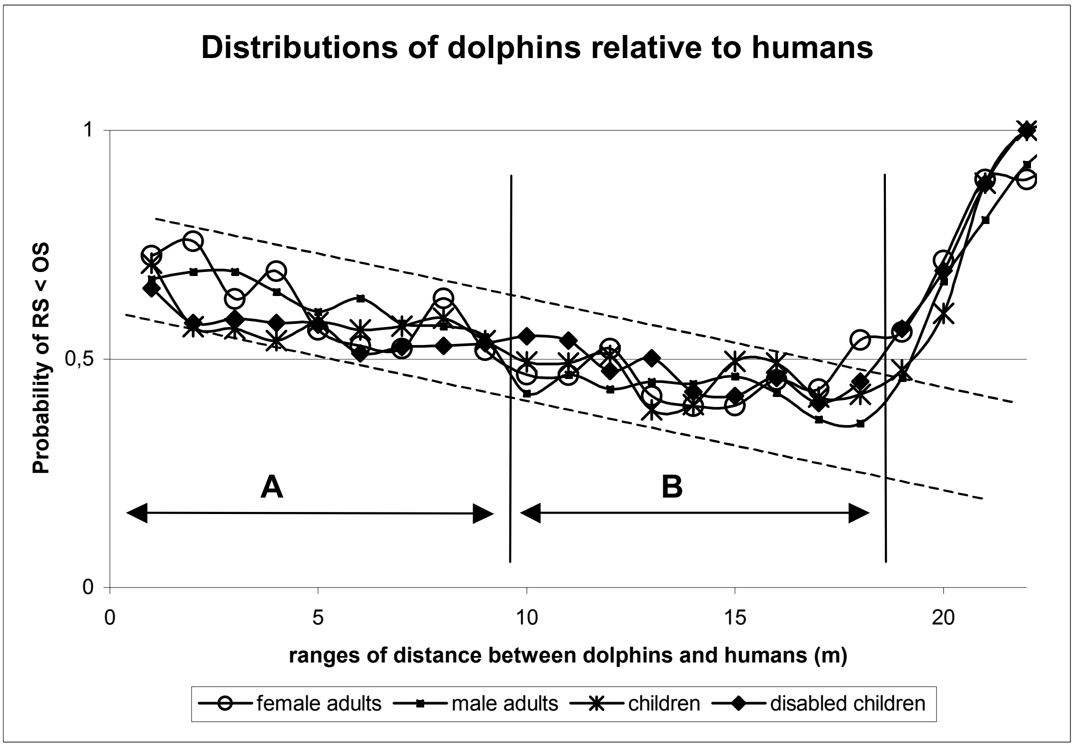

Figure 5.4: Distributions of dolphins relative to humans based on a comparison of random and observed behavior at "Dolphins Plus". If the random separation (RS) is smaller than the observed separation (OS) the probability is greater than 0.5. This means that dolphins were likely to be further from the humans than expected. If the value is smaller than 0.5 the probability is greater that the random separation is larger than the observed separation. This means that the distance between the dolphins and the humans is smaller than expected. The distance ranges were divided stepwise in metres, and the probabilities are plotted at the upper end of the ranges. The double arrow A shows the unfavored distance range category and the double arrow B shows the favored distance range category.

The attraction to humans at "Dolphin Reef" is shown in table 1, 2 and 3. The presence of dolphins in the entry area when humans were present was 17.3 seconds per minute and when humans were absent it was only 6.2 seconds per minute (Table. 1). A comparison of all 21 sessions shows that there is a significant difference (Wilcoxon Test) between these situations and therefore we can conclude that dolphins preferred that area if humans were present. Overall, the average dolphin reemerged in the entry area 3.6 times per session when humans were present and only 1.4 times if humans were absent (Table. 2). The comparison with the Wilcoxon Test shows again that the situations were significantly different. The average retention period for every new entrance into the pool entry area in presence of humans was 27 seconds and without humans 22 seconds. There was no significant difference in the comparison with the Wilcoxon test.

Table 1: Comparison between the presence of dolphins with and without humans in the entry area at "Dolphin Reef", Israel. The value is calculated as the accumulation of the presence of different dolphins. For instance, if in one minute there was one dolphin present for 45 seconds and another dolphin for 35 seconds in the entry area, this would result in an accumulated presence of dolphins for 80 seconds per min. The difference is significant based on the Wilcoxon Test.
* significant influence, p = 0,05

Observed sessions, N = 21	Median / standard deviation
presence of dolphin in presence of humans	17,3 +/- 12,3 * (seconds per min)
presence of dolphin in absence of humans	6,2 +/- 4,6 * (seconds per min)

Table 2: Comparison between the presence of dolphins with and without humans in the entry area at "Dolphin Reef", Israel. The average reemergence of individual dolphins were the accounted entries into the entry area for every individual dolphin and the average retention period is the average time they spend in this area per entry. The difference is significant based on the Wilcoxon Test.
* significant influence, p = 0,05

Observed individuals, N = 12	in presence of humans (Median / standard deviation)	in absence of humans (Median / standard deviation)
Average reemergence of individual dolphins per session	3,6 +/- 3,3 *	1,4 +/- 1,2 *
Average retention period of individual dolphins in seconds	27 +/- 6	22 +/- 9

During the observation of our 16 groups of swimmers, the average dolphin was present for about 62 seconds. Based on an average distribution of dolphins in the whole enclosure, dolphins would be expected in the circle surrounding the swimmers for about 8 seconds (Table. 3). The difference between these values are significant according to the Wilcoxon Test. Furthermore, we observed on average 2.2 body contacts to the swimmers per group and session. In these contacts the dolphins were touched by the humans. No behavior like this was observed at "Dolphins Plus".

Table 3: Comparison between the observed and expected presence of dolphins in a certain area surrounding a group of humans swimmers at "Dolphin Reef", Israel. The area was defined as a circle with diameter of 10 m. The expected value was calculated from the average distribution of one dolphin in the whole enclosure. The difference is significant based on the Wilcoxon Test.

* significant influence, p = 0,05

Observed group of swimmers, n = 16	Median / standard deviation (s per session)
Observed presence by one dolphin	62 +/- 32 *
Expected presence by one dolphin	8 +/- 2 *

Discussion

The aim of this study was to evaluate the behavior of dolphins when interacting with different kinds of humans and to assess, in particular, whether such interactions can be stressful for the animals. Furthermore, a comparison between two very differently sized pens was made, focusing on humans as an attractant for dolphins.

Observations at "Dolphins Plus"

We first need to discuss the **reference behavior** where the dolphins were undisturbed by humans. Figure 5.2 shows the individual behavior. The average speed of the dolphins at "Dolphins Plus" was 3.3km/s, much less than the observed speed of 5 to 8km/h in the wild (Würsig and Würsig 1979; Irvine et al. 1981; Tanaka 1987; Shane 1990; Mate et al. 1995; Ridoux et al. 1997). This low speed is easily explained by the small pool and the resulting high number of directional changes. The sub-adult male Bob had the highest speed, this is comparable with observations of wild sub-adult males (Lockyer and Morris 1987). The depth of diving is not comparable with observation in the wild because the depth of the pool was limited. The frequency of breathing was similar to the behavior observed in the wild, where dolphins breathe every 20 to 40 seconds (Würsig 1978; Irvine et al. 1981; Ridgway and Harrison 1986; Shane 1990). The group dynamic is described by distance, difference of speed, contact frequency and duration of contacts (figure 5.3). Pair 5 (Jessica, Isla) stands out because of its small distance and high duration of contacts. Further, these dolphins had a very low difference of speed and an equal depth of diving. All these data defined pair 5 as a real subgroup. However, the speed shows Isla to be faster than Jessica. This inconsistency is explicable if we assume that Isla was swimming very fast when she was not swimming together with Jessica. Establishing a subgroup is very common among dolphins (Norris and Dohl 1980; Wells, Scott and Irvine 1987). It is of particular relevance to our aim, because disturbance of that close social connection can cause stress for the dolphins. Samantha (pairs: 3,6,8,10) showed the shortest duration of contacts compared to her pool mates, all her other parameters were non-remarkable. This means that Samantha had no intensive social contacts to the other dolphins. In addition, her skin is marked by several scratches and it was often observed that she was attacked by the other dolphins, so she can be defined as subordinate (Rowell 1966; Hausfater 1975). In contrast to Samantha, Sarah was called "princess" by the trainers at "Dolphins Plus" and she had no lesions on her skin. All the pairs involving Sarah (pairs: 1,2,3,4) maintained a greater distance than the other six pairs. The difference of speed might also be expected to be greater, but appears (not significantly) smaller. It is improbable that one dolphin adjusted its behavior to several dolphins but it is possible that several dolphins adjusted their behavior to one dolphin. That means that the interaction partners of Sarah were adjusting their behavior to Sarah's. The high distance and the adjusted speed of the other dolphins to Sarah can be interpreted as dominance (Pryor 1990). This statement (excluding subgroup 5) is with a P of 0.052 nearly significant. But there are also reports that dominant dolphins are in the middle of the group (Tavolga 1966). Bob's group dynamic behavior is not very noticeable, except for the long duration of contacts to Sarah (pair 4). This behavior is interpretable as an interaction between a dominant and a sub-adult animal.

We can now discuss the influence of different kinds of human on **individual dolphins** at "Dolphins Plus"**.** As described above the interaction with different kinds of humans resulted in a significant increase in speed (figure 5.2), adults having the greatest influence. The speed increased to the average speed of dolphins in the wild (Würsig and Würsig 1979; Irvine et al. 1981; Tanaka 1987; Shane 1990; Mate et al. 1995; Ridoux et al. 1997). We have to take into consideration the fact that dolphins in the wild are usually traveling in one direction and that the dolphins at "Dolphins Plus" had to permanently change direction because of the limited space. It is possible that this could be a serious stressor. Additionally, we have to realize that in the presence of adults, dolphins not only increase their speed but also try to dive significantly deeper, and that most dolphins significantly increase their frequency of breathing. These data suggest that dolphins were disturbed by humans and that they try to avoid them. Based on this conclusion we should have a closer look at the **group dynamic parameters**.

We will focus first on exceptions to general behavior and the establishment of sub-groups. Based on the reference behavior we identified only one subgroup - pair 5 (Jessica, Isla). In contrast to the other pairs, this pair decreased its distance and difference of speed (figure 5.3) significantly in the presence of humans and increased the parameters speed, depth of diving and frequency of breathing (figure 5.2). In other words, these dolphins adjusted their behavior towards each other and came closer. This strategy has been observed in the context of stress and danger (Norris and Dohl

1988), and supports the statement that pair 5 is particularly stressed by humans. We were told by the owners of the "Dolphins Plus" that both dolphins were caught from the same group in the Gulf of Mexico. This fact, and the possibility of kinship, may explain the motivation for the close contact (Wells et al. 1987; Duffield and Wells 1990; Smolker et al. 1992).

Another very interesting exception to general behavior was the behavior of pair 3 (Sarah, Samantha) in the presence of children (figure 5.3). The dominant animal Sarah and the most subordinate animal Samantha reduced dramatically their separation and their difference of speed, and increased the number of contacts and the duration of contacts by more than 300 percent. In other words they established a subgroup when children were present. There is no known precedent for this behavior, especially since neither animal showed a preference for children (Brensing and Linke in press). It would be interesting to determine whether the establishment of the subgroup was restricted to our observation period or remained stable over time.

The general response of the dolphins at "Dolphins Plus" was an increase of distance (if we exclude subgroups five and three) and difference of speed and also a decrease of contact frequency if humans, especially adults, were present in the water. That means that the dolphins' behavior was less mutually adjusted. Children and patients did not have such a strong impact on the behavior of the dolphins.

As described above, there is a serious risk to make a Type I error if there are multiple tests. Therefore, we estimated the probability of making this error through the binominal test. In both cases, the individual and the group dynamic behavior, the probability was less than P=0.05. That means that a Type I error is very unlikely.

The groups of bigger (adults) and smaller (children and patients) humans have a significant impact on all pairs of dolphin in at least one parameter (figure 5.3) and all kinds of humans have a significant impact on six pairs of dolphins (pair 2;4;5;8;9;10). This makes our hypothesis highly persuasive, that different kinds of swimmers have a different impact on the social structure of the interacting group of dolphins at "Dolphins Plus". Additionally, we conclude that overall dolphins swim faster, dive deeper and reduce the intensity of contacts to their pool mates in the presence of humans.

These observed impacts can be interpreted in two ways. On the one hand, <u>dolphins were</u> stressed by humans, and try to avoid them. On the other, <u>dolphins are attracted</u> by humans and they try to swim quickly from one human to the next so that they do not have the time to interact with their pool mates. To accept one hypothesis or the other we need to predict the hypothetical behavior of dolphins in the absence of humans and to compare that behavior with the observed behavior.

As shown in a figure 5.4, dolphins prefer to keep a distance of more than 9m between themselves and humans. If we consider that we see edges effects based on the size of the pool beginning at 18m we can divide the pool in two ranges: one part close to the humans and one part far away from the humans. Dolphins prefer the area far away from humans. This statement is significant except for patients who do not have such a strong impact. Comparing this finding with the other data such as individual and group dynamic parameters, we are now able to explain the differences to the reference behavior as a kind of human-avoidance behavior.

Our results contrast with the official information provided at "Dolphins Plus", where visitors are told that the dolphins seek contact and like to swim with humans. Indeed, visitors leave with the impression that dolphins had self-motivated contact with them and they are usually satisfied with the experience. However, the contacts to humans do not appear to result from great interest on the part of the dolphins but rather from random exploration and coincidence because space is restricted and the dolphins cannot avoid the contact (Frohoff and Packard 1993). We therefore have to <u>accept the hypothesis that dolphins were stressed by humans, especially by adults</u>, at "Dolphins Plus".

<u>Observations at "Dolphin Reef"</u>

Dolphins are known to be very interested in humans in the wild, so the behavior of dolphins at "Dolphins Plus" must have something to do with the environment or with the personal experience of the dolphins. It is impossible to determine the latter but it is possible to observe dolphins in different environments. That is why we studied the dolphins at "Dolphin Reef", Israel, where dolphins live in a huge open-water area and can leave it and escape to the open ocean whenever they want. As at "Dolphins Plus", the dolphins at "Dolphin Reef" were not fed as a reward for correct behavior in interaction with humans, so their behavior is also self-motivated. Unfortunately it was not possible to observe the behavior of the dolphins at "Dolphin Reef" in as much detail as at "Dolphins Plus". It is also difficult to compare observations from an area of 14000m^2 (Dolphin Reef) with those from an area of

$600m^2$ (Dolphins Plus). However, even if the methods are not comparable, it is possible to compare conclusions.

As shown in table 1, 2 and 3, dolphins at "Dolphin Reef" were attracted by humans. First they were attracted by the entry area if humans were going in or out of the water. The presence and the reemergence (Table 1 and 2) of dolphins in the entry area were significant, there was no difference in the retention period (Table 2). That could mean that dolphins examine the entry area with the same procedure independently if humans were present or not. It seems likely that they do not tend to establish a statistically relevant contact to humans in this area. However, the overall presence of dolphins is nearly three times grater with humans present in the entry area than without humans in this area. It could be argued that dolphins prefer the shallow water in the entry area as a fishing ground, as described by Connor et al. (2000). But that cannot be a full explanation in this case as there are other shallow areas in the "Dolphin Reef". Additionally, these dolphins can leave the enclosure. Furthermore, dolphins were regularly fed by the staff, so they had no real need to forage. Secondly, the dolphins were interested in moving groups of swimmers (Table 3). They allowed --in contrast to the dolphins at "Dolphins Plus"-- close body contact with unknown swimmers. So as a result of these findings, we can conclude that dolphins at the "Dolphin Reef" were attracted by humans.

But why should dolphins at "Dolphin Reef" be attracted by humans, when those at "Dolphins Plus" are not? The bottlenose dolphins at "Dolphins Plus" were caught in the Gulf of Mexico and the dolphins at "Dolphin Reef" were caught in the Black Sea. That could result in different behavior towards humans, but there is no obvious reason why this should be so. A more likely reason could be that the groups of swimmers at "Dolphin Reef" are always guided by staff who are well known to the dolphins. These guides had mostly developed a very close relationship to the dolphins and the dolphins trust them. This approach to achieving human interaction with dolphins seems to be very successful, perhaps because the dolphins at "Dolphin Reef" have an area were human activities are not allowed and can leave the enclosure whenever they want. In many countries gates to the open ocean may be impossible because the owner can no longer control the dolphins and incidents may occur for which no-one can be held responsible. However, the establishment of an area where the presence of humans is prohibited and to which dolphins can retreat is advised by the Final Environmental Statement on the Use of Marine Mammals in Swim-With-

The-Dolphin-Programs (NMFS 1990); therefore all facilities should include that kind of area.

If dolphins are stressed it increases the risk for swimmers (Samuels and Spradlin 1995). Between 1985 and 1994, 16 serious injuries were reported in the USA (NMFS 1994). Aggressive behavior towards humans in the wild is very rare and generally results from misbehavior on the part of the humans (Conner and Smolker 1985; Lockyer 1990; NMFS 1994). Therefore agonistic behavior towards humans by dolphins in captivity results from the living conditions. Signs of agonistic behavior like tail slaps, tail swishes and jaw claps (Caldwell and Caldwell, 1965; Norris and Dohl, 1980; Ralston and Herman, 1989 and Pryor and Schallenberger, 1991) were not recorded during our observed sessions at "Dolphins Plus" or "Dolphin Reef". Agonistic behavior was observed once, at "Dolphins Plus", but the session was stopped immediately. We cannot conclude from this observation that humans are in danger when interacting with dolphins at "Dolphins Plus", but our data suggest that the motivation for agonistic behavior is still present. Dolphins may have adapted to this situation over the years thereby reducing agonistic behave.

Dolphin-assisted therapy is a growth business all over the world, and expansion from pens to tanks is likely to occur. Regardless of the fact that patients do not have such a strong impact on the behavior of dolphins as do healthy adults and that these programs may at least be more justifiable, an extension to oceanariums would involve an additional serious risk to the health of the dolphins. Interaction between dolphins and humans has a serious risk of infections and parasitism (Geraci and Ridgway 1991) for both interacting parties. To minimize this risk, most oceanariums have to increase the concentration of chlorine which can results, for example, in irritation to eyes and skin. We have shown that dolphins can be stressed if they do not have an area to retreat to even if they don't behave agonistically. Our findings also indicate that it is advisable for groups of unknown swimmers to be guided by a familiar to the dolphins, such as is the case at "Dolphin Reef".