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Effects of Pool Size on Free-Choice Selections by Atlantic Bottlenosed Dolphins at One Zoo Facility

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Dolphin pool design often derives from the concept that cetaceans are ocean based and ipso facto should live in open, deep, watery spaces. This emotionally appealing rationale is not data driven. Researchers report that in the wild, some populations of Atlantic bottlenosed dolphins (*Tursiops truncatus*) reside in shallower areas (approximately 2 m deep) and move to deeper areas only when resources become scarce. This study observed a well-established pod of 7 Atlantic bottlenosed dolphins at the Indianapolis Zoo and tested the hypothesis that they would select areas similar to their natural habitat and avoid areas of significantly larger volumes of water (in captivity, a combination of depth and surface area). This hypothesis was confirmed. When given free choice, the dolphins used moderate areas 67.8% of the time, smaller areas 36% of the time, and larger areas 2.9% of the time. This study evaluated the choices using 4 models based on surface area, volume (in gallons), depth, and location preferences, respectively. Choices of pool and area were significantly different from surface area, volume, depth, and location preference null hypothesis predictions—suggesting that larger pools in captive facilities may not be the preferred environment for dolphins.

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There appears to be a trend in regulations concerning pool sizes for captive cetaceans, driven by the theory that "bigger is better." This popular and political wisdom in dolphin pool design often has derived from the (not unreasonable) rationale that cetaceans are marine animals, ocean-based species who ipso facto live in wide open, deep, watery spaces. However, this rationale, although emotionally appealing, is not data driven. In fact, habitats in the oceans differ as much as do those on land. This report concerns the issue of captive environment sizes for Atlantic bottlenosed dolphins (*Tursiops truncatus*), specifically pool dimensions.

However, only a few published scientific studies mention the characteristics of the environment in which *Tursiops* are found. In their studies of the residential pods found in the Sarasota Bay area, Irvine and Wells (1972); Irvine, Scott, Wells, Kaufmann (1981); and Wells, Irvine, and Scott (1980) found this population in six different physiographic subdivisions of habitat. These subdivisions included narrow and shallow waterways 2 to 3 m deep, flats and shallows less than 2 m deep, wide bays 2 to 5 m deep, passages between areas that were 2 to 11 m deep, and offshore areas less than 2 m deep. Most sightings showed these animals in areas less than 3 m deep. These scientists' reports indicate that the dolphins resided in the shallower areas (approximately 2 m deep) and moved to the somewhat deeper areas predominantly for feeding—and only when resources become less available in shallower areas (Barros & Wells, 1998; Wells & Hoffman, 1997). Therefore, for this species in captivity, it is possible that bigger is not necessarily better. Indeed, these reports indicate that in the wild these bottlenosed dolphins may frequent shallower, more than deeper, waters.

It appears that few studies have been done on this species' preferences for pool sizes in captive environments. Anecdotal reports from keepers, trainers, and other marine mammal professionals suggest that, when given a choice, bottlenosed dolphins will tend to stay in shallower pool environments. Myers and Overstrom (1978) found, however, that some show dolphins resisted leaving their larger performance pools after a performance. Bassos and Wells (1998) reported on the effects of pool size (comparing a 16.45 m × 12.19 m × 2.44 m deep pool to a 9.14 m diameter × 1.83–2.13 m deep pool) on activity levels in two bottlenosed dolphins. Data were collected while the dolphins were restricted to one pool at a time. They found that the dolphins traveled (circled) significantly more in the larger pool and rested (floated motionlessly) significantly more in the smaller pool. No other behavioral differences were found. They also cite early research by Caldwell and Caldwell (1968) who found that very small pools correlated with increased aggression in some dolphins. Neither study, however, gave the dolphins free choice in selecting which pools to use nor free access to switch pool locations.

Therefore, we determined to study the pool preferences of seven captive Atlantic bottlenosed dolphins at the Indianapolis Zoo to continue to address the question of pool size preferences. We tested the hypothesis that the dolphins

would tend to stay in pools and areas more similar to their natural habitat (i.e., the shallower pool areas).

It is necessary to recognize the limitations of this study. Across pools, we are unable to control for underwater noise differences, ambient light, volume of water, and conditioned associations the dolphins may have developed over the years. For example, the Medical Pool is associated with separation from conspecifics and uncomfortable medical procedures and thus, although the shallowest pool, may be a less preferred environment. The Main Pool is the primary public demonstration area and may be so heavily associated with performance training and feeding that—although it is the largest pool—it may produce positive associations. For a few years, the East Holding Pool was used to house other whales, and dolphins were restricted from it. We present findings from times when all seven dolphins had free access to all pool areas.

METHODS

Subjects

At the time of study (1996), the two male and five female Atlantic Bottlenosed dolphins at the Indianapolis Zoo were approximately 12 years old. They all were from the Gulf of Mexico taken from the resident population at Pine Island Sound, Florida, a region similar in topography to Sarasota Bay where Wells and Hoffman (1997) did their wild population studies. The dolphins are a well-established pod acclimated to the facility and to each other. They have been together since 1988 and maintained at the Indianapolis Zoo since 1989.

Facilities

The Indianapolis Zoo's dolphin facility is an indoor facility housed in the Whale/Dolphin Pavilion. It is lighted by both artificial and natural lighting through large windows high up on the south wall. In early evenings (when our observations took place), the facility has supplementary lighting supplied by large floodlights aimed at the ceiling of the pavilion. These floodlights are mounted in front of a catwalk (see following) 12.2 m above the dolphin pools.

Pool Descriptions

The facility consists of four pools ranging in depths in strict increments of 3.96 m, 5.49 m, and 8.23 m; five peripheral shallows ranging in graded increments of

from .25 m to approximately .5 m in depth; and two semicircular pulpits approximately 1 m deep. For full dimensions, see Table 1. For facility design, see Figure 1. Unlike in the wild, these pools do not have graded slopes leading from one depth to another; therefore, gradations of preferences cannot be measured. Only specific preferences can be measured. In three of the four pools (Main, East Holding, and West Holding), dolphins receive equal amounts of training time and feeding. The fourth pool (Medical) is used for medical procedures (examinations, injections, blood draws, and treatments) and for quarantine of new or sick animals. Some training and feeding also is done in this area.

In Bassos and Wells (1998), their larger pool contained approximately the same surface area but half the depth of each of our holding pools. Their smaller pool had approximately the same surface area but half the depth of our Medical Pool.

Main Pool. This is a very large pool open to public viewing and stands on the south side of the facility. The top of its south wall is 1.8 m high clear acrylic for public viewing. Two thirds of the way toward the bottom are five large 2 m × 1.8 m viewing windows for lower level public viewing. In addition, there are two 0.6 m × 0.8 m underwater viewing ports on the maintenance side (east and west sides) of this pool.

The Main Pool contains one wide shallow area, a beaching platform on the public viewing side of the pool, and a dry feeding platform on the opposite side. Feeding and training sessions occur primarily in these areas, although other areas are used as well. The Main Pool also contains two shallow "pulpit" areas—semicircular shallows on the east and west ends of the pool and two narrow shallow shelves near the gates leading to the East and West Pools, respectively. Post hoc comparisons of usage (which was zero) led us to combine these shallows and shelf areas into a single area, the "Main Pool Shallows."

TABLE 1
Dimensions of Different Pools and Areas in the Dolphin Facilities at The Indianapolis Zoo

Pool or Area	*Depth*[a]	*Surface Area*[b]	*Volume*[c]
Main Pool	8.23	3675.58	1,437,148
West Holding Pool	5.49	936.74	320,000
East Holding Pool	5.49	936.74	320,000
Medical Holding Pool	3.96	464.81	56,737
East Holding Pool Shallows	Graded 0.25 to 0.5	87.75	≅2600
West Holding Pool Shallows	Graded 0.25 to 0.5	87.75	≅2600
Main Pool West Pulpit	1.0	1.84	145
Main Pool East Pulpit	1.0	1.84	145
Beaching Platform	Graded 0.25 to 0.5	22.42	886
Main Pool Feeding Platform	—	Dry	—

[a]Given in meters. [b]Given in meters^2. [c]Given in gallons.

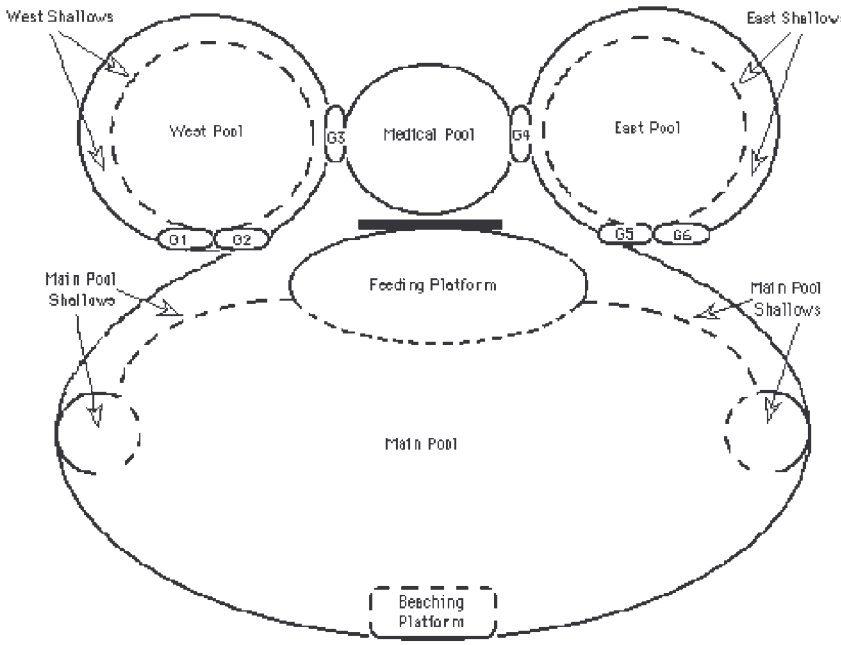

FIGURE 1 The Indianapolis Zoo's dolphin facilities consist of four primary pools and six shallows (G1 through G6 are gates between pools).

East and West Holding Pools. The East and West Pools are alike in all dimensions. They are visible to the public but contain no public viewing glass. Each has two viewing ports of like dimensions (see Main Pool previously described) on the maintenance side. Each one has a narrow shallow shelf running almost completely around the outer edges of the pool. The East Pool is closest to the staff and fish preparation center. The East and West Pools connect to the Main Pool through two independent sets of gates and connect to each other through the Medical Holding Pool.

Medical Holding Pool. This is the smallest of all four pools. It is located between the East and West Pools, connected through two independent sets of gates. It too contains a shallow shelf area.

Procedures

Our observations took place in 1996 from March 5 to April 30 (a 7-week period), three to five times per week, from 6:00 p.m. to 8:00 p.m. (eastern standard

time). This time was chosen because it was after Zoo hours (both public and keeper) and thus ensured the least disruption of the dolphins' behaviors. It also was early enough to ensure that the dolphins were active. Whenever possible, the dolphins had access to all seven pools and shallows. Because of husbandry necessities, however, the dolphins sometimes were restricted to less than all seven areas or were divided into separate subpods and separated into one or more different area combinations.

One of three student research assistants made unobtrusive observations from a high catwalk located on the south side of the dolphin facility. As a double blind control, the assistants were kept unaware of our hypothesis. They were told we were interested in area preferences but not that we expected the dolphins to prefer any particular area.

A student assistant arrived 10 min before observations began to reduce dolphin reactivity as a confound when she entered the (closed) public viewing area to climb to the catwalk. Reactivity was minimal, as the dolphins also were used to maintenance and facility personnel walking through the exhibit during these times. Once on the catwalk, the student was hidden in shadows behind the large floodlights aimed at the ceiling of the facility. Once in place, the assistant was able to make unobtrusive observations of the dolphins. By noting which pool gates were open and closed, the student first recorded which areas were available to which subpods or the full pod of dolphins. Using the method of instantaneous sampling, every 10 min the student research assistant scanned the pools and shallows and recorded the locations of all seven dolphins. The medical pool was the only pool unavailable to view, but counting the number of dolphins in the other six areas allowed us to calculate the number of dolphins in the medical pool.

Each student observer recorded 12 instantaneous samples per night. A total of 18 days of observations were collected for a total number of 216 instantaneous samples. On 7 of these 18 days, all seven dolphins had access to all seven areas. Thus, we have 588 data points of dolphin locations during complete free-choice opportunities (7 days × 7 areas × 12 samples/day).

RESULTS

Data was tabulated to compare the overall frequencies of the dolphins in each pool and shallows for all 84 instantaneous samples. These data are mutually exclusive in that when a dolphin is in one area it is impossible for that dolphin to be in any other area. These data were then analyzed by different theoretical models based on pool or area dimensions: depth, surface area, volume in gallons, and simple location (see Table 1), using a chi-square goodness-of-fit test. Statistically, depth is the more conservative measure, but all other comparisons are made. Also, depth, surface area, and volume are correlated for these pools. Observed frequencies and expected frequen-

TABLE 2
Expected Frequencies for Surface Area, Volume in Gallons, and Location Compared to Observed Frequencies

	Depth					
Pool	*Expected*	*Observed*	*Surface Area*	*Gallons*	*Location*	*Observed*
Main Pool[a]	196	17	394	394	65	17
West Holding Pool[b]	196	399	88	88	65	266
East Holding Pool[b]			88	88	65	133
West Holding Shallows[c]	196	172	< 1	1	65	59
East Holding Shallows[c]			8	1	65	2
Medical Pool[c]			16	16	65	111
Main Pool West Pulpit[c]			< 1	< 1	65	0
Main Pool East Pulpit[c]			< 1	< 1	65	0
Beaching Platform[c]			< 1	< 1	65	0

Note. Surface area and volume assumes equal distribution across total dimension. Depth and location assumes equal preference for all locations.

[a]Depth is deep (> 5.94 meters). [b]Depth is moderate (5.94 meters). [c]Depth is shallow (< 5.94 meters).

cies are presented for these models in Table 2 and are discussed in each analysis following. However, no individual pair-wise comparisons (across pairs of pools or areas) were performed because chi-square analyses assume that comparisons are made between mutually exclusive and exhaustive choices, and our pair-wise data violates the latter assumption.

Depth

In our first analysis, we tested whether the dolphins' choices were different from an equal distribution across all three depths; that is, if the frequencies one would expect if the dolphins had equal preference for all three depths differed from what the dolphins actually did (suggesting no preference). The dolphins showed unequal use of the three depths when compared to equal preference (i.e., unbiased or chance) usage, $\chi^2(2, N = 588) = 378, p < .0001$.

Looking at percentage observed (see Figure 2), the results indicate that the deep, moderate, and shallow depth preferences were significantly different from each other. The dolphins were found most often (67.8% of the time) in the moderate depth areas (5.49 m) and least often (2.9% of the time) in deep areas (8.23 m). Their presence in the shallows areas (0.25 to 3.49 m) is between these two (29.7%).

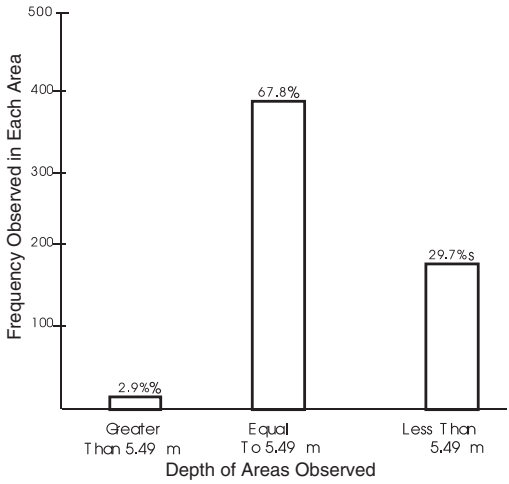

FIGURE 2 Overall percentages and frequencies of observed instances for the dolphins for each depth.

Volume in Gallons

Another possibility is that the dolphins were choosing pools based on overall amount of water in each area (volume in gallons for all nine areas). The assumption was made that dolphins would be equally distributed across the total volume so that larger volume areas (larger pools) would, by having more volume, be used more. Gallons per pool or area were divided by total gallons. Then this was multiplied by the total number of observations to generate an expected frequency for each pool or area (see Table 2). Results did not support this model, $\chi^2(8, N = 588) = 12{,}700$, $p < .0001$. The dolphins were not using the different pools as would be predicted by proportional volume. Instead, dolphins tended to use moderately sized pools most, then smaller areas, and the largest pool least (see Figure 3).

Surface Area

Similar calculations were made for surface area. Again, the assumption was made that dolphins will be equally distributed across the total surface area so that larger areas would be expected to have more use (see Table 2). Expected frequencies were calculated by dividing total surface area into individual surface areas and then multiplying by total number of observations. This model was also not supported, $\chi^2(8, N = 588) = 1{,}643$, $p < .0001$. Instead, again, dolphins tended to use moderately sized pools most, then smaller areas, and the largest pool least.

Location Preferences—Individual Pools

Our final analysis made the assumption that the dolphins (for any number of reasons) had specific area or pool preferences that were not related to any dimensional function. That is, the dolphins were biased toward specific areas because of such hypothetical (i.e., not testable) factors as history, ambient light or noise differences, and territorial or social factors. This analysis assumed as its null hypothesis that the dolphins would choose each area equally often. Expected frequencies were set equally by dividing total number of observations by total number of areas (see Table 2). This model also was not supported, $\chi^2(8, N = 588) = 1{,}091$, $p < .0001$. The dolphins did not choose areas or pools equally often but instead again chose moderate or shallow areas more often than large. There is some bias toward the West Pool areas, but the East Pool and Medical Pool also were used much more than the Main Pool.

DISCUSSION AND CONCLUSIONS

In this study, we tested the hypothesis that the dolphins would tend to stay in pools and areas more similar to their natural habitat. Previous reports led to suggestions that bottlenosed dolphins in the wild may prefer shallower waters over

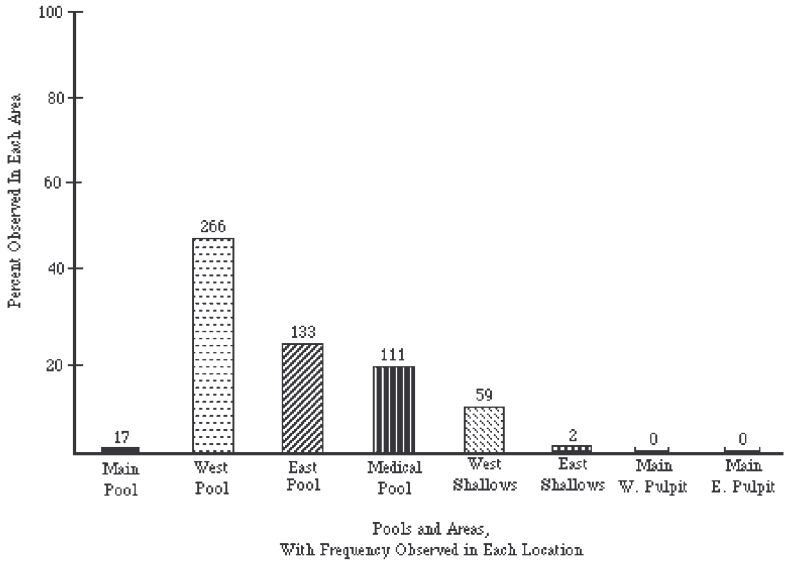

FIGURE 3 Overall percentages and frequencies of observed instances for the dolphins in each area.

deeper and that two captive dolphins (who were not given pool selection choices) were more active in a 90,000 gallon than a 35,000 gallon pool. Ours is the first study (that we could find) actually to give the dolphins selection choices as to which pools they stayed in and the freedom to switch between them. We predicted that the dolphins would be found in the generally smaller areas rather than in the larger areas. In this report, we can conclude that the dolphins most often chose areas that were moderately sized pools, then smaller pools (0.25 to 3.49 m), and the deeper pool least. Our results coincide with Bassos and Wells (1998) in that their dolphins showed more activity in their larger pool that, in surface area at least, was most similar to our East and West Holding Pools (although half their depths).

Our four models—surface area, depth, volume, and no preference—all showed that the dolphins were not acting in accordance with these predicted null hypotheses. The dolphins did not choose pools in proportion to any of these dimensions (i.e., larger dimensions paralleling greater use), nor did the dolphins behave in a way that indicated no preferences between depths or between locations. Instead, the dolphins had preferences. These preferences were not correlated with increasing sizes or proportions. They related—at least on the dimension of overall depth—to findings with some populations of dolphins in the wild (Barros & Wells, 1998; Wells & Hoffman, 1997).

It is impossible to state why the dolphins preferred the West Pool over any other choice. Years of associational learning with the various areas and other factors, along with the influence produced by pool dimensions, may have combined to influence choice. For example, when the facility housed a different species of *odontocete* for a few years in the East Pool, the dolphins were consistently restricted from using the East Pool and, when in the Main or Medical Pools, were able to see these whales through the gates. This could have set up a bias against this pool. What we can conclude, however, is that the dolphins absolutely spend little time in the Main Pool. Indeed, one student observer noted that "the dolphin in the Main Pool was just swimming through when I looked up, it didn't stay any time at all." These preliminary data support the suggestion that for this species, bigger is not necessarily better.

Although recognizing the limitations of drawing conclusions from the study of a single captive dolphin facility, we do feel strongly that it is premature to assume that an increase in pool size would be beneficial to all groups of *Tursiops* in captivity. Indeed, research on some wild *Tursiops* populations and our own results indicate that the opposite may be true. In our study, we conclude that the dolphins prefer moderate to shallow areas and will make use of both types of areas far more than the large pool. We encourage other dolphin managers to pursue similar research into their dolphins' free choice of different area depth and welcome collaboration on this question. We would gladly send our protocol to any facility interested and will help with data analysis if desired.

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