PART II

CHAPTER 15

THE EFFECTS OF PROVISIONING ON MATERNAL CARE IN WILD BOTTLENOSE DOLPHINS, SHARK BAY, AUSTRALIA

Janet Mann and Courtney Kemps

INTRODUCTION

Tourism is currently the world's largest industry (Goodwin 1996) and ecotourism is its fastest growing sector (Cater 1994). Although there is little consensus regarding the definition of ecotourism (Goodwin 1996), ecotour companies frequently advertise that their tours offer close encounters with wild animals. One way to bring wild animals close to people is to entice them with food. Such enticement is typically initiated by tour operators, individuals, or through passive means (e.g. rubbish, discarded by-catch). On some occasions, provisioning has been initiated by researchers attempting to observe their subjects at close range. After three years of mere glimpses in the forest, Jane Goodall habituated wild chimpanzees (*Pan troglodytes*) with banana boxes at her camp in Gombe Stream Reserve, Tanzania (Wrangham 1974; Goodall 1986). Similarly, at Wamba in the Democratic Republic of Congo, researchers provisioned bonobos (*Pan paniscus*) with sugar cane so that they may observe these elusive animals (Furuichi 1997). At Monkey Mia, in Shark Bay, Australia, researchers did not initiate or direct provisioning of wild bottlenose dolphins (*Tursiops* sp.), but capitalized on the close viewing it provided (Connor and Smolker 1985; Connor *et al.* 1992; Mann and Smuts 1999).

Descriptions of the effects of supplying food to wild animals range from controlled experiments to anecdotal accounts of human and non-human interaction. However, no one has yet investigated how provisioning affects female care of dependent offspring. This link is critical, given that provisioning affects not only female diet, but potentially activity budgets, ranging, and patterns of association. With respect to bottlenose dolphins, the effect of provisioning on maternal care has become important in light of the higher mortality for calves of provisioned compared to non-provisioned females (Mann *et al.* 2000) and the fact that there are currently four dolphin-provisioning tourist attractions in Australia, three of them state-licensed (Orams 1995; Garbett and Garbett 1997; Samuels *et al.* 2000). Cetaceans command considerable public interest and provisioning sites attract worldwide attention. Despite substantial fines in some countries, the pressures to feed wild dolphins are high. Illegal feeding is common off the US coasts of South Carolina, Florida and Texas (Samuels *et al.* 2000). The aims of the current study were to quantify the effects of provisioning on maternal care in wild bottlenose dolphins at Monkey Mia, and to offer strategies that might minimize the effects of provisioning on dolphin welfare.

Table 1 Common effects of or parameters associated with provisioning wildlife

Effects or correlates of provisioning	Documented species	Common names
Increase in population growth or density	*Tamaisciurus hudsonicus*,[1] *T. douglassi*,[2] *Spermophilus columbianus*,[3] *Eutamias townsendii*,[4] *Microtus ochrogaster*,[5] *M. townsendii*,[6] *Peromyscus maniculatus*,[7] *Lepus americanus*,[8] *Odocoileus virginianus*,[9] *Macaca fuscata*[10]	Squirrels,[1–3] chipmunks, voles,[5, 6] deer mice, snowshoe hares, white-tailed deer, Japanese macaques
Advanced or extended breeding season	*M. townsendii*,[6] *Lepus americanus*,[8] *Tamaisciurus hudsonicus*[1]	Voles, snowshoe hares, squirrels
Higher reproductive rate, shorter interbirth interval	*Papio cynocephalus*,[11] *Peromyscus maniculatus*,[7] *Macaca fuscata*[12]	Yellow baboons, deer mice, Japanese macaques
Faster growth, earlier age at first reproduction	*Macaca fuscata*,[12] *Odocoileus virginianus*,[9] *Eutamias townsendii*[4]	Japanese macaques, white-tailed deer, chipmunks
Higher body weight or mass	*Macaca fuscata*,[10] *Ursus maritimus*,[13] *Odocoileus virginianus*,[9] *Eutamias townsendii*[4]	Japanese macaques, polar bears, white-tailed deer, chipmunks
Decrease in mortality	*Macaca fuscata*,[10] *Eutamias townsendii*[4]	Japanese macaques, chipmunks
Increase in calf mortality	*Tursiops* sp.[14]	bottlenose dolphins
Decrease in home range	*M. townsendii*,[6] *Peromyscus maniculatus*,[7] *Prunella modularis*[15]	Voles, deer mice, dunnocks
Heightened aggression, increase in dominant-subordinate interactions	*Pan troglodytes*,[16] *Papio anubis*,[16] *Macaca mulatta*,[17] *Macaca fuscata*,[18] *Presbytis* spp.,[19] *Tursiops* sp.[20]	Chimpanzees, anubis baboons, rhesus monkeys, Japanese macaques, Hanuman langurs, bottlenose dolphins
Increased disease, pathogen exposure	*Pan troglodytes*[16]	chimpanzees
Altered activity budgets	*Papio cynocephalus*,[11] *Tursiops* sp.[21]	Yellow baboons, bottlenose dolphins
Increased polygyny, monopoly of females	*Prunella modularis*,[15] *Presbytis* spp.[19]	Dunnocks, hanuman langurs
Increase in innovation, exploration	*Macaca fuscata*[22]	Japanese macaques

1 Sullivan 1990; Klenner and Krebs 1991; 2 Sullivan and Sullivan 1982; 3 Dobson and Kjelgaard 1985; 4 Sullivan *et al.* 1983; 5 Cole and Batzli 1978; 6 Taitt and Krebs 1981; 7 Taitt 1981; 8 Boutin 1984; 9 Ozoga and Verme 1982; 10 Mori 1979; 11 Altmann and Muruthi 1988; 12 Watanabe *et al.* 1992; 13 Lunn and Stirling 1985; 14 Wilson 1994; Mann *et al.* 2000; 15 Davies and Lundberg 1984; 16 Wrangham 1974; 17 Loy 1970; 18 Furuichi 1985; 19 Sterck 1999; 20 Orams *et al.* 1996; Mann and Smuts 1999; 21 Mann and Smuts 1999; 22 Huffman 1984; Kawamura 1959

Effects of provisioning on wild animals

Provisioning of free-ranging animals can have a variety of outcomes, including changes in population density, group composition, reproduction, ranging patterns, individual behaviour, survival and growth rate (terrestrial vertebrates, Boutin 1990; primates, Asquith 1989) (Table 1). In most cases, food-supplemented populations of terrestrial mammals increased in population density 2–3 fold compared to non-supplemented populations (reviewed by Boutin 1990). However, despite increases in birth rate, immigration and survival, the general pattern of population dynamics do not change. However, supplemental food supplies generally cannot prevent major population declines. Finally, there is a greater response to additional food when environmental conditions are poor than when they are fair to good.

Numerous problems have resulted from feeding wild animals *ad libitum*, among bears, baboons, and dolphins. Feeding can occur directly through active feeding (humans intentionally leave food for animals or hand-feed), or passively (rubbish, bycatch). In either case, animals learn to associate humans with food, become habituated and become more bold and aggressive in their attempts to get food. The situation can then become dangerous for both the humans and the animals, occasionally leading to the destruction of property and/or physical harm to person or animal. Problem bears have sometimes been relocated, or even killed, after forming the habit of approaching people and campsites in search of food (Follmann and Hechtel 1990; Mattson *et al.* 1992). Provisioning encourages dolphins to follow fishing boats or steal bait, and occasionally dolphins have been killed as a result (reviewed in Samuels *et al.* 2000).

In a 1994 report to the US Congress on feeding wild dolphins (Bryant 1994), a number of deleterious effects of feeding were documented for both dolphins and humans. These included; alteration of natural foraging and social behaviour, loss of wariness of humans leading to injuries from boats or from people who may regard them as pests, indiscriminate acceptance of food

possibly leading to the ingestion of harmful or contaminated substances, and aggressive behaviour causing increased injury to humans. The report was initiated in response to concern over the growing number of dolphin feeding cruises and the receipt of the first application for a permit from the National Marine Fisheries Service (NMFS) to feed wild dolphins (Bryant 1994). Currently, NMFS regulations stipulate that feeding wild dolphins constitutes harassment as defined in a 1994 amendment to the US Marine Mammal Protection Act and is not permitted, although unlicensed and unregulated feeding occurs (Samuels *et al*. 2000).

In all three Australian state-licensed programs, feeding wild bottlenose dolphins combines regulated supplemental feeding with human-dolphin interaction. In the fourth, not state-licensed program, Tin Can Bay in Queensland, tourists can purchase fish at the site and individually feed Indo-Pacific humpback dolphins (*Sousa chinensis*). Human-dolphin interaction is encouraged, but feeding is not strictly regulated. Because human-dolphin interaction is combined with provisioning, it is important to consider both the effects of provisioning on wild animals and the effects and potential problems linked to human involvement and the inevitable learned association between humans and food.

History of provisioning dolphins at Monkey Mia: 1960–1994

Monkey Mia is the longest-running provisioning site for wild bottlenose dolphins in the world. Since the 1960s, at least eleven adult dolphins (no more than seven adults at any one time) have visited the shores of Monkey Mia, Shark Bay, to accept fish hand-outs and touching from fishers and tourists standing in knee-deep water (Connor and Smolker 1985; Mann *et al*. 2000). Although the feeding began when fishers tossed their bait or unwanted catch to dolphins near the shoreline, provisioning has been regulated by The Shire of Shark Bay and The Department of Conservation and Land Management (CALM) in Western Australia since 1986, when the Monkey Mia Dolphin Information Centre was built. In the 1960s and 1970s, fishers came to Monkey Mia primarily from March to August, when temperatures cooled and the waters were relatively calm. Tourists occasionally bought frozen bait fish to feed to the dolphins, but fishers typically fed fresh fish to dolphins that followed their boats to shore. After the centre was built, tourists could purchase small buckets of defrosted fish and occasionally fresh fish to feed to the dolphins. By 1987, up to 35 kg of frozen fish was sold to tourists daily by CALM and The Shire of Shark Bay (CALM 1993). From 1986–1994, fishers and recreational boaters continued to feed dolphins at various times during the day. Only the provisioned dolphins that visited the beach also begged for fish from boats, so the wider dolphin population remained relatively unaffected (Table 2).

Resort facilities (e.g. cabins, restaurant, tennis court, swimming pool) were added to the existing caravan park in 1990–1991. Dolphin interaction and feeding continued to be managed by CALM and The Shire. The road to Monkey Mia was sealed in 1989 and a new airport built in 1991, allowing greater year-round access for visitors. In February and March of 1989, before any development took place, seven dolphins which had a long history of visiting Monkey Mia disappeared (three dependant calves, one juvenile and three adult males; Table 2) and water testing revealed high levels of *E. coli* bacteria. The dolphins' complete disappearance from the Monkey Mia region was interpreted to indicate that they had died. This was traced to leakage from septic tanks built too close to the water (EPA 1989). Although not responsible for the septic tanks, the Monkey Mia Dolphin Resort paid to move sewage treatment far from the water line and CALM now regularly tests water quality.

CALM began regulating feeding in February 1989 by restricting the amount of fish offered to each dolphin to 2 kg day^{-1} (averaged over a month) (Gales 1989). Tourists standing in knee-deep water on a 90 m stretch of beach (Figures 1 and 2), were selected by rangers to give designated dolphins fish. Feeding from boats still occurred, although this practice was discouraged. Females with newborn calves were permitted up to 4 kg day^{-1} during the first week of their return, which typically occurred in the first week post-partum, and females could be fed extra if they missed a day.

After the 1989 presumed deaths, four adult females and dependent offspring continued to visit the beach regularly. A fifth female (named Surprise) began accepting fish in 1990. Two of the older females (Crookedfin and Holeyfin) died in 1992 and 1995 respectively. At present, three adult females (Nicky, Surprise and Puck) and their dependent offspring visit Monkey Mia almost daily. The Monkey Mia dolphins have become part of a multi-million dollar industry, and their survival is integral to economy of Shark Bay, with over 98% of the approximately 100 000 annual visitors coming to Shark Bay (a World Heritage Area, UNEP) to see the dolphins (Reark 1995).

Dolphin research at Monkey Mia

Researchers began long-term monitoring and intensive study of the provisioned and non-provisioned dolphins in 1982. Currently, an international team of scientists from Australia, North America and Europe focus on specific aspects of bottlenose dolphin behaviour, development, life history, communication, ecology, social systems, genetics, and the effects of tourism. All collaborators contribute to a database that tracks individual life histories, ranging, and patterns of behaviour and association for over 600 animals. Research on the provisioned dolphins included communication (Smolker and Pepper 1999), male alliances (Connor *et al*. 1992) and newborn development and maternal behaviour (Mann and Smuts 1998, 1999). A number

Table 2 Regular visitors to Monkey Mia Beach and their offspring.

Dolphin name	Sex	Mother	Birth year	Death	Probable cause of death	Regularly provisioned	Notes (MM=Monkey Mia)
Charlie	?	?	<1955	1977?	gunshot		Details not known.
Beautiful	F	?	<1960	~1982	?	Y	A regular MM visitor since the 1970s.
Bibi	M	Beautiful	1975	1989	septicemia	Y	Began visiting Monkey Mia regularly after his mother's death.
Goldee	F	Beautiful	1981	1982	?	N	
Snubnose	M	?	~1975	1989	septicemia	Y	Brought to MM by his alliance partner Bibi (see Connor *et al.* 1992). Snubnose became a regular MM visitor in the mid-1980s
Sicklefin	M	?	~1975	1989	septicemia	Y	Brought to MM by his alliance partner Bibi (see Connor *et al.* 1992). Sicklefin became a regular MM visitor in the mid-1980s
Holeyfin	F	?	~1960	1995	Stingray spine	Y	A regular MM visitor since the 1970s
Nicky	F	Holeyfin	1975			Y	The most regular MM visitor since birth
Joy	F	Holeyfin	1979			N	Rarely visited beach post-weaning; has two surviving daughters, Bliss and Laughin
Holly	F	Holeyfin	1983	1989	septicemia	N	Although weaned and not accepting fish, Holly visited MM with her mother.
Koorda	M	Holeyfin	1988	1989	septicemia	N	
No name	?	Holeyfin	1990	1990	?	N	
Nova (Welcome)	F	Holeyfin	1991	1992	Poor condition; shark attack	N	Nova was in visibly poor condition prior to shark attack
Hobbit	F	Holeyfin	1993	1994	Poor condition; shark attack	N	Hobbit was emaciated prior to attack by tiger shark
Nipper	F	Nicky	1987	1989	septicemia	N	Nicky's first calf
Rabble (Finnick)	M	Nicky	1990	1994	Poor condition	Y	Emaciated prior to his disappearance, one year after weaning. Clearly dependent on handouts; First provisioned at 1.5 yrs of age.
Nakita	M	Nicky	1993	1994	?	N	
Holikin	M	Nicky	1995			N	Does not visit MM beach and was never provisioned.
Nomad	M	Nicky	1998	2002	?	N	Disappeared around the time of weaning.
Crookedfin	F	?	~1960	1992	?	Y	Crookedfin, obviously elderly likely died of natural causes.
Puck	F	Crookedfin	1976			Y	Regular visitor at MM
Fudge	M	Crookedfin	1986	1987	Poor condition	N	Emaciated, see Connor and Smolker 1990
Cookie	M	Crookedfin	1988			N	Cookie didn't allow human contact and did not visit MM after his mother's death. He was orphaned at 3.5 yrs of age.
No Name	?	Puck	1989	1989	septicemia	N	Puck's first calf.
Petal	?	Puck	1990	1990	?	N	
Pepe	M	Puck	1991	1991	?	N	
Piccolo	F	Puck	1992			N	Piccolo visits MM almost daily; refused first offers of fish in 1999
Kiya	F	Puck	1997			N	Weaned in 2002; not offered fish but visits MM almost daily.d
Surprise	F	?	~1977			Y	Became a regular MM visitor in 1990 with the help of Holeyfin, who escorted her in repeatedly.
Shadow	M	Surprise	1992	1993	?	N	Surprise's first calf.
Shock	F	Surprise	1994			N	Still visiting MM, but not yet offered fish.
Sparky	M	Surprise	1998			N	Weaned in 2002. Will not be offered fish.

Figure 1 Typical provisioning scene at the shores of Monkey Mia. Photo by Jana Watson.

of research projects on the provisioned dolphins have been conducted, but most of the research has focused on the non-provisioned animals (see www.monkeymiadolphins.org for full publication list).

There is only one study that specifically contrasts the behaviour of the provisioned dolphins at, and away from the provisioning beach (Mann and Smuts 1999). This study compared the behaviour, associations, and spatial relationships for mothers and newborn calves observed in and away from the provisioning area. All observations took place before the new feeding policies were introduced in 1995. At the provisioning area, mothers socialised and foraged significantly less often and interacted with boats or people more often, than when away from the provisioning area. In the provisioning area, females were more aggressive to each other than when away from the provisioning area. Calves spent significantly less time swimming in 'echelon' position (<30 cm parallel with the mother) and spent more time further away from their mothers (2–10 m) when at the provisioning area compared to when away from it. Both group composition and group size differed. At the provisioning area, mothers and calves spent more time with other females, and less time alone together than they do away from the provisioning area. Away from the provisioning area, mothers and newborn calves spend 44.4% of their time alone together. At the provisioning area, mother and calf were alone only 8.0% of the time. This is largely an artifact of the provisioning protocol. Feeding did not typically occur until all three mothers were present at the beach, with the likely consequence that all provisioned females arrived and departed at the provisioning beach at roughly the same time. In summary, provisioning appeared to alter mother and calf activity budgets, mother-calf distance, and association patterns. When provisioned females were away from the Monkey Mia beach, their

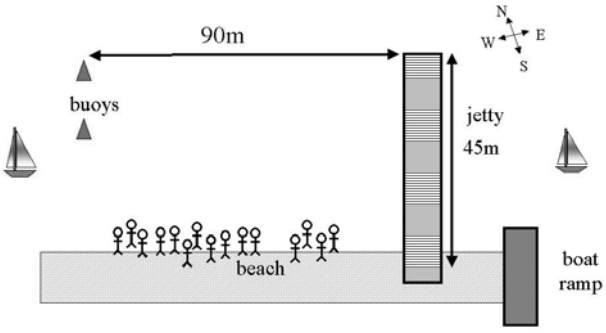

Figure 2 Diagram of provisioning area at Monkey Mia. Feedings currently occur up to three times daily in shallow water (<1m) between the jetty and the buoyed area (approximately 90 m long). Swimming is permitted west of the provisioning beach. East of the jetty is a boat ramp. Boats are also moored west of the provisioning beach. We refer to both as the "boat area (B)". North of the buoys or >40 m from shore is considered "out (O)". When the dolphins are within 2 m of people standing in water, we considered them "in (I)". When the dolphins are >2 m from people (out of reach), but within the buoyed area, we designated their location as "K".

behaviour was indistinguishable from that of non-provisioned females except that the provisioned females occasionally approached and begged from boats.

In March and April of 1994, three major events occurred (Mann *et al*. 2000). First, Finnick, Nicky's recently weaned calf became beach dependent, emaciated and died. He had been fed by humans since 18 months of age and rarely hunted on his own. After weaning at age three, he rarely associated with other young males and his mother frequently attacked him when he came near the beach. He would come in to be fed after his mother left the area, or would beg for fish from boats near the provisioning area (Mann, personal observation). Second, Hobbit, Holeyfin's last calf, was killed by a tiger shark near the jetty while Holeyfin begged for fish from tourists about 70 m away (Mann and Barnett 1999). Holeyfin subsequently defended Hobbit's carcass from the tiger shark, suggesting she might have prevented the death had she not been pre-occupied. Hobbit was visibly emaciated and, like many of the calves born to provisioned females, may well have died soon from causes other than the shark attack (Mann and Barnett 1999). Finally, Puck became entangled in a fishing net while chasing mullet and nearly drowned (Mann, personal observation). Her dependent calf Piccolo would have died as well. Although not directly related to provisioning per se, the provisioned dolphins show little fear or avoidance of human activity, and of several dolphins near the mullet nets, only Nicky and Puck (both provisioned) charged the nets to feed on mullet. These events prompted CALM to study the calf mortality at Monkey Mia, which resulted in changes to the feeding practices (Wilson 1994) that were adopted in 1995 and are still in effect today.

Changes in provisioning practices at Monkey Mia: 1995 to present

There were several problems associated with the provisioning (Wilson 1994), including high juvenile mortality and marked changes in behaviour. It was concluded that the Monkey Mia dolphin feeding was not sustainable unless calves were not fed, and adults were fed less and spent less time at the beach. Changes in the feeding policy included: 1) eliminate or markedly reduce un-regulated feeding (from boats or outside the purview of CALM); 2) restrict dolphins to a maximum of three feeds between 8:00–13:00; 3) restrict all adult females to a maximum of 2 kg day^{-1}, rather than averaging daily amounts over the entire month; 4) eliminate feeding of dependent calves; 5) eliminate feeding of male offspring (because males tend to be more aggressive to dolphins and people and sons infrequently associate with their mothers post-weaning); and 6) restrict feeding to known regular dolphins and their juvenile female offspring (at least one year post weaning). The policy changes appear to have been successful. In the seven years prior to the change in feeding practices (1987–1994), 92% (11 of 12) of nursing calves born to provisioned females died (Table 1). The calf death rate was more than twice that of non-provisioned dolphins who do not visit Monkey Mia (Mann *et al*. 2000). In the seven years since the restrictions were in place, no nursing calves have died and all six have survived to weaning.

Despite the clear reduction in mortality, it remains unclear why calves born to provisioned females suffered such high mortality in the first place, although several hypotheses have been advanced (Mann *et al*. 2000); (1) disease resulting from human contact (e.g. EPA 1989); (2) change in maternal behaviour (Mann and Smuts 1999); (3) change in diet; (4) altered density or distribution of predators and prey near shore; (5) sampling bias.

Although human contact (i.e. septic tank leakage) was strongly implicated in several dolphin deaths, other factors cannot be ruled out. Sampling bias, or low sample size issues are unlikely to be responsible for the dramatic difference between provisioned and non-provisioned populations, especially since researchers have intensively monitored the site with the help of tour operators since 1993. Since the feeding policy changes at the beginning of 1995, all calves born to provisioned females have survived. This suggests that some aspects of provisioning were related to mortality, although with so many changes implemented simultaneously, it is difficult to identify independently whether, for example, reduced boat feeding or spending less time near Monkey Mia had positive effects on female diet, behaviour, or predation risk. We suggest that poor maternal care (neglect) at the provisioning area was the primary cause of the high calf mortality; the 1995 policy changes being successful because they reduced the amount of time that mothers and calves spend at the provisioning area (from 2.7–2.8 visits per day in 1991–1994 to 2.0–2.2 in 1995–1999; Mills 2000), thus reducing the amount of time that calves were neglected.

Focus of the current study

For this study, we examine maternal care beyond the newborn period. Unfortunately, because so few calves survived beyond the newborn period prior to 1995, we cannot compare maternal behaviour pre- to post–1995. Thus, the main question is: *how does maternal care at the provisioning beach differ from maternal care away from the provisioning beach*? Our primary measure of maternal care is infant position, defined as when the calf swims under the mother, lightly touching her abdomen. From three months of age until weaning, calves of non-provisioned mothers spend 30–60% of their life in the infant position (Mann 1997), while weaned calves never swim there. All nursing occurs from the infant position and it offers contact and protection to the calf. Further, time in infant position is correlated with calf mortality (Mann and Watson, submitted). Our research suggests that calves in poor health seek more contact (infant position) with their mothers and mothers typically accommodate them. We suggest that at the provisioning beach, mothers deny their

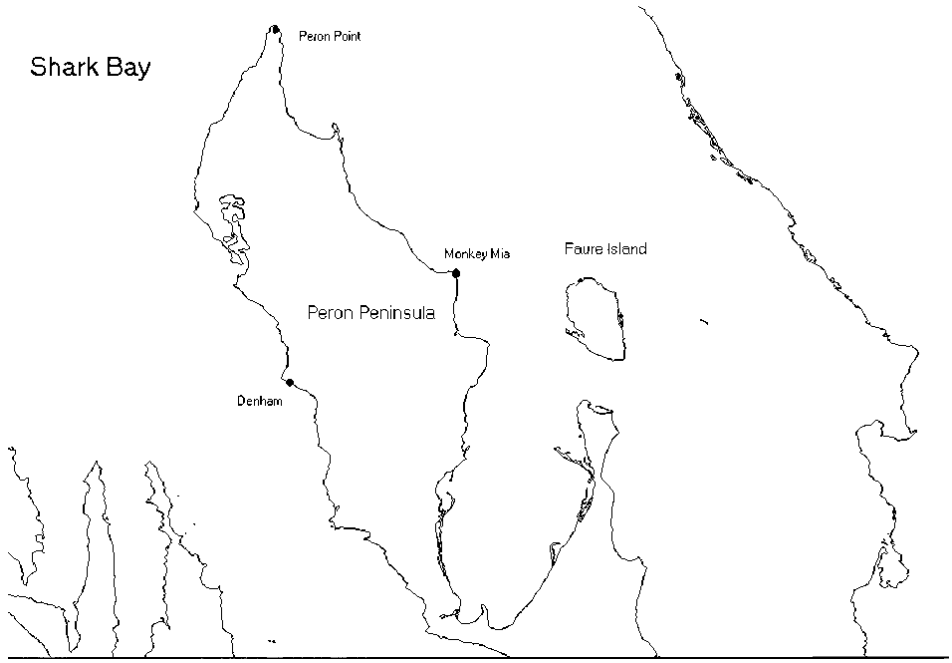

Figure 3 Map of Shark Bay, approximately 850 km north of Perth on the west coast of Australia. Monkey Mia is about 24 km from Denham. The main study area stretches from Peron Point to Faure Island.

calves contact and provide less care than is sought by the calf. We examine infant position and attempts at gaining infant position in relation to maternal and calf location in the provisioning area and with respect to the timing of feeds.

METHODS

Field site

Shark Bay is located 2547' S, 11343' E in Western Australia, about 850 km north of Perth. The study area presently extends 300 km^2 off the east side of the Peron Peninsula and includes over 600 animals. The study site is predominantly sandflats, seagrass beds (<5 m depth) bisected by deeper channels (> 8 m depth) and embayment plains (5–12 m depth). Monkey Mia is located 24 km from the town of Denham, located on the western side of the Peron peninsula (Figure 3). The current study focuses on 9 calves and 4 provisioned mothers that visited the Monkey Mia shores between 1991 and 1999 (Table 3). Calves were observed between 3–54 months of age for a total of 441.7 hours; 194 hrs at the Provisioning Area (PA) and 248 hrs away from it (non-PA). If calves were observed at the Provisioning Area during a given age, they were also observed away from the Provisioning Area.

Observations at the provisioning area

Figures 1 and 2 show the provisioning area (Figure 2 is not to scale). Behavioural observations were typically conducted from the jetty. Point sampling at one-minute intervals was used to record mother and calf location, distance, behaviour and the calf's nearest neighbour (within 10 m). Approaches and leaves (within a two meter radius) by mother and/or calf were scored continuously. Five locations were indicated for mother and calf: 1) IN, within 2 m of people; 2) BUOYS, between the buoys and jetty, but not within 2 m of people; 3) OUT, north of the buoys, boat area or jetty (>40 m offshore); and 4) BOAT area, west of the buoys and east of the jetty by the boat ramp. Mother-calf distance was scored as infant position (in contact, calf under mother's abdomen), or estimated by distance classes (<0.3 m, 0.3 m <2.0 m, 2.0 <5.0 m, 5.0<10.0 m, 10.0<20.0 m, 20.0<50.0 m, 50.0<100.0 m, 100.0 m). Focal observations were initiated in the mornings when at least one member of the focal mother-calf pair was in view. Observations were terminated at 30 minutes or if both mother and calf were out of sight for 15 minutes or more. Activities are defined in Table 4.

Events concerning the feeds were always recorded in sequence. Rangers first ask the tourists to move out of the water; then the buckets are brought down and each ranger takes a bucket to a specific female. The feeding begins with rangers calling one person at a time to approach each bucket. The ranger hands each person a fish and they feed it to the dolphin head-first. After they have given the fish to the dolphin, they are asked to leave the water immediately so the next person can be called. Typically three to five small fish (typically bream, *Acanthopagrus latus*, butterfish, *Selentoca multifasciata*, or tailor, *Pomatomus saltator*)

Table 3 Number of minutes each calf was observed at each age in the provisioning area (PA) and when away from the beach (non-PA Italicised numbers are calves who were observed pre–1995. Only one calf (Piccolo) was observed before and after feeding practices changed. Hobbit, Nakita, Finnick and Nomad did not survive. All other calves were still alive in 2002.

Mother	Calf	Sex	B-DAY	3–11 mos.		12–23 mos.		24–35 mos.		36–47 mos.		48–59 mos.		Total Minutes Observed		
				PA	non-PA	PA	non-PA	PA	non-PA	PA	non-PA	PA	non-PA	PA	non-PA	Both areas
Holeyfin	Hobbit	F	27 Nov 1993	*271*	*315*	–	–	–	–	–	–	–	–	**271**	**315**	**586**
Nicky	Holikin	M	23 Aug 1995	241	202	878	179	674	–	–	–	–	–	**1793**	**381**	**2174**
Nicky	Nakita	M	1 Dec 1993	*1010*	*1022*	–	–	–	–	–	–	–	–	**1010**	**1022**	**2032**
Nicky	Nomad	M	3 Nov 1998	502	665	–	–	–	–	–	–	–	–	**502**	**665**	**1167**
Nicky	Finnick	M	16 Apr 1990	–	–	*825*	*853*	*936*	*1012*	–	–	–	–	**1761**	**1865**	**3626**
Puck	Kiya	F	13 Dec 1997	384	557	324	610	–	–	–	–	–	–	**708**	**1167**	**1875**
Puck	Piccolo	F	6 Dec 1992	*983*	*925*	*895*	*929*	–	–	780	3362	1114	1549	**3772**	**6765**	**10537**
Surprise	Shock	F	25 Oct 1994	–	–	424	402	480	605	653	938	–	–	**1557**	**1945**	**3502**
Surprise	Sparky	M	14 Nov 1998	266	738	–	–	–	–	–	–	–	–	**266**	**738**	**1004**
Total Minutes Observed				**3657**	**4424**	**3346**	**2973**	**2090**	**1617**	**1433**	**4300**	**1114**	**1549**	**11640**	**14863**	**26503**
Total Hours Observed				**61.0**	**73.7**	**55.8**	**49.6**	**34.8**	**27.0**	**23.9**	**71.7**	**18.6**	**25.8**	**194.0**	**247.7**	**441.7**

Table 4 Ethogram

Activity	Definition
Infant Position	Calf swims under the mother, in intermittent in contact, with the calf's head touching the mother's abdomen. Indicated for calf only.
Attempt Infant Position	Calf butts, bumps or pokes mother around peduncle, abdomen, typically pushing to try and get under the mother in infant position. Occasionally calf follows the mother closely, but she accelerates each time the calf comes close to getting into infant position.
Social	Rubbing, petting (flipper or flukes actively moving on body part of another), chasing, mounting, poking, contact swimming (excluding infant position), and other forms of active contact.
People	Physical contact with people (including rangers); displays, begging gesture (head out of water) and obvious interactions with people, including aggression (hits, head jerks).
Forage	Characterised by fast swims, rapid direction changes, bottom-grubbing, belly-up chases of fish, fish catches and fish fleeing.
Rest	Slow (<3 kph) non-directional movement, frequent hanging at the surface.
Travel	Steady, moderate or fast (>2 kph) directional movement.

are fed at each feed to each adult dolphin. The last fish is offered to each dolphin simultaneously to avoid competition over buckets. After the final fish is offered, the buckets are tipped over and dipped in water to show the dolphins that the feed is over. From the time the tourists are asked to step out of the water, the entire process usually takes about three to five minutes. The dolphins almost always leave the area within five minutes after the feed.

Observations away from the provisioning area

For mother-calf focal observations away from the provisioning area, activity and mother-calf distance were recorded using point sampling (at 1.0 min or 2.5 min intervals), predominant activity sampling (2.5 min intervals) and continuous sampling. Every minute (after 1996) or five minutes (prior to1996), group composition (using a 10 m chain rule) was taken using scan sampling. Onset and offset of infant position was recorded using continuous sampling (based on first surfacing or sighting in or out of infant position).

Data analysis

Calves did not differ in the proportion of time spent in infant position with age. We therefore combined data for all ages for each calf and treated each calf independently. All analyses, except where indicated, used the Wilcoxon Matched Pairs Signed Ranks Test. With a small sample size (n=9), this non-parametric test was most appropriate. Means ± standard error, medians and ranges are presented. For values presented by location (e.g. % time in infant position while close to people), we controlled for the proportion of time spent in each area. Individual data for calves are presented in figures because of variation between calves and between mothers.

Results

Location at the provisioning area

Figure 4 shows the median proportion of time mothers and calves spent in different areas near the provisioning beach. Mothers spent significantly more time within 2 m of people at the provisioning area (mean = 51.5±6.1%, median = 51.7, range = 19.9–84.7) than their calves (mean = 24.3±6.9%, median = 18.1, range = 2.3–62.7; Matched Pairs Signed Ranks Test, Z = 2.67; p = .008). Calves spent more time in all other areas compared to their mothers, including the boat area (Calf: mean = 2.7±0.6%, median 2.3, range=0–6.0; Mother: mean = 1.7± 0.5%, median = 1.8, range = 0–4.5; Matched Pairs Signed Ranks Test, Z=2.07, p=.038), buoy area (Calf: mean = 57.6±5.5%, median = 61.3, range = 21.5–73.5; Mother: mean = 37.8± 4.0%, median = 40.5, range = 10.6–49.8; Matched Pairs Signed Ranks Test, Z = 2.67, p = .008) and out, more than 40m from shore (Calf: mean = 20.9±3.0%, median = 15.3, range = 0.9–26.3; Mother: mean = 7.7± 3.1%, median = 4.1, range = 0.9–31.2; Matched Pairs Signed Ranks Test, Z = 2.07, p = .038). In summary, mothers spent most of their time close to people, in shallow water. Calves spent most of their time away from people, in deeper water.

Infant position and location at the provisioning area

At the provisioning area, calves were in infant position significantly less often than when away from the provisioning area (Provisioning Area: mean=16.2±1.9%, median =15.5, range= 6.6–24. 1; Non-Provisioning Area: mean = 27.8± 3.0%, median = 26.7, range = 16.6–48.7; Matched Pairs Signed Ranks Test, Z = 2.54, p=.011; Figure 5). This raises the question as to whether this difference is due to the location within the provisioning area, or just being near shore and people. To address this, we examined how the proportion of time spent in infant position varied by location within the Provisioning Area. This was contrasted with the overall proportion of time spent in infant position in the Provisioning Area. Calves spent significantly less time in infant position when their mothers were close to people compared to overall (Matched Pairs Signed Ranks Test Z = 2.67, p = .008; % time in infant position near people: mean = 1.6±0. 6%, median = 1.0, range = 0–4.4). In contrast, they tended to

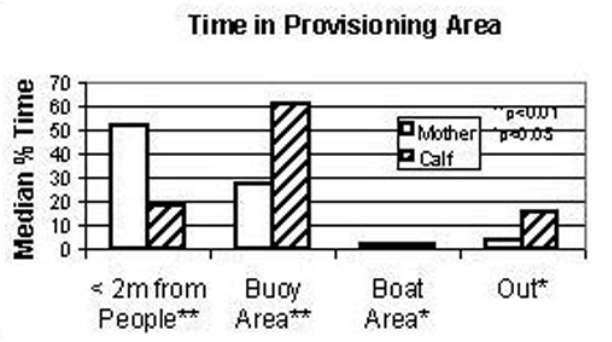

Figure 4 The median proportion of time mothers and calves spent in different areas near the provisioning beach. Refer to text and Figure 2 for how areas were delineated.

spend more time in infant position when in the boat area compared to overall (Matched Pairs Signed Ranks Test Z=1.86, p = .063; % time in infant position in boat area: mean = 29.3±07.4%, median = 28.6, range = 0–62.5). Infant position was more prevalent in the buoy area and out (>40 m from the beach) than overall (Matched Pairs Signed Ranks Test Z = 2.67, p = .008; % time in infant position in buoy area: mean = 27.8±2.8%, median = 25.4, range = 14.2–43.8; % time in infant position when >40 m out: mean = 53.2±6.9%, median = 52.7, range = 28.0–100). In summary, calves were least likely to be in infant position when their mothers were close to people in shallow water.

Attempts at infant position and location within the provisioning area

At the provisioning area, infants attempted infant position 5.0±1.5% of the time (median = 3.5, range = 0.75–13.2). This behaviour was virtually never observed away from the provisioning area, so rates could not be compared. Attempts at infant position were also linked to location within the provisioning area. Calves spent significantly less time attempting infant position when their mothers were 'out' away from the Provisioning beach (controlling for the proportion of time mothers spent >40 m from shore) than in all other areas (Matched Pairs Signed Ranks Test Z = 2.67, p = .008; Figure 6). Calves were, in general, not particularly successful at achieving infant position. Within one-minute of each attempt, calves were successful on average 21.5±6.0% of the time (median = 14.5, range = 0–50.0).

Relationship between provisioning and infant position

The onset of provisioning or feeding was defined as when the buckets were down at the beach and the dolphins were stationed at each bucket. The feed, which typically lasts three minutes, was considered to be over when the buckets were turned over. Calves were rarely in infant position during the three minutes that preceded the feed (% of three-minute intervals prior to feed that calf was in infant position: mean = 14.5±4.3, median 12.5, range = 0–33.3). During feeds, calves were never observed in infant position. However, after the feeds, calves very often achieved infant position within three minutes, typically as they left the beach area with their mother (% of three minute intervals following feeds that calf was in infant position: mean = 93.6±3.6, median 96.4, range = 66.7–100). Calves were more likely to be in infant position following a feed than before it (Matched Pairs Signed Ranks Test Z = 2. 67, p = .008). Because mothers were typically in the Provisioning Area for 30 minutes or more, calves tended to have longer bouts between infant position contact at the Provisioning Area compared to when away from it, with 26.2±3.9% of interbout intervals lasting 15 minutes or more at the Provisioning Area (median = 27.3, range = 10.3–44.8) compared to 18.3±3.5% when away from the Provisioning Area (median = 15.4, range = 2.4–35.9; Matched Pairs Signed Ranks Test, Z = 1.84, p = .066).

DISCUSSION

Research findings and the future of provisioning

Monkey Mia, Shark Bay, is one of the most popular places in the world to view wild bottlenose dolphins. Over 100 000 tourists visit Monkey Mia annually. Provisioning is likely to continue given that: 1) only a few dolphins are provisioned; 2) they provide enormous satisfaction to the viewing public; 3) the dolphins offer powerful educational venues for promoting conservation and World Heritage values; and, 4) much of the

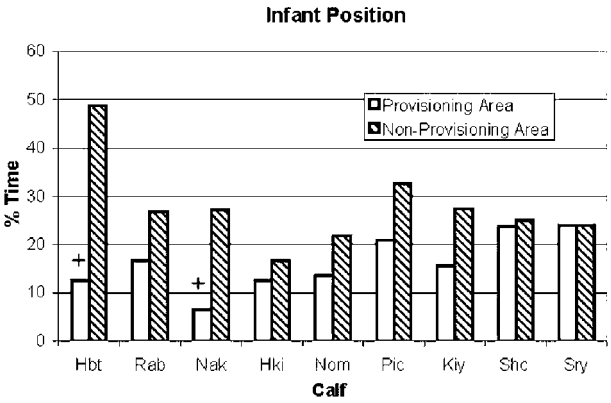

Figure 5 The proportion of time each calf spent in infant position when at, and away from the Provisioning Area. Calves spent significant less time in infant position when at the Provisioning Area compared to when away from it (Matched Pairs Signed Ranks Test, Z=2. 55, p. 011). Note the individual differences between mothers. Surprise (mother of SHC and SRY) appeared to care for her calves equally at and away from the Provisioning Area. The other females showed more dramatic effects of provisioning. Calves marked with + did not survive to weaning and show the biggest difference (>20% difference) between infant position time at the provisioning area and away from it.

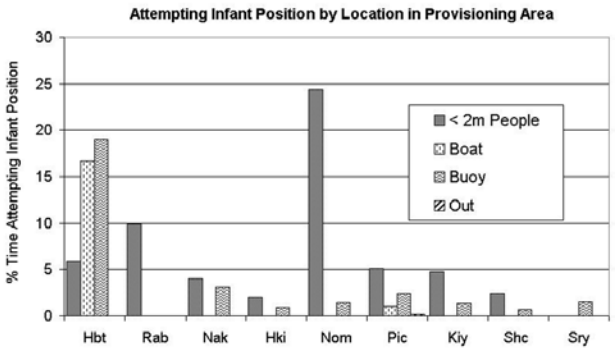

Figure 6 Calves were least likely to attempt infant position when out, >40 m from the beach than all other locations (Matched Pairs Signed Ranks Test Z=2. 67, p=. 008). Only one calf was observed attempting infant position in that location. Even in the buoy area, calf attempts at infant position tended to be close to people, but >2 m from them.

local economy is dependent on tourism generated from Monkey Mia. In late 2002, efforts to feed Piccolo, the nine-year-old daughter of Puck, were underway. This underscores the state Government's commitment to provisioning the next generation of Monkey Mia dolphins. Although provisioning of marine mammals is currently illegal under Western Australia's Wildlife Conservation Notice 1998, Shark Bay is an exception. The act states that 'subject to the Shark Bay dolphin notice a person may only feed a marine mammal if the person (a) is acting in accordance with a licence under section 16 of the Act; (b) is authorised in writing by the Executive Director; or (c) is acting under the supervision and control of a person to whom paragraph (a) or (b) applies'. Monkey Mia and Bunbury (south of Perth) both operate under permits in Western Australia. Finally, the dramatic increase in calf survivorship since 1995 suggests that the change in feeding practices has lessened the adverse effects of provisioning. Provisioning seems to offer social and economic benefits while imposing relatively minor effects on only few animals.

However, provisioning clearly affects maternal and calf behaviour, specifically the amount of time calves spend in infant position with nursing access. Calves spend less time in infant position when in the provisioning area compared to when not, and this is particularly true when their mothers are close to people. At the provisioning area, calves repeatedly try to get into infant position, with little success. As soon as the feeds are over, calves rapidly move into infant position. Since mothers are often in the provisioning area for more than half an hour, calves must sometimes wait that long before regaining infant position contact with their mothers. Away from the provisioning area, calves appear to have little conflict over infant position contact; they spend more time in infant position and have greater success in getting in infant position compared to when their mothers are in the provisioning area. We suggest that at the provisioning area mothers are preoccupied with obtaining fish and, in fact, use shallow water to prevent calves from gaining contact and nursing access.

While these effects may have a negligible impact on calf survival, the long-term effects are not known. Furthermore, provisioning appears to affect some individuals more than others. Maternal care by Nicky, Puck, and Holeyfin has been more affected by the provisioning situation than that of Surprise. Notably, Surprise began visiting the beach in 1990, when she was a late adolescent or young adult. She first gave birth in 1992, and like other first births in the population, was likely to be 12–14 years of age at the time (see Mann *et al*. 2000). Of the provisioned females, Surprise has remained the least frequent visitor to the beach (Mills 2000). She typically comes into the Provisioning Area half an hour or more after Nicky or Puck arrive, thereby spending minimal time there before feeds begin. Similarly, even when at the Provisioning Area, she only spends 33% and 21% of her time (with two different calves respectively) near people. All other females spent 45–85% of their time close to people. Surprise's calves are notably larger than calves born to other provisioned females from the first year of life through weaning. Although speculative, this difference may be a direct result of her care and how little the provisioning situation affects her pattern of care.

Reduced infant position access may not increase mortality risk during the nursing period, but may have long-term consequences for some of the calves. All three of Nicky's calves that survived post-weaning were visibly small for their age, and two died within the year after weaning; Nicky is the most reliable visitor to Monkey Mia (Mills 2000) and spends more time close to people than the other provisioned females. We did not directly address whether maternal care has improved since the change in feeding policies. However, even the small sample we have suggests that maternal care in the provisioning area has not markedly improved. Figure 6 shows that Nomad (Nom, born 1998) had the highest level of conflict (attempting infant position) with his mother when she was close to people. There appears to be greater similarity among calves born to the same mother than to calves observed pre- versus post-1995. The fact that provisioning can affect individual mother and calves differently suggests that careful control is needed.

Our research suggests that calves who spend more time in infant position are more likely to die pre-weaning (Mann and Watson, submitted) as calves in poor condition seek additional contact with their mothers. Calves in good condition separate from their mothers more often and spend more time foraging and socializing. These findings are relevant to the current study, but should not be interpreted to mean that calves born to provisioned mothers have better survival prospects because they spend less time in infant position. The critical link here is mother-calf

conflict. Compared to calves of provisioned females, calves of non-provisioned females are rarely denied infant position access. Heightened mother-calf conflict over infant position access may be a good indicator of both calf condition and maternal responsiveness.

Comparisons with other provisioning sites

The Shark Bay dolphin population is one of the best-studied dolphin populations in the world and researchers have carefully detailed the behaviour of provisioned and non-provisioned dolphins. No other provisioning site has information sufficient to document the effect of provisioning on the population. Few data are available on the other three provisioning sites, but some preliminary descriptions are published from Tangalooma. Further, the Monkey Mia research informed a revised feeding protocol that appears to be successful and has been adopted at other sites (e.g. Tangalooma, Neil and Brieze 1998). Tangalooma has, in some ways, improved on Monkey Mia's protocols by allowing for only one feed per day (so that the dolphins spend less time at the provisioning area), no sunscreens, lotions, or insect repellents are permitted, and all those that handle fish disinfect their hands first (see Neil and Brieze 1998). However, Tangalooma is a resort and far fewer people have access to the dolphins. It may be less feasible to implement similar protocols at Monkey Mia without compromising the current, already limited, level of access.

Other differences may or may not benefit the dolphins. Touching the dolphins is not allowed at Tangalooma; it is discouraged at Monkey Mia. This may reduce the chances of disease transmission, but the effect of touching is not known. At Tangalooma, male dolphins of all ages are provisioned. This is strictly prohibited at Monkey Mia because of male aggression towards tourists, other dolphins, and their tendency to force non-provisioned females into the provisioning area during the breeding season. In addition, sons rarely associate with their mothers post-weaning and provisioning of male offspring would create conflict post-weaning (as it did for Finnick). On the other hand, daughters continue to associate with their mothers post-weaning and develop foraging strategies similar to their mothers (Mann and Sargeant in press). Thus, by maintaining the provisioning tradition within matriline, the process more closely mimics their 'natural' behaviour. For example, currently the three juvenile daughters of provisioned females visit Monkey Mia almost daily with their mothers, despite the fact that they are not fed. For Piccolo, this has continued five years after weaning. No surviving son visited the beach regularly after weaning except Finnick, who became dependent on hand-outs and was repeatedly attacked by his mother, and Bibi, who began visiting Monkey Mia regularly only after his mother's death (Table 2). Finally, at Tangalooma, calves are provisioned as early as two years of age. Provisioning such young animals clearly had deleterious effects at Monkey Mia and provisioning is not initiated until the calves are at least one year post-weaning. Calves are dependent on their mothers for three to six years. During that time, they must develop hunting and social skills in a challenging physical and social environment. Given their social system, life history, and ecology, the procedure of provisioning only females, and then daughters of those females well after weaning is likely to have the most success.

Recommended changes to the current provisioning program

That said, there is room for improvement at Monkey Mia. Calves still undergo periods when they are unable to nurse or gain contact with their mothers in the provisioning area. Clearly, shorter (15–20 minutes) and fewer (one or two) visits will allow calves to regain contact with their mothers more quickly and allow for the dolphins to spend more time engaging in natural behaviour away from the provisioning beach. Currently, with three feeds on most days, and visits that last over 30 minutes, sometimes the provisioned females spend most of their morning at the Provisioning Area. The females are reinforced for spending 30 min or more close to people. It may be possible to reduce the amount of fish fed and time at the provisioning area without affecting the quality of the experience for tourists.

Other effects of the provisioning may also be long-term. The provisioned females have the smallest core home ranges in the Red Cliff Bay population (Mann and Watson unpublished data). The provisioning may reduce their need to range more widely to exploit prey in other habitats, making them more dependent on hand-outs. Further, the fact that Nicky continues to beg from boats (personal observation) suggests that unregulated boat feeding continues. Consistent and persistent monitoring will reduce the likelihood of boat feeding (fines for feeding dolphins without ranger supervision are AUS$4,000). Continued long-term monitoring and research on the provisioned dolphins and the larger population are clearly critical to successful management and sustainability of Monkey Mia. Although CALM has successfully corrected most of the problems associated with provisioning. Small changes could reduce these problems even further.

Dramatic improvements in education and interpretation have occurred in recent years. One or more rangers typically stand in the water with the tourists and explain dolphin life history, ecology, behaviour, and their social system. Researchers give evening seminars up to five nights per week. A new Information Centre has been built and provides educational materials and videos. CALM has reduced the emphasis on touching and feeding the dolphins and emphasizes the unique characters of the animals themselves. However, tourism websites, brochures and advertisements continue to highlight touching and feeding wild dolphins. Dissemination of information on the effects of

provisioning will hopefully help shift human interest away from human-dolphin interaction and towards observing and conserving their natural way of life.

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