THE RAFFLES BULLETIN OF ZOOLOGY 2002 Supplement No. **10**: 97-103

OBSERVATIONS ON BEHAVIOR AND ECOLOGY OF THE YANGTZE FINLESS PORPOISE (*NEOPHOCAENA PHOCAENOIDES ASIAEORIENTALIS*) GROUP AT TIAN-E-ZHOU OXBOW OF THE YANGTZE RIVER

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ABSTRACT. – The authors made 39 surveys (a total of 161 days) in the Tian-e-Zhou Oxbow of the Yangtze River, China, for observing 13 Yangtze finless porpoises (*Neophocaena phocaenoides asiaeorientalis*) captured from the main stream of the Yangtze River and 7 juveniles born in the oxbow from January 1997 to July 2000. The animals were usually divided into several "core" groups and moved around in shallow, muddy-bottom areas with the largest individual in the lead. Each core group was composed of 2-3 animals (either 2 adults, 1 adult and 1 juvenile, 2 adults and 1 juvenile, or 2 adults and 1 calf). Newly-released animals joined the other animals first, and then reorganized their own groups one or two days later. Average breath interval was 34.4 s (± s.d. 4.39) for individuals in the group. The animals mated from May through June and gave birth during the second and last ten days of April of the next year. The gestation period was estimated as 310 - 320 days. Calves over 5 months old began to eat small fish. The distance of calves swimming apart from their suspected mothers increased each month. These findings will help in the management of the reserve to protect this unique freshwater porpoise.

KEY WORDS. – Yangtze finless porpoise, *Neophocaena phocaenoides asiaeorientalis*, ecology, behavior, Yangtze River, China.

INTRODUCTION

Field studies of the behavioral ecology of cetaceans began in the 1940s (Brown & Norris, 1956). Similar research on the two cetacean species in the Yangtze River of China, the baiji (*Lipotes vexillifer*) and Yangtze finless porpoise (*Neophocaena phocaenoides asiaeorientalis*), did not begin until the 1980s. Although no detailed, comprehensive behavior studies have been done, observations and preliminary behavior studies on Yangtze finless porpoises have been published (Chen et al., 1980; Zhou et al., 1980, 1989; Hua et al., 1989; Hou, 1993; Hua et al., 1993, 1994; Wang et al., 1996, 1997). Recently, Yang et al. (1994, 1996) reported behaviour of three porpoises in a surrounding net and movements of porpoises in an oxbow of the middle reaches of Yangtze River known as the Tian-e-Zhou Oxbow (Fig. 1).

Zhang et al. (1996) and Würsig et al. (2000) tracked three porpoises by radio tags in the oxbow and reported on the animals' respiratory patterns. Acoustic and behavior tracking, using data loggers, were recently conducted in the oxbow to obtain echolocation click events, dive depth and swim speed data (Akamatsu et al., 2000). Akamatsu et al. (1998) compared echolocation ranges of captive and free-ranging porpoises, the baiji and bottlenose dolphin (*Tursiops truncatus*). Visual and passive acoustic detection of porpoises in the Yangtze River were compared by Akamatsu et al. (2001).

This oxbow was approved as a National Baiji Reserve by the Chinese central government in 1992, and Yangtze finless porpoises have been introduced into the oxbow since 1990 (Wang et al., 2000; Zhang et al., 1995). For the purpose of better management, the behavior and reproduction of the Yangtze finless porpoise population in this reserve were investigated from January 1997 to July 2000. This paper reports our observations during this period.

MATERIALS AND METHODS

Study Site and Subjects. – The Tian-e-Zhou Oxbow (20° 30' - 29° 37' N, 112° 13' -112° 48' E) was cut off from the main stream of the Yangtze River and formed naturally by water current forces in 1972 (Fig. 1). It is 21 km long, 1 - 1.5 km wide, and has an average bottom depth of 4.5 m. Water velocity is almost zero during the dry season (November to May), when the oxbow disconnects with the main stream of Yangtze River and no water flows in or out. Current speed is 0.2 - 0.5 m/s during the flood season (June to October), when it connects with the main stream of the

river and water flows into and out of the oxbow from the river. Three zones were designated for the purpose of management, according to the height of the water level (above sea level of Wusongkou in Shanghai):

1) core zone - <34.5 m,
2) buffer zone - 34.5 - 35.5 m; and
3) experimental zone - 35.5 - 36.5 m (see Fig. 1).

Some of the target animals were introduced from the mainstream of the Yangtze River into the oxbow before or during our investigation (see Fig. 2), and the others were born in the oxbow (Table 1). Newly-introduced animals were followed continuously until they joined existing groups in the reserve.

Habitat Types. – Four types of habitats were recognized, largely based on river bed and bank features, as follows:

1) Type I (stony and steep slope area) - dyke covered by stones, bottom steep, with little vegetation, channel width < 400 m and bottom depth > 8 m;
2) Type II (muddy slope area) - dyke constructed of natural soil, some aquatic vegetation along bank, channel width > 800 m and bottom depth > 5 m;
3) Type III (muddy, shallow area) - large muddy beaches with plentiful aquatic vegetation, abundant small fish preferred by the porpoises, course width > 1000 m and bottom depth 3-5 m; and
4) Type IV (central area of the oxbow course) - depth > 10 m, no aquatic vegetation on the bottom.

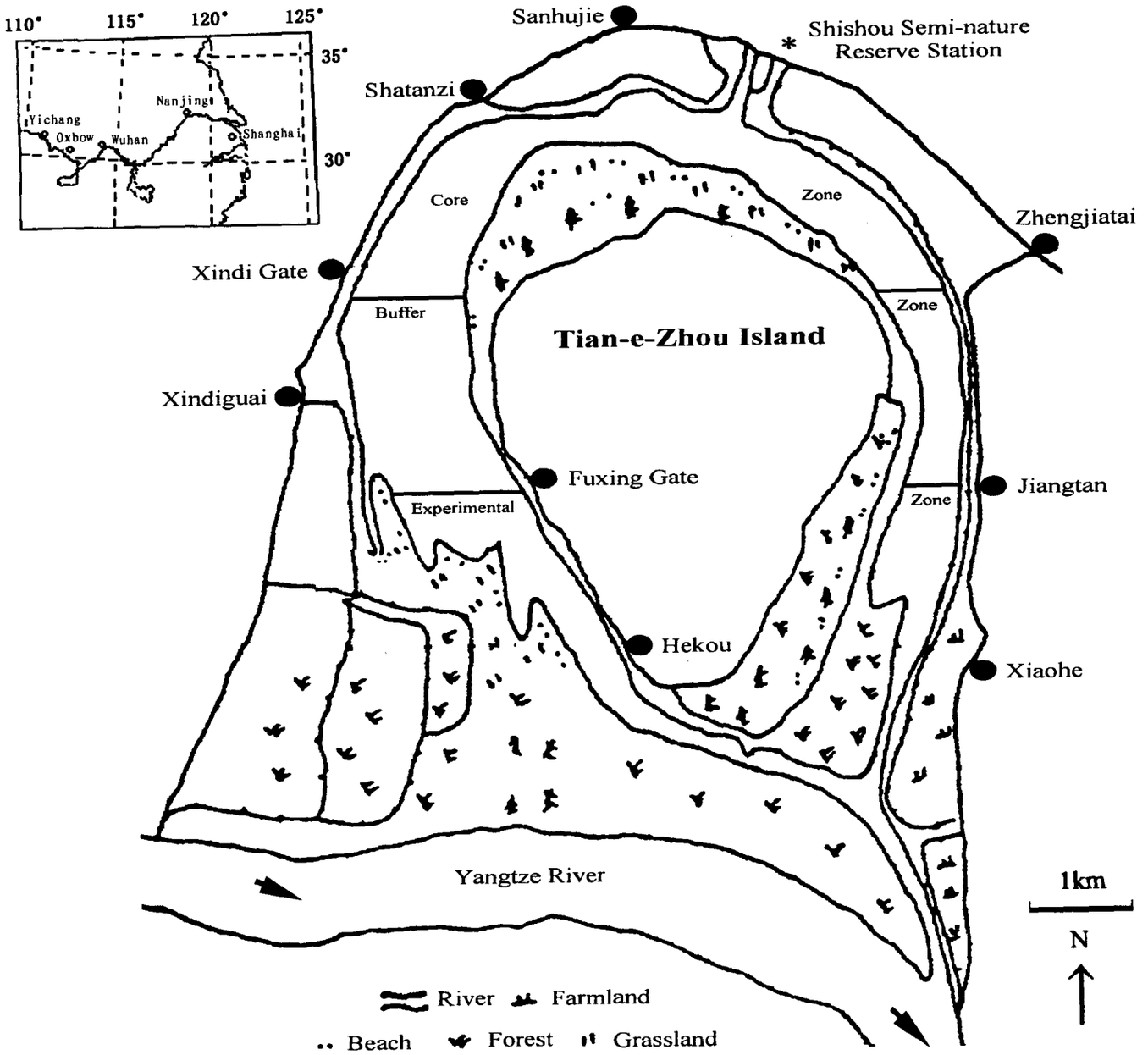

Fig. 1. The study site, the Tian-e-Zhou Oxbow, which is periodically connected to the Yangtze River. The inset shows the location of the oxbow along the middles reaches of the Yangtze River, China.

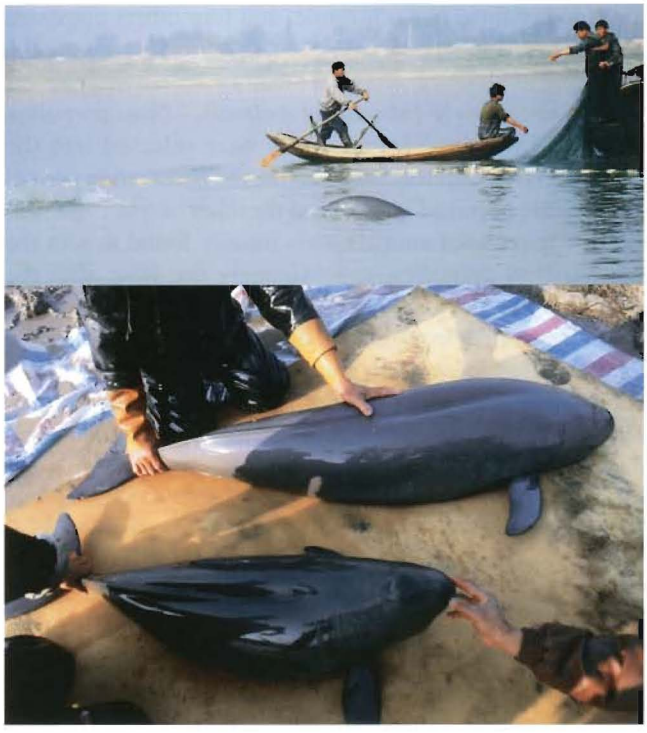

Fig. 2. Capture operation in the Yangtze River for obtaining porpoises to place into the oxbow (top), and a close-up of two captured animals awaiting release into the reserve (bottom).

Besides type IV, most of types II and III are found in the core zone, and most of type I is in the experimental zone. Overall, the size ratio among types I to IV is approximately 12%:18%:24%:46%.

Survey Procedures. – Although wind speed does not translate into sea state conditions as reliably in river and lake areas as it does in the open sea, all surveys were carried out in calm waters, with sea states under the equivalent of Beaufort 3. Two fishing boats (power: 4.5 hp, size: 8.5 m x 1.5 m) surveyed along the two sides of the oxbow. Each survey lasted for 3 - 5 days (approx. 45 hours) every 1-2 months, and all effort was conducted during daytime. One to two observers on the front of each boat (2.1 - 2.3 m eye height above water level) searched the left and right sides of the bow, respectively. Communication between vessels was maintained by using VHF hand-held radios. In addition to naked eye, binoculars (12X50) were used to search for the animals. Still cameras (Nikon SLR, with 80-300 mm lenses, color film) and Sony digital tape recorders (C-1400L) were used to take photos of the behaviors of the animals and to record observations. Bottom depth was measured using an Furuno Electric Co. FCV-663 depth finder. Two survey paths (see Fig. 1) were typically surveyed once each day:

1) Route I - Reserve Station - Sanhujie - Shatanzi - Xindi Gate - Xindiguai - Fuxing Gate - Hekou - Fuxing Gate - Xindiguai - Xindi Gate - Shatanzi - Sanhujie - Reserve Station - Zhengjiatai - Jiangtan - Xiaohe - Jiangtan - Zhengjiatai - Reserve Station; and
2) Route II - Reserve Station - Zhengjiatai - Jiangtan - Xiaohe - Jiangtan - Zhengjiatai - Reserve Station - Sanhujie - Shatanzi - Xindi Gate - Xindiguai - Fuxing Gate - Hekou - Fuxing Gate - Xindiguai - Xindi Gate - Shatanzi -Sanhujie - Reserve Station.

Table 1. Estimated dates of birth for seven finless porpoise calves born in the Tian-e-Zhou Oxbow during 1997-2000.

Year	Calf No	Estimated Birthdate
1997	1	April 21-24
1998	2	April 25-26
	3	April 27-29
1999	4	April 17-19
	5	April 24-26
2000	6	April 24-26
	7	April 26-27

Data recorded included date, start and end time of survey and/or time of each group observation, location and distance of the animals from the nearest bank and the boat, group size and composition, behavior, habitat type, temperature (water and air), barometric pressure, human fishing activity, associated birds, etc. The study lasted from January 1997 through July 2000.

Definitions, Data Collection and Analyses. – A group was defined as all the animals traveling in the same direction, either singly or in apparent association and engaging in similar activities in the area in naked eye view of the observers. Calves were defined as animals under one year old, and juveniles were defined as animals between one and three years old. Behavioral data were collected using continuous and instantaneous sampling methods (Altmann, 1974). No photo-identification effort was made, since finless porpoises have no dorsal fin, and it is very difficult to identify individuals by natural markings (see Beasley & Jefferson, 2002). Age was estimated by body length and size (based on information in Zhang, 1992). Calves were classified as those animals that appeared to be < 1.15 m, juveniles about 1.2-1.25 m, and adults > 1.3 m. Because the animals were observed on a regular basis, it was generally not difficult to recognize newborn calves, and to keep track of juveniles. Pregnancy could sometimes be determined by the size of the belly (observed while the animal was surfacing) one to two months prior to giving birth. No births were directly observed, dates of birth were estimated by the initial sighting of neonates.

To evaluate habitat associations, we pooled the number of sightings made in each habitat type, treating calves and juveniles/adults separately. Then, we tested these according to observed vs. expected sighting frequencies (the latter based on the relative proportion of each habitat type in the oxbow - see above). Distances were estimated with naked eye by trained, experienced observers. As soon as a group with a calf was sighted, distances between the calf and the adult in the group (suspected mother) were sampled instantaneously and continuously, whenever possible. All the maximum distance measurements were pooled across ages of calves in months to examine monthly changes in maximum distance

between the calf and the suspected mother. Only the initial estimated distances were pooled to calculate the distances between the animals and the bank. Average breath interval for each individual in the group was obtained by taking the total number of group breaths, divided by group size, then divided by the total recording time.

RESULTS

Thirty-nine surveys (a total of 161 days) were conducted in the Tian-e-Zhou Oxbow from January 1997 to July 2000. Porpoise groups were encountered on 152 of these days, and approximately 1,477 hours were spent observing the animals. Distances between porpoises and the observation boat were usually between 200 - 500 m when the animals were first sighted, with 70% of the sightings between 250 - 350 m. The best distances for following, but not disturbing, the animals were between 200 - 400 m.

"Population" Size. – The porpoises in the oxbow were isolated from their conspecifics in the Yangtze River, and so they are treated here as a separate "population." There were four porpoises in the oxbow when the survey started in January 1997. One was born later in April of that year. Another two were born in late April and three were introduced from mainstream of the Yangtze River in 1998. Two more were born in late April and six more were introduced in 1999. In 2000, two more were born in late April. The total number of animals came to 20 when this study ended in July 2000.

Habitat Association. – Distances between porpoises and the nearest bank were usually between 100 - 500 m when the animals were first sighted, and 85% of these were between 150 - 300 m. Average distance to the bank was 233 ± s.d. 83.62 m (range = 50-500, n = 278). Frequency of porpoise groups sighted in different habitat types is presented in Fig. 3, while frequency of porpoises under 1 year old in different habitat types is presented in Fig. 4. Porpoise groups generally moved or stayed near the bank in habitat types I, II, or III, but spent much less time in the central area of the oxbow course in habitat type IV (Chi-square = 70.53, df = 3, $p < 0.001$). Calves under one year of age spent most of their time in habitat type III, no matter if they stayed with groups or not (Chi-square = 302.07, df = 3, $p < 0.001$).

Social organization. – Usually, two to three individuals stayed and moved together to form a basic unit (core group). Each core group was composed of 2-3 animals (2 adults, 1 adult and 1 juvenile, 2 adults and 1 juvenile, or 2 adults and 1 calf). We could not confirm if these core groups remained stable over periods of months or years, but they did appear to do so during the short periods of our observations. In general, the largest individual swam ahead, leading the group. Calves most of the time stayed together with one or two large individuals in the core group. Several core groups sometimes joined to form a larger group. Up to July 2000, the animals in the oxbow had formed nine core groups. Among them, five groups each consisted of three animals, two had a calf and another three had a juvenile, and four others consisted of only two animals.

Reactions to Newly-Introduced Animals. – Nine porpoises captured from the Yangtze River were released into the oxbow at three different times during the observation period. One release occurred in 1998 and the other two in 1999. All the newly-released animals were usually found to join the other oxbow porpoises, approximately one hour after the release. One to two days later, some porpoises were usually found separated from the other oxbow animals, and we assumed that these were the new animals that had now formed their own groups. This result is consistent with our observations on other releases before this study (unpublished data of authors).

In December 1998, five animals (two adult males, one adult female, one juvenile male and one juvenile female) were captured from the oxbow itself and held in a fine-mesh temporary enclosure net at an inlet in the oxbow to attach data loggers (Akamatsu et al., 2000). During the holding period of these animals, three other porpoises had been moving around outside of the enclosure; among them there was one calf which was born in April of that year. This calf was found to try to get into the enclosure and it became entangled in the nets on several occasions. All five animals were released into the oxbow again three or four days later (three carrying data loggers). After the release, the animals moved toward the other animals in the oxbow very quickly, joined them and did the first surfacing together.

Breath Intervals. – The longest recorded breath interval for calves was 60 s; the longest one for adults was 139 s. The average breath interval for each individual in the group was 34.4 s (± s.d. 4.39, range = 28-42, n = 53 groups). With the few data currently available, it appears that when air pressure

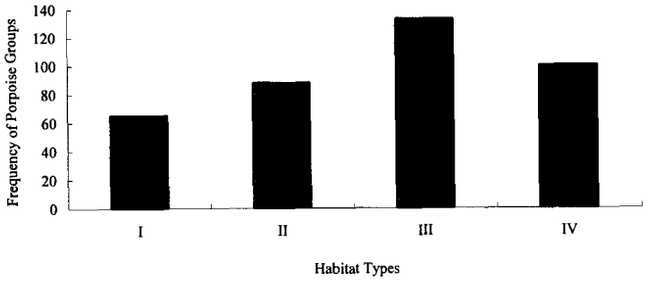

Fig. 3. Frequency of porpoise groups sighted in different habitat types.

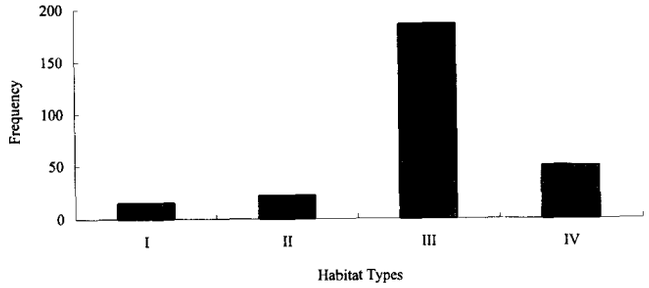

Fig. 4. Frequency of porpoises under 1 year of age sighted in different habitat types.

was relatively low, while the weather was changing to bad (raining or windy), the animals breathed more often, exposed a larger part of their body while surfacing, and jumped out of the water more frequently. When the weather was good (sunshine or calm winds) and air pressure was relatively high, the animals dived longer, with less of their body exposed and jumped less often. We hope to examine this issue more systematically in the future.

Reproduction. – Mating behavior between porpoise adults was observed in May through June every year in the oxbow; a total of 13 mating events were observed. Mating usually occurred in muddy, shallow areas (habitat type III). The typical mating process was usually as follows: two large individuals (adults) chased each other in muddy, shallow water and caused some large waves; sometimes they jumped out of the water. Six to seven minutes later, they swam very closely and slowly with their bodies touching each other, with both of their tails sticking out of the water and much splashing on the surface. One to two minutes later, both surfaced out of the water, and the mating apparently ended.

Seven calves were born in the oxbow from April 1997 to April 2000 (see Table 1). During the early part of pregnancy, it was difficult to identify pregnant females. One or two months prior to giving birth, the pregnant females could be recognized (due to their large bellies), and they usually travelled with a mid- to large-sized individual, keeping some distance from the group. All seven births occurred during mid- to late April. Therefore, the gestation period was estimated as about 310 - 320 days (but could be as wide as 300-350 days).

Calf Behavior. – During the first four months, calves always followed two adults to form a group, with a maximum distance of separation from the group of less than 110 m. They usually moved slowly and most often in muddy, shallow areas. The adults were always in the lead, while the calf followed. Sometimes a calf was observed swimming above the flipper or on the back of an adult while surfacing. After 5 months, calves sometimes swam behind the adults to follow them to catch fish that escaped from the adults while they were engaged in group feeding. Sometimes, two to three calves were also found to chase and catch fish together.

Monthly changes in the maximum estimated distance between the suspected mother and calf under 1 year old are presented in Fig. 5. The distance of calves apart from their suspected mothers increased with time, but to no more than 2000 m when the calf was one year old. After one year, calves were more independent and showed stronger swimming capabilities.

DISCUSSION AND RECOMMENDATIONS

The porpoises in the oxbow usually stayed < 300 m from the river bank, and this is consistent with observations in the river (Zhang et al., 1993). In that study, 83% of the animals were first sighted within a distance of 300 m from the bank. Figure 3 shows that the porpoise groups preferred to stay and move around in areas near the bank, with less time spent in central areas of the oxbow course. Figure 4 shows that the calves under one year old spent most of their time in habitat type III, even if they were temporarily separated from the adults. Except for rare occasions when they moved into central areas of the oxbow course, they also spent relatively less time in habitat types I and II, compared with the adults. This might be related to the slow water currents, predictable and rich food resources, and shallow water depths in habitat type III.

The porpoises usually stayed and swam together as a group of 2 - 3 individuals. This is very similar to results reported by Zhang et al. (1993) and Wang et al. (1997) for porpoises in the Yangtze River. In the work of Zhang et al. (1993), 47% of the 333 randomly-sampled groups consisted of 2 - 3 individuals. Newly-released animals were found to join the other animals in the oxbow first, but separated from them later. We suspect that capture operations and transportation put these newly-captured animals in a very stressful situation, and looking for companions may be their first natural reaction to the stress. As soon as they started to get used to the new environment, they returned to their own groups. We also suspect that the adult female in the temporary holding enclosure in 1998 was the mother of the calf that tried several times to get into the enclosure. Quick unification of the released animals with the animals outside of the enclosure may support this speculation in a sense. In October 1993, we did another capture operation in the oxbow for carrying out a radio-tracking study (Zhang et al., 1996; Würsig et al., 2000). One calf was held in a net enclosure for two days at the same inlet in the oxbow mentioned above. During this period, one adult female outside the enclosure never left the area, and the calf also continuously moved along the nets between it and the adult female. As soon as the calf was released on the third day, they joined together immediately and moved away quickly (Chen et al., 1997). Based on these observations, we suspect that some core groups of the Yangtze finless porpoise may be composed of related individuals, and these associations are stable at least for short periods. This hypothesis needs to be tested and confirmed by further research (see discussion below).

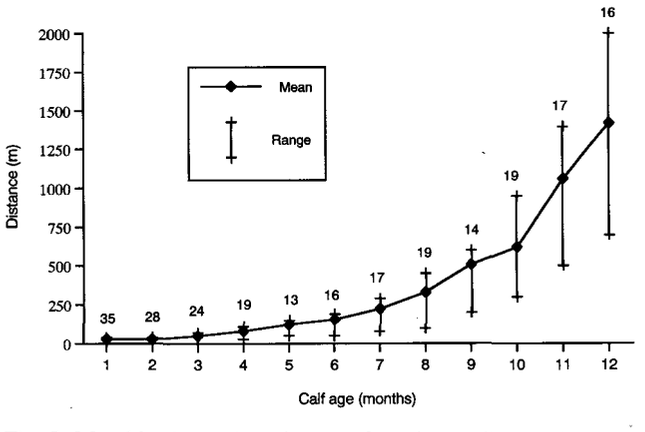

Fig. 5. Monthly change in estimates of maximum distance between calves and their suspected mothers.

The mean breath interval we recorded in the oxbow was 34.4 s (± s.d. 4.39), which is much longer than the 13 - 19 s reported by Hua et al. (1993) for animals in a circle net. The animals in the circle net were in a relatively small area and in much higher density, which probably stressed the animals, in turn increasing their respiration rates. For porpoises in captivity, breath intervals were also relatively shorter, most of them were between 10 and 20 s (Hou, 1993). This might also be related to the relatively small area the animals lived in. Zhang et al. (1993) reported breath intervals while porpoises moved around in calm waters in Yangtze River were around 40 s, and this is similar to our results. Meanwhile, baiji in the wild were reported to breathe usually once every 40 - 60 s (Hua et al., 1989), but average breath intervals of baiji in captivity were reported to be between 24 - 32 s (Chen et al., 1997). Individual porpoises that were radio-tracked in the oxbow conducted dives lasting from 40 sec. to 4.03 minutes, intersperse with 2-6 surfacings of less than 40 sec. (Zhang et al., 1996; Würsig et al., 2000). However, because these data on individual dive times were not directly comparable to our data, so we did not attempt a comparison here.

Mating behavior described in this study is similar to that reported by Hua et al. (1993, 1994) for animals in a circle net. The estimated 310 - 320 days gestation period is close to results from life history studies of various finless porpoise populations, which range from about 10.5-11.5 mos. (see reviews in Chang & Zhou, 1995; Jefferson et al., 2002). Chen et al. (1997) reported that nursing lasted for about 6 months in Yangtze finless porpoises, and Zhang (1992) found both milk and fish in the stomach of a 6-month old calf. These results are consistent with our observations that calves in the oxbow started catching fish after they were about 5 months old.

Pilleri & Chen (1979) reported that Yangtze finless porpoises sometimes carry their calves on their backs in the river. Hua et al. (1993) supported this finding by observing animals in a net circle. These findings are consistent with our observations on animals in the oxbow. Calves were found to follow adults to catch fish that escaped from the adults while they were doing group feeding, or several calves occasionally joined together to chase and catch fish. We believe that this represents some kind of learning or mimicking of the feeding technique of adults. Mann & Smuts (1998, 1999) showed that wild bottlenose dolphin calves increased their distance of separation from their mothers significantly during the first two months, and the maximum distance of separation was about 100 m. This is similar to our results for the porpoises in the oxbow. But, since we did not know for sure which adult was the calf's mother, we could not describe associations and/or interactions between calves, mothers and other adults (non-mothers) in as much detail as they did. We are planning to recapture these animals, once for each core group. This will allow us to place visual tags on the animals to check group stability, and to conduct DNA fingerprinting analyses to determine the relationships among them. This will greatly expand our knowledge about the population biology of this species, and will assist our behavioral observations in the future.

Of the sex-determined porpoises in the oxbow, females are fewer in number. For better management of this porpoise population, it is necessary to know the exact sex ratio of the porpoises in the oxbow, and this can also be done by a carefully-planned capture operation. We may need to introduce more animals from the river in the future to form a larger group and to achieve a better sex ratio and a more healthy group structure for breeding (Chen et al., 1997). Since April through June is the breeding season for these animals, the whole oxbow must be carefully managed to decrease any possible interference with the animals' normal activity during this period. The core zone is especially important, since most area in the zone is habitat type III (muddy, shallow area), and these are the main mating, calving and feeding habitats for the porpoises. In the future, more attention should also be paid to pregnant females and newborns. For example, all human fishing activities must be forbidden, and passenger and monitoring boats must be kept at least 200 m away from these animals.

In summary, behavior and ecology of the porpoises in this oxbow are similar and comparable to those of free-ranging porpoises in Yangtze River (see Chen et al., 1997). This is understandable, since the oxbow used to be a section of the river, and its environment is still very similar to the main stream of the river (Zhang et al., 1995). Our experience in rearing Yangtze finless porpoises in the oxbow for the last 11 years has shown that they not only survive, but also reproduce, in this oxbow (also see Wang et al., 2000). This oxbow reserve may serve as a model for the conservation of the Yangtze finless porpoise for establishing more such reserves, if necessary, and some individuals may be returned to the main stream of the river in the future. This work represents one of the first attempts at ex-situ conservation efforts for a cetacean species, and as such will shed light on the conservation of other endangered marine mammals.

ACKNOWLEDGEMENTS

Mr. Yu Zikun from Harvard University attended part of field observations. Prof. Liu Renjun, and three anonymous reviewers provided constructive criticism on this paper, and Dr. Thomas Jefferson provided valuable editorial assistance. This work was supported by the Chinese Academy of Sciences (CAS), grant numbers: 1999051, KZ951-A1-105 and KSCX2-1-03. The Ocean Park Conservation Foundation also provided some funding for some of the capture operations.

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