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Distribution and movement of Chinese sturgeon, *Acipenser sinensis*, on the spawning ground located below the Gezhouba Dam during spawning seasons

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Summary

Sonic tracking of 40 adult pre-spawning Chinese sturgeons (35 females, 5 males) was done during 8 spawning seasons (1996–2004). Fish spent most of the time close to the dam (within 7 km). A yearly mean of 64% of the tracking locations of pre-spawners were in the small area of 1.08 km distance below the dam (cell I-B of the tracking grid system). These movements indicate fish continue to attempt to move farther upstream to pass the dam. Adults did not visit areas without major water spills or flow, i.e., the boat canal (the Sanjiang River), the spill gates, and 1# ship lock. Adults were not tracked in the fast current tail waters of the Erjiang power plant and rarely in the Yichang port, although their occurrence ranged from 4 km to 10 km downstream of the dam while also occuring in the channel. Pre-spawning Chinese sturgeon use the Yichang reach in a non-random manner while seeking certain habitats and avoiding others. Adults arrived on the "spawning ground" one day before spawning. Adults move quickly about the spawning ground. After spawning, females quickly moved downstream, whereas males remained for 12-21 days. During a spawning season, females moved less than males.

Introduction

With regard to the length and quantity of the water resource, the Yangtze River is the third largest one in the world. The total length is shorter than the Nile in Africa and the Amazon River in South America only. The distance from the headstream to the estuary is about 6,300 km. The water volume contained in this river is estimated with 9616×10^8 m^3 and is somewhat less than that of the Amazon River and similar to the Congo River (Zaire River) (Wen Fubo, 1999).

Chinese sturgeon (*Acipenser sinensis* Gray) is China's national listed endangered fish species (Office of Aquatic Wildlife Conservation of MoA, 2002; Wang, 1994). Its distribution is widespread in the Far East Asian region and the species occurs in the major coastal rivers from the East Sea to the Yellow Sea and historically also beyond these regions (Anonymous. 1988; Chang and Cao, 1999). Chinese sturgeon is an anadromous species and spawns mainly in the Yangtze River. The eggs are deposited and incubated in the spawning grounds in upstream river stretches while larvae swim or drift downstream with development and reach the East Sea and Yellow Sea as juveniles (Yang, et al. 2005). Chinese sturgeons spent years at sea before maturating and returning to the estuary to begin their upstream spawning migration as maturing adults. The age of females and males at this stage is commonly above 14 years and 9 years, respectively. Migrating spawners usually arrive at the spawning ground about 18 months after starting the upstream migration. Their gonads develop from stage III into stage IV during the upstream migration (Anonymous. 1988; Chang, 1999). The range of their spawning ground locations before the construction of the Gezhouba Dam reached from the Maoshui (lower reaches of the Jingsha River, Leibo County) to the Mudong (upper reaches of the Yangtze River, Chongqin). Historically there were about 16 spawning grounds of the Chinese sturgeon recorded between Maoshui and Mudong. The length of this river stretch is about 600 km. Therefore, the adults of the Chinese sturgeon needed to swim upstream for about 3000 km to propagate before the Gezhouba dam was constructed (Anonymous. 1988; Wei et al, 1997). In 1981, the Gezhouba dam was errected and the migration route of the Chinese sturgeon to their former spawning grounds was obstructed. However, it was first discovered in autumn 1982 that the mature fish started to spawn below the Gezhouba dam (Hu et al. 1983; Yu Zhitang et al. 1986), indicating that the sturgeons tried to find an alternative site to spawn while being hindered by Gezhouba dam to migrate further upstream. In the following years, the natural spawning of the Chinese sturgeon in the river stretch below the Gezhouba dam was continually investigated. The results indicated a very restricted spawning ground ranging from the area immediately below the dam to Yidu City, Hubei Province, covering a river stretch which is actually over 80 km long. However, the exact spawning locations and the range inhabited by mature fish is still not clearly known and assumed to be smaller (Hu. et al. 1985) (Fig. 1).

The investigations on the actual spawning activity of Chinese sturgeon below the Gezhouba dam had continued for more than ten years. The number of matured fish returning to the spawning grounds declined year after year and this not only because of the dam but also because of overfishing and pollution (Chang, 1999; Chang and Cao, 1999; Wei, 2003; Wei and Yang, 1998; 2003). Nevertheless, the Chinese sturgeon continued to spawn every year while the spawning ground below the dam did not change appreciably (Wei, 2003). This indicated that the "new" ("alternative") spawning ground below the dam was relative steady over time. Nevertheless, the exact locations of spawning on these grounds and the spawning behaviour during the spawning seasons are still largely unknown. Modern biotelemetry is one of the main methods to unreavel this behaviour and other ecological features of migra-

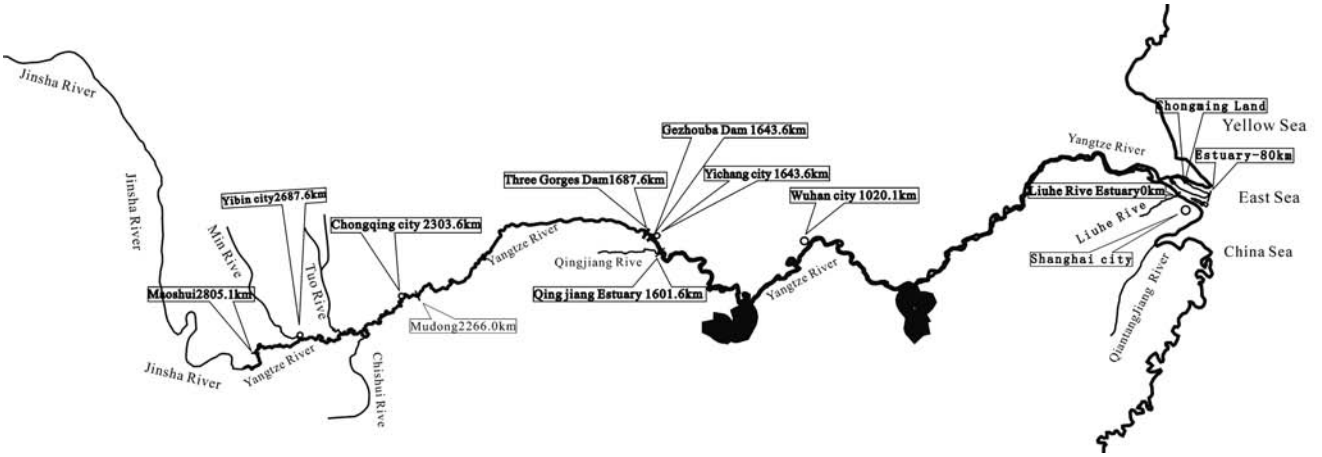

Fig. 1. Map of the Yangtze River showing the location of the past spawning grounds for the Chinese sturgeon before and after the construction of the Gezhouba dam. The range of study area extents from 1601.6rkm to 1643.6rkm

tory aquatic animals (Kieffer, M., and B. Kynard. 1993; 1996; Kynard B., Suciu R., and Horgan M. 2002). For this reason tracking trials using ultrasonic telemetry were initiated between 1993 and 1995 to explore the behavioural cues of Chinese sturgeon exposed to the complex environmental conditions of the Yangtze River (Kynard et al., 1995; Wei Qiwei, et al. 1998). Subsequently, research on the distribution and movements of sturgeons on this spawning ground were conducted during the spawning seasons between 1996 and 2004 (except for 2002). This manuscript summarizes the results of these multi-year investigations.

Materials and Methods

Study Area

The original spawning grounds of the Chinese sturgeon ranged from the lower reaches of the Jingsha River to the upper reaches of the Yangtze River. After the construction of the Gezhouba dam in 1981 the migration route was blocked. Since 1982 an alternative spawning ground has been chosen by the migratory fish which is now located below the Gezhouba dam and apparently ranges downstream to the Yidu City. The area of distribution and movement of mature adults during the spawning seasons was observed mainly in the section between the Gezhouba dam and Gulaobei. For this reason the present research work was carried out mainly in this river section (Fig. 2). A river stretch of about 8 km was marked off with reference points along the riverside while also dividing the river bed into grid sections in order to locate and record the observations reliably (Fig. 3).

Equipment

The equipment included the acoustic telemetry instrumentation with ultrasonic emitter (tag) and receiver (hydrophone) systems. Additionally the Global Position System (GPS) receiver was used while all items commonly needed to conduct field research on sturgeon movements and habitats were also available. The tracking was done from a special boat.

The cylinder-shaped ultrasonic emitter (tag) had a size of 18×110 mm and weighted 38 g in air (13g in water). It was sealed by waterproof material. The working lifespan of the emitter depended on the lifetime of the interior battery (up to 18 months; continuous). Ultrasonic signals emitted continuously special digital codes after switch on. Therefore, fish with tags were tracked and located at given times. Frequency of emission waves of the tags were 40 KHz and 78 KHz, respectively. The ultrasonic emitter used was from Sonotronic Corporation Inc. (USA).

A special directional hydrophone with high sensitivity and signal direction was used which was also produced by Sonotronic Corp Inc. The hydrophone was of 15 cm diameter, fitted to a steel tube which was fixed on the wing of yacht and was kept at depth of about 100 cm under water during operation. There was an artificial blade installed behind the hydrophone to control the direction of

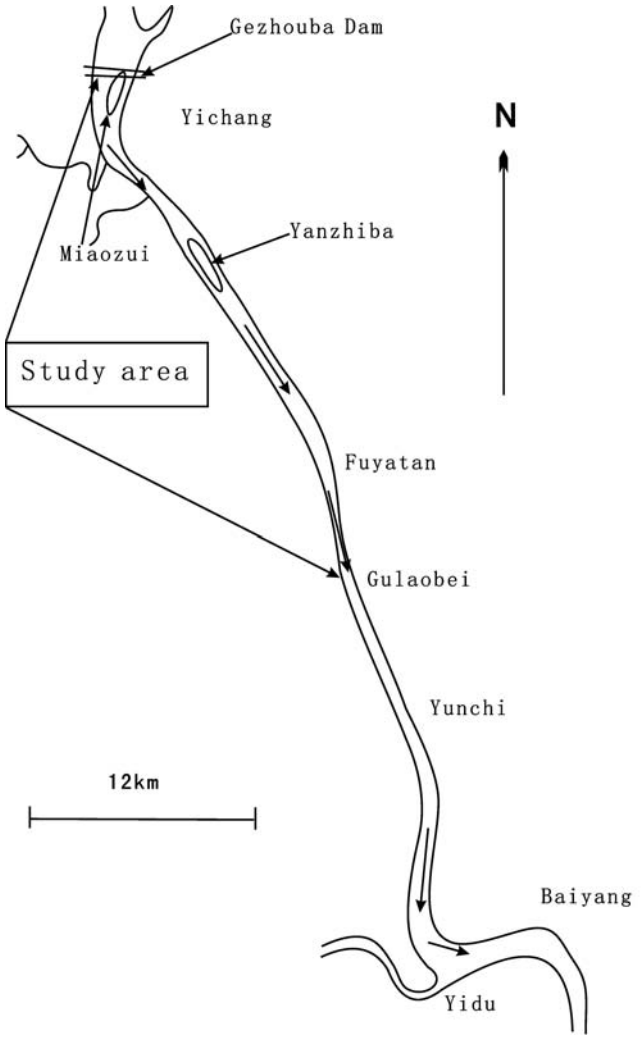

Fig. 2. Map showing the river stretch of the study area below the Gezhouba dam

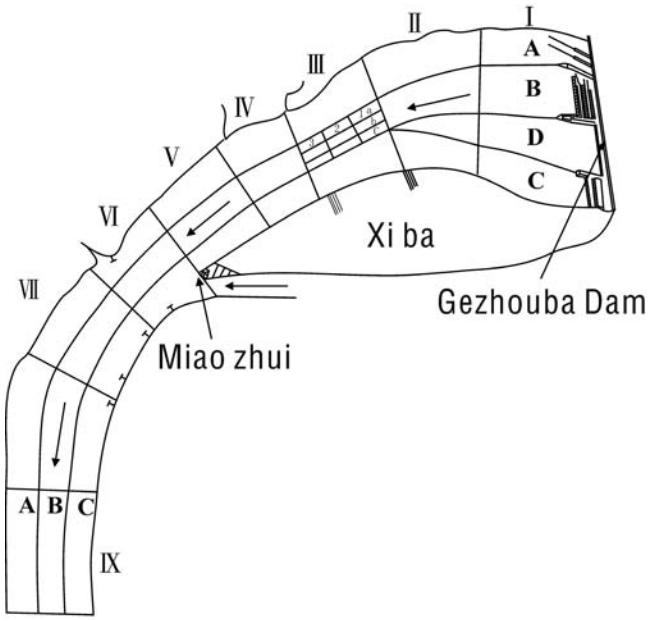

Fig. 3. Map of Yichang section of the Yangtze River showing the observation grid and the labeling of the grid for allocation of re-locations of tagged and released mature sturgeons

signals for effective tracking. The ultrasonic receiver used was an USR-5W instrument with the frequencies of signals received in the range of 28-88 KHz. The range of distances for signal detection relative to river conditions were within 500 m to1000 m.

The Global Position System (GPS) receiver was Meridian before 1997. Its position precision was about 15 m. The equipment was replaced in 1997 by a GARMIN 12XL system with difference functions improving the precision to about 5 m.

The length of the tracking boat was 630 cm powered by a 63.4 kw engine. The boat could easily reach high speed, operated at low noise level and was easy to control.

Fish Capture and tagging

Adult Chinese sturgeons were captured by fishermen in the autumn each year from 1996 to 2004 (except 2002). The river range in which Chinese sturgeons were captured was from the dam downstream to Miaozhui (Fig 2). Fish used for the tracking study were carefully selected to be healthy with no external damages when received from fisherman. Sex and stage of gonad developmental were identified. Males and females showing advanced gonadal development (middle to late stage IV) were tagged with both ultrasonic emitter and stainless steel tag (size is 5cm×10 cm, with the affiliation of the investigators identified on the tags (e.g. telefon number and full address of the Yangtze River Institute).

Tags were fixed near the fifth or sixth dorsal scute of the body by stainless steel wire or brass wire (diameter was 1.5-2.0 mm). Tagged sturgeons were immediately released into the Yangtze River. The site of release was in the section of Miaozui, Yichang City, Hubei Province (Fig. 2). Total time needed from the time of arrival to tagging and final release took on average no longer than 45 min. There were in total forty Chinese sturgeons tagged between 1996 and 2004 (except 2002). Thirty –five of these fish were females and five were males (Table. 1).

Locating fish and tracking

Tracking begun immediately after release of the fish. Thereafter, tracking periods were set four times every day, starting generally at 06:00 hrs (Beijing time zone), continuing at 10:00 h, 14:00 h and at 18:00. No tracking was done during the night. The time for locating fish was usually between 1 and 2 hours. During tracking the boat moved slowly downstream, adjusting the direction and speed frequently to properly cover the study area. The identified spot data of a tagged sturgeon were recorded immediately when the code signals the from taggs detected. Data recorded included the serial number of coded tag, the GPS location information and the water depth.

Results

Overall tagging and tracking

A total of forty Chinese sturgeons were tagged over the eight years study period. The total number of times fish were re-located was 1619 between 1996 and 2004 (Table. 2). Table 2 also provides the information on the date of release, the size and sex of the fish and the number of re-locations of each fish during the respective observation period. We tagged and tracked ten Chinese sturgeons (9 females and 1 male) in 1996. Seven tagged sturgeons (6 females and 1 male) were located on the spawning ground when they actually spawned. Six sturgeons (4 females and 2 males) were tagged, tracked and re-located in 1997. The number of sturgeon tagged is ten in 1998. Nine sturgeons of them are female and one is male. One female sturgeon (fish code is 249) had not been detected for our tracked after released.

Unsuccessful tracking trials

The data obtained in 1999 and 2000 are considered not reliable because of tag signals being detected from the river came from always from the same position whenever tagged sturgeons were released since a few days. Also, the spot located was not changed for a long time in 1999 and 2000. For example, the sturgeon with tag code 5 (fish 5#) was released in Oct 18, 1999. The code signal was detected at the case I2-Bb (Fig. 3) all along from Oct 23 into Nov 16, 1999 while again the same position was detected in the autumn 2000 and 2001. Similarly, fish 339# and fish 12# showed the same fixed location as fish 5# in 1999. It can be assumed that the continued signals refer to lost tags.

Table 1
Capture and tagging data for adult Chinese sturgeons in the Yangtze River used for hydro-acoustic tracking between 1996 and 2004 (except 2002)

Years	Number of Chinese sturgeon tagged		
	Total	Females (no and total length range, cm)	Males (no and total length, cm)
1996	10	9 (280-342)	1 (246)
1997	6	4 (279-345)	2 (257-270)
1998	10	9 (285-330)	1 (270)
1999	3	3 (320-360)	0
2000	3	3 (275-330)	0
2001	2	2 (325-345)	0
2003	3	2 (291-326)	1 (265)
2004	3	3 (293-335)	0
Total n	40	35	5

Table 2
Capture and tagging histories of adult Chinese sturgeons tagged and tracked during the telemetry study at the river stretch below the Gezhouba dam; f = females, m = males

Fish code	Sex	TL (cm)	Capture/tag date	Number of days tracked	Number of times located	Number of days located	located on spawning days
999	f	280	Oct 10, 1996	45	120	39	Yes
239	f	342	Oct 11, 1996	17	34	13	Yes
248	f	310	Oct 11, 1996	15	67	15	Yes
338	f	320	Oct 12, 1996	43	108	36	Yes
285	f	330	Oct 12, 1996	17	65	15	Yes
294	f	320	Oct 12, 1996	15	48	14	Yes
357	f	304	Oct 13, 1996	9	21	8	
257	f	295	Oct 13, 1996	6	11	5	
347	f	342	Oct 14, 1996	13	31	12	
339	m	246	Oct 15, 1996	15	67	15	Yes
555	m	257	Oct 9, 1997	32	53	27	Yes
456	f	345	Oct 9, 1997	15	24	10	Yes
267	m	270	Oct 9, 1997	33	56	30	Yes
258	f	279	Oct 10, 1997	12	30	11	Yes
249	f	338	Oct 14, 1997	10	19	8	Yes
348	f	305	Oct 14, 1997	10	19	8	Yes
357	f	330	Oct 8, 1998	62	123	50	Yes
447	f	299	Oct 8, 1998	19	46	17	
339	m	270	Oct 8, 1998	32	72	28	Yes
258	f	322	Oct 9, 1998	13	10	6	
249	f	330	Oct 9, 1998	13	0		
267	f	300	Oct 10, 1998	18	37	16	Yes
348	f	315	Oct 18, 1998	52	104	41	Yes
446	f	330	Oct 22, 1998	17	22	13	Yes
245	f	330	Oct 23, 1998	4	15	4	Yes
365	f	291	Oct 23, 1998	4	7	4	Yes
339	f	360	Oct 7, 1999	41	91		
5	f	344	Oct 18, 1999	30	63		
12	f	320	Oct 21, 1999	26	52		
8	f	275	Oct 11, 2000	60	88		
9	f	310	Oct 14, 2000	40	78		
11	f	330	Oct 19, 2000	16	9		
7	f	323	Oct 16, 2001	39	0		
6	f	345	Oct 20, 2001	35	0		
335	f	326	Oct 9, 2003	39	2		
243	f	291	Oct 10, 2003	38	0		
333	m	265	Oct 19, 2003	39	9		
4567	f	310	Oct 14, 2004	33	5		
333	f	335	Nov 5, 2004	23	8		
234	f	293	Nov 6, 2004	22	1		

In 2001, we tagged and released two female sturgeons at the same site but did not detect any signals from the tags after release. The reasons are unknown but may be due to electrical failures.

In 2003, we tagged and released three sturgeons but the total number of times located is 11 only. Fish no 335 (female) was recaptured 7 days after release but was located only two times during this period. Fish no. 333 (male) was located 8 times. Fish no 243 (female) was never found after release. Few re-locations were obtained in 2004 and the core period for sound data analysis of this study focuses on the period 1996 to 1998.

Distribution based on tracking results

Total number of re-locations of tagged fish were 1,209 over the three years (1996-1998) observation period which always covered the spawning season. The results indicate a narrow distributional area coverage by the mature fish. The section mostly used by the tagged sturgeons appeared to be the area I-B and this holds for the observation period of each year (Fig. 3). It can be concluded that this area forms the center of distribution in this river stretch and below the Dajiang power plant of the Gezhouba dam. The area is close to the buildings of Gezhouba dam and the distance covered is about 250-500 m. The percentage of re-locations in this area was 53.7% in 1996. In 1997 and 1998, the percentage was 83.6% and 51.9%, respectively. However, there were no significant differences (t-test) observably between different years. (Table.3)

Both females and the male were primarily observed in the areas I-B and II-B before they spawned. The percentage of times the females were located in I-B area was 60.4% and in II-B area was 19.4% prior to spawning. In total, the 79.8% overall detection rate is satisfactory. The percentage value of the times the male was detected in areas I-B and II-B was 64.2% and 7.5%, respectively. There was no obvious difference in the distribution of the detected locations of tagged sturgeons in different years (t-test). The percentage of detected locations for the male was slightly higher in the lower river section then that for females (Table 4).

The tagged sturgeon have two main areas of distribution during their propagation period. For example, the nine tagged mature sturgeons during first propagation period (20th, October) in 1996 arrived at areas I-IIBb within 1 to 2 days before they spawned. Five of them were in this area while the other 4 remained downstream within areas III-IVB during spawning. The data assure us that the area of actual spawning of the Chinese sturgeon is in sections I2-3Bb which is also in accordance with the results of location and collection of Chinese sturgeon eggs at the bottom of the river. During the second period of propagation (about October 27th) of this year, eight sturgeons (7 females and 1 male) were located (one female code 357 left after the first spawning). The spawning spot was identified in area sections III2-IV3Bb. Six of the fish (5 females and 1 male) were detected in area III-IVBb during active spawning, however, another two sturgeons (fish code is 239 and 347) were detected in area IB.

There were six sturgeons (4 females and 2 males) tagged and released in 1997. Three females were detected on the spawning ground (areas III2-IV3Bb) during the first propagation period (October 22nd) while three (1 female and 2 males) were located in area I1Bb. During the second propagation period, the male coded 267 was still located in the area I2-Bb on November 18.

Ten fish (9 females and 1 male) were tagged in 1998 and 8 of them (7 females and 1 male) were located on October 26, and 7 of them (6 females and 1 male) were located in areas IVBb and the remaining female (code 267) was detected in area I1-Bb.

Water depth of located adult Chinese sturgeon

We recorded also the water depth of the locations at which tagged sturgeons were located. Statistical analysis was performed to distinguish between pre-spawning and spawning period detections. Twenty-five tagged sturgeons were located in total 790 times during the pre-spawning period in the years 1996 to1998. The mean value of water depth of the locations where fish were detected ranged from 9.7 to 14.5m. while the mode value was 7.9 to 9.8 m.

Table 3
Number of times and proportion of the tagged sturgeon located per case on the spawning ground between 1996 and 1998. Positions as identified in the grid of Figure 3

Position of case	1996		1997		1998	
	Number of times located	Proportion (%)	Number of times located	Proportion (%)	Number of times located	Proportion (%)
A	8	1.4	1	0.5	3	0.7
B	307	53.7	168	83.6	227	51.9
C	5	0.9			1	0.2
A	6	1.0	4	2.0	1	0.2
B	132	23.1	10	5.0	11	2.5
C	3	0.5			1	0.2
D	2	0.3				
A	6	1.0			2	0.5
B	30	5.2	5	2.5	6	1.4
C	1	0.2	1	0.5		
A	6	1.0	1	0.5	3	0.7
B	29	5.1			104	23.8
C	1	0.2			1	0.2
A	19	3.3	1	0.5	21	4.8
B	9	1.6	2	1.0	12	2.7
C	1	0.2	2	1.0	15	3.4
A	2	0.3			8	1.8
B	3	0.5			10	2.3
C			2	1.0	1	0.2
A	2	0.3	2	1.0	4	0.9
B			1	0.5	2	0.5
C			1	0.5		
A					2	0.5
B					1	0.2
C					1	0.2

This indicated the range of water depths where tagged sturgeons mostly appeared was within the 8-12m range. There were distinct differences for water depth in 1996 and 1998 which were not as apparent in 1997.

During the spawning period, the overall mean values for water depth locations ranged from 7.8 to 15.2 m for the studies between 1996 and 1998. The mode values ranged between 7.6 and 9.4m with little changes between years. Both females and males stayed most frequently at water depths ranging between 8m and 12m. Comparatively, small males seemed to move more frequently. There were differences in water depth occurrences by sex during the actual spawning period.

Discussion

Behaviour and movement of mature Chinese sturgeons during the propagation period

Table 4
Number of times and proportion of the tagged sturgeon females and males located each time on the spawning ground from 1996 to 1998

Position of case	female		male		Female and male	
	Number of times located	Proportion (%)	Number of times located	Proportion (%)	Number of times located	Proportion (%)
A	8	1.3			8	1.1
B	361	60.4	102	64.2	463	61.2
A	3	0.5	3	1.9	6	0.8
B	116	19.4	12	7.5	128	16.9
C	3	0.5	1	0.6	4	0.5
A	7	1.2			7	0.9
B	20	3.3	2	1.3	22	2.9
C	1	0.2			1	0.1
A	6	1.0	1	0.6	7	0.9
B	9	1.5	6	3.8	15	2.0
C			1	0.6	1	0.1
A	22	3.7	6	3.8	28	3.7
B	12	2.0	5	3.1	17	2.2
C	15	2.5	2	1.3	17	2.2
A	4	0.7	7	4.4	11	1.5
B	3	0.5	9	5.7	12	1.6
C	1	0.2	1	0.6	2	0.3
A	3	0.5	1	0.6	4	0.5
B	1	0.2			1	0.1
A	3	0.5			3	0.4

The tagged Chinese sturgeons displaced usually three behaviour patterns when released into the Yangtze River. Observations are limited and therefore are reported here rather than presented as firm results. Some of the fish swam upstream, some moved downstream and others stayed around the point of release for no longer than 24 hrs and usually swam upstream towards the dam thereafter. For example, of the ten tagged sturgeons released in 1996, five swam immediately upstream at different speeds while two were detected soon downstream at short distances from the releasing point. The other three were not recorded instantly, while they appeared in areas I-II about two to three days later. Again, there was no continuous recording and one can only draw indirect conclusions from these observations.

Likewise, the mature sturgeons appear to be more actively moving the last two to three days before spawning starts. This seems to be obvious from tracking and locating of tagged sturgeons, particularly in males. Further research is needed to assure whether mature sturgeons search actively for suitable spawning spots at this period. Commonly, mature females moved to the spawning ground one day before spawning. The distance to the spawning ground inhabited was not long and females swam fast to the spawning ground when they began spawning. There were only four records during the propagation in areas III-IVBb between 1996 and 1998. Although the number of observations is small, the tagged sturgeons were always detected in areas I-IIB one day before spawning. During the active propagation period in 1996, a total of five mature sturgeons were observed to move from area I-IIB to areas III-IVBb (the identified active spawning ground) within a time frame of 20 min to 16 hrs. The number of observations are indicative but not sufficient to draw firm conclusions and further studies are needed.

The question on how many hours are needed for a running ripe female or male for spawning and how long do individuals stay in total on the spawning ground is certainly of high interest Only a rough estimate is possible from our study, leading to the assumption that females stay most likely less than 24 hours in the actual spawning area while males may stay up to 75 hours. However, these estimates do contain uncertainties because tracking and relocating were not performed continuously.

There were some differences in movements between females and males after spawning. Usually, tagged females left the area immediately after spawning. Even when tracking further downstream to the Gulaobei section of the river, it was impossible to detect females any longer (down to Yichang City). The only reasonable explanation is that after spawning females migrate downstream very fast. However, several females swam first upstream towards the dam (area I-II, Figure 3) and stayed there for quite some time. Possibly these females may not have spent all eggs and may have waited for a second spawning. There were 8 female tracked and tagged in 1996 and 6 of them disappeared immediately after spawning. The other two females stayed at sections below the dam, mainly in area I-IIB. There were 7 females tagged in 1998 and 4 disappeared after spawning. The other three stayed below the dam and one of the three (code 446) stayed mainly in area I, while frequently moving between areas I and VIII. This sturgeon disappeared on day 13 after spawning (Nov. 7, 1998). Another two sturgeons (code 357 and 348) were in IV2Bb and I3Bb area respectively. Again, there need to be further tagging experiments with more intensive time resolution in observations to draw clear conclusions. In several cases signals may also have originated from lost tags, imitating a stationary behaviour of the fish.

Distribution and environmental ecology during propagation

The spawning ground of Chinese sturgeon as revealed in this study extended primarily from just below the Gezhouba dam to the Yan-

zhiba section of the Yangtze River (Wei, 2003). The area coverage of the spawning ground has been located quite reliably and exactly in our investigations between 1996 and 2004. More precisely, the upper boundary of the spawning ground is from below of the Dajiang hydro-power plant to the lower boundary of the Miaozui section of the Yangtze River. The length of this stretch is about 5 km. Apparently, fish did not move to the area below the Erjiang hydro-power plant which exhibits the highest water velocities at all times along the spillway. Likewise fish did not appear in area of the Sanjiang River which has slow currents all along. Sometimes few mature adults would appear in the main stream of the Yangtze River from Miaozui to Yanzhiba, however, this area seems to be nothing but a quick pathway during spawning migration.

Hydrodynamics in the river and the topography of the riverbed seem to be most important factors to trigger spawning of the Chinese sturgeon (Wei, 2003). The identified spawning habitat of the sturgeons exhibits two important physical components: (a) rocky substrate and (b) a moderate water velocity (Bemis and Kynard, 1997). These factors seem not to be within acceptable level at Erjiang to provide the appropriate cues. The behavioural urge of the Chinese sturgeon to migrate upstream for spawning to the upper of Yangtze River still exists and influence the behaviour, thereby continuing the search for ways upstream near the section from the water outlet of the Dajiang hydro-power plant to Miaozui which seem to content similarity in conditions. Therefore, this area seems to be very important as an alternative spawning area and needs to be maintained for the remaining Chinese sturgeon stock.

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