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INTENSIVE CULTURE OF AMUR STURGEON (ACIPENSER SCHRENCKI) FINGERLINGS IN A RECIRCULATING AQUACULTURE SYSTEM

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ABSTRACT The present paper described a recirculating system of Amur sturgeon fingerlings intensive culture. In the recirculating system of 120 m3 water and 19kg/m3 sturgeon culture density, we utilized a set of BAF-40 two-layer floating bead biofilter with 4kW power and 40 T/h flow, and some other components to treat the culture water for reuse. During culture period, pH, DO, turbidity, ammonia, nitrite and nitrate were recorded and the length and weight of culture sturgeon were measured. The result shown that if water recycle was 3 hours and water exchange rate was 15% per day, the water quality was good and pH in 7~7.5, DO≥5mg/l, turbidity≤160 FTU, ammonia≤1.16mg/l, nitrite≤0.1~0.2mg/l, nitrate≤21mg/l. After 8 month culture, fish survival rate was 80%, and gained 5 times weight growth. The recirculating culture system can be successfully used in Amur sturgeon fingerlings culture.

Keywords: Floating bead, biofilter, recirculating system, sturgeon culture

INTRODUCTION Amur sturgeon (*Acipenser schrencki*) is an important component of Heilongjiang River Basin's fish resource. In the middle of 1990s, the capture amount of Amur sturgeon was dramatically decreased and this species become endangered in China [1]. Since then, a large amount of Amur sturgeon fingerlings was released into the river in autumn of each year to increase Amur sturgeon natural resource [2]. But, the recovery of Amur sturgeon resource is not evident [3] [4]. A rational reason was those released fingerlings were too small to resist the severe ice-covered water environment of winter. Releasing large fingerlings in spring season is an alternative way and the fingerlings must be reared indoor over winter period until up to the spring of next year. For this purpose, our research tried the feasibility of utilizing a recirculating culture system to culture Amur sturgeon fingerling.

In recirculating system, the success of aquaculture operation depends on how it effectively handles aquaculture wastes. The main wastes of aquaculture system are uneaten feed, excreta, chemicals and therapeutics [5] and the critical of those wastes are ammonia and solid waste [6]. Most recirculating systems require capable biological filters and solid capture devices to treat these wastes, together with other necessary components to maintain a favorable system environment. With research and development of recirculating system, its performance has been greatly improved and had been successfully used for culture of eel [7], rainbow trout[8], marine shrimp[9] and Nile tilapia [10], but did not attempt to rear Amur sturgeon fingerling.

In nature waters, Amur sturgeon fry and fingerling grow well in the temperature of 15~25℃, dissolved oxygen above 5mg/l and pH 7~8. Under the circumstance of recirculating aquaculture system, we must create a favorable water environment for Amur sturgeon fingerling to grow normally. In our study, based on the water treatment capacity of recirculating system and Amur sturgeon fingerling biological features, a recirculating system was designed, constructed and tested. During the experiment, water quality including pH, turbidity, DO, ammonia, nitrite, nitrate and alkalinity were measured and the growth rate and survival rate of fingerlings were recorded. The test result showed that it was possible to utilize recirculating system for Amur sturgeon fingerlings culture indoor.

1. Materials and methods

1.1. Composition of recirculating system

The system mainly consisted of twenty culture pools (No.1~20), equipped with water recirculating treatment components. Each pool could hold 6 m^3 of water. When the system run, the used water in culture pools was pressured to pass through mechanical filter and waste gasses stripping screen by the water-head difference between sediment tank and culture pools, and then flowed into sediment tank. In sediment tank, some chemicals were added to control water quality. Waste solids from mechanical filter and sediment tank were condensed as drain mud. Clear water flowed in an inlet tank, where the pump (with 40 T/h flow) worked. The pumped water passed through floating bead bio-filtering (with $2m^3$ plastic bead), ultraviolet (UV) irradiation, temperature control, and aeration, and then back to culture pools for reuse, as shown in Fig.1. The make-up water tank could supply the water loss of back washing bead bio-filter and 15% day's culture water exchange.

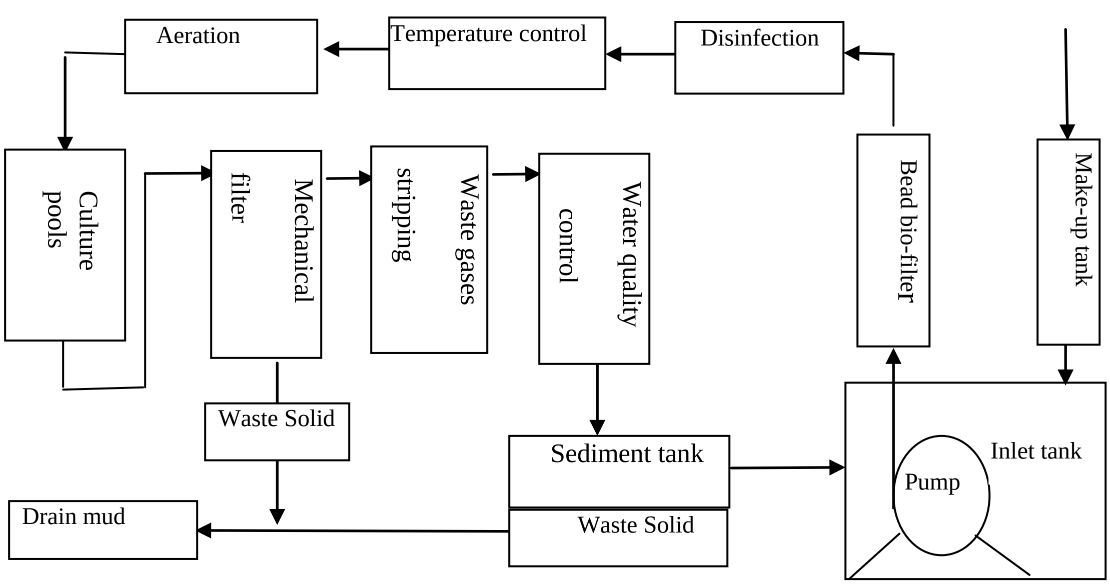

Fig.1.The recirculating culture system of Amur sturgeon fingerlings

Besides the system of culture water reuse, an on-line monitoring system of key water quality parameters was designed, including temperature (T), dissolved oxygen (DO), pH, and turbidity (TU). In the system, aYSI6920EDS V2-2 sonde was used as multi-sensor to take the variation signals of water quality. The YSI6920EDS V2-2 consists of T sensor, DO sensor (6562), pH sensor (6561), TU sensor (606136), and conductivity (CD) sensor. A SIMATIC S7-200 was used as programmable logical controller (PLC) and an EM231 as parameter identification connector. The monitor and control system was shown as Fig.2.

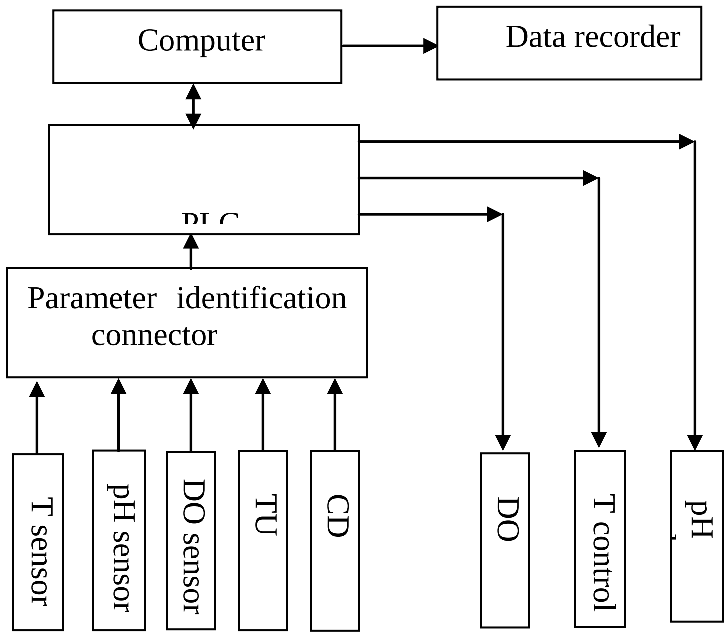

Fig.2 diagram of on-line monitoring and controlling water parameters

1.2. Materials

Amur sturgeon fingerlings were 5000 fishes with mean length of 30±0.20 cm and mean weight of 112±0.42g. At beginning, the culture density was 4.7 kg/m^3. During period of culture, the sturgeon commercial pellet was feed, $NaHCO_3$ (concentration1g/l) and NaOH (concentration11g/l) solutions were added into culture water to adjust alkalinity. The original culture water was ground water.

1.3. Methods

The culture experiment lasted for eight month from October to May of next years. The fingerlings were feed three times every day, at 8, 13, and 18 o'clock, with feed quantity of 1.5~2% total fish weight. Culture water was exchanged by 15% at 10 o'clock and meanwhile, if needed, the bead bio-filter was backwashed. Some quality parameters of culture water were monitored throughout culture period by monitoring system such as temperature, dissolved oxygen, pH value, and turbidity, and others were measured with test kits at 15 o'clock of everyday from every pool, such as ammonia, nitrite, nitrate and alkalinity. The fish growth was measured in body length and body weight in the 20th of every month, 20 fishes sample from each culture pool.

2. Result and discussion

2.1 Fish growth

In 8 month culture period, the total of 4013 fishes was survived and survival rate was 80%, the total weight of 2283 kg fingerlings was gained and the final culture density was 19kg/m^3.The fingerlings gained 5 times growth in mean body weight up to 569g and mean body length gotten 1.8 times long up to 57.7 cm. Fish growth variation was shown in Table 1.

From this experiment, sturgeon fingerlings were successfully cultured in recirculating culture system, and the problem of releasing large sturgeon fingerlings was solved for increasing the resource of natural waters. Although the culture density of 19 kg/m^3 was low, we tried a way of culturing Amur sturgeon fingerlings indoor during winter. Comparing with other species recirculating culture [7][8][9][10], the density should be increased up to 30~40kg/m^3 [11]. The probable improvement was to increased recycle water quantity from 40T/h to 60T/h~80 T/h to reduce the stay time of aquaculture wastes, or increase the volume of plastic bead to increase the capacity of waste treatment. After practical productive innovation, an effective recirculating culture system of sturgeon fingerlings is feasible.

Table1. Variation of fish growth and culture density

MONTH	MEAN LENGTH (CM)	GROWTH PER DAY (CM)	MEAN WEIGHT (G)	GROWTH PER DAY (G)	TOTAL NUMBER (FISH)	TOTAL WEIGHT (KG)	SURVIVAL RATE (%)	CULTURE DENSITY (KG/M^3)
OCTOBER	30.2±1.7		112±6		5000	560		4.7
NOVEMBER	34.9±2.1	0.16	134±8	0.72	4685	627	93.7	5.2
DECEMBER	40.4±2.6	0.18	164±11	1.01	4446	729	94.9	6.1
JANUARY	43.1±2.9	0.09	213±13	1.63	4245	904	95.5	7.5
FEBRUARY	46.0±3.2	0.10	273±15	2.02	4092	1117	96.4	9.3
MUCH	50.2±3.8	0.14	370±20	3.23	4018	1487	98.2	12.4
APRIL	53.5±4.2	0.11	468±24	3.26	4014	1879	99.9	15.7
MAY	57.7±5.1	0.14	569±31	3.22	4014	2284	100	19.0

2.2 Monitor and Control of water quality

During culture period, the water quality parameters of temperature, dissolved oxygen, pH value, and turbidity were monitored on-line and recorded in computer data recorder. All the four parameters were controlled well throughout of culture time. The variation of those parameters varied little from day to day.

In monitoring culture temperature, we designed the range of control as 18±1℃, and it was easy and effective. In culture process, there was little fluctuation of temperature, sturgeon grew normal and the recirculating system performed well.

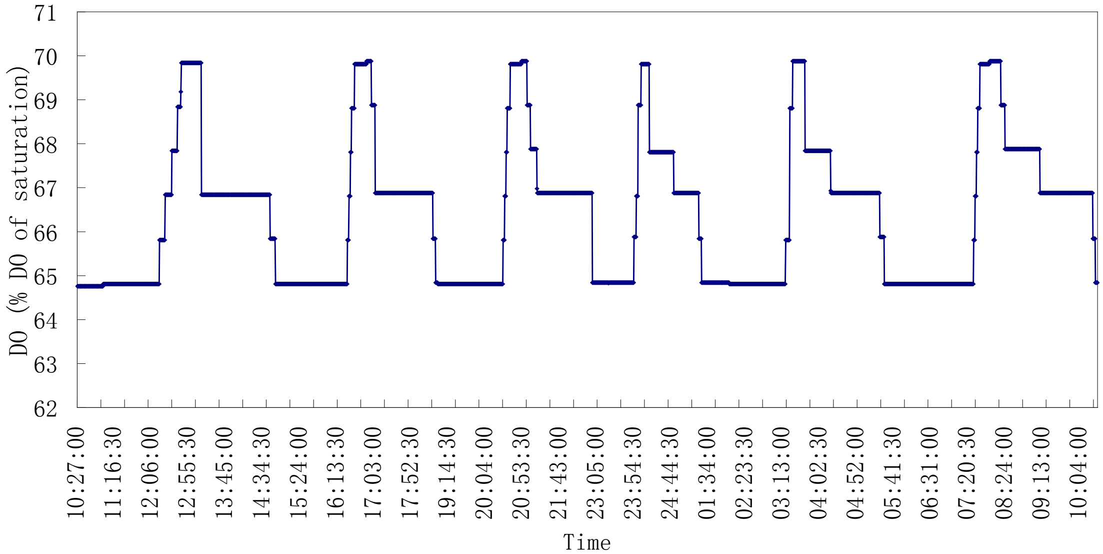

Fig.3 Variation of DO in 24 hour

In DO control, we set a range of DO as 65%~70% of saturation. When DO was less than 65% saturation, the controller droved the air-blower to work to supply aeration, and when DO reached to 70% of saturation, the air-blower was stopped aerating. In this way, DO was reliably supplied. The monitor and control system was effective. Fig.3 shows the variation of DO in a day. From Fig.3, we could find that the air-blow aerated the culture water for six times in 24 hour, and it worked for 30~60 minutes in each time. Through controlling air-blower, the DO of recirculating system was automatically supplied. The DO control could not only supplied enough DO for fish culture, but also save power and reduced cost.

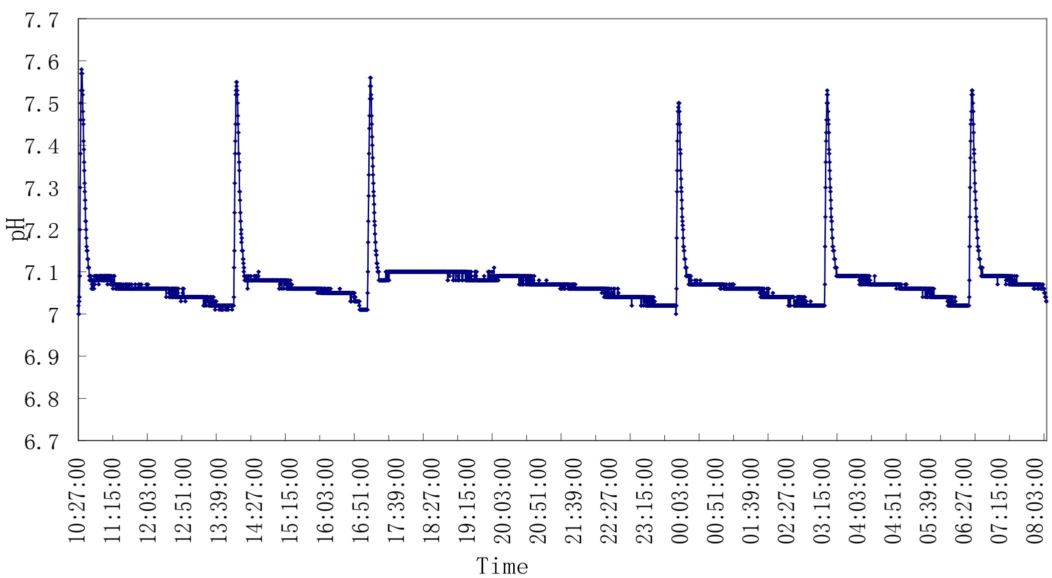

Fig.4 Variation of pH in 24 hour

In pH control, the control range of pH was set in 7.0~7.5. When pH was less than 7.0, the controller droved two electromagnetic valves opened to add $NaHCO_3$ (concentration1g/l) and NaOH (concentration11g/l) solutions respectively into culture water. The alkalinity of water was adjusted to increase pH. When pH was over 7.5, the electromagnetic valves were closed and the process of adjusting alkalinity ended. Fig. 4 shows the variation of pH in 24 hour. The value of pH was effectively controlled in range of 7.0~7.5. In this way, culture water alkalinity could meet the need of fish growth and ammonia nitrification.

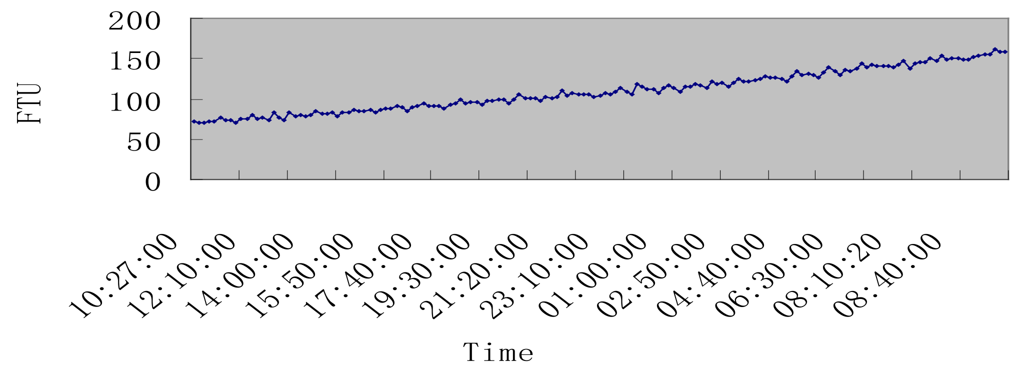

Fig. 5 Variation of Turbidity in 24 hour

In monitoring turbidity, the maximum of 150 FTU was set and the everyday record of turbidity was output from computer. When turbidity was over the max, the water exchange of everyday would be increased. By this way, water turbidity could be controlled. Fig. 5 shows the variation of turbidity in a day. From Fig.5, we could find that the turbidity was accumulated gradually in 24 hour, and the minimum was the value of half pass 10 when water exchange occurred.

2.3 Measurement of water quality parameters

Besides temperature, dissolved oxygen, pH, and turbidity, water quality management includes other factors that should be ammonia, nitrite, nitrate and alkalinity. Those water quality factors were measured with test kits everyday. The measurement data showed that ammonia and nitrate were increased gradually, and nitrite and alkalinity were stable in eight month culture period.

Fig.6 shows the variation of ammonia. The maximum value reached 1.16 mg/l from 0.01mg/l of beginning and was in the range of control standard. But, ammonia was accumulated slightly. In our experiment, the total fish weight of 560~2284kg could consumed 8.4~34.3kg feed (with 45% protein) per day and produced 0.3~1.4 ammonia-nitrogen (approximately 4% of feed becomes ammonia-nitrogen) [12]. According to about 325gTAN/m^3/day nitrifying ability of bead bio-filter [13], the bio-filter bead of 2m^3 was enough for the density 4~10kg/ m^3, but not for 19 kg/ m^3. Meanwhile, one recycle of culture water took 3 hour, it was much more than two hours of bio-filter recirculating time permit [14][15]. In order to control the buildup of ammonia, we increased the water exchange of everyday up to 15% of total culture water. Because of inadequate bead and insufficient water flow, bio-filter nitrification capacity was not enough and should be enlarged in future operation.

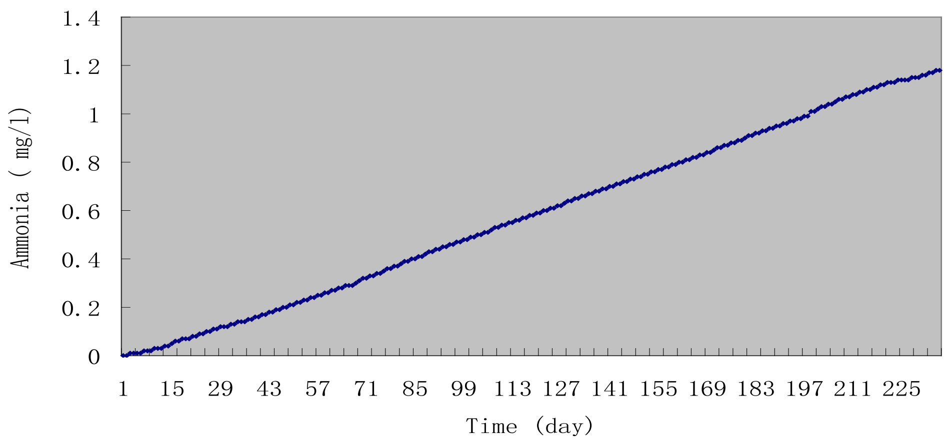

Fig.6 Variation of ammonia in culture period

Fig.7 shows the variation of nitrite. The data of measurement was fluctuated between 0.1mg/l and 0.2mg/l. Nitrite concentration was controlled well and no fish's toxicity was occurred. The 0.2mg/l of nitrite could be tolerant by Amur sturgeon. The result shows the bio-filter worked properly in the stage of converting nitrite to nitrate and nitrite could not buildup. Those results were benefited from good condition of water quality, including on-line control of DO in 65~70% saturation, pH in 7.0~7.5, and turbidity under 150 FTU. A good water environment factors ensured bio-filter work well and could reduced the toxicity of nitrite and ammonia.

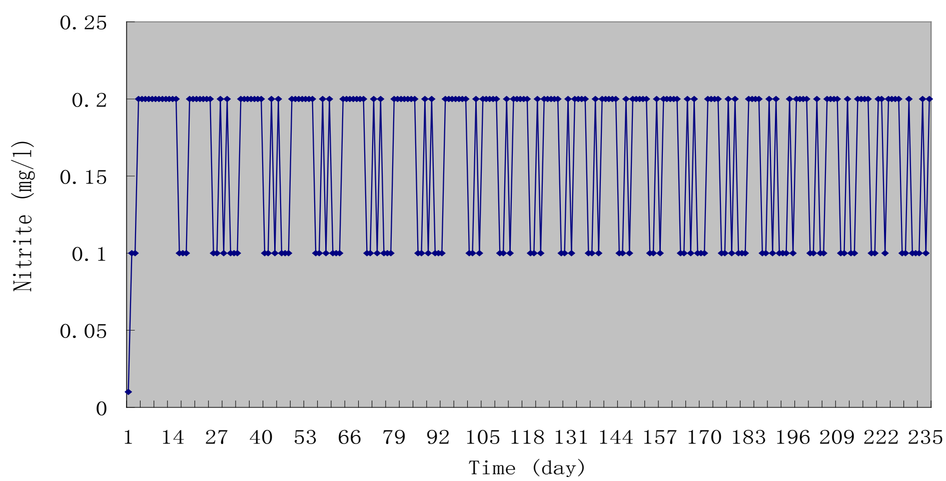

Fig.7 Variation of nitrite in culture period

Fig.8 shows the variation of nitrate. Nitrate increased greatly up to 21mg/l. The factor of nitrate increase indicated that bio-filter worked effectively during culture period. Because of relatively nontoxic, Nitrate could be accumulated up to relative high concentration in recirculating system. In the operation of system, exchange water of everyday could carry away certain nitrate, and in the process of bio-filter nitrification, some denitrification occurred and converted nitrate into nitrogen gases. The concentration of nitrate could not be increased such high as to toxicity to fish.

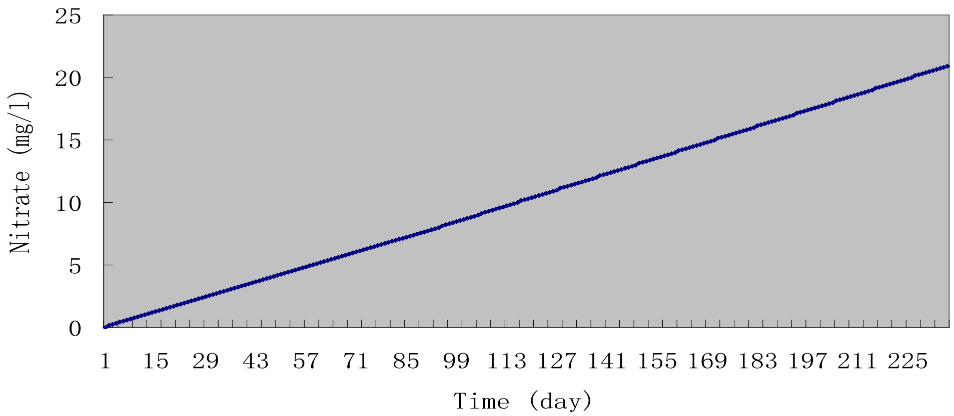

Fig. 8 Variation of nitrate in culture period

Fig.9 shows the variation of alkalinity. The alkalinity was changed between 1.1~1.3 meg/l. Because of pH on-line control with $NaHCO_3$ and NaOH solutions, the alkalinity was well adjusted in culture period and maintained optimum levels. The desired range of alkalinity was 50~100 mg/l or more as $CaCO_3$. In our experiment, the alkalinity of 1.1~1.3 meg/l was equal to 111 ~131mg/l $CaCO_3$, and could supply enough acid neutralizing substance. In adjustment of alkalinity, NaOH buffer was used to adjust pH quickly and $NaHCO_3$ was used to supply alkalinity. Sodium hydroxide was very caustic and could not be added directly to culture pools to harm fishes.

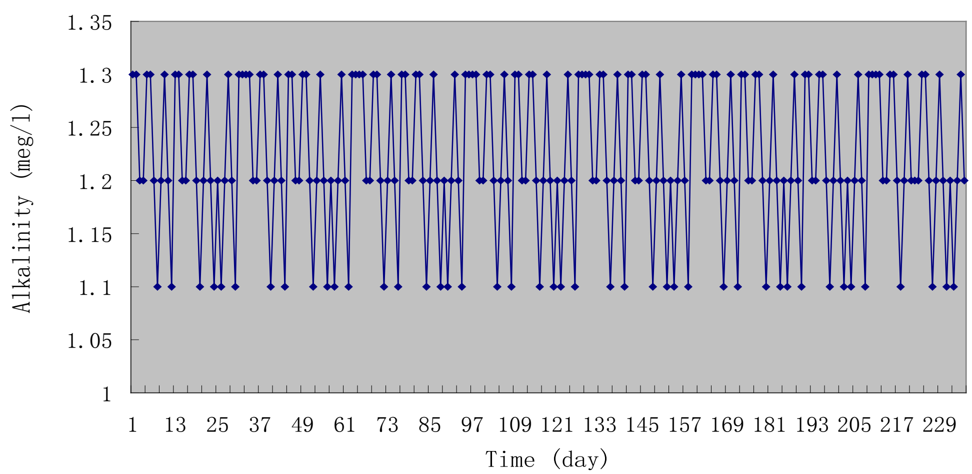

Fig. 9 Variation of alkalinity in culture period

3. Conclusions

Facility for growing Amur sturgeon fingerlings using recirculating systems is successful. The experiment result shows that the fingerlings grew normally and the quantity of culture water could meet the needs of fish growing. The experiment try supplied a feasibility to grow larger Amur sturgeon fingerlings for releasing in the program of resource increasing and shown that it was possible to culture Amur sturgeon fingerlings in door during severe winter.

Although the recirculating system could be used in culturing sturgeon fingerlings, it was at an experiment stage. For a practical commercial system, there is still a lot of technology to be improved. Firstly, the productive capacity of the facility should be enlarged and the density of culturing should be increased for increasing the efficiency of system. Secondly, the design of system should be improved in matching waste treatment with ability of equipments to save the investment. Thirdly, all the important parameters of water quality should be measured automatically to reduce the cost of test kits consume. To meet the conditions required for cost efficiency, an improved recirculating rearing system has to be adapted to Amur sturgeon fingerlings, the specific geographical location of cold weather and the economic situation.

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