Kootenai River, White sturgeon

Effects of environmental temperature on sturgeon reproduction

The adult sturgeon and paddlefish (Chondrostei) tolerate environmental temperature between 4 and 30^0, but their normal reproduction occurs in narrow temperature range. Temperature adaptations of the broodfish and progenies evolved from the reproductive strategy of Chondrostei: spawning in the upper-mid parts of the river, larval drift downstream, and the juvenile growth in the lower reaches and deltas. Most Condrostei species are the long-day breeders, spawning around the time from the spring equinox to summer solstice. The optimal temperature range for the broodstock maturation, spawning, and early life stages shifts, accordingly, from cooler to warmer water.

Several researchers conducted field and experimental observations on temperature requirements for sturgeon reproduction. Temperature effect on the final ovarian maturation, spawning, and embryogenesis in sturgeon from the Caspian and Azov Seas was reviewed by Detlaf et al. (1981). The effect of the thermal stress on maturation of the ovarian follicle in gravid sturgeon female was investigated by Detlaf and Davydova (1979). Igumnova (1985) described temperature effect on beluga sturgeon larvae. Kroll et al.(1993) elucidated survival and growth of the northamerican paddlefish larvae at different temperature.

In the white sturgeon (Acipenser transmontanus), temperature tolerance and development of the early life stages were investigated by Wang et al. (1985, 1987), and Buddington et al.(1993). The additional information on temperature effect on the late stages of oogenesis and spawning of domestic white sturgeon female was obtained by the White Sturgeon Broodstock Development Program in California (Domestic White Sturgeon Broodstock, 1992, 1993, unpublished). Based on the experience with white sturgeon stock of Sacramento River, we identified the optimal environmental range for the temperature-sensitive reproductive stages (Table). The Kootenai River stock is expected to have similar ranges, with possible 1-2^0 shift to cooler temperature and approximately 2-3 month delay in the ovarian development and reproductive season.

Table. Estimated optimal range of environmental temperature for temperature-sensitive reproductive stages of white sturgeon.

STAGE	RANGE (^{0}C)	SEASON
A. Final gonadal maturation	8 - 12 46-54F	Jan - Feb
B. Spawning & Embryogenesis	14 - 16 57-61F	Mar - Apr
C. Larvae to metamorphosis	16 - 22 61-72F	May - Jun

Brief description of each stage follows.

Stage A:

At this stage gavid sturgeon female completes vitellogenesis and polarization of the oocytes. The fish reside in deep river holes and are relatively inactive. Polarization of the oocyte includes the migration of nucleus (germinal vesicle, GV) towards the animal pole of the oocyte. It is measured by the polarization index (PI), a ratio of the GV distance from animal pole to oocyte diameter. Temperature-sensitive period starts when the PI is equal or less than 0.3 and extends to spawning, when the PI is less than 0.1. The mechanism of temperature sensitivity are not clear yet, but they may be related to endocrine secretion and temperature effects on egg microtubules and microfilaments. The cool water, below of spawning threshold level, is necessary for the female to complete this process. Low temperature delays maturation but allows spawning later in the season. Elevated temperature results in the egg reabsorption and the loss of spawning.

Stage B:

This stage encompasses spawning and embryonic stages from fertilization to hatching, with similar temperature ranges. The mature fish with completed stage A move from the holes to spawning grounds. Rise of water temperature to spawning level and the river flooding act as environmental cues for spawning. If the water temperature rises too high or the water level suddenly drops, the fish cease spawning and leave spawning grounds (Detlaf et al., 1993). Single female and several males constitute one breeding cohort. The process of ovulation and spawning continue for several hours (likely, 12-24 h). The eggs are dispersed by current over the large river area. The single egg attaches to the substrate by the adhesive gelatinous coat. Presence of the firm-surface unsilted substrate (large gravel, rocks, compact clay) and the river current are two prerequisites for the normal spawning and successful embryonic development. Embryos are temperature-sensitive, especially at cleavage and gastrulation (first three days after fertilization). Temperature below 8^0 and above 20^0 appear to be lethal for cleavage stage. Temperatures $8-12^0$ and $17-19^0$ may be suboptimal. After the gastrulation, embryos are less sensitive to temperature changes.

Stage C:

The development from hatching to metamorphosis (fry 30-35 mm TL, with differentiated fins and dorsal row of scutes) includes approximately 10-12 days of yolk sac stage and 15-20 days of the exogenous feeding stage. The yolk sac stage includes pelagic phase (passive drift downstream) and settlement phase (demersal). From the onset of feeding to metamorphosis, the larval development and survival primarily depend on the availability of zooplancton (cladoceran and copepod). After the metamorphosis, they become opportunistic feeders, with the major feeding upon benthic and nectobenthic animals (insect larvae, mysids, gammarids, etc). Warmer water after the onset of exogenous feeding benefits their

growth and survival. From approximately the end of yolk sac resorption (day 8-10 after hatching), the larvae and fry can tolerate wide temperature fluctuations (from 10 to 24^0), but their survival at low and high temperature extremes may be compromised by slow growth and respiratory stress, respectively. Temperature tolerance range of fingerling (after the metamorphosis) is likely to be similar with the adult form.

References

Buddington, R.K., J.R. Hazel, S.I. Doroshov, and J. Van Eenennaam. 1993. Ontogeny of the Capacity for Homeoviscous Adaptation in White Sturgeon (Acipenser transmontanus). The Journal of Experimental Zoology, 265: 18-28.

Detlaff, T.A. and S.I. Davydova. 1979. Differential sensitivity of cells of follicular epithelium and oocytes in the stellate sturgeon to unfavorable conditions, and correlating influence of triiodothyronine. General and Comparative Endocrinology, 39: 236-243.

Detlaff, T.A., A.S. Ginzburg, and O.I.Schmalgauzen. 1981. The Development of Acipenserid Fish, 223 p. Publishing House "Nauka", Moscow. (In Russian; English translation is now available from Springer-Verlag, 1993).

Domestic White Sturgeon Broodstock Program. 1992. Fifth Annual Report, October 1992. Aquaculture and Fisheries Program, University of California, Davis.

Domestic White Sturgeon Broodstock Program. 1993. Sixth Annual Report, October 1993. Aquaculture and Fisheries Program, University of California, Davis.

Igumnova, L.V. 1985. Effect of temperature drops on embryonic development of the beluga sturgeon and the stellate sturgeon. Journal of Ichthyology, 24: 85-90.