# LOWER YELLOWSTONE RIVER PALLID STURGEON STUDY

by

Jay H. Watson
Phillip A. Stewart

State of Montana
Department of Fish, Wildlife and Parks
Fisheries Division
Miles City, MT 59301

In Cooperation with

U.S. BUREAU OF RECLAMATION
Great Plains Region
Billings, MT 59107-6900

(GRANT AGREEMENT NO. 1-FG-60-01840)

September 1991

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**ABSTRACT**

Drifted gill nets, trammel nets and baited long lines were used to locate pallid sturgeon in the Yellowstone River and two major tributaries between the Cartersville and Forsyth diversion dams from April to August 1991. A total of 16 fish species were captured, with shovelnose sturgeon being the fish most frequently collected. A single pallid sturgeon was captured July 18.

## INTRODUCTION AND OBJECTIVES

The general level of interest in the pallid sturgeon has greatly increased because of its listing as an endangered species in 1990 (Federal Register 1990). The impetus for the study was the proposed rehabilitation and increase in elevation of the Tongue River Dam spillway. The increased reservoir storage would possibly allow it to be operated to seasonally increase spring streamflows to benefit pallid sturgeon spawning if there were, in fact, pallid sturgeon still present in the Tongue River or nearby Yellowstone River.

There is evidence that the pallid sturgeon was once common in the Yellowstone River near the mouth of the Tongue River but, until the present study, the most recent, well documented, sighting upstream of Intake Diversion dam was in 1950.

One objective of the present study was to determine if pallid sturgeon were still present in the Yellowstone River between the Cartersville (Forsyth) and Intake diversion dams. The second objective was to tag any pallid sturgeon collected.

The survey was undertaken through funds provided by the U.S. Bureau of Reclamation, Billings, Montana (Grant Agreement No. 1-FG-60-01840).

## STUDY AREA DESCRIPTION

The study area is located in southeastern Montana in the Yellowstone River drainage. It included 314.0 kilometers (195 miles) of river as follows: the Yellowstone River between the Cartersville Diversion Dam at Forsyth and the Intake Diversion Dam northeast of Glendive (267.7 km; 166 miles), the Tongue River from the Tongue and Yellowstone Diversion to its confluence with the Yellowstone (32.8 km; 20.4 miles), and the Powder River from river km 13.5 (mile 8.4) to its confluence with the Yellowstone (Figure 1).

The river system was further divided into seven sections which displayed a wide variety of characteristics (Table 1). There are three diversion dams located within the study area which provide at least a partial physical barrier to fish movement. The only study area that did not include a diversion dam was the Powder River. The upper boundary of the Powder River study section was set at river km 13.5 simply because it was difficult to travel above that point in the jet boat.

## METHODS

Information on streamflows in the study area streams was obtained from the Billings office of the U.S. Geological Survey (Table 2).

Two methods were used to capture pallid sturgeon (Scaphirhynchus albus). These were set lines and drift nets. This gear was used in the study area over the period April 23 through August 1, 1991.

Set lines, known as long lines, were placed throughout the study period in all the river sections. They consisted of one or two anchors, 6-10 detachable hooks, and a length of rope between 100 and 200 feet long. The number of anchors and hooks and the length of rope used was determined by the size of the river or channel and by the speed of the current. Long line position and depth, current and substrate present and any special features were all taken into consideration and recorded when making sets. Flathead chubs (Hybopsis gracilis) were used for bait, when available, since they are thought to be a preferred food of pallids (Bill Gardner, Pers. Com.). Common carp (Cyprinus carpio), channel catfish (Ictalurus punctatus), goldeye (Hiodon alosoides), leopard frog (Rana pipiens), shorthead redhorse (Moxostoma macrolepodotum), river carp sucker (Carpoides carpio), white sucker (Catostomus commersoni), and yellow bullhead (Ictalurus natalis) were all used to a lesser extent.

Lines were set and left for approximately 24 hours before they were checked. Set line effort was then described by set line days for any given section of river or time period (Tables 3 and 4).

Two types of drift nets were used in the sampling effort. Sinking trammel nets 150 feet long, 6 feet deep, with a 2-inch mesh inner wall and 12-inch mesh outer wall received the most use. Three-inch mesh sinking gill nets in lengths of 50 and 150 feet were used under certain conditions when trammel nets were not suitable. These conditions were 1) when working small, slow and shallow rivers, 2) during very high debris periods, and 3) during high water periods in very fast water.

Both types of nets were set from the bow of the boat and towed into position to begin a drift. The net was allowed to drift downstream for a maximum time of 45 minutes. Net effort was recorded from the time the net was in the water and in a position to catch fish until it was pulled back into the boat. This was recorded both in hours and by river miles (Tables 3 and 4).

Fish caught were then tallied by drift net or long line set. Fork length and weight were taken on all sturgeon and 70% of the other fish caught. Eleven additional measurements to determine hybridization between pallid sturgeon and shovelnose sturgeon (Scaphirhynchus platorynchus) were also taken (Appendices 1-3). These measurements were taken on approximately 25% of the shovelnose and on the one pallid sturgeon captured.

## RESULTS

### Pallid Sturgeon

A pallid sturgeon was captured in a trammel net on 18 July 1991 near Fallon, Montana at river km 208.2 (mile 129.3). The river in this area is fairly wide and shallow, being three to six feet deep with a deeper, six to ten feet, outside bend. It was most likely caught on the upstream side of a submerged gravel bar in three to five feet of water. The current at this location was of moderate speed but was the fastest water in the vicinity because of gravel bars on either side of the river which funneled flow into a narrow channel. Upstream of this point, the river was wide and shallow for approximately one mile before it narrowed and deepened.

Downstream from the capture site, there was a long and gradual bend which exhibited some deeper water on the outside bend and very shallow water on the inside bend. The substrate was composed mainly of gravel and rock with some large rocks in deep water below the capture site. Two shovelnose sturgeon (SNS) were also caught at the same time near the capture site of the pallid sturgeon.

The pallid weighed 11.34 kg and the fork length measured 1,340 mm, one of the smaller fish captured in Montana in recent studies. It was tagged with a yellow floy disk tag number 1,111, photographed and released.

Two more drifts were attempted later that day but they produced only one more shovelnose sturgeon. Three days later the area was again sampled with a trammel net but no additional pallid sturgeon were captured. During the total field period, trammel and gill nets were drifted for 95 hours in 264.5 kilometers (164.3 miles) of river to obtain this single pallid.

### Other Fish Species

A total of 724 fish were captured by all sampling methods during the study period. In addition to the one pallid sturgeon, we captured 349 shovelnose sturgeon and 374 fish comprising 14 other species. Sturgeon were caught only in nets. Of the other species, 91% were caught in nets and 9% on set lines. Set lines caught mostly channel catfish. Total effort for all sampling techniques by time periods and river sections is shown in Tables 3 and 4.

Streamflows during the field portion of the study (April through July) were mostly near average with the exception of May and especially June on the Yellowstone River (Table 2). Sampling effort during June on the Yellowstone River was reduced because of hazardous working conditions from high flows and because nets rapidly filled with debris.

Shovelnose sturgeon were the most frequently caught species. They composed over 46% of the total fish caught. A few shovelnose sturgeon were caught in all habitat types, but the majority were taken in areas with level bottom, moderate to fast current and gravel substrates. This was true for both the spawning and early summer periods.

Numbers of shovelnose sturgeon collected by time period are shown in Table 5. Catch per unit effort is given in Table 6. Both the numbers caught and the catch rate were highest in the two tributaries during the spawning period and in the Yellowstone River in late July. Both tributaries are known spawning areas (Peterman and Haddix 1975; Rehwinkel 1978). Low catch per effort in the Yellowstone River during the spawning period was probably caused by migration into the two tributaries and by high water.

Length and weight data for shovelnose sturgeon captured are given in Table 7. Sturgeon in the two tributaries tended to be larger than those sampled in the Yellowstone River. Both tributaries have sturgeon present only during the spawning period. Sturgeon less than 1.16 kilograms (2.56 pounds) in weight were not collected in the Tongue or Powder Rivers, but sturgeon smaller than this were common in the Yellowstone River.

Tables 8 and 9 show numbers of non-sturgeon fish species captured by time periods and river section. Of these species, river carpsucker and channel catfish were most abundant. Catch rates were lowest during the June high water period. Table 10 contains the mean, minimum and maximum lengths and weights for non-sturgeon fish species. Except for channel catfish, most of these fish were caught in trammel nets. Most channel catfish were caught on long lines.

Morphological measurements were taken on the pallid sturgeon and a number of the shovelnose sturgeon (See Appendices). These are shown by percent of total length and used to determine the amount of pallid and SNS hybridization. This data has not been analyzed. There has been no evidence yet to suggest that there is any hybridization occurring in the Yellowstone River (Clancy 1991). Sturgeon with morphology intermediate between the pallid and the shovelnose have not been found.

## DISCUSSION

Sampling techniques used in this study (netting and set lines) were constantly being altered to improve sampling efficiency. Late April and early May were unproductive in the Yellowstone River even though the river flow conditions were suitable for sampling. In this case, the low catch rates were probably due to fish location. Fish were inhabiting areas that could not be effectively sampled. As the flow increased in the Yellowstone, it also increased in the

Tongue and Powder rivers. These tributaries then became accessible by boat for sampling starting in mid-May. Prior to this time, low flows prevented any kind of sampling by boat. Starting in mid-July, the Yellowstone River flow decreased enough to begin effective sampling again. This coincided with flow decreases in the Tongue and Powder rivers, which once again prevented any kind of boat access. Sampling on the Yellowstone after mid-July became much more productive than in earlier months.

High flows not only decreased sampling effectiveness by increasing velocity of the river, but also by increasing the amount of debris in the water. Trammel nets were ineffective under these conditions. The trammel net, having a much greater surface area, rapidly filled with debris. The current pushed the top end of the net down. This decreased the amount of area that the net would sample since it was not hanging vertically. In addition, sampling time was lost when the net filled with debris and had to be cleaned and repaired.

It took up to one hour to clean and repair nets in this condition. Gill nets did not eliminate these problems but lessened them considerably.

Set lines were also unproductive under high water conditions. Debris collected on the line and covered the hooks at times. Water temperature and turbidity may have also contributed to the low catch rates.

## RECOMMENDATIONS

1. Continue efforts to sample pallid sturgeon in the study area and to understand its status.

2. Extend sampling effort into August and September on the Yellowstone River. Sampling efficiency seemed to increase greatly in late July. August and September might also be good sampling months.

3. Continue sampling in all habitat types. Pallid sturgeon preferred habitat in the study area is not yet defined.

4. Eliminate Yellowstone River sampling during the high flow period and concentrate instead on tributary streams where sampling is more effective.

5. Eliminate early spring sampling. Very few fish of any kind were collected during this period.

6. De-emphasize sampling with set lines. This technique was ineffective for sturgeon.

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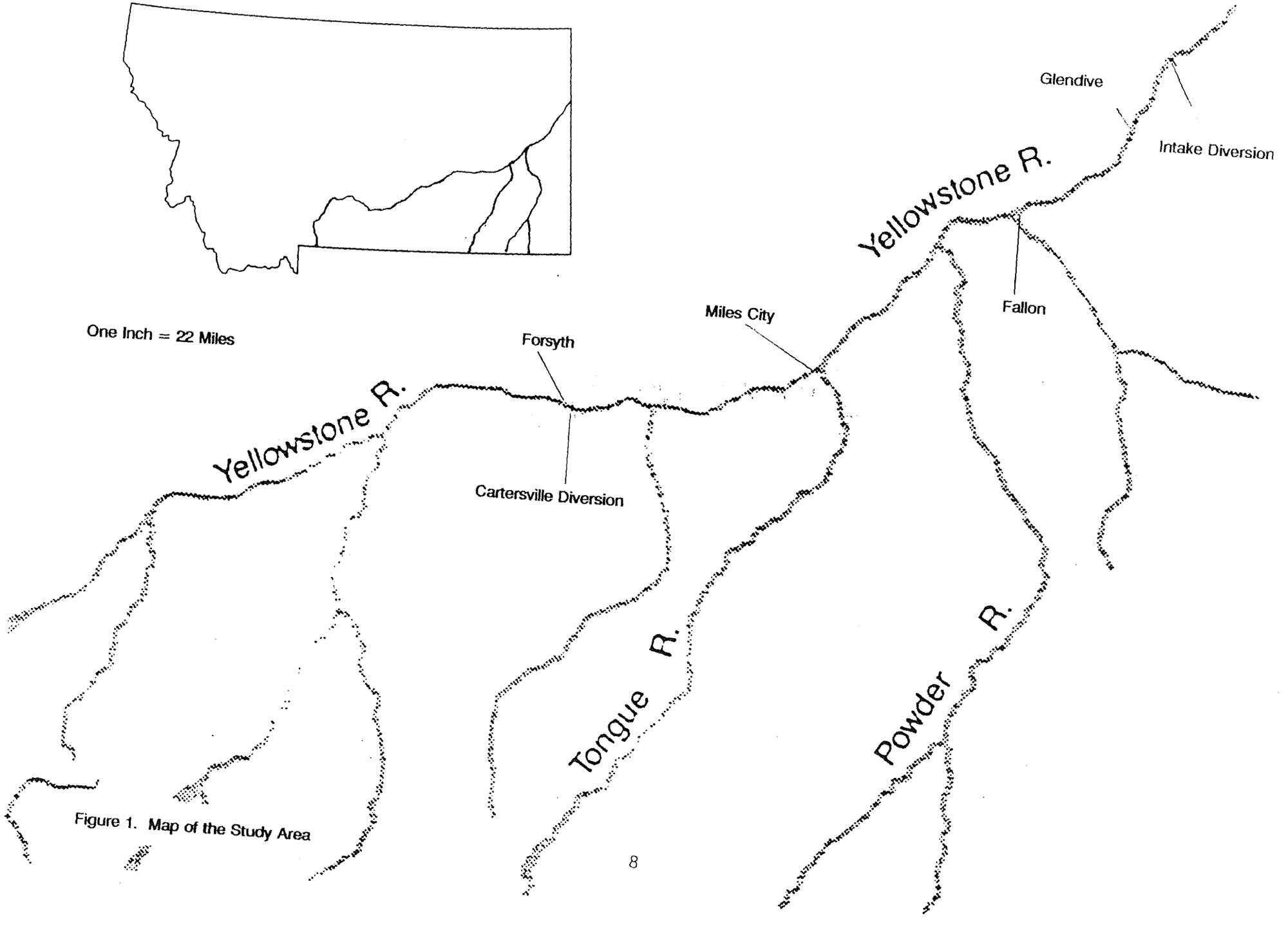



Figure 1. Map of the Study Area

Table 1. General description of river sections in the study area.

| River Section | Section length (kilometers) | Characteristics |
|---|---|---|
| Tongue River - T&Y Diversion to mouth | 32.8 | Shallow, slow, and meandering with few riffles. Many cut and undercut soil banks. Downstream ends of inside banks are usually slow and of a uniform shallow depth. Mostly sand and small gravel substrate. |
| Powder River - River kilometer 13.5 to mouth | 13.5 | Shallow and braided with a slow to moderate current. High water can turn this section into a very fast and rough river. Numerous rocks and shelf rock ledges. Mostly sand and small gravel substrate. |
| Yellowstone River #1 - Cartersville Diversion to Tongue River | 84.3 | Showed a variety of features including deep pools, riffles and some braided sections around islands. The current is mostly moderate with some fast areas where the river narrows. Substrate contains mostly medium sized gravel and rock. |
| Yellowstone River #2 - Tongue River to Powder River | 57.1 | Characterized by a moderate to fast current with numerous rapids. Mostly a single channel with few islands. Some deep pools occur between the fast water areas. Medium to large gravel and rock make up the majority of the substrate. |
| Yellowstone River #3 - Powder River to Fallon Bridge | 36.4 | Deeper and slower for the most part with a few sets of rapids on the upper end. Many deep outside bends occur on the north side of the river. Inside corners can be very slow and shallow. Medium gravel, rock and large rocks comprise the bulk of the substrate. |

Table 1. Continued.

| River Section | Section length (kilometers) | Characteristics |
|---|---|---|
| Yellowstone River #4 - Fallon Bridge to Glendive | 54.7 | Similar to Yellowstone #1 in having a variety of features but with a slightly slower current. Many large island compelxes in the middle and lower portions making for numerous shallow channels. Long, straight and fairly deep stretches occur between islands. Substrate contains mostly medium sized gravel with some rocky areas. |
| Yellowstone River #5 - Glendive to Intake Diversion Dam | 35.1 | Slow and deep for the most part with several large islands. Mostly larger and deeper channels. Some areas of relatively fast deep water where channels converge. Current slows dramatically as it nears the diversion. Substrate is mainly gravel of medium to large size. |

Table 2. 1991 and long term (for period of record) monthly mean streamflows (cfs) for key stream gauges in the study area.[a]

| | Tongue River near Miles City (1938-41; 1946-91) | Powder River near Locate (1938-1991) | Yellowstone River at Miles City (1922-23; 1928-91) |
|---|---|---|---|
| APRIL | | | |
| 1991 | 466 | 601 | 7,870 |
| Mean | 461 | 757 | 8,260 |
| MAY | | | |
| 1991 | 1,140 | 1,660 | 22,900 |
| Mean | 725 | 1,150 | 17,200 |
| JUNE | | | |
| 1991 | 1,320 | 1,440 | 46,000 |
| Mean | 1,331 | 1,680 | 35,200 |
| JULY | | | |
| 1991 | 304 | 246 | 19,600 |
| Mean | 462 | 572 | 20,500 |

[a] Data from USGS. 1991 data are provisional and subject to revision.

Table 3. Trammel net, gill net and set line sampling effort by time period.

| Date | 2" Trammel Net | | | 3" Gill Net | | | Set Line Days[a] (Average # of Hooks per set) |
|---|---|---|---|---|---|---|---|
| | Hours | Miles | # Drifts | Hours | Miles | # Drifts | |
| 4/23 - 4/30 | 0.8 | 1.0 | 2 | | | | 17 (7) |
| 5/1 - 5/15 | 8.2 | 15.6 | 16 | 2.1 | 3.2 | 6 | 19 (8) |
| 5/16 - 5/31 | 9.1 | 16.7 | 18 | 8.3 | 14.5 | 29 | 2 (8) |
| 6/1 - 6/15 | - | - | 0 | 8.0 | 13.2 | 20 | 3 (7) |
| 6/15 - 6/30 | 1.1 | 1.2 | 3 | 4.8 | 3.9 | 18 | 7 (7) |
| 7/1 - 7/15 | 10.7 | 22.4 | 24 | 3.8 | 5.0 | 22 | 18 (8) |
| 7/16 - 8/1 | 38.1 | 67.6 | 83 | - | - | 0 | 18 (8) |
| Total | 68.0 | 124.5 | 146 | 27.0 | 39.8 | 95 | 84 (8) |

[a] A day is approximately 24 hours

Table 4. Trammel net, gill net and set line sampling effort by river section.

| River Section | 2" Trammel Net | | | 3" Gill Net | | | Set Line Days |
|---|---|---|---|---|---|---|---|
| | Hours | Miles | # Drifts | Hours | Miles | # Drifts | (Average # of Hooks per set) |
| Tongue | 1.7 | 1.4 | 4 | 17.5 | 22.9 | 67 | 16 (7) |
| Powder | 0.3 | 0.5 | 1 | 3.9 | 5.7 | 17 | 4 (7) |
| Yellowstone | | | | | | | |
| 1 | 15.4 | 28.7 | 36 | | | | 21 (8) |
| 2 | 6.9 | 14.3 | 15 | | | | 20 (8) |
| 3 | 9.9 | 19.2 | 15 | 1.8 | 3.0 | 2 | 8 (8) |
| 4 | 16.5 | 29.5 | 39 | 2.2 | 5.4 | 5 | 8 (7) |
| 5 | 17.3 | 30.9 | 36 | 1.6 | 2.8 | 4 | 7 (8) |
| **Total** | 68.0 | 124.5 | 146 | 27.0 | 39.8 | 95 | 84 (8) |

Table 5. Number of shovelnose sturgeon caught in drift nets by time period and river section (hours of netting effort in parentheses).

| Time Period | Tongue | Powder | Yellowstone 1 | Yellowstone 2 | Yellowstone 3 | Yellowstone 4 | Yellowstone 5 | Period Total |
|---|---|---|---|---|---|---|---|---|
| 4/23-4/30 | | | 0 (0.8) | | | | | 0 (0.8) |
| 5/1 -5/15 | 5 (2.1) | | 1 (4.5) | | | 2 (3.7) | | 8 (10.3) |
| 5/16-5/31 | 57 (3.6) | 12 (2.3) | | | 0 (1.1) | 1 (2.2) | 0 (8.2) | 70 (17.4) |
| 6/1 -6/15 | 82 (4.1) | 4 (1.0) | | | 1 (1.8) | | 0 (1.1) | 87 (8.0) |
| 6/16-6/30 | 57 (5.0) | 15 (0.9) | | | | | | 72 (5.9) |
| 7/1 -7/15 | 8 (4.4) | | 0 (3.2) | 1 (6.9) | | | | 9 (14.5) |
| 7/16-8/1 | | | 30 (6.9) | | 23 (8.8) | 42 (12.8) | 8 (9.6) | 103 (38.1) |
| Total | 209 (19.2) | 31 (4.2) | 31 (15.4) | 1 (6.9) | 24 (11.7) | 45 (18.7) | 8 (18.9) | 349 (95.0) |

Table 6. Number of shovelnose sturgeon caught per hour of netting effort by time period and river section.

| Time Period | Tongue | Powder | Yellowstone 1 | Yellowstone 2 | Yellowstone 3 | Yellowstone 4 | Yellowstone 5 | Mean |
|---|---|---|---|---|---|---|---|---|
| 4/23 -4/30 | | | 0 | | | | | 0 |
| 5/1 -5/15 | 2.4 | | 0.2 | | | 0.5 | | 0.8 |
| 5/16-5/31 | 15.8 | 5.2 | | | 0 | 0.4 | 0 | 4.0 |
| 6/1 -6/15 | 20.0 | 4.0 | | | 0.6 | | 0 | 10.9 |
| 6/16-6/30 | 11.4 | 16.6 | | | | | | 12.2 |
| 7/1 -7/15 | 1.7 | | 0 | 0.1 | | | | 0.6 |
| 7/16-8/1 | | | 4.3 | | 2.6 | 3.3 | 0.8 | 2.7 |
| **Mean** | 10.9 | 7.4 | 2.0 | 0.1 | 2.1 | 2.4 | 0.4 | 3.7 |

Table 7. Maximum, minimum and mean fork length and weight of shovelnose sturgeon by river section.

| | Tongue | Powder | Yellowstone 1 | Yellowstone 2 | Yellowstone 3 | Yellowstone 4 | Yellowstone 5 | All Fish Combined |
|---|---|---|---|---|---|---|---|---|
| **Fork Length (mm)** | | | | | | | | |
| Max | 994 | 910 | 892 | 776 | 865 | 836 | 911 | 994 |
| Min | 657 | 628 | 631 | 776 | 506 | 330 | 644 | 330 |
| Mean | 801 | 789 | 771 | 776 | 690 | 686 | 798 | 775 |
| **Weight (kg)** | | | | | | | | |
| Max | 5.67 | 4.76 | 4.01 | 1.83 | 3.26 | 2.79 | 4.20 | 5.67 |
| Min | 1.16 | 1.16 | 0.86 | 1.83 | 0.47 | 0.12 | 1.02 | 0.12 |
| Mean | 2.74 | 2.51 | 2.27 | 1.83 | 1.50 | 1.51 | 2.73 | 2.44 |
| Sample Size | 209 | 31 | 31 | 1 | 24 | 45 | 8 | 349 |

Table 8. Fish species (excluding sturgeon) caught by time period.

| Species | 4/23-4/30 | 5/1-5/15 | 5/16-5/31 | 6/1-6/15 | 6/16-6/30 | 7/1-7/15 | 7/16-8/1 | Total |
|---|---|---|---|---|---|---|---|---|
| Bigmouth buffalo | | | | 1 | | | | 1 |
| Blue sucker | | 1 | | 2 | 2 | | 23 | 28 |
| Carp | | | 1 | | 3 | 2 | 52 | 58 |
| Channel catfish | 1 | 6 | 5 | | 6 | 11 | 35 | 64 |
| Goldeye | 5 | 2 | 4 | | | | 12 | 23 |
| Longnose sucker | | | | | | | 13 | 13 |
| Paddlefish | | | | | 1 | | | 1 |
| Shorthead redhorse | | 12 | 3 | 1 | 14 | 5 | 9 | 44 |
| River carp sucker | | 1 | 33 | 2 | 24 | 8 | 21 | 89 |
| Sauger | | 6 | | | | 3 | 5 | 14 |
| Smallmouth bass | | | | | | | 2 | 2 |
| Smallmouth buffalo | | 2 | | | 7 | 1 | 12 | 22 |
| Stonecat | 2 | 3 | | | | | | 5 |
| White sucker | | 4 | | | 1 | | 5 | 10 |
| Total | 8 | 37 | 46 | 6 | 58 | 30 | 189 | 374 |

Table 9. Fish species (excluding sturgeon) caught by river section.

| Species | Tongue | Powder | Yellowstone 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|---|---|
| Bigmouth buffalo | 1 | | | | | | | 1 |
| Blue sucker | 3 | | 5 | | 4 | 8 | 8 | 28 |
| Carp | 2 | | 17 | | 4 | 20 | 15 | 58 |
| Channel catfish | 9 | 3 | 9 | 12 | 10 | 10 | 11 | 64 |
| Goldeye | | | 9 | | 4 | 4 | 6 | 23 |
| Longnose sucker | | | 10 | | | 3 | | 13 |
| Paddlefish | | 1 | | | | | | 1 |
| Shorthead redhorse | 11 | | 16 | 1 | 5 | 4 | 7 | 44 |
| River carpsucker | 31 | 10 | 11 | | 11 | 12 | 14 | 89 |
| Sauger | 1 | | 1 | | | 2 | 10 | 14 |
| Smallmouth bass | | | 2 | | | | | 2 |
| Smallmouth buffalo | 2 | 1 | 8 | | 3 | 5 | 3 | 22 |
| Stonecat | | | 5 | | | | | 5 |
| White sucker | 1 | | 7 | | | 1 | 1 | 10 |
| Total | 61 | 15 | 100 | 13 | 41 | 69 | 75 | 374 |

Table 10. Maximum, minimum and mean fork length and weight for all fish species (excluding sturgeon and stonecat).

| Species | Fork length (mm) | | | Weight (kg) | | | Sample size |
|---|---|---|---|---|---|---|---|
| | Max | Min | Mean | Max | Min | Mean | |
| Bigmouth buffalo | 690 | 690 | 690 | 8.39 | 8.39 | 8.39 | 1 |
| Blue sucker | 735 | 545 | 640 | 5.44 | 1.68 | 2.89 | 20 |
| Carp | 587 | 293 | 434 | 4.27 | 0.51 | 1.54 | 56 |
| Channel catfish | 640 | 290 | 439 | 3.80 | 0.27 | 1.26 | 49 |
| Goldeye | 333 | 217 | 274 | 0.44 | 0.11 | 0.22 | 7 |
| Longnose sucker | 445 | 375 | 410 | 1.14 | 0.66 | 0.85 | 13 |
| Paddlefish | 970 | 970 | 970 | - | - | - | 1 |
| Shorthead redhorse | 441 | 245 | 382 | 1.25 | 0.55 | 0.79 | 33 |
| River carpsucker | 466 | 245 | 361 | 1.73 | 0.40 | 0.87 | 40 |
| Sauger | 570 | 420 | 454 | 1.72 | 0.58 | 0.92 | 8 |
| Smallmouth bass | 375 | 297 | 336 | 0.95 | 0.54 | 0.74 | 2 |
| Smallmouth buffalo | 673 | 405 | 557 | 6.57 | 1.10 | 3.42 | 17 |
| White sucker | 440 | 357 | 410 | 1.15 | 0.66 | 0.83 | 8 |
| | | | | | | | 254 |

Appendix 1. Diagram of measurements made for sturgeon .

A: head length (HED)

B: tip of snout to base of outer barbel (SOT)

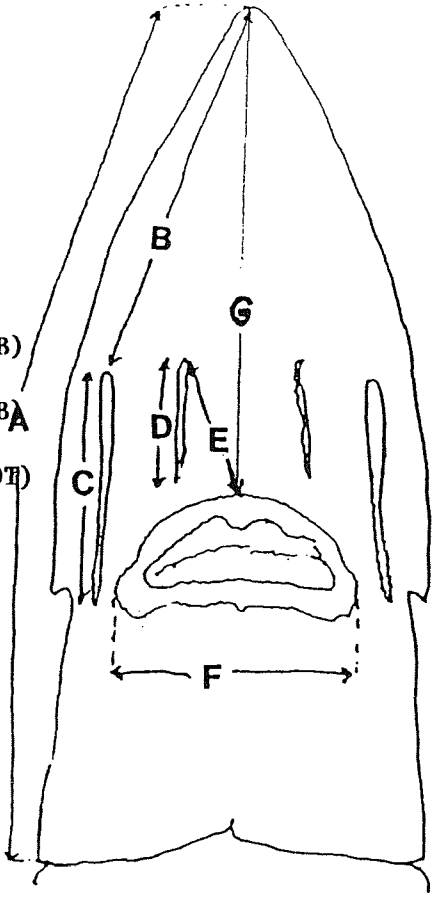
C: outer barbel length (OTB)

D: inner barbel length (INB)

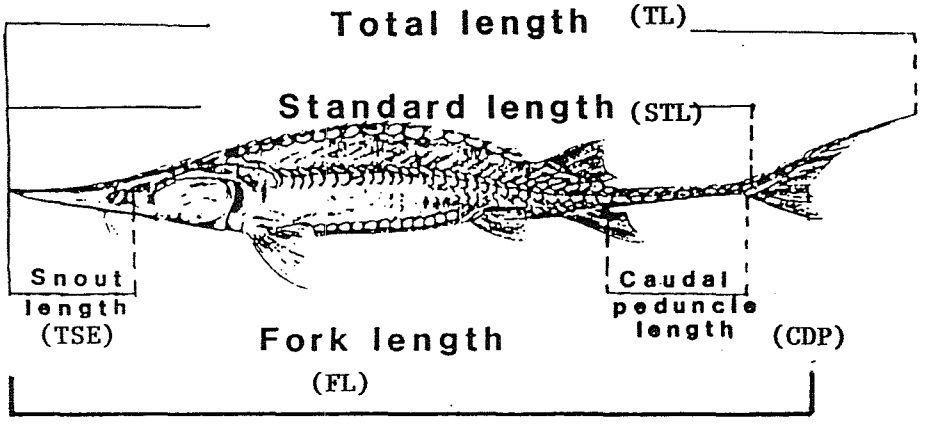
E: anterior midpoint of mouth to base of inner barbels (MOT)

F: mouth width (MTH)

G: Tip of snout to anterior midpoint of mouth (TSM)





Appendix 2. Morphometric measurements of the pallid sturgeon caught July 18, 1991 and these measurements as percent of total length.

| Weight (kg) | Lengths (mm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FL[a] | STL | HED | MTH | SOT | MOT | OTB | INB | CDP | TSM | TSE | TL |
| 11.34 | 1340 | 1275 | 424 | 120 | 193 | 60 | 128 | 40 | 170 | 227 | 227 | 1441 |

| | (Measurement/total length) x 100 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | FL[a] | STL | HED | MTH | SOT | MOT | OTB | INB | CDP | TSM | TSE |
| | 93.0 | 88.5 | 29.4 | 8.3 | 13.4 | 4.2 | 8.9 | 2.8 | 11.8 | 15.8 | 15.8 |

[a] Abbreviations are defined in Appendix 1.

Appendix 3. Morphometric measurements as percent of total length for 90 shovelnose sturgeon.

| Record | FL | STL | HED | MTH | SOT | MOT | OTB | INB | CDP | TSM | TSE | TL (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 90.8 | 84.4 | 24.2 | 7.0 | 9.0 | 5.6 | 7.4 | 5.6 | 16.5 | 13.1 | 13.6 | 557 |
| 2 | 89.2 | 82.2 | 23.4 | 6.8 | 8.7 | 4.8 | 6.2 | 4.4 | 17.1 | 12.8 | 13.2 | 585 |
| 3 | 92.3 | 84.6 | 24.8 | 7.4 | 8.7 | 5.8 | 7.7 | 5.6 | 15.0 | 13.8 | 14.2 | 585 |
| 4 | 91.5 | 83.6 | 23.0 | 6.6 | 9.5 | 4.9 | 7.9 | 4.9 | 15.6 | 13.1 | 13.0 | 610 |
| 5 | 90.2 | 83.7 | 23.7 | 6.5 | 8.3 | 5.3 | 7.9 | 5.8 | 16.8 | 13.5 | 13.4 | 674 |
| 6 | 90.1 | 83.6 | 24.7 | 6.8 | 9.0 | 6.1 | 7.4 | 5.3 | 15.9 | 13.8 | 13.9 | 675 |
| 7 | 91.6 | 85.1 | 23.8 | 6.8 | 8.0 | 4.8 | 6.2 | 4.6 | 14.6 | 12.6 | 13.2 | 690 |
| 8 | 91.9 | 85.4 | 23.8 | 6.9 | 8.2 | 5.2 | 7.4 | 5.2 | 13.7 | 12.4 | 12.6 | 693 |
| 9 | 93.9 | 92.3 | 27.7 | 8.4 | 8.6 | 5.7 | 9.0 | 6.3 | 16.4 | 13.7 | 14.3 | 700 |
| 10 | 89.8 | 83.3 | 23.7 | 6.6 | 8.8 | 5.8 | 7.0 | 5.2 | 15.0 | 13.7 | 13.6 | 713 |
| 11 | 89.8 | 83.3 | 22.9 | 6.8 | 7.7 | 5.7 | 7.4 | 5.5 | 14.8 | 12.8 | 12.4 | 725 |
| 12 | 90.7 | 84.2 | 23.3 | 6.7 | 6.8 | 5.3 | 6.7 | 5.3 | 14.4 | 13.3 | 13.2 | 730 |
| 13 | 89.8 | 84.2 | 23.0 | 6.8 | 8.2 | 5.3 | 6.8 | 4.4 | 14.4 | 12.7 | 12.9 | 735 |
| 14 | 90.8 | 84.0 | 24.0 | 6.8 | 8.4 | 5.4 | 7.3 | 4.1 | 15.0 | 12.5 | 12.9 | 738 |
| 15 | 91.2 | 85.1 | 23.8 | 7.2 | 7.6 | 5.5 | 7.6 | 5.4 | 13.9 | 12.8 | 12.8 | 740 |
| 16 | 92.8 | 93.4 | 27.8 | 8.3 | 9.3 | 6.0 | 7.3 | 5.4 | 13.6 | 14.8 | 15.0 | 755 |
| 17 | 90.3 | 84.3 | 23.3 | 6.1 | 8.7 | 5.1 | 6.6 | 4.6 | 14.5 | 13.0 | 14.6 | 759 |
| 18 | 92.1 | 86.2 | 24.3 | 6.6 | 9.2 | 5.7 | 7.9 | 5.7 | 13.8 | | | 760 |
| 19 | 92.4 | 86.2 | 24.3 | 6.9 | 7.8 | 5.7 | 7.8 | 6.0 | 14.1 | 12.5 | 12.9 | 767 |
| 20 | 91.6 | 85.2 | 22.7 | 6.5 | 8.4 | 5.5 | 6.5 | 4.5 | 13.7 | 13.0 | 12.9 | 775 |
| 21 | 93.7 | 87.5 | 24.5 | 6.7 | 8.5 | 5.5 | 7.7 | 5.5 | 13.0 | 12.9 | 13.4 | 775 |
| 22 | 91.6 | 85.2 | 24.9 | | 8.4 | 6.3 | 7.7 | 5.7 | 14.6 | 13.8 | 13.4 | 775 |
| 23 | 91.0 | 85.2 | 24.5 | 6.5 | 9.2 | 5.8 | 7.0 | 4.9 | 14.8 | 14.8 | 13.9 | 775 |
| 24 | 93.3 | 86.9 | 25.1 | 7.3 | 8.2 | 5.7 | 7.7 | 5.7 | 13.5 | 13.4 | 14.5 | 777 |
| 25 | 90.3 | 84.0 | 23.8 | 7.1 | 8.3 | 5.6 | 7.0 | 5.3 | 12.5 | 13.1 | 12.7 | 786 |
| 26 | 89.9 | 84.1 | 23.5 | 6.8 | 8.2 | 5.6 | 7.1 | 4.8 | 13.0 | 13.0 | 12.8 | 790 |
| 27 | 95.3 | 89.5 | 26.5 | 8.1 | 9.1 | 5.7 | 8.1 | 5.9 | 18.9 | | | 792 |
| 28 | 90.7 | 84.5 | 23.0 | 6.3 | 8.8 | 5.5 | 7.0 | 5.3 | 13.6 | 13.5 | 13.0 | 795 |
| 29 | 91.3 | 84.8 | 25.8 | 7.7 | 8.1 | 5.5 | 7.6 | 5.4 | 14.2 | 13.2 | 13.6 | 802 |
| 30 | 91.0 | 84.6 | 26.3 | 7.3 | 7.5 | 5.7 | 7.5 | 5.3 | 14.3 | 12.7 | 13.7 | 804 |
| 31 | 92.0 | 85.8 | 24.7 | 7.0 | 8.3 | 6.1 | 6.6 | 5.2 | 14.4 | 13.4 | 13.4 | 805 |
| 32 | 90.9 | 84.3 | 22.1 | 6.1 | 8.1 | 5.0 | 7.1 | 5.3 | 16.0 | | | 815 |

Appendix 3 (continued)

| Record | FL | STL | HED | MTH | SOT | MOT | OTB | INB | CDP | TSM | TSE | TL (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 33 | 90.8 | 84.7 | 24.0 | 6.5 | 8.8 | 5.6 | 8.1 | 5.5 | 14.4 | 12.8 | 14.5 | 815 |
| 34 | 91.3 | 84.8 | 23.5 | 7.3 | 8.7 | 5.6 | 7.9 | 5.5 | 23.9 | 13.8 | 13.8 | 820 |
| 35 | 91.2 | 84.8 | 22.9 | 6.8 | 7.7 | 5.5 | 7.3 | 5.7 | 14.9 | 12.2 | 12.1 | 820 |
| 36 | 92.9 | 86.8 | 23.4 | 7.7 | 9.1 | 5.4 | 8.0 | 5.7 | 14.0 | 13.4 | 13.9 | 820 |
| 37 | 93.0 | 86.3 | 25.0 | 8.1 | 8.6 | 6.0 | 6.9 | 5.1 | 12.5 | 13.6 | 13.4 | 823 |
| 38 | 91.4 | 86.1 | 23.9 | 7.1 | 7.8 | 5.4 | 6.7 | 5.2 | 14.0 | 13.7 | 13.7 | 830 |
| 39 | 93.0 | 87.3 | 26.1 | 7.9 | 9.0 | 5.2 | 8.3 | 5.9 | 13.4 | 14.3 | 13.9 | 834 |
| 40 | 92.3 | 85.7 | 24.3 | 7.1 | 8.6 | 5.3 | 8.0 | 5.9 | 13.7 | 13.3 | 13.5 | 835 |
| 41 | 92.0 | 86.3 | 24.4 | 6.7 | 8.8 | 5.2 | 6.2 | 5.0 | 13.2 | 13.1 | 13.3 | 840 |
| 42 | 93.5 | 86.9 | 25.0 | 7.3 | 8.5 | 6.0 | 9.3 | 6.0 | 13.7 | 13.7 | 13.7 | 840 |
| 43 | 90.7 | 84.9 | 23.3 | 7.3 | 8.6 | 5.8 | 7.3 | 5.2 | 13.8 | 13.2 | 13.0 | 840 |
| 44 | 91.0 | 84.7 | 22.6 | 6.3 | 7.8 | 5.0 | 7.0 | 4.9 | 13.9 | 13.4 | 12.2 | 841 |
| 45 | 92.0 | 86.1 | 23.7 | 7.1 | 8.4 | 5.3 | 6.6 | 5.0 | 13.6 | 13.1 | 13.0 | 848 |
| 46 | 92.7 | 86.5 | 24.1 | 6.8 | 8.4 | 5.3 | 7.4 | 5.4 | 13.5 | 13.2 | 13.5 | 850 |
| 47 | 92.2 | 85.8 | 23.4 | 6.9 | 8.1 | 5.3 | 7.7 | 5.8 | 13.6 | 12.5 | 12.6 | 855 |
| 48 | 93.0 | 86.5 | 17.5 | 7.5 | 9.9 | 5.6 | 7.3 | 5.5 | 12.9 | 14.6 | 14.3 | 855 |
| 49 | 92.8 | 86.5 | 25.6 | 7.6 | 8.8 | 6.2 | 9.9 | 7.1 | 13.5 | 13.9 | 13.8 | 857 |
| 50 | 90.9 | 85.2 | 24.3 | 7.7 | 7.6 | 5.7 | 8.0 | 5.9 | 13.0 | 12.2 | 12.5 | 859 |
| 51 | 91.7 | 85.0 | 24.3 | 7.0 | 8.0 | 5.9 | 8.3 | 5.8 | 14.1 | 13.4 | 13.2 | 859 |
| 52 | 92.9 | 86.3 | 26.0 | 6.9 | 9.0 | 5.9 | 8.1 | 6.0 | 13.0 | 13.6 | 13.7 | 860 |
| 53 | 92.1 | 86.5 | 25.7 | 7.8 | 8.9 | 5.8 | 6.8 | 5.4 | 12.2 | 13.9 | 14.2 | 864 |
| 54 | 93.3 | 87.9 | 26.6 | 7.5 | 8.7 | 6.0 | 7.4 | 5.2 | 13.3 | 13.9 | 14.5 | 870 |
| 55 | 91.6 | 85.6 | 25.2 | 7.1 | 9.2 | 5.7 | 7.6 | 5.7 | 13.1 | 14.5 | 14.0 | 870 |
| 56 | 96.6 | 91.6 | 25.6 | 7.6 | 9.2 | 6.2 | 9.7 | 6.7 | 15.7 | | | 870 |
| 57 | 93.1 | 87.4 | 25.3 | 7.2 | 8.4 | 6.2 | 8.9 | 6.0 | 14.4 | 14.0 | 13.7 | 870 |
| 58 | 92.4 | 87.1 | 24.4 | 7.6 | 8.3 | 5.6 | 7.5 | 5.4 | 12.2 | 13.4 | 12.3 | 870 |
| 59 | 90.5 | 84.7 | 24.5 | 7.5 | 8.2 | 5.4 | 8.4 | 6.0 | 13.2 | 13.0 | 13.4 | 870 |
| 60 | 91.8 | 86.2 | 22.5 | 6.9 | 7.5 | 5.1 | 7.7 | 5.3 | 15.0 | 12.0 | 12.0 | 875 |
| 61 | 93.2 | 87.6 | 25.5 | 8.3 | 8.3 | 5.7 | 8.3 | 5.9 | 12.4 | 12.9 | 13.1 | 878 |
| 62 | 92.7 | 87.4 | 23.6 | 6.9 | 7.8 | 5.5 | 8.5 | 6.0 | 14.8 | 12.4 | 13.4 | 880 |
| 63 | 92.5 | 87.5 | 26.4 | 7.4 | 9.9 | 6.1 | 8.8 | 6.0 | 13.9 | 14.8 | 14.8 | 880 |
| 64 | 93.2 | 87.5 | 25.6 | 8.0 | 8.6 | 5.7 | 8.0 | 5.7 | 13.6 | 13.6 | 13.8 | 880 |
| 65 | 94.7 | 88.7 | 26.2 | 8.2 | 8.6 | 6.8 | 8.2 | 5.7 | 13.3 | 14.1 | 13.9 | 882 |
| 66 | 93.0 | 86.7 | 24.5 | 7.4 | 8.5 | 5.9 | 7.4 | 5.7 | 13.3 | 13.0 | 13.2 | 882 |
| 67 | 92.2 | 86.7 | 25.4 | 7.5 | 9.0 | 6.2 | 7.2 | 5.6 | 13.8 | 13.7 | 13.7 | 885 |

Appendix 3 (continued)

| Record | FL | STL | HED | MTH | SOT | MOT | OTB | INB | CDP | TSM | TSE | TL (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68 | 94.5 | 88.8 | 24.0 | 7.8 | 8.5 | 6.0 | 7.1 | 5.5 | 14.4 | 13.0 | 13.0 | 885 |
| 69 | 92.2 | 87.5 | 24.9 | 7.3 | 8.5 | 5.8 | 7.3 | 5.4 | 14.1 | | | 889 |
| 70 | 90.4 | 84.4 | 24.0 | 7.3 | 8.4 | 6.1 | 7.1 | 5.6 | 13.1 | 13.3 | 13.1 | 890 |
| 71 | 92.0 | 85.3 | 22.1 | 7.2 | 8.0 | 5.2 | 7.0 | 5.2 | 14.6 | 12.1 | 12.1 | 891 |
| 72 | 93.3 | 86.6 | 24.1 | 7.2 | 7.8 | 4.9 | 7.0 | 5.3 | 14.4 | 12.6 | 13.1 | 895 |
| 73 | 91.1 | 85.2 | 23.7 | 6.8 | 7.9 | 5.6 | 6.7 | 4.7 | 13.7 | 12.8 | 12.7 | 896 |
| 74 | 92.3 | 86.6 | 23.9 | 8.2 | 7.9 | 6.0 | 7.4 | 6.2 | 12.9 | 12.8 | 12.9 | 900 |
| 75 | 90.9 | 84.9 | 23.2 | 6.4 | 8.5 | 5.6 | 7.3 | 5.6 | 14.4 | 13.3 | 13.1 | 905 |
| 76 | 91.3 | 84.4 | 25.4 | 8.3 | 8.5 | 5.7 | 7.6 | 5.6 | 11.7 | 13.6 | 13.5 | 906 |
| 77 | 91.2 | 84.8 | 22.9 | 6.9 | 8.7 | 6.0 | 7.8 | 5.7 | 13.7 | 13.2 | 12.7 | 910 |
| 78 | 92.1 | 86.0 | 25.4 | 8.0 | 9.0 | 6.0 | 7.9 | 6.1 | 12.6 | 13.9 | 13.9 | 915 |
| 79 | 92.2 | 86.9 | 24.5 | 7.7 | 8.0 | 5.9 | 6.3 | 4.9 | 12.7 | 13.1 | 13.3 | 915 |
| 80 | 91.5 | 85.7 | 25.3 | 7.1 | 8.9 | 6.0 | 7.0 | 5.3 | 13.6 | 14.2 | 13.9 | 918 |
| 81 | 92.2 | 86.1 | 25.6 | 7.5 | 9.2 | 6.2 | 7.5 | 5.6 | 13.6 | 14.2 | 13.9 | 922 |
| 82 | 91.9 | 85.5 | 24.7 | 7.4 | 7.5 | 4.9 | 6.9 | 5.3 | 12.5 | 12.4 | 12.5 | 930 |
| 83 | 91.4 | 88.4 | 25.2 | 8.0 | 9.2 | 5.4 | 8.6 | 5.6 | 13.0 | 13.7 | 13.8 | 930 |
| 84 | 93.0 | 86.8 | 25.2 | 7.3 | 7.7 | 6.1 | 7.7 | 5.5 | 13.5 | 13.3 | 13.4 | 935 |
| 85 | 94.2 | 88.1 | 24.4 | 7.5 | 7.4 | 6.1 | 8.2 | 6.7 | 13.0 | 13.0 | 12.6 | 965 |
| 86 | 92.2 | 86.2 | 23.8 | 7.1 | 8.9 | 5.6 | 6.8 | 5.2 | 13.8 | 13.4 | 13.4 | 975 |
| 87 | 93.6 | 87.7 | 24.3 | 7.0 | 8.3 | 5.7 | 7.3 | 5.3 | 14.2 | 12.8 | 13.2 | 980 |
| 88 | 96.5 | 90.5 | 24.1 | 7.5 | 8.3 | 6.0 | 8.4 | 6.1 | 12.2 | 13.0 | 13.1 | 1005 |
| 89 | 92.5 | 84.6 | 23.9 | 7.4 | 8.3 | 5.5 | 7.5 | 5.5 | 27.9 | | | 1005 |
| 90 | 89.2 | 82.8 | 22.5 | 6.8 | 7.7 | 5.4 | 6.3 | 4.6 | 14.7 | 11.9 | 12.0 | 1020 |
| MAX | 94.7 | 93.4 | 27.8 | 8.4 | 9.9 | 6.8 | 9.9 | 7.1 | 27.9 | 14.8 | 15.0 | 1020 |
| MIN | 89.2 | 82.2 | 17.5 | 6.1 | 6.8 | 4.8 | 4.8 | 4.1 | 11.7 | 11.9 | 12.0 | 557 |
| MEAN | 92.0 | 86.0 | 24.3 | 7.2 | 8.4 | 5.6 | 7.5 | 5.5 | 14.3 | 13.3 | 13.4 | 831 |