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FINAL REPORT

RESEARCH AND SURVEYS

OKLAHOMA

DEPARTMENT OF WILDLIFE CONSERVATION

FEDERAL AID PROJECT NO. F-37-R-9
FISH RESEARCH AND SURVEYS FOR OKLAHOMA LAKES AND RESERVOIRS
JOB NO. 6
PADDLEFISH INVESTIGATIONS
OCTOBER 1, 1983 THRU FEBRUARY 28, 1987

505 35/874 0115

FINAL REPORT

State: Oklahoma Project Number: F-37-R

Project Title: Fish Research and Surveys for Oklahoma Lakes and Reservoirs

Study Title: Paddlefish Investigations

Period Covered: 1 October 1983 to 28 February 1987

Objective Number: 6

Job Number: 6

ABSTRACT

The paddlefish (Polyodon spathula Walbaum) fishery in the Neosho River-Grand Lake system was investigated during 1983, 1984, 1985, and 1986 to determine the population size and structure, the harvest and rate of exploitation by sport and commercial fisheries. There were 3,028 paddlefish tagged and released during 1983-86 in the Neosho River and Grand Lake for determination of population parameters and exploitation. The creel survey in 1986 showed the sport angling pressure, catch rates and harvests had decreased significantly from the levels observed in 1979 and 1980; the sport angling exploitation of paddlefish in 1986 was calculated to be 3.5% compared to 15.2% in 1979 and 18.8% in 1980. A decrease in the average length of paddlefish from the 1986 creel compared to the 1979 creel indicated an abundance of small fish (less than 900 mm body length) in the population. The commercial exploitation of paddlefish increased from 1979-80 (0.7%) and 1980-81 (0.2%) to 1984-85 (6.1%) and 1985-86 (5.8%). The commercial harvests of paddlefish for caviar increased ten fold during this time period (1980 N = 191, 1983 N = 1,936) and remains high (1986 N = 1,628). The 1985-86 estimated population size (22,534 from O.D.W.C.

gill netting, and 23,396 from commercial gill netting) was around 23,000. The 1979-80 estimate of the population size for paddlefish was 25,118 from the creel surveys. Length frequencies of paddlefish tagged in 1983-86 compared to 1979-80 showed an increase in the numbers of small paddlefish in the population. Length frequencies of paddlefish tagged during observation of the commercial fisheries 1983-86 showed decreasing numbers of fish 1,000 mm (40 inches) body length and longer in their releases (proportion greater than 1,000 mm 1983-84 = 40.2%, 1984-85 = 35.3%, 1985-86 = 15.7%). Paddlefish 1,000 mm and longer were being harvested by commercial fishermen at a rate from two to three times higher than their proportional abundance in the population. Length frequencies of paddlefish indicated good recruitment into the population from previous high flow years. Growth of paddlefish was calculated from recaptured fish at large at least 10 months. Caviar production of paddlefish from the commercial fishery was investigated. Gonadal somatic parameters were gathered from 315 female fish in the catch. The average weight of the fish harvested was 28.9 kg (63.7 lb.), yielding an average of 5.2 kg (11.5 lb.) of raw eggs and 3.5 kg (7.7 lb.) of processed caviar. Analysis of the exploitation by the commercial fishery showed that new restrictions on the fishery are needed. Reducing the number of fishermen, reducing the season or legal commercial harvest, and development of a harvest quota not to exceed 10% of the population estimate were recommended for the commercial fishery. A suggestion to lower daily creel and possession limits of paddlefish by sport angling from 3 to 2 was recommended to ensure a uniform regional (basin-wide) limit and to distribute the catch

among more anglers. Future research and management needs to provide a stable commercial and sport fishery also were discussed.

I. OBJECTIVE:

To determine the population size, size structure, and harvest exploitation of the Neosho River paddlefish population.

II. BACKGROUND:

Paddlefish (Polyodon spathula) have a large historical range in Oklahoma which includes the Arkansas River as far west as Great Salt Plains and the Red River to Lake Texoma which includes many of both rivers' major drainages (Miller and Robison 1973). Their status, in all but the Grand Lake and upper Neosho River, remains virtually unknown (Gengerke 1986). In Oklahoma, paddlefish were studied in Fort Gibson Reservoir by Houser and Bross (1959) and Houser (1965). These studies were concerned with early growth rates of paddlefish, but because of their long maturation time and potential overharvest, the authors expressed concern over the commercial exploitation of the resource. The sport harvest exploitation was studied on the Grand Lake-Neosho River population (Combs 1982). Historically, the Neosho River is the only river system in Oklahoma where paddlefish have been regularly observed and harvested by sport and commercial fisheries (Combs 1981). There appears to be an expanding population of paddlefish in the Arkansas River below Keystone Reservoir. Several paddlefish have appeared in the gill netting and angling for striped bass at this area (Personal Communication Al Zale, OSU Coop. 1987).

According to Carlson and Bonislawsky (1981), factors affecting the distribution and abundance of paddlefish are related to habitat alteration (through dam building, stream channelization, and de-

watering); industrial pollution; and overharvest. Paddlefish managers along the western range of the fish expressed concern over rates of exploitation by sport fisheries. Initially begun by Purkett's (1963) analysis of over-exploitation on the paddlefish population in the Osage River, Missouri investigations were begun and continue in several states. Exploitation investigations of sport fisheries were conducted in Montana (Robinson 1966, Rehwinkel 1978, Needham 1979, Elser 1979, Stewart 1986), South Dakota (Sprague 1959, 1960, Unkenholz 1977, 1979, 1980, 1982), North Dakota (Van Eeckhout 1980), Nebraska (Rupp 1977, Hesse 1980, Rosen, et. al. 1982, Schuckman 1984), Iowa (Gengerke 1978), Missouri (Russell et. al. 1980), Kansas (Bonislawsky 1977) and Oklahoma (Combs 1981, 1982).

Concern about the sport fishery impacts on the paddlefish population in the Neosho River began in the mid 1970's with anglers reporting increased pressure, depleting harvests, and reduced catch sizes. An investigation was undertaken; it revealed that sport angler exploitation at Miami exceeded the 15% annual harvest recommended by the Paddlefish Workshop Committee (1979). Regulation changes in the sport harvest of paddlefish reduced the daily creel and possession limit from 5 to 3, and the commercial harvest was restricted by shortening the season and limiting the number of commercial fishermen entry.

During the early part of this century, commercial exploitation of paddlefish in the Mississippi River and major drainages depleted most populations. The paddlefish became a major commercial species after the lake sturgeon (<u>Acipenser fulvescens</u>) and Atlantic watering); industrial pollution; and overharvest. Paddlefish managers along the western range of the fish expressed concern over rates of exploitation by sport fisheries. Initially begun by Purkett's (1963) analysis of over-exploitation on the paddlefish population in the Osage River, Missouri investigations were begun and continue in several states. Exploitation investigations of sport fisheries were conducted in Montana (Robinson 1966, Rehwinkel 1978, Needham 1979, Gilge 1979, Stewart 1980); South Dakota (Sprague 1959, 1960, Unkenholz 1977, 1979, 1980, 1982); North Dakota (Van Eeckhout 1980); Nebraska (Rupp 1977, Rosen 1980, Rosen, et. al. 1982, Schoeckman 1984); Iowa (Gengerke 1978), Missouri (Russell et. al. 1980), Kansas (Kozlowsky 1977) and Oklahoma (Combs 1981; 1982).

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During the early part of this century, commercial exploitation of paddlefish in the Mississippi River and major drainages depleted most populations. The paddlefish became a major commercial species after the lake sturgeon (*Acipenser fulvescens*) and Atlantic sturgeon (Acipenser oxyrhynchus) populations were decimated and the demand for caviar continued. Biologists at the time expressed concern about survival of these stocks, and restrictions on the fishery for roe were recommended (Alexander 1914). Paddlefish display characteristics which make them vulnerable to commercial exploitation; these include their schooling tendencies, predictable spawning runs and winter distribution (Pasch and Alexander 1986). The increased demand put on domestic caviar producing populations by the problems of obtaining roe from Iran, Iraq, and the U.S.S.R. have compounded the problem. Commercial exploitation of the paddlefish population in Grand Lake increased after roe from other sources were exhausted. Commercial exploitation of the paddlefish population in Grand Lake, the only lake in Oklahoma where commercial paddlefish harvest is legal, needed to be monitored to determine the overall exploitation on the paddlefish population. An annual rate of exploitation in mixed sport/commercial harvests of 15-20% is considered acceptable from these fisheries (Pasch and Alexander 1986). The areas included in this study are Grand Lake and the upstream portion of the Neosho River to Chetopa, Kansas. During the study, tag returns occurred from the confluence of the Neosho River and Arkansas River upstream 264 Km to Chetopa, Kansas. The wide distribution of tag recoveries illustrates how mobile this species of fish can be and how managing them may include a large territory often overlapping lakes and states.

III. PROCEDURES:

The investigation was composed of three major segments in order to meet the desired objectives: 1) tag and release paddlefish

captured by Department personnel below the low water dam prior to the sport harvest season, 2) tag and release paddlefish not harested by the commercial operations below Sailboat Bridge on Grand Lake, and 3) conduct angler creel surveys at the low water dam in Miami. Harvest, exploitation, and population parameters of size and structure were to be gathered from commercial fishing, sport angler harvests, and the resulting tag returns.

Oklahoma Department of Wildlife Conservation Tagging:

Capture and tagging sites extended from the damsite of Grand Lake upstream into the Neosho River for 3.2 kilometers. Paddlefish were captured with the use of two different depths of gill nets, 2.4 m and 6 m. The 2.4 m deep nets were either 127 or 152 mm bar mesh and 91 m long. The 6 m deep nets were 152 mm bar mesh and 91 m long. Gillnetting sets were suspended at different depths from 2 m to 25 m depending on water depth and recent succss, or failure, at capturing fish. Some netting sets in the Neosho River and the upper end of Grand Lake were bottom sets. Water depths at some of these locations did not exceed 5 m. Most gill-netting sets were made perpendicular to the river channel or shoreline. The gill netting in the lake usually occurred over, or near, the inundated river channel. Gill nets were run according to the catch rates observed; as the catch rate increased, so did the number of times that each net was fished during a 24 h period. The captured paddlefish were measured by body length (anterior orbit of the eye to the fork of the tail, Ruelle and Hudson 1977). Each paddlefish released was tagged with either a numbered Monel jaw tag (#16) on the anterior portion of the

mandible or a numbered Monel self-piercing strap tag (#49) attaced to the posterior portion of the dorsal fin base. All tags were marked with an identifying number and the name of the agency for return. Tagged fish were released approximately 0.5 km from the netting location. Netting and tagging operations were terminated when river conditions warranted removal of netting gear or when harvest at Miami began.

Commercial Fisherman Assisted Tagging:

Capture and tagging sites extended from the dam upstream to below Sailboat Bridge. Paddlefish were captured with the use of 152 mm bar mesh x 7.6 m x 91 m long gill nets which were fished suspended over the river channel or over adjoining flats. Depths fished varied from 5 m to 30 m depending on the water depth. Nets were run according to the number of fish being encountered and the number of gravid females harvested dead. The mortality of harvested female paddlefish will not produce a usable egg for high grade caviar. Department personnel accompanied the commercial fisherman when our netting was not producing very many paddlefish for tagging. Paddlefish captured were measured by body length and those fish that were to be released were tagged with tags similar to those used in the Department netting; recaptures were recorded, and growth rates from previous years tagging were calcuated. All paddlefish captured during the commercial fishing with Department personnel were measured by body length and were either tagged, released untagged if less than 400 mm body length, recaptured and released, or harvested. The released paddlefish were measured by length but not by weight and they were not sexed because of the limited space and time available for handling

each fish. Length-weight relationships were developed in an earlier study and duplication of the effort was deemed unnecessary. Observation of commercial fishing extended from October to March 21 annually during the investigation.

Creel Surveys:

During the harvest seasons of 1979 and 1980, an abbreviated creel was conducted at the low water dam in the City of Miami (Combs 1981) and was found to provide a more cost effective survey than the intensive creel. The abbreviated creel survey, designed by Combs, at the low water dam at Miami was to begin when an instantaneous angler pressure count exceeded 20 anglers; the creel area was restricted to the east and west banks of the river below the dam (approximately 300 m downstream). The abbreviated creel randomly sampled 15 of 30 paddlefish harvest days. Two creel sections (east and west banks) were sampled randomly for interview and pressure periods. Two interview periods, one day and one night (four hours in duration each), were conducted on selected creel days. Pressure counts were made hourly during the interview period. The abbreviated creel was initiated as harvest began and terminated on the last selected creel day or when pressure decreased to no anglers for three creel periods.

Population parameters of paddlefish were taken from fish captured during the commercial netting and from the Departments netting. Paddlefish captured during the gill netting were measured by body length, examined for tags, and either harvested or released back into the population. Population size and rates of exploitation

were derived from tag returns either at Miami or by commercial fishermen. Exploitation was calculated from the equation, $u = R/M$ to $R/M-R$.

Where: u = exploitation rate

R = number of tag returns

M = number of marked fish available in the system

Population size estimates were made from mark and recapture statistics from the 1985-86 commercial gill netting and from the 1986 Oklahoma Department of Wildlife Conservation gill netting. A modified Schnabel estimate (Ricker 1975),

$$N = \frac{\Sigma (Ct \cdot Mt)}{R + 1}$$

Where Ct = Number of fish caught that date

Mt = Total marked fish at large less removals

R = Number of recaptures in the sample Ct

N = The population present throughout the investigation

was used as the estimator.

The determination of spawning success or failure was attempted during the 1984, 1985 and 1986 spawning season to determine the impact of the current harvests upon spawning success as incidental information to the project. Conical shaped plankton nets with a mouth diameter of 50 cm, a mesh size of 64 microns, and length of 160 cm were periodically suspended in the water column in the Neosho, Spring and Elk rivers. Evidence of larval paddlefish in the samples was used as a criteria for determining spawning

success in the rivers.

IV. RESULTS AND DISCUSSION:

The 3,028 paddlefish that were tagged 1983-86 by O.D.W.C. personnel (Table 1) came from two sources. Paddlefish were captured and tagged during O.D.W.C. gillnetting and commercial gillnetting operations. The paddlefish returned by the commercial fishermen unharmed were tagged each season providing an abundant source of fish for mark-recapture. The tagging of paddlefish released from the commercial gill netting provided more fish than the Department netting because commercial fishermen used more and longer nets than were available to Department personnel. During 1983-84, there were 25 and 1,047 paddlefish marked during O.D.W.C. and commercial gill netting, respectively. In 1984-85, there were 109 and 439 tagged during O.D.W.C. and commercial gill netting, respectively, and 1985-86 there were 162 and 1,246 tagged. The length frequencies of the commercially released and tagged paddlefish appear in Figure 1 (1983-84), Figure 2 (1984-85), Figure 3 (1985-86) and Figure 4 (1983-86). The length frequencies for the paddlefish tagged during O.D.W.C. netting appear in Figure 5 (1983-84), Figure 6 (1984-85), Figure 7 (1985-86) and Figure 8 (1983-86). During each year of the study period, attempts to capture paddlefish in Department gill nets in the Neosho River were limited due to high water levels and low water temperatures. Due mainly to the high volume of the rivers discharge, and the consequent floating and suspended debris, gillnetting activities were restricted to the upper end of Grand Lake. During each season there were a few paddlefish that were tagged but their

lengths were not obtained. There were 32 tagged paddlefish from 1983-86 in the commercial fishery whose lengths were not secured and 7 paddlefish from the O.D.W.C. operations 1983-86 whose lengths were not attained. The length frequency of the 575 paddlefish tagged during the 1979-80 survey is found in Figure 9. A comparison of the length frequencies from the 1979-80 and 1983-86 O.D.W.C. gill netting can be found in Figure 10. A comparison of the paddlefish tagged during the O.D.W.C. tagging 1983-86 and those tagged during the commercial operations 1983-86 appears in Figure 11. The length frequencies of the paddlefish harvested by commercial fishermen appears in Figure 12 (1983-84), Figure 13 (1984-85), Figure 14 (1985-86), and Figure 15 (1983-86). A comparison of the length frequencies of the 1983-86 commerical harvest and the fish tagged from releases by the commercial fishermen 1983-86 appears in Figure 16.

A creel survey was attempted at the low water dam in Miami and the Neosho River each spring from 1984 through 1986, but high discharges throughout the peak (March-April) snagging period limited the harvest. The creel surveys did not provide the required harvest data for estimating the paddlefish population parameters. The data from the commercial fishing observed by Department personnel were used to make the population estimate and the commercial exploitation estimate for the fishery.

A summary of the paddlefish population parameters gathered during the 1985-86 commercial fishery can be found in Table 2, for the fish greater than 400 mm (16 inches) body length (BL) and for those paddlefish 401 mm to 1,000 mm BL in Table 3. The estimate of the population greater than or equal to 400 mm is 15,998 based

on the equation $N = \frac{\Sigma C \cdot M}{R + 1}$ (Ricker 1975).

All paddlefish captured by commercial fisherman were not tagged at the same rate. Older paddlefish, those greater than 1,000 mm (40 in) BL, were preferred by the commercial fishermen for harvest (Table 4) and therefore were not available for tagging. At around 1,000 mm body length and age six or seven, Grand Lake paddlefish become sexually mature, and mature female paddlefish are preferred for the commercial caviar (roe) fishery. Since all paddlefish sizes were not equally available for tagging and recapture, another approach was required to estimate the true population size. Therefore, a proportional subset estimate was made on those paddlefish 401 mm to 1,000 mm. The equation $N = \frac{\Sigma C \cdot M}{R + 1}$ was used as the estimator for the subset of the population. The estimate for the population to 1,000 mm (Table 3) is 17,126 (95% C.I. 12,937 to 24,466). From the 1985-86 O.D.W.C. gillnetting, where all paddlefish encountered had an equal chance of being tagged, the proportion of the population 401 mm to 1,000 mm was 136/179 = 76%. The commercial fishing for 1985-86 produced a proportion of the population 401 mm to 1,000 mm of 1299/1774 = 73.2%. From the proportional estimate of the population in the commercial fishery for all paddlefish greater than 400 mm, the population estimate is 23,396. For the proportional estimate from the commercial fishery using the proportion developed during the O.D.W.C. gillnetting, the population estimate of those paddlefish greater than or equal to 401 mm is 22,534. Dividing the 95% confidence interval for paddlefish of 401 mm to 1000 mm (12,937 to 24,466) by the proportion of that size range in the total population larger than 400 mm gives a reasonable confidence interval for those greater than

400 mm. The confidence intervals thus obtained approximate, but are not strictly 95%. Given that, the confidence intervals of paddlefish greater than 400 mm based on commercial and O.D.W.C. gillnetting data from 1985-86 were 17,673 to 33,423 and 17,022 to 32,192, respectively. The estimate of those paddlefish which were greater than 700 mm (28 in) in 1979-80 was 25,118 with a 95% confidence interval of 19,375 to 32,485 (Combs 1982). Those data may be compared directly with these since the smallest paddlefish in the 1979-80 study was 721 mm. All three estimates have confidence intervals which broadly overlap; therefore, from the commercial and O.D.W.C. netting data in this study,the present population size apparently has not changed much from the 1979-80 population estimate in numbers of individual present.

A comparison of the length frequencies of the 1979-80 and 1983-86 O.D.W.C. gillnetted and tagged paddlefish (Figure 10) indicates there are more small paddlefish (less than 800 mm or 32 in BL) in the population presently than in 1979-80. Also indicated is the decreased abundance of some length groups from 1979-80 to 1983-86. The length frequencies of the paddlefish marked during the commercial fishing operations 1983-86 (Figures 1-3, 4) indicate that a decreasing percentage of the fish tagged each year were over 1,000 mm in body length. The percentage of paddlefish greater than 1,000 mm tagged from commercial releases was 40.2% for 1983-84, 35.3% for 1984-85 and 15.7% 1985-86 (Table 4). The tagging of smaller paddlefish increased as their abundance increased and their susceptibility to capture in the gill nets was increased due to their growth. Also indicated is a reduction in the abundance of some length groups greater than 1,000 mm

which were heavily selected for by the commercial fishermen in search of roe.

In some populations female paddlefish become sexually active in three year intervals (Elser 1982) and some fish released by the commercial fishermen each season may have been from fish not eligible for the caviar production that year. The recruitment of smaller paddlefish into the population masked the harvest of paddlefish by commercial fishermen in our population estimates. Increased recruitment is often a normal result of exploitation in some fish species. This increased recruitment may have been due more to better spawning conditions than exploitation for this population. For paddlefish to support a stable fishery, losses from mortality must be balanced by gains from growth and recruitment.

Paddlefish populations are vulnerable to overexploitation for two reasons: first, because their behavior makes them easy to catch with commercial fishing methods; and second, because their relatively low recruitment and growth rates make it difficult for them to withstand periods of heavy fishing pressure (Pasch and Alexander 1986). Paddlefish populations normally have low turnover rates and will not sustain harvest levels as high as those with high turnover rates (Hackney and Minns 1974). In paddlefish populations, a large increase in harvest will result in a decrease in average size and numbers caught (Pasch and Alexander 1986) and reproductive success may be affected by a reduction in adult abundance (Alexander and McDonough 1983). Rapid declines in harvest rates have followed commercial fishing for paddlefish in

several southern reservoirs (Carroll, Hall, Bishop 1963, Harned 1979, Bowers 1980, Alexander and McDonough 1983). Paddlefish stocks once depleted may take as long as 20 years to recover to harvestable levels (Alexander and Peterson 1982). When a population is depleted, adverse environmental conditions can increase both the time required for recovery, and the probability that the remaining stock will die without reproducing successfully (Pasch and Alexander 1986).

In paddlefish, survival of year-classes to recruitment remains unknown, so prediction of annual surplus production is not possible. Paddlefish fisheries may be supported by one or two year-classes for several years (Russell 1986). With caviar demand increasing and individual fish worth over $200, the potential for overharvest from our commercial fishery needs careful monitoring and management if the resource is to remain stable.

Paddlefish harvests for Grand Reservoir have increased dramatically since 1982 (Table 5). Caviar production from Oklahoma paddlefish began in 1982 and increased to about 4,200 pounds in 1984 from Grand Lake. Caviar production has fallen every year since 1984; this indicates that the maximum sustainable harvest level has been exceeded. Regulation changes shortened the commercial fishing season starting in 1987. The commercial fishermen on Grand Lake prior to 1981 were not restricted by a season as demand for paddlefish was low. Starting in 1983 (Table 6), commercial fishermen were restricted from fishing from 21 March to 1 June annually to allow the paddlefish to migrate upstream freely to spawning areas. Continued summer commercial fishing, with floating/

suspended gill nets specifically for paddlefish, was accounting for 24% of the annual harvest on Grand Lake. The summer mortality from the commercial fishery was reduced by extending the closure from 21 March to 1 September annually. The closed season may have to be extended to allow paddlefish harvest only during October, November, December, January, and February. The reduction in the length of the season may accomplish some of the desired results, but careful monitoring of the commercial harvests needs to continue. A reduction in the number of commercial licenses permitted on Grand Lake or a contract bid for removal of only a certain number of paddlefish per season should also be considered as a method of reducing the harvest of paddlefish. Results from a closely monitored commercial fishery can aid in better management of the paddlefish resource in Grand Lake.

The commercial exploitation of paddlefish based on tag returns from 1979-80 was 0.7%, from 1980-81 0.2%, from 1984-85 6.1%, and from 1985-86 5.8%. The exploitation rates are within desired levels for a combination sport and commercial fishery (15-20%, Gengerke 1978, Combs 1982, Pasch and Alexander 1986) but the segment of the population that the commercial fishermen are concentrting on harvesting (those paddlefish greater than 1,000 mm = 40 in body length) is out of proportion to their abundance in the population (Figure 16). A proportional harvest (PH) index for 1983-84, 1984-85, and 1985-86 of those paddlefish $\geq$ 1,000 mm was 239, 223, and 375%, respectively. The PH index indicates that paddlefish greater than 1,000 mm were being harvested at a rate from two to three times higher than their proportion in the population. The exploitation estimates from the Schnabel pop-

ulation estimate of u = R/M to R/M-R (Table 2) for those paddlefish 400 mm and longer is 5.5-5.8%, for those 401 mm to 1,000 mm is 3.8-4.0%, and for those greater than 1,000 mm is 13.9-16.1%. The length frequency of paddlefish commercially harvested and observed by O.D.W.C. personnel 1985-86 (Figure 14) indicates 164 of the 279 harvested fish were greater than 1,000 mm (40 in) body length (58.8%). There were 1,628 paddlefish harvested during 1985-86 by commercial fishermen. Based on 58.8% of the harvest being greater than 1,000 mm body length, of the 1,628 paddlefish harvested, 957 were greater than 1,000 mm body length. From the 1985-86 commercial netting, the number greater than 1,000 mm is 23,396 x (1-.732) = 23,396 x .268 = 6270, and therefore the exploitation of those greater than 1,000 mm is 957/6270 = 15.3%.

From the O.D.W.C. netting operations,the estimated number of paddlefish greater than 1,000 mm is 22,534 x (1-.760) = 22,534 x .240 = 5408, and therefore the exploitation rate is 957/ 5408= 17.7%. Under the assumption our population is about 23,000 (greater than 400 mm) and 28.1% of those are greater than 1,000 mm (from the 1983-86 commercial tagging data), then the total number of fish available greater than 1,000 mm = 23,000 x .281 = 6463. The average harvest from 1984-86 = 1,614 x .823 (greater than 1,000 mm) = 1351 (greater than 1,000 mm). Exploitation of paddlefish greater than 1,000 mm during 1983-86 (1351/6463) = 20.9%. This also indicates that paddlefish are being overharvested within this size group, and the estimated rate of exploitation increased during the 1983-86 study to 26.5% for the 1985-86 harvest.

Sport angling for paddlefish in the Neosho River above Grand

Lake during 1984-86 was limited in duration and success; the levels of sport harvest observed in 1979-80 were never reached during 1984-86. High discharge rates, low water temperatures, and low fishing pressure all contributed at some time during 1984-86 to low angler harvests. A partial creel was executed in 1986 at the Miami, Oklahoma park (Table 8). The pressure, number harvested, and the catch rate during 1986 never approached the levels of 1979-80; in fact, catch rates observed in 1986 were almost half those observed in 1979 and 1980. Due to the low angling pressure and problems associated with anglers being able to harvest paddlefish, the creels were not capable of providing the harvest, exploitation, sex ratio or age distributin information that the 1979-80 creel provided. Apparently the creels of 1979 and 1980 happened to coincide with flow rates and temperatures that were optimum for sport angler harvest in Miami (Table 9). The angler exploitatin of paddlefish for 1986 was calculated at 3.5%, well below the 15.2% of 1979 and 18.8% of 1980. There have been 3,598 paddlefish tagged from 1979 through 1986 by O.D.W.C. personnel. Of the 3,598 paddlefish tagged, there have been 426 tags returned by sport and commercial fishermen for an exploitation rate of 11.8%.

The average length of paddlefish in the 1979 creel was 1011 mm on weekdays and 1006 mm on weekends whereas during the 1986 creel it was 873 mm on weekdays and 896 mm on weekends. The reduction in mean length of the individuals in the creel reflects the recruitment of paddlefish into the population and the harvest of several large potential spawning paddlefish by commercial fishermen. Paddlefish populations have displayed a fluctuating average size

in other sport fisheries where reproduction has been adequate (Stewart 1986, Rehwinkel 1978, Russell et al. 1980) and may be natural due to differences in the rate of sexual maturation and recruitment into the population, i.e. males mature earlier.

Paddlefish sport angling is not limited to the Miami Riverview Park; under low water conditions, the main snagging areas are in the upper end of Grand Lake and upstream to the Twin Bridges State Park area. When river flows are high enough (usually somewhere around 4000-5000 cfs in the Neosho River), paddlefish will move upstream to spawning areas in the Neosho River. Paddlefish movement and spawning are not restricted to the Neosho River; during the 1985 spring spawning movement, the Spring River had a higher discharge than the Neosho River and more tag recoveries were made in the Spring River than the Neosho River. When water flows inundate the low water dam at Miami (usually about 10,000-12,000 cfs), paddlefish can ascend the Neosho river above the dam. Paddlefish during 1984, 1985, and 1986 were captured by snaggers at Chetopa, Kansas which is 40 km upstream of Miami, Oklahoma. The Kansas Fish and Game Commission opens an area downstream of a low water dam to the county line to paddlefish snagging at these times (Bonislawsky 1977). During 1986, there were several paddlefish harveted at the low water dam in Chetopa, and movement over the low water dam was possible in 1984-85. The rest of the Neosho River upstream is closed to paddlefish snagging, so it is unknown exactly how far upstream the Grand Lake paddlefish moved. It can be assumed under high flow conditions that they could move all the way to Burlington, Kansas at the base of John Redmond Reservoir.

Paddlefish tag recoveries has been made below all the dams downstream on the Neosho-Grand River system. During 1984, 1985, and 1986, releases of water through the spillways on Grand Reservoir allowed some paddlefish to move downstream. Grand Lake impounds the Neosho-Grand River upstream of Hudson Lake and Fort Gibson Lake. Paddlefish tag recoveries have been made in the tailwaters, which are open to snagging, downstream to its confluence with the Arkansas River some 264 km downstream of Chetopa, Kansas. Apparently, the dams on the river are not prohibiting movement of paddlefish downstream. Any population estimates for the Grand Lake-Neosho River system must be made while the gates on the spillways of Pensacola Dam remain closed as there is movement out of the population when they are open.

Reproduction of paddlefish in the Neosho River has been documented (Combs 1981). Spawning success at that time was defined as successfully capturing larval paddlefish downstream of the spawning areas. The successful spawning of paddlefish in the Neosho River-Grand Lake population seems to be related to flows and temperature of the water. From the length frequencies of the paddlefish tagged from releases by commercial fishermen 1985-86 (Figure 3), it appears that reproduction of paddlefish has been good the past few years. Paddlefish apparently will utilize, or move up, any of the three major river arms of Grand Lake during high flows. During 1986, the water flows in the Elk River arm reached 50,000 cfs before flows in either the Neosho or Spring Rivers increased, and several paddlefish were taken at the mouth of Elk River. The Elk River in Missouri is closed to snagging, and no paddlefish tags have been recovered from there to date. Spawning areas are

unknown on all three major rivers and need to be delineated for protection of the fishery. During 1985, paddlefish moved up the Spring River, presumably to spawn, but O.D.W.C. personnel were unable to document spawning in the river. Spawning requirements for paddlefish in the Grand Lake system are unknown. The location and preservation of spawning sites is crucial in the preservation of paddlefish fisheries. Commonly the most popular fishing areas for paddlefish anglers are in areas where they are concentrated for spawning. Paddlefish reproduction was documented in the Neosho River during 1985 by drift netting a plankton net from Conners Bridge just downstream of the Miami Riverview Park. Attempts at capturing paddlefish eggs or larvae proved unsuccessful during 1984 and 1986. The spawning of paddlefish in the lower reservoirs of the Grand River system has not been documented. The recent apprehension of illegally produced caviar by O.D.W.C. law enforcement personnel from the Fort Gibson Lake area documents the presence of a viable population in the reservoir. Spawning in tailwaters has been documented from several locations throughout the paddlefishes range (Pasch et al. 1980, Wallus 1986) and could be possible in some of the tialwaters of the Grand River system. The movement upstream by paddlefish through dams has been documented (Southall and Hubert 1984) but such movement is not possible in the Grand River system. The need to delineate paddlefish spawning habitat was the data need most commonly identified by a panel of 11 experts on paddlefish in a Delphi exercise (Crance 1987).

The schooling tendencies of paddlefish have been documented by several researchers (Wagner 1908, Bryan 1942, Gengerke 1978, Rosen et al. 1982, Hevel and Alexander 1983, Southall and Hubert

1984) though evidence of paddlefish forming polarized schools in which movements of individuals are coordinated has not been documented. During tagging operations by O.D.W.C. personnel on the upper end of Grand Reservoir, there were 3 paddlefish tagged on 17 April 1984. Those paddlefish were released in the upper end of Grand Lake on 27th April 1985; the three paddlefish were recaptured by an angler on a snagline set in the Spring River. The paddlefish had apparently formed a school prior to tagging and after their release together had maintained that school for a period of over a year.

There were 64 paddlefish that were tagged and recovered the following season. Their growth increments and time at large are found in Table 10. The 64 paddlefish averaged just under 21 months (10 to 60 months) at large and an average growth of 57 mm (2 to 275 mm). The differential growth of paddlefish that were less than 1,000 mm when first tagged and those that were greater than 1,000 mm when first tagged was investigated. There were 21 of the 64 paddlefish recovered that were greater than 1,000 mm when first tagged; they grew an average of 37 mm (2 to 132 mm) during 20 months (10 to 47 months) at large. There were 43 paddlefish that were less than 1,000 mm when first tagged that were recovered; but their length increment averaged 70 mm (2 to 275 mm) during 21 months (10 to 60 months) at large. The differential growth of those paddlefish greater and less than 1,000 mm can be explained by the reaching of sexual maturity at about age seven or eight years and around 1,000 mm in body length (Table 11). After paddlefish reach sexual maturity, their growth in length slows but their growth in girth and weight increases. The growth in body length

(mm) for paddlefish that were less than 1,000 mm when first tagged appears to be almost twice that of the paddlefish that were greater than 1,000 mm when first tagged.

Some of the paddlefish that were harvested by commercial fishermen during 1983-84 were used to determine the average amount of roe produced by a female harvested for the caviar operations. There were 315 paddlefish which were used for complete gonadal somatic measurements (Table 12). The investigation determined that the paddlefish being harvested for caviar productin during 1983-84 averaged 28.89 kg (63.7 lb.) and yielded an average of 5.19 kg (11.5 lb.) of raw eggs and 3.51 kg (7.7 lb.) of processed eggs (caviar). A strong relationship between body length and egg weight, or body weight and egg weight, did not exist. Therefore, it was not possible to predict the weight of eggs from a paddlefish of a given length or weight. For caviar production from paddlefish, their eggs reach prime condition in late winter and early spring before they become fully ripe (Jarvis 1943). Consequently, paddlefish fisheries for roe are going to be operating during late winter and early spring (October-March).

V. RECOMMENDATIONS:

The goal of these recommendations is to 1) provide a stable, self-perpetuating, and regionally important sport and commercial fishery; 2) monitor the effects of current regulations so that accurate explotiation rates and their long term, delayed results can be evaluated; 3) delineate areas of research to be conducted so that a specific management plan for this unique, fluctuating, and fragile fishery can be developed on a regional (river basin wide) and statewide approach.

The Commercial Fishery: Grand Lake appears to have an adequate number of harvestable size paddlefish to permit a limited commercial harvest. Because of the market driven high exploitation rate of the fishery on fish greater than 1,000 mm (40 inches) body length, it is recommended that additional regulations be placed on the fishery to control the catch.

1) Restrict entry into the fishery by limiting the number of commercial license available to one on a contractual basis. This in theory would eliminate about half the annual harvest by commercial fishermen on Grand Lake. The contractual agreements should have requirements which ensure accurate information collection.
2) A further restriction of the season to include October 1 to March 21 would allow 173 days of harvest, and would reduce the seasonal harvest another 3.9% based on reported harvest data.
3) Develop a harvest quota on paddlefish numbers that can be harvested during a season. A 10-15% seasonal harvest has been found to provide a stable fishery. The commercial harvest when coupled with the potential sport harvest should not exceed the 10-15% population estimate to prevent over-harvest. Therefore, commercial harvest of paddlefish should be limited to approximately 10% of the adult paddlefish in the population. Since estimated number of paddlefish larger than 1,000 mm (40 in) in the population greater than 1,000 mm body length is approximately 6,000 fish, a ten percent harvest would allow a seasonal harvest of 600 fish within that size range. Current regulations restrict the gear, season, and areas open to harvest. Using a quota in addition to these

restrictions would encourage commercial fishermen to attain the highest economic return for their efforts not in pursuit of an impractical level of catch and harvest. Harvest quota regulations take supervision, enforcement and accurate data collection to ensure compliance. The harvest of paddlefish under a quoata requires being able to close the fishery when the harvest quota has been met. Harvest of paddlefish by commercial fishermen should not exceed 600 fish greater than 1,000 mm (40 inches). The fishery should be closed when the harvest of 600 fish greater than 1,000 mm (40 in) BL is reached.

Paddlefish populations should be evaluated regularly to determine the effects of harvests on the population age and size structure. Population parameters that should be gathered from observing the commercial catch are population size estimates (numbers caught, released, tagged, recaptured and and harvested), catch per unit effort, and the age and size structure of harvests. Population parameters could be gathered by having the commercial fishermen accompanied by either O.D.W.C. personnel or contracted creel clerks. The paddlefish fishery on Grand Lake will continue to remain an economic asset only if it is properly observed and managed.

The Sport Fishery:

1) Daily and possession limits should be lowered from 3 to 2 to be in accordance with daily and possession limits in Kansas and Missouri and to make enforcement of creel limits easier and more uniform. As interest in paddlefish angling continues to grow, the harvest will likely increase. The next time

flow and temperatures trigger a larger run, a reduction in the daily creel and possession limits would distribute the catch among more anglers and would lessen the probability of overharvest.

2) An annual creel survey of the sport snagging and trotline-snagline fisheries in the Neosho River-Grand Lake system should begin to gather harvest trend data. The paddlefish fishery is located at different sites during different flows, and the creel will have to move accordingly. Agreements with the Kansas Fish and Game Commission allowing observation and collection of data at the Chetopa, Kansas fishery during high flow years need to be reached. Current exploitation estimates for sport rod and reel snagging and snagline fishing have not been adequately determined. A randomized creel survey to determine harvest and pressure for each fishery should be conducted.

Additional Research Needs:

Present fishing regulations may need reconsideration if angler exploitation rates increase to levels observed in 1979-80 or beyond. Possible management regulations if the level increases, are imposing a legal snagging season, a tag-limit system allowing harvest of only 8-10 fish per season per angler, determination of a quota for sport harvests annually, restriction of the use of snaglines in the Neosho and Spring Rivers during spawning runs, and if the exploitation reaches critical levels, a closure or prohibition of harvest may be appropriate. Further investigations are needed to determine whether current regulations or some combination of new ones will best meet management objectives

for the fishery.

Annual fluctuations in paddlefish sport harvest are related to changes in water level, flows and temperature. Intrastate movement makes management of the paddlefish resource in the Neosho River-Grand Lake a regional concern. With almost half of our paddlefish sport anglers coming from Kansas and Missouri, and with a common interest in preserving this regional resource, cooperative investigations with the Kansas Fish and Game Commission and Missouri Department of Conservation may be appropriate to better manage the resource.

The downstream impoundments from Grand Lake (lakes Hudson and Fort Gibson) have paddlefish populations that remain relatively unknown. Investigation of the paddlefish populations in these reservoirs needs to be undertaken so that a management plan for the fisheries in these reservoirs, tailwaters, and river system can be developed. Feasibility of a contract commercial fishery on these reservoirs should also be performed. A commercial fishery operation might curtail some of the illegal harvests brought on by the demand for paddlefish roe for caviar.

A request to the Kansas Fish and Game Commission to eliminate stocking of cultured paddlefish fingerlings in John Redmond Reservoir on the Neosho River needs to be made. Stocking of unknown gene paddlefish may adversely impact the Neosho population. Research of paddlefish gene pools needs to be completed before stocking dilutes or alters the fish in the Neosho system.

The most critical research need of paddlefish in the Neosho River-

Grand River system is the identification and protection of spawning sites and their various requirements. Paddlefish spawning locations and success under various flows and velocities needs to be determined. Paddlefish will utilize either the Neosho, Spring or possibly Elk River under different flow patterns. For successful management of this resource, the movement of spawning paddlefish from Grand Lake to various spawning areas, at different flows, needs to be understood. Protection of the spawning sites will allow paddlefish reproduction to continue and possibly enhance the fishery. Success of spawning paddlefish may affect the paddlefish populations and fisheries in downstream impoundments.

Determination of whether flow conditions and spawning requirements are met in the tailwaters of the downstream impoundments would allow development of a system wide management plan to enhance paddlefish stocks in the lower reservoirs and tailwaters. A telemetry study of adult female paddlefish behavior to determine spawning areas and utilization at various flows is recommended. The suitability of various velocities for larval and age 0 paddlefish remain unknown, and the movement of larval paddlefish away from the spawning sites and their subsequent dispersal into nursery areas are critical research needs for maintenance of a self-supporting population.

Paddlefish research and management in Oklahoma should be expedited to preserve and enhance this regional resource. Cooperation with the Kansas Fish and Game Commission, the Missouri Department of Conservation, and other agencies involved with paddlefish research and management is urged.

Summary of Immediate Concerns:

The adult stock of paddlefish in Grand Lake appears to have been negatively impacted by the increased commercial harvest in recent years despite the lack of a significant sport fishery. A season or two of high harvest by both the sport and commercial fisheries, and/or a few years of poor paddlefish reproduction, could be devastating to the population. Thus, some restrictions to the harvest of paddlefish in Grand should be applied immediately. We recommend limiting the commercial harvest of paddlefish over 1,000 mm (40 in) body length to 600 per year (season). Probably the most enforceable way of accomplishing this objective is by further limiting the number of commercial fishermen by contractual bidding for the available harvest and an additional shortening of the commercial fishing season. Also, the sport fishery creel and possession limit should be reduced from 3 to 2 per day to control harvest of paddlefish during high harvest seasons and to make regulations more uniform on a regional basis.

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Table 1. Summary of paddlefish tagged 1979-86 in the Neosho River-Grand Lake system.

Season	O.D.W.C. Netting		Commercial Netting
1979	362		---
1980	208		---
1979-80	570		---
1983-84	25		1,020
1984-85	105		434
1985-86	159		1,246
1983-86 Total Measured	289		2,700
1983-86 No Lengths Available	7		32
1983-86 Total Tagged		3,028	
1979-86 Commercial & O.D.W.C.	866		2,732
Combined Total		3,598	

able 2 . Summary of paddlefish tagging from selected dates during observation of the commercial fishery 3 December 1985 through 20 March 1986.

ate	Number Caught Total (C)	Number Recaptures (R)	Number Marked Less Removals	Number Marked At Large (M)	C·M
ec. 3, 1985	21	0	15	0	0
10	57	0	46	15	855
16	34	0	30	61	2,074
17	43	1	36	91	3,913
19	40	0	34	127	5,080
23	53	1	43	161	8,533
24	41	5	25	204	8,364
27	147	5	131	229	33,663
31	91	1	76	360	32,760
an. 3,1986	97	2	86	436	42,292
29	30	0	24	522	15,660
30	41	5	30	546	22,386
31	29	3	21	576	16,704
eb. 4, 1986	28	0	20	597	16,716
5	19	2	15	617	11,723
19	48	2	34	632	30,336
21	33	1	27	666	21,978
25	25	2	22	693	17,325
26	25	3	20	715	17,875
27	54	3	40	735	39,690
arch 4, 1986	63	0	49	775	48,825
5	62	4	44	824	51,088
6	62	4	50	868	53,816
7	21	0	19	918	19,278
10	104	5	55	937	97,448
11	63	7	25	992	62,496
12	74	4	51	1017	75,258
13	117	9	79	1068	124,956
14	43	2	30	1147	49,321
19	80	1	58	1177	94,160
20	129	1	89	1324	159,315
OTAL	1774	73	1324	1324	1,183,888

Table 3 . Summary of paddlefish population subset (greater than 400 mm but less than 1000 mm observed during the commercial fishing 3 December 1985 through 20 March 1986.

Date	Number Caught (C) 401-1000 mm	Number Recaptures (R) 401-1000 mm	Number Marked Less Removals 401-1000 mm	Number Marked At Large (M) 401-1000 mm	C.M 401-1000 mm
Dec. 3,1985	17	0	13	0	0
10	41	0	40	13	533
16	23	0	20	53	1,219
17	24	0	23	73	1,752
19	29	0	28	96	2,784
23	38	0	36	124	4,712
24	25	1	23	160	4,000
27	126	2	120	183	23,058
31	66	0	63	303	19,998
Jan. 3, 1986	79	2	75	366	28,914
29	19	1	17	441	8,379
30	27	3	16	458	12,366
31	22	1	13	474	10,428
Feb. 4, 1986	17	0	15	487	8,279
5	13	0	13	502	6,526
19	24	0	24	515	12,360
21	24	1	22	539	12,936
25	18	1	17	561	10,098
26	21	2	19	578	12,138
27	44	1	39	597	26,268
March 4, 1986	52	0	42	636	33,072
5	50	2	40	678	33,900
6	44	2	42	718	31,592
7	15	0	15	760	11,400
10	52	3	43	775	40,300
11	34	5	21	818	27,812
12	47	3	37	839	39,433
13	97	7	71	911	84,972
14	37	2	26	947	35,039
19	64	1	52	973	62,272
20	110	1	76	1025	112,750
TOTAL	1299	41	1101	1101	719,290

Table 4. Summary of paddlefish tagging and harvests observed in Neosho River-Grand Lake 1979-86.

Season/	O.D.W.C.	Tagging	Commercial Release		Commercial	
Size Group	N	%	N	Tagging %	N	Harvests %
1979-80						
≥401	575	---	---	---	---	---
401-1000	485	84.3	---	---	---	---
≥1000	90	15.7	---	---	---	---
1983-84						
≥401	25	---	1020	---	510	---
401-1000	22	88.0	610	59.8	21	4.1
≥1000	3	12.0	410	40.2	489	95.9
1984-85						
≥401	105	---	434	---	104	---
401-1000	72	68.6	281	64.8	22	21.2
≥1000	33	31.4	153	35.2	82	78.8
1985-86						
≥401	159	---	1246	---	279	---
401-1000	135	84.9	1051	84.3	115	41.2
≥1000	24	15.1	195	15.7	164	58.8
1983-86						
≥401	289	---	2700	---	893	---
401-1000	229	79.2	1942	71.9	158	17.7
≥1000	60	20.8	758	28.1	735	82.3

Table 5. Commercial Harvests of Paddlefish from Grand Lake 1975-86.

Year	Number Harvested	Flesh Sold (Wt.-Pounds)	Caviar (Eggs) Sold Wt. (lbs.)
1975	287	3,443	---
1976	242	5,375	---
1977	857	18,956	---
1978	1,238	13,189	---
1979	431	10,682	---
1980	191	5,613	---
1981	Closed	---	---
1982	713	17,106	701
1983	1,936	43,617	2,233
1984	1,730	47,594	4,188
1985	1,566	42,957	3,638
1986	1,628	32,693	2,969

Table 6. Commercial Harvests of Paddlefish by Month from May 1982 through December 1986.

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year Total
1982 N	---	---	---	---	128	---	14	53	14	17	27	560	713
Meat (lbs)	---	---	---	---	2510	---	677	2569	605	767	1006	8972	17,106
Eggs (lbs)	---	---	---	---	100	---	---	---	---	---	---	601	701
1983 N	362	608	305	DNF*	DNF	93	36	121	29	70	158	154	1,936
Meat (lbs)	7713	14,436	7051	---	---	1881	949	3764	889	1531	2752	2651	43,617
Eggs (lbs)	276	704	503	---	---	---	---	---	---	106	289	355	2,233
1984 N	168	436	404	DNF	DNF	20	47	141	61	255	119	79	1,730
Meat (lbs)	4709	13,008	11,472	---	---	626	980	4234	1850	6060	2672	1986	47,597
Eggs (lbs)	804	1659	1012	---	---	---	---	---	---	210	110	393	4,188
1985 N	181	179	248	DNF	DNF	180	54	114	90	196	100	224	1,566
Meat (lbs)	4600	5117	6578	---	---	5337	1620	3430	2620	5644	2861	5110	42,957
Eggs (lbs)	607	644	707	---	---	---	---	---	---	96	340	1058	3,638
1986 N	242	127	306	DNF	DNF	1	261	162	63	108	149	209	1,628
Meat (lbs)	5566	2240	4950	---	---	29	4446	3691	1449	2154	3042	4126	32,693
Eggs (lbs)	1105	570	848	---	---	---	---	---	---	---	125	321	2,969
Total Number	953	306	1263	DNF	128	294	412	591	257	646	553	1126	6,529
Total Meat (lbs)	22,588	34,801	30,051	---	2,510	7,913	8,672	17,688	7,413	16,156	12,333	23,845	183,970
Total Eggs (lbs)	2,792	3,577	3,070	---	100	---	---	---	---	412	864	2,728	13,543

* Did Not Fish

Table 7. Proportional harvest (PH) data for the commercial paddlefish harvest and commercial tagging on Grand Lake 1983-86.

Season	% Greater than 1000 mm Harvested	% Greater than 1000 mm Tagged	PH (≥1000)
1983-84	95.9	40.2	239
1984-85	78.8	35.3	223
1985-86	58.8	15.7	375
1983-86	82.3	28.1	293

Table 8 . Summary of paddlefish sport harvest on the Neosho River at Miami, Oklahoma from 1979, 1980, and 1986.

	1979		1980		1986	
Period	Pressure (h)	Number Harvested	Pressure (h)	Number Harvested	Pressure (h)	Number Harvested
Weekday Rate	20,670	2,495	13,611	1,663	1,632	95
Weekend Rate	13,985	1,379	7,556	478	3,906	262
Total Rate	34,674	3,874	21,167	2,141	5,538	357
Catch	---	0.112/h	---	0.101/h	---	0.064/h

Table 9 . Mean, Maximum, Minimum, and Total Discharge in cubic feet per second (cfs) from the U.S.G.S. Gauging Station Commerce, Neosho River.

Date		Mean (cfs)	Maximum (cfs)	Minimum (cfs)	Total (cfs)
1971	Feb	2,806	12,100	511	78,559
	Mar	2,630	8,040	575	81,532
	Apr	438	1,780	181	13,154
1972	Feb	883	2,050	454	25,615
	Mar	422	889	244	13,092
	Apr	1,364	7,550	189	40,934
1973	Feb	8,642	20,500	1,670	241,970
	Mar	21,630	33,500	1,640	670,640
	Apr	18,360	28,500	7,760	550,690
1974	Feb	3,911	15,400	786	109,494
	Mar	13,050	65,000	1,620	404,450
	Apr	3,153	10,100	878	94,594
1975	Feb	9,074	28,900	3,280	254,080
	Mar	7,759	20,400	2,280	240,520
	Apr	4,514	10,200	2,840	135,420
1976	Feb	161	333	109	4,656
	Mar	968	4,620	101	29,993
	Apr	928	9,000	104	27,850
1977	Feb	91.3	158	70	2,557
	Mar	116	298	70	3,603
	Apr	173	1,190	47	5,185
1978	Feb	2,983	13,500	382	83,530
	Mar	8,054	27,900	1,530	249,670
	Apr	7,104	17,100	1,710	213,120
1979	Feb	2,345	15,000	80	65,655
	Mar	5,728	13,000	2,000	177,580
	Apr	3,427	14,300	1,090	102,810
1980	Feb	1,627	4,670	220	47,177
	Mar	4,396	26,400	649	136,269
	Apr	9,883	26,400	2,540	296,490
1981	Feb	41.7	60	27	1,168
	Mar	30.2	59	12	935
	Apr	62.6	460	11	1,878
1982	Feb	6,881	19,700	3,600	192,660
	Mar	4,587	23,800	1,000	142,200
	Apr	948	3,870	257	28,453
1983	Feb	4,448	21,800	1,690	124,540
	Mar	4,457	17,500	890	138,182
	Apr	18,820	39,400	7,630	564,450
1984	Feb	2,270	16,600	277	65,816
	Mar	12,140	33,200	1,780	376,450
	Apr	15,880	27,800	7,960	476,540
1985	Feb	13,980	70,800	566	391,300
	Mar	12,730	28,200	1,640	394,540
	Apr	2,572	8,540	1,030	77,150
1986	Feb	3,539	13,700	403	99,097
	Mar	1,314	3,510	706	40,747
	Apr	4,529	17,600	165	135,858

Table 10. Growth increments in body length (mm) of paddlefish tagged 1979-85 and recaptured 1983-86.

Tag Number	Recapture B.L. (mm)	B. L. When Tagged (mm)	Growth (mm)	Duration At Large Months
790	1135	1108	27	28
1678	985	953	32	15
1219	1084	1066	18	27
816	950	930	20	17
935	904	897	7	15
1447	927	892	35	14
803	906	885	21	17
1281	883	862	21	14
644	948	930	18	17
849	1020	980	40	11
1014	1066	1031	35	14
1011	1174	1171	3	15
1472	1306	1270	36	12
1082	998	980	18	13
1534	931	916	15	11
832	1011	942	69	16
547	992	836	156	17
859	961	880	81	11
884	1034	1032	2	10
1204	945	915	30	11
670	1003	970	33	12
1237	1045	1037	8	12
667	933	889	44	24
1201	1170	1038	132	22
1159	1060	991	69	10
905	1065	1025	40	10
1696	815	727	88	10
1207	1073	982	91	23
1574	1095	1080	15	12
1564	714	643	71	12
739	1047	1015	32	25
886	1035	948	87	21
1544	1130	1114	16	22
1095	1215	940	275	24
1243	1083	997	86	24
1064	967	907	60	24
842	1175	1155	20	27
1758	1019	1005	14	14
624	1040	987	53	27
1337	980	937	43	25
967	986	935	51	25
828	921	845	76	28
1562	1082	1062	20	15
1320	1040	965	75	24
726	986	911	75	28
2014	937	895	42	12
578	945	888	57	29
956	1080	970	110	25
928	1160	1123	37	25
515	997	945	52	29
671	1058	1050	8	26
726	984	911	73	28
832	1068	942	126	28
1534	962	916	46	23
724	1152	995	157	28
956	1090	970	120	25
1219	1095	1066	29	25
1264	1005	990	15	24
1838	1122	1084	38	12
670	1035	970	65	26
1464	1100	1010	90	24
1263	1095	1020	75	24
342	1052	924	128	59
295	1134	1054	80	47
114	1132	965	167	60

Table 11. Age and size ranges of paddlefish aged from the 1979-80 creel survey at Miami, Oklahoma.

Age	Mean Body Length (mm)	Range in Body Length (mm)
I		
II		
III		
IV		
V		
VI	872	785-935
VII	903	790-983
VIII	969	890-1,087
IX	1,016	911-1,110
X	1,076	939-1,163
XI	1,099	1,050-1,174
XII	1,123	1,110-1,157
XIII	1,163	1,124-1,182

able 12. Mean, standard deviation, minimum, and maximum body length, body weights, raw egg weights[1], and processed egg weights[2] from paddlefish harvested by commercial fishermen during November, 1983 through March, 1984 from Grand Lake, Oklahoma.

Variable	N	Mean	Std. Dev.	Minimum	Maximum
ody length (mm)	383	1,140.26	58.82	550.00	1,290.00
ody weight (g)	382	28,887.28	4,224.28	13,620.00	43,584.00
aw egg weight (g)	372	5,192.55	1,252.81	2,099.75	11,406.75
rocessed egg weight (g)	315	3,511.02	1,046.49	822.88	9,278.63

Raw egg weights were recorded from ovaries freshly removed from fish.

Processed egg weights were recorded from eggs that had been screened through wire mesh screens and had connective, mucid, and fat tissues removed.

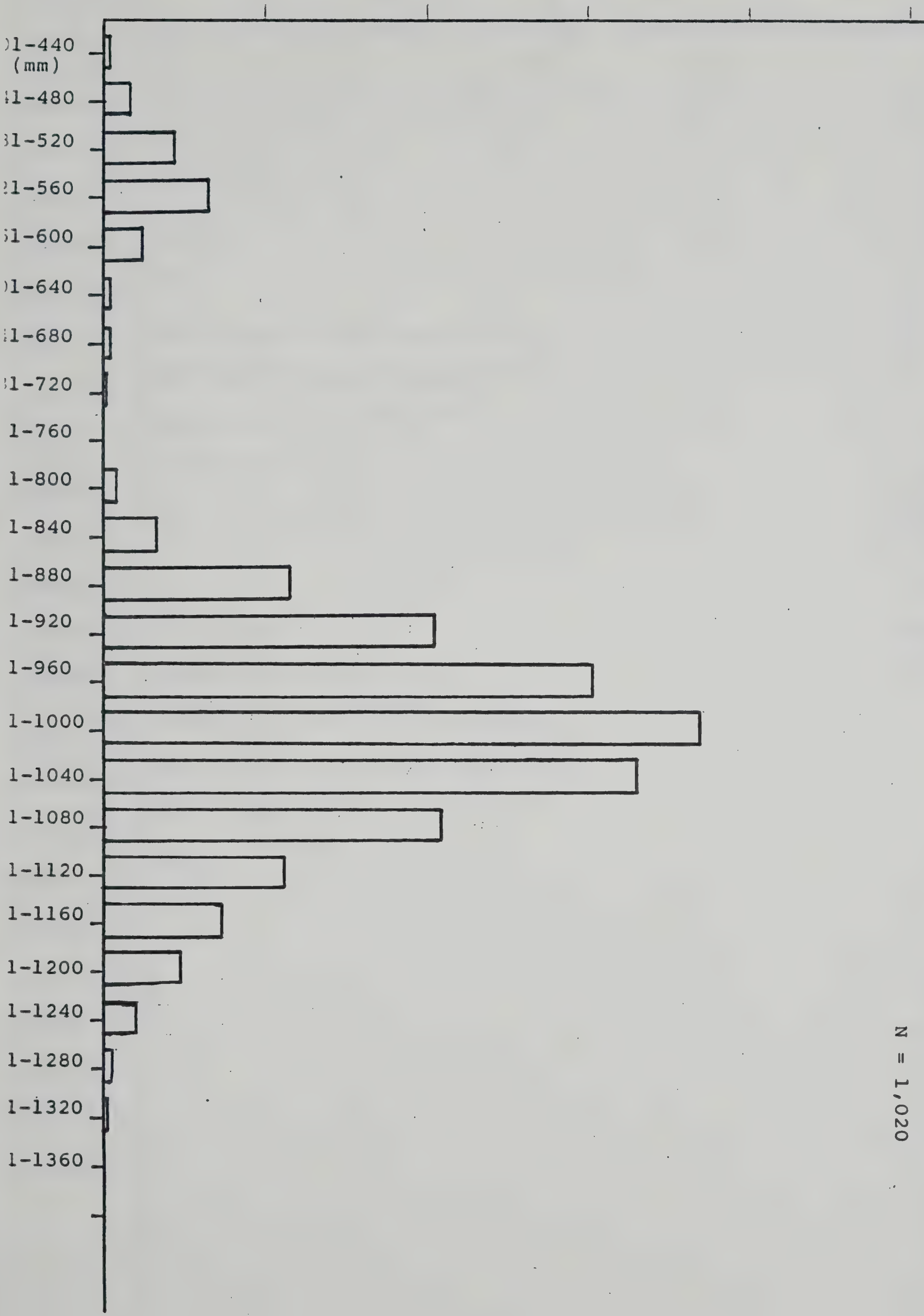


Figure 1. Length frequency of paddlefish greater than or equal to 401 mm tagged from releases by the commercial fishermen 1983-84.

Figure 2. Length frequency of paddlefish greater than or equal to 401 mm tagged from releases by the commercial fishermen 1984-85.

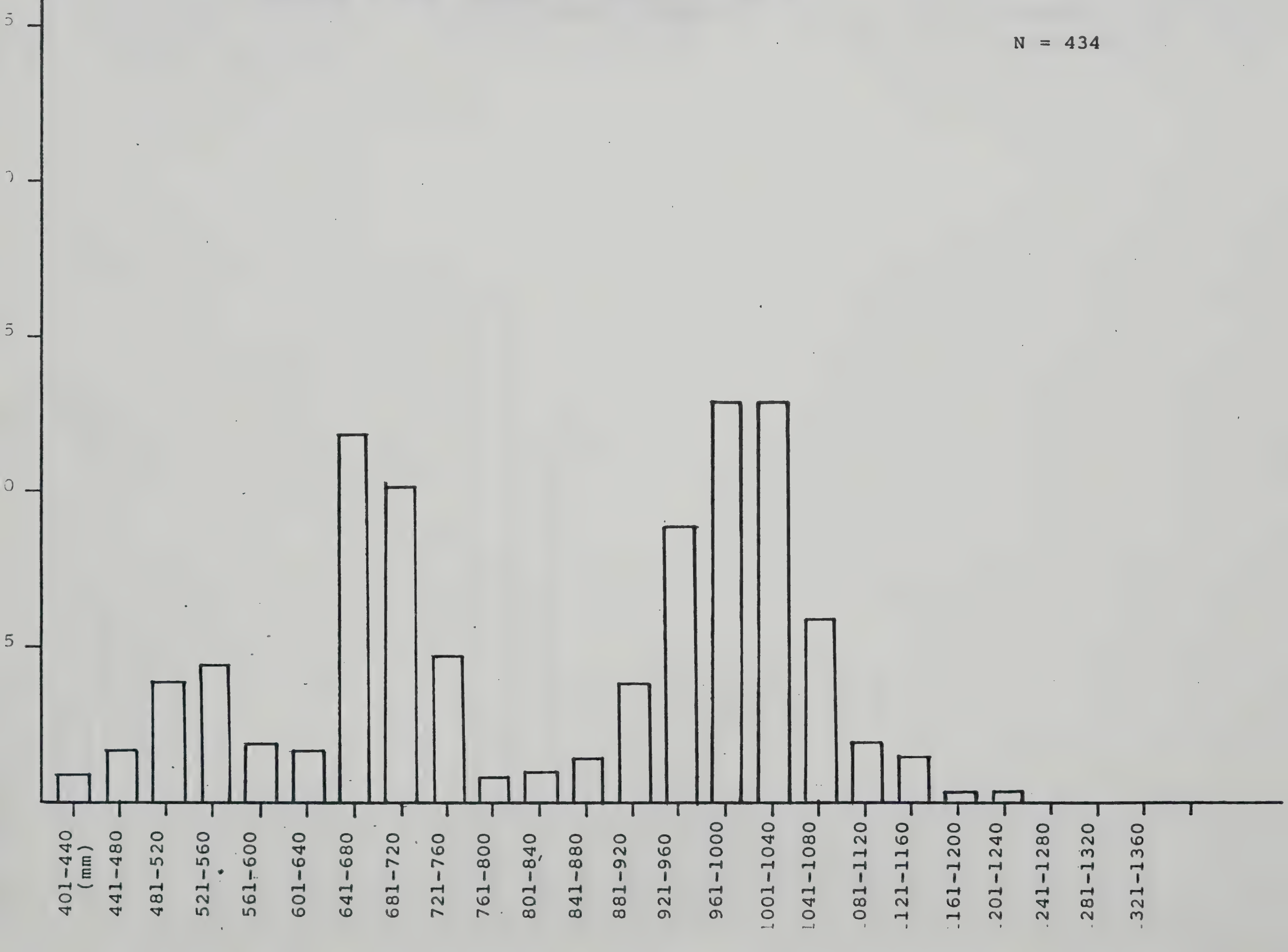


Figure 3. Length frequency of paddlefish greater than or equal to 401 mm tagged from releases by the commercial fishermen 1985-86.

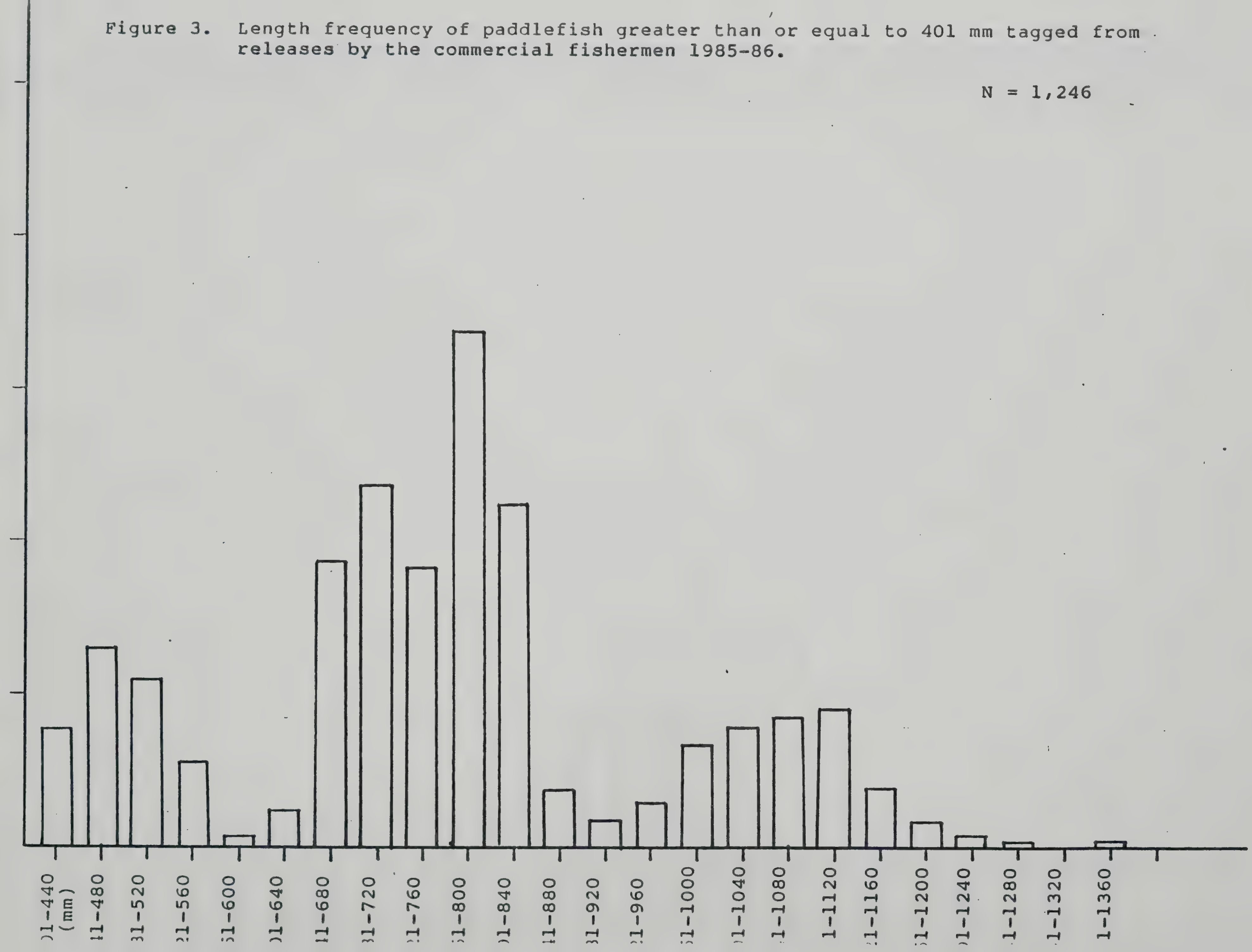


Figure 4. Length frequency of paddlefish greater than or equal to 401 mm tagged from releases by the commercial fishermen 1983-86.

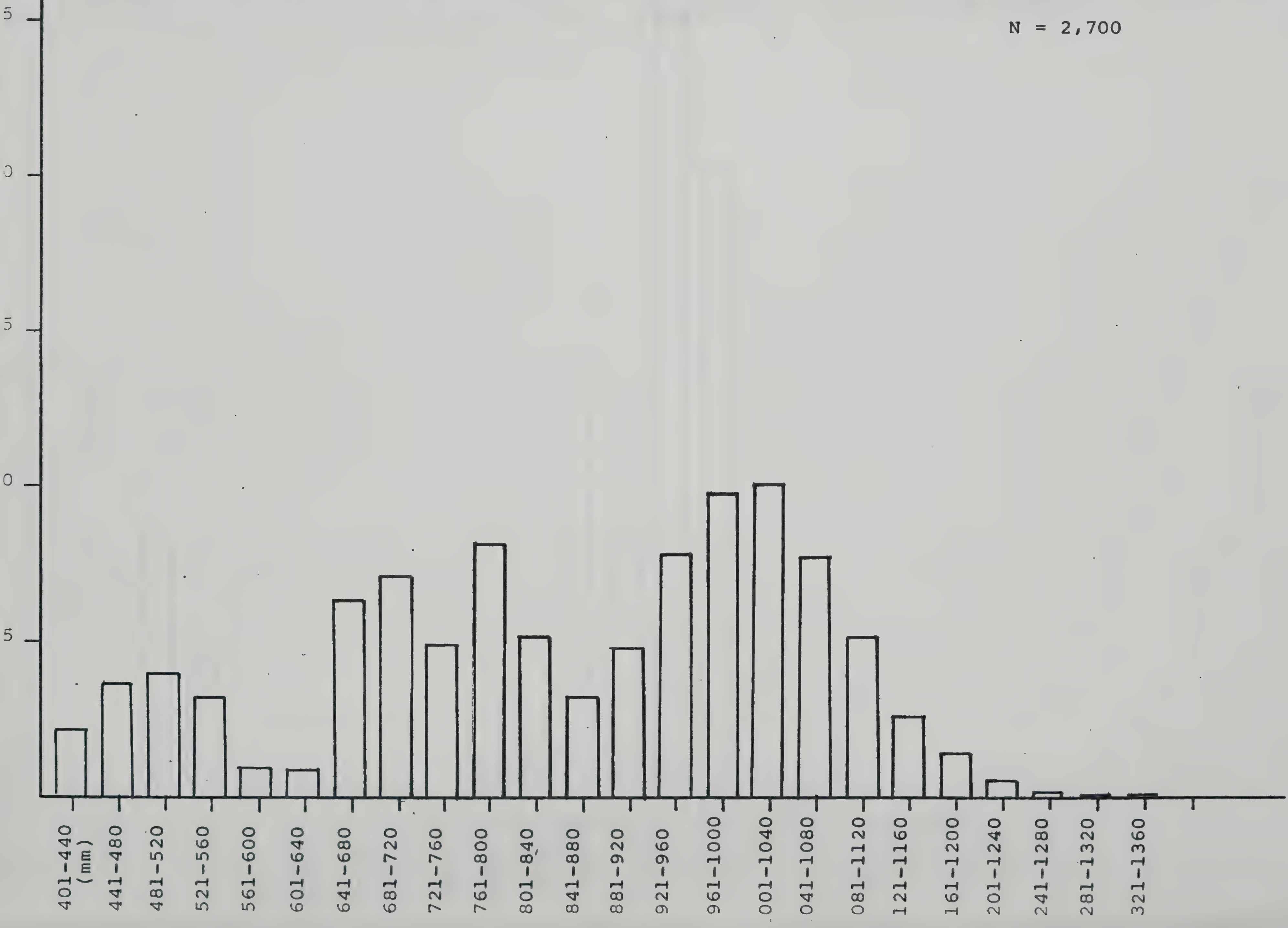


Figure 5. Length frequency of paddlefish greater than or equal to 401 mm tagged from O.D.W.C. gill netting during 1983-84.

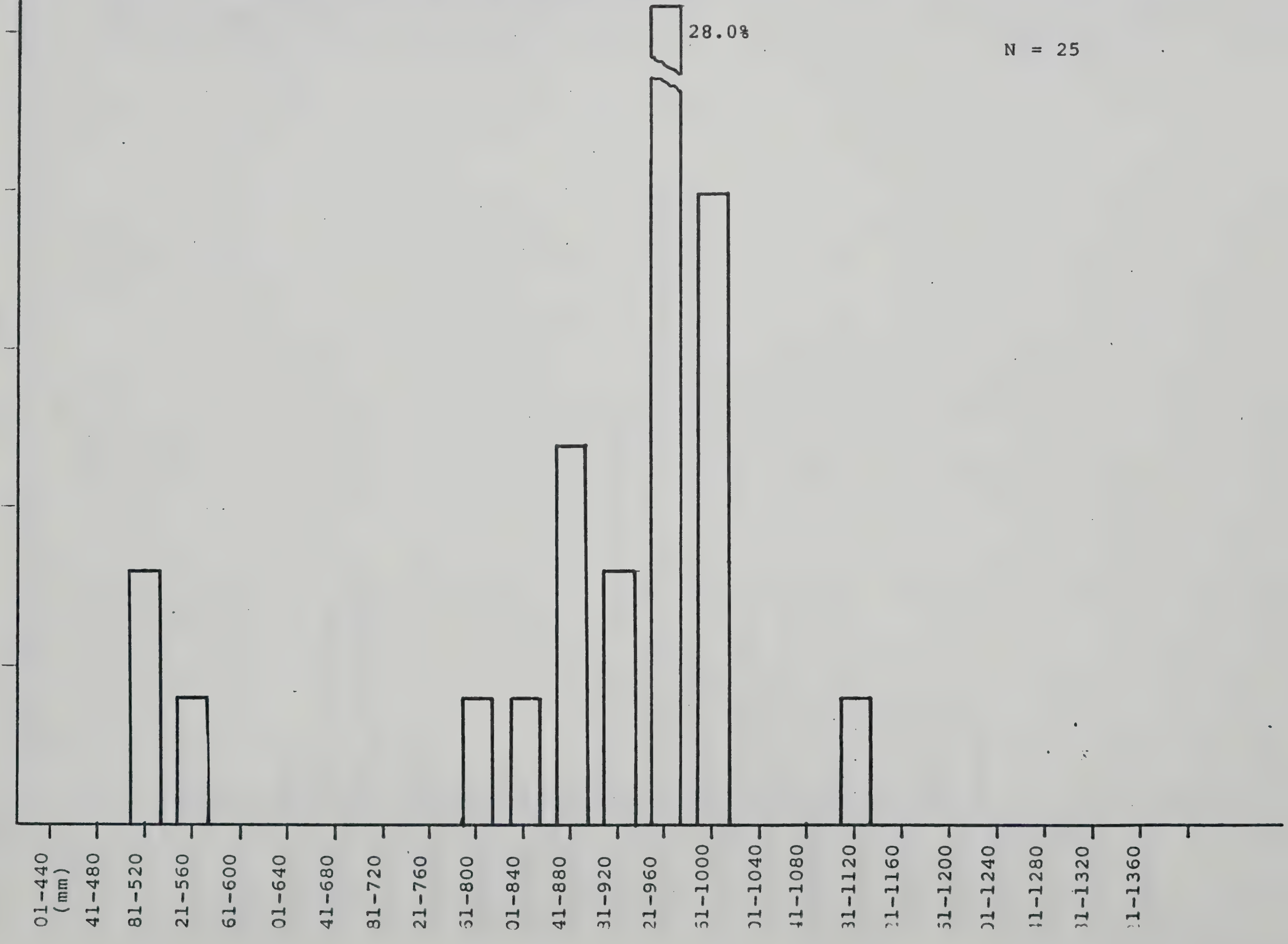
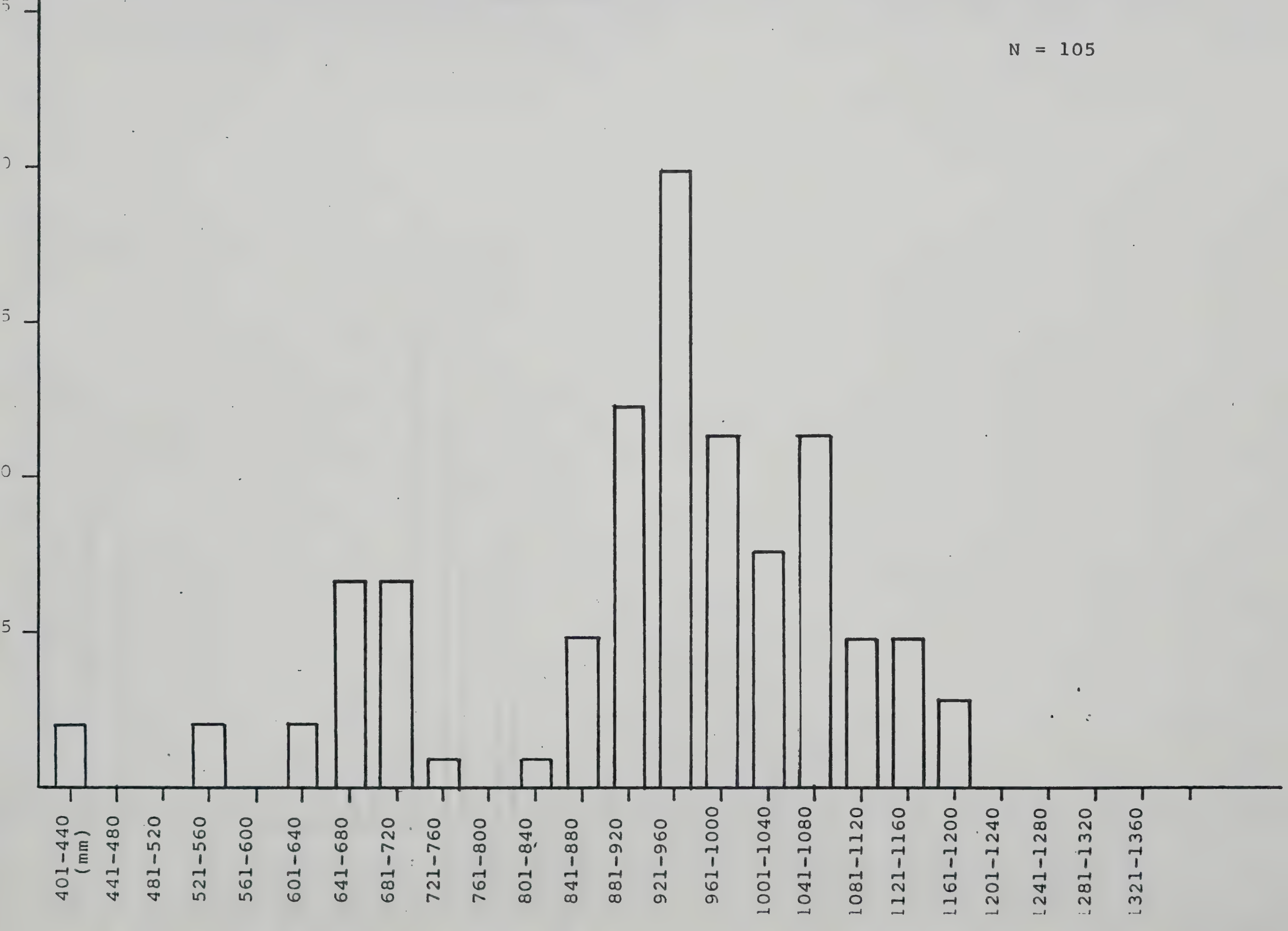


Figure 6. Length frequency of paddlefish greater than or equal to 401 mm tagged from O.D.W.C. gill netting during 1984-85.



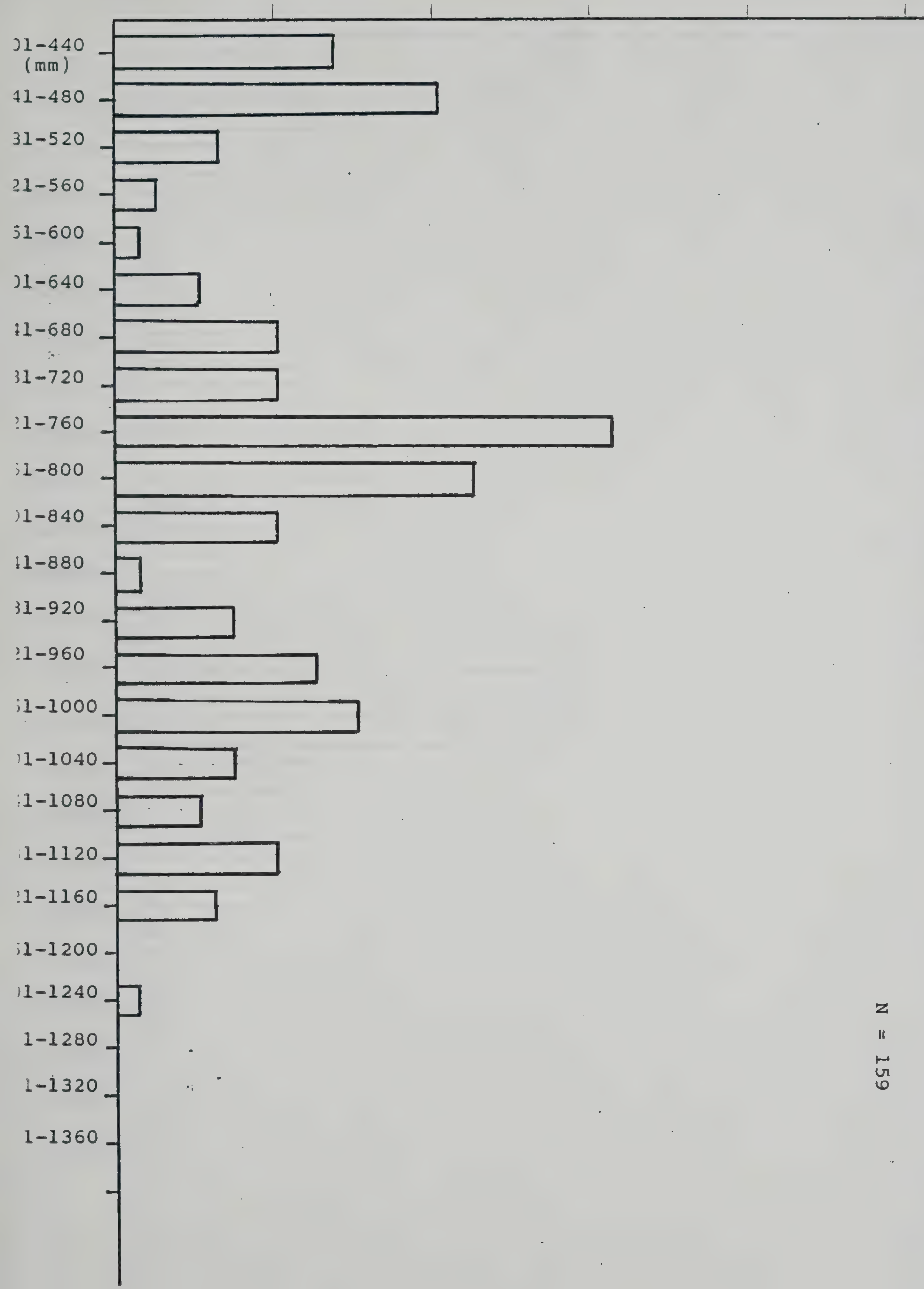


Figure 7. Length frequency of paddlefish greater than or equal to 401 mm tagged from O.D.W.C. gill netting during 1984-85.

Figure 8. Length frequency of paddlefish greater than or equal to 401 mm tagged from O.D.W.C. gill netting during 1983-86.

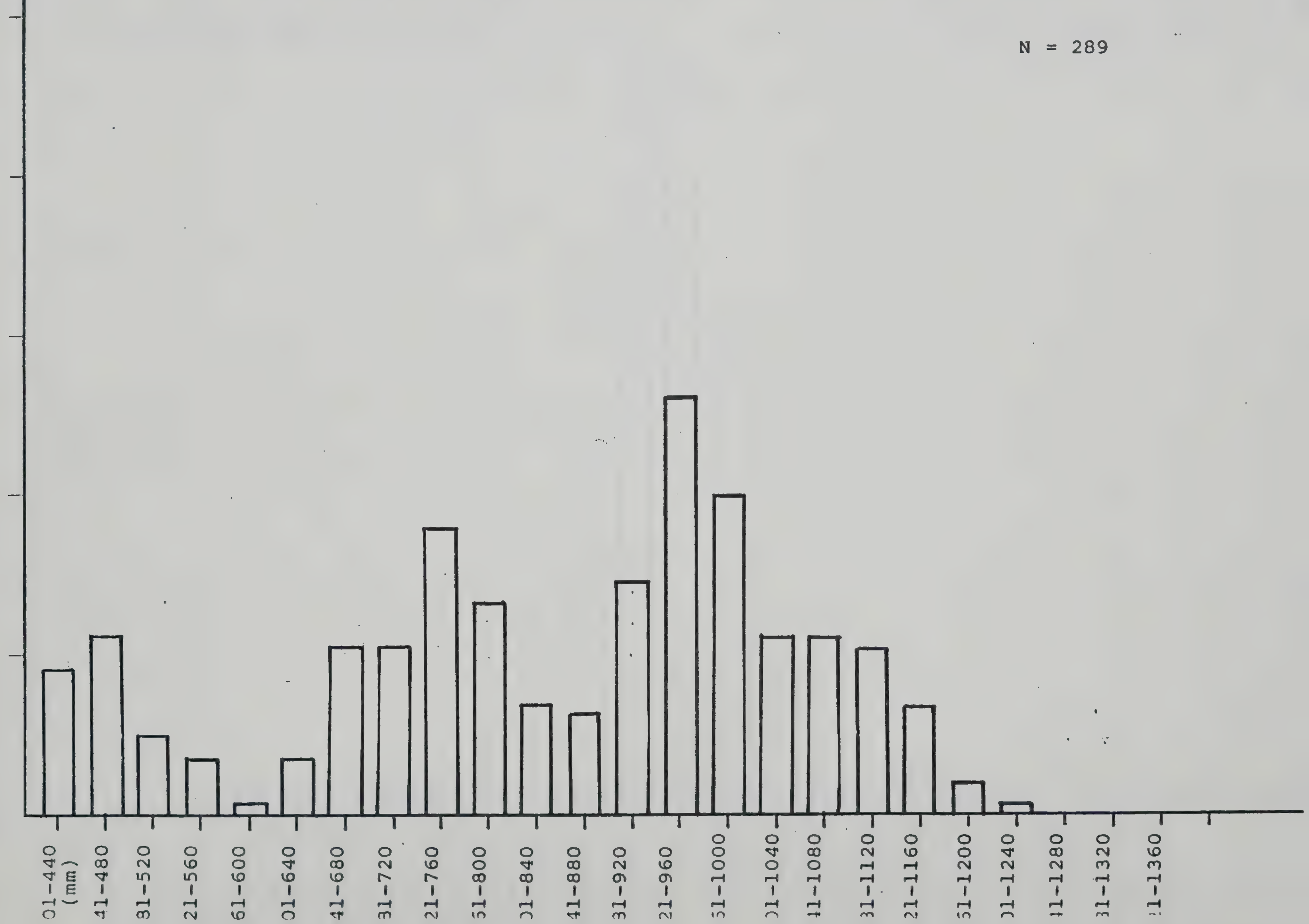


Figure 9. Length frequency of paddlefish greater than or equal to 701 mm tagged from O.D.W.C. gill netting during 1979-80.

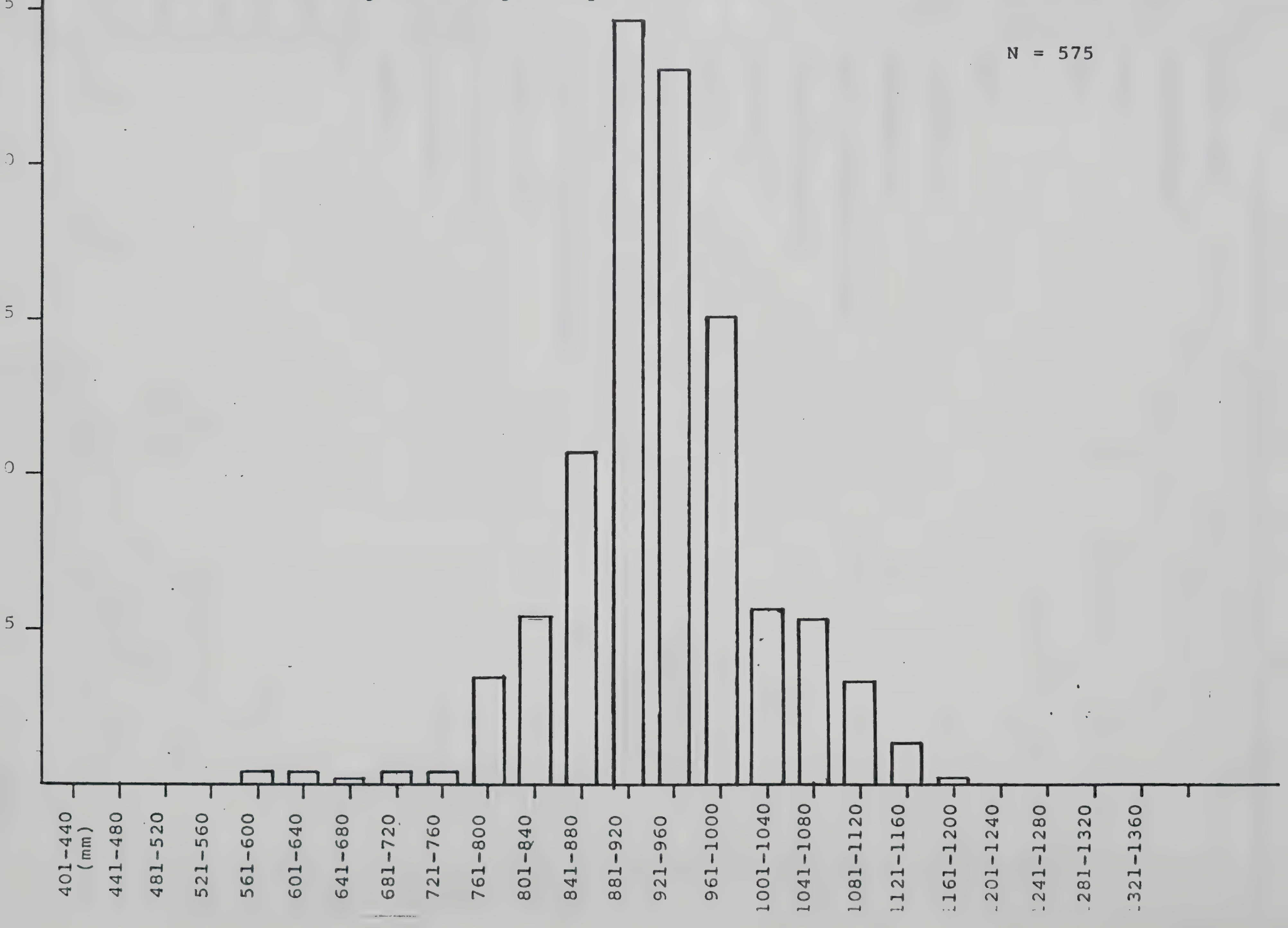


Figure 10 . Length frequencies of paddlefish tagged during O.D.W.C. gill netting 1979-80 and 1983-86.

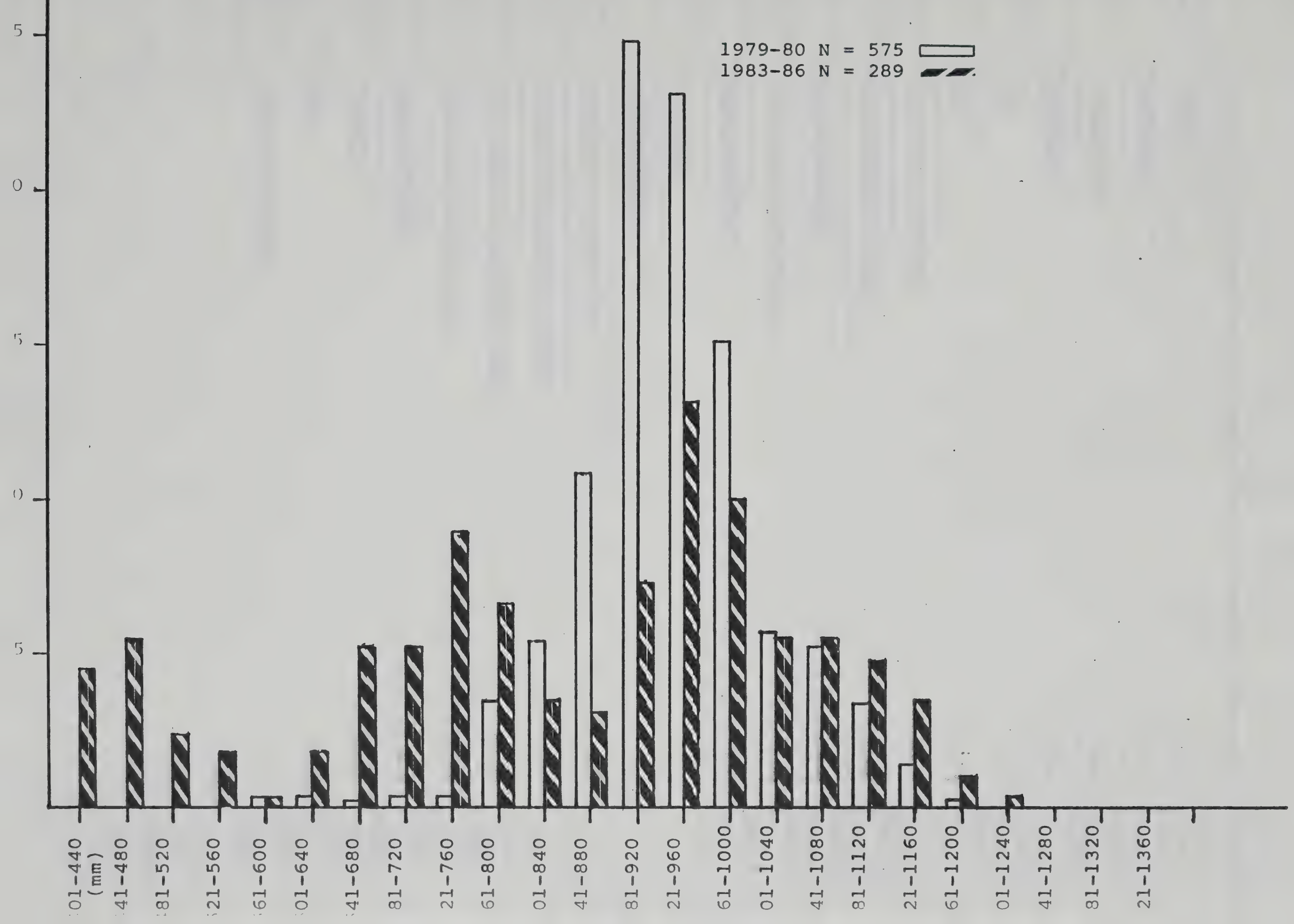


Figure 11. Length frequencies of paddlefish tagged by O.D.W.C. gill netting 1983-86 and commercial fishermen gill netting 1983-86.

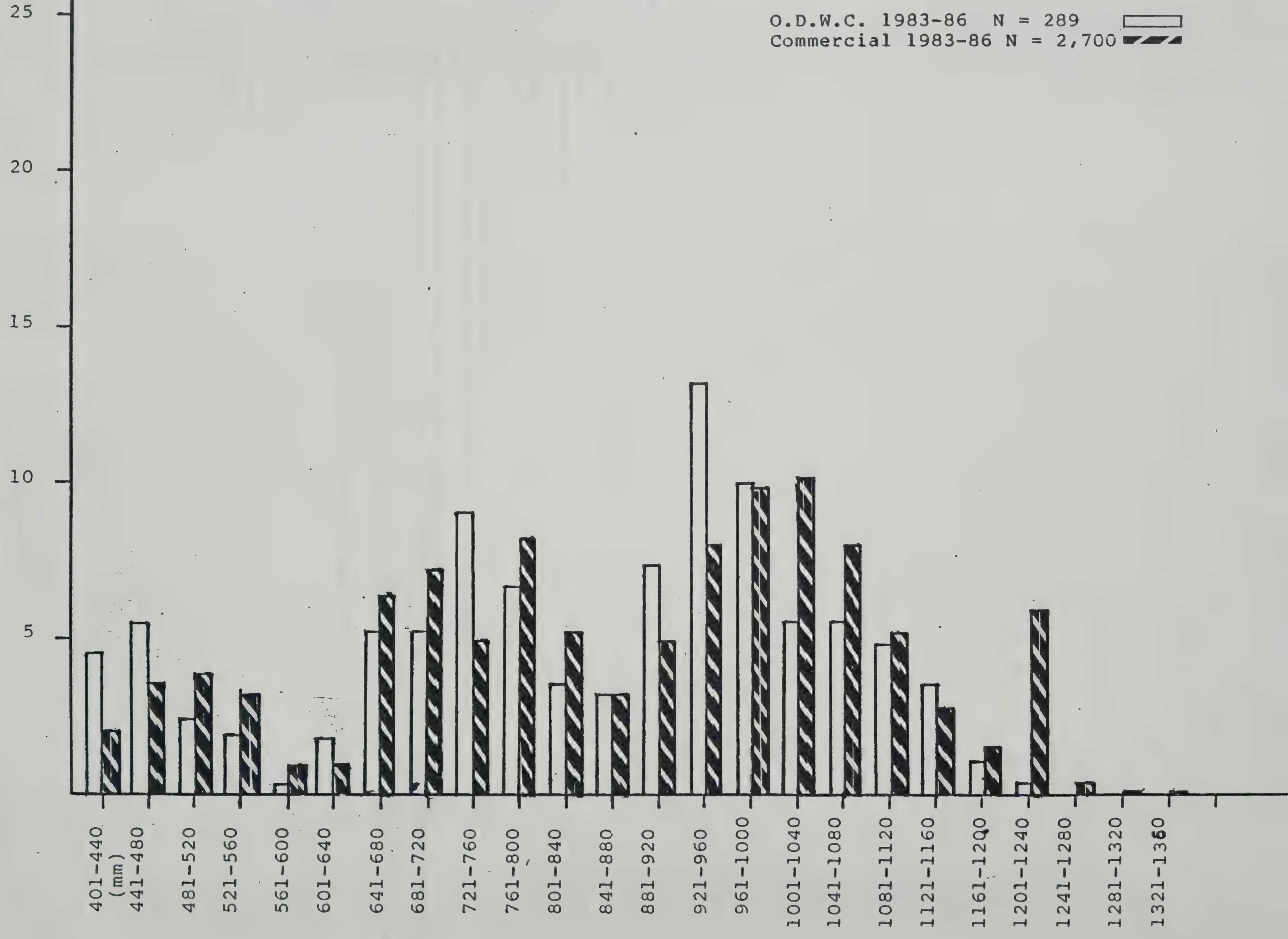


Figure 12. Length frequency of paddlefish ≥ 401 mm harvested by commercial fishermen and observed by O.D.W.C. personnel 1983-84.

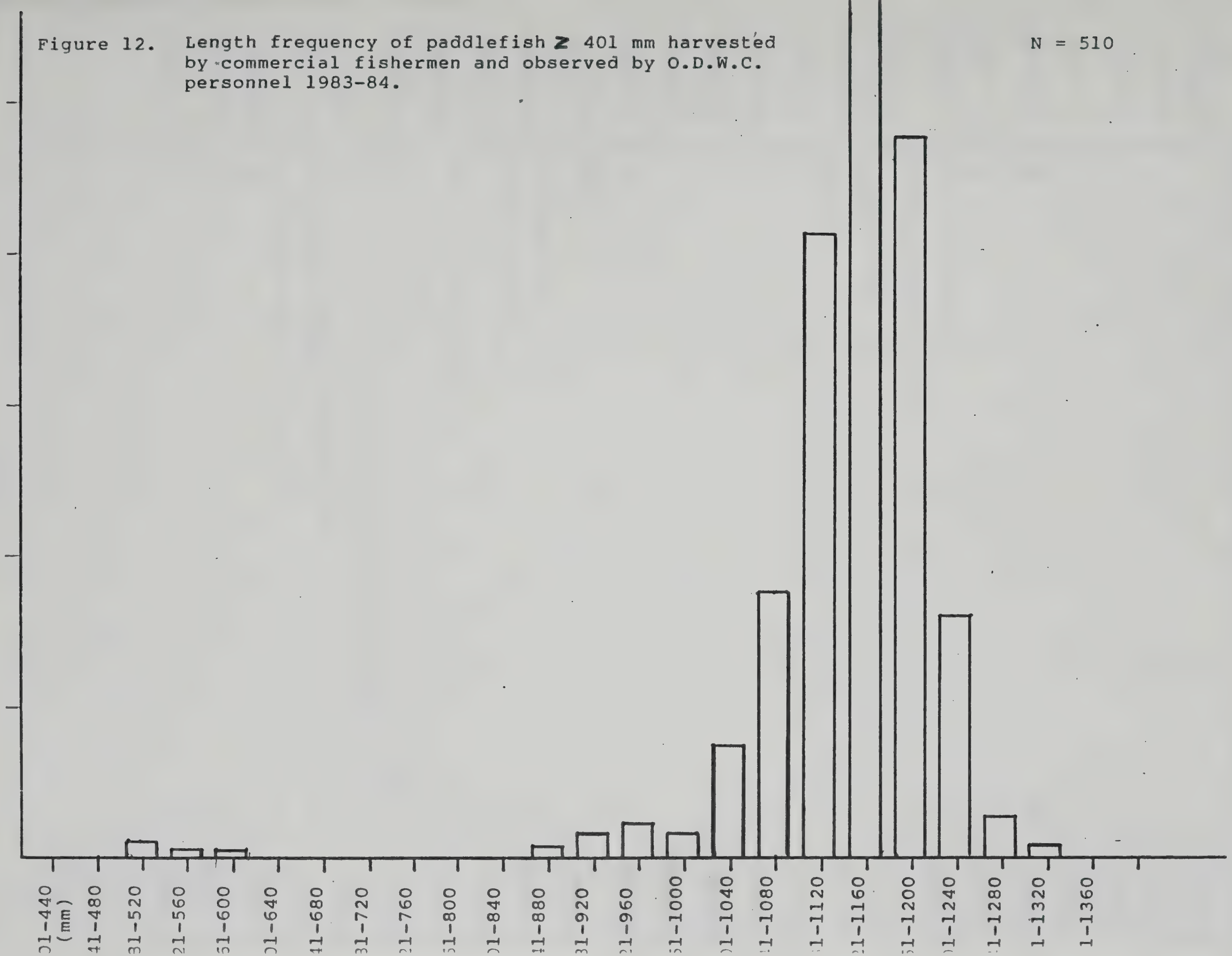


Figure 13. Length frequency of paddlefish ≥ 401 mm harvested by commercial fishermen and observed by O.D.W.C. personnel 1984-85.

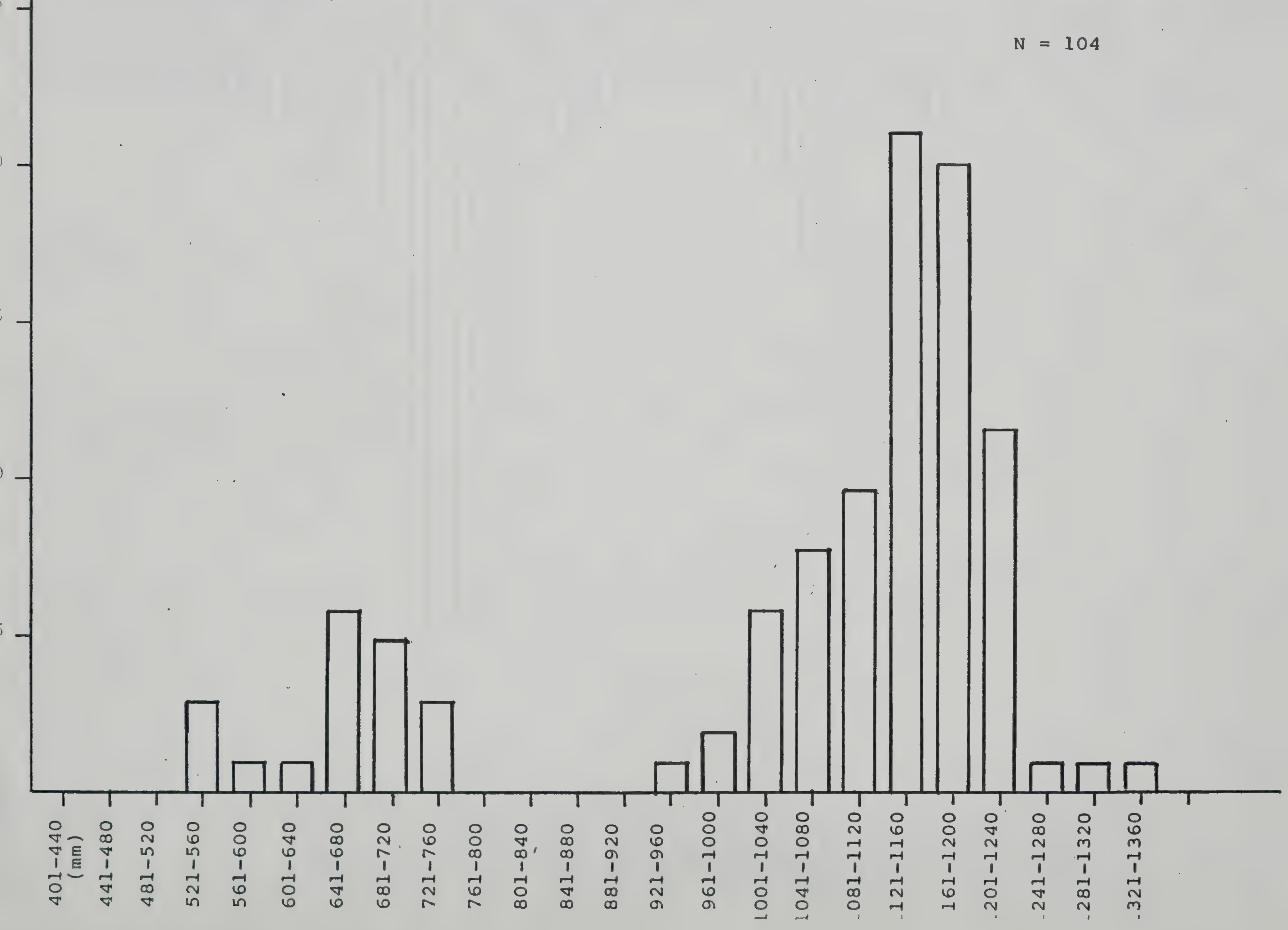
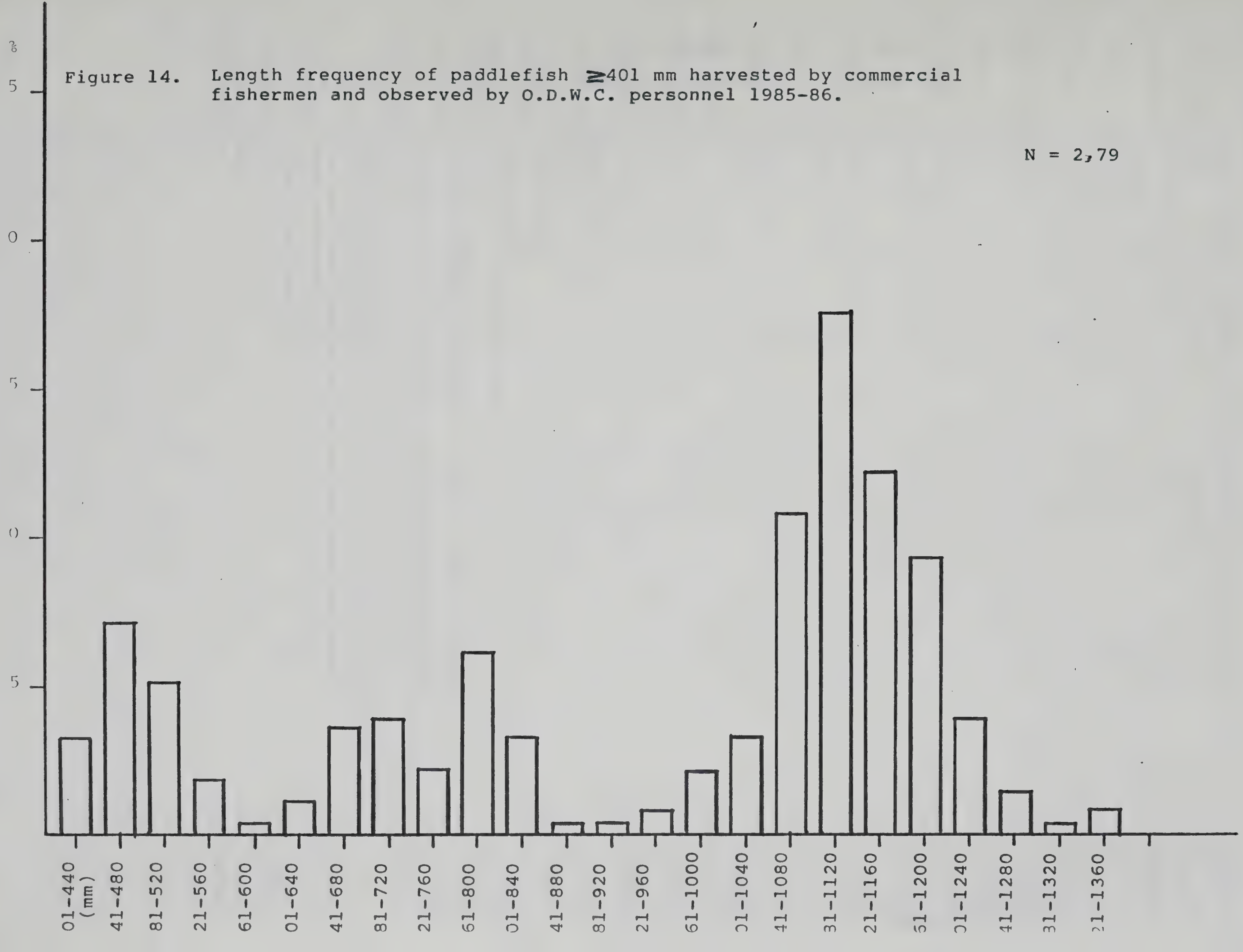


Figure 14. Length frequency of paddlefish ≥401 mm harvested by commercial fishermen and observed by O.D.W.C. personnel 1985-86.



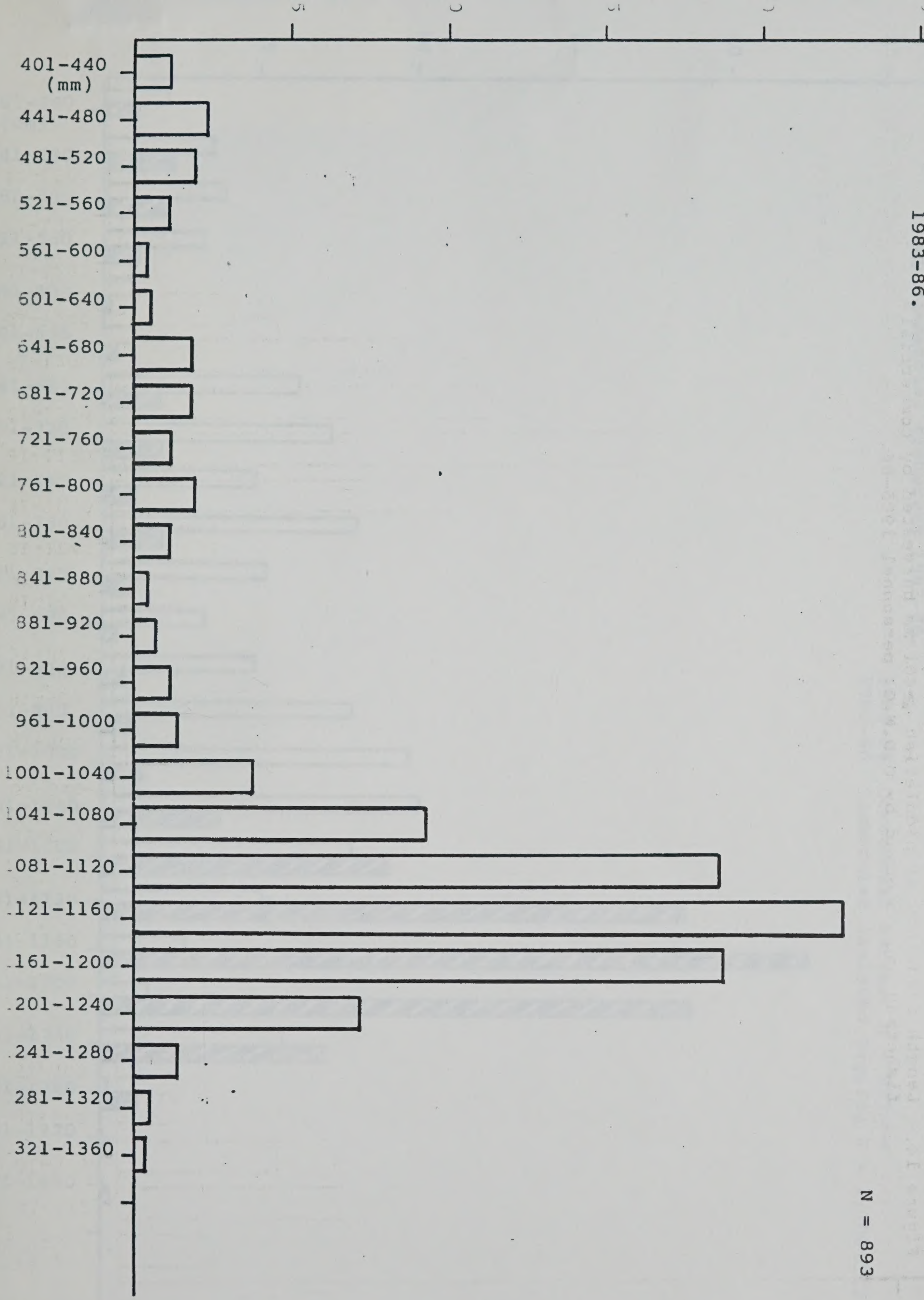


Figure 15. Length frequency of paddlefish ≧ 401 mm harvested by commercial fishermen and observed by O.D.W.C. personnel 1983-86.

Figure 16. Length frequencies of paddlefish tagged with commercial fishermen and harvested by commercial fishermen 1983-86.