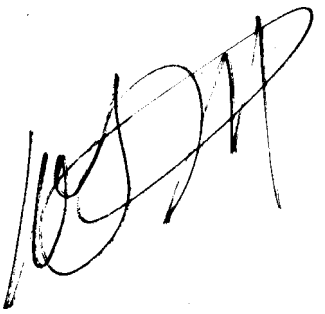

ANNOTATED BIBLIOGRAPHY FOR THE WOUNDFIN
Plagopterus argentissimus

by

Terry J. Hickman

Western Ecosystems
P.O. Box 1575
St. George, Utah

September 1987

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I would like to express my appreciation to the following people for their critical review of this document: Dr. James Deacon (UNLV), Gerald Burton (USFWS), Don Archer (USFWS), Randy Radant (UDWR) and Dean Hendrickson (AGF). I would also like to thank the U.S. Fish and Wildlife Service for the printing of this document. Funds were provided by the Washington County Water District.

INTRODUCTION

The woundf in, Plagopterus argentissimus, is a streamlined silvery minnow with a flat head and a conspicuous, sharp dorsal spine.It belongs to a unique tribe of fishes, the Plagopterini, within the family Cyprinidae. The Plagopterini consists of three genera, Meda, Lepidomeda, and Plagopterus, all of which are endemic to the Colorado River basin. Historically, the range of the woundfin extended from near the junction of the Salt and Verde Rivers at Tempe, Arizona, to the mouth of the Gila River at Yuma, Arizona. Further to the north, a separate population occurred in the Virgin River basin of Nevada, Arizona and Utah. The woundfin is now confined to the Virgin River basin from an area above Lake Mead, Nevada upstream to the Ash and La Verkin Creek confluence area in Utah. Except for the lower portion of La Verkin Creek, the woundfin is restricted to the mainstream of the Virgin River.

The Virgin River, a tributary of the Colorado River prior to construction of Lake Mead in the late 1930's, begins from two major forks in Utah; the North and East Forks. The North Fork begins at an elevation of 10,000 ft in Iron Co. and flows through Zion Canyon. The East Fork begins at an elevation of 8,000 ft in Kane Co., flows through Parunweap Canyon, and unites with the North Fork one mile south of Springdale, Utah(Washington Co.) at an elevation of 3900 ft. The upper limit of the woundfin occurs below this point at approximately 3,000 ft elevation. The river then proceeds through southwestern Utah, into the Virgin Gorge (where it drops from 2477 to 1950 ft) in the northwestern corner of Arizona, and then through southern Nevada where it empties into Lake Mead, at an elevation of approximately 1200 ft. The Virgin River supplies water for irrigation, municipal and industrial uses, and recreation and power generation.

The woundfin was placed on the endangered species list by the Department of the Interior on 13 October 1970. The major limiting factor for the woundfin today is modification and loss of habitat. The introduction and spread of exotic species also appears to have a negative impact on the woundf in. As the demands for water increase (due to the increase in population of the southwest) it will become even more necessary to have the information needed to protect the woundf in. The coexistence of water development and the woundfin is possible through careful planning and knowledge of the requirements of both entities.

I hope that this bibliography will be useful in present and future studies and that it will contribute to the management and protection of the woundf in. A total of 90 references are

included in this bibliography; references that pertained to related species were not included unless they mentioned the woundf in.

Blakely, L.S. and D.R. Hetzel. 1979. The effects of a thermal mineral spring on the biota of the Virgin River. Rept. prep. for Jim Deacon, Univ. Nev. Las Vegas. 24pp.

The effects of Pa Tempe Springs, a system of over 100 thermal springs, upon the biota of the Virgin River near La Verkin, Utah, was examined on Nov. 17&18, 1979. Six stations were selected to compare different parameters from the main spring to 2200 meters downstream. It was concluded that the springs has an effect on the Virgin River's water quality, as well as the distribution of fish, benthic invertebrates, and periphyton communities. The springs cause an increase in the conductivity and temperature values of the river, while causing a decrease in the pH and dissolved oxygen parameters. The first fish collected was 1250 meters downstream of the springs and it was a Virgin River chub (no other chub were collected during the study). Eight spinedace were collected about 1340 meters below the springs (no other spinedace were collected during the study). Woundfin were first collected 2200 meters below the springs (below the power plant). Fish numbers were low during study, therefore conclusions on fish distribution were not made. The report indicated that other studies during 1979 found low fish numbers in the power plant area.

Bolhke, J. 1953. A catalogue of the type specimens of recent fishes in the Natural History Museum of Stanford University. Stanford Ichthyology Bul. 5:1-168.

On page 36 the syntype of the woundfin is listed as the Colorado Chiquito River. This was later rejected by Miller and Hubbs 1960.

Branson, B.A. 1966. Some rare and vanishing fishes. BioSci. 1966:611-613.

A picture of the woundfin is given on page 612 with the following account: "the woundf in, once common throughout the Gila River drainage, is now restricted to a few riffles in the Virgin River of Nevada."

Branson, B.A. 1968. Notropis venustus: another introduced species in the overburdened Nevada fish fauna. Copeia: 1968: 870-871.

On July 14, 1964, the author collected woundfin and red shiner from the Virgin River near the Bunkerville Bridge, Nevada. It was noted that Miller and Hubbs (1960) sampled the same area and collected only woundfin. The red shiner has been known from the Lower Colorado Drainage since 1953 (Hubbs 1954), having escaped from a commercial minnow raising corporation near Ehrenburg, Az.
"What the final impact of the introduction of the shiner, which doubtless migrated upstream from the Lake Mead Impoundment, will be on P. argentissimus is, of course, problematic. However, the woundfin's range is slowly diminishing. The species is now extinct in the Lower Colorado (Miller and Lowe 1964); the Virgin River is its last stronghold."

Colorado River Wildlife Council. 1977. Endemic fishes of the Colorado River system. Prep. by Endemic Species Coun. 15pp.

The status and distribution of the woundfin in Utah, Arizona and Nevada is discussed on page 10.

Cope, E.D. 1874. On the Plagopterinae and the ichthyology of Utah. Proc. Amer. Philosoph. Soc. 14:129-139.

The original description of the woundfin is given on page 130. The type locality was listed as the San Luis Valley, Western Colorado. The scientific name, Plagopterus argentissimus, came from the following meanings: the Greek word argentissimus roughly translated means "most silvery" and the word plagos means to wound and the word pterus means fin.

Cope, E.D. and H.C. Yarrow. 1875. Report upon the collections of fishes made in portions of Nevada, Utah, California, Colorado, New Mexico, and Arizona, during the years 1871, 1872, 1873, and 1874. Rept. Geog. and Geol., Expl. and Surv. W. 100th Mend. (Wheeler Survey), 5:635-703.

This report is an early taxonomic description of fishes in the southwestern United States. The woundfin is mentioned on pages 640 and 641. The same information presented in Cope 1874 was repeated in this paper, including the type locality (San Luis Valley, Western Colorado).

Cross, J.N. 1975. Ecological distribution of the fishes of the Virgin River (Utah, Arizona, Nevada). M.S. thesis, Univ. Nevada-Las Vegas. 187pp.

One hundred and twenty-three collections were made within the Virgin River basin from June 21, 1973 through March 15, 1975. Fish were collected with nylon seines. Each station was sampled with three consecutive seine hauls within each habitat type. Air and water temperatures, conductivity, current velocity, width, depth of capture, average depth of habitat and length of seine haul were recorded at each station. A total of 5000 woundfin (out of 10,822 native specimens) were collected during the study period. Information on woundfin distribution, taxonomy, habitat selection, reproduction, food habits, historical abundance, and status are presented. It was collected 75% of the time from runs, 20% from riffles and 5% from pools. The woundfin is adapted to the extreme fluctuating conditions (discharge, suspended sediment, temperature, etc.) of the mainstream Virgin River. It is commonly found in habitat unsuitable for other native species and can tolerate high temperatures that occur in the river during periods of low water. These factors likely account for the continued abundance of the woundfin over most of its original range in the Virgin River system. It once occurred throughout the lower Colorado River basin, but due to drought, agricultural operations, water shortage and diversion and the introduction of exotics, it has been extirpated from all areas except the Virgin River basin.

Cross, J.N. 1978. Contributions to the biology of the woundfin, Plagopterus argentissimus (Pisces: Cyprinidae), an endangered species. Great Basin Naturalist. 38(4):463-468.

This paper is a presentation of the woundfin data obtained during a M.S. study at UNLV. Over 5000 woundfin were collected between 21 June 1973 and 15 March 1975 from various stations in the Virgin River basin, Utah, Arizona, Nevada. The woundfin occurred in 33% of the collections in the lower mainstream (downstream from Mesquite, Nevada) and made up 30-100% of the catch but averaged less than 50%. In the middle reaches of the mainstream (downstream from Hurricane, Utah) it was present in 90% of the collections and generally comprised 50% of the catch. In the upper mainstream it occurred in 65% of the collections and averaged less than 33% of the catch. It was present in all of the collections in the lower reaches of La Verkin Creek and generally comprised less than 50% of the fish fauna. It

occurred most frequently in runs and over sand substrates and less frequently in riffles and over rock substrates. It was common over at least half of its original range within the Virgin River. It was uncommon in the lower mainstream due to habitat alterations and, presumably, predation by and competition with exotic species.

Cross, J.N. 1985. Distribution of fish in the Virgin River, a tributary of the lower Colorado River. Environmental Biology of Fishes. 12(1) : 13-21.

The Virgin River, a major tributary of the lower Colorado River, contains a unique, though impoverished, native ichthyofauna (six species) that is largely intact despite the introduction of exotic fishes (13 species) and alterations of the river. The main conclusions of the study are: (1) The longitudinal distribution pattern of native species does not follow theoretical expectations of a downstream increase in species richness; (2) for the size of the basin (>15,000 km), the native ichthyofauna is extremely depauperate; and (3) most of the exotic fish are not established in the river, but persist through repeated invasions from downstream reservoirs. As a result of loss of habitat, chemical modifications of the river, and the introduction of exotic species, the woundfin has decreased in abundance.

Deacon, J. E. 1977. Population structure of woundfin in the Virgin River on 25-26 November 1977. Envir. Consult., Inc. 4452 Live Oak Drive, Las Vegas, NV 13pp.

Several areas along the Virgin River were sampled on November 25-26, 1977 to determine if woundfin reproduction and survival of young above the Virgin Gorge had been more successful than was previously reported. In order to determine the relative age of the population at various sites, length-frequency graphs were developed and mean lengths were calculated for each location sampled. The areas with the smallest mean size reflects the segment of the woundfin population which has had the greatest reproductive success. Based upon length-frequency analysis those fish less than 60mm were considered young-of-the-year, with the understanding that some fish in the 50-60mm range may be from the previous year's spawn. Woundfin reproduction did occur in the upper Virgin River during 1977, however, reproductive success below the gorge was much higher in 1977 than from any location above the gorge. Reproductive success appears to have been far poorer in 1977 than in 1973 throughout the entire length of the Virgin River. It is

reasonable to conclude that the poor reproductive success of woundfin in the upper river is attributable to habitat conditions created by low water flows in 1977.

Deacon, J.E. 1977. Habitat requirements of the woundfin in the Virgin River in relation to the proposed Warner Valley Project. In: Impact of Warner Valley Project on endangered fish of the Virgin River. Vaughn Hansen Assoc. Salt Lake City, Utah. Prep. for City of St. George, Utah.

This paper analyzes the impacts of the Warner Valley Project on the woundf in. Field collections were conducted from early May through late September, 1977 from various areas along the Virgin River in Utah, Arizona and Nevada. During spawning, woundfin use pools of up to 1m in depth for spawning aggregations. At other times of the year they may aggregate in pools as a refuge from declining flows or during periods of high temperature. Except for these situations, adults generally prefer runs and become especially abundant in areas where large amounts of organic debris are mixed in with the shifting sandy bottom. Young prefer shallow, moderately flowing water in areas adjacent to stream banks or in eddy currents below rocks or in brush or other cover. Spawning occurs from 15-20 C and temperatures above 30-32 C are detrimental to woundf in. Reproduction and survival of young was good throughout the river during 1973. In 1977 survival of young was good only at Big Bend, fair at Beaver Dam Wash, poor at Berry Springs and non-existent at Riverside, St. George and the Power Plant. Poor reproduction and survivorship of young above the gorge in 1977 resulted from a combination of unfavorably high temperature and a declining food availability. The high temperature would probably be ameliorated by higher flows. Based upon an analysis of data from 1973 (good spawning year) and 1977 (poor spawning year) flows of 80-100cfs from April to mid-July and 60cfs for the rest of the summer are recommended above the gorge. Flows of 80-100cfs are recommended for the winter. Floods at intervals throughout the year are considered essential to maintaining suitable populations of woundf in.

Deacon, J.E. 1979. Endangered and threatened fishes of the west. Great Basin Naturalist Memoirs. The Endangered Species: A Symposium 3:41-64.

The endangered and threatened fish fauna of the United States exhibits problems resulting primarily from habitat modification by man. The evolutionary history of the fauna

has left it especially sensitive to biotic interactions. In addition, many forms are of such restricted distribution that the entire taxon can be destroyed by very minor perturbations. The effects of habitat modification on woundfin and roundtail chub in the Virgin River of Utah, Arizona, and Nevada are discussed.

Deacon J.E. 1980. Annual report on woundfin monitoring in the Virgin River. Envir. Consult., Inc. 4452 Live Oak Drive, Las Vegas, NV 12pp.

This is the first annual report on the woundfin monitoring activities in the Virgin River. Survey methods are discussed in the Woundfin Recovery Plan. There were eight stations on the Virgin River (ranging from the mouth of La Verkin Creek to six miles below Riverside, NV) that were sampled on the following dates: 28 Sep. 1978, 8,9 Feb. 1979, 11 Apr. 1979, 20,21 Jun. 1979, 27 Sep. 1979, and 11 Dec. 1979. Flows in the Virgin River were well above normal in 1979. Abundance of woundfin in La Verkin Springs to Washington diversion and Beaver Dam Wash areas of the Virgin River appeared to be relatively high through summer 1979. Abundance in the St. George and Riverside areas of the river was erratic, but relatively high during certain times of the year. Reproduction of woundfin during summer 1978, a good water year, was good throughout the river. In 1979 (through mid-July) evidence of reproductive success was obtained in the Beaver Dam Wash and Mesquite areas of the river, but little evidence of good reproduction in the upper river was obtained. Data from 1978 and 1979 continued to suggest that both low and high flows may be detrimental to woundfin reproduction in the Virgin River. No evidence was developed to suggest an alteration of the biological opinion that 110 cfs or normal flows, whichever is less, is necessary to insure the survival of woundfin in the Virgin River.

Deacon, J.E. 1980. Effects of low flow on woundfin in the Virgin River. pp.79. In: E.P. Pister (ed.) Proc. Desert Fish. Coun. Vol. 12. Bishop, CA.

The record low flow in the Virgin River during 1979 adversely affected reproduction and survival of woundfin throughout the river. The adverse effects differed in different sections of the river, but were evident through 1980. Most severely affected were woundfin living in the more heavily impacted sections below major irrigation diversions at Washington, Utah and Mesquite, Nevada.
Good reproduction with reestablishment of normal population densities did not occur until the summer of 1980 in spite of

return of normal to above normal flows in 1978, 1979 and 1980. The data demonstrates that mean flows in the Virgin River during April, May and June of 90-94 cfs coincided with poor reproduction of woundfin. Mean flows in April-June in excess of 450 cfs coincide with good reproductive success, provided an adequate brood stock is available in the population. Factors other than flow can also influence reproductive success. Critical flow requirements however, clearly appear to fall somewhere between 90 and 450 cfs.

Deacon, J.E. 1983. Annual report of monitoring activities by the woundfin recovery team. Environ. Consult., Inc., 4452 Live Oak Drive, Las Vegas, NV 12pp.

The woundfin recovery team sampled the mainstream Virgin River on 14 April and 27 September 1983. Data summaries and raw data from these collections are included in this report. Streamflow in 1983 was exceptionally high, with mean monthly flows in March, May, June, July, and August showing higher levels than have occurred since 1977 when the monitoring studies began. Recruitment of young-of-the-year woundfin into the juvenile population during summer 1983 was excellent in nearly every segment of the river. Relatively high mean flow during the period 30-60 days prior to collection continues to be associated with high proportions of juveniles in the population at the time of collection. Woundfin reproduction at Twin Bridges was poor in 1982 but good in 1983. the higher flows in 1983 appear to have resulted in a decline of red shiners in the Beaver Dam Wash, Mesquite, and Riverside areas.

Deacon, J.E. 1985. Fish population monitoring activities by the woundfin recovery team in the Virgin River, Utah, Arizona, Nevada on April 18 and October 5, 1984. Envir. Consul,. Inc., 4452 Live Oak Drive, Las Vegas, NV 10pp.

The woundfin recovery team conducted population monitoring activities on 18 April and 5 October, 1984. Data collected during these sampling periods are added to past data and presented in this report. Regular sampling stations have been established by the woundfin recovery team below La Verkin Springs at six points along the mainstream of the Virgin River. Four of these stations are located at, or a short distance downstream from major irrigation diversion structures in what is referred to as "disturbed" segments of the river. These areas are: the mouth of Ash Creek, Twin Bridges, upper Mesquite Diversion and just below the Riverside Bridge, NV. The other two stations are in "undisturbed" segments of the river. One is in a canyon about two miles below Berry Springs and the other is at

Beaver Dam Wash, AZ. Woundfin reproduced successfully in much of their Virgin River habitat in 1983. The 1983 year class appears to have survived well through 1984. Reproductive success in 1984 was relatively poor throughout the river and essentially ineffective in the area of Ash Creek confluence and at the Mesquite and Riverside areas.

Deacon, J.E. 1986. Fish population monitoring activities by the woundfin recovery team in the Virgin River, Utah, Arizona, Nevada on April 18 and October 9, 1985. Envir. Consul., Inc., 4452 Live Oak Drive, Las Vegas, NV 26pp.

The woundfin recovery team conducted fish population monitoring activities on 18 April and 9 October, 1985 in the mainstream of the Virgin River below La Verkin Springs. Data collected are presented in this report and is compared to past data. Comparative data on mean size and relative abundance leave little doubt that the native fish population in the Virgin River found their most favorable conditions in 1978 and 1983. Similarly, conditions in 1985, 1984, 1982, and 1977 encouraged expansion of the red shiner population in those areas of the river to which it had access. Water quality, in addition to low flow, appears to have degraded all fish habitats in the Virgin River segment in Utah during 1985. it is clear that all low flow conditions are associated with relatively poor woundfin recruitment. These conditions occurred in 1977, 1981, and 1984. Intermediated flow conditions occurred only in 1978, a year in which recruitment throughout the river appears to have been excellent. At higher flows there is considerable variability. It is apparent that mean flow during spring is not the only parameter influencing woundfin reproduction. The flow/reproduction/survival relationship is probably more precisely defined by the flow conditions throughout the year as well as water quality.

Deacon, J.E. In Press. The endangered woundfin and water management in the Virgin River, Utah, Arizona, Nevada. Fisheries. 1988.

Attempts to define conditions permitting compatible existence of endangered fishes and water development projects in the Virgin River Basin have met with limited success. One project (Warner Valley) was abandoned in 1980 because of jeopardy to the endangered woundf in. A substitute water project (Quail Creek) was completed in 1985 following acceptance of conditions judged essential to insure survival of the woundfin. Flow requirements specified for that project, however, were apparently violated for at least 112

days in June-October 1985 and 108 days during June-September 1986. In 1985 and 1986 the red shiner, for the first time, became the dominant species throughout the Arizona/Nevada reach of the Virgin River. During this period native species declined. The red shiner first appeared in the Utah reach of the Virgin River in 1984, dominated the population by 1986, and may be responsible for introducing the Asian tapeworm into the native fishes of the Virgin River. Woundfin population size has declined dramatically in more than 50% of its remaining range since construction of Quail Creek Reservoir.

Deacon, J.E. and T.M. Baugh. 1984. Fish population monitoring activities by the woundfin recovery team, Virgin River, Utah, Arizona, Nevada, April 18, 1984. Envir. Consul., Inc., 585 Royal Crest Circle, Las Vegas, NV 13pp.

The woundfin recovery team conducted its spring population monitoring on 18 April 1984. Data from this sampling period is presented and summarized. Where possible, this data is compared with past data. Woundfin at the Ash Creek area comprised only 18% of the fish population sampled and were predominantly adults. Relative abundance and mean size are about the same as last fall (1983). Woundfin comprised about 76% of the population sampled at the Berry Springs area and averaged 37mm T.L. These figures are similar to last fall, suggesting that very little growth occurred over the winter. At Twin Bridges woundfin comprised 78% of the population. Average size and relative proportion of sizes in the population appears to be about the same as it was last fall. Of note is the collection of red shiners in this area, this marks the first time that red shiners have been collected above the Virgin Gorge. At Beaver Dam Wash, woundfin comprised about 30% of the population compared to 49% last fall. Much of this shift can be attributed to the abundance of red shiner. At Mesquite woundfin comprised 5% of the population sampled while red shiner comprised 87%. Last fall woundfin comprised 48% and red shiner 30%. At Riverside 99% of the population consisted of red shiner, only two woundfin were collected. Woundfin reproduced well in 1983 and survived the winter of 1983-84 with little apparent mortality.

Deacon, J.E. and W.G. Bradley. 1972. Ecological distribution of fishes of Moapa (Muddy) River in Clark County, Nevada. Trans. Amer. Fish. Soc., 3:408-419.

Fish collections were made at nine stations along the Moapa River of Southern, Nevada. Four native species are

ecologically separated into headwater and middle-stream types. The headwater fishes are ecologically segregated into one pond species (Crenichthys baileyi) and one stream species (Moapa coriacea). Both Gila robusta and Rhinichthys osculus are most abundant in the turbid middle portion of the stream in undisturbed, deep riffle habitats. A fifth native species, Plagopterus argentissimus, is extremely rare or of accidental occurrence. The only specimen of woundfin to be collected from the Moapa River was at the lower end on October 26, 1963. This undoubtedly was a straggler from the Virgin River.

Deacon, J.E. and T.B. Hardy. 1980. Population structure and reproductive success of woundfin in the Virgin River 1977-80. Envir. Consul. Inc., 2772 Quail Ave., Las Vegas, NV 28pp.

This is the second annual report for the woundfin monitoring program on the Virgin River. This report compares the data collected from 1977-1980. In 1977 woundfin spawning and recruitment of young was very poor from La Verkin Springs to Washington Fields Diversion. The resulting poor year class of 1977 produced a relatively poor spawn in 1979. The low woundfin population size during winter 1979-80 in the upper Virgin River resulted from a combination of the poor 1977 year class and the relatively poor 1979 year class. In 1977, spawning, recruitment of young and survival of adults was very poor near St. George. Recovery of the population did not occur until 1980, the effects of 1977 may extend beyond 1980. In 1977 and 1979, reproduction in the section of Virgin River near Beaver Dam Wash was apparently below normal. Information on flows needed to insure successful spawning and recruitment are also presented. The following

- conclusions pertaining to woundfin life history were made: two and three year olds are the primary spawners in the spring, a smaller secondary spawn by one year old fish may occur in July or August and a major period of adult mortality appears to immediately follow reproduction.

Deacon, J.E. and T.B. Hardy. 1982. Final report of monitoring activities by the woundfin recovery team. Envir. Consul. Inc., 1001 Dumont #162, Las Vegas, NV 11pp.

The woundfin recovery team made collections on the Virgin River on 7-8 April and 21-22 September, 1982. Data prior to 1982 are also analyzed in this report. Flows in 1982 were substantially higher than in 1981, especially during May. This difference probably accounts for the increased success in reproduction and recruitment in 1982 compared to 1981.

Flows similar to the 1982 hydrograph apparently represent the best approximation of the minimum conditions essential to perpetuating the woundfin in the Virgin River. The increased population of red shiners at Beaver Dam Wash, suggest that a few flood events in excess of those occurring thus far in 1982 would be advantageous toward inhibiting the establishment of non-native fishes. Reproductive success for woundfin was high at Berry Springs, moderate at the Power Plant and poor at Twin Bridges. At Mesquite reproductive success appeared moderate to good. It is probably erroneous to consider reproductive success moderate to good at Mesquite since the fish population is dominated by red shiners. Good woundfin recruitment in 1982 was likely a response to the actual flows in the river rather than to mean spring flows or mean flows 30-60 days prior to the collection. The data continues to show that flows in 1977 were poor throughout the year and reproductive success for woundfin was poor to non-existent in most parts of their natural range.

Deacon, J.E. and T.B. Hardy. 1984. Streamflow requirements of woundfin (Plagopterus argentissimus): Cyprinidae in the Virgin River, Utah, Arizona, Nevada. pp. 45-56. In: N. Horner (ed.). Festschrift for Walter W. Dalquest, in honor of his 66th birthday. midwestern State University.

Population structure of the woundfin in the Virgin River, Utah, Arizona, Nevada was examined at various times in the spring, summer and autumn from 1977-1982. Poor recruitment of the year class into the adult population occurred in 1977, the year of lowest streamflow on record. During 1981 streamflow was also relatively low. The woundfin populations occurring downstream from major diversion structures showed poor recruitment in 1981. Low streamflow therefore, appears to adversely affect recruitment of woundfin into the adult population. poorest recruitment is associated with flows during spring of less than about 130 cfs. Best recruitment occurs when flows during spring are about 200-800 cfs. Spring flows in excess of 1000 cfs are also associated with relatively poor recruitment.

Deacon, J.E., G. Kobetich, J.D. Williams, S. Contreras, and other members of the Endangered Species Committee of the American Fisheries Society. 1979. Fishes of North America endangered, threatened, or of special concern:1979. Fisheries, 4:29-44.

This publication contains a list of freshwater fishes of North America that have been placed in one of three

categories- either Endangered, Threatened, or Of Special Concern. Members of the American Fisheries Society Endangered Species Committee spent three years compiling this list from the available literature and from input by various biologists. The common and scientific name, status, historical distribution, and present threats are given for each fish. The woundfin is listed as endangered on page 35. It is threatened by the present or potential destruction, modification, or curtailment of its habitat or range.

Deacon, J.E. and P.B. Holden. 1977. Technical report analyzing the impact of the Allen-Warner Valley Energy System on the native fishes of the Virgin River. BIO/WEST, Inc., Logan, UT 21pp.

The Allen-Warner Valley Energy System will impact the Virgin River mainstream from the Hurricane diversion downstream to the river's mouth at Lake Mead. Three rare fish inhabit the Virgin River in this area- the woundf in, Virgin River chub and the Virgin River spinedace. The woundfin is abundant in the main stream of the Virgin River where it appears to prefer swift water (avg. 0.42 m/sec.) of medium depth (avg. 43 cm.) over a sand bottom. These areas are generally classified as runs. They are able to tolerate high salinities (12,000 umhos/cm.) and high temperatures (35.5 C) for at least short periods of time. It is probable that temperatures over 30 C are unsuitable over long periods of time. This fish is usually most abundant in relatively unmodified habitats in which native fishes make up the overwhelming majority of the fauna. Below Mesquite Diversion, Nevada, the woundfin occurs but the red shiner is frequently the dominant species. The expected alteration in stream flow due to the project is a reduction in winter flows of approximately one-half, such that projected winter flows will approach present summer flows. The summer flows will be relatively unchanged. Present information suggests that so long as winter and summer flows are approximately 60-90 cfs, fish populations are unlikely to be seriously affected. The project will also result in increased sediment loads, increased probability of introductions of exotics and increased abundance (competition) of red shiners.

Deacon, J.E. and W.L. Minckley. 1973. Population dispersion and community structure of fishes of the Virgin River system. Unpubl. prog. rept. to Bur. Sports Fish and Wildl. Salt Lake City, UT 49pp.

This report, done in four parts, provides information on the effects of capping La verkin Springs on the fish of the Virgin River. Part I is a review of information on the

woundfin by J.E. Deacon and W.L. Minkley. Part II is a report prepared by J. Lockhart and J.E. Deacon on research conducted on the woundfin from July 1 to September 30, 1973. Part III is a report on the ecological distribution of the fishes of the Virgin River system (May-September, 1973) by J. Cross and J.E. Deacon. Part IV provides conclusions and opinions regarding the probable effects of capping La Verkin Springs. Part I summarizes published and unpublished information on the woundf in, most of which deals with taxonomy. Additional information is provided on distribution, life history, and ecology. Data gaps are identified and some speculation is included on life history requirements based on literature and personal experience with ecologically similar types of minnows. Part II provides information on woundfin (size, location and abundance) collected between July 1 and September 30, 1973. Information is presented on physical and chemical characteristics of La Verkin Springs in relation to it's effects on woundfin. In Part IV the following conclusions are made for woundfin: (1) the historical and present distribution suggests dependence on highly saline, fluctuating, turbid, sandy bottom rivers and large streams in the lower Colorado Basin and; (2) their distribution in the Virgin River suggests that La Verkin Springs may provide either a point of orientation for the species or a limitation to upstream dispersal.

Deacon, J.E. and W.L. Minckley. 1974. Desert Fishes, In: W.G. Brown (ed.) Desert Biology Vol. 2. Academic Press, New York. Chapt. 7, pp. 385-488.

This chapter presents information on the aquatic environments of deserts (southwestern United States and northern Mexico),and the ecology of these environments including physical factors (current,turbulence,suspended solids,sediments,drought, desiccation,direct effects of light,and temperature) chemical conditions (hydrogen-ion concentration,salinity and dissolved gases) and the biological responses to these environmental conditions. Examples of geographical areas and fish species are used to illustrates various environmental situations. The woundfin is mentioned on pages 436 and 437 as a species which has adapted to sediment loads and river currents. Many of its traits are similar to features of some bottom-dwelling, swift-water, silty-stream minnows of eastern United States, and elsewhere. The woundfin has developed barbels, a dermal keel, coarse, close-set papillae on the intermandibular (gular) region, a depressed, ventrally flattened head, dorsal-lateral and relatively small eyes, and large fins. The woundfin is also mentioned on page 439 in a discussion pertaining to population responses to changes in habitat.

Despite being adapted to silty-water and current, its distribution is restricted by availability and continuity of their special habitat. Gradual but continuing depletion and reductions in the range of the woundfin has occurred with the increasing modification of its habitat by man.

Deacon, J.E., P.B. Schumann and E.L. Stuenkel. In Press. Thermal tolerances and preferences of fishes of the Virgin River System (Utah, Arizona, Nevada).

Critical thermal maxima (CTM) and thermal preferenda of the common fishes of the Virgin River were examined. Differences in final temperature preferenda and CTM for species with low thermal lability (speckled dace, spinedace, Virgin River chub) correspond well with differences in their distribution and abundance in the river. These species shifted their acute thermal preferences relatively little as acclimation temperature increased. For thermal labile species (woundfin, red shiner, desert sucker and flannelmouth sucker), the final preferendum is a less precise indicator of possible distribution. The woundfin has a high CTM (39.5 C at 25 C acclimation) and a labile acute preferendum (slope nearest 1) compared to other species in the system. The red shiner likewise has a high CTM and a labile acute preferendum. In cooler temperatures, its acute preferendum shifts more rapidly than does that of the woundfin. At higher temperatures (above 15 C), the red shiner does not shift its acute preferendum as rapidly as does the woundfin. The red shiner, however, has a higher final preferendum. At higher temperatures the red shiner may have an advantage over the woundfin, while at lower temperatures (below 25 C), the reverse may occur. For thermal labile species, influence of acclimation temperature on mean preferendum, together with CTM, provides a better insight into distributional relationships within the system.

Eddy, S. 1957. How to know the freshwater fishes. Wm. C. Brown Co., Dubuque, Iowa.

A taxonomic key for the identification of the woundfin is given on page 105.

Eddy, S. 1969. How to know the freshwater fishes. Wm. C. Brown Co., Dubuque, Iowa. 2nd edition, revised.

Taxonomic and distributional information is presented for the woundfin on page 97.

Ellis, M.M. 1914. Fishes of Colorado. Univ. of Colorado

studies. 11(1):1-136.

Information on the woundfin is presented on page 70. This is the first time that the type locality for the woundin (San Luis Valley, Western Colorado) was questioned.

Evermann, B.W. and C. Rutter. 1895. The fishes of the Colorado basin. Bul. U.S. Fish. Comm. 14:473-486.

This paper present a historical account and checklist of the fishes of the Colorado River System. Taxonomic and distributional information for the woundfin is given on page 479.

Follett, W.I. 1960. The freshwater fishes-- their origins and affinities. In: Symposium: The biogeography of Baja California and adjacent seas. Syst. Zool. 9:212-232.

The woundfin is listed on page 226 under cyprinidae and the following information is presented: "a few species were procured in the mouth of the Rio Gila at Yuma, Arizona (Gilbert and Scofield 1898:496). This locality is so close to the international boundary as to suggest the possibility that under primitive conditions this minnow was carried downstream into Baja, California during heavy floods."

Fowler, H.W. 1925. Notes on North American cyprinoid fishes. Proc. Acad. Nat. Sci. Philadelphia. 76:389-416.

A discussion of woundfin syntypes is given on page 415. The taxonomic description and type locality (San Luis Valley, Western Colorado) for the woundfin is repeated from Cope (1874). Lepidomeda vittata, Meda fulgida and Plagopterus argentissimus are listed under the Plagopterinae group and a taxonomic description of each is given.

Gilbert, C.H. and N.B. Scofield. 1898. Notes on a collection of fishes from the Colorado Basin in Arizona. Proc. U.S. Nat. Mus. 20:487-499.

A taxonomic description of the woundfin is given on pages 496 and 497 from specimens collected from the mouth of the Gila River at Yuma and from the Salt River at Tempe. The authors stated that "the species had been reported hitherto only from the San Luis Valley in western Colorado." They compared these specimens with the type specimens and found no difference.

Greger, P.D. 1983. Food partitioning among fishes of the Virgin River. M.S. Thesis, Univ. Nevada, Las Vegas. 84pp.

Food partitioning of one introduced (red shiner) and six native species of fish was investigated from two different sites in the Virgin River (Nevada and Arizona) on 8-9 Feb., 19-20 Jun., 27-28 Sep. and 11-12 Dec., 1979. The diet of the woundfin, an omnivorous feeder, consisted of an array of benthic and drift animals and plant matter. The spinedace had similar feeding habits to the woundfin while the red shiner and speckled dace were both insectivorous, consuming large numbers of small dipterans. Food overlap among the native fish was uncommon, most occurring between the two sucker species. Biologically significant food overlap between the red shiner and native fishes occurred on four of the sixteen possible occasions.

Greger, P.D. and J.E. Deacon. 1982. Observations on woundfin spawning and growth in an outdoor experimental stream. Great Basin Nat. 42(4):549-552.

The response of woundfin to different substrates and current speeds was investigated in an outdoor experimental stream. Approximately 50 adult woundfin were collected from the Virgin River at Beaver Dam Wash on 26 April 1980 and placed in an experimental stream on the University of Nevada Las Vegas campus. The following observations were made from an analysis of these fish from 26 April through September 1980. The woundfin spawned in groups of 15-20 over 5-10 cm rock substrate in a .06 to .09 m/sec. current at a depth of 10 cm. Eggs are adhesive and drop between the interstices of rocks, where they adhere to the underside. Spawning occurs primarily in the spring when water temperatures reach about 25-26 C. Woundfin 10-12mm TL are restricted in their movements by current, at 17-20mm TL they are able to move freely throughout the stream in a variety of current speeds. The period of development was 10-11 days and they were about 8-11mm upon hatching. A mean growth rate of about 3mm/week (or 50mm in the first four months) was observed. Growth may then slow after the first four months, but an average size of 55-60mm during the first growing season is not unlikely.

Greger, P.D. and J.E. Deacon. 1986. Diel food utilization by woundfin, Plagopterus argentissimus, in Virgin River, Arizona. Envir. Biol. Fishes. Vol. 13.

Woundfin fed predominantly on simuliid larvae during the

day, and shifted to the larger Hydropsyche spp. at night. Ephemeropteran larvae were eaten nearly uniformly throughout the 24 hour period. Mean weight of food consumed varied from 20-40mg per individual (0.7-2.5% body weight) throughout the 24 hour period. The estimated daily ration of about 8% body weight, at temperatures that varied between 15-25 C, is based upon measurements of mean gut contents over a 24 hour period, combined with intestinal evacuation rates suggested for other cyprinids in the literature. The relatively continuous feeding pattern suggests a foraging strategy that would minimize competition with other species for food during June, a period of minimum annual food abundance in the Virgin River.

Greger, P.D. and J. E. Deacon. In press. Food partitioning among fishes of the Virgin River.

Food partitioning of one introduced and six native species of fish was investigated from two different sites in the Virgin River (Beaver Dam Wash, Arizona and below the Mesquite Diversion, Nevada). Woundfin and spinedace were omnivorous, consuming an array of benthic and drift animals and plant matter. Speckled dace and red shiners were insectivorous, consuming large numbers of small dipterans. Food overlap among native fishes was uncommon, however, red shiners and woundfin show considerable useage of a common resource, especially below the Mesquite diversion. Competition for food could then be more severe below the Mesquite diversion than near Beaver Dam Wash when food becomes limited. A niche shift under conditions of reduced food abundance did occur between red shiner and woundfin at Beaver Dam Wash in 1979.

Hardy, T.B. and J.E. Deacon. 1982. Impact analysis of the proposed Quail Creek Reservoir on Plagopterus argentissimus (woundfin) in the Virgin River. Unpub. Biological assessment prep. for Washington County Water Conservancy District. 43pp.

This biological assessment is an analysis of the potential impacts of the proposed Quail Creek project on the woundf in. The proposed water withdrawal of Quail Creek Reservoir was examined for a 40 year period from 1941 through 1980. This analysis addressed the relative change in available habitat that a particular life stage might utilize given the present altered flow regime. The analysis is based on mean monthly discharges and only water withdrawal is considered, no releases from Quail Creek Reservoir were examined. Species criteria for adults and juveniles were derived by analyzing

six years of data collected from 1977 to 1982. Criteria for spawning and fry were developed from studies conducted in an artificial stream at UNLV and from professional judgments. The study showed that the greatest available habitat for the entire study area occurs at 30 cfs for spawning, 200 cfs for fry, 90 cfs for juveniles and 85 cfs for adults. There were 23 months out of the 480 month period that the project showed a net reduction in available habitat. October, June and September accounted for all but 2 of the 23 months.

Heckman, R.A., J.E. Deacon and P.D. Greger. 1986. Parasites of the woundfin minnow, Plagopterus argentissimus, and other endemic fishes from the Virgin River, Utah. Great Basin Nat. 46(4):662-676.

Two hundred woundfin collected in the summer of 1985 from four sites along the Virgin River, Utah, were examined for parasites. The foreguts of 211 woundfin collected on four dates throughout 1979 from the Virgin River near Beaver Dam Wash, Arizona and Mesquite, Nevada, were examined for cestodes. Seven parasites were found inhabiting the woundfin: (1) a trematode (yellow grub), Posthodiplostomum minimum, (2) a cestode known as the Asian fish tapeworm (Bothriocephalus acheilognathi, (3) Diplostomum spathaceum, a metacercariae, (4) a monogenetic trematode, Gyrodactylus sp., (5) the anchor worm Lernaea cyprinacea, (6) a ciliate, Trichodina sp., and (7) the ICH ciliate, Ichthyophthirius multifilis. The Asian tapeworm has the potential of being highly detrimental to the endemic fish of the Virgin River, especially the chub. The Asian tapeworm probably gained access to the Virgin River fish through the red shiner (Notropis lutrensis). Parasite loads were correlated with water quality and habitat disturbance, with highest number and frequency occurring in "disturbed" sites. Low river flows and increased total dissolved solids appear to be associated with a higher parasite frequency and mean number in fishes of the Virgin River.

Heckman, R.A., P. D. Greger, and J.E. Deacon. 1985. Parasites of the woundfin minnow, Plagopterus argentissimus, from the Virgin River, Utah. Rept. prep. for Utah Div. Wildl. Res., Salt lake City. 89pp.

Woundfin were collected from the Virgin River in Utah on 27, 28 July and 24, 25, and 31 August 1985, for the purpose of identifying the species, frequency of occurrence and abundance of parasites inhabiting them. Collections were made from the Hurricane bridge area, 2 miles below Berry Springs, at Twin Bridges and below the Santa Clara Creek confluence. A trematode (yellow grub), Posthodiplostomum

minimum, was found attached and within the viscera, and occasionally in the eyes. The ciliate, Trichodina sp., was found on the gill surface. Also the ICH ciliate, Ichthyophthirius multifilis, was found on the gill surface. The anchor worm, Lernaea cyprinacea-elegans, was found at the base of the fins and within the oral cavity. The highest number and frequency of Trematode in woundfin occurred at the Twin Bridges site, followed by the Santa Clara site, both disturbed areas.

Heckman, R.A., P.D. Greger and J.E. Deacon. 1987. New host records for the Asian tapeworm, Bothriocephalus acheilognathi, in endangered fish species from the Virgin River, Utah, Nevada, and Arizona. J. Parasit. 73(1):226-227.

This note represents the first published record of the Asian tapeworm in fishes of the Virgin River. It was found in the Virgin River chub, woundfin, spinedace, speckled dace and red shiner. It is assumed that the tapeworm entered the Virgin River through fish introductions such as the red shiner or from fish migrating from the Colorado River or Lake Mead. The Asian tapeworm infections for the Virgin River need to be closely monitored and a management program developed that will minimize the adverse effects to these endangered fish species.

'Hickman, T.J. 1985. Study of fishes in the Virgin River (Utah). Ann. Rept., 1984. Western Ecosystems, P.O. Box 1575, St. George, UT 49pp.

This is the first annual report of a five year study on the fishes in the Virgin River in Utah. Six stations between Pa Tempe Springs and the Utah - Arizona border, plus La Verkin Creek, are sampled once every month. Collections were made via seines or electrofishing, the seining techniques were the same as those described in the woundfin recovery plan. In addition to fish collections, water quality, velocity, substrate, cover and depth measurements were recorded at each station. All species collected were recorded and measured. Monthly samples were made from July through December, 1984. Woundfin were the most abundant species collected during each month. They were collected from virtually every habitat type available (although a majority were collected in runs over a shifting sand substrate) and were present in over 75% of all the collections. Stations 2 (above Quail Creek Reservoir), 3 (below Hurricane Bridge) and 4 (above Washington Fields Diversion) provided the best habitat for all size classes of woundfin, while station 5 (below Washington Fields

Diversion) contained the most adults. The best habitat for woundfin appears to be a 10 mile stretch of river between station 1 (below Ash and La Verkin Creek confluence) and station 2 to the Washington Fields Diversion. This is the least modified section of the river in Utah. Flows were below average in 1984, although a few summer floods did occur.

Hickman, T.J. 1986. Study of fishes in the Virgin River (Utah). Ann. Rept., 1985. Western Ecosystems, P.O. Box 1575, St. George, UT 42pp.

This is the second annual report of a five year study on the fishes in the Virgin River in Utah. Six stations between Pa Tempe Springs and the Utah - Arizona border, plus La Verkin Creek, are sampled once every month. Collections were made via seines or electrofishing, the seining techniques were the same as those described in the woundfin recovery plan. In addition to fish collections, water quality, velocity, substrate, cover and depth measurements were recorded at each station. All species collected were recorded and measured. Monthly samples were made from January through December, 1985. A total of 19,728 woundfin were collected and analyzed in 1985. They were the most abundant species collected during each month and usually were the most abundant species at each station (the exception was station 1 where the increased flows from Pa Tempe Springs in 1985 had eradicated the woundfin from the area). Except for station 1, spawning was more successful in 1985 compared to 1984. Comparing flows in 1984 to those of 1985; 1984 had slightly higher flows in the winter, lower spring flows(relatively no spring run-off in 1984, the 1984 peak occurred on 17 April with a mean daily flow of 349 cfs at the Hurricane Gauge while in 1985 it occurred on 10 April and was 982 cfs) and 1984 had higher summer flows with more floods. Pa Tempe Springs had a tremendous affect on the river during 1985. Increased spring flows (which increased the conductivity and water temperature and decreased the turbidity) combined with low summer flows impacted the fish in 1985, especially above Quail Creek Reservoir.

Hickman, T.J. 1987. Study of fishes in the Virgin River (Utah). Ann. Rept., 1986. Western Ecosystems, P.O. Box 1575, St. George, UT 86pp.

This is the third annual report of a five year study on the fishes in the Virgin River in Utah. Six stations between Pa Tempe Springs and the Utah - Arizona border, plus La Verkin Creek, are sampled once every month. Collections were made via seines or electrofishing, the seining techniques were

the same as those described in the woundfin recovery plan. In addition to fish collections; water quality, velocity, substrate, cover and depth measurements were recorded at each station. All species collected were recorded and measured. Monthly samples were made from January through December, 1986. A total of 12932 were collected and analyzed in 1986. The best woundfin areas (in terms of abundance and size diversity) are station 2 (above Quail Creek Reservoir), station 3 (below the Hurricane Bridge) and station 4 (above Washington Fields Diversion). No young-of-year woundfin were found at stations 1 and 5. Station 5 is located below Washington Fields Diversion and is the most impacted area on the river in Utah. Station 1 was impacted by increased flows of Pa Tempe Springs in 1985 and the woundfin were just beginning to return to this area at the end of 1986. The woundfin spawned about one month earlier in 1986 (end of April) compared to 1985 (end of May). Flows in 1986 were below average in the summer (there were no summer floods), average in the fall, average to below average in the winter and below average in the spring.

Holden, *P.B.*, R. Stone, W. White, G. Somerville, D. Duff, R. Gervais, and S. Gloss. 1974. Threatened fishes of Utah. Proc. Utah Acad. Sci., Arts and Let. Vol. 51(2):46-65.

A list of species and populations of fish that are endangered or threatened are presented in this report. A brief discussion is given for each species. Definitions of endangered and threatened species follow the Endangered Species Act of 1973 (P.L. 93-205). The woundfin is listed as endangered on page 56. A discussion on the taxonomy, biology, distribution and factors influencing the decline of the woundfin is presented on pages 56 through 58. Loss of habitat in the Gila River system through irrigation demands and in the main Colorado River and lower Virgin River by reservoir construction appear to be major decimating factors for the woundf in. Virgin River populations remain strong, although recent construction of Interstate 15 through the Virgin Gorge, may have a negative effect on the population in this area.

Hubbs, C.L. 1955. Hybridization between fishes in nature. Syst. Zool. 4:1-20.

This paper places the tribe Plagopterini (of which the woundfin is a member) under the subfamily Leusiscinae. This tribe is composed of genera which are among the few North American cyprinids that are not known to hybridize with

other genera.

Illick, H.J. 1956. A comparative study of the cephalic lateral- line system of North American Cyprinidae. Amer. Midl. Nat. 56:204-223.

The lateral-line canals (in the head) of 83 species, representing 38 genera, were studied to determine the generalized pattern for the family as well as the individual and group variations of this pattern. A taxonomic key for the cyprinidae family is presented based upon this analysis. In conjunction with other studies, a knowledge of cephalic lateral-line characters will contribute toward an ultimate understanding of the relationships with in this large family of fishes. Information on the woundfin is presented on pages 215-218 and 220.

Johnson, J.E. 1987. Protected fishes of the United States and Canada. American Fish. Soc. Bethesda, MD. 42pp.

This paper lists 517 taxa (described and undescribed species and subspecies) of native fish receiving some degree of protection in the United States and Canada. Two categories, Protected and Special Concern, are used to describe the status of the fish. Protected taxa are provided some degree of legal security under endangered species legislation by one or more agencies enabled to enforce laws. Taxa of Special Concern are recognized by those same agencies as declining in numbers or distribution, but are either more secure than Protected taxa or too few data are available to determine if they are in need of full protection. The woundfin is listed as a Protected species in Utah, Nevada and Arizona. A picture of the woundfin is presented on page 17.

Jordan, D.S. 1885. Identification of the species of Cyprinidae and Catostomidae, described by Charles Girard, in the Proceedings of the Academy of Sciences of Philadelphia for 1856. U.S. Natl. Mus. Proc. 8:118-127.

Information on woundfin distribution and taxonomy is presented on page 122. The genus of the woundfin was changed from Plagopterus to Meda. The following information is given on page 122: "In the types of Meda fulgida, the teeth are 2,4 or 5-5, 1 or 2. The genus is precisely identical with Plagopterus. Meda fulgida and Meda argentissimus are, however, apparently distinct species, although closely

related."

Jordan, D.S. and H.E. Copeland. 1876. Check list of the fishes of the freshwaters of North America. Bul. Buffalo Soc. Nat. Sci. 3:133-164.

Taxonomic and distributional information is presented for the woundfin on page 155. The type locality (San Luis Valley, Western Colorado) is repeated from Cope 1974.

Jordan, D.S. and B.W. Evermann. 1896. The fishes of North and Middle America. Part. I. U.S. Natl. Mus. Bull. 47:1-1240.

A taxonomic description (after Cope 1874) is presented for the woundfin on page 329. The following information is given: "body entirely scaless. Fins as in Meda and Lepidomeda. Small size. Length 2 1/2 inches." Colorado Basin in Western Colorado (Cope) and Fort Yuma, Arizona (Gilbert).

Jordan, D.S., B.W. Everman, and H.W. Clark. 1930. Checklist of the fishes and fishlike vertebrates of North and Middle America north of the northern boundary of Venezuela and Columbia. Rept. U.S. Fish. Comm. 1928(2):1-670.

Taxonomic and distributional information is presented for the woundfin on page 147. The genus was changed from Meda back to Plagopterus.

Jordan, D.S. and C.H. Gilbert. 1883. Synopsis of the fishes of North America. U.S. Nat. Mus. Bul. 16(1882):1-1018.

On page 253 a description of the woundfin is given based upon information from Cope 1874.

Kimsey, J.B. and L.O. Fisk. 1960. Keys to the freshwater and anadramous fishes of California. Calif. Fish and Game. 46(4):453-479.

A taxonomic key for the woundfin is presented on page 468.

La Rivers, I. 1952. A key to Nevada fishes. Bul. So. Calif. Acad. Sci. 51:86-102.

A key to the identification of the woundfin is presented on page 97.

La Rivers, I. 1962. Fishes and fisheries of Nevada. Nevada State Print. Office, Carson City.

A discussion of woundfin taxonomy, distribution and status is given on pages 475 through 478.

LaRivers, I. and T.J. Trelease. 1952. An annotated checklist of the fishes of Nevada. Calif. Fish and Game 38(1):113-123.

This is the first exhaustive list of Nevada fishes to appear in print, it is intended to provide the basis for a more detailed report in the future. A total of 55 fish species are presented, 21 of which have been introduced into the state. The woundfin appears on page 118 and its distribution is listed as Virgin River, Clark County, Nevada.

Lockhart, J.N. 1979. Ecology of the woundfin minnow, Plagopterus argentissimus, Cope. Manuscript, Univ. Nevada Las Vegas. 187pp.

Woundfin were collected and analyzed from several sites along the Virgin River in Utah, Nevada and Arizona in the 1970's. Information is provided on taxonomy, distribution, habitat requirements, competition, predation, parasites and diseases, metabolism, food and feeding habits, age and growth and reproduction. Woundfin were collected in temperature ranges from 7 C to 35.5 C, optimum appeared to be between 25 C and 28 C. Woundfin are capable of spawning more than once per year and may spawn in September if conditions are favorable. Fecundity data indicates that the female can produce approximately 1500 eggs. The areas where the red shiner have apparently displaced the woundfin (from Mesquite downstream to Lake Mead) are continually modified by man such that man is the greatest exotic spatial competitor to whom the woundfin must, but apparently cannot, adjust. Biotic factors associated with stable conditions do not favor woundfin over other introduced species while chemical and physical factors associated with unstable conditions are favorable for the woundfin.

Meek, S.E. 1904. The freshwater fishes of Mexico north of the Isthmus of Tehuantepec. Publ. Field. Columb. Mus.

93 Zool. Ser. 5:i +lxiii, 1-252.

Information on the taxonomy and distribution of the woundfin is presented on page 83.

Miller, R.R. 1946. Distributional records of North American fishes, with nomenclatorial notes on the genus Psenes. J. Washington Acad. Sci., 36:206-212.

The distribution of the woundfin is discussed on page 206.

Miller, R.R. 1952. Bait fishes of the lower Colorado River, from Lake Mead, Nevada, to Yuma, Arizona, with a key to their identification. California Fish and Game. 38:7-42.

The use of the woundfin as a bait fish, its distribution and a key to their identification is presented on pages 18 and 36. On June 16, 1952 one woundfin was obtained from the boat dock at Lake Mead. No other woundfin were observed in the bait tanks along the Colorado River.

Miller, R.R. 1961. Man and the changing fish fauna of the American Southwest. Pap. Michigan Acad. Sci., Arts, Lett. 46:365-404.

The past and present distribution of the woundfin is presented on page 374.

Miller, R.R. 1968. Rare and endangered world freshwater fishes. International Union Cons. Nature and Natl. Res. 1110 Morges, Switzerland. 6pp.

On page 2 the following remarks are given for the woundfin: now restricted to the Virgin River below St. George, Utah, where it is endangered by the proposed construction of a dam above St. George.

Miller, R.R. 1969. Red Data Book, Volume 4 (Pisces). International Union Cons. Nature and Natl. Res. Morges, Switzerland.

The woundfin is listed as an endangered species.

Miller, R.R. 1972. Threatened freshwater fishes of the United States. Trans. Amer. Fish. Soc. 101:239-252.

Threatened native freshwater fishes are listed for 49 of the 50 states. Over 300 kinds are included in a formal classification, cross indexed to states, followed by lists and the status of each fish, whether rare, endangered, depleted or undetermined. The woundfin is listed under the states of Nevada, Utah and Arizona and its status is listed as rare and endangered in each of these states.

Miller, R.R. and C.L. Hubbs. 1960. The spiny-rayed cyprinid (Plagopterini) of the Colorado River system in western North America. Misc. Publ. Mus. Zool. Univ. Michigan. 115:1-39.

The tribe Plagopterini, an endemic group of fishes comprising the cyprinid genera Lepidomeda, Meda, and Plagopterus, is revised in this paper. Although these three genera have been known for 75-100 years, little had been written (prior to this paper) about their classification or distribution. Information on woundfin taxonomy, speciation, biology and distribution is presented. The type locality designated by Cope (San Luis Valley, Western Colorado) for the woundfin is disputed in this paper. This is based on the fact that woundfin have never been known from Colorado and that other records from the Wheeler survey have contained erroneous localities and dates. The syntypes in the National and Stanford collections bear the locality "Colorado Chiquito River," in Arizona, but this is probably also incorrect since the woundfin is not known from the Little Colorado drainage. It is thought that the type specimens for the woundfin were collected in the Virgin River in the area where the type specimens for the Virgin River chub were collected (Washington County, Utah) by the Wheeler Survey naturalists. They maintained a camp on Ash Creek (tributary to the Virgin River) during 1872.

Miller, R.R. and C.H. Lowe. 1964. An annotated check-list of the fishes of Arizona. In: The vertebrates of Arizona, ed. by C.H. Lowe. Univ. Arizona Press, Tucson. pp 133-151.

On page 143 the range and status of the woundfin is discussed.

Minkley, W.L. 1969. Native Arizona fishes, Part II- spiny rayed minnows. Wildlife Views. 16:4-9.

The woundfin is discussed on page 7 and information on its distribution, taxonomy and status is given.

Minkley, W.L. 1971. Keys to native and introduced fishes of Arizona. J. Arizona Acad. Sc., 6:183-188.

A taxonomic key for the identification of woundfin is given on page 184.

Minckley, W.L. 1973. Fishes of Arizona. Arizona Game and Fish Dept., Phoenix. 293pp.

Information on woundfin taxonomy, distribution, life history and status are given on pages 115 and 116.

Minckley, W.L. and J.E. Deacon. 1968. Southwestern fishes and the enigma of "endangered species." Science. 159:1424-1432.

Man's invasion of the deserts (particularly in the American Southwest) has created problems for native animals, especially for freshwater fish. Declines in the populations of native fishes in the American Southwest are largely due to habitat changes associated with man's modification of various aquatic environments. Examples of this are presented and rationales for preserving these fish are given. Information on the woundfin is presented on page 1427. The woundfin was collected in the Salt River at Tempe and in the Gila River at Yuma, Dome and Gila City, Arizona, in the period 1890 to 1895. The last reproducing population of the woundfin now lives in the lower Virgin River of southwest Utah, northwest Arizona and southeast Nevada. The U.S. Bureau of Reclamation is planning to construct a dam on the lower Virgin River 8 miles above St. George, Utah. Due to changes in the habitat resulting from the operation of this dam, it is likely that construction of the dam will be detrimental to the woundf in. Construction of the dam should be avoided until some attempt has been made to define habitat requirements for the species.

Moore, G.A. 1957. Fishes. In: Vertebrates of the United States, ed. by W.F. Blair., McGraw-Hill Book Co., New York. Pp. 31-210.

A key to the taxonomic identification of the woundfin and a discussion of its distribution is presented on page 138.

Moore, G.A. 1968. Fishes. In: Vertebrates of the United States, Revised edition. ed. by W.F. Blair., McGraw-Hill Book Co., New York. Pp. 21-165.

A key to the taxonomic identification of the woundfin and a discussion of its distribution is presented on page 97.

Peters, E.J. 1970. Changes with growth in selected body proportions of the woundfin (Plagopterus argentissimus Cope: =Cyprinidae). Unpubl. M.S. thesis. Brigham Young Univ., Provo, Utah. 25pp.

This study describes the morphological changes that occur during the growth of the woundfin and, where possible, correlates these changes with life history and ecological data. Woundfin were collected each month from July 1967 through July 1968 from four stations on the Virgin River between St. George and Hurricane, Utah. A wide variation of lengths within the age groups was noted and was attributed to the extended length of the reproductive period. The spawning period for 1968 was from the end of April through June. It was concluded that females do not spawn until the beginning of their third year of life while the males are capable of spawning after their first year of life. Males and females can be distinguished by their pectoral fins. In general, the pectoral fins of the male are hardened and more rounded than those of the female. This is noticed after their first year of life.

Shapovalov, L. and W.A. Dill. 1950. A check list of the fresh water and anadromous fishes of California. Calif. Fish and Game. 36:382-391.

The woundfin is listed on page 386. The name woundfin is proposed as the common name for Plagopterus argentissimus.

Sigler, W.F. and R.R. Miller. 1963. Fishes of Utah. Utah State Dept. of Fish and Game. Salt Lake City. 203pp.

Information on woundfin distribution, taxonomy, life history, and habitat requirements are given on pages 91 and 92.

Snyder, J.O. 1915. Notes on the collection of fishes made by Dr. Edgar A. Mearns from rivers tributary to the Gulf of California. Proc. U.S. Nat. Mus. 49:573-586.

An analysis of several fish collected between 1892 and 1894

from the lower Colorado River drainage is presented in this report. Three woundfin from the Gila River near Gila City were analyzed. A description is presented on page 584.

U.S. Department of the Interior. 1973. Threatened Wildlife of the United States. Bureau of Sport Fish. and Wildl. Res. Pub. No. 114. 289pp.

Information on the taxonomy, distribution and status of the woundfin is presented on pages 34, 286 and 287.

United States Fish and Wildlife Service. 1985. Woundfin recovery plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 74pp.

Information is presented on distribution, description, taxonomy, habitat requirements, associated species, food habits, reproduction, movements, habitat destruction, changes in abundance, limiting factors and conservation efforts. The woundfin was placed on the endangered species list by the Department of the Interior on October 13, 1970. Its historic range has been documented in the Salt River near Tempe, Arizona; at the mouth of the Gila River near Yuma, Arizona; in the Colorado River near Yuma, Arizona; in the Virgin River in Nevada, Arizona, and Utah and in La Verkin Creek, a tributary to the Virgin River in Utah. Presently it occurs from La Verkin Springs on the mainstream of the Virgin River and the lower portion of La Verkin Creek in Utah, downstream to Lake Mead, Nevada. Attempts to transplant woundfin into four localities have been unsuccessful. They were placed in the Hassayampa River, Arizona in 1972, in the Salt River, Arizona in 1972, in Sycamore Creek, Agua Fria drainage, Arizona in 1972 and in the Paria River, Utah-Arizona several times between 1969 and 1972.

Uyeno, T. and R.R. Miller. 1973. Chromosomes and the evolution of the Plagopterine fishes (Cyprinidae) of the Colorado River system. Copeia 1973 4:

Chromosome morphology was used to evaluate the interrelationships of the Plagopterines. All species examined had a diploid chromosome number of 50. Sex chromosomes were not identifiable. The woundfin has a karyotype comprised of nine pairs of metacentric, 13 pairs of submetacentric-subtelocentric, and 3 pairs of acrocentric chromosomes. The data suggests that Meda and Plagopterus share a more recent ancestor than with Lepidomedia.

Vaughn Hansen Associates. 1977. Impact of Warner Valley Water Project on endangered fish of the Virgin River. Vaughn Hansen Assoc. Salt Lake City, Utah. Prep. for City of St. George, UT.

This report presents the findings of a study team which analyzed the impacts of the Warner Valley water project on the woundfin. The team consisted of two hydrologist (Owen and Hansen), two aquatic invertebrate specialists (Winget and Baumann) and one fisheries specialist (Deacon). The following conclusions were presented: 1) exotic species will increase in the Virgin River system and the red shiner may become abundant above the Virgin River gorge. However, Winget and Baumam stated that they found no evidence of competition existing between the woundfin and red shiner. They also stated that other exotic species would not negatively impact the woundfin. 2) the pool, run and riffle environment will be maintained with post project flow and the instream desilting operation will not impact woundfin habitat. 3) Deacon recommended minimum flows for woundfin between 80 and 100 cfs while Winget recommended 30-40cfs. The project would have no adverse impacts on either flow recommendation. The reported concluded that the 30-40cfs figure is the **most probable minimum flow requirement for woundfin. Information on hydrology, sediment transport, water quality and habitat analysis are also presented as well as comments to the various reports and a summary of a seminar on rare fishes of the Virgin River held Nov. 1 and 2, 1977. Papers by Deacon, Winget and Baumann presented in this report are discussed elsewhere in this bibliography.**

Williams, J.E. 1977. Adaptive responses of woundfin, Plagopterus argentissimus, and red shiner, Notropis lutrensis, to a salt spring and their probable effects on competition. Unpubl. M.S. thesis. Univ. Nevada, Las Vegas. **91pp.**

This report analyzed the effects that the proposed desalinization of **La** Verkin Springs would have on the woundfin and red shiner. Currently the woundfin is under stress by interaction with the red shiner. The springs has a profound effect on the Virgin River. Salinity, conductivity and temperature increase dramatically and dissolved oxygen decreases in the vicinity of the spring outflow. As a result of these changes, the La Verkin springs have prevented the upstream dispersal of the woundfin. Both species displayed a high degree of stress, as measured by increased plasma osmotic pressure and respiratory rates, when exposed to the higher salinity concentrations of the spring water. However, the woundfin appeared able to adjust to the increased salinities more efficiently. The desalinization of La Verkin

Springs will reduce the highly variable conditions which have historically existed in the Virgin River system and may further deplete river flow. The net effect of this will be to render the Virgin River less desirable to native fishes and favor exotic species.

Williams, J.E., Bowman, D.B., Brooks, J.E., Echelle, A.A., Anthony A., Edwards, R.J., Hendrickson, D.A. and Landye, J.J. 1985. Endangered aquatic ecosystems in North American Deserts with a list of vanishing fishes of the region. Jour. of the Arizona-Nevada Acad. of Sci. 20:1-62.

Habitat degradation and the introduction of exotic species are endangering an increasing number of fishes and other aquatic organisms in the desert areas of North America. The authors identified 164 fishes from North American deserts as endangered, vulnerable, rare or of indeterminate status. A total of 18 recently extinct fishes are recorded while 46 are considered endangered. The woundfin is listed as endangered on page 8. A discussion of the distribution of the woundfin is presented on page 18. Its extirpation from the Gila River appears attributable to reduced stream flows and degradation of habitat.

Winget, R.N. 1977. Update of impact of Warner Valley Water Project on woundfin and other fishes of the Virgin River. In: Impact of Warner Valley Project on endangered fish of the Virgin River. Vaughn Hansen Assoc. Salt Lake City, Utah. Prep. for City of St. George, Utah.

Water quality and temperature evaluation and channel profile analysis all indicate that during 1977, conditions above the Washington Fields Diversion were adequate for successful woundfin reproduction. As a result of the statement by Deacon (1977) that woundfin reproduction was not successful in the area above the Washington Diversion in 1977, a group of biologists sampled the river on Nov. 14 & 15, 1977. Five stations above Washington Diversion were sampled with a 1/4 inch mesh seine. Woundfin collected ranged in size from 47-92mm. It was determined that woundfin in the 47-67mm size range during November 1977, were y-o-y. This was based upon the assumption that y-o-y in June 1977, ranged from 16-37mm and 31-55mm in August 1977. Y-0-Y woundfin were collected at all stations. The biological data confirmed the physical-chemical measurements in that woundfin reproduction was successful in 1977. Water conditions *in* 1977, a record low water year, were generally worse than projected post Project conditions. As result,

successful woundfin reproduction in 1977, indicates that there should be no negative impacts from the Warner Valley Water Project on the woundfin in the Virgin River.

Winget, R.N. and R.W. Baumann. 1977. Virgin River, Utah-Arizona-Nevada, aquatic habitat, fisheries and macro-invertebrate studies. In; Impact of Warner Valley Project on endangered fish of the Virgin River. Vaughn Hansen Assoc. Salt Lake City, Utah. Prep. for City of St. George, Utah.

A discussion of the food habits of fish, macroinvertebrates, water quality, hydrology, sediment transport and habitat of the Virgin River is presented in this paper. Three factors had the greatest impact on macroinvertebrate densities: 1) toxic substances in the waters of Pa Tempe Springs reduced densities; 2) extreme flows reduce densities; and 3) organic enrichment (such as irrigation return flows) greatly increased densities. Food analysis of red shiner and woundfin at Riverside, Nevada showed that they were widely separated in their food habits, woundfin were more selective while red shiner were generalists. Woundfin stomachs contained almost pure animal matter while red shiner stomachs contained large amounts of detritus and inorganic material. The woundfin and Virgin spinedace appear to be the most closely related with reference to food niche preference. From channel and water surface profile studies, it is obvious that 30-40 cfs is adequate for physical habitat requirements of spawning, nursery, feeding and resting activities of the woundfin. The project will negatively impact the area above Washington Diversion during summer where post project flows will be less than pre-project flows 50% of the time. Post project flows during the remainder of the year should present no serious problems to the woundf in.

Winn, H.E. and R.R. Miller. 1954. Native postlarval fishes of the lower Colorado River basin, with a key to their identification. California Fish and Game. 40:27 285.

A taxonomic key for the identification of woundfin larvae is presented on page 274.

Woodbury, A.M. 1933. Biotic relationships of Zion Canyon, Utah with special reference to succession. Ecol. Monog. 3(2):147-245.

A description of the woundfin is briefly given.