RECOVERY PLAN FOR THE PEPPERED CHUB, *Macrhybopsis tetranema* Gilbert, IN KANSAS

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for

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I. INTRODUCTION

The peppered chub, *Macrhybopsis tetranema* Gilbert, is considered endangered in Kansas. Globally it is considered critically imperiled. The fish is endemic to the large, plains streams of the Arkansas River basin from Pueblo, Colorado to Tulsa County, Oklahoma (Eisenhour, 1999). This species has received legal protection from the Kansas Department of Wildlife and Parks under the authority of the state's Nongame and Endangered Species Conservation Act of 1975. The species is considered endangered under Kansas statute (K.A.R. 115-15-1). This plan, as outlined by K.A.R. 115-15-4, outlines specific strategies and methods to recover and delist the peppered chub.

II. SPECIES ACCOUNT

A. TAXONOMY DESCRIPTION

1. Original Description

From Eisenhour (1999)…

> Largest female 63.5 mm SL (77 mm TL); largest male 58.1 mm SL (73 mm TL). Dorsal rays 8; principal caudal rays usually 19 (range15-21); anal rays usually 8 (7-9); pelvic rays usually 8 (6-9); pectoral rays 13-16 (12-18). Lateral line scales usually 37-43 (35-48); predorsal scales usually 13-17 (2-20); scales above lateral line usually 5-6 (4-8); scales below lateral line usually 5 (4-7); caudal peduncle scales usually 12-16 (12-18). Nape fully scaled in about 97% of specimens. Belly posterior to pelvic basses less than 33% scaled in 46% of specimens; belly anterior to pelvic bases usually naked. Infraorbital pores usually 12-16 (9-19); preoperculomandibular pores usually

10-13 (9-15). Total vertebrae usually 36-38 (36-39); precaudal vertebrae usually 17-18 (16-19); caudal vertebrae usually 19-20 (19-21).

Body fusiform, fairly deep at dorsal-fin origin, but rapidly tapering anteriorly to narrow, pointed head and posteriorly to moderately slender caudal peduncle. Dorsal fin directly above or just ahead of anal fin origin. Anal and dorsal fins slightly falcate; pelvic fins rounded. Pectoral fins long, falcate, and just reaching bases of pelvic fins in adult males; adult females with shorter and pointed pectoral fins, usually not reaching pelvic bases. Head conical, but flattened ventrally with long and relatively pointed snout. Mouth inferior and horizontal; width slightly narrower than head when viewed ventrally. Lips fleshy and thickened posteriorly. Eyes round or nearly so. Two distinct pairs of barbells present, length of posterior pair usually greater than orbit length, length of shorter pair usually greater than 50% of orbit length. Large taste buds present over most of body, enlarged into barbel-like papillae on gular area. Gillrakers absent or present as 1-3 dorsal rudiments. Pharyngeal teeth 0,4-4,0, slender, hooked with little or no grinding surface.

Pigment nearly confined to dorsal half of body. Medium-large melanophores scattered over dorsolateral surface. Some individuals with few scales bearing clusters (2-8) of medium-sized melanophores. Smaller melanophores randomly scattered, usually not concentrated on margin or submargin of scales. Lateral stripe poorly defined and centered one scale row above lateral line. Small pale areas often present at posterior and anterior base of dorsal fin. Head with pigment over brain; preorbital bar present, but

often indistinct. Dorsal fin rays weakly pigmented, darker at bases. Pigmentation lacking on pectoral, pelvic, and anal fins. Caudal fin with white ventral border; rays poorly pigmented, darker at base of each caudal lobe.

Pectoral ray 2-10 greatly thickened in large nuptial males, bearing rows of small, conical, antrorse tubercles. Basal part of rays bears 1-2 rows of tubercles. Usually two tubercles per segment on posterior primary branch, 1-2 tubercles per segment on anterior primary branch. Some specimens with tubercles arranged uniserially on secondary branches. Females without tubercles.

2. Taxonomic Description

The peppered chub was originally described by Gilbert (1886) from eight specimens collected by F.W. Cragin in the Elm and Spring creeks in the Salt Fork of the Arkansas River drainage (Eisenhour 1999).

Eisenhour re-described the species on the justification that the types are no longer "extant" and the original description could also be applied to the speckled chub (*Macrhybopsis aestivalis*) a closely related species. He designated KU 26843 as the neotype. It is a topotype to Gilbert's original 1886 description. The fish was collected by F.B. Cross and A.B. Leonard on July 21, 1951 from Elm Creek in Barber County, Kansas. The species no longer inhabits this area (Eisenhour 1999). It has been extirpated from most of its historic range (Figure 1). The species can now only be found in the Canadian River between Ute Reservoir in New Mexico and Meredith Reservoir in Texas, the South Fork Ninnescah River in Kingman, Sedgwick, and Pratt Counties, Kansas the Ninnescah River in

Sedgwick and Sumner Counties, Kansas and the Arkansas River in Sedgwick and Sumner Counties, Kansas (Eisenhour 1999; Luttrell et al. 1994, Kansas Biological Survey Natural Heritage Commission, Figures 1-5).

The Peppered chub is a member of the Order Cypriniformies and the Family Cyprinidae. It is a member of the *Macrhybopsis aestivalis* complex. This group includes *M. aestivalis* (Girard), *M. australis* (Hubbs and Ortenberger), *M. hyostoma* (Gilbert), *M. marconis* (Jordan and Gilbert), *M. tetranema* (Gilbert), and at least two undescribed species from the East Gulf Slope. The complex is characterized by black spots randomly scattered over the dorsum of the body, 2-4 prominent maxillary barbells, and unusual sensory systems (Eisenhour 1999).

B. HISTORICAL AND CURRENT DISTRIBUTION

1. Description of habitats and locations of occurrence

Historically, the peppered chub inhabited the main stem of the Arkansas River from Pueblo, Colorado to Tulsa County, Oklahoma, and the Ninnescah, Salt Fork, Cimarron, North Canadian and South Canadian River drainages in Kansas, New Mexico, Oklahoma, and Texas (Figure 1). Due to habitat degradation from extensive irrigation practices and reservoir construction, the species has been extirpated from up to 90% this range (Luttrell et al., 1999). *M. tetranema* now persists as two widely separated populations, one in Kansas and another in Texas and New Mexico (Figure 1). The Texas-New Mexico population will likely be extirpated. Hemmed in by two reservoirs, it is in danger of being decimated by a severe drought. If flows in the South Canadian River fall below sustainable levels the peppered chub will be extirpated since reestablishing populations are blocked

by reservoirs, dams, and long distances. The Kansas population is freer to move with changing water levels. However, if water levels in the Arkansas, South Fork Ninnescah, and Ninnescah River systems are not maintained to provide sufficient habitat, these fish could also be lost.

The peppered chub is described as "prefer[ing] shallow channels where currents flow over clean fine sand (Cross and Collins, 1995; Collins et al., 1995; KDWP web site, 2004). It avoids calm waters and silted stream bottoms. This fish is found in the lower Arkansas River and its major tributaries." *M. tetranema* is apparently more adapted for headwaters of streams than other members of the *M. aestivalis* complex (Luttrell et al., 1999).

2. Known collection sites

Peppered chub collections were plotted on county maps provided by the Kansas Department of Transportation (2000) (Figures 2-13). Collection sites were designated as follows: pre-1960 by a triangle, 1961-1979 by a square, and sites after 1980 by a circle. Multiple collections at a single site were designated by the number of collections at that site which yielded peppered chubs. Collection data was compiled from information provided by the Kansas Department of Wildlife and Parks and the Kansas Biological Survey, Kansas Natural Heritage Inventory (2004).

3. Associated fish species and communities

Limited information about the species associations of peppered chubs is available in literature. Cross et. al. (1985) did find that peppered chubs were often closely associated with the Arkansas River shiner. The association was so

common that the author remarked, “In our early collections they frequently occurred in the same seine-hauls, indicating preference for similar habitats”.

Data collected by Kansas Department of Wildlife and Parks between 1994 and 2003 at 16 sites indicates that peppered chubs are strongly associated with many species (Table 1). Channel catfish (*Ictalurus punctatus*), green sunfish (*Lepomis cyanellus*), red shiners (*Notropis lutrensis*), and sand shiners (*Notropis stramineus*) were present at all the sites where peppered chubs were captured. Common carp (*Cyprinus carpio*), plains killifish (*Fundulus zebrinus*), and river carpsuckers (*Carpiodes cyprinus*) were present 93.75% of the time, and bluegill (*Lepomis macrochirus*), bullhead minnows (*Pimephales vigilax*), emerald shiners (*Notropis atherinoides*), fathead minnows (*Pimephales promelas*), gizzard shad (*Dorosoma cepedianum*), largemouth bass (*Micropterus salmoides*), longnose gar (*Lepisosteus osseus*), smallmouth buffalo (*Ictiobus bubalus*), and mosquitofish (*Gambusia affinis*) were present in at least 80% of the samples. Central stonerollers (*Campostoma anomalum*), flathead catfish (*Pylodictis olivaris*), freshwater drum (*Aplodinotus grunniens*), and suckermouth minnows (*Phenacobius mirabilis*), also had strong associations, over 60% of the time.

Many of the species that showed strong associations with peppered chubs are habitat generalists and should not be used as indicators of suitable habitat for the chubs. It would probably be safe to conclude that sand shiners, red shiners, and river carpsuckers share an affinity for similar habitats and could possibly be used as indicators with further research since data indicated strong species associations and these species’ life histories indicate strong habitat selectivity. It

may also be safe to use Arkansas River shiners as indicators since the Cross et al. (1985) study indicated a strong species association with peppered chubs.

C. Population Sizes and Abundance

Very little information is available about the size and abundance of peppered chub populations. There are only two known populations remaining throughout their wide historic range. An isolated population occurs between Meredith Reservoir in Texas and Ute Reservoir in New Mexico on the South Canadian River. The more viable, connected population occurs in the Arkansas, South Fork Ninnescah, and Ninnescah Rivers in Sedgwick, Kingman, Pratt, and Sumner Counties, Kansas (Figures 2-5).

Collections by KDWP and the Kansas Biological Survey, Kansas Natural Heritage Inventory seem to indicate that populations are represented by only a few individuals at a specific site. Collections dating back to November 1936 tended to yield only one individual and rarely more than ten. However, a collection in June 1999 on the Arkansas River in Sedgwick County yielded 64 specimens and another in Sumner County on the same river yielded 89 specimens in September 2000. Population sizes have not been noted in literature. However, population estimates could be calculated if sample area were joined with the aforementioned collection data.

The low incidences of occurrence indicated in the collections may be attributable to the fish's habitat preference, body shape, and inadequate sampling techniques. The turbid waters in which these fish occur are not conducive to electrofishing. Stunned fish are harder to capture in these waters unless their air bladders float them near the surface. Stream currents may also compound this problem by holding the fish on the bottom as water flows over its streamlined body (Layher per comm. 2004). Seining, which seems

to be the preferred sampling method for these fish, may be inadequate. It is conceivable that many of these small, streamlined, substrate dwelling fish simply slide underneath the lead line of the seine thus under representing the population in the samples. It is not likely that the fish was misidentified in samples, due to its distinct appearance. If a peppered chub specimen were misidentified it would most likely be confused with *M. hyostoma,* its closest relative with which it shares some of its range.

D. REPRODUCTION

Reproduction of the peppered chub is considered to be the same as other members of the *M. aestivalis* complex which have generally short life spans (1½-2 years), and, therefore, must mature quickly. Reproduction occurs at the end of the first growing season when fish reach 27 to 35 mm in length (Pflieger, 1975; Robison and Buchanan, 1988). They broadcast semi-buoyant eggs into strong currents once water temperatures reach 21°C (70°F), usually between May and August (Cross and Collins, 1995; Robison and Buchanan, 1988, Pflieger, 1975). This may be a means of providing sufficient oxygen for developing eggs in the highly turbid streams in which they inhabit. Fertilized eggs develop as they drift in the current, and hatch 25-28 hours after fertilization (Robison and Buchanan, 1988; Pflieger, 1975). Successful reproduction appears to be dependent on frequency and magnitude of summer flooding (Bonner and Wilde, 2002).

E. FOOD AND FEEDING REQUIREMENTS

Peppered chubs have evolved for feeding in highly turbid streams. Bonner and Wilde (2002) found that prey consumption by peppered chubs only decreased 21% over a gradient of 0 to 4000 nephelometric turbidity units (NTUs). Comparatively, Arkansas River shiner (another species tolerant of high turbidity) prey consumption decreased by

59% over the same gradient. Peppered chubs have barbells, large numbers of olfactory lamellae, and taste buds all over their bodies, including their eyes (Bonner and Wilde, 2002). These adaptations help them find prey in waters where site feeding is almost useless. They feed primarily on larval insects, small crustaceans, immature aquatic insects, and plant material (Pflieger, 1975; Robison and Buchanan, 1988). Wilde et al. (2001) describes Peppered chubs as feeding "at or near the substrate". Pflieger (1975) described their feeding as follows: they "swim slowly about with the pectoral fins widespread and the rather long barbels in contact with the bottom. Large quantities of sand are taken into the mouth, sorted for any food it may contain, and then ejected from the mouth and gill openings".

F. OTHER PERTINENT INFORMATION AND SUMMARY

Data received from the Kansas Department of Wildlife and Parks, Environmental Services Division for sixteen sites where peppered chubs were captured reveals some useful relationships between water chemistry and the species' densities (Figures 15-26). Peppered chubs appear to prefer water temperatures around 20 °C. Five mg/L dissolved oxygen appears to be their minimum requirement. Of the sixteen sites, peppered chubs were most often found in sites with pHs between 7.8 and 8.7. The chubs appear to prefer water with nitrate levels less than 4.0 mg/L. The data did not seem to show a relationship between peppered chub densities and conductance, turbidity, total dissolved solids, alkalinity, chlorides, ammonia, phosphorus, or velocity. However, this is a very limited set of data and not all relationships are reliable. More in depth analyses would be required to determine actual habitat requirements and limiting factors of peppered chubs.

For instance, research by Bonner and Wilde (2002) has shown a preference by peppered chubs for more turbid water.

III. OWNERSHIP OF PROPERTIES

Properties where peppered chubs are known to occur are primarily in private interests. Several known sites occur in the municipalities of Wichita, Kingman, and Oxford (Figures 2-5). It is likely that populations span the length of streams between known collections where adequate habitat is found.

IV. POTENTIAL THREATS

Like most endangered species, loss of habitat is the greatest threat to the persistence of the peppered chub. In Kansas, dewatering and water quality changes are the chief threats (Collins et al., 1995; Luttrell et al., 1999). Stream obstruction has also played a major role in Kansas and other states (Collins et al., 1995).

Dewatering is the greatest peril to existing stocks of peppered chubs (Cross and Collins, 1995; Luttrell et al., 1999). The Arkansas River has been reduced to subsurface flows from Great Bend, Kansas westward into Colorado due to excessive pumping for agricultural and municipal uses. Insufficient flows have and instream barriers have inhibited re-colonization of upstream sites by downstream populations after droughts extirpate local populations (Luttrell et al., 1999). As a result the peppered chub has been extirpated from Colorado and large portions of Kansas, which consists of a large part of their historical range (Figure 2).

Increased pollution and lower suspended solid loads have played a role in peppered chub losses. Collins et al. (1995) postulates that, while dewatering is the main cause of peppered chub declines; oil, feedlot, and pesticide pollution have probably contributed to its

decline. While often considered a sign of stream health, Bonner and Wilde (2002) proposed that reduced turbidity in streams has also played a role in displacing the Peppered chub. As suspended solid loads are reduced, fishes adapted to sight feeding are able to out compete fish like the peppered chub, which have adaptations for feeding in turbid streams.

Stream obstructions in the Arkansas, Canadian, and Cimarron River Systems in Oklahoma, Texas, and New Mexico isolated populations of peppered chubs. As stretches of streams dried up from drought and elevated human demands, local populations were lost. Unable to bypass dams and reservoirs, downstream populations could not re-colonize these stretches of streams (Luttrell, 1999). This scenario was multiplied many times over time throughout these drainages, and has resulted in only two disjunct populations in Texas and New Mexico which are hemmed in by Meredith and Ute Reservoirs, respectively (Figure 2).

V. PROTECTIVE LAWS

A. FEDERAL

A number of federal laws may apply to the protection of peppered chubs and their habitat. Most notably the U.S. Army Corps of Engineers administers a permit program under Section 404 of the Clean Water Act. This governs fill placed into streams and stream realignment projects. Section 401 of the Clean Water Act provides for state review of water quality impacts from such activities and, while authorized by federal law, is administered by the Kansas Department of Health and Environment. The National Pollution Discharge Elimination System (NPDES) permits awarded under section 402 of the same act are also permitted by KDHE. The U.S. Fish and Wildlife Coordination Act provides for the review and comment of both state and federal agencies concerning fish and wildlife impacts for any federal or nonfederal project which is approved by a federal

agency that serves to impound, deepen the channel of, or otherwise control, pollute, or modify waters of the U.S. for any purpose whatsoever. Other federal laws may be relevant in specific instances. For a review of applicable major federal laws affecting Kansas Fish and Wildlife, see Layher (1985).

B. STATE

1. Permitting requirements

Several state statutes, regulations and procedures may be invoked related to habitat alteration associated with Peppered chubs. Some of these require permits to be acquired.

Foremost, K.A.R. 115-15-1 and 115-15-2 lists species declared to be threatened or endangered. K.A.R. 115-15-3 provides for a permit system including review of habitat alterations. The permit program and review system is administered by the Kansas Department of Wildlife and Parks. This allows the critical review of projects potentially affecting Peppered chub habitats and the project described in applications may be accepted, modified or revoked.

A host of other actions may trigger various permit requirements of other agencies, especially actions allowing for discharge, dam construction, stream alteration or flood plain development. Most significant of agencies involved is the Division of Water Resources of the State Board of Agriculture. Permit applications through this office are sent out to be reviewed by KDWP as a result of the Water Projects Coordination Act, which was designed to simplify the state overall permitting systems and allow fish and wildlife interest review. Projects

identified as potentially impacting a threatened or endangered species would require appropriate permits as well from KDWP.

The KDWP has several MOUs with other agencies, notably the Kansas Department of Transportation, which aids in the identification of road and bridge projects in areas with threatened or endangered species. This MOU has been in force for years and was revised February 2000.

Many other permit systems may be activated through a variety of agencies. For a comprehensive review see Monda et al. (1992) and Layher (1985).

2. Critical habitat designation

The Kansas Department of Wildlife and Parks has designated the following areas as critical habitat for the Peppered chub in Kansas (refer to the appropriate county map for specific population locations):

a. The main stem Arkansas River from the U.S. 281 crossing in Section 33, Township 19 South, Range 13 West, Barton County, to the Kansas-Oklahoma border in Section 18, Township 35 South, Range 5 East, Cowley County.

b. The main stem Medicine Lodge River from the point it enters Barber County at Section 18, Township 30 South, Range 15 West, to the Kansas-Oklahoma border in Section 13, Township 35 South, Range10 West.

c. The main stem North Fork Ninnescah River from Cheney Reservoir Dam in Section 6, Township 27 South, Range 3 West, Sedgwick County to its

confluence with the South Fork Ninnescah in Section 36, Township 28 South, Range 4 West, Sedgwick County.

d. The main stem South Fork Ninnescah River from the Pratt County Lake in Section 7, Township 28 South, Range 12 West to its confluence with the North Fork Ninnescah in Section 36, Township 28 South, Range 4 West, Sedgwick County.

e. The main stem Ninnescah River from its origin in Section 36, Township 28 South, Range 4 West, Sedgwick County to its confluence with the Arkansas River in Section 25, Township 31 South, Range 2 East, Sumner County.

VI. RECOVERY

A. OBJECTIVES

Monitoring, evaluation, recovery, and reestablishment of the Peppered chub should be addressed on a watershed basis. Downlisting should be addressed on a statewide basis. Historically the chub only occurred in four watersheds in Kansas: the Arkansas, Ninnescah, Medicine Lodge, and Cimarron Rivers. It now only occurs in the Arkansas River and Ninnescah River watersheds.

B. RECOVERY CRITERIA

Peppered chubs should be downlisted from endangered to threatened if items VII.:B.1.1., B.1.2., B.1.3., B.1.4., B.1.5., B.1.6., B.1.7., and B.1.8. are accomplished in the Arkansas and Ninnescah River Watersheds and maintained for a period of ten years. If items B.2.1., B.2.2., B.2.3., B.2.4., B.2.5., and B.2.6. are also accomplished the species should be downlisted to SINC (Species In Need of Conservation) after stable populations are

maintained in these rivers for a period of ten years. If stable populations and sufficient habitat are maintained in all historic streams for an additional five years the species could then be removed from the SINC category. Therefore complete delisting could occur twenty-five years after implementation of items in section B.1. De-listing should occur no earlier than 2030.

VII. NARRATIVE OUTLINE

A. ADDITIONAL SPECIES INFORMATION NEEDS

Available data regarding Peppered chubs does not provide sufficient information to evaluate the current status of the Kansas population. This is mostly due to the rarity of the species in fish samples. Even at known sample sites the species rarely exceeds 10 individuals per sample. This may be due in part to ineffective sampling techniques. Items A.1, A.2, A.3, and A.4 should be investigated to better evaluate the current status of peppered chubs in Kansas.

A.1. Determine most suitable sampling method for capture of Peppered chubs.

A.2. Determine population sizes within known streams of occurrence.

A.3. Define habitat variables in relation to density of peppered chubs.

A.4. Identify suitable habitat sites on stream sections and tributary streams between known locations of occurrence.

B. MANAGEMENT ACTIVITIES FOR MAINTAINING SPECIES POPULATIONS AND FOR SPECIES RECOVERY

The current Kansas population of peppered chubs is confined in two river systems in the state, the Ninnescah and Arkansas rivers in four counties (Figures 3-6). This makes the population highly susceptible to loss through dewatering and contamination.

Therefore, recovery strategies should focus on re-establishment of the species in historic locations, maintenance of sufficient water flows and quality in streams of occurrence, and removal or modification of unnatural instream barriers.

Recovery Recommendations for Existing Stocks

B.1.1. Determine the most effective, yet least harmful method for sampling peppered chubs.

B.1.2. Establish regular sampling sites along the South Fork Ninnescah, Ninnescah, and Arkansas Rivers in Pratt, Kingman, Sumner, and Sedgwick counties.

B.1.3. Evaluate suitable standing stocks of peppered chubs in the South Fork Ninnescah, Ninnescah, and Arkansas Rivers in Pratt, Kingman, Sumner, and Sedgwick counties for reintroduction to historic locations.

B.1.4. Remove or modify existing, unnatural barriers to fish movement in the Arkansas and Ninnescah River watersheds.

B.1.5. Enforce existing minimum instream flow laws in the Arkansas and Ninnescah River watersheds to preserve sufficient flow levels in identified habitats.

B.1.6. Establish Total Maximum Daily Loads (TMDLs) reflective of peppered chub's requirements in South Fork Ninnescah, Ninnescah, and Arkansas rivers.

B.1.7. Identify suitable habitats along the South Fork Ninnescah, Ninnescah, and Arkansas rivers for reestablishment where the species does not occur.

B.1.8. Re-establish peppered chubs in historic ranges of South Fork Ninnescah, Ninnescah, and Arkansas rivers from identified stocks.

Recovery Recommendations for Reestablishment

B.2.1. Remove or modify existing, unnatural barriers to fish movement in the Medicine Lodge, Chikaskia, North Fork Ninnescah, Cimarron, Salt Fork of the Arkansas River, and the Upper Arkansas River watersheds.

B.2.2. Enforce existing minimum instream flow laws in historic watersheds to preserve sufficient flow levels in identified habitats.

B.2.3. Establish Total Maximum Daily Loads (TMDLs) reflective of peppered chub requirements in historic watersheds.

B.2.4. Identify suitable habitats in historic streams.

B.2.5. Re-establish peppered chubs in identified habitats.

B.2.6. Establish regular sampling sites in historic streams for monitoring.

VIII. COSTS OF RECOVERY PLAN IMPLEMENTATION

Existing Stocks

Item B.1.1. Sampling method determination.

Item B.1.2. Sampling site establishment.

Item B.1.3. Standing stock evaluation.

Item B.1.4. Removal/modification of barriers.

Item B.1.5. Minimum instream flow enforcement.

Item B.1.6. Establishment of Total Maximum Daily Loads (TMDLs)

Item B.1.7. Habitat identification

Item B.1.8. Reestablishment.

Reestablishment

Item B.2.1. Removal/modification of barriers.

Item B.2.2. Minimum instream flow enforcement.

Item B.2.3. Establish Total Maximum Daily Loads (TMDLs)

Item B.2.4. Habitat identification.

Item B.2.5. Re-establishment.

Item B.2.6. Sampling sites establishment.

Table 1: Percent of sites where peppered chubs and various species were captured together (species association).

Common Name	Number of Sites	% Association
Arkansas darter	7	43.75%
Bigmouth buffalo	3	18.75%
Black buffalo	8	50.00%
Black crappie	4	25.00%
Bluegill	14	87.50%
Bluntnose minnow	8	50.00%
Brook silverside	1	6.25%
Bullhead minnow	14	87.50%
Central stoneroller	10	62.50%
Channel catfish	16	100.00%
Common carp	15	93.75%
Emerald shiner	14	87.50%
Fathead minnow	13	81.25%
Flathead catfish	11	68.75%
Freshwater drum	11	68.75%
Gizzard shad	14	87.50%
Golden shiner	1	6.25%
Goldfish	1	6.25%
Grass carp	2	12.50%
Green sunfish	16	100.00%
Inland silverside	2	12.50%
Largemouth bass	13	81.25%
Logperch	1	6.25%
Longear sunfish	3	18.75%
Longnose gar	13	81.25%
Orangespotted sunfish	6	37.50%
Orangethroat darter	3	18.75%
Peppered chub	16	100.00%
Plains killifish	15	93.75%
Plains minnow	5	31.25%
Quillback	8	50.00%
Red shiner	16	100.00%
River carpsucker	15	93.75%
Sand shiner	16	100.00%
Saugeye	1	6.25%
Shorthead redhorse	2	12.50%
Shortnose gar	3	18.75%
Silver chub	7	43.75%
Slenderhead darter	7	43.75%
Smallmouth buffalo	13	81.25%
Sucker (unidentified)	1	6.25%
Suckermouth minnow	10	62.50%
Walleye	2	12.50%
Warmouth	3	18.75%
Western mosquitofish	13	81.25%
White bass	6	37.50%
White crappie	8	50.00%
White perch	6	37.50%
Yellow bullhead	5	31.25%
TOTAL	**402**	

Table 2. Peppered chub densities for sites of occurrence.

Site #	Stream	Number of Peppered chubs present & collection year
AFCJB53070*023*KS	MEDICINE LODGE RIVER	1936: 1
AFCJB53070*022*KS	MEDICINE LODGE RIVER	1938: 1
AFCJB53070*020*KS		1950: 1
AFCJB53070*019*KS		1950: 9
AFCJB53070*014*KS	MEDICINE RIVER-ELM CREEK CONFLUENCE	1951: 4
AFCJB53070*021*KS		1951
AFCJB53070*003*KS	ARKANSAS RIVER	1952: 1
AFCJB53070*012*KS	ARKANSAS RIVER	1952: 1
AFCJB53070*013*KS	ARKANSAS RIVER	1952: 1
AFCJB53070*011*KS	ARKANSAS RIVER-SPRING CREEK	1956: 1
AFCJB53070*010*KS	MEDICINE RIVER	1957: 1
AFCJB53070*009*KS	MEDICINE RIVER	1958: 1
AFCJB53070*008*KS	ARKANSAS RIVER	1958: 1
AFCJB53070*001*KS	MULE CREEK CROSSING	1964: 5
AFCJB53070*002*KS	NINNESCAH RIVER-N FK	1963: 1, 1964: 1
AFCJB53070*005*KS	NINNESCAH RIVER-S FK	1964: 1
AFCJB53070*015*KS	ARKANSAS RIVER-OXFORD	1986: 1
AFCJB53070*017*KS		1992: 5
AFCJB53070*006*KS	ARKANSAS RIVER-OXFORD	1964: 27, 1984: 1, 1992: 5, 1993: 8
AFCJB53070*016*KS		1992: 14, 1993: 2
AFCJB53070*004*KS	ARKANSAS RIVER	1999: 64, 1952: 1
9484	Ninnescah River	1994: 2
9624	South Fork Ninnescah River	1995: 3
023-STWD-96	South Fork Ninnescah River	1996: 1
032-GEMO-99	South Fork Ninnescah River	1999: 1
039-LARB-99	South Fork Ninnescah River	1999: 1
079-LARB-00	Ninnescah River	2000: 3
082-LARB-00	South Fork Ninnescah River	2000: 17
088-LARB-00	Arkansas River	2000: 16
089-LARB-00	Arkansas River	2000: 114
101-LARB-01	South Fork Ninnescah River	2001: 8
121-LARB-01	South Fork Ninnescah River	2001: 9
2124	South Fork Ninnescah River	2001: 2
130-LARB-01	Ninnescah River	2001: 1
135-LARB-01	Arkansas River	2001: 1
051-PBLA-02	South Fork Ninnescah River	2002: 1
059-PBLA-03	Ninnescah River	2003: 1

Table 3: Mean density of peppered chubs in Kansas streams in relation to increments of physical and chemical variables. See also figures 14-27.

Habitat Variable & Range (≤ X <)	N	Mean Density (#/ha)	Habitat Variable & Range (≤ X <)	N	Mean Density (#/ha)
Water Temperature (°C)			Turbidity (FTUs)		
18-19	1	0.39	0-20	4	2.25
19-20	1	6.65	20-40	10	7.26
20-21	2	29.09	40-60	0	0.00
21-22	0	0.00	60-80	0	0.00
22-23	1	1.34	80-100	0	0.00
23-24	1	0.42	100-120	0	0.00
24-25	4	0.85	120-140	0	0.00
25-26	4	3.97	140-160	0	0.00
26-27	1	5.22	160-180	0	0.00
			180-200	0	0.00
Conductance (Siemens)			200-220	1	9.91
800-900	1	2.77			
900-1000	0	0.00	Dissolved Oxygen (mg/L)		
1000-1100	1	0.50	4.75-5.25	1	0.42
1100-1200	2	0.71	5.25-5.75	2	6.34
1200-1300	3	5.38	5.75-6.26	3	2.61
1300-1400	3	1.07	6.25-6.75	3	19.72
1400-1500	1	48.27	6.75-7.25	3	0.93
1500-1600	3	5.97	7.25-7.75	0	0.00
			7.75-8.25	0	0.00
TDS Groups (mg/L)			8.25-8.75	0	0.00
410-450	1	2.77	8.75-9.25	2	3.99
450-490	0	0.00	9.25-9.75	0	0.00
490-530	1	0.50	9.75-10.25	0	0.00
530-570	0	0.00	10.25-10.75	0	0.00
570-610	3	3.98	10.75-11.25	0	0.00
610-650	3	2.05	11.25-11.75	1	0.59
650-690	2	1.35			
690-730	0	0.00	Alkalinity (mg/L as $CaC0_3$)		
730-770	4	16.54	80-100	1	0.50
			100-120	0	0.00
pH			120-140	2	2.02
6.875-7.125	0	0.00	140-160	4	2.03
7.125-7.375	1	0.39	160-180	1	1.04
7.375-7.625	0	0.00	180-200	3	7.25
7.625-7.875	0	0.00	200-220	1	5.22
7.875-8.125	6	3.58	220-240	0	0.00
8.125-8.375	3	18.25	240-260	1	48.27
8.375-8.625	2	6.64			
8.625-8.875	0	0.00	1220-1240	1	0.42
8.875-9.125	2	0.54			

Table 3 Continued.

Chloride (mg/L)		
17.5-52.5	2	0.96
52.5-87.8	0	0.00
87.8-122.5	0	0.00
122.5-157.5	0	0.00
157.5-192.5	1	2.77
192.5-227.5	0	0.00
227.5-262.5	5	1.51
262.5-297.5	3	19.76
297.5-332.5	2	5.59
332.5-367.5	0	0.00
367.5-402.5	1	6.65
Nitrate (mg/L)		
0-1	6	1.66
1-2	2	5.93
2-3	3	16.86
3-4	1	6.65
4-5	0	0.00
5-6	0	0.00
6-7	0	0.00
7-8	1	0.42
8-9	0	0.00
9-10	0	0.00
10-11	0	0.00
11-12	1	9.91
Velocity (m/s)		
0.175-0.225	1	0.50
0.225-0.275	0	0.00
0.275-0.325	1	1.00
0.325-0.375	2	5.89
0.375-0.425	0	0.00
0.425-0.475	4	4.19
0.475-0.525	1	48.27
0.525-0.575	3	3.84
0.575-0.625	1	0.50
0.625-0.675	1	0.42
0.675-0.725	1	0.39
0.725-0.775	1	1.34
Wetted Width (m)		
20-26	1	1.34
26-32	0	0.00
32-38	2	1.90
38-44	1	6.65
44-50	1	2.11
50-56	3	7.23

Ammonia (mg/L)		
0.00-0.05	8	8.88
0.05-0.10	3	2.33
0.10-0.15	0	0.00
0.15-0.20	1	0.39
0.20-0.25	1	1.04
0.25-0.30	0	0.00
0.30-0.35	0	0.00
0.35-0.40	0	0.00
0.40-0.45	0	0.00
0.45-0.50	0	0.00
0.50-0.55	0	0.00
0.55-0.60	1	9.91
Phosphorus (mg/L)		
0.00-0.15	9	3.23
0.15-0.30	1	0.59
0.30-0.45	1	48.27
0.45-0.60	1	0.42
0.60-0.75	1	10.51
0.75-0.90	0	0.00
0.90-1.05	0	0.00
1.05-1.20	0	0.00
1.20-1.35	0	0.00
1.35-1.50	0	0.00
1.50-1.65	0	0.00
1.65-1.80	0	0.00
1.80-1.95	1	0.50
Mean Depth (m)		
0.04-0.06	1	1.00
0.06-0.08	1	0.50
0.08-0.10	4	1.89
0.10-0.12	4	2.78
0.12-0.14	0	0.00
0.14-0.16	2	5.47
0.16-0.18	0	0.00
0.18-0.20	0	0.00
0.20-0.22	1	9.91
0.22-0.24	0	0.00
0.24-0.26	2	24.33
0.26-0.28	1	2.77
Wetted Width (m) continued		
56-62	2	2.90
62-68	3	0.67
68-74	0	0.00
74-80	2	24.35
80-86	1	0.39

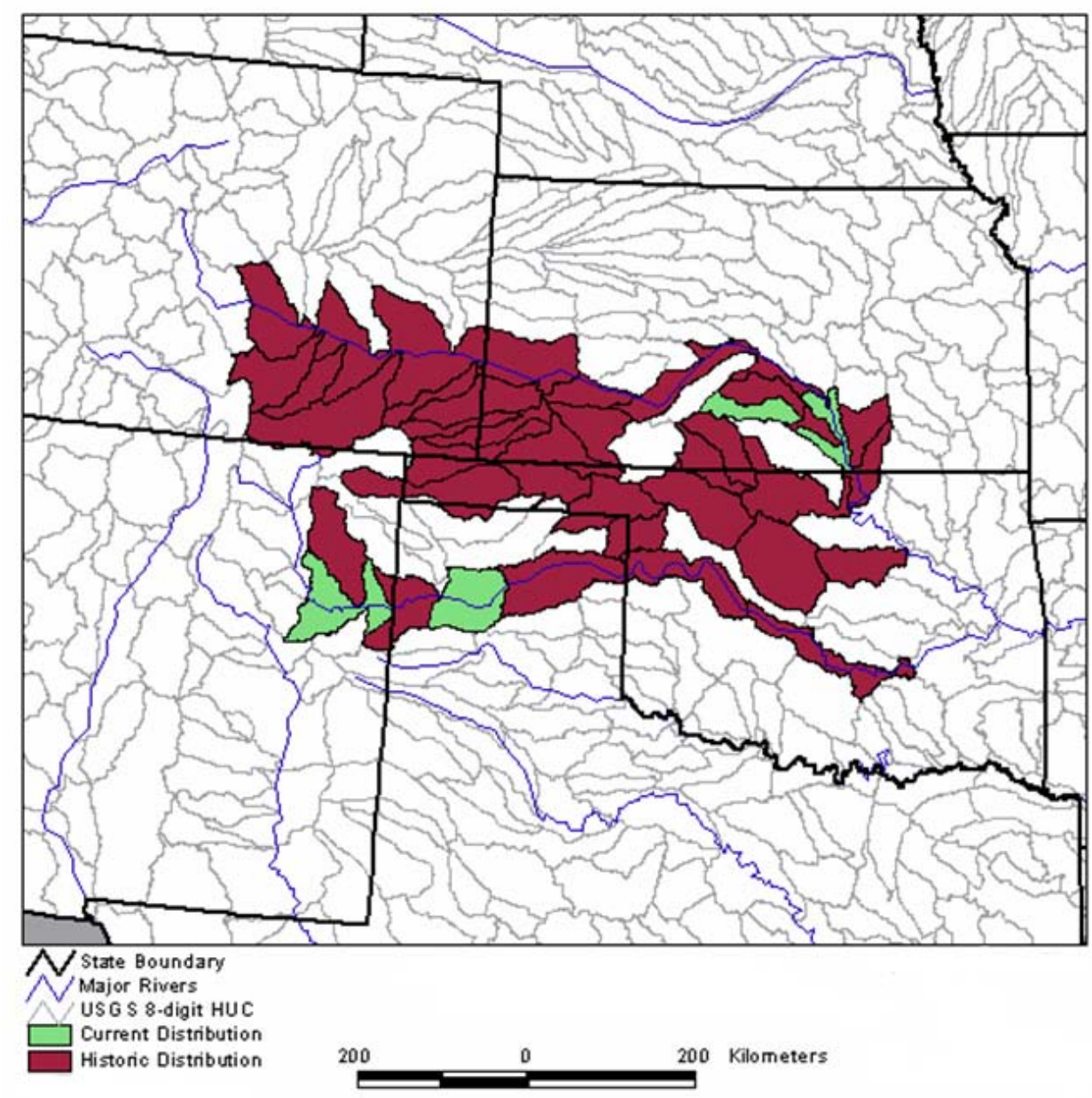

Figure 1: Peppered chub (*Macrhybopsis tetranema*) Distribution

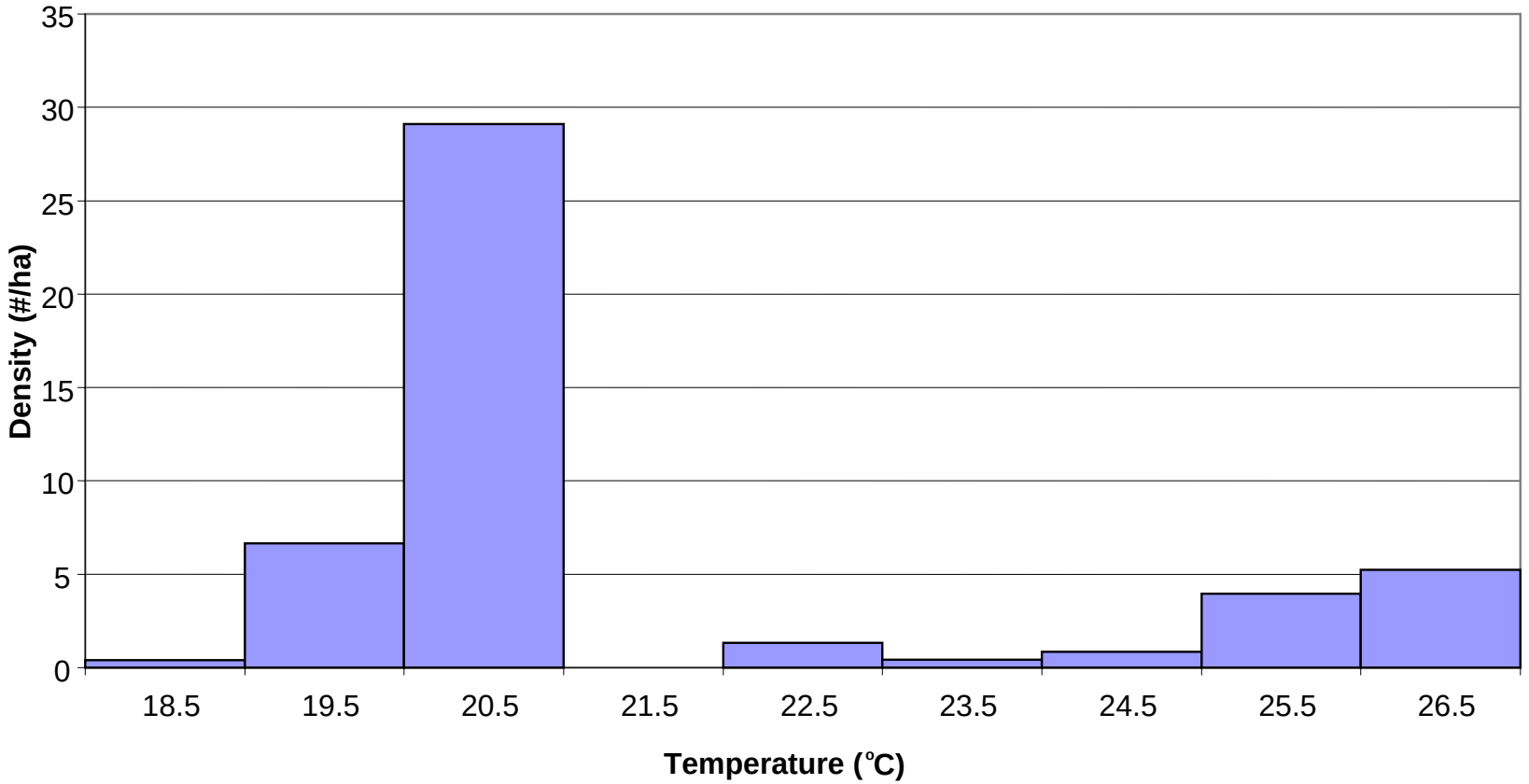

Figure 14: Relationship between peppered chub density and temperature.

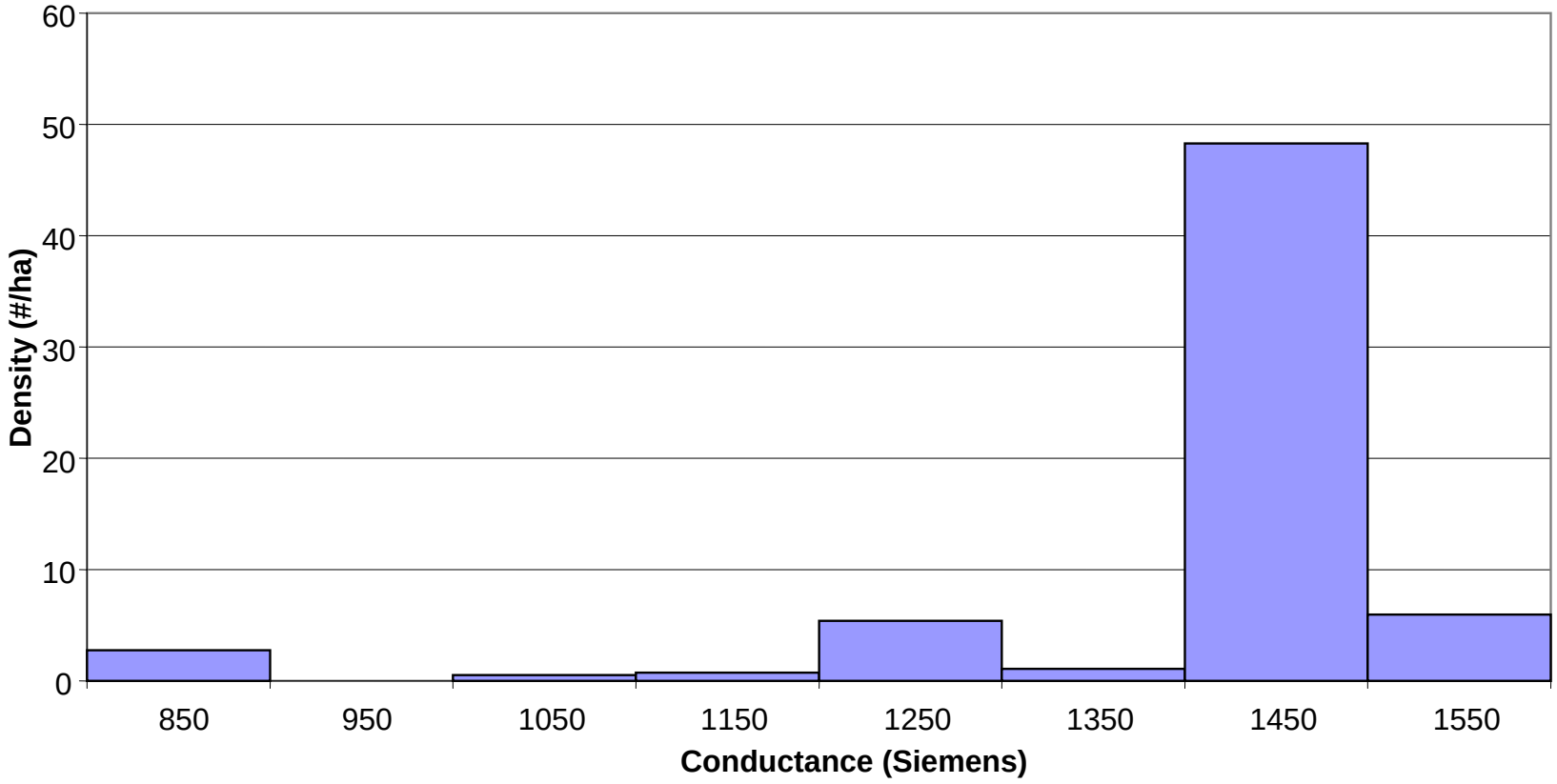

Figure 15: Relationship between peppered chub density and conductance.

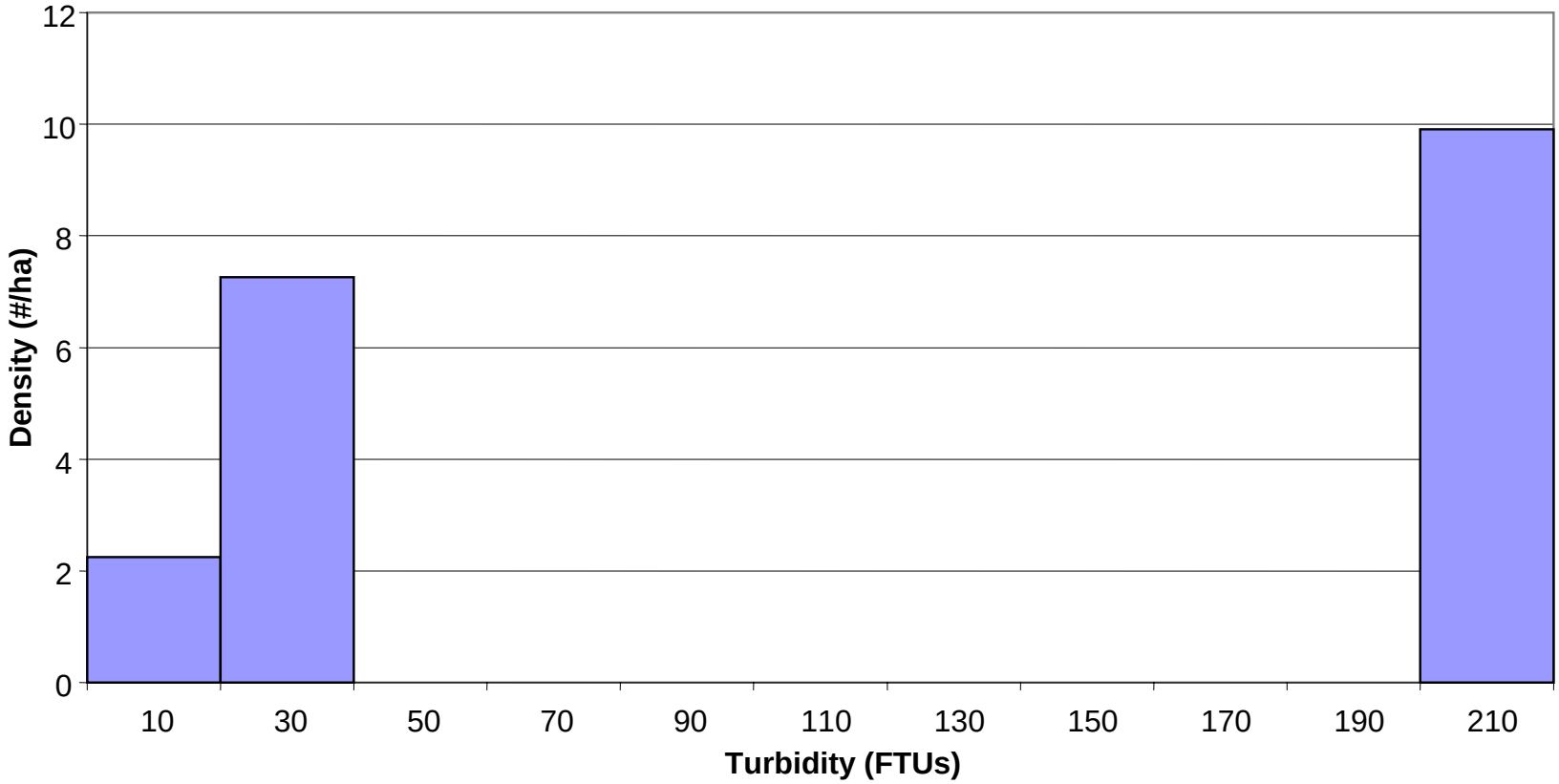

Figure 16: Relationship between peppered chub density and turbidity.

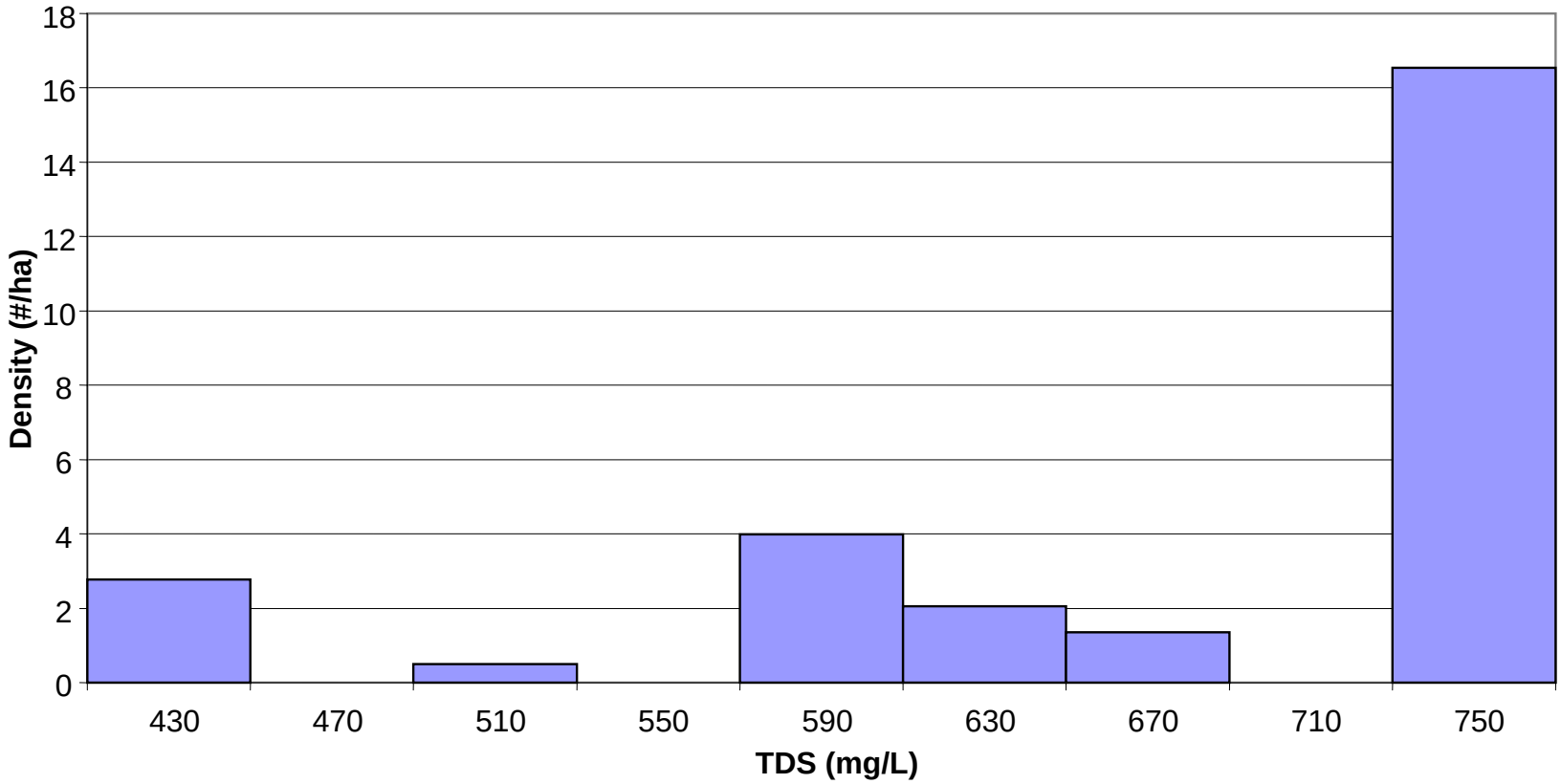

Figure 17: Relationship between peppered chub density and total dissolved solids.

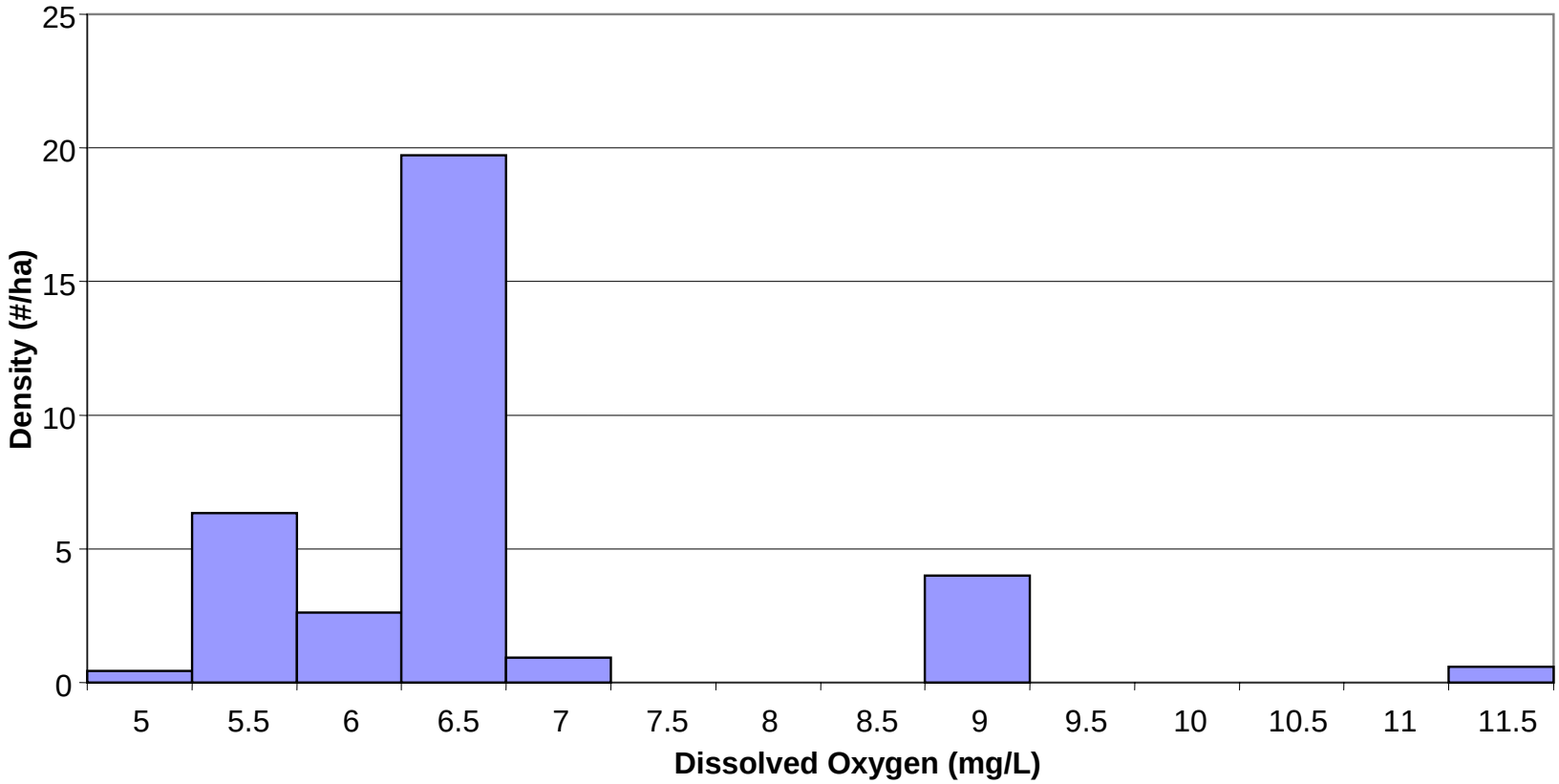

Figure 18: Relationship between peppered chub density and dissolved oxygen.

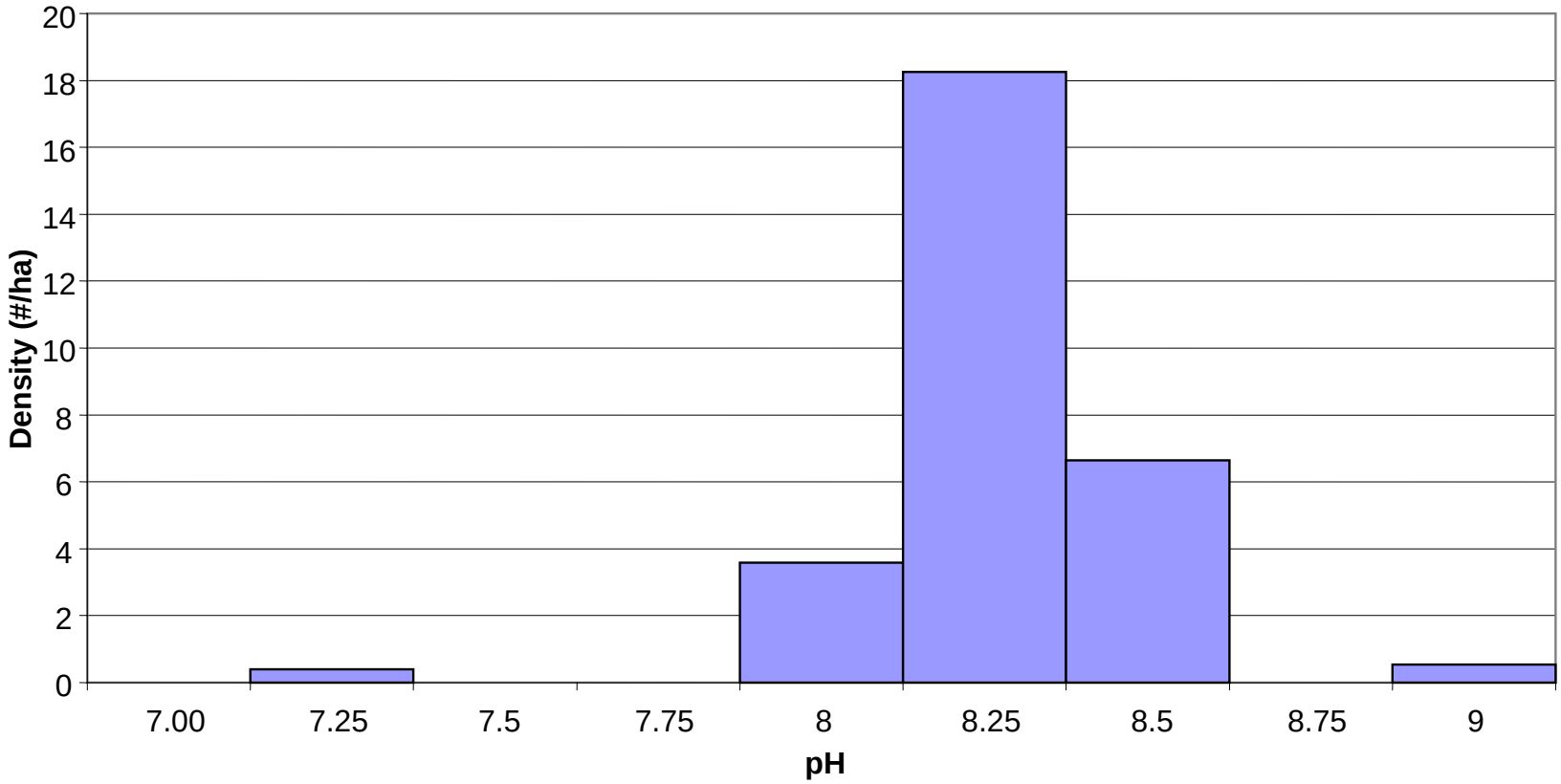

Figure 19: Relationship between peppered chub density and pH.

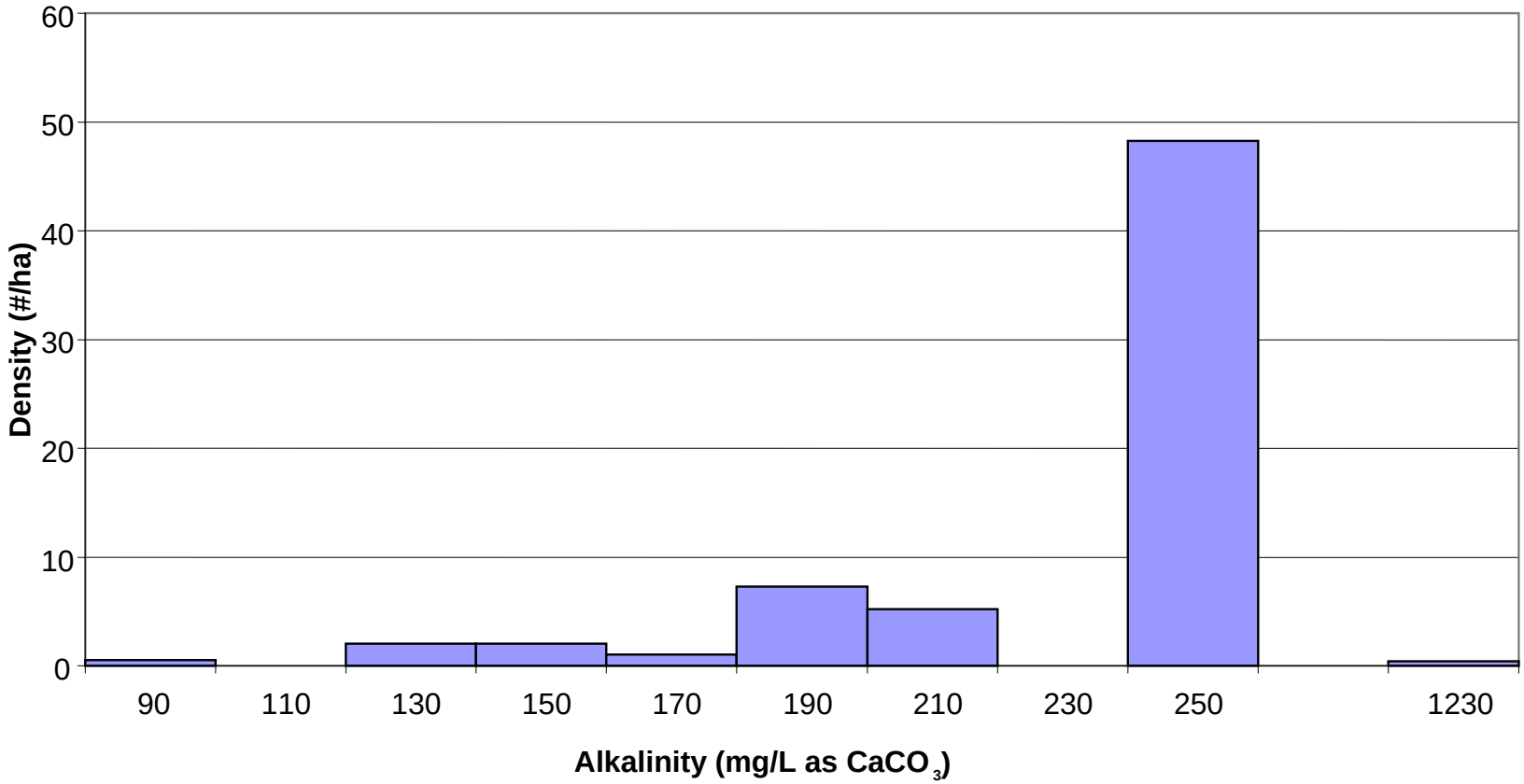

Figure 20: Relationship between peppered chub density and alkalinity.

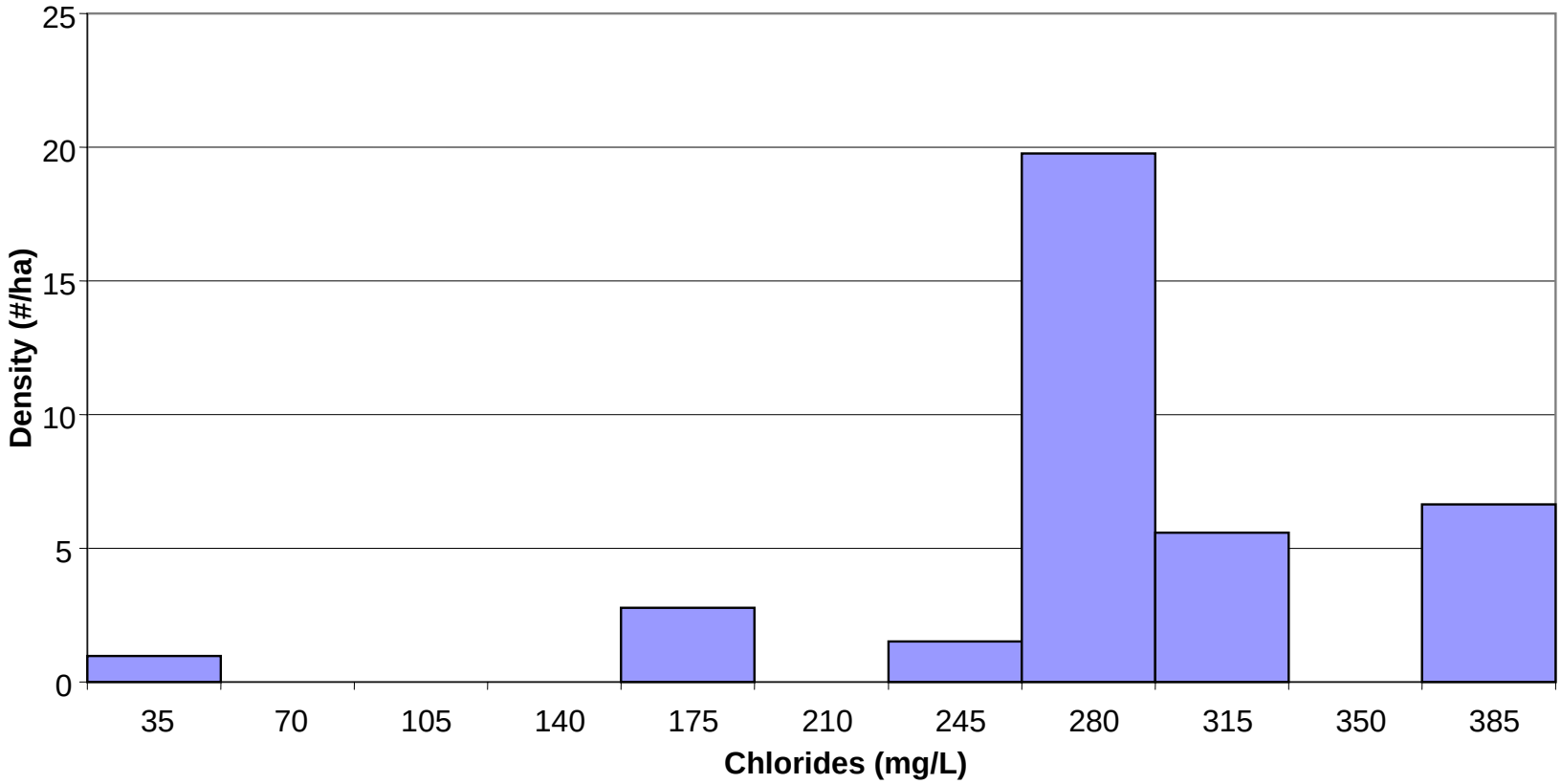

Figure 21: Relationship between peppered chub density and chlorides.

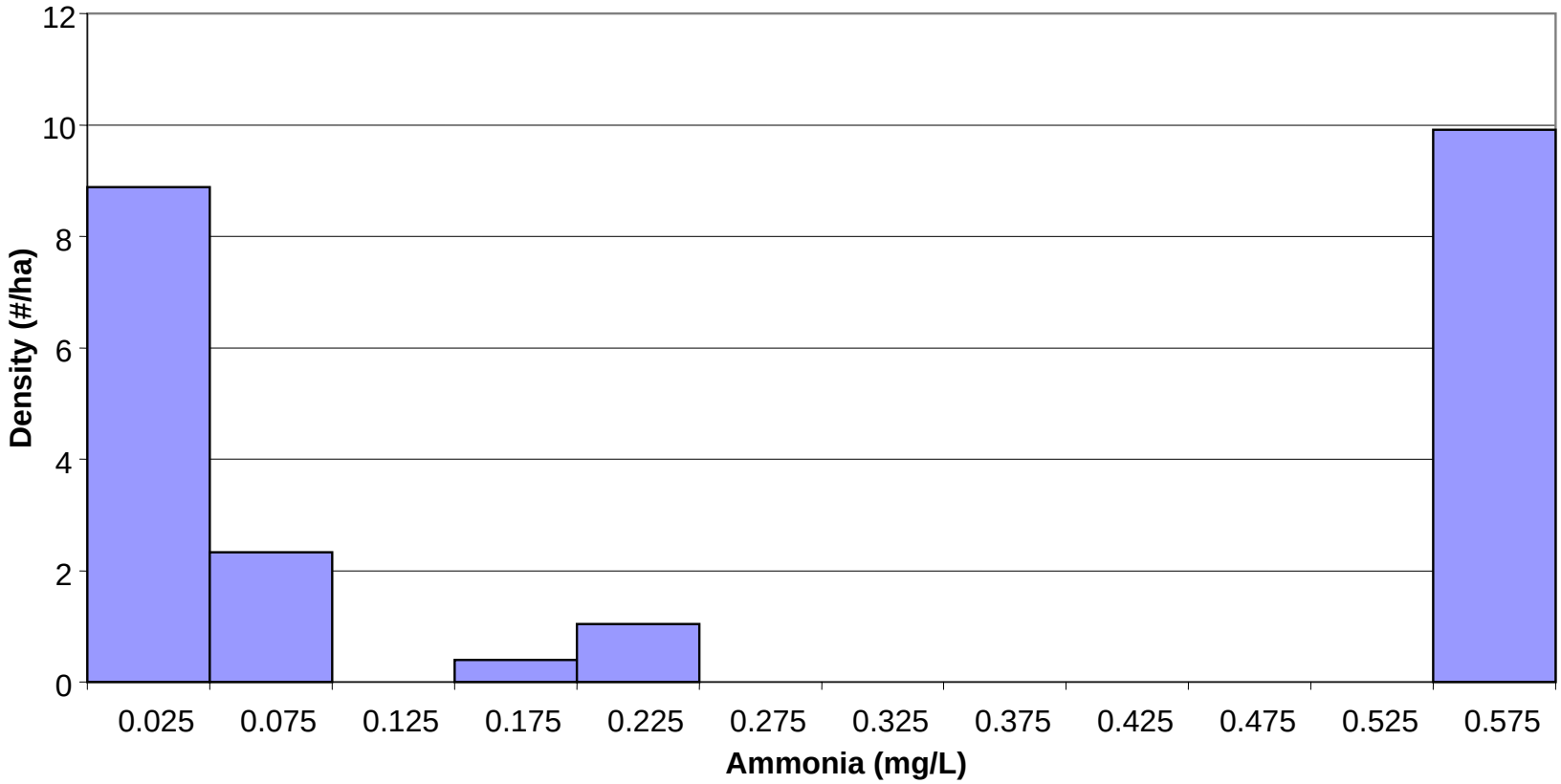

Figure 22: Relationship between peppered chub density and ammonia.

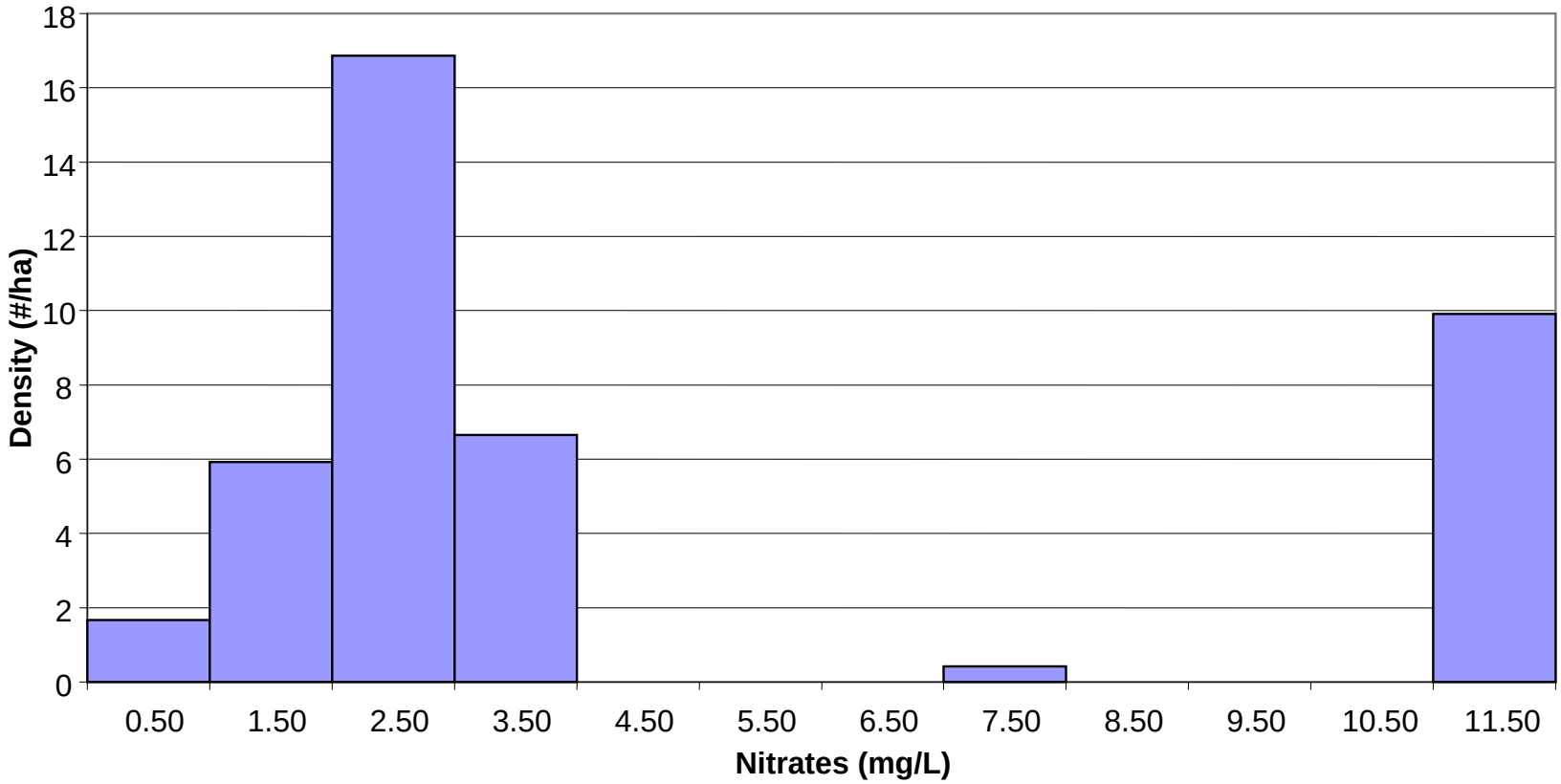

Figure 23: Relationship between peppered chub density and nitrates.

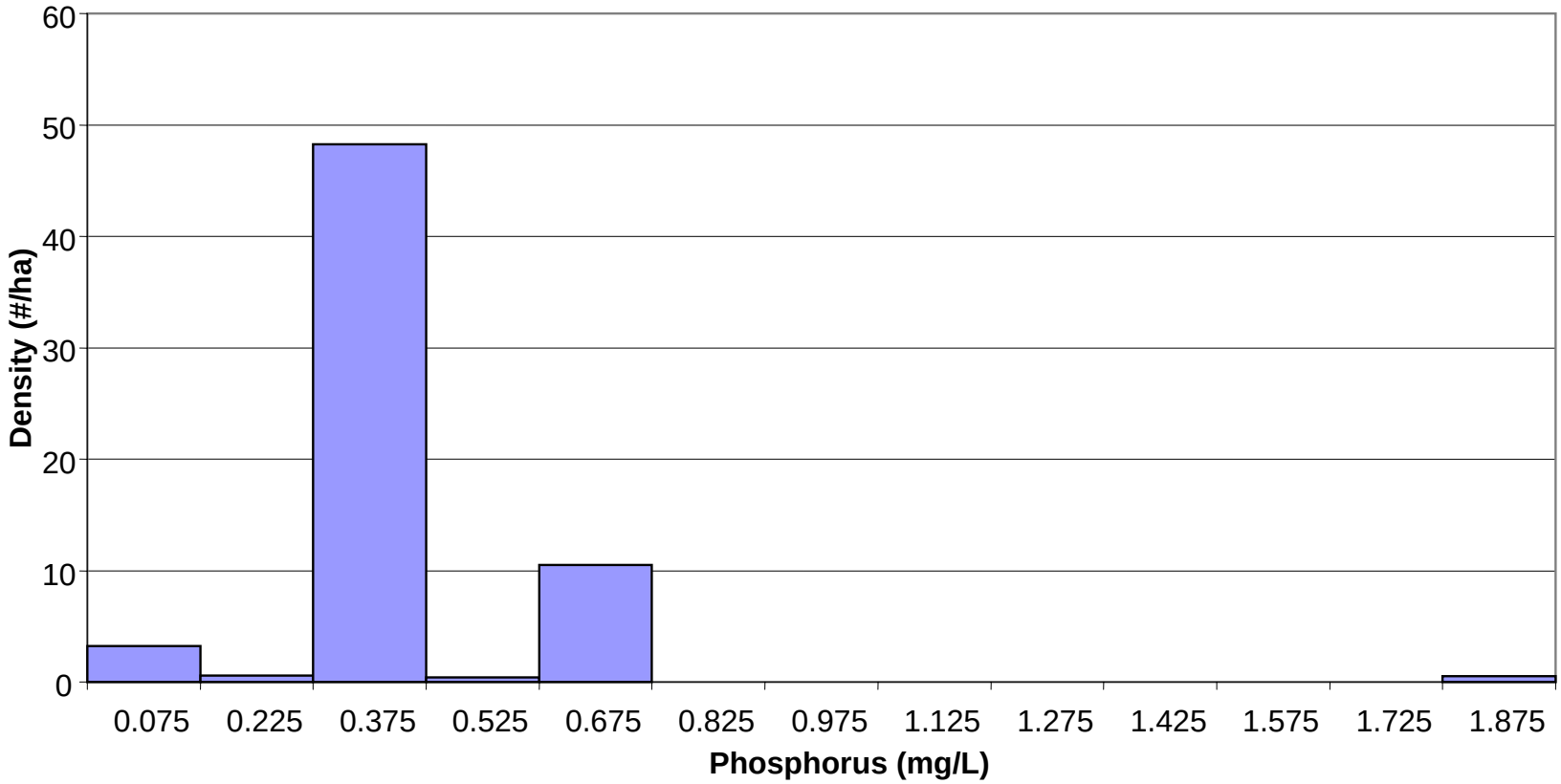

Figure 24: Relationship between peppered chub density and phosphorus.

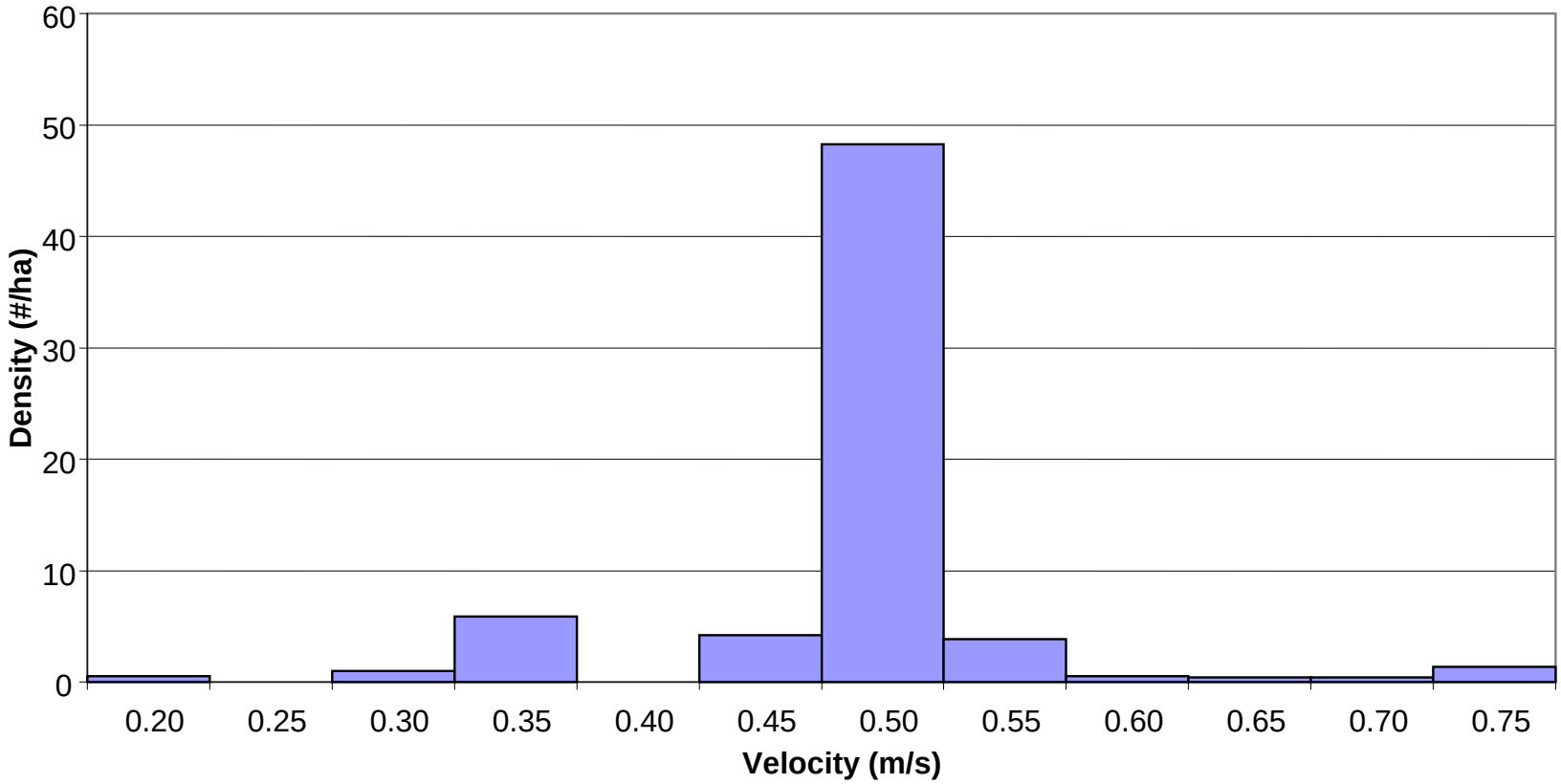

Figure 25: Relationship between peppered chub density and velocity.

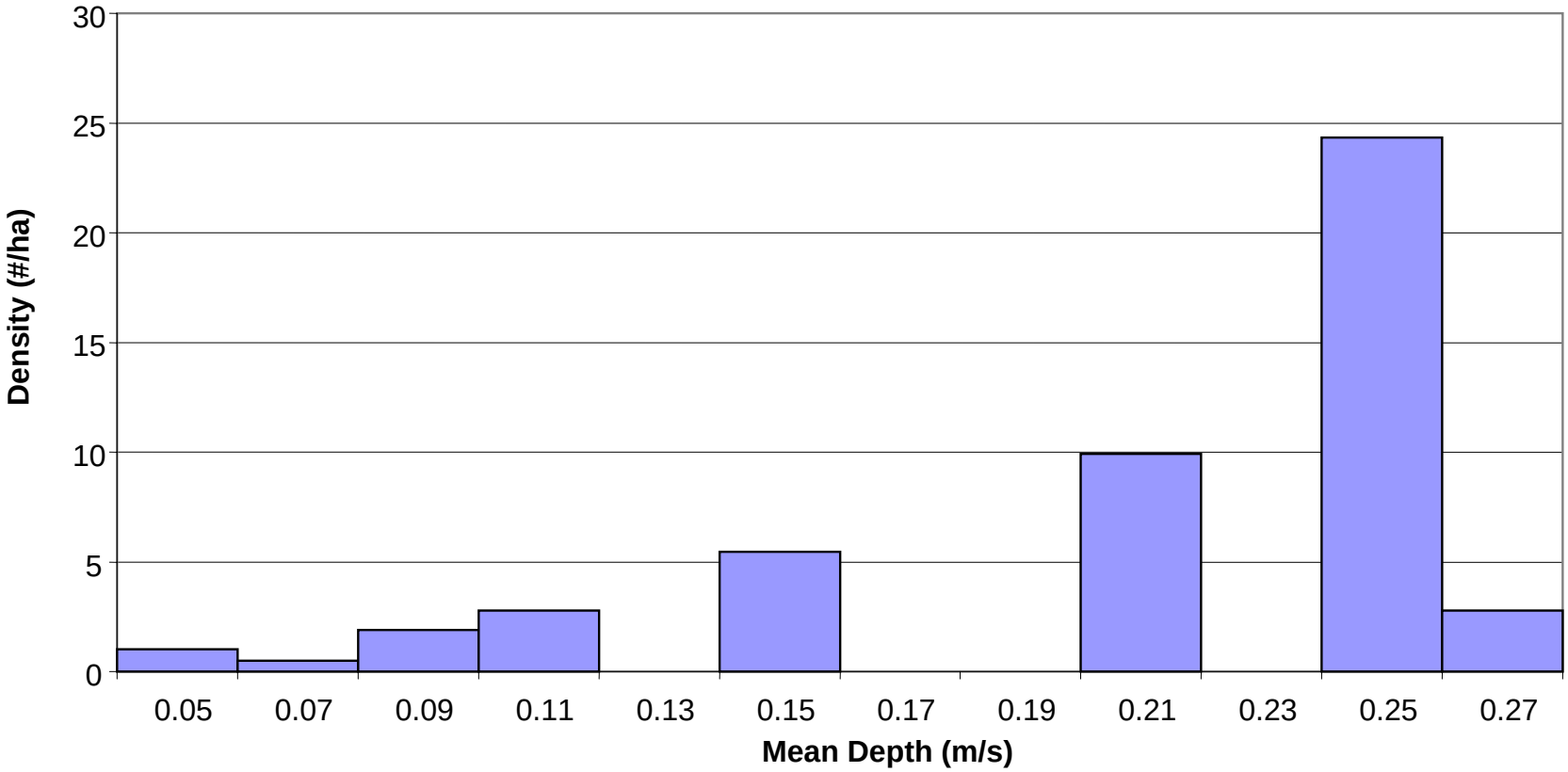

Figure 26: Relationship between peppered chub density and mean depth.

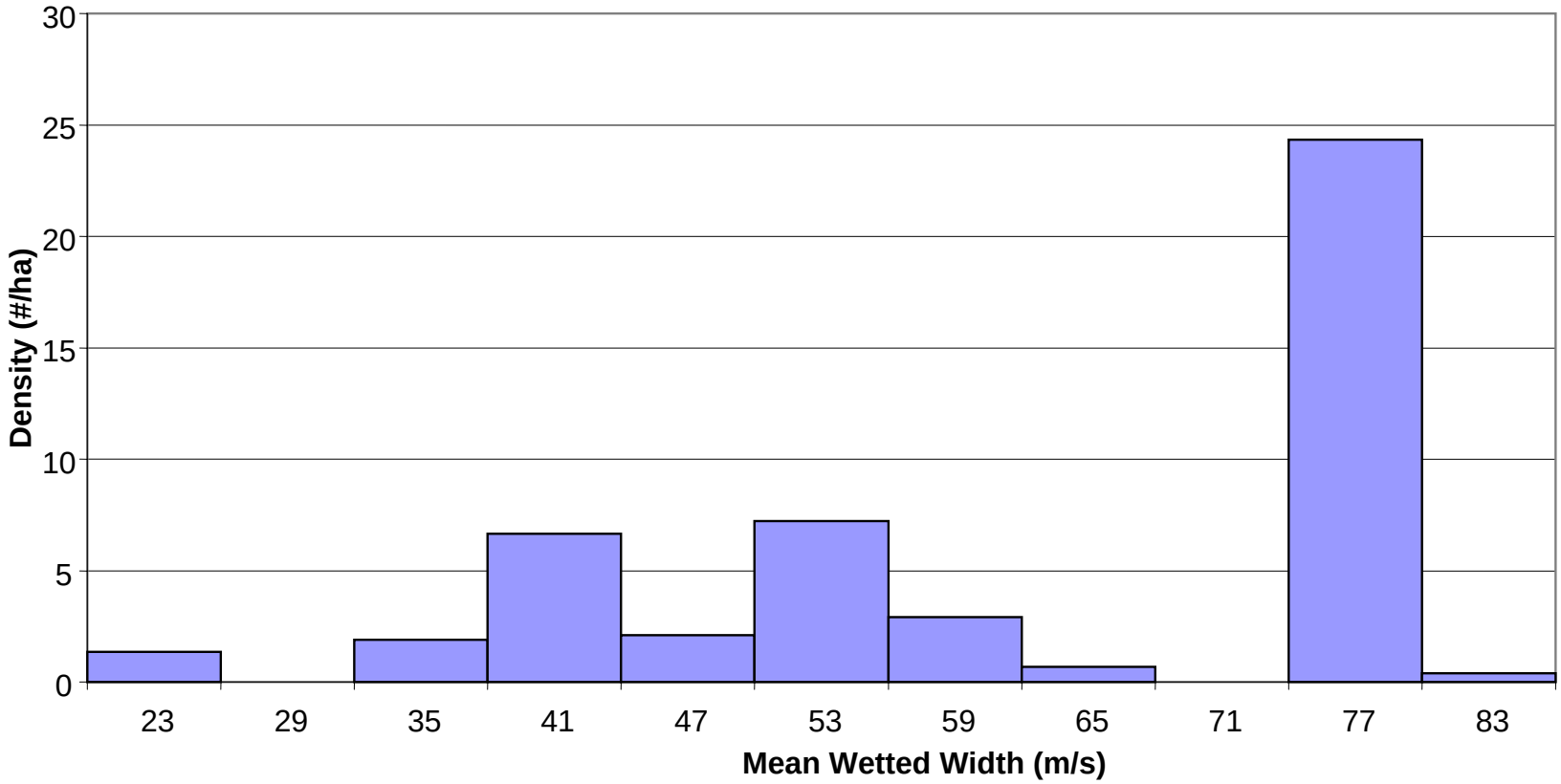

Figure 27: Relationship between peppered chub density and mean wetted width.

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