

HABITAT SELECTION BY SPAWNING WALLEYE AND WHITE BASS IN
IRRIGATION RESERVOIRS OF THE REPUBLICAN RIVER BASIN, NEBRASKA

by

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HABITAT SELECTION BY SPAWNING WALLEYE AND WHITE BASS IN IRRIGATION RESERVOIRS OF THE REPUBLICAN RIVER BASIN, NEBRASKA

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Recruitment of walleye *Sander vitreus* and white bass *Morone chrysops* is limited in irrigation reservoirs of the Republican River Basin in southwestern Nebraska. The causal mechanism for this limited recruitment is unknown, but may be related to a lack of suitable spawning habitat. Habitat selection by spawning walleye and white bass was studied at Enders and Red Willow reservoirs using shoreline electrofishing and acoustic telemetry. Patch occupancy models describing habitat selection for each species were developed using electrofishing data. Adult walleye selected sites with cooler water temperatures and greater fetch at Enders Reservoir, and large rock substrate and no cover at Red Willow reservoir. These sites were limited to areas on or near the riprap dams. Acoustic telemetry confirmed these areas as the primary spawning locations for walleye in both reservoirs, with most walleye congregating near the southern end of each dam. Walleye egg abundance was also greatest in these areas; however, larval walleye abundance was not greatest in these areas. I failed to quantify habitat selection by adult white bass because bass were caught throughout each reservoir during the spawning period. Similarly, acoustic telemetry revealed no primary spawning areas, though small (<50 ha) home ranges during spring were discovered for 12 of 27 white bass. Variation in size of white bass home range could not be attributed to fish size or condition.

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Chapter 1. Spawning Habitats of Walleye and White Bass in Irrigation Reservoirs

Introduction

Spawning and subsequent recruitment of young fishes is considered a limiting factor of population growth. Fish species have generally evolved to spawn on sites that meet a certain suite of physical and biological characteristics. In ecosystems with sufficient spawning habitat, fish like walleye *Sander vitreus* typically have moderate to strong year classes; however year-class strength of walleye is usually quite variable in systems with insufficient spawning habitat.

Fishes do not select spawning sites randomly within reservoirs, but rather select sites with habitat characteristics that increase probability of successful hatch and offspring survival by avoiding areas of low dissolved oxygen and reducing vulnerability of eggs and larvae to predation. Kokanee salmon *Oncorhynchus nerka* spawned in three unique areas in Flaming Gorge Reservoir, Utah-Wyoming (Gipson and Hubert 1993); these areas contained steep slopes with large areas of small shale rocks and were 12 to 30-m deep. Bluegill *Lepomis macrochirus* spawned in sites with firmer gravel substrate, lower vegetation density, and greater dissolved oxygen concentrations than random sites within Lake Cochrane, South Dakota (Gosch et al. 2006). Lake whitefish *Coregonus clupeaformis* spawned in sites with 10-20 % slopes and 2.7-3.5 m mean depths (Anras et al. 1999).

Alteration, anthropogenic or natural, of existing habitat may produce more desirable conditions for spawning and subsequent recruitment of fishes. Improvement of existing spawning habitats may be achieved through water-level manipulation in reservoirs (Groen and Schroeder 1978; Becker 1983; Kallemeyn 1987). Increases in

spring reservoir water level, through management actions or natural precipitation, are positively correlated with year-class strength of many fishes, such as walleye, white bass *Morone chrysops* and white crappie *Pomoxis annularis* (Chevalier 1977; Groen and Schroeder 1978; Beam 1983; Kallemeyn 1987; Cohen and Radomski 1993; Pope et al. 1997; Quist et al. 2003). These increases in water level may improve year-class strength of fishes by increasing available spawning habitat (i.e., increasing length of shoreline) or nursery habitat (e.g., flooding terrestrial vegetation).

Spawning-habitat management in irrigation reservoirs, like those of the Republican River basin of southwestern Nebraska, is difficult because intra- and inter-annual fluctuations in water level are great. These fluctuations decrease availability of habitat for fishes that spawn in the littoral zone by reducing the amount of flooded terrestrial vegetation available (Neal et al. 2001). Thus, research is needed to understand the dynamics of varying spawning-habitat availability with water levels and sport-fish production.

The reservoirs of the Republican River basin in southwest Nebraska (Figure 1-1) have two different sources of inflow: groundwater or runoff from precipitation. These reservoirs were originally all dependent on groundwater inflows or runoff to fill them annually post-irrigation. However, increases in the number of irrigation wells depleted groundwater levels in the basin (Burt et al. 2002, Wen and Chen 2006) such that most of these reservoirs no longer completely fill. Enders, Red Willow, and Swanson reservoirs are all currently experiencing a low-water period; over the last decade, water levels in these reservoirs have been insufficient to allow consistent irrigation. Conversely, Medicine Creek Reservoir fills every year due to spring-fed groundwater inflows,

supporting irrigation during the summer months. This difference in filling and subsequent irrigation created a gradient of intra-annual water-level fluctuation among reservoirs during 2002-2007, with Medicine Creek experiencing the greatest amount of fluctuation and Swanson Reservoir experiencing the least amount (Figure 1-2). These fluctuations lead to changes in habitat available to fishes. Along this gradient, one would expect that reservoirs with minor fluctuations would have more established vegetation, larger mean substrate size, and lower turbidity values than reservoirs with greater fluctuations.

I investigated the relative importance of spawning habitat for both walleye and white bass in irrigation reservoirs of the Republican River basin. I examined habitat selection by both adult and larval walleye and white bass using patch occupancy modeling and acoustic telemetry to understand which habitats are critical for spawning. By understanding the spawning habitat selection by these two important gamefish and how they vary along this gradient of intra-annual water-level fluctuation, managers can more effectively address the issue of limited recruitment.

Study Fishes

Walleye

The walleye is the largest member of the Percidae family in North America and usually inhabits lakes, reservoirs, and large rivers (Scott 1967; Williams 1995). The native range of the walleye includes much of the eastern half of the USA and Canada (Scott and Crossman 1973). However, the present distribution of walleye has been expanded into western USA and Canada via human introductions to enhance sport fisheries in reservoirs (Scott and Crossman 1973; Colby et al. 1979). In Nebraska,

walleye are distributed throughout the Missouri, Platte, and Republican River basins (Morris et al. 1972).

Walleye spawn in many different habitats: tributaries entering lakes (Pflieger 1997); flooded marshes (Priegel 1970); upper riverine portions of reservoirs (Quist et al. 2004); small patches of gravel located within larger sandy shores (Johnson 1961); gravelly, sandy, or stony shallow shoals within lakes (Scott 1967); and rocky wave-washed shoreline in lakes with no inlet streams (Becker 1983). At Harlan County Reservoir, Nebraska, and Canton Reservoir, Oklahoma, the primary spawning site of walleye is riprap on the face of the dam (Grinstead 1971; Morris et al. 1972). Within a single water body, walleye may differ in inherent spawning site selection (Jennings et al. 1996).

Walleye migration to spawning sites begins when water temperature is 4.4-5.6 °C (Rawson 1957) and mature male walleye will congregate at spawning sites up to one month prior to the arrival of mature female walleye (Pflieger 1997). Walleye spawn shortly after the breakup of ice, when water temperature is 5-15 °C; peak spawning occurs when water temperature is 7-12 °C (Rawson 1957; Scott 1967; Pitlo 1989). In Nebraska, walleye spawn during late March to early April when water temperature is 7-10 °C (Morris et al. 1972).

The physical act of spawning occurs at night with fish congregating at sunset (Ellis and Giles 1965). During spawning, eggs are broadcast over substrates in waters that are 0.3-0.75 m deep (Priegel 1970). During the first few hours after spawning, walleye eggs will adhere to one another and to the substrate (Becker 1983). Eggs are hardened by water after a few hours and lose their adhesive qualities.

The principal requirements of spawning habitat for walleye are the presence of flowing water and silt-free substrate (Becker 1983; Pflieger 1997). The combination of flowing water and silt-free substrate is required to maintain adequate dissolved oxygen in areas where immobile eggs are located. Greater numbers of viable walleye eggs and greater survival rates of those eggs are found in areas of clean gravel compared to areas of sand, muck, or detritus (Johnson 1961). A minimum dissolved oxygen level of 6.0 mg/L and a mean weekly water temperature between 11 and 18 °C are described as ideal factors to the spawning of walleye (McMahon et al. 1984). A rising- or stable-water elevation during spawning and embryo development is also critical to spawning success and subsequent recruitment (McMahon et al. 1984).

Other factors affecting walleye egg survival include the absence of common carp *Cyprinus carpio* on spawning grounds (Priegel 1970) and the absence of a substantial drop in water level post-spawn (Groen and Schroeder 1978). Survival rates of eggs were also greater on substrates in which the chemical oxygen demand was less than 40 mg O₂ per gram of dry mass (Auer and Auer 1990). This measure of chemical oxygen demand included concentrations of ammonia-nitrogen and hydrogen sulfide in the sediments.

Incubation time of walleye eggs depends on water temperature and rates of warming in lakes (Colby et al. 1979). Eggs generally hatch in 21 days at 10-12.8 °C and in 7 days at 13.9 °C (Ney 1978; Becker 1983; Pflieger 1997). A rapid warming rate (greater than 0.28 °C/day) in lakes produces strong year classes, whereas a slower warming rate produces weak to strong year classes (Busch et al. 1975). An increased warming rate decreases incubation and development time, resulting in reduced predation risk to eggs and larvae. Optimum levels of dissolved oxygen, greater than 5-6 mg/L, also

decrease incubation time and result in a greater mean length-at-hatch (Oseid and Smith 1971).

Larval walleye are pelagic at hatching and may disperse throughout the reservoir. Walleye fry are positively phototactic and spend a majority of time in the lighted portion of the water column (Bulkowski and Meade 1983). Larval walleye are usually carried by wind and water currents to the limnetic zone (Houde and Forney 1970). When fry are 25-mm total length, they become demersal and are generally located in coves (Becker 1983; Olson et al. 1978; Grinstead 1971).

White Bass

The white bass is the only member of the Moronidae family native to Nebraska (Morris et al. 1972). The native range of the white bass includes large streams, lakes, reservoirs, and rivers within most of eastern USA, excluding the southeast and the eastern coast (Scott 1967; Scott and Crossman 1973; Williams 1995). White bass have also been introduced in reservoirs outside their native range and their present distribution has been extended to the eastern coast of the USA (Lee et al. 1980). In Nebraska, white bass inhabit the Missouri, North Platte, and the Republican River basins (Morris et al. 1972).

White bass spawning habitat generally includes sand, gravel, or cobble substrate in tributaries or lakes with relatively clear water (Williams 1995; Willis and Paukert 2002). Shallow areas or gravel shoals in lakes without tributaries may also be used for spawning (Scott 1967). At Harlan County Reservoir, Nebraska, white bass migrate to the major tributary during spring to spawn (Morris et al. 1972).

White bass are early spring spawning fish and begin to enter tributaries or riverine zones of reservoirs as waters warm (Pflieger 1997; DiCenzo and Duval 2002; Guy et al. 2002). In Tennessee, spawning migrations begin during late February to early March, and spawning begins during mid-March when water temperature is 11.7 °C (Webb and Moss 1967). In Kansas reservoirs, spawning is closely related to inflows after water temperature exceeds 12 °C (Quist et al. 2002). White bass males move to spawning habitats prior to the arrival of female white bass (Pflieger 1997).

White bass spawning consists of no nest building or parental care for eggs and larvae. Demersal eggs are broadcast over suitable substrate, attach to the substrate, and hatch in about two days (Pflieger 1997). Spawning is generally completed in five to 10 days in a particular water body (Pflieger 1997).

The success of white bass spawning is strongly related to temperature and inflows within reservoirs. Spring precipitation, inflow, and the resulting rise in water elevation enhance year-class strength by increasing the amount of habitat available to white bass for spawning (Beck et al. 1997; Pope et al. 1997; DiCenzo and Duval 2002). Whereas a temporary increase in water elevation during spawning may allow access to better quality spawning habitat, reductions in water elevation after spawning are less likely to damage white bass year-class strength due to their short incubation time (Webb and Moss 1967).

Study Reservoirs

Republican River Basin

The Republican River begins in Colorado, crosses the northwest corner of Kansas, continues into southwest and south central Nebraska, and then returns to Kansas;

the Republican River crosses central and eastern Kansas and empties into the Missouri River. Within Nebraska, the Republican River basin drains 24,993 km² of land into 1,826 km of streams and river (Bliss and Schainost 1973). In a 1972 Republican River basin fisheries study, there were 37 species of fish sampled within the basin's streams. During that survey, 729 km of stream were classified as environmentally degraded, with the primary cause being water withdrawal for irrigation purposes (Bliss and Schainost 1973).

There are five major multipurpose reservoirs located within the Republican River basin in Nebraska (Figure 1): Swanson Reservoir, Enders Reservoir, Hugh Butler (Red Willow) Lake, Harry Stunk (Medicine Creek) Lake, and Harlan County Reservoir. Swanson and Harlan County reservoirs are on the mainstem Republican River, whereas Enders, Red Willow, and Medicine Creek reservoirs are on tributaries to the Republican River. Harlan County Reservoir was not included in this study.

Data on the construction and pool elevations for these reservoirs were collected from the U.S. Bureau of Reclamation's dataweb and the U.S. Army Corps of Engineers websites (2007) unless otherwise noted. Fish sampling data were collected as part of the Nebraska Game and Parks Commissions statewide fish sampling program. Under this sampling program, autumn gillnetting is used to index the relative abundance of certain sport fishes in reservoirs of Nebraska, including walleye and white bass.

Swanson Reservoir

Swanson Reservoir was constructed during 1949-1953 on the mainstem Republican River. It drains a watershed of 22,326 km² in southwest Nebraska, northwest

Kansas, and northeast Colorado, and conservation pool elevation is 838.8 m above mean sea level. During the walleye and white bass spawning period, March through April, the five-year (2003-2007) mean \pm SE end-of-month pool elevation was 832.71 ± 0.27 m above mean sea level.

Enders Reservoir

Enders Reservoir was constructed in 1951 on Frenchman Creek in southwest Nebraska. It drains a watershed of $2,841 \text{ km}^2$ and conservation pool elevation is 948.6 m above mean sea level. During March and April, the five-year mean \pm SE end-of-month pool elevation was 941.09 ± 0.10 m above mean sea level. Water levels during spring 2008 were approximately 2 m higher than in spring 2007 due to a flood event in June 2007.

Hugh Butler (Red Willow) Lake

Red Willow reservoir was constructed during 1960-1962 on Red Willow Creek in southwest Nebraska. It drains a watershed of 1890 km^2 (Ferrari 1998) and conservation pool elevation is 801.01 m above mean sea level. During March and April, the five-year mean \pm SE end-of-month pool elevation was 782.85 ± 0.21 m above mean sea level. Water levels during spring 2008 were approximately 2 m higher than in spring 2007 due to a flood event in June 2007.

Harry D. Stunk (Medicine Creek) Lake

Medicine Creek reservoir was constructed in 1949 on Medicine Creek in southwestern Nebraska. It drains a watershed of 2,279 km² and conservation-pool elevation is 721.18 m above mean sea level. During March and April, the five-year mean \pm SE end-of-month pool elevation was 720.34 ± 0.23 m above mean sea level.

Reservoir Fish Community

The fish community of these four reservoirs primarily consists of walleye, white bass, hybrid striped bass *Morone chrysops* x *M. saxatilis*, white crappie, flathead catfish *Pylodictis olivaris*, and channel catfish *Ictalurus punctatus*. Largemouth bass *Micropterus salmoides*, smallmouth bass *Micropterus dolomieu*, and bluegill are also present in lesser abundance. Northern pike *Esox lucius* are present in Red Willow reservoir and muskellunge *Esox masquinongy* are present in Enders Reservoir. Gizzard shad *Dorosoma cepedianum* are the primary prey base in each reservoir. Common carp *Cyprinus carpio*, river carpsucker *Carpiodes carpio*, and freshwater drum *Aplodinotus grunniens* compromise the rough fish community of these reservoirs.

Goal

The goal of my research is to understand spawning habitat selection by walleye and white bass in irrigation reservoirs of the Republican River basin of southwestern Nebraska.

Objectives

- 1) Describe the habitat selected by adult walleye and white bass for spawning using patch occupancy modeling within a given reservoir.
- 2) Document differences in abundances of walleye and white bass eggs and larvae among varying habitats within a given reservoir.
- 3) Describe movements of adult walleye and white bass during spawning season using acoustic telemetry within a given reservoir.

Research Hypotheses

- 1a) Adult fish (walleye and white bass) select spawning habitats with dominant substrate of gravel or larger size.
- 1b) Adult fish (walleye and white bass) select spawning habitats located in depths less than 1.5 m.
- 1c) Adult fish (walleye and white bass) select spawning sites in areas with greater maximum fetch.

Habitats with large substrate, shallow depth, and greater maximum fetch may increase probability of egg survival through less siltation aided by lateral currents and wind action, and through greater levels of dissolved oxygen aided by increased wind action and reduced abundance of bacteria that leads to reduced total respiration.

- 2a) Walleye and white bass egg abundance increases with increasing substrate size.
- 2b) Walleye and white bass egg abundance increases with decreasing substrate embeddedness.

Adult fish may deposit eggs onto substrates of greater size and lesser embeddedness to decrease probability of exposing eggs to low dissolved oxygen levels associated with silt substrates, thereby increasing probability of egg survival.

- 3a) Larval fish (walleye and white bass) abundance increases with increasing substrate size.
- 3b) Larval fish (walleye and white bass) abundance increases with increasing dissolved oxygen concentration

Larval abundance should be greatest in areas containing larger substrate and greater dissolved oxygen because egg abundance and rate of survival are predicted to be greater in those areas.

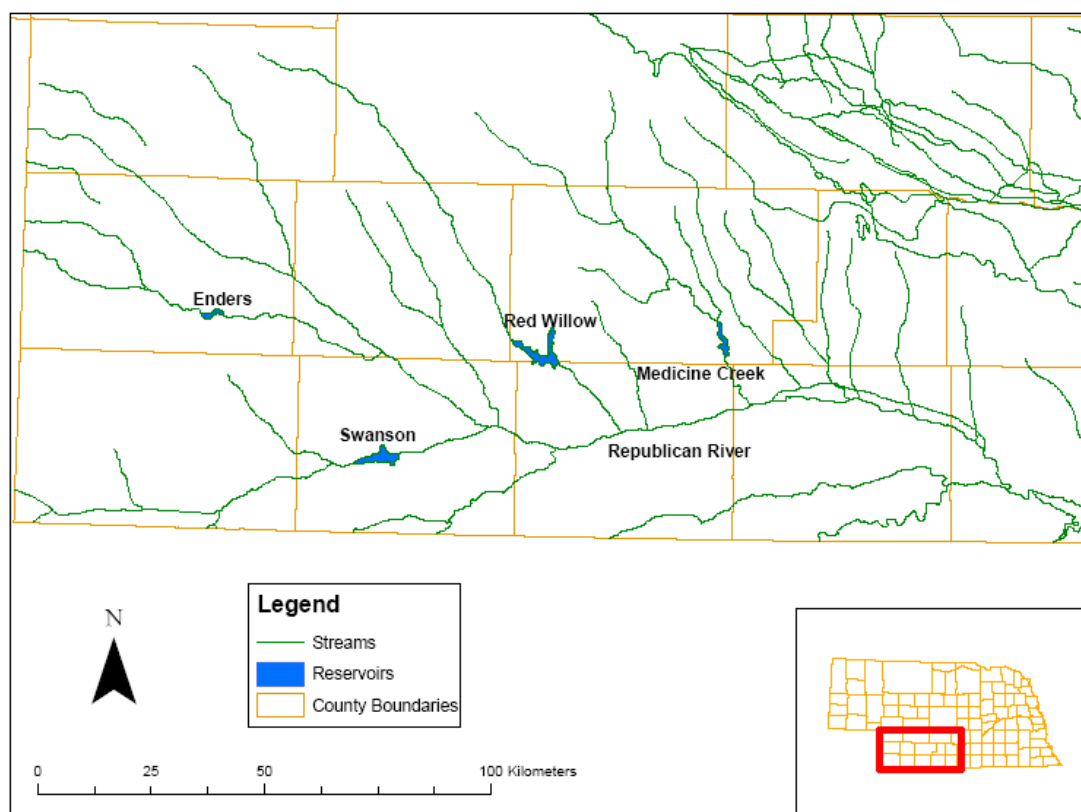


Figure 1-1. Map of study reservoirs within the Republican River basin in southwestern Nebraska, USA.

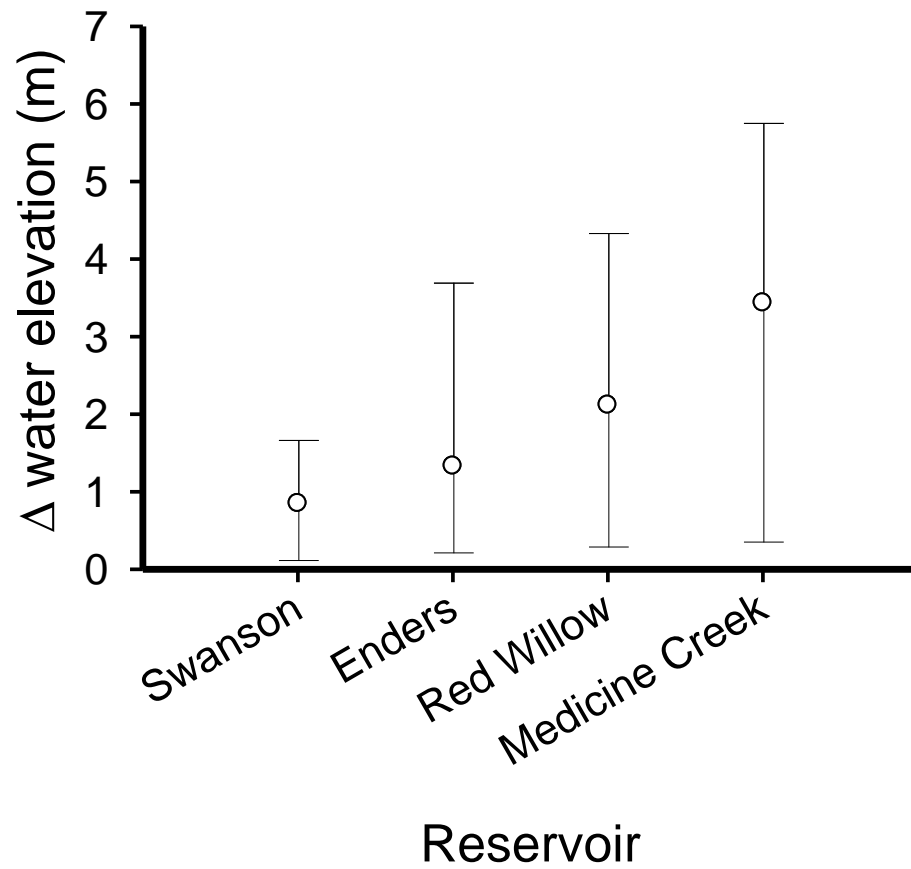


Figure 1-2. Mean (circles) and range (bars) of intra-annual change (Δ) in water elevation for reservoirs of the Republican River basin in southwestern Nebraska, USA during 2002-2007.

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Chapter 2. Spawning Habitat Selection by Walleye and White Bass: A Patch Occupancy Modeling Approach

Introduction

Adult fish usually select sites to maximize hatching and survival rates of progeny. Substrate type, depth, dissolved oxygen, and temperature are commonly cited as critical spawning habitat characteristics (Gipson and Hubert 1993; Gosch et al. 2006; McMahon et al. 1984), though characteristics of spawning habitat vary widely among species. Walleye *Sander vitreus* typically spawn along windswept shorelines with larger substrate (Becker 1983; Pflieger 1997). These sites maximize dissolved oxygen and minimize siltation on eggs during the 10-14 day hatching period and lead to greater survival rates of eggs (Johnson 1961; McMahon et al. 1984). White bass *Morone chrysops* typically spawn on sites with sand, gravel, or rubble substrate in tributaries, or shallow areas with sand or gravel substrate in lakes without tributaries (Scott 1967; Williams 1995; Willis and Paukert 2002). Success of white bass spawning is related to spring precipitation and resulting increases in water-level that increase availability of habitat (Beck et al. 1997; Pope et al. 1997; DiCenzo and Duval 2002).

Traditional habitat selection methods (logistic regression and multivariate analysis of variance) may underestimate habitat selection by failing to account for the probability of detection given the sampling method (Gu and Swihart 2004). Habitat variables positively related to this detection probability may be over-emphasized in traditional habitat selection modeling (Gu and Swihart 2004). Detection probability is generally < 1.0 and when unaccounted may cause biased estimates of habitat use (Tyre et al. 2003). These weaknesses have created a need for a new method that explicitly accounts for detection probability. Patch occupancy modeling is a modeling technique for estimating

site occupancy that explicitly accounts for detection probability and covariate information (MacKenzie et al. 2002). Unfortunately, only one paper (Burdick et al. 2008) to date has been published in the fisheries literature using this method.

Patch occupancy model assumptions include: 1) sites are closed (an occupied site is considered occupied throughout the sampling period), 2) species are never falsely detected at a site, and 3) detection of species is independent among sites (MacKenzie et al. 2002). Of these assumptions, the closure assumption is the most difficult to meet and is typically met by making repeated visits to fixed sites within a brief period. The increased effort required to sample each site repeatedly for patch occupancy modeling can be offset by reducing the number of sites at each reservoir (MacKenzie and Royle 2005).

My objective was to examine habitat selection by adult walleye and white bass during spawning season using patch occupancy modeling. I created a set of *a priori* research hypotheses about adult, egg, and larval abundance of walleye and white bass that were used to guide modeling efforts:

- 1) Adult fish (walleye and white bass) abundance is greatest in habitats with large substrates, depths less than 1.5 m, and greater maximum fetch.
- 2) Egg abundance increases with increasing substrate size, decreasing siltation, and increasing dissolved oxygen concentration.
- 3) Larval fish abundance increases with increasing substrate size and increasing dissolved oxygen concentrations.

I used a set of models with *a priori* selected covariates for detection and occupancy probabilities to determine the best descriptive adult walleye and white bass spawning

habitat selection models. Further support for these models was provided by the presence of walleye eggs at sampling sites with the greatest occupancy probabilities. I also examined habitat selection of larval walleye using patch occupancy modeling.

Study Area

Enders Reservoir is an irrigation reservoir constructed along Frenchmen Creek, in southwestern Nebraska, by the U.S. Bureau of Reclamation in 1951. At conservation-pool, Enders Reservoir is characterized by a water level of 948.5 m above mean sea level, surface area of 485 ha and maximum depth of 18.3 m. The shoreline of Enders Reservoir is mostly composed of silt/sand substrate with small cottonwood *Populus deltoides* trees lining the shoreline.

Red Willow reservoir (Hugh Butler Lake) is an irrigation reservoir constructed along Red Willow Creek in southwestern Nebraska, by the U.S. Bureau of Reclamation in 1962. At conservation pool, Red Willow reservoir is characterized by a water level of 786.9 m above mean sea level, surface area of 660 ha, and maximum depth of 15.2 m. Red Willow reservoir has two inflow sources creating a reservoir with two arms: Spring Creek to the north and Red Willow Creek to the west. The shoreline of Red Willow reservoir is mostly composed of silt substrate with small cottonwood trees lining the shoreline.

The fish communities of both reservoirs primarily consist of walleye, white bass, white crappie *Pomoxis annularis*, and channel catfish *Ictalurus punctatus*. Largemouth bass *Micropterus salmoides*, smallmouth bass *Micropterus dolomieu*, and bluegill *Lepomis macrochirus* are also present in lesser abundance. Northern pike *Esox lucius* are

present in Red Willow reservoir and muskellunge *Esox masquinongy* are present in Enders Reservoir. Gizzard shad *Dorosoma cepedianum* are the primary prey base in both reservoirs.

Both reservoirs are located within the Republican River basin in southwestern Nebraska and the watersheds are dominated by rolling grasslands and irrigated cropland. The Republican River basin has been the source of much controversy over water allocations between the three states within the basin: Colorado, Nebraska, and Kansas. Water withdrawals for irrigation are quite variable within and among each of the basin's reservoirs because of this controversy.

Drought conditions have dominated southwestern Nebraska for the past decade and have limited the amount of water available for irrigation withdrawals. Low water levels have allowed small trees to become established along the shoreline of both reservoirs. Rainfall during the spring of 2007 and 2008 caused increases in water level and subsequent flooding of those established small trees. This increase in water level altered the habitat available for spawning fishes between 2007 and 2008 from a simple habitat of mostly barren substrate to a more complex habitat of flooded trees.

Methods

Sampling Sites

Sampling sites for this study were selected using ArcMap 9.3 (ESRI Inc., 2008). A shoreline layer was created for both reservoirs from current elevation data (U.S. Bureau of Reclamation) and existing bathymetric maps of each reservoir at normal pool elevation (Lake Mapping Program of the Nebraska Game and Parks Commission

[NGPC]). From this shoreline layer, 50 sites (minimum of 60-m apart) were randomly selected for each reservoir with an additional 15 replacement sites. Sampling for adults, eggs, and larvae was paired at the first 25 randomly selected sites. The additional 25 randomly selected sites were used for sampling adult fish only.

Adult fish

Pulsed-DC boat-mounted electrofishing (Reynolds 1996) was used to sample the 50 randomly selected sites. Standardization of electrofishing in waters with differing conductivities is critical when monitoring temporal or spatial differences in fish populations (Miranda and Dolan 2003). Thus, I measured water conductivity at the beginning of each sampling event and adjusted power output (Kolz and Reynolds 1989; Burkhardt and Gutreuter 1995).

Sampling for adult walleye occurred at night when water temperature was 7-10 °C. Each site was sampled five times between 25 March and 5 April 2008 at both Enders and Red Willow reservoirs. Sampling for adult white bass occurred at night when water temperature was 12-15 °C. Each site was sampled three times between 3 May and 13 May 2008 at Enders Reservoir and between 3 May and 8 May 2008 at Red Willow reservoir. Sampling at Red Willow reservoir on 7 May was cut short (10 sites) because of equipment problems and the third sampling attempt was completed on 8 May.

A starting point was chosen randomly from the list of sites for each sampling occasion and sampling proceeded in a random (clockwise or counter-clockwise) direction around the reservoir. Sampling effort at each individual site consisted of electrofishing for 30 m in a random (left or right) direction from the sampling point within the littoral area. During sampling, all walleye and white bass were collected and measured for total

length (TL; mm), examined to determine gender and reproductive maturity by gently squeezing the abdomen (Schreck and Moyle 1990), and released alive. Catch per unit effort was calculated as the number of adult fish per transect (30 m). Walleye and white bass were considered adults if they were ≥ 250 -mm TL or were extruding milt or eggs (Carlander 1945; Guy et al. 2002). Abiotic habitat variables were measured at the end of each 30-m transect.

Fish eggs

Sampling for walleye and white bass eggs using egg mats occurred at the 25 paired sampling sites. These sites were sampled concurrent with electrofishing for 7-10 night periods during walleye spawn and for 4-5 night periods during white bass spawn. Three subjective sites were also sampled during white bass spawning to increase the probability of capturing eggs.

Egg mats were constructed of tractor disc blades (mean diameter = 43 cm, range 32-57 cm). Metal washers were welded upright in the center of each disc concave-side up and discs were covered with outdoor carpeting. A line was attached to each washer and to a float for ease of deployment and retrieval.

Egg mats were deployed prior to sunset along transects extending perpendicular into the reservoir from the shoreline sampling site. An egg mat was placed on each of the 0.5-m and 1.0-m depth contours. Eggs were collected by rinsing egg mats with water from a boat-mounted pump and gently running hands over the carpet to dislodge any attached eggs. Mats were visually examined and any remaining eggs were removed with forceps. Eggs were preserved in a 5% formalin solution (Kelso and Rutherford 1996) for

counting and analysis in the laboratory. Walleye and white bass eggs were identified by comparison with egg samples attained from NGPC hatcheries. Results for egg sampling were reported as presence/absence of eggs at each site.

Larval fish

Larval fish were sampled at the 25 paired sites per reservoir. Walleye larvae were targeted 7-10 days after electrofishing and white bass larvae were targeted 2-4 days after electrofishing (periods that correspond with egg development time of these two species). Sites were sampled a minimum of three times within 10 d to allow for analysis using a patch occupancy modeling technique. Sampling season for larval walleye was extended for 2 weeks past peak walleye hatch in an attempt to catch larval walleye at Red Willow.

A modified version (Southern Concepts, Birmingham, AL) of the quatrefoil light trap (Floyd et al. 1984; Secor et al. 1992) was used to sample larval fish. These light traps have an entrance slot width of 4-mm and are powered by three “D” alkaline batteries. A central light distributing rod spreads light evenly along the depth of the light trap from a LED light source. I assumed a constant level of darkness and catch rate throughout the night; thus, sampling began one hour after sunset and concluded prior to one hour before sunrise. During sampling, one light trap was deployed at each site and allowed to fish for 60 min. Each reservoir was split into four sections, each having 6-7 sites, and sections were sampled in a random order. Sites within each section were also sampled in a random order to establish a random yet logistically-feasible method of sampling. Light traps were deployed every 10 min at four sampling sites. After sampling, light traps were moved to the next site and deployed again. This allowed for

four sites per hour and 25 sites per night to be sampled. Abiotic habitat variables were measured after retrieval of each light trap.

All larval fish collected were preserved in an ethanol solution for identification and enumeration in the laboratory. Larval fish were identified using keys from Auer (1982), and measured for TL (mm) using an ocular micrometer. Catch per unit effort was calculated as the number of larval fish per trap-hour.

Habitat Variables

Abiotic variables were measured at each site for inclusion in patch occupancy modeling. Covariates measured included the presence and type of cover, type of substrate, fetch, conductivity, dissolved oxygen, pH, temperature, and turbidity. Cover and substrate type were visually assessed. In areas where substrate was not visible, a substrate sampler made of 102-mm diameter metal pipe was used. Maximum, northwest, and south fetch were calculated in ArcMap GIS. Cover, substrate and fetch were assumed to remain constant across the spawning season and thus, were only measured once for each species. Water-quality covariates were measured 0.5-m below the water's surface on each sampling occasion.

Model Selection

Patch occupancy modeling was conducted for each species, life stage, and reservoir combination separately using Program PRESENCE (Hines 2006). Reservoirs were analyzed separately because habitat available for spawning fishes was reservoir specific. A single-season model based on presence-absence data was used to analyze both adult and larval fish occupancies. This model allows detection probability (p) and

probability of site occupancy (ψ) to be constant or vary with specified covariates. Site-specific covariates were those that remained constant across sampling periods and consisted of cover type, substrate type, and fetch. Sampling-specific covariates were those that varied between sampling attempts and consisted of water temperature, dissolved oxygen, conductivity, pH, and turbidity.

I first determined whether detection probability was a function of habitat variables. Habitat variables were temperature, conductivity, turbidity, cover type, and substrate type for adult analysis and were temperature, turbidity, and cover type for larval analysis (Table 2-1). Each suite of models was compared against the null model in which detection probability was held constant ($P(\cdot)$, $\psi(\cdot)$) and a survey-specific ($t = \text{time}$) detection probability model ($P(t)$, $\psi(\cdot)$).

Models were compared using the small-sample size adjustment of Akaike's Information Criterion (AICc; Burnham and Anderson 2002) and tested for overdispersion using the global (over-parameterized) model. Detection probability models with a relative AICc value (i.e., difference between that models AICc value and the AICc value of the best model; ΔAICc) of less than 2.0 were considered to have substantial support. This set of models was then used to test occupancy probability.

Occupancy probability was tested in the same manner with each of the best detection probability models. Occupancy probability was allowed to vary with temperature, dissolved oxygen, pH, turbidity, fetch, cover type, and substrate type for both adult and larval analyses (Table 2-1). The final suite of models accounting for detection probability and occupancy probability consisted of models with $\Delta\text{AICc} < 2.0$.

Occupancy estimates were averaged across the suite of best models for each life stage to obtain an overall average occupancy parameter for each site using

$$\hat{\bar{\psi}} = \sum_{i=1}^R \hat{\psi}_i \omega_i$$

where $\hat{\bar{\psi}}$ is the model-averaged estimate of ψ , $\hat{\psi}_i$ is the site-specific occupancy estimate for each model, and ω_i is the AICc weight for each model (Burnham and Anderson 2002). For model averaging, AICc weight values were calculated across the suite of best models instead of across the entire model set.

Results

Available Habitat

Most shoreline habitat in Enders and Red Willow reservoirs was characterized by silt substrates with small, woody trees. Sites with rock substrate were found in the lower portion of Enders Reservoir and only on the riprap dam in Red Willow reservoir. Temperatures were coolest and fetch was generally greater in the lower portions of each reservoir, whereas dissolved oxygen, conductivity, pH, and turbidity were similar throughout each reservoir (Appendices 1-4).

Walleye

Adult walleye were captured at 42% and 16% of sampled sites in Enders ($N = 111$) and Red Willow ($N = 70$) reservoirs, respectively (Figure 2-1). Walleye catches were clustered in the lower section of each reservoir (Figures 2-2 and 2-3) with greatest

abundance found at sites on the face of the dam. However, some walleye were captured at sites in the middle and upper sections of each reservoir.

The suite of best models quantifying detection probability of adult walleye included models in which detection probability varied as a function of temperature, cover type, and substrate type in Enders Reservoir (Table 2-2), whereas detection probability varied only as a function of substrate type in Red Willow reservoir (Table 2-3). Detection probability was inversely related to temperature and positively related to the absence of cover in Enders Reservoir (Table 2-4). Detection probability was inversely related to the presence of silt in both reservoirs (Tables 2-4 and 2-5). Detection probability of adult walleye from the best model ranged between 0.001 and 0.82, and between 0.03 and 0.18 in Enders and Red Willow reservoirs, respectively.

Thirty-one competing models quantifying occupancy probability were assessed in Enders reservoir to determine habitat variables most related to distribution of adult walleye during the spawning period. Models included detection probability varying as a function of temperature, cover type, and substrate type in combinations with occupancy probability covariates, and the global model (Table 2-6). The suite of best models included models in which detection probability varied as a function of cover type and occupancy probability varied as a function of temperature and two measures of fetch: northwest and maximum (Table 2-6). Occupancy probability was inversely related to temperature and positively related to both northwest and maximum fetch (Table 2-4; Figure 2-4). Occupancy probability of adult walleye ranged between 0.01 and 0.77 for the best model in Enders Reservoir.

Eleven competing models quantifying occupancy probability were assessed in Red Willow reservoir to determine habitat variables most related to distribution of adult walleye during the spawning period. Models included detection probability varying as a function of substrate type and occupancy probability covariates, and the global model (Table 2-7). The suite of best models included adult walleye occupancy probability varying as a function of the presence of woody cover and substrate type (Table 2-7). Cover type was reduced to the presence or absence of woody vegetation due to convergence issues with the full cover model. Occupancy probability was not significantly related to the presence of silt substrate, rock substrate, or woody cover (Table 2-5; Figure 2-5). Occupancy probability of adult walleye ranged between 0.12 and 1.0 for the best model in Red Willow reservoir.

Model averaged estimates of occupancy were compared using a linear measurement of distance from each site to the midpoint of the dam (Figure 2-6). Averaged occupancy probabilities in Enders Reservoir were inversely related to distance from the dam. Averaged occupancy probabilities in Red Willow reservoir were low at all sites with the exception of four sites with rock substrate in the lower reservoir.

Walleye eggs were captured at one site at Enders Reservoir and two sites at Red Willow reservoir (effort = 1,945 mat-nights; Table 2-8). At Enders Reservoir, eggs were collected on both the 0.5-m and 1.0-m depth egg mats on the riprap dam (Figure 2-7). At Red Willow reservoir, eggs were collected on both the 0.5-m and 1.0-m depth egg mats on the riprap dam and at the 1.0-m depth egg mat adjacent to the dam (Figure 2-8).

Larval walleye were captured on three of four sampling dates in Enders Reservoir (effort = 100 trap-hr; Figure 2-9) and were distributed throughout the reservoir (Figure 2-

10). The greatest catch of larval walleye occurred in the shallow, upper reservoir (Figure 2-10). No larval walleye were caught in Red Willow reservoir despite six sampling attempts (effort = 242 trap-hr).

The suite of best models quantifying detection probability of larval walleye included models in which detection probability varied as a function of the presence of woody vegetation in Enders Reservoir (Table 2-9). Cover type was reduced to the presence or absence of woody vegetation due to convergence problems with the fully expanded cover model. Detection probability was inversely related to the presence of woody vegetation (Table 2-10). Detection probability of larval walleye ranged between 0.03 and 0.22 for the best model in Enders Reservoir.

Eleven competing models quantifying occupancy probability were assessed in Enders Reservoir to determine habitat variables most related to distribution of larval walleye. Data were insufficient (i.e., low catch rates and small sample size) to analyze both detection probability and occupancy probability in the same model. Thus, models assessed included the null detection probability model in combinations with occupancy probability covariates, and the global model. The suite of best models included models in which occupancy probability varied as a function of maximum fetch (measured in km rather than m because of convergence issues) and cover (Table 2-11; Figure 2-11). However, because of low consistency of site occupancy, coefficient and standard error values were large (Table 2-10). Occupancy probability of larval walleye ranged between 0 and 1.0 for the best model in Red Willow Reservoir.

Model averaged occupancy estimates for larval walleye were not related with linear distance from the dam at Enders Reservoir (Figure 2-12). Sites near the dam had a

high probability of occupancy as did sites in the upper end of the reservoir. This is most likely because an averaging interaction existed between cover type (woody vegetation prevalent in the upper reservoir) and maximum fetch (greatest near the dam and middle of reservoir).

White Bass

Adult white bass were captured at 8% and 38% of sampled sites in Enders and Red Willow reservoirs, respectively. Catches of adult white bass at Enders Reservoir were low ($N = 4$) and precluded any potential habitat selection modeling. White bass catches at Red Willow reservoir were greater ($N = 38$) and sufficient for habitat-selection modeling (Figure 2-13).

The suite of best models quantifying detection probability of adult white bass included models in which detection probability varied as a function of the presence of woody cover, the presence of silt substrate, and sampling date (Table 2-12). The null model, which held detection probability constant within and across sampling dates, also was included in the suite of best models. Thus, no measured covariate was better than the mean value (0.26) for describing probability of detecting adult white bass at sites sampled with a boat electrofisher (Table 2-13).

Twelve competing models quantifying occupancy probability were assessed in Red Willow reservoir to determine habitat variables most related to distribution of adult white bass during the spawning period. Models included the null detection probability parameter in combinations with occupancy probability covariates (with the *post hoc* addition of a covariate describing the location of sampling site: cove or open water), and

the global model (Table 2-14). The suite of best models included models in which occupancy probability varied as a function of the absence of cover, type of substrate, and northwest fetch (Table 2-13; Figure 2-14). The null model, which held occupancy probability constant within and across sampling dates, also was included in the suite of best models. Thus, no measured covariate was better than the mean value (0.63) for describing the probability of adult white bass occupying a given site.

Model-averaged site occupancy estimates were relatively constant across the reservoir (Figure 2-15). Sites near the dam had the lowest averaged occupancy because of the additive effects of the absence of cover, presence of rock substrate, and greater northwest fetch. Median values for northwest fetch, woody cover, and silt substrate led to the relatively consistent averaged occupancy probability of around 0.50 for each site in the middle and upper reservoir.

Sampling for white bass eggs was conducted over 12 days in early May at both reservoirs. No white bass eggs were collected at either reservoir (combined effort = 888 mat-nights). The only eggs collected during this sampling effort were of the Cyprinidae family.

Larval white bass sampling was conducted between 15 May and 25 May with each site sampled three times at both reservoirs (combined effort = 150 trap-hr). No larval white bass were captured in either reservoir. Larval fish were captured in three light trap sets; catches consisted of walleye, white sucker *Catostomus commersonii*, and an unidentified centrarchid species.

Discussion

Patch occupancy modeling facilitated quantification of habitat selection by both adult and larval walleye in irrigation reservoirs of southwestern Nebraska, while explicitly accounting for variation in detection probability. Detection probability was significantly affected by habitat covariates for both adult and larval walleye.

Electrofishing efficiency for adult fish is generally thought to have a high and constant detection probability, especially when applied power is standardized for water conductivity as was done in this study; however my modeling results indicate that electrofishing efficiency varies with sampling covariates such as temperature, substrate type, and cover type. These covariates may alter electrofishing efficiency due to a loss of power in vegetation and silt substrate or change in fish reaction to electrofishing at different water temperatures (Zalewski and Cowx 1990; Reynolds 1996). Light-trap efficiency for larval fish is not well-defined; I found that detection probability of larval fish with light traps was affected by the presence of cover, which may alter light transfer and reduce the effective sampling area.

Adult walleye occupancy probability was mainly a factor of substrate type and fetch. This supports my *a priori* hypotheses (based on manager's observations and previous literature) that adult walleye abundance would increase with increasing substrate size and increasing dissolved oxygen concentrations. Predominant winds and greatest effective fetch during walleye spawn were from the northwest (NOAA 2008). However, adult walleye occupancy probability also varied with temperature and cover type. This combination of covariates (large substrate, large fetch, cool temperature, and absence of cover) is only available on the riprap dam of both reservoirs. Nonetheless, I believe that

the main factor affecting habitat selection by adult walleye is the presence of large rock substrate because areas with large rock substrate were only available near the dams, whereas areas with large fetch and absence of cover were available elsewhere in both reservoirs. Furthermore, it seems illogical to believe that fish would select cooler water temperatures, which increase the period of egg development. Catches of eggs provided support for the model predictions of walleye spawning site selection, with all eggs being captured on larger substrates (natural rock or riprap) on or near the dams.

Larval walleye were captured throughout the reservoirs and did not conform to my *a priori* hypothesis of being congregated in areas of greatest adult abundance during spawn. There are at least three possible explanations for this discrepancy. First, even though spawning (based on adult and egg abundances) was greatest near the dam, larval survival in that area may have been low due to increased competition for zooplankton or increased predation. Second, naturally-produced larval walleye may quickly disperse throughout the reservoir facilitated by lateral currents and wind action. Third, the larval fish I detected may be of hatchery-origin. Hatchery fish were stocked in the middle portions of each reservoir 2-3 d prior to sampling with light traps. I have no way of knowing the origin (hatchery or naturally-produced) of walleye larvae collected in my samples. My modeling results provide support for the second and third hypotheses with larval walleye found in areas with greater maximum fetch. North-northwesterly winds were predominant with brief periods of southerly winds during sampling (NOAA 2008). It is unlikely that these winds dispersed naturally produced larval walleye from the dams to the sites where I captured larval walleye; therefore, I suspect that most larval fish captured were of hatchery-origin.

Habitat selection by white bass during the spawning period and the associated spatial distribution of fish did not conform to my *a priori* hypotheses of spawning adults being congregated in habitats with large substrates, shallow depths, and large maximum fetch. In addition, adult white bass were distributed throughout the reservoir and did not congregate during the primary spawning period. White bass may have been cued by increased inflows into Enders and Red Willow reservoirs prior to and during the spawning period, causing them to migrate into tributaries where I could not effectively sample. Low catch rates during electrofishing sampling and high mobility of some white bass (as observed with telemetry; Chapter 3) caused difficulties with analysis of habitat selection by adult white bass. Alternative methods, such as stationary gill nets, may allow capture of white bass in specific areas over long periods. The absence of larval white bass in light trap samples may be a function of missing the peak hatching dates of larval white bass or of samples not being taken in the inflowing streams of each reservoir.

Variation between adult walleye and white bass habitat selection is likely driven by differences in their basic life histories. Both species evolved in riverine systems, but employ different spawning strategies (e.g., different spawning period and duration of egg maturation). Walleye spawn during early spring when water temperatures are colder and water levels are either steady or rising, allowing a longer egg maturation time (10-14 days) and greater size at hatch. Previous studies suggest that adult walleye select spawning sites with larger substrates and greater dissolved oxygen concentrations to increase probability of egg survival to hatch. White bass spawn during late spring when water temperatures are warmer and water levels are more variable because of increased precipitation, creating a need for quicker (~2 days) egg maturation time. White bass

should benefit from spawning in many different locations to increase probability that eggs will survive to hatching. Differences in spawning habitat selection may also be driven from the optimization of larval survival. Larval walleye are more developed and larger than larval white bass at hatching (Holland-Bartels et al. 1990) and may feed on larger zooplankton at first exogenous feeding. White bass larvae are smaller than walleye and must feed on smaller zooplankton at first exogenous feeding. White bass may benefit from spawning in multiple locations across the reservoir and increasing the probability of encountering small zooplankton.

My results support previous findings that, when available, walleye spawn on large rock (e.g., riprap). Within irrigation reservoirs such as Enders and Red Willow, large rock is generally available only at the dam, which results in concentration, perhaps even over-crowding of spawning walleye at the dam. Year-class strength of walleye is quite variable, with missing year-classes common, in irrigation reservoirs of the Republican River basin in southwestern Nebraska. It is likely that concentration of spawning walleye into a small portion of these reservoirs leads to unfavorable conditions (e.g., increased intraspecific competition and attraction of predators) for egg and larval survival.

Addition of riprap in upper portions of irrigation reservoirs would probably disperse spawning walleye, potentially increasing recruitment of walleye and perhaps minimizing variability of year-class strength within reservoirs. To test this hypothesis, I suggest that new riprap be oriented perpendicular to depth contours in a manner that provides submerged riprap at multiple water levels because fluctuations in water level are common in irrigation reservoirs.

Table 2-1. Description of *a priori* covariate effects for both detection and occupancy probability parameters of adult and larval walleye and white bass. Detection probability was allowed to differ based on adult and larval sampling methods. None indicates that no effect of that covariate was expected.

Covariate	Detection Probability	Occupancy Probability
Water Temperature °C (Temp)	<i>Adult</i> – may affect fish response to electricity <i>Larval</i> – may affect swimming ability towards light source	May alter fish habitat selection due to lethality of extreme low observations and increased survival of eggs/larvae at optimal values
Dissolved Oxygen mg/L (DO)	<i>Adult</i> – none <i>Larval</i> – none	May alter fish habitat selection due to lethality of extreme values
Conductivity mS/cm (Cond)	<i>Adult</i> – may alter effectiveness of electrofishing <i>Larval</i> – none	None
pH	<i>Adult</i> – none <i>Larval</i> – none	May alter fish habitat selection due to toxicity of extreme values
Turbidity NTU (Turb)	<i>Adult</i> – may affect ability to detect fish <i>Larval</i> – may alter effective fishing distance due to light transfer	May alter fish habitat selection due to light penetration and food availability
Substrate type -Silt, sand, gravel, cobble, rock (Subs)	<i>Adult</i> – may alter electric field produced <i>Larval</i> – none	May alter fish habitat selection due to availability of substrate types
Cover type None, woody, submerged, emergent -(Cover)	<i>Adult</i> – may affect ability to detect fish after shocked because of vegetation <i>Larval</i> – may alter effective fishing distance due to light transfer	May alter fish habitat selection due to availability of cover types
Maximum Fetch m (Max_fetch)	<i>Adult</i> – none <i>Larval</i> – none	May alter fish habitat selection due to storm events
Northwest Fetch m (NW_Fetch)	<i>Adult</i> – none <i>Larval</i> – none	May alter fish habitat selection due to prevailing winds or storm events
South Fetch m (S_Fetch)	<i>Adult</i> – none <i>Larval</i> – none	May alter fish habitat selection due to prevailing winds or storm events

Table 2-2. Detection probability models for adult walleye at Enders Reservoir, Nebraska during spring 2008. p(covariate) indicates covariate by which detection probability varies.

Model ^a	# of parameters	-2 log likelihood	AICc	Δ AICc	Akaike ω
p(temp), psi(.)	3	191.86	198.39	0.00	0.56
p(cover), psi(.)	4	191.23	200.12	1.73	0.24
p(subs), psi(.)	6	186.42	200.38	1.99	0.21
p(turb), psi(.)	3	209.16	215.69	17.30	0.00
p(.), psi(.)	2	212.04	216.30	17.91	0.00
p(cond), psi(.)	3	212.02	218.55	20.16	0.00
p(t), psi(.)	6	210.35	224.30	25.92	0.00

^aCovariates described in Table 2-1 unless otherwise noted.

Table 2-3. Detection probability models for adult walleye at Red Willow Reservoir, Nebraska during spring 2008. p(covariate) indicates covariate by which detection probability varies.

Model ^a	# of parameters	-2 log likelihood	AICc	Δ AICc	Akaike ω
p(subs), psi(.)	4	86.49	95.38	0.00	0.90
p(cond), psi(.)	3	95.37	101.90	6.51	0.03
p(.), psi(.)	2	98.70	102.96	7.57	0.02
p(temp), psi(.)	3	96.59	103.11	7.73	0.02
p(cover), psi(.)	4	95.50	104.39	9.01	0.01
p(turb), psi(.)	3	98.07	104.59	9.21	0.01
p(t), psi(.)	6	92.69	106.64	11.26	0.00

^aCovariates described in Table 2-1 unless otherwise noted.

Table 2-4. Estimates of covariate effect size (β) and standard error (SE), odds ratio, and 95% confidence limits (CLs) on odds ratio for adult walleye at Enders Reservoir, Nebraska during spring 2008. Covariates are ordered from the best-fitting to worst-fitting by AICc values from the suite of best models.

Parameter	Covariate	β		Odds Ratio ^a	Odds Ratio CLs	
		Estimate	SE		Lower	Upper
p	Temperature (°C)	-1.65	0.38	0.19	0.09	0.40
	No cover	2.64	1.23	14.01 ^b	1.26	156.15
	Woody cover	0.54	1.23	1.72 ^b	0.15	19.12
	Silt	-3.32	0.74	0.04 ^c	0.01	0.15
	Sand	-0.96	0.79	0.38 ^c	0.08	1.80
	Cobble	-0.65	0.89	0.52 ^c	0.09	2.99
	Rock	-0.74	0.68	0.48 ^c	0.13	1.81
psi	Temperature (°C)	-1.00	0.38	0.37	0.17	0.77
	NW fetch (m)	0.0018	0.0008	1.00	1.00	1.00
	Max fetch (m)	0.0028	0.0013	1.00	1.00	1.01

^aOdds ratios >1.0 indicate an increase in probability of detection or occupancy with a 1.0-unit increase in the covariate unless otherwise noted.

^bOdds ratio calculated as the increase in detection probability relative to the baseline detection probability (intercept) estimated at sites with submerged cover.

^cOdds ratio calculated as the increase in detection probability relative to the baseline detection probability (intercept) estimated at sites with gravel substrate.

Table 2-5. Estimates of covariate effect size (β) and standard error (SE), odds ratio, and 95% confidence limits (CLs) on odds ratios for adult walleye at Red Willow Reservoir, Nebraska during spring 2008. Covariates are ordered from the best-fitting to worst-fitting by AICc values from the suite of best models.

Parameter	Covariate	β		Odds Ratio ^a	Odds Ratio CLs	
		Estimate	SE		Lower	Upper
p	Silt	-4.33	1.3	0.01 ^b	0.00	0.17
	Rock	-0.76	1.2	0.47 ^b	0.04	4.91
psi	Woody Cover	-35.96	102.86	0.00 ^c	6.71×10^{-104}	8.69×10^{71}
	Silt	-1.19	1.33	0.30 ^d	0.02	4.12
	Rock	26.19	395.13	2.37×10^{11} ^d	0.00	^e

^aOdds ratios >1.0 indicate an increase in probability of detection or occupancy with a 1.0-unit increase in the covariate unless otherwise noted.

^bOdds ratio calculated as the increase in detection probability relative to the baseline detection probability (intercept) estimated at sites with cobble substrate.

^cOdds ratio calculated as the increase in occupancy probability relative to the baseline occupancy probability (intercept) estimated at sites with woody cover.

^dOdds ratio calculated as the increase in occupancy probability relative to the baseline occupancy probability (intercept) estimated at sites with cobble substrate.

^eNo CL was calculated because SE of estimate was too large.

Table 2-6. Occupancy probability models given best detection probability model for adult walleye at Enders Reservoir, Nebraska during spring 2008. p(covariate) indicates covariate by which detection probability varies and psi(covariate) indicates covariate by which occupancy probability varies. The global model includes all covariates for both detection and occupancy probabilities.

Model ^a	# of parameters	-2 log likelihood	AICc	Δ AICc	Akaike ω
p(cover), psi(temp)	5	181.73	193.09	0.00	0.30
p(cover), psi(NW_fetch)	5	182.92	194.28	1.19	0.16
p(cover), psi(Max_fetch)	5	183.51	194.87	1.78	0.12
p(temp), psi(NW_fetch)	4	186.45	195.34	2.24	0.10
p(temp), psi(temp)	4	188.39	197.28	4.18	0.04
p(cover), psi(subs)	8	177.82	197.33	4.24	0.04
p(subs), psi(Max_fetch)	7	180.92	197.59	4.49	0.03
p(temp), psi(Max_fetch)	4	188.80	197.68	4.59	0.03
p(subs), psi(NW_fetch)	7	181.27	197.94	4.84	0.03
p(temp), psi(subs)	7	181.59	198.26	5.16	0.02
p(temp), psi(.)	3	191.86	198.39	5.29	0.02
p(subs), psi(temp)	7	182.17	198.84	5.74	0.02
p(temp), psi(pH)	4	190.25	199.13	6.04	0.01
p(temp), psi(DO)	4	190.38	199.27	6.17	0.01
p(temp), psi(S_fetch)	4	191.05	199.94	6.85	0.01
p(cover), psi(.)	4	191.23	200.12	7.02	0.01
p(subs), psi(.)	6	186.42	200.38	7.28	0.01
p(temp), psi(turb)	4	191.56	200.45	7.35	0.01
p(cover), psi(pH)	5	190.17	201.53	8.44	0.00
p(cover), psi(DO)	5	190.32	201.69	8.59	0.00
p(cover), psi(S_fetch)	5	190.75	202.11	9.02	0.00
p(cover), psi(turb)	5	190.80	202.16	9.07	0.00
p(temp), psi(cover)	5	190.91	202.28	9.18	0.00
p(subs), psi(DO)	7	185.62	202.29	9.19	0.00
p(subs), psi(pH)	7	185.85	202.52	9.42	0.00
p(cover), psi(cover)	6	188.92	202.87	9.78	0.00
p(subs), psi(turb)	7	186.40	203.07	9.97	0.00
p(subs), psi(S_fetch)	7	186.41	203.08	9.98	0.00
p(subs), psi(subs)	10	177.53	203.17	10.08	0.00
p(subs), psi(cover)	8	186.18	205.69	12.60	0.00
Global	26	135.70	248.75	55.65	0.00

^aCovariates described in Table 2-1 unless otherwise noted.

Table 2-7. Occupancy probability models given best detection probability model for adult walleye at Red Willow Reservoir, Nebraska during spring 2008. p(covariate) indicates covariate by which detection probability varies and psi(covariate) indicates covariate by which occupancy probability varies. The global model includes all covariates for both detection and occupancy probabilities.

Model ^a	# of parameters	-2 log likelihood	AICc	ΔAICc	Akaike ω
p(subs), psi(woody_cover) ^b	5	75.69	87.06	0.00	0.63
p(subs), psi(subs)	6	75.00	88.96	1.90	0.24
p(subs), psi(temp)	5	81.75	93.12	6.06	0.03
p(subs), psi(pH)	5	82.06	93.42	6.36	0.03
p(subs), psi(NW_fetch)	5	82.29	93.65	6.60	0.02
p(subs), psi(DO)	5	83.12	94.48	7.43	0.02
p(subs), psi(Max_fetch)	5	83.39	94.75	7.69	0.01
p(subs), psi(.)	4	86.50	95.38	8.33	0.01
p(subs), psi(S_fetch)	5	86.28	97.64	10.59	0.00
p(subs), psi(turb)	5	86.32	97.69	10.63	0.00
Global	20	49.90	118.86	31.81	0.00

^aCovariates described in Table 2-1 unless otherwise noted.

^bReduced to the presence of woody cover due to model convergence issues.

Table 2-8. Summary of walleye egg catches at Enders and Red Willow reservoirs, Nebraska during spring 2008.

Reservoir	Date Collected	Site #	Depth (m)	Count
Enders	04/03/2008	34	0.5	15
			1.0	38
	04/13/2008	34	0.5	6
			1.0	2
Red Willow	04/04/2008	34	0.5	11
			1.0	5
	04/04/2008	35	1.0	18
			1.0	34

Table 2-9. Detection probability models for larval walleye at Enders Reservoir, Nebraska during spring 2008. p(covariate) indicates covariate by which detection probability varies.

Model ^a	# of parameters	-2 log likelihood	AICc	Δ AICc	Akaike ω
p(woody_cover), psi(.) ^b	3	53.23	59.75	0.00	0.78
p(.), psi(.)	2	59.61	63.87	4.12	0.10
p(t), psi(.)	5	53.83	65.19	5.44	0.05
p(temp), psi(.)	3	59.14	65.66	5.91	0.04
p(turb), psi(.)	3	59.61	66.13	6.38	0.03

^aCovariates described in Table 2-1 unless otherwise noted.

^bReduced to the presence of woody cover due to model convergence issues.

Table 2-10. Estimates of covariate effect size (β) and standard error (SE), odds ratio, and 95% confidence limits on odds ratio for larval walleye at Enders Reservoir, Nebraska during spring 2008. Covariates are ordered from the best-fitting to worst-fitting by AICc values from the suite of best models.

Parameter	Covariate	β		Odds Ratio ^a	Odds Ratio CLs	
		Estimate	SE		Lower	Upper
p	Woody Cover	-2.04	0.86	0.13 ^b	0.02	0.70
psi	Max Fetch (km)	935.17	38472.98	^c	^c	^c
	No Cover	43.75	597.79	1.00×10^{19d}	^c	^c
	Woody Cover	21.69	111.59	2.63×10^{9d}	2.71×10^{-86}	2.55×10^{104}

^aOdds ratios >1.0 indicate an increase in probability of detection or occupancy with a 1.0-unit increase in the covariate unless otherwise noted.

^bOdds ratio calculated as the increase in detection probability relative to the baseline detection probability (intercept) estimated at sites with no cover.

^cNo odds ratio or CL were calculated because SE of estimate was too large.

^dOdds ratio calculated as the increase in occupancy probability relative to the baseline occupancy probability (intercept) estimated at sites with emergent cover.

Table 2-11. Occupancy probability models given best detection probability model for larval walleye at Enders Reservoir, Nebraska during spring 2008. p(covariate) indicates covariate by which detection probability varies and psi(covariate) indicates covariate by which occupancy probability varies. The global model includes all covariates for both detection and occupancy probabilities.

Model ^a	# of parameters	-2 log likelihood	AICc	Δ AICc	Akaike ω
p(.), psi(Max_fetch/1000) ^b	3	53.15	59.68	0.00	0.53
p(.), psi(cover)	4	52.75	61.64	1.96	0.20
p(.), psi(.)	2	59.61	63.87	4.19	0.07
p(.), psi(S_fetch)	3	57.96	64.48	4.81	0.05
p(.), psi(pH)	3	58.57	65.09	5.42	0.04
p(.), psi(NW_fetch)	3	58.90	65.42	5.75	0.03
p(.), psi(temp)	3	58.94	65.46	5.79	0.03
p(.), psi(turb)	3	59.36	65.88	6.21	0.02
p(.), psi(DO)	3	59.54	66.06	6.39	0.02
p(.), psi(subs)	6	53.45	67.40	7.73	0.01
Global	26	39.56	152.60	92.39	0.00

^aCovariates described in Table 2-1 unless otherwise noted.

^bReduced to maximum fetch in km due to model convergence issues.

Table 2-12. Detection probability models for adult white bass at Red Willow Reservoir, Nebraska during spring 2008. p(covariate) indicates covariate by which detection probability varies.

Model ^a	# of parameters	-2 log likelihood	AICc	Δ AICc	Akaike ω
p(woody_cover), psi(.) ^b	3	129.25	135.77	0.00	0.31
p(silt_subs), psi(.) ^c	3	129.71	136.23	0.46	0.25
p(t), psi(.)	5	125.74	137.11	1.34	0.16
p(.), psi(.)	2	133.29	137.54	1.77	0.13
p(turb), psi(.)	3	132.63	139.15	3.38	0.06
p(temp), psi(.)	3	133.19	139.71	3.94	0.04
p(cond), psi(.)	3	133.29	139.81	4.03	0.04

^aCovariates described in Table 2-1 unless otherwise noted.

^bReduced to the presence of woody cover due to model convergence issues.

^cReduced to the presence of silt substrate due to model convergence issues.

Table 2-13. Estimates of covariate effect size (β) and standard error (SE), odds ratio, and 95% confidence limits on odds ratio for adult white bass at Red Willow reservoir, Nebraska during spring 2008. Covariates are ordered from the best-fitting to worst-fitting by AICc values from the suite of best models.

Parameter	Covariate	β		Odds Ratio ^a	Odds Ratio CLs	
		Estimate	SE		Lower	Upper
p	Woody Cover	26.03	78.71	2.02×10^{11b}	2.02×10^{-56}	2.01×10^{78}
	Silt	1.78	1.09	5.93^b	0.700	50.219
	Null Model	^d				
	Null Model	^d				
psi	No Cover	-25.62	172.98	0.00^e	4.26×10^{-159}	1.31×10^{136}
	Null Model	^d				
	Silt	1.25	1.61	3.49	0.149	81.908
	Rock	-25.86	0.43	0.00^f	2.53×10^{-12}	1.37×10^{-11}
	NW Fetch (m)	-0.00066	0.00063	1.00	0.998	1.001

^aOdds ratios >1.0 indicate an increase in probability of detection or occupancy with a 1.0-unit increase in the covariate unless otherwise noted.

^bOdds ratio calculated as the increase in detection probability relative to the baseline detection probability (intercept) estimated at sites with woody cover.

^cOdds ratio calculated as the increase in detection probability relative to the baseline detection probability (intercept) estimated at sites with no silt substrate.

^dNo estimates were calculated for null models.

^eOdds ratio calculated as the increase in occupancy probability relative to the baseline occupancy probability (intercept) estimated at sites with cover present.

^fOdds ratio calculated as the increase in occupancy probability relative to the baseline occupancy probability (intercept) estimated at sites with cobble substrate.

Table 2-14. Occupancy probability models given best detection probability model for adult white bass at Red Willow Reservoir, Nebraska during spring 2008. P(covariate) indicates covariate by which detection probability varies and psi(covariate) indicates covariate by which occupancy probability varies. The global model includes all covariates for both detection and occupancy probabilities.

Model ^a	# of parameters	-2 log likelihood	AICc	Δ AICc	Akaike ω
p(.), psi(no_cover) ^b	3	130.30	136.82	0.00	0.21
p(.), psi(.)	2	133.29	137.54	0.72	0.15
p(.), psi(subs)	4	128.74	137.63	0.81	0.14
p(.), psi(NW_fetch)	3	132.10	138.62	1.79	0.09
p(.), psi(COVE) ^c	3	132.37	138.89	2.07	0.07
p(.), psi(S_fetch)	3	132.61	139.14	2.31	0.07
p(.), psi(DO)	3	132.71	139.24	2.41	0.06
p(.), psi(Max_fetch)	3	132.74	139.26	2.44	0.06
p(.), psi(turb)	3	132.76	139.28	2.46	0.06
p(.), psi(temp)	3	133.28	139.81	2.98	0.05
p(.), psi(pH)	3	133.29	139.81	2.98	0.05
Global	24	109.97	205.97	69.15	0.00

^aCovariates described in Table 2-1 unless otherwise noted.

^bReduced to the absence of cover due to model convergence issues.

^cCovariate added *post hoc* because of observed distribution of white bass captured.

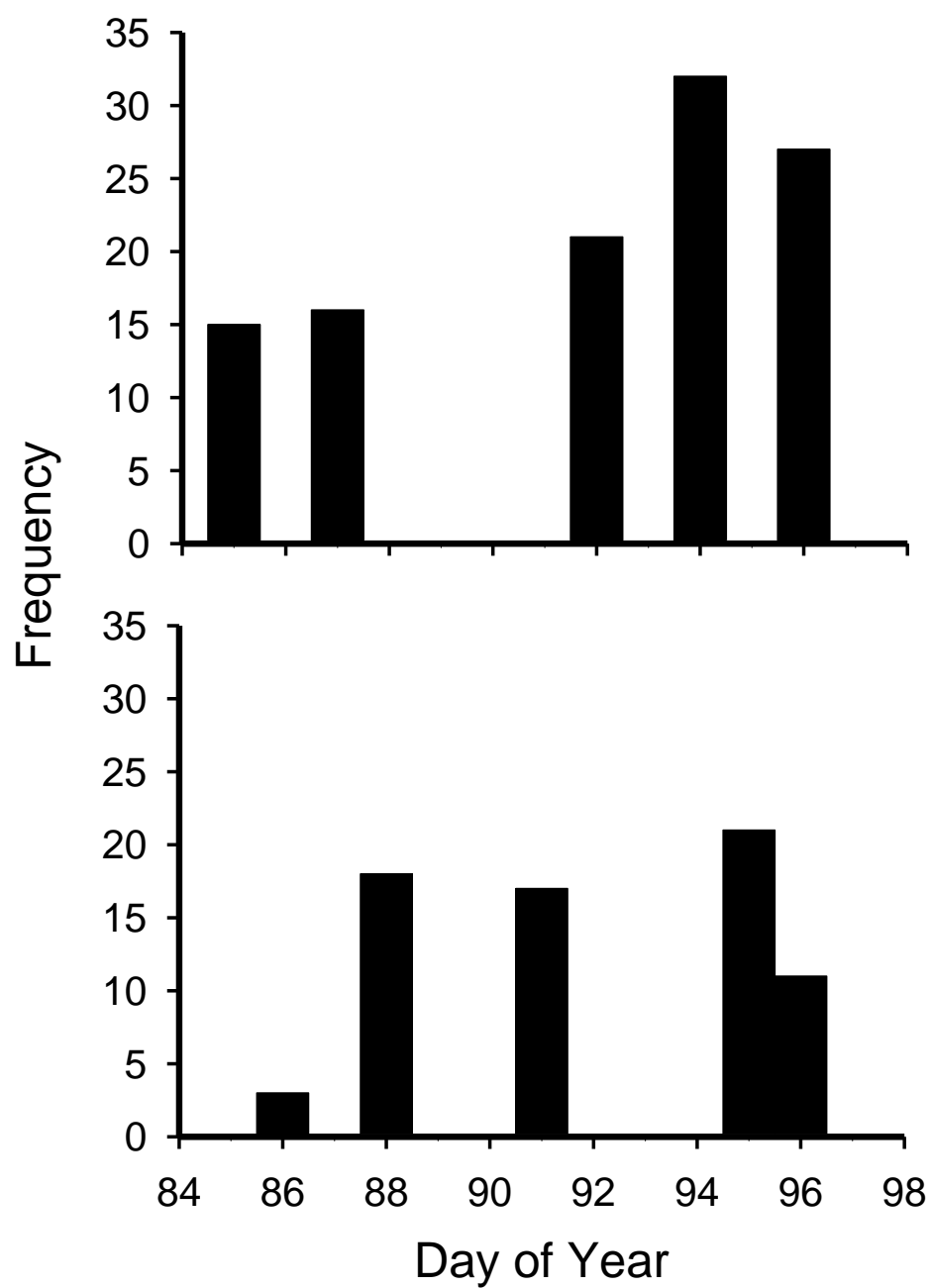


Figure 2-1. Total number of adult walleye caught using electrofishing by ordinal date in spring 2008 at Enders Reservoir (top panel) and Red Willow Reservoir (bottom panel), Nebraska.

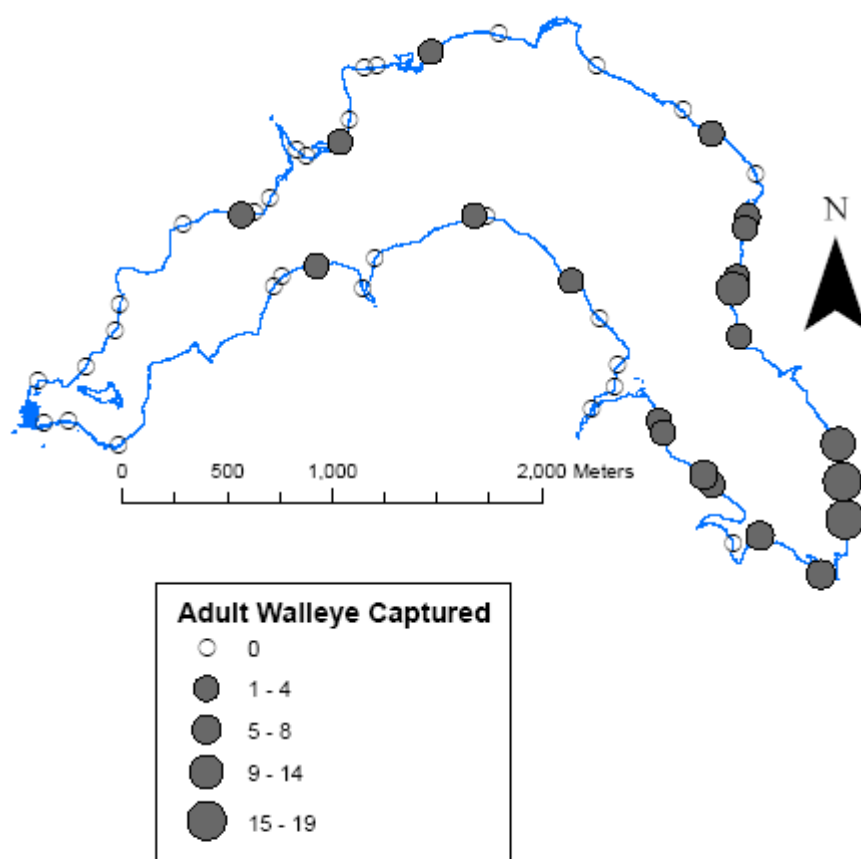


Figure 2-2. Spatial distribution of adult walleye captured using electrofishing during spring 2008 at Enders Reservoir, Nebraska. Increasing circle diameter indicates greater number of walleye captured.

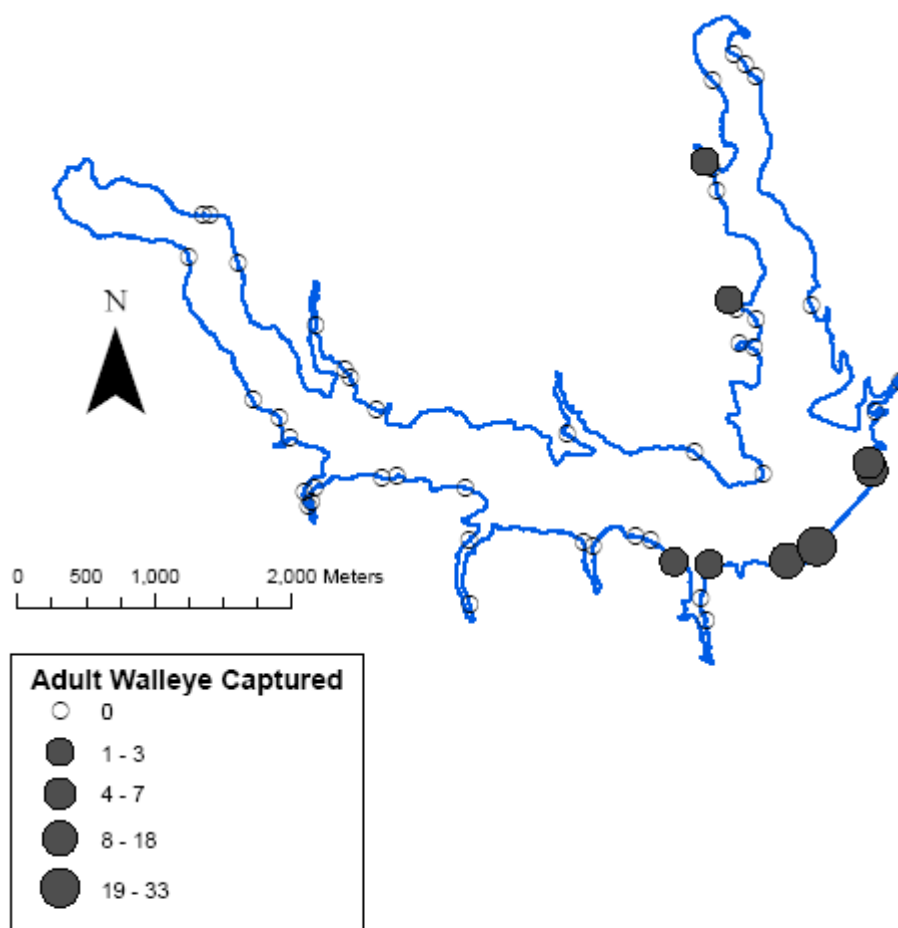


Figure 2-3. Spatial distribution of adult walleye captured using electrofishing during spring 2008 at Red Willow Reservoir, Nebraska. Increasing circle diameter indicates greater number of walleye captured.

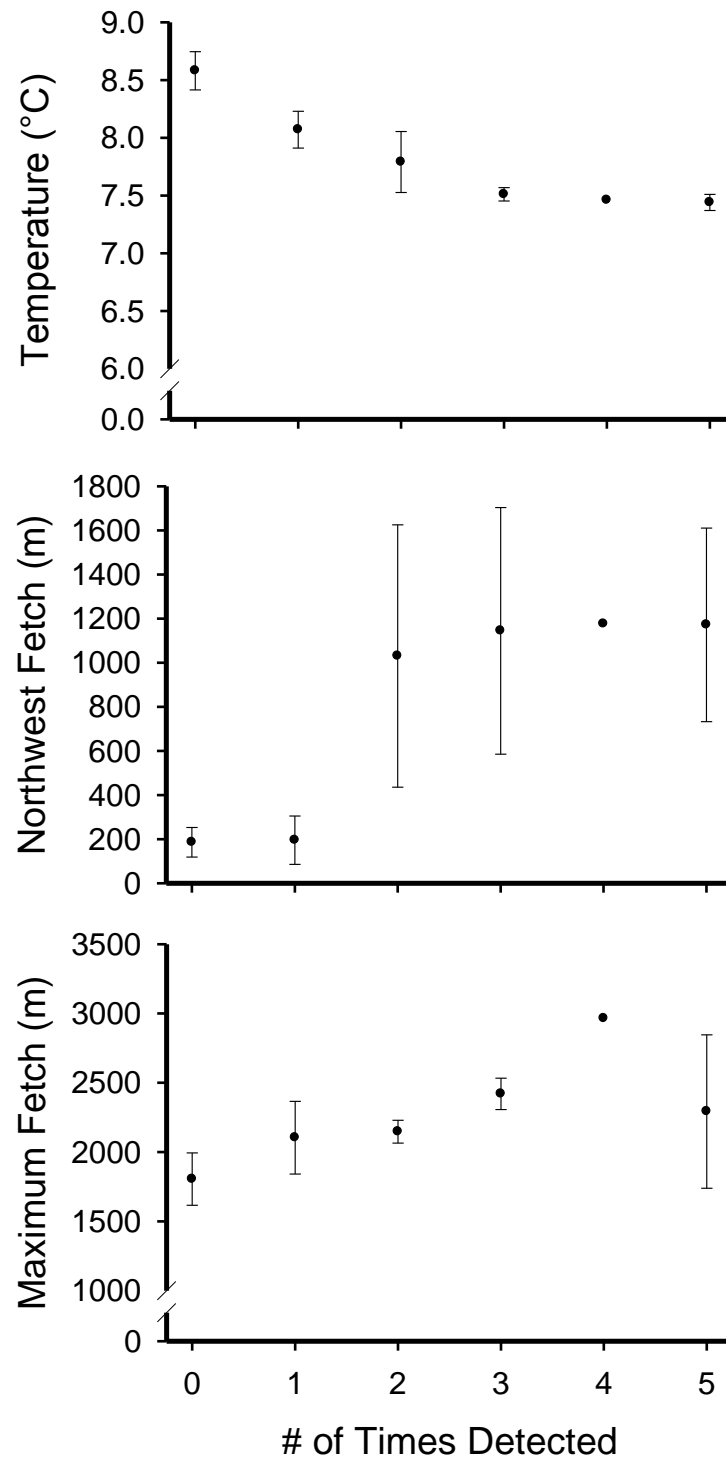


Figure 2-4. Mean \pm SE water temperature ($^{\circ}$ C), northwest fetch (m), and maximum fetch (m) as a function of the number of times walleye were detected at each site at Enders Reservoir, Nebraska during spring 2008. No error bars shown for site ($N = 1$) in which walleye were detected four times.

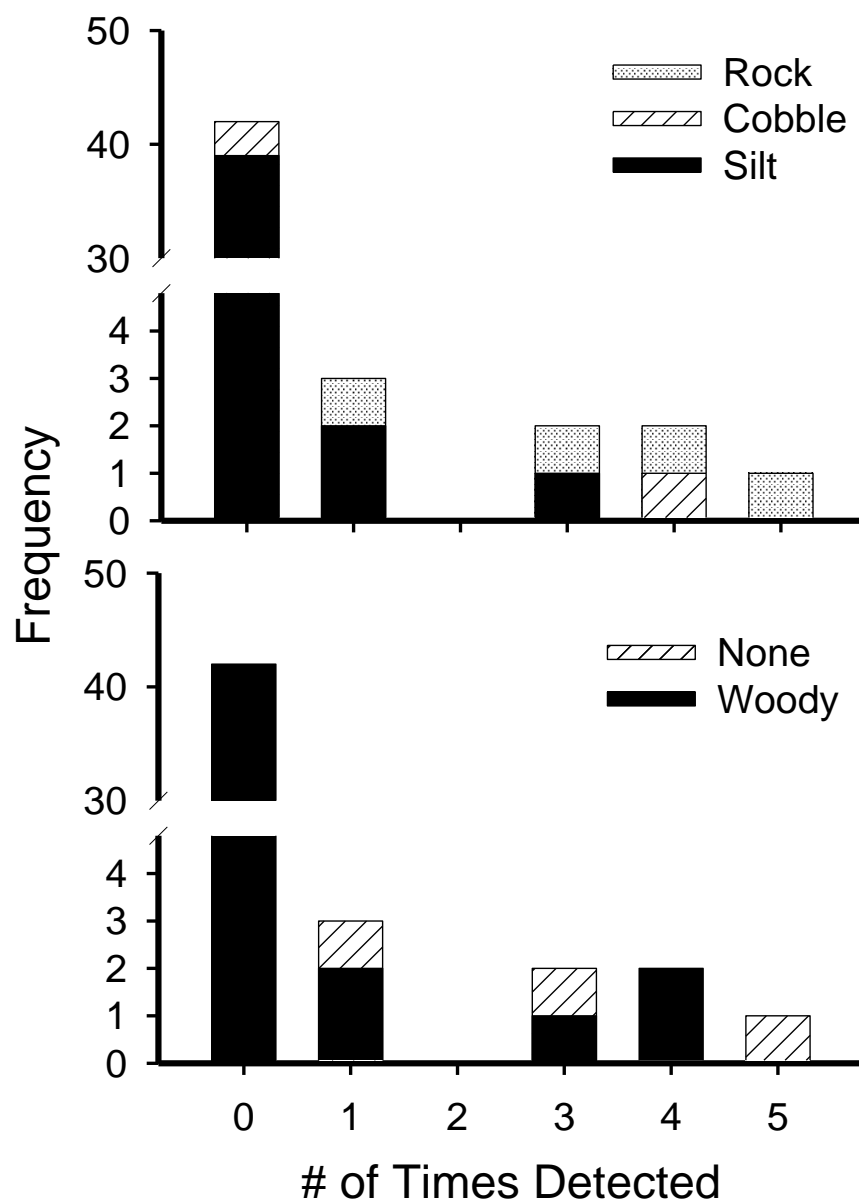


Figure 2-5. Cover type (top panel) and substrate type (bottom panel) as a function of the number of times walleye were detected at each site at Red Willow Reservoir, Nebraska during spring 2008.

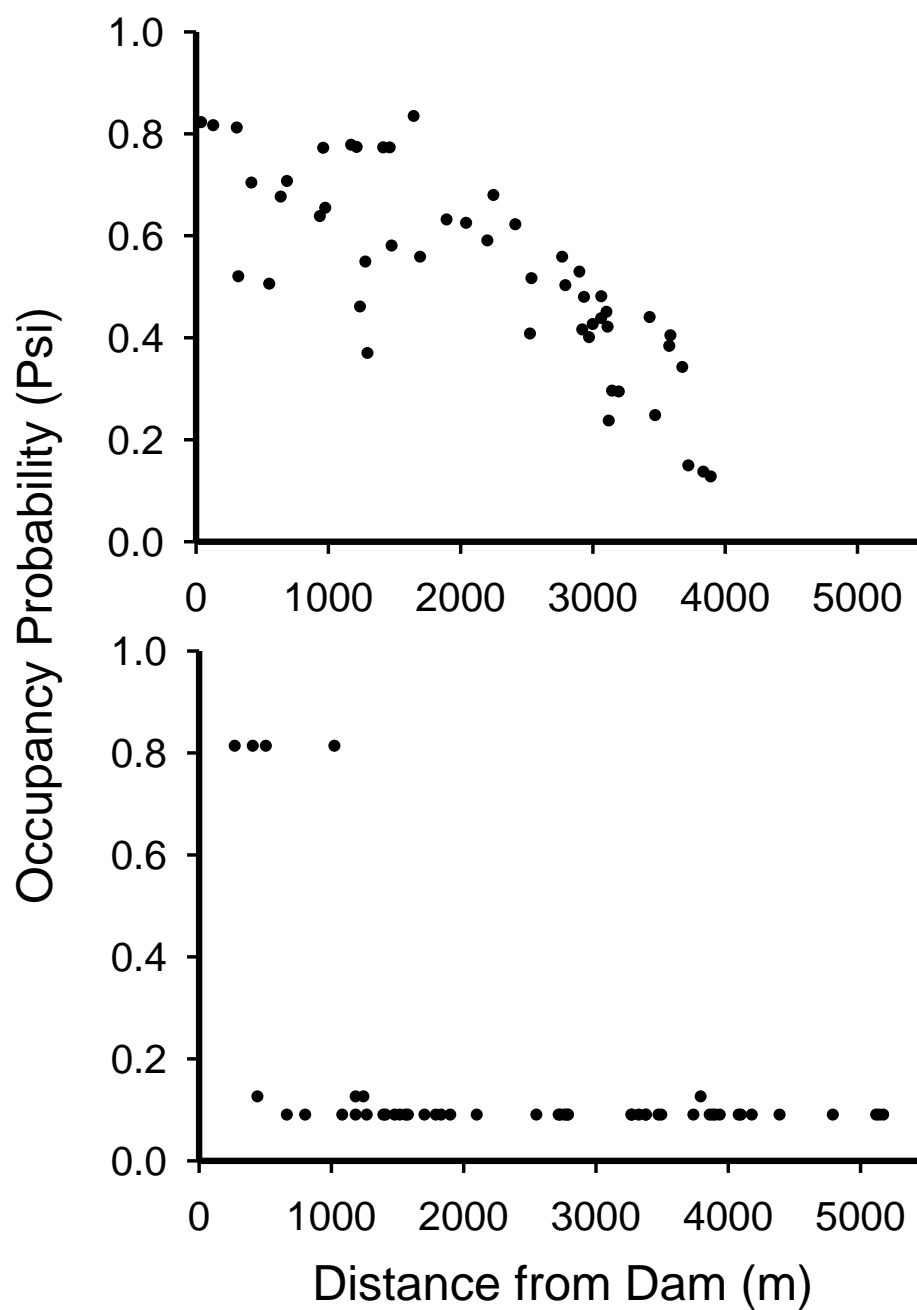


Figure 2-6. Model-averaged occupancy estimates for adult walleye at sites as a function of distance from the midpoint of the dam (m) at Enders Reservoir (top panel) and Red Willow Reservoir (bottom panel), Nebraska during spring 2008.

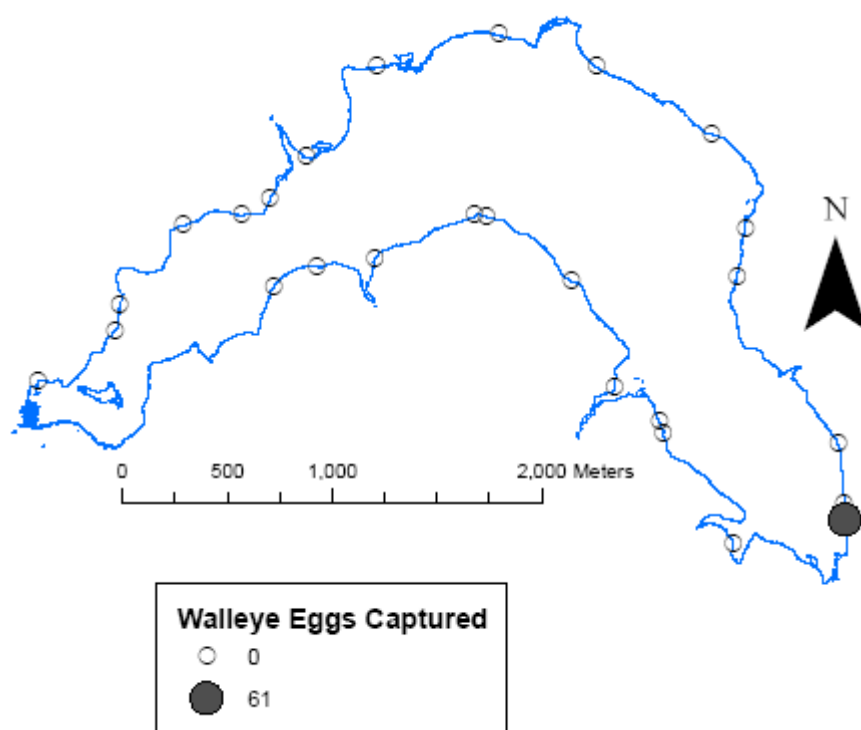


Figure 2-7. Spatial distribution of walleye eggs collected using egg mats during spring 2008 at Enders Reservoir, Nebraska. Increasing circle diameter indicates greater number of walleye eggs collected.

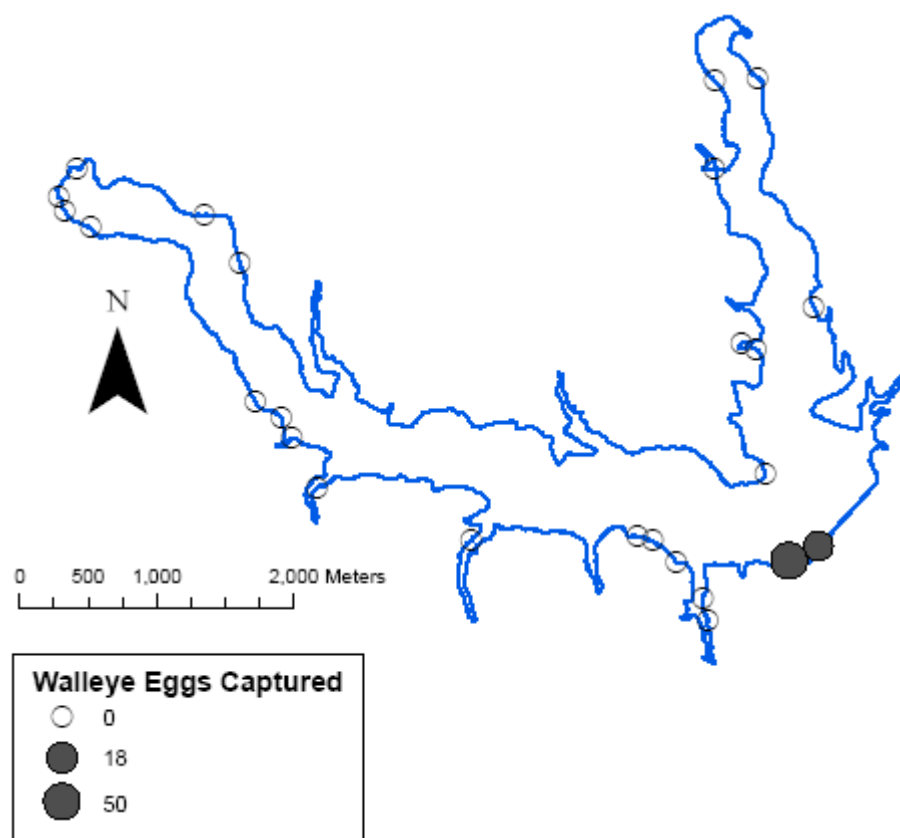


Figure 2-8. Spatial distribution of walleye eggs collected using egg mats during spring 2008 at Red Willow Reservoir, Nebraska. Increasing circle diameter indicates greater number of walleye eggs collected.

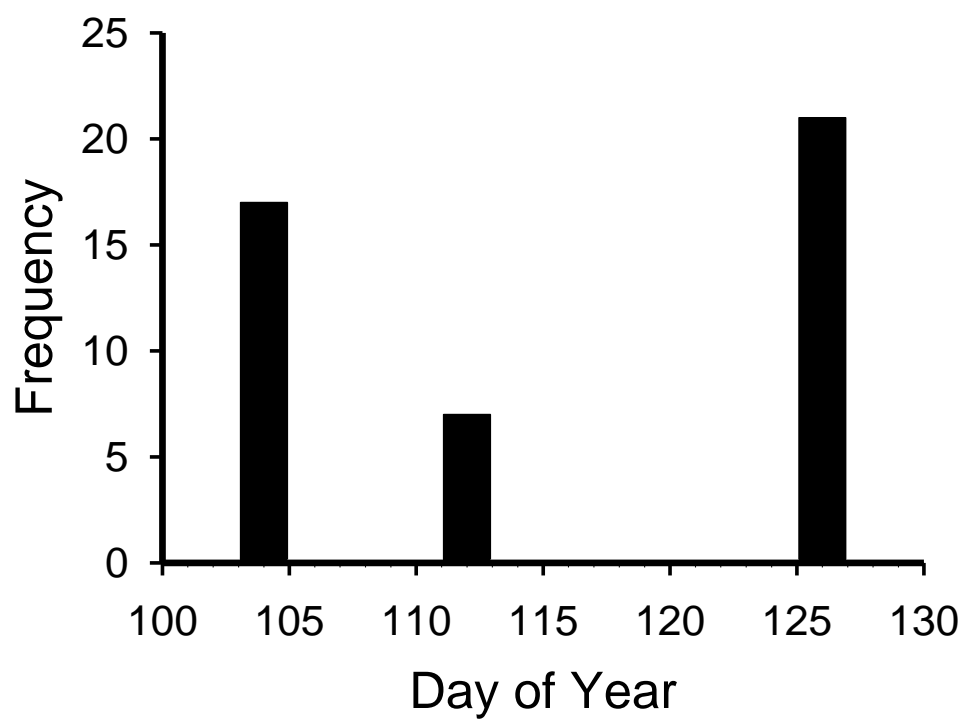


Figure 2-9. Total number of larval walleye captured using light traps by ordinal date during spring 2008 at Enders Reservoir, Nebraska.

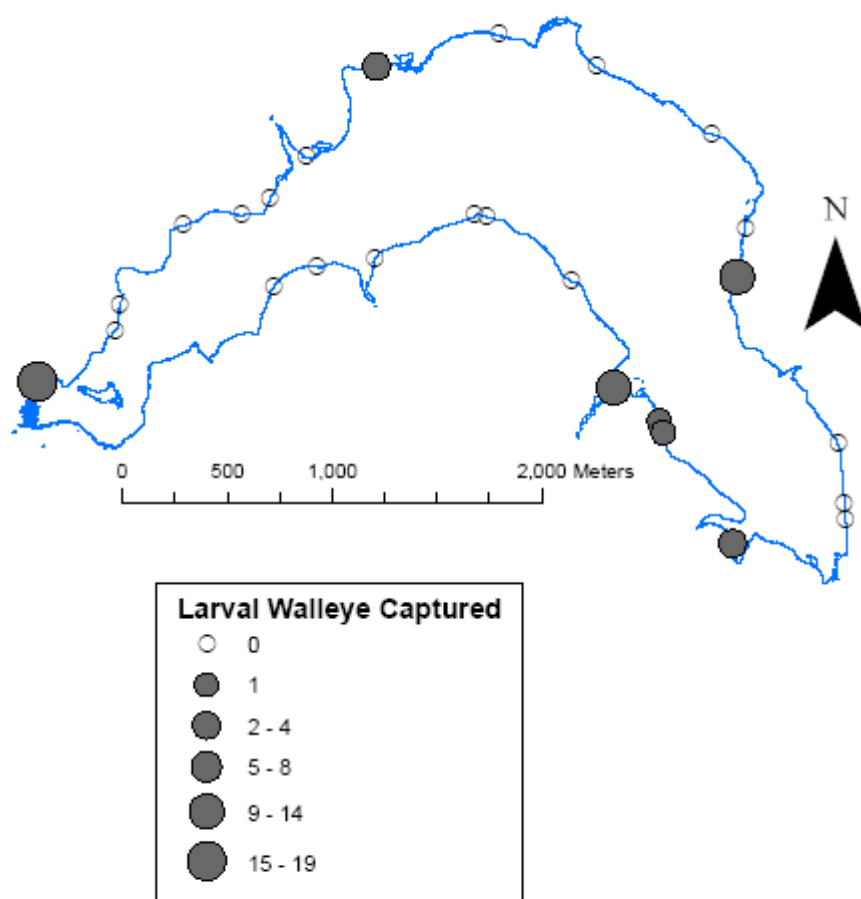


Figure 2-10. Spatial distribution of larval walleye captured using light traps during spring 2008 at Enders Reservoir, Nebraska. Increasing circle diameter indicates greater number of walleye captured.

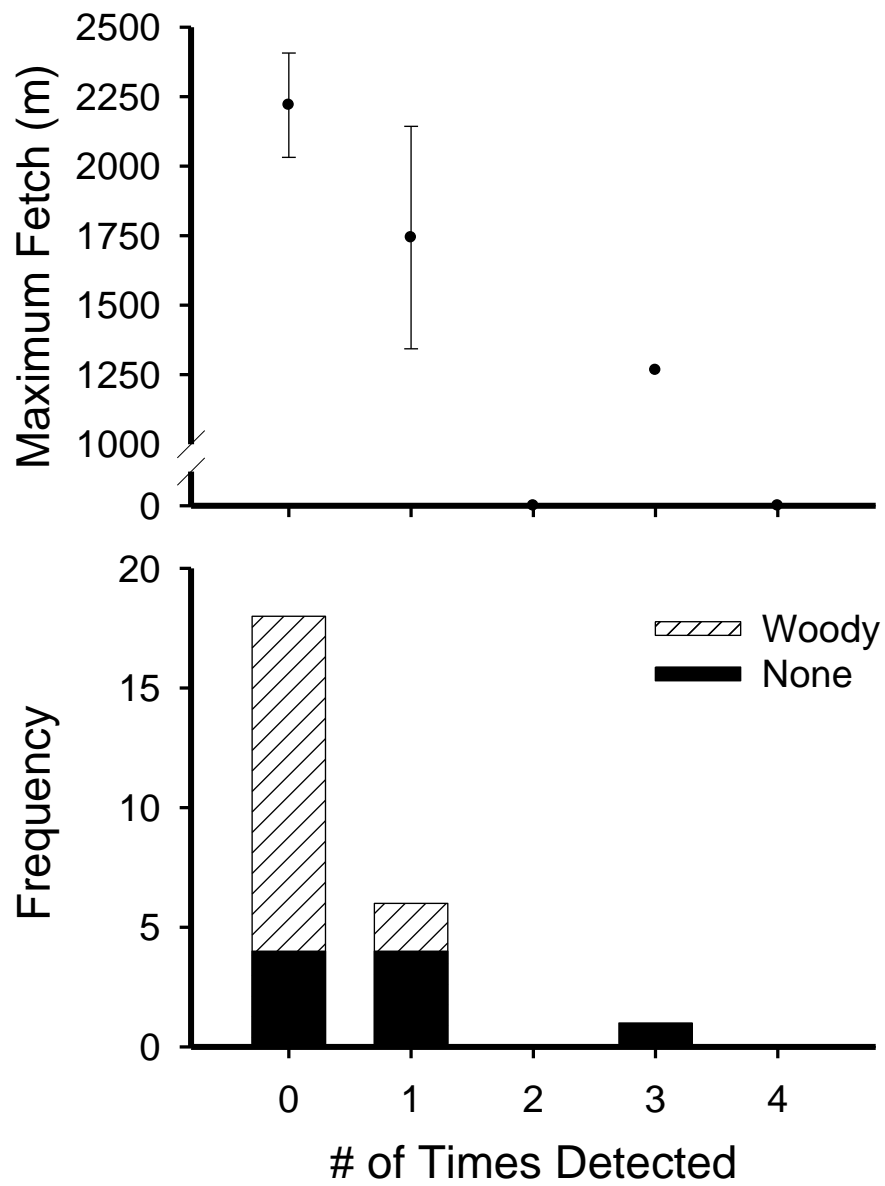


Figure 2-11. Mean \pm SE maximum fetch (m) (top panel) and frequency of cover types (bottom panel) as a function of the number of times larval walleye were detected out of a possible four times at each site at Enders Reservoir, Nebraska during spring 2008.

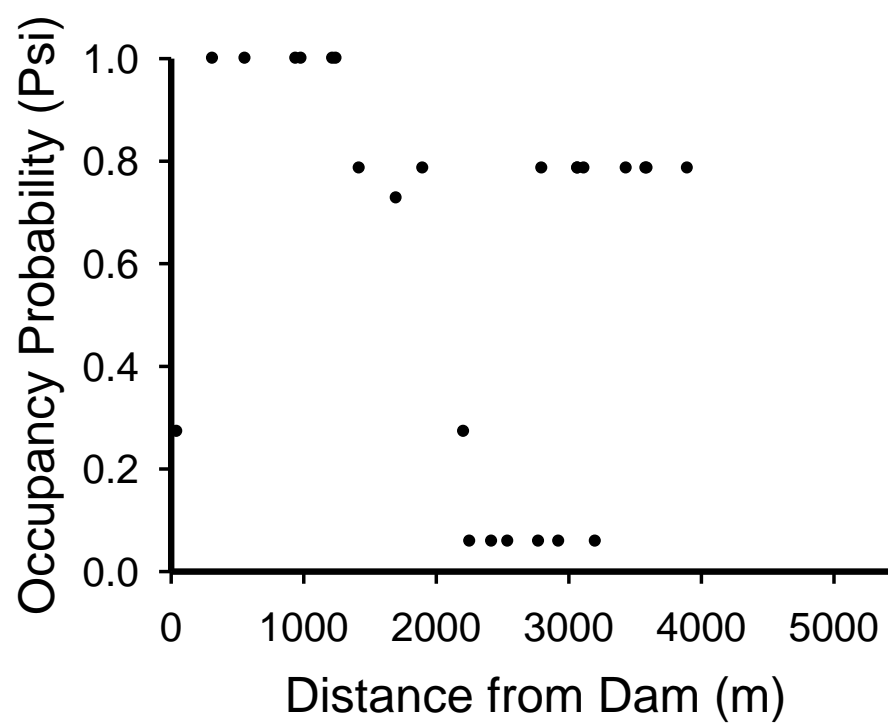


Figure 2-12. Model-averaged occupancy estimates for larval walleye at sites as a function of distance from the midpoint of the dam (m) at Enders Reservoir, Nebraska during spring 2008.

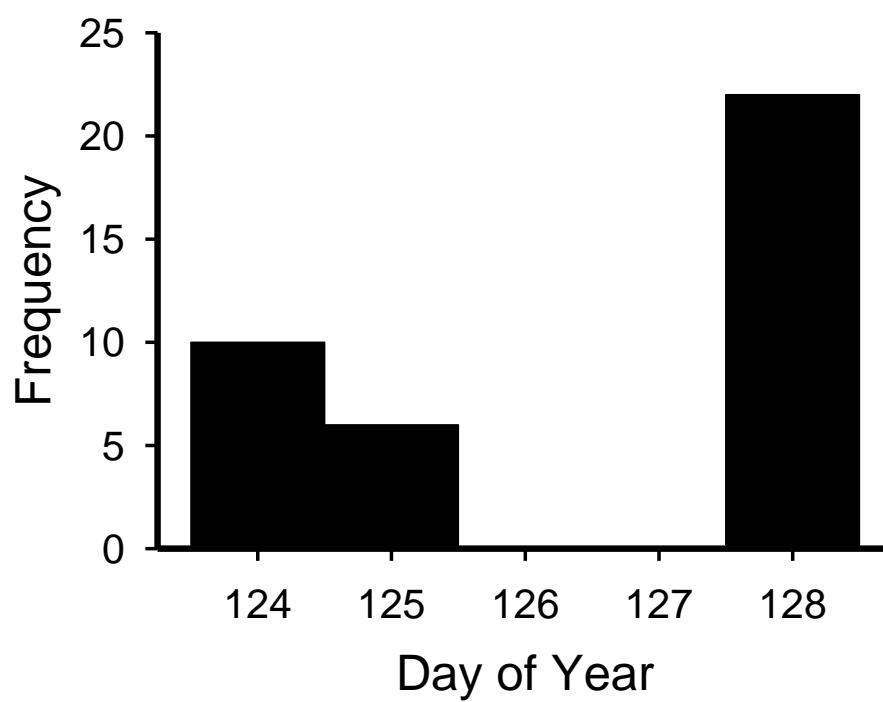


Figure 2-13. Total number of adult white bass captured using electrofishing by ordinal date during spring 2008 at Enders Reservoir, Nebraska.

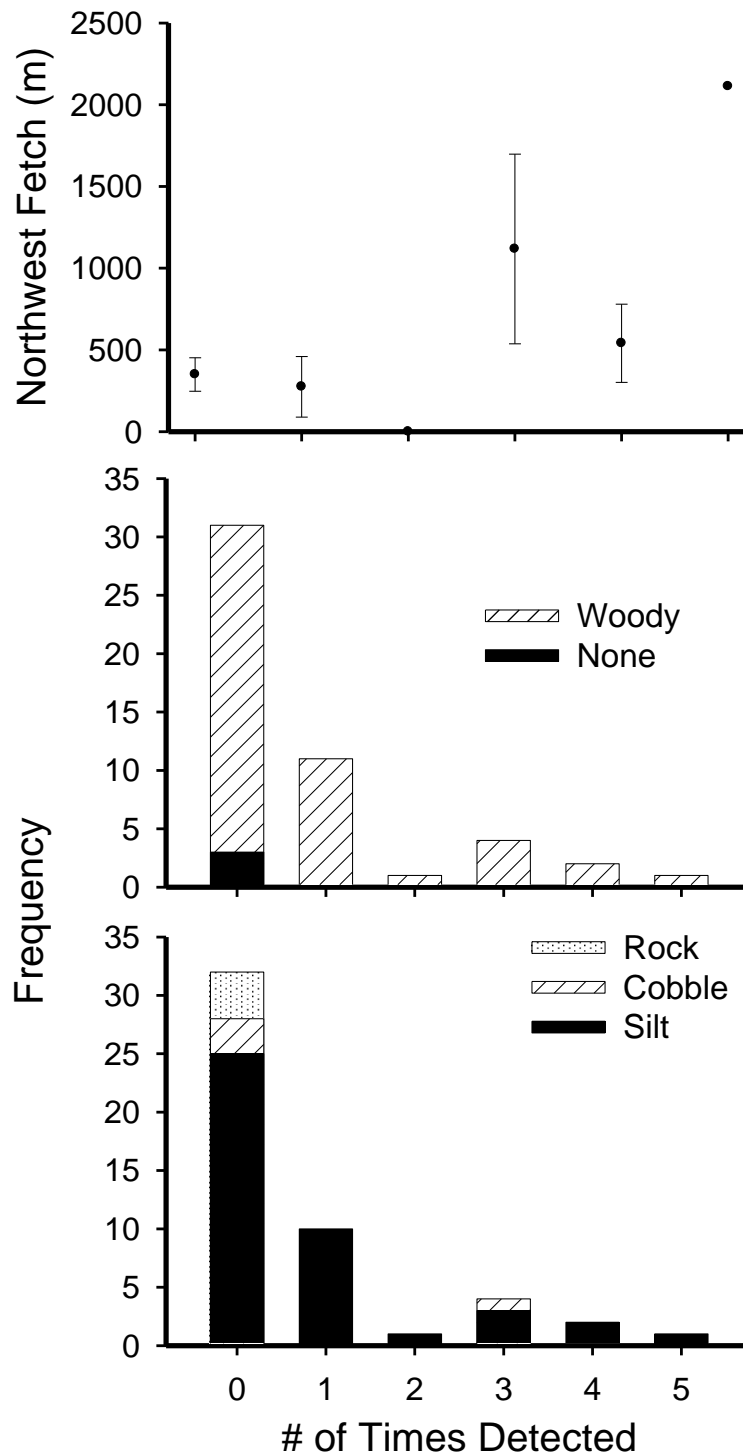


Figure 2-14. Mean \pm SE northwest fetch (m; top panel), frequency of cover type (middle panel), and frequency of substrate type (bottom panel) as a function of the number of times adult white bass were detected at each site at Red Willow Reservoir, Nebraska during spring 2008.

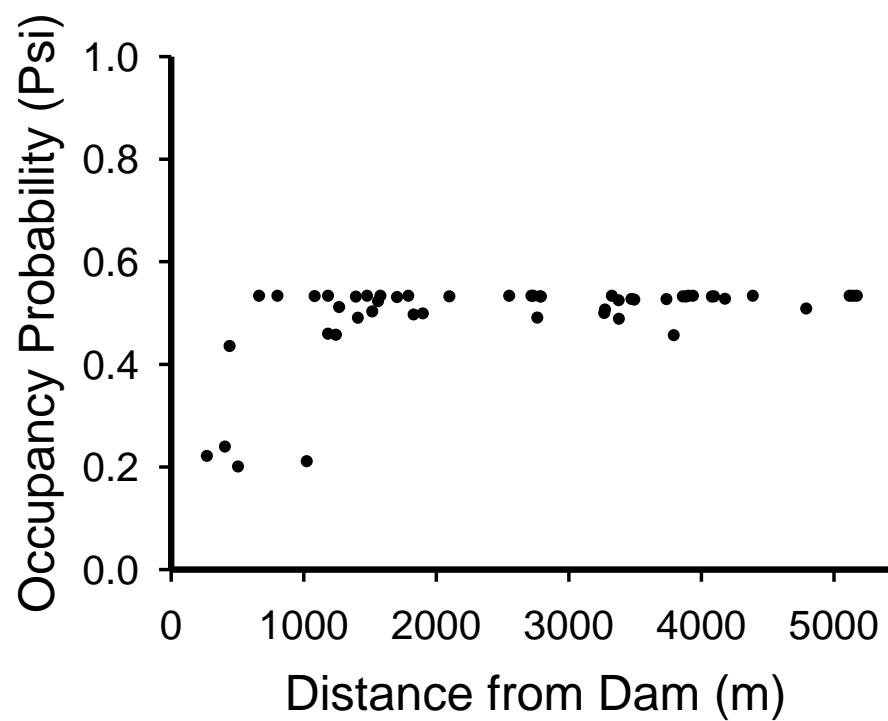


Figure 2-15. Model-averaged occupancy estimates for adult white bass at sites as a function of distance from the midpoint of the dam (m) at Red Willow Reservoir, Nebraska during spring 2008.

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Chapter 3. Spring Movements of Walleye and White Bass in Irrigation Reservoirs in Southwest Nebraska

Introduction

An understanding of essential habitat (Langton et al. 1996) and movements related to spawning is needed for better management of important gamefish like walleye *Sander vitreus* and white bass *Morone chrysops*. Adult walleye selected habitats with large substrate, large fetch, cool temperature, and absence of cover for spawning in irrigation reservoirs of southwestern Nebraska (Chapter 2). This essential habitat is only available in the lacustrine zone of both Enders and Red Willow reservoirs. Information on essential habitat of white bass for spawning in irrigation reservoirs is nonexistent.

In addition to describing habitat selection using patch occupancy models, movements of individual fish in relation to spawning activity can be documented using acoustic telemetry. For example, telemetry was used to identify spawning habitats of Atlantic salmon *Salmo salar* (Johnsen and Hvidsten 2002), lake trout *Salvelinus namaycush* (Flavelle et al. 2002), lake whitefish *Coregonus clupeaformis* (Begout Anras et al. 1999), paddlefish *Polyodon spathula* (Zigler et al. 2003), sauger *Sander canadensis* (Kuhn et al. 2008), and walleye (DePhilip et al. 2005). Telemetry provides an opportunity to frequently record the location of an individual fish and hence determine movement patterns; however, the intensity of tracking and tag battery life determine the number of spatial data points that can be collected with telemetry.

The objectives of this study were to: 1) determine locations of tagged walleye and white bass throughout the spring, and 2) document any suspected spawning sites of walleye and white bass. Results of this acoustic telemetry provided further support for

spawning habitat selection models that were developed for both adult walleye and white bass (Chapter 2). My *a priori* research hypothesis was:

Abundance of adult fish (walleye and white bass) during the primary spawning period is greatest in habitats with large substrates, depths less than 1.5 m, and large maximum fetch.

Spawning habitats with large substrates, shallow depths, and large maximum fetch may increase dissolved oxygen concentration and decrease siltation on eggs, and thus, increase egg survival rate to hatching (Johnson 1961; Scott 1967; Becker 1983; Pflieger 1997).

Study Area

Enders Reservoir is an irrigation reservoir constructed on Frenchmen Creek, in southwestern Nebraska, by the U.S. Bureau of Reclamation in 1951. At conservation-pool, Enders Reservoir has a water level of 948.5 m above mean sea level, surface area of 485 ha and maximum depth of 18.3 m. The shoreline is mostly composed of a silt/sand substrate with a few areas of natural rock near the riprap dam. Small cottonwood trees *Populus deltoides* dominate the shoreline cover.

Red Willow (Hugh Butler Lake) reservoir is an irrigation reservoir constructed on Red Willow Creek, in southwestern Nebraska, by the U.S. Bureau of Reclamation in 1962. At conservation-pool, Red Willow reservoir has a water level of 786.9 m above mean sea level, surface area of 660 ha, and maximum depth of 15.2 m. Red Willow reservoir has two inflow sources creating a branched reservoir with two arms: Spring Creek to the north and Red Willow Creek to the west. The shoreline is mostly composed

of silt substrate with a few areas of natural rock near the riprap dam. Small cottonwood trees also dominate the shoreline, with areas of large, dead trees found in the upper reaches of the Spring Creek arm.

Methods

Thirty adult walleye and thirty adult white bass (15 of each species at both Enders and Red Willow reservoirs) were implanted with Sonotronics ultrasonic tags (model IBT-96-9-1) during autumn 2006 (Table 3-1) and again during autumn 2007 (Table 3-2). Transmitter tags (42-mm long, 10.5-mm diameter, 3.9-g weight in water, $\leq 1\%$ body weight) were implanted using techniques described by Hart and Summerfelt (1975). Tags had a manufacturer's battery life expectancy of 9 months. Walleye and white bass were tagged to study spring movement patterns and identify spawning locations in Enders and Red Willow reservoirs.

Attempts to locate tagged fish were made weekly during spring 2007 and 2008. A typical sampling attempt consisted of a period of 12 h with days split into morning (03:00-15:00 hours) and evening (15:00-03:00 hours) sessions. Tracking attempts ended on 29 May 2007 and 2 June 2008 due to loss of tag battery life. During each sampling attempt, I systematically worked around the reservoir stopping about every 300 m to scan (cycling through all frequencies with the directional hydrophone pointed at 0, 60, 120, 180, 240, 300, and 360°) for tags. Once a tag was detected, I maintained a constant frequency while moving the boat to pinpoint the location of the fish. After pinpointing a fish, I continued the systematic search. At least three laps of the reservoir were completed during each sampling event; i.e., I attempted to locate each fish every 4 hours within a sampling period.

Geographical coordinates were recorded with a Garmin eTrex GPS unit at each fish location and habitat characteristics were measured. Water quality measurements were taken at 0.5-m depth and included: temperature, turbidity, dissolved oxygen, pH, and conductivity. Other habitat characteristics included: depth, cover type (none, woody, submerged, emergent), and substrate type (silt, sand, gravel, cobble, rock). Depth was measured using a boat-mounted depth finder, cover type was visually assessed, and substrate type was assessed using a 102-mm diameter metal tube sampler. Habitat characteristics were recorded to determine influential variables in habitat selection by walleye and white bass. Locations were mapped using ArcMap version 9.3 (ESRI, Inc., 2008) and compared to bathymetric maps of the reservoirs created with data from the Lake Mapping Program of the Nebraska Game and Parks Commission.

Results

Walleye

Enders Reservoir

During 2007, 14 of the 15 tagged walleye were located 84 times during the spring sampling period; the number of locations per fish ranged from two to 12. During 2008, 13 of the 15 tagged walleye were located 251 times during the spring sampling period; the number of locations per fish ranged from one to 27. The majority of tagged walleye were located weekly from early March through mid-April 2007 and 2008.

Walleye at Enders Reservoir with greater than five locations (chosen as minimum number of locations needed to draw movement conclusions) can be split into three groups based on the amount of reservoir occupied during spring 2007 and 2008. The first group

(#43 and #61; Figures 3-1 and 3-2) had spring movements restricted to the upper half of the reservoir. Both fish stayed in an area with a relatively flat bottom and gradually sloping shorelines of silt substrate and small woody trees.

The second group had spring movements restricted to the lower half of the reservoir and can be subdivided into two sets based on locations during the primary spawning period of mid- to late-March. The first subset (#57 and #156; Figures 3-3 and 3-4) was located on or near the dam during the primary spawning period, whereas the second subset (#62, #63, #160, #172, and #182; Figures 3-5 through 3-9) was located throughout the lower half of the reservoir during the primary spawning period. These fish exhibited a more exploratory behavior roaming the lower reservoir during the primary spawning period.

The third group had spring movements extending across most of the reservoir and can be subdivided based on locations during the primary spawning period. The first subset (#54, # 69, #158, #162, and #181; Figures 3-10 through 3-14) was located on or near the dam during the primary spawning period and had both pre- and post-spawn migrations. For example, walleye #158 trekked toward the riverine portion of the reservoir following a brief (1 d) increase in inflow during the spawning period, and then returned to the dam. The second subset (#130 and #174; Figures 3-15 and 3-16) was located along the steep, natural rock shoreline of the lower reservoir during the primary spawning period. The third subset (#61, #121, and #131; Figures 3-17 and 3-19) was located throughout the lower reservoir during the primary spawning period and exhibited a more exploratory behavior.

Locations were few ($N \leq 5$) for 12 tagged walleye (Figures 3-20 through 3-22). Angler harvest of one of these walleye in January 2008 prevented further locations. Causes of the limited relocations are potentially numerous and unknown. Thus, no conclusions are made about movements of these fish. Locations of four walleye (#45, #59, #60, and #65; Figure 20) with few locations indicate a possible staging area for spawning in the middle reservoir whereas three walleye (#46, 50, and 52; Figure 21) indicate the dam as a possible staging and spawning area.

Batteries of most tags expired during late May, preventing further tracking of those tagged individuals. However, tag #61 is noteworthy because its battery life far exceeded factory specifications. Tag #61 was placed in a walleye, which was tracked during both spring 2007 and 2008. Locations of walleye #61 were concentrated in the central portion of the reservoir during the 2007 spawning period (Figure 3-2) and concentrated in the lower portion of the reservoir during the 2008 spawning period (Figure 3-17).

Red Willow Reservoir

During 2007, 11 of the 15 tagged walleye were located 74 times during the spring sampling period; the number of locations per fish ranged from two to 13. During 2008, all 15 tagged walleye were located 265 times during the spring sampling period; the number of locations per fish ranged from five to 23. The majority of tagged walleye were located weekly from early March through mid-April 2007 and 2008.

Walleye at Red Willow reservoir with greater than five locations can be split into four groups based on locations during the primary spawning period of 2007 and 2008.

The first group had locations away from the dam during spawning and can be subdivided based on the location during the primary spawning period. The first subset (#9 and #32; Figures 3-23 and 3-24) were located near the mouth of a cove on the northern end of the dam. The second subset (#24 and #112; Figures 3-25 and 3-26) were located in the Spring Creek arm. The third subset (#22 and #175; Figures 3-27 and 3-28) were located along the southern shore of the Red Willow Creek arm.

The second group (#11, #23, #34, #108, #110, #123, and #152; Figures 3-29 through 3-35) had locations on or near the dam during the primary spawning period. These fish all congregated near the southern end of the dam and most exhibited both pre- and post-spawn migrations. This area of the dam is near the reservoir outflow and adjacent to an area of steep shoreline with natural rock.

The third group (#7, #124, #128, #161, and #176; Figures 3-36 and 3-40) had locations offshore in the lower reservoir during the primary spawning period. Most of these fish were located around an underwater point that extends into the reservoir. For example, walleye #7 was located off the point separating the two arms of the reservoir.

The fourth group (#137, #144, #153, #154, and #155; Figures 3-41 through 3-45) had locations on the dam and exhibited a more exploratory behavior with locations throughout the lower reservoir during the primary spawning period. These fish were all eventually found on the dam, though they were highly mobile during this period. Many of these walleye trekked toward the riverine portion of the reservoir following a brief (1 d) increase in inflow during the spawning period, and then returned to the dam.

Locations were few ($N \leq 5$) for three tagged walleye (Figure 3-46). Causes of the limited relocations are potentially numerous and unknown. Thus, no conclusions are made about movements of these fish.

White Bass

Enders Reservoir

During 2007, 14 of the 15 tagged white bass were located 73 times during the spring sampling period; the number of locations per fish ranged from one to 11. During 2008, eight of the 15 tagged white bass were located 116 times during the spring sampling period; the number of locations per fish ranged from one to 27. The majority of tagged white bass were located weekly from early March to mid-April 2007 and 2008.

White bass at Enders Reservoir with greater than five locations can be split into three groups based on movement and area of the reservoir used during spring 2007 and 2008. The first group (#51, #115, #129, #140, #157, and #166; Figures 3-47 through 3-52) had movements restricted to small areas of the reservoir. White bass #51 and #166 both used small relatively flat areas of silt substrate in the upper reservoir, whereas #115 used an area of sand and natural rock substrate along the eastern shore of the reservoir. White bass #129 and #140 both used an area of steep natural rock shoreline on the northern edge of the dam, whereas #157 used a similar habitat on the western shore of the reservoir.

The second group had movements restricted to a larger area of the reservoir and can be subdivided based on the area of the reservoir used. The first subset (#58, #67, and #68; Figures 3-53 through 3-55) were located in an area of the middle reservoir that is relatively flat with gradually sloping shorelines dominated by small trees with the

exception of a few sandy beaches along the southern shore of this area. The second subset (#44, #47, and #64; Figures 3-56 through 3-58) were located throughout the lower half of the reservoir during the spring tracking season.

The third group (#53, #125, and #171; Figures 3-59 through 3-61) had movements ranging across the majority of the reservoir. Most locations of white bass #53 were in the lower half of the reservoir though it did make a migration to the upper end during May. Most locations of #125 and #171 were in the upper half of the reservoir.

Locations were few ($N \leq 5$) for six tagged white bass (Figure 3-62). Causes of the limited relocations are potentially numerous and unknown. Thus, no conclusions are made about movements of these fish.

Red Willow Reservoir

During 2007, six of the 14 tagged white bass were located 24 times during the spring sampling period; the number of locations per fish ranged from one to six. During 2008, 12 of the 15 tagged white bass were located 129 times during the spring sampling period; the number of locations per fish ranged from two to 17. The majority of tagged white bass were located weekly from early March to mid-April 2007 and 2008.

White bass at Red Willow reservoir with greater than five locations can be split into three groups based on movement and area of the reservoir used during spring 2007 and 2008. The first group (#39, #101, #116, #122, and #141; Figures 3-63 through 3-67) had movements restricted to small areas of the reservoir. Movements by these fish were restricted to small areas in the Red Willow Creek arm of the reservoir, with the exception

of #141. White bass #141 used a small area of large, dead trees near an old creek channel in the upper portion of the Spring Creek arm.

The second group (#19 and #38; Figures 3-68 and 3-69) had movements restricted to a large area of the lower reservoir. White bass #19 was located near an underwater point extending into the reservoir across from the dam. White bass #38 was located throughout the lower reservoir during the spring.

The third group (#107, #127, #151, and #168; Figures 3-70 and 3-73) had movements ranging across a large portion of the reservoir. Locations of white bass #151 and #168 were restricted to the Red Willow Creek arm of the reservoir, whereas white bass #107 and #127 were located throughout both arms of the reservoir.

Locations were few ($N \leq 5$) for six tagged white bass (Figures 3-74 and 3-75). Causes of the limited relocations are potentially numerous and unknown. Thus, no conclusions are made about movements of these fish.

Angler Harvest

Some tagged walleye were harvested and reported to UNL or NGPC personnel. Those reports are summarized below and represent the known minimum harvest rate for these fish (i.e., it is possible that some fish were harvested and not reported). Reported angler harvest of tagged walleye was greater during 2007 at Red Willow reservoir ($N = 4$; 27%) than in Enders Reservoir ($N = 1$; 7%; Table 3-3). Reported angler harvest of tagged walleye was low during 2008, with only one walleye captured through the ice at Enders Reservoir. Reported angler harvest of tagged white bass was low in both years with one white bass harvested during the study (Table 3-3).

Discussion

Locations and movements of tagged fish during the spawning period provided additional support for habitat selection models (i.e., walleye selected habitats with large rock substrate, cool water temperatures, large fetch, and the absence of cover (Chapter 2)) of both adult walleye and white bass. Most adult walleye were found at or near the dam during the primary spawning period and exhibited pre- or post-spawn migrations. Walleye exhibited two distinct movement strategies during the peak spawning period. Some fish migrated directly to the primary spawning location on the face of the dam, whereas other fish roamed the lower reservoir during the spawning period. Although gender was unknown for the fish I implanted, I hypothesize that the observed differences in movements are gender-related with males migrating directly to the spawning sites and females roaming the lower reservoir.. Mature male walleye often congregate at spawning sites up to one month prior to the arrival of mature female walleye (Pflieger 1997).

White bass were found throughout the reservoir during the primary spawning period and did not exhibit any directed spawning migrations; thus, supporting results of models quantifying habitat selection during spawning (i.e., no spawning habitat selection detected (Chapter 2)). White bass exhibited two different movement strategies during spring that created large variation in spring home range sizes (Chapter 4). Unfortunately, the amount of individual variation in movement patterns and the relatively coarse scale of tracking used in this study were not sufficient to capture movements related to spawning in white bass. Future research should incorporate more intensive tracking of fewer fish to determine habitat use by white bass during spawning.

Both acoustic telemetry and patch occupancy models provided similar results for adult walleye and white bass spawning habitat selection. The use of patch occupancy modeling to determine habitat selection over a short period may be more beneficial to biologists for future assessments than acoustic telemetry because effort and associated costs required to achieve desired results are less. However, acoustic telemetry should be used if the research goal is to study habitat selection over a longer period or to determine movement patterns on a temporal scale that is less than possible with repeated sampling of sites (e.g., electrofishing).

Table 3-1. Information on walleye (WAE) and white bass (WHB) tracked during 2007 at Enders and Red Willow reservoirs, Nebraska. Total length (TL; mm) weight (Wt; g) and gender were recorded prior to tag implantation. * indicates missing data.

Tag #	Reservoir	Species	TL	Wt	Gender	Tag #	Reservoir	Species	TL	Wt	Gender
43	Enders	WAE	435	*	U	2	Red Willow	WAE	472	890	U
45	Enders	WAE	478	960	U	3	Red Willow	WAE	381	440	U
46	Enders	WAE	380	449	U	5	Red Willow	WAE	573	1600	U
50	Enders	WAE	436	755	U	6	Red Willow	WAE	362	470	U
52	Enders	WAE	374	*	U	7	Red Willow	WAE	384	420	U
54	Enders	WAE	471	802	U	9	Red Willow	WAE	704	3400	U
57	Enders	WAE	430	675	U	11	Red Willow	WAE	693	2420	U
59	Enders	WAE	350	360	U	16	Red Willow	WAE	472	860	U
60	Enders	WAE	411	567	U	23	Red Willow	WAE	513	1160	U
61	Enders	WAE	406	541	U	24	Red Willow	WAE	548	1400	U
62	Enders	WAE	417	592	U	26	Red Willow	WAE	400	550	U
63	Enders	WAE	489	967	U	32	Red Willow	WAE	411	540	U
65	Enders	WAE	527	1299	U	33	Red Willow	WAE	665	2850	U
69	Enders	WAE	372	427	U	34	Red Willow	WAE	694	3920	F
70	Enders	WAE	487	999	U	35	Red Willow	WAE	531	1520	U
41	Enders	WHB	328	408	U	1	Red Willow	WHB	328	360	U
42	Enders	WHB	275	246	U	4	Red Willow	WHB	288	280	U
44	Enders	WHB	331	439	M	10	Red Willow	WHB	293	*	U
47	Enders	WHB	342	505	U	17	Red Willow	WHB	290	*	U
48	Enders	WHB	342	436	U	18	Red Willow	WHB	292	280	U
49	Enders	WHB	344	428	U	19	Red Willow	WHB	295	*	U
51	Enders	WHB	315	*	U	20	Red Willow	WHB	300	270	U
53	Enders	WHB	306	360	M	21	Red Willow	WHB	287	260	U
55	Enders	WHB	302	319	U	25	Red Willow	WHB	308	265	U
56	Enders	WHB	276	355	U	33	Red Willow	WHB	290	310	U
58	Enders	WHB	321	409	M	36	Red Willow	WHB	300	260	U
64	Enders	WHB	259	239	U	38	Red Willow	WHB	314	320	U
67	Enders	WHB	325	436	M	39	Red Willow	WHB	300	275	U
68	Enders	WHB	269	253	U	40	Red Willow	WHB	283	*	U
71	Enders	WHB	331	458	U						

Table 3-2. Information on walleye (WAE) and white bass (WHB) tracked during 2008 at Enders and Red Willow reservoirs, Nebraska. Total length (TL; mm) weight (Wt; g) and gender were recorded prior to tag implantation.

Tag #	Reservoir	Species	TL	Wt	Gender	Tag #	Reservoir	Species	TL	Wt	Gender
121	Enders	WAE	378	469	U	108	Red Willow	WAE	377	453	U
130	Enders	WAE	379	452	U	110	Red Willow	WAE	571	1802	U
131	Enders	WAE	543	1499	U	112	Red Willow	WAE	471	882	U
136	Enders	WAE	379	450	U	123	Red Willow	WAE	401	531	U
156	Enders	WAE	393	531	U	124	Red Willow	WAE	372	436	U
158	Enders	WAE	402	557	U	128	Red Willow	WAE	378	417	U
159	Enders	WAE	452	744	U	137	Red Willow	WAE	616	1958	U
160	Enders	WAE	392	486	U	144	Red Willow	WAE	376	437	U
162	Enders	WAE	403	960	U	152	Red Willow	WAE	398	501	U
170	Enders	WAE	467	876	U	153	Red Willow	WAE	383	470	U
172	Enders	WAE	412	554	U	154	Red Willow	WAE	690	2842	U
173	Enders	WAE	411	575	U	155	Red Willow	WAE	394	479	U
174	Enders	WAE	434	667	U	161	Red Willow	WAE	378	491	U
181	Enders	WAE	395	969	U	175	Red Willow	WAE	389	479	U
182	Enders	WAE	481	957	U	176	Red Willow	WAE	403	496	U
102	Enders	WHB	336	480	U	101	Red Willow	WHB	262	200	U
111	Enders	WHB	366	507	U	106	Red Willow	WHB	268	209	U
115	Enders	WHB	334	434	U	107	Red Willow	WHB	316	343	U
125	Enders	WHB	309	371	M	109	Red Willow	WHB	316	348	U
126	Enders	WHB	324	426	U	113	Red Willow	WHB	304	280	U
129	Enders	WHB	300	357	U	114	Red Willow	WHB	308	233	U
139	Enders	WHB	338	440	U	116	Red Willow	WHB	310	311	U
140	Enders	WHB	341	480	U	122	Red Willow	WHB	297	230	U
145	Enders	WHB	357	513	M	127	Red Willow	WHB	265	200	U
157	Enders	WHB	349	526	M	138	Red Willow	WHB	285	256	U
166	Enders	WHB	351	568	U	141	Red Willow	WHB	266	189	U
167	Enders	WHB	373	618	U	142	Red Willow	WHB	311	282	U
169	Enders	WHB	316	396	U	143	Red Willow	WHB	284	232	U
171	Enders	WHB	306	357	U	151	Red Willow	WHB	276	241	U
183	Enders	WHB	354	567	U	168	Red Willow	WHB	286	257	U

Table 3-3. Angler reported harvest of tagged walleye and white bass at Enders and Red Willow reservoirs, Nebraska during 2007 and 2008. * indicates missing data.

Date	Reservoir	Species	Tag #
Mar. 2007	Enders	Walleye	*
May 2007	Red Willow	Walleye	32
Jun. 2007	Red Willow	Walleye	34
July 2007	Red Willow	Walleye	5
Aug. 2007	Red Willow	Walleye	2
Aug. 2007	Enders	White Bass	58
Jan. 2008	Enders	Walleye	159

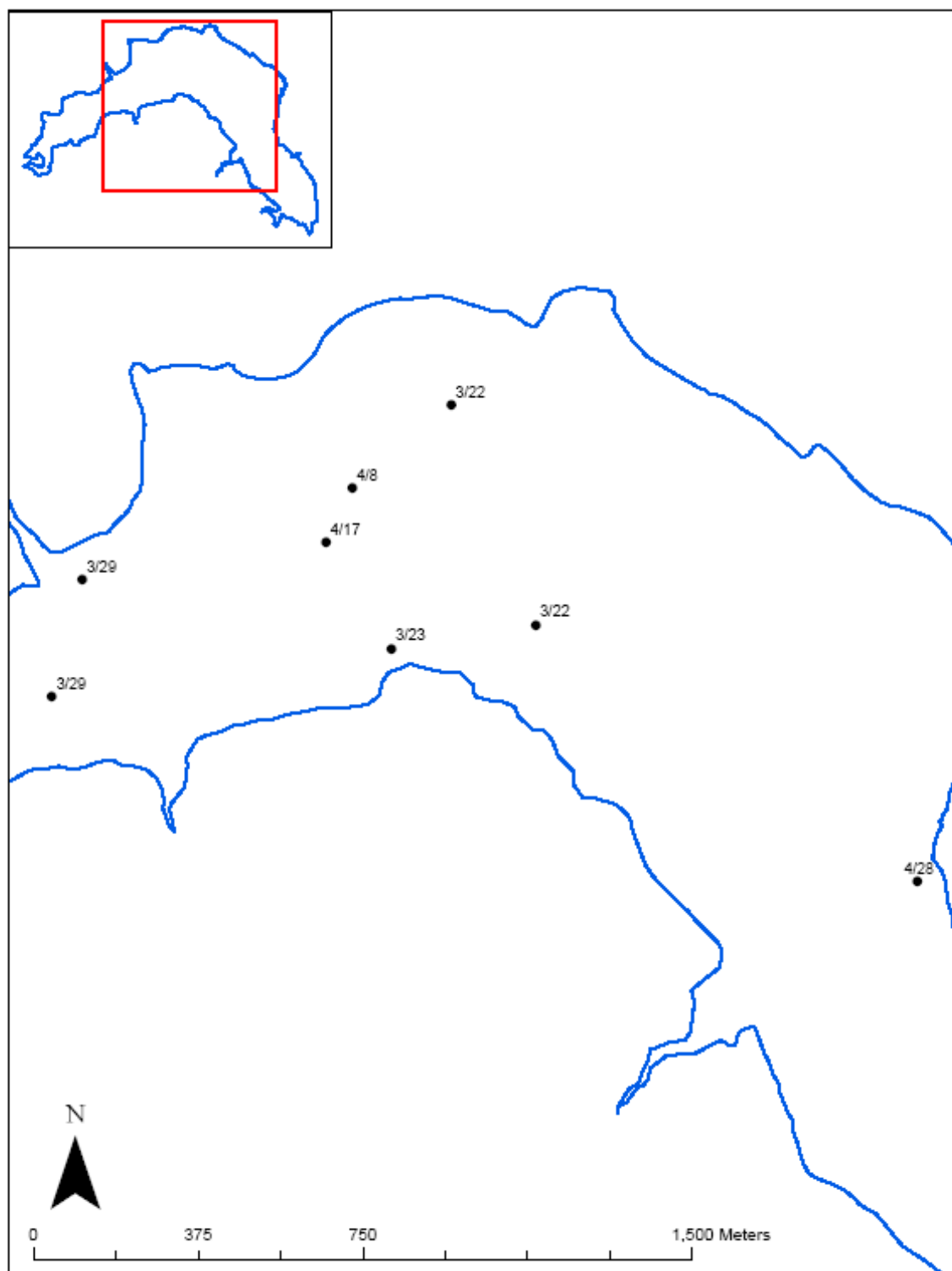


Figure 3-1. Telemetry locations of walleye #43 at Enders Reservoir, Nebraska during spring 2007.

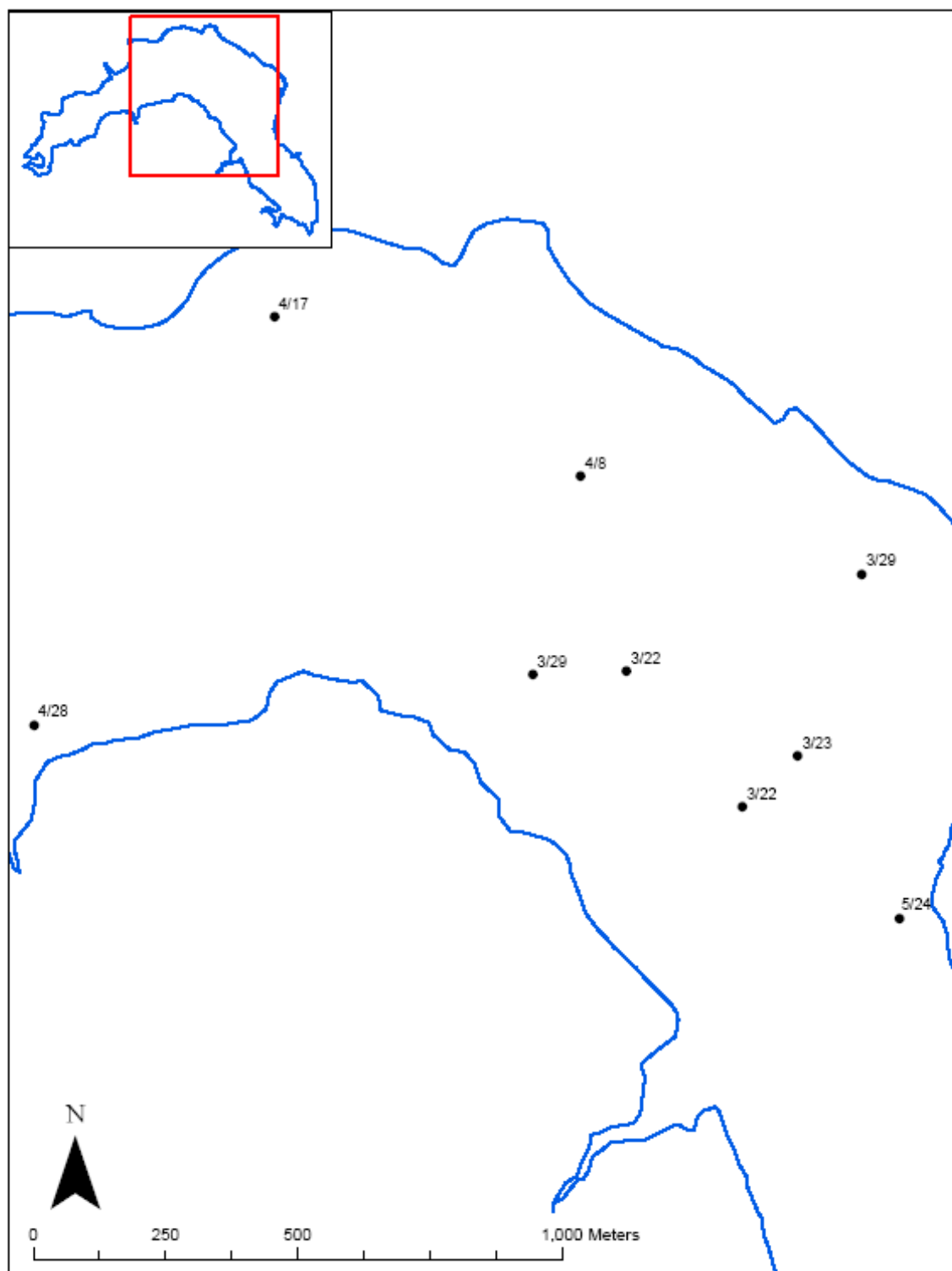


Figure 3-2. Telemetry locations of walleye #61 at Enders Reservoir, Nebraska during spring 2007.

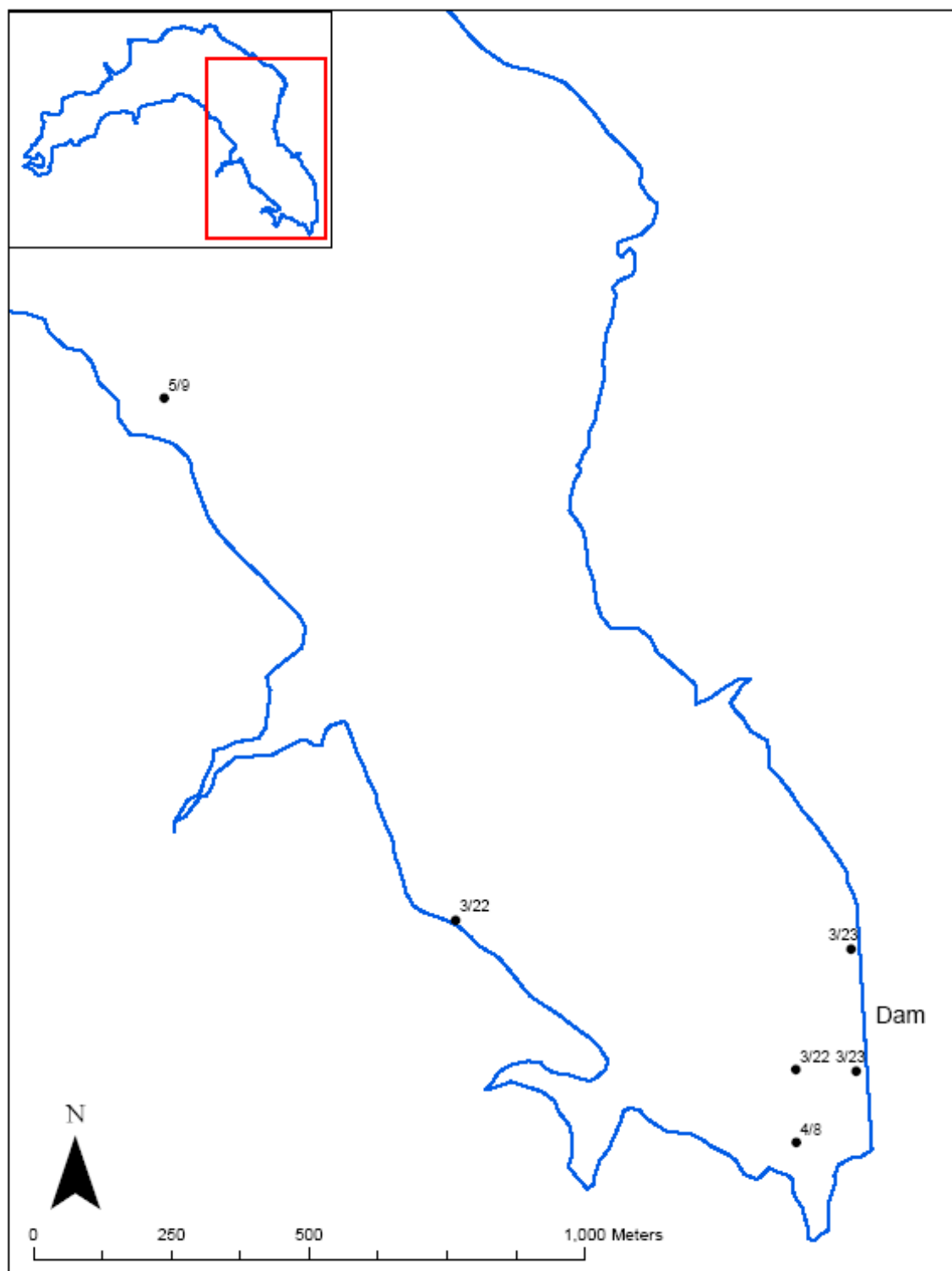


Figure 3-3. Telemetry locations of walleye #57 at Enders Reservoir, Nebraska during spring 2007.

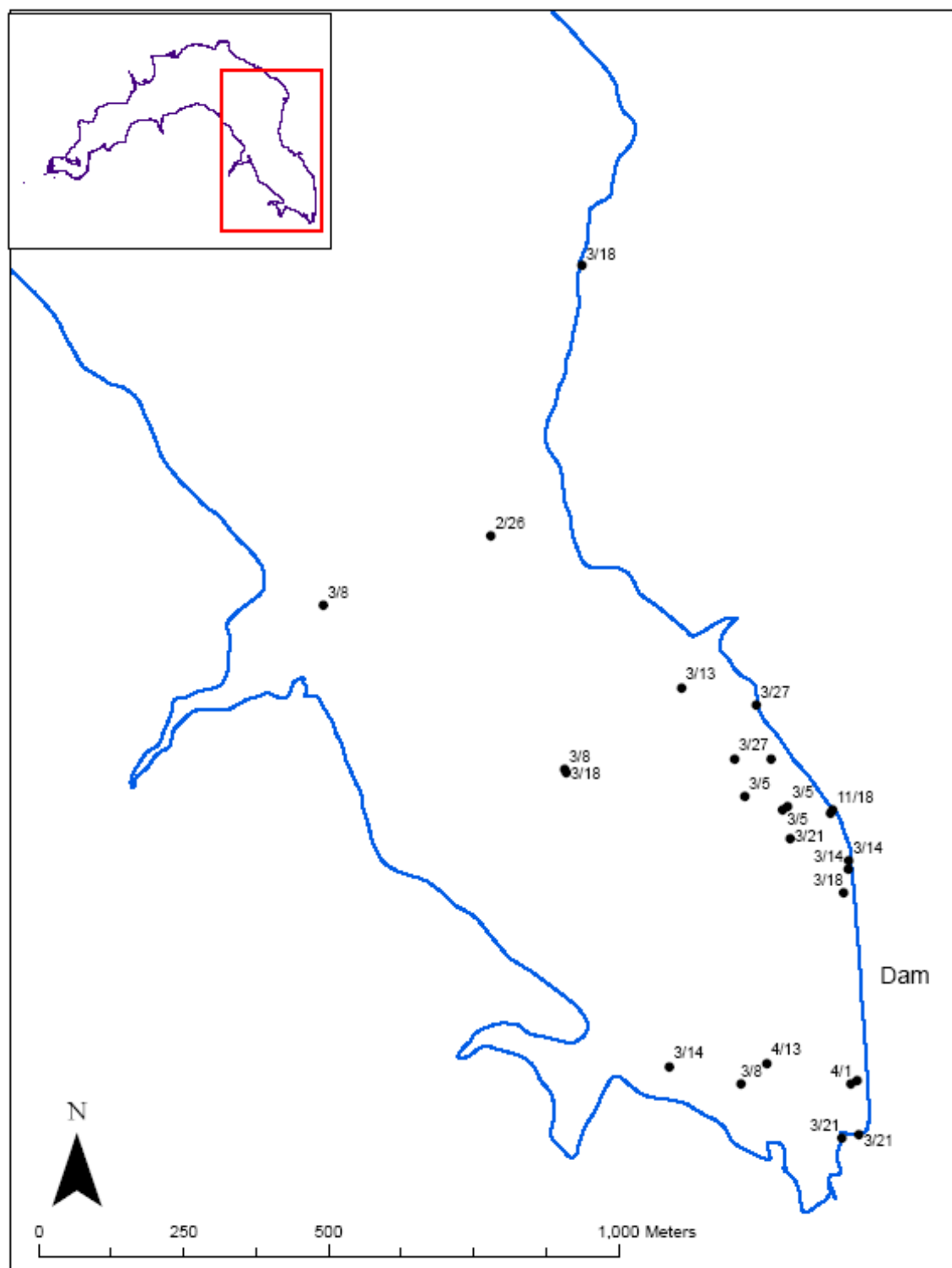


Figure 3-4. Telemetry locations of walleye #156 at Enders Reservoir, Nebraska during spring 2008. One location was recorded before ice cover in November 2007.

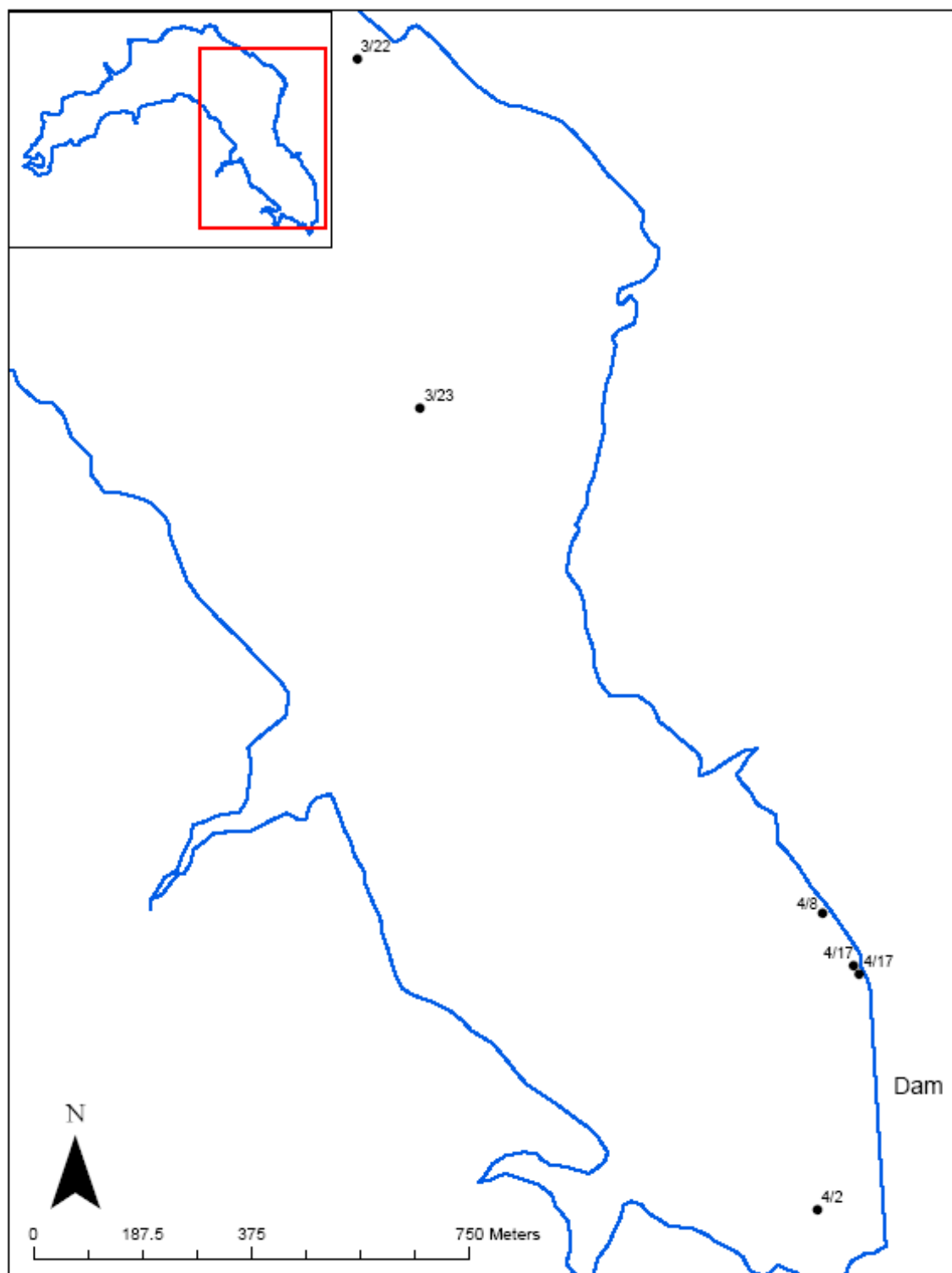


Figure 3-5. Telemetry locations of walleye #62 at Enders Reservoir, Nebraska during spring 2007.

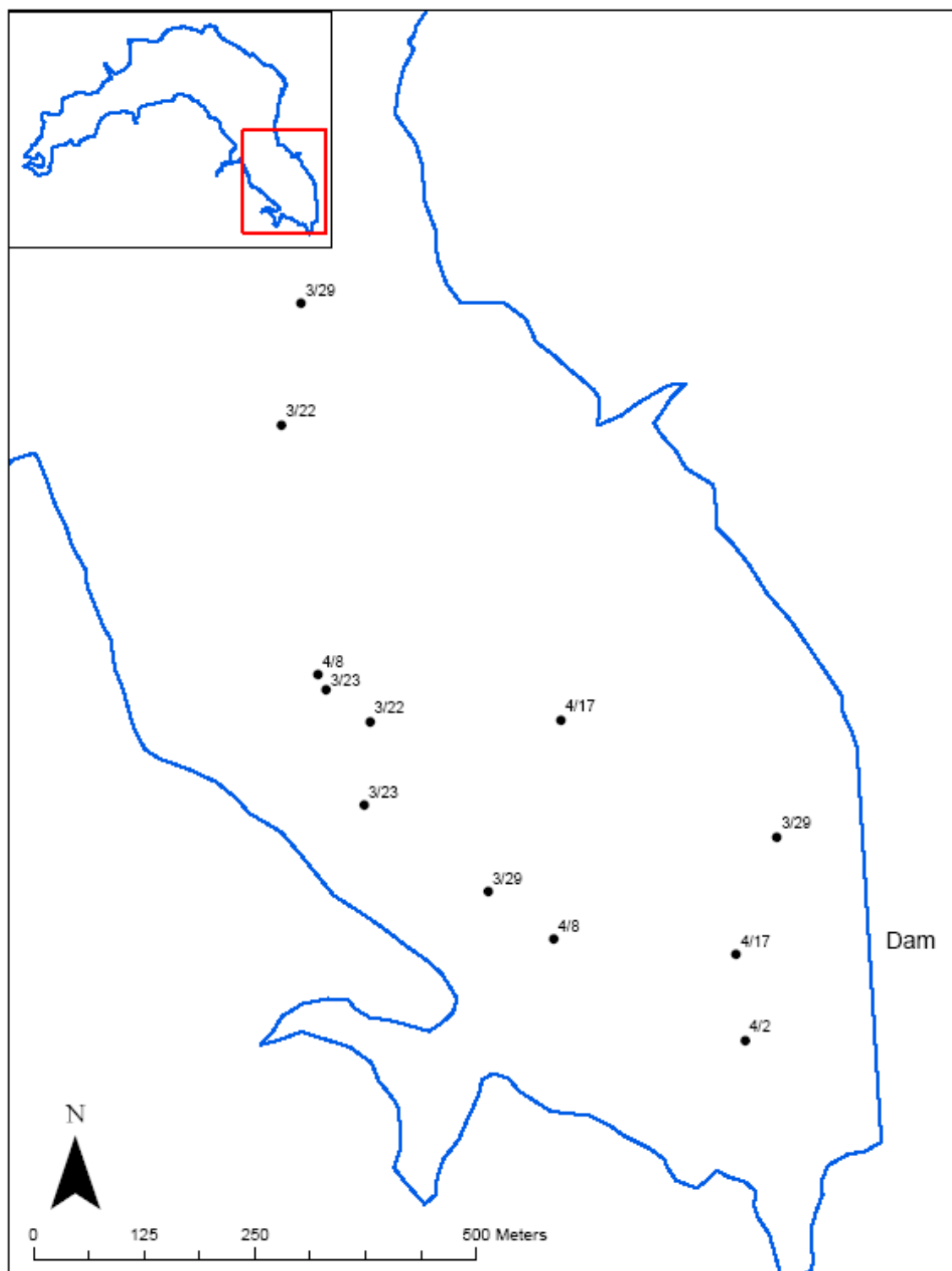


Figure 3-6. Telemetry locations of walleye #63 at Enders Reservoir, Nebraska during spring 2007.

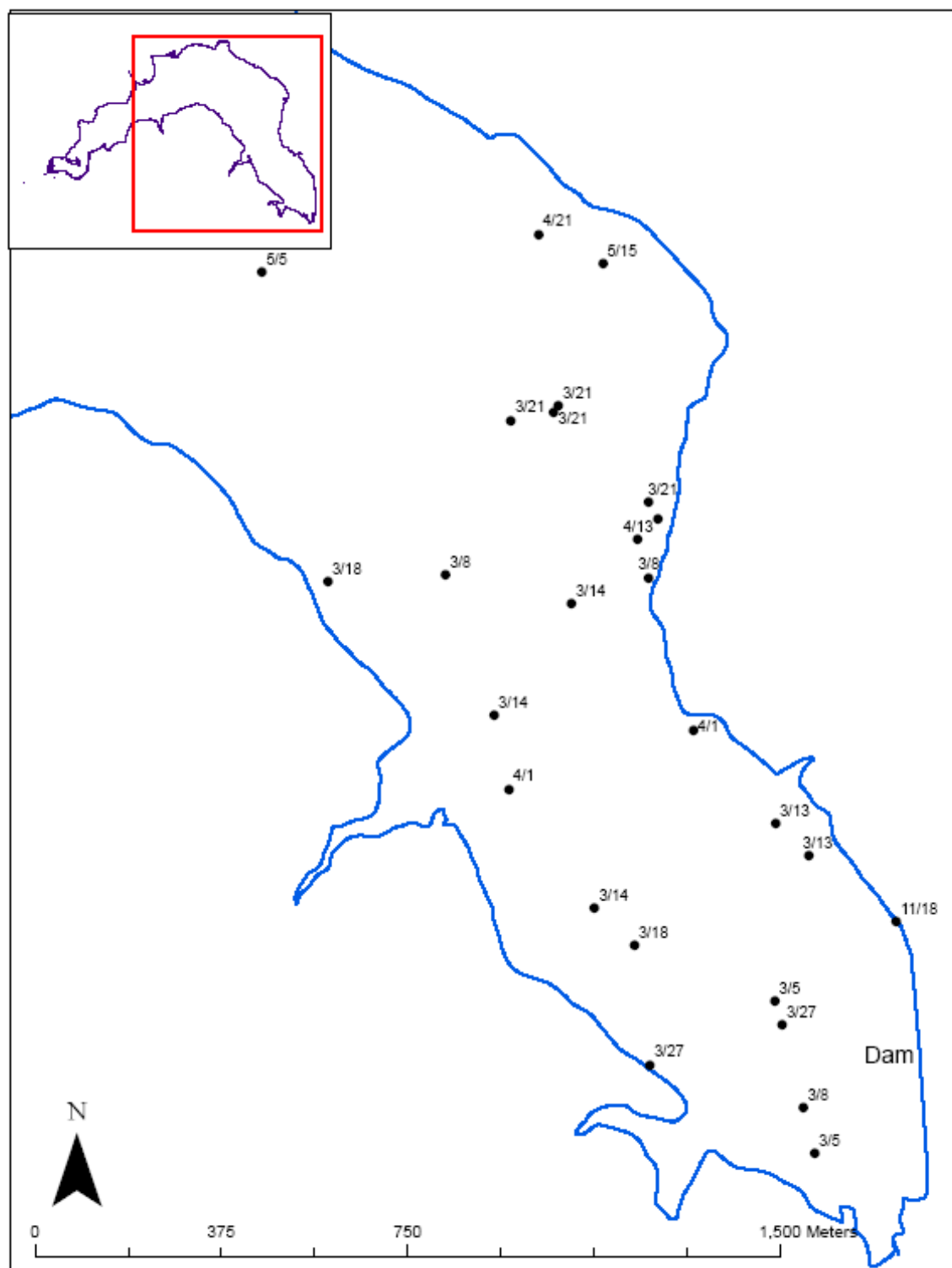


Figure 3-7. Telemetry locations of walleye #160 at Enders Reservoir, Nebraska during spring 2008. One location was recorded before ice cover in November 2007.

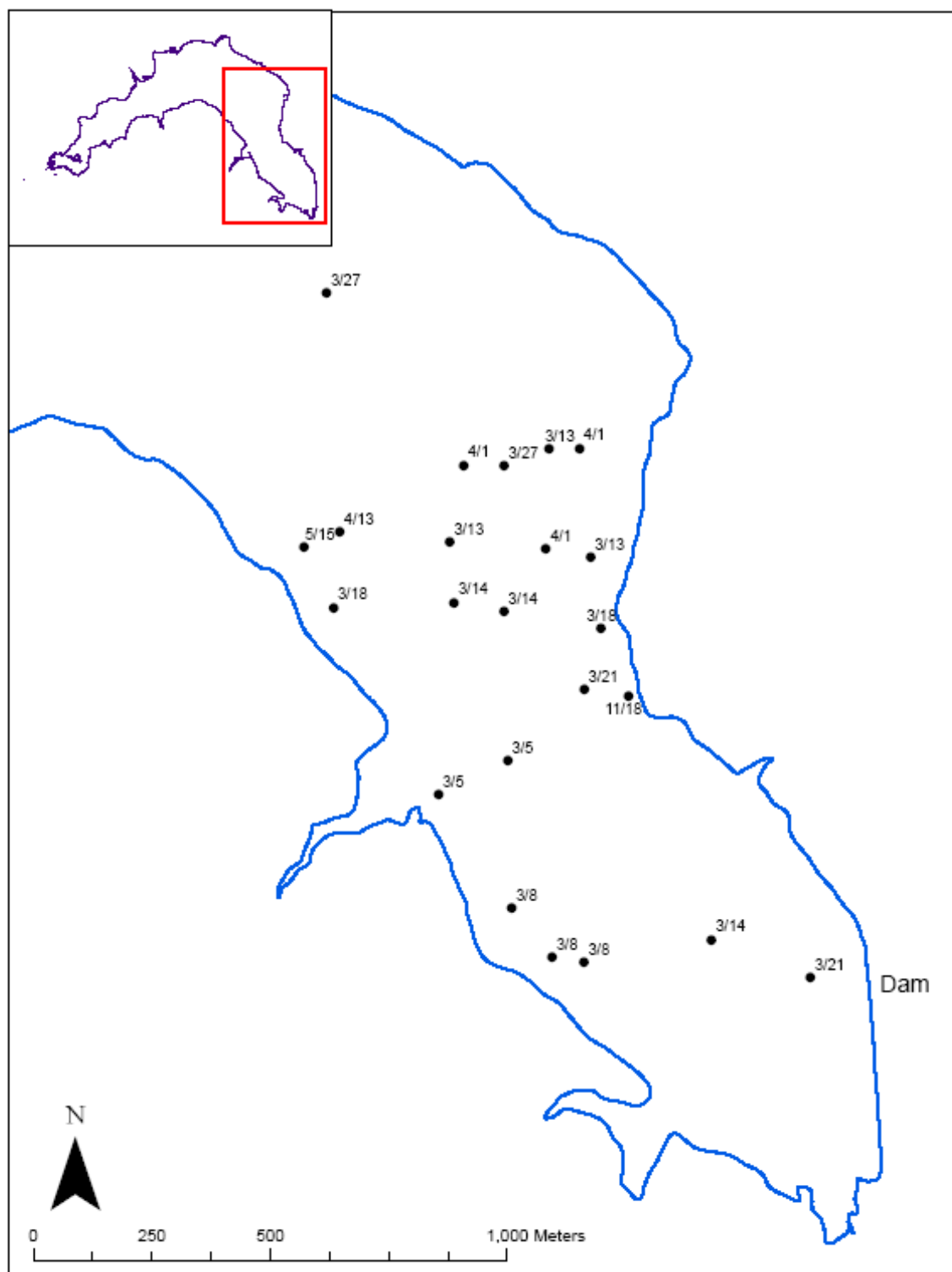


Figure 3-8. Telemetry locations of walleye #172 at Enders Reservoir, Nebraska during spring 2008. One location was recorded before ice cover in November 2007.

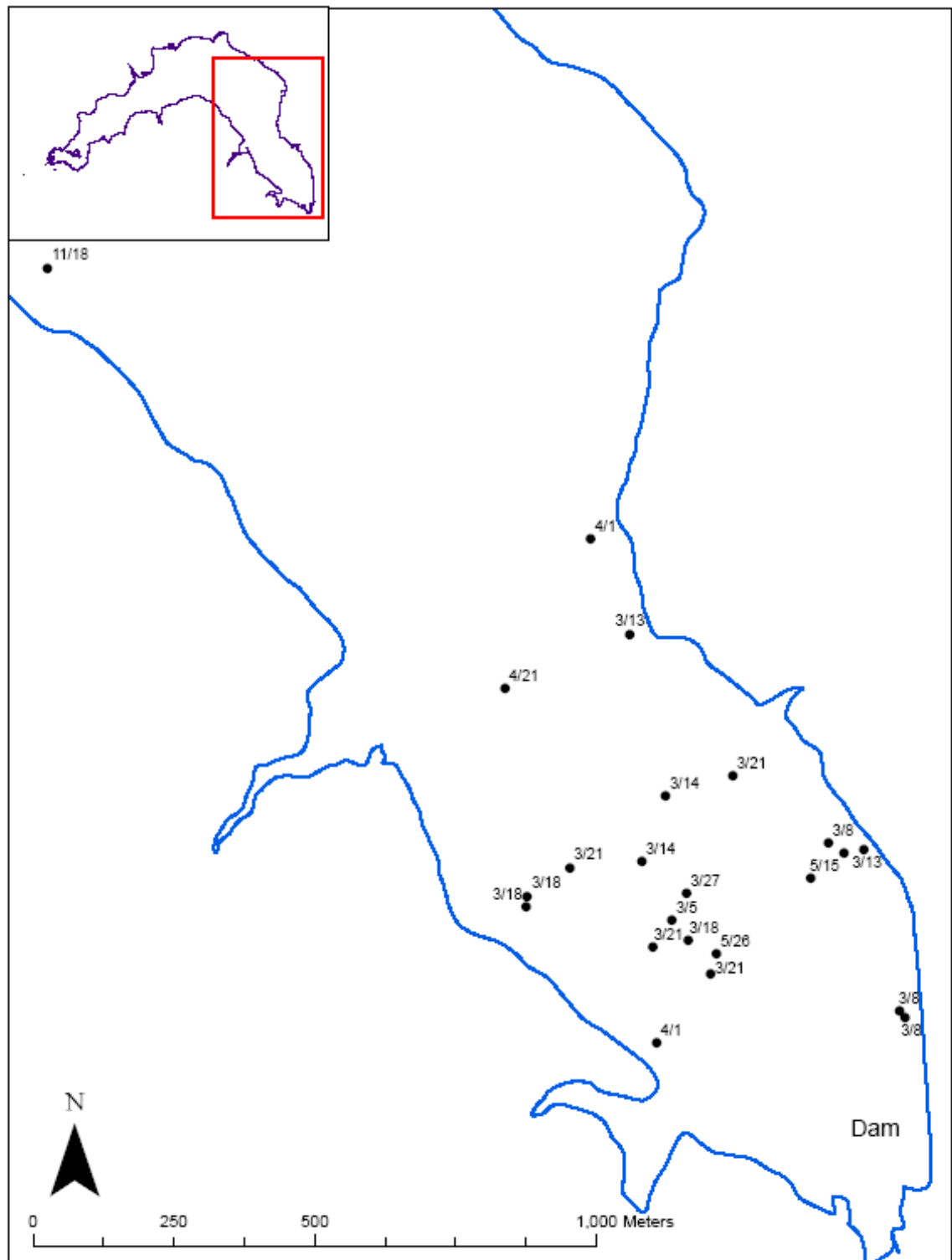


Figure 3-9. Telemetry locations of walleye #182 at Enders Reservoir, Nebraska during spring 2008. One location was recorded before ice cover in November 2007.

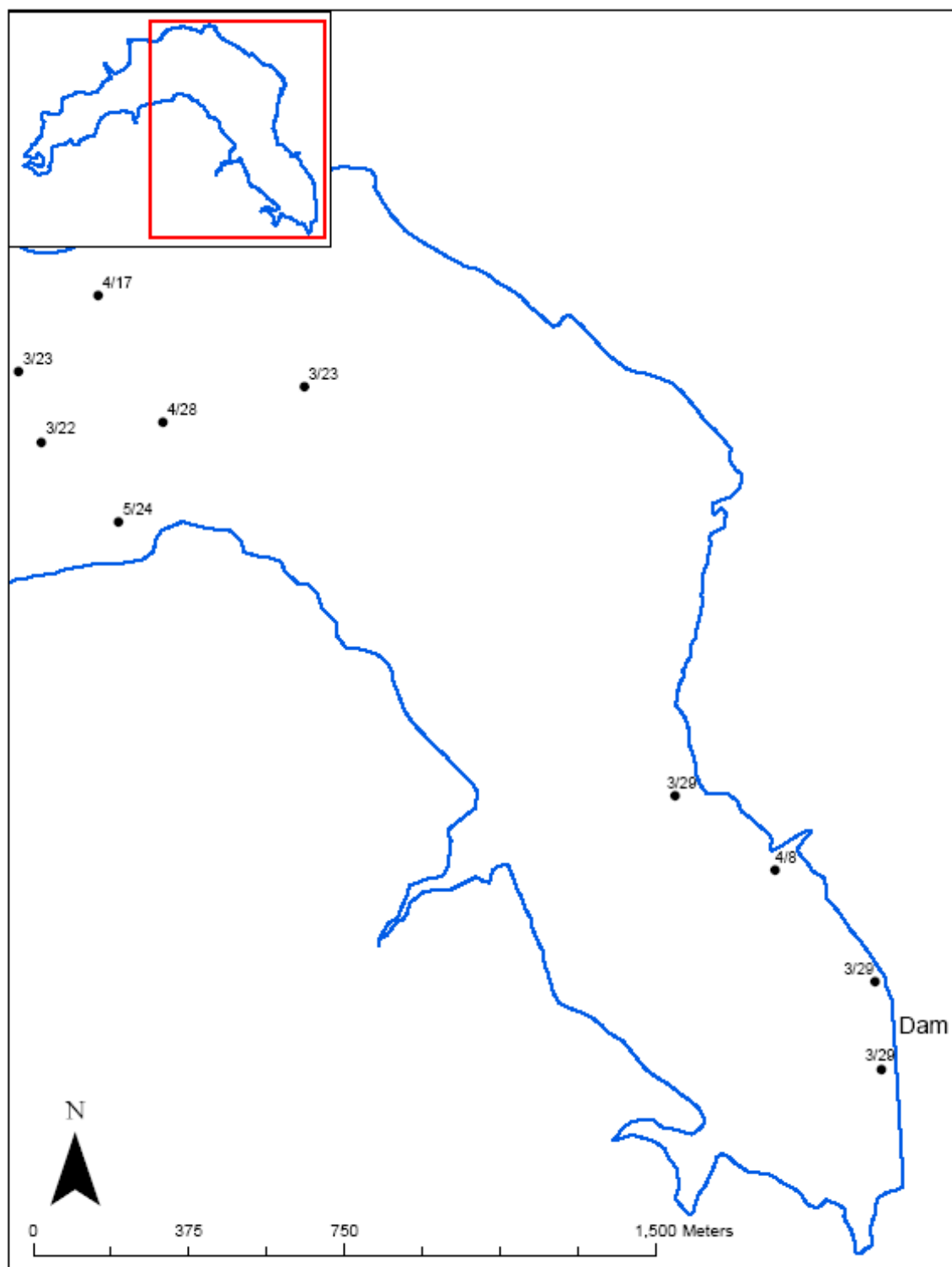


Figure 3-10. Telemetry locations of walleye #54 at Enders Reservoir, Nebraska during spring 2007.

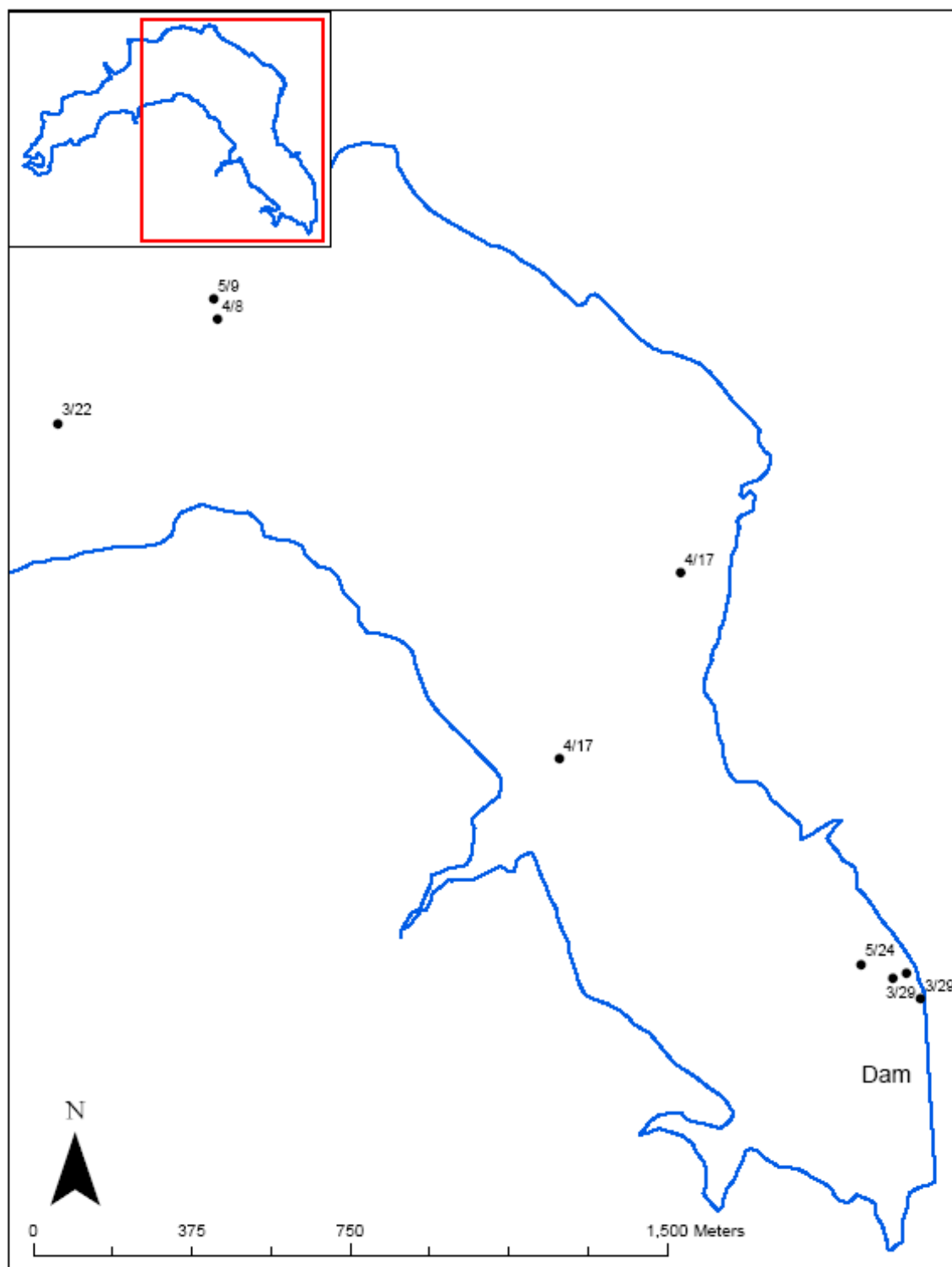


Figure 3-11. Telemetry locations of walleye #69 at Enders Reservoir, Nebraska during spring 2007.

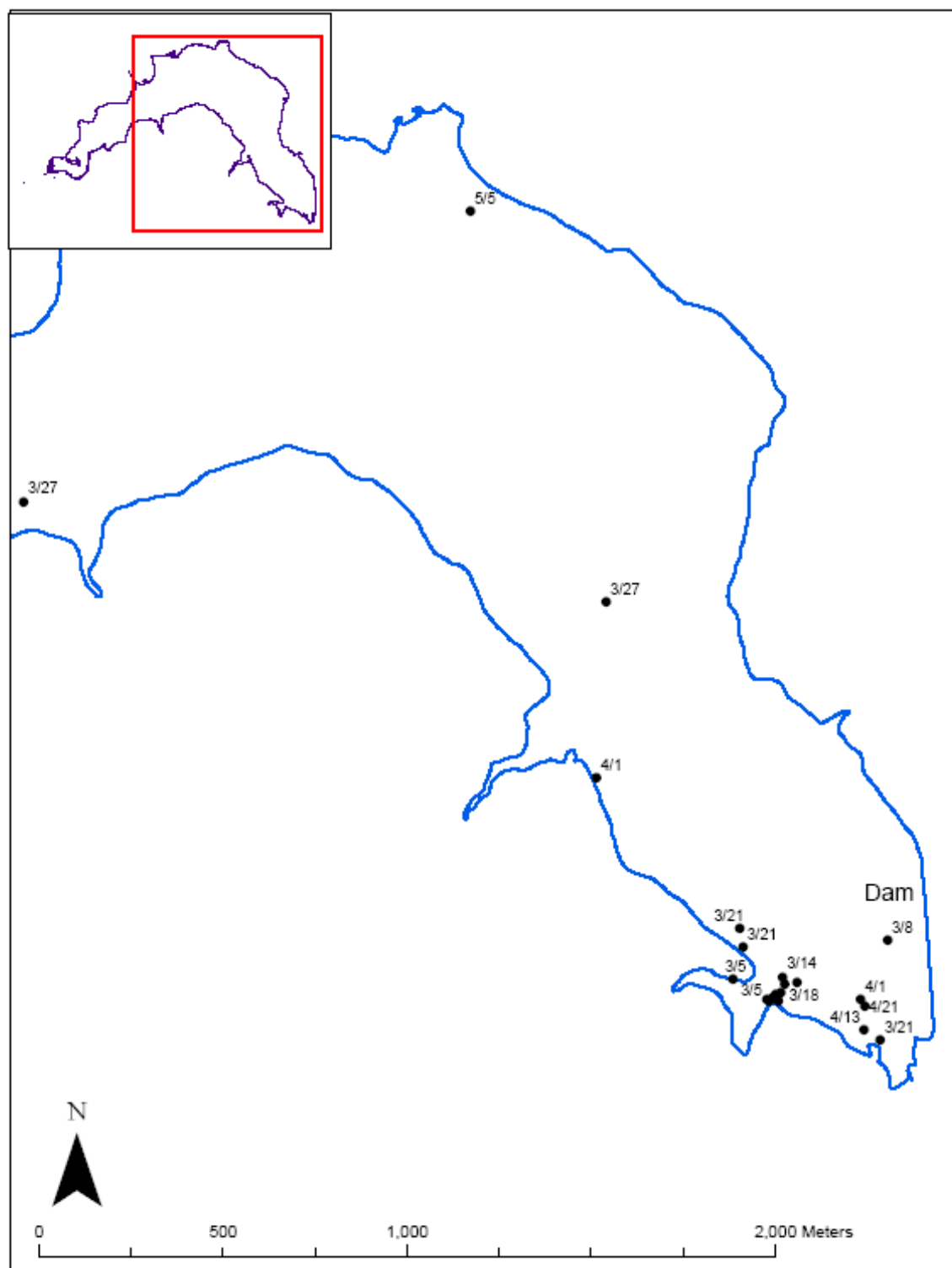


Figure 3-12. Telemetry locations of walleye #158 at Enders Reservoir, Nebraska during spring 2007.

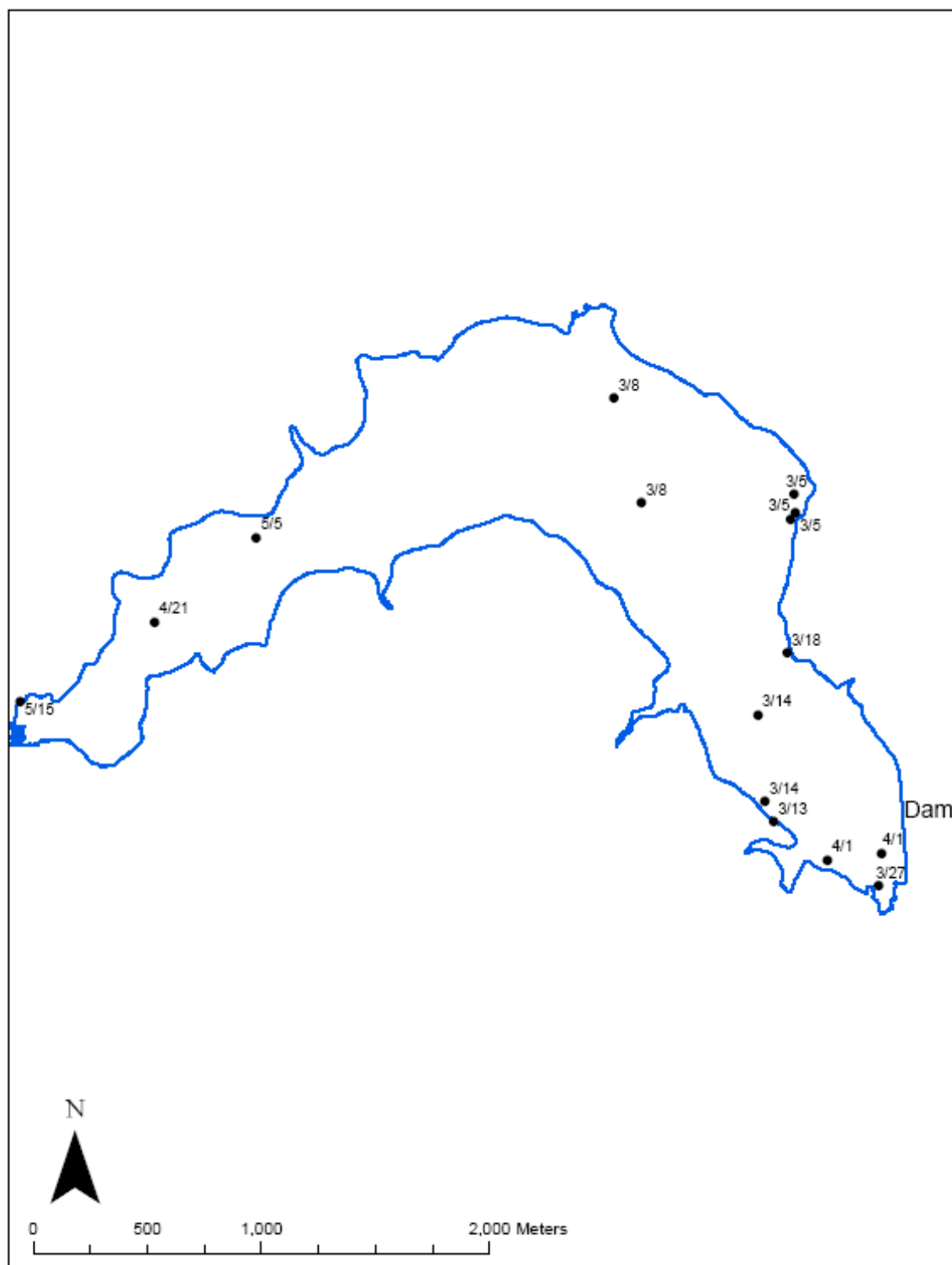


Figure 3-13. Telemetry locations of walleye #162 at Enders Reservoir, Nebraska during spring 2008.

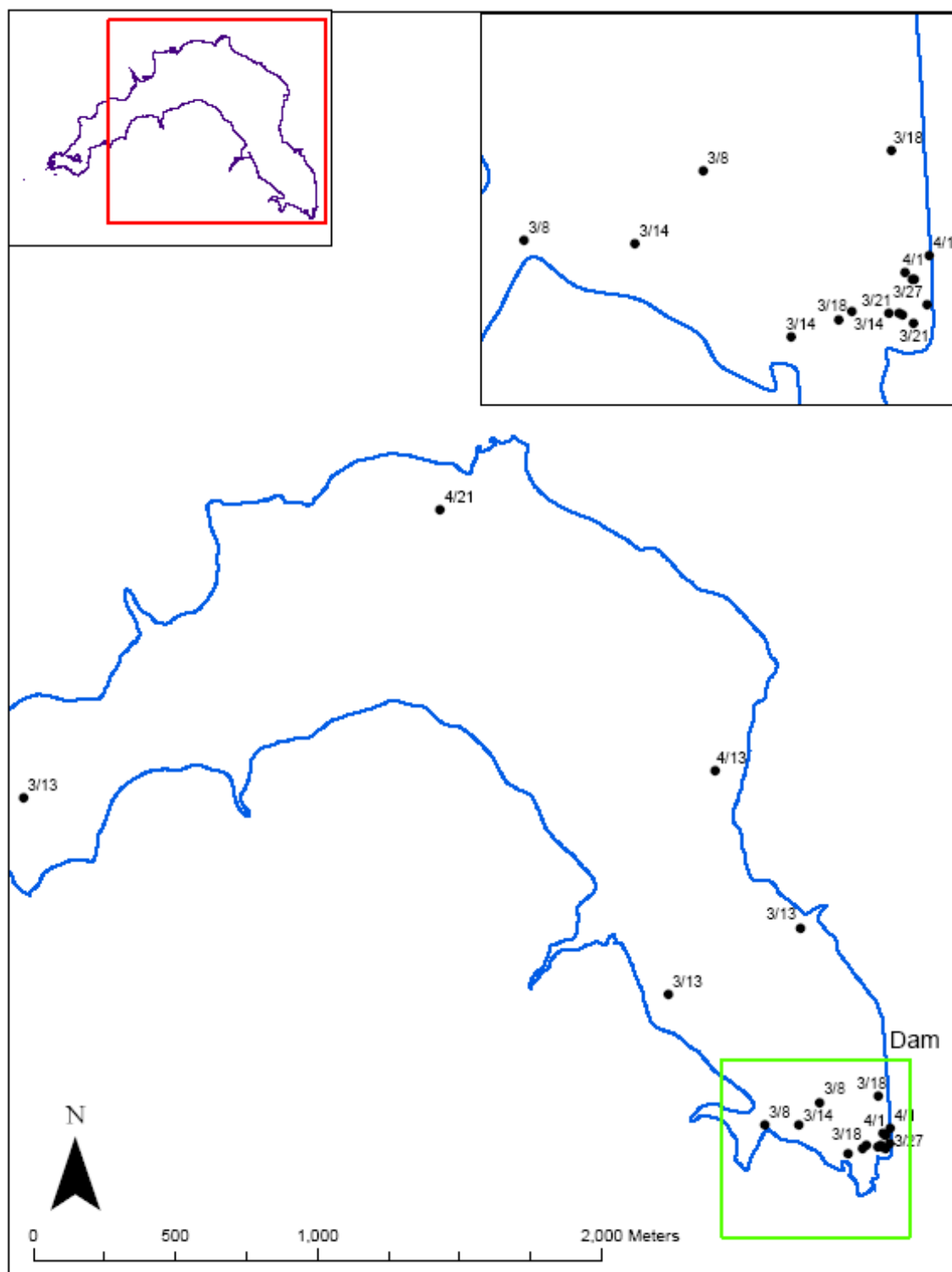


Figure 3-14. Telemetry locations of walleye #181 at Enders Reservoir, Nebraska during spring 2008.

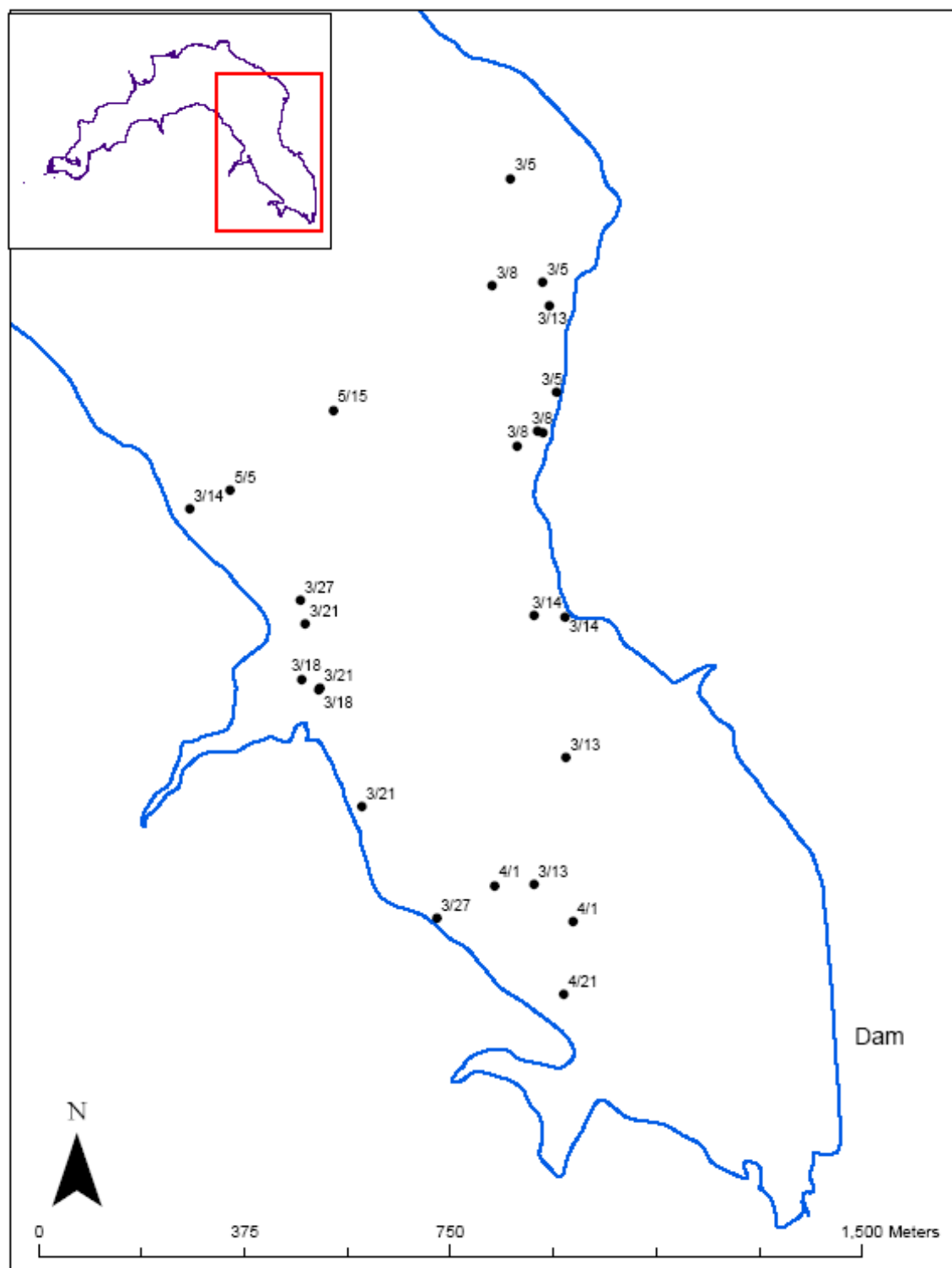


Figure 3-15. Telemetry locations of walleye #130 at Enders Reservoir, Nebraska during spring 2008.

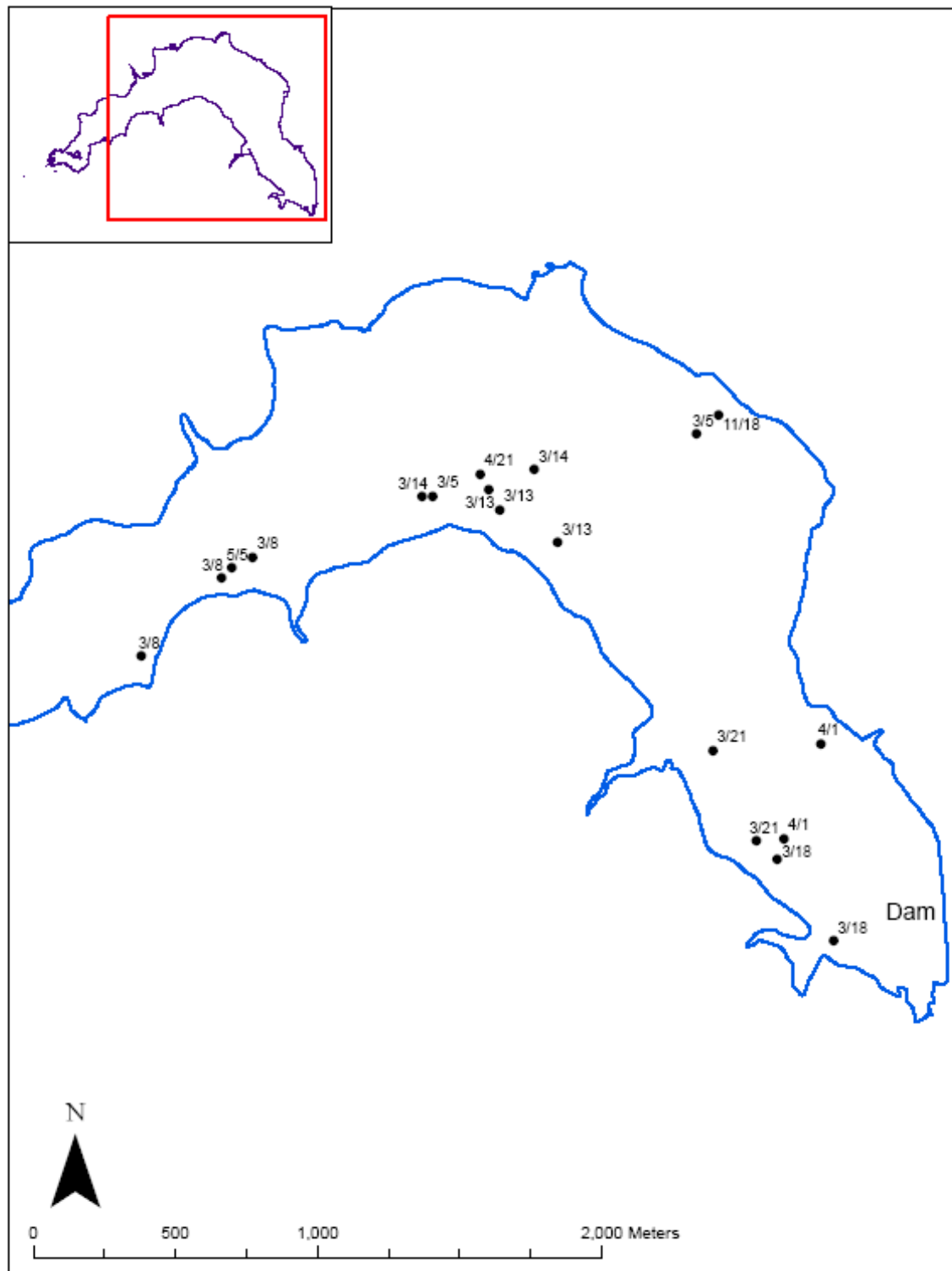


Figure 3-16. Telemetry locations of walleye #174 at Enders Reservoir, Nebraska during spring 2008. One location was recorded before ice cover in November 2007.

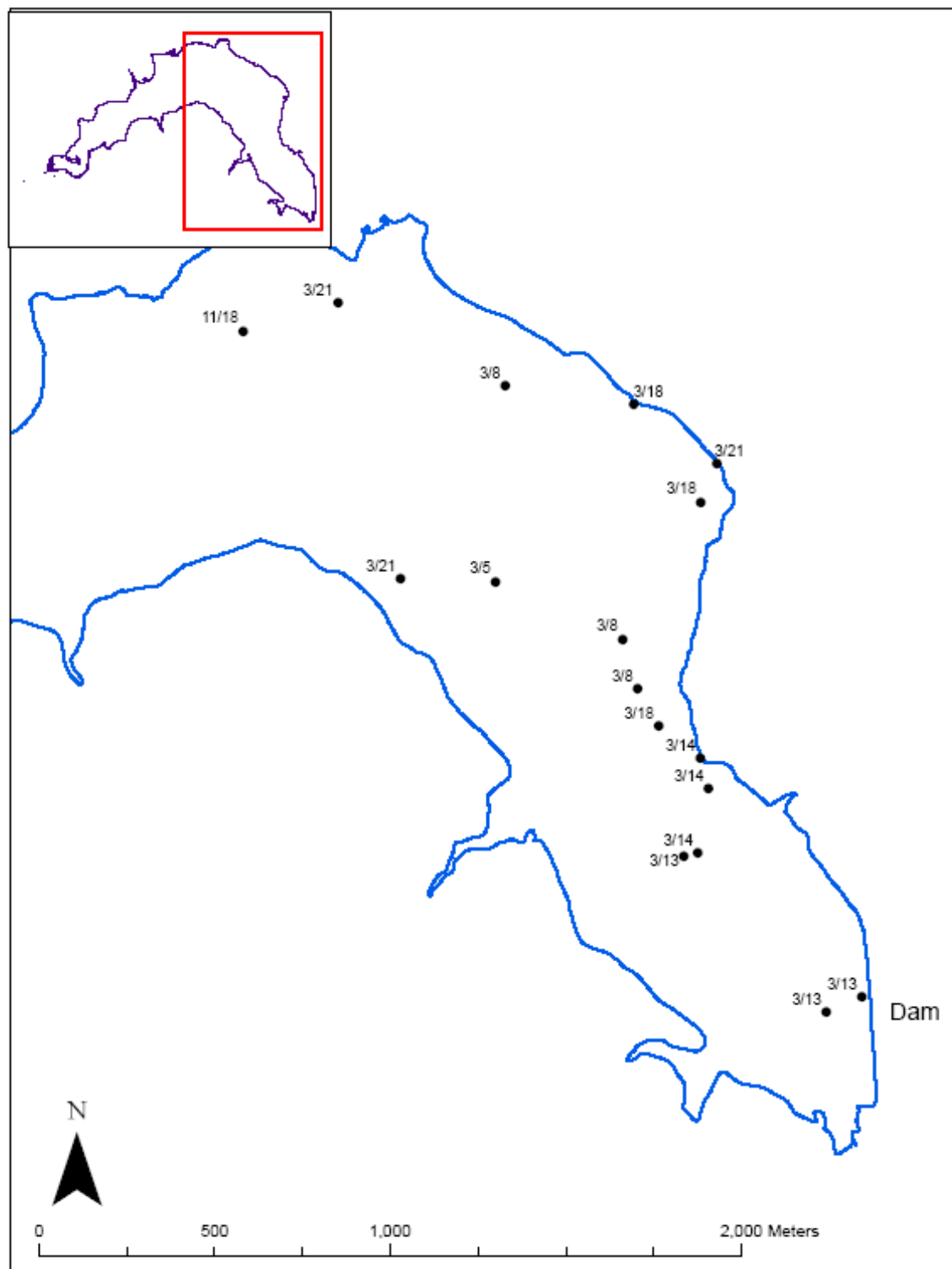


Figure 3-17. Telemetry locations of walleye #61 at Enders Reservoir, Nebraska during spring 2008. One location was recorded before ice cover in November 2007.

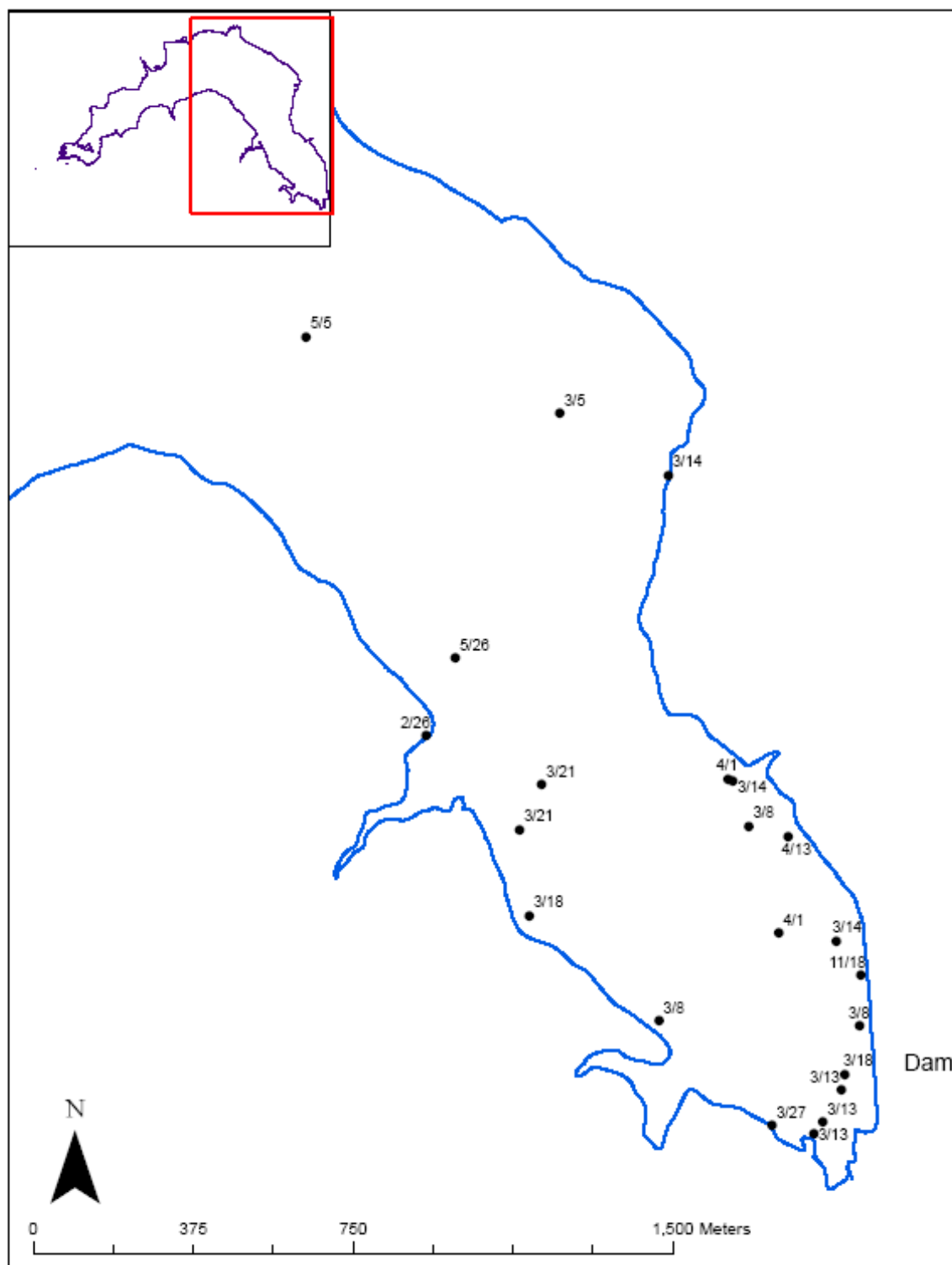


Figure 3-18. Telemetry locations of walleye #121 at Enders Reservoir, Nebraska during spring 2008. One location was recorded before ice cover in November 2007.

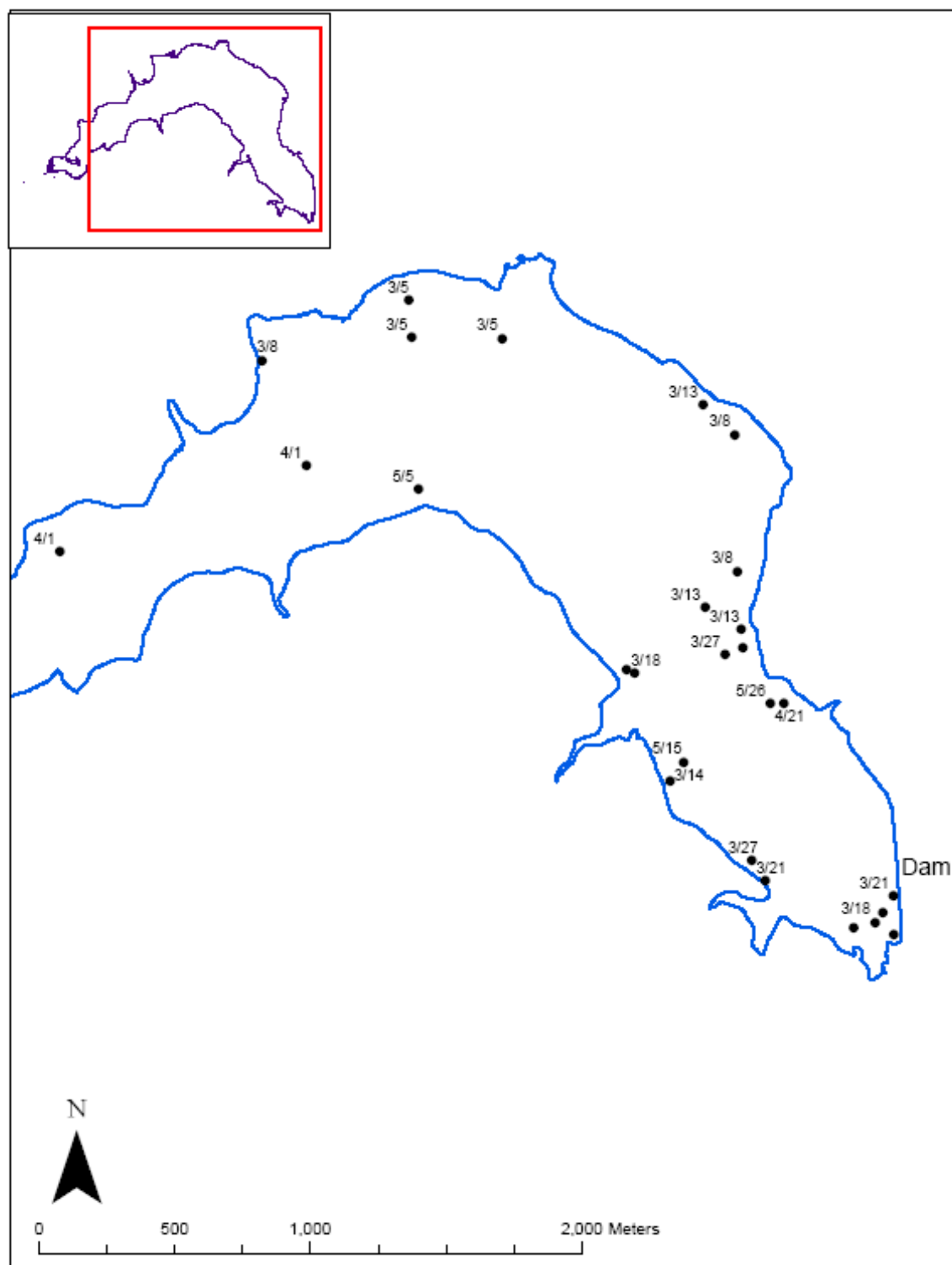


Figure 3-19. Telemetry locations of walleye #131 at Enders Reservoir, Nebraska during spring 2008. Locations without date labels are from the same day as nearby locations.

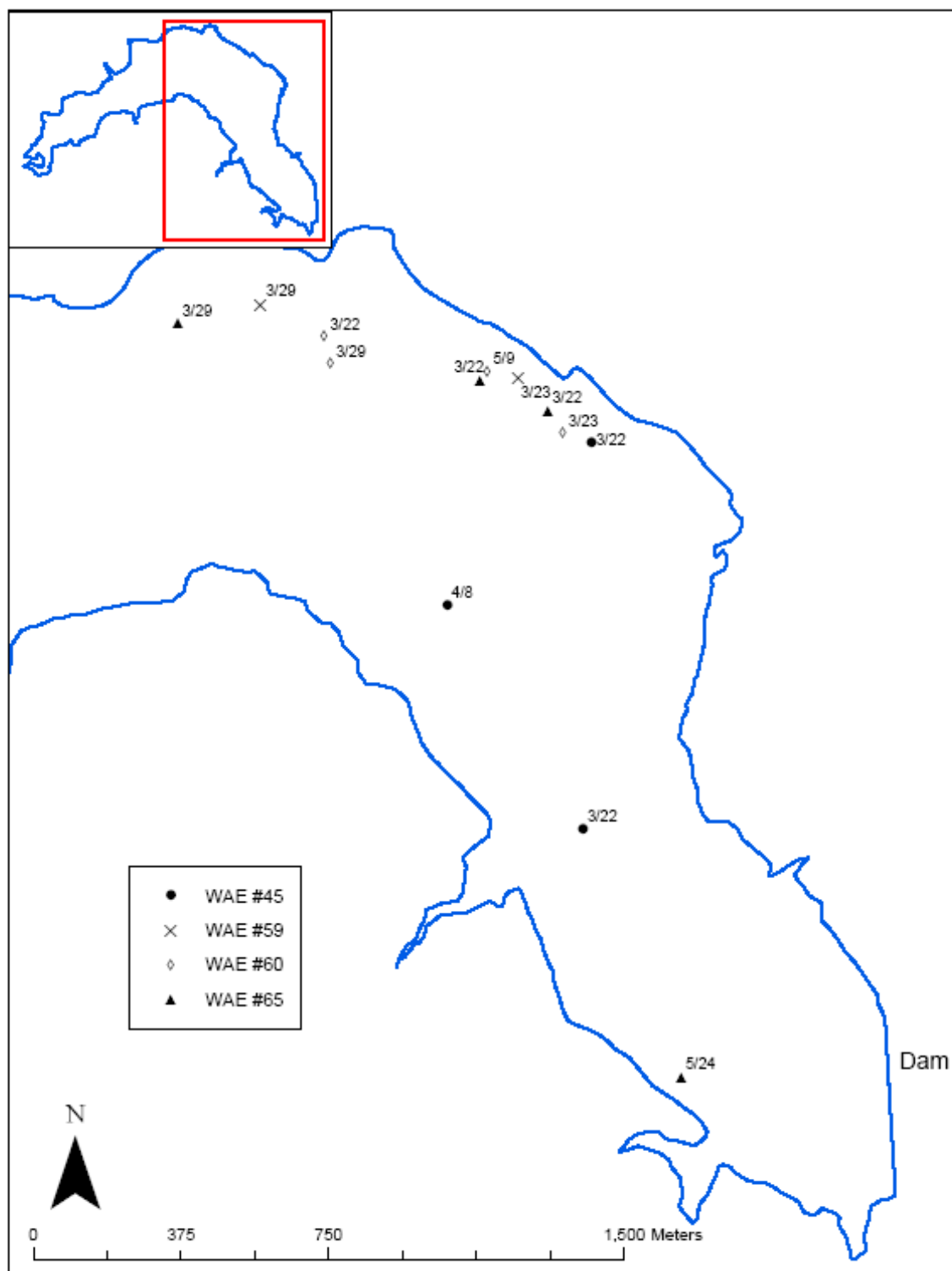


Figure 3-20. Telemetry locations of walleye with fewer than five locations at Enders Reservoir, Nebraska during spring 2007.

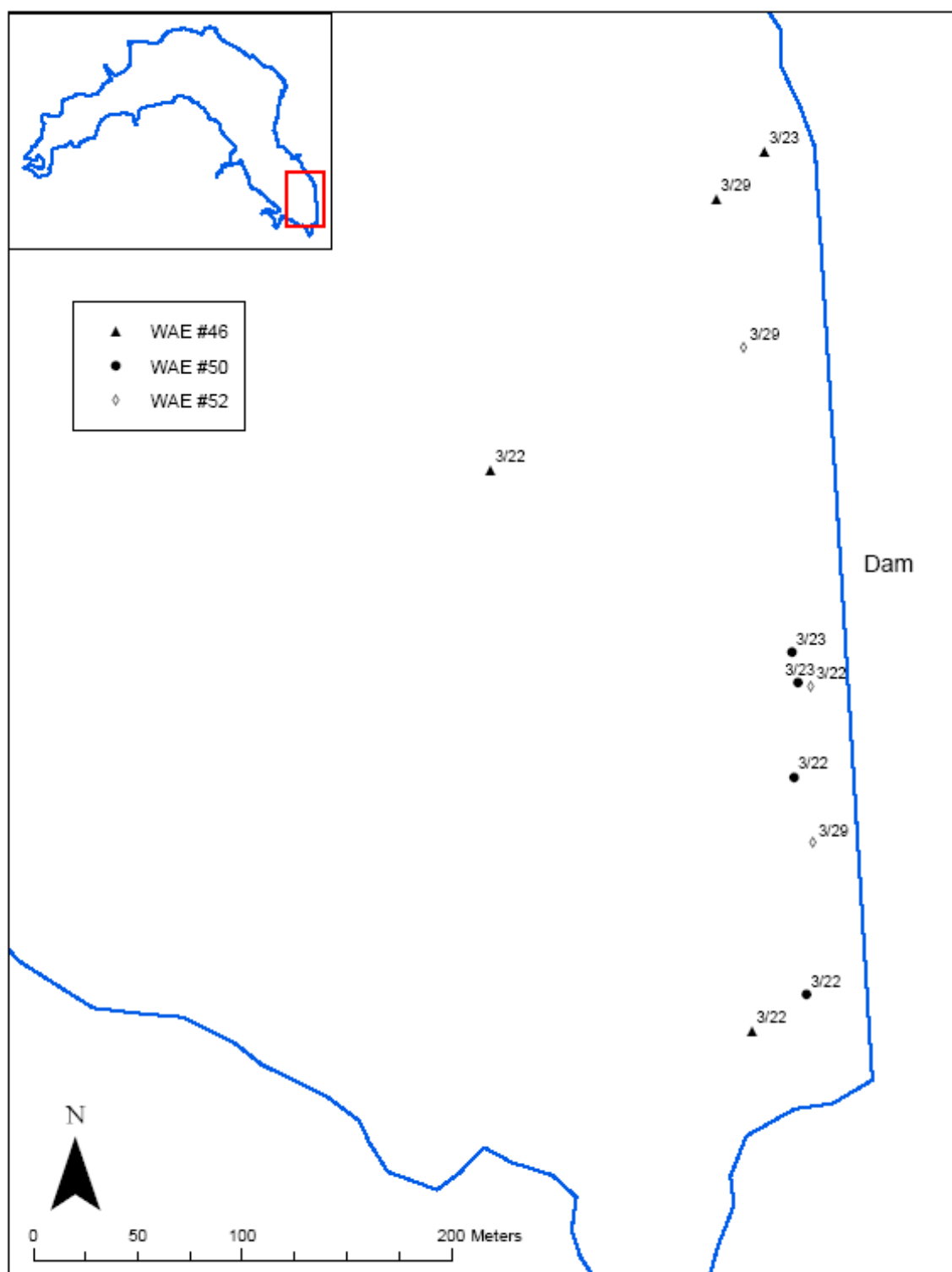


Figure 3-21. Telemetry locations of walleye with fewer than five locations at Enders Reservoir, Nebraska during spring 2007.

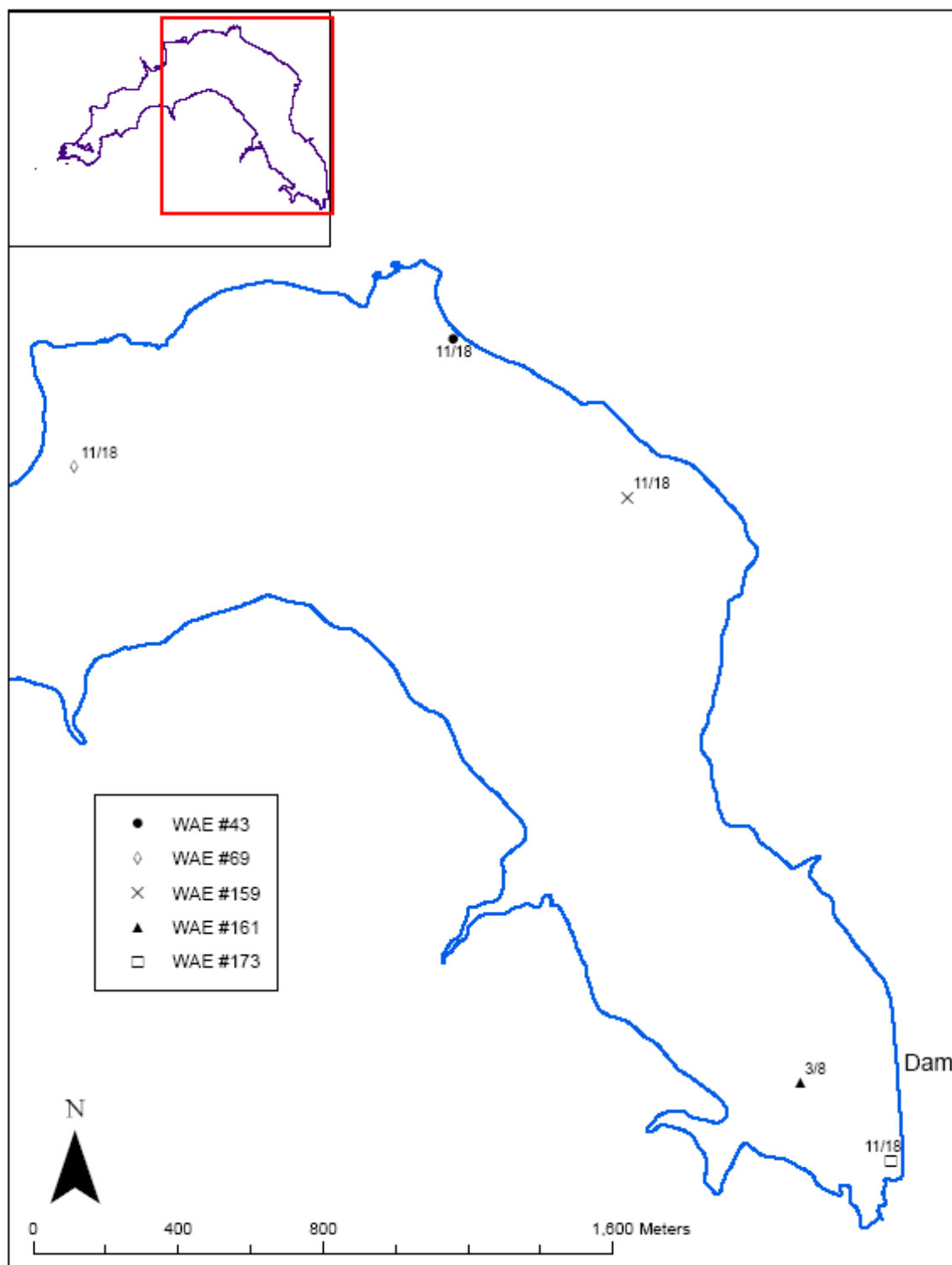


Figure 3-22. Telemetry locations of walleye with fewer than five locations at Enders Reservoir, Nebraska during spring 2007. One location was recorded before ice cover in November 2007.

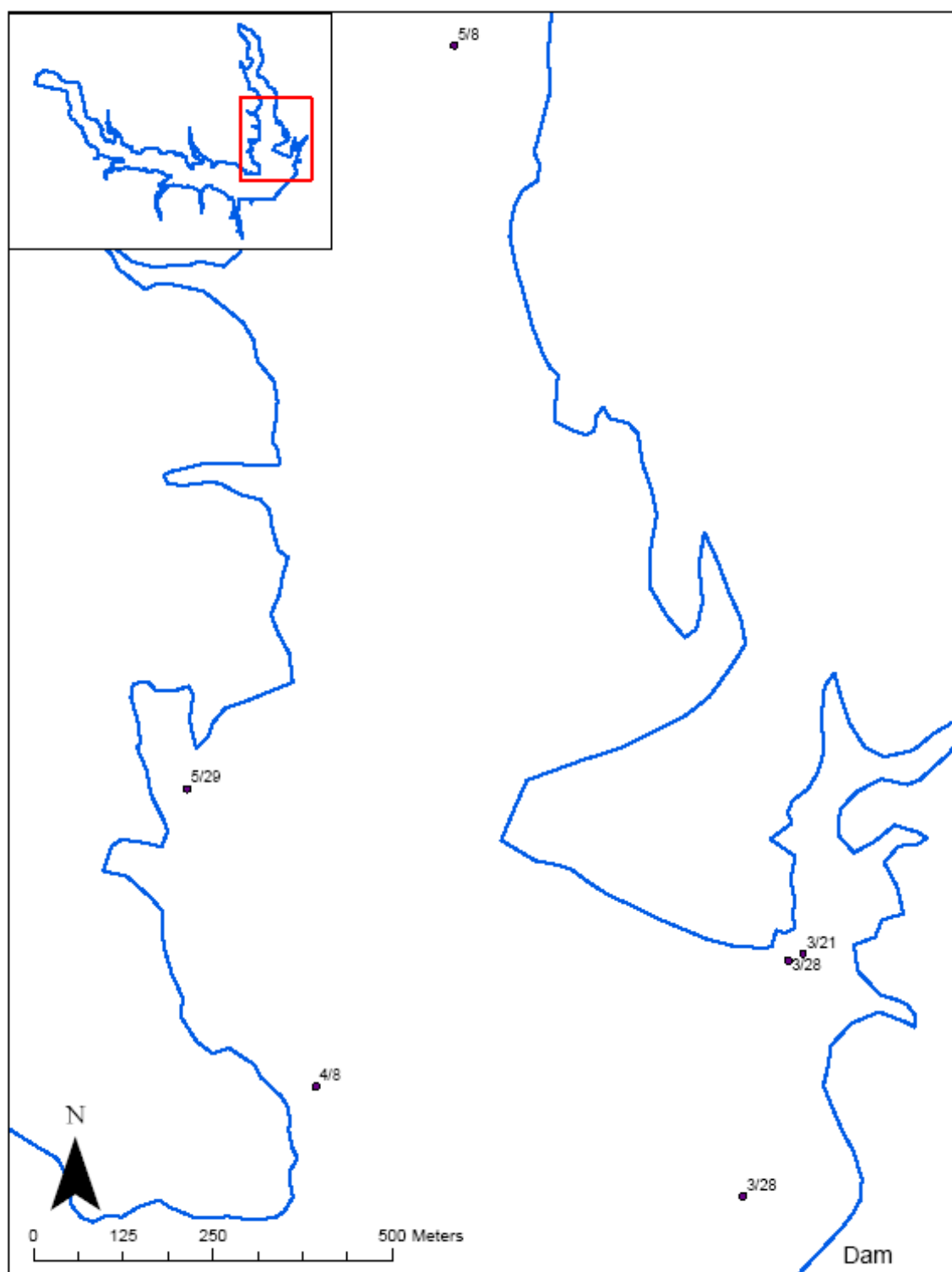
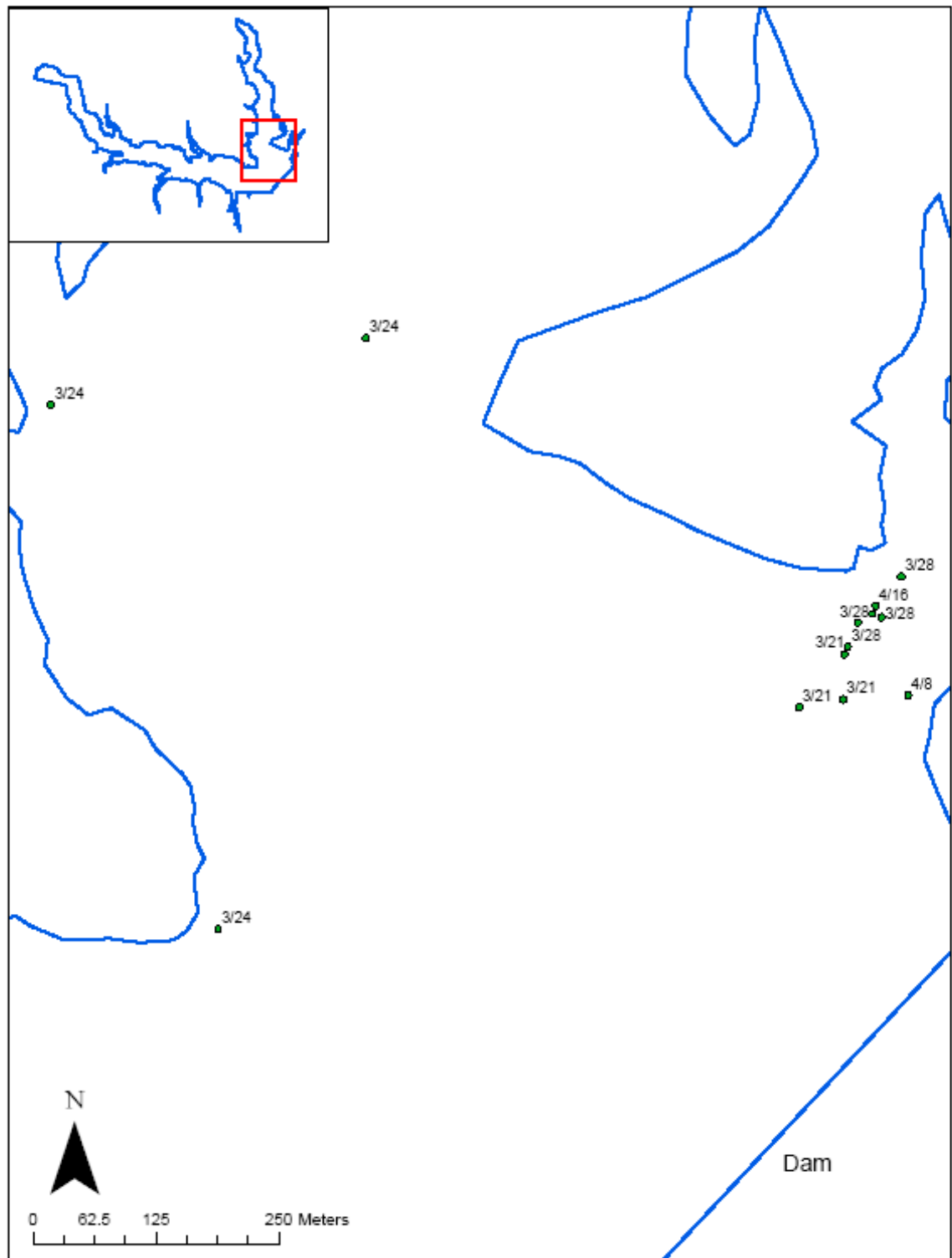


Figure 3-23. Telemetry locations of walleye #9 at Red Willow reservoir, Nebraska during spring 2007.



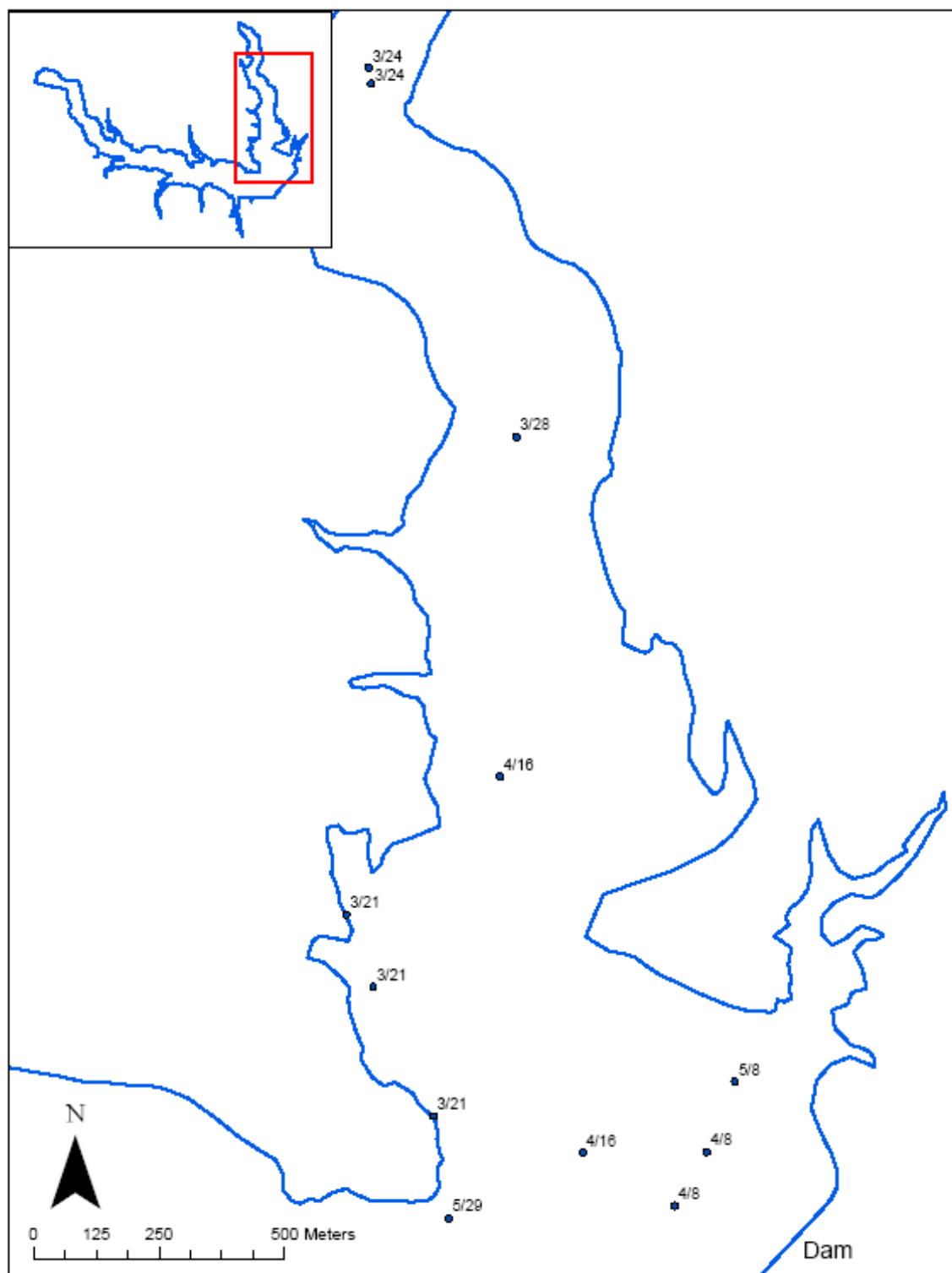


Figure 3-25. Telemetry locations of walleye #24 at Red Willow reservoir, Nebraska during spring 2007.

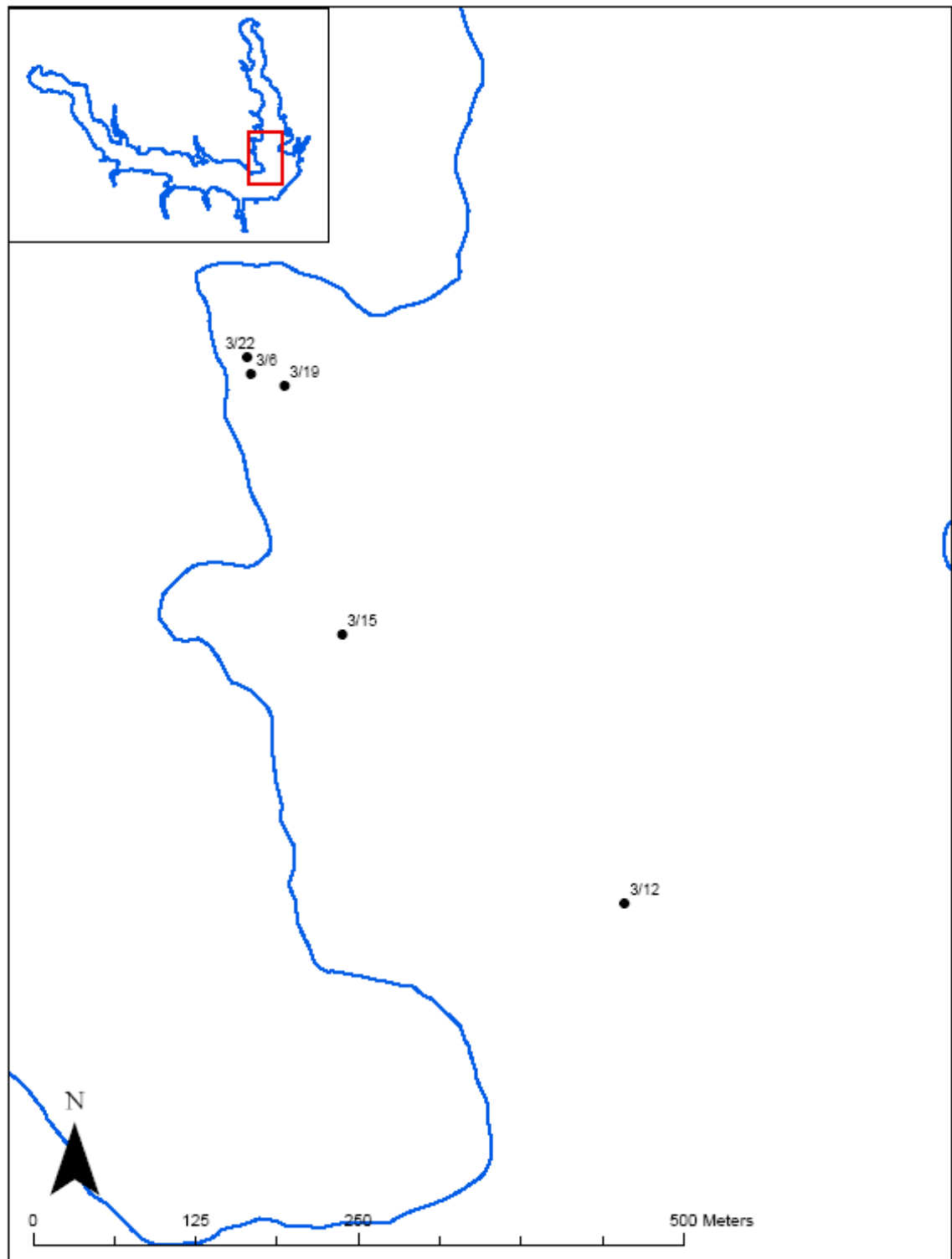


Figure 3-26. Telemetry locations of walleye #112 at Red Willow reservoir, Nebraska during spring 2008.

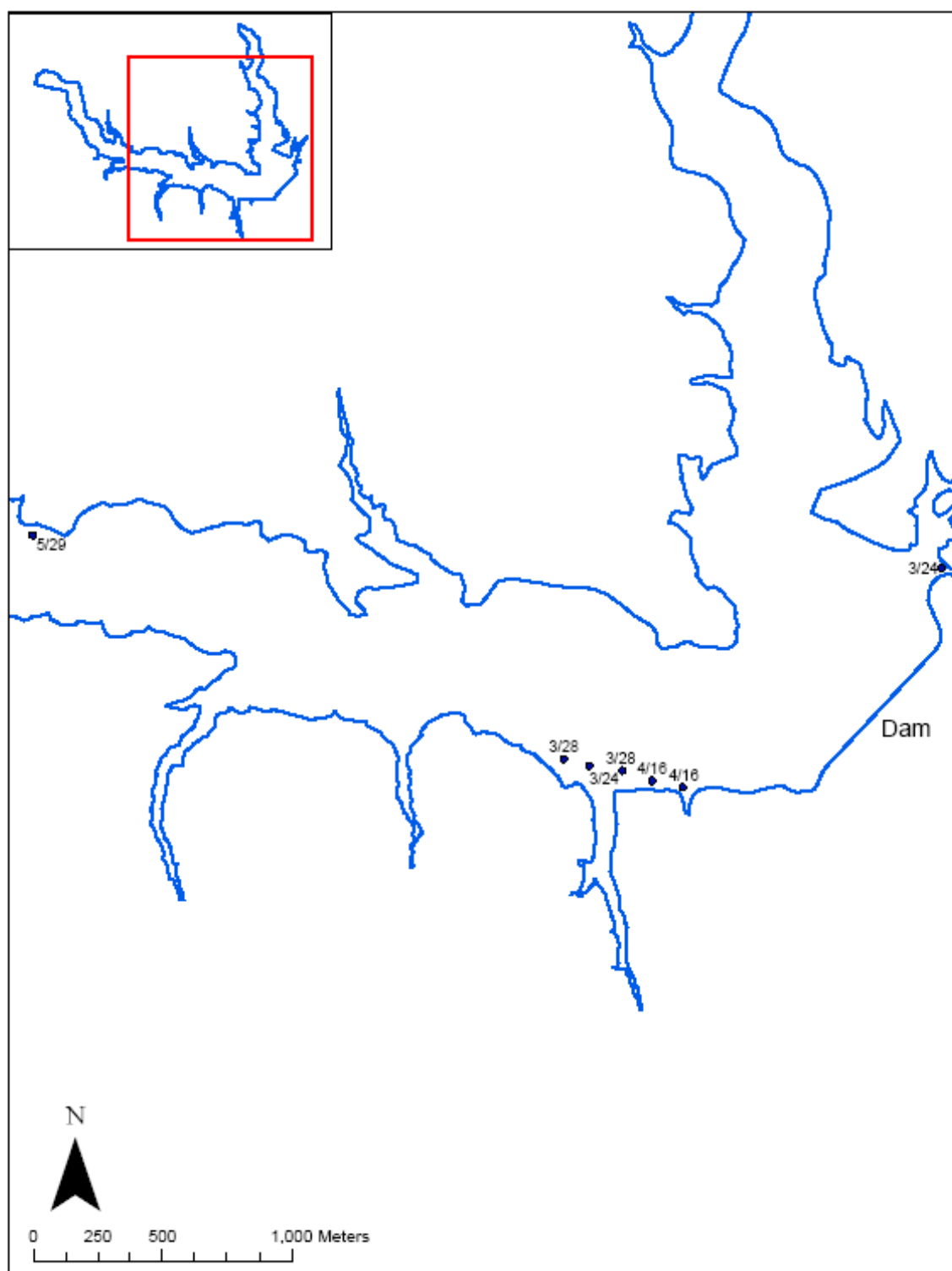


Figure 3-27. Telemetry locations of walleye #22 at Red Willow reservoir, Nebraska during spring 2007.

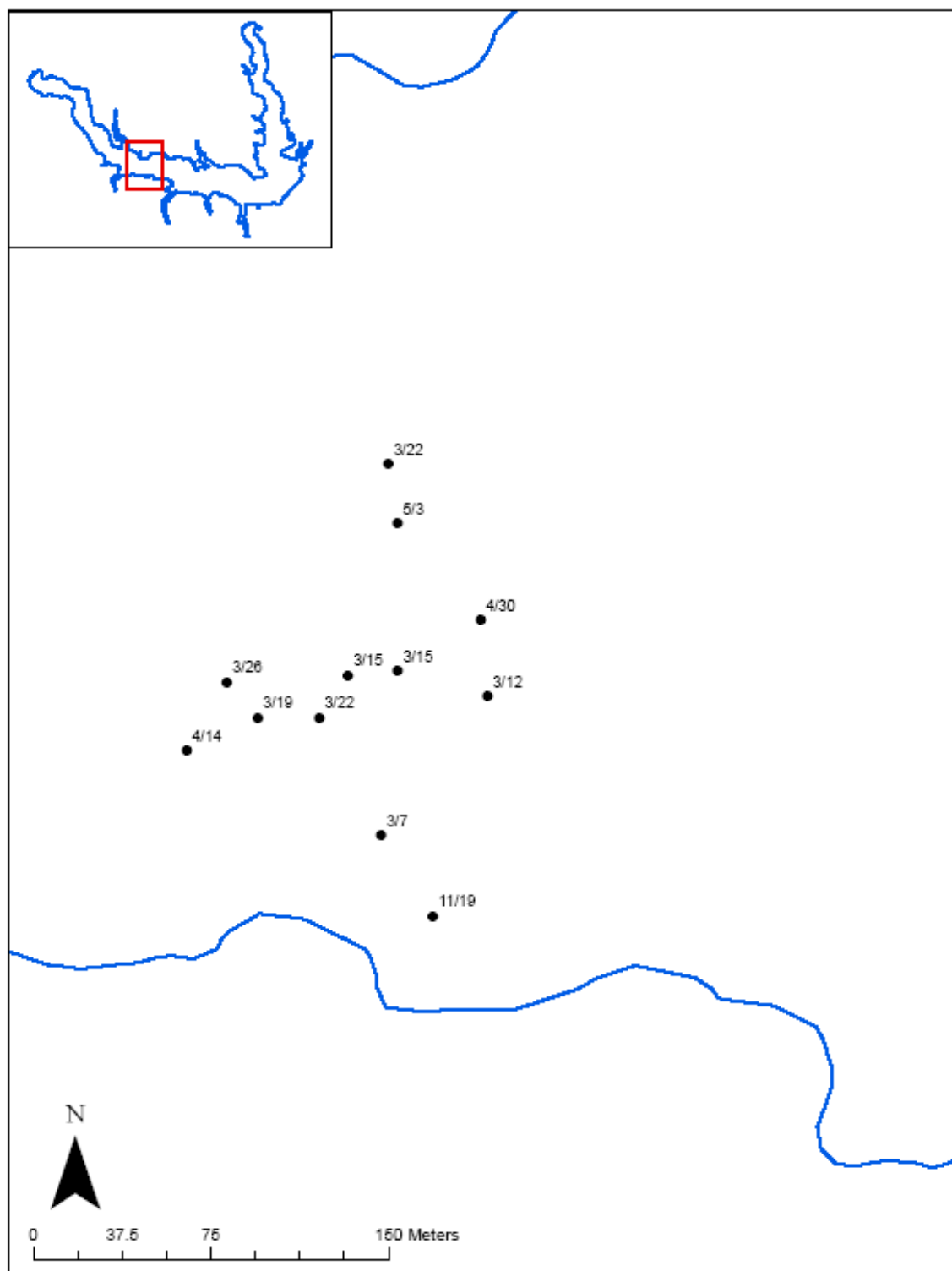


Figure 3-28. Telemetry locations of walleye #175 at Red Willow reservoir, Nebraska during spring 2008.

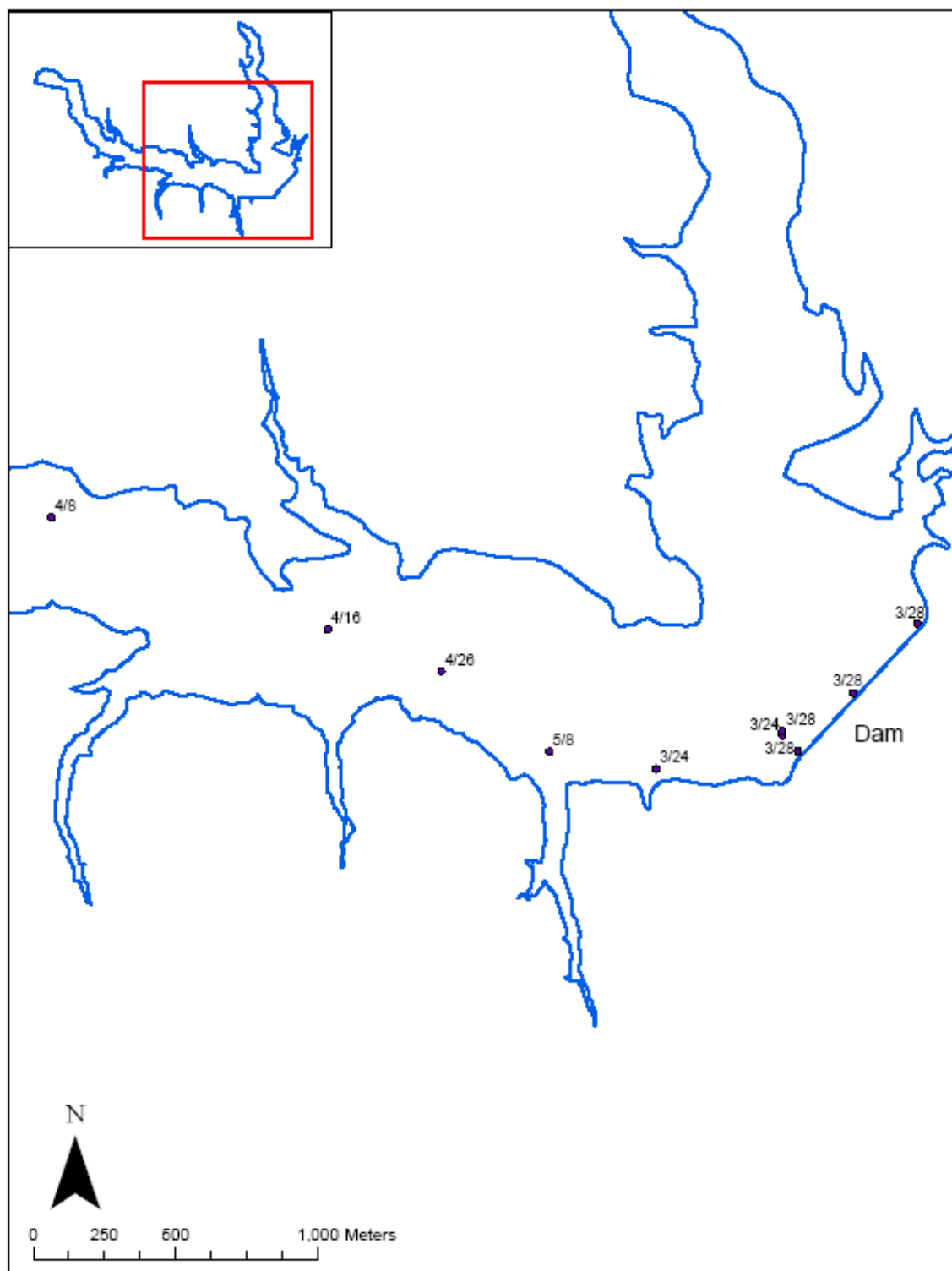


Figure 3-29. Telemetry locations of walleye #11 at Red Willow reservoir, Nebraska during spring 2007.

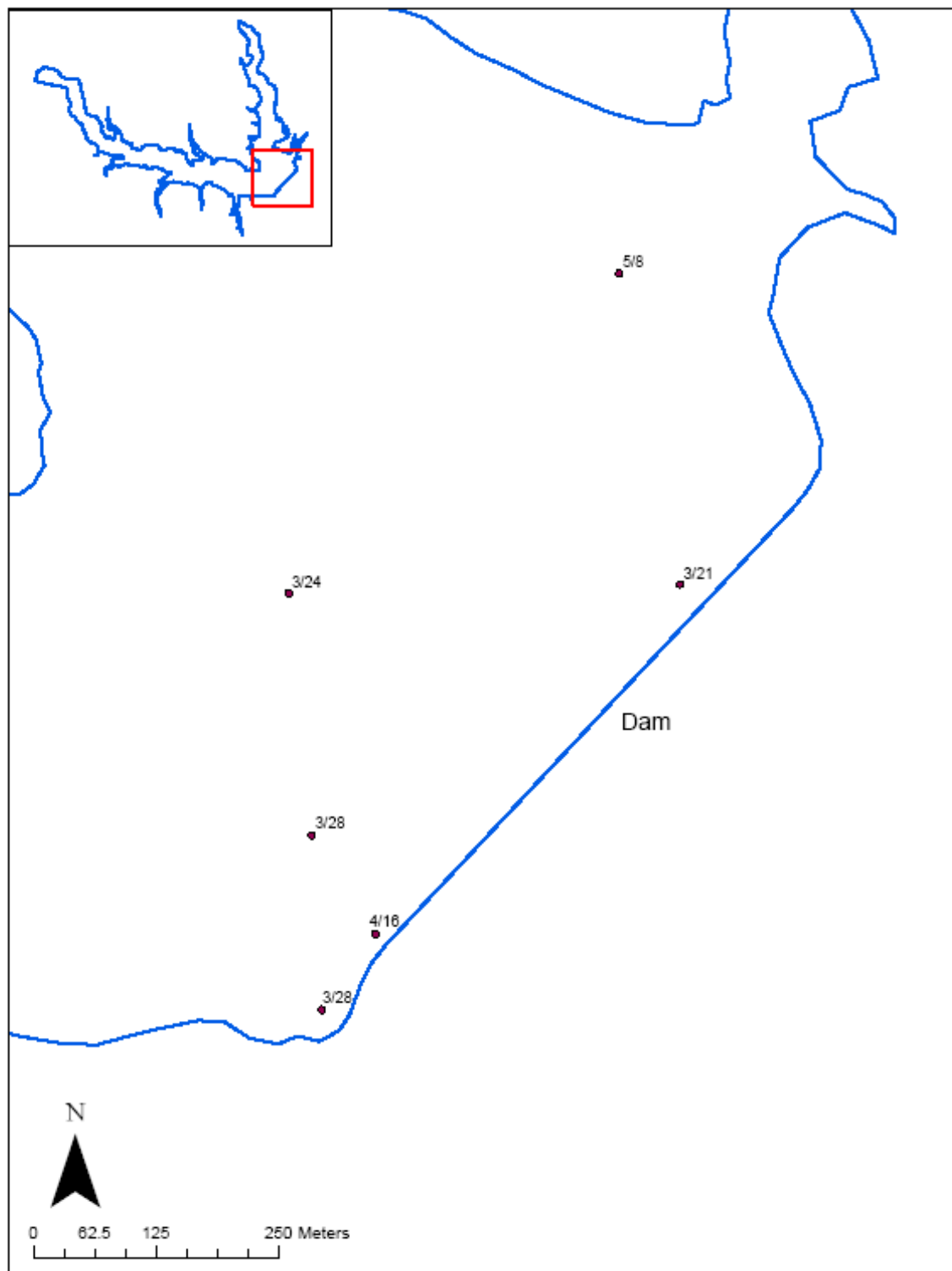


Figure 3-30. Telemetry locations of walleye #23 at Red Willow reservoir, Nebraska during spring 2007.

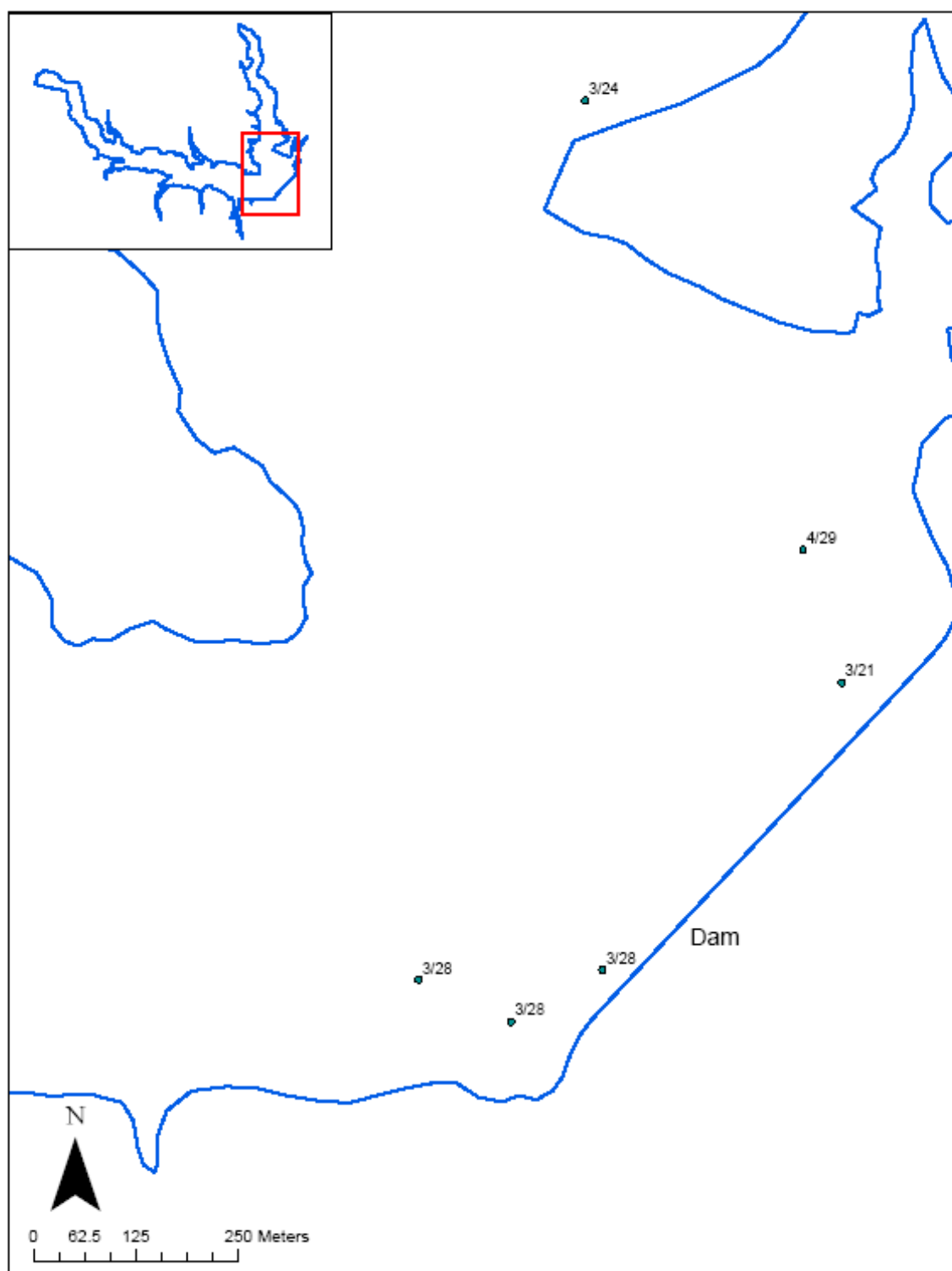


Figure 3-31. Telemetry locations of walleye #34 at Red Willow reservoir, Nebraska during spring 2007.

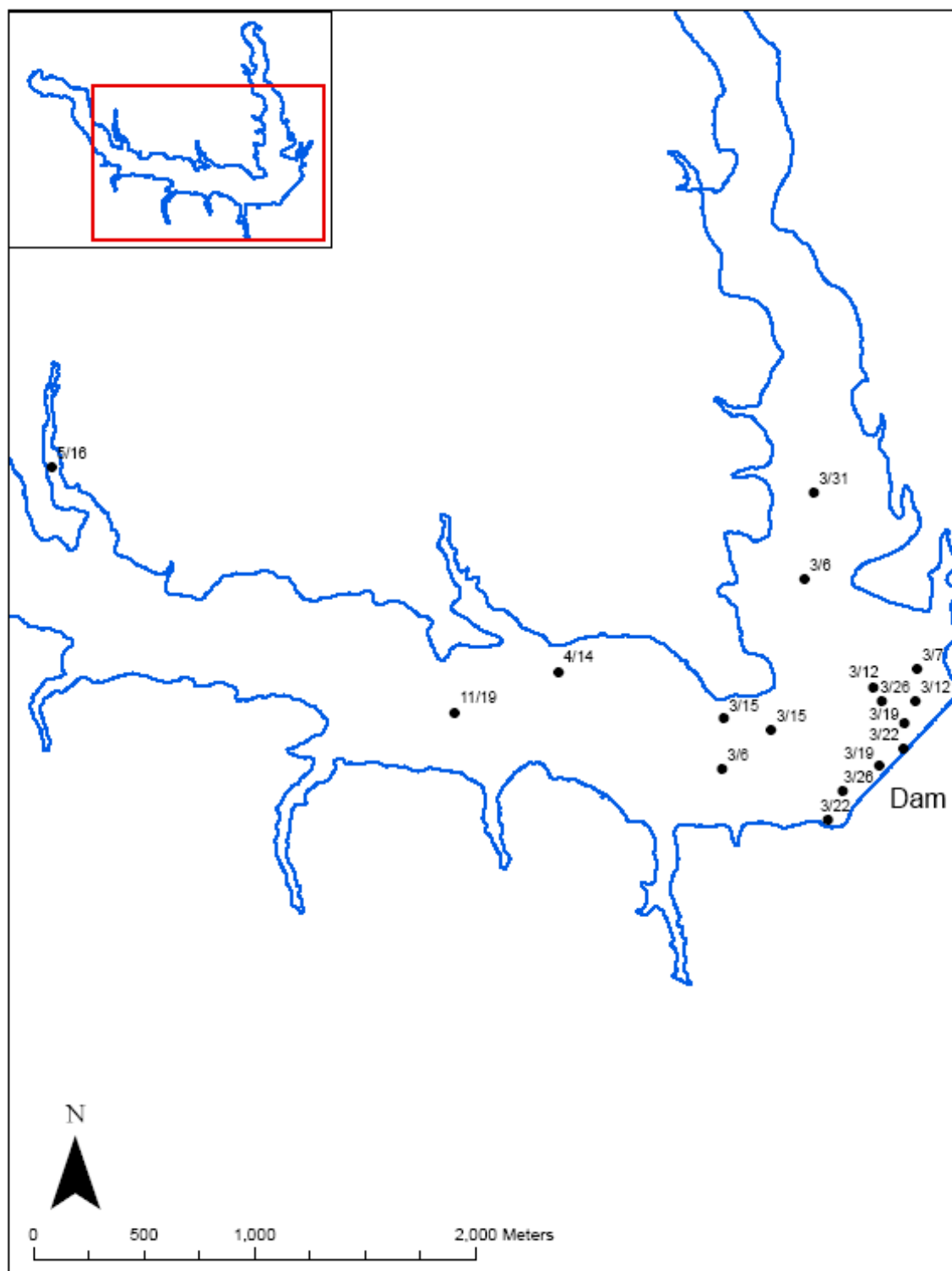
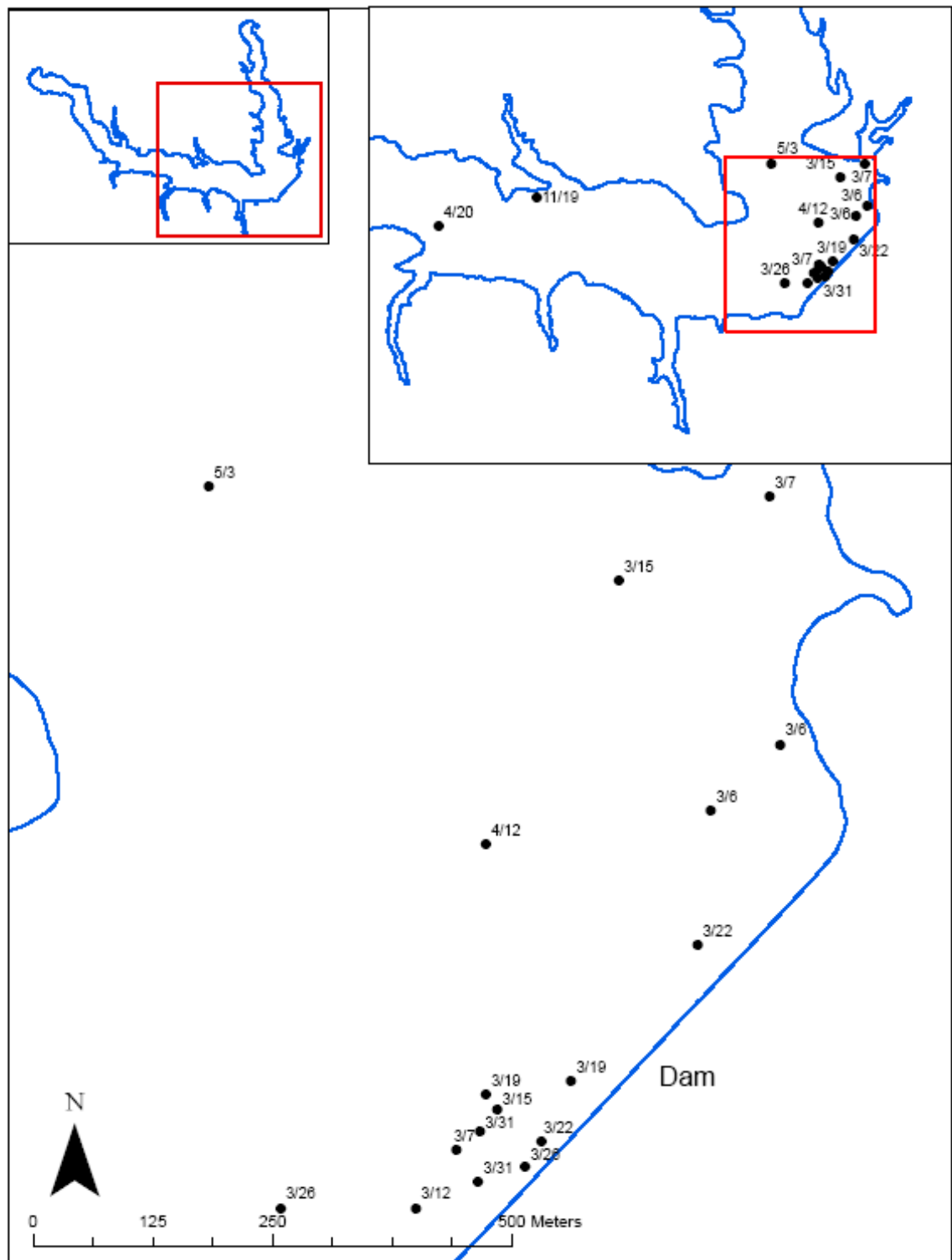


Figure 3-32. Telemetry locations of walleye #108 at Red Willow reservoir, Nebraska during spring 2008. One location was recorded before ice-cover during November 2007.



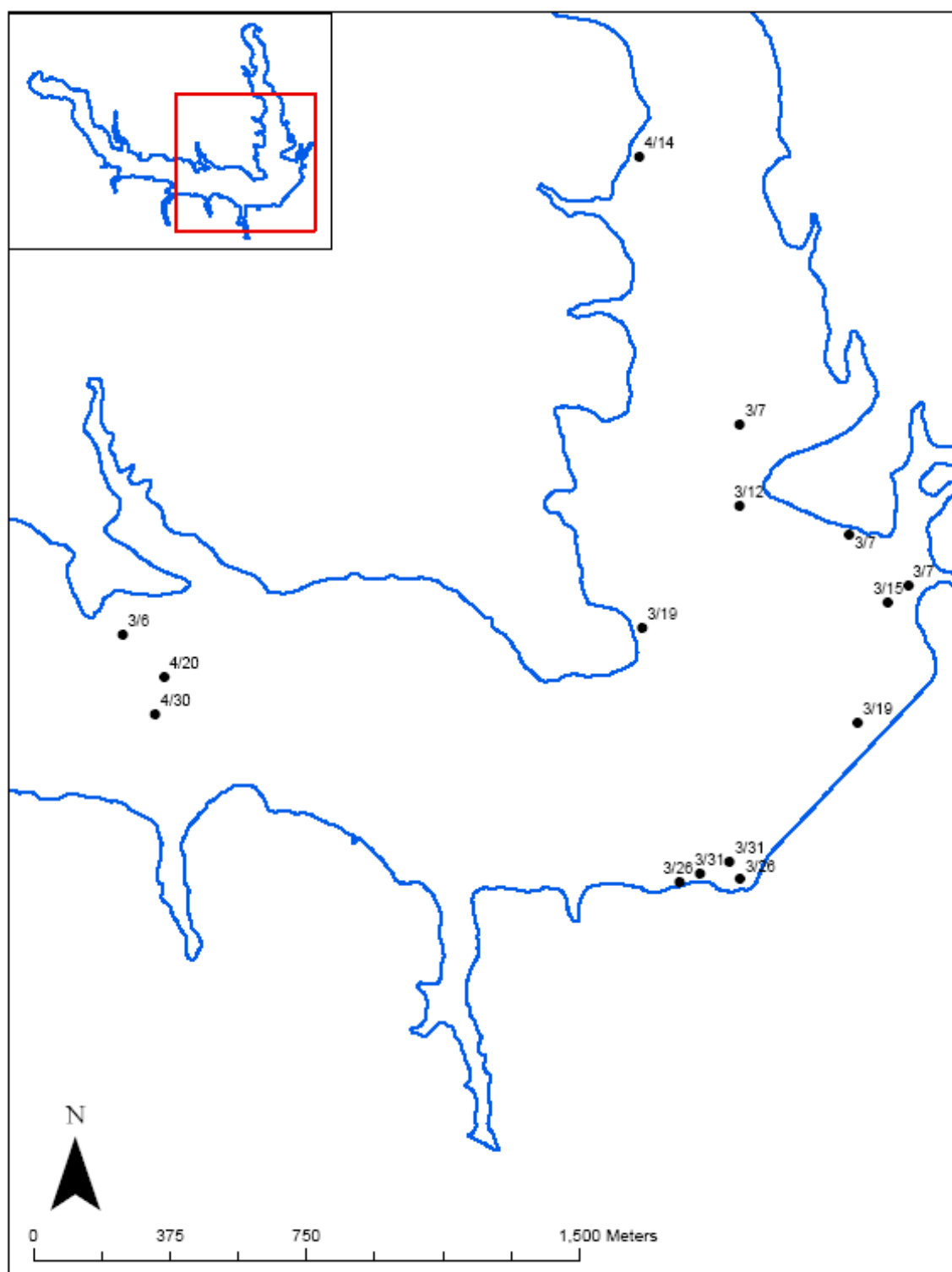
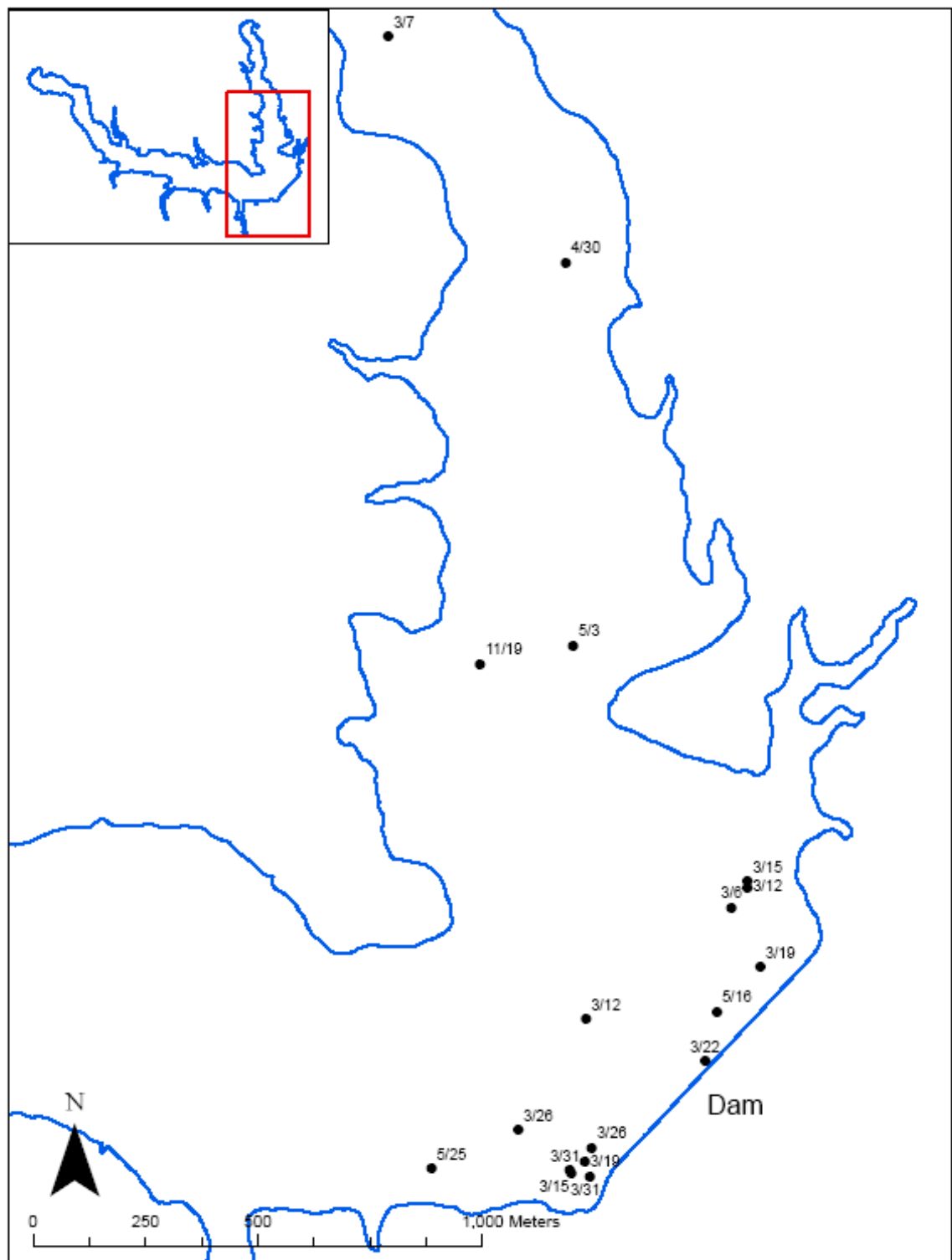


Figure 3-34. Telemetry locations of walleye #123 at Red Willow reservoir, Nebraska during spring 2008.



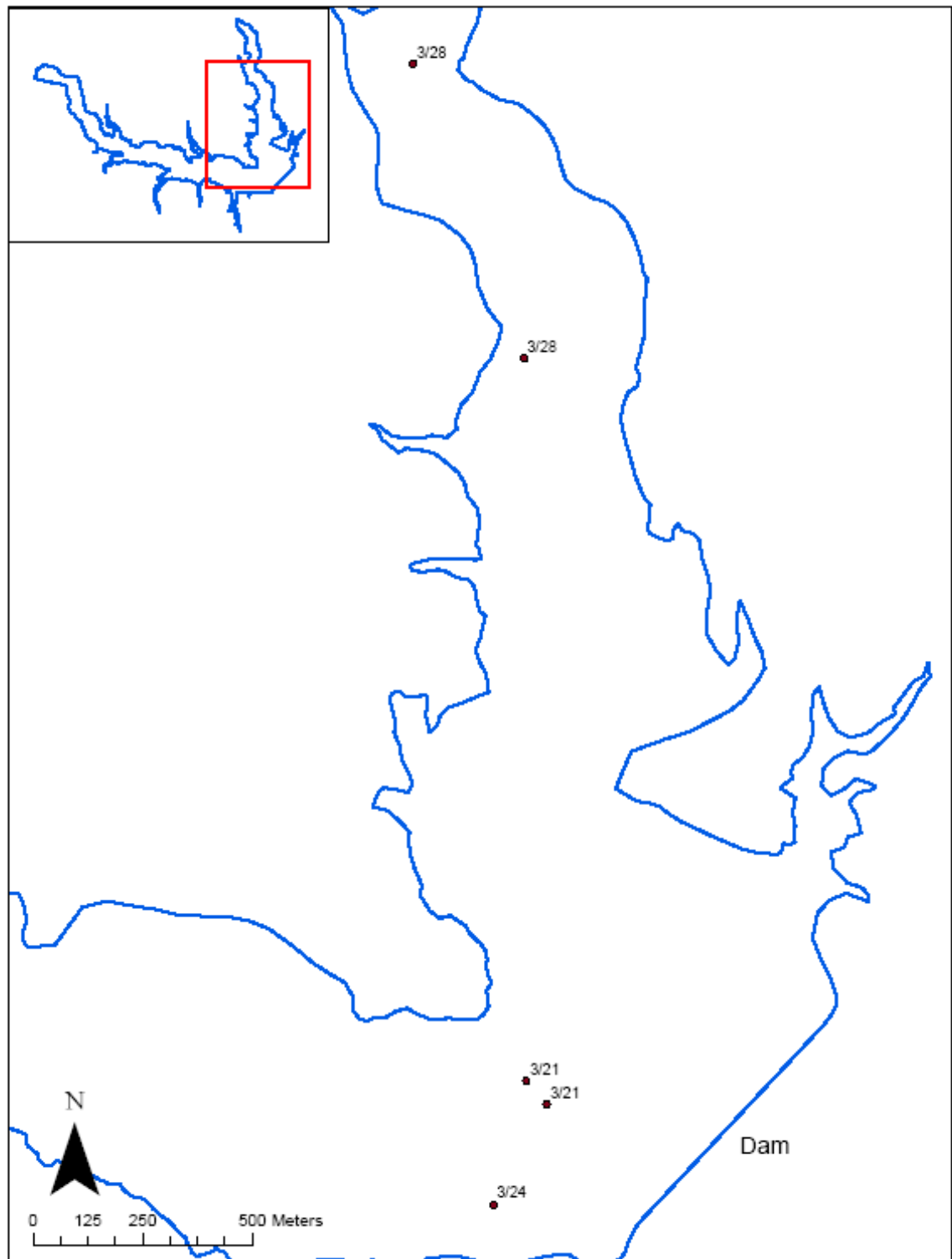


Figure 3-36. Telemetry locations of walleye #7 at Red Willow reservoir, Nebraska during spring 2007.

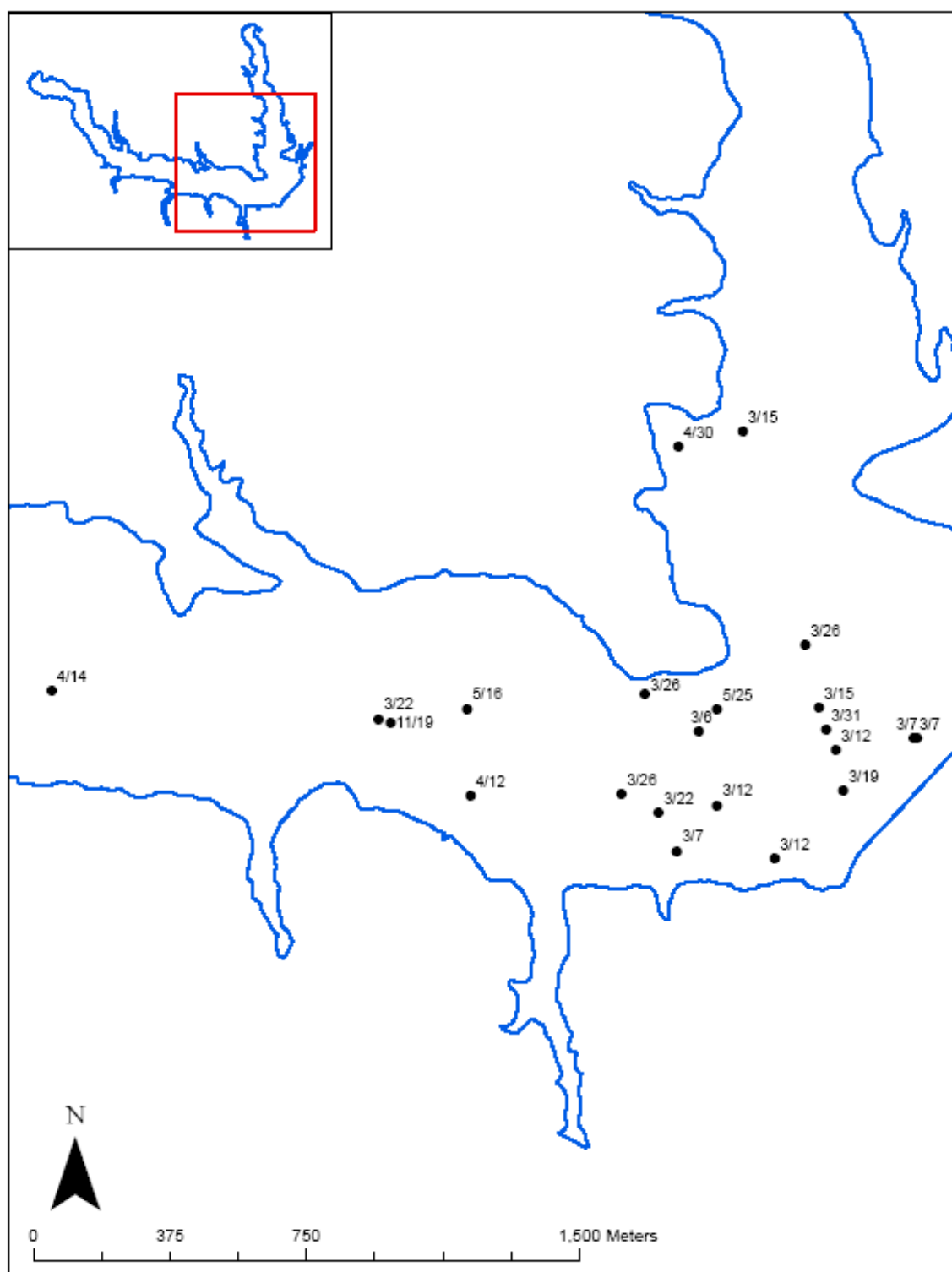


Figure 3-37. Telemetry locations of walleye #124 at Red Willow reservoir, Nebraska during spring 2008. One location was recorded before ice-cover during November 2007.

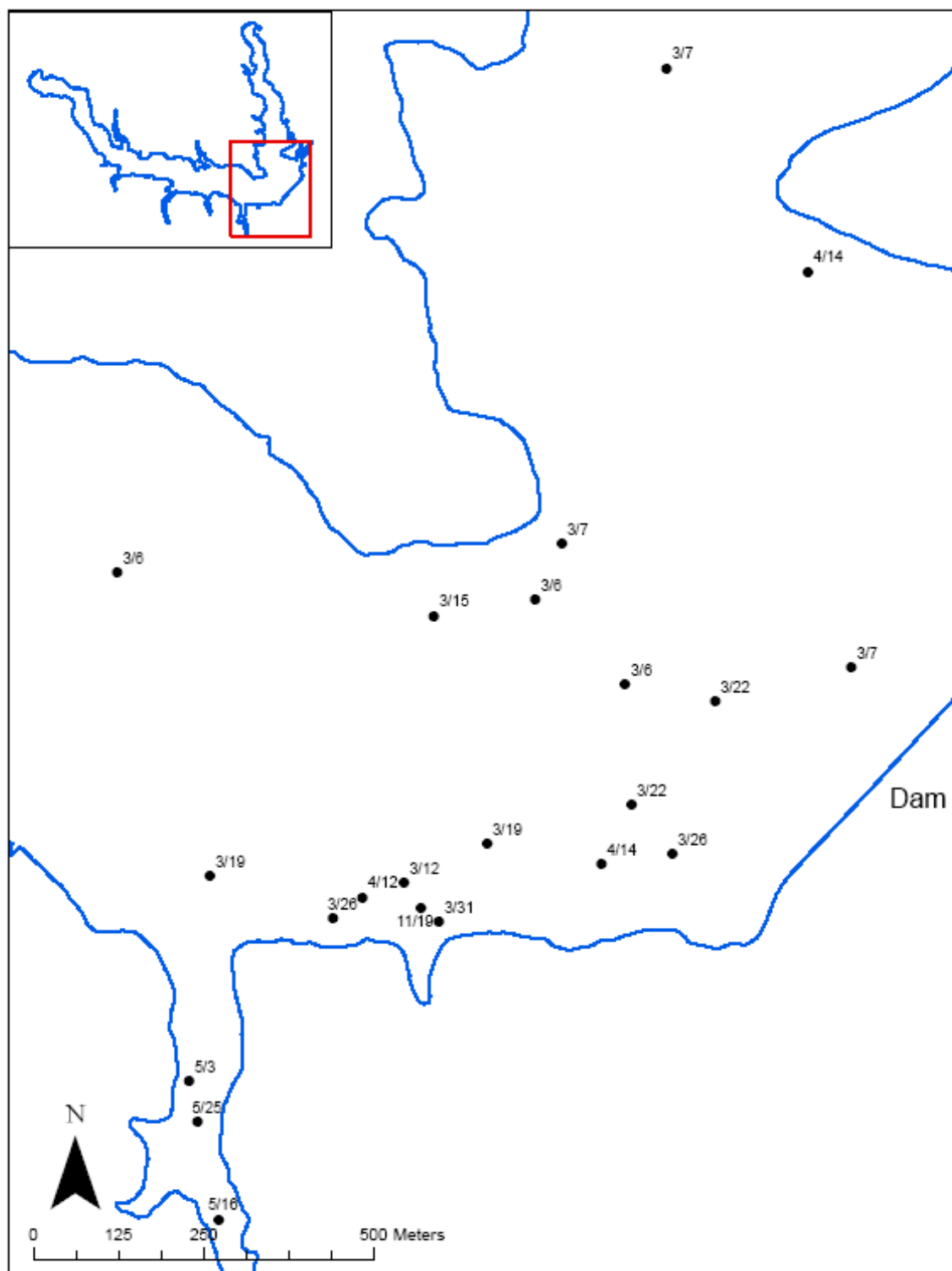


Figure 3-38. Telemetry locations of walleye #128 at Red Willow reservoir, Nebraska during spring 2008. One location was recorded before ice-cover during November 2007.

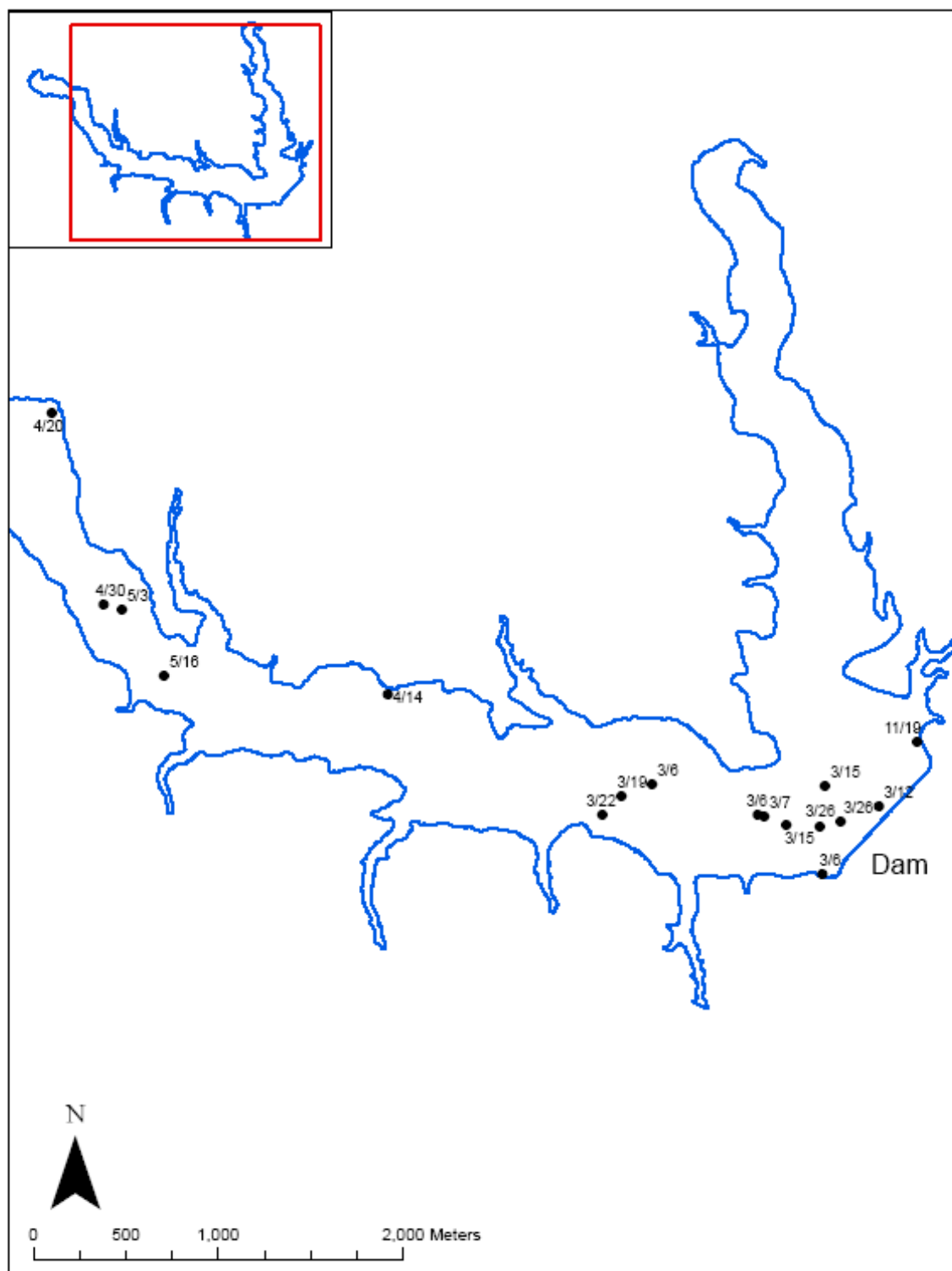


Figure 3-39. Telemetry locations of walleye #161 at Red Willow reservoir, Nebraska during spring 2008. One location was recorded before ice-cover during November 2007.

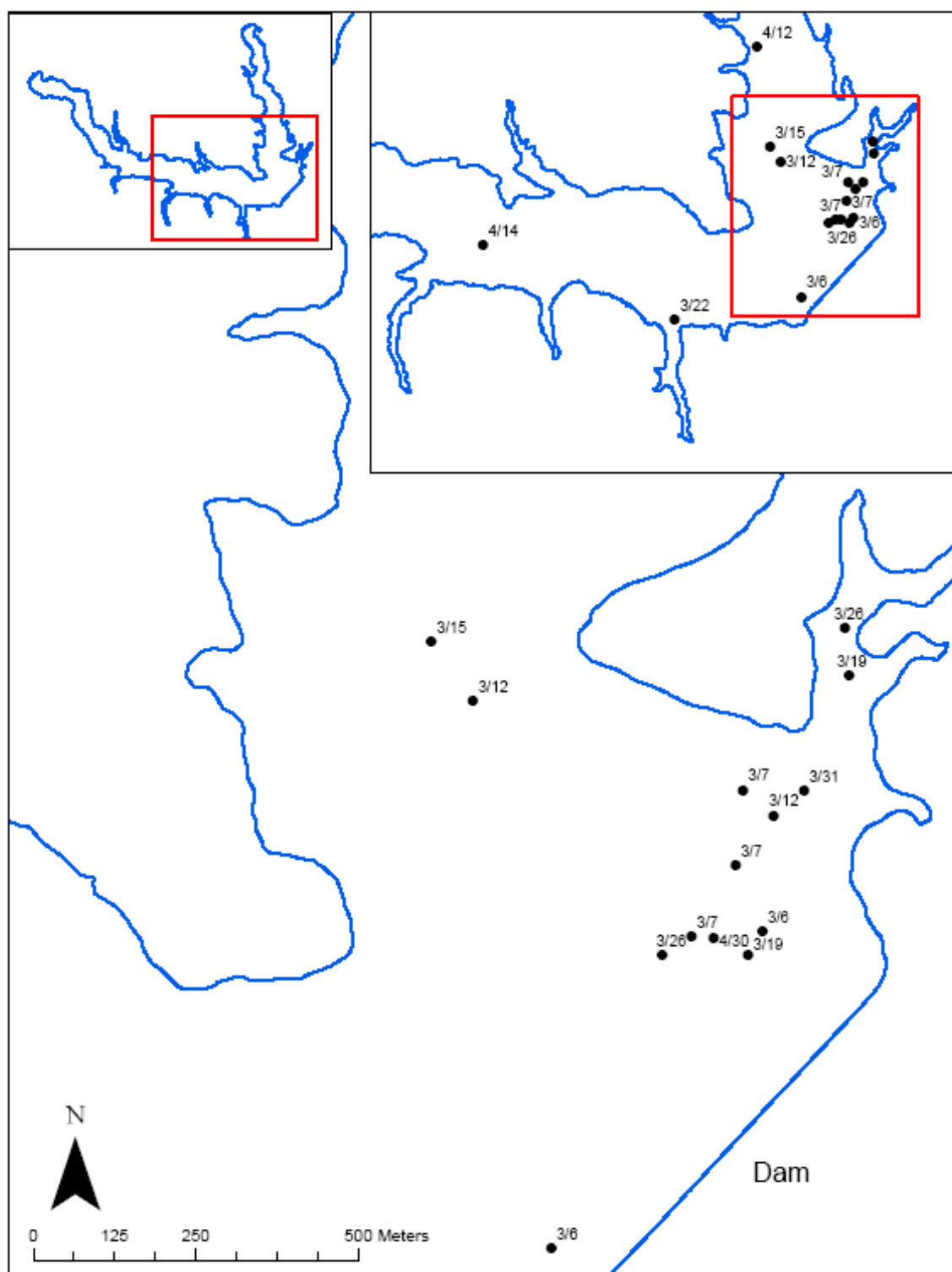


Figure 3-40. Telemetry locations of walleye #176 at Red Willow reservoir, Nebraska during spring 2008.

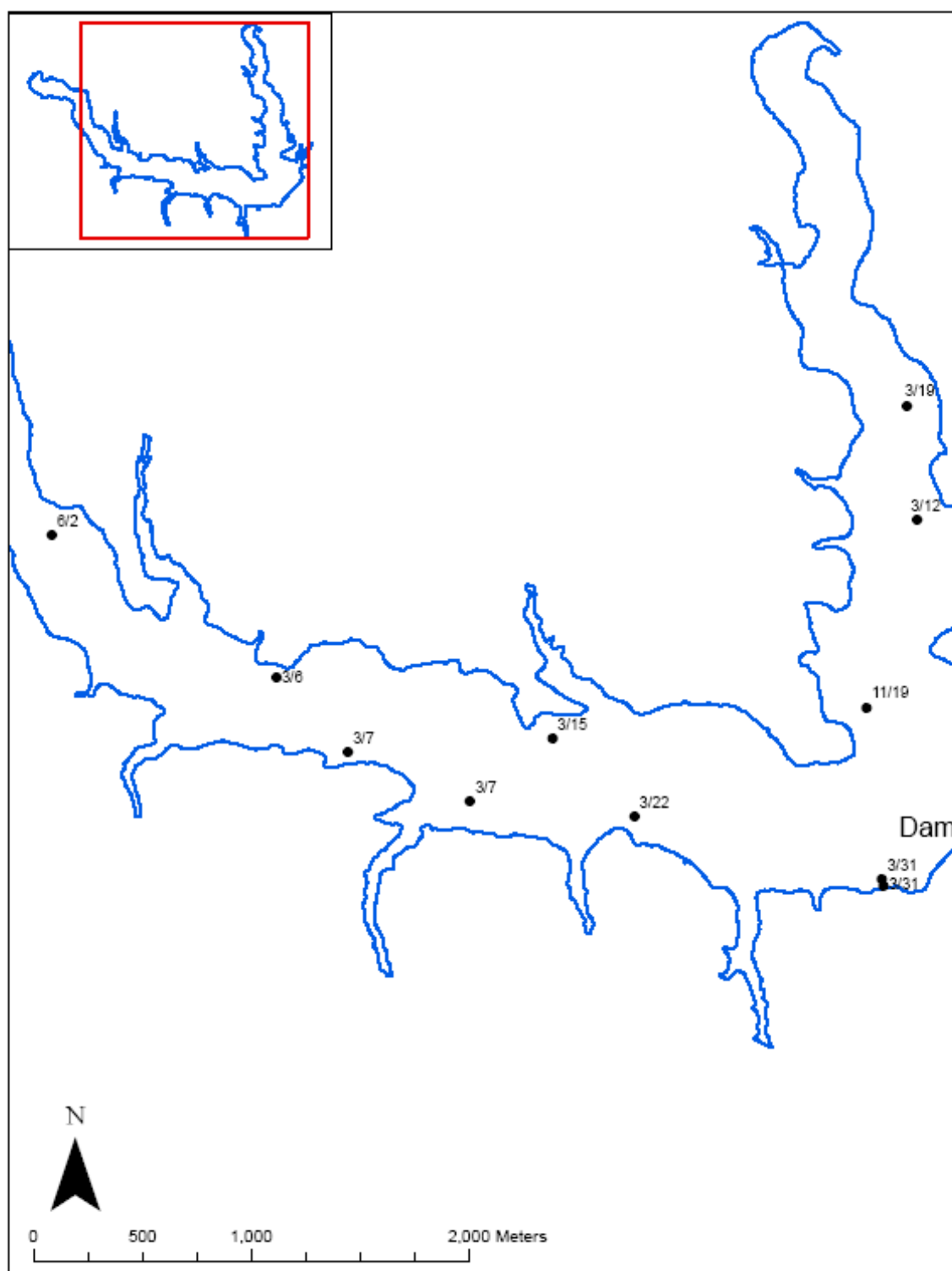


Figure 3-41. Telemetry locations of walleye #137 at Red Willow reservoir, Nebraska during spring 2008. One location was recorded before ice-cover during November 2007.

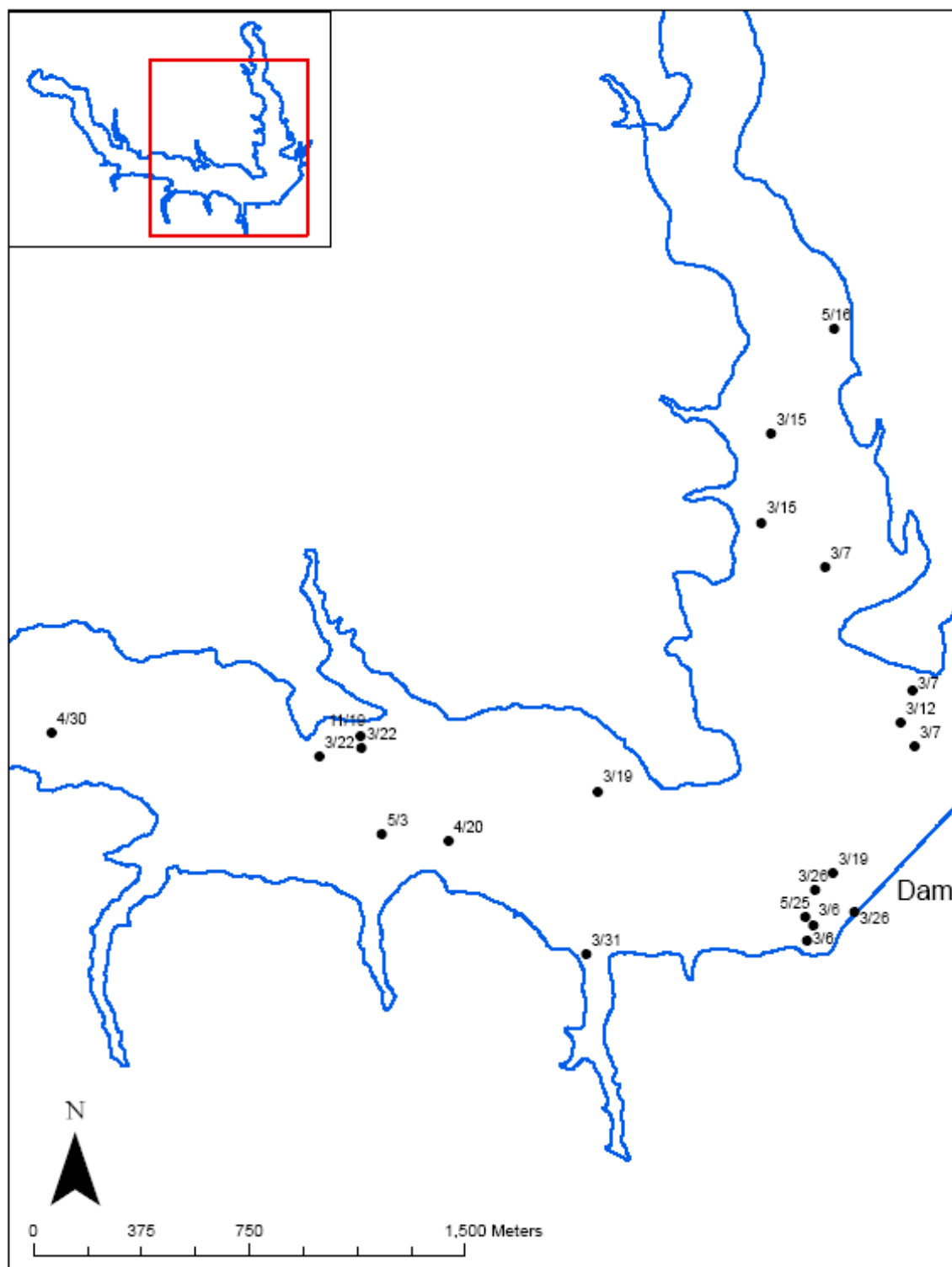


Figure 3-42. Telemetry locations of walleye #144 at Red Willow reservoir, Nebraska during spring 2008. One location was recorded before ice-cover during November 2007.

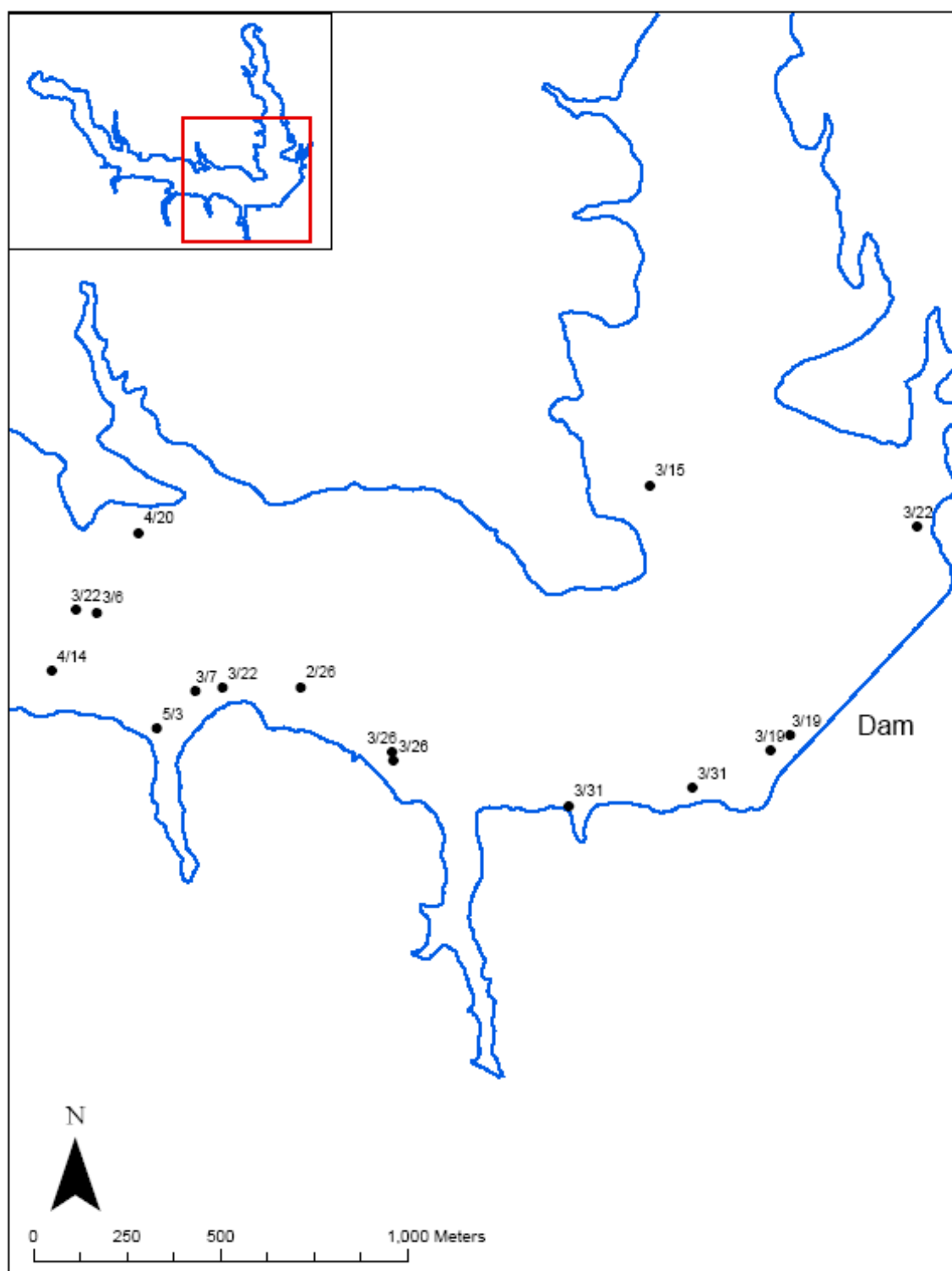


Figure 3-43. Telemetry locations of walleye #153 at Red Willow reservoir, Nebraska during spring 2008.

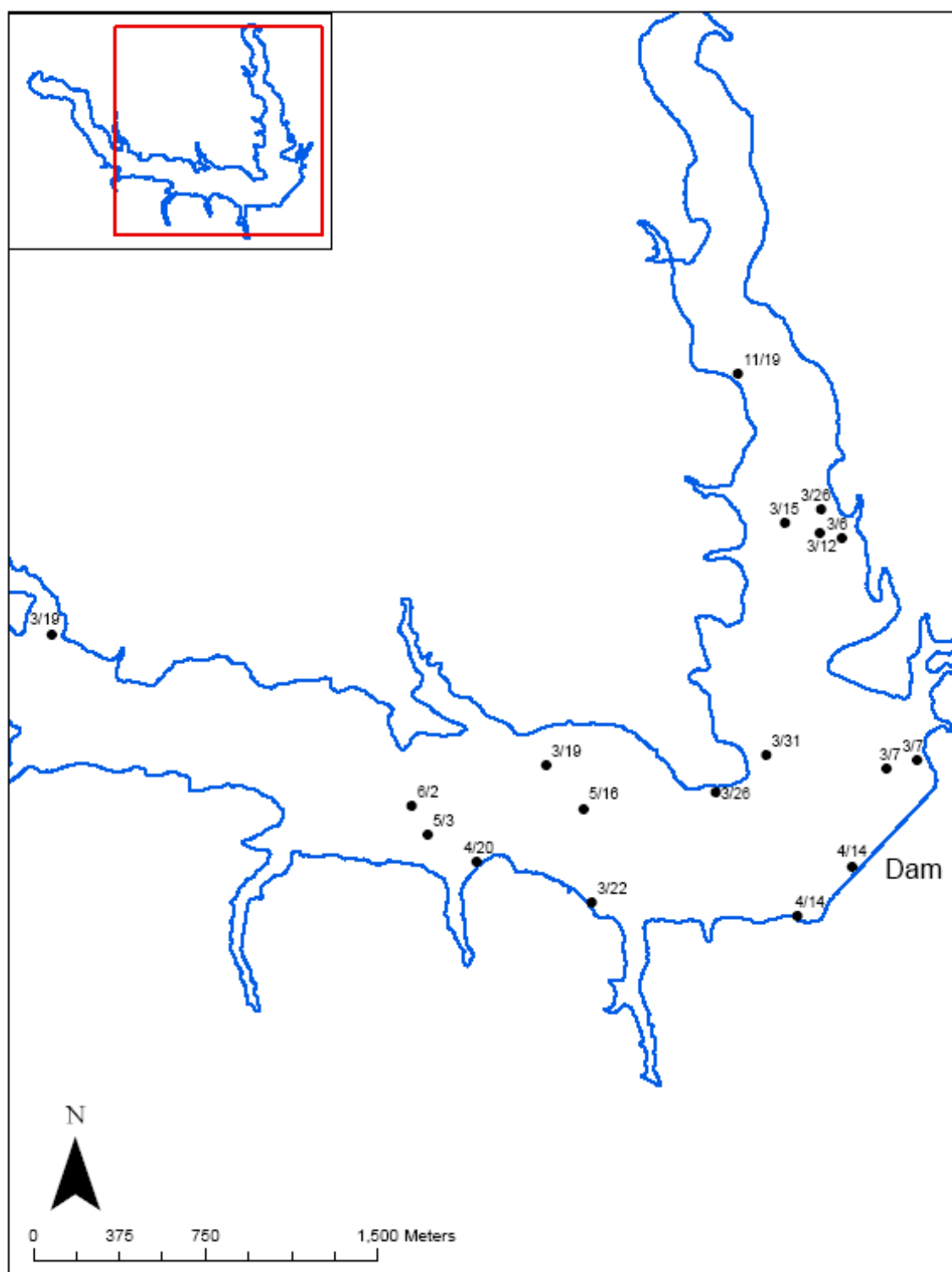


Figure 3-44. Telemetry locations of walleye #154 at Red Willow reservoir, Nebraska during spring 2008. One location was recorded before ice-cover during November 2007.

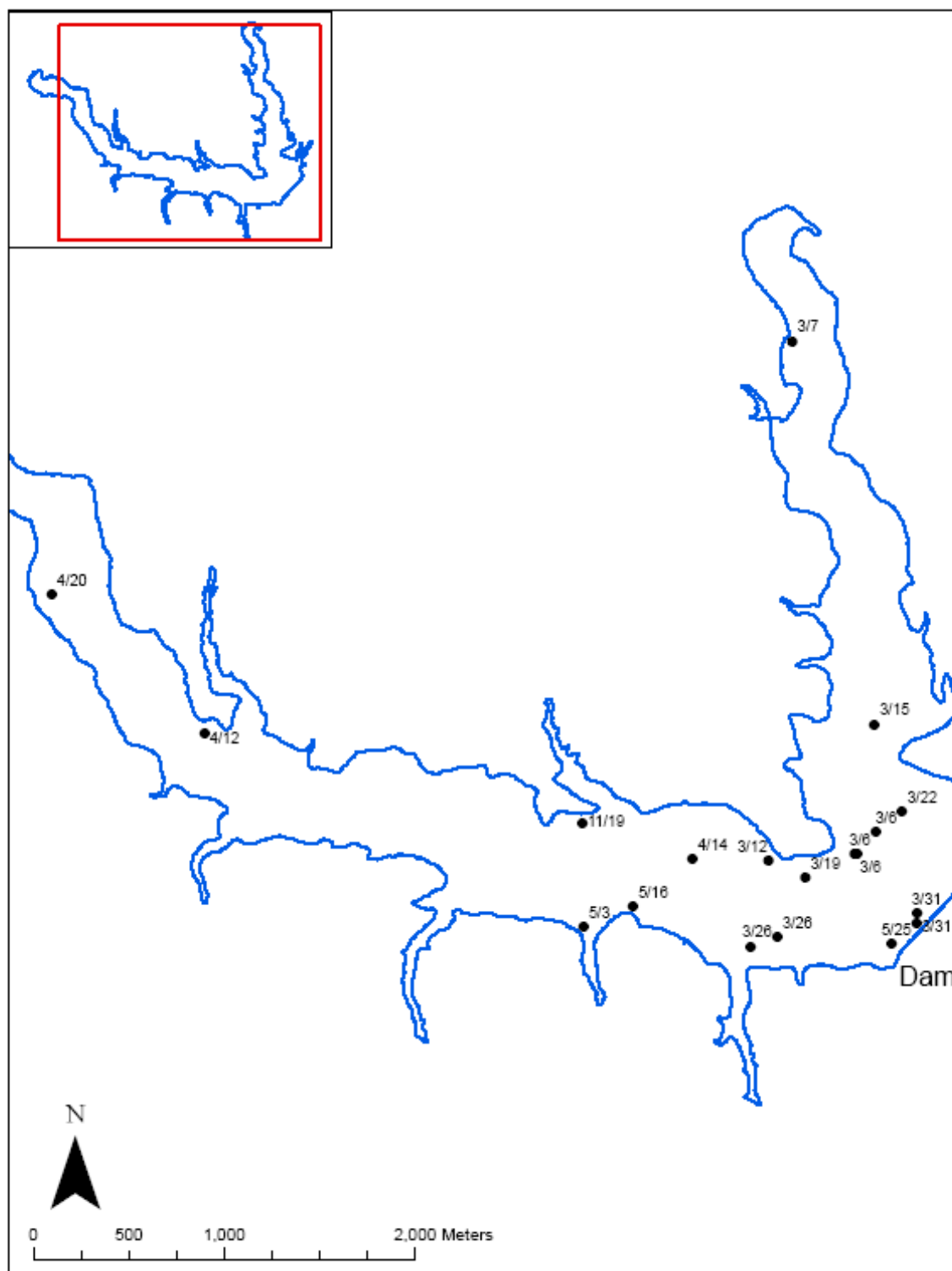


Figure 3-45. Telemetry locations of walleye #155 at Red Willow reservoir, Nebraska during spring 2008. One location was recorded before ice-cover during November 2007.

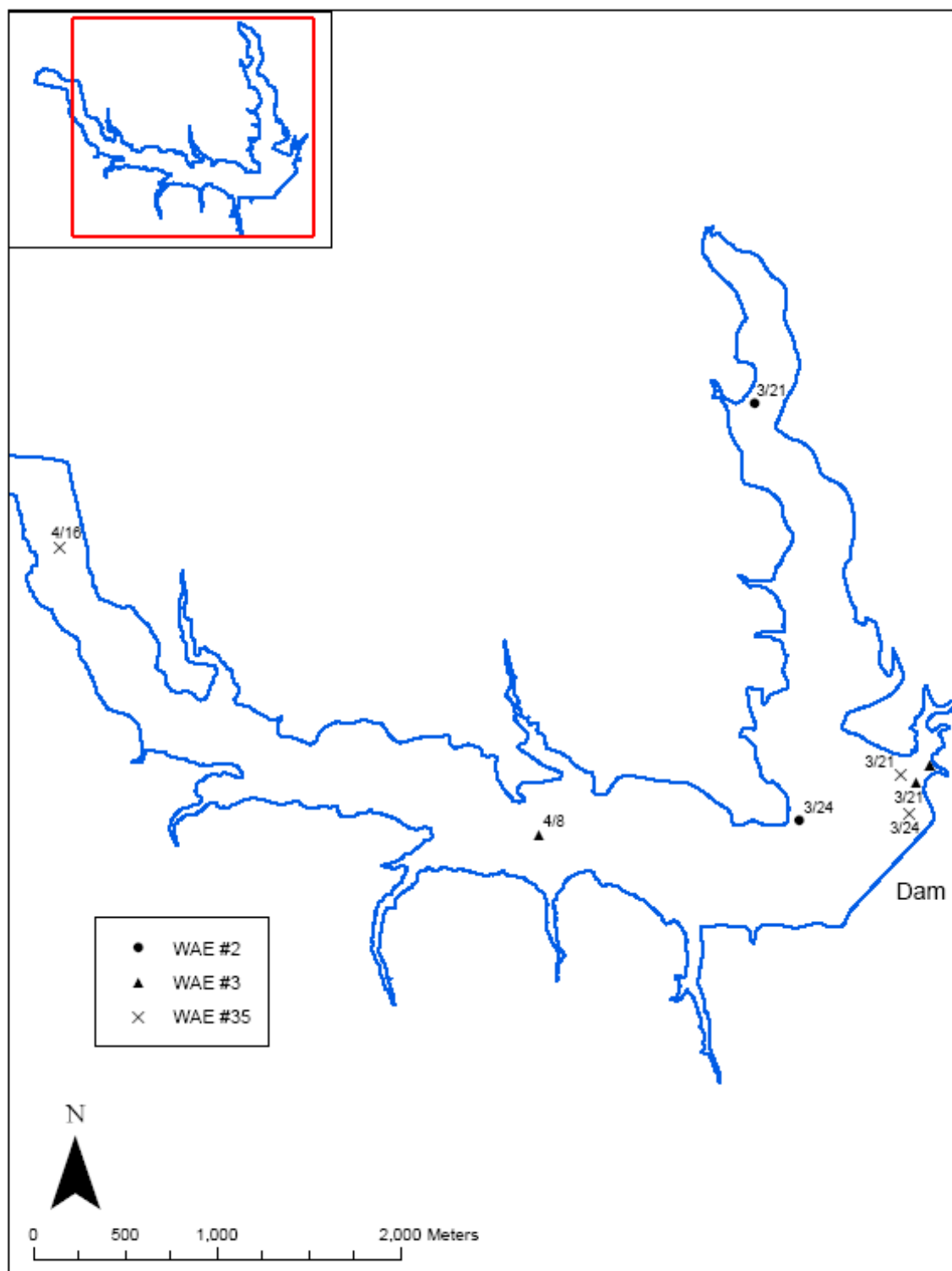


Figure 3-46. Telemetry locations of walleye with fewer than five locations at Red Willow reservoir, Nebraska during spring 2007.

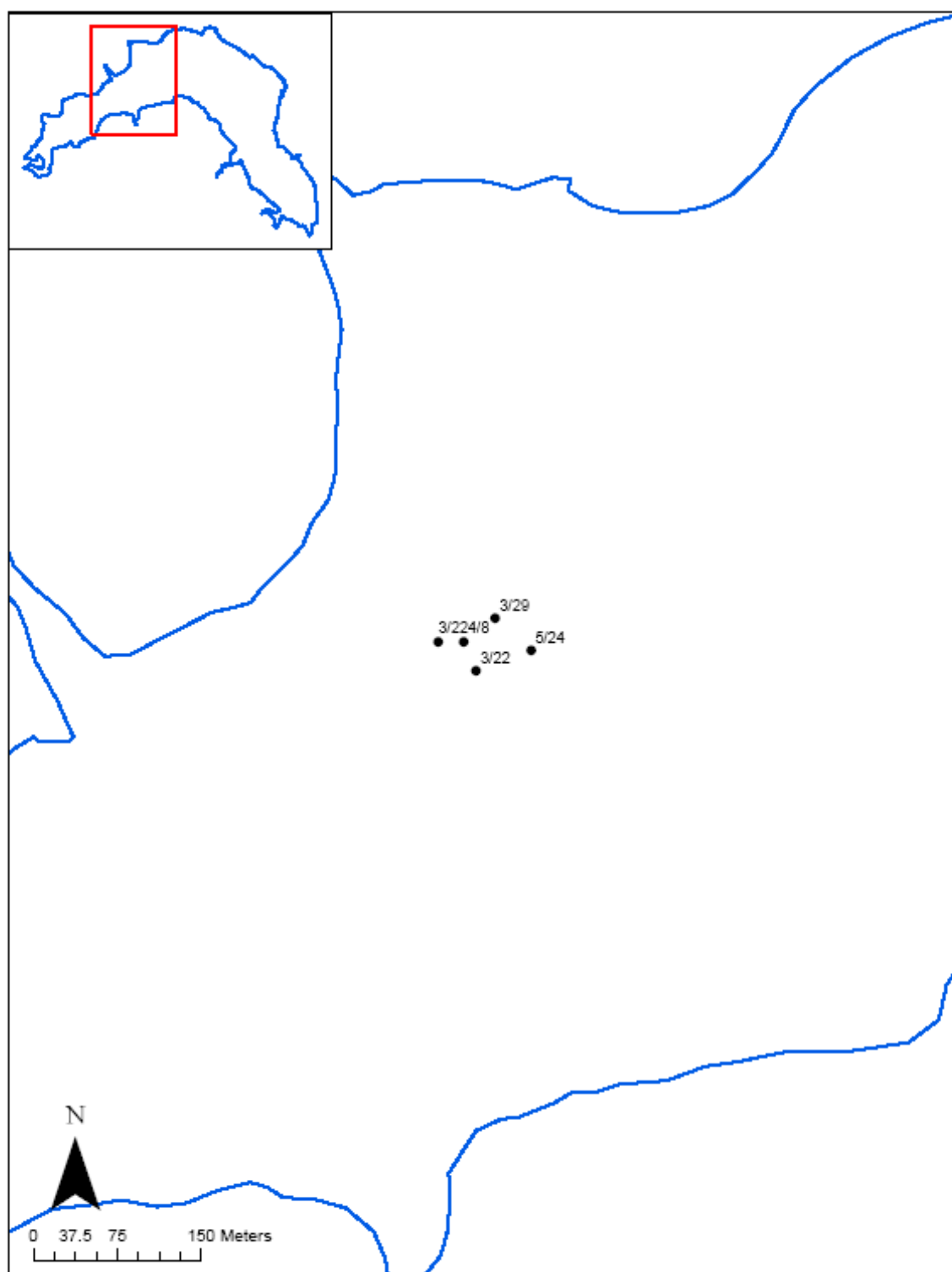


Figure 3-47. Telemetry locations of white bass #51 at Enders Reservoir, Nebraska during spring 2007.

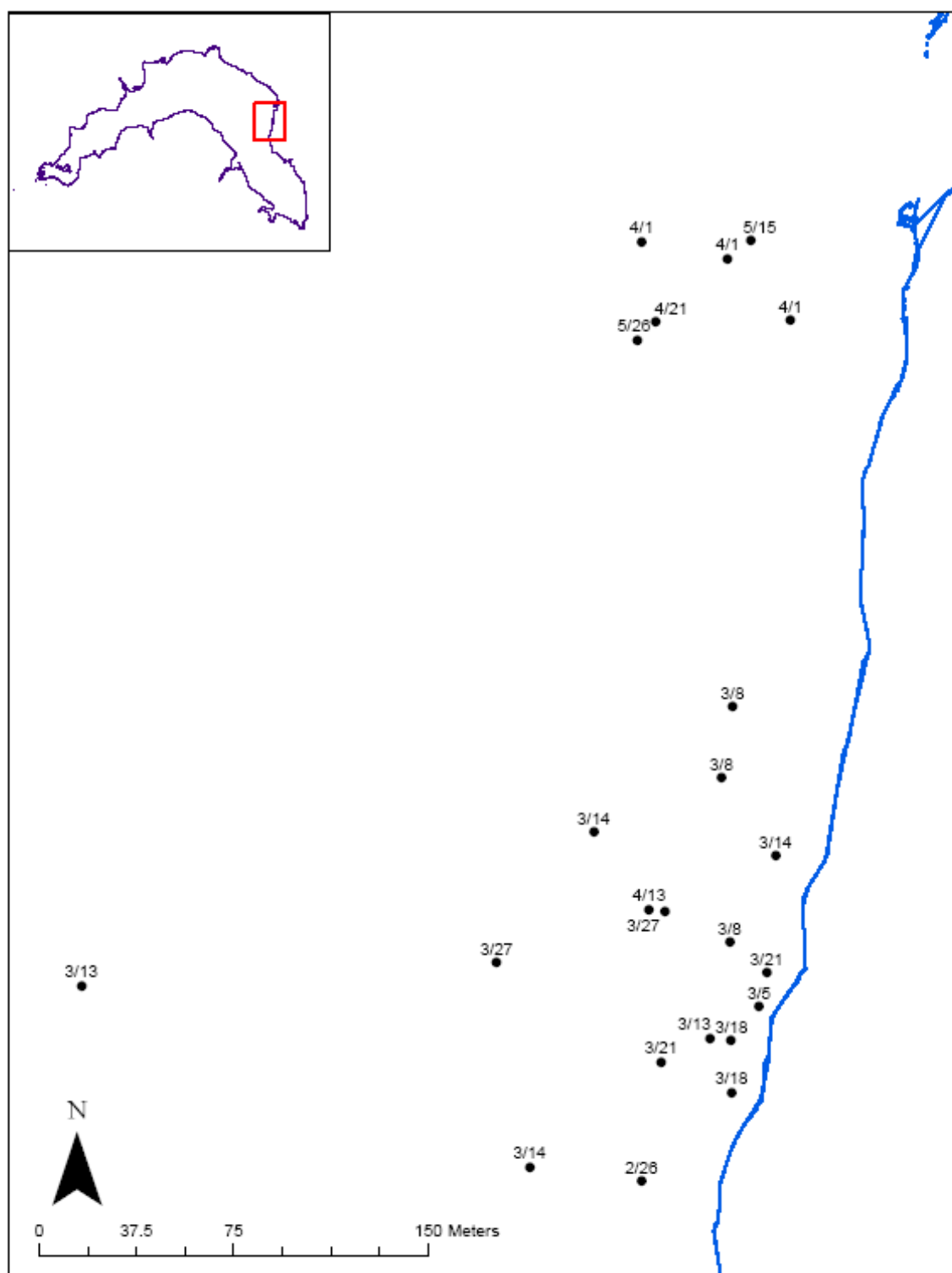


Figure 3-48. Telemetry locations of white bass #115 at Enders Reservoir, Nebraska during spring 2008.

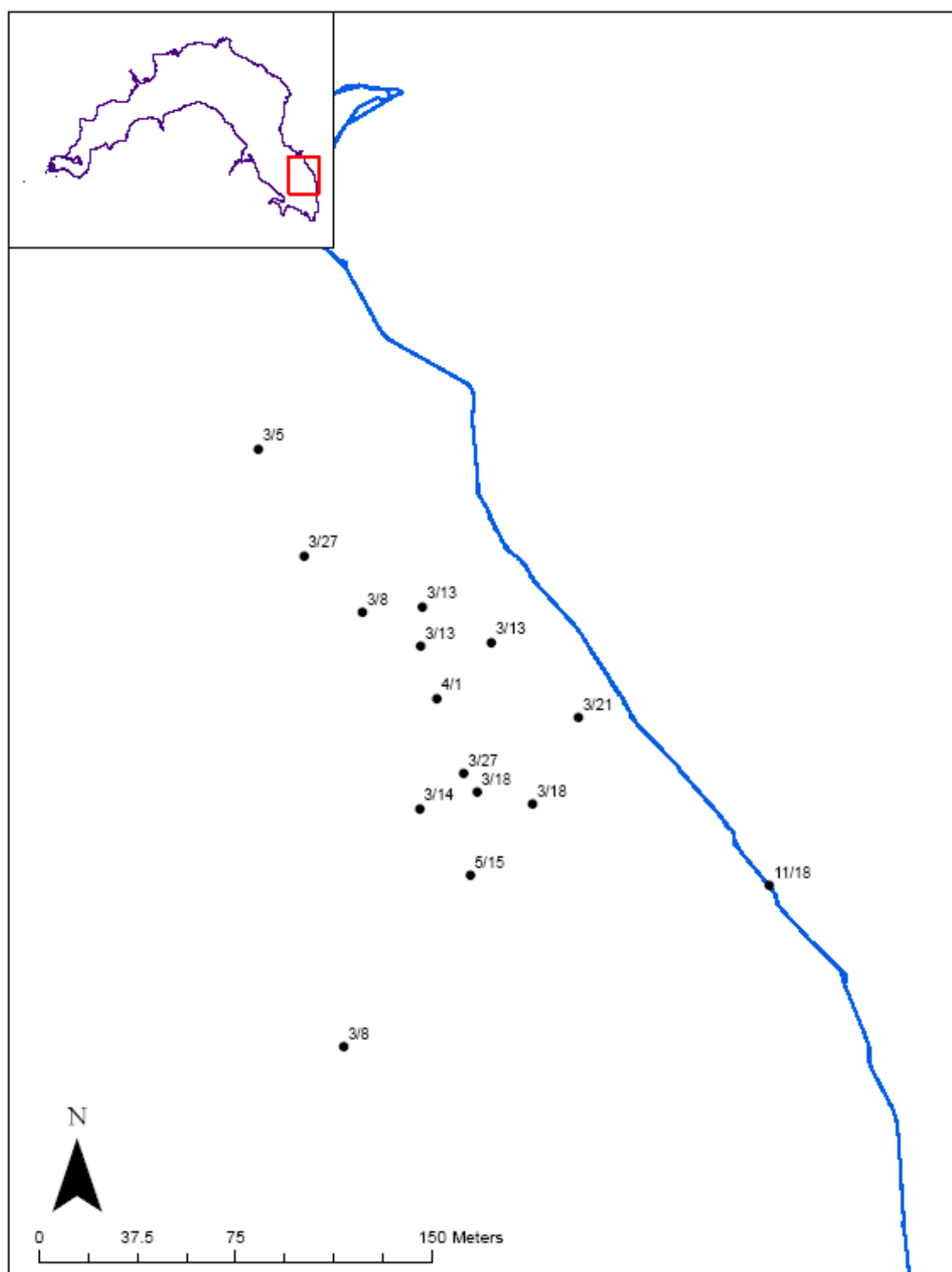


Figure 3-49. Telemetry locations of white bass #129 at Enders Reservoir, Nebraska during spring 2008. One location was recorded before ice-cover during November 2007.

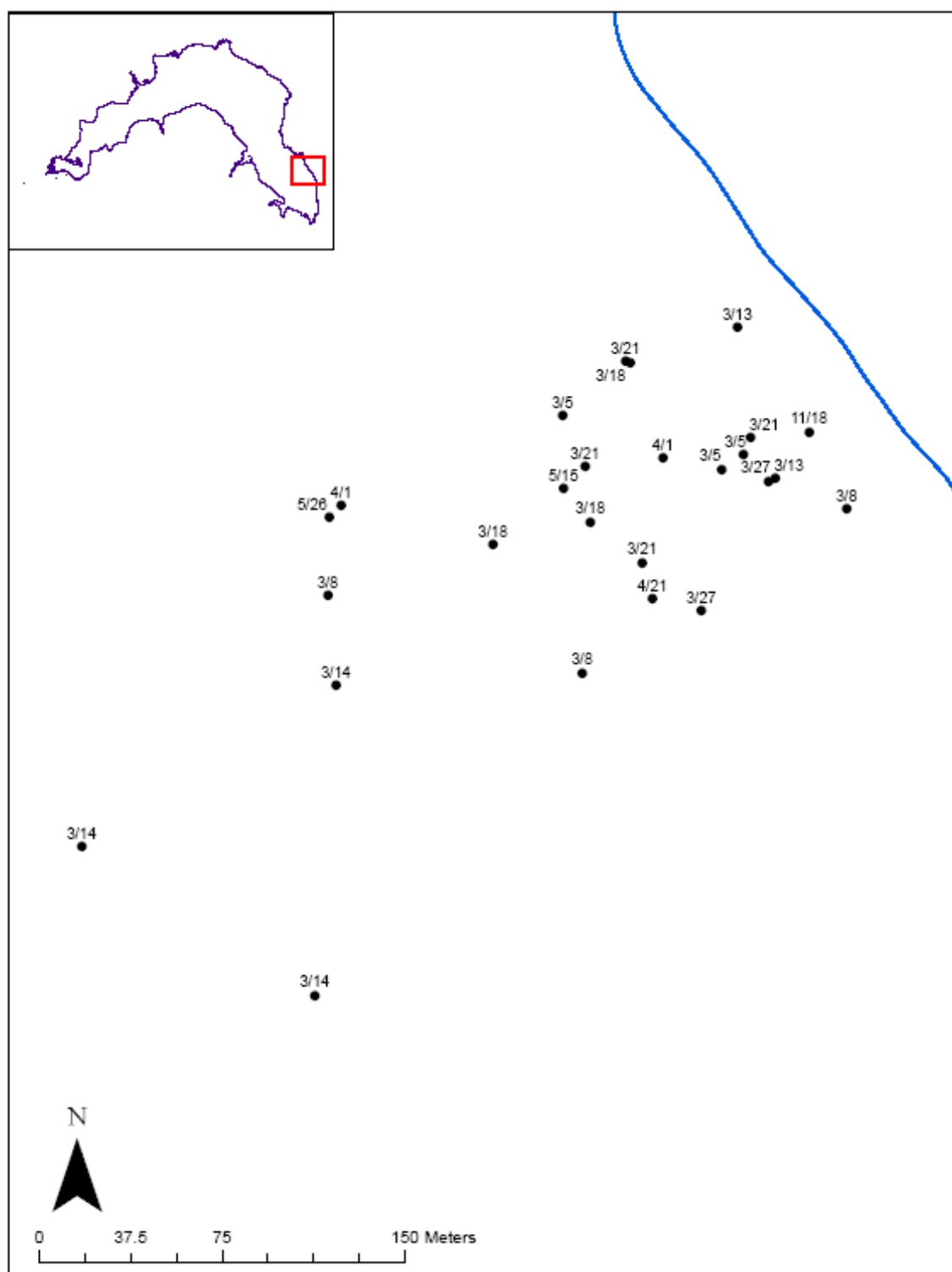


Figure 3-50. Telemetry locations of white bass #140 at Enders Reservoir, Nebraska during spring 2008. One location was recorded before ice-cover during November 2007.

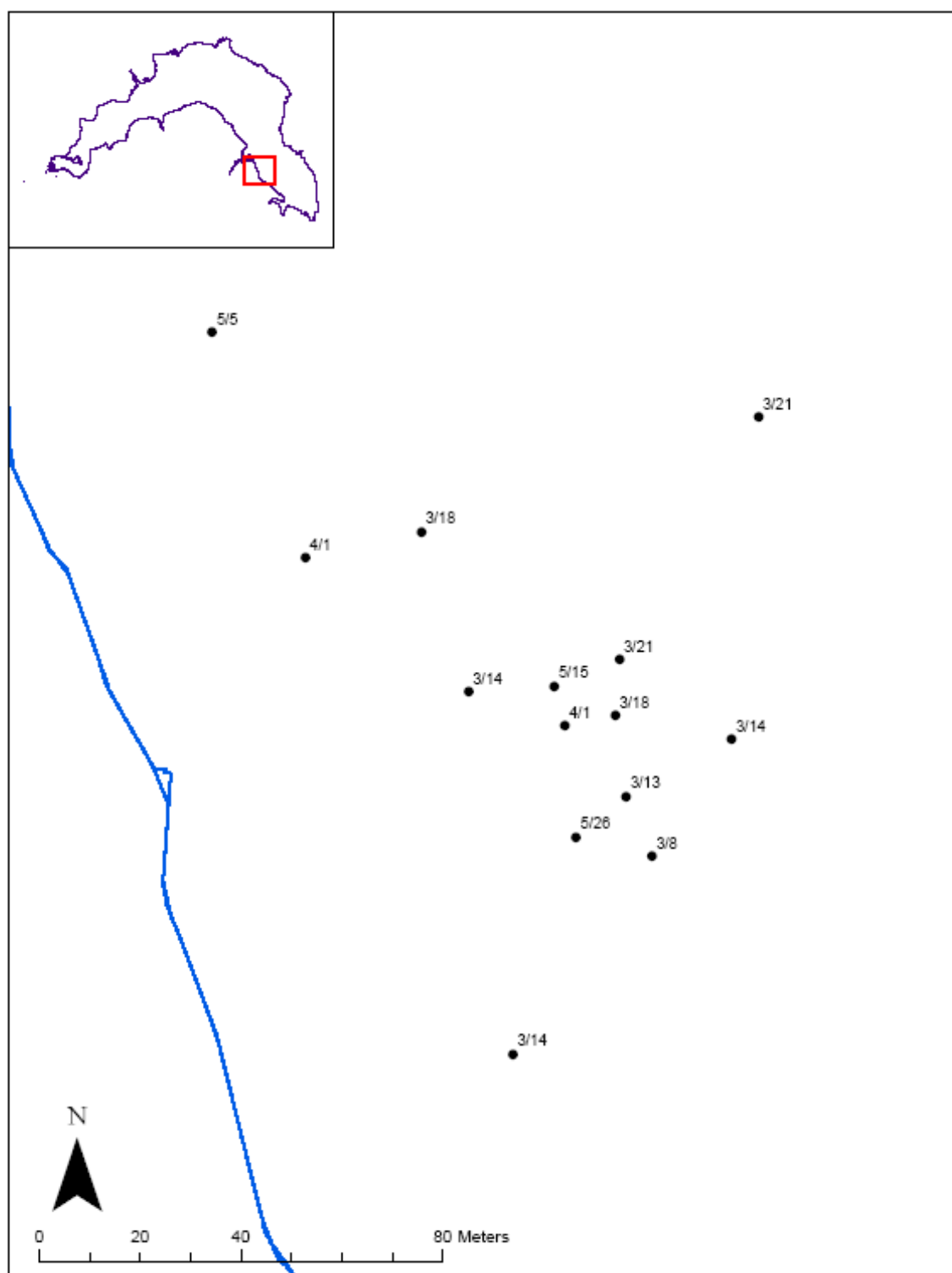


Figure 3-51. Telemetry locations of white bass #157 at Enders Reservoir, Nebraska during spring 2008.

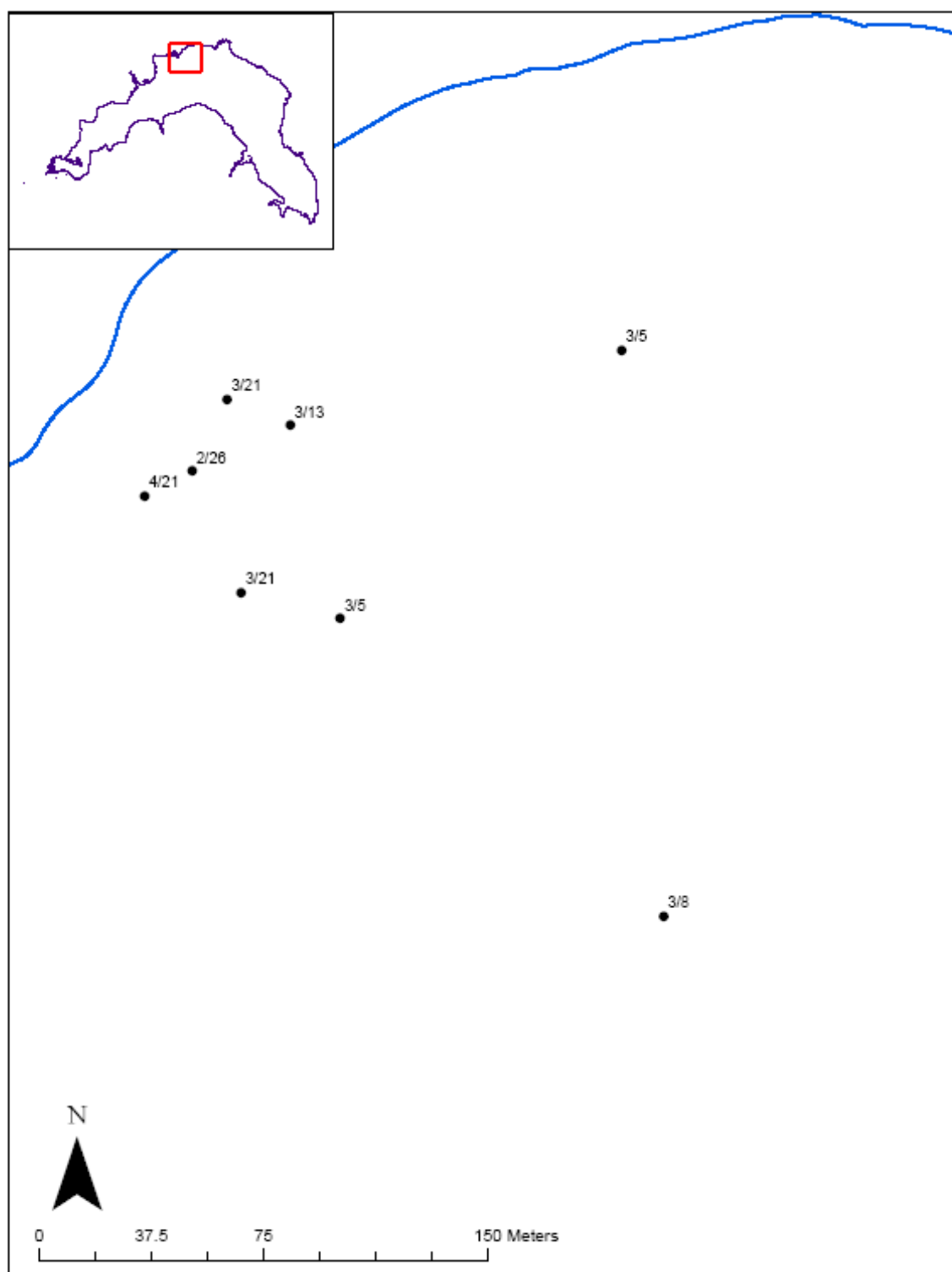


Figure 3-52. Telemetry locations of white bass #166 at Enders Reservoir, Nebraska during spring 2008.

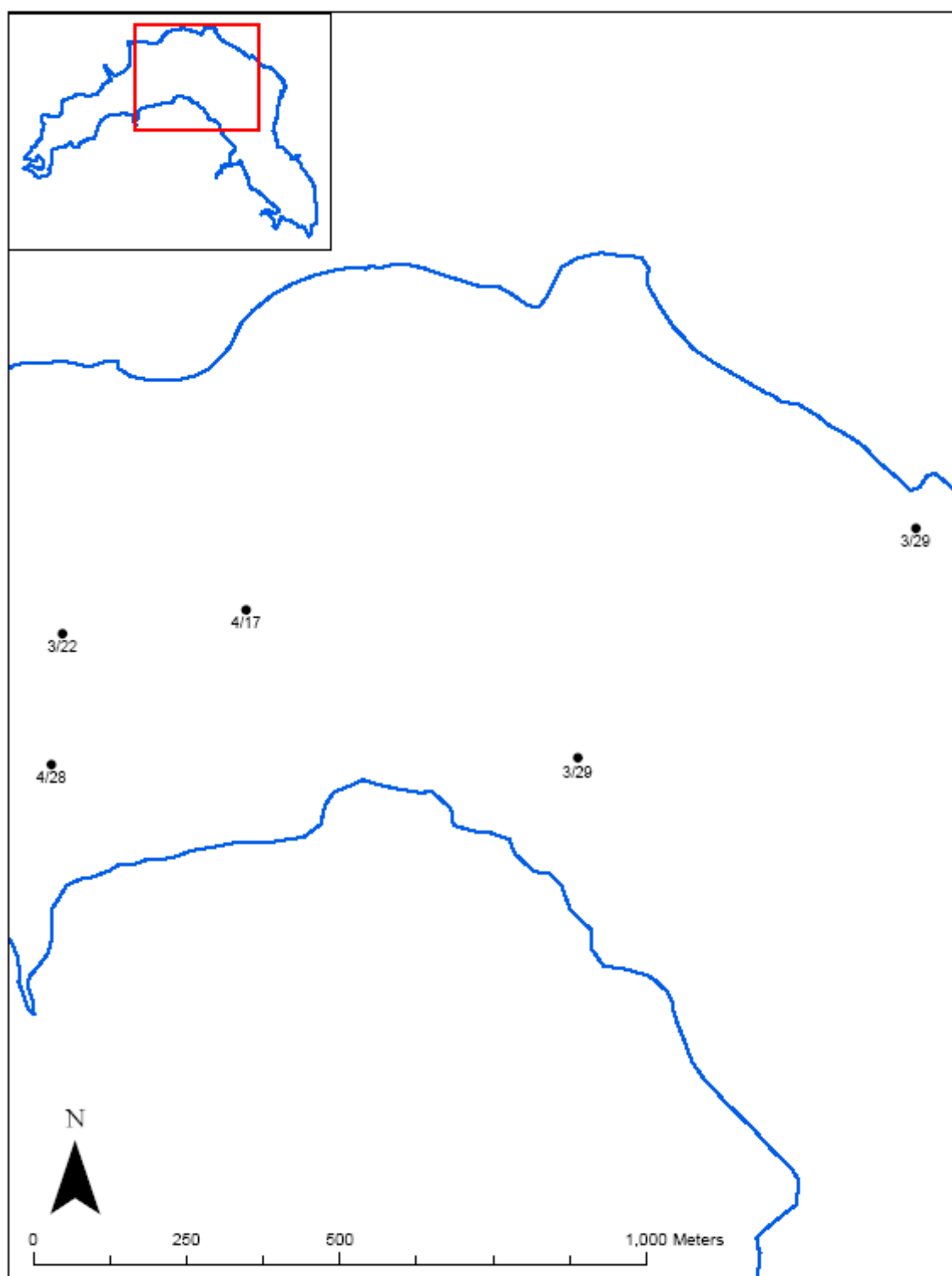


Figure 3-53. Telemetry locations of white bass #58 at Enders Reservoir, Nebraska during spring 2007.

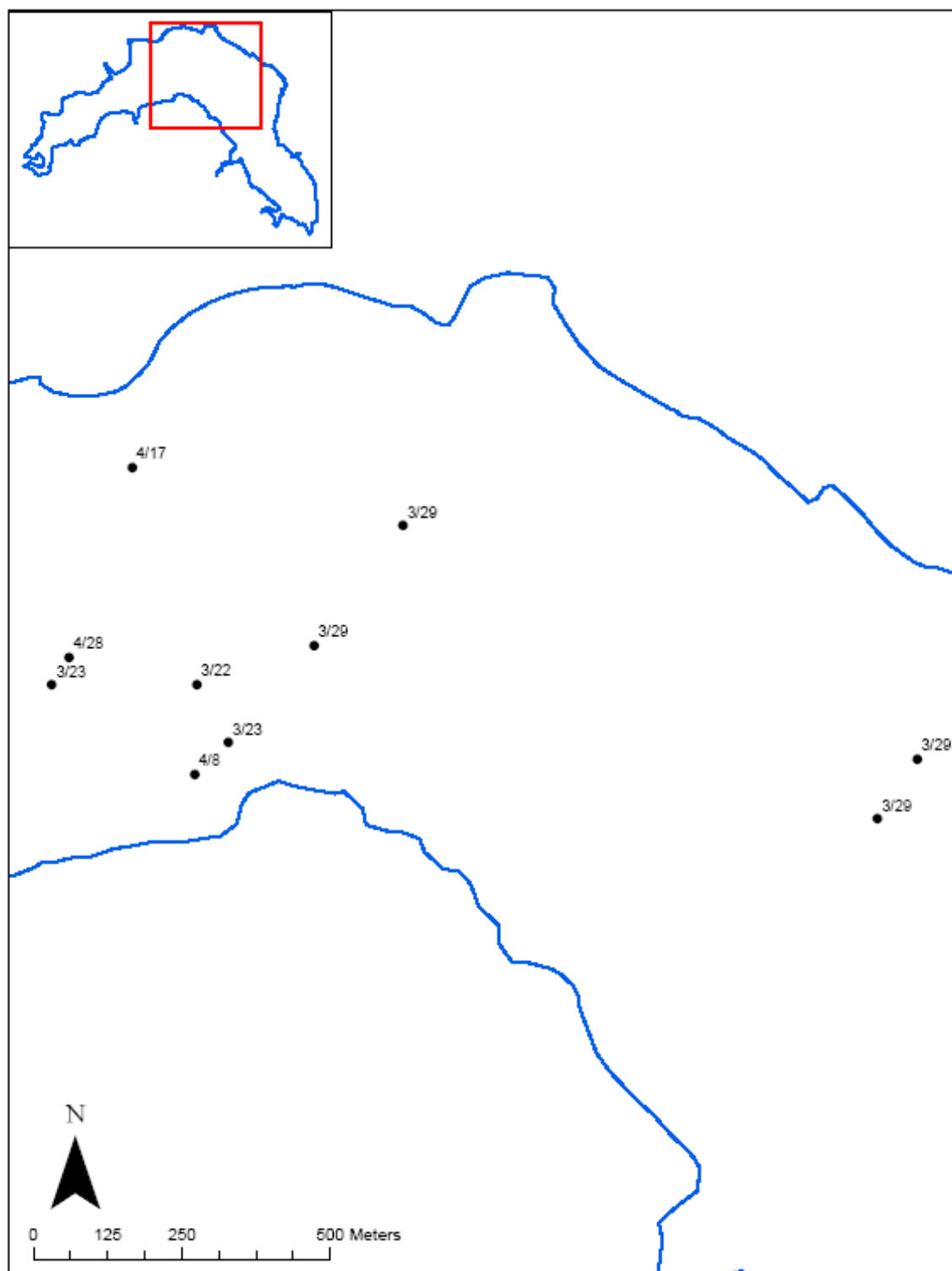


Figure 3-54. Telemetry locations of white bass #67 at Enders Reservoir, Nebraska during spring 2007.

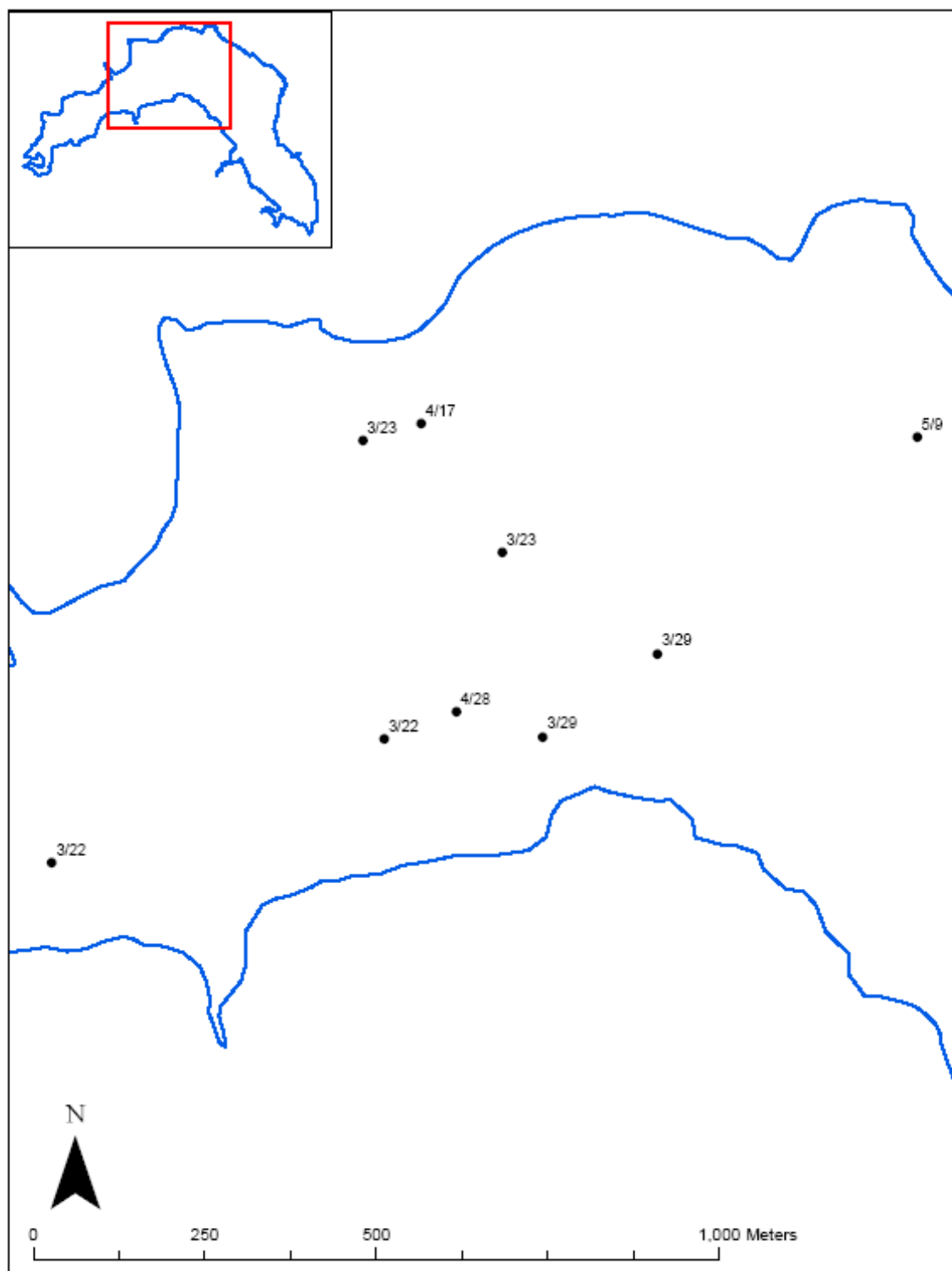


Figure 3-55. Telemetry locations of white bass #68 at Enders Reservoir, Nebraska during spring 2007.

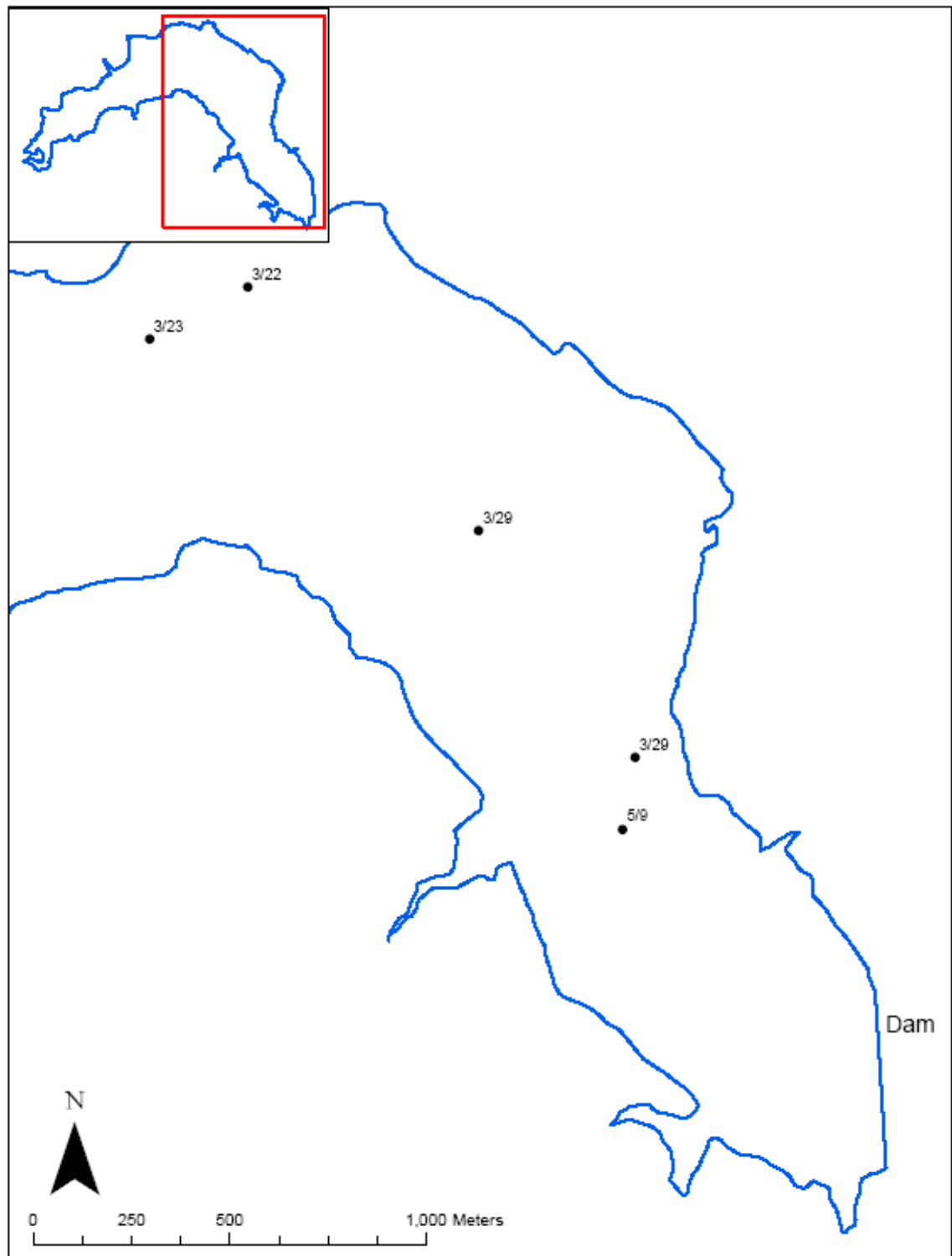


Figure 3-56. Telemetry locations of white bass #44 at Enders Reservoir, Nebraska during spring 2007.

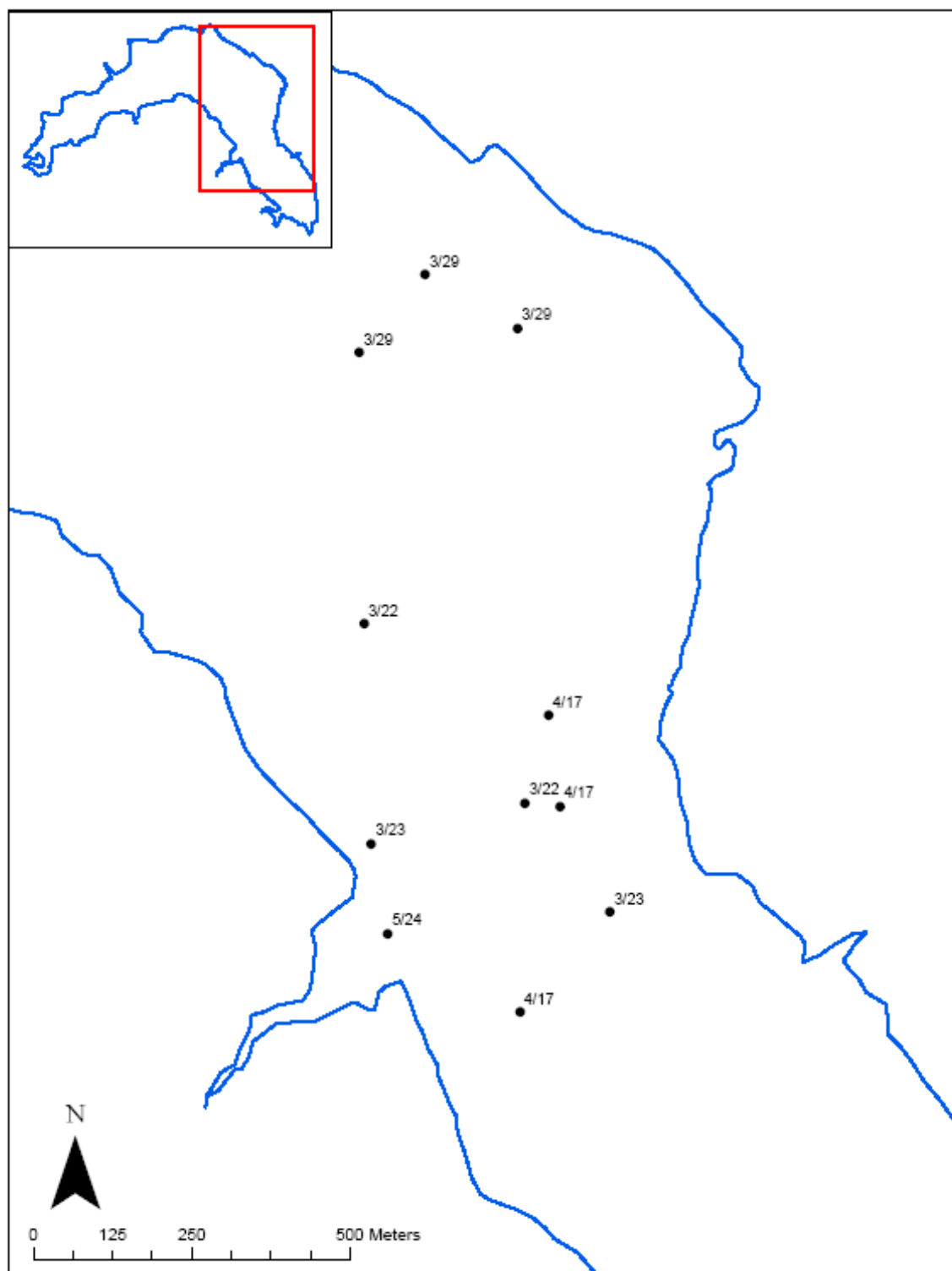


Figure 3-57. Telemetry locations of white bass #47 at Enders Reservoir, Nebraska during spring 2007.

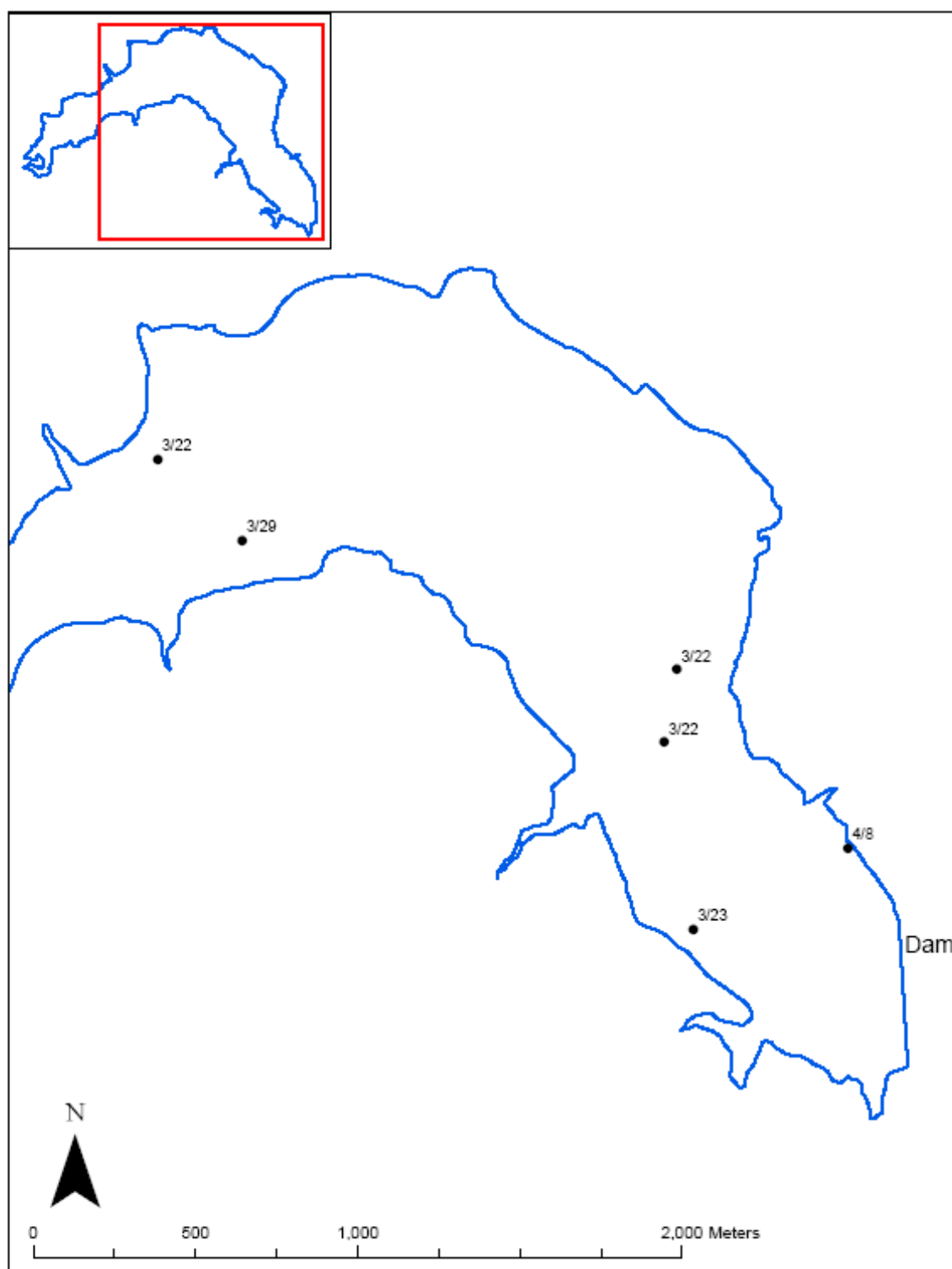


Figure 3-58. Telemetry locations of white bass #64 at Enders Reservoir, Nebraska during spring 2007.

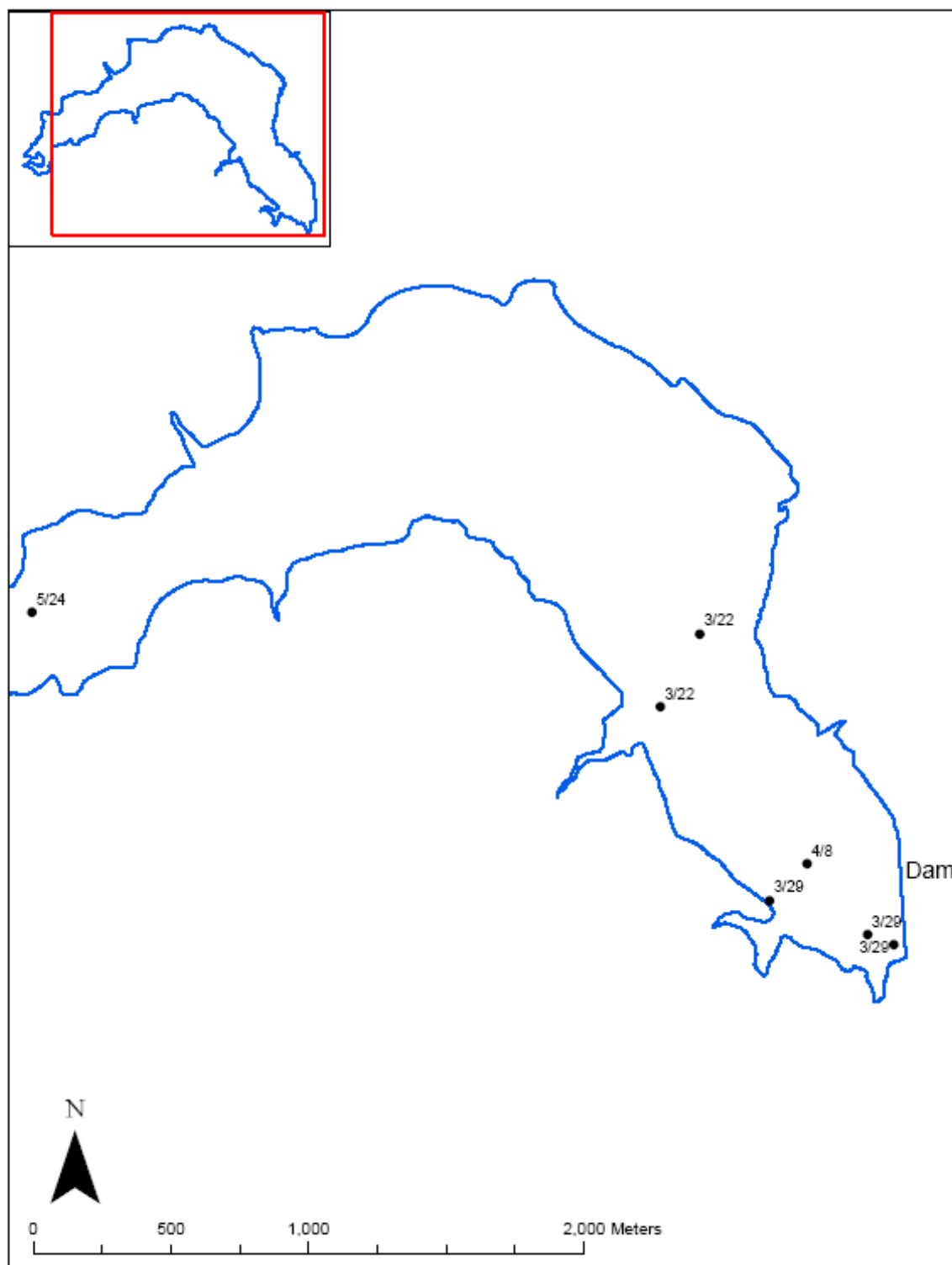


Figure 3-59. Telemetry locations of white bass #53 at Enders Reservoir, Nebraska during spring 2007.

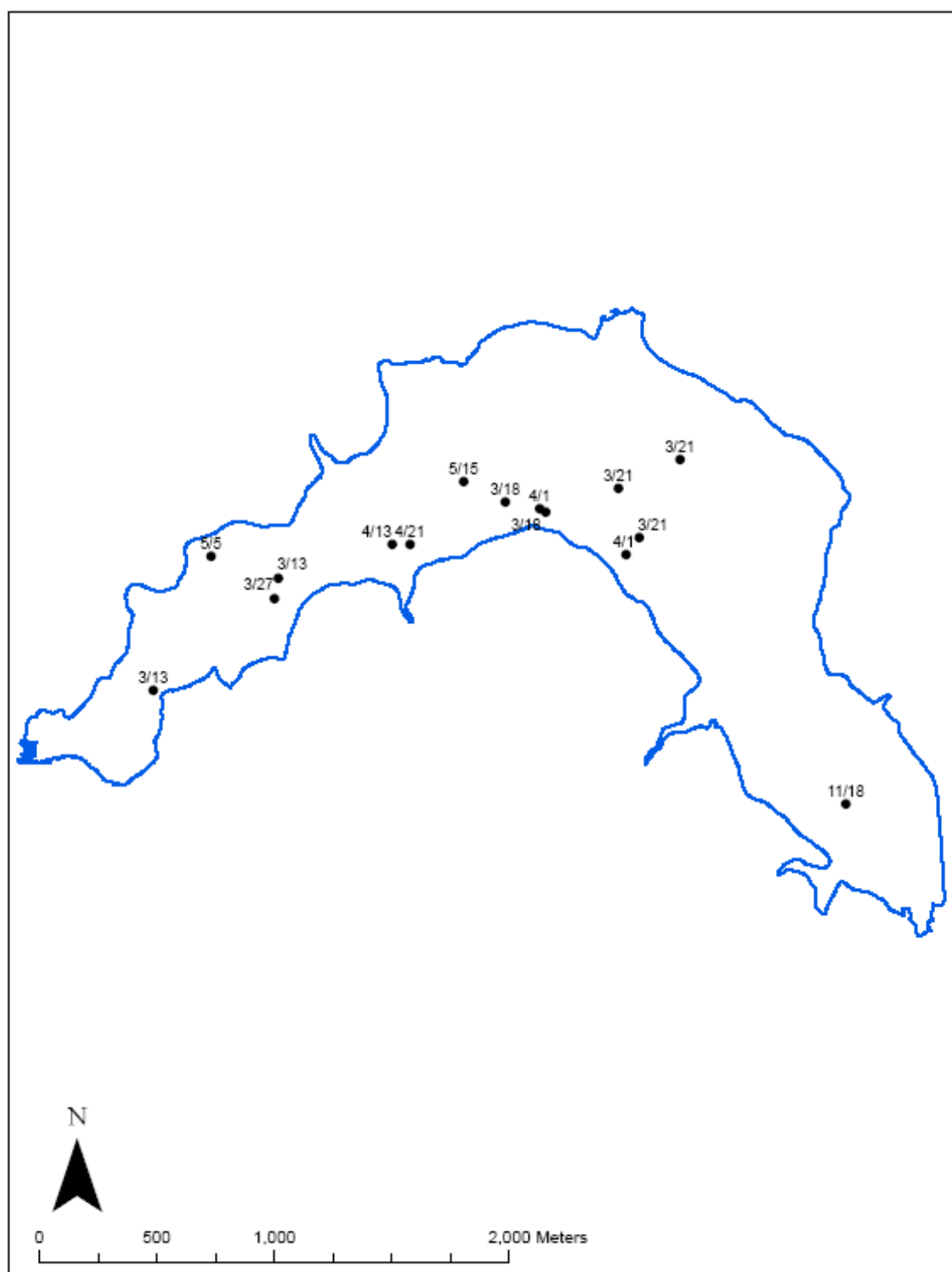


Figure 3-60. Telemetry locations of white bass #125 at Enders Reservoir, Nebraska during spring 2008. One location was recorded before ice-cover during November 2007.

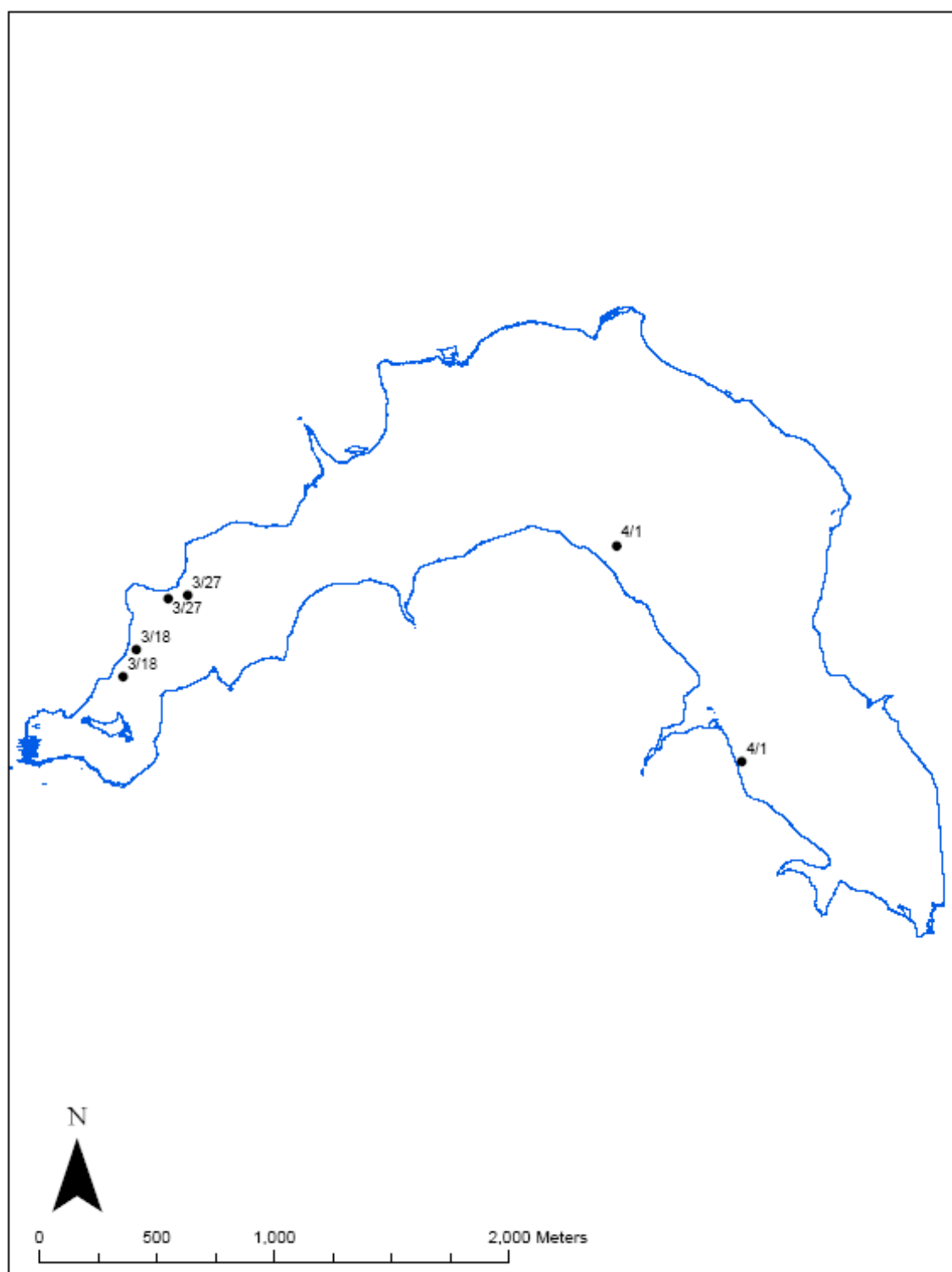


Figure 3-61. Telemetry locations of white bass #171 at Enders Reservoir, Nebraska during spring 2008.

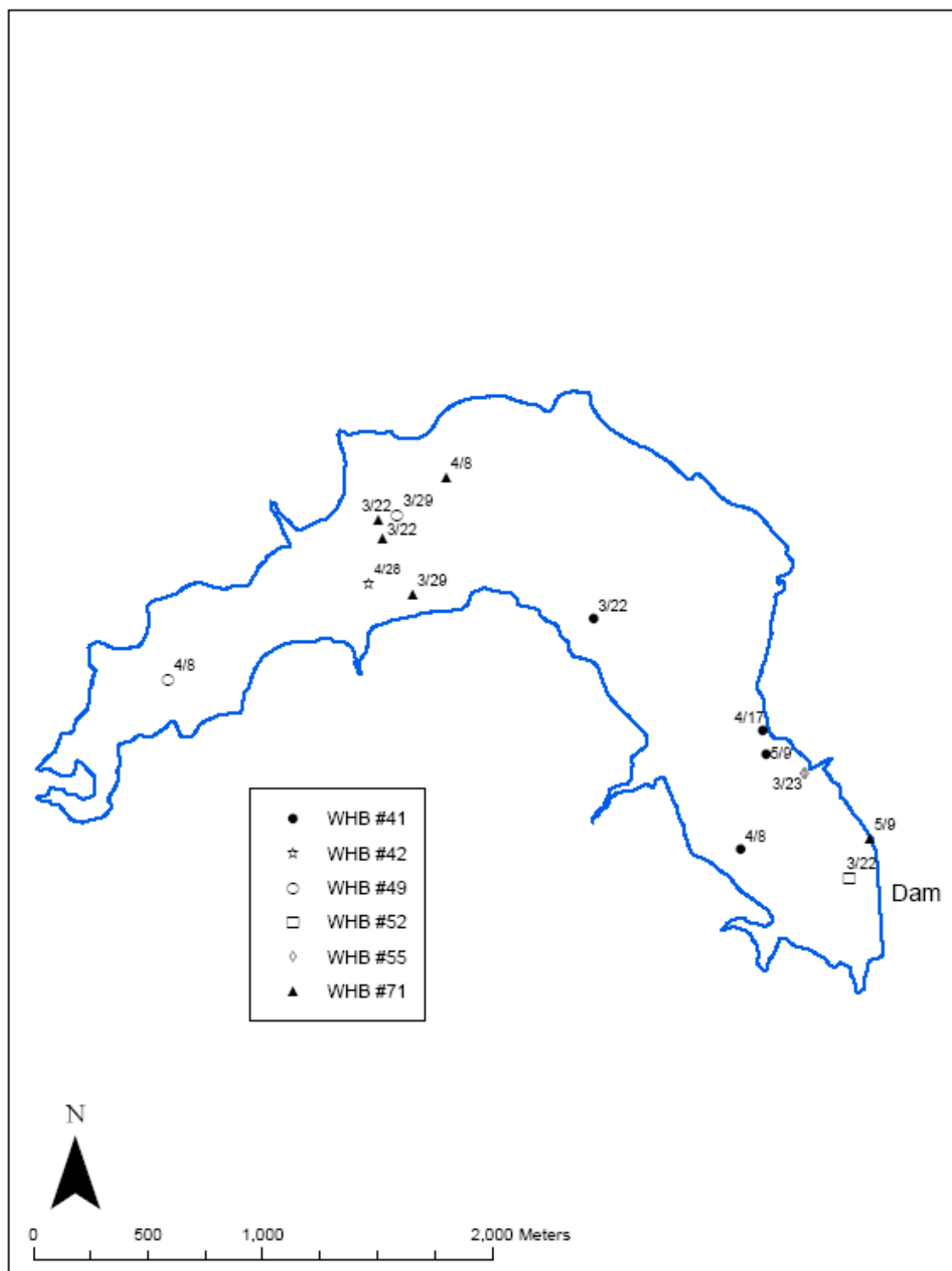


Figure 3-62. Telemetry locations of white bass with fewer than five locations at Enders Reservoir, Nebraska during spring 2007.

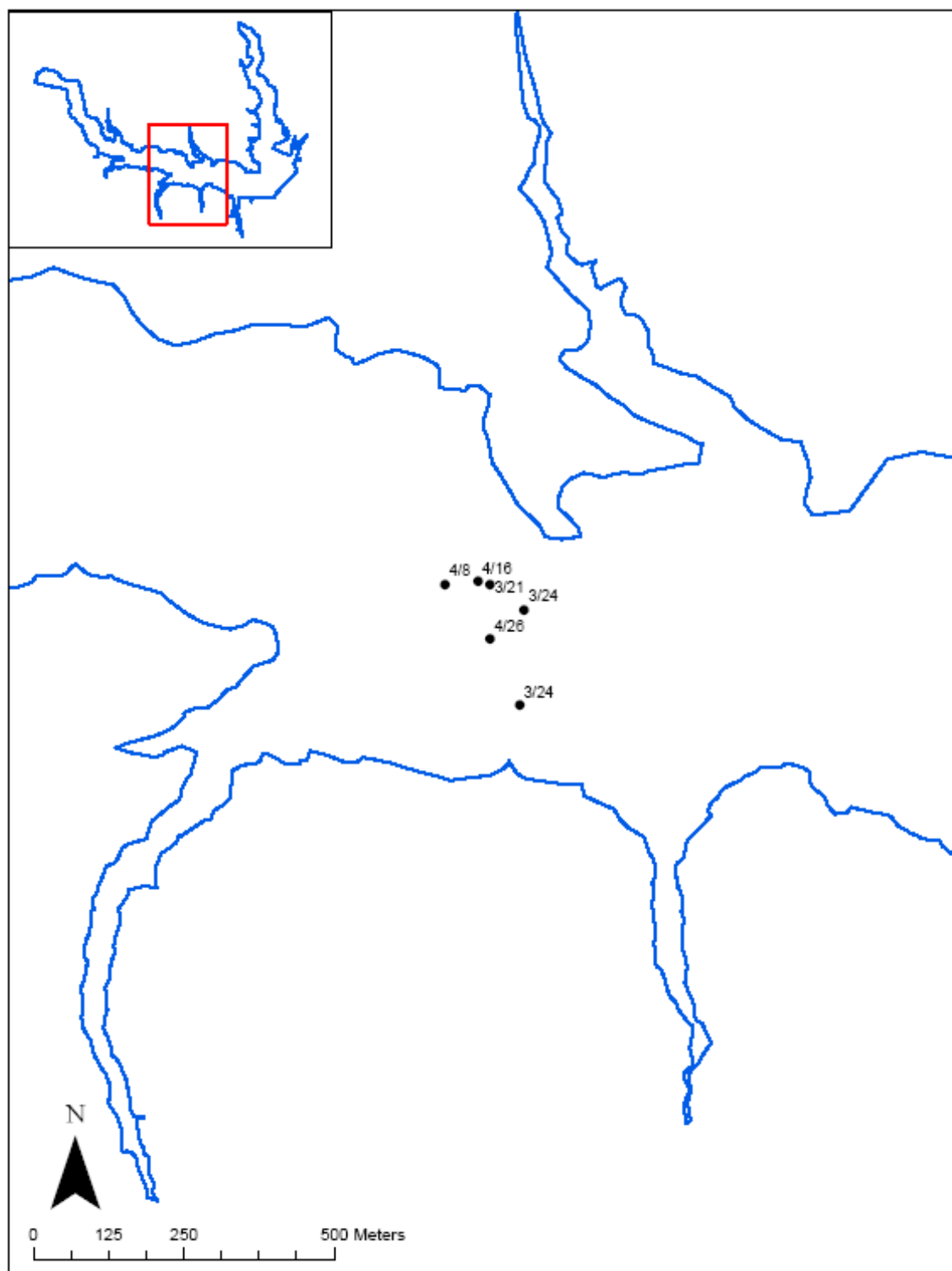


Figure 3-63. Telemetry locations of white bass #39 at Red Willow reservoir, Nebraska during spring 2007.

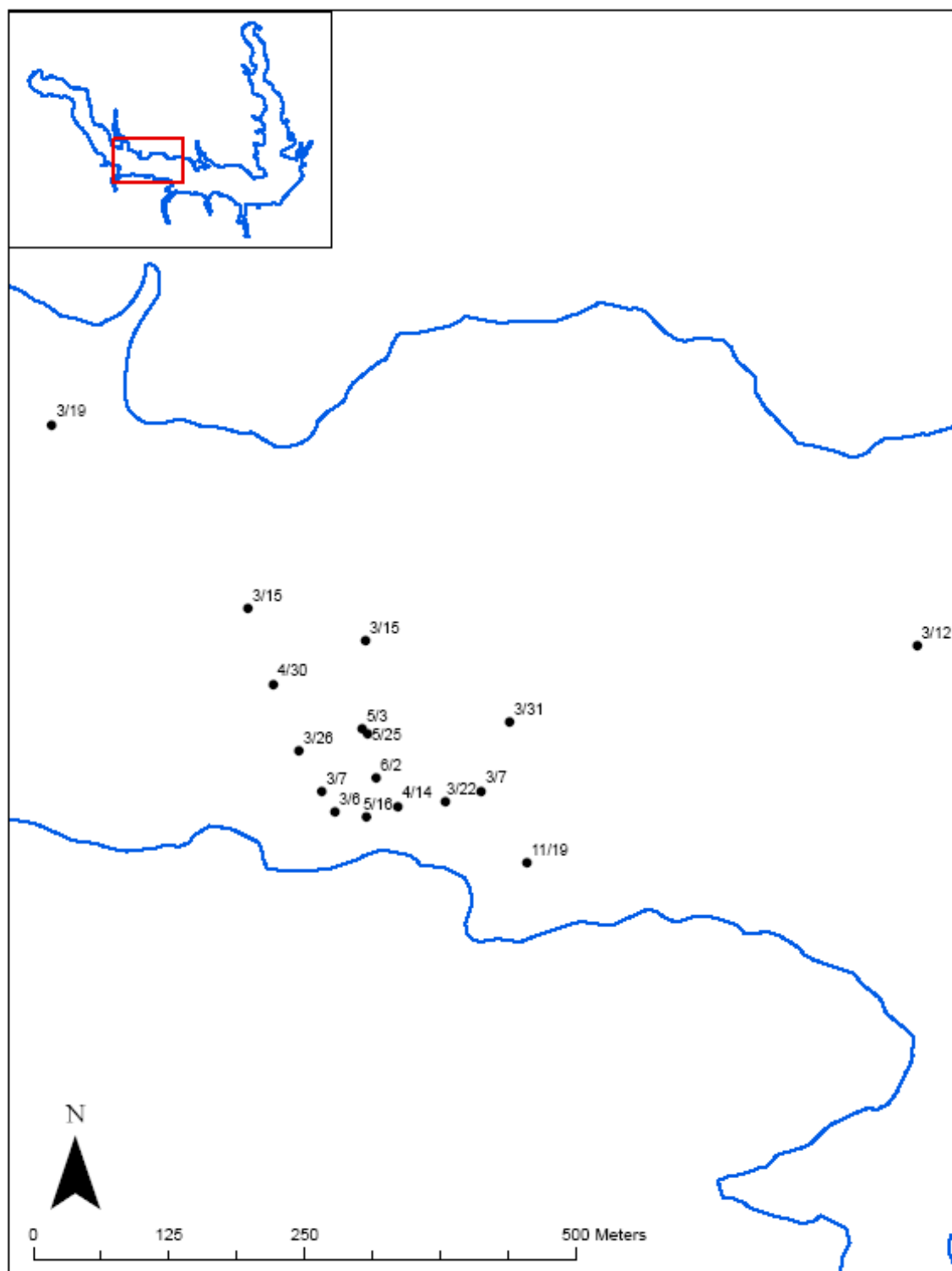


Figure 3-64. Telemetry locations of white bass #101 at Red Willow reservoir, Nebraska during spring 2008. One location was recorded before ice-cover during November 2007.

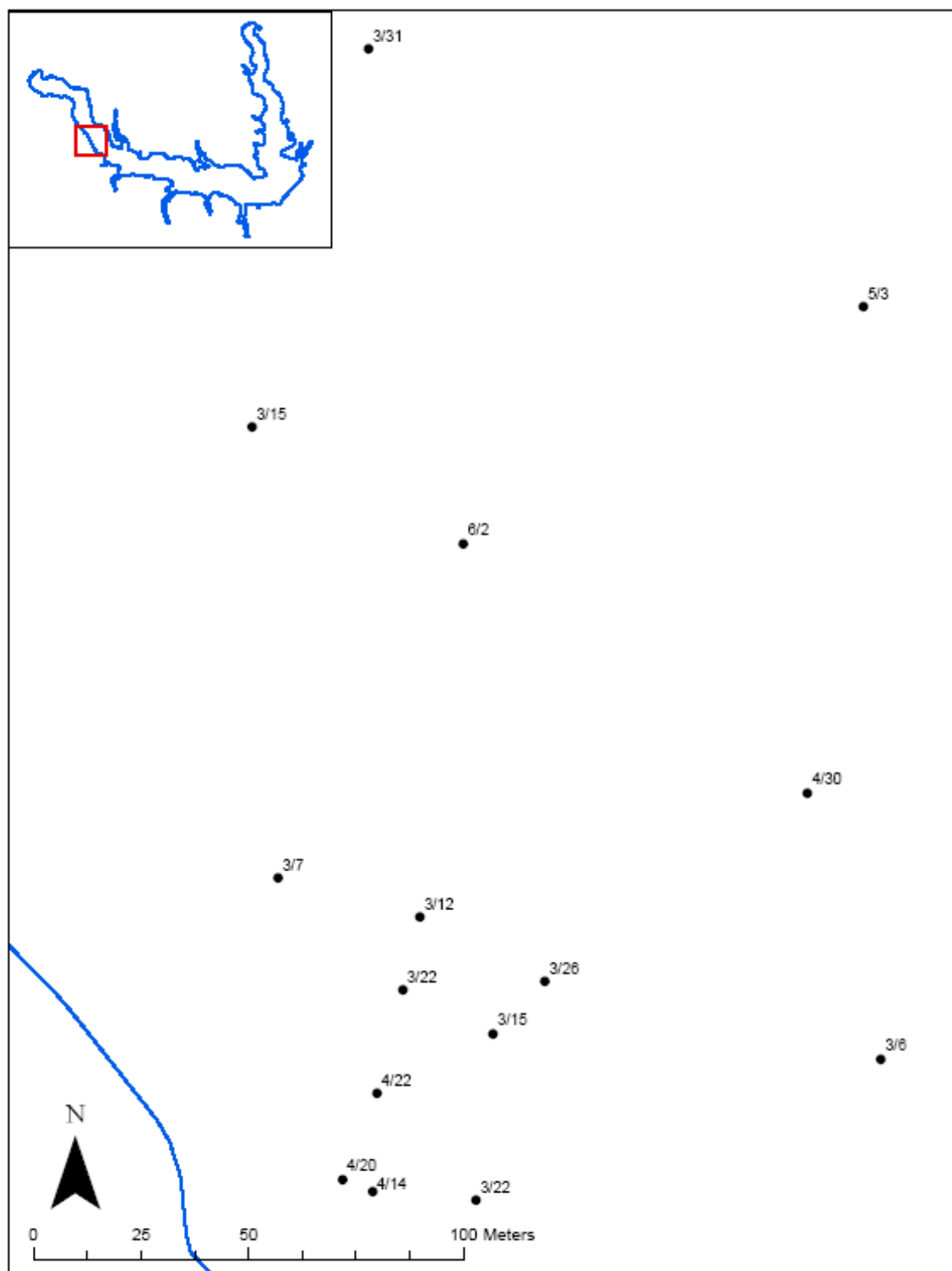


Figure 3-65. Telemetry locations of white bass #116 at Red Willow reservoir, Nebraska during spring 2008.

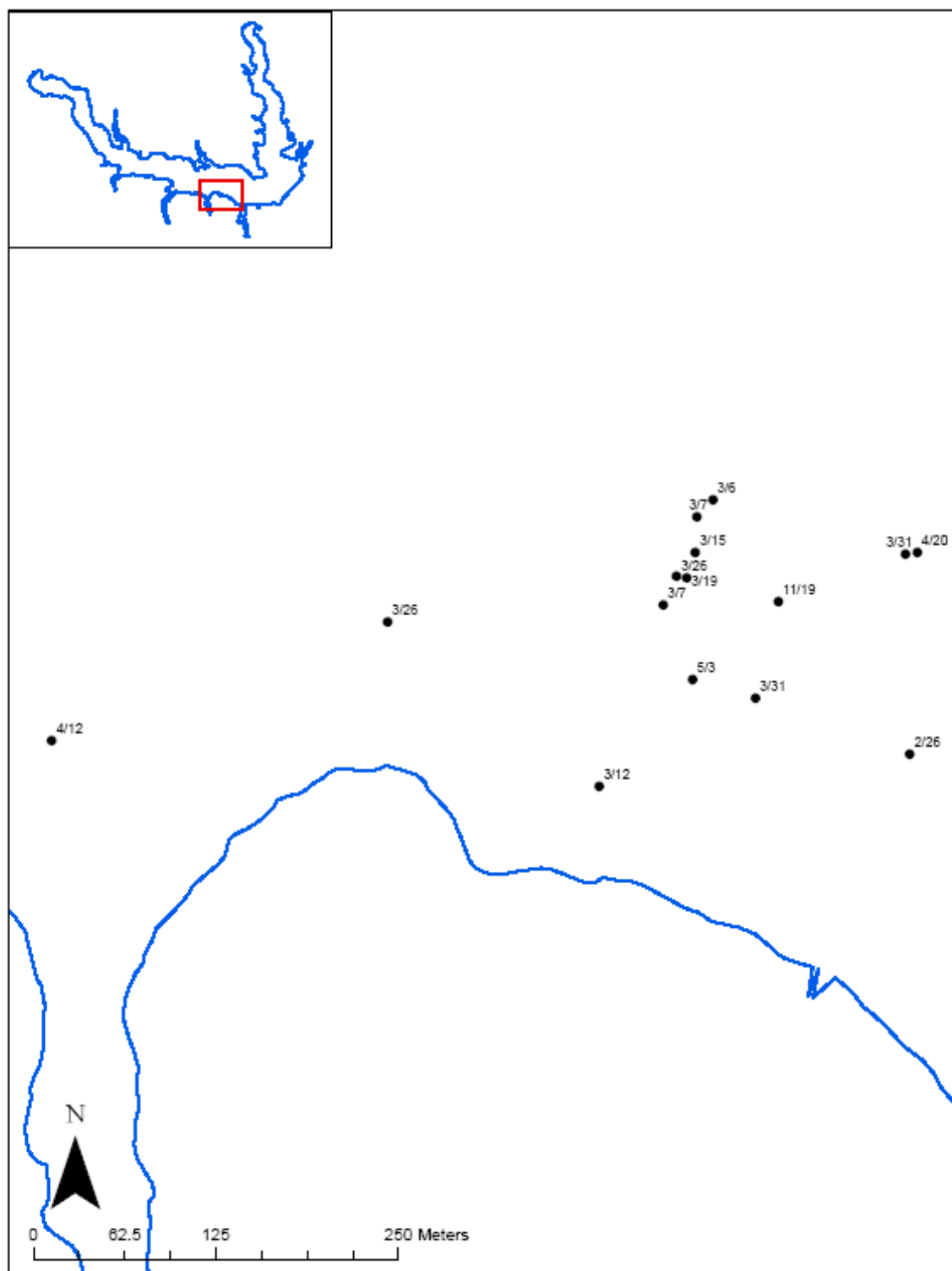


Figure 3-66. Telemetry locations of white bass #122 at Red Willow reservoir, Nebraska during spring 2008. One location was recorded before ice-cover during November 2007.

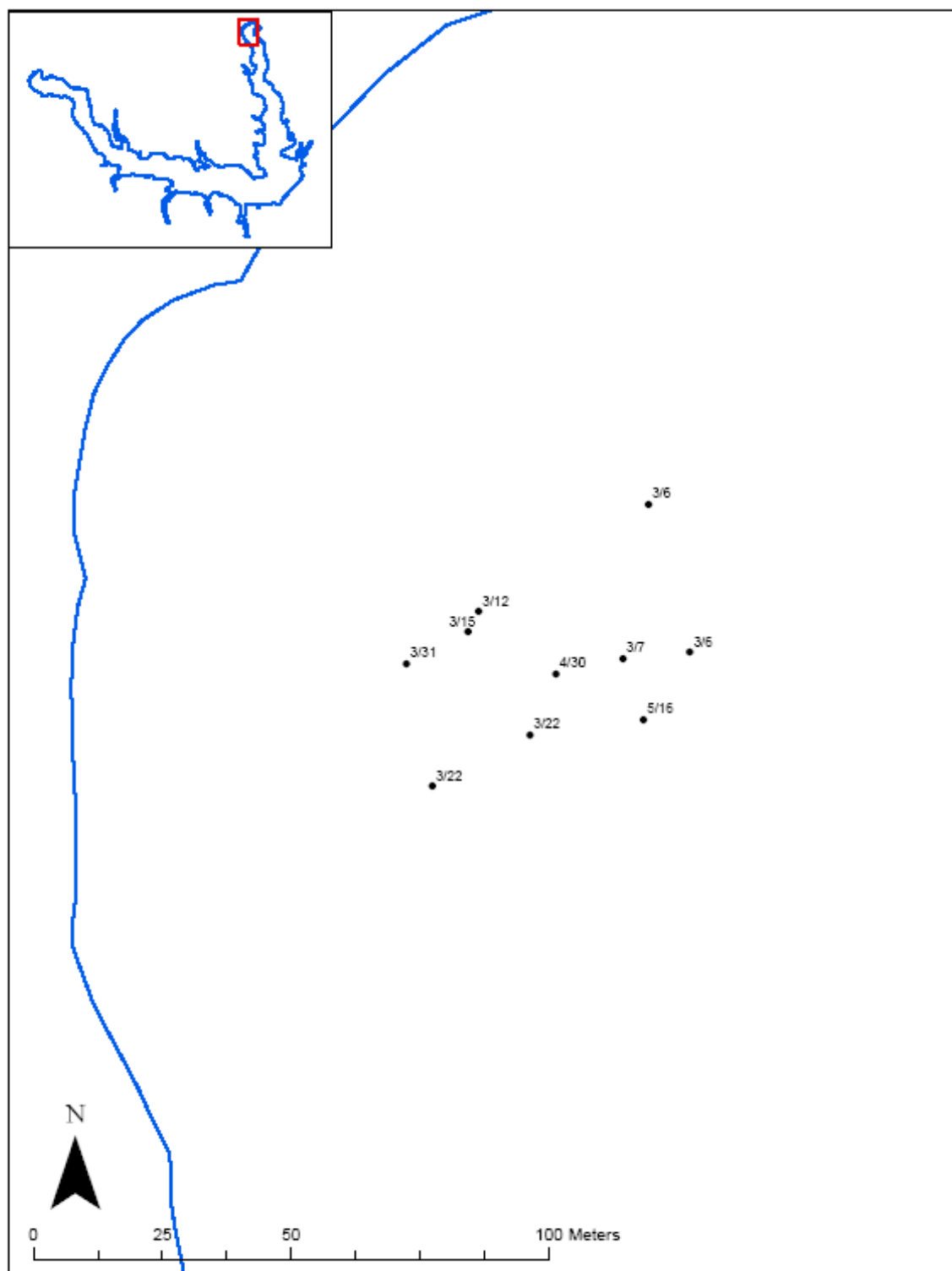


Figure 3-67. Telemetry locations of white bass #141 at Red Willow reservoir, Nebraska during spring 2008.

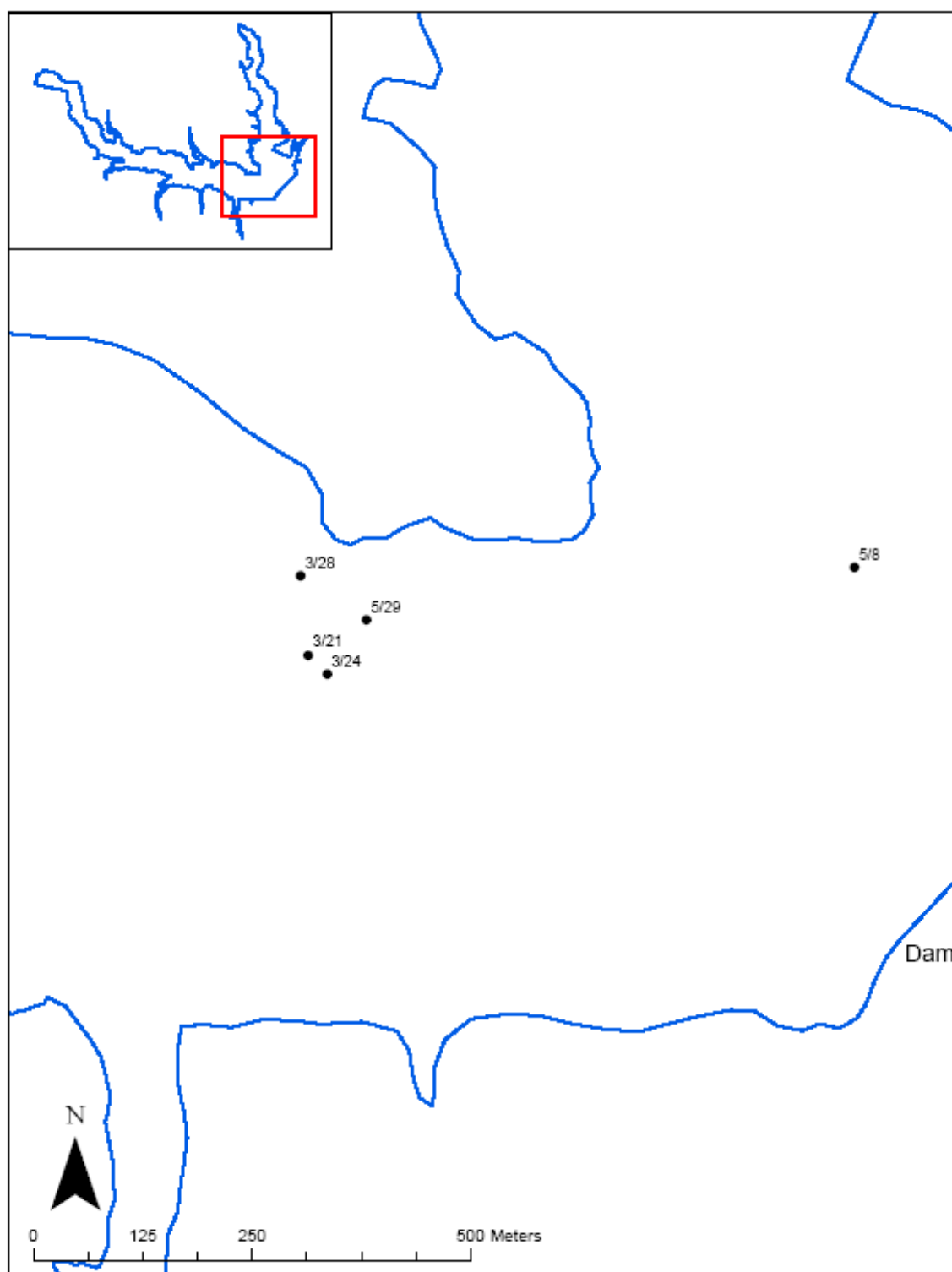


Figure 3-68. Telemetry locations of white bass #19 at Red Willow reservoir, Nebraska during spring 2007.

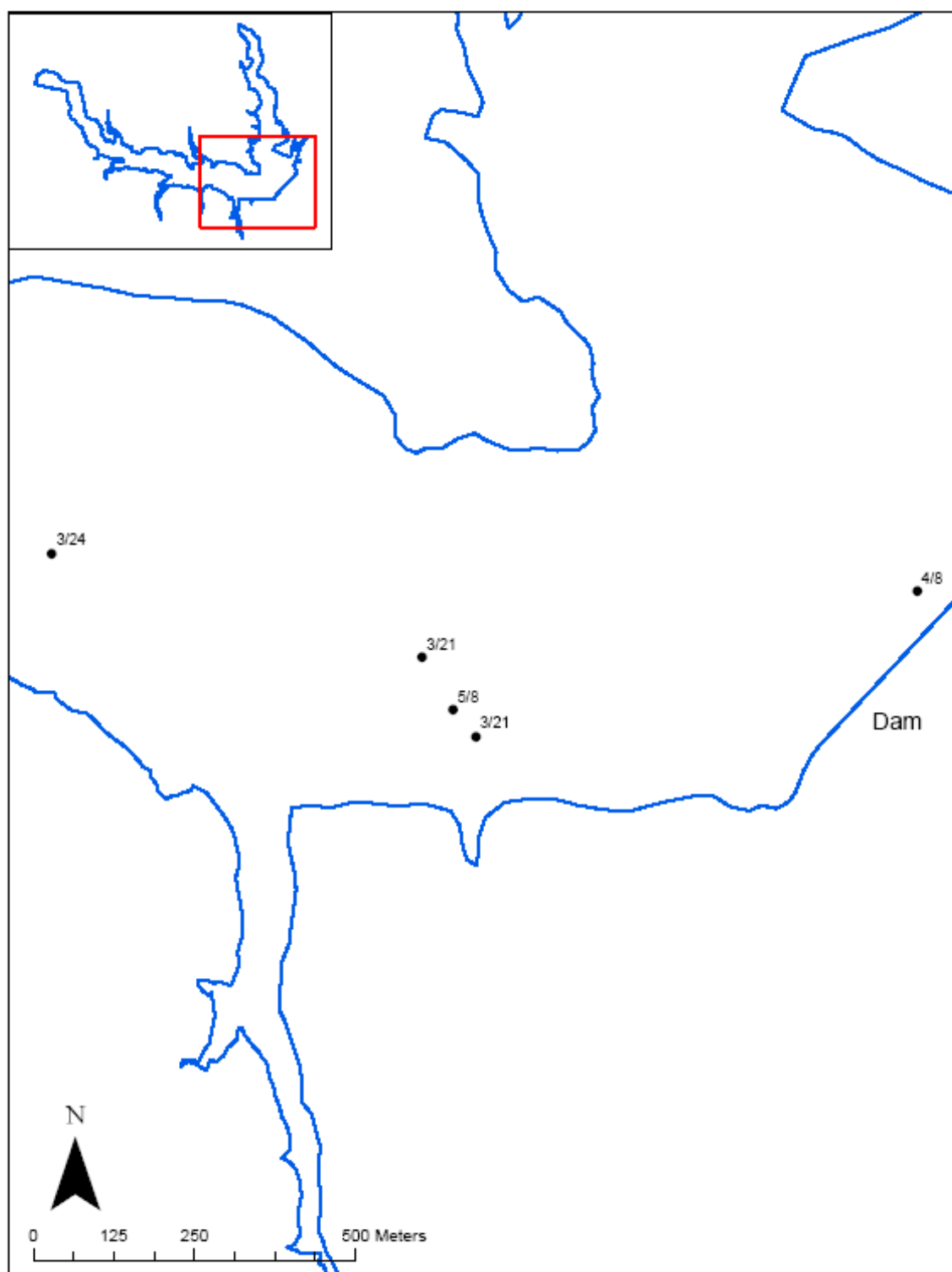


Figure 3-69. Telemetry locations of white bass #38 at Red Willow reservoir, Nebraska during spring 2007.

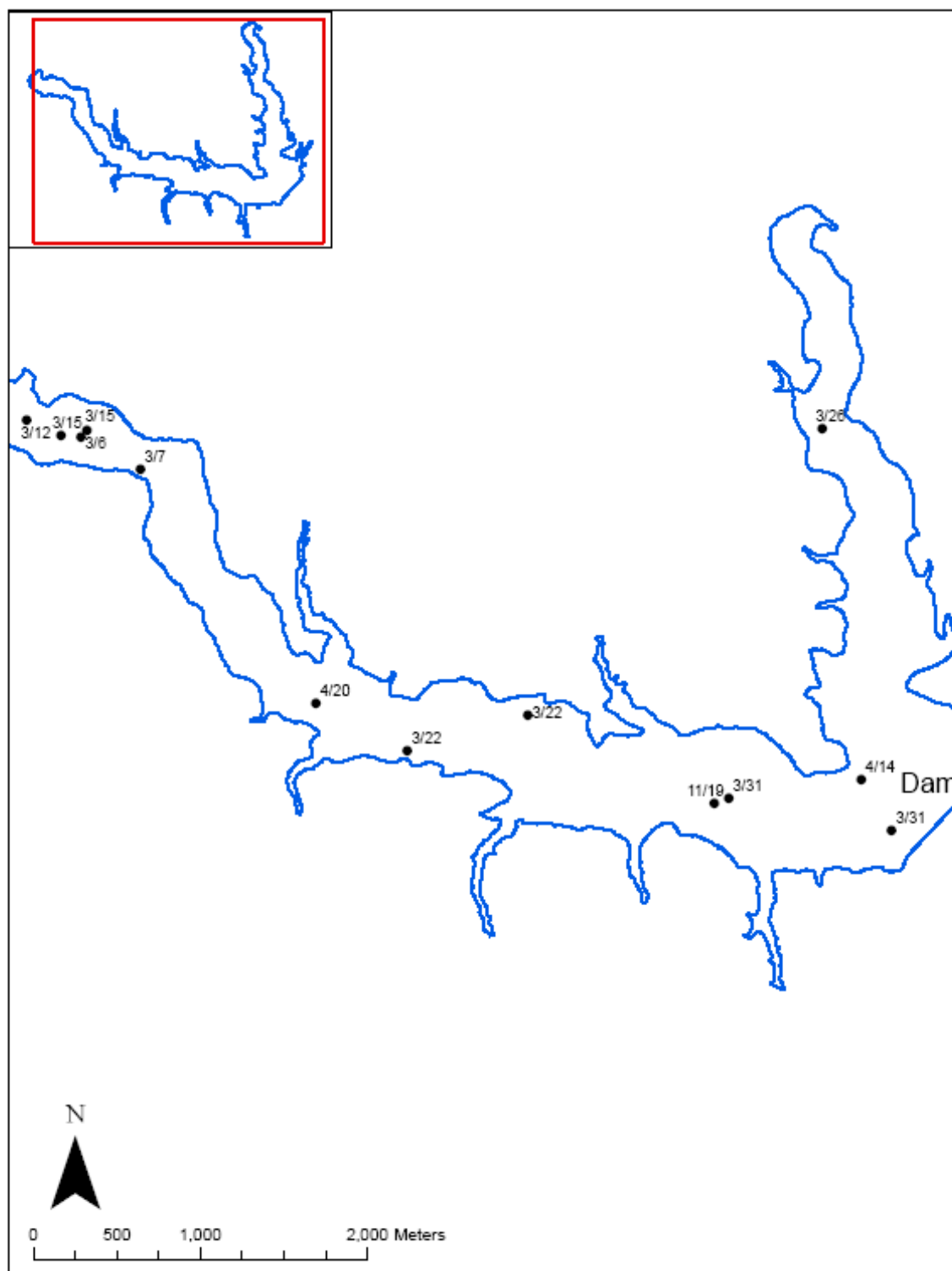


Figure 3-70. Telemetry locations of white bass #107 at Red Willow reservoir, Nebraska during spring 2008. One location was recorded before ice-cover during November 2007.

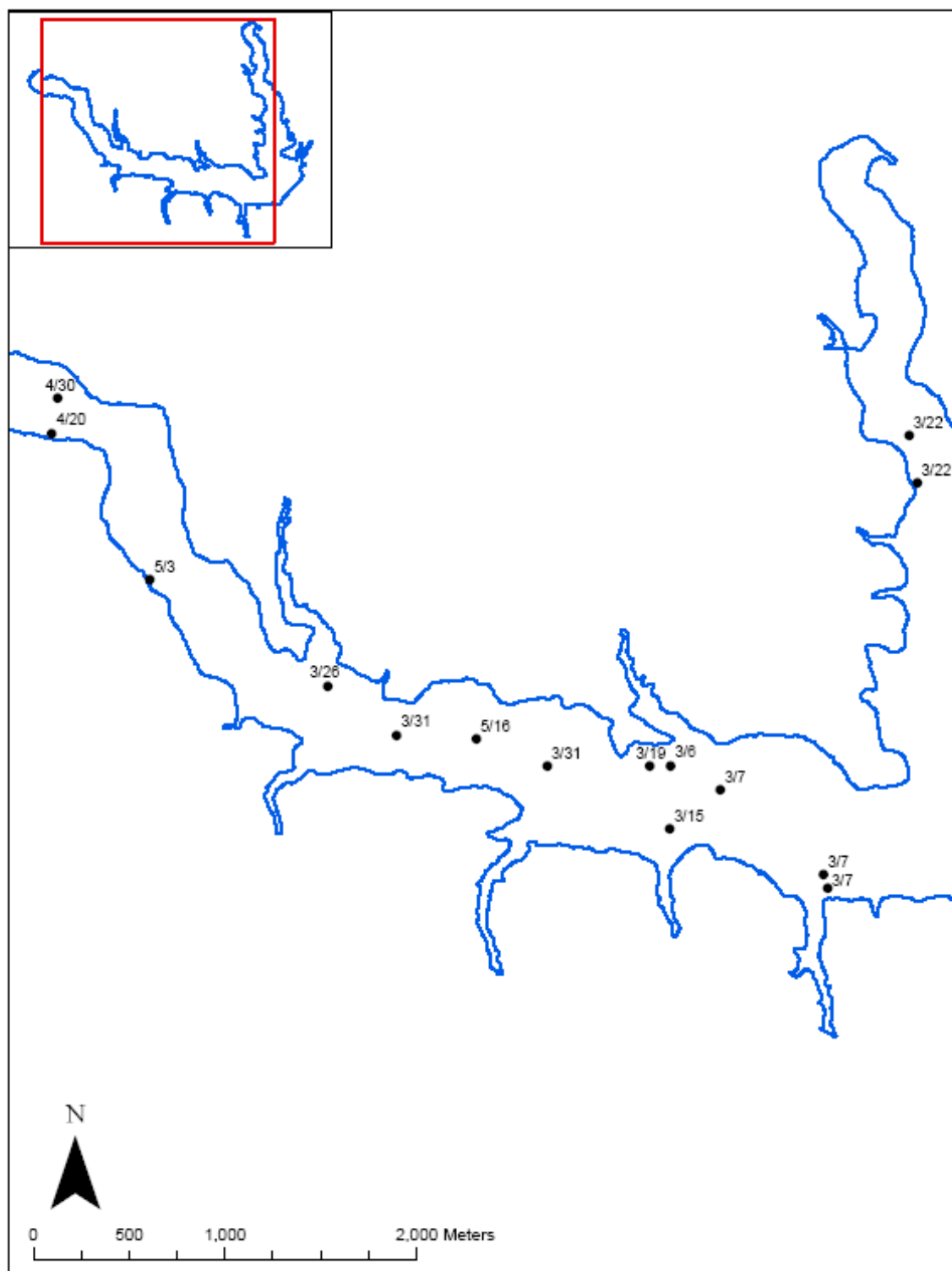


Figure 3-71. Telemetry locations of white bass #127 at Red Willow reservoir, Nebraska during spring 2008.

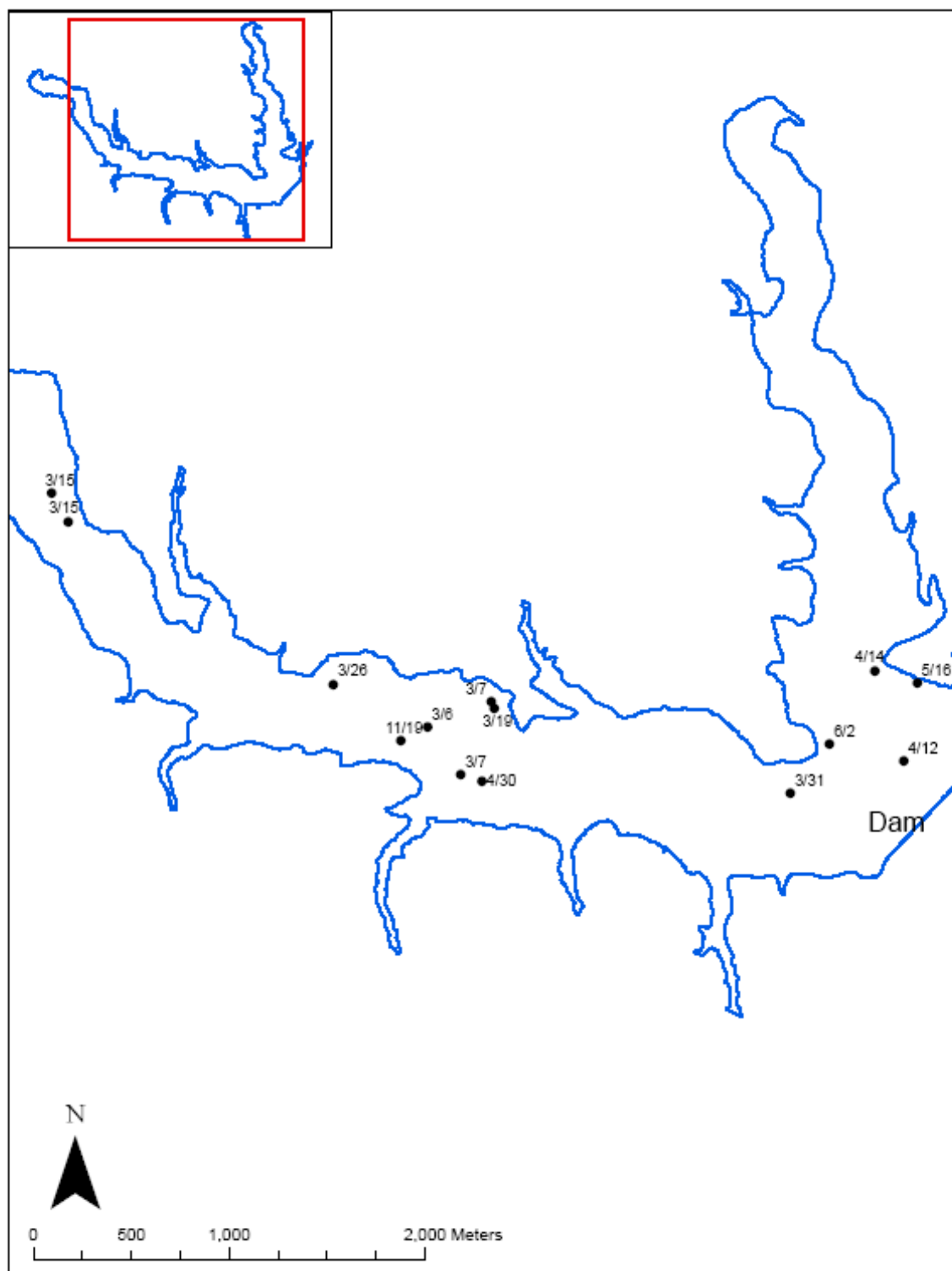


Figure 3-72. Telemetry locations of white bass #151 at Red Willow reservoir, Nebraska during spring 2008. One location was recorded before ice-cover during November 2007.

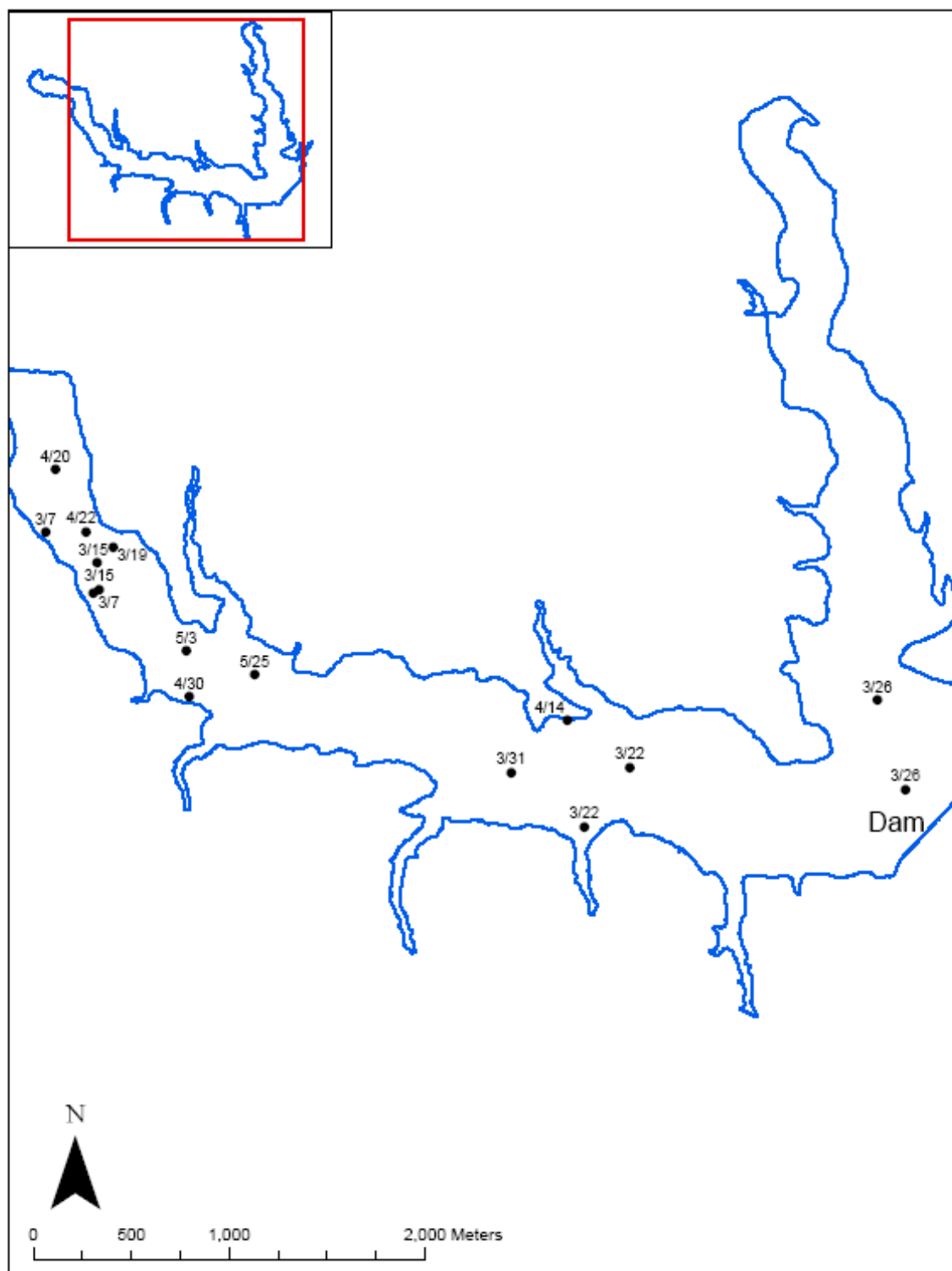


Figure 3-73. Telemetry locations of white bass #168 at Red Willow reservoir, Nebraska during spring 2008.

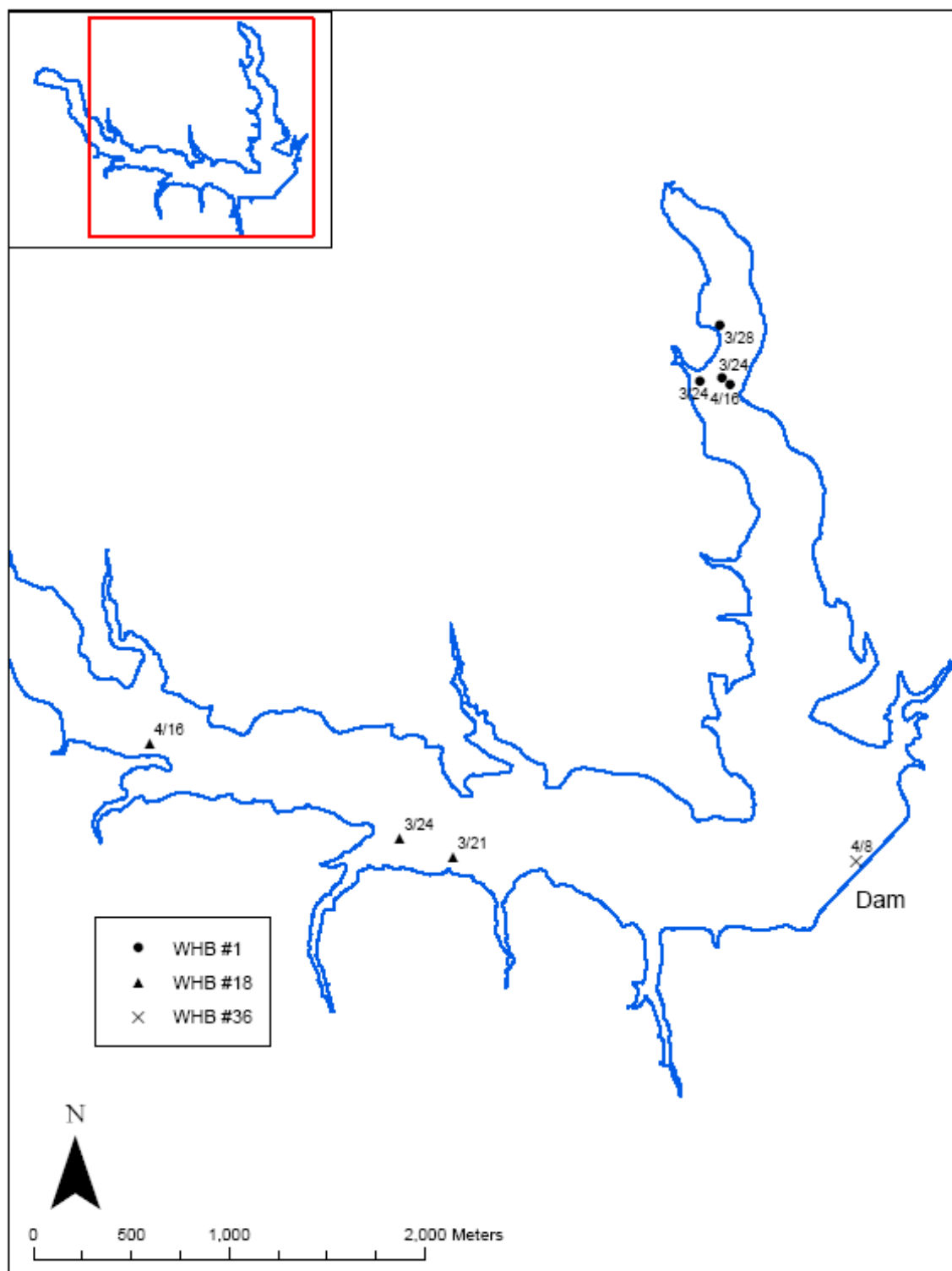


Figure 3-74. Telemetry locations of white bass with fewer than five locations at Red Willow reservoir, Nebraska during spring 2007.

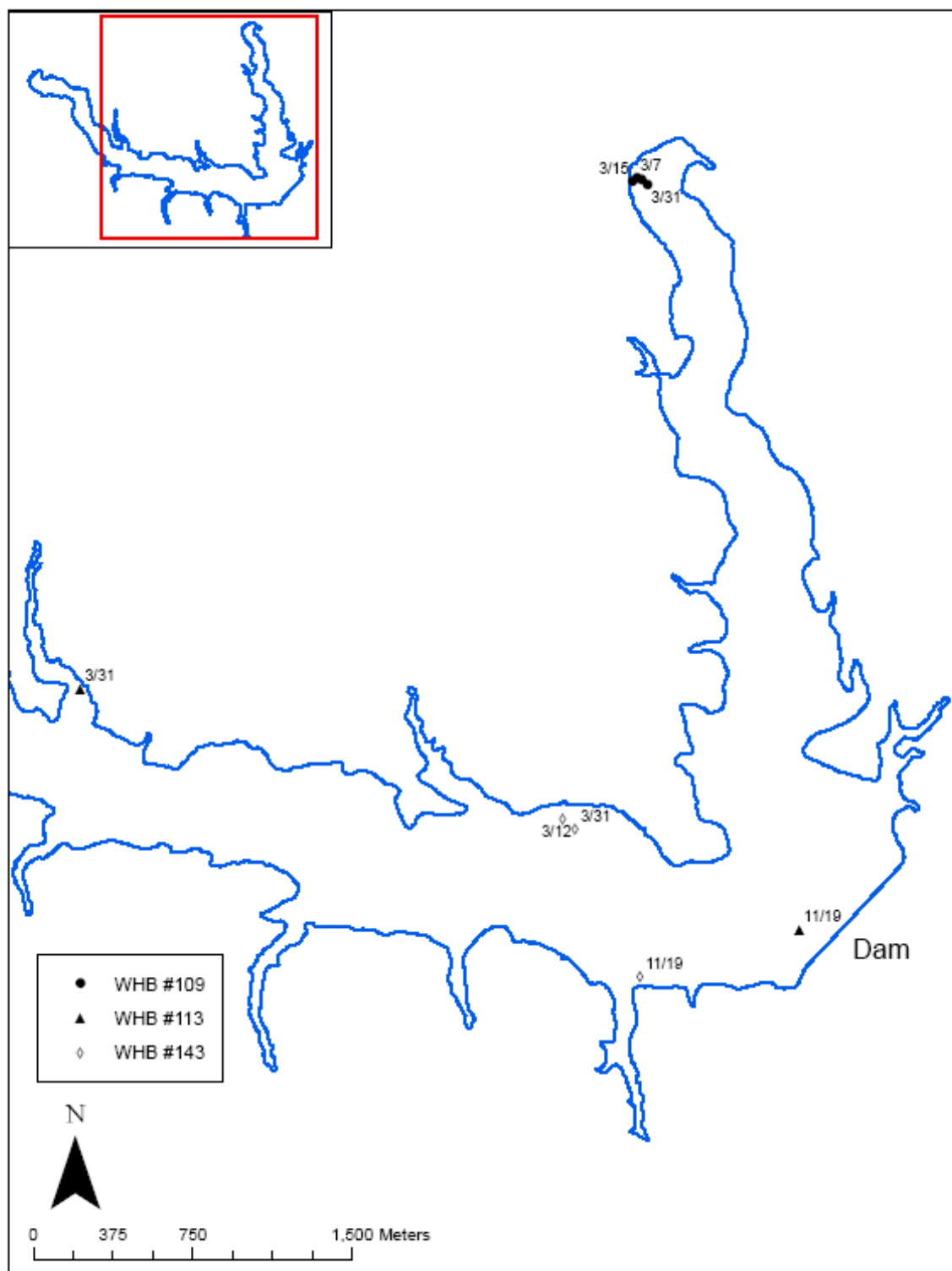


Figure 3-75. Telemetry locations of white bass with fewer than five locations at Red Willow reservoir, Nebraska during spring 2008. One location was recorded before ice-cover during November 2007.

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Chapter 4. Spring Home Ranges of White Bass

Introduction

Home range is defined as the area that an individual travels through and uses for daily activities during a given period (Burt 1943). Home ranges have been described for many freshwater fish species including bluegill *Lepomis macrochirus* (Paukert et al. 2004), largemouth bass *Micropterus salmoides* (Winter 1977), flathead catfish *Pylodictis olivaris* (Vokoun 2003, Weller and Winter 2001), and walleye *Sander vitreus* (Foust and Haynes 2007). Most home ranges previously estimated are for littoral species that spend large amounts of time along the shoreline of a reservoir.

Movements defining a home range are specific to individuals and differ from population-directed movements such as seasonal and spawning migrations. Within a single population, some fish may have restricted movements and small home ranges whereas other fish may have large home ranges (Gerking 1959). However, the source of this variation among individual home range size is often unknown.

Pelagic freshwater fish, such as the white bass *Morone chrysops*, are often highly mobile and may roam an entire water body in search of food and other necessary resources. There is little existing information on white bass movements in either lentic or lotic environments. However, individual white bass may move up to $11.1 \text{ km} \cdot \text{d}^{-1}$ in search of food (Scott and Crossman 1973). A recent study used biotelemetry to study the spatial and temporal movement and distributions of white bass in a South Dakota glacial lake (Beck and Willis 2000). White bass were usually located nearshore during spring and autumn months and offshore during winter and summer months. Multiple regression models quantifying distance of white bass locations from the nearest shore were weakly

affected by temperature, cloud cover, precipitation, and moon phase (all $R^2 < 0.26$; Beck and Willis 2000). The congeneric striped bass *Morone saxatilis* had strong site fidelity and small home ranges in both estuary and reservoir systems (Jackson and Hightower 2001, Ng et al. 2007). Summer home ranges of the striped bass were limited because of low dissolved oxygen and high temperatures in portions of the reservoirs (Jackson and Hightower 2001).

In this chapter, I quantify spring home ranges of white bass in two reservoirs within the Republican River basin of southwestern Nebraska. Data used to estimate home ranges were gathered while studying white bass movements to identify spawning habitats. Neither seasonal nor annual home ranges for white bass have been previously reported.

Study Area

Enders Reservoir is an irrigation reservoir constructed along Frenchmen Creek, in southwestern Nebraska, by the U.S. Bureau of Reclamation in 1951. At conservation-pool, Enders Reservoir has a water level of 948.5 m above mean sea level, surface area of 485 ha and maximum depth of 18.3 m. The shoreline of Enders Reservoir is mostly composed of a silt/sand substrate with small cottonwood *Populus deltoides* trees lining the shoreline.

Red Willow (Hugh Butler Lake) reservoir is an irrigation reservoir constructed along Red Willow Creek in southwestern Nebraska, by the U.S. Bureau of Reclamation in 1962. At conservation pool, Red Willow reservoir has a water level of 786.9 m above mean sea level, surface area of 660 ha, and maximum depth of 15.2 m. Red Willow

reservoir has two inflow sources creating a reservoir with two arms: Spring Creek to the north and Red Willow Creek to the west. The shoreline of Red Willow Reservoir is mostly composed of a silt substrate with small cottonwood trees lining the shoreline.

Methods

Thirty adult white bass (15 in Enders Reservoir and 15 in Red Willow reservoir) were implanted using techniques described by Hart and Summerfelt (1975) with Sonotronics ultrasonic tags (model IBT-96-9-1, 42 mm long, 10.5 mm diameter, 3.9 g weight in water) during autumn 2006 and another 30 white bass were implanted during autumn 2007 (total tagged fish $N = 60$). Tag weight was $< 2.0\%$ body weight and had a manufacturer's battery life expectancy of 9 months. White bass were tagged to study spring movement patterns and identify spawning locations in Enders and Red Willow reservoirs.

Attempts to locate tagged white bass were made weekly during spring 2007 and 2008. A typical sampling attempt consisted of a period of 12 h with days split into morning (03:00-15:00 hours) and evening (15:00-03:00 hours) sessions. Tracking attempts ended on 29 May 2007 and 2 June 2008 due to loss of tag battery life. During each sampling attempt, I systematically worked around the reservoir stopping about every 300-m to scan (cycling through all frequencies with the directional hydrophone pointed at 0, 60, 120, 180, 240, 300, and 360°) for tags. Once a tag was detected, I maintained a constant frequency while moving the boat to pinpoint the location of the fish. After pinpointing a fish, I continued the systematic search. At least three laps of the reservoir were completed during each sampling; i.e., I attempted to locate each fish every 4 hours within a sampling period.

Geographical coordinates were recorded with a Garmin eTrex GPS unit at each fish location and habitat characteristics were measured. Water-quality measurements were taken at 0.5-m depth and included: temperature, turbidity, dissolved oxygen, pH, and conductivity. Other habitat characteristics included: depth, cover type (none, woody, submerged, emergent), and substrate type (silt, sand, gravel, cobble, rock). Depth was measured using a boat-mounted depth finder, cover type was visually assessed, and substrate type was assessed using a 102-mm diameter metal tube sampler. Habitat characteristics were recorded to determine influential variables in habitat selection by white bass. Locations were mapped using ArcMap version 9.3 (ESRI, Inc., 2008) and compared to bathymetric maps of the reservoirs created with data from the Lake Mapping Program of the Nebraska Game and Parks Commission.

Twenty-seven white bass were located a minimum of five times (range 5-25 locations per fish) during spring of 2007 ($N = 12$) and 2008 ($N = 15$, Table 4-1). White bass with less than five locations ($N = 12$) were not included in analysis because at least five locations are needed to calculate home ranges. Of those 27 white bass, 16 were at Enders Reservoir and 11 were at Red Willow reservoir. Mean \pm SE total length for all 27 fish was 306 ± 5.29 mm, mean weight \pm SE was 350 ± 22.11 g and mean \pm SE condition (relative weight (W_r); Wege and Anderson 1978; Brown and Murphy 1991) was 86 ± 2 (Table 4-1).

I chose to calculate home ranges with two methods: the adaptive kernel method and a linear home range method. The two methods vary widely in their use in the literature and each has its associated drawbacks. Area-based metrics, like the kernel method, tend to overestimate home range size when the number of relocations is less than

25 (Schoener 1981) and researchers may introduce bias when reducing a kernel-based home range to the actual available home range within a water body. The linear method defines home range as the minimum distance between the two most extreme relocations and tends to underestimate home range size by limiting the home range to one dimension. However, in fishery studies this issue may be minimized because most systems are longer in one dimension (e.g. river channel, reservoir system) than the other.

A 95% utilization distribution (UD) was calculated for each fish with the Home Range Tools (HRT; Rodgers et al. 2007) extension for ArcGIS using the kernel analysis tool. Adaptive kernel UD's (Worton 1989) were calculated using the unit variance method for variance standardization and the reference method for selection of smoothing parameters. Polygons were clipped to the shoreline because the UD often extended onto dry land. The adaptive kernel UD has a cumulative distribution probability of 1.0 and clipping of these polygons adds some bias in the resulting "actualized home range" (a home range defined by the fish movements but restricted to only the available water habitat).

A linear home range was calculated for each individual fish using ArcGIS because of concerns for introduced bias through clipping of kernel UD estimates and for overestimation of home range area when the number of relocations is less than 30 per fish (Worton 1987). This home range was defined as the minimum distance needed for a fish to swim between the two most extreme relocations. I calculated this distance by following a straight-line between points unless the two extreme points were separated by land. If land blocked the two extreme points, I calculated this distance by following the shortest distance needed to travel between these two points (Figure 4-1).

Results

Kernel home-range estimates ranged from 0.66 to 518.07 ha, with a mean \pm SE of 164.25 ± 32.57 ha (Table 4-1). Kernel home-range estimates were not correlated with the number of locations per fish ($P = 0.55$; Figure 4-2). Twelve white bass had small (≤ 50 ha; defined *post hoc* based on distribution) home ranges, nine bass had home ranges encompassing 25-75% of the reservoir and six bass had home ranges encompassing almost the entire reservoir (Figure 4-3).

Linear home-range estimates varied from 69 to 8,154-m, with a mean \pm SE of $1,968.89 \pm 421.86$ m (Table 4-1). Linear and kernel home-range estimates were highly correlated ($P < 0.001$, $R^2 = 0.91$; Figure 4-4). Five fish could be considered potential outliers. The three fish with largest negative residuals had home ranges extending around the middle point of Enders Reservoir, though locations were restricted to the lower half of the reservoir. The two fish with largest positive residuals had home ranges that may have been biased because, given the shape of Red Willow reservoir and the fish locations within that reservoir, clipping of home ranges to the shoreline removed substantial portions of their home ranges. Linear home-range size did not differ between years (Kruskal-Wallis test, $X^2 = 0.18$, $P = 0.67$) or reservoirs ($X^2 = 0.10$, $P = 0.75$), thus observations were pooled for further analysis. Linear home range was not correlated with total length (Spearman rank = -0.23, $P = 0.25$; Figure 4-5), weight (Spearman rank = -0.17, $P = 0.42$; Figure 4-5), or relative weight (Spearman rank = 0.10, $P = 0.65$; Figure 4-5).

Enders Reservoir

Six white bass had home ranges restricted to small areas at Enders Reservoir during spring 2007 and spring 2008. The remaining 10 white bass had spring home ranges extending across large portions of the reservoir. Each white bass spring home range was compared with a bathymetric map of Enders Reservoir (Figure 4-6) to determine any preference for underwater features.

The first six white bass had small spring home ranges at Enders Reservoir. White bass #51 had the smallest spring home range at Enders Reservoir, which was characterized by a flat, shallow area (Figure 4-7). White bass #157 had a small spring home range located along a steep area of natural rock on the west shoreline of the lower reservoir (Figure 4-8). White bass #129 and #140 both had small overlapping spring home ranges restricted to a steep area of natural rock at the northern extent of the riprap dam (Figures 4-9 and 4-10). The spring home range of white bass #166 was located in the middle reservoir along a shallow, relatively flat area with inundated trees along the shoreline (Figure 4-11). White bass #115 also had a small spring home range that was restricted to an area with two riprap jetties along the eastern shore (Figure 4-12).

Four white bass had spring home ranges that extend across larger portions of Enders Reservoir, but did not encompass the majority of the reservoir. White bass #47 had a spring home range extending across the center of the lower reservoir characterized by a relatively deep basin with steep shorelines (Figure 4-13). White bass #58, #67, and #68 had spring home ranges extending across the middle portion of the reservoir characterized by a shallow flat area with shorelines dominated by small woody trees with

the addition of some sandy beaches along the southern shoreline of the spring home ranges (Figures 4-14 through 4-16).

The remaining six white bass had spring home ranges that extended across the majority of Enders Reservoir. White bass #125 had a spring home range extending across the upper half of the reservoir with locations centered around the sandy point in the middle of the reservoir (Figure 4-17), whereas the spring home range of white bass #44 encompassed most of the lower, deeper half of the reservoir (Figure 4-18). White bass #53, #64, #71, and #171 were found throughout the reservoir and had spring home ranges encompassing most of the reservoir (Figures 4-19 through 4-22).

Red Willow Reservoir

Six white bass had home ranges restricted to small areas of Red Willow reservoir during spring 2007 and spring 2008. The remaining five white bass had spring home ranges extending across large portions of the reservoir. Each white bass spring home range map was compared with a bathymetric map of Red Willow reservoir (Figure 4-23) to determine any preference for underwater features.

Six white bass had small spring home ranges at Red Willow reservoir. White bass #141 had the smallest spring home range at Red Willow reservoir, which was characterized by a small area of dead, standing trees along an old creek channel in the Spring Creek arm (Figure 4-24). White bass #39 had a small spring home range in a relatively flat area adjacent to a point extending into the Red Willow Creek arm (Figure 4-25). White bass #116 had a small spring home range located in upper section of the Red Willow Creek arm with most locations occurring along a steep break near shore

(Figure 4-26). The spring home range of #122 was centered on a large underwater point extending across the middle of the reservoir with some locations nearby along the southern shore (Figure 4-27). White bass #19 had a small spring home range characterized by locations on either side of a point extending into the lower reservoir (Figure 4-28). White bass #101 had a similar, yet slightly larger spring home range located along a submerged point further west (Figure 4-29). White bass #38 had a larger spring home range in the lower reservoir with locations along drop-offs (Figure 4-30).

The remaining four white bass are characterized by spring home ranges extending across most of Red Willow reservoir. White bass #151 and #168 had locations throughout the Red Willow Creek arm and their spring home ranges encompassed large areas of this arm (Figures 4-31 and 4-32). White bass #107 and #127 both had locations and spring home ranges extending across the entire reservoir (Figures 4-33 and 4-34).

Discussion

The identification of home ranges by white bass during spring is critical to understanding their basic biology, which is a prerequisite for successful management of this important gamefish (i.e., broodstock collection and spawning habitat management). The discontinuity in size of white bass home ranges during spring indicates that there may be two distinct behaviors of white bass in these reservoirs during spring. One behavior produces movement of white bass throughout most of the reservoir. The other behavior produces movement of white bass within a small area, which was a surprise given that white bass are pelagic species. There are four potential hypotheses for the discontinuity in size of spring home ranges that was observed: 1) larger fish may require

greater home range areas to obtain food needed for growth and reproduction (Minns 1995; Peters 1983), 2) fish in greater condition (e.g., W_r) may not travel as far because they are in an area with abundant resources (optimal foraging theory; MacArthur and Pianka 1966), 3) male fish may remain at potential spawning sites throughout the pre-spawn and spawn periods, and 4) older, reproductively senescent fish may travel little because of lack of migration and exploratory behavior associated with spawning.

Hypotheses 1 and 2 are not supported by my results (i.e., body size and W_r were not correlated with home-range size), though sample size was admittedly limited ($N = 27$). I did not gather age or sex data on tagged fish, and thus, was unable to test hypotheses 3 and 4. Further research is needed to determine the mechanism responsible for variation in white bass spring home range size.

White bass with small home ranges selected areas characterized in one of two ways: underwater drop-offs or relatively flat areas with small trees. These areas likely provide abundant food such that time spent and energy consumed is minimized during the search phase. These areas may also provide habitat necessary for spawning, although my results from patch occupancy modeling and acoustic telemetry do not support this contention (Chapters 2 and 3).

Table 4-1. Size and condition of fish (measured during tag implantation during September of previous year), number of locations, and size of home range (linear and 95% utilization distribution) for white bass at Enders and Red Willow reservoirs, Nebraska during 2007 and 2008. Condition was assessed using relative weight (Wege and Anderson 1978; Brown and Murphy 1991).

Year	Reservoir	Total		Relative		# of Locations	Linear HR (m)	HR area (ha)
		Fish #	Length (mm)	Weight (g)	Weight (W _r)			
2007	Enders	44	331	439	88	5	1725	269.52
		47	342	505	92	11	1186	101.77
		51	315	*	*	5	86	1.28
		53	306	360	92	7	3825	295.48
		58	321	409	90	6	1809	166.16
		64	259	239	102	6	2460	312.39
		67	325	436	93	10	1460	174.89
		68	269	253	96	9	1401	154.02
		71	331	458	92	5	2560	319.71
	Red Willow	19	295	*	*	5	632	34.44
		38	314	320	76	5	1345	103.43
		39	300	275	75	6	239	9.34
2008	Enders	115	334	434	85	23	397	14.25
		125	309	371	92	14	2472	219.67
		129	300	357	97	14	231	4.75
		140	341	480	88	25	343	10.94
		157	349	526	90	14	168	3.41
		166	351	568	95	8	239	10.18
		171	306	357	91	6	3312	290.67
	Red Willow	101	262	200	82	17	838	44.94
		107	316	343	79	12	8154	518.07
		116	310	311	76	15	298	10.40
		122	297	230	64	14	605	25.14
		127	265	200	80	15	7266	514.00
		141	266	189	74	10	69	0.66
		151	276	241	85	13	5035	414.69
		168	286	257	81	16	5005	410.68

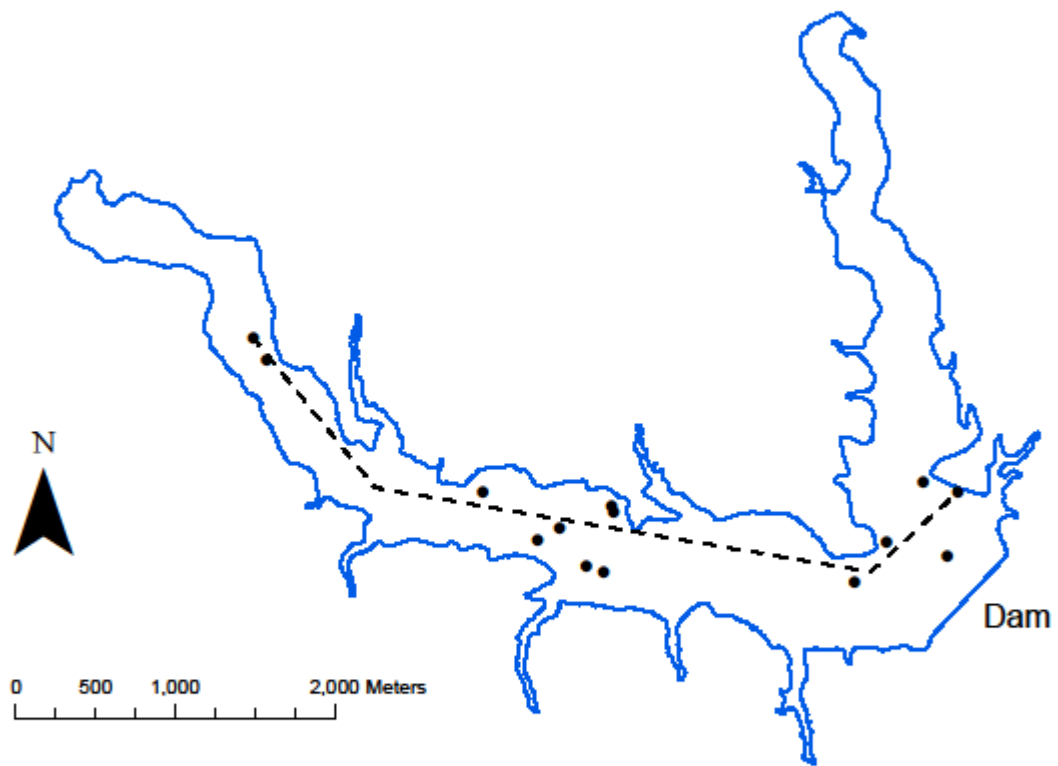


Figure 4-1. Example of linear home range (dashed line) calculation for white bass #157 at Red Willow reservoir, Nebraska.

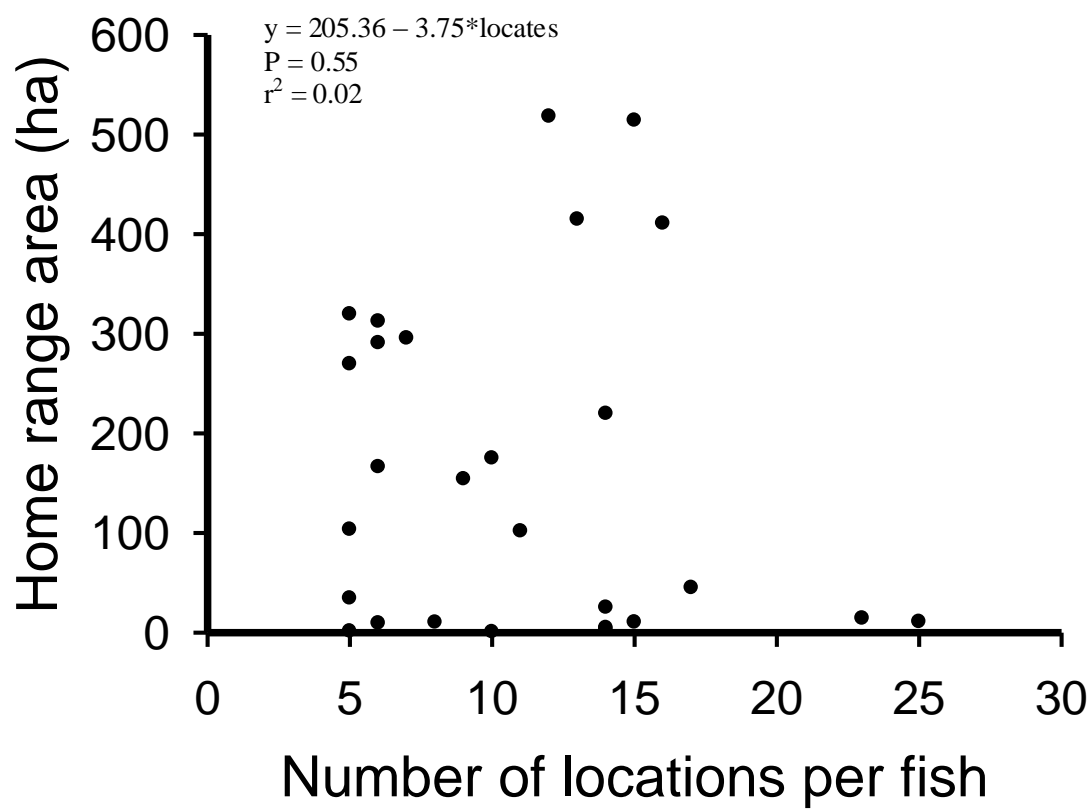


Figure 4-2. Linear regression of home range area with the number of locations per individual white bass tracked during spring 2007 and spring 2008 at Enders and Red Willow reservoirs, Nebraska.

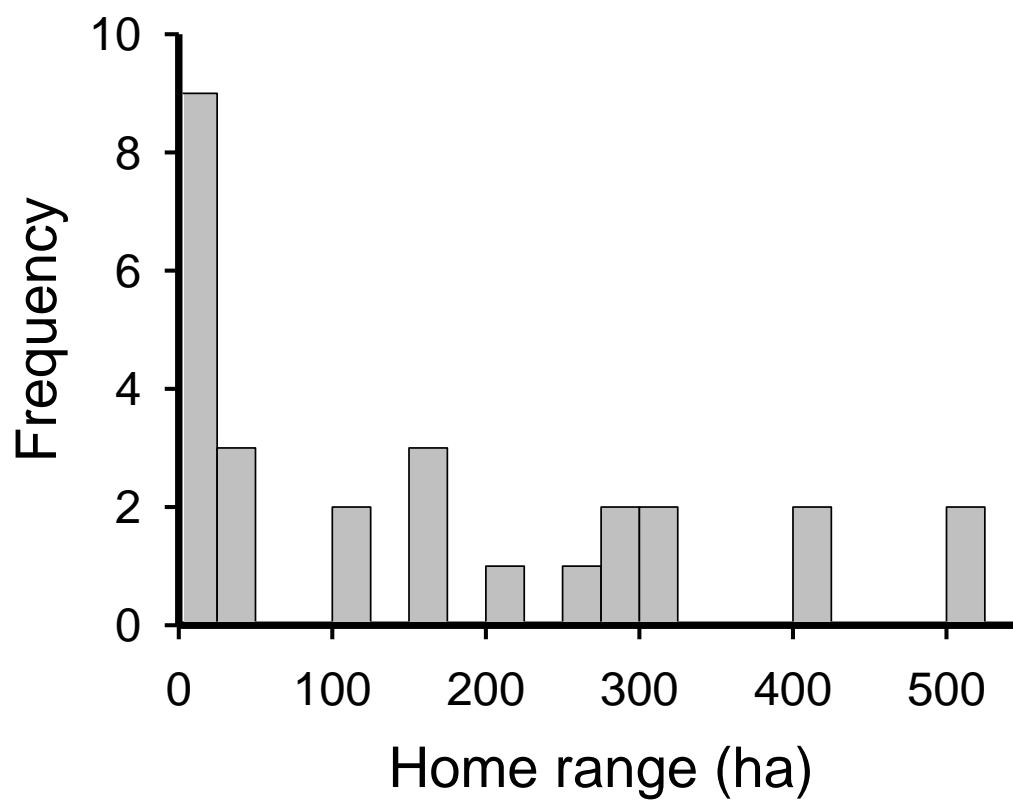


Figure 4-3. Histogram (25-m bins) of calculated home range area for all tagged white bass at Enders and Red Willow reservoirs, Nebraska during spring 2007 and 2008.

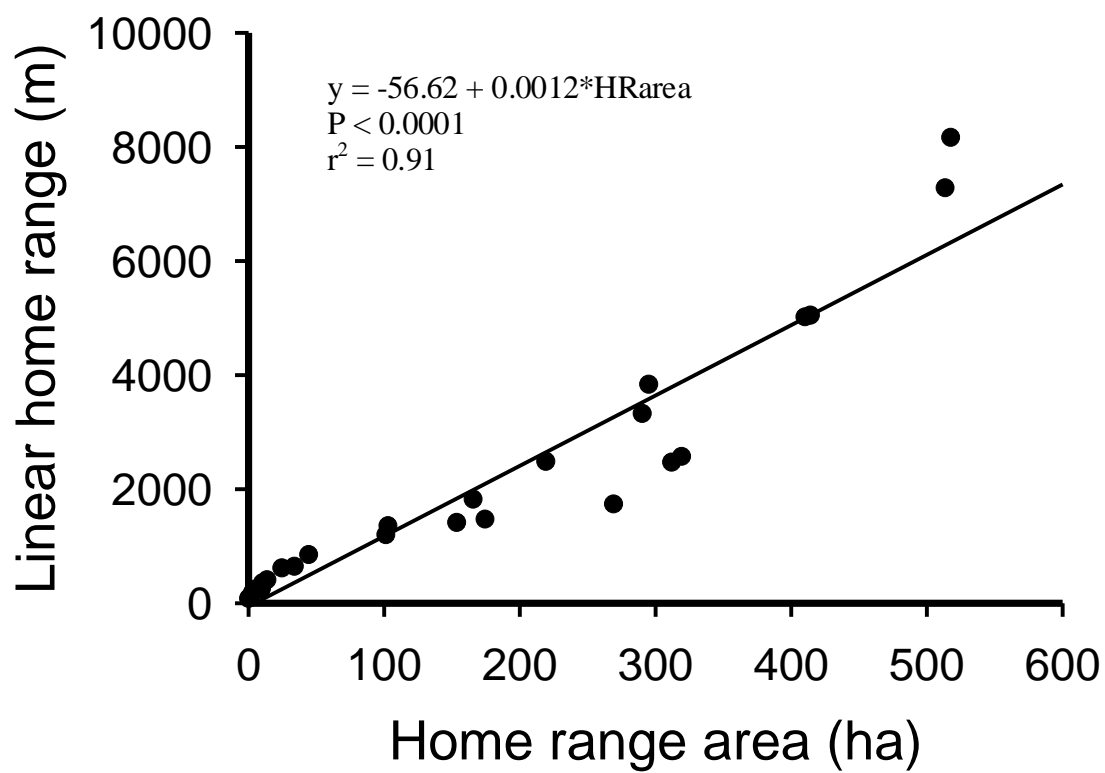


Figure 4-4. Linear regression of linear home range with adaptive kernel home range area for tagged white bass at Enders and Red Willow reservoirs, Nebraska during spring 2007 and 2008.

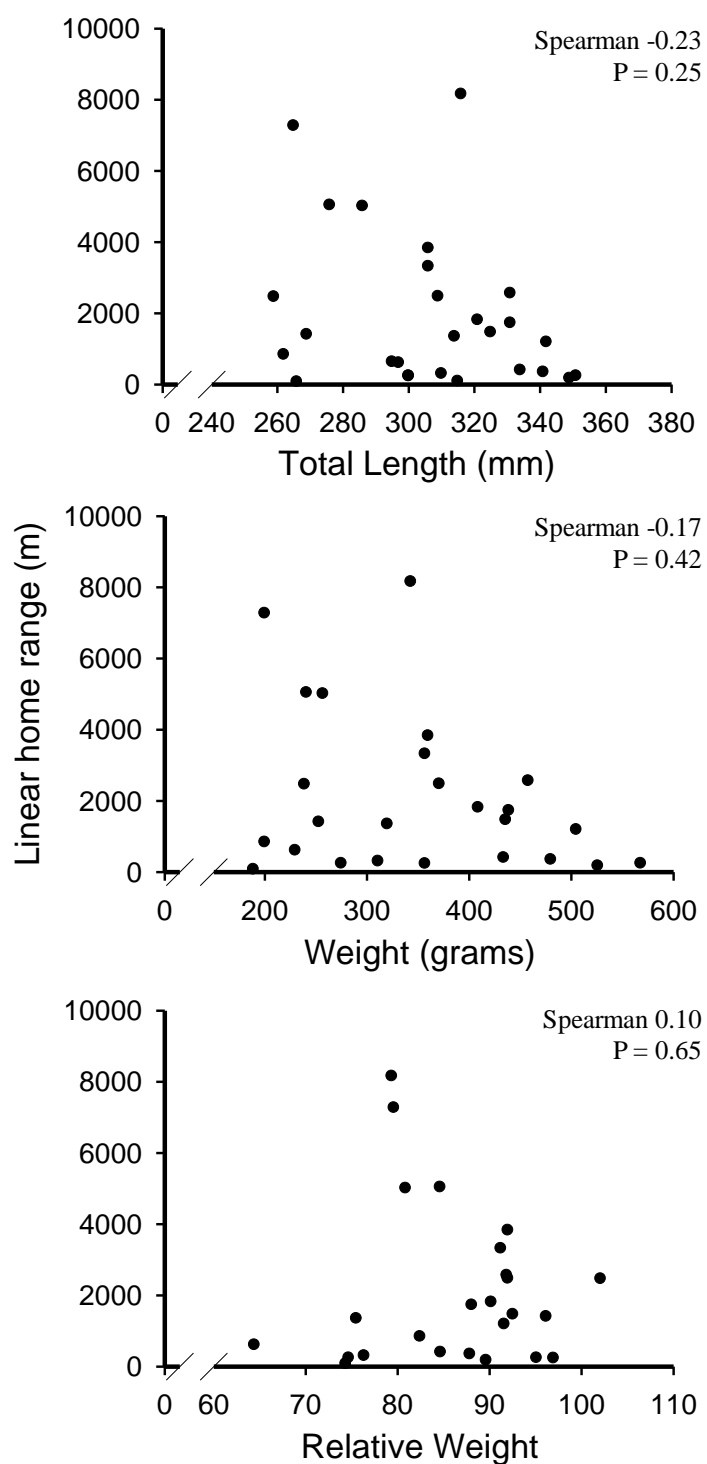


Figure 4-5. Spearman rank correlations of calculated linear home range for tagged white bass with total length (top panel), weight (middle panel), and relative weight (bottom panel) at Enders and Red Willow reservoirs, Nebraska during spring 2007 and 2008. Fish size and condition were measured at time of tag implantation.

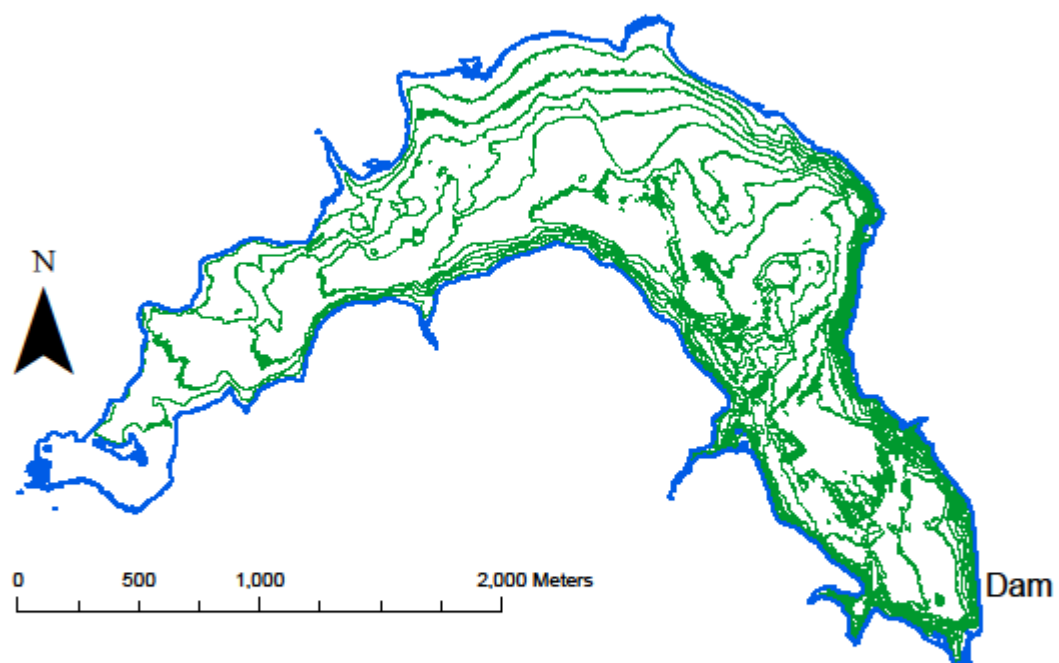


Figure 4-6. Bathymetric map of Enders Reservoir, Nebraska with 1-m contour intervals.

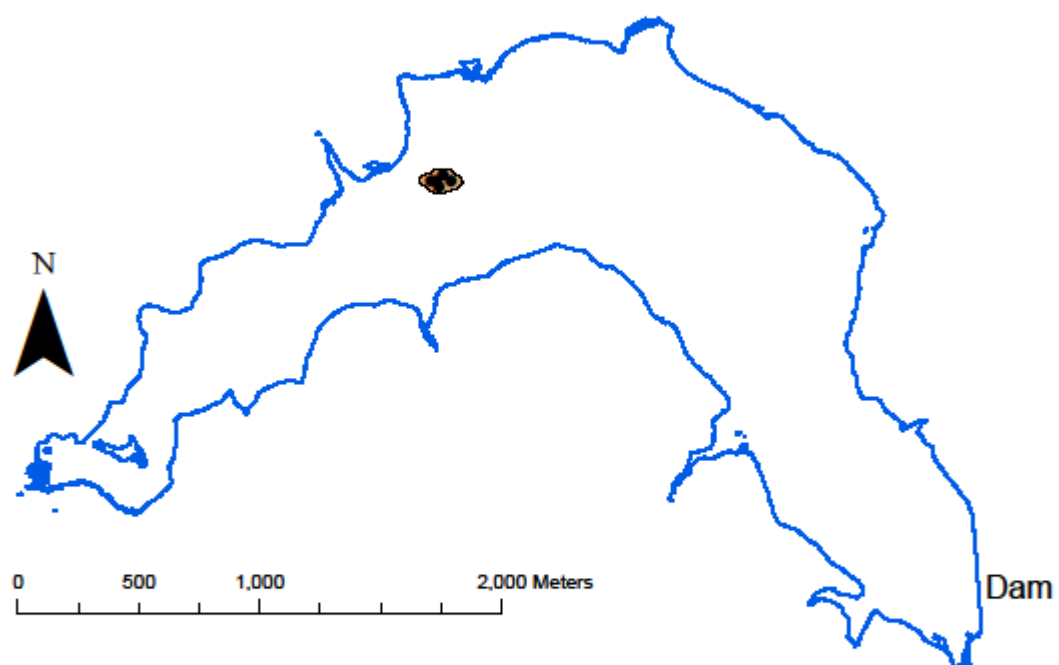


Figure 4-7. Telemetry relocations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #51 at Enders Reservoir, Nebraska from March to May 2007.

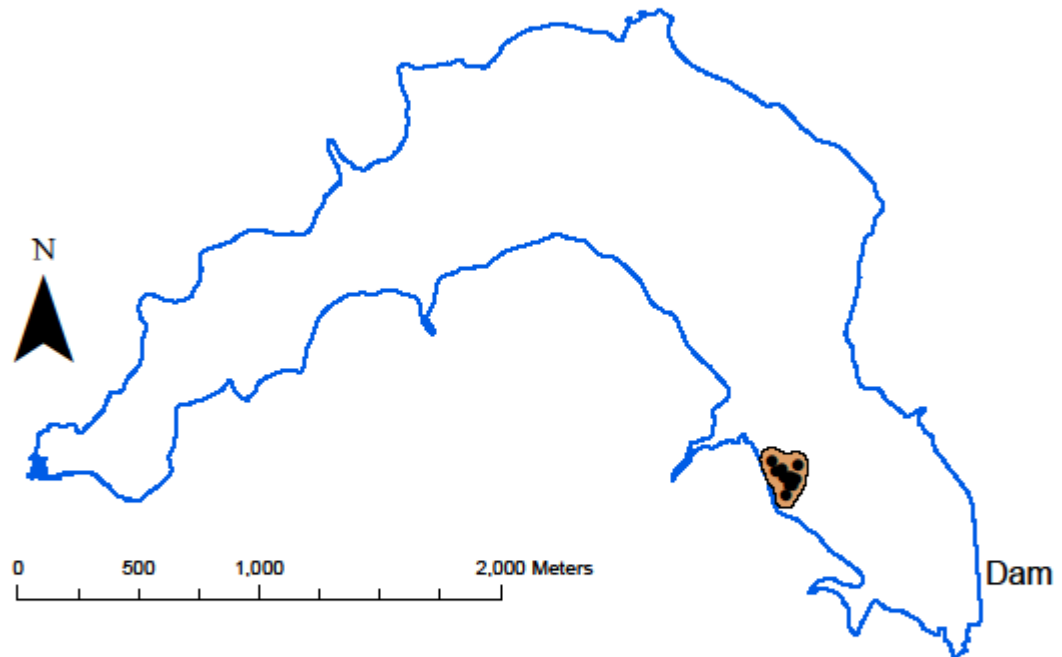


Figure 4-8. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #157 at Enders Reservoir, Nebraska from March to May 2008.

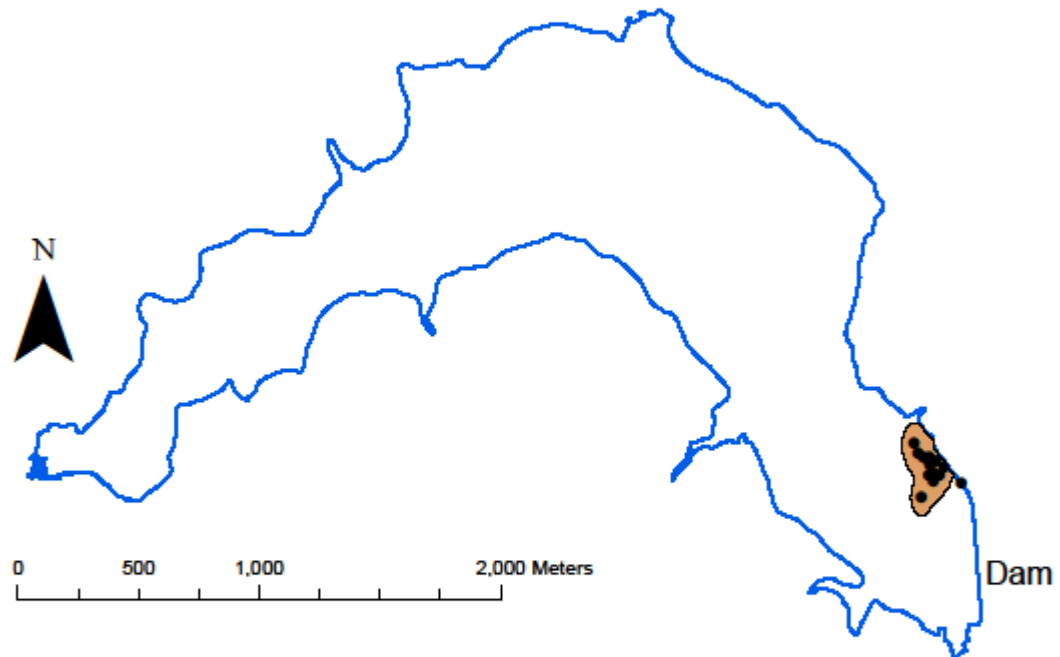


Figure 4-9. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #129 at Enders Reservoir, Nebraska from March to May 2008. Location outside home range is from November 2007.

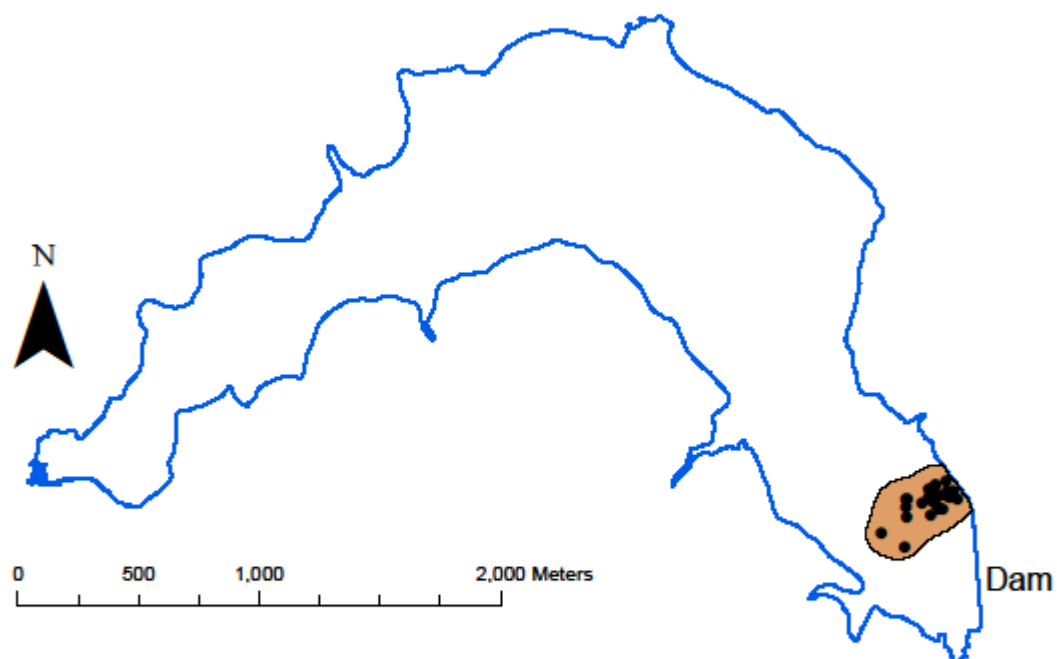


Figure 4-10. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #140 at Enders Reservoir, Nebraska from March to May 2008.

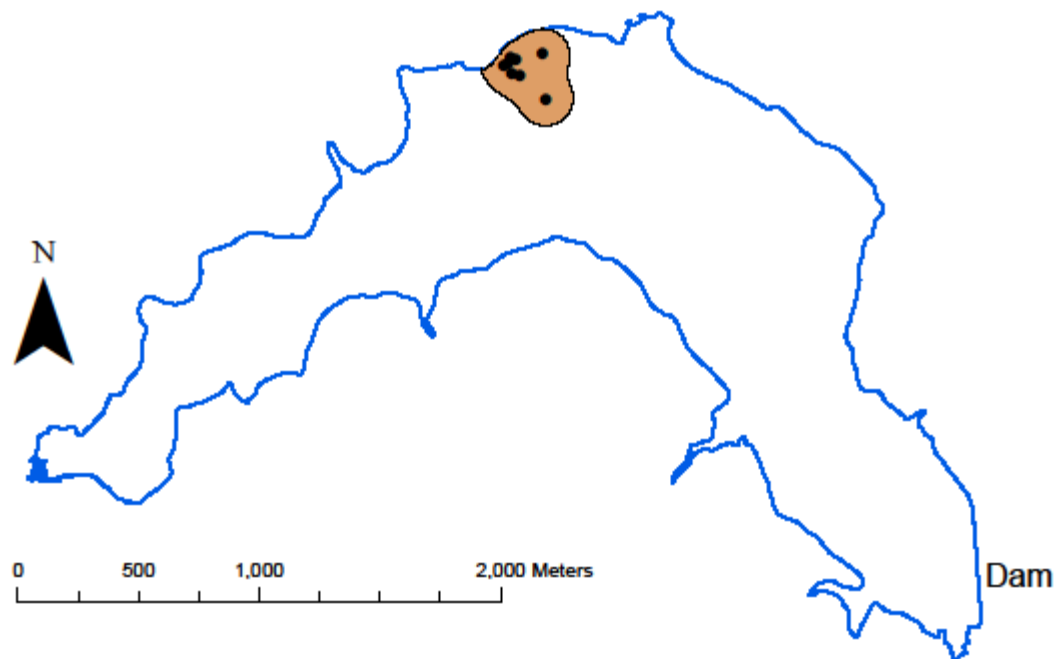


Figure 4-11. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #166 at Enders Reservoir, Nebraska from March to May 2008.

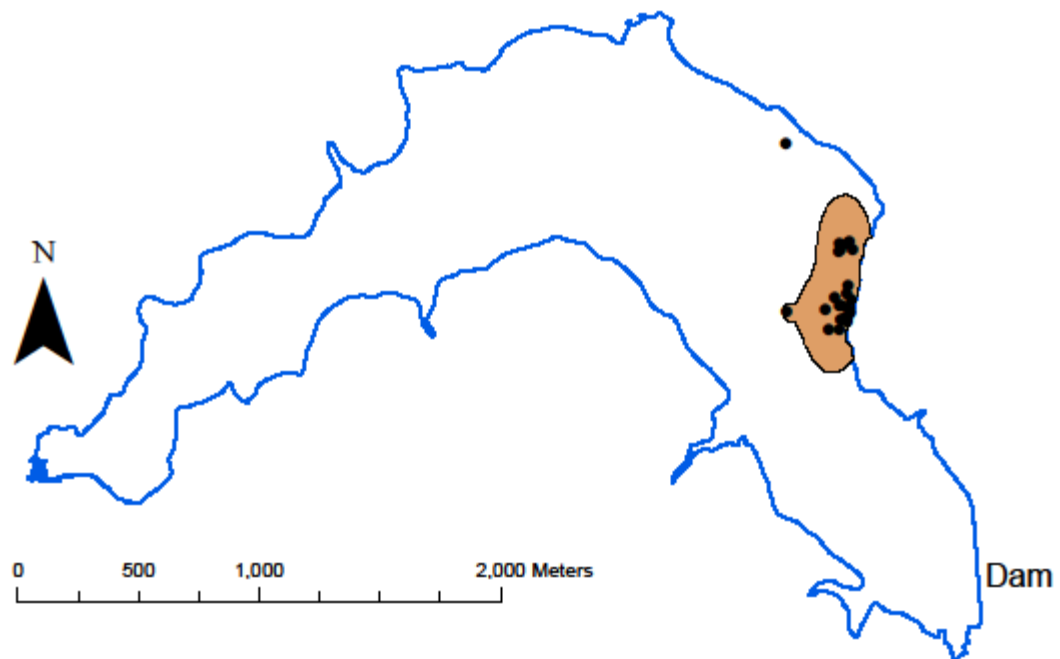


Figure 4-12. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #115 at Enders Reservoir, Nebraska from March to May 2008. Location outside home range is from November 2007.

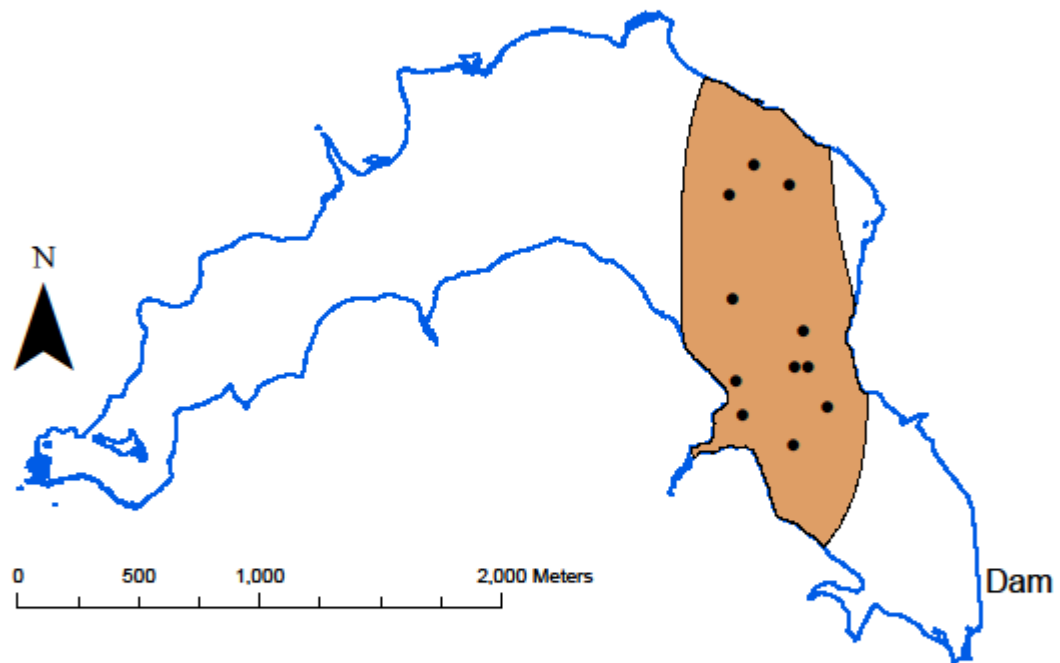


Figure 4-13. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #47 at Enders Reservoir, Nebraska from March to May 2007.

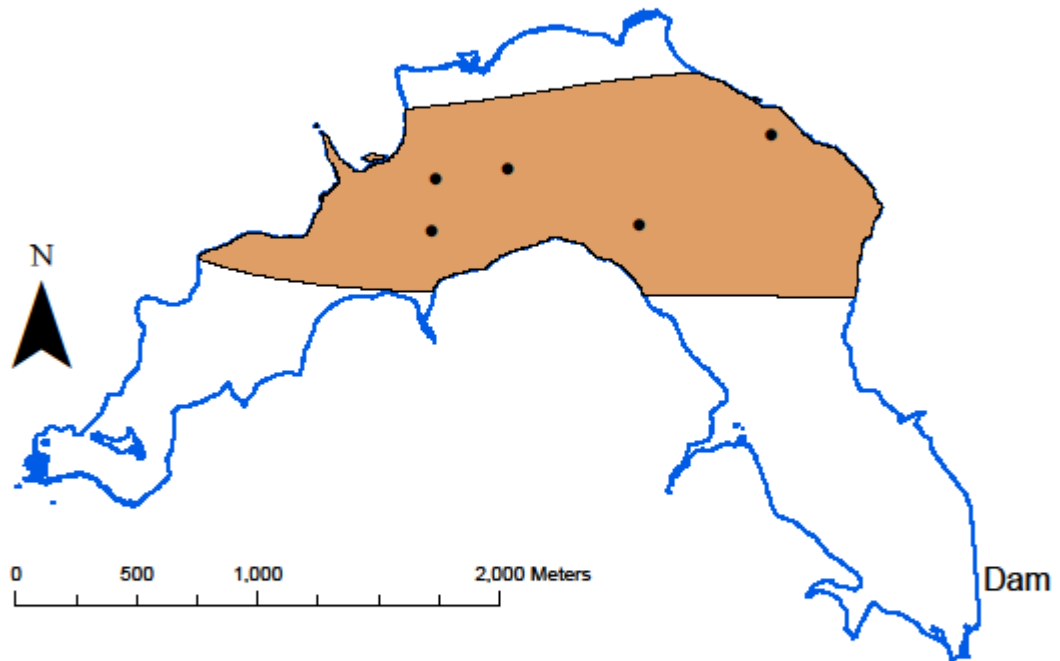


Figure 4-14. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #58 at Enders Reservoir, Nebraska from March to May 2007.

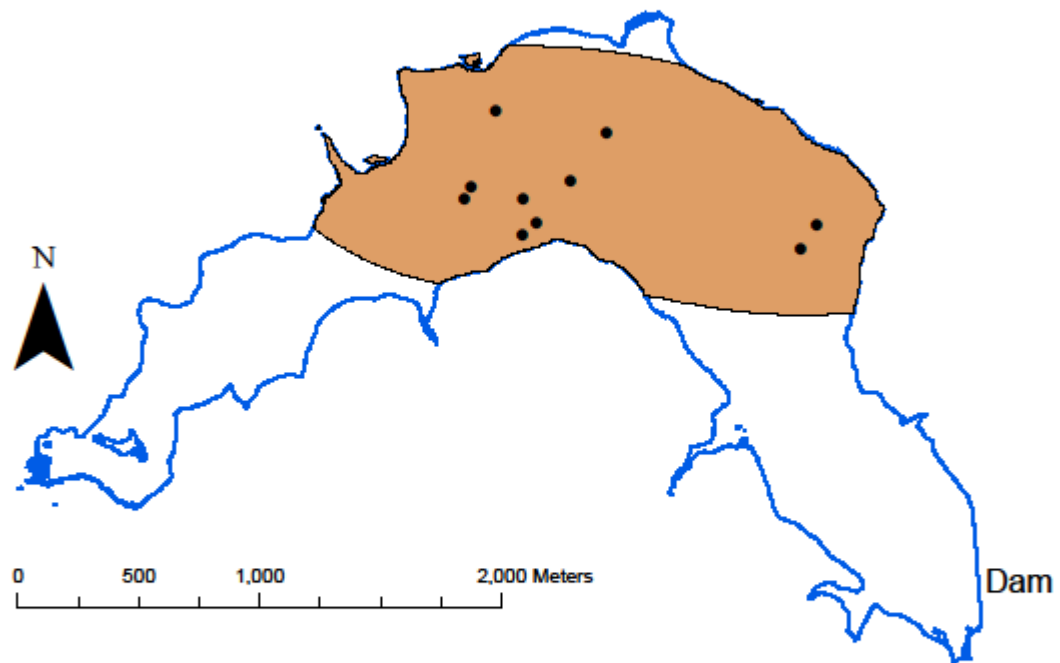


Figure 4-15. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #67 at Enders Reservoir, Nebraska from March to May 2007.

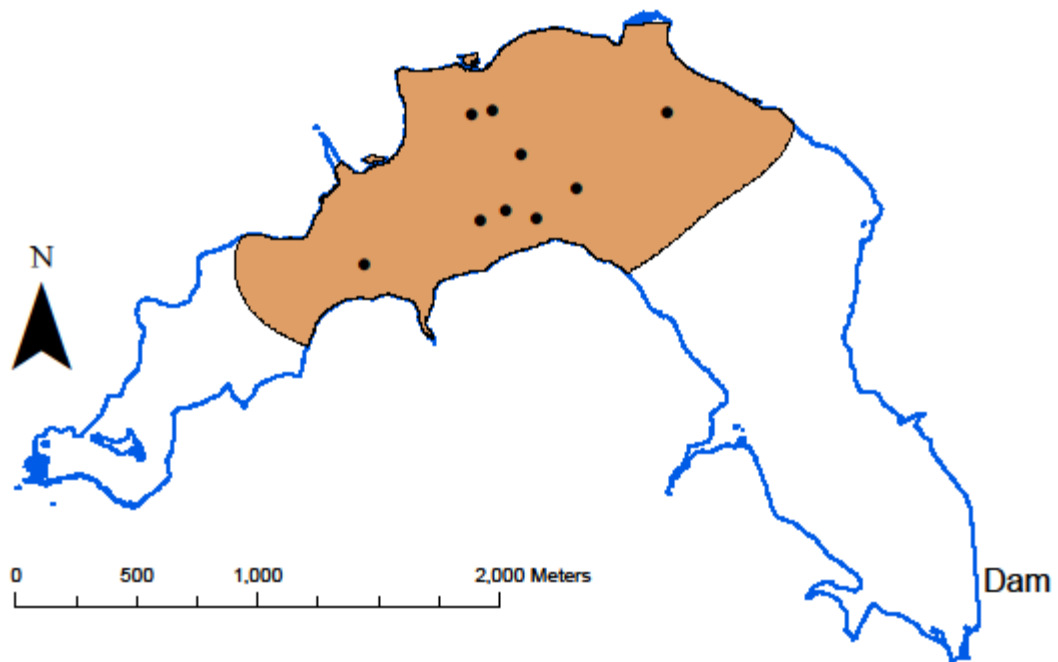


Figure 4-16. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #68 at Enders Reservoir, Nebraska from March to May 2007.

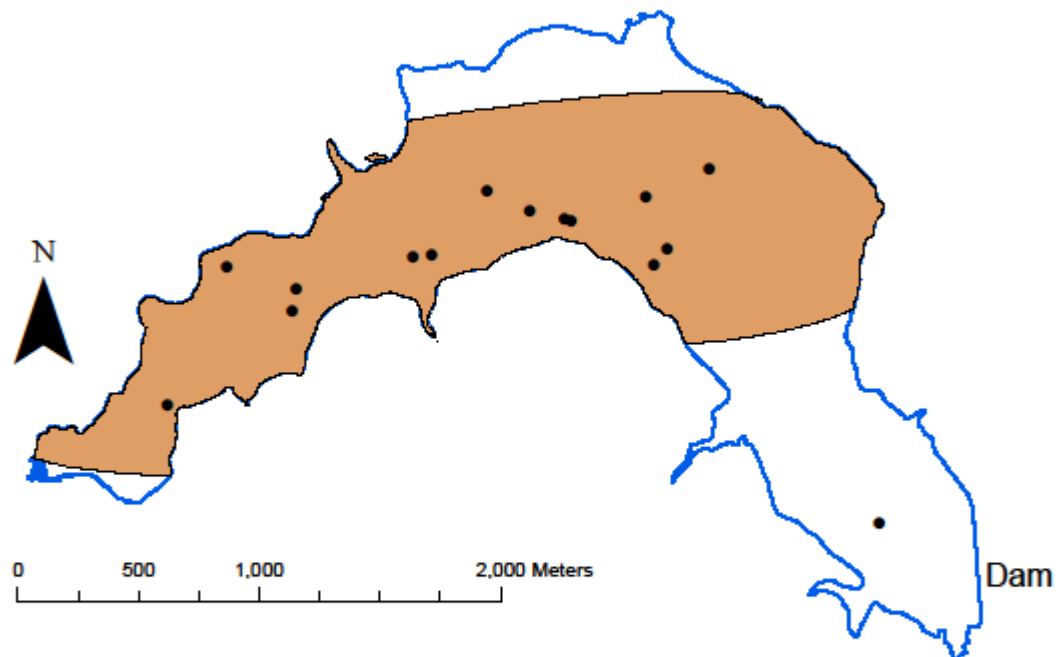


Figure 4-17. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #125 at Enders Reservoir, Nebraska from March to May 2008. Location outside home range is from November 2007.

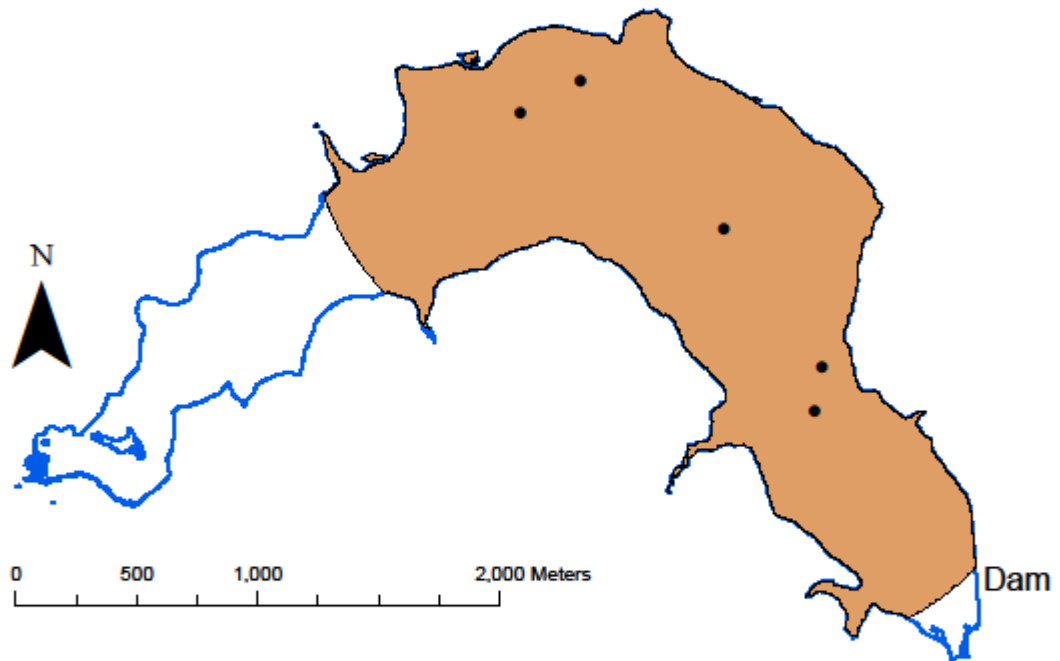


Figure 4-18. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #44 at Enders Reservoir, Nebraska from March to May 2007.

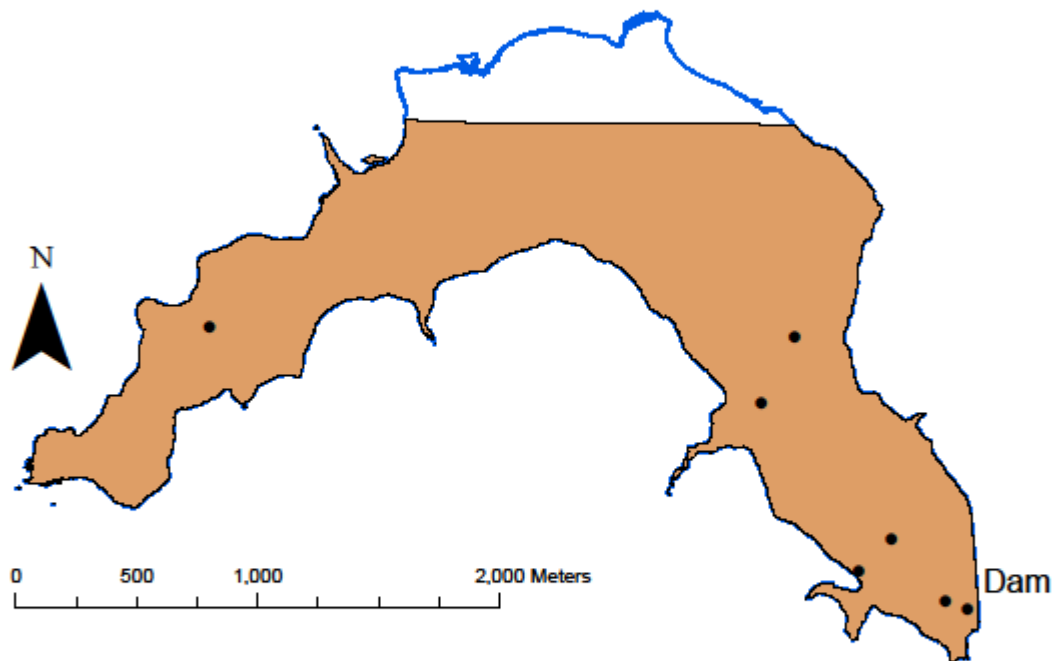


Figure 4-19. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #53 at Enders Reservoir, Nebraska from March to May 2007.

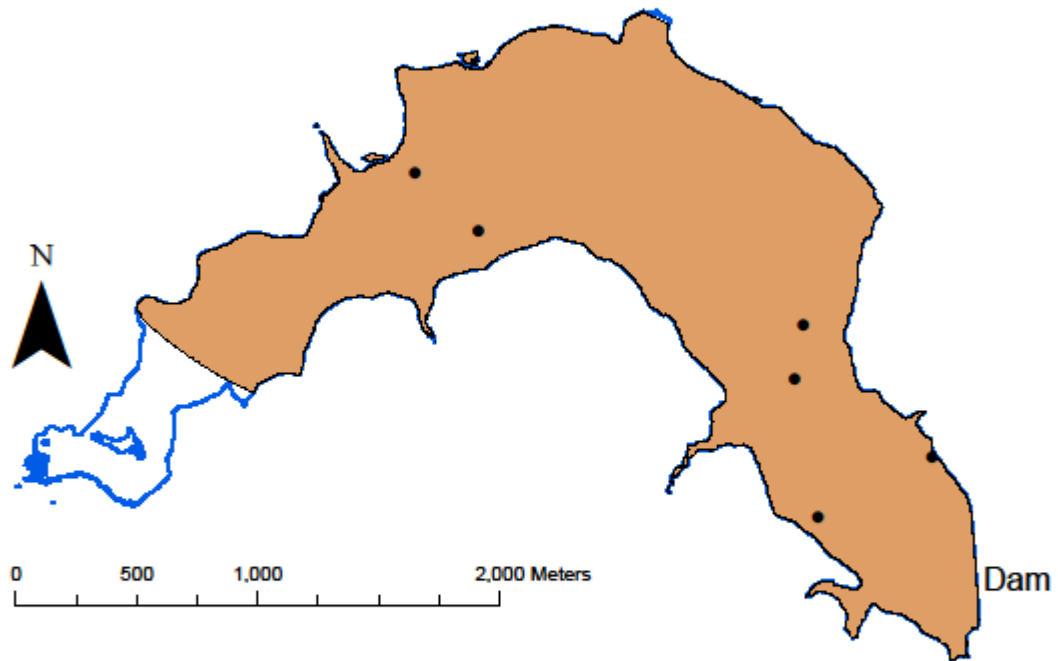


Figure 4-20. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #64 at Enders Reservoir, Nebraska from March to May 2007.

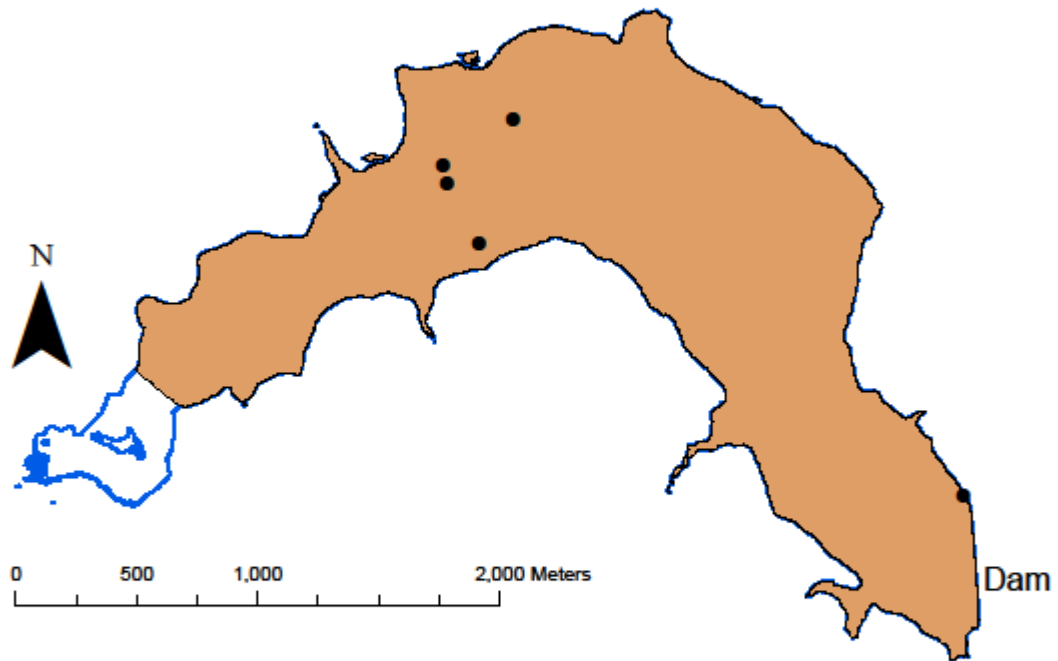


Figure 4-21. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #71 at Enders Reservoir, Nebraska from March to May 2007.

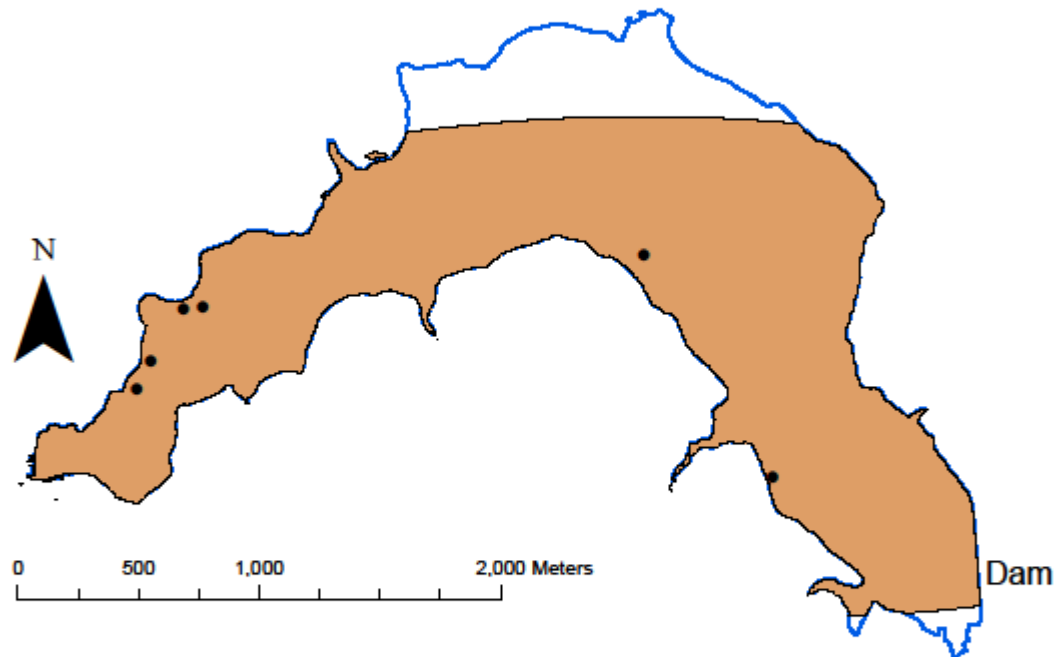


Figure 4-22. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #171 at Enders Reservoir, Nebraska from March to May 2008.

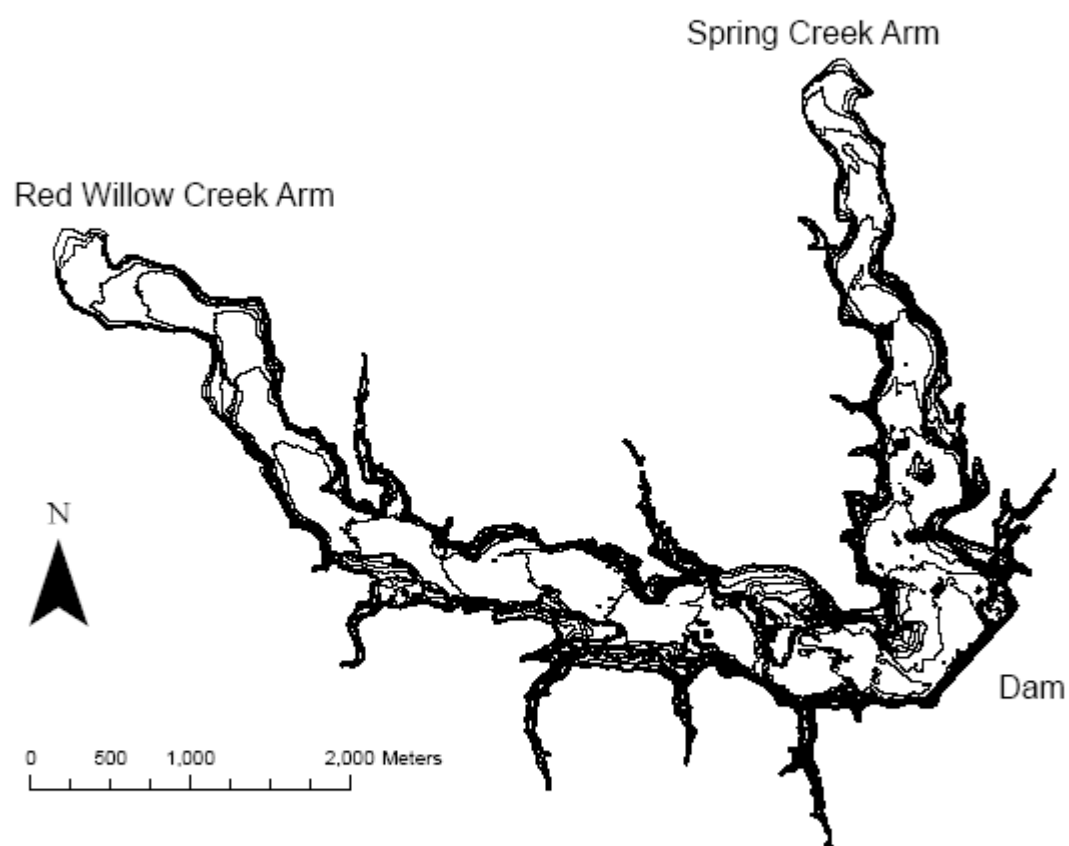


Figure 4-23. Bathymetric map of Red Willow reservoir, Nebraska with 1-m contour intervals.

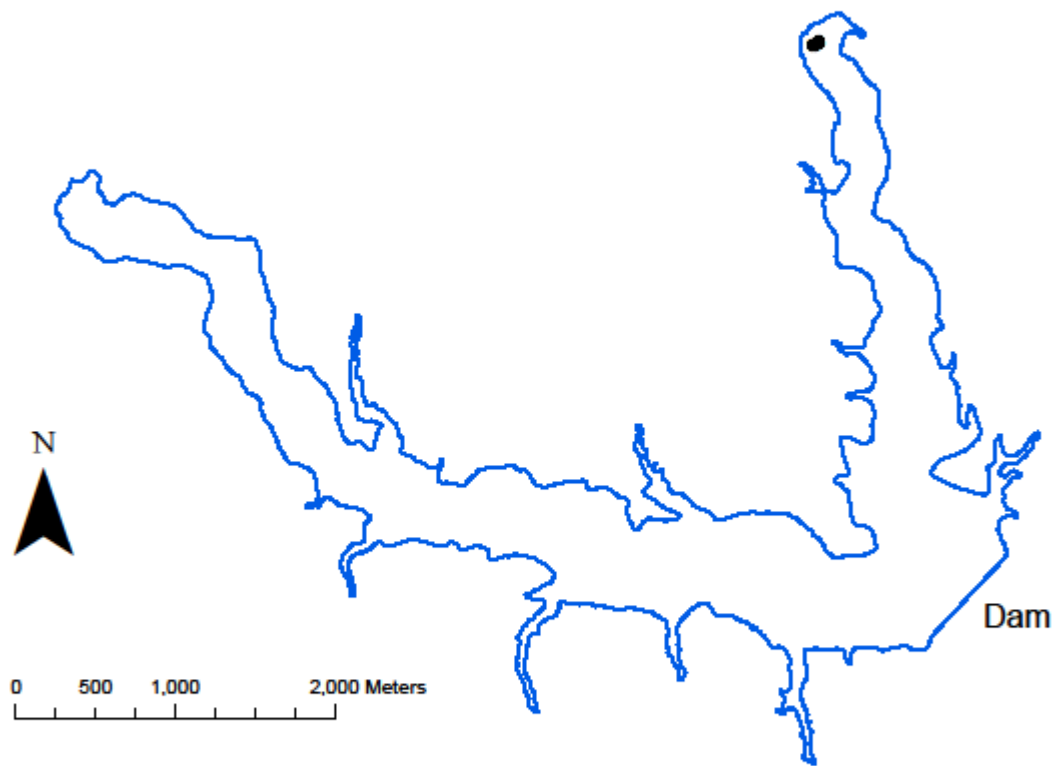


Figure 4-24. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #141 at Red Willow reservoir, Nebraska from March to June 2008.

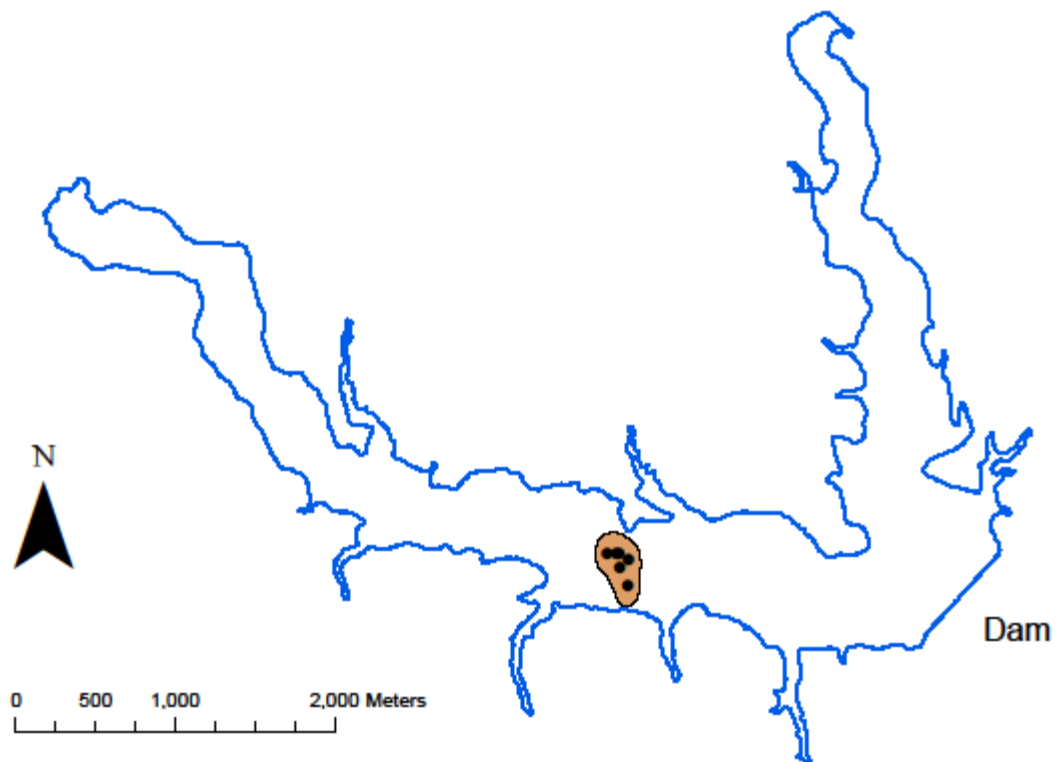


Figure 4-25. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #39 at Red Willow reservoir, Nebraska from March to May 2007.

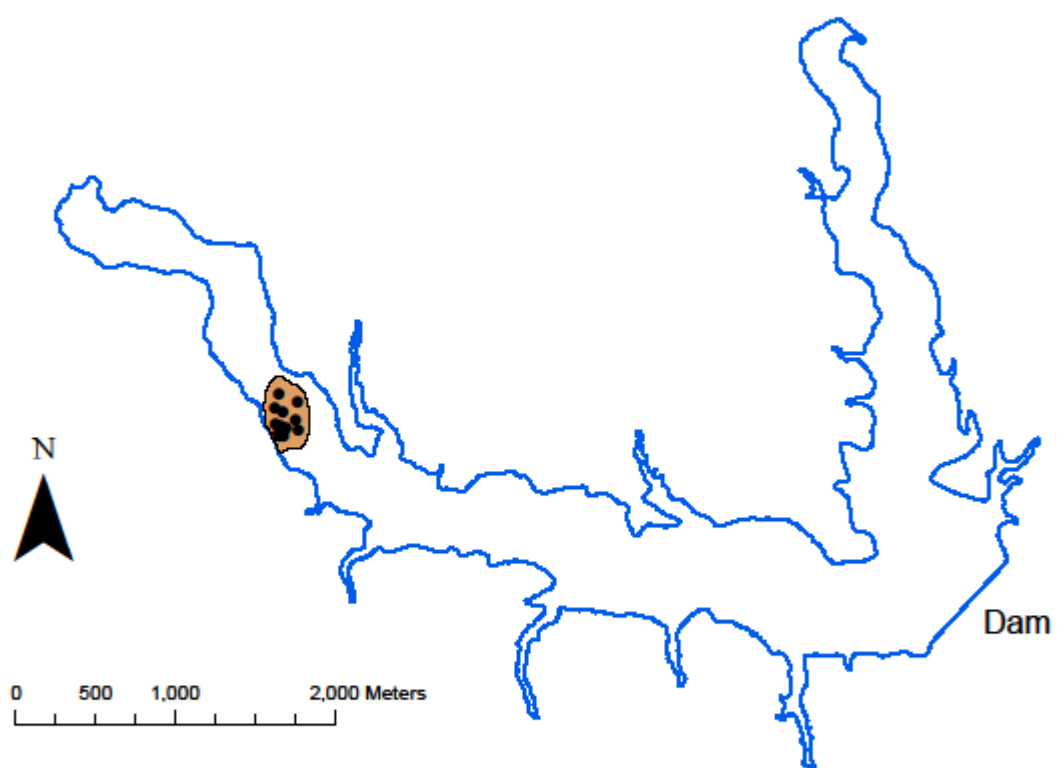


Figure 4-26. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #116 at Red Willow reservoir, Nebraska from March to June 2008.

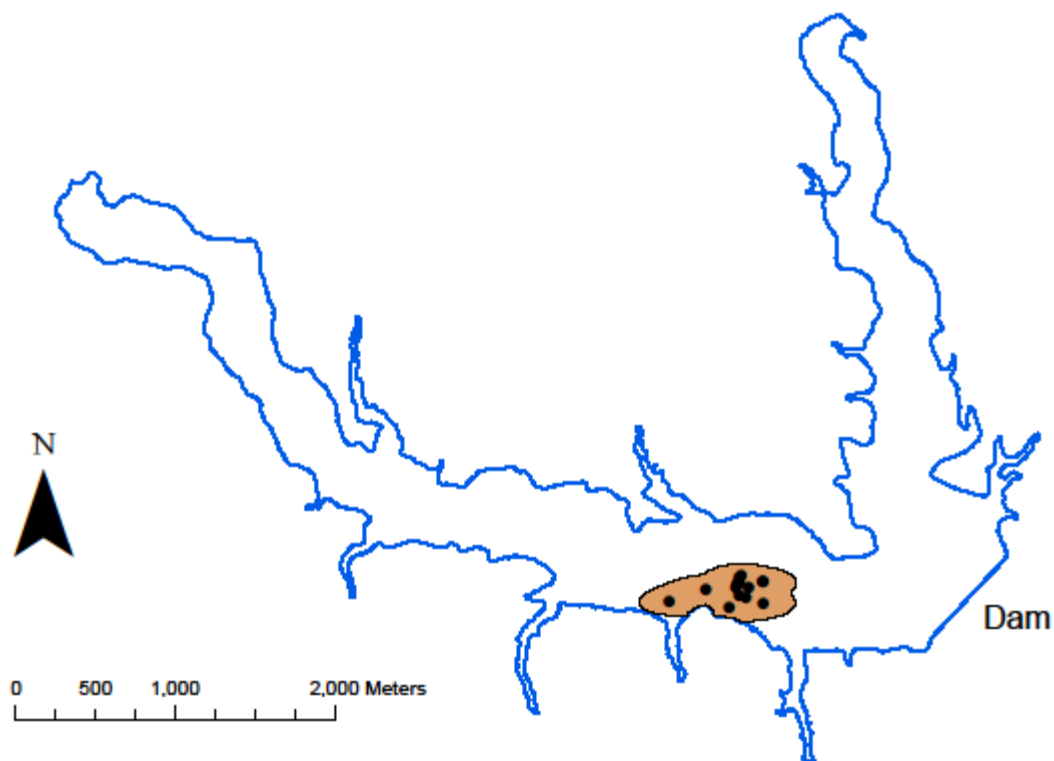


Figure 4-27. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #122 at Red Willow reservoir, Nebraska from March to June 2008.

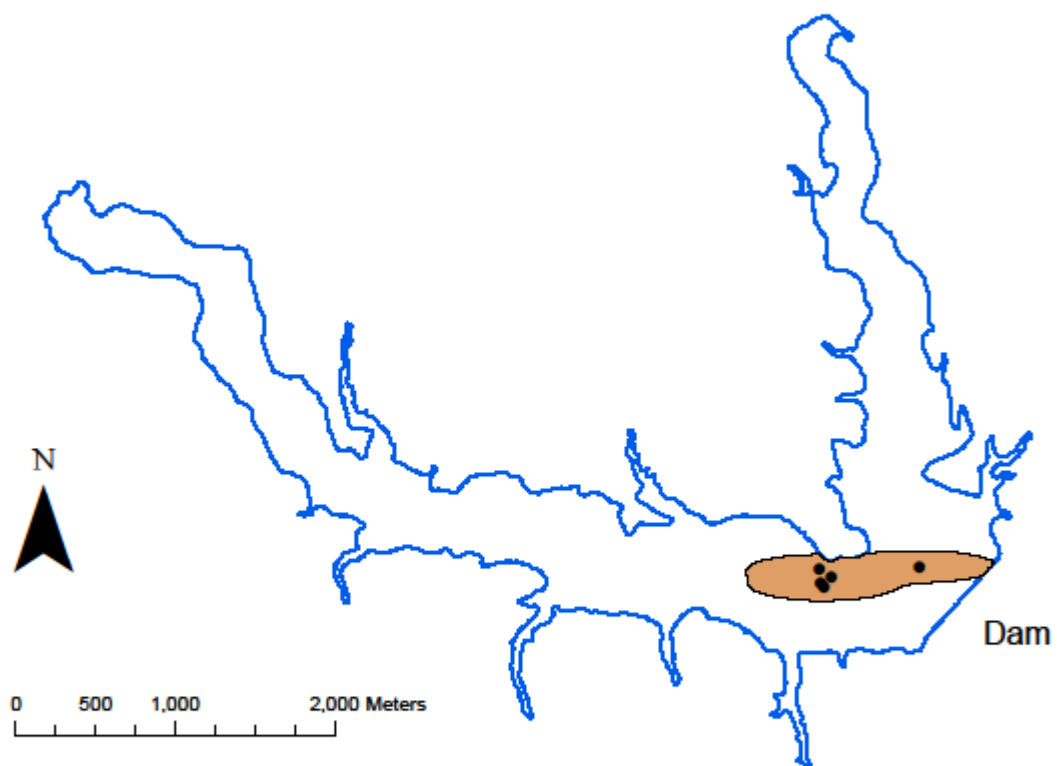


Figure 4-28. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #19 at Red Willow reservoir, Nebraska from March to May 2007.

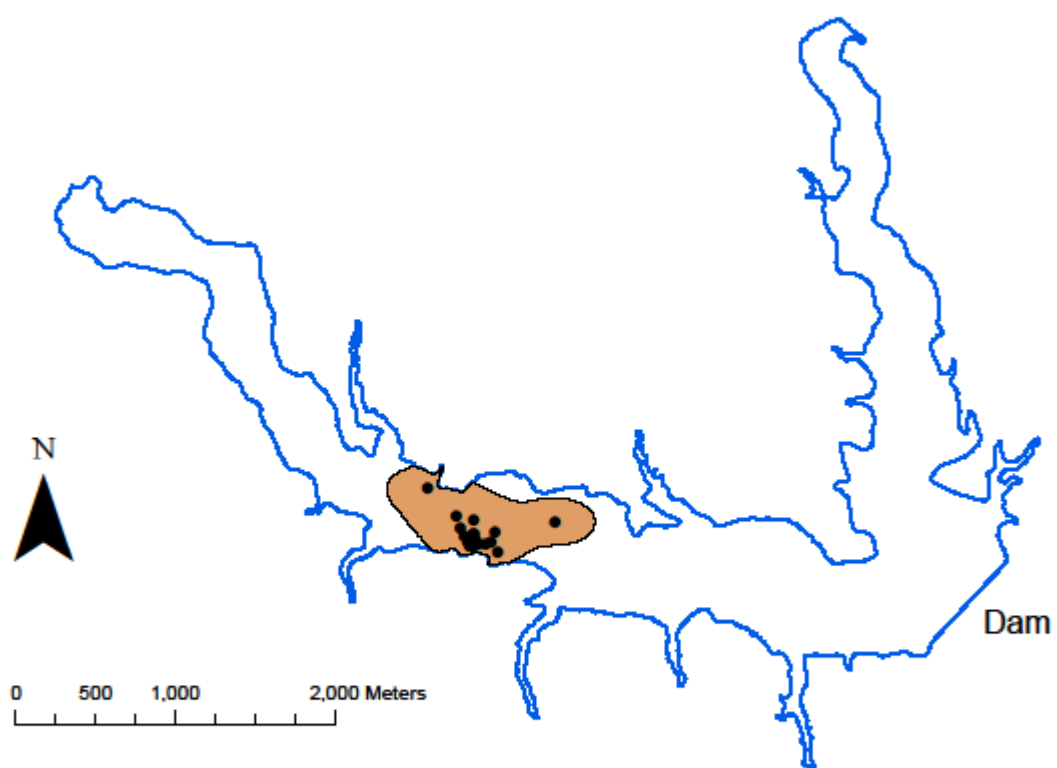


Figure 4-29. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #101 at Red Willow reservoir, Nebraska from March to June 2008.

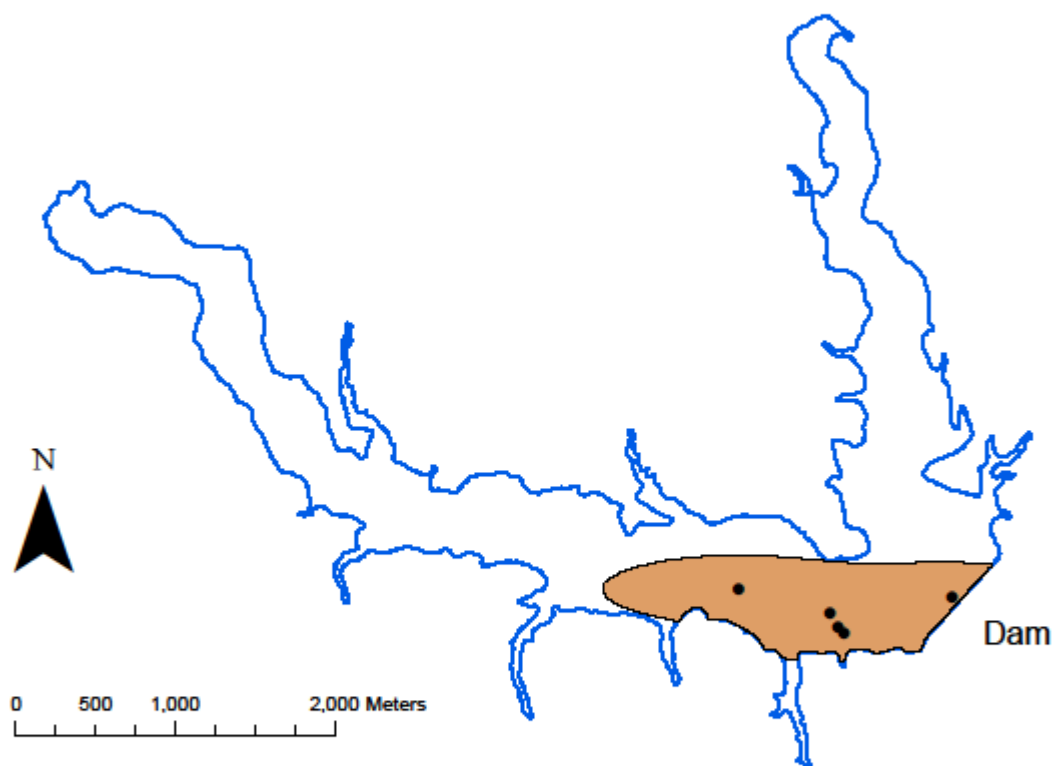


Figure 4-30. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #38 at Red Willow reservoir, Nebraska from March to May 2007.

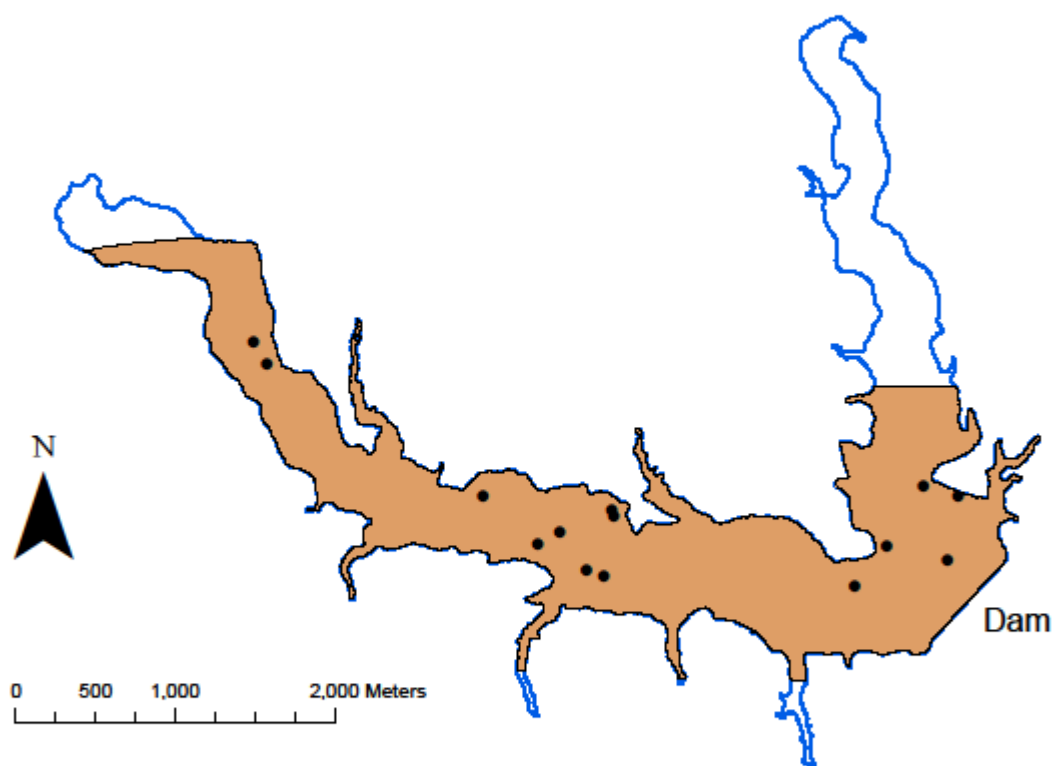


Figure 4-31. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #151 at Red Willow reservoir, Nebraska from March to June 2008.

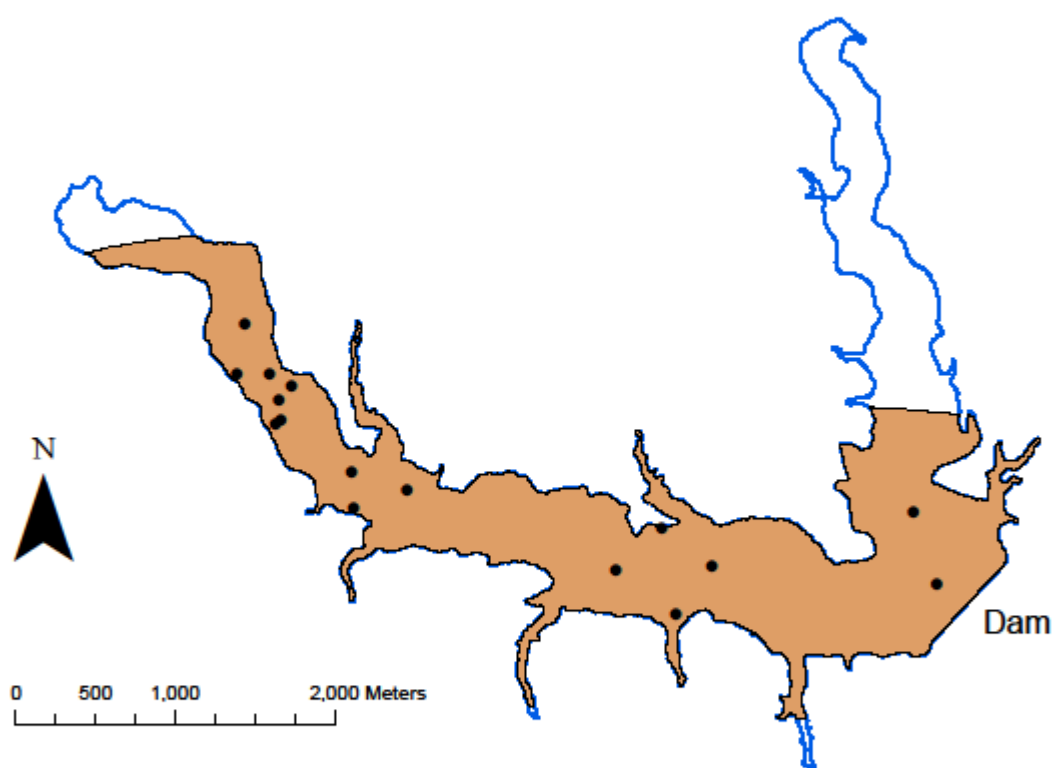


Figure 4-32. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #168 at Red Willow reservoir, Nebraska from March to June 2008.

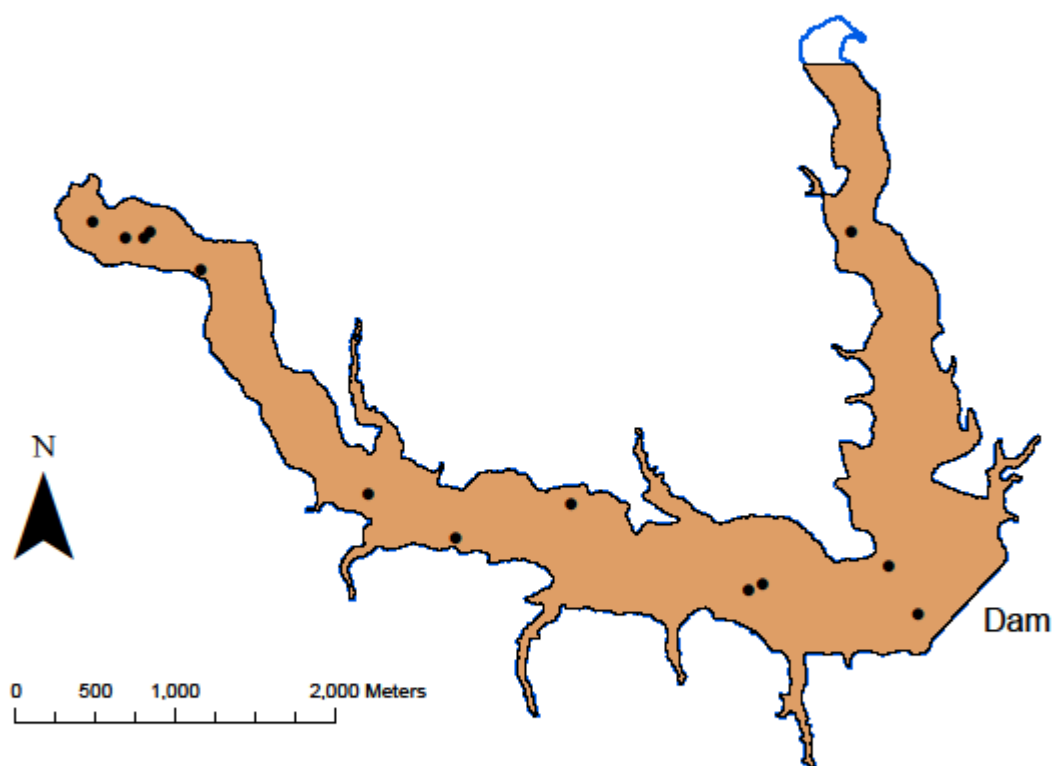


Figure 4-33. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #107 at Red Willow reservoir, Nebraska from March to June 2008.

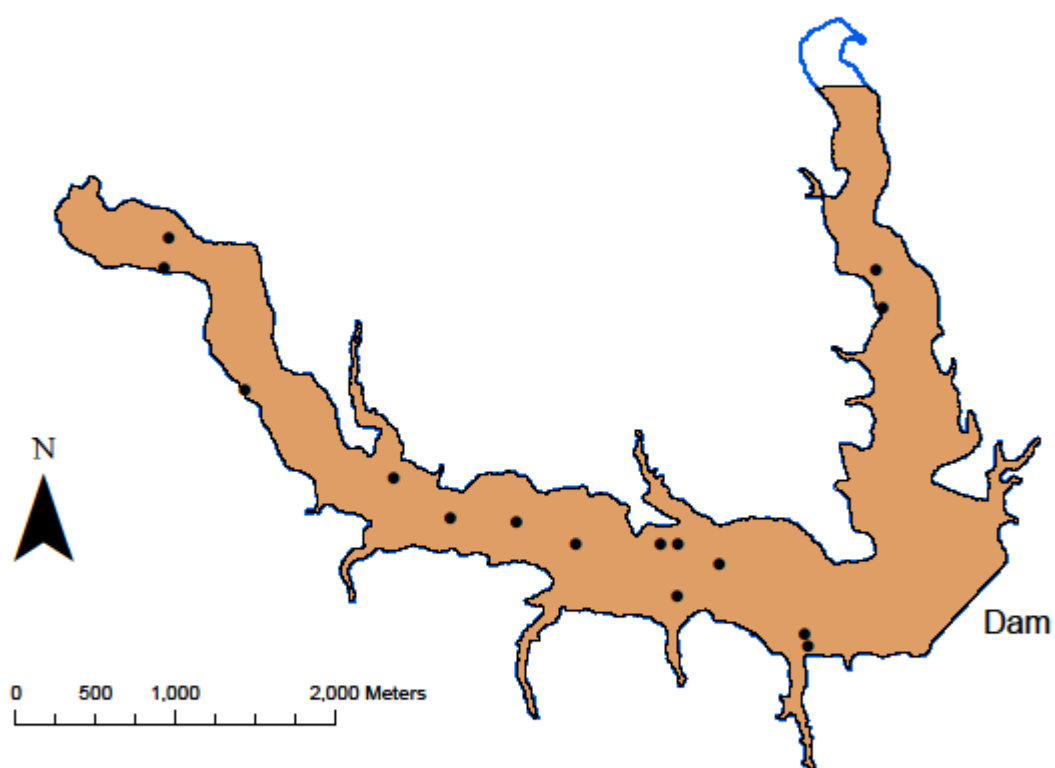


Figure 4-34. Telemetry locations (black circles) and 95% adaptive kernel home range (shaded area) of white bass #127 at Red Willow reservoir, Nebraska from March to June 2008.

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Chapter 5. Conclusions and Future Research

Understanding habitat selection by spawning walleye and white bass in irrigation reservoirs of the Republican River basin in southwestern Nebraska is important.

Restricted spawning habitat may be responsible for the limited recruitment of sportfishes often observed in these reservoirs. Spawning habitat varies greatly among years because irrigation practices cause large fluctuations in water levels.

I determined that walleye are selecting for spawning sites characterized by large substrate, cool water temperature, large fetch, and the absence of cover in irrigation reservoirs. In both Enders and Red Willow reservoirs, the only available habitat that meets these selection criteria is located on or near the riprap dam. Acoustic telemetry confirmed the dam as the primary location of walleye congregation during peak spawning of 2007 and 2008. The capture of walleye eggs on the dam gave further support to habitat selection observations from both electrofishing and acoustic telemetry analyses. However, larval walleye catches were not greatest in suspected spawning areas (analysis was confounded by stockings of larval walleye during my sampling period).

One management technique that would likely increase recruitment of walleye is the creation of additional spawning habitat. Ideally one could increase available spawning habitat by modifying existing habitat so that characteristics selected by spawning walleye (cool water temperature, no cover, rock substrate, and large fetch) are also present in modified habitats. I contend that rock substrate is the primary characteristic selected by spawning walleye. If correct, the thoughtful addition of riprap in the middle and upper portions of irrigation reservoirs would increase the amount of spawning habitat available to walleye. A concurrent study is investigating the use of

added rock habitat (i.e., riprap) by spawning walleye in Sherman Reservoir, an irrigation reservoir in Sherman County, Nebraska (J. Katt, University of Nebraska-Kearney, personal communication). Riprap was added inside and outside of coves in the middle and upper portions of Sherman Reservoir such that riprap will be available with warm and cool water as well as large and small fetch. That study will provide a first test of my claim that rock is the important characteristic selected by spawning walleye in irrigation reservoirs of southwestern Nebraska.

I failed to detect any habitat selection by spawning white bass. White bass spawning habitat selection may occur on a smaller temporal scale than either my electrofishing (every 2-3 days) or acoustic telemetry (weekly) sampling. Acoustic telemetry results indicate that white bass spend the majority of time swimming offshore during the spring and may make short-term movements inshore to spawn and then return immediately offshore. More intensive acoustic telemetry (tracking a small number of white bass continuously over the suspected spawn) may provide the necessary detail to detect spawning movements and habitat selection.

The discovery of restricted spring home ranges in some white bass indicates large variability in movements among fish. No differences in body size or condition were found between the highly mobile group and the sedentary group; differences in age and gender remain untested. Future analysis of spawning habitat selection may be confounded by the presence of spring home ranges without first understanding this underlying variability.

Overall, spawning habitat for walleye seems limited within irrigation reservoirs of the Republican River Basin in southwestern Nebraska. Increases in available spawning

habitat for walleye may be achieved by the addition of rock substrate in the lower portion of the reservoir. No conclusion can be drawn on the relative importance of white bass spawning habitat in these reservoirs.

Appendix 1. Habitat characteristics of sites sampled in Enders Reservoir during March-April 2008. Mean \pm SE values were calculated from five sampling occasions targeting adult walleye.

Site #	UTM N	UTM E	Cover Type	Substrate Type	Maximum Fetch (m)	Northwest Fetch (m)	South Fetch (m)	Mean ± SE				
								Water Temp (°C)	Dissolved Oxygen (mg/L)	Conductivity (µs/cm)	pH	Turbidity (NTU)
0	4478619	282898	Woody	Sand	3016	0	648	9.03 ± 0.13	13.75 ± 0.85	251.80 ± 1.16	8.85 ± 0.06	7.01 ± 0.55
1	4478504	282876	Woody	Sand	2920	0	292	9.26 ± 0.23	13.54 ± 0.67	257.80 ± 3.43	8.88 ± 0.06	7.69 ± 1.09
2	4478332	282734	Woody	Silt	2982	0	101	9.75 ± 0.34	13.82 ± 0.46	271.20 ± 4.53	8.86 ± 0.06	11.86 ± 1.09
3	4478263	282504	Woody	Silt	536	0	207	10.25 ± 0.41	12.27 ± 0.78	291.60 ± 3.56	8.63 ± 0.11	17.96 ± 2.85
4	4478060	282531	Woody	Silt	479	121	0	10.16 ± 0.54	12.74 ± 0.80	293.80 ± 5.94	8.68 ± 0.12	22.06 ± 3.53
5	4478072	282647	Woody	Silt	380	231	0	10.09 ± 0.49	13.37 ± 0.54	290.40 ± 4.04	8.75 ± 0.08	28.09 ± 10.17
7	4477956	282886	Woody	Silt	1125	479	0	9.56 ± 0.48	12.58 ± 0.92	273.60 ± 5.90	8.80 ± 0.06	14.94 ± 1.86
12	4478704	283632	Woody	Silt	1108	521	0	8.58 ± 0.16	13.65 ± 0.83	245.00 ± 1.45	8.92 ± 0.05	8.40 ± 1.15
13	4478747	283673	Woody	Silt	1847	503	0	8.51 ± 0.14	13.51 ± 0.79	243.40 ± 1.12	8.90 ± 0.06	8.24 ± 0.84
14	4478797	283839	Woody	Silt	1991	581	0	8.32 ± 0.17	13.66 ± 0.90	241.80 ± 1.11	8.91 ± 0.06	11.83 ± 2.55
15	4478689	284057	Woody	Silt	1280	0	30	8.13 ± 0.24	13.64 ± 0.92	239.40 ± 1.69	8.91 ± 0.06	10.05 ± 1.94
16	4478827	284114	Woody	Silt	1229	572	0	8.09 ± 0.24	13.75 ± 0.84	239.40 ± 1.63	8.91 ± 0.05	9.53 ± 1.54
17	4479029	284594	Woody	Sand	1757	789	0	7.87 ± 0.22	13.43 ± 0.87	237.80 ± 1.39	8.91 ± 0.06	7.08 ± 0.64
18	4479025	284650	None	Sand	998	780	0	7.74 ± 0.28	13.36 ± 0.89	236.60 ± 1.89	8.90 ± 0.05	6.88 ± 0.94
19	4478713	285053	Submerged	Silt	1269	85	0	7.74 ± 0.25	13.38 ± 0.90	236.40 ± 1.96	8.88 ± 0.05	5.74 ± 0.46
20	4478533	285184	Submerged	Cobble	1477	46	0	7.72 ± 0.23	13.46 ± 0.82	236.40 ± 1.69	8.87 ± 0.06	8.22 ± 1.90
21	4478313	285268	None	Sand	1412	0	162	7.84 ± 0.20	13.58 ± 0.79	237.00 ± 1.38	8.89 ± 0.06	8.27 ± 1.23
22	4478202	285250	None	Sand	1266	0	54	7.98 ± 0.11	13.78 ± 0.86	237.60 ± 0.75	8.90 ± 0.06	7.89 ± 1.11
23	4478097	285139	Woody	Gravel	109	0	23	7.99 ± 0.08	13.74 ± 0.89	236.60 ± 0.51	8.92 ± 0.05	9.87 ± 2.16
24	4478042	285464	None	Sand	1951	0	0	7.59 ± 0.24	13.52 ± 0.83	236.60 ± 1.08	8.87 ± 0.06	7.29 ± 1.03
25	4477986	285483	None	Sand	1780	0	0	7.61 ± 0.25	13.51 ± 0.83	237.00 ± 1.05	8.88 ± 0.05	10.34 ± 1.78
27	4477784	285675	None	Rock	2408	248	0	7.56 ± 0.24	13.46 ± 0.87	236.20 ± 1.16	8.85 ± 0.06	7.34 ± 0.77
28	4477738	285713	None	Rock	2458	0	0	7.52 ± 0.22	13.48 ± 0.88	235.20 ± 1.62	8.84 ± 0.06	7.85 ± 0.81
31	4477457	285808	None	Cobble	771	0	65	7.47 ± 0.20	13.65 ± 0.81	234.60 ± 1.44	8.85 ± 0.07	5.51 ± 0.46

Appendix 1. Continued.

Site #	UTM N	UTM E	Cover Type	Substrate Type	Maximum Fetch (m)	Northwest Fetch (m)	South Fetch (m)	Mean \pm SE				
								Water Temp (°C)	Dissolved Oxygen	Conductivity (μ S/cm)	pH	Turbidity (NTU)
32	4477491	285938	Woody	Sand	2737	107	0	7.34 \pm 0.18	13.39 \pm 0.89	234.80 \pm 0.58	8.84 \pm 0.05	10.64 \pm 3.35
33	4477409	286177	None	Gravel	789	0	0	7.30 \pm 0.18	13.47 \pm 0.94	234.60 \pm 0.68	8.82 \pm 0.06	9.39 \pm 2.52
34	4477565	286346	None	Rock	3167	1313	0	7.39 \pm 0.16	13.43 \pm 0.93	234.40 \pm 0.81	8.83 \pm 0.06	8.37 \pm 2.01
35	4477745	286335	None	Rock	3083	1245	0	7.45 \pm 0.19	13.65 \pm 1.04	234.80 \pm 1.28	8.85 \pm 0.04	8.16 \pm 2.01
37	4477922	286314	Woody	Gravel	2964	1176	0	7.46 \pm 0.22	13.60 \pm 0.89	235.00 \pm 1.14	8.90 \pm 0.02	8.14 \pm 1.77
40	4478441	285851	None	Sand	2318	2110	806	7.60 \pm 0.20	13.65 \pm 0.89	235.40 \pm 1.12	8.84 \pm 0.06	10.63 \pm 1.72
41	4478667	285824	None	Sand	2131	2128	0	7.63 \pm 0.20	13.50 \pm 0.93	235.60 \pm 1.21	8.84 \pm 0.06	13.11 \pm 5.67
42	4478722	285842	None	Cobble	2216	2112	0	7.54 \pm 0.15	13.56 \pm 0.90	214.80 \pm 20.47	8.83 \pm 0.06	8.20 \pm 1.61
43	4478954	285884	Woody	Gravel	2270	2068	0	7.50 \pm 0.12	13.55 \pm 0.86	234.80 \pm 0.49	8.83 \pm 0.06	6.01 \pm 0.50
44	4479010	285897	Woody	Rock	2298	2053	0	7.49 \pm 0.11	13.58 \pm 0.85	234.80 \pm 0.66	8.83 \pm 0.06	6.67 \pm 0.90
46	4479210	285936	Woody	Sand	2840	1671	125	7.40 \pm 0.22	13.70 \pm 0.84	234.20 \pm 1.24	8.84 \pm 0.06	5.74 \pm 0.48
47	4479407	285728	Woody	Rock	2968	0	1668	7.57 \pm 0.25	13.51 \pm 0.81	235.20 \pm 1.43	8.83 \pm 0.06	6.88 \pm 0.72
48	4479514	285592	Woody	Silt	2956	99	1660	7.69 \pm 0.26	13.63 \pm 0.84	229.80 \pm 4.80	8.83 \pm 0.05	7.92 \pm 1.42
49	4479731	285182	Woody	Silt	2898	301	1176	7.84 \pm 0.23	13.70 \pm 0.85	236.80 \pm 1.36	8.85 \pm 0.07	7.19 \pm 0.80
50	4479887	284720	Woody	Silt	3034	0	875	8.23 \pm 0.20	14.11 \pm 1.10	238.20 \pm 1.24	8.90 \pm 0.04	8.19 \pm 1.55
52	4479808	284396	Woody	Silt	3140	0	857	8.27 \pm 0.22	13.87 \pm 0.99	238.80 \pm 1.46	8.88 \pm 0.05	10.41 \pm 2.55
53	4479742	284137	Woody	Silt	3204	0	891	8.36 \pm 0.18	14.46 \pm 0.92	238.20 \pm 0.20	8.94 \pm 0.06	6.67 \pm 1.03
54	4479736	284077	Woody	Silt	3209	0	1064	8.42 \pm 0.18	14.13 \pm 0.94	239.60 \pm 0.98	8.90 \pm 0.06	8.35 \pm 1.97
55	4479490	284002	Woody	Silt	2624	0	697	8.58 \pm 0.24	13.82 \pm 0.89	241.40 \pm 1.29	8.89 \pm 0.05	6.86 \pm 0.71
57	4479384	283955	Woody	Silt	2069	0	584	8.58 \pm 0.23	13.82 \pm 0.90	241.40 \pm 1.40	8.88 \pm 0.06	9.84 \pm 1.55
58	4479317	283796	Woody	Silt	2175	104	516	8.56 \pm 0.22	14.29 \pm 1.12	240.60 \pm 1.36	8.91 \pm 0.05	9.04 \pm 1.73
59	4479351	283749	Woody	Silt	663	68	559	10.41 \pm 1.34	17.57 \pm 4.35	291.40 \pm 46.21	10.59 \pm 1.68	10.85 \pm 1.27
60	4479121	283619	Woody	Silt	2346	0	459	8.78 \pm 0.17	14.02 \pm 0.81	243.00 \pm 0.95	8.91 \pm 0.06	6.07 \pm 0.42

Appendix 1. Continued.

Site #	UTM N	UTM E	Cover Type	Substrate Type	Maximum Fetch (m)	Northwest Fetch (m)	South Fetch (m)	Mean \pm SE				
								Water Temp (°C)	Dissolved Oxygen (mg/L)	Conductivity (μs/cm)	pH	Turbidity (NTU)
61	4479050	283543	Woody	Silt	1076	0	571	8.63 \pm 0.15	13.71 \pm 0.86	240.80 \pm 2.13	8.89 \pm 0.07	7.97 \pm 1.29
62	4479045	283484	Woody	Silt	1070	0	564	8.68 \pm 0.12	13.75 \pm 0.93	243.60 \pm 0.51	8.89 \pm 0.05	6.75 \pm 1.18
64	4478999	283203	Woody	Silt	2768	0	606	8.79 \pm 0.18	13.73 \pm 0.86	243.80 \pm 1.20	8.89 \pm 0.06	9.29 \pm 2.46

Appendix 2. Habitat characteristics of sites sampled in Red Willow reservoir during March-April 2008. Mean \pm SE values were calculated from five sampling occasions targeting adult walleye.

Site #	UTM N	UTM E	Cover Type	Substrate Type	Maximum Fetch (m)	Northwest Fetch (m)	South Fetch (m)	Mean \pm SE				
								Water Temp (°C)	Dissolved Oxygen (mg/L)	Conductivity (μ S/cm)	pH	Turbidity (NTU)
0	4469915	354728	Woody	Cobble	828	247	793	8.95 \pm 0.35	13.62 \pm 0.99	306.40 \pm 2.89	8.86 \pm 0.05	6.82 \pm 0.53
1	4470239	354519	Woody	Silt	227	54	0	9.39 \pm 0.28	14.44 \pm 1.00	306.60 \pm 2.27	8.91 \pm 0.05	10.56 \pm 2.14
2	4470706	353958	Woody	Silt	1430	1118	793	9.18 \pm 0.31	14.10 \pm 0.80	313.20 \pm 2.48	8.91 \pm 0.06	10.80 \pm 0.98
3	4471050	353756	Woody	Silt	1730	0	851	9.60 \pm 0.33	14.53 \pm 1.17	317.00 \pm 3.16	8.95 \pm 0.05	11.76 \pm 1.65
4	4471056	353700	Woody	Silt	1795	0	799	9.63 \pm 0.33	14.45 \pm 1.18	317.60 \pm 3.43	8.95 \pm 0.05	10.46 \pm 1.18
10	4470748	353594	Woody	Silt	658	0	0	9.24 \pm 0.28	14.50 \pm 1.15	314.80 \pm 2.03	8.94 \pm 0.04	10.05 \pm 1.64
11	4469698	354057	Woody	Silt	4459	0	0	8.74 \pm 0.20	13.77 \pm 0.98	308.60 \pm 2.11	8.89 \pm 0.05	9.96 \pm 1.40
12	4469574	354246	Woody	Silt	4193	284	0	8.67 \pm 0.22	13.70 \pm 1.01	307.00 \pm 1.70	8.87 \pm 0.05	8.74 \pm 1.58
13	4469421	354320	Woody	Silt	4174	72	0	8.61 \pm 0.23	13.69 \pm 1.17	305.80 \pm 1.83	8.87 \pm 0.05	7.45 \pm 1.20
15	4469028	354421	Woody	Silt	1166	0	78	9.30 \pm 0.31	14.21 \pm 0.82	306.20 \pm 2.63	8.93 \pm 0.05	8.12 \pm 1.20
16	4468921	354451	Woody	Silt	1171	0	0	9.28 \pm 0.33	14.55 \pm 0.66	305.60 \pm 2.82	8.95 \pm 0.04	6.37 \pm 1.30
17	4468958	354470	Woody	Silt	144	66	0	9.32 \pm 0.31	14.99 \pm 0.96	305.80 \pm 2.75	8.94 \pm 0.05	6.71 \pm 1.51
18	4469059	354499	Woody	Silt	721	56	0	9.25 \pm 0.29	14.66 \pm 1.00	306.20 \pm 2.33	8.85 \pm 0.07	6.81 \pm 0.93
19	4469129	354989	Woody	Silt	2141	1949	0	8.52 \pm 0.30	13.67 \pm 0.92	303.00 \pm 2.49	8.26 \pm 0.66	7.01 \pm 1.53
20	4469141	355101	Woody	Silt	2101	1485	0	8.55 \pm 0.29	10.10 \pm 2.53	303.20 \pm 2.31	8.86 \pm 0.06	8.98 \pm 1.21
21	4469044	355599	Woody	Silt	2968	1850	0	8.39 \pm 0.31	13.43 \pm 0.90	301.20 \pm 2.48	8.84 \pm 0.02	7.31 \pm 1.47
22	4468661	355622	Woody	Silt	1013	0	95	8.74 \pm 0.31	13.57 \pm 1.04	301.60 \pm 2.25	8.81 \pm 0.04	7.25 \pm 0.91
23	4468199	355624	Woody	Silt	231	60	99	8.80 \pm 0.39	14.74 \pm 1.10	299.80 \pm 3.12	8.82 \pm 0.06	6.86 \pm 1.30
24	4468644	356457	Woody	Silt	1520	1520	0	8.09 \pm 0.28	13.31 \pm 1.06	297.60 \pm 2.54	8.76 \pm 0.04	5.11 \pm 0.54
25	4468609	356530	Woody	Silt	1598	1598	259	8.11 \pm 0.36	13.21 \pm 1.05	297.20 \pm 2.73	8.77 \pm 0.04	4.33 \pm 0.73
26	4468678	356838	Woody	Silt	1888	1355	0	7.96 \pm 0.27	13.06 \pm 1.02	236.86 \pm 58.41	8.75 \pm 0.05	3.84 \pm 0.53
27	4468645	356949	Woody	Silt	1864	1860	0	7.94 \pm 0.25	13.02 \pm 1.01	296.60 \pm 2.04	8.72 \pm 0.05	4.46 \pm 0.97
29	4468491	357118	Woody	Silt	1809	999	0	7.83 \pm 0.23	13.10 \pm 1.08	295.60 \pm 1.86	8.74 \pm 0.04	5.42 \pm 1.50

Appendix 2. Continued.

Site #	UTM N	UTM E	Cover Type	Substrate Type	Maximum Fetch (m)	Northwest Fetch (m)	South Fetch (m)	Mean \pm SE				
								Water Temp (°C)	Dissolved Oxygen (mg/L)	Conductivity (µs/cm)	pH	Turbidity (NTU)
30	4468056	357346	Woody	Cobble	223	205	41	8.00 \pm 0.40	13.01 \pm 0.99	296.80 \pm 3.20	8.73 \pm 0.05	4.41 \pm 0.56
31	4468224	357310	Woody	Cobble	1164	109	0	7.97 \pm 0.34	12.93 \pm 0.98	296.60 \pm 2.69	8.72 \pm 0.04	4.19 \pm 0.61
32	4468471	357378	None	Rock	2424	2424	0	7.87 \pm 0.29	12.90 \pm 1.01	296.20 \pm 2.42	8.71 \pm 0.04	5.04 \pm 1.40
34	4468489	357944	None	Rock	2927	2927	0	7.78 \pm 0.24	12.79 \pm 1.01	295.00 \pm 2.10	8.70 \pm 0.04	4.01 \pm 0.57
35	4468594	358164	None	Rock	4324	1971	0	7.83 \pm 0.29	12.93 \pm 1.10	295.60 \pm 2.42	8.73 \pm 0.04	5.82 \pm 0.75
37	4469140	358575	Submerged	Rock	3003	1213	105	7.95 \pm 0.42	13.04 \pm 0.91	296.00 \pm 3.03	8.74 \pm 0.06	7.30 \pm 2.42
38	4469194	358550	Woody	Cobble	2803	1175	176	7.94 \pm 0.41	13.14 \pm 0.87	296.20 \pm 2.96	8.74 \pm 0.05	2.95 \pm 0.17
39	4469561	358601	Woody	Silt	1557	0	56	8.53 \pm 0.36	13.22 \pm 1.09	247.00 \pm 54.57	8.76 \pm 0.04	4.47 \pm 0.45
40	4469792	358784	Woody	Silt	51	27	0	8.88 \pm 0.55	13.79 \pm 1.05	301.60 \pm 4.32	8.80 \pm 0.05	5.26 \pm 1.67
42	4470343	358142	Woody	Silt	1957	501	727	8.46 \pm 0.38	13.19 \pm 1.02	298.40 \pm 2.77	8.78 \pm 0.05	8.22 \pm 2.28
43	4472013	357752	Woody	Silt	1227	1202	488	9.33 \pm 0.46	14.76 \pm 1.46	301.20 \pm 2.82	8.89 \pm 0.06	6.23 \pm 1.60
44	4472105	357679	Woody	Silt	1459	419	1242	9.42 \pm 0.46	14.32 \pm 1.27	301.80 \pm 3.06	8.92 \pm 0.04	5.06 \pm 1.06
45	4472130	357585	Woody	Silt	1583	302	661	9.55 \pm 0.42	14.06 \pm 0.70	302.80 \pm 2.65	8.92 \pm 0.04	7.20 \pm 0.90
47	4471993	357440	Woody	Silt	526	0	0	9.29 \pm 0.38	14.51 \pm 1.10	300.60 \pm 2.66	8.93 \pm 0.05	6.93 \pm 1.19
48	4471336	357465	Woody	Silt	1704	56	0	8.64 \pm 0.36	13.60 \pm 1.01	298.60 \pm 2.79	8.82 \pm 0.04	5.82 \pm 0.50
49	4471298	357463	Woody	Silt	794	0	57	8.70 \pm 0.36	13.72 \pm 0.98	298.60 \pm 2.54	8.85 \pm 0.05	5.78 \pm 0.99
50	4471185	357460	Woody	Silt	1161	0	0	8.63 \pm 0.33	13.64 \pm 1.05	298.60 \pm 2.54	8.82 \pm 0.05	5.48 \pm 1.30
52	4470393	357545	Woody	Silt	68	0	31	8.69 \pm 0.40	13.15 \pm 0.88	299.20 \pm 3.28	8.74 \pm 0.06	12.03 \pm 4.76
53	4470322	357594	Woody	Silt	118	118	0	8.66 \pm 0.26	13.54 \pm 0.94	299.00 \pm 2.21	8.77 \pm 0.04	7.83 \pm 2.21
54	4470249	357736	Woody	Silt	820	0	0	8.22 \pm 0.29	13.04 \pm 0.87	297.20 \pm 2.22	8.65 \pm 0.08	4.00 \pm 0.67
55	4470075	357612	Woody	Silt	693	0	30	8.56 \pm 0.34	13.33 \pm 0.89	299.00 \pm 2.57	8.78 \pm 0.04	6.96 \pm 2.05
56	4470037	357719	Woody	Silt	782	80	0	8.30 \pm 0.23	13.27 \pm 0.95	297.40 \pm 1.86	8.76 \pm 0.05	6.71 \pm 1.44

Appendix 2. Continued.

Site #	UTM N	UTM E	Cover Type	Substrate Type	Maximum Fetch (m)	Northwest Fetch (m)	South Fetch (m)	Mean \pm SE				
								Water Temp (°C)	Dissolved Oxygen (mg/L)	Conductivity (µs/cm)	pH	Turbidity (NTU)
58	4469123	357775	Woody	Silt	2017	0	645	7.93 \pm 0.28	13.09 \pm 0.99	295.60 \pm 2.09	8.74 \pm 0.05	4.51 \pm 0.73
59	4469293	357277	Woody	Silt	1984	0	1197	8.12 \pm 0.35	12.99 \pm 0.84	297.40 \pm 2.87	8.72 \pm 0.04	4.57 \pm 1.01
61	4469426	356349	Woody	Silt	2060	55	0	8.41 \pm 0.32	13.14 \pm 0.86	300.20 \pm 2.71	8.76 \pm 0.05	6.78 \pm 1.19
63	4469624	354957	Woody	Silt	1068	358	478	8.63 \pm 0.26	13.09 \pm 0.86	303.80 \pm 2.01	8.81 \pm 0.04	5.30 \pm 0.78
64	4469860	354770	Woody	Silt	789	320	726	8.89 \pm 0.32	13.52 \pm 0.90	306.00 \pm 2.83	8.83 \pm 0.04	6.58 \pm 1.68

Appendix 3. Habitat characteristics of sites sampled in Enders Reservoir during April 2008. Mean \pm SE values were calculated from four sampling occasions targeting larval walleye.

Site #	UTM N	UTM E	Cover Type	Substrate Type	Maximum Fetch (m)	Northwest Fetch (m)	South Fetch (m)	Mean \pm SE				
								Water Temp (°C)	Dissolved Oxygen (mg/L)	Conductivity (μ S/cm)	pH	Turbidity (NTU)
0	4478619	282898	Woody	Sand	3016	0	648	11.45 \pm 1.42	11.57 \pm 0.87	268.25 \pm 8.72	8.97 \pm 0.06	6.32 \pm 1.06
1	4478504	282876	Woody	Sand	2920	0	292	11.66 \pm 1.54	10.84 \pm 0.57	270.50 \pm 9.35	8.98 \pm 0.05	8.50 \pm 0.71
3	4478263	282504	Woody	Silt	536	0	207	12.41 \pm 2.22	11.46 \pm 0.80	287.75 \pm 14.11	9.08 \pm 0.04	12.29 \pm 2.48
12	4478704	283632	Woody	Silt	1108	521	0	10.96 \pm 1.18	10.84 \pm 0.45	261.25 \pm 8.38	8.91 \pm 0.02	5.31 \pm 1.19
14	4478797	283839	Woody	Silt	1991	581	0	10.93 \pm 1.18	10.87 \pm 0.41	261.00 \pm 8.50	8.93 \pm 0.02	4.26 \pm 0.54
16	4478827	284114	Woody	Silt	1229	572	0	10.87 \pm 1.10	10.65 \pm 0.43	259.75 \pm 7.79	8.93 \pm 0.02	6.57 \pm 1.84
17	4479029	284594	Woody	Sand	1757	789	0	10.67 \pm 1.14	9.97 \pm 0.70	258.50 \pm 8.03	8.81 \pm 0.07	4.75 \pm 0.66
18	4479025	284650	None	Sand	998	780	0	10.60 \pm 1.16	10.56 \pm 0.37	258.25 \pm 8.53	8.80 \pm 0.08	4.87 \pm 0.93
19	4478713	285053	Emergent	Silt	1269	85	0	10.37 \pm 1.08	10.67 \pm 0.31	256.25 \pm 7.87	8.77 \pm 0.08	4.40 \pm 0.90
22	4478202	285250	None	Sand	1266	0	54	10.72 \pm 0.97	10.42 \pm 0.34	259.25 \pm 7.13	8.87 \pm 0.03	4.59 \pm 0.35
24	4478042	285464	None	Sand	1951	0	0	10.42 \pm 0.96	10.60 \pm 0.38	257.25 \pm 7.10	8.86 \pm 0.03	5.09 \pm 1.25
25	4477986	285483	None	Sand	1780	0	0	10.43 \pm 0.91	10.54 \pm 0.36	257.50 \pm 6.85	8.87 \pm 0.02	3.50 \pm 0.45
31	4477457	285808	None	Cobble	771	0	65	10.49 \pm 0.89	10.47 \pm 0.26	257.75 \pm 6.98	8.86 \pm 0.02	4.34 \pm 0.86
34	4477565	286346	None	Rock	3167	1313	0	10.36 \pm 0.87	10.50 \pm 0.40	256.75 \pm 6.66	8.86 \pm 0.04	4.42 \pm 0.63
37	4477922	286314	None	Sand	2964	1176	0	10.15 \pm 0.87	10.52 \pm 0.43	255.50 \pm 6.59	8.86 \pm 0.04	4.35 \pm 0.66
42	4478722	285842	None	Cobble	2216	2112	0	10.17 \pm 1.02	10.72 \pm 0.37	255.50 \pm 7.64	8.87 \pm 0.04	4.67 \pm 0.95
43	4478954	285884	Woody	Gravel	2270	2068	0	10.14 \pm 1.13	10.60 \pm 0.41	255.25 \pm 8.26	8.85 \pm 0.03	6.17 \pm 1.22
47	4479407	285728	Woody	Rock	2968	0	1668	10.03 \pm 1.27	10.31 \pm 0.30	255.25 \pm 8.77	8.79 \pm 0.07	5.04 \pm 1.12
49	4479731	285182	Woody	Silt	2898	301	1176	10.27 \pm 1.34	10.30 \pm 0.39	256.50 \pm 10.66	8.83 \pm 0.06	5.31 \pm 1.15
50	4479887	284720	Woody	Silt	3034	0	875	11.27 \pm 1.75	11.03 \pm 0.58	259.00 \pm 11.16	8.98 \pm 0.07	5.06 \pm 1.36
53	4479742	284137	Woody	Silt	3204	0	891	11.36 \pm 1.54	11.40 \pm 0.71	260.50 \pm 10.81	9.00 \pm 0.06	5.92 \pm 1.31
58	4479317	283796	Woody	Silt	2175	104	516	11.32 \pm 1.49	11.50 \pm 0.67	261.25 \pm 9.50	8.96 \pm 0.06	4.49 \pm 0.80
60	4479121	283619	Woody	Silt	2346	0	459	11.36 \pm 1.50	11.18 \pm 0.76	261.25 \pm 9.98	8.99 \pm 0.06	3.43 \pm 0.60
62	4479045	283484	Woody	Silt	1070	0	564	10.85 \pm 1.36	10.80 \pm 0.42	260.00 \pm 8.90	8.93 \pm 0.03	6.82 \pm 1.34
64	4478999	283203	Woody	Silt	2768	0	606	11.45 \pm 1.87	11.26 \pm 0.67	256.50 \pm 7.19	8.95 \pm 0.06	5.24 \pm 1.01

Appendix 4. Habitat characteristics of sites sampled in Red Willow Reservoir during May 2008. Mean \pm SE values were calculated from four sampling occasions targeting adult white bass.

Site #	UTM N	UTM E	Cover Type	Substrate Type	Maximum Fetch (m)	Northwest Fetch (m)	South Fetch (m)	Mean \pm SE				
								Water Temp (°C)	Dissolved Oxygen (mg/L)	Conductivity (µs/cm)	pH	Turbidity (NTU)
0	4469915	354728	Woody	Cobble	828	247	793	13.36 \pm 1.44	11.97 \pm 1.12	345.67 \pm 11.68	8.94 \pm 0.06	7.90 \pm 0.84
1	4470239	354519	Woody	Silt	227	54	0	13.66 \pm 1.80	12.79 \pm 1.32	345.00 \pm 16.04	8.91 \pm 0.06	7.22 \pm 0.54
2	4470706	353958	Woody	Silt	1430	1118	793	13.20 \pm 1.41	13.36 \pm 1.27	349.33 \pm 10.04	9.09 \pm 0.03	11.32 \pm 0.55
3	4471050	353756	Woody	Silt	1730	0	851	13.02 \pm 1.36	13.51 \pm 1.41	348.33 \pm 10.59	9.05 \pm 0.08	11.01 \pm 1.61
4	4471056	353700	Woody	Silt	1795	0	799	13.10 \pm 1.50	14.10 \pm 1.83	348.67 \pm 11.46	9.09 \pm 0.06	12.72 \pm 2.52
10	4470748	353594	Woody	Silt	658	0	0	13.13 \pm 1.24	12.99 \pm 2.13	347.00 \pm 9.50	9.13 \pm 0.09	10.88 \pm 0.82
11	4469698	354057	Woody	Silt	4459	0	0	13.26 \pm 1.08	12.84 \pm 1.32	348.67 \pm 8.41	9.05 \pm 0.11	10.45 \pm 0.80
12	4469574	354246	Woody	Silt	4193	284	0	13.13 \pm 1.01	13.44 \pm 2.00	345.33 \pm 7.13	9.14 \pm 0.05	7.32 \pm 1.20
13	4469421	354320	Woody	Silt	4174	72	0	13.08 \pm 1.01	13.41 \pm 2.12	344.33 \pm 5.90	9.00 \pm 0.07	12.46 \pm 1.28
15	4469028	354421	Woody	Silt	1166	0	78	13.46 \pm 0.99	12.28 \pm 1.63	345.33 \pm 7.54	8.94 \pm 0.04	9.41 \pm 1.57
16	4468921	354451	Woody	Silt	1171	0	0	13.61 \pm 0.99	12.26 \pm 1.24	345.33 \pm 7.54	8.93 \pm 0.07	10.40 \pm 1.53
17	4468958	354470	Woody	Silt	144	66	0	13.57 \pm 1.02	11.99 \pm 1.29	346.00 \pm 7.77	8.90 \pm 0.08	15.53 \pm 2.49
18	4469059	354499	Woody	Silt	721	56	0	13.40 \pm 1.02	11.79 \pm 1.26	346.00 \pm 7.77	8.91 \pm 0.06	11.88 \pm 1.85
19	4469129	354989	Woody	Silt	2141	1949	0	13.14 \pm 0.87	11.68 \pm 0.92	344.67 \pm 5.78	8.94 \pm 0.08	7.38 \pm 0.72
20	4469141	355101	Woody	Silt	2101	1485	0	12.96 \pm 0.89	11.35 \pm 1.19	344.33 \pm 6.98	8.80 \pm 0.09	7.02 \pm 1.66
21	4469044	355599	Woody	Silt	2968	1850	0	12.95 \pm 0.87	11.57 \pm 0.99	342.67 \pm 5.78	8.89 \pm 0.08	6.37 \pm 1.64
22	4468661	355622	Woody	Silt	1013	0	95	13.21 \pm 0.87	11.97 \pm 1.05	342.67 \pm 6.33	8.92 \pm 0.08	6.61 \pm 2.13
23	4468199	355624	Woody	Silt	231	60	99	13.26 \pm 0.90	11.85 \pm 1.18	342.67 \pm 7.06	8.89 \pm 0.07	7.51 \pm 0.75
24	4468644	356457	Woody	Silt	1520	1520	0	13.09 \pm 0.68	11.72 \pm 1.07	343.33 \pm 4.48	8.89 \pm 0.08	8.36 \pm 2.92
25	4468609	356530	Woody	Silt	1598	1598	259	13.31 \pm 0.65	11.81 \pm 1.07	345.33 \pm 4.06	8.89 \pm 0.08	5.00 \pm 0.73
26	4468678	356838	Woody	Silt	1888	1355	0	13.01 \pm 0.71	11.52 \pm 1.04	343.00 \pm 4.73	8.87 \pm 0.08	4.02 \pm 1.44
27	4468645	356949	Woody	Silt	1864	1860	0	13.02 \pm 0.70	11.40 \pm 0.97	343.00 \pm 4.73	8.86 \pm 0.08	4.37 \pm 1.27
29	4468491	357118	Woody	Silt	1809	999	0	12.92 \pm 0.73	11.40 \pm 0.95	341.67 \pm 4.81	8.86 \pm 0.07	4.10 \pm 0.57
30	4468056	357346	Woody	Cobble	223	205	41	13.61 \pm 0.72	11.80 \pm 1.04	346.33 \pm 4.70	8.89 \pm 0.06	7.16 \pm 2.14

Appendix 4. Continued.

Site #	UTM N	UTM E	Cover Type	Substrate Type	Maximum Fetch (m)	Northwest Fetch (m)	South Fetch (m)	Mean \pm SE				
								Water Temp (°C)	Dissolved Oxygen (mg/L)	Conductivity (µs/cm)	pH	Turbidity (NTU)
31	4468224	357310	Woody	Cobble	1164	109	0	13.41 \pm 0.64	11.74 \pm 1.13	345.33 \pm 4.18	8.88 \pm 0.07	4.16 \pm 1.30
32	4468471	357378	None	Rock	2424	2424	0	13.02 \pm 0.65	11.42 \pm 0.94	343.00 \pm 4.36	8.88 \pm 0.06	2.74 \pm 0.72
34	4468489	357944	None	Rock	2927	2927	0	13.02 \pm 0.63	11.39 \pm 1.03	342.67 \pm 4.06	8.87 \pm 0.05	3.67 \pm 0.61
35	4468594	358164	None	Rock	4324	1971	0	13.01 \pm 0.62	11.09 \pm 0.92	343.00 \pm 3.79	8.82 \pm 0.08	2.71 \pm 1.37
37	4469140	358575	Emergent	Rock	3003	1213	105	13.02 \pm 0.55	11.39 \pm 0.99	342.33 \pm 3.84	8.85 \pm 0.06	3.27 \pm 1.33
38	4469194	358550	Woody	Cobble	2803	1175	176	13.05 \pm 0.59	11.47 \pm 1.06	342.33 \pm 4.26	8.84 \pm 0.07	3.62 \pm 1.04
39	4469561	358601	Woody	Silt	1557	0	56	13.35 \pm 0.64	11.58 \pm 0.96	344.33 \pm 4.67	8.87 \pm 0.07	6.12 \pm 2.87
40	4469792	358784	Woody	Silt	51	27	0	13.40 \pm 0.60	12.50 \pm 1.08	341.33 \pm 3.84	8.92 \pm 0.08	3.05 \pm 1.26
42	4470343	358142	Woody	Silt	1957	501	727	13.30 \pm 0.34	11.97 \pm 1.30	357.00 \pm 13.65	8.83 \pm 0.08	6.20 \pm 2.69
43	4472013	357752	Woody	Silt	1227	1202	488	13.19 \pm 0.68	12.07 \pm 1.21	340.33 \pm 5.61	8.82 \pm 0.07	6.43 \pm 0.96
44	4472105	357679	Woody	Silt	1459	419	1242	13.02 \pm 0.97	12.71 \pm 1.72	336.33 \pm 8.67	8.81 \pm 0.06	6.67 \pm 0.13
45	4472130	357585	Woody	Silt	1583	302	661	13.24 \pm 0.88	12.54 \pm 2.04	337.00 \pm 8.39	8.92 \pm 0.02	9.12 \pm 2.40
47	4471993	357440	Woody	Silt	526	0	0	13.09 \pm 0.77	12.22 \pm 1.28	336.33 \pm 7.69	8.89 \pm 0.08	7.46 \pm 1.25
48	4471336	357465	Woody	Silt	1704	56	0	13.00 \pm 0.84	12.72 \pm 1.94	337.00 \pm 7.57	8.90 \pm 0.05	4.29 \pm 0.08
49	4471298	357463	Woody	Silt	794	0	57	12.93 \pm 0.88	12.11 \pm 1.28	337.00 \pm 7.21	8.95 \pm 0.02	10.32 \pm 1.61
50	4471185	357460	Woody	Silt	1161	0	0	12.87 \pm 0.82	11.96 \pm 1.19	337.33 \pm 6.17	8.88 \pm 0.07	7.22 \pm 4.29
52	4470393	357545	Woody	Silt	68	0	31	12.95 \pm 0.76	12.01 \pm 1.23	337.00 \pm 7.00	8.75 \pm 0.10	4.76 \pm 0.57
53	4470322	357594	Woody	Silt	118	118	0	12.85 \pm 0.81	11.98 \pm 1.18	337.67 \pm 6.69	8.84 \pm 0.06	4.92 \pm 1.62
54	4470249	357736	Woody	Silt	820	0	0	12.92 \pm 0.74	11.78 \pm 1.15	339.67 \pm 5.49	8.84 \pm 0.07	2.75 \pm 1.45
55	4470075	357612	Woody	Silt	693	0	30	12.75 \pm 0.79	12.12 \pm 1.38	337.33 \pm 6.39	8.89 \pm 0.03	6.66 \pm 1.90
56	4470037	357719	Woody	Silt	782	80	0	12.79 \pm 0.74	11.90 \pm 1.24	338.00 \pm 5.86	8.86 \pm 0.07	3.90 \pm 1.58
58	4469123	357775	Woody	Silt	2017	0	645	13.59 \pm 1.07	11.23 \pm 1.34	346.67 \pm 7.69	8.84 \pm 0.05	5.86 \pm 1.55
59	4469293	357277	Woody	Silt	1984	0	1197	13.12 \pm 0.84	11.79 \pm 1.43	342.33 \pm 6.17	8.86 \pm 0.04	3.10 \pm 0.57

Appendix 4. Continued.

Site #	UTM N	UTM E	Cover Type	Substrate Type	Maximum Fetch (m)	Northwest Fetch (m)	South Fetch (m)	Mean \pm SE				
								Water Temp (°C)	Dissolved Oxygen (mg/L)	Conductivity (μ S/cm)	pH	Turbidity (NTU)
61	4469426	356349	Woody	Silt	2060	55	0	13.01 \pm 0.81	11.58 \pm 1.10	342.67 \pm 5.70	8.94 \pm 0.02	7.01 \pm 2.56
63	4469624	354957	Woody	Silt	1068	358	478	13.10 \pm 1.13	12.01 \pm 1.16	344.33 \pm 8.88	8.94 \pm 0.05	7.21 \pm 0.29
64	4469860	354770	Woody	Silt	789	320	726	13.09 \pm 1.25	12.13 \pm 1.14	343.67 \pm 9.68	8.92 \pm 0.06	5.26 \pm 0.26

Appendix 5. Habitat characteristics of telemetry locations of tagged walleye in Enders Reservoir during 2007-2008. * indicates missing data.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/22/07	45	4:25	285557	4478365	>5	*	N	8.90	*	241.00	*	*
03/22/07	46	5:30	286168	4477728	>5	*	N	8.60	*	250.40	*	*
03/22/07	57	5:38	286212	4477581	>5	*	N	8.10	*	241.00	*	*
03/22/07	50	5:58	286313	4477581	>5	*	N	8.40	*	251.00	*	*
03/22/07	63	6:40	285674	4478247	>5	*	N	8.50	*	249.50	*	*
03/22/07	61	7:59	285445	4478783	>5	*	N	8.50	*	252.30	*	*
03/22/07	43	8:29	284900	4479129	*	*	N	8.90	*	253.40	*	*
03/22/07	60	10:45	284901	4479619	3	Sand	N	8.90	*	252.80	*	*
03/22/07	65	10:57	285296	4479506	3.7	Sand	N	8.60	*	252.00	*	*
03/22/07	62	11:15	285442	4479480	1	Sand	N	8.60	*	251.60	*	*
03/22/07	52	12:04	286321	4477625	>5	*	N	8.80	*	249.70	*	*
03/22/07	50	12:06	286319	4477477	>5	*	N	8.70	*	252.10	*	*
03/22/07	46	12:09	286293	4477459	>5	*	N	8.60	*	253.50	*	*
03/22/07	57	12:22	285596	4477854	1	Cobble	N	8.90	*	253.70	*	*
03/22/07	63	12:41	285774	4477911	>5	*	N	8.90	*	254.70	*	*
03/22/07	61	13:03	285226	4479039	>5	*	N	9.10	*	255.80	*	*
03/22/07	69	13:30	284274	4479233	3	Sand	N	9.60	*	259.10	*	*
03/22/07	54	13:30	284274	4479233	3	Sand	N	9.60	*	259.10	*	*
03/22/07	43	14:46	284708	4479631	2.4	Sand	N	9.20	*	257.10	*	*
03/22/07	65	14:58	285468	4479430	2.4	Sand	N	9.00	*	255.60	*	*
03/22/07	45	15:13	285579	4479351	4.6	Sand	N	9.10	*	257.00	*	*
03/23/07	50	15:45	286315	4477626	5	Rock	N	9.80	*	257.00	*	*
03/23/07	57	15:52	286322	4477580	5	Rock	N	9.70	*	257.20	*	*
03/23/07	63	16:15	285724	4477947	>5	*	N	9.90	*	257.90	*	*
03/23/07	54	16:55	284219	4479402	3	Sand	N	11.40	*	270.60	*	*
03/23/07	60	18:05	285506	4479374	4.3	Sand	N	10.10	*	260.00	*	*

Appendix 5. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/23/07	59	18:30	285394	4479512	2.5	Sand	N	10.40	*	261.60	*	*
03/23/07	61	19:01	285550	4478879	>5	*	N	10.20	*	261.10	*	*
03/23/07	62	19:09	285550	4478879	>5	*	N	10.20	*	261.11	*	*
03/23/07	46	19:35	286299	4477881	4	Rock	N	9.50	*	258.30	*	*
03/23/07	57	19:49	286313	4477802	4	Rock	N	9.30	*	253.50	*	*
03/23/07	50	20:04	286312	4477641	5	Rock	N	8.90	*	251.60	*	*
03/23/07	63	20:24	285767	4477816	>5	*	N	9.20	*	255.20	*	*
03/23/07	43	20:56	284572	4479075	3	Silt	N	10.20	*	263.30	*	*
03/23/07	54	22:30	284907	4479366	4	Sand	N	10.30	*	261.60	*	*
03/29/07	61	4:05	285671	4479225	>5	*	N	11.98	*	267.00	8.86	11.20
03/29/07	54	4:25	285801	4478377	>5	*	N	11.34	*	264.00	8.72	9.18
03/29/07	69	5:18	286315	4477868	1.5	Rock	N	10.97	*	261.00	8.70	7.27
03/29/07	63	5:27	285907	4477718	>5	*	N	11.12	*	263.00	8.71	7.11
03/29/07	43	6:15	283800	4478966	4	Silt	N	13.16	*	277.00	8.74	15.50
03/29/07	60	6:54	284917	4479551	3	Sand	N	11.69	*	265.00	8.76	13.00
03/29/07	63	8:12	285696	4478384	>5	*	N	11.59	*	266.00	8.73	12.80
03/29/07	69	8:23	286249	4477915	>5	*	N	10.97	*	261.00	8.71	11.40
03/29/07	46	8:31	286276	4477858	>5	*	N	10.98	*	262.00	8.71	8.62
03/29/07	54	8:49	286297	4477718	>5	*	N	11.03	*	262.00	8.71	10.08
03/29/07	52	9:05	286322	4477550	4.5	Rock	N	10.94	*	262.00	8.71	7.54
03/29/07	43	9:55	283869	4479231	1.5	*	N	12.29	*	270.00	8.72	18.90
03/29/07	63	12:05	286233	4477781	>5	*	N	11.06	*	262.00	8.75	7.53
03/29/07	52	12:20	286289	4477787	>5	Rock	N	11.14	*	262.00	8.73	*
03/29/07	69	13:04	286281	4477928	>5	*	N	11.29	*	263.00	8.78	8.66
03/29/07	54	13:04	286281	4477928	>5	*	N	11.29	*	263.00	8.78	8.66
03/29/07	61	13:55	285049	4479033	>5	*	N	12.13	*	269.00	8.75	11.70

Appendix 5. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/29/07	65	14:20	284530	4479650	3	Sand	N	11.92	*	267.00	8.78	10.74
03/29/07	59	14:40	284739	4479699	1.5	Sand	N	12.08	*	268.00	8.76	11.50
04/02/07	63	6:20	286197	4477551	>5	*	N	11.36	*	265.00	8.68	19.50
04/02/07	62	6:29	286233	4477497	>5	*	N	11.34	*	265.00	8.73	9.75
04/08/07	63	5:45	285981	4477665	>5	*	N	9.11	*	253.00	8.67	11.70
04/08/07	62	20:10	286242	4478008	3	Gravel	N	9.26	*	254.00	8.75	13.60
04/08/07	54	20:17	286041	4478198	2	Sand	N	9.34	*	254.00	8.70	13.20
04/08/07	57	20:36	286213	4477449	>4	*	N	9.23	*	253.00	8.71	14.00
04/08/07	63	20:55	285715	4477964	>4	*	N	9.18	*	253.00	8.73	10.45
04/08/07	45	21:05	285214	4478936	>4	*	N	9.00	*	251.00	8.75	10.18
04/08/07	61	21:42	285139	4479409	>4	*	N	8.48	*	249.00	8.75	7.56
04/08/07	69	21:59	284652	4479479	>4	*	N	8.36	*	246.00	8.76	8.83
04/08/07	43	22:06	284483	4479440	>4	*	N	8.60	*	249.00	8.71	16.00
04/17/07	43	0:04	284423	4479317	3.5	Silt	N	11.32	*	269.00	9.03	4.16
04/17/07	69	1:03	285747	4478877	5.5	*	N	10.58	*	264.00	9.25	2.85
04/17/07	62	2:35	286305	4477903	0.5	Sand	N	10.54	*	263.00	9.12	3.09
04/17/07	63	4:15	286187	4477648	>8	*	N	10.58	*	263.00	9.24	10.68
04/17/07	69	4:35	285460	4478438	3.5	Silt	N	10.53	*	263.00	8.95	7.08
04/17/07	62	19:15	286295	4477919	1.5	Sand	N	10.42	*	263.00	8.95	6.42
04/17/07	63	19:47	285989	4477913	8	*	N	11.00	*	266.00	8.83	5.72
04/17/07	54	22:15	284411	4479586	1.5	Silt	N	11.15	*	268.00	9.16	4.64
04/17/07	61	22:35	284560	4479711	1.5	Silt	N	10.66	*	264.00	8.81	3.18
04/28/07	43	20:30	285767	4478543	>4	*	N	16.66	*	310.00	10.73	6.45
04/28/07	54	20:42	284567	4479280	>4	Silt	N	15.51	*	304.00	11.36	6.13
04/28/07	61	21:24	284106	4478939	3	Silt	N	15.55	*	304.00	11.67	4.46
05/09/07	69	0:12	284643	4479526	4.4	*	N	18.77	*	326.00	14.03	7.09

Appendix 5. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
05/09/07	60	1:14	285315	4479532	3.6	Silt	N	18.24	*	321.00	13.65	6.61
05/09/07	57	1:35	285068	4478800	1.5	Silt	N	17.76	*	318.00	13.29	5.72
05/24/07	65	17:04	285806	4477732	6	Silt	N	19.84	*	338.00	10.01	12.40
05/24/07	69	17:14	386174	4477950	6	Silt	N	20.58	*	345.00	9.64	11.80
05/24/07	61	17:25	285742	4478572	5	Silt	N	20.54	*	344.00	10.11	11.10
05/24/07	54	18:02	284460	4479038	3	Silt	N	19.60	*	337.00	10.20	19.70
11/18/07	174	18:02	285565	4479412	4.6	Silt	None	8.88	12.57	230.00	7.03	9.08
11/18/07	159	18:12	285610	4479296	7.7	Silt	None	8.62	8.02	228.00	7.03	7.91
11/18/07	172	19:12	285830	4478430	5	Silt	None	8.57	11.02	227.00	8.75	8.60
11/18/07	131	19:17	285779	4478499	*	Silt	None	8.55	11.02	227.00	8.65	8.61
11/18/07	156	19:46	286294	4477961	1.7	Gravel	None	8.87	11.35	229.00	8.74	8.64
11/18/07	160	19:48	286294	4477961	1.7	Gravel	Woody	8.87	11.35	229.00	8.74	8.64
11/18/07	121	20:01	286317	4477768	3.1	Rock	None	8.95	11.67	229.00	8.69	6.90
11/18/07	173	20:17	286317	4477453	8.9	Silt	None	9.05	11.38	230.00	8.74	6.25
11/18/07	182	20:45	284801	4479057	*	Silt	None	8.47	11.41	228.00	8.58	7.67
11/18/07	69	21:16	284084	4479400	4.1	Silt	None	8.27	11.12	227.00	8.69	8.17
11/18/07	61	21:24	284573	4479634	*	Silt	None	8.35	11.29	227.00	8.72	8.82
11/18/07	43	21:30	285135	4479741	2	Silt	Emergent	8.40	11.01	226.00	8.68	9.70
02/07/08	121	15:20	*	*	*	*	ICE	2.63	12.52	206.00	8.67	*
02/07/08	172	15:50	*	*	*	*	ICE	2.63	12.52	206.00	8.67	*
02/07/08	174	15:54	*	*	*	*	ICE	2.63	12.52	206.00	8.67	*
02/07/08	182	16:15	*	*	*	*	ICE	2.63	12.52	206.00	8.67	*
02/07/08	61	16:15	*	*	*	*	ICE	2.63	12.52	206.00	8.67	*
02/07/08	130	17:40	*	*	*	*	ICE	2.63	12.52	206.00	8.67	*
02/07/08	160	17:40	*	*	*	*	ICE	2.63	12.52	206.00	8.67	*
02/26/08	174	8:13	*	*	5.6	Silt	ICE	2.86	14.22	206.00	8.43	3.05

Appendix 5. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
02/26/08	121	9:15	285302	4478345	1.4	Silt	ICE	2.96	13.69	205.00	8.63	7.82
02/26/08	156	9:45	285710	4478441	*	Silt	None	2.96	13.54	205.00	8.56	2.84
03/05/08	130	3:40	285769	4479190	9.8	Silt	None	3.92	12.80	212.00	8.64	2.21
03/05/08	131	4:10	284563	4479794	2.1	Silt	None	4.33	13.24	213.00	8.57	2.44
03/05/08	158	5:30	285809	4477571	2.4	Silt	None	4.24	13.32	213.00	8.55	1.07
03/05/08	156	5:55	286208	4477963	11.5	Silt	None	4.25	13.19	213.00	8.54	1.86
03/05/08	130	6:15	285849	4478799	*	Cobble	None	4.45	13.04	214.00	8.58	2.46
03/05/08	162	6:30	285878	4479117	9.3	Silt	None	4.16	13.19	213.00	8.58	2.60
03/05/08	174	7:30	285488	4479349	6.8	Silt	None	4.24	13.11	213.00	8.56	1.78
03/05/08	131	7:42	284573	4479658	*	Silt	None	4.19	13.07	213.00	8.57	1.76
03/05/08	172	9:38	285574	4478296	*	Silt	None	4.08	13.13	212.00	8.51	4.38
03/05/08	121	9:50	285625	4479100	*	Silt	None	4.10	13.15	212.00	8.46	4.62
03/05/08	158	10:08	285900	4477516	*	Cobble	None	4.27	13.25	213.00	8.53	2.16
03/05/08	160	10:22	286048	4477804	11.9	Silt	None	1.09	13.25	212.00	8.53	3.66
03/05/08	156	10:34	286143	4477986	11.9	Silt	None	4.03	13.12	212.00	8.53	6.96
03/05/08	182	10:50	285896	4477885	12	Silt	None	3.98	12.88	211.00	8.53	1.77
03/05/08	130	11:01	285824	4478724	*	Gravel	None	4.16	13.55	213.00	8.53	2.48
03/05/08	162	11:21	285882	4479035	*	Rock	None	4.57	13.24	214.00	8.57	1.29
03/05/08	131	11:50	284907	4479651	4	Silt	None	4.23	13.10	213.00	8.57	2.50
03/05/08	174	12:07	284557	4479140	*	Silt	None	4.29	13.23	213.00	8.56	1.76
03/05/08	61	13:37	285284	4478911	9.1	Silt	None	4.08	13.12	212.00	8.56	16.70
03/05/08	172	13:47	285427	4478226	*	Silt	None	4.53	13.22	215.00	8.53	2.13
03/05/08	158	14:01	285932	4477508	*	Sand	None	4.27	13.25	213.00	8.53	1.98
03/05/08	160	14:13	286125	4477497	12.2	Silt	None	4.07	13.16	212.00	8.53	2.22
03/05/08	156	14:25	286217	4477969	*	Silt	None	4.16	13.28	212.00	8.54	1.82
03/05/08	162	14:39	285861	4479007	*	Rock	None	4.47	13.04	214.00	8.57	1.03

Appendix 5. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/05/08	130	14:44	285826	4478999	10.1	Silt	None	4.21	13.42	213.00	8.55	2.75
03/08/08	182	0:04	286298	4477718	7.8	Silt	None	4.04	12.84	211.00	8.61	4.13
03/08/08	156	0:25	285420	4478325	*	Silt	None	3.97	12.73	211.00	8.63	5.65
03/08/08	172	0:42	285579	4477984	*	Silt	None	3.98	12.85	211.00	8.61	3.60
03/08/08	174	2:33	283921	4478932	5.6	Silt	None	4.17	13.37	212.00	8.66	5.40
03/08/08	130	15:54	285776	4478701	7.5	Silt	None	4.16	13.55	213.00	8.53	5.84
03/08/08	61	16:17	285644	4478742	9.9	Silt	None	4.02	13.35	212.00	8.55	5.26
03/08/08	131	16:23	285763	4478781	10.7	Silt	None	4.15	13.28	212.00	8.52	6.10
03/08/08	121	16:31	286058	4478123	*	Silt	None	4.02	13.24	212.00	8.56	4.82
03/08/08	182	16:37	286175	4478018	*	Silt	None	4.12	13.24	212.00	8.56	3.75
03/08/08	158	16:47	286230	4477671	11.4	Silt	None	4.05	13.26	212.00	8.52	5.66
03/08/08	156	16:51	286131	4477489	12.1	Silt	None	4.08	13.17	212.00	8.51	6.00
03/08/08	160	17:04	286103	4477589	12	Silt	None	4.05	13.15	212.00	8.51	7.45
03/08/08	181	17:15	285906	4477522	*	Silt	None	4.27	13.25	213.00	8.53	3.63
03/08/08	172	17:24	285663	4477879	*	Silt	None	4.13	13.19	212.00	8.45	3.88
03/08/08	174	18:07	283525	4478586	3.9	Silt	None	4.78	13.52	219.00	8.63	4.16
03/08/08	162	18:46	285092	4479543	*	Silt	None	4.27	13.16	213.00	8.62	3.82
03/08/08	61	19:01	285318	4479469	6	Silt	None	4.17	13.20	212.00	8.58	5.58
03/08/08	131	19:11	285760	4479286	6.5	Silt	None	4.20	13.19	212.00	8.57	2.01
03/08/08	130	19:26	285734	4478994	9.2	Silt	None	4.03	12.97	211.00	8.57	1.52
03/08/08	160	19:37	285803	4478663	*	Silt	None	4.41	13.18	213.00	8.60	3.63
03/08/08	181	20:26	286101	4477599	12.9	Silt	None	4.01	12.99	211.00	8.58	2.54
03/08/08	121	20:46	286313	4477650	6.9	Rock	None	4.13	12.85	212.00	8.56	1.03
03/08/08	182	20:55	286308	4477707	6.8	Rock	None	4.13	12.96	212.00	8.56	1.80
03/08/08	156	21:06	285833	4478037	12.2	Silt	None	3.93	12.82	211.00	8.55	1.13
03/08/08	172	21:16	285730	4477868	11.2	Silt	None	4.09	13.17	212.00	8.61	1.13

Appendix 5. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/08/08	174	21:51	283811	4478859	5	Silt	None	4.50	13.04	212.00	8.68	2.84
03/08/08	131	22:31	284020	4479581	1.8	Sand	Emergent	4.69	13.43	215.00	8.72	1.00
03/08/08	162	22:52	285209	4479083	8.5	Silt	None	3.93	12.89	211.00	8.61	2.45
03/08/08	160	23:02	285394	4478673	9.1	Silt	None	3.93	12.75	211.00	8.58	1.48
03/08/08	130	23:16	285813	4478727	5.3	Silt	None	4.27	13.03	213.00	8.62	1.38
03/08/08	61	23:24	285685	4478600	11.1	Silt	None	4.14	12.93	211.00	8.61	1.19
03/08/08	121	23:43	285842	4477666	7.4	Silt	None	4.15	13.38	212.00	8.61	0.34
03/08/08	161	23:53	286071	4477671	12.1	Silt	None	3.84	12.92	211.00	8.60	4.51
03/13/08	130	3:57	285837	4478957	8.3	Silt	None	5.32	14.20	220.00	8.59	5.51
03/13/08	131	4:09	285774	4478565	*	Silt	None	5.29	13.08	220.00	8.34	5.98
03/13/08	182	4:20	285827	4478394	7.6	Silt	None	5.30	13.16	220.00	8.46	4.82
03/13/08	172	4:32	285456	4478760	9.2	Silt	None	5.31	13.32	220.00	8.46	6.17
03/13/08	181	4:55	286018	4476215	3.4	Silt	None	5.20	13.10	219.00	8.52	5.65
03/13/08	61	5:11	286212	4477672	11.6	Silt	None	5.14	13.53	218.00	8.40	4.71
03/13/08	121	5:35	286203	4477396	*	Silt	None	5.04	13.22	218.00	8.60	4.64
03/13/08	156	5:52	286036	4478176	7.5	Silt	None	5.24	13.06	219.00	8.44	4.51
03/13/08	158	6:02	285917	4477517	*	Sand	None	5.26	13.20	219.00	8.55	4.47
03/13/08	174	6:33	284753	4479158	7.5	Silt	None	5.43	13.58	220.00	8.64	5.12
03/13/08	172	7:29	285668	4478954	8.5	Silt	None	5.25	12.92	219.00	8.37	7.65
03/13/08	131	8:22	285643	4478648	10.1	Silt	None	5.21	13.14	219.00	8.65	3.61
03/13/08	160	8:31	286053	4478163	8.1	Silt	None	5.13	12.93	218.00	8.64	3.61
03/13/08	130	8:40	285798	4477899	*	Silt	None	5.08	13.04	218.00	8.63	5.27
03/13/08	162	8:50	285772	4477677	*	Rock	None	5.02	13.06	218.00	8.63	8.07
03/13/08	158	8:55	285929	4477524	*	Sand	None	5.10	13.09	218.00	8.66	3.15
03/13/08	121	9:03	286224	4477424	*	Silt	None	5.00	13.09	218.00	8.68	5.45
03/13/08	61	9:20	286364	4477713	2.6	Rock	None	5.08	13.09	218.00	8.65	4.25

Appendix 5. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/13/08	182	9:31	286203	4478000	*	Silt	None	5.17	13.03	219.00	8.64	3.84
03/13/08	156	9:44	286291	4477957	2.3	Silt	None	4.97	13.17	217.00	8.66	3.78
03/13/08	181	10:00	285572	4477986	*	Silt	None	5.17	13.07	219.00	8.61	6.12
03/13/08	174	10:23	284791	4479089	7.3	Silt	None	5.45	13.29	221.00	8.67	7.99
03/13/08	131	11:37	285642	4479396	3.5	Silt	None	5.51	13.50	220.00	8.74	11.10
03/13/08	130	12:28	285859	4478131	12	Silt	None	5.32	13.43	220.00	8.70	4.10
03/13/08	160	12:32	286120	4478097	8.7	Silt	None	5.34	13.42	220.00	8.65	4.51
03/13/08	156	12:37	286189	4478049	*	Silt	None	5.45	13.29	221.00	8.67	3.80
03/13/08	182	12:47	286238	4478005	3.7	Silt	None	5.45	13.29	221.00	8.66	4.81
03/13/08	121	12:55	286269	4477500	*	Silt	None	5.37	13.35	220.00	8.71	5.32
03/13/08	158	13:04	285982	4477560	*	Silt	None	5.24	13.21	220.00	8.69	4.24
03/13/08	61	13:29	285811	4478121	11.9	Silt	None	5.41	13.35	221.00	8.68	4.79
03/13/08	172	13:45	285753	4478724	*	Silt	None	5.54	13.42	221.00	8.73	9.59
03/13/08	174	13:59	284994	4478972	7.4	Silt	None	5.68	13.39	223.00	8.74	7.77
03/13/08	181	14:30	283312	4478705	*	Silt	None	6.69	13.61	230.00	8.81	9.03
03/14/08	174	0:00	284519	4479136	7	Silt	None	5.99	13.18	224.00	8.74	2.92
03/14/08	121	0:31	285878	4478952	0.7	Silt	None	5.67	12.91	220.00	8.74	4.26
03/14/08	160	0:46	285489	4478389	9.6	Silt	None	5.54	12.97	221.00	8.75	2.65
03/14/08	130	1:10	285178	4478593	3.4	Silt	None	5.53	13.21	221.00	8.81	4.18
03/14/08	61	1:21	285884	4478312	8.2	Silt	None	5.56	13.03	221.00	8.77	3.21
03/14/08	181	1:32	286263	4477445	11.5	Silt	None	5.30	12.74	219.00	8.71	3.21
03/14/08	156	1:41	286320	4477859	2.4	Rock	None	5.37	13.01	220.00	8.76	3.87
03/14/08	172	1:55	285999	4477913	12.8	Silt	None	5.51	12.83	221.00	8.73	3.76
03/14/08	158	2:15	285944	4477576	9.2	Silt	None	5.57	13.30	220.00	8.79	3.88
03/14/08	131	2:41	285506	4478011	7.8	Silt	None	5.52	12.97	221.00	8.74	4.33
03/14/08	130	15:55	285804	4478390	10.2	Silt	None	5.66	13.42	222.00	8.73	6.61

Appendix 5. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/14/08	160	16:04	285647	4478612	10.8	Silt	None	5.74	13.38	223.00	8.71	6.88
03/14/08	172	16:08	285569	4478611	8	Silt	None	5.77	13.34	223.00	8.64	8.69
03/14/08	61	16:17	285852	4478128	12.3	Silt	None	5.61	13.24	222.00	8.68	7.45
03/14/08	182	16:21	285844	4477988	12	Silt	None	5.62	13.28	222.00	8.68	6.78
03/14/08	131	16:45	286176	4477464	10	Silt	None	5.66	13.21	222.00	8.71	6.52
03/14/08	158	16:50	285924	4477527	1.9	Sand	None	6.04	13.35	224.00	8.71	4.88
03/14/08	156	17:00	286008	4477521	11.8	Silt	None	5.71	13.20	222.00	8.69	5.68
03/14/08	181	17:12	286027	4477519	12	Silt	None	5.68	13.18	222.00	8.72	5.57
03/14/08	121	17:31	286261	4477850	8.8	Silt	None	5.80	13.27	223.00	8.71	4.18
03/14/08	162	17:59	285735	4477767	11.5	Silt	None	5.77	13.24	223.00	8.83	4.47
03/14/08	174	19:40	284915	4479229	8	Silt	None	5.98	13.21	224.00	8.76	5.77
03/14/08	172	19:55	285464	4478633	7.2	Silt	None	5.78	13.30	222.00	8.72	7.22
03/14/08	130	20:19	285860	4478387	1.8	Silt	None	5.68	13.22	222.00	8.74	3.05
03/14/08	160	20:36	285687	4477997	11.3	Silt	None	5.59	13.05	221.00	8.72	2.70
03/14/08	162	20:51	285708	4478148	12.2	Silt	None	5.53	13.04	221.00	8.75	7.77
03/14/08	121	21:17	286022	4478231	1.7	Silt	None	5.61	13.26	221.00	8.80	5.87
03/14/08	61	21:24	285861	4478399	1.7	Sand	None	5.59	13.28	221.00	8.77	4.80
03/14/08	182	21:31	285887	4478105	12.3	Silt	None	5.59	13.06	221.00	8.73	6.14
03/14/08	156	21:45	286321	4477874	1.6	Rock	None	5.89	13.08	223.00	8.78	6.52
03/14/08	131	22:13	285351	4478424	5.4	Silt	None	5.67	13.08	222.00	8.76	4.10
03/14/08	181	22:36	286197	4477417	5.1	Silt	None	5.38	13.21	220.00	8.79	4.21
03/14/08	158	23:04	285907	4477512	1	Sand	None	5.77	13.08	222.00	8.74	8.03
03/18/08	160	0:40	285157	4478662	2.4	Silt	None	5.73	12.80	225.00	8.84	10.55
03/18/08	162	0:54	285839	4478419	2.7	Sand	None	5.43	13.01	224.00	8.80	5.76
03/18/08	121	1:15	286277	4477536	11.1	Silt	None	5.76	13.20	218.00	8.80	19.30
03/18/08	181	1:21	286306	4477621	7.8	Silt	None	5.94	13.22	219.00	8.82	9.79

Appendix 5. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/18/08	131	2:01	285381	4478410	6.1	Silt	None	5.66	12.94	221.00	8.84	10.94
03/18/08	182	2:16	285924	4477848	11.5	Silt	None	5.48	13.29	221.00	8.80	9.24
03/18/08	156	2:26	285836	4478032	12.7	Silt	None	5.43	12.76	217.00	8.78	6.58
03/18/08	61	2:53	285744	4478493	10.7	Silt	None	5.36	12.65	224.00	8.76	7.10
03/18/08	156	15:35	285872	4478909	1.5	Gravel	None	5.78	13.48	223.00	8.79	12.00
03/18/08	130	15:55	285410	4478258	7	Sand	None	5.94	13.00	224.00	8.80	8.34
03/18/08	160	16:06	285766	4477921	11.3	Silt	None	5.72	13.04	223.00	8.78	8.44
03/18/08	172	16:24	285773	4478573	6.3	Sand	None	5.72	13.04	222.00	8.76	8.87
03/18/08	174	16:40	285755	4477844	11.3	Sand	None	5.74	13.10	222.00	8.73	6.04
03/18/08	181	17:11	286249	4477436	9	Gravel	None	6.28	13.28	225.00	8.78	6.10
03/18/08	158	17:16	285939	4477531	3.2	Sand	None	5.95	13.34	223.00	8.74	6.83
03/18/08	131	17:36	286284	4477517	10.9	Sand	None	6.10	13.24	224.00	8.79	6.63
03/18/08	182	17:49	285640	4477929	10.6	Silt	None	5.72	13.19	222.00	8.73	6.48
03/18/08	121	18:01	285540	4477918	5.9	Silt	None	5.87	13.24	223.00	8.74	11.90
03/18/08	61	19:27	285871	4479132	3.3	Silt	None	6.40	13.31	226.00	8.82	9.26
03/18/08	160	19:37	285823	4478780	7.2	Sand	None	5.62	13.26	221.00	8.78	7.69
03/18/08	130	20:04	285379	4478279	7.1	Sand	None	5.90	13.31	223.00	8.81	10.13
03/18/08	156	20:58	286312	4477818	6.9	Rock	None	5.41	13.02	220.00	8.73	8.37
03/18/08	131	21:16	286256	4477481	11.8	Silt	None	5.91	13.08	223.00	8.71	13.10
03/18/08	181	21:21	286318	4477442	9	Sand	None	6.00	13.14	224.00	8.76	18.00
03/18/08	174	21:35	285949	4477555	5.9	Sand	None	5.78	13.10	222.00	8.77	9.35
03/18/08	158	21:37	285949	4477555	5.9	Sand	None	5.78	13.10	222.00	8.77	9.35
03/18/08	182	21:47	285637	4477910	10.6	Silt	None	5.63	13.35	221.00	8.80	5.97
03/18/08	172	22:21	285210	4478625	6.4	Silt	None	5.91	13.04	223.00	8.82	5.42
03/18/08	61	23:35	285682	4479410	2	Silt	Woody	5.54	13.09	219.00	9.89	6.33
03/21/08	130	3:35	285486	4478045	6.7	Silt	None	6.12	12.93	225.00	8.72	8.74

Appendix 5. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/21/08	160	3:55	285805	4478814	9.5	Silt	None	6.13	12.96	225.00	8.62	9.70
03/21/08	174	4:17	285532	4478233	9.2	Silt	None	5.93	13.13	223.00	8.73	7.61
03/21/08	182	4:27	285716	4477979	11.3	Silt	None	5.92	13.03	223.00	8.70	5.31
03/21/08	156	4:41	286221	4477912	10.5	Silt	None	6.02	13.04	224.00	8.73	6.20
03/21/08	172	4:46	286207	4477830	11.1	Silt	None	6.00	12.96	224.00	8.74	6.59
03/21/08	131	4:54	286324	4477578	7	Rock	None	5.92	12.95	223.00	8.74	7.08
03/21/08	181	5:04	286329	4477481	7.4	Silt	None	5.95	13.00	224.00	8.74	4.75
03/21/08	158	5:17	286207	4477400	3.7	Sand	None	5.71	13.01	225.00	8.71	5.37
03/21/08	121	5:31	285520	4478121	9.9	Silt	None	6.01	12.89	224.00	8.69	5.29
03/21/08	61	6:05	285014	4478921	7	Silt	None	6.18	12.99	223.00	8.78	5.01
03/21/08	174	7:49	285681	4477909	11	Silt	None	5.86	12.79	226.00	8.82	12.00
03/21/08	121	7:54	285573	4478226	11.5	Silt	None	5.88	12.87	224.00	8.79	8.04
03/21/08	130	8:01	285386	4478380	5.4	Silt	None	5.95	12.87	227.00	8.81	5.27
03/21/08	160	8:15	285616	4478999	10.3	Silt	None	5.92	13.02	223.00	8.78	5.96
03/21/08	172	8:26	285737	4478444	10.5	Silt	None	5.91	12.90	226.00	8.77	11.50
03/21/08	182	8:33	286007	4478139	12.6	Silt	None	5.87	12.89	224.00	8.78	3.92
03/21/08	156	8:52	286334	4477398	0.5	Sand	None	5.55	12.84	220.00	8.81	9.96
03/21/08	181	8:55	286330	4477433	2.4	Rock	None	5.75	12.99	222.00	8.82	4.53
03/21/08	131	8:57	286324	4477437	5.3	Rock	None	5.80	12.93	224.00	8.81	5.88
03/21/08	158	9:04	285928	4477514	1.2	Cobble	None	5.98	13.01	221.00	8.80	8.65
03/21/08	61	10:29	284844	4479710	3.5	Silt	None	6.26	13.04	226.00	8.82	6.55
03/21/08	130	11:31	285412	4478261	6.4	Silt	None	6.08	12.98	225.00	8.84	12.30
03/21/08	160	11:40	285625	4479011	10.4	Silt	None	6.14	13.08	225.00	8.79	7.13
03/21/08	156	12:09	286304	4477394	0.6	Sand	None	6.17	13.15	225.00	8.82	6.27
03/21/08	181	12:15	286314	4477444	9	Rock	None	6.31	13.08	226.00	8.82	6.48
03/21/08	131	12:21	285853	4477636	3.3	Sand	None	6.24	13.22	225.00	8.81	7.73

Appendix 5. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/21/08	158	12:34	285829	4477709	11.3	Silt	None	6.41	13.02	227.00	8.79	7.41
03/21/08	182	12:53	285862	4477836	10.6	Silt	None	6.54	13.03	228.00	8.82	6.33
03/21/08	61	13:50	285918	4479241	1.7	Silt	Woody	7.05	13.32	231.00	8.84	6.57
03/21/08	160	14:09	285529	4478983	9.1	Silt	None	6.77	13.21	229.00	8.83	10.29
03/21/08	182	14:29	285964	4477788	12.4	Silt	None	6.76	13.27	229.00	8.84	6.65
03/21/08	181	14:33	286303	4477443	8.3	Sand	None	7.28	13.07	233.00	8.80	6.48
03/21/08	158	14:57	285837	4477656	4.2	Silt	None	7.19	13.04	232.00	8.81	11.60
03/27/08	131	0:03	285714	4478475	5.9	Silt	None	7.38	12.97	234.00	8.89	8.03
03/27/08	121	0:29	286105	4477417	1	Sand	None	7.49	12.70	234.00	8.93	8.18
03/27/08	181	0:45	286345	4477453	3.9	Rock	None	7.49	13.00	234.00	8.92	5.59
03/27/08	156	1:17	286126	4478052	13.9	Silt	None	7.27	13.34	232.00	8.89	7.21
03/27/08	172	17:32	285573	4478919	7.9	Silt	None	7.50	18.10	237.00	8.66	10.78
03/27/08	158	18:10	285476	4478601	8.2	Silt	None	7.55	17.34	237.00	8.61	6.51
03/27/08	130	18:15	285378	4478424	6.1	Silt	None	8.27	16.94	242.00	8.63	5.54
03/27/08	156	18:44	286164	4478144	1	Rock	Woody	7.28	18.07	233.00	8.65	7.57
03/27/08	160	19:02	286062	4477756	12.2	Silt	None	7.28	17.10	234.00	8.55	4.14
03/27/08	131	19:21	285803	4477714	11.6	Silt	None	7.96	17.27	240.00	8.62	5.92
03/27/08	162	19:37	286228	4477391	5.8	Silt	None	7.74	18.12	237.00	8.68	5.32
03/27/08	181	19:49	286331	4477480	7	Rock	None	7.55	16.47	237.00	8.66	4.79
03/27/08	182	20:01	285922	4477930	12.5	Silt	None	7.21	16.90	233.00	8.59	5.43
03/27/08	158	21:23	283898	4478892	6.9	Silt	None	8.38	12.94	240.00	8.95	11.00
03/27/08	172	22:31	285202	4479290	7.8	Silt	None	7.60	12.82	235.00	8.89	7.62
03/27/08	130	23:27	285620	4477840	9.8	Silt	None	7.94	12.71	237.00	8.94	12.90
03/27/08	160	23:41	285795	4477679	3.3	Silt	None	7.90	12.84	237.00	8.93	7.53
04/01/08	158	0:35	286155	4477510	11.5	Silt	None	7.27	16.73	235.00	8.39	3.37
04/01/08	182	0:47	285866	4477666	8	Silt	None	7.22	16.45	234.00	8.53	2.84

Appendix 5. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
04/01/08	174	0:54	285779	4477919	11.3	Silt	None	7.32	16.69	234.00	8.58	2.66
04/01/08	181	1:05	286321	4477487	7.7	Cobble	None	7.22	16.09	234.00	8.63	4.56
04/01/08	156	1:05	286321	4477487	7.7	Cobble	None	7.22	16.09	234.00	8.63	4.56
04/01/08	162	1:20	286243	4477535	11.3	Silt	None	7.23	16.30	234.00	8.48	2.48
04/01/08	121	1:33	286126	4477869	12.1	Silt	None	7.24	16.79	234.00	8.71	3.31
04/01/08	131	2:07	284180	4479187	5.4	Silt	None	8.61	16.78	244.00	8.69	4.52
04/01/08	172	2:32	285732	4478956	8.5	Silt	None	7.64	16.89	237.00	8.70	2.76
04/01/08	174	15:59	285913	4478253	9.7	Silt	None	9.13	17.46	248.00	8.65	3.06
04/01/08	160	16:12	285890	4478352	7.3	Silt	None	9.24	17.46	248.00	8.49	4.86
04/01/08	182	16:21	285759	4478563	8.5	Silt	None	8.93	17.37	247.00	8.61	5.06
04/01/08	172	16:29	285659	4478744	10	Silt	None	9.36	16.95	249.00	8.60	4.05
04/01/08	121	17:04	286011	4478234	1.5	Silt	None	8.63	17.31	244.00	8.68	4.40
04/01/08	156	17:44	286331	4477494	8.2	Cobble	None	7.79	17.58	238.00	8.68	4.42
04/01/08	181	17:48	286347	4477506	4.3	Rock	None	7.78	17.44	238.00	8.68	4.98
04/01/08	162	18:28	286005	4477508	12.4	Silt	None	7.72	18.27	238.00	8.66	5.19
04/01/08	130	19:01	285726	4477898	11.1	Silt	None	7.78	17.77	238.00	8.53	3.22
04/01/08	158	19:10	285444	4478120	5	Sand	None	7.88	17.39	239.00	8.64	3.63
04/01/08	131	20:14	283268	4478880	2.5	Silt	None	8.97	16.99	247.00	8.38	3.75
04/01/08	172	21:57	285488	4478923	8.1	Silt	None	7.50	17.03	237.00	8.38	8.60
04/01/08	160	22:27	285517	4478239	10.3	Silt	None	7.54	16.86	237.00	8.66	4.93
04/01/08	130	22:58	285868	4477830	10.2	Silt	None	7.35	16.94	236.00	8.50	4.97
04/13/08	158	0:04	286163	4477427	7	Silt	None	7.76	11.52	237.00	8.95	6.22
04/13/08	156	0:07	286176	4477525	11.3	Silt	None	7.74	11.48	237.00	8.95	5.08
04/13/08	121	0:15	286150	4478098	7.5	Silt	None	7.74	11.36	237.00	8.94	6.47
04/13/08	172	2:23	285225	4478784	8.4	Silt	None	7.48	11.56	235.00	8.94	6.27
04/13/08	160	3:26	285782	4478740	8.2	Silt	None	7.40	11.66	235.00	8.95	6.62

Appendix 5. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
04/13/08	181	3:29	285744	4478774	10.6	Silt	None	7.40	11.66	235.00	8.95	6.62
04/21/08	131	0:20	285928	4478295	7.4	Silt	None	10.66	10.51	259.00	8.69	1.90
04/21/08	160	20:00	285589	4479358	*	Silt	None	10.09	9.99	255.00	8.90	7.64
04/21/08	174	20:09	284724	4479216	7.2	Silt	None	11.37	9.95	264.00	8.84	9.98
04/21/08	181	20:16	284788	4479704	3.4	Silt	None	11.24	10.35	263.00	8.84	6.10
04/21/08	162	20:55	282741	4478589	2.2	Silt	Submerged	12.94	11.87	277.00	8.87	10.80
04/21/08	182	21:19	285604	4478300	11.3	Silt	None	11.26	10.29	263.00	8.83	4.50
04/21/08	130	22:10	285850	4477698	11.2	Silt	None	11.48	10.25	265.00	8.83	5.05
04/21/08	158	22:16	286166	4477492	11.6	Silt	None	11.19	10.30	263.00	8.85	3.53
05/05/08	174	1:45	283847	4478892	5.2	Silt	None	13.48	11.53	279.00	8.84	4.03
05/05/08	131	2:55	284580	4478096	9.2	Silt	None	11.65	10.98	266.00	8.88	1.44
05/05/08	130	22:11	285252	4478625	7.7	Silt	None	12.21	10.85	270.00	8.69	5.02
05/05/08	160	22:29	285031	4479287	8.1	Silt	None	12.65	11.09	273.00	8.78	4.50
05/05/08	121	22:31	285031	4479287	8.1	Silt	None	12.65	11.09	273.00	8.78	4.50
05/05/08	158	22:37	285119	4479667	3.9	Silt	None	13.13	10.89	277.00	8.83	5.30
05/05/08	162	23:40	283520	4478950	4.5	Silt	None	13.43	11.34	278.00	8.95	1.35
05/15/08	172	1:31	285149	4478752	5.8	Silt	None	13.81	9.47	283.00	8.86	2.90
05/15/08	130	1:39	285442	4478770	9	Silt	None	13.77	9.36	283.00	8.87	7.00
05/15/08	160	1:44	285718	4479298	7.3	Silt	None	13.58	9.34	282.00	8.87	3.35
05/15/08	131	2:46	285558	4478081	10.2	Silt	None	13.82	9.53	283.00	8.88	6.45
05/15/08	182	2:59	286143	4477956	11.5	Silt	None	13.98	9.63	284.00	8.88	6.09
05/15/08	162	23:52	282477	4478238	1	Silt	Woody	16.16	10.37	327.00	9.06	12.00
05/26/08	131	20:15	285878	4478293	9	Silt	None	16.96	13.70	306.00	8.92	4.09
05/26/08	182	20:24	285974	4477822	12.4	Silt	None	16.71	14.63	304.00	8.91	3.15
05/26/08	121	20:37	285373	4478525	8.1	Silt	None	16.94	14.74	305.00	8.89	3.70

Appendix 6. Habitat characteristics of telemetry locations of tagged walleye in Red Willow reservoir during 2007-2008. * indicates missing data.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/21/07	7	4:40	357926	4468837	> 5	*	None	8.30	*	310.50	*	*
03/21/07	24	6:10	357702	4469201	1	Silt	None	8.30	*	313.30	*	*
03/21/07	7	6:50	357880	4468890	3.6	Silt	None	8.20	*	315.90	*	*
03/21/07	23	8:30	358441	4468940	>5	*	None	8.30	*	311.40	*	*
03/21/07	34	8:35	358445	4468982	>5	Rock	None	8.30	*	313.30	*	*
03/21/07	35	8:50	358406	4469309	3.6	Silt	None	8.40	*	312.40	*	*
03/21/07	32	9:15	358404	4469270	>5	Silt	None	8.40	*	311.00	*	*
03/21/07	3	9:30	358490	4469258	>5	*	None	8.40	*	313.40	*	*
03/21/07	2	10:42	357610	4471328	2.1	Silt	Woody	10.00	*	317.70	*	*
03/21/07	24	11:10	357662	4469459	>5	*	None	8.70	*	311.70	*	*
03/21/07	32	11:50	358450	4469324	2.4	Silt	None	8.70	*	312.00	*	*
03/21/07	3	11:57	358567	4469354	1.1	Cobble	None	9.30	*	315.30	*	*
03/21/07	32	13:30	358449	4469278	>5	*	None	9.60	*	316.80	*	*
03/21/07	9	13:40	358503	4469401	>5	Silt	None	9.10	*	316.50	*	*
03/21/07	3	13:55	358565	4469357	1	Cobble	None	9.90	*	315.30	*	*
03/21/07	24	14:10	357608	4469603	1	Silt	None	9.80	*	308.00	*	*
03/24/07	2	0:00	357854	4469056	>5	*	None	9.60	*	315.10	*	*
03/24/07	24	0:43	357653	4471291	2	Silt	None	12.50	*	336.90	*	*
03/24/07	22	2:24	357223	4468572	>5	*	None	10.00	*	317.30	*	*
03/24/07	32	2:44	357814	4469044	4	*	None	9.50	*	315.20	*	*
03/24/07	22	15:39	358586	4469340	4	Gravel	Woody	10.80	*	326.80	*	*
03/24/07	32	16:04	357644	4469578	>5	Sand	Woody	9.90	*	316.30	*	*
03/24/07	11	18:38	358077	4468644	>5	*	None	9.60	*	312.40	*	*
03/24/07	35	18:47	358453	4469093	>5	*	None	10.00	*	317.50	*	*
03/24/07	32	20:25	357964	4469646	>5	*	None	10.10	*	319.70	*	*
03/24/07	34	20:37	358133	4469692	>5	Sand	None	10.30	*	322.40	*	*

Appendix 6. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/24/07	24	20:54	357658	4471259	2.5	Silt	Woody	12.70	*	338.30	*	*
03/24/07	11	23:15	357634	4468527	>5	*	None	9.60	*	313.50	*	*
03/24/07	7	23:35	357805	4468608	>5	*	None	9.80	*	315.50	*	*
03/24/07	23	23:48	358042	4468931	>5	*	None	9.50	*	316.50	*	*
03/28/07	22	3:34	357124	4468601	>5	*	None	11.24	*	324.00	8.76	14.40
03/28/07	34	3:58	358043	4468569	>5	*	None	10.58	*	320.00	8.77	12.00
03/28/07	11	4:07	358078	4468660	>5	*	None	10.71	*	320.00	8.80	12.00
03/28/07	23	4:17	358066	4468684	>5	*	None	10.74	*	321.00	8.79	10.25
03/28/07	9	4:28	358420	4469063	4.5	Silt	None	11.14	*	324.00	8.82	8.90
03/28/07	32	4:35	358479	4469365	2.5	Silt	None	11.05	*	323.00	8.82	9.06
03/28/07	7	5:10	357622	4471214	3	Silt	Woody	11.29	*	327.00	8.85	24.70
03/28/07	22	6:33	357352	4468555	>5	*	None	11.22	*	324.00	8.87	11.70
03/28/07	34	6:54	357930	4468620	>5	*	None	10.44	*	319.00	8.82	10.86
03/28/07	32	7:10	358464	4469356	2.5	Silt	None	11.05	*	323.00	8.88	9.09
03/28/07	9	7:15	358482	4469391	3	Silt	None	11.07	*	323.00	8.89	11.10
03/28/07	24	7:45	357946	4470555	5	Sand	None	10.96	*	323.00	8.89	15.60
03/28/07	11	10:03	358132	4468590	3	Rock	None	9.91	*	316.00	8.80	13.30
03/28/07	34	10:12	358154	4468632	>5	Rock	None	10.29	*	319.00	8.82	12.60
03/28/07	32	10:35	358488	4469362	3	Silt	None	11.06	*	323.00	8.89	9.55
03/28/07	23	12:20	358076	4468506	>5	Rock	None	9.71	*	316.00	8.74	15.70
03/28/07	11	12:40	358549	4469037	>5	*	None	11.11	*	324.00	8.86	9.67
03/28/07	32	12:58	358508	4469403	3.5	Silt	None	11.41	*	326.00	8.91	10.19
03/28/07	7	13:23	357874	4470541	*	*	None	11.37	*	327.00	8.87	24.50
03/28/07	11	14:15	358326	4468794	>5	Rock	None	11.01	*	324.00	8.85	15.40
03/28/07	32	14:27	358454	4469332	2	Silt	None	11.50	*	327.00	8.83	11.90
04/08/07	11	0:15	355516	4469410	*	*	None	9.73	*	320.00	8.73	34.30

Appendix 6. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
04/08/07	3	1:45	356437	4468970	*	*	None	9.95	*	320.00	8.74	29.30
04/08/07	9	4:53	357826	4469216	>5	Silt	None	9.72	*	316.00	8.73	28.40
04/08/07	24	5:07	358325	4469130	*	*	None	9.98	*	319.00	8.73	28.10
04/08/07	32	9:00	358515	4469282	2	Silt	None	9.64	*	317.00	8.70	28.80
04/08/07	24	9:25	358261	4469023	*	*	None	9.86	*	317.00	8.75	27.50
04/16/07	22	0:30	357584	4468491	1.5	Silt	None	12.19	*	346.00	8.52	15.60
04/16/07	24	4:06	358078	4469129	>4	*	None	10.63	*	329.00	8.69	13.10
04/16/07	35	6:30	353830	4470545	2	Silt	None	10.95	*	359.00	8.97	19.10
04/16/07	22	7:26	357466	4468515	1.5	Silt	None	11.30	*	336.00	8.85	*
04/16/07	23	7:35	358131	4468584	>4	Rock	None	11.10	*	335.00	8.77	14.20
04/16/07	32	7:48	358482	4469373	2.5	Silt	None	10.04	*	324.00	8.84	19.70
04/16/07	24	8:01	357914	4469878	>4	*	None	10.14	*	324.00	8.80	18.60
04/16/07	11	23:44	356483	4469017	>4	*	None	10.75	*	330.00	8.79	17.70
04/26/07	11	1:36	356883	4468870	>4	Silt	None	13.80	9.32	360.00	11.77	24.70
04/29/07	34	14:15	358398	4469144	7.5	Silt	None	16.32	*	384.00	14.02	*
05/08/07	11	0:19	357260	4468587	10.2	*	None	17.98	*	406.00	12.79	9.03
05/08/07	23	4:11	358379	4469258	9	Silt	None	18.24	*	405.00	12.66	7.24
05/08/07	24	4:23	358381	4469270	8.8	Silt	None	18.17	*	404.00	12.85	5.68
05/08/07	9	4:45	358018	4470667	4.7	Silt	None	*	*	*	*	*
05/29/07	24	11:45	357812	4468998	2	Silt	None	19.54	*	426.00	11.19	18.60
05/29/07	9	11:52	357647	4469631	3	Silt	None	19.70	*	425.00	11.62	19.90
05/29/07	22	12:55	355070	4469468	3	Silt	None	20.52	*	440.00	11.58	27.70
11/19/07	124	6:07	356851	4468920	10.6	Silt	None	8.86	10.64	291.00	8.50	20.60
11/19/07	110	6:17	356462	4469231	7.8	Silt	None	8.77	10.45	290.00	8.60	93.00
11/19/07	155	6:17	356462	4469231	7.8	Silt	None	8.77	10.45	290.00	8.60	93.00
11/19/07	144	6:19	356462	4469231	7.8	Silt	None	8.77	10.45	290.00	8.60	93.00

Appendix 6. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
11/19/07	108	6:35	356330	4468985	9.6	Silt	None	8.70	10.59	289.00	8.63	41.30
11/19/07	175	7:15	355179	4469143	2.8	Silt	Woody	8.43	11.09	289.00	8.69	18.30
11/19/07	128	7:56	357601	4468523	7.7	Silt	None	8.91	10.65	290.00	8.68	17.90
11/19/07	161	8:15	358523	4469203	2.1	Silt	None	9.10	10.79	291.00	8.68	19.40
11/19/07	152	8:30	357839	4469688	9.2	Silt	None	9.08	10.58	291.00	8.60	18.80
11/19/07	137	8:36	357829	4469316	10	Silt	None	9.03	10.60	291.00	8.61	24.50
11/19/07	154	8:53	357733	4470858	5.6	Silt	None	8.64	11.31	287.00	8.73	17.90
02/07/08	152	9:00	*	*	*	*	ICE	2.90	12.27	262.00	8.52	*
02/07/08	154	9:04	*	*	*	*	ICE	2.90	12.27	262.00	8.52	*
02/07/08	144	9:05	*	*	*	*	ICE	2.90	12.27	262.00	8.52	*
02/07/08	128	9:08	*	*	*	*	ICE	2.90	12.27	262.00	8.52	*
02/07/08	161	9:08	*	*	*	*	ICE	2.90	12.27	262.00	8.52	*
02/07/08	176	9:35	*	*	*	*	ICE	2.90	12.27	262.00	8.52	*
02/07/08	123	9:40	*	*	*	*	ICE	2.90	12.27	262.00	8.52	*
02/07/08	155	9:46	*	*	*	*	ICE	2.90	12.27	262.00	8.52	*
02/26/08	152	1:03	*	*	2.6	Silt	ICE	3.66	13.48	262.00	8.62	9.64
02/26/08	155	1:12	*	*	10	Silt	ICE	3.52	12.86	262.00	8.55	1.20
02/26/08	144	1:16	*	*	10.3	Silt	ICE	3.39	13.39	262.00	8.51	1.84
02/26/08	108	1:40	*	*	9.8	Silt	ICE	3.80	13.49	267.00	8.54	2.80
02/26/08	123	1:40	*	*	9.8	Silt	ICE	3.80	13.49	267.00	8.54	2.80
02/26/08	153	2:00	356856	4468796	10.9	Silt	None	3.66	13.82	267.00	8.56	2.12
02/26/08	176	12:40	*	*	12	Silt	ICE	3.36	13.07	263.00	8.63	1.80
02/26/08	161	12:45	*	*	12	Silt	ICE	3.36	13.07	263.00	8.63	1.80
03/06/08	128	3:50	357155	4469016	6.3	Silt	None	3.91	13.47	264.00	8.69	3.14
03/06/08	144	4:04	358032	4468571	12.8	Silt	None	3.93	13.60	263.00	8.67	3.54
03/06/08	152	4:16	358398	4469146	11	Silt	None	3.88	12.59	263.00	8.58	5.46

Appendix 6. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/06/08	155	4:27	357888	4469071	9.7	Silt	None	3.86	12.77	262.00	8.60	3.69
03/06/08	176	4:36	358406	4469132	10.8	Silt	None	3.94	13.39	264.00	8.71	3.10
03/06/08	154	4:58	358185	4470140	1.5	Silt	Woody	3.37	12.49	256.00	8.61	4.29
03/06/08	161	5:45	357091	4468968	5.4	Silt	None	3.87	12.46	263.00	8.65	3.62
03/06/08	108	7:25	357539	4468725	12.7	Silt	None	3.87	12.51	263.00	8.63	4.86
03/06/08	128	7:40	357769	4468976	3.1	Silt	None	3.92	13.03	264.00	8.62	4.52
03/06/08	161	7:48	357664	4468804	12.3	Silt	None	3.78	13.16	263.00	8.51	6.60
03/06/08	155	8:07	357999	4469182	11	Silt	None	3.82	13.42	262.00	8.68	4.23
03/06/08	110	8:16	358456	4469093	5.9	Silt	None	3.63	13.13	261.00	8.52	3.75
03/06/08	144	8:27	358011	4468516	11.7	Rock	None	3.70	12.69	261.00	8.61	10.00
03/06/08	112	8:50	357591	4469713	4.3	Silt	None	3.91	13.35	262.00	8.62	15.80
03/06/08	123	10:52	356363	4469170	2.6	Silt	Woody	4.10	13.67	264.00	8.67	4.71
03/06/08	153	11:02	356312	4468996	9.7	Silt	None	3.98	13.49	264.00	8.65	5.79
03/06/08	137	11:13	355122	4469451	6.9	Silt	None	4.07	13.29	265.00	8.66	3.53
03/06/08	161	12:46	358012	4468481	3	Gravel	None	4.11	13.40	265.00	8.61	1.60
03/06/08	176	12:53	358081	4468644	12.6	Silt	None	4.07	13.49	265.00	8.58	1.20
03/06/08	124	13:01	357696	4468897	12.4	Silt	None	4.13	13.27	266.00	8.58	2.10
03/06/08	128	13:07	357901	4468852	7.8	Silt	None	4.24	13.33	266.00	8.57	9.49
03/06/08	110	13:23	358528	4469162	3.7	Gravel	None	4.16	13.65	264.00	8.61	0.91
03/06/08	155	13:36	357902	4469072	8.8	Silt	None	4.07	13.39	265.00	8.56	18.50
03/06/08	108	13:52	357911	4469591	9.5	Silt	None	4.16	13.34	264.00	8.57	10.30
03/07/08	154	0:55	358512	4469173	2.4	Silt	None	3.78	12.85	262.00	8.61	5.50
03/07/08	124	1:05	358286	4468881	12	Silt	None	3.98	13.26	263.00	8.63	5.59
03/07/08	176	1:15	358297	4469125	11.4	Silt	None	3.88	13.14	262.00	8.61	6.51
03/07/08	123	1:42	358057	4469751	9	Silt	None	3.81	13.17	260.00	8.63	7.58
03/07/08	144	2:01	358074	4469818	8.8	Silt	None	3.79	13.10	260.00	8.64	7.77

Appendix 6. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/07/08	128	2:07	357962	4469759	9.3	Silt	None	3.74	13.53	261.00	8.67	8.43
03/07/08	153	2:26	356575	4468786	4.3	Silt	None	3.81	13.32	262.00	8.69	9.53
03/07/08	137	2:42	356010	4468883	8.6	Silt	None	3.93	13.64	263.00	8.68	8.66
03/07/08	161	15:40	357696	4468793	12.5	Silt	None	4.20	14.19	266.00	8.41	5.84
03/07/08	176	15:50	358365	4469235	10.9	Silt	None	4.18	13.68	265.00	8.54	5.41
03/07/08	110	15:56	358190	4468738	12.2	Silt	None	4.17	13.50	265.00	8.58	5.10
03/07/08	124	16:04	357636	4468570	13	Silt	None	4.21	13.59	266.00	8.63	5.40
03/07/08	128	16:12	358233	4468877	11.9	Silt	None	4.18	13.85	265.00	8.60	5.57
03/07/08	144	16:17	358384	4469189	10.9	Silt	None	4.18	13.69	265.00	8.50	5.27
03/07/08	108	16:22	358419	4469184	10.6	Silt	None	4.17	13.68	265.00	8.58	4.89
03/07/08	123	16:28	358520	4469307	5.6	Silt	None	4.42	13.66	266.00	8.60	3.51
03/07/08	137	17:25	355449	4469107	2.6	Silt	None	4.67	13.89	269.00	8.69	5.92
03/07/08	155	19:01	357562	4471759	2.9	Silt	Woody	4.18	13.89	255.00	8.76	4.37
03/07/08	152	19:22	357635	4471087	6	Silt	None	4.19	13.54	262.00	8.63	2.63
03/07/08	128	20:30	357808	4469058	*	Silt	None	3.98	12.99	263.00	8.67	5.36
03/07/08	144	20:43	358377	4469386	1.9	Silt	None	3.92	13.28	263.00	8.66	4.67
03/07/08	176	20:51	358376	4469351	4.9	Silt	None	3.93	13.64	263.00	8.63	5.02
03/07/08	123	21:03	358358	4469445	1	Silt	Woody	3.90	13.69	262.00	8.65	5.40
03/07/08	154	21:11	358379	4469133	10.9	Silt	None	3.87	13.21	263.00	8.60	4.13
03/07/08	124	21:16	358295	4468881	12	Silt	None	4.21	13.45	264.00	8.65	4.25
03/07/08	110	21:24	358517	4469422	6.6	Silt	None	4.05	13.63	262.00	8.67	3.82
03/07/08	175	22:27	355157	4469177	5.8	Silt	None	4.09	13.66	263.00	8.70	7.14
03/12/08	152	3:21	358433	4469190	10.3	Silt	None	4.74	13.76	269.00	8.71	6.23
03/12/08	108	3:32	358222	4469101	11.4	Silt	None	5.01	13.86	271.00	8.65	5.85
03/12/08	124	3:46	358072	4468849	11.3	Silt	None	4.93	13.71	271.00	8.67	5.95
03/12/08	110	3:51	358148	4468677	12	Silt	None	4.97	13.68	271.00	8.67	5.50

Appendix 6. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/12/08	112	4:07	357878	4469306	10.3	Silt	None	4.69	13.85	269.00	8.71	5.84
03/12/08	128	4:17	357576	4468559	14.5	Silt	None	4.79	13.51	270.00	8.67	5.49
03/12/08	144	4:33	358336	4469274	10.8	Silt	None	4.92	13.77	270.00	8.69	5.58
03/12/08	176	4:56	357961	4469487	9.6	Silt	None	4.67	13.39	268.00	8.68	6.15
03/12/08	161	5:17	358315	4468849	11.8	Silt	None	5.00	14.16	271.00	8.77	5.30
03/12/08	137	6:02	358061	4470176	6.4	Silt	None	4.85	13.22	268.00	8.71	5.07
03/12/08	154	6:04	358090	4470163	7.5	Silt	None	4.81	13.51	268.00	8.72	3.64
03/12/08	175	7:59	355202	4469236	*	Silt	None	4.96	13.68	271.00	8.75	8.39
03/12/08	155	9:16	357439	4469031	7.7	Silt	None	4.67	13.85	269.00	8.72	9.86
03/12/08	124	9:24	357904	4468549	12.9	Silt	None	4.80	13.74	270.00	8.72	6.92
03/12/08	152	9:37	358074	4468898	10.8	Silt	None	4.91	13.73	270.00	8.71	13.80
03/12/08	108	9:55	358411	4469037	6.4	Silt	None	4.93	13.80	270.00	8.71	6.36
03/12/08	176	10:52	358423	4469311	5.8	Silt	None	4.90	14.54	270.00	8.77	5.66
03/12/08	123	12:04	358057	4469525	7.2	Silt	None	4.96	14.74	271.00	8.75	7.56
03/12/08	124	12:26	357747	4468696	12.9	Silt	None	4.87	14.22	271.00	8.77	8.08
03/15/08	124	0:10	357817	4469724	8.2	Silt	None	6.22	13.42	280.00	8.65	6.11
03/15/08	154	0:45	357937	4470206	8.2	Silt	None	5.80	13.12	276.00	8.59	6.49
03/15/08	155	1:00	357992	4469749	9.1	Silt	None	5.83	13.29	277.00	8.68	6.34
03/15/08	153	1:29	357788	4469336	10.3	Silt	None	5.67	13.35	275.00	8.82	5.76
03/15/08	123	1:45	358463	4469260	9.6	Silt	None	5.37	13.08	274.00	8.81	5.35
03/15/08	112	1:59	357661	4469512	9.4	Silt	None	6.23	13.57	280.00	8.86	5.98
03/15/08	144	2:17	357886	4470278	7.9	Silt	None	5.83	13.12	276.00	8.80	5.67
03/15/08	175	15:32	355143	4469245	7.4	Silt	None	6.17	13.61	281.00	8.75	7.88
03/15/08	137	17:01	356388	4469171	7	Silt	None	6.74	13.46	285.00	8.79	11.80
03/15/08	128	17:16	357620	4468953	12.4	Silt	None	6.71	13.51	284.00	8.78	6.95
03/15/08	108	17:29	357760	4468905	3.7	Silt	None	6.41	13.74	282.00	8.81	13.40

Appendix 6. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/15/08	161	17:55	358026	4468964	10.6	Silt	None	6.55	13.78	283.00	8.84	5.70
03/15/08	124	17:56	358026	4468964	10.6	Silt	None	6.55	13.78	283.00	8.84	6.87
03/15/08	152	18:12	358433	4469203	10	Silt	None	6.73	13.43	285.00	8.80	7.11
03/15/08	110	18:15	358360	4469334	7	Silt	None	6.77	13.74	285.00	8.78	5.33
03/15/08	176	18:43	357897	4469579	9.8	Silt	None	6.60	13.54	284.00	8.81	6.16
03/15/08	144	18:57	357852	4469972	8.5	Silt	None	6.43	13.76	282.00	8.84	6.26
03/15/08	175	22:07	355164	4469247	7.4	Silt	None	5.82	12.96	278.00	8.70	7.79
03/15/08	108	22:57	357546	4468959	12.4	Silt	None	5.77	13.67	276.00	8.58	5.90
03/15/08	152	23:07	358042	4468552	12.2	Silt	None	5.39	12.94	274.00	8.28	5.76
03/15/08	110	23:20	358233	4468780	12.2	Silt	None	5.57	13.25	275.00	8.60	5.22
03/15/08	161	23:43	357815	4468753	12.4	Silt	None	5.44	12.92	275.00	8.46	5.30
03/19/08	152	0:29	358072	4468579	12.3	Silt	None	5.81	13.23	277.00	8.79	5.69
03/19/08	153	0:35	358110	4468626	12.1	Silt	None	5.77	13.34	277.00	8.80	4.81
03/19/08	108	0:41	358248	4468745	9.5	Silt	None	5.74	13.38	276.00	8.81	6.90
03/19/08	123	0:46	358380	4468929	12.2	Silt	None	5.76	13.54	276.00	8.84	4.74
03/19/08	110	1:12	358221	4468795	12.3	Silt	None	5.70	13.40	276.00	8.80	4.70
03/19/08	155	1:24	357630	4468949	12.5	Silt	None	5.66	13.27	276.00	8.82	8.74
03/19/08	154	1:35	356898	4469147	12.9	Silt	None	5.64	13.28	276.00	8.83	4.68
03/19/08	112	2:00	357617	4469704	6	Silt	Woody	5.56	13.14	274.00	8.80	21.00
03/19/08	144	2:16	358101	4468749	11.8	Silt	None	5.71	13.26	276.00	8.81	4.78
03/19/08	128	2:31	357291	4468569	12.2	Silt	None	5.77	13.05	277.00	8.84	4.65
03/19/08	176	2:46	358539	4469527	6.1	Silt	None	6.01	13.61	277.00	8.86	6.28
03/19/08	124	19:30	358093	4468737	12.3	Silt	None	6.03	13.52	279.00	8.80	12.40
03/19/08	153	19:40	358162	4468666	10.6	Silt	None	6.03	13.48	279.00	8.76	13.20
03/19/08	108	19:47	358362	4468938	12.3	Silt	None	5.82	13.50	277.00	8.78	12.50
03/19/08	152	19:55	358462	4469013	6.9	Silt	None	5.73	13.45	277.00	8.77	8.65

Appendix 6. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/19/08	110	20:05	358310	4468810	9.8	Silt	None	6.02	13.48	279.00	8.80	10.50
03/19/08	176	20:13	358384	4469096	8.8	Silt	None	5.68	13.39	276.00	8.73	11.40
03/19/08	123	20:28	357789	4469188	2.3	Silt	None	5.62	13.63	276.00	8.76	7.40
03/19/08	128	20:41	357698	4468617	12.5	Silt	None	5.69	13.47	277.00	8.79	6.72
03/19/08	144	20:56	357284	4469036	4.2	Silt	None	5.80	13.47	277.00	8.77	10.99
03/19/08	161	21:07	356925	4468907	11.2	Silt	None	5.61	13.45	276.00	8.82	13.60
03/19/08	175	21:54	355105	4469227	7.2	Silt	None	6.09	13.20	281.00	8.83	7.69
03/19/08	154	22:13	354745	4469723	6	Silt	None	6.09	13.25	280.00	8.52	12.50
03/19/08	137	23:45	358015	4470704	6.7	Silt	None	5.86	13.32	276.00	8.87	12.70
03/22/08	152	3:41	358339	4468804	6	Rock	None	6.66	12.22	284.00	8.69	7.25
03/22/08	108	3:56	358358	4468822	2.6	Rock	None	6.64	12.57	284.00	8.57	7.62
03/22/08	154	4:27	357096	4468550	2.2	Silt	None	6.72	12.78	285.00	8.60	7.75
03/22/08	110	4:45	358279	4468747	7.6	Silt	None	6.61	12.91	284.00	8.81	7.15
03/22/08	112	5:05	357588	4469726	4	Silt	None	5.93	12.82	278.00	8.79	6.06
03/22/08	128	5:20	358033	4468827	11.3	Silt	None	6.41	12.89	282.00	8.79	6.25
03/22/08	161	6:02	356821	4468804	10.7	Silt	None	6.64	12.59	285.00	8.86	7.75
03/22/08	176	6:24	357293	4468513	11.8	Silt	None	6.56	12.68	284.00	8.84	7.65
03/22/08	124	6:54	356817	4468934	11	Silt	None	6.43	13.03	263.00	8.84	6.03
03/22/08	137	7:00	356764	4468812	10.3	Silt	None	6.66	12.96	285.00	8.83	5.94
03/22/08	153	7:07	356256	4469004	9.9	Silt	None	6.43	12.72	283.00	8.84	10.92
03/22/08	144	7:26	356319	4469154	1.3	Silt	None	6.29	12.82	282.00	8.84	5.95
03/22/08	175	7:52	355160	4469334	7.7	Silt	None	6.35	12.84	283.00	8.84	6.66
03/22/08	155	9:24	358137	4469292	9.8	Silt	None	6.09	13.04	279.00	8.82	7.38
03/22/08	110	9:32	358442	4468953	10	Silt	None	6.51	12.91	283.00	8.82	11.70
03/22/08	153	10:00	358501	4469224	3.4	Silt	None	6.50	13.11	283.00	8.85	5.45
03/22/08	108	10:07	358015	4468499	6.2	Silt	None	6.49	13.02	283.00	8.82	5.33

Appendix 6. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/22/08	128	10:19	357910	4468675	12.4	Silt	None	6.40	13.01	283.00	8.81	4.14
03/22/08	124	10:25	357586	4468673	12.7	Silt	None	6.26	13.06	281.00	8.82	4.43
03/22/08	153	10:44	356647	4468794	3.3	Silt	None	6.64	13.07	285.00	8.85	6.94
03/22/08	144	10:55	356465	4469186	9.9	Silt	None	6.28	13.02	282.00	8.82	5.77
03/22/08	175	14:09	355131	4469227	7.3	Silt	None	6.98	13.13	289.00	8.84	8.11
03/26/08	124	0:14	357988	4469137	11	Silt	None	7.46	12.70	291.00	8.83	5.78
03/26/08	110	0:21	358007	4468677	11.4	Silt	None	7.18	12.73	289.00	8.83	6.83
03/26/08	144	0:27	358175	4468613	2.1	Rock	None	7.18	12.19	289.00	8.81	7.47
03/26/08	161	0:39	358110	4468766	11.6	Silt	None	7.22	12.95	289.00	8.62	5.56
03/26/08	176	1:15	358533	4469601	5.8	Silt	None	8.26	13.27	296.00	8.86	6.67
03/26/08	154	1:41	358095	4470264	1.9	Silt	None	7.60	13.03	291.00	8.86	7.29
03/26/08	153	16:04	357100	4468623	12	Silt	None	7.34	12.70	291.00	8.73	11.40
03/26/08	124	16:13	357484	4468728	12.5	Silt	None	7.34	12.72	291.00	8.69	7.49
03/26/08	154	16:21	357635	4469033	1.9	Silt	None	7.58	12.77	293.00	8.70	10.07
03/26/08	155	16:28	357484	4468633	12.3	Silt	None	7.32	12.84	291.00	8.73	8.06
03/26/08	128	17:04	357970	4468603	12.8	Silt	None	6.96	13.98	291.00	8.56	3.31
03/26/08	144	17:21	358039	4468692	11.5	Silt	None	7.18	14.16	292.00	8.55	2.91
03/26/08	161	17:29	357998	4468745	11.2	Silt	None	7.26	14.25	292.00	8.56	3.45
03/26/08	152	17:43	358087	4468610	12	Silt	None	7.23	15.64	292.00	8.56	2.94
03/26/08	123	17:57	358058	4468500	11.2	Silt	None	6.89	14.45	290.00	8.59	3.95
03/26/08	176	18:15	358252	4469097	11.5	Silt	None	7.44	15.76	293.00	8.62	3.11
03/26/08	108	18:25	358261	4469033	11.7	Silt	None	7.48	14.67	294.00	8.61	2.48
03/26/08	110	18:45	358262	4468720	5.1	Rock	None	8.32	15.05	300.00	8.63	1.46
03/26/08	153	20:02	357103	4468597	13.5	Silt	None	7.37	16.99	293.00	8.61	5.44
03/26/08	155	20:11	357344	4468583	11.9	Silt	None	7.38	16.61	293.00	8.61	5.06
03/26/08	128	20:26	357472	4468507	3.9	Silt	None	7.24	16.47	292.00	8.60	4.81

Appendix 6. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/26/08	124	20:39	357549	4469003	10.2	Silt	None	7.15	16.09	291.00	8.58	1.75
03/26/08	175	22:47	355092	4469242	7.1	Silt	None	7.89	13.11	297.00	8.89	7.93
03/26/08	152	23:29	357924	4468649	12.3	Silt	None	7.25	13.05	290.00	8.89	6.57
03/26/08	123	23:47	357892	4468489	4.1	Rock	None	7.10	12.67	289.00	8.86	8.19
03/26/08	108	23:52	358084	4468631	12.3	Silt	None	7.11	12.62	289.00	8.86	8.81
03/31/08	144	0:35	357245	4468467	8	Silt	None	7.65	15.61	296.00	8.57	3.37
03/31/08	128	0:46	357627	4468501	6.8	Cobble	None	7.52	15.48	295.00	8.57	6.83
03/31/08	152	2:05	358038	4466560	12.4	Silt	None	7.47	15.84	294.00	8.62	7.44
03/31/08	137	2:10	357901	4468527	12.3	Silt	None	7.48	16.16	294.00	8.61	6.61
03/31/08	153	2:10	357901	4468527	12.3	Silt	None	7.48	16.16	294.00	8.61	6.61
03/31/08	123	2:21	358029	4468544	12.1	Silt	None	7.47	15.75	294.00	8.60	6.49
03/31/08	110	2:31	358215	4468757	12.1	Silt	None	7.43	15.89	294.00	8.63	6.20
03/31/08	155	2:31	358215	4468757	12.1	Silt	None	7.43	15.89	294.00	8.63	6.20
03/31/08	108	20:40	357953	4469979	8.8	Silt	None	7.73	15.89	295.00	8.45	4.29
03/31/08	153	21:32	357571	4468479	2.8	Cobble	None	7.60	16.77	295.00	8.60	3.32
03/31/08	123	21:45	357948	4468513	10.9	Silt	None	7.54	15.85	295.00	8.55	3.20
03/31/08	152	22:01	358083	4468546	10.4	Silt	None	7.51	15.93	295.00	8.58	2.92
03/31/08	137	22:18	357908	4468497	6.1	Sand	None	7.52	15.88	295.00	8.55	2.97
03/31/08	110	22:41	358213	4468704	9.9	Rock	None	7.53	15.72	295.00	8.61	3.49
03/31/08	155	22:41	358213	4468704	9.9	Rock	None	7.53	15.72	295.00	8.61	3.49
03/31/08	176	23:11	358470	4469348	5.8	Silt	None	7.39	15.84	294.00	8.52	3.26
03/31/08	154	23:30	357855	4469196	8.9	Silt	None	7.42	15.79	294.00	8.60	3.48
03/31/08	124	23:41	358045	4468903	3.8	Silt	None	7.57	16.08	294.00	8.58	2.69
04/12/08	110	1:16	358221	4469058	8.8	Silt	None	7.61	15.13	294.00	8.88	8.35
04/12/08	128	2:19	357515	4468538	9.3	Silt	None	7.59	10.62	295.00	8.91	6.15
04/12/08	124	2:29	357069	4468720	11.8	Silt	None	*	*	*	*	*

Appendix 6. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
04/12/08	176	3:27	357824	4470198	8.3	Silt	None	*	*	*	*	*
04/12/08	155	23:33	354486	4469701	6.1	Silt	None	7.66	15.69	295.00	8.73	5.89
04/14/08	175	0:15	355075	4469213	7	Silt	None	8.61	11.56	305.00	8.80	3.09
04/14/08	124	0:31	355920	4469011	4.6	Silt	None	8.22	11.47	301.00	8.80	1.89
04/14/08	123	1:25	357781	4470487	4.1	Silt	None	8.55	12.02	301.00	8.70	4.08
04/14/08	128	2:15	358170	4469460	7.8	Silt	None	8.31	11.59	300.00	8.81	2.90
04/14/08	154	2:37	357991	4468492	1.5	Rock	None	8.07	11.84	299.00	8.74	3.68
04/14/08	50	3:12	358116	4468533	2.9	Rock	None	7.96	11.26	298.00	8.79	3.67
04/14/08	128	21:17	357866	4468586	12.5	Silt	None	8.12	11.20	299.00	8.73	7.66
04/14/08	155	21:36	357040	4469045	3.3	Silt	None	8.26	11.54	301.00	8.73	6.63
04/14/08	154	21:52	358230	4468710	7.4	Silt	None	8.28	11.56	300.00	8.78	5.03
04/14/08	153	22:46	356191	4468841	8	Silt	None	8.29	11.71	301.00	8.61	7.24
04/14/08	108	23:04	356800	4469169	3.6	Silt	None	8.38	11.62	300.00	8.78	4.98
04/14/08	176	23:31	356115	4468984	5.5	Silt	None	8.42	11.58	302.00	8.80	7.67
04/14/08	161	23:40	355662	4469460	8.6	Silt	None	8.72	11.74	304.00	8.81	2.10
04/20/08	154	0:51	356594	4468731	1.7	Silt	None	10.64	11.22	321.00	8.88	1.09
04/20/08	123	0:56	356477	4469054	9.9	Silt	None	11.22	11.19	326.00	8.88	2.08
04/20/08	153	1:00	356423	4469209	8.6	Silt	None	11.87	11.27	330.00	8.91	1.78
04/20/08	144	1:57	356766	4468863	10.8	Silt	None	11.08	10.91	324.00	8.88	0.40
04/20/08	161	22:11	353847	4470984	2.5	Silt	None	13.55	9.83	349.00	8.79	10.58
04/20/08	155	22:44	353686	4470428	1.5	Silt	Emergent	12.76	11.78	346.00	8.98	7.88
04/20/08	110	23:58	355849	4469061	4.3	Silt	None	11.23	11.49	326.00	8.87	0.45
04/30/08	144	0:34	355389	4469241	7.9	Silt	None	13.40	11.34	347.00	8.94	6.12
04/30/08	161	0:50	354129	4469943	5.6	Silt	None	14.05	11.39	357.00	9.08	6.15
04/30/08	124	3:36	357640	4469683	6	Silt	None	13.72	11.16	343.00	8.92	7.38
04/30/08	152	20:35	358029	4470583	6.8	Silt	None	13.82	10.73	346.00	8.94	1.56

Appendix 6. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
04/30/08	176	22:12	358331	4469122	11.4	Silt	None	11.75	10.80	331.00	8.88	3.48
04/30/08	123	22:27	356453	4468950	10	Silt	None	13.24	10.52	344.00	8.89	2.99
04/30/08	175	23:31	355199	4469268	7.5	Silt	None	13.52	10.76	349.00	8.93	3.19
05/03/08	175	0:00	355164	4469309	7.6	Silt	None	11.64	14.15	335.00	8.77	5.31
05/03/08	154	0:20	356381	4468846	6.6	Silt	None	11.87	13.59	336.00	8.82	8.81
05/03/08	153	0:27	356472	4468686	4.5	Silt	None	12.08	13.71	337.00	8.73	6.73
05/03/08	155	0:28	356472	4468686	4.5	Silt	None	12.08	13.71	337.00	8.73	6.73
05/03/08	144	0:33	356535	4468888	8	Silt	None	11.80	13.69	335.00	8.72	5.40
05/03/08	110	1:03	357932	4469432	10.3	Silt	None	11.88	13.25	334.00	8.69	4.36
05/03/08	152	1:11	358046	4469729	9.1	Silt	None	11.84	13.52	333.00	8.70	5.07
05/03/08	128	1:46	357260	4468267	9.3	Silt	None	12.15	13.86	337.00	8.74	6.30
05/03/08	176	23:19	353721	4470476	2.8	Silt	None	11.51	15.07	337.00	8.92	9.70
05/03/08	161	23:41	354225	4469919	5.6	Silt	None	11.55	14.25	336.00	8.82	7.33
05/16/08	144	1:39	358104	4470646	6.1	Silt	None	15.55	9.70	362.00	8.95	3.61
05/16/08	128	2:56	357304	4468064	7.3	Silt	None	16.32	9.81	371.00	8.95	4.03
05/16/08	108	3:14	354511	4470092	3.2	Silt	None	15.33	9.98	363.00	9.04	6.08
05/16/08	161	21:14	354453	4469561	6.3	Silt	None	16.14	13.19	380.00	9.07	15.60
05/16/08	124	21:51	357060	4468962	3.6	Silt	None	16.07	11.17	371.00	9.09	8.65
05/16/08	154	21:53	357060	4468962	3.6	Silt	None	16.07	11.17	371.00	9.09	8.65
05/16/08	155	23:46	356728	4468795	4.6	Silt	None	16.34	11.68	375.00	9.11	6.57
05/16/08	152	23:52	358365	4468914	12.2	Silt	None	16.01	10.72	369.00	8.79	5.30
05/25/08	152	21:41	357731	4468563	12.7	Silt	None	18.64	9.87	387.00	8.91	7.76
05/25/08	144	21:46	358005	4468599	12.8	Silt	None	17.92	9.40	380.00	8.92	7.90
05/25/08	155	21:48	358083	4468594	12.6	Silt	None	17.75	9.60	379.00	8.89	10.54
05/25/08	128	21:59	357273	4468208	9.8	Silt	None	19.71	9.42	396.00	8.90	6.73
05/25/08	124	22:29	357747	4468959	5.4	Silt	None	18.57	9.25	370.00	8.93	17.60

Appendix 6. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
06/02/08	154	20:27	356313	4468971	10.2	Silt	None	19.69	9.88	398.00	9.04	6.68
06/02/08	137	20:51	354092	4470106	5.4	Silt	None	20.23	12.10	408.00	9.08	5.90

Appendix 7. Habitat characteristics of telemetry locations of tagged white bass in Enders Reservoir during 2007-2008. * indicates missing data.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/22/07	64	4:35	285600	4478436	>5	*	None	8.90	*	243.50	*	*
03/22/07	53	4:50	285460	4478347	>5	*	None	8.80	*	243.40	*	*
03/22/07	52	5:15	286205	4477774	>5	*	None	8.70	*	245.10	*	*
03/22/07	55	6:25	286016	4478233	0.5	Sand	None	7.80	*	243.50	*	*
03/22/07	47	7:50	285337	4478780	>5	*	None	8.50	*	252.20	*	*
03/22/07	41	8:10	285092	4478903	*	*	None	8.80	*	253.40	*	*
03/22/07	67	8:49	284477	4479204	4.3	Sand	None	9.10	*	254.90	*	*
03/22/07	68	9:34	283824	4478930	3	Sand	None	10.00	*	263.80	*	*
03/22/07	58	9:55	284124	4479278	2.4	Sand	None	9.70	*	257.90	*	*
03/22/07	71	10:09	284172	4479258	3.4	*	None	9.20	*	256.10	*	*
03/22/07	51	10:15	284131	4479280	2.3	Sand	None	9.20	*	257.60	*	*
03/22/07	53	11:30	285603	4478613	>5	*	None	8.80	*	252.40	*	*
03/22/07	64	11:35	285639	4478659	>5	*	None	8.60	*	251.20	*	*
03/22/07	47	12:52	285591	4478497	>5	*	None	8.80	*	253.20	*	*
03/22/07	68	13:21	284308	4479110	*	*	None	9.70	*	258.10	*	*
03/22/07	71	13:38	284155	4479337	3	Sand	None	9.50	*	256.40	*	*
03/22/07	51	13:42	284097	4479307	2.7	Sand	None	9.80	*	258.90	*	*
03/22/07	64	13:46	284040	4479309	2.4	Sand	None	9.90	*	261.00	*	*
03/22/07	44	14:38	284728	4479681	1.8	Sand	None	9.30	*	255.80	*	*
03/23/07	47	15:23	285725	4478325	>5	*	None	10.40	*	259.80	*	*
03/23/07	55	15:34	286005	4478234	1	Sand	None	10.20	*	260.50	*	*
03/23/07	67	16:35	284233	4479202	2.7	Sand	None	10.70	*	266.10	*	*
03/23/07	68	17:45	284277	4479546	1	Sand	None	12.20	*	275.60	*	*
03/23/07	64	20:29	285689	4477859	>5	*	None	9.20	*	255.80	*	*
03/23/07	47	20:45	285348	4478433	3	Sand	None	9.90	*	257.90	*	*
03/23/07	67	21:04	284530	4479105	3	Silt	None	10.40	*	263.30	*	*

Appendix 7. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/23/07	44	21:32	284478	4479547	2	Sand	None	10.70	*	265.10	*	*
03/23/07	68	22:00	284480	4479382	3	Silt	None	10.70	*	266.70	*	*
03/29/07	47	3:48	285579	4479249	>5	*	None	11.97	*	267.00	8.70	13.10
03/29/07	67	4:15	285689	4479078	>5	*	None	11.97	*	267.00	8.74	11.60
03/29/07	53	5:08	286306	4477479	>5	*	None	10.92	*	262.00	8.74	8.86
03/29/07	58	5:45	284963	4479075	>5	*	None	12.03	*	268.00	8.76	10.29
03/29/07	64	6:01	284300	4479058	*	*	None	12.50	*	271.00	8.76	11.00
03/29/07	71	6:05	284303	4479012	3.5	Silt	None	12.45	*	271.00	8.74	12.10
03/29/07	51	6:37	284148	4479328	2.5	Sand	None	12.22	*	267.00	8.75	12.70
03/29/07	49	6:46	284236	4479359	2	Sand	None	12.15	*	268.00	8.75	15.80
03/29/07	47	7:01	285433	4479333	>5	*	None	11.83	*	266.00	8.74	12.00
03/29/07	44	7:55	285315	4479059	>5	*	None	11.78	*	267.00	8.76	11.50
03/29/07	67	8:05	285622	4478976	>5	*	None	11.77	*	266.00	8.75	11.70
03/29/07	53	8:55	286212	4477518	>5	*	None	11.09	*	263.00	8.71	7.63
03/29/07	68	9:27	284539	4479114	>5	*	None	12.28	*	270.00	8.74	14.50
03/29/07	67	10:06	284824	4479471	>5	*	None	11.75	*	267.00	8.73	12.30
03/29/07	47	10:15	285329	4479211	>5	*	None	11.67	*	260.00	8.74	10.63
03/29/07	44	11:23	285712	4478482	>5	*	None	11.46	*	265.00	8.75	7.74
03/29/07	53	13:27	285856	4477641	0.5	Gravel	None	11.63	*	266.00	8.72	9.91
03/29/07	68	14:07	284706	4479235	>5	*	None	12.31	*	270.00	8.78	13.30
03/29/07	67	14:09	284674	4479270	>5	*	None	12.29	*	270.00	8.74	12.10
03/29/07	58	14:55	285514	4479449	>5	*	None	12.20	*	270.00	8.76	11.70
04/08/07	49	0:11	283238	4478638	2	Silt	None	7.08	*	240.00	8.79	3.75
04/08/07	64	20:25	286166	4478109	2	Sand	None	9.44	*	255.00	8.71	12.60
04/08/07	53	20:45	285993	4477775	>4	*	None	9.31	*	254.00	8.70	10.10
04/08/07	41	20:52	285731	4477897	>4	*	None	9.20	*	253.00	8.71	9.67

Appendix 7. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
04/08/07	71	22:09	284450	4479518	>4	*	None	8.60	*	249.00	8.79	8.97
04/08/07	67	22:50	284473	4479052	>4	*	None	8.42	*	248.00	8.78	7.27
04/08/07	51	23:26	284120	4479307	3	Silt	None	8.30	*	247.00	8.84	9.44
04/17/07	58	0:06	284423	4479317	3.5	Silt	None	11.32	*	269.00	9.03	4.58
04/17/07	47	1:24	285646	4478492	>8	*	None	10.83	*	265.00	9.25	1.69
04/17/07	47	2:57	285583	4478167	5	Silt	None	10.68	*	264.00	9.24	2.33
04/17/07	41	20:45	285828	4478414	>4	*	None	10.30	*	262.00	8.95	3.08
04/17/07	47	20:56	285628	4478636	8	Silt	None	10.42	*	263.00	9.25	4.91
04/17/07	68	22:04	284362	4479570	1	Silt	None	11.24	*	269.00	9.17	3.32
04/17/07	67	22:09	284368	4479569	1.5	Silt	None	11.19	*	268.00	9.21	4.14
04/28/07	68	20:53	284413	4479149	>4	Silt	None	14.47	*	295.00	11.69	6.93
04/28/07	58	20:59	284106	4479065	3	Silt	None	15.07	*	301.00	11.65	6.26
04/28/07	42	21:01	274111	4479059	3	Silt	None	15.29	*	303.00	10.97	*
04/28/07	67	21:13	284262	4479250	2.5	Silt	None	14.22	*	294.00	11.72	5.57
05/09/07	41	2:35	285842	4478312	7.4	*	None	16.45	*	307.00	13.44	4.91
05/09/07	44	2:47	285680	4478300	9.7	*	None	16.56	*	308.00	13.88	4.52
05/09/07	71	3:58	286294	4477943	*	Cobble	None	15.50	*	301.00	13.79	4.67
05/09/07	68	20:55	285084	4479550	3.5	Silt	None	18.83	*	326.00	13.83	5.53
05/24/07	51	17:42	284180	4479298	2.5	Silt	None	20.63	*	346.00	9.65	13.00
05/24/07	53	17:49	283182	4478688	2	Silt	None	21.05	*	349.00	9.71	24.40
05/24/07	47	18:15	285374	4478291	3.5	Silt	None	19.45	*	335.00	10.15	15.10
11/18/07	115	17:55	285565	4479412	4.6	Silt	None	8.88	12.57	230.00	7.03	9.08
11/18/07	68	18:37	285764	4479166	10.2	Silt	None	8.82	11.94	229.00	8.67	7.66
11/18/07	41	18:43	285757	4479145	10.1	Silt	None	8.79	11.23	228.00	8.70	7.12
11/18/07	44	18:54	285822	4478889	*	Silt	None	8.65	11.19	227.00	8.69	8.20
11/18/07	140	19:40	286244	4477978	4.2	Silt	None	8.82	11.01	229.00	8.72	8.74

Appendix 7. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
11/18/07	129	19:50	286276	4477989	1.3	Gravel	Woody	8.85	11.11	229.00	8.70	7.35
11/18/07	67	20:06	286307	4477894	2.7	Rock	None	8.95	11.32	229.00	8.67	7.55
11/18/07	125	20:30	285937	4477832	12.4	Silt	None	8.88	11.36	229.00	8.72	7.35
11/18/07	53	21:04	283307	4478591	*	Silt	None	8.19	11.96	234.00	8.72	7.31
02/07/08	171	15:30	*	*	*	*	ICE	2.63	12.52	206.00	8.67	*
02/07/08	125	16:30	*	*	*	*	ICE	2.63	12.52	206.00	8.67	*
02/07/08	140	17:40	*	*	*	*	ICE	2.63	12.52	206.00	8.67	*
02/26/08	166	8:53	284419	4479755	1.5	Silt	Woody	2.64	13.58	203.00	8.47	2.34
02/26/08	125	9:15	*	*	9.3	Silt	ICE	2.96	13.69	205.00	8.63	7.82
02/26/08	157	9:15	*	*	9.3	Silt	ICE	2.96	13.69	205.00	8.63	7.82
02/26/08	115	9:50	285778	4478635	*	Silt	None	2.91	13.63	205.00	8.57	2.83
03/05/08	166	4:10	284563	4479794	2.1	Silt	None	4.33	13.24	213.00	8.57	2.44
03/05/08	140	5:55	286208	4477963	11.5	Silt	None	4.25	13.19	213.00	8.54	1.86
03/05/08	129	6:06	286083	4478158	8.2	Silt	None	4.21	13.00	212.00	8.60	3.05
03/05/08	166	7:37	284468	4479705	2.4	Silt	None	4.23	13.14	213.00	8.55	7.20
03/05/08	140	10:34	286143	4477986	11.9	Silt	None	4.03	13.12	212.00	8.53	6.96
03/05/08	115	11:03	285824	4478702	*	Gravel	None	4.16	13.55	213.00	8.53	2.99
03/05/08	140	14:25	286217	4477969	*	Silt	None	4.16	13.28	212.00	8.54	1.82
03/08/08	140	0:14	286046	4477913	12.2	Silt	None	3.92	12.91	210.00	8.59	3.77
03/08/08	157	0:42	285579	4477984	*	Silt	None	3.98	12.85	211.00	8.61	3.60
03/08/08	129	0:51	286122	4478095	8.7	Silt	None	3.98	13.05	211.00	8.63	3.78
03/08/08	166	1:30	284575	4479604	*	Silt	None	4.14	12.87	212.00	8.64	5.73
03/08/08	115	15:55	285788	4478690	4	Silt	None	4.16	13.55	213.00	8.53	5.84
03/08/08	140	16:41	286259	4477946	*	Silt	None	4.25	13.19	213.00	8.54	8.11
03/08/08	129	17:04	286113	4477929	*	Silt	None	4.06	13.11	212.00	8.56	3.68
03/08/08	49	17:56	284566	4479250	6.7	Silt	None	4.20	13.10	213.00	8.54	3.69

Appendix 7. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/08/08	115	19:31	285815	4478818	*	Silt	None	4.17	13.05	212.00	8.56	1.84
03/08/08	140	21:01	286150	4477880	*	Silt	None	3.92	12.99	212.00	8.57	1.13
03/08/08	115	23:15	285813	4478727	5.3	Silt	None	4.27	13.03	213.00	8.62	1.38
03/13/08	129	5:57	286145	4478097	8.8	Silt	None	5.19	13.15	219.00	8.46	5.88
03/13/08	125	6:55	283535	4478826	4.6	Silt	None	6.29	13.05	228.00	8.47	5.49
03/13/08	115	7:43	285563	4478713	8.3	Silt	None	5.21	13.44	219.00	8.49	4.77
03/13/08	140	9:40	286230	4477959	8.2	Silt	None	5.17	13.14	219.00	8.65	4.77
03/13/08	129	9:51	286144	4478082	8.8	Silt	None	5.16	13.09	219.00	8.66	5.55
03/13/08	125	10:42	282996	4478352	1.3	Silt	Emergent	7.79	12.96	257.00	8.72	10.79
03/13/08	166	11:21	284452	4479770	1.7	Sand	None	5.66	13.77	222.00	8.76	4.86
03/13/08	115	12:20	285805	4478690	*	Silt	None	5.54	13.53	221.00	8.73	4.40
03/13/08	129	12:40	286171	4478083	7.2	Silt	None	5.45	13.32	221.00	8.69	4.34
03/13/08	140	12:45	286215	4478021	*	Silt	None	5.46	13.29	221.00	8.72	7.60
03/13/08	157	13:20	285574	4477996	9.6	Silt	None	5.38	13.35	221.00	8.68	9.34
03/14/08	115	0:37	285761	4478770	11.3	Silt	None	5.67	12.89	222.00	8.67	4.61
03/14/08	140	2:01	286039	4477749	11.9	Silt	None	5.42	12.94	220.00	8.73	3.34
03/14/08	157	2:33	285595	4478007	10.5	Silt	None	5.52	12.95	221.00	8.75	6.10
03/14/08	115	15:47	285735	4478641	10.8	Silt	None	5.74	13.51	223.00	8.68	6.61
03/14/08	129	16:33	286143	4478020	11.7	Silt	None	5.58	13.17	222.00	8.66	8.43
03/14/08	140	17:24	285944	4477811	12.9	Silt	None	5.71	13.18	222.00	8.72	5.57
03/14/08	157	17:43	285551	4477945	9.2	Silt	None	5.74	13.29	222.00	8.74	5.80
03/14/08	115	20:09	285831	4478760	3.1	Silt	None	5.60	13.07	221.00	8.74	4.75
03/14/08	157	20:43	285543	4478017	9.8	Silt	None	5.66	13.10	222.00	8.72	12.80
03/14/08	140	23:15	286049	4477876	12.2	Silt	None	5.50	12.87	221.00	8.72	3.22
03/18/08	115	0:27	285833	44787410	2.1	Sand	None	5.37	12.79	225.00	8.85	6.07
03/18/08	140	1:02	286171	4478007	12.2	Sand	None	5.54	12.97	221.00	8.79	7.52

Appendix 7. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/18/08	157	2:34	285572	4478012	9.9	Silt	None	5.59	12.78	222.00	8.79	5.73
03/18/08	115	16:17	285813	4478669	2.2	Sand	None	5.91	13.25	225.00	8.77	8.26
03/18/08	129	16:50	286165	4478026	11.8	Sand	None	5.75	13.12	222.00	8.76	5.86
03/18/08	140	17:00	286114	4477933	12.4	Silt	None	5.57	13.08	221.00	8.72	7.08
03/18/08	125	18:24	284503	4479138	7	Silt	None	5.70	13.12	222.00	8.79	7.78
03/18/08	171	18:42	282928	4478525	2.8	Silt	None	6.43	13.87	238.00	8.83	7.67
03/18/08	115	19:45	285813	4478689	2.4	Silt	None	5.59	13.23	221.00	8.79	7.97
03/18/08	129	20:44	286186	4478021	10.5	Sand	None	5.29	12.87	219.00	8.78	6.94
03/18/08	140	21:06	286154	4477942	12.4	Silt	None	5.53	13.11	221.00	8.67	4.09
03/18/08	157	21:52	285534	4478049	9.7	Silt	None	5.84	13.07	222.00	8.78	5.17
03/18/08	125	22:39	284674	4479095	7.1	Silt	None	5.78	13.00	222.00	8.80	5.27
03/18/08	171	23:14	282869	4478411	2.2	Silt	Woody	6.38	13.61	241.00	8.91	8.24
03/21/08	115	4:02	285786	4478681	3.8	Sand	None	6.17	12.91	225.00	8.68	6.50
03/21/08	140	4:36	286175	4477925	12.2	Silt	None	6.01	13.02	224.00	8.72	5.38
03/21/08	157	5:40	285573	4478023	10.1	Silt	None	5.97	12.94	224.00	8.76	7.17
03/21/08	125	5:52	285071	4478982	8	Silt	None	6.13	12.97	225.00	8.72	5.66
03/21/08	166	6:45	284435	4479714	2.1	Silt	None	6.23	12.91	225.00	8.78	10.31
03/21/08	49	7:00	284545	4479319	6.4	Silt	None	6.26	12.95	226.00	8.82	13.00
03/21/08	129	7:26	286204	4478054	3.5	Silt	None	5.90	12.94	224.00	8.78	3.61
03/21/08	115	8:08	285827	4478715	2.6	Sand	None	5.67	12.93	225.00	8.78	4.27
03/21/08	140	8:40	286220	4477976	9.5	Silt	None	5.90	12.89	220.00	8.78	5.62
03/21/08	125	10:10	285249	4479308	1.9	Silt	None	6.11	13.02	225.00	8.80	9.03
03/21/08	166	10:22	284431	4479779	1.6	Silt	Submerged	6.31	13.19	224.00	8.86	12.50
03/21/08	140	11:56	286152	4477965	12.3	Silt	None	6.05	12.98	224.00	8.81	16.90
03/21/08	125	13:22	284984	4479193	7.9	Silt	None	6.72	13.27	229.00	8.84	6.33
03/21/08	140	14:20	286169	4478008	12	Silt	None	6.39	13.22	227.00	8.82	5.48

Appendix 7. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/21/08	157	14:48	285601	4478071	11.8	Silt	None	6.91	13.12	231.00	8.83	6.29
03/27/08	140	1:00	286227	4477958	9.8	Silt	None	7.40	13.04	234.00	8.89	5.74
03/27/08	129	1:27	286160	4478033	10.5	Silt	None	7.32	12.88	232.00	8.87	6.11
03/27/08	171	2:29	283148	4478754	0.7	Sand	None	8.63	12.59	244.00	8.58	14.00
03/27/08	115	17:42	285723	4478720	11.3	Silt	None	7.42	17.77	236.00	8.60	6.80
03/27/08	129	18:51	286100	4478117	7.6	Silt	None	7.10	17.21	233.00	8.56	3.73
03/27/08	140	20:10	286199	4477905	11.9	Silt	None	7.27	17.32	234.00	8.60	6.60
03/27/08	125	21:36	283517	4478740	5.6	Silt	None	8.89	12.75	246.00	8.98	6.37
03/27/08	171	21:47	283065	4478740	3.9	Silt	None	8.90	12.62	246.00	8.97	7.03
03/27/08	115	23:14	285788	4478739	9.6	Silt	None	7.18	12.79	232.00	8.89	7.39
04/01/08	140	1:43	286052	4477950	12.5	Silt	None	7.29	16.92	234.00	8.64	2.78
04/01/08	125	2:02	284648	4479108	6.9	Silt	None	7.61	16.92	238.00	8.73	2.50
04/01/08	115	2:42	285839	4478967	8.2	Silt	None	7.71	16.72	238.00	8.70	2.13
04/01/08	115	16:41	285815	4478991	10	Silt	None	9.25	17.00	249.00	8.66	3.75
04/01/08	129	17:16	286150	4478062	10.4	Silt	None	8.41	17.77	242.00	8.67	3.96
04/01/08	140	17:28	286184	4477968	11.9	Silt	None	8.52	17.64	243.00	8.70	4.02
04/01/08	157	19:06	285511	4478044	9.3	Silt	None	7.84	17.59	239.00	8.64	2.84
04/01/08	125	19:23	285014	4478908	6.8	Silt	None	7.51	17.68	237.00	8.69	4.61
04/01/08	171	19:26	284975	4478948	6.8	Silt	None	7.45	17.68	236.00	8.65	3.52
04/01/08	115	21:44	285782	4478998	10.7	Silt	None	7.85	17.47	239.00	8.72	4.34
04/01/08	157	23:14	285562	4478010	9.6	Silt	None	7.40	16.92	236.00	8.45	4.40
04/01/08	171	23:20	285497	4478020	8.4	Silt	None	7.38	16.75	235.00	8.57	3.41
04/13/08	115	3:27	285782	4478740	8.2	Silt	None	7.40	11.66	235.00	8.95	6.62
04/13/08	125	21:44	284020	4478960	5.4	Silt	None	8.01	11.45	239.00	8.71	8.62
04/21/08	115	0:29	285787	4478967	10.3	Silt	None	10.23	10.47	256.00	8.80	2.80
04/21/08	166	20:23	284403	4479747	1.3	Sand	Submerged	11.95	10.50	267.00	8.90	6.24

Appendix 7. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
04/21/08	125	20:30	284096	4478960	5.9	Silt	None	11.54	10.47	265.00	8.85	5.13
04/21/08	140	22:04	286179	4477910	11.7	Silt	None	11.16	10.22	263.00	8.84	4.44
05/05/08	157	2:51	285493	4478089	9.3	Silt	None	11.60	10.98	266.00	8.88	4.49
05/05/08	125	23:35	283249	4478921	2.6	Silt	None	14.27	11.68	285.00	8.99	2.33
05/15/08	115	1:51	285824	4478998	9.8	Silt	None	13.59	9.47	282.00	8.87	4.86
05/15/08	157	2:49	285560	4478018	9.5	Silt	None	13.86	9.58	253.00	8.89	4.99
05/15/08	140	3:00	286143	4477956	11.5	Silt	None	13.98	9.63	284.00	8.88	6.09
05/15/08	129	3:03	286162	4477994	11.6	Silt	None	13.91	9.51	284.00	8.88	5.35
05/15/08	125	22:29	284328	4479225	5.3	Silt	None	14.20	7.79	286.00	8.79	6.22
05/15/08	167	22:47	283862	4479364	1	Silt	Woody	14.81	10.49	287.00	8.97	5.77
05/26/08	140	20:00	286047	4477945	11.9	Silt	None	16.73	14.16	304.00	8.91	4.15
05/26/08	115	20:07	285780	4478960	10.2	Silt	None	16.71	13.14	304.00	8.96	4.99
05/26/08	157	20:29	285564	4477988	9.4	Silt	None	17.11	14.97	307.00	8.90	3.70
05/26/08	167	20:50	283895	4479341	0.9	Silt	Woody	17.02	14.97	306.00	8.98	6.48

Appendix 8. Habitat characteristics of telemetry locations of tagged white bass in Red Willow reservoir during 2007-2008. * indicates missing data.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/21/07	19	7:30	357468	4468901	>5	*	None	8.30	*	315.00	*	*
03/21/07	38	7:45	357525	4468709	>5	*	None	8.30	*	312.50	*	*
03/21/07	38	11:30	357608	4468587	>5	*	None	8.60	*	306.50	*	*
03/21/07	18	12:35	356261	4468840	2	Silt	None	9.30	*	312.80	*	*
03/21/07	39	13:05	356207	4469080	>5	*	None	9.20	*	308.80	*	*
03/24/07	38	1:30	356951	4468871	>5	*	None	10.10	*	320.10	*	*
03/24/07	39	1:40	356256	4468879	>5	*	None	10.50	*	321.10	*	*
03/24/07	1	16:31	357519	4471276	2	Silt	Woody	12.90	*	340.60	*	*
03/24/07	1	21:00	357632	4471292	2.5	Silt	Woody	12.80	*	338.50	*	*
03/24/07	19	21:25	357489	4468879	>5	*	None	10.30	*	318.30	*	*
03/24/07	39	21:44	356264	4469038	>5	*	None	10.70	*	322.40	*	*
03/24/07	18	21:58	355989	4468940	2	*	None	10.50	*	320.80	*	*
03/28/07	1	8:04	357621	4471560	1	Sand	Woody	11.33	*	327.00	8.82	24.50
03/28/07	19	9:50	357459	4468991	*	*	None	11.02	*	322.00	8.87	12.30
04/08/07	39	1:35	356132	4469081	*	Silt	None	9.93	*	320.00	8.76	30.90
04/08/07	36	9:15	358316	4468822	>5	Rock	None	9.87	*	319.00	8.73	29.70
04/08/07	38	9:18	358292	4468812	>5	Rock	None	9.88	*	319.00	8.72	29.50
04/16/07	1	3:09	357673	4471254	2.5	Silt	Woody	11.42	*	342.00	8.79	20.40
04/16/07	18	6:47	354715	4469427	2.5	Silt	None	12.34	*	371.00	8.91	17.70
04/16/07	39	7:07	356187	4469085	>4	*	None	11.24	*	340.00	8.89	14.00
04/26/07	39	1:21	356207	4468989	>4	*	None	13.77	9.91	361.00	10.12	29.70
05/08/07	38	1:33	357573	4468628	10.4	*	None	17.66	*	403.00	12.52	11.00
05/08/07	19	4:40	358091	4469001	*	Silt	None	17.63	*	398.00	12.57	7.24
05/29/07	19	11:30	357534	4468941	>7	*	None	19.62	*	427.00	11.35	16.40
11/19/07	107	6:00	356973	4468870	11.1	Silt	None	8.89	10.82	291.00	8.57	16.60
11/19/07	122	6:00	356973	4468870	11.1	Silt	None	8.89	10.82	291.00	8.57	16.60

Appendix 8. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
11/19/07	101	6:53	355398	4469110	3.9	Silt	None	8.49	11.22	289.00	8.67	31.50
11/19/07	151	7:05	355650	4469161	5.6	Silt	None	8.52	10.80	288.00	8.64	19.00
11/19/07	143	7:52	357356	4468523	13.6	Silt	None	8.96	10.95	291.00	8.69	19.10
11/19/07	142	8:05	357974	4468938	8.6	Silt	None	9.01	10.93	291.00	8.65	30.50
11/19/07	113	9:17	358104	4468741	11.6	Silt	None	8.97	10.64	291.00	8.58	45.10
02/07/08	151	9:35	*	*	*	*	ICE	2.90	12.27	262.00	8.52	*
02/07/08	109	9:40	*	*	*	*	ICE	2.90	12.27	262.00	8.52	*
02/07/08	142	9:47	*	*	*	*	ICE	2.90	12.27	262.00	8.52	*
02/26/08	151	1:47	*	*	9.6	*	ICE	3.71	14.08	267.00	8.57	2.65
02/26/08	122	2:08	357063	4468765	11.1	Silt	None	3.66	13.35	267.00	8.50	2.07
03/06/08	127	5:55	356530	4469170	9.9	Silt	None	4.00	13.09	263.00	8.68	5.66
03/06/08	101	6:10	355221	4469156	3.8	Silt	None	3.54	13.40	257.00	8.73	6.86
03/06/08	141	9:58	357418	4472301	1.7	Silt	Woody	3.97	12.96	249.00	8.79	9.42
03/06/08	122	10:30	356928	4468940	11	Silt	None	3.95	13.72	264.00	8.60	3.92
03/06/08	151	11:07	355787	4469232	8.7	Silt	None	4.02	13.74	263.00	8.71	4.08
03/06/08	116	11:32	354146	4469881	5.5	Silt	None	4.05	13.59	262.00	8.74	4.56
03/06/08	107	11:50	353180	4471071	2.2	Silt	None	3.86	15.02	268.00	8.79	10.55
03/06/08	141	14:25	357426	4472272	1.5	Silt	Woody	5.02	14.59	259.00	8.80	18.30
03/07/08	127	0:40	357328	4468598	12.7	Silt	None	3.93	13.48	263.00	8.67	6.79
03/07/08	122	16:46	356894	4468868	11	Silt	None	4.19	13.94	266.00	8.67	9.78
03/07/08	127	16:51	356790	4469040	10.7	Silt	None	4.12	13.88	265.00	8.63	5.63
03/07/08	151	17:00	356113	4469366	8	Silt	None	4.25	13.76	265.00	8.66	5.38
03/07/08	101	17:19	355356	4469176	7.5	Silt	None	4.32	14.09	266.00	8.70	5.92
03/07/08	116	18:00	354006	4469923	4.6	Silt	None	4.06	14.23	263.00	8.77	7.85
03/07/08	168	18:00	354006	4469923	4.6	Silt	None	4.06	14.23	263.00	8.77	7.85
03/07/08	109	18:42	357344	4472273	2.1	Silt	Woody	4.51	14.81	257.00	8.82	7.63

Appendix 8. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/07/08	141	18:47	357413	4472271	1.5	Silt	Woody	4.74	14.81	260.00	8.80	6.72
03/07/08	127	21:46	357348	4468527	14.2	Silt	None	4.01	13.09	263.00	8.64	5.55
03/07/08	122	21:54	356917	4468928	10.8	Silt	None	3.90	13.41	263.00	8.66	7.94
03/07/08	151	22:06	355958	4468988	4.9	Silt	None	4.02	13.48	264.00	8.66	6.90
03/07/08	101	22:23	355209	4469175	6.9	Silt	None	4.15	13.62	264.00	8.70	8.27
03/07/08	168	22:45	353762	4470230	2.9	Silt	None	3.98	13.79	262.00	8.77	8.24
03/07/08	107	22:56	353536	4470876	2.6	Silt	None	3.77	14.58	267.00	8.75	10.13
03/12/08	143	7:12	356994	4469258	2.3	Silt	None	4.55	13.34	268.00	8.78	4.72
03/12/08	122	7:31	356850	4468743	7.7	Silt	None	4.95	13.58	271.00	8.75	5.07
03/12/08	101	7:45	355758	4469310	9.1	Silt	None	4.76	13.58	270.00	8.74	5.50
03/12/08	116	8:17	354039	4469914	5.1	Silt	None	5.12	13.72	273.00	8.79	19.80
03/12/08	107	8:40	352855	4471175	0.7	Silt	Woody	6.12	10.78	318.00	8.52	29.80
03/12/08	141	11:15	357385	4472280	1.7	Silt	Woody	6.09	14.30	273.00	8.80	8.99
03/15/08	101	15:25	355249	4469315	7.8	Silt	None	6.27	13.48	282.00	8.65	7.36
03/15/08	116	15:46	354056	4469887	5.3	Silt	None	6.69	13.60	287.00	8.82	8.97
03/15/08	168	15:51	354034	4469940	5.3	Silt	None	6.72	13.60	287.00	8.82	8.81
03/15/08	151	16:02	353867	4470431	4.6	Silt	None	7.25	13.36	283.00	8.83	9.97
03/15/08	107	16:18	353217	4471114	2.2	Silt	None	8.16	12.96	310.00	8.78	18.10
03/15/08	122	17:10	356916	4468904	11.2	Silt	None	6.92	13.39	287.00	8.79	5.42
03/15/08	109	18:27	357322	4472260	0.8	Silt	Woody	7.86	13.84	288.00	8.87	17.30
03/15/08	141	18:31	357383	4472276	1.1	Silt	Woody	8.31	13.88	290.00	8.88	30.40
03/15/08	107	21:02	353062	4471083	1.7	Silt	None	8.03	12.93	311.00	8.91	24.80
03/15/08	151	21:17	353951	4470289	4.8	Silt	None	6.90	12.87	288.00	8.75	12.50
03/15/08	116	21:31	354000	4470028	5.2	Silt	None	6.51	13.29	285.00	8.66	8.23
03/15/08	168	21:33	354024	4470076	5.5	Silt	None	6.53	13.10	286.00	8.72	14.50
03/15/08	101	22:02	355141	4469345	7.5	Silt	None	6.21	13.57	281.00	8.69	7.09

Appendix 8. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/15/08	127	22:42	356526	4468838	6.6	Silt	None	5.53	12.97	276.00	8.70	7.09
03/19/08	122	21:02	356910	4468886	11.2	Silt	None	5.75	13.39	277.00	8.97	10.93
03/19/08	127	21:22	356421	4469163	9.9	Silt	None	5.63	13.00	276.00	8.81	12.10
03/19/08	151	21:41	356128	4469330	9	Silt	None	5.73	13.41	277.00	8.88	13.50
03/19/08	101	22:30	354960	4469515	7	Silt	None	5.81	13.23	278.00	8.84	7.09
03/19/08	168	22:45	354105	4470158	5.2	Silt	None	6.21	13.56	283.00	8.88	8.37
03/22/08	168	7:15	356515	4468724	5	Silt	None	6.70	12.69	285.00	8.85	11.80
03/22/08	107	8:00	355135	4469191	6.5	Silt	None	6.81	12.81	287.00	8.85	14.10
03/22/08	116	8:14	354035	4469897	5.2	Silt	None	6.80	12.63	288.00	8.84	11.20
03/22/08	141	8:51	357395	4472256	1.2	Silt	Woody	7.54	12.89	285.00	8.97	14.60
03/22/08	127	9:10	357817	4470648	2.9	Silt	Woody	6.64	12.82	282.00	8.86	18.10
03/22/08	168	10:35	356745	4469029	10.8	Silt	None	6.32	12.86	282.00	8.83	4.69
03/22/08	107	11:04	355858	4469407	8.8	Silt	None	6.30	13.05	282.00	8.80	5.69
03/22/08	116	13:50	354052	4469848	5.2	Silt	None	7.20	13.23	293.00	8.90	11.10
03/22/08	101	14:04	355323	4469166	5.7	Silt	None	6.97	13.06	289.00	8.85	9.49
03/22/08	141	14:27	357376	4472246	1.4	Silt	Woody	8.25	13.41	292.00	8.83	13.00
03/22/08	127	14:39	357774	4470894	5.8	Silt	None	6.84	13.15	285.00	8.83	8.83
03/26/08	168	0:56	358010	4469373	10.3	Silt	None	7.42	12.81	291.00	8.79	4.95
03/26/08	107	1:52	357620	4471121	5.5	Silt	None	8.13	13.41	294.00	8.91	11.20
03/26/08	122	2:47	356903	4468887	11.1	Silt	None	7.38	13.25	291.00	8.80	6.38
03/26/08	168	18:31	358154	4468916	11.7	Silt	None	7.46	14.79	294.00	8.59	2.55
03/26/08	122	19:29	356705	4468856	7.6	Silt	None	7.48	16.46	294.00	8.62	1.70
03/26/08	116	22:11	354068	4469899	5.4	Silt	None	8.35	13.39	302.00	8.98	12.30
03/26/08	127	22:27	354743	4469586	6.8	Silt	None	8.08	13.20	299.00	8.91	9.04
03/26/08	101	22:44	355188	4469213	7.4	Silt	None	7.91	13.09	297.00	8.89	8.21
03/26/08	151	22:59	355305	4469456	7.7	Silt	None	7.86	13.17	295.00	8.88	8.88

Appendix 8. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
03/31/08	151	0:08	357642	4468896	12.6	Silt	None	7.47	15.44	294.00	8.55	3.29
03/31/08	107	1:09	357060	4468903	7.8	Silt	None	7.47	15.48	294.00	8.60	7.47
03/31/08	122	1:09	357060	4468903	7.8	Silt	None	7.47	15.48	294.00	8.60	7.47
03/31/08	127	1:48	355100	4469329	7.4	Silt	None	7.96	15.53	300.00	8.72	10.83
03/31/08	122	17:04	356957	4468804	11.6	Silt	None	7.69	15.90	296.00	8.40	4.21
03/31/08	143	17:20	357052	4469214	3	Silt	None	7.82	16.08	297.00	8.47	5.13
03/31/08	168	17:38	356140	4469002	9.8	Silt	None	7.87	15.76	298.00	8.50	5.13
03/31/08	127	17:50	355887	4469167	9.1	Silt	None	7.95	15.63	299.00	8.57	4.39
03/31/08	101	18:10	355382	4469239	8.2	Silt	None	8.21	16.08	303.00	8.66	3.45
03/31/08	113	18:27	354731	4469867	4.6	Silt	None	8.26	16.08	303.00	8.66	5.12
03/31/08	116	18:50	354027	4470116	5.5	Silt	None	8.38	16.03	306.00	8.68	7.04
03/31/08	141	19:57	357371	4472270	1.2	Silt	Woody	8.48	17.33	295.00	8.56	10.22
03/31/08	109	20:05	357392	4472245	1.6	Silt	Woody	8.49	17.48	296.00	8.77	12.70
03/31/08	107	21:55	358036	4468710	12	Silt	None	7.51	15.94	295.00	8.53	2.92
04/12/08	151	1:12	358221	4469058	8.8	Silt	None	7.61	15.13	294.00	8.88	8.35
04/12/08	122	1:25	356475	4468775	8.8	Silt	None	7.61	15.13	294.00	8.88	8.35
04/14/08	116	0:47	354028	4469850	4.8	Silt	None	8.74	11.92	311.00	8.91	8.93
04/14/08	107	22:04	357854	4469014	9.1	Silt	None	8.14	11.53	299.00	8.76	6.03
04/14/08	151	22:18	358073	4469523	6.9	Silt	None	8.34	11.61	300.00	8.78	4.58
04/14/08	168	23:17	356427	4469270	1.4	Silt	Woody	9.06	11.84	307.00	8.82	6.62
04/14/08	101	23:59	355279	4469162	5.9	Silt	None	8.53	11.68	304.00	8.43	3.69
04/20/08	122	2:00	357068	4468904	7.3	Silt	None	11.01	11.08	323.00	8.87	1.30
04/20/08	116	22:23	354021	4469853	4.6	Silt	None	12.29	10.93	341.00	8.94	6.67
04/20/08	127	22:35	353302	4470906	1.9	Silt	Woody	14.39	12.35	366.00	9.08	13.40
04/20/08	168	22:49	353811	4470555	4.2	Silt	None	12.94	11.97	348.00	8.82	7.10
04/20/08	107	23:44	354588	4469471	6.6	Silt	None	11.63	11.64	331.00	8.67	2.34

Appendix 8. Continued.

Date	Tag #	Time	UTM N	UTM E	Depth (m)	Substrate Type	Cover Type	Temp (°C)	DO (mg/L)	Cond (µS/cm)	pH	Turbidity (NTU)
04/22/08	116	22:09	354029	4469873	5.1	Silt	None	12.92	11.20	345.00	8.95	2.43
04/22/08	168	22:12	353967	4470237	4.9	Silt	None	13.63	11.53	353.00	8.99	4.28
04/30/08	116	0:50	354129	4469943	5.6	Silt	None	14.05	11.39	357.00	9.08	6.15
04/30/08	141	20:17	357400	4472268	1.4	Silt	Woody	17.77	9.59	373.00	9.01	6.61
04/30/08	127	20:54	353332	4471089	2.5	Silt	None	16.16	13.36	377.00	9.25	8.44
04/30/08	151	21:44	356066	4468954	4.8	Silt	None	13.55	10.64	347.00	8.89	3.32
04/30/08	168	23:21	354495	4469391	1.7	Silt	None	14.03	11.16	353.00	8.99	6.56
04/30/08	101	23:34	355164	4469275	7.5	Silt	None	13.58	10.68	349.00	8.93	3.55
05/03/08	101	0:04	355246	4469233	7.6	Silt	None	11.78	14.11	336.00	8.77	9.05
05/03/08	122	0:45	356914	4468817	11.3	Silt	None	11.83	13.67	335.00	8.68	6.94
05/03/08	127	23:27	353812	4470137	1.8	Silt	Emergent	11.51	15.02	337.00	8.92	15.80
05/03/08	116	23:45	354142	4470056	5.4	Silt	None	11.52	14.25	336.00	8.85	7.55
05/03/08	168	23:51	354481	4469624	6.2	Silt	None	11.52	14.16	335.00	8.81	6.72
05/16/08	151	0:09	358289	4469461	1.5	Silt	None	15.91	9.97	367.00	9.01	1.58
05/16/08	141	1:19	357417	4472259	1.4	Silt	Woody	15.69	10.89	358.00	8.95	12.10
05/16/08	109	1:22	357364	4472266	1.5	Silt	Woody	15.34	10.97	355.00	9.03	11.70
05/16/08	101	21:25	355250	4469152	4	Silt	None	16.34	12.29	376.00	9.16	10.29
05/16/08	127	21:37	355516	4469309	8.2	Silt	None	15.93	11.91	373.00	9.13	7.88
05/25/08	168	20:56	354828	4469505	7.2	Silt	None	18.94	10.24	395.00	9.00	9.20
05/25/08	101	21:04	355251	4469229	7.9	Silt	None	18.95	9.99	393.00	8.97	7.54
06/02/08	151	20:07	357842	4469148	8.4	Silt	None	19.56	9.94	391.00	9.06	4.58
06/02/08	101	20:39	355259	4469188	7.8	Silt	None	19.84	10.12	401.00	9.02	7.99
06/02/08	116	20:56	354049	4470001	5.9	Silt	None	20.06	12.33	406.00	9.07	12.00