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SPAWNING BIOLOGY OF CHANNEL CATFISH

Ictalurus punctatus (Rafinesque)

IN WILLARD BAY RESERVOIR, UTAH

by

Stuart Terry Shipman

A thesis submitted in partial fulfillment  
of the requirements for the degree

of

MASTER OF SCIENCE

in

Wildlife Science

Approved:

UTAH STATE UNIVERSITY  
Logan, Utah

1977

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## ABSTRACT

This study was conducted on Willard Bay Reservoir, Utah, during the summers of 1972 and 1973, to study the spawning biology of the channel catfish (Ictalurus punctatus), and to evaluate potential reproduction for this species in the reservoir. Potential reproduction was evaluated through examination of available natural habitat and use of artificial habitat provided for this study.

Channel catfish were found to mature by the end of their fourth year and spawn from mid-June through August. A total of 12 nesting channel catfish were observed along 15, 0.8 kilometer (0.5 mile) sections of dike. Ten of these 12 nests were along the dike-bottom interface. Numerous other areas along these sections of dike were considered to be favorable spawning habitat.

Only four fish, two black bullheads (Ictalurus melas) and two channel catfish, were observed using artificial spawning habitat. All four fish utilized milk cans as spawning structures, rather than tire groups or plastic trash cans.

Results indicated that there is suitable habitat available in the reservoir to accommodate a much larger population of channel catfish spawners. Length frequency analysis and capture of young-of-the-year show that channel catfish had spawned successfully each year since 1971.



## INTRODUCTION

Willard Bay Reservoir is a freshwater impoundment with the potential for developing an outstanding sport fishery. The bay is unique in that it has only a limited amount of natural shoreline, enclosed almost entirely by a riprap dike. It has a topography similar to that of a farm pond with mostly steep banks grading down to a uniform sediment basin.

One of the principal game fish in Willard Bay Reservoir is the channel catfish (Ictalurus punctatus). The development of the channel catfish fishery, however, has been disappointing, showing only limited productive success (Summers 1971). This study was initiated to determine the channel catfish reproductive potential in Willard Bay Reservoir. Hopefully, this information can then be extrapolated to other bodies of water where channel catfish are desired but natural reproduction is limited.

The objectives of this study were:

1. Study the parameters of channel catfish spawning biology in Willard Bay Reservoir.
2. Evaluate the riprap dike as channel catfish spawning habitat.
3. Study the feasibility of using artificial structures as channel catfish spawning habitat.
4. Make recommendations on improving the reproductive potential of channel catfish in Willard Bay Reservoir.

## REVIEW OF LITERATURE

Morphological description and range

Channel catfish are members of the family Ictaluridae, the freshwater catfish. Channel catfish are distinguished by a naked, slender body and a deeply forked tail. Their body color ranges from bluish-olive to dark gray, often with distinct black spots. Members of this family also have an adipose fin and numerous barbels around the mouth. Channel catfish are often confused with blue catfish; however, the two species can be readily distinguished on the basis of anal fin rays, with channel catfish having 24 to 29 rays and blue catfish having over 30 rays (Eddy and Underhill 1974; Harlan and Speaker 1956; Hubbs and Lagler 1958; Pflieger 1975; Sigler and Miller 1963; Trautman 1957).

The channel catfish native range extends from east of the rockies through the Ohio Valley, north to the Canadian prairie provinces and south to the Gulf of Mexico and Florida. This historic range has been extended to many lakes and rivers in both the Atlantic and Pacific drainages (Eddy and Underhill 1974; Hubbs and Lagler 1958; Sigler and Miller 1963; Trautman 1957).

Channel catfish were first stocked in Utah about 1888 (Sigler and Miller 1963). Utah Lake was first stocked in 1911 and numerous times since then (Lawler 1960). Presently, channel catfish are considered common in the Bear, Green, and Colorado Rivers and abundant in Utah Lake (Sigler and Miller 1963).

### Habitat

Channel catfish have been found to inhabit and flourish in a wide range of habitats (Dill 1944). Trautman (1957) considered the greatest channel catfish populations to occur in deep, large waters with fairly clear bottoms of sand, gravel, or boulders. Hubbs and Lagler (1958) described channel catfish as typical of large rivers and lowland lakes. Miller (1966) described the channel catfish favorite habitat as moderate to swift flowing streams. He also considered them abundant in many sluggish streams, lakes, and large reservoirs. Pflieger (1975) also considered channel catfish especially characteristic of large streams having low to moderate gradients. Numerous large reservoirs have moderate to very good channel catfish populations and fisheries (California Fish and Game 1971; Carrol and Hall 1964; Conder and Hoffarth 1962; Jearld 1970; Jester 1962; Nelson 1961; Schoffman 1967; Shields 1957; Sprague 1959, 1960, 1961; Stevens 1959).

Because channel catfish are found over such a wide range of habitats, it follows that they can tolerate wide variations in water quality. In general, these fish do tolerate water from 1C to 34C (Allen and Strawn 1968) with 21C to 29C considered an optimum temperature range (Byford 1970; Hatcher 1972). They feed sparingly if water temperature is under 16C (Hatcher 1972) and go off feed completely if water temperature is below 10C (Collins 1970).

Dissolved oxygen levels are considered favorable for channel catfish if they range from saturation to 5 ppm (McNeely and Pearson 1974; Simco and Cross 1966; Smith 1971; Weeks and Ogburn 1972). This species can also tolerate dissolved oxygen levels of 2 to 3 ppm for short periods of time (Simco and Cross 1966; Smith 1971). Acclimatized

channel catfish from 20 to 105 gm died when oxygen levels were 0.76, 0.89, and 0.92 ppm with water temperatures of 25, 30, and 35C respectively (Moss and Scott 1961).

Wallen (1951) found that small channel catfish in aerated aquaria succumbed at a turbidity value of 85,000 ppm, a level seldom obtained in nature. Excessive turbidity has been linked to retarding time to maturity for channel catfish (Buck 1956; Lawler 1960). However, a naturally reproducing population of channel catfish has been documented in the Little Missouri River where turbidity has been measured as high as 85,570 ppm (Van Eeckhout 1974).

Channel catfish have successfully reproduced in waters with salinities of 2.0 ppt (Perry 1968, 1973). Other investigators considered 7 to 8 ppt as a maximum allowable salinity for successful catfish culture (Byford 1970; Perry and Avault 1969; Weeks and Ogburn 1972). Allen and Avault (1969) found that channel catfish eggs could tolerate salinities up to 16 ppt. Perry (1968) observed channel catfish in water with salinities to 11.4 ppt. Generally, channel catfish can stand fairly high salinity levels but will avoid, if possible, high salinity concentrations (Lantz 1970; McCammon and La Faunce 1961).

Total alkalinity and hardness are important when considering the buffering capacity and relative productivity of a system. Byford (1970) and Weeks and Ogburn (1972) established minimum alkalinity and hardness levels necessary in channel catfish culture at 25 ppm and 20 ppm respectively. Simco and Cross (1966) stated that total alkalinity ranging from 50 to 150 ppm was preferred in catfish culture. Hatcher (1972) thought a hardness level of above 15 ppm was adequate for maintenance of channel catfish.

The channel catfish optimum range for pH is 6.5 to 9.0 (Hatcher 1972; Simco and Cross 1966; Smith 1971; Walker 1972). Simco and Cross (1966) did not consider small diurnal fluctuations in pH a problem in catfish culture, as long as the system was well buffered.

In summary, channel catfish can tolerate a wide range of physical and chemical conditions. Water temperature from 10 to 34°C with dissolved oxygen concentrations from 5 ppm to saturation are considered liveable. Channel catfish are very turbidity resistant. They can survive in salinities up to 11.4 ppt but prefer concentrations under 2.0 ppt. Minimum levels for total alkalinity and hardness are 25 ppm and 15 ppm respectively. Optimum pH lies between 6.5 and 9.0.

#### Movement and distribution

Many studies have been conducted concerning the movement of channel catfish. Most of this work has been done on river systems and tributaries to reservoirs and lakes. Harrison (1953), Muncy (1958), Behmer (1964), and Mayhew (1971) all studied the movement of channel catfish in the Des Moines River, Iowa. These studies indicated that the majority of the channel catfish in this river were rather sedentary, but movements of individuals could range from 113 km downstream to 249 km upstream.

Hubley (1963), studying the movement of stocked and resident channel catfish in the Mississippi River, found that the resident population tended toward downstream movement, while a large percentage of the stocked fish moved upstream. Maximum distances traveled were 179 km downstream and 344 km upstream. Welker (1967), working in the Little Sioux River, Iowa, also found that stocked fish showed a greater tendency toward upstream movement, while resident fish generally moved downstream.

Seaman (1948) showed that commercially raised channel catfish stocked in the Ohio River, West Virginia, had a greater tendency toward downstream movement. Wickliff (1933, 1938) reported that channel catfish taken from Ohio Lakes would move downstream when later stocked in streams.

Humphries (1965) described the movement of channel catfish from the Savannah River, Georgia, as consisting of three distinct types; limited movement associated with normal activity, spring ascent into tributary streams, and random, long distant movement throughout a system.

Funk (1955) considered the channel catfish of Missouri as consisting of two separate groups. One group was sedentary, showing only limited movement within a fairly confined section of river. The second group was highly mobile, moving large distances in an apparent random fashion.

Thompson (1933) thought movement of channel catfish in Illinois was mostly random rather than a predetermined migration, while Trautman (1957) reported that adult channel catfish were highly migratory, often ascending small tributaries to spawn.

Movement and distribution of channel catfish in lakes and reservoirs is not well documented. Many investigators have described channel catfish migrations out of reservoirs into tributaries (Madsen 1969, 1970, 1971; Messman 1973; Van Eeckhout 1974; Wahtola 1971). Houser (1959) studied the homing tendency of channel catfish in large reservoirs in Oklahoma. Although only a small percentage of the tagged fish were recaptured at their home station; Houser considered it significant evidence of homing.

Ziebell (1973) tracked channel catfish in Parker Canyon Lake, Arizona, using ultrasonic transmitters. He described their favored habitat as among the boulders of the dam and at the edges of Myrio phyllum beds in small pockets or holes. Ziebell also thought one pair of tagged catfish moved to the dam to spawn.

Lawler (1960) described the channel catfish in Utah Lake as mostly sedentary. They did exhibit some movement toward shore in spring and into deeper water in fall. However, their most consistent movement was toward spawning areas each spring.

Jester (1962), working on Conchas Lake, New Mexico, found that channel catfish there tended to congregate around flowing tributaries. McNeely and Pearson (1974) stated that channel catfish in a thermally heated reservoir in Texas were evenly distributed throughout the lake. Sprague (1960) and Nelson (1961) found that channel catfish were evenly distributed throughout Gavins Point Reservoir, South Dakota.

#### Collection techniques

A variety of sampling gear has been shown to be effective in the collection of channel catfish. Traps and nets are passive gear which depend on the movement of fish into or through an area. Hoop or frame traps are often baited to attract catfish to the sampling area. Types of baits proven to be effective include cheese (Muncy 1957), cottonseed meal (McCammon 1956; Humphries 1965), scrap fish (Jacocks 1943; Menzel 1945), ripe females (Helms 1975; Moyle 1955; Muncy 1957; Starrett and Barnickol 1955) and various commercially prepared stink baits. Timms and Kleerekoper (1972) showed that ripe female channel catfish release a sexual pheromone which solicits

a locomotor response from male channel catfish. The male's response was shown to diminish as the concentration of pheromone decreased.

Gill nets are also effective in sampling channel catfish, especially in standing water. Numerous investigators have used gill nets to sample channel catfish in reservoirs and lakes (Elrod 1974; Jearld 1970; Jearld and Brown 1971; Jester 1962; Lawler 1960; Nelson 1961; Shields 1957; Singer 1973; Sprague 1959, 1960, 1961; Stewart and Murawski 1973).

Various designs of beach seines have been used to collect young-of-the-year channel catfish from shoreline areas, although most investigators have noted difficulty in capturing large numbers of young catfish with this gear (Bailey and Harrison 1948; Hall and Jenkins 1953; Helms 1975; Nelson 1961; Sprague 1960).

Other types of gear used to a lesser extent for collection of channel catfish include: otter trawls for young-of-the-year catfish (Walburg 1975), can-type traps (Jearld 1970), electro-fishing (Jearld 1970; Singer 1973), and hook and line (Conder and Hoffarth 1962).

#### Age and growth determination

Techniques for conducting age and growth studies on fish lacking scales have been conducted for many years. Lewis (1949), Hooper (1949), Appleget and Smith (1951), and Barnickol and Starret (1951) used channel catfish vertebrae for age and growth determination. Jenkins, Leonard and Hall (1952) and Hall and Jenkins (1954) found that age and growth information obtained from catfish dorsal spines was more uniform than those of pectoral spines. Appleget and Smith (1951), Sneed (1951), and Marzolf (1955) confirmed the accuracy of obtaining age and growth data from various bony parts. Marzolf (1955) took this



a step further when he compared age and growth data collected from spines and vertebrae of the same fish. He concluded that spines were the preferred aging structure because of ease of collection, preparation, and reading. Spines also yielded more reliable age information and fewer false annuli. However, vertebrae did provide a better approximation of actual growth history.

Leonard and Sneed (1951), Witt (1961), Carlton and Jackson (1964), Scholl (1968), and Ihm (1968) all contributed to the techniques involved in the collection, sectioning, and mounting of catfish spines for age and growth studies. The procedure for sectioning the spine with the distal end of the basal groove serving as a reference point was set forth by Marzolf (1955), Lawler (1960), Morris (1960), Russell (1965), and Jearld (1970). Sneed (1951) found that more accurate measurements of annuli could be made if these measurements were taken along the expanded edge of the spine cross section.

Length frequency data has also been used to delineate age and size classes. This has been a trend when exact age and growth information was not required. Jester (1962) and Perry and Carver (1972) used length frequency histograms to indicate age groups. Shields (1957), Sprague (1959, 1960, 1961), and Nelson (1961) used channel catfish length frequency distributions as proof of reproduction and indexes of relative year class strength. The information obtained in length frequency diagrams is most valuable when used to indicate the success or failure of a particular year class.

### Spawning habitat

Under natural conditions, channel catfish use overhanging rocks, rock outcrops, hollow logs, eroded root structures, animal burrows, and other areas that provide seclusion and overhead cover as spawning habitat (Brown 1942; Davis 1959; Deacon 1961; Harlan and Speaker 1956; Lawler 1960; Marzolf 1957; Sigler and Miller 1963; Stickney 1971; Van Eeckhout 1974; Weeks 1972). Jester (1962) found channel catfish in Conchos Lake to be moving to major tributaries to spawn. Finnel and Jenkins (1954), studying the reservoirs of Oklahoma, found that ones in which the inundated stream contained resident catfish populations usually had successful catfish fisheries after impoundment.

Although channel catfish requires a rather selective type of spawning habitat, it can be very adaptive in the use of existing habitat. Geibel and Murray (1961) and Nickum (1976) both observed successful channel catfish nests on the mud-bottom floors of farm ponds.

In some waters where natural habitat has been destroyed or is otherwise lacking, artificial structures have been added. Miller (1966) reported that two nail kegs telescoped together would provide adequate channel catfish spawning habitat. Stewart and Murawski (1973) added nail kegs and milk cans to several of New Jersey's public fishing lakes that lacked suitable catfish spawning habitat. Channel catfish reproduction was documented in these structures. Unfortunately, some factor other than reproductive habitat limited the expansion of these catfish populations.

Lantz (1970) found that 18.91 cans and large grease drums placed in Lac Des Allemands, Louisiana, by commercial fishermen provided extra

channel catfish nest sites. He postulated that this was responsible for the high channel catfish population density in this system. This work was documented earlier by Schafer, Posey, and Davidson (1966) and Davidson (1967).

Helms (1975), working on the Mississippi River in Iowa, found that channel catfish were using rip-rapped railroad grades along the river as spawning sites. He considered catfish reproduction in these areas to somewhat compensate for the destruction of other instream habitat through dredging.

Ziebell (1973), using ultrasonic tracking equipment, was able to trace movements of channel catfish in Parker Canyon Reservoir, Arizona. He found that the dam contained numerous holes and clefts which were thought to be suitable spawning habitat. Channel catfish tracked during the study frequently occupied areas on the dam and were believed to have spawned at the dam site.

Schoonover (1976) stated that several lake associations in Kansas had used milk cans staked along shoreline areas to supplement channel catfish spawning habitat. Spawning catfish were observed utilizing these structures. However, in Kansas the use of such habitat is not recommended. Most lakes with channel catfish populations have overabundance and stunting problems rather than a lack of recruitment. Therefore, in areas where channel catfish recruitment is inadequate for existing pressure, maintenance stocking of catchable channel catfish is instituted.

## Fecundity

Numerous investigators have made fecundity estimates for channel catfish. Early fecundity estimates were made from rather limited samples. Canfield (1947) estimated the fecundity of only four females ranging in size from 397 gm to 1,814 gm. They contained from 3,100 to 8,000 eggs respectively. Lagler (1939) reported that a 413 mm channel catfish contained 8,110 eggs. Dill (1944) counted the number of eggs in two channel catfish (216 and 660 mm long) and found 1,600 and 34,500 eggs respectively. Menzel (1945) included ten catfish in his study. These fish ranged in size from 406 to 508 mm and contained between 4,200 and 10,600 eggs respectively (mean 7,430 eggs). Doze (1925) and Brown (1942) found that channel catfish in Kansas have between 2,500 and 70,000 eggs per female. Katz (1954) and Migdalski (1955) reviewed the literature of the time and found fecundity estimates of 2,000 to 70,000 per female channel catfish.

More recent fecundity estimates have been made by Muncy (1958), Lawler (1960), Jearld (1970), Martin (1967), Byford (1970), Jearld and Brown (1971), Weeks (1972), and Helms (1975). Muncy (1958) made fecundity estimates from channel catfish collected in the Des Moines River. These fish ranged in size from 201 mm to 653 mm and contained between 2,682 and 9,721 eggs with a mean of 6,123 eggs. Lawler (1960) estimated the fecundity of channel catfish in Utah Lake and found that a one kilogram fish contained 10,211 eggs. Jearld (1970) and Jearld and Brown (1971) found channel catfish in Lake Carl Blackwell, Oklahoma, from 201 to 653 mm contained 1,052 to 64,629 eggs (mean 13,177 eggs). Martin (1967), Byford (1970), and Weeks (1972) found that channel catfish contain between 6,608 to 8,811 eggs per kilogram of fish.

Helms (1975) found Mississippi River channel catfish from 330 to 732 mm contained between 2,894 and 36,376 eggs per fish (average  $\pm$  1,858 eggs).

#### Culture technique

The culture of channel catfish was pioneered from the early to mid-1900's. Early investigators would collect wild catfish and stock them in culture ponds. These ponds contained artificial spawning containers such as nail kegs, milk cans, or earthen crock jars (Brown 1942; Canfield 1947; Clapp 1929; Doze 1925; Lenz 1947; Menzel 1945; Mobley 1931; Morris 1939; Rennick 1942; Shira 1917a, 1917b; Toole 1951). A detailed account of channel catfish spawning behavior was described by Clemens and Sneed (1957) from experiments conducted in aquariums. Many of the presently used culture techniques were developed by these early investigators. Present-day culture uses three different techniques for spawning channel catfish. They are: (1) open pond method, (2) pen spawning method, and (3) aquarium method.

The open pond method makes use of the natural desire of catfish to reproduce. Brood fish are placed in a spawning pond which contains artificial spawning nests. These nests include milk cans, grease drums, nail kegs, crock jars, drain tile pipe, prefabricated wooden boxes, and other structures which provide semi-darkened, overhead cover and a restricted opening (Avault 1972; Byford 1970; Simco and Cross 1966; Davis and Hughes 1970; Dillard 1966; Geibel and Murray 1961; Gray 1975; Grizzell, Dillon, and Sullivan 1969; Martin 1967; Meyer, Sneed, and Eschmeyer 1973; Regier 1963; Steinbach and Klussman 1971; Tiemeier and Deyoe 1973; Thune 1968; Weeks 1972). These nests are staked down to prevent movement (Gray 1975; Grizzell, Dillon, and Sullivan 1969; Martin 1967) and partially filled with sand or gravel,

which serves as spawning substrate (Mobley 1931; Nelson 1957; Thune 1968). Nests are placed in water from 15.2 to 152.4 cm deep (Avault 1972; Byford 1970; Davis and Hughes 1970; Geibel and Murray 1961; Gray 1975; Grizzell, Dillon, and Sullivan 1969; Kahrs 1970; Martin 1967; Meyer, Sneed, and Eschmeyer 1973; Weeks 1972). Positioning of spawning structures within a pond is not critical, but they are usually placed with the opening toward the center of the pond (Davis and Hughes 1970; Geibel and Murray 1961; Martin 1967; Meyer, Sneed, and Eschmeyer 1973; Tiemeier and Deyoe 1973; Weeks 1972). Most culturists use two or three spawning structures per four pair of spawners, because all the fish will not spawn at the same time (Byford 1970; Gray 1975; Martin 1967; Meyer, Sneed, and Eschmeyer 1973; Weeks 1972). Brood catfish are allowed to choose a mate and spawn at will. The eggs are either left to be hatched by the male or removed and hatched in troughs.

The pen method is used when selection of spawning pairs is important. With this technique, spawning nests are placed in various size pens. A male and female are then selected and placed in the enclosure until a successful spawn is obtained. The female is usually removed after spawning to prevent fighting. The male is then left to guard the eggs or the eggs are removed and hatched in troughs (Byford, 1970; Geibel and Murray 1961; Gray 1975; Grizzell, Dillon, and Sullivan 1969; Kahrs 1970; Meyer, Sneed, and Eschmeyer 1973; Steinbach and Klussmann 1971; Thune 1968; Tiemeier and Deyoe 1973; Weeks 1972).

The aquarium method allows for the greatest control and selection of brood pairs. Tar paper is placed in the bottom of a 114 to 189 l aquarium to serve as a spawning mat. This paper also facilitates the

removal of the fertilized eggs. The selected catfish are placed in the aquarium and induced to spawn by the injection of hormones, either fish pituitary or human chorionic gonadotropin. After completion of spawning, the eggs are removed and hatched in troughs. This allows for the spawning of numerous pairs of catfish in the same aquarium (Byford 1970; Gray 1975; Meyer, Sneed, and Eschmeyer 1973; Steinbach and Klussman 1971; Weeks 1972).

Each of these three techniques has advantages and disadvantages. The main advantage of the open pond method is that it requires the least amount of time and space. The major disadvantage of this technique is a lack of selection of spawning pairs. The pen method allows this selection of breeding pairs but requires more elaborate facilities. The aquarium technique permits the greatest control over spawning pairs, but again requires much more elaborate facilities.

### Management

Present management of channel catfish in states where they are abundant includes restricting commercial harvest through seasons, size limits, gear limitations, and creel quotas (Helms 1975; Lantz 1970; Ranthum 1974). In some areas where sports harvest is allowed, channel catfish management has been directed toward maintenance of an adequate fishable population.

In many waters this can be achieved through creel and minimum size limits. However, on waters where recruitment appears to be limiting, other techniques have been implemented. Several investigators have reported the use of artificial channel catfish spawning habitat (Carnes 1971; Davidson 1967; Lantz 1970; Miller 1966; Schafer, Posey, and Davidson 1966; Schoonover 1976; Stewart and Murawski 1973).

However, only the work of Schafer et al., Davidson, and Lantz, all in Louisiana, has shown that artificial spawning habitat had a positive impact on catfish recruitment.

It is known that channel catfish require some type of cover for reproduction and protection from predation. Marzolf (1957) and Miller (1966) reported that channel catfish in clear ponds were much more vulnerable to predation than those in turbid ponds. Tiemeier (1957) and Dillard (1966) concluded that predation of channel catfish fry and fingerlings significantly limited survival and recruitment in ponds. Carnes (1971) stocked channel catfish in ponds that contained large grease drums. He attributed the channel catfish failure to reproduce to sunfish and bass predation and fishermen activity.

Many states that experience high demand for channel catfish have instituted stocking programs. In general, these states found it to be more practical to improve channel catfish recruitment through stocking than through addition of spawning habitat. Broach (1967), summarizing work completed in Arkansas, indicated that fry and fingerling catfish stockings into existing fish populations failed to enhance recruitment or harvest of the species stocked. However, maintenance stocking of catchable size catfish did improve recruitment and add to the catfish harvest.

Keith (1971) elaborated further on Arkansas' catfish stocking program. He stated that yearling catfish are only stocked in new or renovated waters at rates determined by the basic fertility of the system. Catchable size channel catfish are stocked in waters having insufficient natural recruitment. Stocking rates are based on the amount of fishing pressure and the fertility of the receiving system.



Krummrich and Heidinger (1973) studied the vulnerability of several sizes of channel catfish to predation by largemouth bass. This work indicated the 51, 76, and 102 mm channel catfish experienced significantly greater mortality due to predation than 127 mm catfish. They recommended that only channel catfish 127 mm or longer be used when stocking waters with existing fish populations.

Provine (1973), working on Lake Bastrop, Texas, found stockings of 178 to 305 mm channel catfish greatly increased that species' recruitment and harvest. He found that percent harvest of stocked catfish increased as the size of the stocked fish increased.

Many small county conservation board lakes in Iowa are stocked with catchable size channel catfish. Historically these lakes have experienced such high fishing pressure that maintenance stocking of channel catfish was essential. However, fingerling stockings proved to be an ineffective method of increasing recruitment and harvest. Presently, fingerling channel catfish are raised under cage culture conditions in these lakes, then stocked out as catchable fish. This program has provided an excellent return to the fishermen using these areas (Mitzner and Middendorf 1975).

Schoonover (1976) stated that Kansas has a policy of stocking catchable size channel catfish in public lakes where catfish predation is high and recruitment is low. Channel catfish stocked range in size from 127 to 305 mm.

Rawstron (1976) evaluated the introduction of yearling channel catfish in Merle Collins Reservoir, California. He found that stocking yearling catfish failed to establish a fishable population in this reservoir. Rawstron indicated that returns from stockings of

290 mm channel catfish in southern California had approached 45%. He, therefore, recommended stocking this size catfish in Merle Collins Reservoir. Following this introduction, channel catfish sport harvest improved and the first evidence of channel catfish reproduction was documented. Rawstron concluded that stocking 290 mm catfish had greatly improved the reservoir's channel catfish fishery.

## AREA DESCRIPTION

Willard Bay Reservoir is located on the northeastern shore of the Great Salt Lake in southeastern Box Elder County, Utah. The dike which separates the reservoir from the lake was completed in the early 1960's as part of the Weber Basin Water Reclamation Project (Figure 1). The total perimeter of the reservoir is approximately 17.3 km, of which almost 14.5 km is riprap dike. The reservoir has a surface area of 4,047 ha, a storage capacity of 26,519 hectare-meters, and a maximum depth of 9 m.

Willard Bay Reservoir is a remnant of Great Salt Lake and has a gentle slope with a uniform sediment bottom. Periodic storms with high winds often create surface waves which cause mixing along the bottom of the reservoir. This mixing action picks up bottom debris which is then resuspended in the water column. This suspended silt and detritus, coupled with an annual algal bloom, are the principal causative agents for the low water transparency in the reservoir. This low transparency limits the penetration of light to the bottom muds, and thus prohibits development of rooted vegetation. Subsequently, only a few of the more sheltered reaches of the reservoir have developed stands of emergent or submergent vegetation.

An ecological survey was conducted on Willard Bay Reservoir during the summer of 1970 by the Utah Division of Wildlife Resources. This survey concluded that summertime water temperatures varied from 23.9 to 27.7 C, and dissolved oxygen was at or near the saturation point at all stations and depths monitored. Bicarbonate alkalinity was

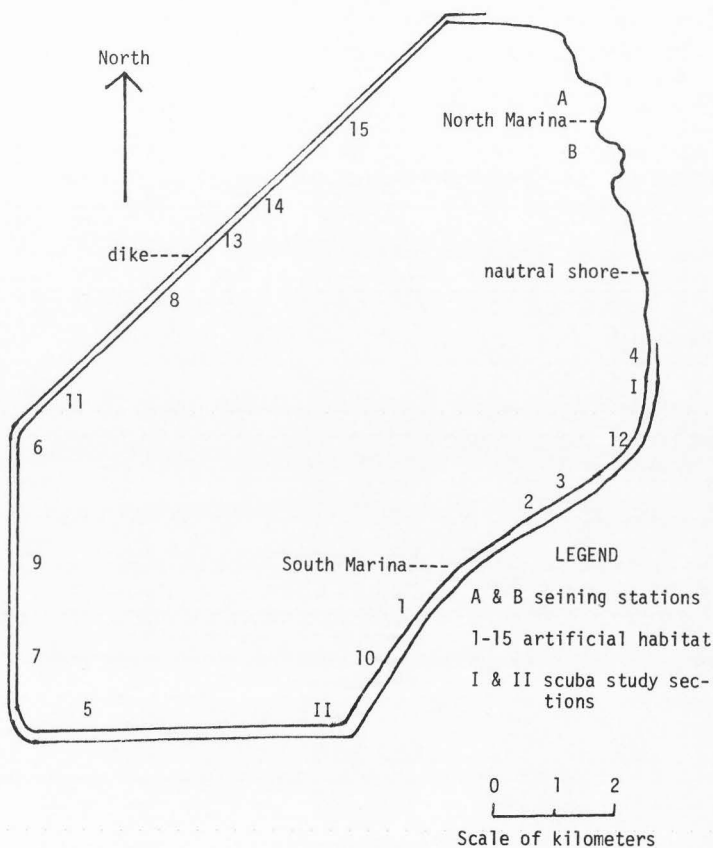


Figure 1. Willard Bay Reservoir, showing location of seining stations, artificial habitat study areas, and sections of dike examined with SCUBA.

found to lie between 222 and 291 ppm. The pH was slightly basic, ranging from 8.0 to 8.5 (Summers 1971). These physical and chemical parameters are reasonable for maintenance of a channel catfish fishery.

## HISTORY OF FISHERY

Channel catfish were first introduced into Willard Bay Reservoir in the fall of 1965. Prior to this time, the reservoir was filled and drained in order to reduce the level of dissolved solids. Four additional stockings of channel catfish have been made since 1965 to supplement the number of potential spawners in the reservoir (Table 1). Other game fishes that were introduced during the same period were walleye (Stizostedion vitreum), largemouth bass (Micropterus salmoides), and white bass (Morone chrysops).

Because water for Willard Bay Reservoir is diverted from the Ogden and Weber Rivers and Willard Creek, the species of fish present in the reservoir reflect the fish composition of these streams. A total of 13 species of fish were identified from collections made during this project. They were: channel catfish, walleye, largemouth bass, black bullhead (Ictalurus melas), black crappie (Pomoxis nigromaculatus), bluegill (Lepomis macrochirus), brown trout (Salmo trutta), carp (Cyprinus carpio), green sunfish (Lepomis cyanellus), mosquitofish (Gambusia affinis), redbreast shiner (Richardsonius balteatus), Utah chub (Gila atraria), and Utah sucker (Catostomus ardens).

Table 1. Date, size, and number of channel catfish stocked in Willard Bay Reservoir by the Utah Division of Wildlife Resources, 1965-1972.

Date	Fish size	Number stocked
Oct. 8, 1965	fry	44,000
July 16, 1966	fry	160,000
Sept. 16, 1966	fry	306,000
Oct. 3 and 7, 1967	fry	312,000
Sept. 6, 1972	fry	74,000

## MATERIALS AND METHODS

### Fish capture techniques

Channel catfish were collected using experimental gill nets (mesh sizes 9.5, 19.1, 25.4, and 38.1 mm bar mesh) each 38.1 m by 1.8 m. Weekly samples (four nets set for 24 hours) were taken along randomly selected sections of dike. Female channel catfish judged to be mature were dissected and examined to determine their reproductive condition. Females were considered mature using the criteria set forth by Davis and Posey (1958) and Perry and Carver (1972). Only females were used because of the difficulty in determining whether male catfish had spawned and the fact that male catfish can spawn with more than one female (Davis 1959). External sexing was accomplished using methods described by Davis (1959), Moen (1959), Martin (1967), and Anonymous (1970). Four classifications were used to define reproductive condition; ripe, spent, reabsorbing eggs, and immature.

Young-of-the-year were collected using a meter net and a 30.5 m bag seine tapered from 1.83 m at the ends to 3.7 m in the middle. The seine was used on beach areas around the north marina (Figure 1). Areas off the dike were sampled using the meter net as a surface trawl. Again, random sections of dike were sampled. Sampling took place at two-hour intervals, both before and after dusk and dawn. Each collection consisted of hauling a net along the surface approximately 30 m behind the boat and 15 m from the dike for 30-minute periods. Numbers and lengths of all young catfish were recorded to document reproduction.



Lengths of all channel catfish collected from mid-August to mid-September were used to document previous reproduction through length frequency analysis. Only catfish captured during this period were used to prevent overlap in length frequency caused by sampling fish that were growing.

#### Examination of dike

The perimeter of the dike was divided into 0.8 km sections. Fifteen of these sections were randomly selected and numbered to be observed using SCUBA, through the channel catfish spawning period. This survey of the dike was initiated to check for nesting channel catfish and to locate areas of sufficient size and seclusion to be favorable catfish spawning habitat. Criteria for judging a suitable nest site was an opening of at least 30.5 cm in diameter, extending back into the dike at least 91.4 cm. These lengths were chosen because they are about the median size of successful artificial habitat. Other information obtained was a general description of nest sites, including water depth and the total number of areas observed along each section that were considered favorable catfish spawning habitat.

#### Artificial spawning habitat study areas

Two areas were selected in Willard Bay Reservoir as artificial habitat study areas on the basis of water depth, bottom type, and dike structure (Figure 1). Water depth at site I was 2.0 m, and the bottom consisted primarily of unconsolidated detritus and sand. The riprap of the dike was submerged to a depth of approximately 1.0 m. At site II the water depth was 1.2 m, and the bottom was composed of pea

gravel (10-15 mm in diameter), rubble (30-60 mm in diameter), and some unconsolidated detritus. No riprap was submerged at this site.

The relative number of channel catfish at any one place along the dike was nonsignificant at the .05 level (Table 2). This indicates that channel catfish are randomly distributed along the dike; therefore, selection of artificial spawning habitat should reflect differences in habitat and study areas rather than the number of channel catfish spawners in proximity to each study area.

Four types of artificial spawning habitat were selected as spawning nests for channel catfish. These included 37.9 l milk cans, 113.6 l plastic trash cans, groups of automobile tires cabled together (1 m in length) and open at both ends, and similar groups of tires cabled together but closed at one end. Many investigators found that milk cans are ideal spawning habitat for channel catfish (Grizzell, Dillon, and Sullivan 1969; Martin 1967; Regier 1963; Toole 1951). Automobile tires were found to be an economical and easy way to handle material for the construction of artificial reefs in marine and fresh waters which would attract fish and increase production (Anonymous 1971; Hooper 1974; Prince, Raleigh, and Corning 1975; Stroud and Massman 1966). Prince Raleigh, and Corning (1975) documented successful white catfish reproduction in a tire reef constructed in South Mountain Lake, Virginia. It was unknown, however, if groups of tires would provide the necessary seclusion apparently needed for channel catfish reproduction. Plastic trash cans were selected because of their size and the durability of the plastic.

Twenty structures of each type were placed at each of the two areas. They were positioned in an alternating manner so that no two

Table 2. Analysis of variance, testing the number of channel catfish captured per net versus location of nets.

Source of variation	Degrees of freedom	Mean squares	"F"
Location of nets	21	0.6845	1.6579
Fish per net	66	0.4129	

structures of the same type were side by side, to prevent biasing of the selection of an artificial spawning site. The order was: trash can, tire group closed at one end, milk can, and tire group open at both ends (Figure 2).

The eighty structures were arranged in a line 6.1 m from the dike. Due to severe wind-caused turbulence, a suitable anchoring method was needed to prevent excessive movement of the artificial habitats. This was provided by cabling the structures between 3.0 m fence posts which had been firmly implanted in an upright position. All of the artificial habitats were placed with the open end toward the dike.

After the structures were secured in place, each study area was monitored at three-day intervals throughout the spawning period. Observations of spawning channel catfish and male channel catfish guarding eggs was noted.

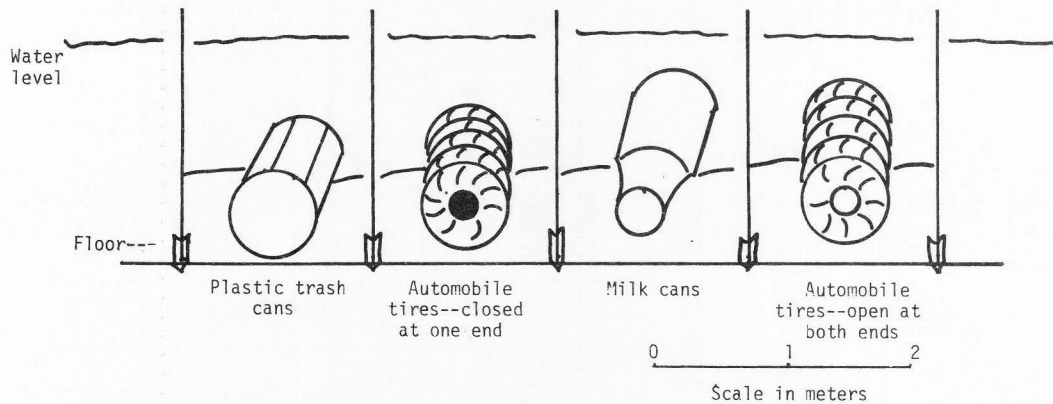


Figure 2. Diagrammatic representation of positioning and anchoring method used for artificial spawning habitat.

## RESULTS AND DISCUSSION

Size and age at maturity

Numerous studies have been conducted to determine at what size and age channel catfish mature. In Texas ponds, channel catfish matured at 18 months (McClellan 1954). Davis and Posey (1958) examined 1,097 female and 1,125 male channel catfish from Louisiana waters. They found that females matured at 266.7 to 279.4 mm, while males matured at 304.8 to 317.5 mm. Lantz (1970) evaluating the channel catfish fishery in Lac Des Allemonds, Louisiana, found that 40% of the males and females from 203.2 to 228.6 were mature. Perry and Carver (1972) also examined the age and size at maturity for channel catfish in Louisiana. The smallest mature female channel catfish collected was in the 200 to 209 mm size class. Females in the 280 to 289 mm size class were 75% mature, while all females over 350 mm were mature. The smallest male with motile sperm was in the 180 to 189 mm size class. All males over 330 mm were found to be mature.

In Kansas ponds, female channel catfish matured at 267 to 279 mm, while males matured at 305 to 318 mm (Davis 1959). In the Kansas River, channel catfish were found to be mature at 305 to 318 mm (Deacon 1961). Simco and Cross (1966) reported that channel catfish spawn for the first time when they grow 381 mm and 0.45 kg.

Harlan and Speaker (1956) stated that female channel catfish in Iowa waters mature at 330.2 to 406.4 mm. Canfield (1947) studied the propagation of channel catfish in Iowa and found that they could not be readily spawned until after their fourth year. Appelget and

Smith (1951) found that channel catfish in the Mississippi River near Lansing, Iowa, do not mature before age V. Virtually all the males and 90% of the females were found to be mature by age VIII. Male and female channel catfish collected in the Des Moines River, Iowa, were found to mature at age IV at a length of 272 mm (Ackerman 1965).

Another study conducted on the Mississippi River found that the smallest mature male and female catfish were 292 mm and 318 mm long respectively (Greenbank and Monson 1947). Barnickol and Starrett (1951) reported that channel catfish in the Mississippi River matured at 305 to 381 mm (four to five years old).

DeRoth (1965) found that 50% of the female catfish in western Lake Erie that were 254 to 279 mm long were mature. This 50% level was not obtained by males until they were 279 to 305 mm long. Channel catfish in this study were maturing in five years.

Lawler (1960) examined the channel catfish population of Utah Lake. He found that no catfish were mature in their first four years. Successive age groups over IV had increasingly higher percentages of mature individuals.

Katz (1954), in a review of the literature, stated that channel catfish mature in four to six years at lengths of 330 to 560 mm.

Substantial numbers of channel catfish were first introduced into Willard Bay Reservoir during 1966 as fry (Table 1). These fish were four years old in 1970. Young-of-the-year channel catfish were first collected in seines during summer, 1971. It, therefore, appears that channel catfish in Willard Bay are maturing during their fifth year.

### Reproductive condition

Spawning activity of channel catfish begins when water temperatures warm to 21.1 to 23.9 C (Anonymous 1970; Avault 1972; Byford 1970; Canfield 1947; Clemens and Sneed 1957; Geibel and Murray 1961; Grizzlell, Dillon, and Sullivan 1969; Harlan and Speaker 1956; Katz 1954; McClellan 1954; Morris 1939; Weeks 1972). This critical temperature was reached in Willard Bay Reservoir during the third week of June, 1973 (Figure 3). Clemens and Sneed (1957) and Crawford (1957) reported that larger, older catfish tended to spawn earlier than smaller, younger individuals. The spawning season for channel catfish is quite long, and begins earlier in lower latitudes (Carlander 1969). Because the initiation of spawning is regulated by lengthening days and increasing water temperatures, spawning period varies over the distributional range of the species.

Channel catfish in Lake Wichita, Texas, spawned in April (Lewis and Dalquest 1955). Stevens (1959) found evidence of spawning activity in March and April in Santee-Cooper Reservoir, South Carolina. Marzolf (1957) and Dillard (1966) found that channel catfish in Missouri ponds usually begin spawning around the end of May and are completed by mid-July. In Conchos Lake, New Mexico, channel catfish were observed spawning from late June to late July (Jester 1962). Jearld (1970) and Jearld and Brown (1971) described the channel catfish spawning period in Lake Carl Blackwell, Oklahoma, as lasting from early May to early June. Cross (1951), working on Canton Reservoir, Oklahoma, found that channel catfish spawned from June to July. Doze (1925), working in Kansas, found channel catfish spawning from June through mid-July. In Lewis and Clark Reservoir, channel catfish spawned in late June



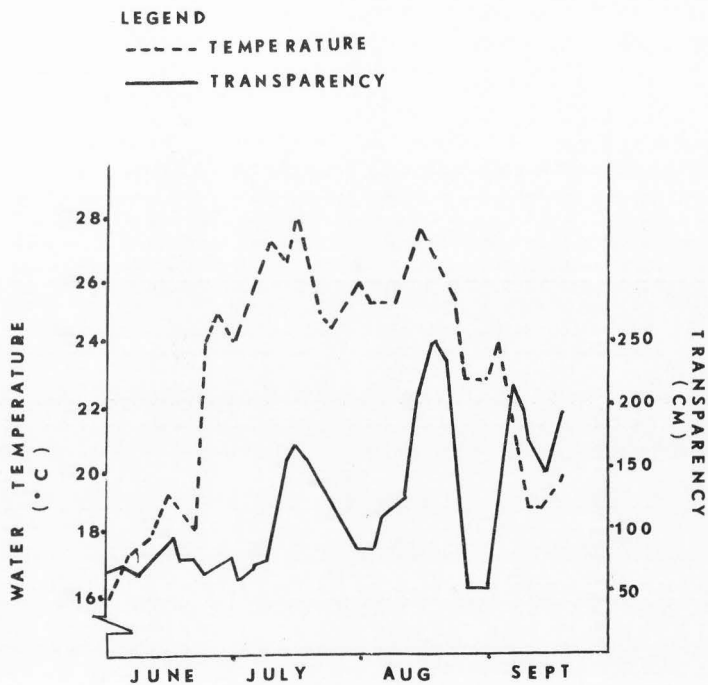


Figure 3. Surface water temperatures and secchi disc transparencies of Willard Bay Reservoir during summer, 1973.

or early July (Walburg 1975). Harlan and Speaker (1951) reported that channel catfish in Iowa usually spawned in July. Channel catfish in Gavin's Point and Fort Randall Reservoirs, South Dakota, were reported to have spawned by mid-June (Shields 1957; Sprague 1959, 1960, 1961; Nelson 1961). On the Little Missouri River, North Dakota, channel catfish were observed nesting from the first week of June to the last week of July (Van Eeckhout 1974). Lawler (1960) found evidence of spawning activity from mid-June until September in Utah Lake, Utah. Channel catfish in Willard Bay Reservoir spawn from mid-June through August.

Spent catfish first appeared in mid-June, and by the first of September, ripe fish were no longer collected (Table 3). A general trend from ripe to ripe and spent catfish, to spent catfish and catfish reabsorbing their eggs is also apparent.

#### Examination of dike

A total of 12 male channel catfish were observed guarding spawns along the 15 study sections of dike (Table 4). The first nest was located on July 17, 1973, and the last, on August 30, 1973. All nests were found at water depths of 1.0 to 3.0 m. Of the 12 nests examined, ten were located along the bottom of the bay where a boulder had been sufficiently undercut to provide overhead cover. The other two nest sites were within the riprap and extended back into the dike 1.0 to 2.0 m. Numerous other cavities of sufficient size and seclusion to be favorable spawning habitat were observed during each survey. The number of cavities was dependent on the amount of submerged riprap at each section and varied from 0 to 50+ (Table 4).

Table 3. Reproductive condition of female channel catfish examined during 1972 and 1973 spawning periods.

Date	Number of female channel catfish examined	Ripe	Spent	Reabsorbing eggs	Immature
6-15-72	3	2	1	0	0
6-20-72	2	2	0	0	0
6-27-72	5	2	2	0	1
7-8-72	2	1	1	0	0
7-14-72	2	2	0	0	0
7-28-72	4	2	1	0	1
8-8-72	3	1	1	0	1
8-17-72	3	1	1	1	0
8-30-72	2	0	1	1	0
9-8-72	3	0	2	1	0
6-7-73	1	1	0	0	0
7-18-73	3	1	1	0	1
7-27-73	5	2	2	0	1
8-8-73	2	0	2	0	0
8-16-73	1	0	1	0	0
8-22-73	5	1	2	1	1
9-5-73	5	0	3	2	0

Table 4. Number of nesting channel catfish and favorable spawning habitat areas observed using SCUBA per section in Willard Bay Reservoir, Utah.

Section number	Date of observation	Average water depth along dike at each section (meters)	Nesting channel catfish observed per section (number)	Areas judged to be favorable spawning habitat per section (number)
1	6-17-73	4.6	1	50
2	6-27-73	6.1	2	50
3	6-28-73	6.1	0	50
4	7-13-73	0.9	0	0-25
5	7-16-73	0.6	0	0-25
6	7-18-73	2.4	2	25-50
7	7-25-73	3.1	2	25-50
8	7-30-73	3.7	1	25-50
9	8-2-73	2.4	0	50
10	8-7-73	5.2	0	50
11	8-8-73	3.1	1	50
12	8-9-73	4.9	0	50
13	8-13-73	3.7	0	25-50
14	8-24-73	3.1	2	25-50
15	8-30-73	1.8	1	25-50

The most favorable cavities were those that extended into the dike at least 1.0 m. These cavities also had to have a somewhat level floor to insure proper aeration of the eggs. However, it appears that the most favored habitat were those where the dike met the floor of the bay. Eighty-three percent of the nest sites (n=10) observed were of this type. This could be linked to the prespawning behavior by both the male and female channel catfish in the preparation of the nest which requires a movable substrate.

Deacon (1961), working in the Neosha River of Kansas, found one channel catfish nest site which had been selected in a hole along a clay bank. The catfish apparently had scooped out the interior of the nest using his tail and fins. The nest site was described as having a clean gravel floor and a mound of gravel restricting its entrance. The nest was 0.8 m long and 0.3 m wide. Davis (1959) also suggested that after the nest was selected, the male would vigorously fan it clean with his fins and body.

Van Eeckhout (1974) described channel catfish nests in the Little Missouri River as being dark and protected from intrusion on one or more sides. Observed nests were semi-darkened cavities that had a stable substrate which protected the developing embryo from shifting silt. Insufficient habitat of the type described was a major limiting factor for channel catfish in the Little Missouri River.

Clemens and Sneed (1957) found from their study of channel catfish spawning behavior that both male and female contribute to the preparation of the nest. Culturists have also found this nest preparation a vital part of channel catfish spawning behavior and have provided

for it by placing gravel in their artificial spawning habitat (Mobley 1931; Nelson 1957).

At Willard Bay Reservoir, nests along the dike bottom interface have stable substrate and restricted openings as found by other investigators (Deacon 1961; Van Eeckhout 1974). This apparently provides optimum seclusion and overhead cover as described by Marzolf (1957) as vitally important to successful channel catfish reproduction.

The Willard Bay Dike provides numerous suitable nest sites other than those along the dike bottom interface. Many of these are crevices that extend more than 2.0 m into the dike, and from all indications, are just as favorable as those along the bottom of the bay. But these areas do lack movable substrate which might be necessary for successful channel catfish reproduction.

Many areas within the dike lack adequate spawning habitat. These areas have a water depth of 1.0 m or less at the base of the dike and so limit the amount of submerged riprap. Also, wave action drives sand and silt into the dike and eventually fills up available habitat. However, if siltation within the riprap could be prevented, these areas could be used effectively as channel catfish nest sites. Culturists have found that channel catfish will spawn in as little as 15.0 cm of water (Clapp 1929; Mobley 1931; Martin 1967; Anonymous 1970). Therefore, it appears that water depth at the base of the dike must be at least 1.0 m at the low water line to prevent loss of available spawning habitat through siltation.

### Use of artificial spawning habitat

Artificial spawning habitat study areas were established by the end of May, 1973. This was at least two weeks before the estimated start of channel catfish spawning. However, several severe storms came through the region during the second and third weeks of June. These storms and their high winds caused disturbance of both study areas, resulting in the loss of several tire groups and trash cans. Prior to this disruption, none of the structures had been used by channel catfish as nesting sites. Lost study structures were replaced during the last week of June, but still none were used for nesting.

Two black bullheads were found in milk cans (1 at each study area) during the first week of July. Both were males guarding eggs. No other artificial spawning habitat was used by either bullheads or channel catfish through the end of July.

During the first week of August, a male channel catfish was observed guarding a nest with sac fry in one of the milk cans at site II. One other milk can was used at site II during the second week of August, where a male channel catfish was observed guarding eggs. These two channel catfish were the only channel catfish observed using the artificial spawning habitat through the study period. Therefore, a total of four study structures were utilized as nests; two by black bullheads, and two by channel catfish. All four were milk cans, three at site II, and one at site I. Site II was located in a part of the bay where no riprap was submerged. This lack of natural habitat along the dike could account for greater use of artificial structures in this area. At site I the riprap was submerged

and spawning habitat was available, making artificial habitat less desirable than at site II.

Black crappie, green sunfish, and largemouth bass were observed in the study areas. Concentrations of these species were much greater than were encountered along the dike. Both green sunfish and black crappie were observed guarding nests amongst the study structures. Ziebell (1976) used similar habitat in an attempt to encourage channel catfish reproduction in Parker Canyon Reservoir, Arizona. Many green sunfish moved into his study area to spawn. He theorized that the lack of channel catfish spawning activity at the study area was due to competition for space with these sunfish.

Investigators working with channel catfish pond culture have found that spawning habitat must be securely staked down to prevent movement before it will be used extensively (Doze 1925; Mobley 1931; Grizzell, Dillon, and Sullivan 1969; Anonymous 1970). It is possible that due to the bouyancy of the anchored tires and plastic trash cans, some movement did occur; therefore, causing the channel catfish to avoid them as nesting sites.

The milk cans were stable throughout the study period. Therefore, minimal use of this type of habitat must be related to some other factor. As suggested in the preceding section, there was adequate habitat in the riprap to accommodate large numbers of spawning channel catfish. It might, therefore, be assumed that the lack of use of artificial structures was due to a lack of need. That is, the dike provided a sufficient number of spawning sites to prevent wide searching for other areas in which channel catfish could nest.



### Length frequency analysis

Successful reproduction occurred in the summer of 1973, both in beach areas around the north marina and along the dike (Tables 5 and 6). However, the inability to capture larger numbers of young catfish does leave some doubt as to the relative strength of the year class. Lawler (1960) also experienced difficulty in capturing young-of-the-year channel catfish. Hall and Jenkins (1953) thought their inability to capture young-of-the-year catfish was due to the selectivity of the gear used and the movements of the young catfish into areas too deep to sample with beach seines.

At Willard Bay Reservoir, young-of-the-year channel catfish began moving off the beach areas around the north marina in late August, as evidenced by the decrease in the number captured after the August 17 sampling (Table 5). The meter net was also ineffective in capturing large numbers of young catfish, probably due to gear selectivity.

Lengths of all channel catfish captured from August 17 to September 14, 1973, were used in preparing a length frequency graph (Figure 4). No pectoral spines were taken to document exact age and growth of the catfish sampled due to a lack of equipment for preparing and reading this type of aging structure. However, age groups 0, I, II, and possibly III are thought to be accurate for several reasons. First, reproduction was documented by staff of the Utah Division of Wildlife Resources for each of the three years reflected in these age groups (1971, 1972, and 1973). Next, the channel catfish is primarily a warm-water species, and its metabolism and activity is affected by water temperatures lower than 15.6 C.

Table 5. Number and average length of young-of-the-year channel catfish collected at seining stations (Figure 1) in Willard Bay Reservoir.

Date	Area sampled	Number of hauls	Total number of young-of-the-year channel catfish captured	Average length
8-3-73	A	3	0	----
	B	3	18	28.5
8-8-73	A	3	3	32.3
	B	4	12	33.7
8-17-73	A	3	18	46.6
	B	4	8	44.3
8-24-73	A	4	-	----
	B	6	0	----
8-28-73	A	4	0	----
	B	7	7	57.6

Table 6. Number and average length of young-of-the-year channel catfish collected in a meter net hauled along randomly selected sections of dike in Willard Bay Reservoir.

Date	Time of hauls	Total number of young-of-the-year channel catfish captured	Average length (mm)
8-8-73	6,8,10,12 (PM)	1	33.0
8-15-73	6,8,10,12 (PM)	0	----
8-22-73	4,6,8,10 (AM)	0	----
8-29-73	6,8,10,12 (PM)	2	40.0
9-13-73	6,8,10,12 (PM)	0	----

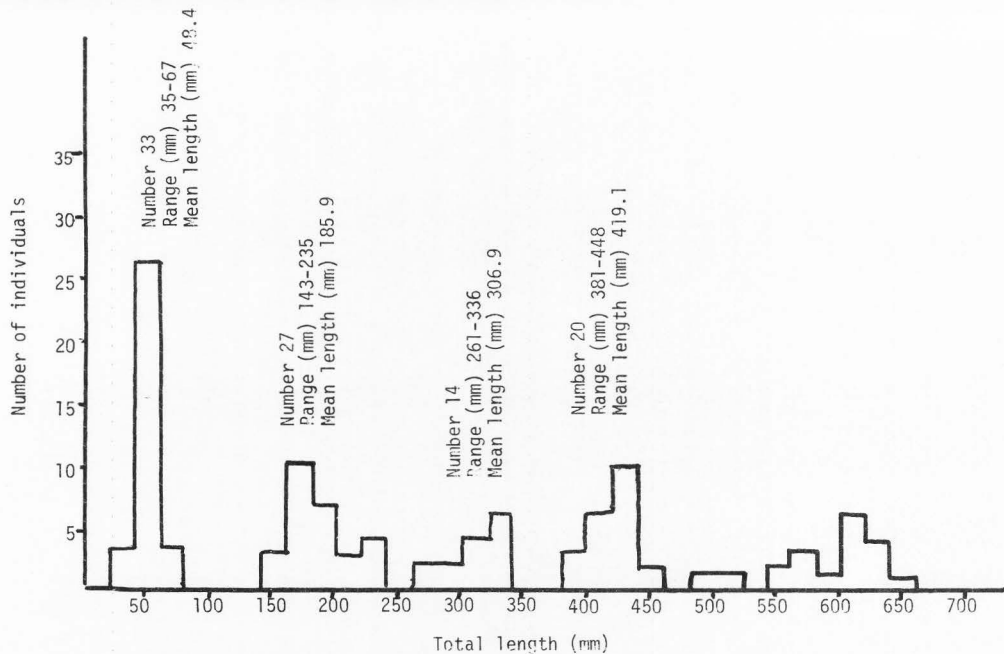


Figure 4. Length frequency graph for all channel catfish captured at Willard Bay Reservoir from 8-17-73 to 9-14-73, with mean length and range of possible age groups 0, I, II, and III.

Green (1969) showed that both movement and feeding were reduced at water temperatures of 15.6 C and almost completely curtailed at temperatures of 10.0 C. Therefore, distinct separation in the length frequency of each year class could be expected, due to this lack of growth caused by a reduction in feeding during winter months. The four age groups all had remarkably good separation by length frequency methods.

Documented reproduction and the length frequency distribution with distinct breaks, support the contention that previous year classes of channel catfish have been successful at Willard Bay Reservoir. However, it is unknown what the relative year class strengths are, or what the actual catfish population is.

## RECOMMENDATIONS FOR FURTHER STUDY

A better understanding of channel catfish population dynamics in Willard Bay Reservoir would aid in management of this fishery by providing information as to year class strength, fishing and natural mortality, and basic age and growth characteristic of the population. If exploitation of this population appears to be high, maintenance stocking of 203 to 305 mm channel catfish should be considered. Work completed in other states has shown that this kind of management practice is the most economical when cost and benefit to the angler is considered. This study indicates that Willard Bay Reservoir could support a much larger channel catfish population. It was also determined that spawning habitat was not a limiting factor. It could be that the major deterrent to expansion of this population is a lack of an adequate number of spawners coupled with possible high predation on young catfish.

If artificial habitat is to be tested further, it should be made of a material that would persist in the water for a long period, and be relatively stable during periods of turbulent weather. Tile drain pipe would be a good material for this purpose. The study could then concentrate on the most favorable size of the pipe (length and diameter of opening), and positioning of the pipes in relation to prevailing winds and available natural habitat. Water depth and other factors such as dissolved oxygen, water, temperature, and water clarity may also prove to be important.

## SUMMARY AND CONCLUSIONS

Reproductive activity for channel catfish in Willard Bay Reservoir appears to begin in mid-June and lasts through August. Ripe and spent catfish were collected along the dike throughout this period.

Examination of the dike indicates availability of numerous areas of sufficient size and seclusion to be rated favorable nest sites. However, optimum areas were along the dike floor interface where boulders had been undercut. The number of favorable nest sites along any section of dike was directly related to water depth at the base of the dike.

Artificial spawning habitat tested at Willard Bay Reservoir was utilized on only four occasions. Then, only milk cans were used as nest sites, two by black bullheads, and two by channel catfish. It appears that tire groups and plastic trash cans lack needed seclusion and stability necessary for successful channel catfish nest sites, due to their bouyant nature. Also, availability of adequate nest sites along the dike kept nest-seeking adults from searching large areas. Therefore, the number of catfish coming in contact with the spawning habitat study area was low.

Young-of-the-year channel catfish were captured for the third consecutive year during the summer of 1973. This, coupled with the length frequency data, indicates that successful year classes have developed during the last three years.

It appears that the dike surrounding Willard Bay Reservoir does provide adequate channel catfish spawning habitat. This was indicated

from the examination of the dike using SCUBA, and the presence of successive year classes of channel catfish. Furthermore, use of artificial spawning habitat proved unsuccessful, possibly due to instability of the study structures and availability of natural habitat.

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## VITA

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