GROWTH, SPAWNING AND HABITAT USE OF CATFISHES IN THE DELAWARE RIVER ESTUARY

by

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Abstract

In the Delaware River estuary, native white catfish (*Ameiurus catus* Linnaeus 1758) have appeared to decline as the introduced channel catfish (*Ictalurus punctatus* Rafinesque 1818) has become more abundant. To determine the current status of these populations and the habitats they use, we surveyed four zones of the Delaware River estuary from April to November, 2007. Hoop nets (N=497) were set in mainstem river, lower tributary, and middle tributary habitats. Upper tributary habitats near the head-of-tide were angled. Our findings indicated that the ratio of channel catfish to white catfish was much less than documented in the early 1990's. Channel catfish and white catfish were found throughout the study area, during all seasons. Channel catfish and white catfish catch-per-net-night (CPNN) increased significantly from spring to fall. ANOVA of white catfish CPNN revealed a significant two-way interaction indicating movement downstream and into the lower estuary during the fall. Both species had unstable age structures indicating variable recruitment. Variable recruitment may account for past differences in ratios of channel catfish to white catfish. Channel catfish in this study lived longer (22 years) when compared to channel catfish collected in other nearby river systems. This difference may be a function of comparing otolith ages (in this study) with age maxima determined by spines and other techniques known to underestimate the age of old catfishes. Few brown bullhead and no yellow bullhead or flathead catfish were collected.

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Introduction

In the Delaware River drainage, white catfish (*Ameiurus catus*) and brown bullhead (*A. nebulosus*) are the only two native Ictalurids not including madtoms. The yellow bullhead *(A. natalis)* also occurs in the Delaware River drainage, but its status is uncertain and debated by researchers (Horwitz, personal comments). Non-native catfish species include channel catfish *(Ictalurus punctatus)* and flathead catfish *(Pylodictus olivaris)*. Channel catfish have been stocked for over a century by regional management agencies and more intensely stocked since the 1970's. Flathead catfish were unintentionally introduced to the Schuylkill River watershed in the mid 1990's and are now found in the lower Delaware River and estuary (Brown et al. 2005).

In general, few studies have been conducted on catfishes in the Delaware drainage. Information that is present raises concerns that the native white catfish population may be declining (Jordan et al. 2004; Daniels et al. 2005) or declining in proportion to channel catfish (Waterfield 1994 as cited in Boyer 1995). In a 1992-93 survey of the Delaware River estuary, O'Herron et al. (1994) documented a 25.5 to 1 channel catfish to white catfish ratio using a variety of gears. Impingement studies at generating stations in the Delaware River estuary have documented ratios of channel catfish to white catfish as low as 0.6 to 1 in 1976-1978 and as high as 26.0 to 1.0 in 1991-1992. At one facility, from 1976-1978 145 channel catfish and 46 white catfish were impinged. From 1991-1992, the same facility impinged 1,427 channel catfish and 59 white catfish (Waterfield 1994 as cited in Boyer 1995). This evidence suggests that a large increase in channel catfish abundance rather than a decline in white catfish abundance is the reason for changes in ratios.

Differences in species abundance may also be due to seasonal habitat use. In the Thames River, CT white catfish have seasonal movements (Schmidt 1971). Historical reports of spring runs in the Schuylkill River suggest that Delaware estuary fish also move seasonally. Spatial differences in size and abundance among mainstem reaches in the Hudson River, NY have also been documented (Jordan 2000). Interpreting changes in catfish ratios and abundances from the Delaware River estuary is difficult with little or no information on seasonal habitat use and population characteristics. In addition, impingement data may not accurately reflect abundances of all catfishes (i.e. one species may be more susceptible to impingement) and therefore a more comprehensive survey is needed to determine ratios.

The purpose of our research was to determine demographics, seasonal habitat use, and ratios of channel catfish and white catfish in the Delaware River estuary. This information was used to assess the status of white catfish and channel catfish populations and to determine if the ratio of channel catfish to white catfish was greater than ratios determined in the early 1990's. Our findings indicate: that the ratio of channel catfish to white catfish is much less than documented in the early 1990's; channel catfish and white catfish are found throughout the freshwater estuary in spring, summer, and fall; in the fall white catfish use the lower freshwater estuary; and Delaware River estuary channel catfish can live at least 22 years, much older then channel catfish collected in other nearby estuarine river systems. Both species had unstable age structures indicating variable annual recruitment. Variable recruitment may account for past differences in ratios of channel catfish to white catfish.

White catfish literature review

Abstract

This section summarizes the existing literature on white catfish (*Ameiurus catus*) biology and management. Biological aspects including reproduction, growth, diet, habitat requirements, and movements are covered. Management aspects including identification problems, declining stocks, overfishing, tagging, and scientific collection are covered. In general, there is a lack of expertise and published literature on the biology and management of bullhead species (*Ameiurus spp*.). In the Hudson, Connecticut, and Delaware Rivers, white catfish abundances have appeared to decline. Declining abundances may be in part due to increasing channel catfish establishment. Other stocks appear secure.

Introduction

In general, there is a lack in expertise and published literature on the biology and management of bullhead species (*Ameiurus spp*.) (Irwin and Hubert 1999).The purpose of this section is to summarize the existing literature on the biology and management of white catfish *(Ameiurus catus)*.

The white catfish is an excellent and valuable food fish (Fowler 1906, Simon and Wallus 2004). Vernacular names for the white catfish such as the Schuylkill catfish and the Potomac channel catfish (Kendall 1910) are likely derived from the localities in which they were found (Schuylkill River in Pennsylvania; Potomac River in Virginia-Maryland). Other vernacular names include the big catfish, river catfish (Fowler 1906) and in Virginia, the white bullhead, river cat, bullhead, and creek cat (Menzel 1945).

Range

Native – The white catfish is native to Atlantic (Glodek 1980) and Gulf slope drainages (Page and Burr 1991) from the Hudson River, NY (Hughes and Carlson 1986), south to the Peace River, FL (Page and Burr 1991), and west to the Chattahoochee and Chipola river systems of eastern Alabama (Boschung and Mayden. 2004).

Introduced – Widely introduced outside of its native range (Glodek 1980; Page and Burr 1991) including inland drainages (Simon and Wallus 2004), Europe (Keller 1926 as cited in Schmidt 1971) and many parts of North America including, Mississippi (Ross 2001), California, Nevada (Kendall 1910), Connecticut, Rhode Island (Schmidt 1971), Ohio (Simon and Wallus 2004), possibly Oregon, Washington (Kendall 1910) and likely eastern Tennessee (Etnier and Starnes 1993).

Description

Physical description – Of moderate size, with blue gray coloration above and white below (Smith 1985) the white catfish is distinguished from similar species of catfishes by its rounded anal fin, "moderately forked caudal fin", and lack of spots (Page and Burr 1991). The white catfish is also characterized by its "broad and flat" head, and white chin barbels (Boschung and Mayden. 2004). In larger white catfish a blue-black coloration on the head and lips is sometimes observed (Page and Burr. 1991). Large channel catfish, in excess of 4.54 kg (10 lbs) with worn barbels and tails often resemble large white catfish (modified from Smith 1985), and at times there has been difficulty differentiating the two (Stevens 1959). In the laboratory, anal fin ray counts and skeletal differences (e.g., pre-occipital morphology) can been used to differentiate these species (J. Lundberg, pers. comm.., author's observation).

Systematics – In the order Siluriformes and known as the family of "North American Catfishes" (Boschung and Mayden 2004), Ictaluridae is comprised of six genera of which *Ameiurus* is one (Lundberg 1992). Referred to as "bullheads", the *Ameiurus* genus includes the white catfish and six other living members (Lundberg 1992). Within Ictaluridae, *Ameiurus* is genealogically more related to *Noturus, Prietella, Pylodictus,* and *Satan* than it is to *Ictalurus* (Lundberg 1982; 1992). The white catfish is most closely related to the flat bullhead (*A. platycephalus*) and the snail bullhead (*A. brunneus*) (Lundberg 1992). No subspecies are recognized (Glodek 1980).

Life history

Reproduction

Age at maturity **–** Depending on the river system, white catfish reach sexual maturity in 2.9 to 4.8 years (Caromile 1994). In the Hudson River, females mature after age three (Hughes and Carlson 1986). Using data obtained from lakes from two regions, Caromile (1994) estimated that white catfish reach sexual maturity earlier in lake environments (2.3 to 3.5 years).

Length at maturity **–** In the Hudson River estuary, females reached maturity at sizes greater than 230 mm total length (TL) (Hughes and Carlson 1986). In a South Carolina reservoir, the smallest ripe female observed was 208 mm (8.2 in.) TL (Stevens 1959). In Virginia, female white catfish first reach sexual maturity at 178-203 mm TL (Menzel 1945). Furthermore, in California's Sacramento-San Joaquin Delta, white catfish first reach sexual maturity as early as 152 mm (6 in.) fork length (FL) and by 229 mm (9 in.) FL nearly all are sexually mature (Borgeson and McCammon 1967). In California, male and female white catfish did not differ in size at maturity (Borgeson and McCammon 1967). The variability of length at maturity between localities may be the result of different levels of exploitation by anglers. Jordan (2000) characterized the Hudson River white catfish fishery as “unexploited or lightly exploited” with low mortality rates while Borgeson and McCammon (1967) determined Sacramento-San Joaquin Delta white catfish over 216 mm FL had a total annual mortality of 57% of which 33% was due to angler harvest.

Fecundity –Ryder (1887) estimated that a clutch of eggs 203 mm (8 in.) long by 102 mm (4 in.) wide and 127-191 mm (0.5 to 0.75 in.) thick contained 2000 eggs. Fowler (1917) stated a female may lay a clutch of 1400-1500 eggs, and Schmidt (1971) estimated that a 300 mm female would produce 5000 eggs on average. Borgeson and McCammon (1967) found a linear relationship between body weight and egg production in which California white catfish weighing 100 to 600 grams produce 600 eggs per 100 grams of body weight. White catfish eggs range between 4.0-4.5 mm in diameter (Menzel 1945), are adhesive and have a yellowish-white tint (Fowler 1917).

Spawning temperatures – In California, white catfish begin spawning when the water temperature reaches approximately 19-21ºC (66-71ºF) (Borgeson and McCammon 1967).

Spawning season – In the Hudson River estuary, spawning occurs in June and July (Hughes and Carlson 1986). In the Delaware River estuary, white catfish spawn during the end of May or early June (Fowler 1917). Jenkins and Burkhead (1994) suggest that Virginia white catfish likely spawn in late May and into July, where in South Carolina; Stevens (1959) suggested spawning peaks in June. In California, spawning takes place in late June and into July when the appropriate spawning temperatures are reached (Borgeson and McCammon 1967). When spring spawning temperatures are reached, spawning may take place for one month (Borgeson and McCammon 1967) to several weeks (Hughes and Carlson 1986).

Spawning habitat – Nesting usually takes place on the bottom in gravel or sand banks (Fowler 1917). In the Hudson River estuary, spawning occurs in channel border areas of the mainstem near cover (Hughes and Carlson 1986). Low capture rates of adults in tributaries indicated tributary habitats may not be used for spawning in the Hudson River estuary (Hughes and Carlson 1986). Conversely, Lippson et al. (1980) documented white catfish spawning in tributaries of the Potomac River (as cited in Hughes and Carlson 1986). White catfish spawn in waters less than 2 ppt salinity (Perry and Avault 1968 as cited in Heard 1975)

Spawning behavior – Fowler (1917) provides a good account of spawning behavior.

> Nests range from 762 mm (30 in.) in diameter to 914 mm (1 yd.) and range from 305-457 mm (12-18 in.) depth. Nests are excavated by both the male and female brushing with fins and moving pebbles in their mouths. Spawning takes place on the bottom, where the male and female are side by side, at periods vibrating and pressing against one another releasing eggs and milt. The eggs are

deposited in the nest over approximately one day and form multiple egg masses usually guarded by the male, to a lesser extent by both parents and even the female alone. The young are then brooded by the male (Fowler 1917).

The male aerates the eggs by agitating the surrounding water with his anal, ventral, and pectoral fins (Ryder 1887). Parental cannibalism of the eggs within the genus was documented by Fowler (1917) for the brown bullhead (*A. nebulosus*) but was not specified for white catfish.

Spawning movement – In the Thames River estuary, Connecticut, Schmidt (1971) interpreted upstream movements in the spring as fish seeking freshwater habitat to spawn, although no spawning fish were collecting. In estuary systems, where white catfish are seasonally found in brackish waters, the upstream movement of white catfish into freshwaters or waters with salinity less than 2 ppt is essential for spawning adults (Heard 1975).

Hatching – Eggs hatch in two to three (Fowler 1917) to six days (Ryder 1887) depending on environmental conditions. Prolarvae are 9-10 mm at hatching and have a large oval yolk sac (Wang and Kernehan 1979).

Growth

Postlarvae – By 14 mm TL the caudal fin is slightly forked and the adipose fin is present (Wang and Kernehan. 1979).

Juvenile – Eighty-eight days after hatching juveniles are approximately 20 mm long (Ryder 1887), “resemble the adult and have a full compliment of fin rays and spines, a homocercal tail, and lightly pigmented barbels” (Wang and Kernehan. 1979). In the Hudson River, by age 3 female white catfish have reached 200 mm TL (Jordan 2000) and will reach sexual maturity at sizes greater than 230 mm TL (Hughes and Carlson 1986).

Adult – Typically white catfish attain lengths of 380 mm (15 in.) TL in the Delaware River (Fowler 1906) and range 305-356 mm (12 -14 in.) TL in the Hudson River (Smith 1985). The maximum total length recorded in New Jersey is 737 mm (29 in.) for a 6.4 kg (14 lbs. 4 oz.) white catfish (NJDEP 2006). The white catfish IGFA (1999) record weight is 8.56 kg for a fish taken from the Withacoochee River, Florida and the FHF (1999) record weight is 10 kg for a California fish (as cited in Boschung and Mayden 2004). The IGFA (1999) and FHF (1999) records do not have total lengths listed although they would most likely be greater than the maximum total length listed here.

River – In river systems white catfish typically reach 300 mm in 4.2 to 7.0 years (Caromile 1994). However, by eight years white catfish in a portion of California’s Sacramento-San Joaquin Delta attained a mean length of only 272 mm (Schaffter 1997). This is one of the slowest growth rates documented for a population of white catfish and may be due to high population densities and low prey availability (Schaffter 1997). The mean total length for a 6 year old white catfish in the St. Johns River, Florida, was 513 mm (Hale 1989 as cited in Crumpton 1999) and is representative of a population with a high growth rate and lengthy growing season (Crumpton et al. 1987). In the Patuxent River, the oldest white catfish collected by Schwartz and Jachowski (1965) was 440 mm and was aged to be 12 years old. Jordan (2000) aged white catfish to 14 years in the Hudson River.

Lacustrine – Within regions, white catfish have shown to have on average higher growth rates in lentic rather than lotic systems (Crumpton 1999, Hale 1989 as cited in Crumpton 1999, Schwartz and Jachowski 1965, Stevens 1959). Caromile (1994) found white catfish reach 300 mm TL in 3.3 to 4.5 years. However, in Florida's Clermont Chain of Lakes, white catfish reached 300 mm TL between 4 to 5 years (Crumpton 1999). In a South Carolina reservoir, white catfish were typically 330 mm (13 in.) and weighed 0.68 kg (1.5 lbs) (Stevens 1959). Some of the oldest specimens were taken from an impounded portion of the Housatonic River, Connecticut, in which three white catfish 565 mm TL were aged to be 20 years old (The Academy of Natural Sciences 1993). Conversely, a 574 mm TL specimen was taken from a Maryland pond and aged to be 14 years old (Schwartz and Jachowski 1965). Differences in age maxima may be due to the different aging techniques used or they may reflect real differences between localities.

Sex differences – In the Thames River estuary, CT, female white catfish were significantly heavier than males (Schmidt 1971), while in parts of California's Sacramento-San Joaquin Delta, males were significantly larger than females after age 4 (Schaffter 1997). In most papers reviewed, sex differences were not evaluated.

Geographic patterns – Geographic patterns exist between lotic systems in North America. With possibly the longest growing season, Florida white catfish have relatively high growth rates and short life spans (Crumpton 1999, Hale 1989 as cited in Crumpton 1999). In contrast, mid-Atlantic and Connecticut white catfish have shorter growing seasons, slower growth rates, and longer life spans (Schwartz and Jachowski 1965, Jordan 2000, Schmidt 1971). In California white catfish have a growing season analogous to the mid-Atlantic, they exhibit slow growth rates and a life span intermediate to Florida and the combination of mid-Atlantic and Connecticut white catfish (Borgeson and McCammon 1967, Jordan 2000, Schaffter 1997, Schmidt 1971). White catfish inhabiting lakes and reservoirs have not shown signs of geographic variation (Crumpton 1999, Stevens 1959, Miller 1966 as cited in Hughes and Carlson 1986) although variable growing seasons are an obvious factor likely to impact annual growth rates.

Influence of competition – In the Hudson, Connecticut, and upper Delaware Rivers, Jordan et al. (2004) implied that declining white catfish abundances may be in part due to increasing channel catfish establishment. Later, though not providing any technical literature, Daniels et al. (2005) stated white catfish populations have declined due to increasing numbers of channel catfish in the Delaware and Connecticut Rivers (Daniels et al. 2005). Although Jordan et al. (2004) documented overlapping habitat use, this review found no published studies on the interspecific competition that may exist between channel and white catfish. However, intraspecific competition in response to low prey availability and high population densities may have limited growth in California's Sacramento-San Joaquin Delta (Schaffter 1997).

Age determination

White catfish have been aged by many techniques, including pectoral spines, dorsal spines, fin rays, otoliths, and vertebrae.

Spines – It is often difficult to accurately age older catfish using spines. However, Crumpton et al. (1987) found the basal recess and mid-spine sections of pectoral spines to be a non-lethal, accurate method for aging Florida white catfish. In California, pectoral spines were insufficient for aging white catfish due to annuli being eroded by an expanding central lumen (Borgeson and McCammon 1967). Crumpton et al. (1987) argued that annuli in pectoral spines of Florida catfish are not erased by the central lumen due to high growth rates and a lengthy growing season. Although requiring fish sacrifice, Crumpton et al (1987) also found sections of the articulating process of pectoral spines to be an accurate method for aging Florida white catfish. When aging South Carolina white catfish, Stevens (1959) experienced lumen erosion and had to estimate the first year of growth for some older catfish. Using pectoral spines, Caromile (1994) was unable to age larger specimens and a 500 mm white catfish, his largest specimen collected. To validate age determinations made using pectoral spines, dorsal spines and pectoral fin rays have also been used (Hughes and Carlson 1986). Using pectoral spines, Jordan (2000) aged white catfish to 14 years in the Hudson River.

Otoliths – In Florida white catfish, Crumpton et al. (1987) found age determinations made utilizing otoliths were unreliable due to a high percent error. To determine percent error, Crumpton et al. (1987) compared otolith ages to those determined by spines. Using otoliths, white catfish from the Housatonic River, CT have been aged to 20 years (The Academy of Natural Sciences 1993). Little published information is available on the use of otoliths to age white catfish. More research is needed as otoliths have been found to be more accurate then spines when aging flathead catfish (Nash and Irwin 1999). As opposed to spines, one draw back to using otoliths is that they require fish sacrifice.

Vertebrae – Others have successfully used vertebrae to age white catfish (Schaffter 1997; Borgeson and McCammon 1967). Schwartz and Jachowski (1965) used vertebrae to age white catfish to 12 years. Age determinations made using vertebrae avoid problems associated with spines and the spine lumen (Borgeson and McCammon 1967), but they also require sacrifice.

Diet and feeding habits

Size differentiation – In white catfish 4-27 cm standard length (SL), fish remains were found "more frequently in larger specimens" when compared to smaller catfish (Heard 1975).

River – White catfish are omnivorous consuming a range of items including, amphipods, fish, and plants, with amphipods occurring the most (Schmidt 1971; Caromile 1994; Heard 1975; Borgeson and McCammon 1967). In Virginia river systems, white catfish have also consumed aquatic insects (Menzel 1945). In the Potomac River, white catfish gorged with eggs have been collected in shad and herring seine hauls (Kendall 1910). White catfish were once frequently taken in the Delaware River by shad fisherman in the spring (Fowler 1906), and in other localities white catfish have been documented to seasonally feed on American shad (*Alosa sapidissima*) (Borgeson and McCammon 1967) and herring (*Pomolobus spp.*) (Menzel 1945). In the St. Johns River, Florida, white catfish mainly fed on threadfin shad or mosquito larvae (Hale unpublished as cited in Crumpton 1999).

Lacustrine – Only two studies were found on the feeding habits of white catfish in a lake habitat. In a Florida lake, white catfish primarily fed upon dipterans and amphipods in addition to consuming large amounts of detritus (Crumpton 1999). In a South Carolina reservoir, white catfish primarily fed on fish (mostly clupeids), pondweed (Potamogeton spp.), and mayfly nymphs (Stevens 1959).

Feeding behavior – Like many Ictalurids, white catfish are largely nocturnal. Heard (1975) found that some small white catfish feed during the day. Conversely, in California, at a pumping facility in the Sacramento-San Joaquin Delta, salvage data (fish diverted from pumps) of mostly juveniles suggests white catfish activity increases at low light intensities (Helfrich et al. 1999).

Mortality

Mortality estimates – Total annual mortality rates vary greatly among regions and have ranged from 0.09 to 0.67 in river systems (Caromile 1994, Schaffter and Kohlhorst 1997). In the northeastern United States, white catfish mortality rates have been estimated to range between 0.09 and 0.20 (Caromile 1994). In a California lake, a white catfish population had a similar mortality rate of 0.19 (McCammon and Seeley 1961). Between 1978 and 1980, total annual mortality rates for white catfish in California's Sacramento-San Joaquin Delta ranged from 0.31 to 0.67 for fish greater than or equal to 240 mm FL. Exploitation rates (fishing pressure) for this region ranged from 0.14 to 0.25 (Schaffter and Kohlhorst 1997). In California total annual mortality estimates have declined as fishing mortality has declined (Schaffter and Kohlhorst 1997).

Habitat requirements

Water temperature – According to Boyer (1995), white catfish have a preference for slightly cooler water than channel catfish and brown bullhead. Kendall and Schwartz (1968) determined the lethal (50% mortality) water temperature for white catfish acclimated at 20.0ºC to be 31.0ºC for fish 160-235 mm TL and 29.2ºC for fish 220-300 mm TL. White catfish acclimated at higher temperatures while exposed to gradual temperature increases would likely achieve a higher lethal limit (Kendall and Schwartz 1968). This study also showed that smaller white catfish have a higher temperature tolerance than larger white catfish (Kendall and Schwartz 1968).

Salinity – White catfish inhabit a wider salinity range then channel catfish. (Markle 1976). In laboratory experiments, a salinity of 14 ppt was found to be lethal (50% mortality) to white catfish after a 60 hour exposure (Kendall and Schwartz 1968). During studies in the field, white catfish were found in salinities as high as 17 ppt in a Georgia estuary (Heard, unpublished data as cited in Heard 1975), although the time of exposure to these salinities is unknown.

pH – White catfish are tolerant of highly acidic lake waters in Virginia (Jenkins and Burkhead 1994). They also inhabit the acidic Clermont Chain of Lakes in Florida, which have a pH of 6.1-6.4 (Hand et al. 1994 as cited in Crumpton 1999).

Post-larval habitat – Young-of-year white catfish have been collected by trawling over shoal habitats in the Hudson River estuary (TI 1981 as cited in Hughes and Carlson 1986).

Juvenile habitat – In the summer season, juvenile white catfish less than 200 mm TL were found lower in the tidal freshwater portion of the Hudson River estuary when compared to juvenile and adult white catfish greater than 200 mm TL (Jordan 2000).

Adult habitat – White catfish inhabit estuarine, lacustrine, lowland, upland, river, and stream habitats (Jenkins and Burkhead 1994). There distribution may be influenced by water temperature, depth, and water quality (Hughes and Carlson 1986). White catfish habitat is intermediate of channel catfish and other bullheads (Trautman 1957 as cited in Smith 1985) as they inhabit near channel areas (Hughes and Carlson 1986) and avoid muddied backwaters (Kendall 1910). In the Delaware River estuary, O'Herron et al. (1994) collected white catfish only in deep and intermediate water depths of greater than 3.05 m at mean low water (MLW) and not in shallow water habitats of less than 3.05 m at MLW. White catfish are commonly found in the mainstem and tributaries to the Potomac River (Lippson and Moran 1974). Their presence has been documented in the in the mainstem and lower tributaries to the Delaware River as well (Fowler 1906).

Migration and movements

River and estuary – Within its native range, the white catfish has shown a tendency to move into low estuary brackish waters in the winter (Markle 1976) and into upper estuary freshwaters during the spring (Heard 1975, Schmidt 1971). In the Thames River estuary, Schmidt (1971) found that white catfish seasonally alternated between these habitats, moving into freshwaters in the spring and fall and brackish waters in the summer and winter. Schmidt (1971) suggested summer distributions were dictated by low dissolved oxygen levels while fall movements were dictated by temperature. In the absence of low dissolved oxygen concentrations, seasonal movements are most likely dictated by changes in temperature (Schmidt 1971), prey availability, or salinity (Heard 1975). In estuary systems, where white catfish are seasonally found in brackish waters, the upstream movement of white catfish into freshwaters or waters with salinity less than 2 ppt is essential for spawning adults (Heard 1975). Despite this, in the channel of the Virginia's York River, white catfish were common in fresh water only in late fall (Markle 1976). In the Hudson estuary, white catfish greater than 200 mm were found in the upper most reach of the estuary significantly more than in three lower estuary reaches (Jordan 2000). Depending on estuary morphology, white catfish may be moving into and using other freshwater habitats in the spring and summer, such as shoal (Hughes and Carlson 1986) and tributary habitats (Fowler 1906, Lippson and Moran 1974).

Seasonal movements have yet to be exhibited or documented outside of the white catfish's native range (Pelgen 1954; Pelgen and McCammon 1955). However, white catfish have exhibit extensive movements outside of it's native range. In the Sacramento-San Joaquin Delta, CA, one white catfish moved 89 km (55 mi.) in just over 2 months, while another moved 40 km (25 mi.) in eight days (Pelgen 1954). Salvage data of mostly juveniles indicates seasonal changes in abundance and increasing activity at low light intensities (Helfrich et al. 1999).

Lake –White catfish have not exhibited seasonal movements in lake environments (Crumpton 1999, McCammon and Seeley 1961).

Management

Most natural resource agencies do little in the way of managing catfish populations (Michaletz and Dillard 1999 as cited in Irwin and Hubert 1999) while at the same time the conservation of many bullheads (*Ameiurus spp.)* is of critical importance to most agencies (Warren et al. 1997 as cited in Irwin and Hubert 1999). In general, there is a lack in expertise and published literature on the management of bullhead species (*Ameiurus spp*.) (Irwin and Hubert 1999).

Identification problems – Some anglers tend not to distinguish white from channel catfish and commonly mistake white catfish for what is thought to be a very stout and washed-out channel catfish (author's observation).

Introduced populations – White catfish were first introduced to the west coast of California in 1874 when 56 white catfish from the Raritan River, NJ were released in the San Joaquin River, near Stockton (Kendall 1910). White catfish from California were transplanted to the state of Nevada in 1877 (Kendall 1910). Since then, populations have been introduced to many parts of North America (Kendall 1910, Simon and Wallus 2004) and Europe (Keller 1926 as cited in Schmidt 1971).

Historical perspective –Kendall (1910) provides a good historical account of catfish collection methods within individual states and their regional productivity:

> Statistical data for the catfish fishery in the Middle Atlantic States (Virginia, Maryland, Delaware, Pennsylvania, and New Jersey) goes back to 1890 of which in that year over 2.7 million pounds were harvested. In Pennsylvania and Delaware fyke nets yielded the most catfish catch, while gill nets, pound nets,

seines, and fish baskets were also used. In New Jersey, the largest numbers of catfish were taken by seines, while pound nets also yielded fish. In the South Atlantic States (Georgia, South Carolina, and North Carolina), approximately 106,000 pounds were harvested in 1887 with pound nets, seines, and lines yielding the most fish. During 1897, over 2.4 million pounds were harvested in Gulf States (Louisiana, Mississippi, Alabama, and Florida) with trap nets, trammel nets, lines, and wooden traps being the most productive. Seines, fyke nets, and pound nets were also used. On the west coast (California, Washington, Oregon), over 620,000 pounds were harvested in 1899 with subsequent annual harvests in excess of 1.2 million pounds. In this region, most fish were taken using fyke nets and trot lines with seines, dip nets and hand lines also being used (Kendall 1910).

Declining fish stocks –In the Hudson, Connecticut, and Delaware Rivers, white catfish abundances have declined (Jordan et al. 2004, Daniels et al. 2005). Though not providing any technical literature, Daniels et al. (2005) stated white catfish populations have declined due to increasing numbers of channel catfish in the Delaware and Connecticut Rivers. The information that is present does raise concerns that the white catfish population may be declining in proportion to channel and other catfishes. According to impingement data at the Burlington generating station situated on the Delaware River in Burlington, New Jersey the ratio of channel catfish to white catfish in 1976-1978 was 2.2 to 1.0, in 1991 to 1992 that same ratio increased to 26.0 to 1.0 (Waterfield 1994 as cited in Boyer 1995). In contrast to the mid-Atlantic populations, other populations appear secure (e.g., Alabama populations small, but secure, Boschung and Mayden. 2004).

Overfishing – Evidence of declining stocks in California’s Sacramento-San Joaquin Delta led to the closure of a commercial white catfish fishery in 1953 (Pelgen and McCammon 1955) and the subsequent institution of creel limits. This management of the fishery proved successful as by 1980 the fishery was considered under-exploited and by 1988 creel limits were removed (Schaffter and Kohlhorst 1997).

Tagging – Floy, disk, staple, hydrostatic and opercular strap tags have all been used to tag and assess white catfish populations (Schmidt 1971; Hughes and Carlson 1986; McCammon and Seeley 1961). Floy tags anchored near the dorsal fin under the pterygiophores were used in the Thames River estuary to assess seasonal movements and population size, although shedding of tags was not evaluated (Schmidt 1971). Despite becoming covered with opaque mucus, opercular strap tags remained in place for one year (Pelgren 1954) but were shed before 22 months and ultimately were found unsuitable for tagging studies of this duration (Pelgen and McCammon 1955). Staple and disk-dangler tags were retained for seven years in a California lake. Hydrostatic tags were also retained for up to seven years although tag returns showed evidence of shedding and indicated these tags to be more suitable for periods less than one year (McCammon and Seeley 1961). In California’s Sacramento-San Joaquin Delta, white catfish were successfully tagged for at least 22 months using disk-dangler tags with no evidence of shedding (Pelgen and McCammon 1955). In the Hudson River, disk tagged fish were recaptured 36 months after release (Hughes and Carlson 1986). Although other tagging methods may be suitable for short periods of time, disk tags fastened through the dorsal musculature, as illustrated by Pelgren (1954), are the best method to tag white catfish for extended periods of time.

Scientific collection – Active methods that have been used to collect white catfish include; trawls, boat electrofishing, seines, and dip nets. Trawls have been used primarily in river and estuary systems (Caromile 1994; Heard 1975; Hughes and Carlson 1986; Markle 1976; Schmidt 1971) although they have also been used in lake environments (Crumpton 1999). Boat electrofishing is a method that has been used in the shallow portions of river systems (Hughes and Carlson 1986; Jordan 2000) as well as shallow lake habitats (author's experience). Seines and dip nets are other active gears that may be used to collect white catfish (Schmidt 1971).

Passive methods that have been used to collect white catfish include; hoop nets, gill nets, trap nets, set lines, and wire traps. Hoop nets are the most frequently used gear to collect catfish for scientific means (Vokoun and Rabeni 1999). They are used in lotic habitats (Hughes and Carlson 1986; Jordan 2000; Schaffter 1997; Schaffter and Kohlhorst 1997) and may be baited with scent baits such as cheese trimmings to attract fish (Gerhardt and Hubert 1989; Jordan 2000). Gill nets are another passive gear that has been used to collect white catfish in both lentic and lotic environments (Hughes and Carlson 1986; Schmidt 1971; Caromile 1994; Crumpton 1999). Trap nets, wire traps, and set lines have also been used (Hughes and Carlson 1986; Crumpton 1999). For information on the suitability and biases of these and other gears see Vokoun and Rabeni (1999).

Contaminants – Due to a high lipid content, catfish in general concentrate organic contaminants and metals (Boyer 1995). In the lower Hudson River, white catfish have been found with high levels of polychlorinated biphenyls (PCB's) (Smith 1985). In the Delaware estuary, white catfish exceed FDA limits for concentrations of PCB's and chlordane (Boyer 1995).

Conclusions

Deficiencies in the literature exist for many aspects of white catfish biology and management. Biologically this review found no published literature on the dissolved oxygen requirements and tolerances of white catfish, very little on pH tolerances, and very little on post-larval and juvenile habitat use. Insufficient literature was found on habitat use and movements of adults as well. Sufficient literature exists for many aspects of growth and diet although both are dependent on local conditions and white catfish diet information is lacking for lake environments.

Published literature on the management of this species appears to be severely lacking as well. No literature was found on habitat preservation and improvement. Little information was found on exploitation and mortality rates as well as creel and size limits. There was, however, sufficient literature on tagging and scientific collection methods. Declines in native fish stocks should be given more attention and the interspecific interactions that may occur between white and channel catfish should be evaluated.

Materials and Methods

Study area and stratification

Four portions (Zones 1, 2, 3, and 4) of the Delaware River estuary from Grubbs Landing, DE (river km 121) to Bordentown, NJ (river km 207) were surveyed. Zone 1 started ~11 river km below the Pennsylvania-New Jersey state freshwater line (river km 131.78) and zone 4 ended ~8 river km downstream from the Delaware estuary head-of-tide (river km 214.5, where the tidal Delaware estuary meets the non-tidal Delaware River). Zones were ~10 river km long and subdivided into mainstem and tributary macrohabitats. Two tributaries per zone were selected, except in zone 4 where only one was selected. Tributary habitats were divided into subhabitats (lower [0-500 m], middle [550-3,050 m upstream from mouth], and upper portions [near the head-of-tide]). In one larger tributary (Rancocas Creek), the lower and middle portions were defined as 0-700 and 750-4,250 m upstream from the mouth. Sampling sites were randomly selected within each habitat within each zone except for sites at the head-of-tide and in one tributary (Crosswicks Creek). Head-of-tide sites were sampled at the same locations.

Sampling gear

Two different-sized hoop nets baited with cheese trimmings were used to sample the mainstem Delaware River, and lower and middle tributary habitats. Hoop nets were either made of 2.2 cm (bar measure) netting with a 1.0 m opening or 2.3 cm (bar measure) netting with a 0.7 m opening. Hoop nets with a 0.7 m opening were composed of two different netting materials. Head-of-tide sites were angled using two rods with barbed “J” hooks: size 1/0 and 4. Earthworms were used as bait. Specimens provided by other research programs were collected by boat and backpack electrofishing.

Collection

In 2007, fish were collected from April to November with hoop nets and by angling. Catfish were identified to species, measured in total length to the nearest millimeter, and weighed. Catfish less than 2 kg were weighed to the nearest 2 g while catfish greater than 2 kg were weighed to the nearest 5 g. Mainstem sample sites were selected by overlaying a numbered grid on top of nautical charts and then randomly selecting a numbered box from that grid. Within selected areas, hoop nets were set for one night. Mainstem waters greater than or equal to 0.9 m and less than or equal to 9.1 m mean-low-low-water (MLLW) were typically sampled. Waters within the shipping channel were not sampled. Tributary sample sites (not including the head-of-tide) were selected by randomly selecting distances within each lower and middle tributary subhabitat. Hoop nets were set adjacent to tributary channels, on one side of the channel, and as close to the selected sites as possible. One tributary head-of-tide site per zone was selected for study. Head-of-tide sites were angled for 1-2 hours per visit. Dissolved oxygen, temperature, transparency, and salinity were measured in each habitat the morning of net retrieval or time of angling. Transparency was usually measured in the shade with a Secchi disk as described by McMahon et al. (1996). Dissolved oxygen, temperature, and salinity were measured using a Yellow Spring Instruments 556 multimeter. For each zone the dominant emergent and submerged aquatic vegetation was documented and identified to species.

Age, growth and spawning

Catfish were aged by counting annuli of transverse sections of sagittal otoliths. Otoliths greater then 3 mm were imbedded in epoxy, thin sectioned using an Isomet saw, and viewed in immersion oil. Otoliths less than 3 mm were prepared as described by Secor et al. (1991). Otolith sections were viewed using a microscope or dissecting scope at 6.3x magnification. Digital images of otolith sections were taken at 6.3x magnification and the distance between primordium and annuli were measured. Fish lengths at age (annuli) were back-calculated using the biological intercept procedure (Campana 1990). To determine spawning periods, whole ovaries of sacrificed fish were weighed and used to create a gonadosomatic index (gonad weight / body weight*100) (Strange 1996).

Habitat use

Habitat use was evaluated using mean catch-per-net-night (CPNN), relative abundance, proportion of channel catfish to [white catfish + channel catfish], relative condition (K_n), and mean length. Relative abundance was defined as the mean species specific catch divided by the CPNN times 100. Typically 12 hoop nets were set per net night. A relative condition index was developed as described by Le Cren (1951). Seasons were defined as April-June (spring), July-September (summer), and October-November (fall). Factorial analysis of variance (ANOVA; general linear model procedure) was used to identify significant differences (α =0.05) between strata (seasons, zones, and macrohabitats). Significant differences were analyzed using Tukey's Honestly Significantly Different (HSD) test (unequal N).

Results

Zone descriptions

Four portions (Zones 1, 2, 3, and 4) of the Delaware River estuary from Grubbs Landing, DE (river km 121) to Bordentown, NJ (river km 207) were surveyed (Figure 1). The dominant emergent vegetation encountered in all zones was yellow waterlily (*Nuphar luteum*). The dominant submerged aquatic vegetation encountered throughout the study area was wild celery (*Vallisneria americana*) and the introduced species hydrilla *(Hydrilla verticillata).* Beds of wild celery were observed in patches and long narrow bands through out the study area, whereas hydrilla was encountered in nets and as floating mats. Zones 2-4 consisted entirely of freshwater throughout the year, while zone 1 was seasonally oligohaline (0.5-5.0 ppt) in late summer and early fall (maximum salinity of 2.8 ppt). Water temperature differed significantly between seasons ($p<0.001$; spring LS mean = 17.8°C; summer LS mean = 25.3°C; fall LS mean = 14.1°C) but not zones or macrohabitats ($p>0.05$). No significant differences in transparency were found between seasons, zones, or macrohabitats ($p>0.05$) (transparency not measured in fall). However, significant differences were found between lower (1 and 2) and upper (3 and 4) zone groups ($p<0.001$; upper LS mean = 124 cm; lower LS mean = 70 cm). Dissolved oxygen (DO) was significantly lower in summer (LS mean = 5.84 mg/l) than in spring (LS mean = 7.70 mg/l) and fall (LS mean = 7.47 mg/l) ($p<0.001$). DO was not measured in zones 3 and 4 during the fall. DO differed significantly between zones 1 and 2 ($p=0.010$; zone 1 mean = 7.61 mg/l; zone 2 = mean 6.48 mg/l) but not macrohabitats ($p>0.05$).

Collection

A total of 553 channel catfish (*Ictalurus punctatus*), 201 white catfish (*Ameiurus catus*), and 31 brown bullhead (*A. nebulosus*) were collected in the estuary (not including young-of-year). Randomly set hoop nets (N=481) collected 528 channel catfish, 181 white catfish and 28 brown bullhead (Figure 2). In 67.6 hours of angling at upper tributary sites (near head-of-tide), 17 channel catfish (20-47 cm TL), 11 white catfish (20-36 cm TL), and 3 brown bullhead (23-35 cm TL) were collected. A 52 cm white catfish weighing 2.17 kg was observed during a fishing tournament weigh in. One young-of-year (YOY) channel catfish and two YOY white catfish were also collected in the estuary. Brown bullhead YOY were collected in a nearby impoundment. Yellow bullhead (*A. natalis*) and flathead catfish (*Pylodictis olivaris*) were not encountered during sampling.

Age and growth

A total of 75 white catfish, 145 channel catfish, and 23 brown bullhead were aged and used to determine mean back-calculated total length at age and age-frequency histograms for each species (Table 1; Figure 3). Released fish were assigned ages using an age-length key based on ages of sacrificed fish (DeVries and Frie 1996). Biological intercepts for back-calculation were determined using two YOY white catfish (mean TL = 3.3 cm), one YOY channel catfish (TL = 10.2 cm), and four YOY brown bullhead (mean TL = 4.3 cm). To detect sex differences, mean back-calculated total length at age was also determined for males and females of each species (Table 2). Differences in mean back-calculated total length suggest that channel catfish males grow faster but females lived longer. To detect length differences between adjacent year classes, individual back-calculated total length at age were plotted for even and odd age fish (Figures 4-6). These plots revealed no difference in the back-calculated total lengths for adjacent year classes.

Spawning and maturity

White catfish gonadosomatic index (GSI) scores indicated a well-defined spawning period in June and early-July (Figure 7). All white catfish with GSI scores greater than 13 (N=7) were collected in tributaries, indicating that white catfish used tributary habitats rather than river habitats for spawning. The smallest ripe female white catfish collected, was 24.1 cm TL and 3 years of age. Channel catfish spawned from late-May thru mid-July and had a lesser defined spawning period as indicated by GSI scores (Figure 8). Channel catfish with GSI scores greater than 11 were collected in both river and tributary habitats. The smallest ripe female channel catfish collected was 35.1 cm TL and 6 years of age.

Habitat use

Channel catfish and white catfish were found throughout the study area during all seasons. Ratios of channel catfish to white catfish collected in randomly set hoop nets were 3.6 to 1.0 in the river, 2.3 to 1.0 in tributaries, and 2.9 to 1.0 for the study area as a whole. Catches from different hoop net types were pooled for each net night since hoop net types were not significantly different for white catfish length and CPNN or channel catfish length and CPNN ($P>0.05$). Hoop net type differences for brown bullhead were not evaluated due to the low number (N=28) collected.

Both white catfish and channel catfish had significant increases in seasonal CPNN (P<0.001; Figure 9). Channel catfish CPNN was not significantly different between river and tributary subhabitats, macrohabitats (tributary and river) or zones (P>0.05). There was no significant season*zone*macrohabitat three-way interaction (P>0.05). However, there was a significant season*zone interaction (P=0.015; Figure 10). Channel catfish relative abundance revealed a significant difference between tributary and river macrohabitats (P=0.04; tributary LS mean=60.3, river LS mean=76.7). When combining zones into lower (1 and 2) and upper (3 and 4) zone groups, channel catfish relative abundance revealed a significant zone group*macrohabitat interaction indicating less tributary use in the upper zone group (P=0.024; Tukey's HSD showed no pairwise difference; lower zone group LS means: river = 74.8, trib. = 71.5, upper zone group LS means: river = 78.6, trib. = 49.1).

As with channel catfish CPNN, white catfish CPNN was not significantly different between river and tributary subhabitats (P>0.05) or macrohabitats (P>0.05), tributary and river). White catfish CPNN was significantly different between zones (P<0.001; Tukey's HSD showed no pairwise difference; CPNN per river and tributary subhabitat per net night LS means for zones; 1 = 0.62, 2 = 0.31, 3 = 0.31, and 4 = 0.26). Like channel catfish CPNN, there was no significant season*zone*macrohabitat three-way interaction for CPNN (P>0.05). White catfish CPNN did not show a significant zone*macrohabitat interaction (P>0.05). However, like channel catfish, white catfish CPNN did show a significant season*zone interaction (P<0.001; Figure 10). White catfish relative abundance was not significantly different between tributary and river macrohabitats (P>0.05).

Channel catfish total length was significantly less in summer (LS mean = 31.8 cm) than in spring (LS mean = 39.2 cm) and fall (LS mean = 39.4 cm) ($P<0.001$). White catfish total length was also significantly different between seasons ($P=0.025$; Tukey's HSD showed no pairwise difference; spring LS mean = 30.6, summer LS mean = 28.5, fall LS mean = 33.0), but not macrohabitats or zones ($P>0.05$). Channel catfish condition during spring (LS mean = 104) was significantly greater than summer (LS mean = 99) but not fall (LS mean = 101) ($P=0.001$). No significant differences were found between macrohabitats ($P>0.05$) or zones ($P=0.059$; Figure 11). However, channel catfish condition was significantly greater in the upper zone group (LS mean = 103, zones 3 and 4) when compared to lower zone group (LS mean = 100, zones 1 and 2) ($P=0.005$). Channel catfish condition also revealed a season*zone group interaction with upper zone group spring condition (LS mean = 108) being significantly higher than other season*zone group combinations (LS means $\leq$101) ($P=0.012$).

White catfish condition during spring (LS mean = 109) was significantly greater than summer (LS mean = 99) and fall (LS mean = 100) ($P<0.001$). Condition was also significant different between zones ($P<0.001$; Figure 11) but not macrohabitats ($P>0.05$). White catfish condition also revealed a significant season*zone interaction ($P=0.003$; Figure 12). White catfish condition did not reveal a significant season*zone group interaction ($P=0.12$). The proportion of channel catfish to white catfish was not significantly different between strata ($P>0.05$) but did show a significant season*zone interaction ($P>0.001$; Figure 13; based on non-transformed data).

Discussion

Age and growth

Channel catfish in this study were aged to 22 years, much older then the maximum age (8 years) determined by Jordan (2000) using pectoral spines on the Hudson River fishery. Pectoral spines have been found to underestimate the age of old flathead catfish when compared to otoliths (Nash and Irwin 1999). This is attributed to an expanding central lumen that erodes early annuli, distorting calculations (Borgeson and McCammon 1967), and necessitating estimation (Stevens 1959). Crumpton et al. (1987) justified the use of pectoral spines to age Florida catfish by stating that the central lumen did not erode early annuli due to high growth rates and a lengthy growing season. With cooler temperatures and a shorter growing season, problems associated with an expanding central lumen are likely more pronounced in the mid-Atlantic and northeastern US. It is likely that Hudson River fish are slow growing and that pectoral spine ages may underestimate the age of these fish.

The maximum white catfish age determined in this study was 14 years, the same maximum found by others in the Hudson River estuary (Jordan et al. 2004) and Patuxent River (Schwarts and Jachowski 1965). Back-calculated lengths for white catfish ages one to three were similar to those determined for the Hudson River (Hughes and Carlson 1986; Jordan et al. 2004). However, at ages greater than three, Delaware River estuary white catfish exhibited slower growth when compared to Hudson River estuary fish. In contrast, back-calculated lengths for white catfish age two to eight were greater than those determined for the Patuxent River (Schwartz and Jachowski 1965). Differences in growth between fish from the Hudson River and other estuaries may be attributed to different aging techniques. Schwartz and Jachowski (1965) used vertebrae to age white catfish and avoided problems associated with spines and the central lumen. Hudson River fish were aged using pectoral spines (Hughes and Carlson 1986; Jordan et al. 2004) and ages of old fish may have been underestimated.

Slower white catfish and channel catfish growth in the Delaware River estuary when compared to the Hudson River estuary, if real, may also be due to competition with a more established channel catfish population (>100 years). Channel catfish were introduced to the Delaware River in the late 1800's (Fish Commissioners of Pennsylvania 1897) and first documented in the Hudson River in the mid to late 1970's (Smith and Lake 1990). A more established channel catfish population may provide greater competition for resources when compared to a 20-25 year old population as was studied in the Hudson River estuary. White catfish have been documented to feed on alosines (i.e. American shad and herring), their eggs, other fishes, and amphipods (Borgeson and McCammon 1967; Heard 1975; Kendal 1910; Menzel 1945). Channel catfish are likely competing for these same items.

Variation in year class strength has been documented for channel catfish (Helms 1975) and white catfish (Jordan 2000). In this study, age frequency distributions for both species indicated poor recruitment to the age three and five year classes (2004 and 2002). Poor recruitment to the same year classes by both species suggests a common variable or set of variables may be impacting year class recruitment. In channel catfish, floods have been found to disrupt spawning (Holland-Bartels and Duval 1988) and cold weather has been found to delay spawning (Helms 1975). In the Delaware River estuary, annual variation in recruitment did not appear to correspond to these factors. However, channel catfish year class strength alternated between high and low abundances, corresponding with New Jersey’s biannual stocking of channel catfish in tributary impoundments. Channel catfish stocking in these impoundments should be reduced if it is determined that channel catfish leave these impoundments for downstream estuary waters. Stocked channel catfish moving from impoundments to estuary waters may explain fluctuations in ratios of channel catfish to white catfish in the estuary. New Jersey’s channel catfish stocking program was intensified in the late 1970’s (NJDEP 2009) just prior to the period when large changes in channel catfish to white catfish ratios were observed.

Spawning

White catfish begin spawning when water temperatures reach approximately 19-21ºC (Borgeson and McCammon 1967). In this study, white catfish spawned from June to early-July, when surface temperatures ranged from 23-25 ºC. (O’Herron et al. (1994) documented little difference (<1 ºC) between surface and bottom temperatures in the Delaware River estuary). Spawning onset observed at higher temperatures is likely due to few females being collected in late May and the quick rise in temperatures from late May to early June. Channel catfish spawned from late May through mid-July when surface temperatures ranged from 20-25 ºC. These results are within the 21-29 ºC spawning temperature determined by Clemens and Sneed (1957).

Tributary spawning by white catfish in the Delaware River estuary differs from observations in the Hudson River. Spawning in the Hudson River estuary occurred in channel border areas of the mainstem (Hughes and Carlson 1986). Hughes and Carlson

(1986) suggested that mainstem spawning in the Hudson River estuary may be due to estuary shape, the location of tributaries upstream of the salt line, and the presence of freshwater. In the Delaware River estuary, both freshwater mainstem and tributary habitat are found above a brackish lower estuary yet spawning white catfish were not collected on the mainstem. Tributary spawning in the Delaware River estuary is likely due to freshwater habitat as well as suitable spawning habitat provided by low gradient coastal plain tributaries with sand bottoms and slower flow. In the Hudson River estuary, there are few low gradient tributaries upstream of the salt line, a fact which may explain differences in spawning habitat between these estuaries.

Channel catfish appeared to spawn in both mainstem and tributary habitats. The mainstem consisted mostly of open or vegetated bottom and to a lesser extent provided cover such as piers, bulk heading, and submerged piles of various materials. Channel catfish have been documented spawning in areas with and without cover (Becker 1983; Geibel and Murray 1961). Since the mainstem and tributary habitats were not stratified into open and near cover areas we can not make any inferences as to whether cover is associated with spawning in the Delaware River estuary.

Habitat use

The proportion of channel catfish to [channel catfish + white catfish] and the relative abundance of both species illustrate the channel catfish's dominance in the freshwater estuary. These indices also suggest zone 3 may provide important pre-spawn or spawning habitat for white catfish but not channel catfish. The study area's largest tributary was located in zone 3 and all spawning white catfish were collected in tributaries. As a whole, Delaware River estuary tributaries provide important spawning habitat for white catfish and represent a large portion of the available catfish habitat in the Delaware River estuary.

Seasonal changes in abundance have been documented for both white catfish and channel catfish (Helfrich, Liston, and Weigmann 1999; Jackson and Jackson 1999). In this study, catch-per-net-night (CPNN) of both species increased from spring to fall. Conversely, in Mississippi's Yockanookany River, Jackson and Jackson (1999) found channel catfish catch rates decreased from spring to fall. They suggested that high water levels and increased current during the fall inhibited collecting gear resulting in lower catch rates. In this study, high spring flows may also have negatively impacted hoop net efficiency resulting in decreased CPNN during the spring. Increased CPNN also occurred after both species' spawning periods suggesting spawning fish may not have been susceptible to hoop nets.

Channel catfish relative abundance was significantly greater in the river than in the tributary macrohabitat. Delaware River estuary tributaries provide slower flow, shallower depths, more submerged and emergent vegetation, and may be more suitable for white catfish and brown bullhead. Although significant differences were not detected for these species (between tributary and river macrohabitats), increased CPNN of white catfish and brown bullhead decreased the relative abundance of channel catfish in the tributary habitat. Conversely, higher flows, deeper water, and more open bottom are habitat characteristics more suitable for channel catfish.

During the fall, channel catfish were distributed throughout the study area and did not show a preference for a specific zone. In the fall, many channel catfish tolerated colder upper estuary waters when compared to white catfish. White catfish appeared to seek warmer waters down estuary. This resulted in white catfish moving downstream during the fall, out of the upper estuary and into the lower estuary (zone 1). In the absence of low dissolved oxygen concentrations, Schmidt (1971) suggested seasonal movements were most likely dictated by temperature changes. Heard (1975) however, suggested prey availability or salinity dictated movements. In the Delaware River estuary, white catfish distribution corresponded with decreasing temperature. It is unclear how prey availability and salinity corresponded with distribution.

The relative conditions of both white catfish and channel catfish were highest during the spring and corresponded with pre-spawn, spawning, and significantly cooler water temperature. Also during the spring, channel catfish relative condition was significantly higher in the upper zone group (zones 3 and 4), corresponding with significantly less turbidity, non-significant increases in zone 4 CPNN and non-significant increases in relative abundance on the mainstem in zone 4. Although some of these patterns are not significant and may not be real, they do indicate a general up-estuary distribution, and possibly an abundance of forage (e.g., Alosine eggs) or spawning habitat for channel catfish in the spring. Lower relative conditions in the summer corresponded to the post-spawn period during which individuals may have been guarding young, water temperature was significantly higher and dissolved oxygen concentrations were significantly lower. Although not significant, in the fall, relative conditions of both species improved, and corresponded with significantly cooler temperatures when compared to summer. In the Delaware River estuary, relative condition of both species appeared to be influenced by spawning and environmental conditions (e.g., dissolved oxygen and water temperature).

Stock status

Since the introduction of channel catfish to the Delaware River drainage in the late 1800's (Fish Commissioners of Pennsylvania 1897) the ratio of channel catfish to white catfish has increased. Over the last 30-40 years, ratios of channel catfish to white catfish have fluctuated with this study's ratio being lower then those documented in the early 1990's and similar to ratios documented in the mid to late 1970's. It remains unclear if fluctuating ratios reflect a decline in one species, an increase in one species, or both. Estimates of channel and white catfish population size are needed to determine if changes in white catfish abundance and ratios reflect real population declines. Fluctuating ratios may be due to variable year class recruitment. Factors influencing year class strength are not well understood for catfishes in Delaware River estuary and need to be determined to better understand catfish abundances. Estuary ratios may also be impacted by stocked channel catfish moving into estuary waters. The emigration of stocked channel catfish from estuary impoundments should be investigated and resulting management decisions should reflect goals for both native fish conservation and game species (e.g., reducing channel catfish stocking to decrease the ratio of channel catfish to white catfish, if it is found that channel catfish negatively impact white catfish). Fluctuating ratios may also reflect interspecific competition between channel catfish and white catfish (Daniels et al. 2005). Daniels et al. (2005) associated white catfish declines in the Delaware and Connecticut Rivers with channel catfish establishment. In the

Hudson River estuary, Jordan et al. (2004) also noted a general decline in white catfish abundance “coincident with channel catfish establishment”. In the Delaware River estuary, channel catfish and white catfish habitat use overlaps to varying degrees. It is likely that white catfish and channel catfish are competing for resources to some degree in the Delaware River estuary.

Tables

Table 1. Mean back-calculated total length (TL) at age (mm), standard error (SE), and sample size (N) of white catfish, channel catfish, and brown bullhead collected in 2007 from the Delaware River estuary.

Species	Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
White catfish	**TL (mm)**	82	162	216	256	278	309	329	345	369	392	414	395	414	435								
	N	75	72	64	58	30	26	15	12	10	8	3	1	1	1								
	SE	1.8	2.7	3.9	4.8	5.7	6.9	10.0	8.5	10.1	14.4	16.1	-	-	-								
Channel catfish	**TL (mm)**	103	181	234	277	312	345	369	395	417	436	450	451	467	481	506	537	535	575	552	569	543	556
	N	145	145	126	120	96	96	72	68	58	54	41	34	23	18	9	8	4	3	2	2	1	1
	SE	1.0	1.5	2.3	3.0	4.3	4.9	6.9	7.3	8.8	8.9	10.7	9.3	10.0	11.9	22.3	21.6	36.7	43.3	40.6	43.0	-	-
Brown bullhead	**TL (mm)**	104	185	239	271	300	318	366	399														
	N	23	23	17	10	9	5	1	1														
	SE	4.7	6.6	7.8	8.9	7.3	11.0	-	-														

Table 2. Sample size (N), mean back-calculated total length (TL) at age (mm), 90^{th} and 10^{th} percentiles for individual back-calculated total lengths by sex for white catfish, channel catfish, and brown bullhead collected in 2007 from the Delaware River estuary.

Species	Sex		Age																					
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
White catfish	Male	90th percentile TL (mm)	104	186	259	298	318	355	376	378	400	430	430											
		10th percentile TL (mm)	66	131	179	213	242	271	286	308	331	343	388											
		Mean TL (mm)	82	161	216	257	279	313	329	347	370	391	409	395	414	435								
		N	41	41	40	38	18	16	10	9	8	7	2	1	1	1								
	Female	90th percentile TL (mm)	99	189	250	301	326	363	372	347	371													
		10th percentile TL (mm)	65	135	178	215	244	271	298	328	359													
		Mean TL (mm)	82	163	215	254	275	303	329	337	365	401	425											
		N	28	28	23	20	11	10	5	3	2	1	1											
		Diff. of means (mm)	0	-2	1	3	4	10	1	11	5	-10	-16											
Channel catfish	Male	90th percentile TL (mm)	114	203	270	323	375	422	464	495	536	568	564	495	518	530								
		10th percentile TL (mm)	87	159	200	237	269	296	318	342	363	380	395	408	421	432								
		Mean TL (mm)	102	182	239	282	320	355	387	408	438	456	466	451	467	477	503	520						
		N	55	55	54	53	43	43	32	29	27	25	18	13	9	7	1	1						
	Female	90th percentile TL (mm)	116	198	261	305	344	382	422	453	465	500	516	537	517	545	584	611	607	635	584	604		
		10th percentile TL (mm)	90	160	194	225	245	274	294	315	332	345	362	383	408	428	430	462	474	515	519	535		
		Mean TL (mm)	103	180	231	272	305	337	355	383	398	419	436	451	467	484	507	540	535	575	552	569	543	556
		N	82	82	69	67	53	53	40	38	31	29	22	21	14	11	8	7	4	3	2	2	1	1
		Diff. of means (mm)	-1	2	8	10	16	19	32	25	40	37	29	0	0	-8	-3	-20						
Brown bullhead	Male	90th percentile TL (mm)	141	231	285	302	319	341																
		10th percentile TL (mm)	83	156	200	243	269	290																
		Mean TL (mm)	106	184	239	272	300	315																
		N	15	15	12	9	8	4																
	Female	90th percentile TL (mm)	125	218	263																			
		10th percentile TL (mm)	78	157	210																			
		Mean TL (mm)	101	190	238	259	298	332	366	399														
		N	7	7	5	1	1	1	1	1														
		Diff. of means (mm)	5	-6	1	13	2	-17																

Figures

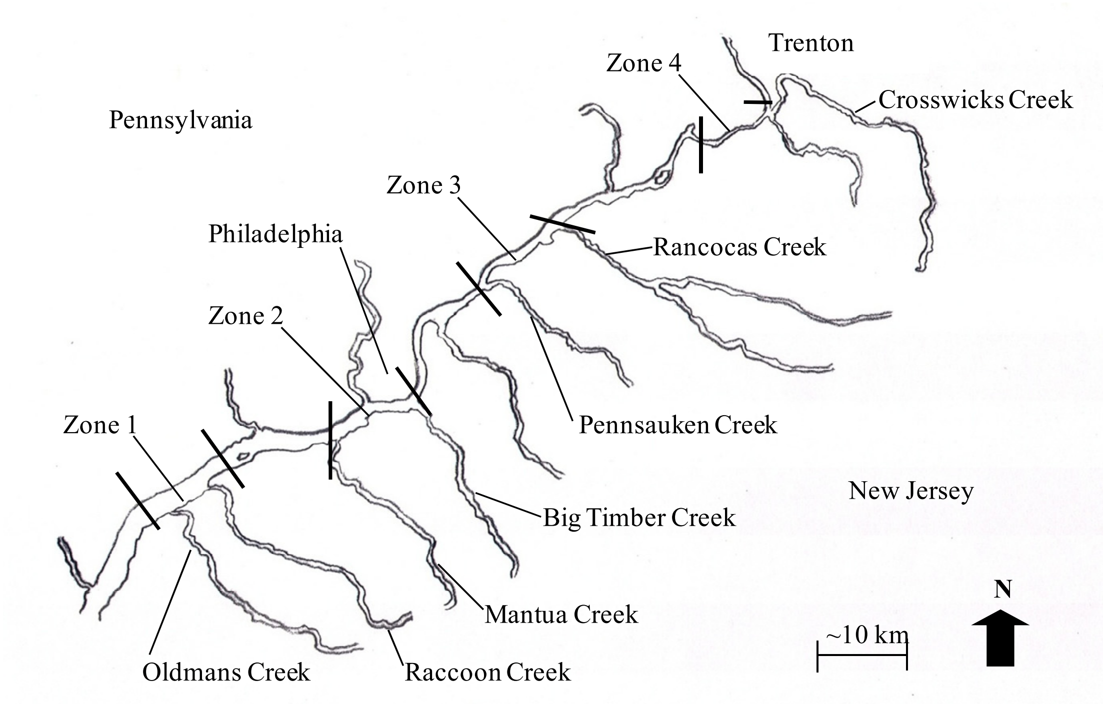


Figure 1. Map of study area in the Delaware River estuary.

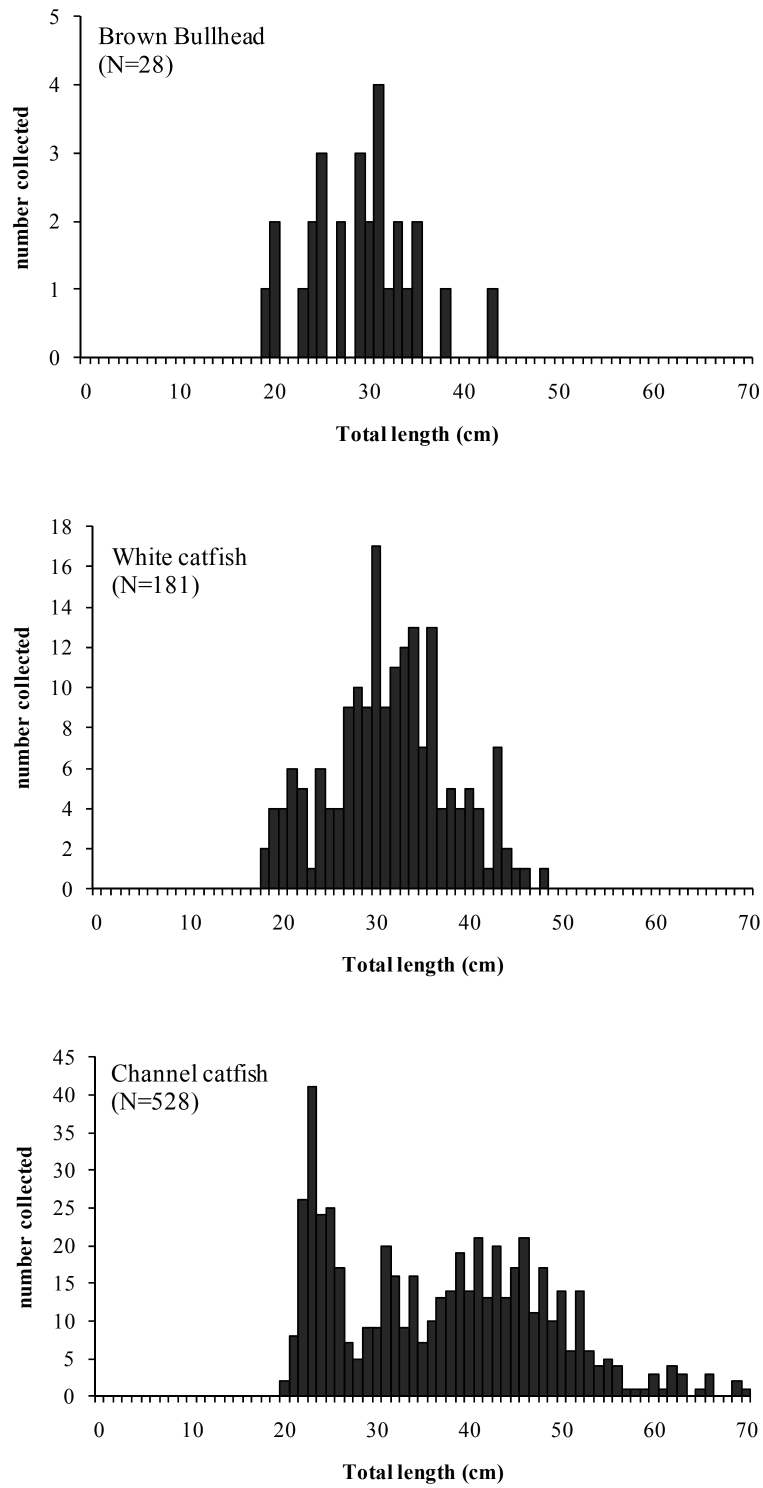


Figure 2. Length frequency histograms for brown bullhead, white catfish, and channel catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary.

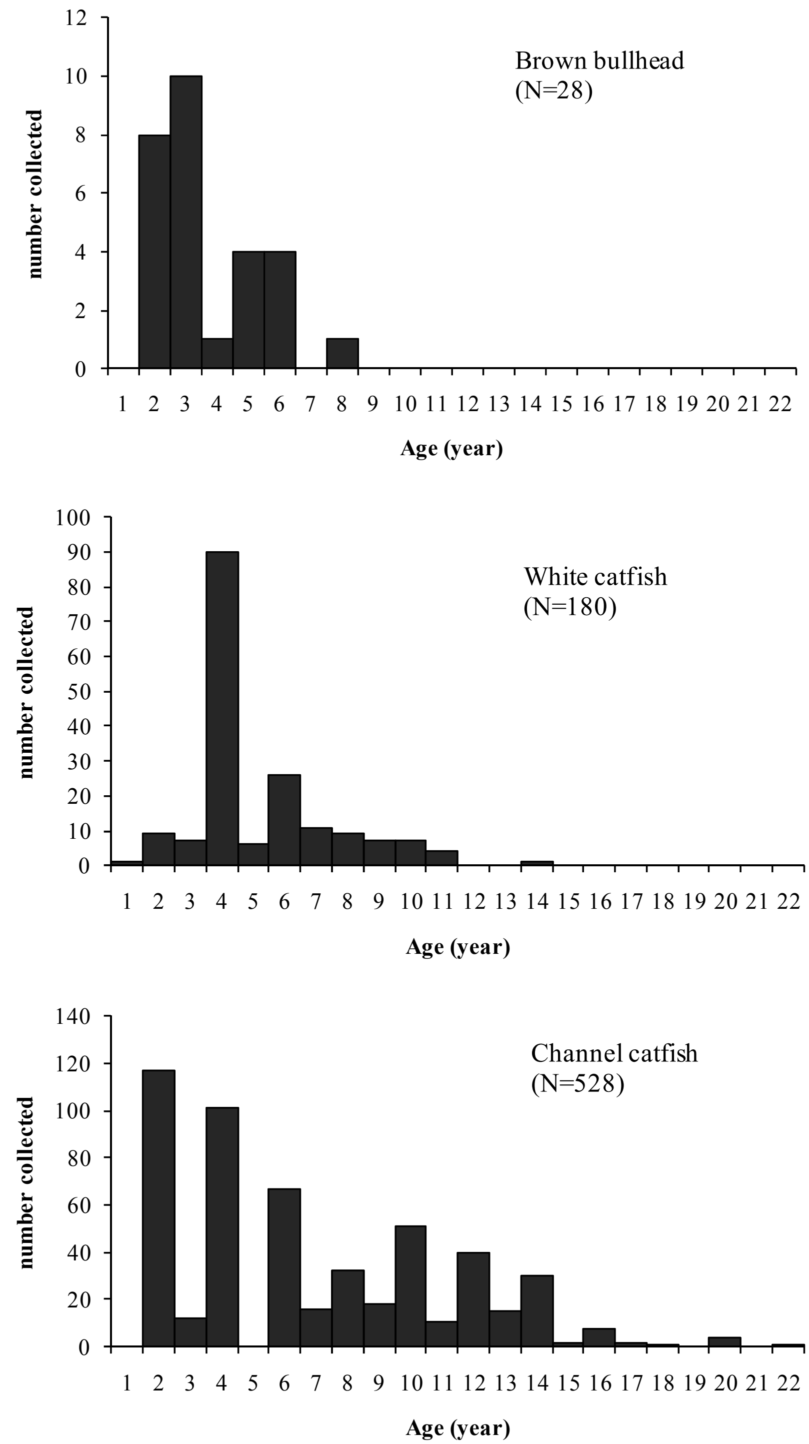


Figure 3. Age frequency histograms for brown bullhead, white catfish, and channel catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. Number collected includes released fish assigned ages using an age-length key.

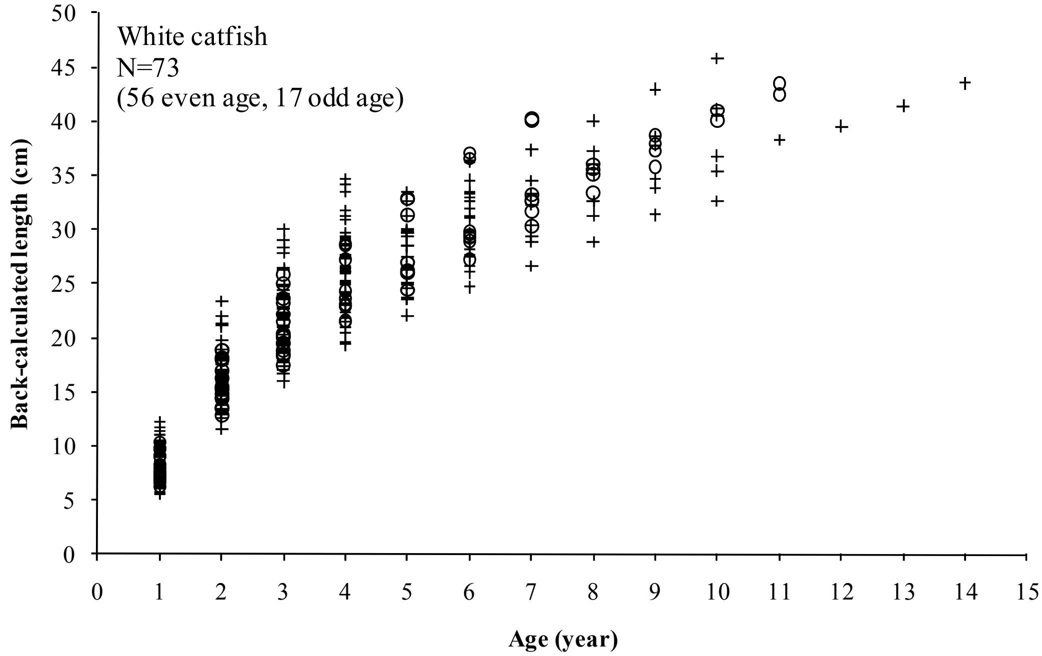


Figure 4. Plot of individual back-calculated lengths by age for white catfish collected in the Delaware River estuary in 2007. O=back-calculated lengths of odd aged fish, +=back-calculated lengths of even aged fish

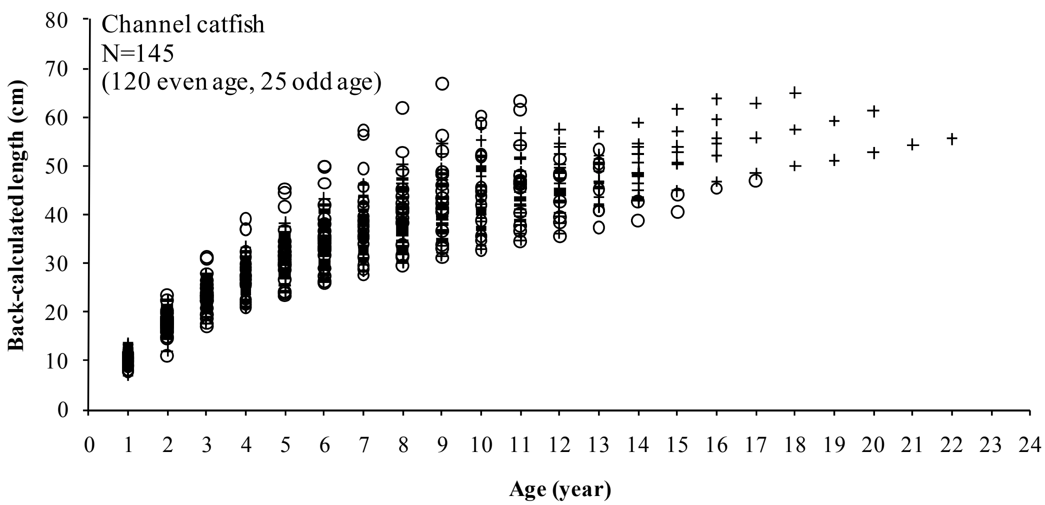


Figure 5. Plot of individual back-calculated lengths by age for channel catfish collected in the Delaware River estuary in 2007. O=back-calculated lengths of odd aged fish, +=back-calculated lengths of even aged fish

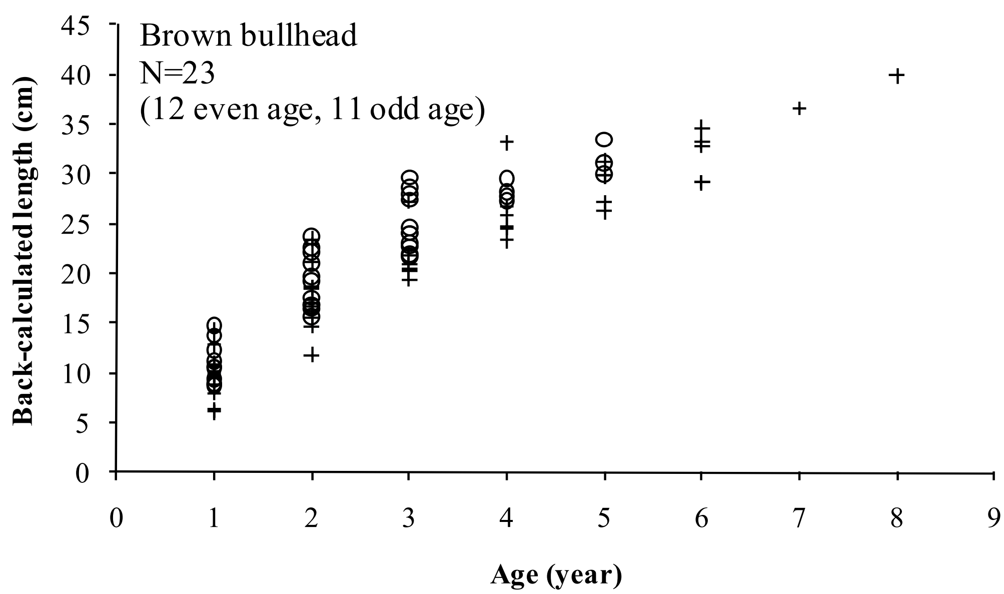


Figure 6. Plot of individual back-calculated lengths by age for brown bullhead collected in the Delaware River estuary in 2007. O=back-calculated lengths of odd aged fish, +=back-calculated lengths of even aged fish

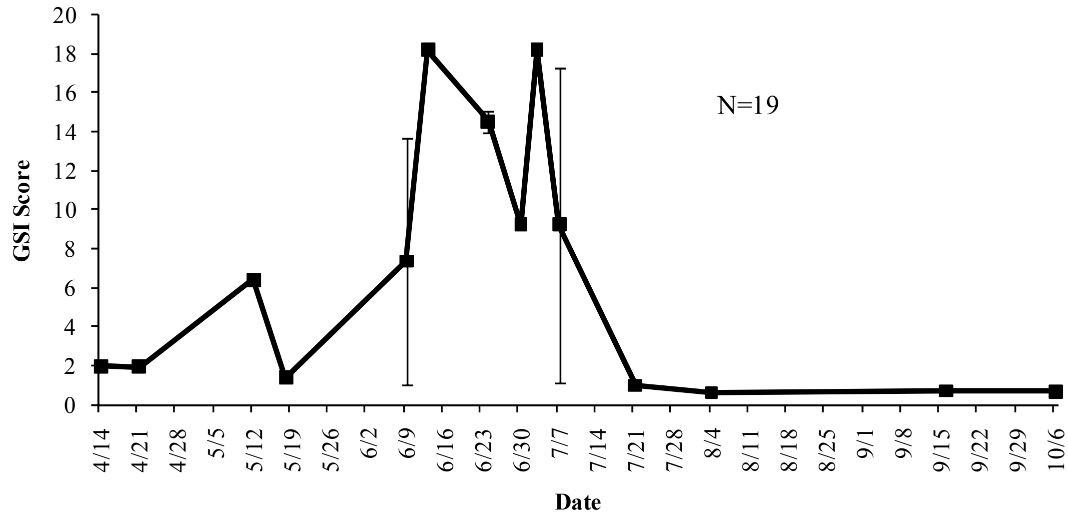


Figure 7. Gonadosomatic index (GSI) scores for female white catfish (>24 cm) collected in 2007 from the Delaware River estuary. Figure includes one specimen collected by Jeffery Ashley (The Academy of Natural Sciences unpublished data). Standard error bars are shown for average scores. Scores with out standard error bars represent one fish.

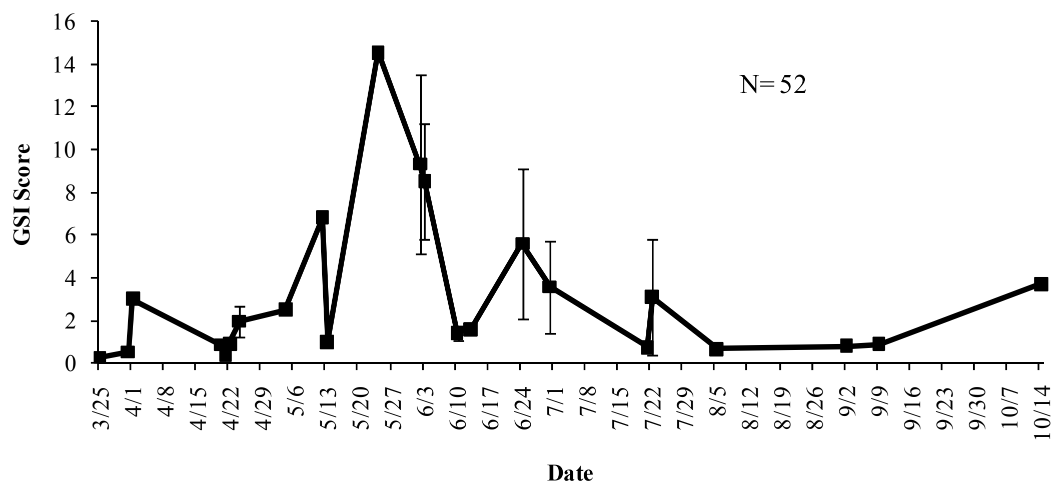


Figure 8. Gonadosomatic index (GSI) scores for female channel catfish (>35 cm) collected in 2007 from the Delaware River estuary. Figure includes one specimen collected by Jeffery Ashley (The Academy of Natural Sciences unpublished data). Standard error bars are shown for average scores. Scores with out standard error bars represent one fish.

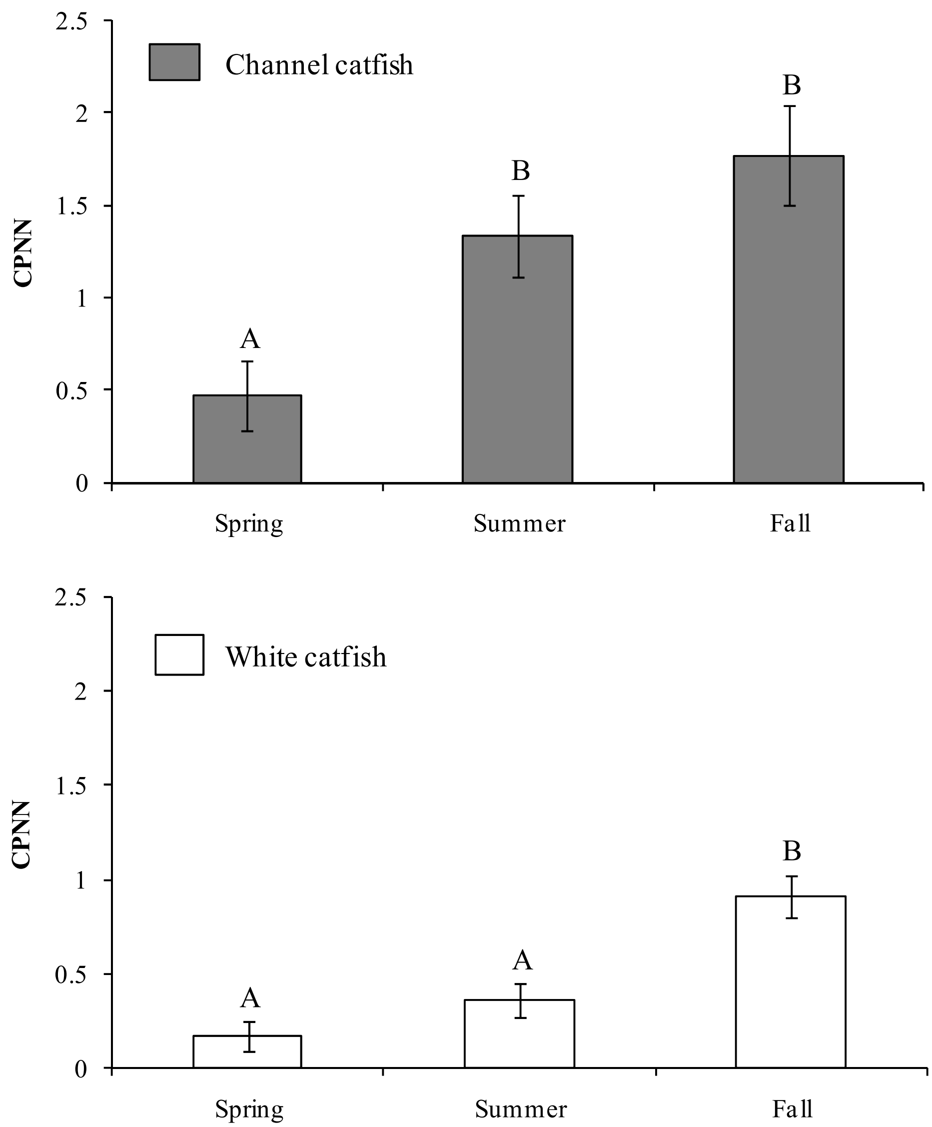
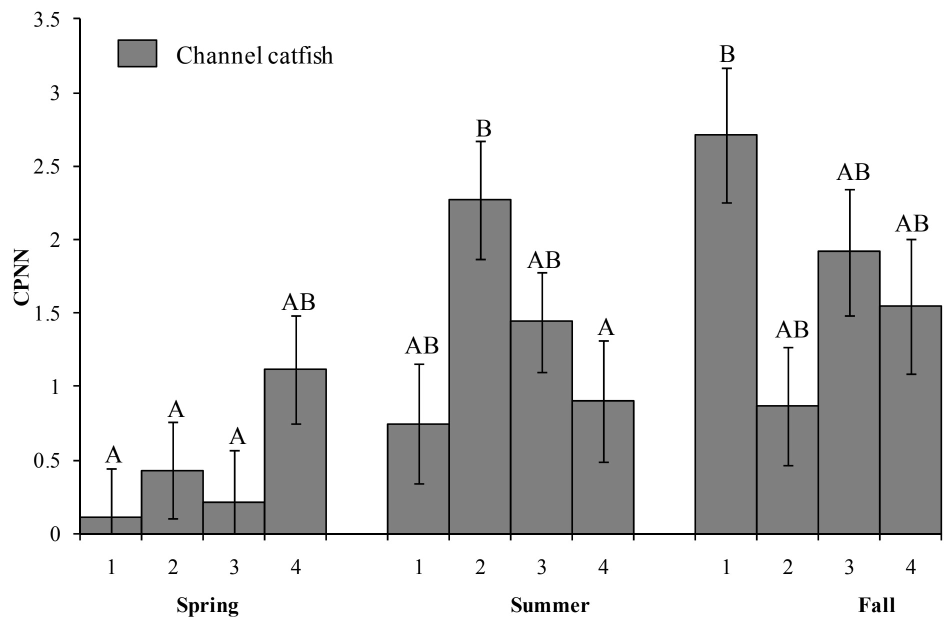


Figure 9. Seasonal mean catch-per-net-night (CPNN) per river and tributary subhabitats with standard error bars for channel catfish and white catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. Means with a letter in common are not significantly different (P>0.05).



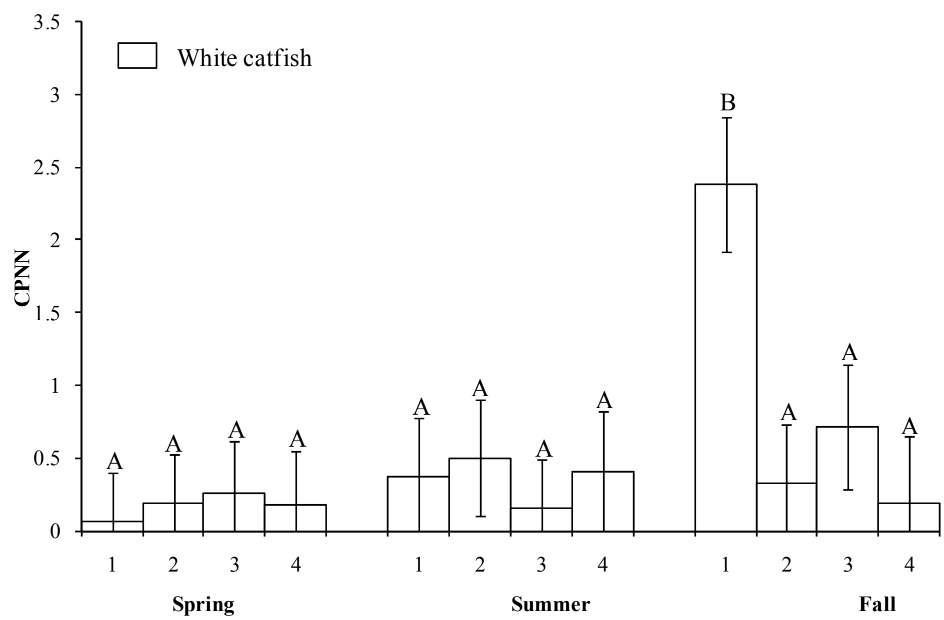
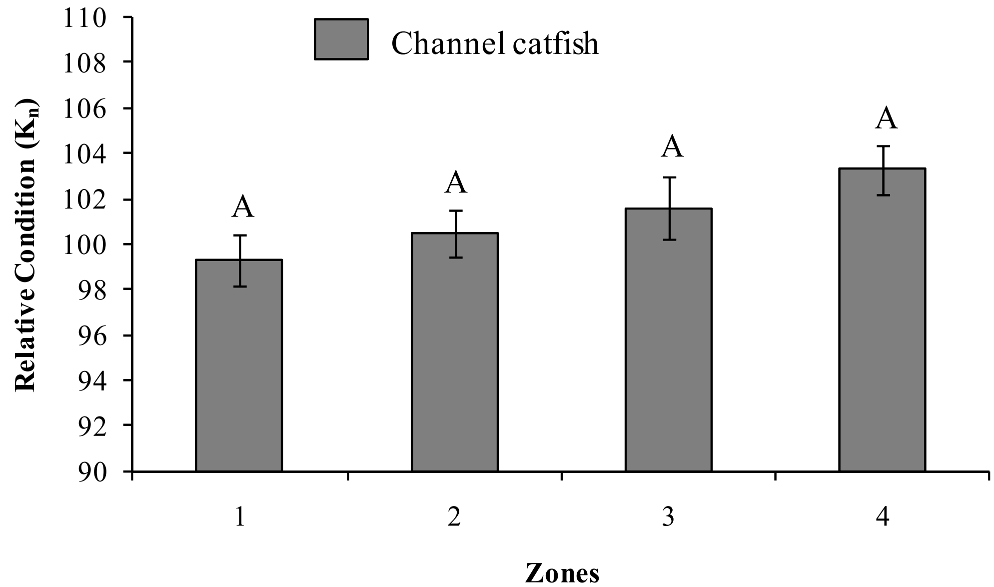


Figure 10. Season-zone comparison of macrohabitat mean catch-per-net-night (CPNN) with standard error bars for channel catfish and white catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. Means with a letter in common are not significantly different (P>0.05).



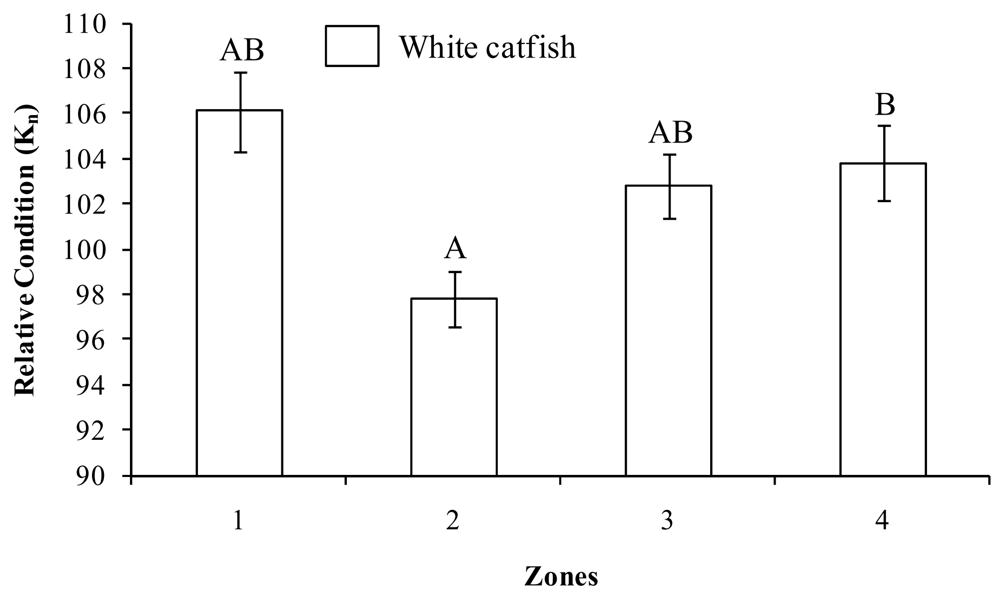


Figure 11. Mean relative condition (K_n) per zone with standard error bars for channel catfish and white catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. White catfish means with a letter in common are not significantly different (P>0.05).

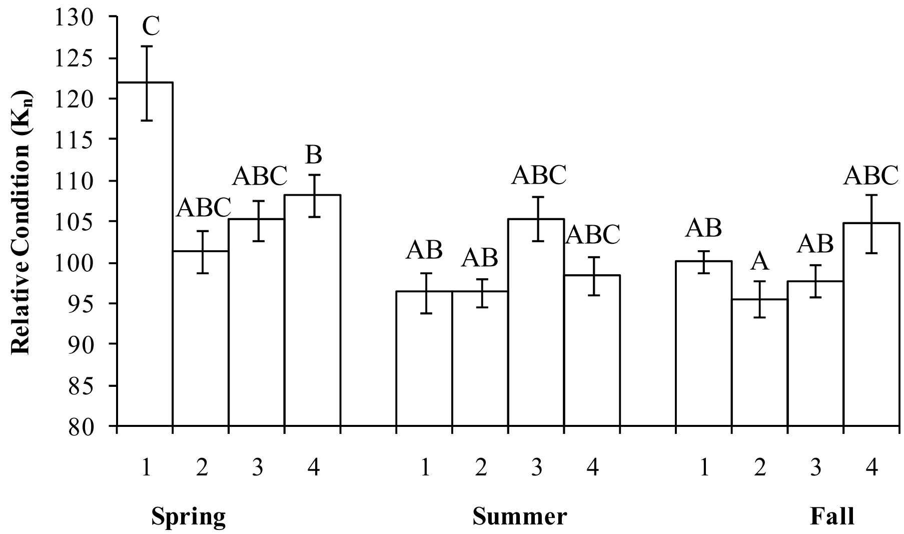


Figure 12. Mean relative condition (K_n) per zone per season with standard error bars for white catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. White catfish means with a letter in common are not significantly different (P>0.05).

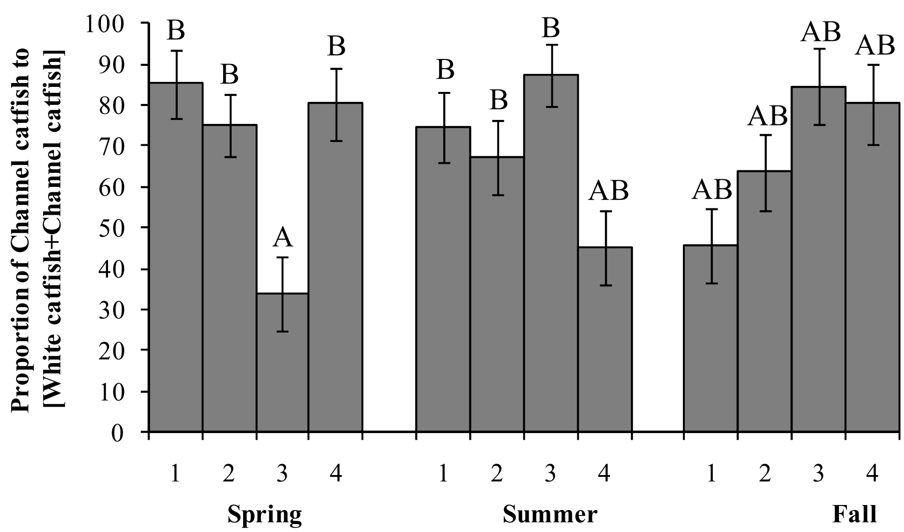


Figure 13. Mean proportion of channel catfish to [white catfish + channel catfish] per zone per season with standard error bars. Fish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. Proportion means with a letter in common are not significantly different (P>0.05).

Appendices

Appendix 1. Length and otolith measurements used to determine mean back-calculated lengths at age for white catfish collected in the Delaware River estuary in 2007.

Fish	Collection	Age	Length	Radius (µm)	Distance from core of otolith cross-section to annulus (µm)													
Analysis #	Date	(yr)	(L_c) (cm)	O_c	O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8	O_9	O_{10}	O_{11}	O_{12}	O_{13}	O_{14}
F-3838	8/17/2007	4	26.0	709	203	412	544	659										
F-3839	8/11/2007	4	30.2	764	244	472	621	728										
F-3840	8/11/2007	3	28.6	621	242	431	567											
F-3841	10/6/2007	4	39.6	741	280	467	579	658										
F-3842	8/11/2007	4	29.5	731	245	437	575	679										
F-3843	8/17/2007	5	24.4	755	258	433	573	668	755									
F-3844	8/17/2007	4	27.8	753	220	433	597	709										
F-3845	8/17/2007	3	23.5	650	231	444	563											
F-3846	8/11/2007	2	21.4	489	234	413												
F-3847	9/1/2007	2	21.5	589	276	473												
F-3848	8/17/2007	1	17.8	367	245													
F-3854	9/1/2007	4	31.0	747	211	417	583	674	729									
F-3862	8/11/2007	4	34.1	723	248	446	571	667										
F-3863	9/9/2007	4	35.5	775	271	426	592	683										
F-3864	9/16/2007	7	42.7	1008	273	478	613	695	788	882	952							
F-3865	9/2/2007	6	38.8	873	292	450	571	675	760	824								
F-3866	8/11/2007	10	42.0	1292	221	452	612	735	829	923	1001	1086	1167	1248				
F-3868	11/17/2007	11	45.9	1327	233	417	565	683	773	875	970	1035	1103	1190	1259			
F-3877	8/5/2007	2	19.3	473	231	388												
F-3878	8/4/2007	2	18.8	509	292	437												
F-3879	7/21/2007	2	19.2	468	237	401												
F-3880	7/21/2007	2	21.8	472	209	407												
F-3881	7/7/2007	4	24.6	646	213	370	529	614										
F-3882	6/24/2007	3	24.3	561	263	431	538											
F-3883	7/3/2007	5	27.7	735	216	406	552	650	717									
F-3884	7/21/2007	4	29.0	709	195	413	552	654										
F-3885	7/7/2007	4	28.1	688	225	433	554	621										

Appendix 1 (cont.). Length and otolith measurements used to determine mean back-calculated lengths at age for white catfish collected in the Delaware River estuary in 2007.

Fish Analysis #	Collection Date	Age (yr)	Length (L_c) (cm)	Radius (µm)	Distance from core of otolith cross-section to annulus (µm)													
				O_c	O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8	O_9	O_{10}	O_{11}	O_{12}	O_{13}	O_{14}
F-3886	8/4/2007	4	32.0	699	195	393	558	652										
F-3887	7/5/2007	4	28.8	737	257	457	595	708										
F-3888	7/21/2007	4	31.3	722	267	453	583	677										
F-3889	6/24/2007	4	35.5	672	231	444	551	639										
F-3890	6/24/2007	4	34.3	693	260	453	576	646										
F-3891	7/5/2007	10	36.3	1160	247	431	587	666	765	858	928	1004	1083	1133				
F-3892	8/4/2007	4	29.9	638	217	383	518	591										
F-3893	7/22/2007	10	33.0	1120	249	452	576	675	755	843	907	982	1065	1108				
F-3894	7/3/2007	5	32.5	794	206	425	559	674	767									
F-3895	6/24/2007	9	36.1	1067	249	419	534	650	733	812	901	988	1058					
F-3928	6/24/2007	8	33.3	927	253	437	571	623	668	735	824	909						
F-3929	6/9/2007	6	33.1	852	298	462	583	684	771	840								
F-3930	6/24/2007	4	35.8	715	242	455	593	684										
F-3931	6/30/2007	4	26.6	721	186	425	601	688										
F-3932	6/30/2007	3	21.4	612	262	450	563											
F-3933	6/30/2007	4	21.3	677	201	383	514	618										
F-3935	6/30/2007	6	35.5	869	275	441	573	690	773	847								
F-3936	5/18/2007	6	28.2	743	253	401	505	599	668	743								
F-3937	6/30/2007	6	27.5	822	211	421	540	636	749	822								
F-3938	5/18/2007	4	23.0	595	215	384	512	595										
F-3939	6/30/2007	4	24.9	687	234	429	558	669										
F-3940	4/29/2007	3	21.5	576	225	463	576											
F-3941	5/12/2007	2	18.6	449	259	449												
F-4052	5/18/2007	3	20.2	522	229	397	522											
F-4071	6/10/2007	2	17.5	441	273	421												
F-4072	5/12/2007	4	26.2	675	269	455	579	675										
F-4073	5/25/2007	4	26.1	686	237	425	567	686										

Appendix 1 (cont.). Length and otolith measurements used to determine mean back-calculated lengths at age for white catfish collected in the Delaware River estuary in 2007.

Fish	Collection	Age	Length	Radius (µm)	Distance from core of otolith cross-section to annulus (µm)													
Analysis #	Date	(yr)	(L_c) (cm)	O_c	O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8	O_9	O_{10}	O_{11}	O_{12}	O_{13}	O_{14}
F-4074	4/21/2007	4	26.5	704	269	484	603	704										
F-4075	4/14/2007	11	42.5	1144	233	415	547	655	718	808	890	951	1008	1081	1144			
F-4076	6/9/2007	7	31.7	846	247	429	551	626	700	775	846							
F-4077	4/21/2007	6	33.5	887	278	455	589	699	790	887								
F-4078	5/3/2007	6	32.9	832	328	478	575	677	764	832								
F-4079	5/3/2007	8	37.2	1016	256	425	558	666	763	862	945	1016						
F-4080	5/4/2007	14	43.5	1292	253	433	538	638	742	832	912	975	1035	1098	1140	1177	1232	1292
F-4081	4/21/2007	7	40.1	1016	269	486	619	737	840	931	1016							
F-4082	5/3/2007	9	38.7	1106	211	392	547	677	782	847	938	1033	1106					
F-4083	5/6/2007	10	41.2	1102	217	421	565	663	775	840	899	968	1035	1102				
F-4084	5/12/2007	6	36.2	851	307	472	581	681	773	851								
F-4085	6/9/2007	6	32.8	825	250	413	521	618	725	805								
F-4086	4/29/2007	4	21.5	602	215	383	495	602										
F-4087	5/25/2007	4	21.8	607	253	410	527	607										
F-4088	5/24/2007	4	29.1	658	237	404	556	658										
F-4089	5/3/2007	10	45.8	1107	212	425	536	625	727	821	913	974	1041	1107				
F-4090	6/9/2007	6	29.3	881	261	488	592	702	794	868								
F-4091	6/9/2007	4	19.9	601	235	393	519	589										
F-4092	5/12/2007	6	32.7	861	320	496	601	698	791	861								
F-4095	5/8/2007	1	5.5	211	211													
F-4096	5/8/2007	1	5.1	200	200													
F-4399	7/29/2008	0	3.5	132														
F-4398	7/29/2008	0	3.3	126														

Appendix 2. Mean and individual back-calculated lengths at age for white catfish collected in the Delaware River estuary in 2007.

Fish Analysis #	Back-calculated length at age (L_a) (cm)													
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}	L_{12}	L_{13}	L_{14}
F-3838	6.2	14.4	19.5	24.0										
F-3839	8.2	17.8	24.1	28.7										
F-3840	9.1	18.8	25.8											
F-3841	12.3	23.3	30.0	34.7										
F-3842	8.3	16.7	22.7	27.2										
F-3843	7.6	13.5	18.3	21.5	24.4									
F-3844	6.9	15.2	21.7	26.1										
F-3845	7.3	15.5	20.1											
F-3846	8.6	17.6												
F-3847	9.1	16.9												
F-3848	10.4													
F-3854	7.0	16.2	23.6	27.7	30.2									
F-3862	9.5	19.7	26.2	31.2										
F-3863	10.4	18.1	26.4	30.9										
F-3864	9.8	18.9	25.0	28.7	32.8	37.1	40.2							
F-3865	11.1	18.6	24.4	29.4	33.4	36.5								
F-3866	6.4	14.0	19.4	23.5	26.6	29.7	32.3	35.1	37.8	40.5				
F-3868	7.0	13.5	18.8	23.0	26.2	29.8	33.2	35.5	37.9	41.0	43.5			
F-3877	8.0	15.3												
F-3878	9.9	15.9												
F-3879	8.4	16.1												
F-3880	7.6	18.3												
F-3881	6.8	13.2	19.8	23.3										
F-3882	9.8	18.0	23.2											
F-3883	6.8	14.5	20.3	24.3	27.0									
F-3884	6.2	15.9	22.0	26.6										
F-3885	7.6	16.8	22.2	25.1										
F-3886	6.6	16.6	24.9	29.6										
F-3887	8.7	17.1	22.8	27.6										
F-3888	9.8	18.6	24.7	29.2										
F-3889	9.3	22.0	28.3	33.5										
F-3890	10.5	21.1	27.9	31.7										
F-3891	7.1	13.0	18.0	20.5	23.7	26.6	28.9	31.3	33.8	35.4				
F-3892	7.9	16.6	23.6	27.4										
F-3893	6.9	13.0	16.7	19.7	22.1	24.7	26.6	28.9	31.4	32.6				
F-3894	6.7	16.3	22.2	27.2	31.3									
F-3895	7.5	13.4	17.5	21.5	24.4	27.2	30.3	33.3	35.8					
F-3928	8.0	14.9	19.9	21.9	23.6	26.1	29.4	32.6						
F-3929	10.3	17.0	22.0	26.2	29.8	32.6								
F-3930	9.6	21.4	29.0	34.1										
F-3931	5.5	15.0	21.9	25.3										
F-3932	8.3	15.3	19.6											

Appendix 2 (cont.). Mean and individual back-calculated lengths at age for white catfish collected in the Delaware River estuary in 2007.

Fish Analysis #	Back-calculated length at age (L_a) (cm)													
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}	L_{12}	L_{13}	L_{14}
F-3933	5.7	11.6	15.9	19.4										
F-3935	9.7	16.9	22.6	27.7	31.3	34.5								
F-3936	8.3	14.3	18.5	22.4	25.2	28.2								
F-3937	6.2	13.5	17.7	21.0	25.0	27.5								
F-3938	6.9	14.1	19.5	23.0										
F-3939	7.4	14.9	19.9	24.2										
F-3940	7.2	16.9	21.5											
F-3941	9.5	18.6												
F-4052	7.6	14.8	20.2											
F-4071	9.9	16.6												
F-4072	9.2	17.0	22.2	26.2										
F-4073	7.7	15.4	21.2	26.1										
F-4074	8.9	17.6	22.4	26.5										
F-4075	7.3	14.3	19.4	23.6	26.0	29.5	32.7	35.0	37.2	40.1	42.5			
F-4076	8.0	15.2	20.0	23.0	25.9	28.9	31.7							
F-4077	9.2	16.3	21.6	26.0	29.6	33.5								
F-4078	11.7	18.0	22.1	26.4	30.0	32.9								
F-4079	8.2	14.6	19.7	23.8	27.5	31.3	34.5	37.2						
F-4080	7.6	13.8	17.4	20.9	24.5	27.6	30.4	32.5	34.6	36.8	38.2	39.5	41.4	43.5
F-4081	9.1	18.1	23.6	28.5	32.8	36.6	40.1							
F-4082	6.3	12.8	18.4	23.2	27.0	29.3	32.6	36.1	38.7					
F-4083	6.7	14.7	20.3	24.1	28.5	31.0	33.3	36.0	38.6	41.2				
F-4084	11.4	18.9	23.9	28.5	32.6	36.2								
F-4085	8.4	15.3	19.9	24.0	28.6	32.0								
F-4086	6.6	13.1	17.4	21.5										
F-4087	8.1	14.2	18.7	21.8										
F-4088	8.6	16.7	24.1	29.1										
F-4089	6.9	16.2	21.0	24.9	29.3	33.4	37.4	40.0	42.9	45.8				
F-4090	7.9	15.7	19.3	23.1	26.3	28.9								
F-4091	7.0	12.6	17.0	19.5										
F-4092	11.0	18.0	22.3	26.2	29.9	32.7								
F-4095	5.5													
F-4096	5.1													
Age (yr)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mean back-calc. length (cm)	8.2	16.2	21.6	25.6	27.8	30.9	32.9	34.5	36.9	39.2	41.4	39.5	41.4	43.5
Number	75	72	64	58	30	26	15	12	10	8	3	1	1	1
Standard Error (cm)	0.18	0.27	0.39	0.48	0.57	0.69	1.00	0.85	1.01	1.44	1.61			
Biological Intercept: x (O_i) = 129 μm, y (L_i) = 3.3 cm														

Appendix 3. Length and otolith measurements used to determine mean back-calculated lengths at age for channel catfish collected in the Delaware River estuary in 2007.

Fish	Collection	Age	Length	Radius (µm)	Distance from core of otolith cross-section to annulus (µm)																					
Analysis #	Date	(yr)	(L_c) (cm)	O_c	O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8	O_9	O_{10}	O_{11}	O_{12}	O_{13}	O_{14}	O_{15}	O_{16}	O_{17}	O_{18}	O_{19}	O_{20}	O_{21}	O_{22}
F-3869	9/2/2007	10	51.9	1248	258	460	594	692	827	914	986	1085	1154	1204												
F-3870	10/14/2007	16	65.5	1446	296	464	599	681	766	825	890	931	1012	1081	1142	1210	1259	1299	1360	1406						
F-3871	9/16/2007	7	61.5	1035	242	423	565	686	782	853	970															
F-3872	10/14/2007	11	66.1	1266	233	383	518	641	725	820	889	948	1025	1128	1181											
F-3873	9/9/2007	13	52.3	1328	204	413	545	644	738	818	881	962	1038	1106	1172	1227	1284									
F-3874	9/2/2007	14	53.6	1363	247	439	583	658	761	828	931	985	1047	1109	1164	1227	1280	1336								
F-3875	9/22/2007	11	66.3	1116	247	392	512	654	728	804	852	903	958	1021	1067											
F-3876	9/2/2007	22	56.8	1883	224	426	569	674	777	882	949	1012	1093	1156	1218	1272	1346	1407	1460	1527	1586	1642	1682	1736	1794	1839
F-3897	7/21/2007	2	21.5	464	246	425																				
F-3898	7/21/2007	3	24.6	556	218	393	516																			
F-3904	7/22/2007	11	55.7	1187	208	374	542	677	745	838	913	968	1029	1110	1156											
F-3905	7/22/2007	6	36.8	852	193	433	524	630	725	804																
F-3906	6/10/2007	12	45.2	1333	209	450	560	667	766	862	969	1044	1114	1185	1234	1301										
F-3907	7/22/2007	6	45.8	941	249	441	580	695	794	891																
F-3908	6/10/2007	10	49.6	1107	253	448	592	674	759	838	907	974	1055	1107												
F-3909	6/10/2007	12	53.7	1316	215	408	542	625	717	803	879	973	1054	1172	1262	1316										
F-3910	7/21/2007	2	25.5	492	285	442																				
F-3911	7/21/2007	2	21.8	441	231	402																				
F-3912	7/21/2007	2	22	498	220	415																				
F-3913	7/22/2007	4	32.1	731	229	385	542	683																		
F-3914	7/22/2007	6	38.6	919	227	426	566	680	787	905																
F-3915	6/10/2007	6	38	856	302	456	558	642	764	838																
F-3916	7/21/2007	8	38.7	1046	267	442	576	682	771	866	933	1004														
F-3917	7/21/2007	14	44.4	1349	242	420	561	672	778	878	962	1021	1073	1118	1167	1220	1278	1322								
F-3918	7/21/2007	16	52.3	1486	296	468	569	658	762	833	907	992	1067	1146	1201	1260	1306	1375	1433	1482						
F-3919	8/5/2007	17	48.4	1389	164	258	442	559	629	721	796	879	946	1001	1063	1120	1165	1219	1257	1298	1344					
F-3920	6/10/2007	13	49.6	1304	243	420	568	682	775	862	925	998	1057	1096	1195	1259	1304									
F-3921	8/5/2007	14	54.5	1391	219	427	557	658	745	820	907	975	1044	1112	1176	1231	1312	1371								
F-3922	6/30/2007	8	47.8	1019	255	423	541					990														
F-3923	6/30/2007	6	34.8	816	262	429	531	608	714	784																
F-3924	5/1/2007	14	42.7	1310	184	401	556	635	734	821	906	975	1046	1117	1177	1234	1276	1310								
F-3925	5/2/2007	9	43.8	1074	230	425	558	660	749	830	925	992	1063													
F-3926	6/10/2007	13	45.1	1484	195	434	563	679	820	907	988	1078	1178	1255	1312	1396	1484									
F-3927	6/3/2007	12	36.1	1276	221	414	562	679	790	889	962	1037	1090	1152	1217	1276										

Appendix 3 (cont.). Length and otolith measurements used to determine mean back-calculated lengths at age for channel catfish collected in the Delaware River estuary in 2007.

Fish Analysis #	Collection Date	Age (yr)	Length (L_c) (cm)	Radius (µm)	Distance from core of otolith cross-section to annulus (µm)																					
				O_c	O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8	O_9	O_{10}	O_{11}	O_{12}	O_{13}	O_{14}	O_{15}	O_{16}	O_{17}	O_{18}	O_{19}	O_{20}	O_{21}	O_{22}
F-3942	6/30/2007	8	37.3	959	257	415	551	643	692	755	855	932														
F-3943	6/30/2007	4	31	636	171	402	545	621																		
F-3944	7/21/2007	4	31.2	679	200	385	543	648																		
F-3945	7/21/2007	14	47	1375	192	367	511	610	708	784	875	944	1054	1141	1213	1251	1319	1351								
F-3946	6/30/2007	8	42.3	1082	204	397	603	724	801	888	1004	1063														
F-3947	7/21/2007	2	25.4	482	273	432																				
F-3948	6/30/2007	2	20.9	405	235	379																				
F-3949	5/4/2007	14	48.5	1328	247	419	559	654	749	837	924	990	1059	1114	1172	1231	1282	1328								
F-3950	6/10/2007	12	52.5	1313	243	429	559	674	789	868	957	1018	1078	1135	1220	1313										
F-3951	7/21/2007	2	22.3	482	272	430																				
F-3952	7/21/2007	2	21.1	475	257	425																				
F-3953	7/21/2007	2	22.4	538	281	476																				
F-3955	7/21/2007	2	21.8	462	224	427																				
F-3959	7/21/2007	2	21.4	412	235	375																				
F-3960	7/22/2007	4	34.9	670	204	413	512	605																		
F-3961	6/2/2007	6	35.8	897	253	441	568	688	789	897																
F-3962	6/25/2007	4	31.8	690	208	433	559	650																		
F-3963	6/2/2007	12	57.6	1282	258	456	584	704	810	899	977	1049	1100	1163	1209	1282										
F-3964	7/21/2007	10	59.4	1248	206	437	577	690	800	894	981	1062	1147	1217												
F-3965	7/21/2007	2	21.7	478	276	427																				
F-3966	6/24/2007	12	47.5	1225	201	385	520	637	733	818	901	984	1051	1103	1172	1225										
F-3967	6/30/2007	4	32.1	642	202	388	522	611																		
F-3968	6/3/2007	13	40.7	1332	224	402	538	642	740	849	926	995	1061	1115	1189	1252	1332									
F-3969	6/30/2007	9	47.1	1033	237	420	520	643	712	764	850	931	1010													
F-3970	6/25/2007	11	47.8	1276	249	432	587	692	782	865	968	1039	1122	1191	1255											
F-3971	6/25/2007	9	69	1319	255	478	617	729	865	967	1086	1187	1281													
F-3972	6/10/2007	11	55.2	1212	255	416	533	659	739	840	916	964	1069	1150	1190											
F-3973	6/30/2007	6	38	872	225	429	542	650	781	836																
F-3974	4/22/2007	6	36.5	875	285	444	573	700	805	875																
F-3975	7/22/2007	4	33.9	789	233	455	614	701																		
F-3976	5/4/2007	3	19.5	525	218	429	525																			
F-3977	6/24/2007	4	30.3	605	227	375	510	583																		
F-3978	6/30/2007	4	28.1	687	175	389	561	661																		
F-3979	6/24/2007	6	31.3	818	203	370	512	625	719	796																

Appendix 3 (cont.). Length and otolith measurements used to determine mean back-calculated lengths at age for channel catfish collected in the Delaware River estuary in 2007.

Fish Analysis #	Collection Date	Age (yr)	Length (L_c) (cm)	Radius (µm)	Distance from core of otolith cross-section to annulus (µm)																					
				O_c	O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8	O_9	O_{10}	O_{11}	O_{12}	O_{13}	O_{14}	O_{15}	O_{16}	O_{17}	O_{18}	O_{19}	O_{20}	O_{21}	O_{22}
F-3980	7/5/2007	4	27.1	703	227	419	553	672																		
F-3981	6/25/2007	4	32.8	733	236	439	611	716																		
F-3982	6/30/2007	6	43.2	933	245	433	547	660	791	890																
F-3983	7/7/2007	14	45.1	1370	228	417	580	667	741	845	937	1017	1098	1161	1221	1283	1321	1362								
F-3984	6/24/2007	6	40.8	878	261	435	556	666	767	840																
F-3985	6/25/2007	6	33.7	871	263	437	540	630	733	840																
F-3986	7/22/2007	6	39.3	801	254	415	507	603	688	753																
F-3987	6/25/2007	4	33.8	657	209	397	549	635																		
F-3988	6/24/2007	12	43.4	1203	243	413	520	626	724	796	875	953	1014	1081	1138	1177										
F-3989	7/7/2007	2	22.1	460	214	413																				
F-3990	6/30/2007	8	38.9	977	257	420	542	626	721	804	877	950														
F-3991	6/24/2007	12	38.3	1161	206	392	527	619	692	765	831	898	954	1009	1089	1161										
F-3992	6/30/2007	8	43.3	1003	239	417	555	663	742	802	887	960														
F-3993	5/24/2007	10	46	1069	251	467	603	684	785	844	888	957	1008	1069												
F-3994	6/24/2007	7	39.4	959	204	447	598	691	783	862	939															
F-3995	4/22/2007	4	31.2	623	243	413	536	623																		
F-3996	6/24/2007	10	41.1	1069	217	408	531	628	733	812	869	939	1011	1069												
F-3997	6/30/2007	10	50.5	1150	244	442	576	665	778	853	906	991	1045	1120												
F-4002	4/22/2007	4	26.1	608	247	399	527	608																		
F-4003	6/30/2007	7	40.6	1092	180	400	577	724	840	978	1065															
F-4004	6/25/2007	3	27.5	579	209	425	559																			
F-4005	6/24/2007	4	28.6	685	211	396	551	641																		
F-4006	5/18/2007	2	20.3	425	225	415																				
F-4007	6/2/2007	12	50.1	1348	249	419	556	653	747	834	941	1018	1107	1172	1275	1338										
F-4008	7/22/2007	14	49.4	1457	258	458	599	700	792	870	962	1029	1094	1165	1222	1291	1341	1422								
F-4009	5/12/2007	12	40	1237	233	403	525	595	698	796	885	966	1025	1098	1168	1230										
F-4010	5/13/2007	15	40.9	1338	225	395	498	656	723	800	859	929	988	1043	1107	1147	1214	1263	1322							
F-4011	6/30/2007	20	61.9	1716	251	435	556	664	803	868	963	1018	1085	1145	1217	1271	1347	1395	1457	1506	1540	1587	1640	1697		
F-4012	5/4/2007	16	52	1472	279	431	565	671	751	832	923	1006	1093	1150	1217	1273	1316	1373	1423	1472						
F-4013	6/24/2007	6	36.9	812	242	415	529	620	711	812																
F-4023	3/31/2007	4	31.2	700	231	408	601	700																		
F-4024	4/21/2007	4	28.8	591	218	386	524	591																		
F-4025	5/13/2007	10	45.9	1161	239	466	600	701	780	871	950	1019	1091	1161												
F-4026	6/10/2007	6	39.6	804	237	422	519	611	694	781																

Appendix 3 (cont.). Length and otolith measurements used to determine mean back-calculated lengths at age for channel catfish collected in the Delaware River estuary in 2007.

Fish	Collection	Age	Length	Radius (µm)	Distance from core of otolith cross-section to annulus (µm)																					
Analysis #	Date	(yr)	(L_c) (cm)	O_c	O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8	O_9	O_{10}	O_{11}	O_{12}	O_{13}	O_{14}	O_{15}	O_{16}	O_{17}	O_{18}	O_{19}	O_{20}	O_{21}	O_{22}
F-4027	4/21/2007	6	36.5	845	242	426	569	675	776	845																
F-4028	6/30/2007	8	47.6	950	249	390	555	634	708	778	875	925														
F-4029	4/21/2007	11	46.6	1222	224	411	522								1222											
F-4030	6/30/2007	6	41.1	855	253	421	537	626	760	847																
F-4031	6/30/2007	6	40.5	879	305	473	573	674	775	842																
F-4032	6/2/2007	12	43.4	1268	266	432	553	659	748	817	905	997	1062	1138	1192	1237										
F-4033	6/10/2007	8	45.1	974	284	403	549	650	725	814	912	974														
F-4034	6/10/2007	10	41.3	1178	242	468	646	751	845	930	993	1039	1126	1178												
F-4035	4/20/2007	18	65	1578	217	403	549	628	717	792	867	964	1019	1086	1153	1218	1263	1321	1382	1442	1525	1578				
F-4036	5/6/2007	7	34	893	208	441	567	654	745	827	893															
F-4037	4/22/2007	13	53.3	1280	227	417	554	650	753	838	897	982	1041	1092	1150	1233	1280									
F-4038	4/22/2007	4	29.4	618	229	401	522	618																		
F-4039	4/22/2007	4	29.1	670	206	413	565	650																		
F-4040	6/30/2007	6	33.9	879	240	425	534	658	772	851																
F-4041	6/30/2007	2	24.1	474	260	405																				
F-4042	4/21/2007	6	36.4	852	243	395	545	675	792	852																
F-4043	6/30/2007	6	41.7	834	261	415	531	634	753	834																
F-4044	6/2/2007	4	31	681	227	466	593	681																		
F-4045	6/2/2007	4	30.7	656	257	413	545	656																		
F-4046	6/30/2007	2	23.3	452	251	437																				
F-4047	6/30/2007	2	21	446	251	405																				
F-4048	5/12/2007	10	55.2	1106	217	396	535	627	740	827	926	991	1051	1106												
F-4049	6/10/2007	6	30.4	775	209	395	504	610	721	775																
F-4050	6/30/2007	4	31.3	680	213	429	565	634																		
F-4051	6/30/2007	16	56.4	1386	255	448	578	672	757	796	875	944	1021	1082	1147	1201	1246	1283	1325	1371						
F-4053	6/30/2007	6	35.6	885	195	407	536	664	773	854																
F-4054	3/25/2007	7	35.5	960	273	466	609	680	792	884	960															
F-4055	4/1/2007	10	39.2	1121	251	409	551	642	742	825	879	946	1040	1121												
F-4056	6/30/2007		37.4	923	250	405	547																			
F-4057	6/24/2007	10	41	1154	202	430	591	690	792	875	922	1000	1056	1121												
F-4058	3/31/2007	8	45.6	1023	260	438	578	685	764	858	955	1023														
F-4059	6/2/2007	9	44.7	1072	244	427	565	655	745	844	930	991	1072													
F-4060	6/9/2007	10	42.7	1073	260	460	594	681	751	834	877	937	995	1073												
F-4061	5/18/2007	4	28	662	194	441	563	662																		

Appendix 3 (cont.). Length and otolith measurements used to determine mean back-calculated lengths at age for channel catfish collected in the Delaware River estuary in 2007.

Fish	Collection	Age	Length	Radius (µm)	Distance from core of otolith cross-section to annulus (µm)																					
Analysis #	Date	(yr)	(L_c) (cm)	O_c	O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8	O_9	O_{10}	O_{11}	O_{12}	O_{13}	O_{14}	O_{15}	O_{16}	O_{17}	O_{18}	O_{19}	O_{20}	O_{21}	O_{22}
F-4062	5/12/2007	6	34.9	833	257	413	542	650	760	833																
F-4063	3/31/2007	10	41.5	1083	241	457	575	666	775	838	899	966	1033	1083												
F-4064	6/30/2007	2	21.9	480	258	426																				
F-4065	6/10/2007	2	23.1	536	227	431																				
F-4066	4/1/2007	14	47.7	1265	175	284	437	529	625	715	810	858	916	985	1048	1136	1209	1265								
F-4067	4/22/2007	4	24.6	620	233	401	535	620																		
F-4068	4/24/2007	10	52.1	1087	198	379	522	613	713	801	856	937	1011	1087												
F-4069	4/24/2007	8	47.6	1016	231	420	529	640	742	866	933	1016														
F-4070	4/24/2007	12	56.8	1109	208	374	488	587	662	742	776	856	915	1012	1109											
F-3954	9/16/2007	0	10.2	234																						

Appendix 4. Mean and individual back-calculated lengths at age for channel catfish collected in the Delaware River estuary in 2007.

Fish Analysis #	Back-calculated length at age (L_a) (cm)																					
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}	L_{12}	L_{13}	L_{14}	L_{15}	L_{16}	L_{17}	L_{18}	L_{19}	L_{20}	L_{21}	L_{22}
F-3869	11.2	19.5	25.0	29.0	34.6	38.2	41.1	45.2	48.0	50.1												
F-3870	13.0	20.7	26.9	30.6	34.5	37.2	40.1	42.0	45.7	48.8	51.6	54.7	57.0	58.8	61.6	63.7						
F-3871	10.7	22.3	31.4	39.1	45.3	49.8	57.3															
F-3872	10.1	18.3	25.6	32.2	36.8	41.9	45.7	48.9	53.0	58.6	61.5											
F-3873	9.0	17.1	22.2	26.0	29.6	32.7	35.1	38.2	41.1	43.8	46.3	48.4	50.6									
F-3874	10.7	18.1	23.6	26.5	30.5	33.0	37.0	39.1	41.5	43.8	46.0	48.4	50.4	52.6								
F-3875	11.0	20.2	27.9	36.9	41.6	46.5	49.5	52.8	56.3	60.3	63.2											
F-3876	9.9	15.6	19.7	22.6	25.5	28.5	30.4	32.2	34.5	36.3	38.0	39.5	41.6	43.3	44.8	46.7	48.4	50.0	51.1	52.6	54.3	55.6
F-3897	10.8	19.6																				
F-3898	9.5	17.3	22.8																			
F-3904	9.0	16.9	24.9	31.4	34.6	39.0	42.6	45.2	48.2	52.0	54.2											
F-3905	8.4	18.8	22.7	27.2	31.3	34.7																
F-3906	9.4	17.1	20.6	24.0	27.1	30.2	33.6	36.0	38.2	40.5	42.0	44.2										
F-3907	11.0	20.6	27.6	33.4	38.4	43.3																
F-3908	11.1	19.9	26.4	30.1	33.9	37.5	40.6	43.6	47.3	49.6												
F-3909	9.4	17.2	22.6	25.9	29.6	33.1	36.1	39.9	43.2	47.9	51.5	53.7										
F-3910	13.2	22.5																				
F-3911	10.0	19.6																				
F-3912	9.6	18.3																				
F-3913	10.0	16.9	23.8	30.0																		
F-3914	9.9	18.2	24.0	28.7	33.1	38.0																
F-3915	13.2	20.1	24.7	28.4	33.9	37.2																
F-3916	11.4	17.5	22.2	25.9	29.0	32.4	34.7	37.2														
F-3917	10.4	15.9	20.2	23.6	26.9	30.0	32.5	34.3	35.9	37.3	38.8	40.4	42.2	43.6								
F-3918	12.3	18.1	21.5	24.5	28.0	30.3	32.8	35.7	38.2	40.9	42.7	44.7	46.2	48.6	50.5	52.2						
F-3919	7.9	11.0	17.1	20.9	23.3	26.3	28.8	31.5	33.7	35.6	37.6	39.5	41.0	42.8	44.0	45.4	46.9					
F-3920	10.5	17.0	22.5	26.7	30.1	33.3	35.6	38.3	40.5	41.9	45.6	47.9	49.6									

Appendix 4 (cont.). Mean and individual back-calculated lengths at age for channel catfish collected in the Delaware River estuary in 2007.

Fish Analysis #	Back-calculated length at age (L_a) (cm)																					
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}	L_{12}	L_{13}	L_{14}	L_{15}	L_{16}	L_{17}	L_{18}	L_{19}	L_{20}	L_{21}	L_{22}
F-3921	9.6	17.6	22.6	26.4	29.8	32.6	36.0	38.6	41.2	43.8	46.3	48.4	51.5	53.7								
F-3922	11.2	19.3	24.9					46.4														
F-3923	11.4	18.4	22.8	26.0	30.5	33.4																
F-3924	8.7	15.2	19.9	22.3	25.3	27.9	30.5	32.6	34.7	36.9	38.7	40.4	41.7	42.7								
F-3925	10.0	17.8	23.2	27.2	30.8	34.0	37.8	40.5	43.4													
F-3926	9.1	15.8	19.4	22.6	26.6	29.0	31.3	33.8	36.6	38.7	40.3	42.6	45.1									
F-3927	9.9	14.7	18.4	21.3	24.0	26.5	28.3	30.2	31.5	33.0	34.6	36.1										
F-3942	11.1	17.0	22.0	25.5	27.3	29.7	33.4	36.3														
F-3943	6.9	18.9	26.3	30.2																		
F-3944	8.6	17.3	24.8	29.7																		
F-3945	8.8	14.5	19.1	22.3	25.5	27.9	30.9	33.1	36.6	39.5	41.8	43.0	45.2	46.2								
F-3946	9.1	16.4	24.2	28.7	31.7	35.0	39.3	41.6														
F-3947	12.6	22.3																				
F-3948	10.3	19.3																				
F-3949	10.7	16.7	21.6	24.9	28.2	31.3	34.4	36.7	39.1	41.0	43.0	45.1	46.9	48.5								
F-3950	10.6	17.8	22.9	27.4	32.0	35.1	38.5	40.9	43.3	45.5	48.9	52.5										
F-3951	12.1	19.8																				
F-3952	11.2	18.8																				
F-3953	12.1	19.9																				
F-3955	9.7	20.0																				
F-3959	10.3	19.1																				
F-3960	8.5	20.3	25.9	31.2																		
F-3961	10.9	18.2	23.1	27.7	31.6	35.8																
F-3962	9.0	19.6	25.6	29.9																		
F-3963	11.3	20.2	26.0	31.5	36.3	40.3	43.8	47.1	49.4	52.2	54.3	57.6										
F-3964	8.8	20.0	26.8	32.3	37.7	42.2	46.4	50.4	54.5	57.9												
F-3965	12.2	19.3																				

Appendix 4 (cont.). Mean and individual back-calculated lengths at age for channel catfish collected in the Delaware River estuary in 2007.

Fish Analysis #	Back-calculated length at age (L_a) (cm)																					
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}	L_{12}	L_{13}	L_{14}	L_{15}	L_{16}	L_{17}	L_{18}	L_{19}	L_{20}	L_{21}	L_{22}
F-3966	9.0	15.9	21.0	25.4	29.0	32.2	35.3	38.4	41.0	42.9	45.5	47.5										
F-3967	8.5	18.5	25.7	30.4																		
F-3968	9.9	14.9	18.6	21.5	24.3	27.3	29.4	31.3	33.2	34.7	36.7	38.5	40.7									
F-3969	10.3	18.8	23.4	29.1	32.3	34.7	38.6	42.4	46.0													
F-3970	10.7	17.3	22.9	26.7	30.0	33.0	36.7	39.2	42.2	44.7	47.0											
F-3971	11.3	23.4	31.0	37.0	44.4	49.9	56.4	61.8	66.9													
F-3972	11.2	18.6	24.0	29.8	33.4	38.1	41.6	43.8	48.6	52.3	54.2											
F-3973	9.8	18.7	23.6	28.3	34.0	36.4																
F-3974	12.3	18.8	24.1	29.3	33.6	36.5																
F-3975	10.2	19.6	26.4	30.1																		
F-3976	9.7	16.4	19.5																			
F-3977	9.8	17.8	25.2	29.1																		
F-3978	7.9	16.3	23.1	27.1																		
F-3979	9.1	15.1	20.2	24.3	27.7	30.5																
F-3980	9.9	16.9	21.7	26.0																		
F-3981	10.3	19.5	27.3	32.0																		
F-3982	10.7	19.6	25.0	30.3	36.5	41.2																
F-3983	10.0	15.8	20.8	23.5	25.8	29.0	31.8	34.3	36.7	38.7	40.5	42.4	43.6	44.9								
F-3984	11.5	19.8	25.5	30.7	35.5	39.0																
F-3985	11.3	17.7	21.5	24.8	28.6	32.6																
F-3986	11.2	19.5	24.2	29.1	33.5	36.8																
F-3987	8.8	19.3	27.8	32.6																		
F-3988	10.5	16.3	20.0	23.6	27.0	29.5	32.2	34.8	36.9	39.2	41.2	42.5										
F-3989	9.1	19.6																				
F-3990	11.1	17.4	22.1	25.3	29.0	32.2	35.0	37.9														
F-3991	9.4	15.0	19.1	21.9	24.1	26.3	28.3	30.3	32.0	33.7	36.1	38.3										
F-3992	10.4	18.1	24.0	28.7	32.1	34.6	38.3	41.4														

Appendix 4 (cont.). Mean and individual back-calculated lengths at age for channel catfish collected in the Delaware River estuary in 2007.

Fish Analysis #	Back-calculated length at age (L_a) (cm)																					
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}	L_{12}	L_{13}	L_{14}	L_{15}	L_{16}	L_{17}	L_{18}	L_{19}	L_{20}	L_{21}	L_{22}
F-3993	10.9	20.2	26.0	29.5	33.8	36.4	38.2	41.2	43.4	46.0												
F-3994	9.0	18.8	24.9	28.6	32.3	35.5	38.6															
F-3995	10.7	19.9	26.5	31.2																		
F-3996	9.6	16.6	21.2	24.8	28.7	31.6	33.7	36.3	39.0	41.1												
F-3997	10.6	19.4	25.2	29.2	34.1	37.4	39.8	43.5	45.9	49.2												
F-4002	10.8	17.2	22.7	26.1																		
F-4003	8.3	16.1	22.4	27.6	31.7	36.6	39.6															
F-4004	8.9	19.8	26.5																			
F-4005	9.3	16.8	23.1	26.8																		
F-4006	9.7	19.8																				
F-4007	10.7	16.8	21.7	25.2	28.6	31.7	35.5	38.3	41.5	43.8	47.5	49.7										
F-4008	11.0	17.4	21.9	25.1	28.1	30.6	33.5	35.7	37.8	40.0	41.9	44.1	45.7	48.3								
F-4009	10.2	15.2	18.8	20.9	24.0	26.9	29.5	31.9	33.7	35.9	37.9	39.8										
F-4010	9.9	14.7	17.5	21.9	23.8	25.9	27.6	29.5	31.2	32.7	34.5	35.6	37.5	38.8	40.5							
F-4011	10.8	17.2	21.4	25.2	30.0	32.3	35.6	37.6	39.9	42.0	44.5	46.4	49.0	50.7	52.9	54.6	55.8	57.4	59.2	61.2		
F-4012	11.7	16.9	21.4	25.0	27.7	30.4	33.5	36.3	39.2	41.1	43.4	45.3	46.7	48.7	50.3	52.0						
F-4013	10.6	18.6	23.8	28.0	32.2	36.9																
F-4023	10.1	18.0	26.7	31.2																		
F-4024	9.4	18.1	25.3	28.8																		
F-4025	10.4	19.1	24.3	28.2	31.2	34.7	37.8	40.4	43.2	45.9												
F-4026	10.4	19.9	24.9	29.6	33.9	38.4																
F-4027	10.5	18.5	24.6	29.2	33.5	36.5																
F-4028	11.0	18.3	27.0	31.1	35.0	38.6	43.7	46.3														
F-4029	9.8	16.7	20.8								46.6											
F-4030	11.1	19.5	25.3	29.7	36.4	40.7																
F-4031	13.5	21.4	26.1	30.9	35.6	38.8																
F-4032	11.2	16.6	20.4	23.8	26.7	28.9	31.7	34.7	36.8	39.2	41.0	42.4										

Appendix 4 (cont.). Mean and individual back-calculated lengths at age for channel catfish collected in the Delaware River estuary in 2007.

Fish Analysis #	Back-calculated length at age (L_a) (cm)																					
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}	L_{12}	L_{13}	L_{14}	L_{15}	L_{16}	L_{17}	L_{18}	L_{19}	L_{20}	L_{21}	L_{22}
F-4033	12.6	18.2	25.1	29.8	33.4	37.6	42.2	45.1														
F-4034	10.5	17.9	23.8	27.2	30.3	33.1	35.2	36.7	39.6	41.3												
F-4035	9.5	17.1	23.0	26.3	29.9	33.0	36.0	40.0	42.2	44.9	47.7	50.3	52.2	54.5	57.0	59.5	62.8	65.0				
F-4036	9.3	17.7	22.2	25.4	28.7	31.6	34.0															
F-4037	9.9	17.7	23.4	27.3	31.6	35.1	37.5	41.0	43.5	45.6	47.9	51.4	53.3									
F-4038	10.0	18.6	24.6	29.4																		
F-4039	9.0	18.0	24.5	28.2																		
F-4040	10.4	17.2	21.2	25.8	30.0	32.9																
F-4041	11.7	20.1																				
F-4042	10.6	17.0	23.4	28.9	33.9	36.4																
F-4043	11.6	19.7	25.8	31.2	37.4	41.7																
F-4044	9.9	21.0	26.9	31.0																		
F-4045	11.3	18.9	25.3	30.7																		
F-4046	11.2	22.4																				
F-4047	11.1	18.9																				
F-4048	9.3	18.6	25.7	30.5	36.3	40.8	45.9	49.3	52.4	55.2												
F-4049	9.3	16.2	20.3	24.2	28.4	30.4																
F-4050	9.2	19.4	25.9	29.1																		
F-4051	11.0	18.8	24.0	27.8	31.2	32.7	35.9	38.7	41.8	44.2	46.8	49.0	50.8	52.3	54.0	55.8						
F-4053	8.7	16.9	22.0	27.0	31.2	34.4																
F-4054	11.6	18.3	23.3	25.7	29.6	32.9	35.5															
F-4055	10.8	15.9	20.6	23.5	26.8	29.5	31.3	33.5	36.6	39.2												
F-4056	10.8	17.0	22.6																			
F-4057	9.1	16.8	22.2	25.5	28.9	31.7	33.2	35.8	37.7	39.9												
F-4058	11.4	19.4	25.6	30.4	34.0	38.2	42.5	45.6														
F-4059	10.6	18.1	23.8	27.5	31.2	35.3	38.9	41.4	44.7													
F-4060	11.2	19.0	24.1	27.5	30.2	33.4	35.1	37.4	39.7	42.7												

Appendix 4 (cont.). Mean and individual back-calculated lengths at age for channel catfish collected in the Delaware River estuary in 2007.

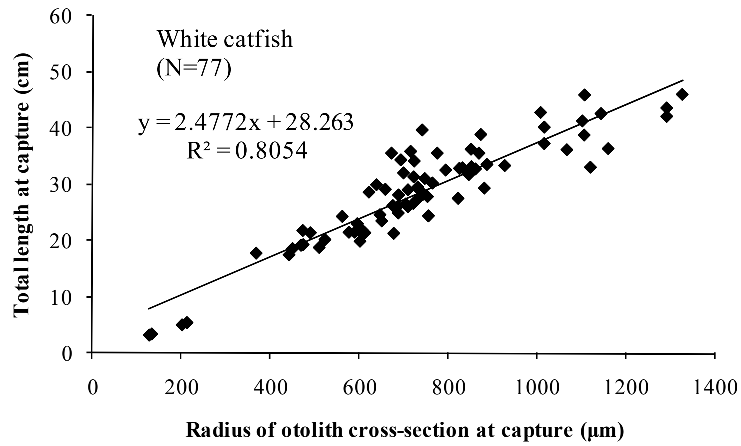
Fish Analysis #	**Back-calculated length at age (L_a) (cm)**																					
	L_1	**L_2**	**L_3**	**L_4**	**L_5**	**L_6**	**L_7**	**L_8**	**L_9**	**L_{10}**	**L_{11}**	**L_{12}**	**L_{13}**	**L_{14}**	**L_{15}**	**L_{16}**	**L_{17}**	**L_{18}**	**L_{19}**	**L_{20}**	**L_{21}**	**L_{22}**
F-4061	8.5	18.8	23.9	28.0																		
F-4062	11.1	17.6	22.9	27.4	31.9	34.9																
F-4063	10.5	18.4	22.8	26.1	30.1	32.5	34.7	37.2	39.7	41.5												
F-4064	11.3	19.3																				
F-4065	9.9	18.6																				
F-4066	8.1	12.0	17.6	20.9	24.4	27.7	31.2	32.9	35.0	37.5	39.8	43.0	45.7	47.7								
F-4067	10.2	16.4	21.4	24.6																		
F-4068	8.4	17.3	24.3	28.8	33.7	38.1	40.8	44.7	48.4	52.1												
F-4069	10.1	19.1	24.3	29.6	34.5	40.4	43.6	47.6														
F-4070	8.8	17.7	23.7	29.0	33.0	37.3	39.1	43.3	46.5	51.6	56.8											
Age (yr)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Mean back-calc. length (cm)	10.0	17.9	23.1	27.4	30.9	34.2	36.6	39.2	41.4	43.4	44.8	44.9	46.5	48.0	50.4	53.6	53.3	57.3	54.9	56.8	54.1	55.5
Number	145	145	126	120	96	96	72	68	58	54	41	34	23	18	9	8	4	3	2	2	1	1
Standard Error (cm)	0.16	0.22	0.30	0.37	0.49	0.54	0.74	0.77	0.92	0.93	1.10	0.94	1.02	1.21	2.26	2.20	3.73	4.47	4.21	4.42		
Biological Intercept: x (O_i) = 234 µm, y (L_i) = 10.2 cm																						

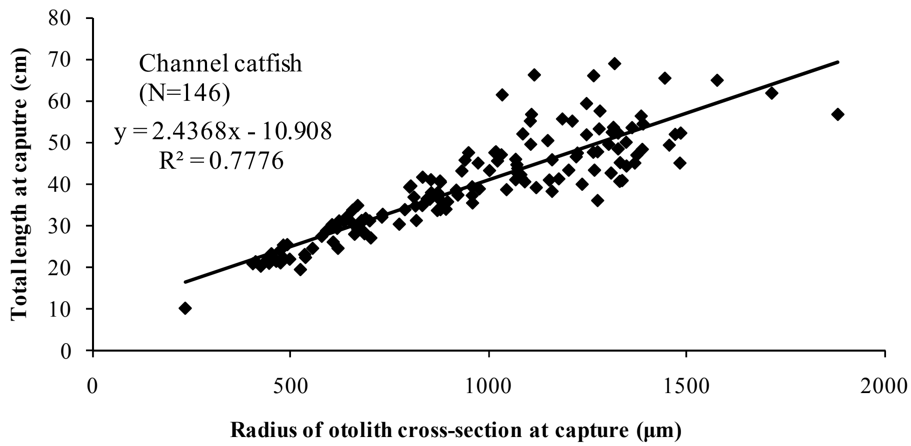
Appendix 5. Length and otolith measurements used to determine mean back-calculated lengths at age for brown bullhead collected in the Delaware River estuary in 2007.

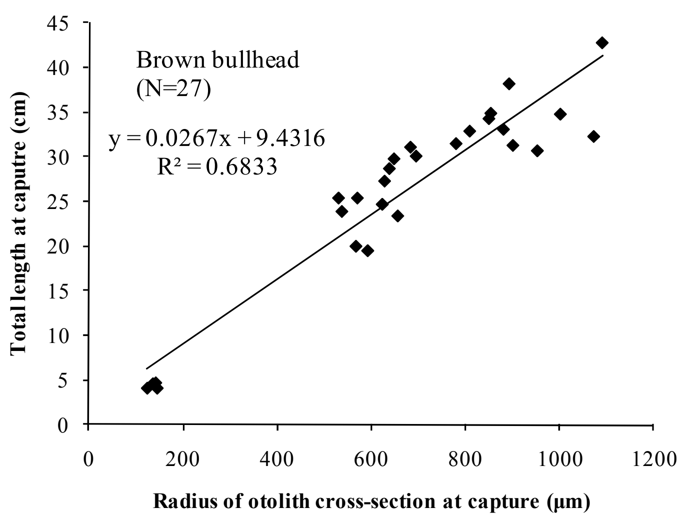
Fish Analysis #	Collection Date	Age (yr)	Length (L_c) (cm)	Radius (µm)	Distance from core of otolith cross-section to annulus (µm)							
				O_c	O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8
F-3849	8/11/2007	2	19.4	592	249	477						
F-3850	8/11/2007	2	19.9	567	289	477						
F-3851	9/2/2007	2	23.8	537	244	430						
F-3852	10/29/2007	2	25.3	530	295	484						
F-3853	8/26/2007	2	25.3	570	251	431						
F-3855	10/29/2007	6	32.2	1073	336	527	670	776	872	970		
F-3856	10/29/2007	6	30.6	953	277	502	641	763	848	911		
F-3857	10/29/2007	2	31.0	683	340	529						
F-3858	11/17/2007	3	31.4	780	300	535	686					
F-3859	10/29/2007	3	27.2	628	233	468	560					
F-3860	10/29/2007	4	38.1	893	278	515	650	782				
F-3861	11/11/2007	8	42.7	1091	186	395	549	674	770	855	939	1021
F-3896	7/7/2007	3	30.0	695	342	524	650					
F-3899	7/5/2007	3	23.3	656	275	468	618					
F-3900	7/7/2007	6	34.2	850	178	315	496	626	745	816		
F-3901	7/7/2007	5	32.8	809	246	403	547	691	769			
F-3902	6/25/2007	5	33.0	881	251	464	614	755	832			
F-3903	7/21/2007	5	34.8	854	281	449	601	729	822			
F-3956	4/1/2007	3	28.6	638	302	513	638					
F-3957	4/22/2007	3	24.6	623	329	494	623					
F-3958	5/6/2007	3	29.7	648	346	528	648					
F-4093	5/12/2007	6	34.7	1002	325	510	637	775	905	1002		
F-4094	5/12/2007	5	31.2	901	316	490	670	789	867			
F-4396	6/25/2008	0	4.6	141								
F-4395RC	6/25/2008	0	4.5	135								
F-4394	6/25/2008	0	4.0	144								
Ave. F-4393, F-4393RC	6/25/2008	0	4.0	123								

Appendix 6. Mean and individual back-calculated lengths at age for brown bullhead collected in the Delaware River estuary in 2007.

Fish Analysis #	Back-calculated length at age (L_a) (cm)							
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8
F-3849	8.0	15.6						
F-3850	9.8	16.6						
F-3851	9.6	18.6						
F-3852	12.8	22.8						
F-3853	9.9	18.6						
F-3855	10.3	15.9	20.2	23.4	26.2	29.1		
F-3856	8.8	16.1	20.6	24.5	27.2	29.2		
F-3857	14.3	23.5						
F-3858	11.2	21.1	27.4					
F-3859	8.8	19.8	24.0					
F-3860	10.6	21.2	27.3	33.1				
F-3861	6.3	14.7	20.9	25.9	29.8	33.2	36.6	39.9
F-3896	13.8	22.1	27.9					
F-3899	9.4	16.4	21.9					
F-3900	6.1	11.8	19.4	24.8	29.8	32.8		
F-3901	9.0	15.6	21.7	27.8	31.1			
F-3902	8.7	16.9	22.7	28.1	31.1			
F-3903	10.5	17.6	24.1	29.5	33.4			
F-3956	12.3	22.5	28.6					
F-3957	12.3	19.2	24.6					
F-3958	14.7	23.7	29.7					
F-4093	10.9	17.4	21.9	26.7	31.3	34.7		
F-4094	10.6	16.7	23.1	27.3	30.0			
Age (yr)	1	2	3	4	5	6	7	8
Mean back-calc. length (cm)	10.4	18.5	23.9	27.1	30.0	31.8	36.6	39.9
Number	23	23	17	10	9	5	1	1
Standard Error (cm)	0.47	0.66	0.78	0.89	0.73	1.12		
Biological Intercept: x (O_i) = 136 μm, y (L_i) = 4.3 cm								







Appendix 7. Length-otolith relationship for white catfish, channel catfish, and brown bullhead collected in the Delaware River estuary in 2007 (two young-of-year white catfish and four young-of-year brown bullhead were collected in 2008).

$$L_a = L_c + (O_a - O_c)\,(L_c - L_i)\,(O_c - O_i)^{-1}$$

where: L_a = back-calculated length at age, a

L_c = fish length at capture

O_a = otolith radius to annulus, a

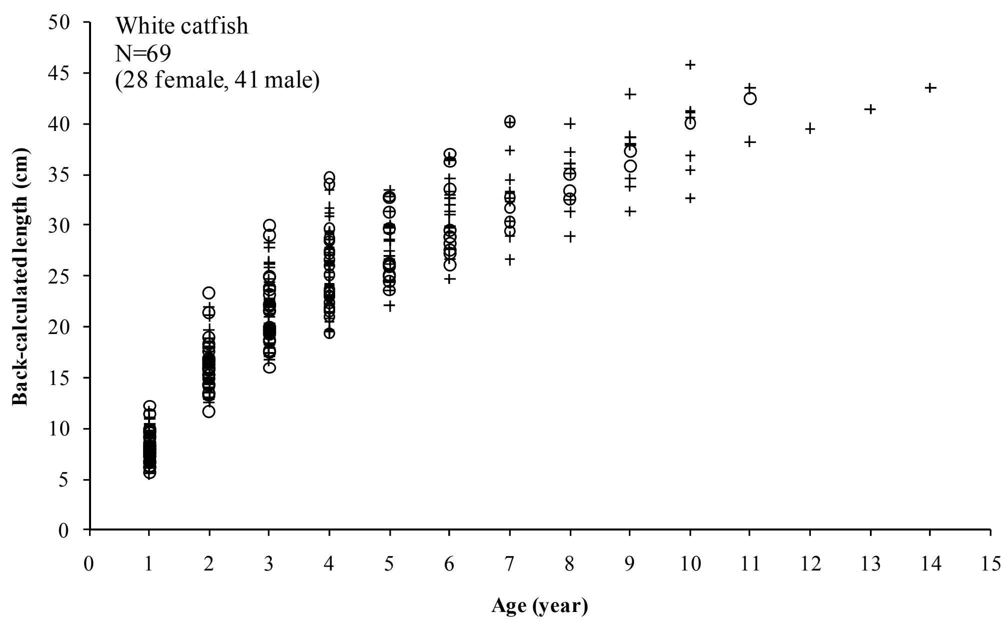
O_c = otolith radius at capture

L_i = length used for biological intercept

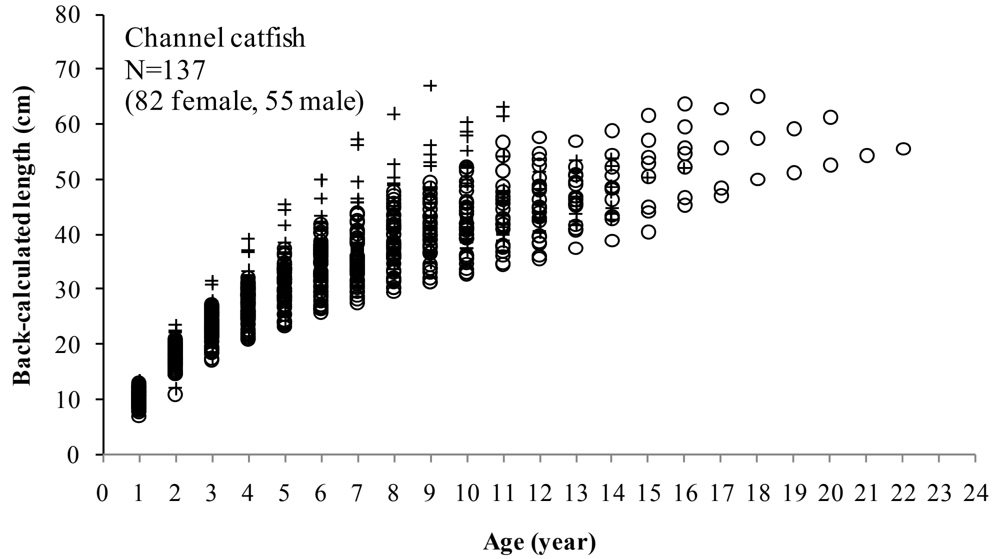
O_i = otolith radius used for biological intercept

Reference: Campana 1990

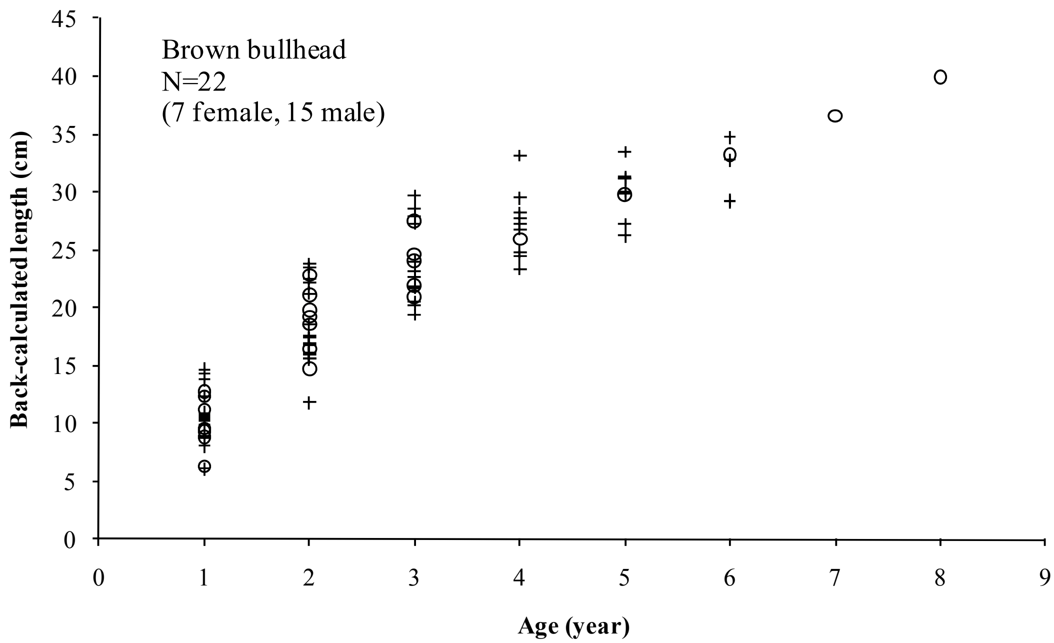
Appendix 8. Biological intercept formula used to back-calculate mean length at age for white catfish, channel catfish, and brown bullhead collected in the Delaware River estuary in 2007.



Appendix 9. Plot of individual back-calculated lengths by age for white catfish collected in the Delaware River estuary in 2007. O=female, +=male



Appendix 10. Plot of individual back-calculated lengths by age for channel catfish collected in the Delaware River estuary in 2007. O=female, +=male



Appendix 11. Plot of individual back-calculated lengths by age for brown bullhead collected in the Delaware River estuary in 2007. O=female, +=male

Appendix 12. Water chemistry collected near hoop nets set in the Delaware River estuary in 2007. Typically two measurements per subhabitat per day were taken. R=river, LT=lower tributary, and MT=middle tributary.

Date	Season	Zone	Habitat	Sub-habitat	Mean DO (mg/L)	Mean Water Temp. (°C)	Mean Conductivity (µS/cm)	Mean pH	Mean transparency (cm)	Mean Salinity (ppt)
4/1/2007	Spring	1	River	R	10.19	7.92	258	7.65	-	0.12
4/1/2007	Spring	1	Trib	LT	10.09	9.43	242	7.75	-	0.06
4/1/2007	Spring	1	Trib	MT	9.86	9.32	280	7.88	-	0.14
4/14/2007	Spring	2	River	R	11.03	7.53	145	7.35	-	-
4/14/2007	Spring	2	Trib	LT	11.04	7.68	150	7.49	-	0.07
4/14/2007	Spring	2	Trib	MT	10.78	8.86	177	7.64	-	0.08
4/20/2007	Spring	3	River	R	11.99	7.36	197	7.97	-	0.10
4/20/2007	Spring	3	Trib	LT	11.65	7.52	188	7.79	-	0.09
4/20/2007	Spring	3	Trib	MT	11.90	7.62	189	7.81	-	0.09
4/21/2007	Spring	1	River	R	9.63	9.78	162	7.60	-	0.08
4/21/2007	Spring	1	Trib	LT	10.16	9.38	159	7.55	-	0.08
4/21/2007	Spring	1	Trib	MT	9.26	9.60	128	7.72	-	0.08
4/22/2007	Spring	2	River	R	8.32	8.98	157	7.41	-	0.08
4/22/2007	Spring	2	Trib	LT	6.57	10.46	177	7.37	-	0.09
4/22/2007	Spring	2	Trib	MT	7.37	11.33	192	7.60	-	0.10
5/5/2007	Spring	3	River	R	-	13.93	-	-	118	-
5/5/2007	Spring	3	Trib	LT	-	15.50	-	-	88	-
5/5/2007	Spring	3	Trib	MT	-	15.28	-	-	88	-
5/6/2007	Spring	4	River	R	-	14.68	-	-	188	-
5/6/2007	Spring	4	Trib	LT	-	14.00	-	-	150	-
5/6/2007	Spring	4	Trib	MT	-	13.96	-	-	115	-
5/12/2007	Spring	2	River	R	6.26	17.21	277	7.57	135	0.13
5/12/2007	Spring	2	Trib	LT	6.22	17.62	264	7.68	56	0.13
5/12/2007	Spring	2	Trib	MT	5.69	17.80	260	7.55	105	-
5/13/2007	Spring	1	River	R	7.65	17.43	292	7.65	100	0.14
5/13/2007	Spring	1	Trib	LT	8.91	18.18	267	7.88	75	0.13
5/13/2007	Spring	1	Trib	MT	8.82	18.42	267	7.70	83	0.13
5/24/2007	Spring	4	River	R	7.89	21.15	272	7.76	175	0.13
5/24/2007	Spring	4	Trib	LT	7.20	20.40	279	7.60	150	0.13
5/24/2007	Spring	4	Trib	MT	7.10	20.23	278	7.59	150	0.13
5/25/2007	Spring	3	River	R	5.60	20.27	278	7.87	150	0.13
5/25/2007	Spring	3	Trib	LT	6.13	20.60	269	7.65	200	-
5/25/2007	Spring	3	Trib	MT	5.38	21.04	269	7.46	200	-
6/2/2007	Spring	1	River	R	6.15	24.01	376	7.53	65	0.17
6/2/2007	Spring	1	Trib	LT	6.10	24.50	356	7.49	60	0.17
6/2/2007	Spring	1	Trib	MT	5.28	24.90	347	7.48	50	0.17
6/3/2007	Spring	2	River	R	4.74	23.64	338	7.40	113	0.16
6/3/2007	Spring	2	Trib	LT	4.71	23.85	344	7.53	78	0.17
6/3/2007	Spring	2	Trib	MT	4.65	24.18	339	7.44	50	0.16

Appendix 12 (cont.). Water chemistry collected near hoop nets set in the Delaware River estuary in 2007. Typically two measurements per subhabitat per day were taken. R=river, LT=lower tributary, and MT=middle tributary.

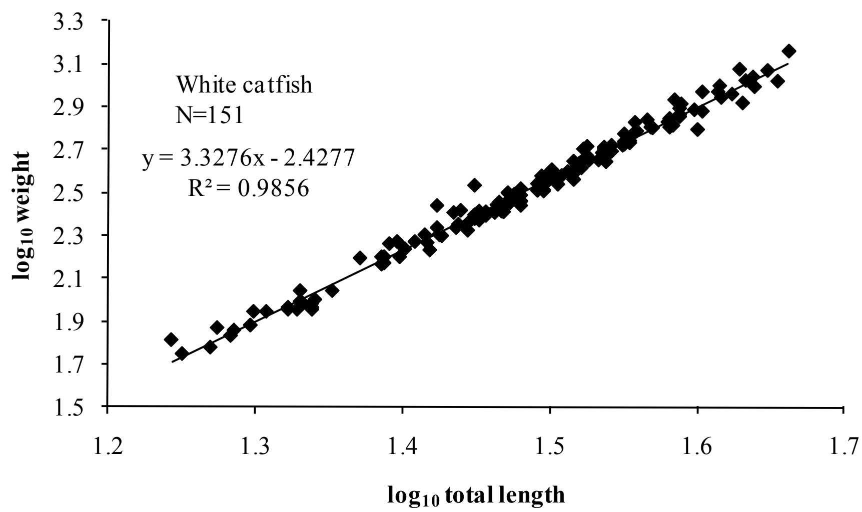
Date	Season	Zone	Habitat	Sub-habitat	Mean DO (mg/L)	Mean Water Temp. (°C)	Mean Conductivity (µS/cm)	Mean pH	Mean transparency (cm)	Mean Salinity (ppt)
6/9/2007	Spring	3	River	R	4.72	24.58	304	7.53	75	0.15
6/9/2007	Spring	3	Trib	LT	4.88	24.66	301	7.56	125	0.15
6/9/2007	Spring	3	Trib	MT	5.00	24.79	298	7.68	75	0.14
6/10/2007	Spring	4	River	R	6.18	24.55	275	7.74	113	0.13
6/10/2007	Spring	4	Trib	LT	5.60	24.95	272	7.78	100	0.13
6/10/2007	Spring	4	Trib	MT	6.63	24.97	272	7.89	100	0.13
6/24/2007	Spring	2	River	R	-	23.15	-	-	110	-
6/24/2007	Spring	2	Trib	LT	-	23.04	-	-	113	-
6/24/2007	Spring	2	Trib	MT	-	22.97	-	-	125	-
6/25/2007	Spring	1	River	R	8.96	24.72	551	7.92	53	0.27
6/25/2007	Spring	1	Trib	LT	8.57	24.31	490	7.76	30	0.24
6/25/2007	Spring	1	Trib	MT	8.60	24.30	475	7.66	40	0.23
6/30/2007	Spring	4	River	R	-	25.99	-	-	75	-
6/30/2007	Spring	4	Trib	LT	-	24.39	-	-	100	-
6/30/2007	Spring	4	Trib	MT	-	23.61	-	-	100	-
7/7/2007	Summer	3	River	R	-	24.05	-	-	85	-
7/7/2007	Summer	3	Trib	LT	-	24.27	-	-	90	-
7/7/2007	Summer	3	Trib	MT	-	24.39	-	-	-	-
7/21/2007	Summer	2	River	R	4.97	25.88	400	8.02	80	0.19
7/21/2007	Summer	2	Trib	LT	5.31	25.87	389	8.12	98	0.19
7/21/2007	Summer	2	Trib	MT	5.18	25.38	382	8.04	90	0.14
7/22/2007	Summer	1	River	R	6.46	26.34	1195	8.06	40	0.60
7/22/2007	Summer	1	Trib	LT	6.63	25.30	877	8.08	60	0.43
7/22/2007	Summer	1	Trib	MT	6.35	25.20	868	7.95	50	0.43
8/4/2007	Summer	4	River	R	5.36	28.99	210	7.81	110	0.10
8/4/2007	Summer	4	Trib	LT	4.80	28.99	208	7.89	160	-
8/4/2007	Summer	4	Trib	MT	4.63	28.96	208	7.89	175	-
8/5/2007	Summer	3	River	R	5.30	27.78	284	7.86	100	0.13
8/5/2007	Summer	3	Trib	LT	5.89	27.91	260	7.71	90	0.12
8/5/2007	Summer	3	Trib	MT	5.81	28.23	244	7.38	50	0.11
8/11/2007	Summer	1	River	R	6.14	27.69	1455	7.65	37	0.69
8/11/2007	Summer	1	Trib	LT	5.28	27.48	1305	7.69	40	0.65
8/11/2007	Summer	1	Trib	MT	5.98	27.24	1257	7.71	30	0.63
8/17/2007	Summer	2	River	R	4.78	27.41	328	7.59	100	0.29
8/17/2007	Summer	2	Trib	LT	4.07	27.04	400	7.68	75	0.19
8/17/2007	Summer	2	Trib	MT	5.13	27.02	343	7.60	75	0.16
8/26/2007	Summer	3	River	R	6.17	23.69	235	8.04	75	0.11
8/26/2007	Summer	3	Trib	LT	5.80	23.68	232	7.81	50	0.11
8/26/2007	Summer	3	Trib	MT	4.77	23.44	205	7.23	50	0.10

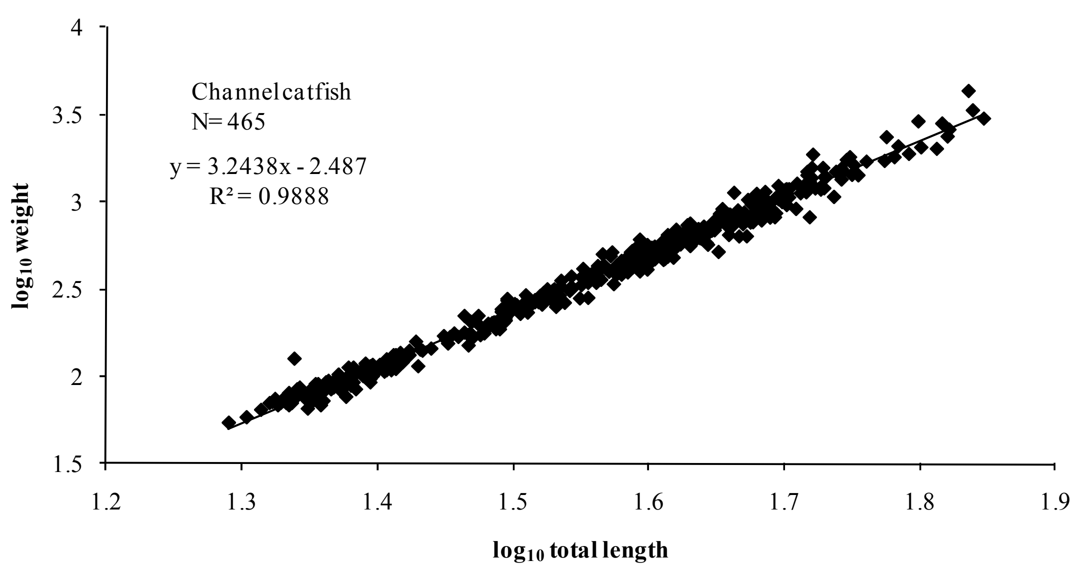
Appendix 12 (cont.). Water chemistry collected near hoop nets set in the Delaware River estuary in 2007. Typically two measurements per subhabitat per day were taken. R=river, LT=lower tributary, and MT=middle tributary.

Date	Season	Zone	Habitat	Sub-habitat	Mean DO (mg/L)	Mean Water Temp. (°C)	Mean Conductivity (µS/cm)	Mean pH	Mean transparency (cm)	Mean Salinity (ppt)
9/1/2007	Summer	4	River	R	6.29	25.69	248	7.65	163	0.12
9/1/2007	Summer	4	Trib	LT	6.70	25.26	247	8.00	150	0.12
9/1/2007	Summer	4	Trib	MT	6.02	25.36	249	7.90	100	0.12
9/2/2007	Summer	3	River	R	5.80	23.99	250	7.54	75	0.12
9/2/2007	Summer	3	Trib	LT	5.81	23.77	242	7.62	100	0.11
9/2/2007	Summer	3	Trib	MT	5.04	24.00	219	7.39	75	0.10
9/9/2007	Summer	1	River	R	6.18	25.85	2123	7.60	37	1.08
9/9/2007	Summer	1	Trib	LT	5.89	25.71	1672	7.67	38	0.85
9/9/2007	Summer	1	Trib	MT	5.58	25.64	1585	7.65	28	0.80
9/16/2007	Summer	2	River	R	5.12	23.97	367	7.56	100	0.18
9/16/2007	Summer	2	Trib	LT	5.66	22.71	362	7.58	88	0.17
9/16/2007	Summer	2	Trib	MT	6.56	22.12	354	7.67	88	0.17
9/22/2007	Summer	4	River	R	7.39	22.05	250	7.77	200	0.12
9/22/2007	Summer	4	Trib	LT	7.86	22.16	248	7.97	200	0.12
9/22/2007	Summer	4	Trib	MT	7.82	22.15	249	7.73	200	0.12
9/23/2007	Summer	3	River	R	6.38	23.30	285	7.81	100	0.14
9/23/2007	Summer	3	Trib	LT	6.52	23.18	285	7.90	100	0.14
9/23/2007	Summer	3	Trib	MT	6.23	23.13	288	7.81	88	0.14
10/6/2007	Fall	1	River	R	6.46	23.12	5029	7.26	50	2.70
10/6/2007	Fall	1	Trib	LT	6.85	23.19	3141	7.39	45	1.65
10/6/2007	Fall	1	Trib	MT	6.43	23.05	4004	7.41	40	2.12
10/7/2007	Fall	2	River	R	4.93	23.21	617	7.29	50	0.30
10/7/2007	Fall	2	Trib	LT	4.94	23.19	582	7.25	63	0.28
10/7/2007	Fall	2	Trib	MT	4.89	23.16	536	7.32	75	0.26
10/14/2007	Fall	3	River	R	-	18.97	-	-	-	-
10/14/2007	Fall	3	Trib	LT	-	17.38	-	-	-	-
10/14/2007	Fall	3	Trib	MT	-	16.94	-	-	-	-
10/15/2007	Fall	4	River	R	-	14.90	-	-	213	-
10/15/2007	Fall	4	Trib	LT	-	14.52	-	-	150	-
10/15/2007	Fall	4	Trib	MT	-	14.45	-	-	150	-
10/29/2007	Fall	2	River	R	7.68	15.20	225	7.62	125	0.11
10/29/2007	Fall	2	Trib	LT	6.95	15.55	257	7.66	90	0.13
10/29/2007	Fall	2	Trib	MT	7.04	14.66	239	7.60	75	0.11
11/4/2007	Fall	4	River	R	-	9.42	-	-	175	-
11/4/2007	Fall	4	Trib	LT	-	9.13	-	-	-	-
11/4/2007	Fall	4	Trib	MT	-	9.03	-	-	175	-
11/11/2007	Fall	3	River	R	-	7.87	-	-	-	-
11/11/2007	Fall	3	Trib	LT	-	7.20	-	-	-	-
11/11/2007	Fall	3	Trib	MT	-	6.42	-	-	-	-

Appendix 12 (cont.). Water chemistry collected near hoop nets set in the Delaware River estuary in 2007. Typically two measurements per subhabitat per day were taken. R=river, LT=lower tributary, and MT=middle tributary.

Date	Season	Zone	Habitat	Sub-habitat	Mean DO (mg/L)	Mean Water Temp. (°C)	Mean Conductivity (µS/cm)	Mean pH	Mean transparency (cm)	Mean Salinity (ppt)
11/17/2007	Fall	1	River	R	8.88	9.52	331	7.50	38	0.16
11/17/2007	Fall	1	Trib	LT	10.45	7.63	377	7.62	38	0.18
11/17/2007	Fall	1	Trib	MT	10.23	7.45	409	7.51	25	0.20
11/18/2007	Fall	2	River	R	9.05	8.12	223	7.64	75	0.11
11/18/2007	Fall	2	Trib	LT	8.42	8.34	242	7.57	100	0.12
11/18/2007	Fall	2	Trib	MT	8.93	9.01	228	7.68	88	0.11





Appendix 13. Log_{10} weight – $\log_{10}$ length relationships for white catfish and channel catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary.

Appendix 14. Relative condition and associated habitat data for 465 channel catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. R=river, LT=lower trib., and MT= middle trib.

Date	Season	Zone	Habitat	Sub-habitat	Field total length	Field gross weight (W)	Predicted weight (W')	Relative Condition (K_n)
					cm	g	g	
4/1/2007	Spring	1	River	R	31.2	210	229	92
4/1/2007	Spring	1	Trib	LT	41.5	480	578	83
4/1/2007	Spring	1	Trib	LT	45.6	850	784	108
4/14/2007	Spring	2	Trib	LT	39.2	610	480	127
4/14/2007	Spring	2	Trib	MT	47.7	850	907	94
4/21/2007	Spring	1	Trib	LT	28.8	168	177	95
4/21/2007	Spring	1	Trib	LT	36.5	430	381	113
4/21/2007	Spring	1	Trib	LT	46.6	790	841	94
4/21/2007	Spring	1	Trib	MT	36.4	344	377	91
4/22/2007	Spring	2	River	R	29.1	178	183	97
4/22/2007	Spring	2	River	R	31.2	244	229	107
4/22/2007	Spring	2	River	R	29.4	176	189	93
4/22/2007	Spring	2	River	R	36.5	410	381	108
4/22/2007	Spring	2	Trib	LT	53.3	1182	1301	91
4/22/2007	Spring	2	Trib	LT	24.6	98	106	93
4/22/2007	Spring	2	Trib	MT	26.1	136	128	106
5/5/2007	Spring	3	River	R	19.5	54	50	108
5/5/2007	Spring	3	River	R	52	1210	1201	101
5/5/2007	Spring	3	River	R	48.5	1148	958	120
5/6/2007	Spring	4	Trib	LT	34	250	303	83
5/12/2007	Spring	2	River	R	40	548	513	107
5/12/2007	Spring	2	River	R	34.9	316	329	96
5/12/2007	Spring	2	River	R	55.2	1352	1457	93
5/13/2007	Spring	1	River	R	45.9	814	801	102
5/13/2007	Spring	1	Trib	MT	40.9	472	551	86
5/24/2007	Spring	4	River	R	46	1134	807	141
6/2/2007	Spring	1	River	R	50.1	1080	1064	102
6/2/2007	Spring	1	River	R	57.6	1714	1673	102
6/2/2007	Spring	1	River	R	44.7	734	735	100
6/2/2007	Spring	1	River	R	43.4	642	668	96
6/2/2007	Spring	1	River	R	35.8	352	358	98
6/2/2007	Spring	1	River	R	31	218	224	97
6/2/2007	Spring	1	River	R	30.7	204	217	94
6/3/2007	Spring	2	Trib	LT	40.7	526	542	97
6/3/2007	Spring	2	River	R	36.1	385	367	105
6/9/2007	Spring	3	Trib	MT	42.7	754	634	119
6/10/2007	Spring	4	Trib	LT	49.6	1242	1030	121
6/10/2007	Spring	4	Trib	LT	41.3	518	569	91
6/10/2007	Spring	4	Trib	LT	52.5	1578	1238	127

Appendix 14 (cont.). Relative condition and associated habitat data for 465 channel catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. R=river, LT=lower trib., and MT= middle trib.

Date	Season	Zone	Habitat	Sub-habitat	Field total length	Field gross weight (W)	Predicted weight (W')	Relative Condition (K_n)
					cm	g	g	
6/10/2007	Spring	4	River	R	23.1	93	86	108
6/10/2007	Spring	4	River	R	39.6	492	496	99
6/10/2007	Spring	4	River	R	45.1	914	757	121
6/10/2007	Spring	4	River	R	45.2	802	762	105
6/10/2007	Spring	4	River	R	55.2	1562	1457	107
6/10/2007	Spring	4	River	R	53.7	1410	1333	106
6/10/2007	Spring	4	River	R	49.6	1066	1030	104
6/10/2007	Spring	4	River	R	45.1	836	757	111
6/10/2007	Spring	4	River	R	38	383	434	88
6/10/2007	Spring	4	River	R	30.4	196	210	93
6/24/2007	Spring	2	Trib	LT	31.3	272	231	118
6/24/2007	Spring	2	Trib	LT	38.3	475	445	107
6/24/2007	Spring	2	Trib	LT	47.5	768	895	86
6/24/2007	Spring	2	Trib	LT	40.8	546	547	100
6/24/2007	Spring	2	River	R	36.9	432	395	109
6/24/2007	Spring	2	River	R	43.4	638	668	96
6/24/2007	Spring	2	River	R	28.6	176	173	102
6/24/2007	Spring	2	River	R	41.1	486	560	87
6/24/2007	Spring	2	River	R	30.3	200	208	96
6/24/2007	Spring	2	Trib	LT	39.4	502	488	103
6/24/2007	Spring	2	Trib	MT	41	572	555	103
6/25/2007	Spring	1	River	R	33.7	300	294	102
6/25/2007	Spring	1	River	R	32.8	266	269	99
6/25/2007	Spring	1	River	R	69	3380	3005	112
6/25/2007	Spring	1	River	R	27.5	144	152	95
6/25/2007	Spring	1	River	R	33.8	310	297	104
6/25/2007	Spring	1	River	R	31.8	256	244	105
6/25/2007	Spring	1	River	R	47.8	984	914	108
6/30/2007	Spring	4	Trib	LT	24.1	112	99	113
6/30/2007	Spring	4	Trib	MT	37.3	490	409	120
6/30/2007	Spring	4	Trib	MT	43.3	702	663	106
6/30/2007	Spring	4	Trib	MT	56.4	1632	1562	104
6/30/2007	Spring	4	Trib	MT	61.9	1898	2113	90
6/30/2007	Spring	4	Trib	MT	37.4	515	412	125
6/30/2007	Spring	4	Trib	MT	23.3	86	89	97
6/30/2007	Spring	4	Trib	MT	21.9	84	73	116
6/30/2007	Spring	4	Trib	MT	20.9	70	62	112
6/30/2007	Spring	4	Trib	MT	28.1	170	163	104
6/30/2007	Spring	4	Trib	MT	47.6	842	901	93

Appendix 14 (cont.). Relative condition and associated habitat data for 465 channel catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. R=river, LT=lower trib., and MT= middle trib.

Date	Season	Zone	Habitat	Sub-habitat	Field total length	Field gross weight (W)	Predicted weight (W')	Relative Condition (K_n)
					cm	g	g	
6/30/2007	Spring	4	Trib	MT	34.8	309	326	95
6/30/2007	Spring	4	River	R	40.5	556	534	104
6/30/2007	Spring	4	River	R	41.1	648	560	116
6/30/2007	Spring	4	River	R	38	460	434	106
6/30/2007	Spring	4	River	R	42.3	670	615	109
6/30/2007	Spring	4	River	R	40.6	490	538	91
6/30/2007	Spring	4	River	R	33.9	292	300	97
6/30/2007	Spring	4	River	R	35.6	414	351	118
6/30/2007	Spring	4	River	R	38.9	541	468	116
6/30/2007	Spring	4	River	R	50.5	1190	1092	109
6/30/2007	Spring	4	River	R	43.2	696	658	106
6/30/2007	Spring	4	River	R	41.7	594	587	101
6/30/2007	Spring	4	River	R	47.8	1118	914	122
6/30/2007	Spring	4	River	R	47.1	1032	871	119
6/30/2007	Spring	4	River	R	31	234	224	104
6/30/2007	Spring	4	River	R	32.1	251	251	100
6/30/2007	Spring	4	River	R	31.3	278	231	120
6/30/2007	Spring	4	River	R	21	71	63	112
7/7/2007	Summer	3	River	R	33.3	265	283	94
7/7/2007	Summer	3	River	R	45.1	776	757	103
7/7/2007	Summer	3	Trib	LT	22.1	80	75	107
7/21/2007	Summer	2	Trib	LT	21.8	75	72	105
7/21/2007	Summer	2	Trib	LT	22.3	78	77	101
7/21/2007	Summer	2	Trib	MT	52.3	820	1223	67
7/21/2007	Summer	2	River	R	21.8	78	72	109
7/21/2007	Summer	2	River	R	24.6	104	106	98
7/21/2007	Summer	2	River	R	25.5	125	119	105
7/21/2007	Summer	2	River	R	21.4	72	67	107
7/21/2007	Summer	2	River	R	21.7	75	71	106
7/21/2007	Summer	2	River	R	22.4	79	78	101
7/21/2007	Summer	2	River	R	44.4	769	719	107
7/21/2007	Summer	2	River	R	38.7	525	460	114
7/21/2007	Summer	2	Trib	LT	59.4	1730	1848	94
7/21/2007	Summer	2	Trib	LT	47	637	865	74
7/21/2007	Summer	2	Trib	LT	21.5	76	68	111
7/21/2007	Summer	2	Trib	LT	22	79	74	107
7/21/2007	Summer	2	Trib	LT	25.4	108	117	92
7/21/2007	Summer	2	Trib	LT	21.1	74	64	115
7/21/2007	Summer	2	Trib	MT	31.2	216	229	94

Appendix 14 (cont.). Relative condition and associated habitat data for 465 channel catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. R=river, LT=lower trib., and MT= middle trib.

Date	Season	Zone	Habitat	Sub-habitat	Field total length	Field gross weight (W)	Predicted weight (W')	Relative Condition (K_n)
					cm	g	g	
7/22/2007	Summer	1	River	R	49.4	864	1017	85
7/22/2007	Summer	1	River	R	45.8	722	795	91
7/22/2007	Summer	1	River	R	32.1	256	251	102
7/22/2007	Summer	1	River	R	38.6	515	457	113
7/22/2007	Summer	1	River	R	34.9	326	329	99
7/22/2007	Summer	1	River	R	34.1	314	305	103
7/22/2007	Summer	1	Trib	LT	36.8	502	391	128
7/22/2007	Summer	1	Trib	LT	33.9	316	300	105
7/22/2007	Summer	1	Trib	LT	55.7	1754	1500	117
7/22/2007	Summer	1	Trib	LT	39.3	460	484	95
7/22/2007	Summer	1	Trib	MT	34.3	354	311	114
7/22/2007	Summer	1	Trib	MT	23.8	91	95	96
8/4/2007	Summer	4	River	R	23.7	86	94	92
8/4/2007	Summer	4	River	R	23.3	86	89	97
8/4/2007	Summer	4	River	R	23.1	94	86	109
8/4/2007	Summer	4	River	R	24.5	100	105	96
8/4/2007	Summer	4	River	R	24	104	98	106
8/4/2007	Summer	4	River	R	26.8	158	140	113
8/4/2007	Summer	4	River	R	24.1	106	99	107
8/4/2007	Summer	4	River	R	28.3	154	167	92
8/4/2007	Summer	4	River	R	32.4	232	259	90
8/4/2007	Summer	4	River	R	25.3	110	116	95
8/4/2007	Summer	4	River	R	24.9	106	110	96
8/4/2007	Summer	4	River	R	24.4	104	103	101
8/4/2007	Summer	4	River	R	23.9	112	96	116
8/4/2007	Summer	4	River	R	23	88	85	103
8/4/2007	Summer	4	River	R	22.4	80	78	102
8/5/2007	Summer	3	River	R	54.5	1074	1398	77
8/5/2007	Summer	3	River	R	21.7	76	71	108
8/5/2007	Summer	3	River	R	43.3	662	663	100
8/5/2007	Summer	3	River	R	21.4	74	67	110
8/5/2007	Summer	3	River	R	30.1	186	204	91
8/5/2007	Summer	3	River	R	23.4	92	90	102
8/5/2007	Summer	3	River	R	22.7	86	82	105
8/5/2007	Summer	3	River	R	23	90	85	106
8/5/2007	Summer	3	River	R	24.6	110	106	104
8/5/2007	Summer	3	River	R	48.4	818	951	86
8/5/2007	Summer	3	Trib	LT	22.8	86	83	104
8/5/2007	Summer	3	Trib	LT	25.6	114	121	95

Appendix 14 (cont.). Relative condition and associated habitat data for 465 channel catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. R=river, LT=lower trib., and MT= middle trib.

Date	Season	Zone	Habitat	Sub-habitat	Field total length	Field gross weight (W)	Predicted weight (W')	Relative Condition (K_n)
					cm	g	g	
8/5/2007	Summer	3	Trib	LT	28.2	162	165	98
8/5/2007	Summer	3	Trib	LT	26.2	128	130	99
8/5/2007	Summer	3	Trib	MT	20.6	64	60	107
8/5/2007	Summer	3	Trib	MT	35.5	370	348	106
8/5/2007	Summer	3	Trib	MT	29.5	166	191	87
8/5/2007	Summer	3	Trib	MT	23.7	92	94	98
8/11/2007	Summer	1	River	R	30.7	186	217	86
8/11/2007	Summer	1	River	R	33.5	316	288	110
8/11/2007	Summer	1	River	R	22.9	86	84	102
8/11/2007	Summer	1	River	R	24.8	92	109	85
8/11/2007	Summer	1	River	R	32.4	246	259	95
8/11/2007	Summer	1	River	R	42.6	622	629	99
8/11/2007	Summer	1	River	R	22.8	74	83	89
8/11/2007	Summer	1	River	R	32.3	292	256	114
8/11/2007	Summer	1	Trib	MT	44.8	518	740	70
8/11/2007	Summer	1	Trib	LT	23.3	92	89	104
8/11/2007	Summer	1	Trib	LT	21.7	70	71	99
8/17/2007	Summer	2	Trib	LT	46.7	748	847	88
8/17/2007	Summer	2	River	R	23.2	90	88	103
8/17/2007	Summer	2	River	R	21.8	74	72	103
8/17/2007	Summer	2	River	R	29.8	198	197	100
8/17/2007	Summer	2	River	R	22.5	86	79	108
8/17/2007	Summer	2	River	R	25.2	112	115	98
8/17/2007	Summer	2	River	R	29.1	222	183	122
8/17/2007	Summer	2	River	R	25.8	120	124	97
8/17/2007	Summer	2	River	R	22.8	68	83	82
8/17/2007	Summer	2	Trib	LT	40.8	600	547	110
8/26/2007	Summer	3	River	R	21.6	80	69	115
8/26/2007	Summer	3	River	R	22.3	74	77	96
8/26/2007	Summer	3	River	R	23.4	96	90	107
8/26/2007	Summer	3	River	R	21.6	68	69	98
8/26/2007	Summer	3	River	R	25.2	116	115	101
8/26/2007	Summer	3	River	R	47.5	992	895	111
8/26/2007	Summer	3	River	R	21.7	78	71	111
8/26/2007	Summer	3	Trib	LT	26.5	132	135	98
8/26/2007	Summer	3	Trib	LT	24.9	112	110	102
8/26/2007	Summer	3	Trib	LT	24.5	110	105	105
8/26/2007	Summer	3	Trib	LT	23	86	85	101
8/26/2007	Summer	3	Trib	LT	24.9	116	110	105

Appendix 14 (cont.). Relative condition and associated habitat data for 465 channel catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. R=river, LT=lower trib., and MT= middle trib.

Date	Season	Zone	Habitat	Sub-habitat	Field total length	Field gross weight (W)	Predicted weight (W')	Relative Condition (K_n)
					cm	g	g	
8/26/2007	Summer	3	Trib	LT	29.8	222	197	113
8/26/2007	Summer	3	Trib	LT	40.2	556	521	107
8/26/2007	Summer	3	Trib	LT	32.4	284	259	110
8/26/2007	Summer	3	Trib	LT	36.5	376	381	99
8/26/2007	Summer	3	Trib	LT	38.3	422	445	95
8/26/2007	Summer	3	Trib	LT	32.8	274	269	102
8/26/2007	Summer	3	Trib	LT	23.2	84	88	96
8/26/2007	Summer	3	Trib	LT	22.5	72	79	91
8/26/2007	Summer	3	Trib	LT	26.1	126	128	98
8/26/2007	Summer	3	Trib	MT	23	86	85	101
9/1/2007	Summer	4	Trib	LT	23.3	90	89	101
9/1/2007	Summer	4	Trib	MT	23.5	102	91	112
9/1/2007	Summer	4	River	R	23	92	85	108
9/1/2007	Summer	4	River	R	22.7	76	82	93
9/1/2007	Summer	4	River	R	22.3	65	77	84
9/1/2007	Summer	4	River	R	25.4	110	117	94
9/1/2007	Summer	4	River	R	21.2	68	65	104
9/1/2007	Summer	4	River	R	23.2	88	88	100
9/1/2007	Summer	4	River	R	23.6	95	93	103
9/2/2007	Summer	3	River	R	33.9	270	300	90
9/2/2007	Summer	3	River	R	43.8	672	688	98
9/2/2007	Summer	3	River	R	22.7	90	82	110
9/2/2007	Summer	3	River	R	46.4	636	830	77
9/2/2007	Summer	3	River	R	49.9	1106	1050	105
9/2/2007	Summer	3	River	R	22	86	74	117
9/2/2007	Summer	3	River	R	38.7	420	460	91
9/2/2007	Summer	3	River	R	22.6	90	80	112
9/2/2007	Summer	3	River	R	35.7	360	354	102
9/2/2007	Summer	3	River	R	45.9	752	801	94
9/2/2007	Summer	3	River	R	51.9	1160	1193	97
9/2/2007	Summer	3	River	R	56.8	1430	1599	89
9/2/2007	Summer	3	River	R	53.6	1204	1325	91
9/2/2007	Summer	3	River	R	25.9	132	125	105
9/2/2007	Summer	3	River	R	25.1	108	113	96
9/2/2007	Summer	3	River	R	24.6	118	106	111
9/2/2007	Summer	3	River	R	35.9	344	361	95
9/2/2007	Summer	3	River	R	31.2	228	229	100
9/2/2007	Summer	3	River	R	23.5	102	91	112
9/2/2007	Summer	3	River	R	25	106	112	95

Appendix 14 (cont.). Relative condition and associated habitat data for 465 channel catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. R=river, LT=lower trib., and MT= middle trib.

Date	Season	Zone	Habitat	Sub-habitat	Field total length	Field gross weight (W)	Predicted weight (W')	Relative Condition (K_n)
					cm	g	g	
9/2/2007	Summer	3	Trib	LT	23.2	86	88	98
9/2/2007	Summer	3	Trib	LT	45.4	738	773	95
9/2/2007	Summer	3	Trib	LT	42.5	738	624	118
9/2/2007	Summer	3	Trib	LT	37.8	392	427	92
9/2/2007	Summer	3	Trib	LT	47.4	970	889	109
9/9/2007	Summer	1	River	R	24	96	98	98
9/9/2007	Summer	1	River	R	30.9	186	222	84
9/9/2007	Summer	1	River	R	30.8	196	220	89
9/9/2007	Summer	1	River	R	25.9	110	125	88
9/9/2007	Summer	1	Trib	LT	29.9	172	199	86
9/9/2007	Summer	1	Trib	LT	29.3	150	187	80
9/9/2007	Summer	1	Trib	LT	23.5	88	91	96
9/9/2007	Summer	1	Trib	LT	21.3	70	66	105
9/9/2007	Summer	1	Trib	MT	21.7	74	71	105
9/9/2007	Summer	1	Trib	MT	40.4	496	529	94
9/9/2007	Summer	1	Trib	MT	34.2	262	308	85
9/9/2007	Summer	1	Trib	MT	33.3	302	283	107
9/9/2007	Summer	1	Trib	MT	36.5	366	381	96
9/9/2007	Summer	1	Trib	MT	23.8	94	95	99
9/9/2007	Summer	1	Trib	MT	22.8	80	83	97
9/9/2007	Summer	1	Trib	MT	26.9	114	142	81
9/9/2007	Summer	1	Trib	MT	24.9	100	110	91
9/9/2007	Summer	1	Trib	MT	52.3	1210	1223	99
9/16/2007	Summer	2	River	R	39.8	462	504	92
9/16/2007	Summer	2	River	R	35.9	282	361	78
9/16/2007	Summer	2	River	R	34.1	314	305	103
9/16/2007	Summer	2	River	R	43.7	724	683	106
9/16/2007	Summer	2	River	R	39.2	558	480	116
9/16/2007	Summer	2	River	R	40.5	516	534	97
9/16/2007	Summer	2	River	R	36.7	358	388	92
9/16/2007	Summer	2	River	R	43.7	705	683	103
9/16/2007	Summer	2	River	R	33.3	286	283	101
9/16/2007	Summer	2	River	R	37.5	338	416	81
9/16/2007	Summer	2	River	R	31.5	240	236	102
9/16/2007	Summer	2	River	R	41.3	544	569	96
9/16/2007	Summer	2	River	R	48.2	786	939	84
9/16/2007	Summer	2	River	R	43.2	658	658	100
9/16/2007	Summer	2	River	R	45.3	840	767	109
9/16/2007	Summer	2	River	R	31	242	224	108

Appendix 14 (cont.). Relative condition and associated habitat data for 465 channel catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. R=river, LT=lower trib., and MT= middle trib.

Date	Season	Zone	Habitat	Sub-habitat	Field total length	Field gross weight (W)	Predicted weight (W')	Relative Condition (K_n)
					cm	g	g	
9/16/2007	Summer	2	River	R	31.2	208	229	91
9/16/2007	Summer	2	River	R	21.7	70	71	99
9/16/2007	Summer	2	River	R	53.5	1576	1317	120
9/16/2007	Summer	2	River	R	31.2	226	229	99
9/16/2007	Summer	2	River	R	32	228	249	92
9/16/2007	Summer	2	River	R	29.3	172	187	92
9/16/2007	Summer	2	River	R	36.8	428	391	109
9/16/2007	Summer	2	River	R	29.4	206	189	109
9/16/2007	Summer	2	River	R	30.6	204	215	95
9/16/2007	Summer	2	River	R	44	570	698	82
9/16/2007	Summer	2	River	R	39.7	410	500	82
9/16/2007	Summer	2	River	R	37.2	398	405	98
9/16/2007	Summer	2	River	R	51.2	1280	1142	112
9/16/2007	Summer	2	River	R	36.5	398	381	105
9/16/2007	Summer	2	River	R	30.5	202	213	95
9/16/2007	Summer	2	River	R	26.5	140	135	104
9/16/2007	Summer	2	River	R	38.8	502	464	108
9/16/2007	Summer	2	River	R	35.4	280	345	81
9/16/2007	Summer	2	Trib	LT	54.7	1498	1415	106
9/16/2007	Summer	2	Trib	LT	40.2	472	521	91
9/16/2007	Summer	2	Trib	LT	22.9	72	84	86
9/16/2007	Summer	2	Trib	LT	31.7	260	241	108
9/16/2007	Summer	2	Trib	LT	27	142	143	99
9/16/2007	Summer	2	Trib	LT	23.3	92	89	104
9/16/2007	Summer	2	Trib	LT	22.5	84	79	106
9/16/2007	Summer	2	Trib	LT	25.6	120	121	100
9/16/2007	Summer	2	Trib	LT	25.5	122	119	103
9/16/2007	Summer	2	Trib	LT	23	84	85	99
9/16/2007	Summer	2	Trib	LT	32.3	256	256	100
9/16/2007	Summer	2	Trib	LT	51.8	1244	1186	105
9/16/2007	Summer	2	Trib	LT	30.1	176	204	86
9/16/2007	Summer	2	Trib	LT	51.1	916	1134	81
9/16/2007	Summer	2	Trib	LT	42.7	560	634	88
9/16/2007	Summer	2	Trib	LT	33.1	290	277	105
9/16/2007	Summer	2	Trib	LT	40.5	532	534	100
9/16/2007	Summer	2	Trib	LT	43.9	584	693	84
9/16/2007	Summer	2	Trib	LT	31.1	202	227	89
9/16/2007	Summer	2	Trib	LT	33.7	276	294	94
9/22/2007	Summer	4	Trib	LT	66.3	2620	2640	99

Appendix 14 (cont.). Relative condition and associated habitat data for 465 channel catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. R=river, LT=lower trib., and MT= middle trib.

Date	Season	Zone	Habitat	Sub-habitat	Field total length	Field gross weight (W)	Predicted weight (W')	Relative Condition (K_n)
					cm	g	g	
9/22/2007	Summer	4	Trib	LT	21.5	70	68	102
9/22/2007	Summer	4	Trib	MT	37.9	406	430	94
9/23/2007	Summer	3	River	R	33	266	275	97
9/23/2007	Summer	3	River	R	26.2	120	130	92
9/23/2007	Summer	3	River	R	34.2	290	308	94
9/23/2007	Summer	3	River	R	34.5	264	317	83
9/23/2007	Summer	3	River	R	24.8	96	109	88
9/23/2007	Summer	3	River	R	39.1	462	476	97
9/23/2007	Summer	3	River	R	47.3	764	883	87
9/23/2007	Summer	3	River	R	56	1818	1527	119
9/23/2007	Summer	3	River	R	32.2	244	254	96
9/23/2007	Summer	3	Trib	LT	31.3	224	231	97
9/23/2007	Summer	3	Trib	LT	33.2	258	280	92
9/23/2007	Summer	3	Trib	LT	48.6	1006	964	104
10/6/2007	Fall	1	River	R	24.2	104	100	104
10/6/2007	Fall	1	River	R	23.6	94	93	102
10/6/2007	Fall	1	Trib	MT	37.5	396	416	95
10/6/2007	Fall	1	Trib	MT	33.8	286	297	96
10/6/2007	Fall	1	Trib	MT	48.4	930	951	98
10/6/2007	Fall	1	Trib	MT	41.8	614	591	104
10/6/2007	Fall	1	Trib	MT	32.1	242	251	96
10/6/2007	Fall	1	Trib	MT	22.3	72	77	93
10/6/2007	Fall	1	Trib	MT	24	88	98	90
10//7/07	Fall	2	River	R	52.1	1498	1208	124
10//7/07	Fall	2	Trib	LT	51.5	1126	1163	97
10//7/07	Fall	2	Trib	LT	42.7	604	634	95
10/14/2007	Fall	3	River	R	65.5	2840	2538	112
10/14/2007	Fall	3	River	R	22.5	82	79	103
10/14/2007	Fall	3	River	R	31.9	240	246	98
10/14/2007	Fall	3	River	R	25.8	120	124	97
10/14/2007	Fall	3	River	R	48.9	816	984	83
10/14/2007	Fall	3	River	R	24.7	108	107	101
10/14/2007	Fall	3	Trib	LT	24.2	84	100	84
10/14/2007	Fall	3	Trib	LT	37.7	386	423	91
10/14/2007	Fall	3	Trib	LT	40.2	470	521	90
10/14/2007	Fall	3	Trib	LT	66.1	2390	2614	91
10/14/2007	Fall	3	Trib	MT	38.4	395	449	88
10/14/2007	Fall	3	Trib	MT	44.6	738	730	101
10/15/2007	Fall	4	Trib	LT	22.7	88	82	108

Appendix 14 (cont.). Relative condition and associated habitat data for 465 channel catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. R=river, LT=lower trib., and MT= middle trib.

Date	Season	Zone	Habitat	Sub-habitat	Field total length	Field gross weight (W)	Predicted weight (W')	Relative Condition (K_n)
					cm	g	g	
10/15/2007	Fall	4	Trib	MT	49.9	1184	1050	113
10/15/2007	Fall	4	River	R	52	1142	1201	95
10/15/2007	Fall	4	River	R	48	982	926	106
10/15/2007	Fall	4	River	R	50.5	1066	1092	98
10/15/2007	Fall	4	River	R	45.5	798	778	103
10/15/2007	Fall	4	River	R	25.4	106	117	90
10/15/2007	Fall	4	River	R	45.5	798	778	103
10/15/2007	Fall	4	River	R	26.5	132	135	98
10/15/2007	Fall	4	River	R	45.6	648	784	83
10/15/2007	Fall	4	River	R	53.3	1222	1301	94
10/15/2007	Fall	4	River	R	55.4	1502	1474	102
10/15/2007	Fall	4	River	R	42.8	630	638	99
10/15/2007	Fall	4	River	R	48.4	1016	951	107
10/15/2007	Fall	4	River	R	24.1	92	99	93
10/15/2007	Fall	4	River	R	25.6	112	121	93
10/15/2007	Fall	4	River	R	21.8	126	72	176
10/15/2007	Fall	4	River	R	41.2	516	564	91
10/15/2007	Fall	4	River	R	48.1	1056	932	113
10/15/2007	Fall	4	River	R	41.7	696	587	119
10/15/2007	Fall	4	River	R	23.8	76	95	80
10/15/2007	Fall	4	River	R	45.8	796	795	100
10/15/2007	Fall	4	River	R	52.3	1288	1223	105
10/15/2007	Fall	4	River	R	60.4	1816	1951	93
10/15/2007	Fall	4	River	R	49.3	820	1010	81
10/15/2007	Fall	4	River	R	52.3	1312	1223	107
10/15/2007	Fall	4	River	R	50	1010	1057	96
10/15/2007	Fall	4	River	R	49.9	1002	1050	95
10/15/2007	Fall	4	River	R	49.5	1080	1023	106
10/15/2007	Fall	4	River	R	34.9	374	329	114
10/29/2007	Fall	2	River	R	52.8	1200	1261	95
10/29/2007	Fall	2	River	R	50.2	1182	1071	110
10/29/2007	Fall	2	River	R	39.8	474	504	94
10/29/2007	Fall	2	River	R	45.2	866	762	114
10/29/2007	Fall	2	River	R	38.6	416	457	91
10/29/2007	Fall	2	River	R	48.8	946	977	97
10/29/2007	Fall	2	River	R	22.8	80	83	97
10/29/2007	Fall	2	River	R	39.8	440	504	87
10/29/2007	Fall	2	River	R	23.9	92	96	95
10/29/2007	Fall	2	Trib	LT	46.8	874	853	102

Appendix 14 (cont.). Relative condition and associated habitat data for 465 channel catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. R=river, LT=lower trib., and MT= middle trib.

Date	Season	Zone	Habitat	Sub-habitat	Field total length	Field gross weight (W)	Predicted weight (W')	Relative Condition (K_n)
					cm	g	g	
10/29/2007	Fall	2	Trib	LT	25.8	132	124	107
10/29/2007	Fall	2	Trib	LT	23.2	90	88	103
10/29/2007	Fall	2	Trib	LT	22.9	86	84	102
10/29/2007	Fall	2	Trib	LT	48.3	1076	945	114
10/29/2007	Fall	2	Trib	LT	52.5	1380	1238	111
10/29/2007	Fall	2	Trib	LT	63.2	2070	2260	92
10/29/2007	Fall	2	Trib	LT	44.5	690	724	95
10/29/2007	Fall	2	Trib	LT	46.8	852	853	100
10/29/2007	Fall	2	Trib	LT	53.7	1380	1333	104
10/29/2007	Fall	2	Trib	LT	44.9	856	746	115
10/29/2007	Fall	2	Trib	LT	34.3	326	311	105
10/29/2007	Fall	2	Trib	MT	25	104	112	93
11/4/2007	Fall	4	Trib	LT	40.8	466	547	85
11/4/2007	Fall	4	Trib	LT	23	92	85	108
11/4/2007	Fall	4	River	R	27.1	140	145	97
11/4/2007	Fall	4	River	R	42	572	600	95
11/11/2007	Fall	3	River	R	59.6	2370	1869	127
11/11/2007	Fall	3	River	R	45	840	751	112
11/11/2007	Fall	3	River	R	24.8	114	109	105
11/11/2007	Fall	3	River	R	52.3	1306	1223	107
11/11/2007	Fall	3	River	R	23.6	82	93	89
11/11/2007	Fall	3	River	R	39.6	426	496	86
11/11/2007	Fall	3	River	R	25.7	108	122	88
11/11/2007	Fall	3	River	R	33.4	282	286	99
11/11/2007	Fall	3	River	R	43.4	622	668	93
11/11/2007	Fall	3	River	R	20.1	58	55	105
11/11/2007	Fall	3	River	R	24.9	100	110	91
11/11/2007	Fall	3	River	R	47.6	876	901	97
11/11/2007	Fall	3	River	R	46.3	898	824	109
11/11/2007	Fall	3	River	R	52.6	1880	1246	151
11/11/2007	Fall	3	River	R	41	524	555	94
11/11/2007	Fall	3	River	R	44.3	686	714	96
11/11/2007	Fall	3	River	R	35.5	334	348	96
11/11/2007	Fall	3	River	R	60.8	2100	1994	105
11/11/2007	Fall	3	River	R	37.2	406	405	100
11/11/2007	Fall	3	River	R	25.5	108	119	91
11/11/2007	Fall	3	River	R	45.9	776	801	97
11/11/2007	Fall	3	River	R	45.8	752	795	95
11/11/2007	Fall	3	Trib	LT	39.2	400	480	83

Appendix 14 (cont.). Relative condition and associated habitat data for 465 channel catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. R=river, LT=lower trib., and MT= middle trib.

Date	Season	Zone	Habitat	Sub-habitat	Field total length	Field gross weight (W)	Predicted weight (W')	Relative Condition (K_n)
					cm	g	g	
11/11/2007	Fall	3	Trib	LT	49.3	1046	1010	104
11/11/2007	Fall	3	Trib	LT	42.5	610	624	98
11/11/2007	Fall	3	Trib	MT	46	836	807	104
11/11/2007	Fall	3	Trib	MT	42.5	700	624	112
11/11/2007	Fall	3	Trib	MT	52.2	1238	1216	102
11/11/2007	Fall	3	Trib	MT	41.9	670	596	112
11/11/2007	Fall	3	Trib	MT	43.2	648	658	98
11/11/2007	Fall	3	Trib	MT	44.5	742	724	102
11/11/2007	Fall	3	Trib	MT	41.5	598	578	104
11/11/2007	Fall	3	Trib	MT	37.7	434	423	103
11/11/2007	Fall	3	Trib	MT	45.7	848	790	107
11/11/2007	Fall	3	Trib	MT	45.2	814	762	107
11/11/2007	Fall	3	Trib	MT	41.7	552	587	94
11/11/2007	Fall	3	Trib	MT	49.7	1094	1037	106
11/17/2007	Fall	1	River	R	43.5	618	673	92
11/17/2007	Fall	1	River	R	64.9	2030	2464	82
11/17/2007	Fall	1	River	R	68.5	4370	2935	149
11/17/2007	Fall	1	River	R	31.5	260	236	110
11/17/2007	Fall	1	River	R	70.3	3030	3193	95
11/17/2007	Fall	1	Trib	LT	38.6	420	457	92
11/17/2007	Fall	1	Trib	LT	39.7	568	500	114
11/17/2007	Fall	1	Trib	LT	43.4	662	668	99
11/17/2007	Fall	1	Trib	LT	43.2	618	658	94
11/17/2007	Fall	1	Trib	LT	50.3	964	1078	89
11/17/2007	Fall	1	Trib	LT	50.3	1190	1078	110
11/17/2007	Fall	1	Trib	LT	43.9	648	693	93
11/17/2007	Fall	1	Trib	LT	39.4	506	488	104
11/17/2007	Fall	1	Trib	LT	56.2	1438	1545	93
11/17/2007	Fall	1	Trib	LT	38.6	468	457	102
11/17/2007	Fall	1	Trib	LT	49.6	1040	1030	101
11/17/2007	Fall	1	Trib	LT	28.4	168	169	100
11/17/2007	Fall	1	Trib	LT	38.8	454	464	98
11/17/2007	Fall	1	Trib	LT	52.1	1430	1208	118
11/17/2007	Fall	1	Trib	LT	37.8	398	427	93
11/17/2007	Fall	1	Trib	LT	48.3	884	945	94
11/17/2007	Fall	1	Trib	LT	62.9	2920	2226	131

Appendix 15. Relative condition and associated habitat data for 151 white catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. R=river, LT=lower trib., and MT= middle trib.

Date	Season	Zone	Habitat	Sub-habitat	Field total length	Field gross weight (W)	Predicted weight (W')	Relative Condition (K_n)
					cm	g	g	
4/20/2007	Spring	3	Trib	LT	42.5	1180	979	120
4/20/2007	Spring	3	Trib	MT	28.1	340	247	138
4/21/2007	Spring	1	River	R	26.5	274	203	135
4/21/2007	Spring	1	Trib	LT	33.5	516	444	116
4/21/2007	Spring	1	Trib	LT	40.1	926	807	115
5/5/2007	Spring	3	Trib	LT	43.5	978	1058	92
5/6/2007	Spring	4	Trib	LT	41.2	988	883	112
5/12/2007	Spring	2	Trib	LT	18.6	60	63	96
5/12/2007	Spring	2	Trib	MT	26.2	170	196	87
5/12/2007	Spring	2	Trib	MT	32.7	396	409	97
5/12/2007	Spring	2	River	R	36.2	608	574	106
5/24/2007	Spring	4	Trib	LT	29.1	276	278	99
5/25/2007	Spring	3	Trib	MT	26.1	184	193	95
5/25/2007	Spring	3	Trib	MT	21.8	92	106	87
6/9/2007	Spring	3	River	R	29.3	258	284	91
6/9/2007	Spring	3	Trib	LT	19.9	88	78	112
6/9/2007	Spring	3	Trib	MT	31.7	402	369	109
6/9/2007	Spring	3	Trib	MT	33.1	432	426	101
6/9/2007	Spring	3	Trib	LT	32.8	440	414	106
6/10/2007	Spring	4	River	R	17.5	65	51	127
6/24/2007	Spring	2	Trib	LT	35.8	536	553	97
6/24/2007	Spring	2	Trib	LT	35.5	534	538	99
6/24/2007	Spring	2	Trib	LT	36.1	668	569	117
6/24/2007	Spring	2	River	R	34.3	460	480	96
6/24/2007	Spring	2	River	R	24.3	158	152	104
6/24/2007	Spring	2	Trib	MT	33.3	502	435	115
6/30/2007	Spring	4	Trib	MT	21.3	90	98	92
6/30/2007	Spring	4	Trib	MT	26.6	202	206	98
6/30/2007	Spring	4	River	R	35.5	590	538	110
6/30/2007	Spring	4	River	R	27.5	260	230	113
6/30/2007	Spring	4	River	R	21.4	110	100	110
6/30/2007	Spring	4	River	R	24.9	186	165	113
7/7/2007	Summer	3	Trib	LT	28.1	248	247	100
7/7/2007	Summer	3	Trib	MT	24.6	182	159	115
7/21/2007	Summer	2	Trib	MT	19.2	68	70	98
7/21/2007	Summer	2	River	R	31.3	363	354	103
7/21/2007	Summer	2	Trib	LT	21.8	90	106	85
7/21/2007	Summer	2	Trib	MT	29	254	275	93
7/22/2007	Summer	1	Trib	LT	33	420	422	100

Appendix 15 (cont.). Relative condition and associated habitat data for 151 white catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. R=river, LT=lower trib., and MT= middle trib.

Date	Season	Zone	Habitat	Sub-habitat	Field total length	Field gross weight (W)	Predicted weight (W')	Relative Condition (K_n)
					cm	g	g	
8/4/2007	Summer	4	Trib	LT	29.9	302	304	99
8/4/2007	Summer	4	River	R	32	376	381	99
8/4/2007	Summer	4	River	R	18.8	74	65	114
8/5/2007	Summer	3	Trib	MT	19.3	72	71	102
8/11/2007	Summer	1	Trib	MT	34.1	446	471	95
8/11/2007	Summer	1	Trib	MT	30.2	274	314	87
8/11/2007	Summer	1	Trib	MT	42	904	942	96
8/11/2007	Summer	1	Trib	MT	29.5	272	291	94
8/11/2007	Summer	1	Trib	MT	21.4	98	100	98
8/11/2007	Summer	1	Trib	MT	28.6	252	262	96
8/17/2007	Summer	2	Trib	LT	23.5	156	136	114
8/17/2007	Summer	2	River	R	17.8	56	54	104
8/17/2007	Summer	2	River	R	24.4	148	155	96
8/17/2007	Summer	2	River	R	27.8	210	239	88
8/17/2007	Summer	2	River	R	26	200	191	105
8/26/2007	Summer	3	River	R	26.5	216	203	106
8/26/2007	Summer	3	Trib	LT	30.2	326	314	104
9/1/2007	Summer	4	Trib	LT	21.5	96	101	95
9/1/2007	Summer	4	River	R	31	322	343	94
9/1/2007	Summer	4	River	R	21.8	96	106	90
9/2/2007	Summer	3	River	R	27.2	254	222	115
9/2/2007	Summer	3	River	R	38.8	814	723	113
9/2/2007	Summer	3	River	R	21	90	94	96
9/9/2007	Summer	1	Trib	LT	32.5	394	401	98
9/9/2007	Summer	1	Trib	MT	28.3	258	253	102
9/9/2007	Summer	1	Trib	MT	35.5	528	538	98
9/16/2007	Summer	2	Trib	LT	31	346	343	101
9/16/2007	Summer	2	River	R	38.1	696	681	102
9/16/2007	Summer	2	River	R	29.4	272	287	95
9/16/2007	Summer	2	River	R	37.1	630	623	101
9/16/2007	Summer	2	River	R	32	344	381	90
9/16/2007	Summer	2	River	R	26.6	200	206	97
9/16/2007	Summer	2	River	R	29.7	294	297	99
9/16/2007	Summer	2	River	R	31.3	320	354	90
9/16/2007	Summer	2	River	R	31.3	324	354	92
9/16/2007	Summer	2	River	R	29.8	290	301	96
9/16/2007	Summer	2	River	R	42.7	822	995	83
9/16/2007	Summer	2	Trib	LT	32.7	386	409	94
9/16/2007	Summer	4	Trib	LT	33.2	410	431	95

Appendix 15 (cont.). Relative condition and associated habitat data for 151 white catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. R=river, LT=lower trib., and MT= middle trib.

Date	Season	Zone	Habitat	Sub-habitat	Field total length	Field gross weight (W)	Predicted weight (W')	Relative Condition (K_n)
					cm	g	g	
9/22/2007	Summer	4	Trib	MT	31.2	348	350	99
9/22/2007	Summer	4	Trib	MT	30.2	288	314	92
9/22/2007	Summer	4	Trib	MT	28.3	252	253	100
9/22/2007	Summer	4	Trib	MT	30.2	306	314	97
9/22/2007	Summer	4	River	R	31.2	376	350	107
9/23/2007	Summer	3	Trib	LT	38.7	710	717	99
10/6/2007	Fall	1	River	R	39.6	764	774	99
10/6/2007	Fall	1	Trib	LT	21	92	94	98
10/6/2007	Fall	1	Trib	LT	24.4	158	155	102
10/6/2007	Fall	1	Trib	LT	29.7	282	297	95
10/6/2007	Fall	1	Trib	LT	19.8	76	77	99
10/6/2007	Fall	1	Trib	LT	32.8	386	414	93
10/6/2007	Fall	1	Trib	LT	22.5	110	118	93
10/7/2007	Fall	2	River	R	29.4	256	287	89
10/14/2007	Fall	3	River	R	28.3	234	253	92
10/14/2007	Fall	3	River	R	40.1	752	807	93
10/14/2007	Fall	3	Trib	LT	21.9	100	108	93
10/14/2007	Fall	3	Trib	LT	24.3	146	152	96
10/14/2007	Fall	3	Trib	LT	30	296	307	96
10/14/2007	Fall	3	Trib	MT	34.8	522	504	104
10/14/2007	Fall	3	Trib	MT	36	590	564	105
10/14/2007	Fall	3	Trib	MT	37	634	618	103
10/14/2007	Fall	3	Trib	MT	27.9	232	241	96
10/14/2007	Fall	3	Trib	MT	38.7	726	717	101
10/14/2007	Fall	3	Trib	MT	44.4	1164	1133	103
10/15/2007	Fall	4	Trib	LT	28.6	246	262	94
10/15/2007	Fall	4	Trib	LT	29.2	284	281	101
10/15/2007	Fall	4	River	R	38.4	850	699	122
10/15/2007	Fall	4	River	R	33.5	466	444	105
10/15/2007	Fall	4	River	R	29.9	309	304	102
10/29/2007	Fall	2	Trib	MT	43.4	1086	1050	103
10/29/2007	Fall	2	Trib	MT	42.9	1046	1010	104
10/29/2007	Fall	2	River	R	28.1	238	247	96
10/29/2007	Fall	2	River	R	29.6	314	294	107
10/29/2007	Fall	2	River	R	34.5	438	489	90
10/29/2007	Fall	2	River	R	26.7	198	209	95
10/29/2007	Fall	2	River	R	38.3	646	693	93
10/29/2007	Fall	2	River	R	45.1	1038	1193	87
10/29/2007	Fall	2	River	R	32.8	362	414	88

Appendix 15 (cont.). Relative condition and associated habitat data for 151 white catfish collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary. R=river, LT=lower trib., and MT= middle trib.

Date	Season	Zone	Habitat	Sub-habitat	Field total length	Field gross weight (W)	Predicted weight (W')	Relative Condition (K_n)
					cm	g	g	
10/29/2007	Fall	2	River	R	33	406	422	96
10/29/2007	Fall	2	River	R	28.6	256	262	98
10/29/2007	Fall	2	Trib	LT	32.2	378	389	97
11/11/2007	Fall	3	Trib	MT	39.8	618	787	79
11/11/2007	Fall	3	Trib	MT	34.8	490	504	97
11/11/2007	Fall	3	Trib	MT	36.8	686	606	113
11/11/2007	Fall	3	Trib	MT	27.3	216	225	96
11/17/2007	Fall	1	River	R	25.2	172	172	100
11/17/2007	Fall	1	River	R	31.4	348	358	97
11/17/2007	Fall	1	River	R	41.3	872	890	98
11/17/2007	Fall	1	River	R	34.7	482	499	97
11/17/2007	Fall	1	River	R	38.7	776	717	108
11/17/2007	Fall	1	River	R	41.1	926	876	106
11/17/2007	Fall	1	River	R	30.2	328	314	104
11/17/2007	Fall	1	River	R	35.5	544	538	101
11/17/2007	Fall	1	River	R	31.8	360	373	96
11/17/2007	Fall	1	River	R	33.6	446	448	100
11/17/2007	Fall	1	River	R	30.2	286	314	91
11/17/2007	Fall	1	River	R	33.6	446	448	100
11/17/2007	Fall	1	River	R	31.6	392	365	107
11/17/2007	Fall	1	River	R	25.6	186	181	103
11/17/2007	Fall	1	River	R	34.4	502	485	104
11/17/2007	Fall	1	River	R	35.4	522	533	98
11/17/2007	Fall	1	River	R	25	158	168	94
11/17/2007	Fall	1	River	R	45.9	1432	1265	113
11/17/2007	Fall	1	Trib	LT	20.3	88	84	105
11/17/2007	Fall	1	Trib	LT	34.3	482	480	100
11/17/2007	Fall	1	Trib	LT	29.8	302	301	100
11/17/2007	Fall	1	Trib	LT	36	590	564	105
11/17/2007	Fall	1	Trib	LT	38.1	634	681	93
11/17/2007	Fall	1	Trib	LT	35.8	548	553	99
11/17/2007	Fall	1	Trib	LT	38	670	675	99
11/17/2007	Fall	1	Trib	LT	27.4	224	227	99
11/17/2007	Fall	1	Trib	LT	34.4	512	485	106

Appendix 16. Habitat use indices developed for white catfish, channel catfish, and brown bullhead collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary.

Date	Season	Zone	Habitat	Sub-habitat	No. of nets	Mean no. of white catfish (CPNN)	Mean no. of channel catfish (CPNN)	Mean no. of brown bullhead (CPNN)	Relative abundance of white catfish	Relative abundance of channel catfish	Relative abundance of brown bullhead	$\hat{P}$ channel catfish to (channel catfish + white catfish)
4/1/2007	Spring	1	River	R	6	0.00	0.17	0.00	0	100	0	1.00
4/1/2007	Spring	1	Trib	LT	2	0.00	1.00	0.00	0	100	0	1.00
4/1/2007	Spring	1	Trib	MT	3	0.00	0.00	0.00	NA	NA	NA	NA
4/14/2007	Spring	2	River	R	6	0.00	0.00	0.00	NA	NA	NA	NA
4/14/2007	Spring	2	Trib	LT	3	0.00	0.33	0.00	0	100	0	1.00
4/14/2007	Spring	2	Trib	MT	2	0.00	0.50	0.50	0	50	50	1.00
4/20/2007	Spring	3	River	R	6	0.00	0.00	0.00	NA	NA	NA	NA
4/20/2007	Spring	3	Trib	LT	3	0.33	0.00	0.00	100	0	0	0.00
4/20/2007	Spring	3	Trib	MT	3	0.33	0.00	0.00	100	0	0	0.00
4/21/2007	Spring	1	River	R	5	0.20	0.00	0.00	100	0	0	0.00
4/21/2007	Spring	1	Trib	LT	3	0.67	1.00	0.00	40	60	0	0.60
4/21/2007	Spring	1	Trib	MT	3	0.00	0.33	0.00	0	100	0	1.00
4/22/2007	Spring	2	River	R	6	0.00	0.67	0.00	0	100	0	1.00
4/22/2007	Spring	2	Trib	LT	2	0.00	1.00	0.50	0	67	33	1.00
4/22/2007	Spring	2	Trib	MT	3	0.00	0.33	0.00	0	100	0	1.00
5/5/2007	Spring	3	River	R	5	0.00	0.60	0.00	0	100	0	1.00
5/5/2007	Spring	3	Trib	LT	3	0.33	0.00	0.00	100	0	0	0.00
5/5/2007	Spring	3	Trib	MT	3	0.00	0.00	0.00	NA	NA	NA	NA
5/6/2007	Spring	4	River	R	4	0.00	0.00	0.00	NA	NA	NA	NA
5/6/2007	Spring	4	Trib	LT	3	0.33	0.33	0.00	50	50	0	0.50
5/6/2007	Spring	4	Trib	MT	3	0.00	0.00	0.33	0	0	100	NA
5/12/2007	Spring	2	River	R	6	0.17	0.50	0.17	20	60	20	0.75
5/12/2007	Spring	2	Trib	LT	3	0.33	0.00	0.00	100	0	0	0.00
5/12/2007	Spring	2	Trib	MT	3	0.67	0.00	0.00	100	0	0	0.00
5/13/2007	Spring	1	River	R	6	0.00	0.17	0.00	0	100	0	1.00
5/13/2007	Spring	1	Trib	LT	4	0.00	0.00	0.00	NA	NA	NA	NA

Appendix 16 (cont.). Habitat use indices developed for white catfish, channel catfish, and brown bullhead collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary.

Date	Season	Zone	Habitat	Sub-habitat	No. of nets	Mean no. of white catfish (CPNN)	Mean no. of channel catfish (CPNN)	Mean no. of brown bullhead (CPNN)	Relative abundance of white catfish	Relative abundance of channel catfish	Relative abundance of brown bullhead	$\hat{P}$ channel catfish to (channel catfish + white catfish)
5/13/2007	Spring	1	Trib	MT	2	0.00	0.50	0.00	0	100	0	1.00
5/24/2007	Spring	4	River	R	6	0.00	0.17	0.00	0	100	0	1.00
5/24/2007	Spring	4	Trib	LT	3	0.33	0.00	0.00	100	0	0	0.00
5/24/2007	Spring	4	Trib	MT	3	0.00	0.00	0.00	NA	NA	NA	NA
5/25/2007	Spring	3	River	R	6	0.00	0.00	0.00	NA	NA	NA	NA
5/25/2007	Spring	3	Trib	LT	3	0.00	0.00	0.00	NA	NA	NA	NA
5/25/2007	Spring	3	Trib	MT	3	0.67	0.00	0.00	100	0	0	0.00
6/2/2007	Spring	1	River	R	6	0.00	1.17	0.00	0	100	0	1.00
6/2/2007	Spring	1	Trib	LT	3	0.00	0.00	0.00	NA	NA	NA	NA
6/2/2007	Spring	1	Trib	MT	3	0.00	0.00	0.00	NA	NA	NA	NA
6/3/2007	Spring	2	River	R	6	0.00	0.17	0.00	0	100	0	1.00
6/3/2007	Spring	2	Trib	LT	3	0.00	0.33	0.00	0	100	0	1.00
6/3/2007	Spring	2	Trib	MT	3	0.00	0.00	0.00	NA	NA	NA	NA
6/9/2007	Spring	3	River	R	6	0.17	0.00	0.00	100	0	0	0.00
6/9/2007	Spring	3	Trib	LT	3	0.67	0.00	0.00	100	0	0	0.00
6/9/2007	Spring	3	Trib	MT	3	0.67	0.33	0.00	67	33	0	0.33
6/10/2007	Spring	4	River	R	6	0.17	1.67	0.00	9	91	0	0.91
6/10/2007	Spring	4	Trib	LT	2	0.00	1.50	0.00	0	100	0	1.00
6/10/2007	Spring	4	Trib	MT	3	0.00	0.00	0.00	NA	NA	NA	NA
6/24/2007	Spring	2	River	R	6	0.33	0.83	0.00	29	71	0	0.71
6/24/2007	Spring	2	Trib	LT	3	1.00	1.67	0.00	38	63	0	0.63
6/24/2007	Spring	2	Trib	MT	3	0.33	0.33	0.00	50	50	0	0.50
6/25/2007	Spring	1	River	R	6	0.00	1.17	0.17	0	88	13	1.00
6/25/2007	Spring	1	Trib	LT	3	0.00	0.00	0.00	NA	NA	NA	NA
6/25/2007	Spring	1	Trib	MT	3	0.00	0.33	0.00	0	100	0	1.00
6/30/2007	Spring	4	River	R	6	0.67	2.83	0.00	19	81	0	0.81

Appendix 16 (cont.). Habitat use indices developed for white catfish, channel catfish, and brown bullhead collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary.

Date	Season	Zone	Habitat	Sub-habitat	No. of nets	Mean no. of white catfish (CPNN)	Mean no. of channel catfish (CPNN)	Mean no. of brown bullhead (CPNN)	Relative abundance of white catfish	Relative abundance of channel catfish	Relative abundance of brown bullhead	$\hat{P}$ channel catfish to (channel catfish + white catfish)
6/30/2007	Spring	4	Trib	LT	3	0.00	0.33	0.00	0	100	0	1.00
6/30/2007	Spring	4	Trib	MT	3	0.67	3.67	0.00	15	85	0	0.85
7/7/2007	Summer	3	River	R	6	0.00	0.50	0.33	0	60	40	1.00
7/7/2007	Summer	3	Trib	LT	3	0.33	0.33	0.33	33	33	33	0.50
7/7/2007	Summer	3	Trib	MT	3	0.33	0.00	0.00	100	0	0	0.00
7/21/2007	Summer	2	River	R	6	0.17	1.33	0.00	11	89	0	0.89
7/21/2007	Summer	2	Trib	LT	3	0.33	2.67	0.33	10	80	10	0.89
7/21/2007	Summer	2	Trib	MT	3	0.67	0.67	0.00	50	50	0	0.50
7/22/2007	Summer	1	River	R	6	0.00	1.33	0.00	0	100	0	1.00
7/22/2007	Summer	1	Trib	LT	3	0.33	1.33	0.00	20	80	0	0.80
7/22/2007	Summer	1	Trib	MT	3	0.00	0.67	0.00	0	100	0	1.00
8/4/2007	Summer	4	River	R	7	0.29	2.14	0.00	12	88	0	0.88
8/4/2007	Summer	4	Trib	LT	3	0.33	0.00	0.00	100	0	0	0.00
8/4/2007	Summer	4	Trib	MT	2	0.00	0.00	0.00	NA	NA	NA	NA
8/5/2007	Summer	3	River	R	6	0.00	1.67	0.00	0	100	0	1.00
8/5/2007	Summer	3	Trib	LT	3	0.00	1.33	0.00	0	100	0	1.00
8/5/2007	Summer	3	Trib	MT	3	0.33	1.33	0.00	20	80	0	0.80
8/11/2007	Summer	1	River	R	6	0.00	1.33	0.33	0	80	20	1.00
8/11/2007	Summer	1	Trib	LT	3	0.00	0.67	0.00	0	100	0	1.00
8/11/2007	Summer	1	Trib	MT	3	2.00	0.33	0.00	86	14	0	0.14
8/17/2007	Summer	2	River	R	6	0.67	1.33	0.00	33	67	0	0.67
8/17/2007	Summer	2	Trib	LT	3	0.33	0.67	0.00	33	67	0	0.67
8/17/2007	Summer	2	Trib	MT	3	0.00	0.00	0.00	NA	NA	NA	NA
8/26/2007	Summer	3	River	R	6	0.17	1.17	0.00	13	88	0	0.88
8/26/2007	Summer	3	Trib	LT	3	0.33	4.67	0.33	6	88	6	0.93
8/26/2007	Summer	3	Trib	MT	3	0.00	0.33	0.00	0	100	0	1.00

Appendix 16 (cont.). Habitat use indices developed for white catfish, channel catfish, and brown bullhead collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary.

Date	Season	Zone	Habitat	Sub-habitat	No. of nets	Mean no. of white catfish (CPNN)	Mean no. of channel catfish (CPNN)	Mean no. of brown bullhead (CPNN)	Relative abundance of white catfish	Relative abundance of channel catfish	Relative abundance of brown bullhead	$\hat{P}$ channel catfish to (channel catfish + white catfish)
9/1/2007	Summer	4	River	R	7	0.29	1.00	0.00	22	78	0	0.78
9/1/2007	Summer	4	Trib	LT	3	0.33	0.33	0.00	50	50	0	0.50
9/1/2007	Summer	4	Trib	MT	2	0.00	0.50	0.00	0	100	0	1.00
9/2/2007	Summer	3	River	R	5	0.60	4.00	0.00	13	87	0	0.87
9/2/2007	Summer	3	Trib	LT	3	0.00	1.67	0.33	0	83	17	1.00
9/2/2007	Summer	3	Trib	MT	4	0.00	0.00	0.00	NA	NA	NA	NA
9/9/2007	Summer	1	River	R	6	0.00	0.67	0.00	0	100	0	1.00
9/9/2007	Summer	1	Trib	LT	3	0.33	1.33	0.00	20	80	0	0.80
9/9/2007	Summer	1	Trib	MT	3	0.67	3.33	0.00	17	83	0	0.83
9/16/2007	Summer	2	River	R	6	1.67	7.00	0.00	19	81	0	0.81
9/16/2007	Summer	2	Trib	LT	3	0.67	7.00	0.00	9	91	0	0.91
9/16/2007	Summer	2	Trib	MT	2	0.00	0.00	0.00	NA	NA	NA	NA
9/22/2007	Summer	4	River	R	7	0.14	0.00	0.00	100	0	0	0.00
9/22/2007	Summer	4	Trib	LT	3	0.33	0.67	0.00	33	67	0	0.67
9/22/2007	Summer	4	Trib	MT	2	2.00	0.50	0.00	80	20	0	0.20
9/23/2007	Summer	3	River	R	6	0.00	1.50	0.00	0	100	0	1.00
9/23/2007	Summer	3	Trib	LT	3	0.33	1.00	0.00	25	75	0	0.75
9/23/2007	Summer	3	Trib	MT	3	0.00	0.00	0.00	NA	NA	NA	NA
10/6/2007	Fall	1	River	R	6	0.17	0.33	0.00	33	67	0	0.67
10/6/2007	Fall	1	Trib	LT	3	2.00	0.00	0.00	100	0	0	0.00
10/6/2007	Fall	1	Trib	MT	3	0.00	2.33	0.00	0	100	0	1.00
10/7/2007	Fall	2	River	R	6	0.17	0.17	0.00	50	50	0	0.50
10/7/2007	Fall	2	Trib	LT	3	0.00	1.33	0.00	0	100	0	1.00
10/7/2007	Fall	2	Trib	MT	3	0.00	0.00	0.00	NA	NA	NA	NA
10/14/2007	Fall	3	River	R	5	0.40	1.20	0.00	25	75	0	0.75
10/14/2007	Fall	3	Trib	LT	3	1.00	1.33	0.00	43	57	0	0.57

Appendix 16 (cont.). Habitat use indices developed for white catfish, channel catfish, and brown bullhead collected in 2007 by 481 randomly set hoop nets in the Delaware River estuary.

Date	Season	Zone	Habitat	Sub-habitat	No. of nets	Mean no. of white catfish (CPNN)	Mean no. of channel catfish (CPNN)	Mean no. of brown bullhead (CPNN)	Relative abundance of white catfish	Relative abundance of channel catfish	Relative abundance of brown bullhead	$\hat{P}$ channel catfish to (channel catfish + white catfish)
10/14/2007	Fall	3	Trib	MT	3	2.00	0.67	0.00	75	25	0	0.25
10/15/2007	Fall	4	River	R	6	0.50	4.67	0.00	10	90	0	0.90
10/15/2007	Fall	4	Trib	LT	3	0.67	0.33	0.00	67	33	0	0.33
10/15/2007	Fall	4	Trib	MT	2	0.00	0.50	1.50	0	25	75	1.00
10/29/2007	Fall	2	River	R	5	1.80	1.80	1.80	33	33	33	0.50
10/29/2007	Fall	2	Trib	LT	3	0.33	4.00	0.00	8	92	0	0.92
10/29/2007	Fall	2	Trib	MT	3	0.67	0.33	0.33	50	25	25	0.33
11/4/2007	Fall	4	River	R	8	0.00	0.25	0.00	0	100	0	1.00
11/4/2007	Fall	4	Trib	LT	3	0.00	0.67	0.00	0	100	0	1.00
11/4/2007	Fall	4	Trib	MT	2	0.00	0.00	0.00	NA	NA	NA	NA
11/11/2007	Fall	3	River	R	6	0.00	3.67	0.00	0	100	0	1.00
11/11/2007	Fall	3	Trib	LT	3	0.00	1.00	0.00	0	100	0	1.00
11/11/2007	Fall	3	Trib	MT	4	1.25	3.00	0.25	28	67	6	0.71
11/17/2007	Fall	1	River	R	6	5.50	3.33	0.17	61	37	2	0.38
11/17/2007	Fall	1	Trib	LT	4	3.00	5.50	0.00	35	65	0	0.65
11/17/2007	Fall	1	Trib	MT	3	3.67	9.00	0.00	29	71	0	0.71
11/18/2007	Fall	2	River	R	6	0.00	0.00	0.00	NA	NA	NA	NA
11/18/2007	Fall	2	Trib	LT	2	0.00	0.00	0.00	NA	NA	NA	NA
11/18/2007	Fall	2	Trib	MT	2	0.00	0.50	0.00	0	100	0	1.00

Appendix 17. Laboratory dissection data for white catfish, channel catfish, and brown bullhead collected in 2007 in the Delaware River estuary. Liver tissue was archived at The Academy of Natural Sciences in Philadelphia. Y = yes, N = no, F = female, M = male, PTU1 = nematode (red worm), PTU2 = yellow-white encysted parasites.

Lab Work up Date	Serial #	Common name	Collection Date	Cont. ID	Fish Analysis #	Lab Total Wt. (g)	Lab Total length (cm)	Liver archived	Sex	Gonad Wt. (g)	Spleen Wt. (g)	Liver Wt. (g)	Notes
2/19/2008	WCR07-1DRHN58	white catfish	10/6/2007	W00706	F-3841	746.1	39.1	Y	F	5.22	1.35	12.14	Some visceral fat
2/19/2008	WCR07-1OCTHN11	white catfish	8/11/2007	W00768	F-3839	267.7	29.6	Y	M	0.51	0.58	3.6	Some visceral fat
2/19/2008	WCR07-1OCTHN11	white catfish	8/11/2007	W00772	F-3840	246.9	28.1	Y	M	0.27	0.16	3.47	Some visceral fat
2/19/2008	WCR07-1OCTHN11	white catfish	8/11/2007	W00770	F-3842	258.8	28.9	Y	M	0.4	0.56	3.85	Some visceral fat
2/19/2008	WCR07-1OCTHN11	white catfish	8/11/2007	W00771	F-3846	95.0	20.8	Y	F	0.31	0.15	1.35	Some visceral fat
2/19/2008	WCR07-2BTLTHN9	white catfish	8/17/2007	W00725	F-3845	148.8	22.8	Y	M	0.23	0.2	2.73	Some visceral fat
2/19/2008	WCR07-2DRHN40	white catfish	8/17/2007	W00722	F-3843	143.4	23.8	Y	M	0.16	0.11	2.1	Some visceral fat
2/19/2008	WCR07-2DRHN40	white catfish	8/17/2007	W00724	F-3844	207.8	27.4	Y	M	0.33	0.3	3.01	Some visceral fat
2/19/2008	WCR07-2DRHN41	white catfish	8/17/2007	W00723	F-3838	194.2	25.4	Y	M	0.28	0.33	3.02	Some visceral fat
2/19/2008	WCR07-4CWLTHN17	white catfish	9/1/2007	W00719	F-3847	84.5	20.9	Y	F	0.18	0.14	1.88	Some visceral fat
2/24/2008	WCR07-1DRHN44	brown bullhead	8/11/2007	W00773	F-3849	83.4	19.0	Y	M	0.05	0.12	1.89	Some visceral fat
2/24/2008	WCR07-1DRHN44	brown bullhead	8/11/2007	W00774	F-3850	88.6	19.6	Y	U	0.05	0.2	1.85	Some visceral fat
2/24/2008	WCR07-1DRHN66	brown bullhead	11/17/2007	W00583	F-3858	375.0	31.1	Y	F	3.1	0.64	8.3	No visceral fat
2/24/2008	WCR07-2DRHN57	brown bullhead	10/29/2007	W00578	F-3855	440.5	31.5	Y	M	0.69	1.68	12.28	Some visceral fat
2/24/2008	WCR07-2DRHN57	brown bullhead	10/29/2007	W00580	F-3859	220.6	26.6	Y	F	1.3	0.3	4.17	Some visceral fat
2/24/2008	WCR07-2DRHN57	brown bullhead	10/29/2007	W00701	F-3860	733.7	37.3	Y	M	1.62	1.52	15.54	Some visceral fat
2/24/2008	WCR07-2MCTHN12	brown bullhead	10/29/2007	W00576	F-3857	353.6	30.2	Y	M	0.51	1.04	6.79	Some visceral fat
2/24/2008	WCR07-3RNLTHN17	brown bullhead	8/26/2007	W00720	F-3853	215.1	24.7	Y	M	0.23	0.57	4.64	Some visceral fat
2/24/2008	WCR07-3RNLTHN19	brown bullhead	9/2/2007	W00713	F-3851	148.7	23.3	Y	F	0.52	0.25	2.9	Some visceral fat
2/24/2008	WCR07-3RNTHN29	brown bullhead	11/11/2007	W00581	F-3861	892.6	41.4	Y	F	3.92	2.28	21.73	Some visceral fat
2/24/2008	WCRO7-2DRHN57	brown bullhead	10/29/2007	W00579	F-3852	200.8	25.0	Y	F	1.79	0.49	4.24	Some visceral fat
2/24/2008	WCRO7-2DRHN57	brown bullhead	10/29/2007	W00577	F-3856	364.8	30.0	Y	M	0.71	0.92	7.37	Some visceral fat, 5-6 cm sore above anal fin.
2/24/2008	WCR07-2DRHN40	white catfish	8/17/2007	W00721	F-3848	58.2	17.4	Y	U	NA	0.04	1.26	Some visceral fat
2/24/2008	WCR07-4DRHN36	white catfish	9/1/2007	W00718	F-3854	314.7	30.5	Y	M	0.63	0.63	5.45	Undetermined if has visceral fat

Appendix 17 (cont.). Laboratory dissection data for white catfish, channel catfish, and brown bullhead collected in 2007 in the Delaware River estuary. Liver tissue was archived at The Academy of Natural Sciences in Philadelphia. Y = yes, N = no, F = female, M = male, PTU1 = nematode (red worm), PTU2 = yellow-white encysted parasites.

Lab Work up Date	Serial #	Common name	Collection Date	Cont. ID	Fish Analysis #	Lab Total Wt. (g)	Lab Total length (cm)	Liver archived	Sex	Gonad Wt. (g)	Spleen Wt. (g)	Liver Wt. (g)	Notes
2/25/2008	WCR07-1DRHN65	white catfish	11/17/2007	W00582	F-3868	1376.6	44.5	Y	M	3.45	5.84	24.4	Some visceral fat
2/25/2008	WCR07-1OCTHN11	white catfish	8/11/2007	W00767	F-3862	433.8	33.4	Y	M	0.85	0.4	4.93	Some visceral fat
2/25/2008	WCR07-1OCTHN11	white catfish	8/11/2007	W00769	F-3866	868.9	41.2	Y	M	1.76	1.59	14.02	Some visceral fat
2/25/2008	WCR07-1OCTHN13	white catfish	9/9/2007	W00711	F-3863	497.4	34.6	Y	M	0.98	0.5	5.7	Some visceral fat
2/25/2008	WCR07-2DRHN47	white catfish	9/16/2007	W00710	F-3864	799.1	41.8	Y	F	5.73	1.06	10.36	Some visceral fat
2/25/2008	WCR07-3DRHN43	white catfish	9/2/2007	W00714	F-3865	788.0	38.0	Y	M	2.36	1.38	10.7	Some visceral fat
2/25/2008	WCR07-3RNTHN26	white catfish	10/14/2007	W00705	F-3867	1133.1	43.0	Y	M	3	2.79	26.45	Some visceral fat
3/2/2008	WCR07-1OCTHN13	channel catfish	9/9/2007	W00712	F-3873	1176.7	51.0	Y	F	10.47	2.2	18.34	
3/2/2008	WCR07-2MCLTHN12	channel catfish	9/16/2007	W00709	F-3871	1973.2	60.2	Y	M	6.95	4.05	18.77	Some visceral fat
3/2/2008	WCR07-3DRHN43	channel catfish	9/2/2007	W00715	F-3869	1096.9	50.5	Y	M	4.01	1.67	12.4	Little visceral fat
3/2/2008	WCR07-3DRHN43	channel catfish	9/2/2007	W00717	F-3874	1168.2	52.2	Y	M	5.64	1.74	18.29	Some visceral fat
3/2/2008	WCR07-3DRHN43	channel catfish	9/2/2007	W00716	F-3876	1376.0	55.6	Y	F	10.95	1.56	20.52	Little visceral fat
3/2/2008	WCR07-3DRHN53	channel catfish	10/14/2007	W00704	F-3870	2733.1	64.3	Y	F	101.78	3.86	47.28	Lots of visceral fat
3/2/2008	WCR07-3PSLTHN7	channel catfish	10/14/2007	W00703	F-3872	2317.3	65.5	Y	M	8.17	4.73	21.28	Some visceral fat
3/2/2008	WCR07-4CWLTHN19	channel catfish	9/22/2007	W00707	F-3875	2485.5	64.8	Y	M	10.45	5.13	15.37	Some visceral fat, 2 sores on right operculum, apx 2x1 and 2x2 cm
3/8/2008	WCR07-1RCUTA5	white catfish	7/5/2007	W00177	F-3887	288.8	27.7	Y	M	0.64	0.48	7.19	Some visceral fat
3/8/2008	WCR07-2BTLTHN6	white catfish	6/24/2007	W00366	F-3889	516.3	34.6	Y	M	1.78	0.41	4.62	Some visceral fat
3/8/2008	WCR07-2BTTHN8	white catfish	7/21/2007	W00978	F-3879	62.5	18.7	Y	F	0.15	0.11	0.89	Did not look for visceral fat
3/8/2008	WCR07-2DRHN30	white catfish	6/24/2007	W00398	F-3882	153.5	23.5	Y	F	0.38	0.25	2.41	Some visceral fat
3/8/2008	WCR07-2DRHN31	white catfish	7/21/2007	W00981	F-3888	347.9	31.1	Y	M	0.35	0.45	5.81	Some visceral fat
3/8/2008	WCR07-2MCLTHN9	white catfish	7/21/2007	W00994	F-3880	86.0	20.0	Y	F	0.32	0.13	1.44	Some visceral fat
3/8/2008	WCR07-2MCTHN8	white catfish	7/21/2007	W00998	F-3884	242.2	28.5	Y	F	2.45	0.41	3.89	Some visceral fat, parasite kept
3/8/2008	WCR07-2MCUTA5	white catfish	7/3/2007	W00176	F-3883	219.6	27.2	Y	M	0.91	0.37	3.8	Some visceral fat
3/8/2008	WCR07-3RNLTHN12	white catfish	7/7/2007	W00186	F-3885	247.0	27.9	Y	F	2.89	0.37	4.35	Some visceral fat

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3/8/2008	WCR07-3RNTHN12	white catfish	7/7/2007	W00187	F-3881	176.0	24.1	Y	F	30.48	0.13	2.15	Ripe. Some visceral fat.
3/8/2008	WCR07-3RNTHN15	white catfish	8/5/2007	W00765	F-3877	65.5	18.5	Y	M	NA	0.1	1.43	Some visceral fat, Gonad too small for accurate weight
3/8/2008	WCR07-4DRHN24	white catfish	8/4/2007	W00762	F-3886	365.1	31.3	Y	F	2.32	0.52	8.44	Some visceral fat
3/8/2008	WCR07-4DRHN30	white catfish	8/4/2007	W00763	F-3878	67.4	18.2	Y	F	0.14	0.08	1.32	Some visceral fat
3/10/2008	WCR07-1OCLTHN9	white catfish	7/22/2007	W00758	F-3893	406.7	32.5	Y	M	1.34	0.62	5.63	Some visceral fat, kept possible parasite
3/10/2008	WCR07-1RCUTA6	white catfish	7/5/2007	W00178	F-3891	629.9	35.7	Y	M	0.65	0.85	8.17	Very little visceral fat, intestines full
3/10/2008	WCR07-2BTLTHN7	white catfish	6/24/2007	W00370	F-3895	644.1	35.5	Y	F	97.86	0.63	11.17	Some visceral fat
3/10/2008	WCR07-2DRHN26	white catfish	6/24/2007	W00373	F-3890	436.1	33.8	Y	M	1.56	0.96	4.86	Some visceral fat
3/10/2008	WCR07-2MCUTA4	white catfish	7/3/2007	W00831	F-3894	426.3	31.5	Y	F	77.6	0.6	6.22	Some visceral fat
3/10/2008	WCR07-4CWLTHN15	white catfish	8/4/2007	W00761	F-3892	286.3	29.0	Y	F	1.75	0.25	5.18	Lots of visceral fat
3/15/2008	WCR07-1DRHN31	brown bullhead	6/25/2007	W00356	F-3902	404.8	31.9	Y	M	0.74	0.55	6.84	Little visceral fat, kept parasites
3/15/2008	WCR07-1RCUTA5	brown bullhead	7/5/2007	W00179	F-3899	166.5	23.0	Y	F	0.49	0.5	3.77	Some visceral fat
3/15/2008	WCR07-2MCLTHN9	brown bullhead	7/21/2007	W00997	F-3903	447.3	34.4	Y	M	1.04	0.83	7.49	Kept remains and parasite, visceral fat not noted
3/15/2008	WCR07-3DRHN27	brown bullhead	7/7/2007	W00182	F-3896	367.4	29.6	Y	M	1.09	0.54	6.51	Some visceral fat, some pustules on liver
3/15/2008	WCR07-3DRHN27	brown bullhead	7/7/2007	W00181	F-3900	599.7	33.8	Y	M	1.4	1.15	11.87	Some visceral fat
3/15/2008	WCR07-3RNLTHN11	brown bullhead	7/7/2007	W00185	F-3901	598.1	32.5	Y	M	1.41	1.04	16.58	Some visceral fat
3/15/2008	WCR07-2DRHN31	channel catfish	7/21/2007	W00983	F-3898	93.5	24.1	Y	F	0.18	0.13	1.22	Some visceral fat, possible parasite encysted (kept)
3/15/2008	WCR07-2MCLTHN9	channel catfish	7/21/2007	W00992	F-3897	64.8	21.8	Y	F	0.11	0.05	0.86	Some visceral fat, *tail cut - estimated length from field length

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3/17/2008	WCR07-1DRHN37	channel catfish	7/22/2007	W00752	F-3907	695.5	44.8	Y	M	0.33	0.58	8.76	Lots of visceral fat, parasites as above - not kept
3/17/2008	WCR07-1OCLTHN10	channel catfish	7/22/2007	W00759	F-3905	487.0	36.1	Y	F	54.65	0.54	8.06	Some visceral fat, possible parasite like above, not kept
3/17/2008	WCR07-1OCLTHN9	channel catfish	7/22/2007	W00756	F-3904	1698.9	54.3	Y	M	3.31	1.71	21.05	Some visceral fat, possible parasite,
3/17/2008	WCR07-4CWLTHN8	channel catfish	6/10/2007	W00379	F-3908	1191.4	48.5	Y	F	13.61	1.95	21.35	Some visceral fat, Same yellow encysted (?) parasites as in other samples tonight.
3/17/2008	WCR07-4DRHN17	channel catfish	6/10/2007	W00387	F-3906	750.7	44.6	Y	M	5.41	2.77	8.22	No visceral fat, parasites kept
3/17/2008	WCR07-4DRHN17	channel catfish	6/10/2007	W00389	F-3909	1341.5	52.4	Y	F	28.01	2.28	23.19	Some visceral fat, parasites kept
5/10/2008	WCR07-1DRHN37	channel catfish	7/22/2007	W00753	F-3913	235.6	31.2	Y	F	0.44	0.21	4.7	Lots of visceral fat
5/10/2008	WCR07-1DRHN37	channel catfish	7/22/2007	W01000	F-3914	500.8	38.0	Y	F	1.23	0.3	7.67	Lots of visceral fat, same white opaque parasites as above
5/10/2008	WCR07-2BTTHN8	channel catfish	7/21/2007	W00976	F-3918	776.3	51.2	Y	F	6.43	1.53	11.98	No visceral fat, thin muscle under skin, same white opaque encysted parasites as seen in other samples today (above).
5/10/2008	WCR07-2DRHN31	channel catfish	7/21/2007	W00984	F-3910	121.0	24.9	Y	M	0.03	0.13	1.92	Some visceral fat, small white and opaque 2-3mm size encysted parasites?
5/10/2008	WCR07-2DRHN31	channel catfish	7/21/2007	W00982	F-3911	57.5	21.5	Y	F	0.11	0.06	0.88	Some visceral fat, parasites same as above and kept.
5/10/2008	WCR07-2DRHN36	channel catfish	7/21/2007	W00989	F-3916	513.5	38.3	Y	M	3.84	0.84	7.62	Some visceral fat, same parsites as above

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5/10/2008	WCR07-2DRHN36	channel catfish	7/21/2007	W00988	F-3917	733.3	43.9	Y	M	6.93	1.71	14.91	Lots of visceral fat, 2 red worm parasites (kept in 95% EtOH) also saw same parasites as above.
5/10/2008	WCR07-2MCLTHN9	channel catfish	7/21/2007	W00993	F-3912	74.7	21.4	Y	F	0.14	0.07	0.98	Some visceral fat, same parasites as above
5/10/2008	WCR07-3DRHN31	channel catfish	8/5/2007	W00766	F-3921	970.6	53.3	Y	M	6.77	2.49	11.89	Little to no visceral fat, red worm just under skin - kept in 95% EtOH
5/10/2008	WCR07-3DRHN32	channel catfish	8/5/2007	W00764	F-3919	772.6	47.4	Y	F	5.12	1.03	9.98	Some visceral fat, many white opaque encysted parasites? On liver
5/10/2008	WCR07-4DRHN17	channel catfish	6/10/2007	W00392	F-3915	371.2	37.4	Y	M	NA	0.27	5.23	Some visceral fat, same parsites as above
5/10/2008	WCR07-4DRHN17	channel catfish	6/10/2007	W00390	F-3920	1034.7	49.1	Y	F	9.43	1.43	19.73	Some visceral fat
5/13/2008	WCR07-2DRHN23	channel catfish	6/3/2007	W00285	F-3927	360.9	35.1	Y	F	40.54	NA	7.3	Little to no visceral fat, did not look for parasites, did not weigh spleen
5/13/2008	WCR07-2MCUTA1	channel catfish	5/1/2007	W00430	F-3924	631.3	42.6	Y	M	3.43	1.2	14.38	Some visceral fat, Parasites as above and others kept
5/13/2008	WCR07-3PSUTA1	channel catfish	5/2/2007	W00431	F-3925	835.3	43.0	Y	M	3.18	1.29	18.39	Little viscerla fat, Some yellow-white/opaque parasites as above
5/13/2008	WCR07-4CWTHN11	channel catfish	6/30/2007	W00734	F-3923	300.8	34.3	Y	M	NA	0.43	3.74	Some visceral fat, encysted parasites as above, gonad too small to be weighed, too much surrounding tissue attached

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5/13/2008	WCR07-4DRHN17	channel catfish	6/10/2007	W00391	F-3926	796.8	44.0	Y	M	4.8	1.39	11.69	Some visceral fat, a few of the same parasites as above
5/13/2008	WCR07-4DRHN22	channel catfish	6/30/2007	W00739	F-3922	1094.4	46.9	Y	F	2.04	0.78	14.76	Some visceral fat, some white/opaque parasites? As seen and kept before.
5/14/2008	WCR07-2BTLTHN6	white catfish	6/24/2007	W00365	F-3930	521.1	35.3	Y	F	69.97	0.94	10.31	Little visceral fat, Redworm parasite-kept
5/14/2008	WCR07-2MCTHN7	white catfish	6/24/2007	W00395	F-3928	484.7	33.1	Y	F	72.58	0.8	11.03	No visceral fat
5/14/2008	WCR07-3PSTHN3	white catfish	6/9/2007	W00282	F-3929	415.0	33.0	Y	M	1.72	0.72	5.87	Little visceral fat, a few white-yellow/opaque encysted parasites
5/14/2008	WCR07-4CWTHN10	white catfish	6/30/2007	W00727	F-3933	83.1	20.4	Y	F	0.29	0.14	1.08	Some visceral fat
5/14/2008	WCR07-4CWTHN12	white catfish	6/30/2007	W00731	F-3931	192.3	26.2	Y	M	0.3	0.26	3.02	Some visceral fat
5/14/2008	WCR07-4DRHN22	white catfish	6/30/2007	W00744	F-3932	103.8	20.6	Y	F	0.22	0.09	1.92	Lots of visceral fat
5/15/2008	WCR07-2BTLTHN3	white catfish	5/12/2007	W00443	F-3941	54.6	18.2	Y	U	0.11	0.07	1.26	Some visceral fat.
5/15/2008	WCR07-3RNTHN2	white catfish	4/14/2007	W00241	F-3934	313.3	28.8	Y	M	1.04	1.36	9.9	Little visceral fat, possible parasite kept.
5/15/2008	WCR07-4CWUTA5	white catfish	5/18/2007	W00297	F-3936	243.2	27.6	Y	F	3.38	0.4	7.4	Some visceral fat, possible parasite kept
5/15/2008	WCR07-4CWUTA5	white catfish	5/18/2007	W00299	F-3938	114.9	22.4	Y	M	0.17	0.18	2.14	Did not look for visceral fat.
5/15/2008	WCR07-4CWUTAs3	white catfish	4/29/2007	W00429	F-3940	98.4	20.9	Y	F	0.35	0.2	2.46	Little-no visceral fat, a few small yellow/opaque encysted parasites?
5/15/2008	WCR07-4DRHN19	white catfish	6/30/2007	W00829	F-3935	569.4	34.2	Y	M	2.05	0.82	9.17	Lots of visceral fat
5/15/2008	WCR07-4DRHN19	white catfish	6/30/2007	W00830	F-3937	252.7	26.8	Y	F	23.35	0.31	4.18	Some visceral fat, Some possible parasites as kept above
5/15/2008	WCR07-4DRHN22	white catfish	6/30/2007	W00745	F-3939	175.5	24.2	Y	M	0.29	0.2	2.89	Lots of visceral fat

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5/16/2008	WCR07-2BTLTHN8	channel catfish	7/21/2007	W00980	F-3951	68.3	21.9	Y	F	0.1	0.08	1.27	Some visceral fat
5/16/2008	WCR07-2MCLTHN9	channel catfish	7/21/2007	W00991	F-3945	603.0	46.4	Y	F	3.9	1.01	7.94	Some visceral fat, some PTU1, 1 PTU2 found in liver and kept
5/16/2008	WCR07-2MCLTHN9	channel catfish	7/21/2007	W00995	F-3947	100.2	24.7	Y	U	0.05	0.09	1.19	Some visceral fat, some PTU1
5/16/2008	WCR07-2MCTHN8	channel catfish	7/21/2007	W00999	F-3944	204.3	30.7	Y	M	0.17	0.2	3.07	Some visceral fat, gonad weight includes surrounding connective tissue, some PTU1
5/16/2008	WCR07-3DRHN7	channel catfish	5/4/2007	W00439	F-3949	1111.6	48.7	Y	F	27.73	1.73	28.3	Some visceral fat, skin has grown over left eye, 2 PTU1s and 3 (2 in ovary) PTU2s seen
5/16/2008	WCR07-4CWLTHN8	channel catfish	6/10/2007	W00382	F-3950	1528.8	51.1	Y	F	34.45	3.17	105.92	Little visceral fat
5/16/2008	WCR07-4CWTHN10	channel catfish	6/30/2007	W00351	F-3942	468.2	36.8	Y	F	1.52	0.43	6.71	Lots of visceral fat, some PTU1
5/16/2008	WCR07-4CWTHN10	channel catfish	6/30/2007	W00730	F-3948	64.3	20.6	Y	U	0.08	0.06	0.67	Some visceral fat, gonad weight includes surrounding tissue, 1 PTU1 seen
5/16/2008	WCR07-4DRHN21	channel catfish	6/30/2007	W00749	F-3946	652.1	41.7	Y	F	2.76	0.74	9.42	Lots of visceral fat, some PTU1
5/16/2008	WCR07-4DRHN22	channel catfish	6/30/2007	W00741	F-3943	223.9	30.5	Y	F	0.39	0.18	3	Some visceral fat, some PTU1 (kept)
5/17/2008	WCR07-2BTTHN1	brown bullhead	4/1/2007	W00246	F-3956	306.1	28.9	Y	M	0.48	0.79	7.4	Some visceral fat, Some PTU1
5/17/2008	WCR07-2MCLTHN3	brown bullhead	4/22/2007	W00231	F-3957	170.5	24.5	Y	F	2.04	0.26	3.68	Some visceral fat, Some PTU1
5/17/2008	WCR07-4CWTHN3	brown bullhead	5/6/2007	W00440	F-3958	322.4	29.4	Y	M	0.59	0.83	4.84	Some visceral fat, Some PTU1
5/17/2008	WCR07-2BTLTHN8	channel catfish	7/21/2007	W00979	F-3955	61.5	21.2	Y	F	0.1	0.05	0.79	Some visceral fat, Some PTU1
5/17/2008	WCR07-2GS1	channel catfish	9/16/2007	W00708	F-3954	6.3	10.2	Y	U	NA	NA	0.06	Undetermined if has visceral fat
5/22/2008	WCR07-1DRHN25	channel catfish	6/2/2007	W00290	F-3961	338.1	35.0	Y	F	0.96	0.25	5.16	Lots of visceral fat, Some PTU1
5/22/2008	WCR07-1DRHN25	channel catfish	6/2/2007	W00287	F-3963	1667.1	56.0	Y	F	137.18	1.39	27.99	Little visceral fat, some PTU1

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5/22/2008	WCR07-1DRHN33	channel catfish	6/25/2007	W00361	F-3962	246.4	30.9	Y	F	0.29	0.14	3.16	Some visceral fat and PTU1
5/22/2008	WCR07-1DRHN40	channel catfish	7/22/2007	W00754	F-3960	311.9	34.1	Y	U	0.17	0.4	4.75	Lots of visceral fat, some PTU1
5/22/2008	WCR07-2MCLTHN9	channel catfish	7/21/2007	W00990	F-3964	1670.7	57.8	Y	M	11.04	3.37	29.09	Some visceral fat, 1 PTU1 and PTU2
5/22/2008	WCRO7-2DRHN31	channel catfish	7/21/2007	W00985	F-3959	67.5	20.7	Y	U	NA	0.06	0.87	Some visceral fat , Gonadal tissue includes some surrounding tissue.
5/25/2008	WCR07-1DRHN31	channel catfish	6/25/2007	W00359	F-3971	3318.9	67.3	Y	M	8.36	2.94	36.62	Lots of visceral fat, A few PTU1 and 1 PTU2.
5/25/2008	WCR07-1DRHN33	channel catfish	6/25/2007	W00362	F-3970	956.4	46.2	Y	M	6.97	1.76	9.93	Little visceral fat, some PTU1, some encysted PTU2
5/25/2008	WCR07-2BTLTHN5	channel catfish	6/3/2007	W00284	F-3968	498.6	39.6	Y	F	28.85	0.59	9.02	Some visceral fat, Some PTU1, 1 encysted PTU2
5/25/2008	WCR07-2BTLTHN6	channel catfish	6/24/2007	W00369	F-3966	734.0	46.2	Y	M	5.92	2.06	7.31	Some PTU1 on liver and digestive tract, no visceral fat (or very very little).
5/25/2008	WCR07-2DRHN34	channel catfish	7/21/2007	W00986	F-3965	72.8	21.0	Y	F	0.1	0.08	1.06	Some visceral fat and PTU1
5/25/2008	WCR07-4DRHN22	channel catfish	6/30/2007	W00742	F-3967	236.6	31.5	Y	F	0.33	0.24	3.11	Little visceral fat, some PTU1
5/25/2008	WCR07-4DRHN22	channel catfish	6/30/2007	W00740	F-3969	976.0	45.9	Y	F	151.42	0.7	9.56	Some visceral fat, some PTU1
6/2/2008	WCR07-1OCLTHN10	channel catfish	7/22/2007	W00760	F-3975	308.8	33.3	Y	F	0.45	0.44	4.57	Some PTU1, lots of visceral fat
6/2/2008	WCR07-2BTLTHN6	channel catfish	6/24/2007	W00367	F-3979	259.4	30.5	Y	M	0.23	0.19	3.37	Some PTU2, gonad wt. includes surrounding tissue
6/2/2008	WCR07-2DRHN30	channel catfish	6/24/2007	W00397	F-3977	189.7	29.5	Y	M	0.14	NA	2.64	Lots of visceral fat, some PTU1, gonad wt. includes surrounding tissue
6/2/2008	WCR07-2DRHN9	channel catfish	4/22/2007	W00227	F-3974	373.8	36.8	Y	F	3.42	0.55	10.41	Some visceral fat

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6/2/2008	WCR07-3DRHN7	channel catfish	5/4/2007	W00437	F-3976	47.7	20.1	Y	F	0.13	0.08	1.38	LTL longer than FTL, some PTU1, some visceral fat.
6/2/2008	WCR07-4CWTHN11	channel catfish	6/30/2007	W00732	F-3978	158.1	27.2	Y	F	0.34	0.16	1.54	Some PTU1, some visceral fat
6/2/2008	WCR07-4DRHN17	channel catfish	6/10/2007	W00388	F-3972	1510.1	54.3	Y	M	6.53	3.34	32.99	Little visceral fat, 1 PTU2 seen, 1 possible new parasite kept
6/2/2008	WCR07-4DRHN21	channel catfish	6/30/2007	W00748	F-3973	450.4	37.5	Y	F	1.92	0.29	7.1	Some visceral fat
6/4/2008	WCR07-4DRHN6	channel catfish	5/24/2007	W00295	F-3993	1111.0	45.2	Y	F	161.53	1.25	19.88	Some visceral fat and PTU1
6/23/2008	WCR07-1OCLTHN3	white catfish	4/21/2007	W00237	F-4081	864.8	40.2	Y	M	3.19	2.18	26.05	Some visceral fat
6/23/2008	WCR07-2DRHN18	white catfish	5/12/2007	W00449	F-4084	565.7	35.0	Y	F	36.28	1.83	25.16	Some visceral fat, 6 PTU2 (2 encysted)
6/23/2008	WCR07-3RNLTHN8	white catfish	6/9/2007	W00377	F-4085	424.0	32.5	Y	M	1.21	0.56	6.42	Some visceral fat, 1 PTU1?
6/23/2008	WCR07-4CWLTHN1	white catfish	5/6/2007	W00441	F-4083	959.7	40.7	Y	M	3.59	2.14	22.51	Some visceral fat
6/23/2008	WCR07-FCUTBP1	white catfish	5/3/2007	W00433	F-4082	883.1	38.3	Y	M	2.86	1.71	36.33	Some visceral fat
6/23/2008	WCR07-FCUTBP1	white catfish	5/3/2007	W00432	F-4089	1404.5	45.0	Y	M	3.72	3.36	35.16	Some visceral fat
5/17/2008	WCR07-2DRHN34	channel catfish	7/21/2007	W00987	F-3953	70.8	21.9	N	F	0.12	0.05	0.98	Some visceral fat, PTU1s on liver and intestines
5/17/2008	WCR07-2MCLTHN9	channel catfish	7/21/2007	W00996	F-3952	52.7	20.7	N	F	0.1	NA	NA	Most of insides decayed
6/2/2008	WCR07-1DRHN31	channel catfish	6/25/2007	W00358	F-3981	253.7	32.2	N	F	0.47	0.27	3.45	Some PTU1 and visceral fat
6/2/2008	WCR07-1RCUTA5	channel catfish	7/5/2007	W00180	F-3980	136.0	26.5	N	F	0.22	0.28	1.59	Little visceral fat, lots of PTU1
6/2/2008	WCR07-3DRHN27	channel catfish	7/7/2007	W00183	F-3983	714.9	44.0	N	M	8.47	1.4	19.16	10+ PTU2 seen encysted and 2 unencysted, some visceral fat
6/2/2008	WCR07-4DRHN22	channel catfish	6/30/2007	W00737	F-3982	673.6	41.8	N	F	2.01	1.09	9.51	Some visceral fat, 3 PTU1 seen
6/3/2008	WCR07-1DRHN31	channel catfish	6/25/2007	W00357	F-3985	288.1	32.8	N	F	1.72	0.34	4.05	Some PTU1, some visceral fat

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6/3/2008	WCR07-1DRHN33	channel catfish	6/25/2007	W00360	F-3987	298.9	32.8	N	M	0.17	0.23	4.36	Gonad wt. includes some surrounding tissue, Some visceral fat and PTU1.
6/3/2008	WCR07-1OCLTHN9	channel catfish	7/22/2007	W00757	F-3986	447.3	38.5	N	F	0.77	0.58	5.43	Some visceral fat, PTU1 and 1 PTU2
6/3/2008	WCR07-2BTLTHN7	channel catfish	6/24/2007	W00371	F-3984	525.9	39.8	N	M	0.14	0.56	7.12	Some visceral fat, Some PTU1
6/3/2008	WCR07-2DRHN27	channel catfish	6/24/2007	W00375	F-3988	623.3	42.5	N	M	4.82	1.59	11.85	Some PTU1 and visceral fat
6/3/2008	WCR07-3RNLTHN11	channel catfish	7/7/2007	W00184	F-3989	72.3	21.7	N	F	0.1	0.07	1.05	Some PTU1 and visceral fat
6/4/2008	WCR07-2BTLTHN6	channel catfish	6/24/2007	W00368	F-3991	459.0	37.6	N	F	70.43	0.66	7.95	No visceral fat, 1 encysted PTU2
6/4/2008	WCR07-2DRHN10	channel catfish	4/22/2007	W00427	F-3995	217.0	31.5	N	M	0.08	0.25	4.61	Some visceral fat and PTU1
6/4/2008	WCR07-2DRHN28	channel catfish	6/24/2007	W00374	F-3996	480.1	40.5	N	F	3.31	0.69	13.78	Some visceral fat and PTU1
6/4/2008	WCR07-2MCLTHN7	channel catfish	6/24/2007	W00394	F-3994	479.0	38.7	N	M	1.54	0.33	10.51	Some visceral fat and PTU1, some PTU2 on liver
6/4/2008	WCR07-4CWTHN10	channel catfish	6/30/2007	W00352	F-3992	688.3	42.3	N	M	0.35	0.69	9.35	Some visceral fat and PTU1
6/4/2008	WCR07-4DRHN21	channel catfish	6/30/2007	W00828	F-3990	525.9	38.2	N	F	122.38	1.08	7.31	Very, very little visceral fat = 0.18 g, some PTU1
6/4/2008	WCR07-4DRHN22	channel catfish	6/30/2007	W00736	F-3997	1158.2	49.4	N	M	0.99	0.97	16.16	Lots of visceral fat, some PTU1 and 4 PTU2
6/5/2008	WCR07-1DRHN25	channel catfish	6/2/2007	W00286	F-4007	1055.6	48.8	N	M	8.8	1.97	15.16	Some PTU1 and visceral fat
6/5/2008	WCR07-1DRHN32	channel catfish	6/25/2007	W00364	F-4004	140.1	26.9	N	M	0.07	0.15	2.41	Some PTU1 and visceral fat
6/5/2008	WCR07-2DRHN27	channel catfish	6/24/2007	W00400	F-4005	169.9	28.2	N	M	0.11	0.19	3	Some PTU1 and visceral fat
6/5/2008	WCR07-2MCTHN2	channel catfish	4/22/2007	W00232	F-4002	123.1	25.8	N	M	0.07	0.2	2.97	Some PTU1, little to no visceral fat
6/5/2008	WCR07-4CWUTA5	channel catfish	5/18/2007	W00298	F-4006	57.9	20.0	N	F	0.11	0.07	0.99	Little visceral fat
6/5/2008	WCR07-4DRHN21	channel catfish	6/30/2007	W00750	F-4003	457.4	38.8	N	M	0.18	0.78	7.72	Some PTU1, very little visceral fat

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6/6/2008	WCR07-1DRHN37	channel catfish	7/22/2007	W00751	F-4008	829.2	48.1	N	F	6.24	1.72	14.93	Some visceral fat, encysted PTU2 on liver and elsewhere
6/6/2008	WCR07-1RCTHN4	channel catfish	5/13/2007	W00277	F-4010	457.2	39.6	N	F	4.54	1.11	8.12	Little visceral fat, some PTU1 and encysted PTU2
6/6/2008	WCR07-2DRHN15	channel catfish	5/12/2007	W00446	F-4009	530.0	39.4	N	F	36.16	1.32	14.55	Some PTU1 and visceral fat
6/6/2008	WCR07-2DRHN25	channel catfish	6/24/2007	W00372	F-4013	416.5	36.0	N	F	1.06	0.51	7.2	Some visceral fat and PTU1
6/6/2008	WCR07-3DRHN7	channel catfish	5/4/2007	W00438	F-4012	1157.1	50.5	N	M	4.53	1.91	23.96	Some PTU1 on liver, no right eye
6/6/2008	WCR07-4CWTHN10	channel catfish	6/30/2007	W00354	F-4011	1857.7	60.8	N	F	22.18	2.3	36.8	Some visceral fat, PTU1 and PTU2
6/11/2008	WCR07-1DRHN12	channel catfish	3/31/2007	W00250	F-4023	217.1	31.3	N	M	0.11	0.4	4.44	Some PTU1, some visceral fat.
6/11/2008	WCR07-1DRHN23	channel catfish	5/13/2007	W00276	F-4025	755.0	44.3	N	M	1.83	1.04	16.17	Some PTU1 and visceral fat
6/11/2008	WCR07-1DRHN25	channel catfish	6/2/2007	W00289	F-4032	617.0	42.3	N	F	105.41	0.54	10.52	Some PTU1, little visceral fat
6/11/2008	WCR07-1OCLTHN2	channel catfish	4/21/2007	W00233	F-4024	144.9	28.9	N	F	0.29	0.3	4.5	Some PTU1, some visceral fat.
6/11/2008	WCR07-1OCLTHN2	channel catfish	4/21/2007	W00234	F-4027	403.0	37.0	N	F	1.75	0.59	9.58	Some PTU1, lots of visceral fat.
6/11/2008	WCR07-1OCLTHN2	channel catfish	4/21/2007	W00235	F-4029	741.9	47.1	N	M	1.63	1.48	14.43	Some PTU1, little visceral fat
6/11/2008	WCR07-4CWLTHN8	channel catfish	6/10/2007	W00381	F-4034	491.3	40.7	N	M	1.61	0.69	6.29	No visceral fat, some PTU1 and 2 PTU2
6/11/2008	WCR07-4CWTHN11	channel catfish	6/30/2007	W00733	F-4028	817.6	47.0	N	F	1.94	0.88	13.67	Lots of visceral fat, some PTU1
6/11/2008	WCR07-4DRHN13	channel catfish	6/10/2007	W00384	F-4026	482.3	39.1	N	M	0.25	0.69	6.58	Some PTU1 and visceral fat
6/11/2008	WCR07-4DRHN14	channel catfish	6/10/2007	W00386	F-4033	893.8	44.2	N	F	6.24	1.2	13.64	Some visceral fat
6/11/2008	WCR07-4DRHN21	channel catfish	6/30/2007	W00747	F-4030	627.4	40.5	N	M	0.34	0.34	9.04	Some PTU1 and visceral fat, gonad wt. includes surrounding tissue.

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6/11/2008	WCR07-4DRHN21	channel catfish	6/30/2007	W00746	F-4031	536.9	39.7	N	M	0.35	0.84	10.85	Some PTU1 and visceral fat, gonad wt. includes surrounding tissue.
6/14/2008	WCR07-1DRHN25	channel catfish	6/2/2007	W00291	F-4044	204.6	30.5	N	F	0.39	0.18	3.12	Some PTU1 and visceral fat
6/14/2008	WCR07-1DRHN25	channel catfish	6/2/2007	W00292	F-4045	191.2	30.0	N	F	0.53	0.16	4.34	Some PTU1 and visceral fat
6/14/2008	WCR07-1OCTHN3	channel catfish	4/20/2007	W00240	F-4035	2708.4	63.7	N	F	23.65	4.89	43.37	Little visceral fat, some PTU1 and PTU2 on liver and elsewhere
6/14/2008	WCR07-1RCTHN2	channel catfish	4/21/2007	W00239	F-4042	324.1	36.7	N	F	0.99	0.35	6.58	Some PTU1 and visceral fat
6/14/2008	WCR07-2DRHN10	channel catfish	4/22/2007	W00426	F-4039	169.8	29.1	N	F	0.26	0.23	2.96	Some PTU1 and visceral fat
6/14/2008	WCR07-2DRHN18	channel catfish	5/12/2007	W00450	F-4048	1276.2	54.0	N	M	6.93	2.57	20.48	Some PTU1 and visceral fat
6/14/2008	WCR07-2DRHN9	channel catfish	4/22/2007	W00226	F-4038	177.5	29.4	N	M	0.09	0.23	4.18	Some PTU1 and visceral fat
6/14/2008	WCR07-2MCLTHN3	channel catfish	4/22/2007	W00229	F-4037	1087.0	53.1	N	M	3.47	2.94	18.34	1 PTU2 seen, some visceral fat
6/14/2008	WCR07-4CWLTHN12	channel catfish	6/30/2007	W00355	F-4041	105.1	23.5	N	F	0.12	0.06	1.62	Lots of visceral fat and some PTU1
6/14/2008	WCR07-4CWLTHN3	channel catfish	5/6/2007	W00442	F-4036	235.8	33.6	N	F	0.68	0.3	3.46	Some visceral fat and PTU1
6/14/2008	WCR07-4CWTHN10	channel catfish	6/30/2007	W00728	F-4046	80.7	22.7	N	U	0.12	0.07	0.89	Some visceral fat, gonad wt. includes surrounding tissue
6/14/2008	WCR07-4CWTHN10	channel catfish	6/30/2007	W00353	F-4051	1576.2	55.4	N	F	8.36	3.54	19.28	No right eye, Some PTU1 and visceral fat
6/14/2008	WCR07-4DRHN17	channel catfish	6/10/2007	W00393	F-4049	187.1	30.0	N	M	0.94	0.26	2.51	Some PTU1 and visceral fat
6/14/2008	WCR07-4DRHN21	channel catfish	6/30/2007	W00826	F-4040	276.3	33.1	N	M	0.33	0.32	3.07	Some PTU1 and visceral fat, gonad wt. includes surrounding tissue.
6/14/2008	WCR07-4DRHN22	channel catfish	6/30/2007	W00738	F-4043	578.1	41.1	N	F	1.53	0.43	6.69	Some PTU1 and visceral fat
6/14/2008	WCR07-4DRHN22	channel catfish	6/30/2007	W00743	F-4050	267.4	30.7	N	F	0.47	0.24	3.79	Some PTU1 and visceral fat

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6/14/2008	WCR07-4DRHN23	channel catfish	6/30/2007	W00735	F-4047	65.2	20.2	N	U	0.76	0.05	0.85	Some visceral fat and PTU1, gonad wt. includes surrounding tissue and kidney
6/14/2008	WCR07-4CWUTA4	white catfish	5/18/2007	W00278	F-4052	69.1	19.8	N	U	0.08	0.12	1.14	No visceral fat
6/21/2008	WCR07-1DRHN25	channel catfish	6/2/2007	W00288	F-4059	709.9	43.7	N	F	18.69	0.98	12.61	Some visceral fat and PTU1
6/21/2008	WCR07-1RCHN1	channel catfish	3/25/2007	I1	F-4054	336.8	35.7	N	F	0.86	0.47	5.59	Some visceral fat and a few PTU1 and 1 PTU2, unkown parasite in muscle tissue - kept
6/21/2008	WCR07-1RCLTHN2	channel catfish	3/31/2007	W00248	F-4058	811.6	45.0	N	F	3.41	0.79	17.6	Lots of visceral fat, PTU1 present
6/21/2008	WCR07-2BTLTHN1	channel catfish	4/1/2007	W00244	F-4055	574.7	39.8	N	F	17.33	0.82	9.12	Some visceral fat and PTU1
6/21/2008	WCR07-2MCTHN6	channel catfish	6/24/2007	W00396	F-4057	554.1	39.4	N	F	33.97	0.57	13.13	Some visceral fat, PTU1 and PTU2
6/21/2008	WCR07-3RNTHN9	channel catfish	6/9/2007	W00378	F-4060	738.0	42.3	N	M	0.89	0.48	14.56	Some visceral fat, some PTU1, 1 PTU2 encysted
6/21/2008	WCR07-4CWTHN10	channel catfish	6/30/2007	W00726	F-4056	501.5	36.6	N	F	1.35	0.66	5.25	Lots of visceral fat, a few PTU1
6/21/2008	WCR07-4DRHN21	channel catfish	6/30/2007	W00827	F-4053	399.9	34.8	N	M	2.06	0.69	4.89	Some PTU1 and visceral fat
6/22/2008	WCR07-1RCLTHN2	channel catfish	3/31/2007	W00247	F-4063	464.0	41.1	N	F	2.89	0.77	8.59	Some visceral fat and PTU1 and PTU2
6/22/2008	WCR07-2BTTHN1	channel catfish	4/1/2007	W00245	F-4066	842.9	47.2	N	M	5.84	1.81	22.81	Some visceral fat and PTU1
6/22/2008	WCR07-2DRHN17	channel catfish	5/12/2007	W00448	F-4062	297.4	33.9	N	F	1.08	0.25	5.16	Some visceral fat and PTU1
6/22/2008	WCR07-2MCLTHN3	channel catfish	4/22/2007	W00230	F-4067	83.8	24.3	N	F	0.27	0.12	1.25	No visceral fat, some PTU1
6/22/2008	WCR07-4CWTBS1	channel catfish	4/24/2007	I1	F-4068	1612.5	52.1	N	F	39.9	3.45	53.25	Some visceral fat, a few PTU1 and 1 PTU2
6/22/2008	WCR07-4CWTBS1	channel catfish	4/24/2007	I2	F-4069	999.7	47.6	N	F	5.19	1.22	25.02	Some visceral fat and PTU1
6/22/2008	WCR07-4CWTBS1	channel catfish	4/24/2007	I3	F-4070	1842.7	56.8	N	F	53.71	3.23	42.25	Some PTU1, and visceral fat

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6/22/2008	WCR07-4CWTHN10	channel catfish	6/30/2007	W00729	F-4064	78.4	21.5	N	F	NA	0.11	1.13	Some visceral fat and PTU1
6/22/2008	WCR07-4CWUTA4	channel catfish	5/18/2007	W00300	F-4061	128.5	27.2	N	M	0.12	0.17	2.12	Some visceral fat and PTU1, Gonad wt. includes surrounding tissue.
6/22/2008	WCR07-4DRHN12	channel catfish	6/10/2007	W00383	F-4065	91.4	22.5	N	F	0.12	0.09	1.13	Some PTU1, little visceral fat
6/22/2008	WCR07-1DRHN13	white catfish	4/21/2007	W00238	F-4074	255.8	27.2	N	M	0.58	0.44	8.84	Some visceral fat, 1 PTU2
6/22/2008	WCR07-1OCLTHN2	white catfish	4/21/2007	W00236	F-4077	489.4	33.4	N	F	9.55	1.27	20.35	Some visceral fat
6/22/2008	WCR07-2BTTHN4	white catfish	5/12/2007	W00444	F-4072	164.6	25.5	N	M	0.28	0.33	5.11	Very little visceral fat
6/22/2008	WCR07-3PSLTHN1	white catfish	5/4/2007	W00436	F-4080	886.6	43.4	N	M	3	3.44	20.13	Little to no visceral fat, 1 PTU1 seen
6/22/2008	WCR07-3PSTHN2	white catfish	6/9/2007	W00283	F-4076	393.4	29.8	N	F	53.79	0.46	9.55	Little to no visceral fat
6/22/2008	WCR07-3RNLTHN2	white catfish	4/14/2007	W00242	F-4075	1110.9	41.8	N	F	22.05	1.74	46.47	Some visceral fat
6/22/2008	WCR07-3RNTHN8	white catfish	5/25/2007	W00293	F-4073	178.5	25.5	N	M	0.17	0.28	3.45	Some visceral fat
6/22/2008	WCR07-4DRHN14	white catfish	6/10/2007	W00385	F-4071	60.1	16.7	N	U	0.1	0.1	0.87	Some visceral fat, gonad wt. includes surrounding tissue
6/22/2008	WCR07-FCUTBP1	white catfish	5/3/2007	W00435	F-4078	507.0	32.0	N	M	1.03	0.6	15.44	Some visceral fat
6/22/2008	WCR07-FCUTBP1	white catfish	5/3/2007	W00434	F-4079	760.6	36.5	N	M	NA	1.51	31.11	Some visceral fat, 2 PTU2 in muscle
6/23/2008	WCR07-2DRHN15	brown bullhead	5/12/2007	W00447	F-4094	457.6	30.5	N	M	1.24	0.92	14.3	Some visceral fat
6/23/2008	WCR07-2MCUTCTT1	brown bullhead		W00243	F-4093	568.2	33.5	N	M	1.06	0.91	14.03	Some visceral fat and PTU1
6/23/2008	WCR07-2BTTHN4	white catfish	5/12/2007	W00445	F-4092	388.1	32.3	N	M	0.94	0.52	7.19	Little visceral fat
6/23/2008	WCR07-3DRHN21	white catfish	6/9/2007	W00376	F-4090	248.3	28.8	N	F	2.64	0.39	4.46	Some visceral fat
6/23/2008	WCR07-3PSLTHN3	white catfish	6/9/2007	W00280	F-4091	84.2	19.5	N	M	NA	0.08	1.63	Some visceral fat and PTU1
6/23/2008	WCR07-3RNTHN8	white catfish	5/25/2007	W00294	F-4087	85.7	21.2	N	F	0.46	0.26	2.34	Little to no visceral fat, some PTU1?
6/23/2008	WCR07-4CWLTHN6	white catfish	5/24/2007	W00296	F-4088	266.6	28.4	N	M	0.79	0.62	6.2	Some visceral fat
6/23/2008	WCR07-4CWUTA2	white catfish	4/29/2007	W00428	F-4086	99.3	21.3	N	M	0.1	0.23	2.38	Very little visceral fat.

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