Chapter C3: Evaluation of I&E Data

This chapter presents the results of EPA's evaluation of the I&E rates reported by the nine Ohio River in-scope facilities that are described in Chapters C1 and C2, and the results of EPA's extrapolation of these rates to other in-scope and out-of-scope CWIS on the Ohio River. Section C3-1 lists species that are impinged and entrained at Ohio River CWIS, Section C3-2 summarizes the life histories of the primary species impinged and entrained, Section C3-3 discusses facility methods for estimating annual I&E, Section C3-4 presents annual impingement at the nine in scope facilities with I&E data, Section C3-5 presents annual entrainment at the nine facilities, Section C3-6 summarizes EPA's methods for extrapolating I&E rates to other Ohio River CWIS, Section C3-7 presents extrapolated annual impingement rates, Section C3-8 presents extrapolated entrainment rates, and Section C3-9 presents a summary of the total cumulative impact of all Ohio River CWIS.

C3-1 Ohio River Aquatic Species Vulnerable to I&E

The Ohio River fish species that are vulnerable to I&E based on their presence in I&E collections are listed in Table C3-1. Note that none of these species are considered commercial species for the purposes of EPA's analysis, since there are currently no commercial fisheries along the Ohio portion of the Ohio River. Species without commercial or recreational value are classified as forage for EPA's analysis. The main species at risk based on their abundance in I&E collections are emerald shiner (*Notropis atherinoides*), freshwater drum (*Aplodinotus grunniens*), gizzard shad (*Dorosoma cepedianum*), sauger (*Stizostedion canadense*), white bass (*Morone chrysops*), white crappie *(Pomoxis annularis*), and white sucker (*Catostomus commersoni*).

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Table C3-1: Aquatic Species Vulnerable to I&E at the Nine Ohio River Facilities.

Common Name	Scientific Name	Recreational	Forage
American eel	*Anguilla rostrata*		X
Banded sculpin	*Cottus carolinae*		X
Bigeye shiner	*Notropis boops*		X
Bigmouth buffalo	*Ictiobus cyprinellus*		X
Black bullhead	*Ameiurus melas*		X
Black crappie	*Pomoxis nigromaculatus*	X	
Blue catfish	*Ictalurus furcatus*	X	
Bluegill	*Lepomis macrochirus*	X	
Bluntnose minnow	*Pimephales notatus*		X
Brown bullhead	*Ameiurus nebulosus*		X
Carp	*Cyprinus carpio*		X
Central stoneroller	*Campostoma anomalum*		X
Channel catfish	*Ictalurus punctatus*	X	
Chestnut lamprey	*Ichthyomyzon castaneus*		X
Coho salmon	*Oncorhynchus kisutch*	X	
Common shiner	*Luxilus cornutus*		X
Creek chub	*Semotilus atromaculatus*		X
Eastern banded killifish	*Fundulus diaphanus diaphanus*		X
Emerald shiner	*Notropis atherinoides*		X
Fantail darter	*Etheostoma flabellare*		X
Fathead minnow	*Pimephales promelas*		X
Flathead catfish	*Pylodictis olivaris*	X	
Freshwater drum	*Aplodinotus grunniens*		X
Gizzard shad	*Dorosoma cepedianum*		X
Golden redhorse	*Moxostoma erythrurum*		X
Golden shiner	*Notemigonus crysoleucas*		X
Goldeye	*Hiodon alosoides*		X
Goldfish	*Carassius auratus*		X
Grass pickerel	*Esox americanus vermiculatus*	X	
Green sunfish	*Lepomis cyanellus*	X	
Highfin carpsucker	*Carpiodes velifer*		X
Largemouth bass	*Micropterus salmoides*	X	
Logperch	*Percina caprodes*		X
Longear sunfish	*Lepomis megalotis*	X	
Longnose gar	*Lepisosteus osseus*		X
Madtom species	*Noturus* spp.		X
Mimic shiner	*Notropis volucellus*		X
Mooneye	*Hiodon tergisus*		X
Muskellunge	*Esox masquinongy*	X	
Northern hog sucker	*Hypentelium nigricans*		X
Northern pike	*Esox lucius*	X	
Paddlefish	*Polyodon spathula*	X	
Pumpkinseed	*Lepomis gibbosus*	X	

Table C3-1: Aquatic Species Vulnerable to I&E at the Nine Ohio River Facilities (cont.).

Common Name	Scientific Name	Recreational	Forage
Quillback	*Carpiodes cyprinus*		X
Rainbow smelt	*Osmerus mordax*		X
Rainbow trout	*Oncorhynchus mykiss*	X	
Redear sunfish	*Lepomis microlophus*	X	
River carpsucker	*Carpiodes carpio*		X
River darter	*Percina shumardi*		X
River redhorse	*Moxostoma carinatum*		X
River shiner	*Notropis blennius*		X
Rock bass	*Ambloplites rupestris*	X	
Rosyface shiner	*Notropis rubellus*		X
Sand shiner	*Notropis stramineus*		X
Sauger	*Stizostedion canadense*	X	
Shorthead redhorse	*Moxostoma macrolepidotum*		X
Silver chub	*Macrhybopsis storeriana*		X
Silver lamprey	*Ichthyomyzon unicuspis*		X
Silver redhorse	*Moxostoma anisurum*		X
Silverjaw minnow	*Notropis buccatus*		X
Skipjack herring	*Alosa chrysochloris*		X
Smallmouth bass	*Micropterus dolomieu*	X	
Smallmouth buffalo	*Ictiobus bubalus*		X
Spotfin shiner	*Cyprinella spiloptera*		X
Spotted bass	*Micropterus punctulatus*	X	
Spotted sucker	*Minytrema melanops*		X
Stonecat	*Noturus flavus*	X	
Striped bass	*Morone saxatilis*	X	
Threadfin shad	*Dorosoma petenense*		X
Troutperch	*Percopsis omiscomaycus*		X
Walleye	*Stizostedion vitreum*	X	
Warmouth	*Lepomis gulosus*	X	
White bass	*Morone chrysops*	X	
White catfish	*Ameiurus catus*	X	
White crappie	*Pomoxis annularis*	X	
White sucker	*Catostomus commersoni*		X
Yellow bullhead	*Ameiurus natalis*		X
Yellow perch	*Perca flavescens*	X	

Sources: Dames and Moore, 1977b, 1977c, 1978; Energy Impact Associates Inc., 1978a, 1978b; Geo-Marine Inc., 1978; Cincinnati Gas and Electric Company, 1979; Potter et al., 1979a, 1979b, 1979c, 1979d; EA Science and Technology, 1987; NMFS, 2001a, 2001b.

C3-2 Life Histories of Primary Species Impinged and Entrained

The life history characteristics of the primary species impinged and entrained at Ohio River CWIS are summarized in the following sections. The species described are those with the highest I&E rates at the facilities examined (presented in Sections C3-4 and C3-5).

Emerald shiner (*Notropis atherinoides*)

Emerald shiner is a member of the family Cyprinidae. It is found in large open lakes and rivers from Canada south throughout the Mississippi Valley to the Gulf Coast in Alabama (Scott and Crossman, 1973). Emerald shiner prefer clear waters in the mid- to upper sections of the water column, and are most often found in deep, slow moving rivers (Trautman, 1981). Because of its small size, emerald shiner is an important forage fish for many species.

Spawning occurs from July to August in Lake Erie (Scott and Crossman, 1973). Females lay anywhere from 870 to 8,700 eggs (Campbell and MacCrimmon, 1970), which hatch within approximately 24 hours (Scott and Crossman, 1973). Young-of-year remain in large schools in inshore waters until the fall, when they move into deeper waters to overwinter (Scott and Crossman, 1973). Young-of-year average 5.1 to 7.6 cm (2 to 3 in) in length (Scott and Crossman, 1973).

Emerald shiner move in schools and prefer clear waters over sand or gravel (Froese and Pauly, 2000). They surface at dusk to feed on microcrustaceans, midge larvae, zooplankton, and algae (Campbell and MacCrimmon, 1970). During the day, they descend to deeper waters.

Emerald shiner are sexually mature by age 2, though some larger individuals may mature at age 1 (Campbell and MacCrimmon, 1970). Most do not live beyond 3 years of age (Fuchs, 1967). Adults typically range in size from 6.4 to 8.4 cm (2.5 to 3.3 in) (Trautman, 1981). Populations may fluctuate dramatically from year to year (Trautman, 1981).

EMERALD SHINER
(*Notropis atherinoides*)

Family: Cyprinidae.

Common names: Emerald shiner.

Similar species: Silver shiner, rosyface shiner.[a]

Geographic range: From Canada south throughout the Mississippi valley to the gulf coast in Alabama.[b,c]

Habitat: Large open lakes and rivers.[b]

Lifespan: Emerald shiner live to 3 years of age.[a,d]

Fecundity: Mature by age 2, although some may mature at age 1. Females can lay approximately 870 to 8,700 eggs.[c]

Food Sources: Microcrustaceans, midge larvae, zooplankton, algae.[d]

Prey for: Gulls, terns, mergansers, cormorants, smallmouth bass, yellow perch, and others.[d]

Life Stage Information

Eggs: demersal
- Eggs hatch in less than 24 hours.[d]

Larvae: pelagic
- Individuals from different year classes can have varying body proportions and fin length, as can individuals from different localities.[a]

Adults
- Typically range in size from 6.4 to 8.4 cm (2.5 to 3.3 in).[a]

[a] Trautman, 1981.
[b] Froese and Pauly, 2000.
[c] Campbell and MacCrimmon, 1970.
[d] Scott and Crossman, 1973.
Fish graphic courtesy of New York Sportfishing and Aquatic Resources Educational Program, 2001.

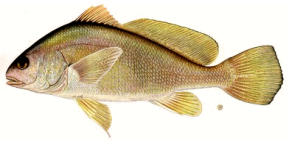
Freshwater drum (*Aplodinotus grunniens*)

Freshwater drum is a member of the drum family, Sciaenidae. Possibly exhibiting the greatest latitudinal range of any North American freshwater species, its distribution ranges north from Manitoba, Canada, south to Guatemala, and throughout the Mississippi River drainage basin (Scott and Crossman, 1973). Freshwater drum is not a favored food item of either humans or other fish (Edsall, 1967; Trautman, 1981; Bur, 1982).

Based on studies in Lake Erie, the spawning season peaks in July (Daiber, 1953), although spent females have been found as late as September (Scott and Crossman, 1973). Females in Lake Erie produce from 43,000 to 508,000 eggs (Daiber, 1953). The eggs are buoyant, floating at the surface of the water (Daiber, 1953; Scott and Crossman, 1973). This unique quality may be one explanation for the freshwater drum's exceptional distribution (Scott and Crossman, 1973). Yolk-sac larvae are buoyant as well, floating inverted at the surface of the water with the posterior end of the yolk sac and tail touching the surface (Swedberg and Walburg, 1970).

Larvae develop rapidly over the course of their first year. Maturity appears to be reached earlier among freshwater drum females from the Mississippi River than females from Lake Erie. Daiber (1953) found Lake Erie females begin maturing at age 5, and 46 percent reach maturity by age 6. Lake Erie males begin maturing at age 4, and by age 5, 79 percent had reached maturity.

Freshwater drum in western Lake Erie were found to live an average of 4 years, although the oldest male was 8 years of age, and the oldest female was 14 years (Edsall, 1967). Adults tend to be between 30 to 76 cm (12 to 30 in) long. The largest reported freshwater drum from the Ohio River was between 88.9 and 99.1 cm (35 and 39 in) long (Trautman, 1981).



FRESHWATER DRUM
(*Aplodinotus grunniens*)

Family: Sciaenidae.

Common names: Freshwater drum, white perch, sheepshead.[a]

Similar species: White bass, carpsuckers.[a]

Geographic range: From Manitoba, Canada, south to Guatemala. They can be found throughout the Mississippi River drainage basin.

Habitat: Bottoms of medium to large sized rivers and lakes.[b]

Lifespan: The average freshwater drum lives 4 years, although individuals up to 14 years have been reported.[c]

Fecundity: Females in Lake Erie produced from 43,000 to 508,000 eggs.[e]

Food Sources:
Juveniles: Cladocerans (plankton), copepods, dipterans.[d]
Adults: Dipterans, cladocerans,[4] darters, emerald shiner.[e]

Prey for:
- Very few species.

Life Stage Information

Eggs: *Pelagic*
- The buoyant eggs float at the surface of the water, possibly accounting for the species' high distribution.[e]

Larvae:
- Prolarvae float inverted at the surface of the water with the posterior end of the yolk sac and their tail touching the surface.[f]

Adults:
- The species owes its name to the audible "drumming" sound that it is often heard emitting during summer months.[e]
- Tend to be between 30 to 76 cm (12 to 30 in) long.[a]

[a] Trautman, 1981.
[b] Froese and Pauly, 2001.
[c] Edsall, 1967.
[d] Bur, 1982.
[e] Scott and Crossman, 1973.
[f] Swedberg and Walburg, 1970.
Fish graphic courtesy of New York Sportfishing and Aquatic Resources Educational Program, 2001.

Gizzard shad (*Dorosoma cepedianum*)

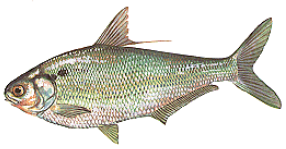
Gizzard shad is a member of the family Clupeidae. Its distribution is widespread throughout the eastern United States and into southern Canada, with occurrences from the St. Lawrence River south to eastern Mexico (Miller, 1960; Scott and Crossman, 1973). Gizzard shad are found in a range of salinities from freshwater inland rivers to brackish estuaries and marine waters along the Atlantic Coast of the United States (Miller, 1960; Carlander, 1969). Gizzard shad often occur in schools (Miller, 1960). Young-of-year are considered an important forage fish (Miller, 1960), though their rapid growth rate

limits the duration of their susceptibility to many predators (Bodola, 1966). Gizzard shad occur in all of the impoundment pools of the Ohio River and account for nearly half of the fish sampled in Ohio River surveys (Hunter Environmental Services Inc., 1989).

Spawning occurs from late winter or early spring to late summer, depending on temperature. Spawning has been observed in early June to July in Lake Erie (Bodola, 1966), and in May elsewhere in Ohio (Miller, 1960). The spawning period generally lasts two weeks (Miller, 1960). Males and females release sperm and eggs while swimming in schools near the surface of the water. Eggs sink slowly toward the bottom or drift with the current, and adhere to any surface they encounter (Miller, 1960). Females produce an average of 378,990 eggs annually (Bodola, 1960), which average 0.75 mm (0.03 in) in diameter (Wallus et al., 1990).

Hatching time may be anywhere from 36 hours to one week, depending on temperature (Bodola, 1966). Young shad may remain in upstream natal waters if conditions permit (Miller, 1960). By age 2 all gizzard shad are sexually mature, though some may mature as early as age 1 (Bodola, 1966). Unlike many other fish, fecundity in gizzard shad declines with age (Electric Power Research Institute, 1987).

Gizzard shad generally live up to 5 to 7 years, but individuals up to 10 years have been reported in southern locations (Miller, 1960; Scott and Crossman, 1973). Mass mortalities due to extreme temperature changes have been documented in several locations during winter months (Williamson and Nelson, 1985).



GIZZARD SHAD
(*Dorosoma cepedianum*)

Family: Clupeidae (herrings).

Common names: Gizzard shad.

Similar species: Threadfin shad.[a]

Geographic range: Eastern North America from the St. Lawrence River to Mexico.[b,c]

Habitat: Inhabits inland lakes, ponds, rivers, and reservoirs to brackish estuaries and ocean waters.[b,c]

Lifespan: Gizzard shad generally live 5 to 7 years, but have been reported at ages of up to 10 years.[b]

Fecundity: Maturity is reached at ages 2 to 3, females may produce between 59,480 and 378,990 eggs.[b]

Food Sources: Larvae consume protozoans, zooplankton, and small crustaceans.[c] Adults are mainly herbivorous, feeding on plants, phytoplankton, and algae. They are one of the few species able to feed solely on plant material.[b]

Prey for: Walleye, white bass, largemouth bass, crappie; among others (immature shad only).[b]

Life Stage Information

Eggs: *Demersal*
- During spawning, eggs are released near the surface and sink toward the bottom, adhering to any surface they touch.

Larvae: *Pelagic*
- Larvae serve as forage to many species.
- After hatching, larvae travel in schools for the first few months.

Adults
- May grow as large as 52.1 cm (20.5 in).[a]
- May be considered a nuisance species because of sporadic mass winter die-offs.[c]

[a] Trautman, 1981.
[b] Miller, 1960.
[c] Scott and Crossman, 1973.
Fish graphic from Iowa Department of Natural Resources, 2001.

Sauger (*Stizostedion canadense*)

Sauger is a member of the perch family, Percidae. Its distribution extends from the St. Lawrence River system south to northern Louisiana and throughout the Mississippi drainage. Sauger is primarily limited to freshwater systems and only occasionally found in brackish water (Scott and Crossman, 1973; Carlander, 1997). It is a close relative of the walleye, and the two species were once thought to be a single species, with the darker colored sauger mistaken for the male of the species (Trautman, 1981). Once plentiful in western Lake Erie, sauger have declined over the last 100 years. Commercial fishing of

sauger in Lake Erie was banned in 1968. While abundance in the Ohio River was never as high as in Lake Erie, it has remained more stable over the years (Trautman, 1981).

Spawning in early April has been documented in Tennessee and in Lake Erie (Carlander, 1997). Males arrive at the spawning grounds before the females. Estimates of female fecundity range from 9,000 to 96,000 eggs per female (Scott and Crossman, 1973). Sauger are able to hybridize with walleye, producing what are locally known as "saugeyes" (Carlander, 1997).

Females broadcast their sticky eggs, which harden and become semibuoyant and nonadhesive. Eggs are 1.44 to 1.86 mm (0.06 to 0.07 in) in diameter. Hatching takes place anywhere from 25 to 29 days at temperatures of 4.4 to 12.8 ˚C (40 to 55 ˚F (Scott and Crossman, 1973). Yolk-sac larvae are 4.5 to 6.2 mm (0.18 to 0.24 in) long after hatching (Scott and Crossman, 1973), and in Ohio, young-of-year are 7.6 to 15.2 cm (2.6 to 6.0 in) by October (Trautman, 1981).

Male sauger typically mature at age 2, and females have been documented to mature anywhere from age 2 to 8 (Scott and Crossman, 1973; Carlander, 1997). In the Ohio River region, sauger generally do not live more than 8 years (Carlander, 1997). Adult male sauger in the Ohio River usually obtain average lengths of 23 cm (9 in), and females obtain lengths of 25.4 to 40.6 cm (10 to 16 in) (Trautman, 1981). The Ohio State record for sauger is 62.2 cm (24.5 in) (Ohio Department of Natural Resources, 2001b).

SAUGER
(*Stizostedion canadense*)

Family: Percidae (perches)

Common names: Sauger, Jack salmon.[a]

Similar species: Walleye, blue pike.[b]

Geographic range: St. Lawrence River system south to northern Louisiana throughout the Mississippi drainage.[c]

Habitat: Inhabits sand and gravel runs, and sandy or muddy pools of rivers. Occasionally found in lakes and impoundments.[d]

Lifespan: Up to 8 years in the Ohio River region.[e]

Fecundity: Females produce anywhere from 9,000 to 96,000 eggs.[c]

Food Source: Juveniles feed on cladocerans, chironomids, fish fry.[e] Adults are sight predators, feeding mainly on gizzard shad and emerald shiner; other prey include freshwater drum, channel catfish, mimic shiner.[f]

Prey for: Other sauger, northern pike, walleye, and yellow perch.[c]

Life Stage Information

Eggs: *Demersal*
- Eggs sink to the bottom after hardening, falling between rocks and gravel.[c]
- Eggs may take 25 to 29 days to hatch.

Larvae: *Pelagic*
- Yolk-sac larvae are 4.5 to 6.2 mm (0.18 to 0.24 in) long after hatching.[c]

Adults
- Can hybridize with walleye (hybrids are known as saugeyes).[e]
- Males in the Ohio River average 23 cm (9 in), females are 25.4 to 40.6 cm (10 to 16 in).[b]

[a] Ohio Department of Natural Resources, 2001b.
[b] Trautman, 1981.
[c] Scott and Crossman, 1973.
[d] Froese and Pauly, 2001.
[e] Carlander, 1997.
[f] Wahl, D.H. and L.A. Nielsen, 1985.
Fish graphic courtesy of New York Sportfishing and Aquatic Resources Educational Program, 2001.

White bass (*Morone chrysops*)

White bass is a member of the temperate bass family, Percichthyidae. It ranges from the St. Lawrence River south through the Mississippi valley to the Gulf of Mexico, though the species is most abundant in the Lake Erie drainage (Van Oosten, 1942). Although white bass is native to the Ohio River, populations were introduced to several of the river's impoundments following dam construction (Trautman, 1981).

Spawning take place in May in Lake Erie and may extend into June, depending on temperatures. Spawning bouts can last from 5 to 10 days (Scott and Crossman, 1973). Adults typically spawn near the surface, and eggs are fertilized as they sink

toward the bottom. Fecundity increases directly with size in females. The average female lays approximately 565,000 eggs. Eggs hatch within 46 hours at a water temperature of 15.6 ˚C (60 ˚F) (Scott and Crossman, 1973).

Larvae grow rapidly, and young white bass reach lengths of 13 to 16 cm (5.1 to 6.3 in) by the fall (Scott and Crossman, 1973). They feed on microscopic crustaceans, insect larvae, and small fish. As adults, the diet switches to fish. Yellow perch are an especially important prey species for white bass (Scott and Crossman, 1973).

Most white bass mature at age 3 (Van Oosten, 1942). Upon reaching sexual maturation, adults tend to form unisexual schools, traveling up to 11.1 km (6.9 mi) a day. Adults tend to occupy the upper portion of the water column, maintaining depths of 6 m or less (Scott and Crossman, 1973). On average, adults are between 25.4 to 35.6 cm (10 to 14 in) long (Ohio Department of Natural Resources, 2001b). White bass rarely live beyond 7 years (Scott and Crossman, 1973).

WHITE BASS
(*Morone chrysops*)

Family: Percichthyidae.

Common names: White bass, silver bass.

Similar species: White perch, striped bass.[a]

Geographic range: St. Lawrence River south through the Mississippi valley to the Gulf of Mexico, highly abundant in the Lake Erie drainage.[b]

Habitat: Occurs in lakes, ponds, and rivers.[c]

Lifespan: White bass may live up to 7 years.[d]

Fecundity: The average female lays approximately 565,000 eggs.[b]

Food Source: Juveniles consume microscopic crustaceans, insect larvae, and small fish.[b] Adults have been found to consume yellow perch, bluegill, white crappie,[b] and carp.[b,d]

Prey for: Other white bass.[a]

Life Stage Information

Eggs: *Demersal*
- Eggs are approximately 0.8 mm (0.03 in) in diameter.[b]

Larvae: *Pelagic*
- White bass experience their maximum growth in their first year.[b]

***Adults*:**
- Travel in schools, traveling up to 11.1 km (6.9 mi) a day.[b]
- Most mature at age 3.[e]
- Adults prefer clear waters with firm bottoms.[a]

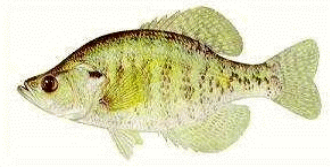
[a] Trautman, 1981.
[b] Scott and Crossman, 1973.
[c] Froese and Pauly, 2000.
[d] Carlander, 1997.
[e] Van Oosten, 1942.
Fish graphic courtesy of New York Sportfishing and Aquatic Resources Educational Program, 2001.

White crappie (*Pomoxis annularis*)

White crappie is a member of the Centrachidae family and is found in the central United States from the Great Lakes to the Gulf of Mexico (Scott and Crossman, 1973). It occurs in freshwater pools, creeks, small to large rivers, and lakes and ponds over sand and mud bottoms. It is found most often in moderately turbid waters (Froese and Pauly, 2000). White crappie tend to school near submerged trees, brush, aquatic vegetation, and boulders (Edwards et al., 1982). Young white crappie feed primarily on zooplankton, and adults feed primarily on small fish, especially gizzard shad (Scott and Crossman, 1973).

White crappie reach sexual maturity between 2 and 3 years (Wang, 1986b). Spawning begins in the spring when water temperatures are between 16 and 20 ˚C (60 and 68 ˚F). Males construct nests by fanning out a depression on the bottom near brush, rocks, and vegetation in water that is usually less than 1.5 m (4.9 ft) deep (Wang, 1986b; Ohio Department of Natural Resources, 2001b). Nests have been observed at average depths of 10 to 420 cm (0.3 to 13.8 ft) (Edwards et al., 1982). Females lay 5,000 to 30,000 eggs per season, but release only a few eggs at a time and often mate with multiple males (Scott and Crossman, 1973; Ohio Department of Natural Resources, 2001b). Males guard their nests until the larvae can swim freely into adjacent plant beds (Wang, 1986b).

Crappie are very popular for sport fishing (Hansen 1951; Dames and Moore, 1977a). Because white crappie are such a prolific species, they often become overcrowded. This can lead to depletion of their food supply and result in slower growth rates and smaller sizes (Carlander, 1969; Steiner, 2000).



WHITE CRAPPIE
(*Pomoxis annularis*)

Family: Centrarchidae (sunfishes).[a]

Common names: White crappie, papermouth, specks.[b]

Similar species: Black crappie, rockbass.[c]

Geographic range: Central United States, including the Mississippi and Great Lakes basins to the Gulf Coast.[c,d]

Habitat: Prefers pools, backwaters of creek, rivers, lakes, and ponds over sand and mud bottoms. Often found in turbid water, and near aquatic vegetation.[a]

Lifespan: The highest reported age is 10 years.[a]

Fecundity: Mature at 2-3 years.[d] Females produce between 5,000 and 30,000 eggs.[b]

Food Sources: Larvae feed on algae, insects, and microcrustaceans; young feed primarily on zooplankton; and adults eat several different types of fish, including gizzard shad, perch, and small crappie.[f]

Prey for: Northern pike, muskellunge.[a]

Life Stage Information

Eggs: *Demersal*
- Laid in nests and guarded by the male. Females often mate with several males in a single spawning season.[d,e]

Larvae:
- 1.22-1.98 mm (0.05 to 0.08 in) at hatching.[d]
- Remain in nest until they can swim freely.[d]

Adults: *Demersal*
- Average length: 15.4 to 30.5 cm (6-12 in).[b]
- Noted as an abundant species in the Ohio River in studies done in 1957-1959 and 1976-1978.[c]

[a] Froese and Pauly, 2000.
[b] Ohio Department of Natural Resources, 2001b.
[c] Trautman, 1981.
[d] Wang, 1986b.
[e] Dames and Moore, 1977a.
[f] Carlander, 1969.
Fish graphic from North Dakota Game and Fish Department, 1986.

White sucker (*Catostomus commersoni*)

The white sucker is a member of the Catostomidae family, and is found throughout most of Canada, and south to North Carolina and New Mexico in the United States (Froese and Pauly, 2000). It inhabits small and large streams, ponds, lakes, and reservoirs.

Male white suckers reach sexual maturity between ages 2 and 6, and females mature 1 to 2 years later (Twomey et al., 1984). White suckers typically run upstream in the spring to spawn. They spawn over shallow gravel substrate, usually in riffles or swift water, but they have been observed spawning in lakes (Carlander, 1969). Females may scatter 20,000 to 50,000 eggs with several males (Steiner, 2000). The eggs may drift downstream before sticking to the gravel (Steiner, 2000). After hatching, larvae remain in the safety of the gravel for up to 2 weeks before moving on.

Adults primarily inhabit pools and areas of slow to moderate velocity, but are tolerant of a wide range of conditions. White suckers move toward shore at dawn and dusk to feed. They are omnivorous bottom feeders, feeding on plants, zooplankton, insects, mollusks, and crustaceans (Steiner, 2000).

Since 1925, this species has been one of the six most abundant fishes in collections across Ohio (Trautman, 1981). It is a popular catch among anglers, and is especially easy to catch during spawning runs (Ohio Department of Natural Resources, 2001b).

WHITE SUCKER
(*Catostomus commersoni*)

Family: Catostomidae (suckers).

Common names: White sucker, common sucker, mullet.[a]

Similar species: Longnose sucker.[b]

Geographic range: Most of Canada, and south through North Carolina to New Mexico in the United States.[a]

Habitat: Small and large streams, ponds, lakes, and reservoirs. Adults primarily inhabit pools and areas of slow to moderate velocity, but are tolerant of a wide range of conditions. Prefer swift water and gravel bottoms for spawning.[c,d]

Lifespan: The average lifespan is 5-7 years.

Fecundity: Males mature between 2 and 6 years, females 1 to 2 years later.[d] Females produce 20,000 to 50,000 eggs.[f]

Food Sources: Fry feed on plankton and small invertebrates; bottom feeding commences upon reaching a length of 1.6 to 1.8 cm (0.6 to 0.7 in).[a] Adults are omnivorous, feeding on plants, zooplankton, insects, mollusks, and crustaceans.[f]

Prey for: Birds, fishes, lamprey, and mammals.[a]

Life Stage Information

Eggs:
- Eggs are released over shallow gravel substrate.[d]

Larvae:
- Approximately 8 mm (0.3 in) upon hatching.[e]
- Remain in gravel substrate for up to 2 weeks.[f]

Adults: *Demersal*
- Maximum size is approximately 64 cm (25 in).[a]
- One of the six most abundant fishes in collections in Ohio since 1925.[b]

[a] Froese and Pauly, 2000.
[b] Trautman, 1981.
[c] Ohio Department of Natural Resources, 2001b.
[d] Twomey et al., 1984.
[e] Stewart, 1926.
[f] Steiner, 2000.
Fish graphic from North Dakota Game and Fish Department, 1986.

C3-3 Facility Impingement and Entrainment Monitoring Methods

This section discusses I&E monitoring at the Ohio River facilities. Sampling methods were slightly different at each facility. Descriptions of these methods are presented in the facility documents and summarized in Tables C3-2 and C3-3. Tables C3-4 and C3-5 indicate how I&E monitoring data were used to develop annual I&E rates.

In reviewing the I&E monitoring data presented here, it is important to note that the available data are over 20 years old and may not reflect current conditions. In fact, increases in fish populations resulting from Ohio River water quality improvements over the past 20 years could result in substantially higher rates of I&E than those in available reports.

C3-3.1 Cardinal Units 1 and 2 Impingement and Entrainment Monitoring

Cardinal impingement monitoring

NUS Corporation conducted impingement monitoring for Cardinal units 1 and 2 from May 11, 1978, to May 4, 1979 (Potter et al., 1979a). Samples were collected weekly from May through the end of October. Biweekly collections were made from November through March, at which time weekly collections were resumed and continued until May. Collections were taken for 28 hours, with fish removed from the traveling screens at 4 hour intervals. The fish collection basket was placed in the screen wash flume of units 1 and 2. The basket screen contained 9.5 mm (0.37 in) diameter holes.

Samples were sorted into groups of live, dead, and dead before impingement (Potter et al., 1979a). Those specimens considered dead before impingement were not included in the impingement estimates. Specimens were identified to the

lowest possible taxon. The average number of fish impinged during the first 24 hours of a 28 hour study was multiplied by 365 days in a year to generate an annual estimate of 163,593 (Potter et al., 1979a).

To calculate the losses in terms of numbers per species, EPA multiplied the percent impinged for each species for the number of days sampled by the total annual estimate (see Table C3-4).

Table C3-2: Summary of Impingement Sampling for all Ohio River Facilities.

Facility	Conducted by	Sampling Dates	Survey Period	Sampling Interval	Cleaning Run	Retaining Basket	Sampling Frequency
Cardinal[c]	NUS Corp.	May 11, 1978-May 4, 1979	28 hours	4 hours	Yes	9.5 mm (0.375 in) diameter mesh basket	Weekly: May - Oct. 1978, April-May 1979 Bimonthly: Nov. 1978 - March 1979
Clifty Creek[d]	EIA	April 29, 1977-April 27, 1978	32 hours	4 hours	Yes	9.5 mm (0.375 in) wire mesh	Weekly: April - Oct. 1977, April 1978 Bimonthly: Nov. 1977 - March 1978
Kammer[e]	NUS Corp.	May 8, 1978 - May 1, 1979	28 hours	4 hours	Yes	9.5 mm (0.375 in) sq. mesh basket	Weekly: May - Oct. 1978, April-May 1979 Bimonthly: Nov. 1978 - March 1979
Kyger[f]	NUS Corp.	April 10, 1978 - April 3, 1979	28 hours	4 hours	Yes	9.5 mm (0.375 in) sq. mesh basket	Weekly: April - Oct. 1978, late March-April 1979 Bimonthly: Nov. 1978 - March 20, 1979
Miami Fort[g]	Dames and Moore Inc; Wapora, Inc.	April, 1977-March, 1978	24 hours	12 hours	Yes	9.5 mm (0.375 in) wire mesh	Weekly: April - Oct. 1977 Bimonthly: Nov. 1977 - March 1978
Philip Sporn[h]	NUS Corp.	May 11, 1978-May 17, 1979	28 hours	4 hours	Yes	9.5 mm (0.375 in) sq. mesh basket[a]	Weekly: May - Oct. 1978, April-May 1979 Bimonthly: Nov. 1978 - March 1979
Tanners Creek[i]	EIA	May, 1977 - May, 1978	32 hours	4 hours	Yes	9.5 mm (0.375 in) wire mesh	Weekly: May - October 1977, April-May 1978 Biweekly from December through March
WC Beckjord[g]	Dames and Moore Inc; Wapora, Inc.	April, 1977-March, 1978	24 hours	12 hours	Yes[b]	9.5 mm (0.375 in) wire mesh[b]	Weekly: April - June 1977 Bimonthly: July 1977 - March 1978
WH Sammis[j]	Geo-Marine	April, 1977-March, 1978	24 hours	1 hr every 3 hrs for the 24 hr period	No	Unknown design	Approximately every 8 days

[a] These methods were assumed to be the same as all other NUC Corporation impingement studies. This page was missing from the document.

[b] These methods were assumed to be the same as those at Miami Fort. This page was missing from the document.

References:

[c] Potter et al., 1979a.

[d] Energy Impact Associates, Inc., 1978a.

[e] Potter et al., 1979b.

[f] Potter et al., 1979c.

[g] Cincinnati Gas and Electric Company, 1979.

[h] Potter et al., 1979d.

[i] Energy Impact Associates 1978b.

[j] Geo-Marine Inc., 1978.

Table C3-3: Summary of Entrainment Sampling for all Ohio River Facilities.

Facility	Conducted By	Survey Period	Sampling Interval	Method Used	Filter	Notes
Cardinal[a]	NUS Corp.	March 16, 1978 - February 1979	6 hour intervals over 24 hr. survey period	Taken from taps of all circulating water pumps, through 1 in. hose	505 µm (0.02 in) mesh net	Weekly: March - Sept. 1978 Bimonthly: Sept-Oct 1978 Monthly: Nov. 1978- Feb. 1979
Clifty Creek[b]	EIA	April 29, 1977- April 27, 1978	Continuously for 24 hrs.	2 submersible pumps, 1 m from surface and 1.5 m from bottom	500 µm (0.02 in) mesh net	Weekly: April through Aug. 1977, April 1978 Bimonthly: Sept. 1977, March 1978 Monthly: Oct. 1977 - Feb. 1978
Kammer[c]	NUS Corp.	March 13, 1978 - February, 1979	6 hour intervals over 24 hr. survey period	Taken from taps of all circulating water pumps, through 1 in. hose	505 µm (0.02 in) mesh net	Weekly: March - Aug. 1978 Bimonthly: Sept.-Oct. 1978 Monthly: Nov. 1978- Feb. 1979
Kyger[d]	NUS Corp.	March 13, 1978 - February, 1979	6 hour intervals over 24 hr. survey period	Taken from taps of all circulating water pumps, through 1 in. hose	505 µm (0.02 in) mesh net	Weekly: March - Aug. 1978 Bimonthly: Sept-Oct. 1978 Monthly: Nov. 1978- Feb. 1979
Miami Fort[e]	Dames and Moore Inc; Wapora, Inc.	April-August, 1977	12 hour intervals over 24 hour survey period	Taken from tap of circulating water pump.	1,000 µm (0.04 in) mesh net	Weekly: April - Aug. 1977
Philip Sporn[f]	NUS Corp.	March 16, 1978 - February, 1979	6 hour intervals over 24 hr. survey period	Taken from taps of all circulating water pumps, through 1 in. hose	505 µm (0.02 in) mesh net	Weekly: March - Aug. 1978 Bimonthly: Sept-Oct. 1978 Monthly: Nov. 1978- Feb. 1979
Tanners Creek[g]	EIA	May, 1977- May, 1978	Continuously for 24 hrs.	2 submersible pumps, 3 ft. from surface and 4.5-6 ft. from bottom	500 µm (0.02 in) mesh net	Weekly: May through Oct. 1977, April 1978 Bimonthly: Sept.-Oct. 1977, March 1978 Monthly: Oct. 1977 - Feb. 1978
WC Beckjord[e]	Dames and Moore Inc; Wapora, Inc.	April-August, 1977	12 hour intervals over 24 hr. survey period	Taken from tap of circulating water pump.	1,000 µm (0.04 in) mesh net	Weekly: April - Aug. 1977
WH Sammis[h]	Geo-Marine	April-August, 1977	4 2-hr. samples were taken	Taken from tap of CWIS	505 µm (0.02 in) mesh net	April through June: Every 4 days July through August: Every 8 days

[a] Potter et al., 1979a.
[b] Energy Impact Associates, Inc., 1978a.
[c] Potter et al., 1979b.
[d] Potter et al., 1979c.
[e] Cincinnati Gas and Electric Company, 1979.
[f] Potter et al., 1979d.
[g] Energy Impact Associates 1978b.
[h] Geo-Marine Inc., 1978.

Table C3-4: Methods Used for Estimating Annual Impingement.

Facility	Facility Annual Impingement Estimates	EPA Annual Impingement Estimates
Cardinal[a]	Multiplied average number of fish impinged during first 24 hrs. by 365.	Calculated by multiplying percent impinged for each species by the reported annual impingement estimate of 163,593.
Clifty Creek[b]	Each interval treated as replicate, extrapolated mean to weekly estimate, summed to monthly, summed to annual.	Used as reported
Kammer[c]	Multiplied average number of fish impinged during first 24 hrs. by 365.	Calculated by dividing the number impinged for each species by the total number of fish impinged to get a percentage of impingement for each species. This number was then multiplied by the reported annual impingement estimate of 12,520.
Kyger[d]	Multiplied average number of fish impinged during first 24 hrs. by 365.	Calculated percent impingement of each species out of total number impinged, then multiplied percent each species by the reported annual impingement estimate of 186,223.
Miami Fort[e]	Multiplied by 365 days/number sampling days (39)	Calculated by multiplying the number of fish impinged for each species by the fraction of days sampled within the year (365 days/36 days, or 10.139).
Philip Sporn[f]	Multiplied average number of fish impinged during first 24 hrs. by 365.	Calculated percent impingement of each species out of total number impinged, then multiplied percent each species by the reported annual impingement estimate of 52,136.
Tanners Creek[g]	Each interval treated as replicate, extrapolated mean to weekly estimate, summed to monthly, summed to annual.	Used as reported
WC Beckjord[h]	Only reported for some species. Calculated by multiplying the number of fish impinged for each species by the fraction of days sampled within the year.	Calculated for all species.
WH Sammis[i]	Extrapolated to a 24 hour period, then multiplied by the sample interval, and summed values for annual estimate.	Calculated by summing the number impinged for each species as presented in Geo-Marine Inc., 1978 (Appendix), then dividing this number by the total number impinged (47,463) to get a percent impingement for each species. These percentages were then multiplied by the reported annual impingement estimate of 380,793.

[a] Potter et al., 1979a.
[b] Energy Impact Associates, Inc., 1978a.
[c] Potter et al., 1979b.
[d] Potter et al., 1979c.
[e] Cincinnati Gas and Electric Company, 1979.
[f] Potter et al., 1979d.
[g] Energy Impact Associates, Inc., 1978b.
[h] Cincinnati Gas and Electric Company, 1979.
[i] Geo-Marine Inc., 1978.

Table C3-5: Methods Used for Estimating Annual Entrainment.

Facility	Facility Annual Entrainment Estimates	EPA Annual Entrainment Estimates
Cardinal[a]	Multiply average number of individuals per 100 m^3 (3,531 ft^3) by volume of water for 24 hour estimate, calculated monthly estimate, summed to annual estimate assuming 0 for months samples were not analyzed.	Used as reported
Clifty Creek[b]	Multiply average number of individuals per 100 m^3 (3,531 ft^3) by volume of water for weekly estimate, grouped by months, calculated weekly mean, summed to monthly, then annual.	Calculated percent entrained for each species from the total number impinged, then multiplied percent entrained by the reported annual entrainment estimate of 70,057,789.
Kammer[c]	Multiply average number of individuals per 100 m^3 (3,531 ft^3) by volume of water for 24 hour estimate, calculated monthly estimate, summed to annual estimate assuming 0 for months samples were not analyzed.	Used as reported
Kyger[d]	Multiply average number of individuals per 100 m^3 (3,531 ft^3) by volume of water for 24 hour estimate, calculated monthly estimate, summed to annual estimate assuming 0 for months samples were not analyzed.	Used as reported
Miami Fort[e]	Not calculated. Daily loss estimates were calculated by the number of larvae entrained per cubic meter by the daily plant intake volume.	Calculated by extrapolating the daily loss estimates for each species to monthly estimates based on the number of sampling days out of the number of days per month, then added monthly estimates for each species to arrive at an annual estimate.
Philip Sporn[f]	Multiply average number of individuals per 100 m^3 (3,531 ft^3) by volume of water for 24 hour estimate, calculated monthly estimate, summed to annual estimate assuming 0 for months samples were not analyzed.	Used as reported
Tanners Creek[g]	Multiply average number of individuals per 100 m^3 (3,531 ft^3) by volume of water for weekly estimate, grouped by months, calculated weekly mean, summed to monthly, then annual.	Calculated by multiplying percent entrained for each species by the reported annual entrainment estimate of 11,789,997.
WC Beckjord[h]	Calculated using data from April-August. Daily loss estimates were calculated by the number of larvae entrained per cubic meter by the daily plant intake volume.	Used as reported
WH Sammis[i]	Multiplied average number of individuals per 100 m^3 (3,531 ft^3) by volume of water for 24 hour estimate, calculated monthly estimate, summed to annual estimate assuming 0 for months samples were not analyzed.	Calculated by multiplying percent entrained for each species by the reported annual entrainment estimate of 17,362,208.

[a] Potter et al., 1979a.
[b] Energy Impact Associates, Inc., 1978a.
[c] Potter et al., 1979b.
[d] Potter et al., 1979c.
[e] Cincinnati Gas and Electric Company, 1979.
[f] Potter et al., 1979d.
[g] Energy Impact Associates, Inc., 1978b.
[h] Cincinnati Gas and Electric Company, 1979.
[i] Geo-Marine Inc., 1978.

Cardinal entrainment monitoring

NUS Corporation conducted entrainment monitoring at Cardinal units 1 and 2 from March 1977 through February 1978 (Potter et al., 1979a). Sampling was conducted weekly from March through September 1978, bimonthly in September and October 1978, and monthly from November 1978 through February 1979. Continuous 24-hour samples were collected for larval entrainment. Samples were collected from taps on circulating pumps through a 1 inch hose into a 505 µm (0.02 in) mesh size plankton net. At 6 hour intervals, samples were collected from the net and preserved for analysis. Sample volumes were determined at 3 hour intervals by placing flow meters in the line of flow of the discharged water. Samples taken from September 1978 through February 1979 were not analyzed at the request of the facility operator.

Annual estimates were calculated by extrapolating daily estimates of each taxa collected by the volume of water from one circulating pump to all operating pumps for each sample date (Potter et al., 1979a; Table C3-5). This value was then assumed constant for all days between collection dates, and extrapolated to a monthly estimate. Monthly estimates were then summed to generate annual estimates. It was assumed that no ichthyoplankton were entrained from September through February.

C3-3.2 Clifty Creek Impingement and Entrainment Monitoring

Clifty Creek impingement monitoring

Energy Impact Associates conducted impingement monitoring at Clifty Creek from April 1977 through April 1978 (Energy Impact Associates, Inc., 1978a). Impingement samples were taken weekly from April to October 1977, in April 1978, and bimonthly from November 1977 to March 1978. Following a cleaning run in which all operational screens were backwashed of debris, a retaining basket constructed of 9.7 mm (0.38 in) mesh screen was placed over the side of the screen house to catch the debris and fish being washed out of the trash trough. Screens were backwashed at 4-hour intervals over a 32 hour sampling period. At the end of each 4-hour sampling interval, the retaining basket was emptied, and the fish were removed and sorted from the debris. The fish were then identified, counted, weighed, and measured. Extrapolating from the 4-hour sampling interval allowed an annual calculation of the mean number of fish impinged. Each 4-hour interval was used as a replicate for the 32-hour sampling period to calculate the mean number and weight of each species. The estimate was then extrapolated to a weekly estimate, then summed to obtain a monthly estimate, and a yearly estimate.

Impingement sampling was conducted again in 1985-1986 (EA Science and Technology, 1987). Collections were made twice a month from December 1985 through February 1986, and weekly from March 1986 through December 1986. Samples were collected from the traveling screens every 8 hours for a 24 hour period on sample dates. The collection basket was constructed of 9.5 mm (0.375 in) mesh, and was placed in the debris trough of the traveling screens before the traveling screens were washed. All organisms and debris rinsed from the traveling screens were caught in the collection basket. Fish were sorted, identified, and counted. Fish obviously dead before impingement were not included in the estimate of annual impingement. Annual estimates were made by first multiplying the 24 hour bimonthly impingement values by 15 and the weekly values by 7 to reflect the number of fish impinged during each sampling interval (the number of days between sampling events) (Table C3-4). These values were summed to generate monthly and annual estimates of fish impingement.

Clifty Creek entrainment monitoring

Energy Impact Associates performed entrainment sampling from April 1977 through April 1978 (Energy Impact Associates, Inc., 1978a). A total of 33 sampling periods took place between April 29, 1977 and April 27, 1978, each conducted over a 24 hour survey period. The sampling periods took place weekly from April through August, bimonthly in September, monthly from October to February, bimonthly in March, and returned to weekly in April 1978.

Sampling was conducted using two submersible pumps (Energy Impact Associates, Inc., 1978a). The pumps were placed in front of the traveling screen, with one pump positioned approximately 1 m (3.3 ft) from the surface and the other approximately 1.5 m (4.9 ft) from the bottom, behind the intake gate opening. Samples were generally collected from units 1 and 6 only. Water was continuously pumped through a 500 µm (0.02 in) mesh plankton net for 24 hours. These samples were then analyzed for species identification, enumeration, and life stage.

Entrainment results from units 1 and 6 were extrapolated to develop an annual estimate for the whole facility by multiplying the average number of larvae entrained by the volume of water withdrawn from the Ohio River by the facility during the sampling period (Energy Impact Associates, Inc., 1978a). This number was extrapolated to a weekly estimate, grouped by month, and then used to calculate a weekly average. These weekly averages were then extrapolated to monthly entrainment losses and summed to determine a total annual loss estimate.

The EPA obtained annual estimates for each species by calculating the percent entrainment for each species for the number of days sampled, then multiplied the percent entrained by the reported annual entrainment estimate of 70,057,789 (Table C3-4).

C3-3.3 Kammer Impingement and Entrainment Monitoring

Kammer impingement monitoring

NUS Corporation conducted impingement monitoring from May 8, 1978 through May 1, 1979 (Potter et al., 1979b). Samples were collected weekly from May 1978 through October 24, 1978. Biweekly collections were made from November through March, at which time weekly collections were resumed and continued until May. Collections lasted 28 hours, with fish removed from the traveling screens at 4 hour intervals. The fish collection basket was placed at the lower end of the screen trash trough. The basket screen contained 9.5 mm (0.375 in) diameter holes.

Samples were sorted into groups of live, dead, and dead before impingement (Potter et al., 1979b). Those specimens considered dead before impingement were not included in the impingement estimates. Specimens were identified to the lowest possible taxon. The average number of fish impinged during the first 24 hours of a 28 hour study was multiplied by 365 days in a year to generate an annual estimate.

Annual impingement estimates are not presented in the facility document by species. To calculate the annual losses in terms of numbers per species, EPA multiplied the percent impinged for each species for the number of days sampled by the total annual estimate (Table C3-4).

Kammer entrainment monitoring

NUS Corporation conducted entrainment monitoring from March 1977 through February 1979 (Potter et al., 1979b). Sampling was conducted weekly from March through August 1978, bimonthly in September and October 1978, and monthly from November 1978 through February 1979. Continuous 24-hour samples were collected from taps on circulating pumps through a 2.5 cm (1 in) hose into a 505 µm (0.02 in) mesh size plankton net. At 6 hour intervals, samples were collected from the net and preserved for analysis. Sample volumes were determined at 3 hour intervals by placing flow meters in the line of flow of the discharged water. Samples taken from September 1978 through February 1979 were not analyzed at the request of the facility operator.

Annual estimates were calculated by extrapolating daily estimates of each taxa collected by the volume of water from one circulating pump to all operating pumps for each sample date (Potter et al., 1979b). This value was then assumed constant for all days between collection dates, and extrapolated to a monthly estimate. Monthly estimates were then summed to generate annual estimates. It was assumed that no ichthyoplankton were entrained from September through February (Table C3-5).

C3-3.4 Kyger Impingement and Entrainment Monitoring

Kyger Creek impingement monitoring

NUS Corporation conducted impingement monitoring from April 10, 1978, through April 3, 1979 (Potter et al., 1979c). Samples were collected weekly from April 1978 through October 1978. Biweekly collections were made from November through March, at which time weekly collections were resumed and continued until May. Collections lasted 28 hours, with fish removed from the traveling screens at 4 hour intervals. The fish collection basket was placed at the lower end of the screen trash trough. The basket screen contained 9.5 mm (0.375 in) diameter holes.

Samples were sorted into groups of live, dead, and dead before impingement (Potter et al., 1979c). Those specimens considered dead before impingement were not included in the impingement estimates. Specimens were identified to the lowest possible taxon. The average number of fish impinged during the first 24 hours of a 28 hour study was multiplied by 365 days in a year to generate an annual estimate of 186,223 fish.

EPA used this annual estimate to calculate annual estimates for each species by calculating the percent impingement of each species out of total number impinged, then multiplying the percent for each species by the reported annual impingement estimate (Table C3-4).

Kyger Creek entrainment monitoring

NUS Corporation conducted entrainment monitoring from March 13, 1977 through February 1979 (Potter et al., 1979c). Sampling was conducted weekly from March through August 1978, bimonthly in September and October 1978, and monthly from November 1978 through February 1979. Continuous 24-hour samples were collected from taps on circulating pumps through a 1 inch hose into a 505 µm (0.02 in) mesh size plankton net. Every 6 hours samples were collected from the net and were preserved for analysis. Sample volumes were determined at 3 hour intervals by placing flow meters in the line of flow of the discharged water. Samples taken from September 1978 through February 1979 were not analyzed at the request of the facility operator.

Annual estimates were calculated by extrapolating daily estimates of each taxa collected by the volume of water from one circulating pump to all operating pumps for each sample date (Potter et al., 1979c). This value was then assumed constant for all days between collection dates, and extrapolated to a monthly estimate. Monthly estimates were then summed to generate annual estimates. It was assumed that no ichthyoplankton were entrained from September through February.

EPA used the annual entrainment numbers for each species as reported (Table C3-5).

C3-3.5 Miami Fort Power Station Impingement and Entrainment Monitoring

Miami Fort impingement monitoring

Dames and Moore conducted impingement sampling from April 1977 through March 1978 (Cincinnati Gas and Electric Company, 1979). Samples were collected from the traveling screens once a week from April through October 1977, and once every two weeks from November 1977 through March 1978. The screens were thoroughly cleaned before each sampling and left in place for 12 hours. At the end of the 12 hours, the screens were washed and the impinged fish were collected from the wash trough using multiple metal sampling screens composed of 9.5 mm (0.375 in) mesh screen identical to the traveling screens. The process was repeated 12 hours later to obtain a 24 hour sampling period. Samples were preserved and analyzed for identification and enumeration. Annual estimates were not calculated by the facility.

EPA developed annual estimates by multiplying the number of fish impinged for each species by the fraction of days sampled within the year (365 days/36 sampling days, or 10.139) (Table C3-4).

Miami Fort entrainment monitoring

Dames and Moore conducted entrainment sampling from April through August 1977 (Cincinnati Gas and Electric Company, 1979). Samples were collected from the tap on the circulating pump for unit 6. Unit 6 is the largest generating unit at Miami Fort that uses a once-through cooling system. Once a week, samples were collected for two blocks of time, each covering 12 hours to obtain a 24 hour sampling period showing daily variations in larval activity. Water collected from the taps was strained through a 1,000 µm (0.04 in) mesh net, and samples were preserved for analysis.

Daily loss estimates were calculated by the number of larvae entrained per cubic meter by the daily plant intake volume (Cincinnati Gas and Electric Company, 1979). No annual entrainment estimates were presented in the facility's § 316(b) demonstration report.

EPA developed annual estimates by extrapolating the daily loss estimates for each species to monthly estimates based on the number of sampling days out of the number of days per month, then added these monthly estimates for each species to arrive at an annual estimate (Table C3-5).

C3-3.6 Philip Sporn Impingement and Entrainment Monitoring

Philip Sporn impingement monitoring

NUS Corporation conducted impingement monitoring from May 11, 1978, to May 17, 1979 (Potter et al., 1979d). Samples were collected weekly from May through the end of October. Biweekly collections were made from November through March, at which time weekly collections were resumed and continued until May. Assuming that NUC Corporation used the same procedures as they did in three other impingement monitoring reports, collections lasted 28 hours, with fish removed from the traveling screens at 4 hour intervals. The fish collection basket was placed in the screen wash flume of units 1 and 2.

The basket screen contained 9.5 mm (0.375 in) diameter holes. Sampling periods of this length in time would capture differences in daily variation.

Samples were sorted into groups of live, dead, and dead before impingement (Potter et al., 1979d). Those specimens considered dead before impingement were not included in the impingement estimates. Specimens were identified to the lowest possible taxa. The average number of fish impinged during the first 24 hours of a 28 hour study was multiplied by 365 days in a year to generate a total annual impingement estimate of 52,136.

To calculate the annual impingement estimate for each species, EPA calculated the percent impingement of each species out of the total number of fish impinged, then multiplied the percent for each species by the reported annual impingement estimate (Table C3-4).

Philip Sporn entrainment monitoring

Entrainment samples were taken from March 16, 1978 through February 1979 with the following frequency of sampling: weekly from March through August 1978, bimonthly from September to October, and monthly from November 1978 through February 1979 (Potter et al., 1979d). Continuous 24-hour samples were collected for larval entrainment. Samples were collected from taps on circulating pumps through a 1 inch hose, into a 505 µm (0.02 in) mesh size plankton net. Every 6 hours samples were collected from the net and were preserved for analysis. Sample volumes were determined at 3 hour intervals by placing flow meters in the line of flow of the discharged water. Samples taken from September 1978 through February 1979 were not analyzed at the request of the facility operator.

Annual estimates were calculated by extrapolating daily estimates of each taxa collected by the volume of water from one circulating pump to all operating pumps for each sample date (Potter et al., 1979d). This value was then assumed constant for all days between collection dates, and extrapolated to a monthly estimate. Monthly estimates were then summed to generate annual estimates. It was assumed that no ichthyoplankton were entrained from September through February.

EPA used the annual entrainment numbers for each species as reported (Table C3-5).

C3-3.7 Tanners Impingement and Entrainment Monitoring

Tanners Creek impingement monitoring

Energy Impact Associates conducted impingement monitoring at Tanners Creek from May 1977 through May 1978 (Energy Impact Associates, Inc., 1978b). Sampling was done weekly from May through October 1977 and April to May 1978, and biweekly from December through March. Fish were collected from the intake traveling every 4 hours during a 32 hour study period. Collections were made once a week from March through October, and once every 2 weeks from November until mid-March of the following year. Fish were collected in 9.7 mm (0.38 in) mesh baskets that were placed in the trash troughs of the traveling screens. Baskets were emptied at the end of each 4 hour sample period. Fish were then identified, counted, measured, and weighed.

Annual estimates were made by determining the average number of each fish species impinged in a 4 hour interval on each sample date (Energy Impact Associates, Inc., 1978b). This estimate was extrapolated to a weekly estimate, which was summed with other weekly estimates to generate a monthly impingement estimate. Monthly impingement estimates were then summed to determine an annual estimate.

EPA used the annual impingement numbers for each species as reported (Table C3-4).

Tanners Creek entrainment monitoring

Energy Impact Associates conducted entrainment monitoring from May 1977 through May 1978. Sampling was done weekly from May through August 1977 and April to May 1978; biweekly in September, October, and March; and monthly from November through February (Energy Impact Associates, Inc., 1978b). Samples collected from September through February were not analyzed. Submersible pumps were placed under water in front of the traveling screens near the intake structure at units 1 and 3. The surface pumps were placed approximately 0.9 m (2.95 ft) below the waters surface and the bottom pumps were placed 1.4 to 1.8 m (4.6 to 5.9 ft) from the bottom, behind the intake gate opening. The pumps were operated continuously for 24 hours during each collection period. Water from the pumps emptied into a 500 µm (0.02 in) mesh plankton net. Larvae collected were identified and counted per the unit volume of water sampled.

Annual estimates were made by first determining the mean number of fish and larvae per species entrained per 100 m^3 (3,531 ft^3) of water in the 24 hour sampling period (Energy Impact Associates, Inc., 1978b). These values were then extrapolated to weekly estimates, which were then summed for monthly and yearly estimates.

EPA calculated the annual entrainment estimate by multiplying the percent of fish entrained for each species by the reported annual entrainment estimate of 11,789,997 (Table C3-5).

C3-3.8 W.C. Beckjord Power Station Impingement and Entrainment Monitoring

For the Beckjord facility, EPA assumed that sampling methods were the same as those used at the Miami Fort Power Station, which were presented together in the same document (Cincinnati Gas and Electric Company, 1979).

W.C. Beckjord impingement monitoring

To sample impingement, intake screens were thoroughly cleaned and left in place for 12 hours. At the end of 12 hours, the screens were washed and the impinged fish were collected from the wash trough using multiple metal sampling screens composed of 9.5 mm (0.375 in) mesh screen identical to the traveling screens. The process was repeated 12 hours later to obtain a 24 hour sampling period. Samples were preserved and analyzed for identification and enumeration.

Impingement samples were collected at Intake 3 once a week from April through June 1977, and bimonthly from July 1977 through March 1978 (Cincinnati Gas and Electric Company, 1979). If more than 100 fish were removed from the traveling screens at Intake 3, then the traveling screens at Intakes 1 and 2 were sampled. Out of 32 days of impingement sampling, Intake 3 was sampled for 25 days, and Intakes 1 and 2 were sampled 7 out of the 32 sampling days. The facility calculated annual impingement for selected species by multiplying the number of fish impinged by the number of days per year divided by the number of sampling days (Cincinnati Gas and Electric Company, 1979; Table C3-4).

W.C. Beckjord entrainment monitoring

Entrainment samples were collected from taps on circulating pumps on units 2,4, 5, and 6 from April through August 1977 (Cincinnati Gas and Electric Company, 1979). The majority of the samples were taken from unit 6 since it is located upstream of the other units and uses the most circulating water. During the sampling, unit 6 was taken out of service for maintenance, and unit 5 became the primary source for the samples. Units 2 and 4 were sampled three times each during the sampling regime. Once a week samples were collected from one of the units for two blocks of time, each covering 12 hours. In this manner, 24 hours of continuous sampling was achieved, to ensure that daily variations in larval activity would be captured. Water collected from the taps was strained through a 1,000 µm (0.04 in) mesh net, and samples were preserved for analysis.

Daily loss estimates were calculated by multiplying the number of larvae entrained per cubic meter by the daily plant intake volume (Cincinnati Gas and Electric Company, 1979). The sum of the monthly estimates for each species for April through July was reported as the annual entrainment estimate, which assumes no entrainment from August through March. EPA used these numbers as provided in the facility's 316(b) Demonstration Report for the annual entrainment estimates (Table C3-5).

C3-3.9 W.H. Sammis Impingement and Entrainment Monitoring

W.H. Sammis impingement monitoring

Dames and Moore collected impingement samples approximately every 8 days from April 7, 1977, to March 27, 1978 (Geo-Marine Inc., 1978). Samples were collected by diverting the screen wash flow into a basket constructed by Ohio Edison for a 1 hour sampling interval every 3 hours for each 24-hour sampling period. Fish that were obviously dead before impingement were removed from the sample. Annual estimates were made by multiplying the number of fish impinged per 1 hour sample by 3 to extrapolate to a 24 hour period. This number was then multiplied by the sample interval (generally 8 days) to get an estimate for that time period, and these estimates were summed to obtain the annual impingement estimate of 380,793.

EPA calculated impingement estimates for each species by summing the number impinged for each species as presented in Geo-Marine Inc. (1978, appendix), then dividing this number by the total number impinged (47,463) to get a percent impingement for each species. While the facility reported a total of 47,464 organisms impinged, EPA calculated 47,463 from

the data reported in the appendix. The percentages were then multiplied by the reported annual impingement estimate (Table C3-4).

W.H. Sammis entrainment monitoring

Geo-Marine conducted W.H. Sammis entrainment monitoring in 1977 (Geo-Marine Inc., 1978). Entrainment samples were collected approximately every 4 days between April and early July, and every 8 days from early July through the end of August. Because of the daily patterns exhibited by larvae, sample collections were spread out over a 24-hour period on each sample date. Four 2-hour sample collections were made over each 24-hour period. Two samples were collected during the day, and two were collected at night to account for the diel movements of ichthyoplankton, resulting in a total of 8 hours of sampling time per 24-hour day. Samples were collected by tapping into a 457 mm (18 in) line in the main condenser cooling line of the CWIS. The water passed through a 10 cm (4 in) tap, then was filtered through a 505 µm (0.02 in) mesh size plankton net. Every 8 days additional sampling was conducted at dawn and dusk for 2 hours at each time period, resulting in a total of 600 m^3 (21,189 ft^3) of water being filtered on these days.

An annual entrainment estimate of 17,362,208 was calculated by multiplying the average number of larvae entrained per 100 m^3 (3,531 ft^3) of water during a given sampling period by the sampling interval and by the volume of water withdrawn from the Ohio River by the power plant for that sampling period for the months of April through August (Geo-Marine Inc., 1978). It was assumed that no entrainment took place outside of those months.

Annual entrainment estimates for each species were calculated by EPA by multiplying the percent entrained for each species by the reported annual entrainment estimate of 17,362,208 (Table C3-5).

C3-4 Annual Impingement at Nine Ohio River Facilities

Annual impingement (numbers of organisms) as estimated from facility monitoring are presented in Table C3-6. Table C3-7 presents the results of EPA's calculations to express these losses as age 1 equivalents, Table C3-8 presents impingement of fishery species as pounds of lost yield, and Table C3-9 presents impingement as pounds of production foregone. The equations used for these calculations are presented in Chapter A5 of Part A this document.

Note that the numbers of species in tables of age 1 equivalents, yield, and production foregone, are fewer than the number of species listed in the table of raw losses. This is because the life history data required to calculate these metrics are unavailable for many species. In such cases, species were grouped and evaluated using life history data for a single representative species. The life history data used these calculations are presented in Appendix C1. Appendix C2 defines the species groups used to calculate losses of rare species for which life history data were lacking.

In examining the impingement results, it is important to bear in mind that the available impingement data are for only a single year of sampling conducted 25 years ago. As noted previously, these data are likely to underestimate current impingement rates because of improvements in fish populations since the data were collected.

C3-5 Annual Entrainment at Nine Ohio River Case Study Facilities

Annual entrainment (numbers of organisms) as estimated from facility monitoring are presented in Table C3-10. The following sections present the results of calculations performed by EPA to express these losses as age 1 equivalents (Table C3-11) , foregone fishery yield (Table C3-12), and biomass production foregone (Table C3-13) using the methods described in Chapter A5 of Part A of this document and the life history data in Appendix C1.

Note that the numbers of species in the tables of age 1 equivalents, yield, and production foregone are fewer than the number of species listed in the table of raw losses. This is because the life history data required to calculate these metrics are unavailable for many species. In such cases, species were grouped and evaluated using life history data for a single representative species. The life history data used these calculations are presented in Appendix C1. Appendix C2 defines the species groups used to calculate losses of rare species for which life history data were lacking.

As noted for impingement, it is important to bear in mind that entrainment results are likely to underestimate entrainment because of improvements in fish populations since the data were collected over two decades ago.

C3-6 Methods Used to Extrapolate I&E Rates to Other Ohio River Facilities

EPA used the results from its detailed analysis of I&E at the 9 Ohio River case study facilities (presented above in Sections C3-4 and C3-5) as a basis for estimating I&E at other Ohio River CWIS. Extrapolation was necessary because there are no I&E data for these other facilities. For the extrapolations, EPA assumed that I&E is strictly proportional to intake flow and that I&E at the 9 Ohio River case study facilities are representative of I&E at other CWIS in the same or nearby pools.[1] Table C3-14 indicates the pool locations of all Ohio River CWIS that were evaluated by EPA, and Table C3-15 indicates how these facilities were grouped according to pool for EPA's analyses. Table C3-16 summarizes how facilities with and without I&E data were linked for extrapolation purposes. EPA extrapolated impingement and entrainment separately using each of three I&E metrics (age-1 equivalents, fishery yield, and production foregone). Impingement results are presented in Tables C3-17 through C3-22. Entrainment results are presented in Tables C3-23 through C3-28. Cumulative impacts are summarized in Tables C3-29 and C3-30 based on the sum of the mean for each pool. The economic value of these losses is discussed in Chapters C4 (benefits transfer) and C5 (RUM analysis). The potential benefits of reducing these losses with the proposed rule are discussed in Chapter E6.

[1] Because many facilities consider intake flow to be "confidential business information" not all of the intake flows used in these calculations are presented in this report.

Table C3-6: Annual Impingement (numbers of organisms), by Species, at Nine Ohio River CWIS as Estimated from Facility Monitoring.

Species	W.C. Beckjord	Cardinal	Clifty Creek	Kammer	Kyger Creek	Miami Fort	Philip Sporn	Tanners Creek	W.H. Sammis
American eel	0	0	2	0	0	0	0	0	0
Banded sculpin	0	0	2	0	0	0	0	0	0
Bigmouth buffalo	0	0	1,378	0	0	180	12	258	0
Black bullhead	0	0	0	0	0	30	0	0	0
Black crappie	172	13,270	1,932	326	2,062	154	3,537	553	3,346
Bluegill	228	3,292	9,826	269	2,047	184	1,836	1,780	1,725
Bluntnose minnow	0	1,601	21	65	374	0	36	0	995
Brown bullhead	0	243	136	65	54	0	97	64	650
Channel catfish	217	10,542	1,670	791	5,222	738	5,823	702	11,513
Chestnut lamprey	0	13	0	0	0	0	0	0	0
Chub	0	0	0	0	0	8	0	0	0
Coho salmon	0	0	6	0	0	0	0	0	0
Common carp	11	1,460	346	82	125	290	61	253	9,844
Crayfish	0	0	0	0	0	0	0	0	2,720
Creek chub	0	0	10	0	8	0	24	0	0
Darter spp.	0	192	0	0	0	0	0	0	0
Eastern banded killifish	0	0	0	0	0	0	0	0	120
Emerald shiner	1,289	24,362	2,482	1,811	11,370	1,358	3,027	1,712	37,612
Freshwater drum	7,836	666	106,176	237	26,125	39,720	13,955	19,868	24
Gizzard shad	31,789	103,879	1,482,220	8,140	133,404	145,212	20,179	110,362	299,545
Golden redhorse	354	423	233	188	163	322	73	43	337
Goldeye	11	0	29	0	0	128	0	95	0
Grass pickerel	0	13	0	0	0	0	0	0	0
Logperch	0	0	142	16	109	38	73	5	289
Longear sunfish	11	0	0	122	475	0	243	94	0
Longnose gar	0	0	306	0	54	30	36	27	0
Madtom spp.	0	0	0	0	0	0	0	0	24
Minnow spp.	0	0	0	0	0	8	0	0	0
Mooneye	11	0	4,107	0	218	358	0	1,560	0
Muskellunge	0	90	0	0	0	0	0	0	24
Northern pike	0	0	0	8	39	0	24	0	0
Paddlefish	11	0	504	0	0	800	0	4,289	0
Percid spp.	11	0	0	0	0	0	0	0	0
Rainbow smelt	0	0	4	0	0	0	0	0	0
Rainbow trout	0	0	0	0	0	0	0	0	48
Red bass	0	0	0	0	0	0	12	0	0
River carpsucker	491	0	0	0	265	4,271	0	341	0
Sauger	1,825	167	7,449	65	2,451	4,576	1,702	1,886	48
Silver chub	23	0	742	8	498	270	960	148	0
Silver lamprey	0	0	6	0	0	0	24	0	0
Skipjack herring	1,711	64	89,012	0	156	18,671	36	32,571	1,564
Smallmouth bass	0	359	334	73	70	0	36	21	722
Stonecat	0	0	4	0	0	0	0	0	0
Stoneroller	0	0	0	0	0	0	12	0	0
Striped bass	0	0	112	0	0	0	0	0	0
Sucker spp.	0	179	2,290	41	0	0	97	0	554
Sunfish spp.	0	1,588	634	0	0	0	0	0	1,584

Table C3-6: Annual Impingement (numbers of organisms), by Species, at Nine Ohio River CWIS as Estimated from Facility Monitoring (cont.).

Species	W.C. Beckjord	Cardinal	Clifty Creek	Kammer	Kyger Creek	Miami Fort	Philip Sporn	Tanners Creek	W.H. Sammis
Troutperch	0	0	0	33	0	0	0	0	329
Unidentified	34	0	8	0	0	616	0	16	0
Walleye	0	26	119	0	8	0	0	0	72
White bass	924	948	15,134	163	786	3,392	170	2,844	6,651
Yellow perch	0	218	17	16	140	0	49	0	834

0 = Sampled, but none collected or rounded to 0.
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Table C3-7: Annual Impingement at 9 Ohio River CWIS Expressed as Numbers of Age 1 Equivalents.

Facility	Bigmouth Buffalo	Black Bullhead	Black Crappie	Bluegill	Bluntnose Minnow	Brown Bullhead	Channel Catfish	Common Carp	Darter spp.	Emerald Shiner	Freshwater Drum	Gizzard Shad	Golden Redhorse
W.C. Beckjord	0	0	208	272	0	0	280	12	0	1,841	9,041	45,413	449
Cardinal	0	0	16,063	3,926	2,341	297	13,587	1,649	257	34,803	768	148,398	536
Clifty Creek	1,746	0	2,338	11,718	31	166	2,153	391	0	3,546	122,503	2,117,457	295
Kammer	0	0	395	321	95	80	1,020	92	0	2,587	273	11,629	238
Kyger Creek	0	0	2,496	2,441	546	66	6,731	141	0	16,243	30,143	190,578	207
Miami Fort	0	37	187	220	0	0	951	327	0	1,939	45,828	207,445	409
Philip Sporn	15	0	4,282	2,189	53	119	7,505	69	0	4,324	16,101	28,826	92
Tanners Creek	327	0	669	2,123	0	78	905	286	0	2,446	22,923	157,660	54
W.H. Sammis	0	0	4,050	2,057	1,455	792	14,839	11,117	0	53,731	28	427,921	427
Mean value	232	4	3,410	2,807	502	178	5,330	1,565	29	13,496	27,512	370,592	301

0 = Sampled, but none collected or rounded to 0.
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Table C3-7: Annual Impingement at 9 Ohio River CWIS Expressed as Numbers of Age 1 Equivalents (cont.).

Facility	Log-perch	Longear Sunfish	Minnow spp.	Muskel-lunge	Paddle-fish	Perch spp.	Rainbow Smelt	River Carpsucker	Sauger	Skip-jack Herring	Small-mouth Bass	Striped Bass	Sucker spp.	Sunfish spp.	Walleye	White Bass	Yellow Perch
W.C. Beckjord	0	18	0	0	0	15	0	622	2,056	2,287	0	0	0	0	0	1,115	0
Cardinal	0	0	0	96	0	0	0	0	188	86	520	0	227	2,647	29	1,144	400
Clifty Creek	190	0	0	0	643	0	5	0	8,392	118,953	485	168	2,901	1,056	137	18,266	31
Kammer	22	204	0	0	0	0	0	0	74	0	106	0	52	0	0	197	30
Kyger Creek	146	791	0	0	0	0	0	335	2,762	208	102	0	0	0	9	949	257
Miami Fort	50	0	11	0	1,021	0	0	5,412	5,156	24,951	0	0	0	0	0	4,094	0
Philip Sporn	97	405	0	0	0	0	0	0	1,917	49	53	0	123	0	0	205	89
Tanners Creek	7	157	0	0	5,479	0	0	432	2,125	43,527	30	0	0	0	0	0	0
W.H. Sammis	386	0	0	26	0	0	0	0	54	2,091	1,047	0	701	2,640	83	8,028	1,531
Mean value	100	175	1	14	794	2	1	756	2,525	21,350	260	19	445	705	29	3,778	260

0 = Sampled, but none collected or rounded to 0.
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Table C3-8: Annual Impingement at 9 Ohio River Facilities Expressed as Yield Lost to Fisheries (in pounds).

Facility	Black Crappie	Bluegill	Channel Catfish
W.C. Beckjord	2	0	9
Cardinal	133	1	425
Clifty Creek	19	2	67
Kammer	3	0	32
Kyger Creek	21	0	210
Miami Fort	2	0	30
Philip Sporn	36	0	234
Tanners Creek	6	0	28
W.H. Sammis	34	0	464
Mean value	28	1	167

0 = Sampled, but none collected or rounded to 0.
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Table C3-8: Annual Impingement at 9 Ohio River Facilities Expressed as Yield Lost to Fisheries (in pounds) (cont.).

Facility	Muskellunge	Paddle-fish	Sauger	Smallmouth Bass	Striped Bass	Sunfish spp.	Walleye	White Bass
W.C. Beckjord	0	0	108	0	0	0	0	85
Cardinal	2	0	10	21	0	1	5	87
Clifty Creek	0	133	440	20	233	0	24	1,392
Kammer	0	0	4	4	0	0	0	15
Kyger Creek	0	0	145	4	0	0	2	72
Miami Fort	0	211	271	0	0	0	0	312
Philip Sporn	0	0	101	2	0	0	0	16
Tanners Creek	0	1,134	111	1	0	0	0	0
W.H. Sammis	0	0	3	43	0	1	15	612
Mean value	0	164	132	11	26	0	5	288

0 = Sampled, but none collected or rounded to 0.
Tue Dec 25 19:18:40 MST 2001
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Table C3-9: Annual Impingement at 9 Ohio River Facilities Expressed as Production Foregone (in pounds).

Facility	Bigmouth Buffalo	Black Bullhead	Black Crappie	Bluegill	Bluntnose Minnow	Brown Bullhead	Channel Catfish	Common Carp	Darter spp.	Emerald Shiner	Freshwater Drum	Gizzard Shad	Golden Redhorse
W.C. Beckjord	0	0	7	3	0	0	15	3	0	10	860	3,879	24
Cardinal	0	0	548	47	3	12	708	464	1	189	73	12,677	29
Clifty Creek	516	0	80	140	0	7	112	110	0	19	11,650	180,881	16
Kammer	0	0	13	4	0	3	53	26	0	14	26	993	13
Kyger Creek	0	0	85	29	1	3	351	40	0	88	2,867	16,280	11
Miami Fort	0	1	6	3	0	0	50	92	0	11	4,358	17,721	22
Philip Sporn	5	0	146	26	0	5	391	19	0	23	1,531	2,462	5
Tanners Creek	97	0	23	25	0	3	47	80	0	13	2,180	67,339	3
W.H. Sammis	0	0	138	24	2	33	774	3,130	0	292	3	36,555	23
Mean value	69	0	116	33	1	7	278	441	0	73	2,616	37,643	16

0 = Sampled, but none collected or rounded to 0.
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Table C3-9: Annual Impingement at 9 Ohio River Facilities Expressed as Production Foregone (in pounds) (cont.).

Facility	Longear Sunfish	Minnow spp.	Paddle-fish	Perch spp.	Sauger	Skipjack Herring	Smallmouth Bass	Striped Bass	Sucker spp.	Sunfish spp.	Walleye	White Bass	Yellow Perch
W.C. Beckjord	0	0	0	0	52	733	410	0	0	0	0	0	104
Cardinal	0	0	56	0	0	67	15	37	0	19	4	11	107
Clifty Creek	1	0	0	1,634	0	2,990	21,306	35	47	245	2	49	1,709
Kammer	0	0	0	0	0	26	0	8	0	4	0	0	18
Kyger Creek	1	1	0	0	28	984	37	7	0	0	0	3	89
Miami Fort	0	0	0	2,595	456	1,837	4,469	0	0	0	0	0	383
Philip Sporn	0	1	0	0	0	683	9	4	0	10	0	0	19
Tanners Creek	0	0	0	13,921	36	757	7,796	2	0	0	0	0	0
W.H. Sammis	2	0	15	0	0	19	374	75	0	59	4	30	751
Mean value	0	0	8	2,017	64	900	3,824	19	5	38	1	10	354

0 = Sampled, but none collected or rounded to 0.
Tue Dec 25 19:18:36 MST 2001 P:/INTAKE/Ohio/Ohio_Science/scode/ohio.summary.tables/ohiosum.pf.imp.csv

Table C3-10: Annual Entrainment (numbers of organisms), by Species, at 9 Ohio River CWIS as Estimated from Facility Monitoring.

Species	W.C. Beckjord	Cardinal	Clifty Creek	Kammer	Kyger Creek	Miami Fort	Philip Sporn	Tanners Creek	W.H. Sammis
Black crappie	404,596	38,200	14,517	0	1,520,400	0	26,700	18,194	104,173
Bluegill	0	0	29,033	0	0	0	0	0	0
Bluntnose minnow	0	38,234,900	145,167	111,249,300	59,223,900	0	15,082,500	0	2,048,741
Brown bullhead	0	0	29,033	0	0	0	64,200	0	69,449
Channel catfish	3,879	76,400	29,033	82,400	481,800	0	19,100	181,944	277,795
Common carp	4,200,488	858,700	14,517	4,770,600	130,089,600	13,867,678	27,648,300	9,097	5,590,631
Darter spp.	0	412,100	0	0	0	0	0	0	0

Table C3-10: Annual Entrainment (numbers of organisms), by Species, at 9 Ohio River CWIS as Estimated from Facility Monitoring (cont.).

Species	W.C. Beckjord	Cardinal	Clifty Creek	Kammer	Kyger Creek	Miami Fort	Philip Sporn	Tanners Creek	W.H. Sammis
Emerald shiner	0	725,100	435,502	0	9,595,600	21,091,478	783,000	118,263	2,830,040
Freshwater drum	73,321	38,200	159,684	0	45,288,800	15,607,150	7,597,100	118,264	0
Gizzard shad	0	0	29,033	0	329,500	19,277,962	45,800	454,861	225,709
Golden redhorse	0	0	0	0	202,800	0	0	0	0
Herring spp.	0	0	0	2,121,700	0	0	0	0	0
Logperch	0	0	0	0	44,400	0	0	27,291	503,504
Longear sunfish	0	0	0	0	1,445,200	0	532,800	9,097	0
Minnow spp.	1,037,966	0	0	0	0	5,394,868	0	36,389	0
Mooneye	0	0	0	0	0	0	0	9,097	0
Mooneye goldeye	0	0	0	0	285,300	0	22,900	0	0

Table C3-10: Annual Entrainment (numbers of organisms), by Species, at 9 Ohio River CWIS as Estimated from Facility Monitoring (cont.).

Species	W.C. Beckjord	Cardinal	Clifty Creek	Kammer	Kyger Creek	Miami Fort	Philip Sporn	Tanners Creek	W.H. Sammis
Paddlefish	0	0	0	0	0	0	0	27,292	0
Perch spp.	204,342	0	0	0	0	0	0	0	0
River carpsucker	48,364,734	0	0	0	211,297,200	3,440,994	0	8,014,651	0
Sauger	0	0	319,368	0	0	7,247,990	0	9,097	0
Silver chub	0	0	0	0	513,400	0	0	0	0
Skipjack herring	2,095,906	580,200	261,301	0	4,358,100	0	949,800	545,833	0
Smallmouth bass	1,897,260	0	145,167	0	95,100	658,260	19,100	0	34,724

Table C3-10: Annual Entrainment (numbers of organisms), by Species, at 9 Ohio River CWIS as Estimated from Facility Monitoring (cont.).

Species	W.C. Beckjord	Cardinal	Clifty Creek	Kammer	Kyger Creek	Miami Fort	Philip Sporn	Tanners Creek	W.H. Sammis
Stonecat	0	0	0	0	0	0	0	0	121,535
Sucker spp	0	190,800	64,744,662	183,400	0	0	16,958,600	0	190,984
Sunfish spp.	0	0	1,451,674	0	0	147,936	0	0	243,071
Unidentified	0	36,352,000	2,194,181	62,605,700	107,662,900	67,437,529	40,400,000	2,228,819	4,271,595
Walleye	0	810,400	58,067	478,200	15,659,000	0	2,091,100	0	312,520
White bass	1,442,562	0	14,517	82,400	114,100	2,073,864	0	0	69,449
Yellow perch	0	633,500	0	628,100	1,199,400	0	1,637,500	0	468,780

0 = Sampled, but none collected or rounded to 0.
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Table C3-11: Annual Entrainment at 9 Ohio River CWIS Expressed as Numbers of Age 1 Equivalents.

Facility	Black Crappie	Bluegill	Bluntnose Minnow	Brown Bullhead	Channel Catfish	Common Carp	Darter spp.	Emerald Shiner	Freshwater Drum	Gizzard Shad	Golden Redhorse	Herring spp.
W.C. Beckjord	16,405	0	0	0	19	20,794	0	0	32	0	0	0
Cardinal	1,549	0	1,098,788	0	378	4,251	14,534	32,959	17	0	0	0
Clifty Creek	1,478	569	7,033	11,613	144	5,807	0	169,054	18,612	1,416	0	0
Kammer	0	0	3,197,065	0	408	23,617	0	0	0	0	0	843
Kyger Creek	61,648	0	1,701,967	0	2,385	644,008	0	436,164	19,822	1,498	1,859	0
Miami Fort	0	0	0	0	0	68,652	0	958,704	6,831	87,627	0	0
Philip Sporn	1,083	0	433,438	318	95	136,873	0	35,591	3,325	208	0	0
Tanners Creek	738	0	0	0	65,590	3,639	0	47,305	1,712	46,890	0	0
W.H. Sammis	4,224	0	58,876	344	1,375	27,676	0	128,638	0	1,026	0	0
Mean value	9,681	63	721,908	1,364	7,822	103,924	1,615	200,935	5,595	15,407	207	94

0 = Sampled, but none collected or rounded to 0.
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Table C3-11: Annual Entrainment at 9 Ohio River CWIS Expressed as Numbers of Age 1 Equivalents (cont.).

Facility	Log-perch	Longear Sunfish	Minnow spp.	Paddle-fish	Perch spp.	River Carpsucker	Sauger	Skipjack Herring	Smallmouth Bass	Sucker spp.	Sunfish spp.	Walleye	White Bass	Yellow Perch
W.C. Beckjord	0	0	29,829	0	7,207	694,736	0	833	152,930	0	0	0	7,141	0
Cardinal	0	0	0	0	0	0	0	231	0	2,741	0	6,525	0	30,021
Clifty Creek	0	0	0	0	0	0	3,534	3,309	11,701	930,025	494,103	468	5,807	0
Kammer	0	0	0	0	0	0	0	0	0	2,634	0	3,851	408	29,766
Kyger Creek	1,566	487,093	0	0	0	3,035,181	0	1,732	7,666	0	0	126,089	565	56,839
Miami Fort	0	0	155,037	0	0	49,428	80,212	0	53,060	0	49,861	0	10,267	0
Philip Sporn	0	179,576	0	0	0	0	0	377	1,540	243,602	0	16,838	0	77,601
Tanners Creek	12,799	6,092	2,838	2,072	0	115,127	3,015	1,472	0	0	0	0	0	0
W.H. Sammis	17,758	0	0	0	0	0	0	0	2,799	2,743	81,925	2,516	344	22,215
Mean value	3,569	74,751	20,856	230	801	432,719	9,640	884	25,522	131,305	69,543	17,365	2,726	24,049

0 = Sampled, but none collected or rounded to 0.
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Table C3-12: Annual Entrainment at 9 Ohio River Facilities Expressed as Yield Lost to Fisheries (in pounds).

Facility	Black Crappie	Channel Catfish
W.C. Beckjord	136	1
Cardinal	13	12
Clifty Creek	12	4
Kammer	0	13
Kyger Creek	511	75
Miami Fort	0	0
Philip Sporn	9	3
Tanners Creek	6	2,049
W.H. Sammis	35	43
Mean value	80	244

0 = Sampled, but none collected or rounded to 0.
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Table C3-12: Annual Entrainment at 9 Ohio River Facilities Expressed as Yield Lost to Fisheries (in pounds) (cont.).

Facility	Longear Sunfish	Paddlefish	Sauger	Smallmouth Bass	Sunfish spp.	Walleye	White Bass
W.C. Beckjord	0	0	0	6,245	0	0	544
Cardinal	0	0	0	0	0	1,145	0
Clifty Creek	0	0	185	478	179	82	442
Kammer	0	0	0	0	0	676	31
Kyger Creek	177	0	0	313	0	22,133	43
Miami Fort	0	0	4,209	2,167	18	0	782
Philip Sporn	65	0	0	63	0	2,956	0
Tanners Creek	2	429	158	0	0	0	0
W.H. Sammis	0	0	0	114	30	442	26
Mean value	27	48	506	1,042	25	3,048	208

0 = Sampled, but none collected or rounded to 0.
Tue Dec 25 19:18:51 MST 2001 P:/INTAKE/Ohio/Ohio_Science/scode/ohio.summary.tables/ohiosum.yield.ent.csv

Table C3-13: Annual Entrainment at 9 Ohio River Facilities Expressed as Production Foregone (in pounds).

Facility	Black Crappie	Bluegill	Bluntnose Minnow	Brown Bullhead	Channel Catfish	Common Carp	Darter spp.	Emerald Shiner	Freshwater Drum	Gizzard Shad	Golden Redhorse	Herring spp.
W.C. Beckjord	14,380	0	0	0	6	27,960	0	0	47	0	0	0
Cardinal	1,358	0	48,601	0	125	5,716	1,189	4,844	25	0	0	0
Clifty Creek	650	30	210	1,992	47	8,297	0	5,266	3,757	2,327	0	0
Kammer	0	0	141,411	0	134	31,755	0	0	0	0	0	169
Kyger Creek	54,037	0	75,281	0	786	865,938	0	64,101	29,098	7,603	3,312	0
Miami Fort	0	0	0	0	0	92,310	0	140,897	10,028	444,844	0	0
Philip Sporn	949	0	19,172	66	31	184,040	0	5,231	4,881	1,057	0	0
Tanners Creek	647	0	0	0	8,744	5,199	0	1,450	369	39,573	0	0
W.H. Sammis	3,702	0	2,604	71	453	37,214	0	18,905	0	5,208	0	0
Mean value	8,414	3	31,920	237	1,148	139,826	132	26,744	5,356	55,624	368	19

0 = Sampled, but none collected or rounded to 0.
Tue Dec 25 19:18:47 MST 2001 P:/INTAKE/Ohio/Ohio_Science/scode/ohio.summary.tables/ohiosum.pf.ent.csv

Table C3-13: Annual Entrainment at 9 Ohio River Facilities Expressed as Production Foregone (in pounds) (cont.).

Facility	Log-perch	Longear Sunfish	Minnow spp.	Paddle-fish	Perch spp.	River Carpsucker	Sauger	Skipjack Herring	Smallmouth Bass	Sucker spp.	Sunfish spp.	Walleye	White Bass	Yellow Perch
W.C. Beckjord	0	0	127	0	590	588,639	0	22,301	443	0	0	0	10,958	0
Cardinal	0	0	0	0	0	0	0	6,173	0	2,322	0	19,287	0	3,685
Clifty Creek	0	0	0	0	0	0	7,849	9,295	1,810	787,996	5,444	6	3,837	0
Kammer	0	0	0	0	0	0	0	0	0	2,232	0	52	626	3,654
Kyger Creek	128	2,576	0	0	0	2,571,661	0	46,371	1,186	0	0	372,669	867	6,977
Miami Fort	0	0	6,858	0	0	41,880	178,126	0	154	0	49	0	15,753	0
Philip Sporn	0	950	0	0	0	0	0	10,106	238	206,400	0	226	0	9,525
Tanners Creek	113	56	30	8,941	0	97,545	3,586	6,587	0	0	0	0	0	0
W.H. Sammis	1,453	0	0	0	0	0	0	0	433	2,324	433	7,438	528	2,727
Mean value	188	398	779	993	66	366,636	21,062	11,204	474	111,253	658	44,408	3,619	2,952

0 = Sampled, but none collected or rounded to 0.
Tue Dec 25 19:18:47 MST 2001 P:/INTAKE/Ohio/Ohio_Science/scode/ohio.summary.tables/ohiosum.pf.ent.csv

Table C3-14: Ohio River CWIS, Operational Flows, CWIS Locations, and Status in Relation to the Proposed § 316(b) Phase II Rule. Facility Names in Bold are the 9 Ohio River Facilities with I&E Data.

Facility Name	Operational Flow (MGD)	Pool	Length of Pool[a]	In-Scope
Richard H. Gorsuch	244.8	Belleville Pool	162-207	yes
Cane Run	358.4	Cannelton Pool	607-721	yes
DuPont	NR	Cannelton Pool	607-721	no
Mill Creek	210.3	Cannelton Pool	607-721	yes
R. Gallagher	NR	Cannelton Pool	607-721	yes
Rohm and Haas Co. Louisville Plant	41.1	Cannelton Pool	607-721	no
Bayer Corp	3.7	Hannibal Pool	84.2-127	no
Kammer	NR	Hannibal Pool	84.2-127	yes
Mitchell	NR	Hannibal Pool	84.2-127	no
Ormet Aluminum Mill Products Corporation	4.8	Hannibal Pool	84.2-127	no
PPG Ind. Inc. C/o P.P.G. Industries Inc.	124.0	Hannibal Pool	84.2-127	no
R.E. Burger	225.0	Hannibal Pool	84.2-127	yes
A.B. Brown	5.6	John T. Myers Pool	776-846	no
Countrymark Cooperative Inc.	0.6	John T. Myers Pool	776-846	no
General Electric Company	9.5	John T. Myers Pool	776-846	no
Joppa Steam	568.2	Lock and Dam 53 Pool	939-962	yes
Shawnee	1,210.0	Lock and Dam 53 Pool	939-962	yes
East Bend	1.3	Markland Pool	436-531.5	no
Miami Fort	207.0	Markland Pool	436-531.5	yes
Tanners Creek	1,092.0	Markland Pool	436-531.5	yes
W.H. Zimmer	41.0	Markland Pool	436-531.5	yes
Walter C. Beckjord	592.0	Markland Pool	436-531.5	yes
Clifty Creek	NR	McAlpine Pool	531.5-607	yes
Ghent	63.9	McAlpine Pool	531.5-607	yes
North American Stainless - Ghent	1.0	McAlpine Pool	531.5-607	no
Trimble County	9.3	McAlpine Pool	531.5-607	no
H.L. Spurlock	3.5	Meldahl Pool	345-436	no
J.M. Stuart	773.3	Meldahl Pool	345-436	yes
Killen Station	7.6	Meldahl Pool	345-436	no
New Boston Coke - American Buckeye Division	8.6	Meldahl Pool	345-436	no
G.F. Weaton Power Station Zinc Corporation of America	68.0	Montgomery Pool	13-32	no
Beaver Valley Nuclear	86.8	New Cumberland Pool	32-54.4	yes
Bruce Mansfield	NR	New Cumberland Pool	32-54.4	yes
W.H. Sammis	NR	New Cumberland Pool	32-54.4	yes
Coleman	248.0	Newburgh Pool	721-776	yes
Elmer Smith	235.9	Newburgh Pool	721-776	yes
F.B. Culley	358.3	Newburgh Pool	721-776	yes
Rockport	115.2	Newburgh Pool	721-776	yes
Warrick	475.0	Newburgh Pool	721-776	yes
Cardinal - Units 1 and 2 Only	NR	Pike Island Pool	54.4-84.2	yes
Weirton Steel Corporation	170.6	Pike Island Pool	54.4-84.2	no
Wheeling-Pittsburgh Steel Corp. - Yorkville Plant	3.6	Pike Island Pool	54.4-84.2	no
Gen. J.M. Gavin	32.8	Robert C. Byrd Pool	239-282	yes

Table C3-14: Ohio River CWIS, Operational Flows, CWIS Locations, and Status in Relation to the Proposed Rule. Facility Names in Bold are the 9 Ohio River Facilities with I&E Data (cont.).

Facility Name	Operational Flow (MGD)	Pool	Length of Pool[a]	In-Scope
Kyger Creek	1,139.0	Robert C. Byrd Pool	239-282	yes
Mountaineer	NR	Robert C. Byrd Pool	239-282	no
Philip Sporn	870.6	Robert C. Byrd Pool	239-282	yes
Pleasants	NR	Willow Island Pool	127-131	yes
Willow Island	NR	Willow Island Pool	127-131	yes

[a] Pool length is from EA Engineering Science and Technology, 2001; US Army Corps Engineers Pittsburgh District, 2001; and US Army Corps Engineers Huntington District, 2001.
NR = Not reported (may be considered CBI by facility).

Table C3-15: Outline of I&E Extrapolations for Ohio River CWIS.

Ohio Facilities With I&E Data	Facilities Extrapolated To
Clifty Creek	Ghent, North American Stainless, Trimble, Cane Run, Du Pont, Mill Creek, Gallagher, Rohm & Haas, Coleman, Elmer Smith, Culley, Rockport, Warwick, AB Brown, County Mark, General Electric, Joppa Steam, Shawnee
Kyger Creek, Philip Sporn	Richard H. Gorsuch, Mountaineer, Gen JM Gavin
Miami Fort, Tanners Creek, W.C. Beckjord	Spurlock, Stuart, Killen, New Boston Coke, Zimmer, East Bend
W.H. Sammis	GF Wheaton, Beaver, Bruce Mansfield
Kammer	Willow Is., Bayer, Mitchell, Ormet, PPG, RE Burger, Pleasants
Cardinal	Weirton, Wheeling-Pittsburg

Table C3-16: Definition of Pool Groups Used by EPA in its I&E Analyses. Facility Names in Bold are the 9 Ohio River Facilities with I&E Data.

Pool Group	Facilities Included in Pool Group	In-Scope of Phase II?
Hannibal Pool	**Kammer**	yes
	Bayer Corp	no
	Mitchell	no
	Ormet Aluminum Mill Products Corporation	no
	PPG Ind. Inc. c/o P.P.G. Industries Inc.	no
	R.E. Burger	yes
	Pleasants	yes
	Willow Island	yes
Markland Pool	**Miami Fort**	yes
	Tanners Creek	yes
	Walter C. Beckjord	yes
	East Bend	no
	W.H. Zimmer	yes
	H.L. Spurlock	no
	J.M. Stuart	yes
	Killen Station	no
	New Boston Coke - American Buckeye Division	no
McAlpine Pool	**Clifty Creek**	yes
	Ghent	yes
	North American Stainless — Ghent	no
	Trimble County	no
	Cane Run	yes
	E. I. du Pont De Nemours & Co. Inc.	no
	Mill Creek	yes
	R. Gallagher	yes
	Rohm and Haas Co. Louisville Plant	no
	A.B. Brown	no
	Countrymark Cooperative Inc.	no
	General Electric Company	no
	Joppa Steam	yes
	Shawnee	yes
	Coleman	yes
	Elmer Smith	yes
	F.B. Culley	yes
	Rockport	yes
	Warrick	yes
New Cumberland Pool	**W.H. Sammis**	yes
	Bruce Mansfield	yes
	Beaver Valley Nuclear	yes
	G.F. Weaton Power Station Zinc Corporation of America	no
Pike Island Pool	**Cardinal - Units 1 and 2 Only**	yes
	Weirton Steel Corporation	no
	Wheeling-Pittsburgh Steel Corp. — Yorkville Plant	no
Robert C. Byrd Pool	Gen. J.M. Gavin	yes
	Kyger Creek	yes
	Philip Sporn	yes
	Mountaineer	no
	Richard H. Gorsuch	yes

C3-7 Annual Impingement at Nine Ohio River Case Study Facilities

The results of EPA's analysis of impingement at the nine Ohio River case study facilities indicates that the primary species impinged are gizzard shad, freshwater drum, skipjack herring, and emerald shiner (Table C3-6). Age 1equivalent losses of these species per year average 370, 592 for gizzard shad, 27,512 for freshwater drum, 21,350 for skipjack herring, and 13,496 for emerald shiner (Table C3-7). Note that because none of these species are fishery species in the case study area, yield estimates underrepresent impingement (Table C3-8).

C3-8 Annual Entrainment at Nine Ohio River Case Study Facilities

The primary species entrained at the nine Ohio River case study facilities are bluntnose minnow, river carpsucker, emerald shiner and common carp (Table C3-10). Age 1 equivalent losses of these species per year average 721,908 for bluntnose minnow, 432,719 for river carpsucker, 200,935 for emerald shiner, and 103,924 for common carp (Table C3-11). As with impinged species, none of these are fishery species and therefore it is important to note that yield estimates underrepresent entrainment (Table C3-12).

C3-9 Cumulative Impacts: Summary of Total Ohio River I&E

Cumulative impacts are summarized in Tables C3-29 through C3-32 based on the sum of the mean for each pool.

C3-9.1 I&E at All In Scope and Out of Scope Ohio River CWIS

EPA's estimate of the cumulative impingement impact of all in scope and out of scope Ohio River facilities is summarized in Table C3-29. Results indicate that about 11.6 million age 1 equivalent fish are impinged per year at the facilities, representing 15,500 pounds of lost fishery yield or over 1.1 million pounds of production foregone. The estimated cumulative entrainment impact of in scope and out of scope facilities is summarized in Table C3-30. About 24.5 million age 1 equivalent fish are entrained each year, representing 40,000 pounds of lost fishery yield or over 10 million pounds of production foregone.

Table C3-17: EPA's Estimates of Annual Impingement at All In Scope and Out of Scope Ohio River CWIS, by Species and Pool, Expressed as Numbers of Age 1 Equivalents.

Species	Hannibal Pool	Markland Pool	McAlpine Pool	Newburgh Pool	Pike Island Pool	Robert C. Byrd Pool	Total
Bigmouth buffalo	0	760	7,104	0	0	20	7,884
Black bullhead	0	85	0	0	0	0	85
Black crappie	786	1,351	9,513	4,745	19,623	4,361	40,379
Bluegill	639	2,713	47,677	2,410	4,796	2,979	61,214
Bluntnose minnow	190	0	125	1,704	2,860	386	5,265
Brown bullhead	158	181	675	928	363	119	2,425
Channel catfish	2,028	2,362	8,758	17,387	16,599	9,159	56,293
Common carp	183	516	1,590	13,026	2,014	135	17,464
Darter spp.	0	0	0	0	314	0	314
Emerald shiner	5,145	9,478	14,429	62,957	42,516	13,232	147,757
Freshwater drum	543	83,134	498,423	33	939	29,751	612,822
Gizzard shad	23,131	432,906	8,615,185	501,397	181,286	141,157	9,895,062
Golden redhorse	473	1,840	1,201	500	654	193	4,861
Logperch	43	66	775	452	0	156	1,493
Longear sunfish	406	273	0	0	0	770	1,448
Minnow spp.	0	8	0	0	0	0	8
Muskellunge	0	0	0	30	118	0	148
Paddlefish	0	7,558	2,617	0	0	0	10,175
Perch spp.	0	146	0	0	0	0	146
Rainbow smelt	0	0	19	0	0	0	19
River carpsucker	0	6,583	0	0	0	431	7,015
Sauger	146	12,431	34,145	64	229	3,010	50,026
Skipjack herring	0	60,626	483,977	2,450	105	165	547,322
Smallmouth bass	212	24	1,973	1,226	635	99	4,169
Striped bass	0	0	683	0	0	0	683
Sucker spp.	103	0	11,803	822	278	159	13,164
Sunfish spp.	0	0	4,296	3,093	3,234	0	10,623
Walleye	0	0	557	97	36	6	696
White bass	392	10,282	74,319	9,406	1,398	743	96,539
Yellow perch	60	0	127	1,794	488	223	2,691
Total	34,637	633,324	9,819,970	624,522	278,482	207,252	11,598,188

Note: In some cases, impingement losses expressed as age 1 equivalents may be larger than raw loss estimates. This can occur because the ages of the impinged fish are assumed to be distributed across the interval between the start of year 1 and the start of year 2, and then normalized back to the start of year 1 by accounting for mortality during this interval (see Chapter A2 of Part A for details).
0 = Sampled, but none collected or rounded to 0.
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Table C3-18: EPA's Estimates of Annual Impingement at All In Scope and Out of Scope Ohio River CWIS, by Species and Pool, Expressed as Yield Lost of Fisheries (in pounds).

Species	Hannibal Pool	Markland Pool	McAlpine Pool	Newburgh Pool	Pike Island Pool	Robert C. Byrd Pool	Total
Black crappie	7	11	79	39	163	36	335
Bluegill	0	1	9	0	1	1	12
Channel catfish	63	74	274	543	519	286	1,759
Longear sunfish	0	0	0	0	0	0	1
Minnow spp.	0	0	0	0	0	0	0
Muskellunge	0	0	0	0	2	0	2
Paddlefish	0	1,565	542	0	0	0	2,106
Sauger	8	652	1,792	3	12	158	2,625
Smallmouth bass	9	1	81	50	26	4	170
Striped bass	0	0	948	0	0	0	948
Sunfish spp.	0	0	2	1	1	0	4
Walleye	0	0	98	17	6	1	122
White bass	30	783	5,663	717	106	57	7,356
Total	116	3,087	9,486	1,372	836	543	15,439

0 = Sampled, but none collected or rounded to 0.
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Table C3-19: EPA's Estimates of Annual Impingement at All In Scope and Out of Scope Ohio River CWIS, by Species and Pool, Expressed as Production Foregone (in pounds).

Species	Hannibal Pool	Markland Pool	McAlpine Pool	Newburgh Pool	Pike Island Pool	Robert C. Byrd Pool	Total
Bigmouth buffalo	0	225	2,101	0	0	6	2,332
Black bullhead	0	2	0	0	0	0	2
Black crappie	27	46	324	162	669	149	1,377
Bluegill	8	32	568	29	57	35	729
Bluntnose minnow	0	0	0	2	4	1	7
Brown bullhead	7	8	28	38	15	5	100
Channel catfish	106	123	457	907	865	478	2,935
Common carp	52	145	448	3,668	567	38	4,917
Darter spp.	0	0	0	0	2	0	2
Emerald shiner	28	51	78	342	231	72	803
Freshwater drum	52	7,906	47,401	3	89	2,829	58,281
Gizzard shad	1,976	78,736	735,940	42,831	15,486	12,058	887,028
Golden redhorse	25	99	65	27	35	10	261
Logperch	0	0	4	2	0	1	7
Longear sunfish	1	0	0	0	0	1	2
Muskellunge	0	0	0	17	68	0	85
Paddlefish	0	19,202	6,649	0	0	0	25,851
Perch spp.	0	1	0	0	0	0	1
River carpsucker	0	555	0	0	0	36	591
Sauger	52	4,430	12,167	23	82	1,073	17,826
Skipjack herring	0	10,859	86,688	439	19	30	98,034
Smallmouth bass	15	2	141	88	45	7	298
Striped bass	0	0	192	0	0	0	192
Sucker spp.	9	0	995	69	23	13	1,110
Sunfish spp.	0	0	7	5	5	0	18
Walleye	0	0	200	35	13	2	250
White bass	37	962	6,955	880	131	69	9,035
Yellow perch	0	0	0	4	1	1	7
Total	2,393	123,385	901,408	49,572	18,408	16,914	1,112,080

0 = Sampled, but none collected or rounded to 0.
Tue Dec 25 20:03:46 MST 2001
P:/INTAKE/Ohio/Ohio_Science/scode/ohio.extrapolation/all.ohio.facilities.extrapolation/summary.tables/agg.pf.lbs.I.csv

Table C3-20: EPA's Estimates of Annual Impingement at All In Scope Ohio River CWIS, by Species and Pool, Expressed as Numbers of Age 1 Equivalents.

Species	Hannibal Pool	Markland Pool	McAlpine Pool	Newburgh Pool	Pike Island Pool	Robert C. Byrd Pool	Total
Bigmouth buffalo	0	749	6,988	0	0	20	7,757
Black bullhead	0	84	0	0	0	0	84
Black crappie	674	1,332	9,358	4,503	16,063	4,326	36,255
Bluegill	548	2,674	46,900	2,287	3,926	2,955	59,289
Bluntnose minnow	163	0	123	1,617	2,341	383	4,627
Brown bullhead	136	179	664	881	297	118	2,274
Channel catfish	1,739	2,328	8,615	16,500	13,587	9,085	51,855
Common carp	157	509	1,564	12,361	1,649	134	16,373
Darter spp.	0	0	0	0	257	0	257
Emerald shiner	4,412	9,341	14,194	59,745	34,803	13,125	135,620
Freshwater drum	466	81,939	490,297	31	768	29,510	603,011
Gizzard shad	19,835	426,682	8,474,732	475,816	148,398	140,014	9,685,477
Golden redhorse	405	1,813	1,182	475	536	191	4,602
Logperch	37	65	762	429	0	155	1,449
Longear sunfish	348	269	0	0	0	763	1,380
Minnow spp.	0	8	0	0	0	0	8
Muskellunge	0	0	0	29	96	0	125
Paddlefish	0	7,449	2,574	0	0	0	10,024
Percid spp.	0	143	0	0	0	0	143
Rainbow smelt	0	0	19	0	0	0	19
River carpsucker	0	6,489	0	0	0	428	6,917
Sauger	125	12,252	33,589	60	188	2,986	49,200
Skipjack herring	0	59,754	476,087	2,325	86	164	538,415
Smallmouth bass	182	23	1,941	1,164	520	99	3,928
Striped bass	0	0	672	0	0	0	672
Sucker spp.	88	0	11,611	780	227	157	12,864
Sunfish spp.	0	0	4,226	2,936	2,647	0	9,809
Walleye	0	0	548	92	29	6	675
White bass	336	10,134	73,107	8,926	1,144	736	94,384
Yellow perch	51	0	125	1,702	400	221	2,499
Total	29,701	624,219	9,659,875	592,659	227,962	205,574	11,339,991

0 = Sampled, but none collected or rounded to 0.
Tue Dec 25 20:10:34 MST 2001
P:/INTAKE/Ohio/Ohio_Science/scode/ohio.extrapolation/in.scope.facilities.benefits/summary.tables/agg.age.1.equiv.I.csv

Table C3-21: EPA's Estimates of Annual Impingement at All In Scope Ohio River CWIS, by Species and Pool, Expressed as Yield Lost of Fisheries (in pounds).

Species	Hannibal Pool	Markland Pool	McAlpine Pool	Newburgh Pool	Pike Island Pool	Robert C. Byrd Pool	Total
Black crappie	6	11	78	37	133	36	301
Bluegill	0	1	9	0	1	1	11
Channel catfish	54	73	269	516	425	284	1,620
Muskellunge	0	0	0	0	2	0	2
Paddlefish	0	1,542	533	0	0	0	2,075
Sauger	7	643	1,763	3	10	157	2,582
Smallmouth bass	7	1	79	48	21	4	160
Striped bass	0	0	932	0	0	0	932
Sunfish spp.	0	0	2	1	1	0	4
Walleye	0	0	96	16	5	1	119
White bass	26	772	5,571	680	87	56	7,192
Total	100	3,042	9,331	1,302	684	538	14,998

0 = Sampled, but none collected or rounded to 0.
Tue Dec 25 20:10:52 MST 2001
P:/INTAKE/Ohio/Ohio_Science/scode/ohio.extrapolation/in.scope.facilities.benefits/summary.tables/agg.yield.lbs.I.csv

Table C3-22: EPA's Estimates of Annual Impingement at All In Scope Ohio River CWIS, by Species and Pool, Expressed as Production Foregone (in pounds).

Species	Hannibal Pool	Markland Pool	McAlpine Pool	Newburgh Pool	Pike Island Pool	Robert C. Byrd Pool	Total
Bigmouth buffalo	0	222	2,067	0	0	6	2,294
Black bullhead	0	2	0	0	0	0	2
Black crappie	23	45	319	154	548	148	1,236
Bluegill	7	32	558	27	47	35	706
Bluntnose minnow	0	0	0	2	3	1	6
Brown bullhead	6	7	27	36	12	5	94
Channel catfish	91	121	449	860	708	474	2,704
Common carp	44	143	440	3,480	464	38	4,610
Darter spp.	0	0	0	0	1	0	1
Emerald shiner	24	51	77	325	189	71	737
Freshwater drum	44	7,793	46,628	3	73	2,806	57,347
Gizzard shad	1,694	77,604	723,942	40,646	12,677	11,960	868,524
Golden redhorse	22	97	64	26	29	10	247
Logperch	0	0	4	2	0	1	7
Longear sunfish	1	0	0	0	0	1	2
Muskellunge	0	0	0	17	56	0	72
Paddlefish	0	18,926	6,541	0	0	0	25,466
Perch spp.	0	1	0	0	0	0	1
River carpsucker	0	547	0	0	0	36	583
Sauger	45	4,366	11,969	21	67	1,064	17,532
Skipjack herring	0	10,703	85,274	416	15	29	96,438
Smallmouth bass	13	2	139	83	37	7	280
Striped bass	0	0	189	0	0	0	189
Sucker spp.	7	0	979	66	19	13	1,085
Sunfish spp.	0	0	7	5	4	0	17
Walleye	0	0	197	33	11	2	243
White bass	31	948	6,842	835	107	69	8,833
Yellow perch	0	0	0	4	1	1	6
Total	2,052	121,611	886,713	47,042	15,069	16,777	1,089,264

0 = Sampled, but none collected or rounded to 0.
Tue Dec 25 20:11:09 MST 2001
P:/INTAKE/Ohio/Ohio_Science/scode/ohio.extrapolation/in.scope.facilities.benefits/summary.tables/agg.pf.lbs.I.csv

Table C3-23: EPA's Estimates of Annual Entrainment at All In Scope and Out of Scope Ohio River CWIS, by Species and Pool, Expressed as Numbers of Age 1 Equivalents.

Species	Hannibal Pool	Markland Pool	McAlpine Pool	Newburgh Pool	Pike Island Pool	Robert C. Byrd Pool	Total
Black crappie	0	13,288	6,013	4,949	1,892	40,359	66,501
Bluegill	0	0	2,316	0	0	0	2,316
Bluntnose minnow	6,359,492	0	28,613	68,986	1,342,297	1,373,845	9,173,233
Brown bullhead	0	0	47,251	403	0	204	47,858
Channel catfish	811	50,854	585	1,611	462	1,595	55,918
Common carp	46,978	72,150	23,625	32,429	5,193	502,391	682,766
Darter spp.	0	0	0	0	17,755	0	17,755
Emerald shiner	0	779,756	687,821	150,726	40,263	303,510	1,962,076
Freshwater drum	0	6,646	75,726	0	20	14,892	97,285
Gizzard shad	0	104,264	5,762	1,202	0	1,098	112,326
Golden redhorse	0	0	0	0	0	1,196	1,196
Herring spp.	1,677	0	0	0	0	0	1,677
Logperch	0	14,880	0	20,807	0	1,007	36,695
Longear sunfish	0	7,082	0	0	0	428,911	435,993
Minnow spp.	0	145,489	0	0	0	0	145,489
Muskellunge	0	0	0	0	0	0	0
Paddlefish	0	2,409	0	0	0	0	2,409
Perch spp.	0	16,758	0	0	0	0	16,758
Rainbow smelt	0	0	0	0	0	0	0
River carpsucker	0	666,034	0	0	0	3,905,457	4,571,492
Sauger	0	64,508	14,380	0	0	0	78,889
Skipjack herring	0	1,787	13,463	0	282	1,357	16,889
Smallmouth bass	0	159,662	47,609	3,280	0	5,922	216,473
Sucker spp.	5,240	0	3,783,944	3,214	3,348	313,450	4,109,197
Sunfish spp.	0	115,941	2,010,330	95,992	0	0	2,222,263
Walleye	7,659	0	1,902	2,949	7,972	91,954	112,436
White bass	811	20,239	23,625	403	0	363	45,442
Yellow perch	59,209	0	0	26,030	36,675	86,494	208,407
Total	6,481,878	2,241,748	6,772,966	412,980	1,456,160	7,074,007	24,439,740

0 = Sampled, but none collected or rounded to 0.
Tue Dec 25 20:03:09 MST 2001
P:/INTAKE/Ohio/Ohio_Science/scode/ohio.extrapolation/all.ohio.facilities.extrapolation/summary.tables/agg.age.1.equiv.E.csv

Table C3-24: EPA's Estimates of Annual Entrainment at All In Scope and Out of Scope Ohio River CWIS, by Species and Pool, Expressed as Yield Lost of Fisheries (in pounds).

Species	Hannibal Pool	Markland Pool	McAlpine Pool	Newburgh Pool	Pike Island Pool	Robert C. Byrd Pool	Total
Black crappie	0	110	50	41	16	335	551
Channel catfish	25	1,589	18	50	14	50	1,747
Logperch	0	0	0	0	0	0	0
Longear sunfish	0	3	0	0	0	156	158
Paddlefish	0	499	0	0	0	0	499
Sauger	0	3,385	755	0	0	0	4,140
Smallmouth bass	0	6,520	1,944	134	0	242	8,840
Sunfish spp.	0	42	730	35	0	0	807
Walleye	1,345	0	334	518	1,399	16,141	19,737
White bass	62	1,542	1,800	31	0	28	3,463
Total	1,432	13,689	5,632	809	1,430	16,951	39,942

0 = Sampled, but none collected or rounded to 0.
Tue Dec 25 20:03:24 MST 2001
P:/INTAKE/Ohio/Ohio_Science/scode/ohio.extrapolation/all.ohio.facilities.extrapolation/summary.tables/agg.yield.lbs.E.csv

Table C3-25: EPA's Estimates of Annual Entrainment at All In Scope and Out of Scope Ohio River CWIS, by Species and Pool, Expressed as Production Foregone (in pounds).

Species	Hannibal Pool	Markland Pool	McAlpine Pool	Newburgh Pool	Pike Island Pool	Robert C. Byrd Pool	Total
Black crappie	0	11,647	2,646	4,338	1,659	35,376	55,665
Bluegill	0	0	120	0	0	0	120
Bluntnose minnow	281,290	0	852	3,051	59,372	60,767	405,333
Brown bullhead	0	0	8,105	84	0	43	8,231
Channel catfish	268	6,783	193	531	152	526	8,452
Common carp	63,167	97,251	33,757	43,604	6,983	675,519	920,281
Darter spp.	0	0	0	0	1,453	0	1,453
Emerald shiner	0	110,333	21,425	22,152	5,917	44,606	204,433
Freshwater drum	0	8,095	15,286	0	30	21,861	45,272
Gizzard shad	0	375,471	9,467	6,103	0	5,572	396,612
Golden redhorse	0	0	0	0	0	2,131	2,131
Herring spp.	337	0	0	0	0	0	337
Logperch	0	131	0	1,702	0	82	1,916
Longear sunfish	0	65	0	0	0	2,269	2,333
Minnow spp.	0	5,437	0	0	0	0	5,437
Muskellunge	0	0	0	0	0	0	0
Paddlefish	0	10,396	0	0	0	0	10,396
Perch spp.	0	1,371	0	0	0	0	1,371
River carpsucker	0	564,321	0	0	0	3,309,033	3,873,353
Sauger	0	140,845	31,934	0	0	0	172,779
Skipjack herring	0	22,391	37,817	0	7,542	36,335	104,084
Smallmouth bass	0	463	7,365	507	0	916	9,251
Sucker spp.	4,440	0	3,206,077	2,724	2,837	265,581	3,481,658
Sunfish spp.	0	113	22,152	508	0	0	22773
Walleye	103	0	25	8,715	23,561	239,907	272,311
White bass	1,245	31,056	15,610	618	0	558	49,086
Yellow perch	7,268	0	0	3,195	4,502	10,617	25,582
Total	358,117	1,386,167	3,412,831	97,831	114,006	4,711,698	10,080,651

0 = Sampled, but none collected or rounded to 0.
Tue Dec 25 20:03:39 MST 2001
P:/INTAKE/Ohio/Ohio_Science/scode/ohio.extrapolation/all.ohio.facilities.extrapolation/summary.tables/agg.pf.lbs.E.csv

Table C3-26: EPA's Estimates of Annual Entrainment at All In Scope Ohio River CWIS, by Species and Pool, Expressed as Numbers of Age 1 Equivalents.

Species	Hannibal Pool	Markland Pool	McAlpine Pool	Newburgh Pool	Pike Island Pool	Robert C. Byrd Pool	Total
Black crappie	0	13,096	5,915	4,697	1,549	40,032	65,289
Bluegill	0	0	2,279	0	0	0	2,279
Bluntnose minnow	5,453,285	0	28,146	65,466	1,098,788	1,362,719	8,008,405
Brown bullhead	0	0	46,480	382	0	203	47,066
Channel catfish	696	50,122	575	1,529	378	1,582	54,883
Common carp	40,284	71,113	23,240	30,774	4,251	498,323	667,985
Darter spp.	0	0	0	0	14,534	0	14,534
Emerald shiner	0	768,545	676,608	143,036	32,959	301,052	1,922,200
Freshwater drum	0	6,551	74,492	0	17	14,771	95,831
Gizzard shad	0	102,765	5,668	1,141	0	1,089	110,663
Golden redhorse	0	0	0	0	0	1,186	1,186
Herring spp.	1,438	0	0	0	0	0	1,438
Logperch	0	14,666	0	19,745	0	999	35,411
Longear sunfish	0	6,980	0	0	0	425,438	432,418
Minnow spp.	0	143,397	0	0	0	0	143,397
Paddlefish	0	2,374	0	0	0	0	2,374
Perch spp.	0	16,517	0	0	0	0	16,517
River carpsucker	0	656,459	0	0	0	3,873,831	4,530,289
Sauger	0	63,581	14,146	0	0	0	77,727
Skipjack herring	0	1,761	13,243	0	231	1,346	16,581
Smallmouth bass	0	157,367	46,832	3,112	0	5,874	213,186
Sucker spp.	4,494	0	3,722,255	3,050	2,741	310,912	4,043,451
Sunfish spp.	0	114,274	1,977,555	91,094	0	0	2,182,923
Walleye	6,568	0	1,871	2,798	6,525	91,210	108,973
White bass	696	19,948	23,240	382	0	360	44,627
Yellow perch	50,772	0	0	24,702	30,021	85,794	191,288
Total	5,558,231	2,209,518	6,662,547	391,910	1,191,995	7,016,722	23,030,922

0 = Sampled, but none collected or rounded to 0.
Tue Dec 25 20:10:27 MST 2001
P:/INTAKE/Ohio/Ohio_Science/scode/ohio.extrapolation/in.scope.facilities.benefits/summary.tables/agg.age.1.equiv.E.csv

Table C3-27: EPA's Estimates of Annual Entrainment at All In Scope Ohio River CWIS, by Species and Pool, Expressed as Yield Lost of Fisheries (in pounds).

Species	Hannibal Pool	Markland Pool	McAlpine Pool	Newburgh Pool	Pike Island Pool	Robert C. Byrd Pool	Total
Black crappie	0	109	49	39	13	332	541
Channel catfish	22	1,566	18	48	12	49	1,715
Longear sunfish	0	3	0	0	0	155	157
Paddlefish	0	491	0	0	0	0	491
Sauger	0	3,336	742	0	0	0	4,079
Smallmouth bass	0	6,426	1,912	127	0	240	8,706
Sunfish spp.	0	42	718	33	0	0	793
Walleye	1,153	0	328	491	1,145	16,011	19,129
White bass	53	1,520	1,771	29	0	27	3,400
Total	1,228	13,493	5,540	767	1,170	16,814	39,012

0 = Sampled, but none collected or rounded to 0.
Tue Dec 25 20:10:44 MST 2001
P:/INTAKE/Ohio/Ohio_Science/scode/ohio.extrapolation/in.scope.facilities.benefits/summary.tables/agg.yield.lbs.E.csv

Table C3-28: EPA's Estimates of Annual Entrainment at All In Scope Ohio River CWIS, by Species and Pool, Expressed as Production Foregone (in pounds).

Species	Hannibal Pool	Markland Pool	McAlpine Pool	Newburgh Pool	Pike Island Pool	Robert C. Byrd Pool	Total
Black crappie	0	11,479	2,602	4,117	1,358	35,089	54,646
Bluegill	0	0	118	0	0	0	118
Bluntnose minnow	241,207	0	839	2,896	48,601	60,275	353,818
Brown bullhead	0	0	7,973	79	0	42	8,095
Channel catfish	229	6,685	190	504	125	522	8,255
Common carp	54,166	95,853	33,207	41,379	5,716	670,049	900,369
Darter spp.	0	0	0	0	1,189	0	1,189
Emerald shiner	0	108,747	21,076	21,021	4,844	44,245	199,933
Freshwater drum	0	7,979	15,037	0	25	21,684	44,724
Gizzard shad	0	370,072	9,313	5,791	0	5,527	390,703
Golden redhorse	0	0	0	0	0	2,114	2,114
Herring spp.	289	0	0	0	0	0	289
Logperch	0	130	0	1,615	0	82	1,827
Longear sunfish	0	64	0	0	0	2,250	2,314
Minnow spp.	0	5,359	0	0	0	0	5,359
Paddlefish	0	10,246	0	0	0	0	10,246
Perch spp.	0	1,351	0	0	0	0	1,351
River carpsucker	0	556,207	0	0	0	3,282,236	3,838,443
Sauger	0	138,820	31,413	0	0	0	170,233
Skipjack herring	0	22,069	37,200	0	6,173	36,041	101,483
Smallmouth bass	0	456	7,245	481	0	909	9,091
Sucker spp.	3,807	0	3,153,808	2,585	2,322	263,430	3,425,953
Sunfish spp.	0	111	21,790	482	0	0	22,383
Walleye	88	0	25	8,270	19,287	237,964	265,634
White bass	1,068	30,609	15,355	587	0	553	48,172
Yellow perch	6,232	0	0	3,032	3,685	10,531	23,480
Total	307,086	1,366,238	3,357,192	92,840	93,324	4,673,543	9,890,223

0 = Sampled, but none collected or rounded to 0.
Tue Dec 25 20:11:02 MST 2001
P:/INTAKE/Ohio/Ohio_Science/scode/ohio.extrapolation/in.scope.facilities.benefits/summary.tables/agg.pf.lbs.E.csv

Table C3-29: Summary, by Pool, of Cumulative Impingement Impacts of All In Scope and Out of Scope Ohio River CWIS.

Pools	# of Age 1 Equivalents	Lbs of Fishery Yield	Lbs of Production Foregone
Hannibal Pool	34,637	116	2,393
Markland Pool	633,324	3,087	123,385
McAlpine Pool	9,819,970	9,486	901,408
Newburgh Pool	624,522	1,372	49,572
Pike Island Pool	278,482	836	18,408
Robert C. Byrd Pool	207,252	543	16,914
Total	11,598,188	15,439	1,112,080

Thu Dec 27 09:47:12 MST 2001
P:/INTAKE/Ohio/Ohio_Science/scode/ohio.extrapolation/all.ohio.facilities.extrapolation/summary.tables/pool.rollup.ALL.imp.csv

Table C3-30: Summary, by Pool, of Cumulative Entrainment Impacts of All In Scope and Out of Scope Ohio River CWIS.

Pools	# of Age 1 Equivalents	Lbs of Fishery Yield	Lbs of Production Foregone
Hannibal Pool	6,481,878	1,432	358,117
Markland Pool	2,241,748	13,689	1,386,167
McAlpine Pool	6,772,966	5,632	3,412,831
Newburgh Pool	412,980	809	97,831
Pike Island Pool	1,456,160	1,430	114,006
Robert C. Byrd Pool	7,074,007	16,951	4,711,698
Total	24,439,740	39,942	10,080,651

Thu Dec 27 09:47:14 MST 2001
P:/INTAKE/Ohio/Ohio_Science/scode/ohio.extrapolation/all.ohio.facilities.extrapolation/summary.tables/pool.rollup.ALL.ent.csv

Table C3-31: Summary, by Pool, of Cumulative Impingement Impacts of All In Scope Ohio River CWIS.

Pools	# of Age 1 Equivalents	Lbs of Fishery Yield	Lbs of Production Foregone
Hannibal Pool	29,701	100	2,052
Markland Pool	624,219	3,042	121,611
McAlpine Pool	9,659,875	9,331	886,713
Newburgh Pool	592,659	1,302	47,042
Pike Island Pool	227,962	684	15,069
Robert C. Byrd Pool	205,574	538	16,777
Total	11,339,991	14,998	1,089,264

Tue Dec 25 20:14:28 MST 2001
P:/INTAKE/Ohio/Ohio_Science/scode/ohio.extrapolation/in.scope.facilities.benefits/summary.tables/pool.rollup.inscope.imp

Table C3-32: Summary, by Pool, of Cumulative Entrainment Impacts of All In Scope Ohio River CWIS.

Pools	# of Age 1 Equivalents	Lbs of Fishery Yield	Lbs of Production Foregone
Hannibal Pool	5,558,231	1,228	307,086
Markland Pool	2,209,518	13,493	1,366,238
McAlpine Pool	6,662,547	5,540	3,357,192
Newburgh Pool	391,910	767	92,840
Pike Island Pool	1,191,995	1,170	93,324
Robert C. Byrd Pool	7,016,722	16,814	4,673,543
Total	23,030,922	39,012	9,890,223

Tue Dec 25 20:14:30 MST 2001
P:/INTAKE/Ohio/Ohio_Science/scode/ohio.extrapolation/in.scope.facilities.benefits/summary.tables/pool.rollup.inscope.ent

C3-9.2 Benefits Baseline — I&E at In Scope Ohio River CWIS

EPA's estimate of the cumulative impingement impact of all in scope Ohio River CWIS is summarized in Table C3-31. Results indicate that annual impingement at in scope facilities is 11.3 million age 1 equivalents, 15,000 pounds of lost fishery yield, or 1.1 million pounds of production foregone. The estimated cumulative entrainment impact of in scope CWIS is summarized in Table C3-32. Annual entrainment at in scope facilities is about 23 million age 1 equivalents, 39,000 pounds of lost fishery yield, or 9.9 million pounds of production foregone.

I&E rates at in scope facilities were evaluated for the benefits analysis discussed in Chapter C6. Because the facilities have not changed their CWIS since the time of I&E data collection, the historical data used to estimate I&E at in scope CWIS were assumed to represent current I&E rates for the purposes of this analysis. However, as noted previously, EPA believes that these estimates are likely to be underestimates of current I&E rates because of increases in fish populations since the time of I&E data collection 25 years ago, which have likely led to increases in the numbers of organisms vulnerable to I&E.

It is also important to bear in mind that most I&E losses at Ohio River facilities are forage species, and therefore analysis of fishery yield alone will underestimate I&E impacts. As discussed in subsequent chapters, this is an important issue for the economic valuation of I&E losses in Chapter C4 (benefits transfer) and Chapter C5 (RUM analysis), and for the benefits analysis in Chapter C6, since economic methods for valuing forage losses are limited.