Chapter I3: Evaluation of I&E Data

EPA evaluated impacts to aquatic organisms resulting from the CWIS of the Monroe facility using the assessment methods described in Chapter A5 of this document. EPA focused its evaluation on data collected when the facility was operated as it is currently configured. Section I3-1 lists fish species that are impinged and entrained at Monroe, Section I3-2 presents life histories of the most abundant species in the facility's I&E collections, and Section I3-3 summarizes the facility's I&E collection methods. Section I3-4 presents annual I&E data, and Section I3-5 summarizes the results of EPA's evaluation of Monroe's I&E data.

CHAPTER CONTENTS

I3-1 Species Impinged and Entrained at Monroe

Table I3-1 lists species known to be impinged and entrained at Monroe, and their classification as recreational, commercial, or forage species. In general, EPA evaluated only those species with impingement and entrainment numbers greater than 1 percent of the total at the facility. However, species that were uncommon in I&E collections were still included if they had commercial or recreational value and there was available site specific life history information.

Table I3-1: Species Vulnerable to I&E by Monroe

Common Name	Scientific Name	Recreational	Commercial	Forage
Alewife	*Alosa pseudoharengus*			X
Black bass	*Micropterus dolomieui*	X		
Black bullhead	*Ameiurus melas*		X	
Black crappie	*Pomoxis nigromaculatus*	X		
Bluegill	*Lepomis macrochirus*	X		
Bluntnose minnow	*Pimephales notatus*			X
Bowfin	*Amia calva*	X		
Brown bullhead	*Ameiurus nebulosus*		X	
Burbot	*Lota lota*	X	X	
Carp	*Cyprinus carpio carpio*		X	
Central mudminnow	*Umbra limi*			X
Channel catfish	*Ictalurus punctatus*	X	X	
Chinook salmon	*Oncorhynchus tshawytscha*	X	X	
Coho salmon	*Oncorhynchus kisutch*	X	X	
Emerald shiner	*Notropis atherinoides*			X
Fathead minnow	*Pimephales promelas*			X
Flathead catfish	*Pylodictis olivaris*	X		
Freshwater drum	*Aplodinotus grunniens*		X	

Table I3-1: Species Vulnerable to I&E by Monroe (cont.)

Common Name	Scientific Name	Recreational	Commercial	Forage
Gizzard shad	*Dorosoma cepedianum*		X	
Golden redhorse	*Moxostoma erythrurum*			X
Goldfish	*Carassius auratus auratus*		X	
Green sunfish	*Lepomis cyanellus*	X		
Hornyhead chub	*Nocomis biguttatus*		X	
Largemouth bass	*Micropterus salmoides*	X		
Logperch	*Percina caprodes*			X
Longnose gar	*Lepisosteus osseus*			X
Mottled sculpin	*Cottus bairdii*			X
Muskellunge	*Esox masquinongy*	X		
Northern hog sucker	*Hypentelium nigricans*		X	
Northern pike	*Esox lucius*	X		
Pumpkinseed	*Lepomis gibbosus*	X		
Quillback	*Carpiodes cyprinus*		X	
Rainbow smelt	*Osmerus mordax mordax*	X	X	
Rainbow trout	*Oncorhynchus mykiss*	X	X	
Rock bass	*Ambloplites rupestris*	X		
Silver lamprey	*Icthyomyzon unicuspis*			X
Smallmouth bass	*Micropterus dolomieui*	X		
Spotfin shiner	*Cyprinella spiloptera*			X
Spottail shiner	*Notropis hudsonius*			X
Sunfish species	Centrarchidae	X		
Tadpole madtom	*Noturus gyrinus*			X
Troutperch	*Percopsis omiscomaycus*			X
Walleye	*Stizostedion vitreum*	X		
White bass	*Morone chrysops*	X	X	
White crappie	*Pomoxis annularis*	X		
White perch	*Morone americana*	X		
White sucker	*Catostomus commersoni*		X	
Whitefish species	Coregoninae	X	X	
Yellow bullhead	*Ameiurus natalis*		X	
Yellow perch	*Perca flavescens*	X		

Sources: (Andrew Nuhfer, Michigan Department of Natural Resources, Fisheries Division, personal communication, 2/13/02; Jude et al., 1983; Cole, 1978; Goodyear, 1978)

I3-2 Life Histories of Major Species Impinged and Entrained

Alewife (*Alosa pseudoharengus*)

Alewife is a member of the herring family, Clupeidae, and ranges along the Atlantic coast from Newfoundland to North Carolina (Scott and Crossman, 1998). Alewives entered the Great Lakes region through the Welland Canal, which connects Lake Erie and Lake Ontario; by 1949, they were present in Lake Michigan (University of Wisconsin Sea Grant Institute, 2001). Because alewives are not a freshwater species, they are particularly susceptible to osmotic stress associated with freshwater. Freshwater fish have larger kidneys, which they use to constantly pump water from their bodies. Since alewives lack this physiological adaptation, they are more susceptible to environmental disturbances.

In the Great Lakes, alewives spend most of their time in deeper water. During spawning season, they move to shallower inshore waters to spawn. Although alewives generally do not die after spawning, the fluctuating temperatures that the adults are exposed to when they move to inshore waters often results in mortality due to osmotic stress. In some years, temperature changes caused by upwelling may result in a massive die-off of spawning alewives (University of Wisconsin Sea Grant Institute, 2001).

Alewife has been introduced to a number of lakes to provide forage for sport fish (Jude et al., 1987b). Ecologically, alewife is an important prey item for many fish.

Spawning is driven by water temperature, beginning in the spring as water temperatures reach 13 to 15 ˚C (55.4 to 59.0 ˚F), and ending when they exceed 27 ˚C (80.6 ˚F) (Able and Fahay, 1998). In their native coastal habitats, alewives spawn in the upper reaches of coastal rivers, in slow-flowing sections of slightly brackish or freshwater. In the Great Lakes, alewives move inshore to the outlets of rivers and streams to spawn (University of Wisconsin Sea Grant Institute, 2001).

In coastal habitats, females lay demersal eggs in shallow water less than 2 m (6.6 ft) deep (Wang and Kernehan, 1979). They may lay from 60,000 to 300,000 eggs at a time (Kocik, 2000). The demersal eggs are 0.8 to 1.27 mm (0.03 to 0.05 in.) in diameter. Larvae hatch at a size of approximately 2.5 to 5.0 mm (0.1 to 0.2 in.) total length (Able and Fahay, 1998). Larvae remain in the upstream spawning area for some time before drifting downstream to natal estuarine waters. Juveniles exhibit a diurnal vertical migration in the water column, remaining near the bottom during the day and rising to the surface at night (Fay et al., 1983a). In the fall, juveniles move offshore to nursery areas (Able and Fahay, 1998).

Maturity is reached at 3 to 4 years for males, and 4 to 5 years for females (Able and Fahay, 1998). The average size at maturity is 265 to 278 mm (10.4 to 10.9 in.) for males and 284 to 308 mm (11.2 to 12.1 in.) for females (Able and Fahay, 1998). Alewife can live up to 8 years, but the average age of the spawning population tends to be 4 to 5 years (Waterfield, 1995; PSEG, 1999c).

ALEWIFE
(Alosa pseudoharengus)

Family: Clupeidae (herrings).

Common names: River herring, sawbelly, kyak, branch herring, freshwater herring, bigeye herring, gray herring, grayback, white herring.

Similar species: Blueback herring.

Geographic range: Along the western Atlantic coast from Newfoundland to North Carolina.[a] Arrived in the Great Lakes via the Welland Canal.[b]

Habitat: Wide-ranging, tolerates fresh to saline waters, travels in schools.

Lifespan: Generally 4-5 years but may live up to 8 years.[c,d]

Fecundity: Females may lay from 60,000 to 300,000 eggs at a time.[e]

Food source: Small fish, zooplankton, fish eggs, amphipods, mysids.[d]

Prey for: Striped bass, weakfish, rainbow trout.

Life stage information:

Eggs: *demersal*
- Found in waters less than 2 m (6.6 ft) deep.[e]
- Are 0.8 to 1.27 mm (0.03 to 0.05 in.) in diameter.[f]

Larvae:
- Approximately 2.5 to 5.0 mm (0.1 to 0.2 in) at hatching.[f]
- Remain in upstream spawning area for some time before drifting downstream to natal estuarine waters.

Juveniles:
- Stay on the bottom during the day and rise to the surface at night.[g]
- Emigrate to ocean in summer and fall.[f]

Adults: *anadromous*
- Reach maturity at 3-4 years for males and 4-5 years for females.[f]
- Average size at maturity is 265-278 mm (10.4-10.9 in.) for males and 284-308 mm (11.2-12.1 in.) for females.[f]
- Overwinter along the northern continental shelf.[f]

[a] Scott and Crossman, 1998.
[b] University of Wisconsin Sea Grant Institute, 2001.
[c] PSEG, 1999c.
[d] Waterfield, 1995.
[e] Kocik, 2000.
[f] Able and Fahay, 1998.
[g] Fay et al., 1983a.
Fish graphic courtesy of New York Sportfishing and Aquatic Resources Educational Program, 2001.

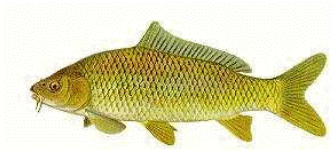
Carp (*Cyprinus carpio carpio*)

Carp is a member of the family of carps and minnows, Cyprinidae, and is abundant in Lake Erie. Carp were first introduced from Asia to the United States in the 1870's and 1880's, and by the 1890's were abundant in the Maumee River and in the west end of Lake Erie (Trautman, 1981). Carp are most abundant in low-gradient, warm streams and lakes with high levels or organic matter, but tolerate all types of bottom and clear to turbid waters (Trautman, 1981). Carp overwinter in deeper water and migrate to shallow water, preferably marshy environments with submerged aquatic vegetation in advance of the spawning season (McCrimmon, 1968). Adults feed on a wide variety of plants and animals, and juveniles feed primarily on plankton.

Carp are often considered a nuisance species because of their habit of uprooting vegetation and increasing turbidity when feeding (McCrimmon, 1968; Scott and Crossman, 1973). Carp are not widely popular fishes for anglers, although carp fishing may be an important recreational activity in some parts of the United States (Scott and Crossman, 1973). They are occasionally harvested commercially and sold for food (Scott and Crossman, 1973).

Male carp reach sexual maturity between ages 3 and 4, and the females reach maturity between ages 4 and 5 (Swee and McCrimmon, 1966). Spawning can occur at water temperatures between 16 and 28 ˚C (60.8 and 82.4 ˚F) with optimum activity between 19 and 23 ˚C (66.2 and 73.4 ˚F) (Swee and McCrimmon, 1966). Fecundity in carp can range from 36,000 eggs for a 39.4 cm (15.5 in.) fish to 2,208,000 in a 85.1 cm (33.5 in.) fish (Swee and McCrimmon, 1966), but individuals may spawn only about 500 eggs at a given time (Dames and Moore, 1977a). Eggs are demersal and stick to submerged vegetation.

Eggs hatch 3 to 6 days after spawning and larvae tend to lie in shallow water among vegetation (Swee and McCrimmon, 1966). The lifespan of a typical carp in North America is less than 20 years (McCrimmon, 1968). Adult carp can reach 102-122 cm (40-48 in.) long, and weigh 18-27 kg (40-60 lb) (Trautman, 1981).



CARP
(*Cyprinus carpio carpio*)

Family: Cyprinidae (minnows or carp).

Common names: Carp.

Similar species: Goldfish, buffalofishes, carpsuckers.[a]

Geographic range: Wide-ranging throughout the United States.

Habitat: Low-gradient, warm streams and lakes with high levels or organic carbon. Tolerates relatively wide range of turbidity. Often associated with submerged aquatic vegetation.[b]

Lifespan: Less than 20 years.[b]

Fecundity: 36,000 to 2,208,000 eggs per season.[c]

Food source: Omnivorous; diet includes invertebrates, small molluscs, ostracods, and crustaceans as well as roots, leaves, and shoots of water plants.[b]

Prey for: Juveniles provide limited forage for northern pike, smallmouth bass, striped bass, and longnosed gar, as well as green frogs, bullfrogs, turtles, snakes, mink.[b]

Life stage information:

Eggs: *demersal*
- During spawning, eggs are released in shallow, vegetated water. Eggs are demersal and stick to submerged vegetation.
- Eggs hatch in 3-6 days.[c]

Larvae:
- Larvae are found in shallow, weedy, and muddy habitats.[d]

Adults:
- May reach lengths of 102-122 cm (40-48 in.).[a]

[a] Trautman, 1981.
[b] McCrimmon, 1968.
[c] Swee and McCrimmon, 1966.
[d] Wang, 1986a.
Fish graphic from North Dakota Game and Fish Department, 2002.

Channel catfish (*Ictalarus punctatus*)

Channel catfish is a member of the Ictaluridae (North American freshwater catfish) family. It is found from Manitoba to southern Quebec, and as far south as the Gulf of Mexico (Dames and Moore, 1977a). Channel catfish can be found in freshwater streams, lakes, and ponds. They prefer deep water with clean gravel or boulder substrates and low to moderate currents (Ohio Department of Natural Resources, 2001b).

Channel catfish reach sexual maturity at ages 5-8, and females will lay 4,000-35,000 eggs dependent on body weight (Scott and Crossman, 1998). Spawning begins when water temperatures reach 24-29 ˚C (75-85 ˚F) in late spring or early summer. Spawning occurs in natural nests such as undercut banks, muskrat burrows, containers, or submerged logs. Eggs approximately 3.5 mm (0.1 in) in diameter are deposited in a large, flat, gelatinous mass (Wang, 1986a). After spawning, the male guards the nest and fans it to keep it aerated. Eggs hatch in 7-10 days at 24-26 ˚C (75-79 ˚F), and the newly hatched larvae remain near the nest for several days (Wang, 1986a). Young fish prefer to inhabit riffles and turbulent areas. Channel catfish are very popular with anglers and are relatively prized as a sport fish (Dames and Moore, 1977a).

CHANNEL CATFISH
(*Ictalarus punctatus*)

Family: Ictaluridae (North American freshwater catfish).

Common names: Channel catfish, graceful catfish.[a]

Similar species: Blue and white catfishes.[b]

Geographic range: South-central Canada, central United States, and northern Mexico.[a]

Habitat: Freshwater streams, lakes, and ponds. Prefer deep water with clean gravel or boulder substrates.[c]

Lifespan: Maximum reported age: 16 years.[a]

Fecundity: 4,000 to 35,000 eggs depending on body weight.[e]

Food source: Small fish, crustaceans, clams, snails.[a]

Prey for: Chestnut lamprey.[a]

Life stage information:

Eggs: *demersal*
- 3-4 mm (0.12-0.16 in.) in diameter.[d]
- Hatch in 7-10 days.[d]

Larvae:
- Remain near nest for a few days then disperse to shallow water.[d]
- Approx. 6.4 mm (0.25 in.) upon hatching.[d]

Adults: *demersal*
- Average length: 30-36 cm (12-14 in.).[c]
- Maximum length: up to 104 cm (41 in.).[c]

[a] Froese and Pauly, 2001.
[b] Trautman, 1981.
[c] Ohio Department of Natural Resources, 2001b.
[d] Wang, 1986a.
[e] Scott and Crossman, 1998.
Fish graphic courtesy of New York Sportfishing and Aquatic Resources Educational Program, 2001.

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 and in Lake Erie (Trautman, 1981). The emerald shiner is one of the most prevalent fishes in Lake Erie, although populations may fluctuate dramatically from year to year (Trautman, 1981). Because of its small size, it 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 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 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 (Fuchs, 1967). Adults typically range from 6.4 to 8.4 cm (2.5 to 3.3 in.) (Trautman, 1981).

EMERALD SHINER
(*Notropis atherinoides*)

Family: Cyprinidae (herrings).

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.[a,d]

Fecundity: Mature by age 2. Females can lay anywhere from approximately 870 to 8,700 eggs.[3]

Food source: 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.

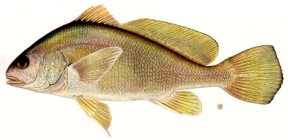
Freshwater drum (*Aplodinotus grunniens*)

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 from Manitoba, Canada, to Guatemala, and throughout the Mississippi River drainage basin (Scott and Crossman, 1973). The freshwater drum is found in deep pools of rivers and in Lake Erie at depths between 1.5 and 18 m (5 and 60 ft) (Trautman, 1981). Drum is not a favored food item of either humans or other fish; however, it supports a minor commercial fishery (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 anywhere 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 their first year. Maturity appears to be reached earlier in freshwater drum females from the Mississippi River than in 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.

The maximum age for fish in western Lake Erie is 14 years for females and 8 years for males (Edsall, 1967). Adults tend to be between 30 to 76 cm (12 to 30 in.) long.



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, 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 maximum age for fish in western Lake Erie is 14 years for females and 8 years for males.[c]

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

Food sources: Juveniles: Cladocerans (plankton), copepods, dipterans.[d] Adults: Dipterans, cladocerans,[d] 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). In Lake Erie, gizzard shad are most populous in the shallow waters of western Lake Erie, around the Bass Islands, and in protected bays and mouths of tributaries (Bodola, 1966).

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 waters (Miller, 1960). The spawning period generally lasts 2 weeks (Miller, 1960). Males and females release sperm and eggs while swimming in schools near the surface of the water. Eggs sink slowly to the bottom or drift with the current, and adhere to any surface they encounter (Miller, 1960). Females have been reported to release an average of 378,990 eggs annually (Bodola, 1966), which average 0.75 mm (0.03 in.) in diameter (Wallus et al., 1990).

Hatching time can be anywhere from 36 hours to 1 week, depending on water 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 6 years in Lake Erie, but individuals up to 10 years have been reported in southern locations (Scott and Crossman, 1973). Mass mortalities have been documented in several locations during winter months, due to extreme temperature changes (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 6 years, but have been reported up to 10 years.[b]

Fecundity: Maturity is reached by age 2; females produce average of 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 to 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 by some to be a nuisance species because of sporadic mass winter die-offs.[3]

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

Lake whitefish (*Coregonus clupeaformis*)

Lake whitefish are a member of the whitefish family, Salmonidae (Coregoninae subfamily). They are distributed widely in fresh water from Alaska, through Canada and south into the Great Lakes and northern New England (Scott and Crossman, 1998). They are a valuable commercial and recreational fish and are prized for their fine tasting meat as well as their eggs, which are prepared and marketed as caviar. Their liver is also used for paté.

Lake whitefish spawn in the autumn, usually in November and December, in the Great Lakes (Scott and Crossman, 1998). They deposit demersal eggs in shallow water of less than 7.6 m (25 ft) over rocky, hard, or sandy substrate. Fecundity is estimated at 16,100 eggs per pound of fish. The eggs are initially about 2.3 mm (0.09 in.) in diameter, but increase to up to 3.2 mm (0.13 in.) after 24 hours in the water. Eggs do not hatch right away, but overwinter and hatch in April or May when water temperatures rise (approximately 140 days; Froese and Pauly, 2001). The optimal temperature range for development is 0.6-6.1 ˚C (33-43 ˚F; Scott and Crossman, 1998).

Young whitefish develop rapidly, and reach the commercial size of 0.9 kg (2 lb) at age 3 in Lake Erie (Scott and Crossman, 1998). They may reach a length of 676 mm (26.6 in.) in Lake Erie. Males generally mature and die earlier than females.

LAKE WHITEFISH
(*Coregonus clupeaformis*)

Family: Salmonidae, subfamily Coregoninae (whitefish).[a]

Common names: Whitefish, Great Lakes whitefish, humpback whitefish.[b]

Geographic range: Alaska and Canada to Great Lakes and New England.[a]

Habitat: Lakes and large rivers.[b]

Lifespan: Maximum reported age: 28 years. In Lake Erie, live to approximately 16 years.[a]

Fecundity: 16,100 eggs per pound in Lake Erie.[a]

Food source: Young consume copepods, cladocerans, and insect larvae. Adults consume eggs and small fish such as darter, alewife, minnow, and stickleback.[a]

Prey for: Lake trout, northern pike, burbot, yellow walleye, whitefish. Parasitized by sea lamprey.[a]

Life stage information:

Eggs: *demersal*
- 2.3-3.2 mm (0.09-0.13 in.) in diameter.[a]
- Hatch in 140 days.[b]

Larvae:
- Approx. 12 mm (0.47 in.) at 1 week.[a]
- Concentrate in shallow water of about 30 cm (12 in.).[c]

Adults: *demersal*
- Maximum length in Lake Erie: up to 67.6 cm (26.6 in.).[a]

[a] Scott and Crossman, 1998.
[b] Froese and Pauly, 2001.
[c] University of Saskatchewan, 2002.
Fish graphic courtesy of New York Sportfishing and Aquatic Resources Educational Program, 2001.

Walleye (*Stizostedion vitreum*)

Walleye is a member of the perch family, Percidae. It is found in freshwater from as far north as the Mackenzie River near the Arctic Coast to as far south as Georgia, and is common in the Great Lakes. Walleye are popular sport fish both in the summer and winter.

Walleye spawn in spring or early summer, although the exact timing depends on latitude and water temperature. Spawning has been reported at water temperatures of 5.6 to 11.1 ˚C (42 to 52 ˚F), in rocky areas in white water or shoals of lakes (Scott and Crossman, 1998). They do not fan nests like other similar species, but instead broadcast eggs over open ground, which reduces their ability to survive environmental stresses (Carlander, 1997). Females typically produce between 48,000 and 614,000 eggs in Lake Erie, and the eggs are 1.4 to 2.1 mm (0.06 to 0.08 in.) in diameter (Carlander, 1997). Eggs hatch in 12-18 days (Scott and Crossman, 1998). Larvae are approximately 6.0 to 8.6 mm (0.23 to 0.33 in.) at hatching (Carlander, 1997).

Walleye develop more slowly in the northern extent of their range; in Lake Erie they typically are 8.9 to 20.3 cm (3.5 to 8.0 in.) by the end of the first growing season. Males generally mature at 2-4 years and females at 3-6 years (Scott and Crossman, 1998), and females tend to grow faster than males (Carlander, 1997). Walleye may reach up to 78.7 cm (31 in.) long in Lake Erie (Scott and Crossman, 1998).

WALLEYE
(*Stizostedion vitreum*)

Family: Percidae (perch).

Common names: Blue pike, glass eye, gray pike, marble eye, yellow pike-perch.[a]

Similar species: Sauger.[b]

Geographic range: Canada to southern United States.[c]

Habitat: Large, shallow, turbid lakes; large streams or rivers.[c]

Lifespan: Maximum reported age: 12 years.[b]

Fecundity: Broadcast spawners; in Lake Erie, 48,000 to 614,000 eggs per spawn.[b]

Food source: Insects, yellow perch, freshwater drum, crayfish, snails, frogs.[a]

Prey for: Sea lamprey, northern pike, muskellunge, sauger.[a]

Life stage information:

Eggs: *demersal*
- 1.4-2.1 mm (0.06-0.08 in.) in diameter.[b]
- Hatch in 12-18 days.[c]

Larvae: *pelagic*
- Approx. 6.2-7.3 mm (0.24-0.29 in.) upon hatching.[b]

Adults: *demersal*
- Maximum length: up to 78.7 cm (31 in.).[c]

[a] Froese and Pauly, 2001.
[b] Carlander, 1997.
[c] Scott and Crossman, 1998.
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, Moronidae. 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). White bass has both commercial and recreational fishing value.

Spawning take place in May in Lake Erie and may extend into June, depending on water 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 to 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 occupy the upper portion of the water column, maintaining depths of 6 m (19.7 ft) 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: Moronidae.

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.

Yellow perch (*Perca flavescens*)

The yellow perch is a member of the Percidae family and is found in fresh waters in the northern and eastern United States and across eastern and central Canada. Yellow perch are also occasionally seen in brackish waters (Scott and Crossman, 1973). They are typically found in greatest numbers in clear waters with low gradients and abundant vegetation (Trautman, 1981). The Great Lakes are a major source of yellow perch for the commercial fishing industry. Perch feed during the day on immature insects, larger invertebrates, fishes, and fish eggs (Scott and Crossman, 1973).

Sexual maturity is reached at age 1 for males and at ages 2 and 3 for females (Saila et al., 1987). Perch spawn in the spring in water temperatures ranging from 6.7 to 12.2 ˚C (44 to 54 ˚F) (Scott and Crossman, 1973). Adults move to shallower water to spawn, usually near rooted vegetation, fallen trees, or brush. Spawning takes place at night or in the early morning. Females lay all their eggs in a single transparent strand that is approximately 3 cm (1.2 in.) wide (Saila et al., 1987) and up to 2.1 m (7 ft) long (Scott and Crossman, 1973). These egg cases are semi-buoyant and attach to submerged vegetation or occasionally to the bottom and may contain 2,000-90,000 eggs (Scott and Crossman, 1973). In western Lake Erie, fecundities for yellow perch were reported to range from 8,618 to 78,741 eggs (Saila et al., 1987).

Yellow perch larvae hatch within about 8-10 days and are inactive for about 5 days until the yolk is absorbed (Scott and Crossman, 1973). Young perch are initially pelagic and found in schools, but become demersal after their first summer (Saila et al., 1987).

Adult perch are inactive at night and rest on the bottom (Scott and Crossman, 1973). Females generally grow faster than males and reach a greater final length (Scott and Crossman, 1973). In Lake Erie, perch may reach up to approximately 31 cm (12 in.) in total length and have been reported to live up to 11 years.

YELLOW PERCH
(*Perca flavescens*)

Family: Percidae (perches).

Common names: Yellow perch, perch, American perch, lake perch.[a]

Similar species: Dusky darter.[b]

Geographic range: Northern and eastern United States.[c]

Habitat: Lakes, ponds, creeks, rivers. Found in clear water near vegetation.[a,b]

Lifespan: Up to 11 years.[c]

Fecundity: 8,618 to 78,741 eggs.[c]

Food source: Immature insects, larger invertebrates, fishes, and fish eggs.[c]

Prey for: Almost all warm to cool water predatory fish, including bass, sunfish, crappies, walleye, sauger, northern pike, muskellunge, and other perch, as well as a number of birds.[c]

Life stage information:

Eggs: *semi-buoyant*
- Eggs laid in long tubes containing 2,000-90,000 eggs.[c]
- Eggs usually hatch in 8-10 days.[c]

Larvae: *pelagic*
- Larvae are 4.1-5.5 mm (0.16-0.22 in.) upon hatching.[d]
- Found in schools with other species.[c]
- Become demersal during the first summer.[d]

Adults: *demersal*
- Reach up to 31 cm (12 in.) in Lake Erie.[c]
- Found in schools near the bottom.

[a] Froese and Pauly, 2001.
[b] Trautman, 1981.
[c] Scott and Crossman, 1973.
[d] Saila et al., 1987.
Fish graphic courtesy of New York Sportfishing and Aquatic Resources Educational Program, 2001.

I3-3 Methods for Estimating I&E at Monroe

EPA examined I&E data from a variety of facility and agency monitoring reports. Impingement data were collected in 1972, 1973, and 1975 by the U.S. Fish and Wildlife Service (Goodyear, 1978), in 1982-83 by the University of Michigan Great Lakes Research Division (Jude et al., 1983), and in 1985-86 by the Michigan Department of Natural Resources (Andrew Nuhfer, Michigan Department of Natural Resources, Fisheries Division, personal communication, 2/13/02). Entrainment data were collected in 1973, 1974, and 1975 by the U.S. EPA (Cole, 1978) and in 1982-83 by the University of Michigan Great Lakes Research Division (Jude et al., 1983). For this benefits case study, EPA determined that only the data for the 1980's are relevant for an evaluation of the facility as it is currently operated and configured. The methods used to collect these data are summarized below.

I3-3.1 Impingement Monitoring

University of Michigan, Great Lakes Research Division, 1982-1983

Impingement was sampled by scientists from the University of Michigan, Great Lakes Research Division once per week from February 18, 1982, to February 7, 1983 (Jude et al., 1983). Samples were collected once a week for the 52 week sampling period, and one additional sample was collected on February 25, 1982, to sample a large gizzard shad impingement event. Sampling lasted for 24 hours and was conducted on Monday to Tuesday, or Tuesday to Wednesday (if Monday was a holiday).

Samples were collected from the two screenhouses via a conveyor belt, which delivered impinged fish from the traveling screens to a dump truck. Trucks were checked to ensure that they were not switched during the sampling period. After the 24 hour sampling period, either all of the fish were counted or, if the collection was too large to count, a subsample was collected. Subsampling was done by leveling the collected fish in the truck bed, visually dividing the bed into square

sections, assigning a number to each section, and randomly selecting a subset of sections (usually two). The remaining fish were spread evenly again, and the length, width, and depth of the pile were measured. The volume of unsampled fish was converted to an estimated weight using a conversion factor of 0.758 g/cm^3, which was derived from 10 replicates of 20 kg (44.09 lb) samples of alewives. This conversion was checked on several dates by comparing the volume of the fish sampled to the volume of the unsampled fish. When the resulting relationship from the volume comparison was consistently different from that calculated by the conversion factor because of variations in fish size and percentage of nonfish debris, the volume comparison was used to determine the percentage of fish subsampled. Estimates of the total number of fish impinged in a sampling period were made from subsampled counts by scaling up to the total amount for a sampling period.

During the large gizzard shad impingement event on February 25, 1982, the sampling method had to be altered because the fish were filling up trucks too quickly to be subsampled according to the usual protocol. A subsample of gizzard shad was collected from each truck, with an attempt made to collect a representative size distribution. Fish other than gizzard shad that were seen were also collected. The time to fill each truck and the volume of fish in the truck were recorded. A subset of the trucks was measured and the information applied to other truckloads collected that day.

The University of Michigan calculated average daily impingement rates by dividing the sum of impingement during all sampling days in the month by the number of sampling days. They then calculated monthly impingement by multiplying the average daily impingement by the number of days in the month. Annual impingement was the sum of all 12 months in the study.

Michigan Department of Natural Resources, 1985-1986

Impingement was also sampled by the Michigan Department of Natural Resources (DNR) from May 16, 1985, to May 6, 1986.

Samples were collected on 3 days in May and June 1985, 5 days per month in July and August 1985, and 4 days per month from September 1985 through April 1986, so that a total of 49 samples were collected. The day of sampling was randomly selected from weekdays (Monday through Friday). The duration of sampling was approximately 24 hours, although shorter periods were sampled when impingement was high and longer periods were sampled when there were few fish.

Samples were collected from the two screenhouses via a conveyor belt, which delivered impinged fish from the traveling screens to a dump truck. When the number of fish collected could be processed in less than 5 hours, the entire sample was counted. When this was not the case, the collection was subsampled. Subsampling was done by leveling the collected fish in the truck bed, visually dividing the bed into square sections, assigning a number to each section, and randomly selecting a subset of sections (approximately 40 percent). Equal numbers of buckets of debris and fish were collected from each selected section to draw a subsample. The subsamples and the remaining fish were weighed to determine what percentage of the total of the subsamples represented. On days when subsamples were taken, they represented an average of 26 percent by weight of the total collection. Subsamples were extrapolated to the total amount by multiplying by an expansion factor (calculated by dividing the weight of the total collection by the weight of the subsample).

The Michigan DNR calculated daily impingement values for each species by standardizing the collection rate to a 24 hour period. Periodic estimates were derived by multiplying the daily estimate by the number of days in a period of time represented by that sampling event (approximately 7). They then calculated monthly totals by summing the periodic rates for a given month. Final annual estimates are representative of both screenhouses combined.

I3-3.2 Entrainment Monitoring

University of Michigan, Great Lakes Research Division, 1982-1983

Entrainment sampling was also conducted from February 1982 to February 1983 (Jude et al., 1983). Samples were taken weekly from March through August; twice a month in January, February, September, and October; and once per month in November and December.

Lake and river water in the intake canal was often stratified because of temperature differences. Thus, samples used to estimate entrainment were collected in the discharge canal, because the water was well mixed. Larvae were collected using a 0.5 m (1.6 ft), 363 µm (0.0014 in) mesh net. A flowmeter was used to measure the volume of water per sample, usually

between 20 and 55 m^3 (706 and 1,942 ft^3). Four replicate samples were collected in each of four daily periods on each sampling date.

In their calculations, the Michigan DNR first multiplied the mean density in each of the four daily periods by the total weekly volume of water that passed through the plant during the corresponding daily period. Then these estimates for each daily time period were summed to estimate a weekly total across all time periods. Annual estimates were calculated by Michigan DNR by summing all of the weekly estimates.

I3-4 Annual Impingement and Entrainment

EPA evaluated annual I&E at Monroe using the methods presented in Chapter A5 of Part A of this document. The species-specific life history values used by EPA for its analyses are presented in Appendix I1. Table I3-2 displays estimates of annual impingement (numbers of organisms) at Monroe for the years of monitoring (1982 and 1985). Table I3-3 presents these numbers expressed as age 1 equivalents, Table I3-4 displays annual impingement of fishery species as pounds of lost fishery yield, and Table I3-5 displays annual impingement expressed as production foregone. Tables I3-6 through I3-9 display the same information for entrainment at Monroe for 1982.

The results of EPA's analysis indicate that both impingement and entrainment collections at Monroe are dominated by gizzard shad, followed by white bass, yellow perch, and freshwater drum. Impingement rates are about 4.5 times entrainment rates. However, more commercial and recreational species are entrained than impinged. About 34.3 million gizzard shad, 0.7 million white bass, 0.3 million yellow perch, and 0.15 million freshwater drum age 1 equivalents are impinged per year. Annual age 1 equivalents entrained average about 8.7 million gizzard shad, 0.8 million white bass, 0.6 million yellow perch, and 0.15 million freshwater drum. Impingement and entrainment of all species combined results in over 2 million pounds of lost fishery yield per year.

I3-5 Summary

Table I3-10 summarizes EPA's estimates of annual I&E at Monroe. Results indicate that, on average, nearly 21 million organisms are impinged at Monroe each year. This represents 35.8 million age 1 equivalents, 1.4 million pounds of lost fishery yield, and 0.7 million pounds of production foregone. Over 4.6 billion organisms are entrained per year, representing about 11.6 million age 1 equivalents, 0.6 million pounds of lost fishery yield, and 3.5 million pounds of production foregone. The economic value of these losses is discussed in Chapter I4, and the potential benefits of reducing these losses with the proposed rule are discussed in Chapter I5.

Table I3-2: Estimates of Annual Impingement (numbers of organisms) at Monroe, 1982 and 1985

Year	Alewife	Blue-gill	Bluntnose Minnow	Bullhead spp.	Carp	Central Mudminnow	Channel Catfish	Coho Salmon	Crappie	Fathead Minnow	Freshwater Drum	Gizzard Shad	Golden Redhorse	Hornyhead Chub	Log-perch
1982	250	750	6	1,732	7,100	12	1,333	18	1,310	170	160,000	30,000,000	12	210	96,800
1985	0	0	0	0	0	0	0	0	0	0	96,847	9,310,023	0	0	137,854
Mean	125	375	3	866	3,550	6	666	9	655	85	128,424	19,655,012	6	105	117,327
Minimum	0	0	0	0	0	0	0	0	0	0	96,847	9,310,023	0	0	96,800
Maximum	250	750	6	1,732	7,100	12	1,333	18	1,310	170	160,000	30,000,000	12	210	137,854
SD	177	530	4	1,225	5,020	8	943	13	926	120	44,656	14,630,023	8	148	29,030
Total	250	750	6	1,732	7,100	12	1,333	18	1,310	170	256,847	39,310,023	12	210	234,654

0=Sampled, but none collected.
Fri Feb 15 13:29:27 MST 2002 Raw.losses. IMPINGEMENT; Plant:monroe; PATHNAME:P:/Intake/Great_Lakes/GL_Science/scodes/monroe/tables.output/raw.losses.imp.monroe.csv

Table I3-2: Estimates of Annual Impingement (numbers of organisms) at Monroe, 1982 and 1985 (cont.)

Year	Longnose Gar	Mottled Sculpin	Muskel-lunge	Northern Pike	Rainbow Trout	Shiner spp.	Silver Lamprey	Smallmouth Bass	Smelt	Suckers	Sunfish	Tadpole Madtom	Walleye	White Bass	Yellow Perch	Other
1982	140	60	7	86	68	320,012	270	194	2,300	8,278	7,412	580	26,000	530,000	370,000	0
1985	0	0	0	0	0	40,491	0	0	6,221	0	0	0	7,374	567,550	78,246	24,817
Mean	70	30	4	43	34	180,252	135	97	4,260	4,139	3,706	290	16,687	548,775	224,123	12,408
Minimum	0	0	0	0	0	40,491	0	0	2,300	0	0	0	7,374	530,000	78,246	0
Maximum	140	60	7	86	68	320,012	270	194	6,221	8,278	7,412	580	26,000	567,550	370,000	24,817
SD	99	42	5	61	48	197,651	191	137	2,773	5,853	5,241	410	13,171	26,552	206,301	17,548
Total	140	60	7	86	68	360,503	270	194	8,521	8,278	7,412	580	33,374	1,097,550	448,246	24,817

0=Sampled, but none collected.
Fri Feb 15 13:29:27 MST 2002 Raw.losses. IMPINGEMENT; Plant:monroe; PATHNAME:P:/Intake/Great_Lakes/GL_Science/scodes/monroe/tables.output/raw.losses.imp.monroe.csv

Table I3-3: Annual Impingement at Monroe Expressed as Numbers of Age 1 Equivalents, 1982 and 1985

Year	Alewife	Blue-gill	Bull-head spp.	Carp	Channel Catfish	Crappie	Fresh-water Drum	Gizzard Shad	Log-perch	Muskel-lunge	Shiner spp.	Small-mouth Bass	Smelt	Suckers	Sun-fish	Wall-eye	White Bass	Yellow Perch
1982	311	894	2,014	7,783	1,718	1,586	184,603	52,388,535	129,361	8	378,718	281	2,770	9,916	12,353	35,303	639,692	436,069
1985	0	0	0	0	0	0	111,739	16,257,949	184,225	0	47,919	0	7,493	0	0	10,013	685,014	92,218
Mean	156	447	1,007	3,891	859	793	148,171	34,323,242	156,793	4	213,319	141	5,132	4,958	6,177	22,658	662,353	264,144
Minimum	0	0	0	0	0	0	111,739	16,257,949	129,361	0	47,919	0	2,770	0	0	10,013	639,692	92,218
Maximum	311	894	2,014	7,783	1,718	1,586	184,603	52,388,535	184,225	8	378,718	281	7,493	9,916	12,353	35,303	685,014	436,069
SD	220	632	1,424	5,503	1,215	1,121	51,523	25,548,182	38,794	5	233,910	199	3,340	7,011	8,735	17,883	32,047	243,139
Total	311	894	2,014	7,783	1,718	1,586	296,342	68,646,484	313,586	8	426,637	281	10,264	9,916	12,353	45,316	1,324,706	528,287

Note: Impingement losses expressed as age 1 equivalents are larger than raw losses (the actual number of organisms impinged). This is because the ages of impinged individuals are assumed to be distributed across the interval between the start of year 1 and the start of year 2, and then the losses are normalized back to the start of year 1 by accounting for mortality during this interval (for details, see description of S*j in Chapter A5, Equation 4 and Equation 5). This type of adjustment is applied to all raw loss records, but the effect is not readily apparent among entrainment losses because the majority of entrained fish are younger than age 1.
0=Sampled, but none collected.
Fri Feb 15 13:35:00 MST 2002 ;Results; I Plant: monroe ; Units: equivalent.sums Pathname:
P:/Intake/Great_Lakes/GL_Science/scodes/monroe/tables.output/I.equivalent.sums.monroe.csv

Table I3-4: Annual Impingement of Fishery Species at Monroe Expressed as Yield Lost to Fisheries (in pounds), 1982 and 1985

Year	Bullhead spp.	Carp	Channel Catfish	Crappie	Freshwater Drum	Gizzard Shad	Smallmouth Bass	Smelt	Suckers	Sunfish	Walleye	White Bass	Yellow Perch
1982	44	3,761	54	13	9,806	2,067,893	11	24	123	4	520	48,743	465
1985	0	0	0	0	5,936	641,738	0	64	0	0	148	52,196	98
Mean	22	1,880	27	7	7,871	1,354,816	6	44	62	2	334	50,469	282
Minimum	0	0	0	0	5,936	641,738	0	24	0	0	148	48,743	98
Maximum	44	3,761	54	13	9,806	2,067,893	11	64	123	4	520	52,196	465
SD	31	2,659	38	9	2,737	1,008,444	8	29	87	3	263	2,442	259
Total	44	3,761	54	13	15,742	2,709,631	11	88	123	4	668	100,939	563

0=Sampled, but none collected.
Fri Feb 15 13:35:17 MST 2002 ;Results; I Plant: monroe ; Units: yield Pathname: P:/Intake/Great_Lakes/GL_Science/scodes/monroe/tables.output/I.yield.monroe.csv

Table I3-5: Annual Impingement at Monroe Expressed as Production Foregone (in pounds), 1982 and 1985

Year	Alewife	Blue-gill	Bull-head spp.	Carp	Channel Catfish	Crappie	Fresh-water Drum	Gizzard Shad	Log-perch	Muskel-lunge	Shiner spp.	Small-mouth Bass	Smelt	Suckers	Sun-fish	Wall-eye	White Bass	Yellow Perch
1982	5	11	53	2,426	90	54	17,556	936,779	645	4	4,654	20	31	1,057	21	6,388	59,868	4,761
1985	0	0	0	0	0	0	10,627	290,714	918	0	589	0	85	0	0	1,812	64,109	1,007
Mean	2	5	26	1,213	45	27	14,091	613,747	781	2	2,621	10	58	529	10	4,100	61,988	2,884
Minimum	0	0	0	0	0	0	10,627	290,714	645	0	589	0	31	0	0	1,812	59,868	1,007
Maximum	5	11	53	2,426	90	54	17,556	936,779	918	4	4,654	20	85	1,057	21	6,388	64,109	4,761
SD	3	8	37	1,716	63	38	4,900	456,837	193	3	2,874	14	38	747	15	3,236	2,999	2,655
Total	5	11	53	2,426	90	54	28,183	1,227,494	1,563	4	5,243	20	116	1,057	21	8,199	123,977	5,768

0=Sampled, but none collected.
Fri Feb 15 13:35:09 MST 2002 ;Results; I Plant: monroe ; Units: annual.prod.forg Pathname:
P:/Intake/Great_Lakes/GL_Science/scodes/monroe/tables.output/I.annual.prod.forg.monroe.csv

Table I3-6: Estimates of Annual Entrainment (numbers of organisms) at Monroe, 1982

Year	Burbot	Carp	Channel Catfish	Crappie	Freshwater Drum	Gizzard Shad	Logperch	Shiner spp.
1982	2,770,000	79,700,000	4,160,000	580,000	158,000,000	4,080,000,000	2,983,000	30,420,000

Fri Feb 15 13:29:29 MST 2002 Raw.losses. ENTRAINMENT; Plant:monroe;
PATHNAME:P:/Intake/Great_Lakes/GL_Science/scodes/monroe/tables.output/raw.losses.ent.monroe.csv

Table I3-6: Estimates of Annual Entrainment (numbers of organisms) at Monroe, 1982 (cont.)

Year	Smallmouth Bass	Smelt	Suckers	Sunfish	Walleye	White Bass	Whitefish	Yellow Perch	Unknown
1982	599,000	11,000,000	6,204,000	923,000	2,080,000	156,000,000	190,000	128,000,000	38,300,000

Fri Feb 15 13:29:29 MST 2002 Raw.losses. ENTRAINMENT; Plant:monroe;
PATHNAME:P:/Intake/Great_Lakes/GL_Science/scodes/monroe/tables.output/raw.losses.ent.monroe.csv

Table I3-7: Annual Entrainment at Monroe Expressed as Numbers of Age 1 Equivalents, 1982

Year	Burbot	Carp	Channel Catfish	Crappie	Fresh-water Drum	Gizzard Shad	Log-perch	Shiner spp.	Small-mouth Bass	Smelt	Suckers	Sunfish	Walleye	White Bass	White-fish	Yellow Perch
1982	1,765	394,554	20,594	23,517	143,558	8,747,005	115,373	276,928	48,283	89,543	89,117	311,090	16,749	772,277	81	567,330

Fri Feb 15 13:34:58 MST 2002 ;Results; E Plant: monroe ; Units: equivalent.sums Pathname:
P:/Intake/Great_Lakes/GL_Science/scodes/monroe/tables.output/E.equivalent.sums.monroe.csv

Table I3-8: Annual Entrainment of Fishery Species at Monroe Expressed as Yield Lost to Fisheries (in pounds), 1982

Year	Burbot	Carp	Channel Catfish	Crappie	Freshwater Drum	Gizzard Shad	Smallmouth Bass	Smelt	Suckers	Sunfish	Walleye	White Bass	Whitefish	Yellow Perch
1982	206	190,659	643	195	7,626	345,264	1,972	766	1,108	113	247	58,845	73	605

Fri Feb 15 13:35:15 MST 2002 ;Results; E Plant: monroe ; Units: yield Pathname: P:/Intake/Great_Lakes/GL_Science/scodes/monroe/tables.output/E.yield.monroe.csv

Table I3-9: Annual Entrainment at Monroe Expressed as Production Foregone (in pounds), 1982

Year	Burbot	Carp	Channel Catfish	Crappie	Freshwater Drum	Gizzard Shad	Logperch	Shiner spp.	Smallmouth Bass	Smelt	Suckers	Sunfish	Walleye	White Bass	Yellow Perch
1982	<1	578,130	6,789	20,614	101,515	970,508	8,873	83,324	7,469	5,350	95,408	1,645	28,802	1,185,004	354,467

Fri Feb 15 13:35:07 MST 2002 ;Results; E Plant: monroe ; Units: annual.prod.forg Pathname:
P:/Intake/Great_Lakes/GL_Science/scodes/monroe/tables.output/E.annual.prod.forg.monroe.csv

Table I3-10: Average Annual Impingement and Entrainment at Monroe (sum of annual means of all species evaluated)

	Impingement	Entrainment
Raw losses (# of organisms)	20,889,043	4,663,609,000
Age 1 equivalents (# of fish)	35,814,243	11,617,765
Fishery yield (lb of fish)	1,415,820	608,321
Production foregone (lb of fish)	702,141	3,447,899

mixed.rollup.chap3.ent Fri Feb 15 14:09:44 MST 2002
P:/Intake/Great_Lakes/GL_Science/scodes/monroe/tables.output/flowchart.chap3.ENT.csv
mixed.rollup.chap3.imp Fri Feb 15 14:09:42 MST 2002
P:/Intake/Great_Lakes/GL_Science/scodes/monroe/tables.output/flowchart.chap3.IMP.csv