5/94

DRAFT

Data re Perch, Other Les Cheneaux Fish, Cormorants, Zooplankton etc. for Model of Les Cheneaux Perch Fishery

1. Perch

1.0 Year 0 Perch

1.0.1 Food and Feeding

Data from Hayes (1988): The diet of young-of-the-year perch shifted from zooplankton to benthos in July.

Data from Wu (1991): Showed that young of year yellow perch in Western Lake Erie underwent an ontogenetic diet shift from exclusive zooplankton to mainly benthic prey during June through August. The shift was size related (at 30 mm total length).

Data from Arts and Sprules (1989): Holopedium gibberum, a cladoceran, were varied between tests in an enclosure with mean lake density of all other zooplankton and with YOY yellow perch. YOY perch grew heavier and longer in tests where there were Holopedium than in tests with none. In the first two weeks of July, with average lake amount of Holopedium present, they were 15-45% of the diet (by wet weight) of perch. However, after the second week of July Holopedium predation decreased dramatically (with no change in Holopedium present), and the dominant prey items included then Chaoborus, chironomids, and Sida. Y-o-y yellow perch show positive selection for Holopedium, after they attain at least 14mm fork length. Holopedium abundance usually occurs from late June to early July in north central Ontario at a time when y-o-y perch are abundant and growing quickly.

Data from Confer and O'Bryan (1989): Planktivorous yellow perch prey rank was found by offering a swarm of one prey type and observing ingestion rates. During the initial feeding burst, larger prey generally ranked higher. During long-term feeding the largest prey, large Daphnia magna, generally declined in rank while the smallest prey, Dioptomus sicilis, increased to the highest or second highest rank. Prey preference was measured with fishes feeding in a swarm of mixed prey. Initially yellow perch selected for large Daphnia, then switched to Diaptomus.

Data from Schaeffer and Margraf (1986): The two species ate similarly until August in year 0, when white perch went to YOY gizzard shad and yelloew perch did not. Food is limiting the growth of yellow perch in western Lake Erie.

Data from Timmons (1984): In a lake in Alabama-Georgia by late summer and fall YOY yellow perch consumed cladocera and dipterans.

Data from Mills and Forney (1981): In early summer Oneida Lake perch which fed on Daphnia pulex were 20 to 50 mm total length, but lengths varied widely in late summer when diet became more diverse. In years when Daphnia collapsed in late summer, perch ate other things and their growth declined.

Data from Confer and O'Bryan (1989): YOY European perch, Perca fluviatilus, select smaller, more elusive copepods over larger and more easily captured Daphnia. Young yellow perch, Perca flavescens, select for mid-size Daphnia. Smaller prey have higher capture costs; larger prey have greater digestive costs.

Data from Clady (1977A): Copepod nauplii is the primary food of larval yellow perch in Oneida Lake. However, nauplii populations are not depleted by predation by yellow perch.

Data from Hansen and Wahl (1981): Yellow perch fry selectively fed on Daphnia pulex that were significantly smaller than those in plankton samples. Yellow perch consistently selected smaller D. pulex than they were capable of consuming. Three possible reasons: (1) learned search images, (2) bigger Daphnia are faster and might escape, and (3) low attack proficiency of young weak-swimming yellow perch fry. Daphnia were the dominant zooplankton in Lake Oneida in the diet of yellow perch in June. Copepods became increasingly important later in the summer. Yellow perch ate copepods, but they preferred Daphnia.

Data from Wu and Culver (1992): Age-0 yellow perch consumed zooplankton exclusively before the decline of zooplankton abundance in western Lake Erie. The onset of consumption of benthic organisms coincided with the declining zooplankton abundance.

Data from Ney (1978): Annual growth is positively correlated with temperature. the young begin feeding as prolarvae on small copepods and nauplii. Copepods and cladocerans are dominant in the diet of y-o-y yellow perch during the entire season, and chironomids and other benthic invertebrates may also be important. Fish are rare in y-o-y diet.

1.0.2 Predation upon Perch

See 2.0.1 and 2.4.1.

Data from M. Clymer: Perch eggs ~~on the bottom~~ are often eaten by bullheads and carp.

Data from Ney (1978): Northern Pike are predators upon yellow perch. Yet yellow perch have been reported to be the major predator on larval northern pike. In the Great Lakes yellow perch and walleye populations have declined after rapid expansion of alewife and rainbow smelt numbers, presumably via predation on y-o-y perch.

1.0.3 Growth

Data from Confer and Lake (1987): Differences in growth frequently varied by 50-300% when YOY yellow perch were fed diets having the same weight but different mixtures of prey. Growth was always by the following ranks: Diaptomus sicilis > Oneida Lake tow samples > Daphnia spp.

Data from Shuter and Post (1990): They use a set of threshold temperatures to determine the start and end of critical processes such as fertilization, growth and starvation. [B. Clymer assumes that the event ages (affected by temperature) are the triggers of events.] They assume that larval development time is an exponentially decreasing function of temperature (see their Fig 2).

Data from Cucin and Faber (1985): Newly hatched yellow perch in Lake Opeongo, Ontario, were 5-6 mm long.

Data from Wu and Culver (1992): Many fish change their habitat use and diet as they grow, a phenomenon called ontogenetic diet shift.

Data from Ney (1978): The pattern of first year growth in length has been reported as sigmoid: posthatch acceleration, then a fairly linear phase in midsummer, then gradual slowdown of growth until early autumn. Optimal growth is attained at 22C. Annual variations in first year growth of Lake Oneida yellow perch could be explained almost entirely as a function of the density of Daphnia spp (Noble 1975 is cited).

1.0.4 Behavior

Data from Dorr (1982): Larval perch dispersed from spawning areas within a few hours of hatching.

Data from M. Clymer: Newly hatched perch migrate out of the enclosed waters of the Snows into the deeper waters of the "big lake" (northern waters of Lake Huron).

Data from Clady (1977A): Newly hatched yellow perch larvae are rapidly dispersed by wind-driven surface currents in Lake Oneida, so that large numbers occur throughout the lake during the time eggs are hatching in May.

Data from Cucin and Faber (1985): Incubation times range from 8 to 15, even to 20 days. Temperatures ranged from 12 to 15 C in Lake Opeongo.

Data from Mills and Forney (1981): In Oneida Lake transition to demersal life begins in mid-June, but most young remain pelagic until attaining a length of 30-50 mm in July.

Data from Ney (1978): Yellow perch hatch at 4.5-7.0 mm total length. The yolksac is absorbed at 7.0 mm.

1.0.5 Mortality

Data from Shuter and Post (1990): Smaller fish are less tolerant of starvation conditions in winter (low temperature and less food). YOY viability through the first winter hinges on attainment of a certain minimum amount of growth before winter.

Data from Cucin and Faber (1985): for many fish species mortality is greatest during the first year of life. The principal causes of mortality during early larval stages are believed to be: starvation, predation, toxic substances, and adverse environmental conditions. Also acid precip appears to cause excess mortality in early life stages.

Data from Ney (1978): Loss of yellow perch from egg through the prolarval stage has been estimated at 82-98% in Oneida Lake. Most of this mortality is in the egg stage and is due climate and weather variables (Ney mentions wind speed and rate of water warmup. Annual mortality of juveniles and adults is markedly lower. Perch longevity has been reported at 11 years for Lake Erie yellow perch.

1.0.6 Population

Data from Kallemeyn (1987): Significant positive correlations were found between lake level and walleye year-class strength in three of the four lakes. [Was this due to loss of viable eggs to drying when level is down?] The strongest year classes of both species were produced in years with higher, more stable temperatures. [Was this due to higher temperature producing greater growth?]

1.1 First Year Perch

1.1.1 Food and Feeding

Data from Hayes (1988): Adult perch shifted from benthos to zooplankton during the second summer of life.

1.1.2 Predation upon Perch

Data from Nielsen (1980): Predation by walleyes was probably the principal cause of mortality of age I and II yellow perch in Oneida Lake.

1.1.3 Growth

1.1.4 Behavior

1.1.5 Mortality

1.1.6 Population

1.2 Second Year Perch

1.2.1 Food and Feeding

Data from Knight, Margraf and Carline (1984): Yellow perch 2 years old and up from western Lake Erie ate invertebrates in spring but clupeids and shiners thereafter. Perch are more opportunistic than are walleyes.

1.2.2 Predation upon Perch

Data from Nielsen (1980): Cohorts of yellow perch in Oneida Lake varied 45-fold in relative abundance at age 0, but 300-fold by age III. Walleye stomachs contained few age-I and II perch, and what there was was mainly in the spring (May-June).

1.2.3 Growth

1.2.4 Behavior

1.2.5 Mortality

1.2.6 Population

1.3 Third and Higher Year Perch

1.3.1 Food and Feeding

Data from Wu and Culver (1992): Adult yellow perch (age 2+ and older) are predators, and 5-20% of their diet in western Lake Erie consists of small yellow perch.

1.3.2 Predation upon Perch

See 1.3.1, Wu and Culver.

1.3.3 Growth

1.3.4 Behavior

1.3.5 Mortality

1.3.6 Population

1.4 Perch Data Independent of Age (or Over Several Ages)

1.4.1 Food and Feeding

Data from Hayes (1988): Perch in both Little Bear Lake and Douglas Lake were stunted, with 4 year old perch averaging less than 130mm in length.

Data from Weisberg and Janicki (1990): In summer and early fall Trichopterans (caddis fly) was the dominant prey item, amounting to 40% of the diet. The amphipod Gammarus fasciatis and chironomids were another 40%. [These are river fish, so they can eat only what is there.] Most foraging was done on the bottom in daylight.

Data from Timmons (1984): Cladocera were the major food item for small (<75 mm) and medium size)75-150 mm) yellow perch; ostracods, hydracarina, and insects (especially chironomids and ceratopogonids) were consumed in lesser amounts. In winter all sizes of perch had a high percentage of empty stomachs or they contained bryozoan statoblasts. Adults fed on a variety of insects and small fishes, especially sunfishes, Lepomis spp. [This is in a southern lake, the farthest south yet studied]. Small YOY yellow perch (25-49 mm) consumed mostly cladocera and copepods (in 92% and 88% of stomachs respectively. The dominant copepods were Cyclops spp and Diaptomas spp; the dominant cladocera were Bosmina spp and Daphnia spp. In the north yellow perch young feed primarily on small crustaceans, then on insects and larger crustaceans; as adults they feed on fish, large insects, and crayfish. Larger adults in summer get the major part of their caloric input from eating fish.

Data from Costa (1979): Maximum feeding by perch during the day was observed just before dark. The daily ration was about 1.4% of wet body weight. The diet in Lake Washington was cottids, mysid shrimps (Acanthomysis awatchensis) and chironomid pupae and larvae.

Data from M. Clymer: Big perch are opportunistic & will eat YOY fishes when their preferred forage is unavailable

Data from Danehy et al. (1991): Alewife juveniles were important food for yellow perch in the fall in Lake Ontario. Benthic invertebrates, primarily Gammarus spp., were the major prey at both types of bottom (cobble/rubble shoals and featureless sand). The diets of yellow perch were dominated by fish: spottail shiner (Notropis hudsonius Clinton) and alewife (Alosa pseudoharengus Wilson) in May and early June. Diet diversified in mid-June to early August, when crayfish provided as much as 70% of the food (dry weight). Fishes, especially YOY alewife, appeared to dominate diets during September and October.

Data from Keast (1977): In Lake Opinicon, Ontario, year 0 perch feed on mainly Cladocera. The Year II class takes a diversified range of insect larvae, whereas from Year class V onwards Anisoptera, nymphs, decapods, and fish dominated the diet. The prey weights are, respectively, 0.1, 0.5-1.0, and 100-250 mg. There are marked month to month changes in types and proportions of different prey con--sumed. Very detailed data are given for diet of perch of each age class. He believes that the appearance of major resources(food) is determined by timing being "under precise day length and temperature control". [B. Clymer believes that the major control is gene expression, disturbed in time by temperature history, and not-understood effects of photoperiod, day length, etc.]

Data from Jansen and Mackay (1992): data from Baptiste Lake, Alberta. Perch diet composition differed significantly between times of day, particularly between day and night. In terms of biomass, forage fish, amphipods, chironomids, and trichoptera were the most important food items on the sampling days (24-25 July and 20-21 August, 1986). They cite three references concerning quantitative estimates of daily food consumption in perch. They say that amphipods and chironomids occurred in the diet at medium to high frequencies at all sampling times. In Baptiste Lake yellow perch between 90 and 246 mm total length fed on a mixture of invertebrates and fish, and they almost completely ignored zooplankton, which were abundant there then. The ontogenetic size threshold for piscivory in yellow perch is reported as 130-150 mm total length. Prey abundance does not adequately explain the dietary pattern that was observed. Forage fish are almost absent from perch stomachs during the night, perhaps due to the greater difficulty of capturing them in low light.

Data from Timmons (1984): With increasing fish size it is uneconomical, in terms of energy, for perch to eat zooplankton.

Data from Knight, Margraf and Carline (1984): Yellow perch in Western Lake Erie ate invertebrates in spring but clupeids and shiners thereafter. Yellow perch were more opportunistic feeders than walleyes. Large yellow perch (>200 mm long) in western Lake Erie are piscivorous. Shiners contributed 5-25% of the diet in spring and 35-40% in autumn. Age-0 clupeids were major prey in summer and autumn, constituting 5-60% and 40-60% of the diet, respectively. Small yellow perch made up 5-20% of the summer diet of adult yellow perch. Most yellow perch ate similar volumes of invertebrates and fishes. Invertebrates constituted 80-100% of the diet from April to August, consisting mostly of pelecypods (40%) and immature chironomids (40%) in spring, and cladocerans (75%) in summer. Yellow perch ate few invertebrates (0-20%) in late summer and early autumn, when they switched to abundant age-0 gizzard shad and shiners. Consumption of invertebrates increased again in late autumn when forage fish availability declined. 200 mm yellow perch ate prey of about 56 mm. Diet selection by yellow perch was influenced most by abundance of vulnerable forage fishes and the size of the yellow perch. Yellow perch probably eat more small yellow perch than do walleyes.

Data from Weisberg and Janicki (1990): Yellow perch diet in the Susquehanna River, Maryland. The amphipod Gammarus was the most important prey for yellow perch, with its importance increasing in early autumn. Cheumatopsyche sp was also important, greatest in late summer. Gastropods constituted more than 35% of the diet in early summer, but was less than 10% at other times. With increase of fish size from <150 to >200 mm, cheumatopsyche sp increased from 15 to 50% of diet biomass, and Gammarus decreased from 60 to 15%. [The data in Fig 7 give food per day, as % of body weight, as 0.185%]. Yellow perch feed almost exclusively during daylight hours.

Data from Confer and O'Bryan (1989): If offered a swarm of prey (one species, different sizes), during the initial feeding burst larger prey generally ranked higher. During long term feeding of a mixture the largest prey, large Daphnia magna, generally declined in rank, while the smallest prey, Diaptomus sicilis, increased to the highest or second highest rank. Prey preference was thus measured by feeding a swarm of mixed prey. Yellow perch have a high growth efficiency on a diet of Diaptomus. The initial burst of feeding declines rapidly in rate, and there is a gradual decrease in chosen size of the species being eaten.

Data from Ney (1978): Adult yellow perch feed heavily on benthic insect larvae (principally chironomids and mayflies) as well as zooplankton, amphipods, leeches and crayfish. Fish enter the summer diet of larger yellow perch and can comprise the major caloric intake. Cannibalism is intense in Oneida Lake.

1.4.2 Predation upon Perch

Data from Nielsen (1980): Ultimate year class strength was influenced strongly by mortality of age I and II fish, which was mainly from predation by walleyes. Walleyes consumed a large proportion of each perch cohort. Age 0 yellow perch are the principal food of juvenile and adult walleyes.
Most mortality of age I and II yellow perch in Oneida Lake is probably attributable to predation by walleyes. Cannibalism of age-0 perch ceases in late summer. No age-I or age-II perch were ever observed in stomachs of adult perch.

Data from Knight, Margraf and Carline (1984): Yellow perch probably eat more small yellow perch than walleyes do.

1.4.3 Growth

Data from Starr (1989): Unstunted (110 to 130 mm) and stunted (80 to 100 mm) yellow perch fed practical feeds will reach market size (195 mm) in 6 to 7 and 9 to 11 months, respectively.

Data from Danehy et al. (1991): Growth rate was significantly higher for yellow perch captured over cobble/rubble shoals than over featureless sand bottom.

Unknown source: perch length changes with age faster than an exponential. That is, in log l = a + bt, b increases with time.

Data from Shuter and Post (1990): They give an equation for the rate of change of weight with consumption, respiration, specific dynamic action, egestion and excretion for fish older than larvae living off their yolk sacks. It is quite complicated and requires data difficult to obtain. They express length as a power function of weight.

Data from Keast (1977): size distribution of perch in September-October in Lake Opinicon, Ontario:

Year class 0	50- 78 mm
Year class I	84-106 mm
Year class II	103-130 mm
Year class III	124-146 mm
Year class IV	140-164 mm
Year class V	154-183 mm
Year class VI	173-204 mm
Year class VII	192-232 mm

The oldest fish caught was 9 years, although males of 15 years have been recovered from Lac Saint-Louis, Quebec.

Data from Jansen and Mackay (1992): they advise figuring fish growth from basic data such as prey size and prey type.

Data from Parrish and Margraf (1993): increased fish density (fish per unit volume of water) caused both yellow and white perch to grow more slowly. The optimal temperature for growth of yellow perch is 23C and for white perch is 28.5C.

1.4.4 Behavior

Data from Dorr (1982): Spawning was done on rough bottoms, where waves could not move the eggs toward shore (where they would dry up). Waves do move eggs laid on a sandy (smooth) bottom.

Data from Kayes and Calbert (1979): Perca flavescens in Lake Mendota, Wisconsin, normally spawn over a two to three week period in April to early May when the temperature reaches 8 to 12 C. [Authors don't know B. Clymer's papers that talk about how temperature quantitatively affects ages at which events, such as spawning, occur.]

Data from Clady (1977B): Fish that have spawned disperse to all parts of the lake, although there is a significantly larger proportion in residence locally. The fish invariably return to the same spawning grounds in following years.

Data from M. Clymer: Perch spawn in early spring, about when the ice goes out, typically in April 17-May 22 in the Snows.

Data from Jansen and Mackay (1992): Data from Baptiste Lake, Alberta. Feeding intensity increased throughout the day, peaked in late evening, and almost ceased after sunset. Perch diet composition changes between times of day could be related both to prey behavior and distribution, and to changes in perch foraging behavior in response to light intensity. In the same reference Jansen and Mackay cite 4 papers which say that the natural feeding rhythm of perch has two peaks, at dawn and dusk, which contradicts a statement above. The discrepancy is not explained. YOY perch show the most pronounced onshore migration during dusk of all age classes. In most lakes perch return to offshore waters at dawn.

Data from Timmons (1984): Daily feeding periodicities of yellow perch coincide with diurnal movement. The start of active feeding began at sunrise and again at sunset in Lake Opinicon, Ontario. Yellow perch remain inactive on the bottom at night, migrate offshore shortly after sunrise, and return onshore at dusk. Some of the largest collections of yellow perch at West Point Lake were along shallow shorelines at dusk.

Data from Cucin and Faber (1985): Yellow perch spawn in Lake Opeong during the latter half of May. Temperatures range from 12 to 15C; other authors say 7-11C. Eggs are at depths of 0.5 to 3 m. Eggs are attached in masses to trees, brush, etc., or directly on bottom.

1.4.5 Mortality

Data from Clady (1977B): The annual survival of adult yellow perch was estimated from tag returns to have been 56%, or a mortality of 44% per year.

Data from M. Clymer: An unknown number of adult perch are killed annually by abandoned gill nets.

get sources

Data from M. Clymer: Perch live up to 13 years.

Data from M. Clymer: 8% of the annual catch of perch is through the ice.

Data from M. Clymer: Perch size distribution as caught:

< 7"	17%
7-8"	48%
8-10"	29%
> 10"	6%
	100 %

Data from Shuter and Post (1990): Death occurs when a fixed proportion of total dry body weight is lost.

1.4.6 Population

Data from Coble (1982): They sampled fish in the Wisconsin River at places where DO (dissolved oxygen) varied from 2 to 8 mg/l. Wherever DO exceeded 5 mg/l, there were a higher % sport fish, % walleyes and yellow perch, % Centrarchidae, number of fish species, and number of species of sport fish. [This makes sense with Ohio stream experience]. [Therefore it would be important to measure DO in the Snows in typical places and depths to see if DO is limiting].

Data from M. Clymer: Adult perch cycled in population from 1968 to 1985, then kept going down, stayed low. Three main factors: alewife eating young perch, sportsmen's catch of adult perch, and cormorants eating perch (rare in Les Cheneaux before 1985). Alewife rose to a peak in 1988, but then salmon were introduced to eat alewifes. Currently the Indians are catching salmon for their roe to sell, so an increase of alewife is expected.

Data from M. Clymer: The angler harvest of perch has varied widely:

Before low of 1987: 200,000 to 400,000 fish/yr
In 1986: 347,257 [about 5 insignificant digits]
Since 1987: 100,000 fish/yr
In 1991 the LCI creel harvest was 40,000 lbs [at 0.5 lb/fish this would be 80,000 fish/yr]

Data from M. Clymer: In 1987 there were a million perch > 7" long in the Snows.

Data from Parrish and Margraf (1990): Since the mid-1970's, white perch (Morone americana) have expanded rapidly, resulting in possible major interactions with the native yellow perch (Perca flavescens). White perch are an East Coast estuarine fish, first collected in Lake Erie in 1953. They did not proliferate until the mid-1970's. In the early 1980's YOY and commercial catches increased greatly. Yellow perch growth rates have declined for 15 years [up to 1990] and for the last few years in the central basin.

Data from Kallemeyr (1987): Weak year classes of yellow perch and walleye frequently have been associated with the occurrence of cold weather during the spawning and incubation season. High winds may generate waves that can cause eggs to be cast ashore or moved to unfavorable substrates, where their survival is at risk.

2. Pike

2.0 Year 0 Pike (see Perch for classification)

2.0.1 Food and Feeding

Data from Lyons and Magnuson (1987): in 1982, when YOY yellow perch were scarce, darters and minnows were important in juvenile walleye diets all summer. Walleye predation accounted for about 100% of adult darter mortality, and 75% of adult minnow mortality. In 1983 YOY perch were abundant, and darters and minnows were important in walleye diet only in June. Walleye predation accounted for 80% of adult darter mortality and 35% of adult minnow mortality. [in June?]

Data from Knight, Margraf and Carline (1984): Age-0 walleyes were entirely piscivorous after July, eating 20-70% YOY soft-rayed fishes and 25-80% clupeids. They ate nothing until July. Then up through November they ate 60% soft-rayed fishes and 40% clupeids. Age-0 walleyes (61-221 mm) selected prey 20-50 mm in August and September, and 30-70 mm long in November.

Data from Ney (1978): Walleye begin feeding as prolarvae on small copepods and nauplii. Rotifers and even diatoms may be important constituents of prolarval walleye diets. Copepods and cladocerans may be important in the early food of young walleyes, as may chironomids and other benthic invertebrates. Fish may become the major food of walleyes as small as 30 mm total length, but more often they are not important until a size of 75-106 mm TL is reached. Yellow perch are often the principal prey of y-o-y walleyes. Adult walleyes prey primarily on fish, but mayflies and chironomids are seasonally important to some populations. Walleyes in Lake Michigan ignored abundant young yellow perch in favor of the larger alewife and rainbow smelt. Walleye cannibalism might occur where alternative forage is lacking.

2.0.2 Predation

Data from Ney (1978): The Northern Pike is a predator upon yellow perch and walleyes.

2.0.4 Behavior

Data from Ney (1978): Hatching times (after spawning) vs temperature:

20C	6 days
8-15C	2-3 weeks
5-6C	50 days

2.0.5 Mortality

Data from Ney (1978): Loss of walleyes from egg through the prolarval stage has been estimated by Forney to be more than 99.5% in Oneida Lake. Most of this mortality is due to wind and water warmup acting on eggs. Longevity record for walleyes has been reported at 26 years for Lake Gogebic, Mich. Walleye populations show characteristically large (10- to 50-fold) annual variations in cohort recruitment.

2.1 First Year Pike

2.2 Second Year Pike

2.3 Third and Higher Year Pike

2.4 Pike Data Independent of Age (or Over Several Ages)

2.4.1 Food and Feeding

Data from Hartman and Margraf (1992): Walleye diets reflected prey fish abundances. In years when gizzard shad and shiners were abundant, they were the major prey. When gizzard shad was not abundant, walleyes ate more white perch and (to a lesser degree) yellow perch. Total consumption was rather constant (range: 84,000 tonnes to 94,000 tonnes).

Data from Lyons (1984): Walleye diet was influenced by the abundance and growth rates of young of the year perch. 1981 YOY perch were abundant but also fast growing, so most were too large to be eaten by small walleyes. In 1982 YOY perch were scarce, so walleyes ate many minnows and darters. In 1983 YOY perch were again abundant, but this time they were slow growing, so they dominated the diets of walleyes of all sizes, and few minnows or darters were eaten. Yet in lab studies walleyes preferred minnows over YOY perch and avoided darters.

Data from Knight, Margraf and Carline (1984): walleyes ate age-1 shiners Notropis atherinoides and N. hudsonius in spring, but switched to age-0 clupeids Dorosoma cepedianum and Alosa pseudoharengus in summer and autumn. Seasonal changes closely followed changes in forage fish availability. Diet selection was governed by of abundance of appropriate size prey and preferences for forage species. Walleyes become piscivorous early in life. Forage fishes in Lake Erie are preyed upon by almost the entire walleye population throughout the year.
"Forage fish" classify thus:

- soft-rayed fishes: shiners, smelt
- spiny-rayed fishes: white bass, yellow perch, freshwater drum,and walleyes
- clupeids: gizzard shad and alewives.

Food of walleyes changed seasonally but was consistent among years. Age-1 or older walleyes were almost entirely pisciverous, eating 75-100% by volume yearling shiners in spring, but switching to abundant age-0 clupeids (60-90%) in late July. Age-0 clupeids and shiners composed 25-70% and 10-40%, respectively, of the diets of age-1 or older walleyes in autumn. Spiny-rayed fishes were the least important prey (0-40%). Yearling walleyes (217-385 mm) selected prey 20-60 mm in spring, 30-85 mm in August. Age-2 or older walleyes (350-583 mm) selected prey 40-90 mm in August. Abundance of appropriate size prey was the primary factor affecting diet swelection of walleyes. There is a progressive change to different prey species as each grows intio the preferred size range of walleyes. Clupeids and shiners are preferred by walleyes or can be caught more easily. When prey are scarce, walleyes will eat smaller than usual prey sizes.

Data from Mills and Forney (1981): In Oneida Lake young yellow perch are important in the diet of walleye. Yellow perch are usually more numerous than all other limnetic prey of walleye.

2.4.2 Predation upon Walleyes

Data from Kallemeyn (1987): Walleye year class strength in Oneida Lake was not set until midway into the fishes' second summer, because older walleyes cannibalized the young until then.

Data from Ney (1978): Walleye egg predation by planaria happens.

2.4.4 Behavior

Data from Ney (1978): Walleyes home to specific spawning grounds. Walleye spawn two weeks before yellow perch.

Data from Ney (1978): Walleyes hatch at 7.0-9.5 mm total length. Yolksac is absorbed by or at 9.5 mm.

3. Other Fish and Prey (not quite the same classification as perch and pike)

3.0 Year 0 Fish

3.0.1 Food and Feeding

Data from Hayes (1988): Suckers initially fed on zooplankton but quickly shifted to benthos.

Data from Shuter and Post (1990): YOY smallmouth bass grow at a rate which increases with temperature up to about 29C, but further increase of temperature causes a sharp dropoff to zero at about 35C. This is true for food availability ranging from 50% to 100% saturation. See their Fig 3.

3.1 Frogs

Data from M. Clymer: There have been no frogs in the Snows since 1964, when there was a dieoff due possibly to low water drying out eggs.

3.2 Mosquito Larvae

Data from M. Clymer: Mosquito larvae are way down. They are eaten by small fish.

3.3 White Perch

Data from Danehy, et al. (1991): White perch consumed relatively few crayfish. White perch fed heavily upon amphipods, shifted to alewife eggs as they became available, and later, as the eggs became scarce, the fish shifted back to amphipods.

Data from Parrish and Margraf (1990): In Lake Erie white perch ate significant amounts of benthic organisms and fish of all lengths (85-205 mm long) ate zooplankton if abundant.

Data from Prout, et al. (1990): Predation of age-0 white perch by walleye is suspected of limiting recruitment of white perch to greater age classes.

Data from Weisberg and Janicki (1990): trichopterans were the dominant prey (at least 40% by mass). Generally the prey corresponded to abundance in the benthos.

Data from Prout et al. (1990): White perch hatched over a 4-6 week period in late May-June, 1987. Copepods, amphipods, and chironomids were the primary prey of YOY white perch in eastern Lake Ontario.

3.4 Channel Catfish

See white perch, Weisberg and Janicki. The amphipod Gammarus fasciatus and chironomids accounted for more than 40% of channel cat diet (by mass).

3.5 Whitefish

Data from Cucin and Faber (1975): They give measurements of mean length of samples on different dates, May 1 to mid-June. The max and min are about + or - 20% from the mean. The growth rate is irregular, there being even a couple of dips in the length curve.

Data from Cucin and Faber (1975): Lake whitefish spawn in the fall during decreasing water temperatures. So do burbot, cisco, and lake trout. Water temperature during whitefish spawning is in the range 8-3C. The whitefish eggs hatch in 4-6 months (175 d in one report). Larval whitefish are normally dispersed throughout lakes in near-surface waters. Length data vs time are given in Fig 14.

3.6 Cisco

Data from Cucin and Faber (1975): Cisco spawned in Lake Opeongo from mid-November well into December.

3.7 Alewives

Data from Evans and Jude (1986): During the 70's and 80's the dominant Lake Michigan planktivore has been the alewife. Adults migrate inshore in spring, spawning in June and July. During summer, young-of-the-year inhabit the nearshore epilimnion and yearlings, while adults are found in and below the thermocline.In the inshore region immature and adult alewives are planktivorous, while in deep waters small (<120 mm) alewives feed on microcrustaceans and adults feed more heavily on the epibenthic Mysis relicta (an omnivorous mysid) and the benthic Pontoporeia hoyi (a detritus-feeding amphipod). Alewife abundances (especially juveniles and adults) declined in the inshore region between 1873 and 1982. They kept decreasing and then remained low in 1984 and 1985. Low numbers of Daphnia in 1982-4 are ascribed to intense planktivory by yellow perch, which were stunted in 1983 and 1984.

4. Cormorants and Other Water Birds

4.1 Food and Feeding

Data from Hobson, Knapton, and Lysack (1989): 6169 prey samples included 16 fish species and one crayfish species. Yellow perch were found most frequently, but White Sucker (Catostomas commersoni) made up nearly half of the prey biomass. The commercially valuable fish, walleye and sauger, did not contribute significantly to the diet of double-crested cormorants. The three most important prey species, suckers, perch and Tullibee concentrate in large schools and thus are more vulnerable to cormorants.

Data from Birt, et al. (1987): Cormorants have not been found to feed extensively on commercially important fish species (such as salmon and trout).

Data from Forney: Over half the fish gotten by making nestlings regurgitate were walleye and yellow perch. They were the predominant species in the lake. Also some year-0 gizzard shad were seen; they predominated in numbers. Yellow perch regurgitated by nestlings range from about 97mm to 259 mm, but 60% of them were over 179 mm. In contrast, yellow perch in the 90-179 mm size range were twice as abundant in trawls as fish 180-259 mm. There is a preference for the larger ones. All walleye regurgitated by nestlings were over 200 mm, and most exceeded in length the largest yellow perch consumed. Cormorants ignored YOY walleye and yellow perch, preferring yearlings and older. Ages 1, 2, and 3 walleye were recovered from stomachs in about equal numbers, and none exceeded age-4. In one year freshwater drum was the fish most taken. In 1991 there were only 60 pair of cormorants feeding in Lake Oneida. However, the number of resident cormorants has steadily increased since 1985, and the eventual level of stabilization is unknown. A model to predict the effects of varying numbers of cormorants on the fishery could be developed from existing data on population dynamics of percids and estimates of numbers of yellow perch and walleye consumed by cormorants. The age distributions of yellow perch and walleye regurgitated by cormorants, Oneida Lake, 1988-91:

Age	Walleye	Yellow perch
1	8	9
2	17	4
3	17	19
4	4	8
5	0	3
6	0	1
7	0	1

Data from Campo et al. (1993): Mean live weight of fish eaten per bird per day was 122 g. The breakdown by sex was males 142 g and females 93g. Those <125 mm accounted for 90% of fish by number. Cormorants do have the potential to impact sport fish populations adversely. Average cormorant weight was 2.3 kg. Sport fishes were a substantial portion of the cormorant food contents by weight, but not by number, on Texas reservoirs. The sport fish eaten by cormorants wwere much smaller than those taken by sportsfishermen. Very few large fishes are taken by cormorants. Cormorants appeared to eat the fish species that were most abundant. ~1/3 lb

4.2 Predation of Cormorants

Data from Hobson, Knapton, and Lysack (1989): evidence of Bald Eagle (Haliaeetus leucoicephalus) predation of hatch-year cormorants was found at four colonies.

Data from Birt, et al.,(1987): Fish densities were significantly lower in bays used by cormorants for feeding than in those outside their foraging range.

Data from Scharf and Shugart (1981): Herring gulls will prey on cormorant eggs and small chicks if adults are kept off the nest.

4.4 Behavior

Data from Pilon, et al. (1983): All double-crested cormorants nest in coniferous trees. The great cormorant (phalacrocorax carbo) nests on the ground, either on cliff ledges or flat tops of rocky islands.

Data from Birt, et al., (1987): Ram Island Cormorants now feed primarily 16 km away from the nests, which is near the limit of their foraging range.

Data from Scharf and Shugart (1981): Favored habitats for ground-nesting cormorants are cobble beaches or rock shelves on isolated islands. The tree-nesters utilize trees varying from deciduous elms and oaks to coniferous cedars.

Data from Findholt (1988): Nesting habitat is currently threatened by decay of nest trees and deterioration or loss of nesting islands brought on by excessively high or low water levels.

Data from Hobson, et al. (1989): Cormorants may travel as much as 20 km to feeding sites.

Data from M. Clymer: Cormorants breed after they are 3-4 years old. Each nest produces about two surviving chicks from a clutch of 3-4 eggs. Breeding birds constitute about 67-75% of the total population. [These data imply a long life.]

4.5 Mortality

Data from Hobson, Knapton and Lysack (1989): Chicks are most vulnerable to be killed by humans, although it is illegal. Colonies disturbed by man have hardly any mobile chicks, whereas undisturbed nests have 1.8 mobile chicks. 15 of 37 colonies had been disturbed at Lake Winnipegosis, Manitoba. Weapons used by man against cormorants include: heating of eggs with a flame thrower, crushing of eggs, killing of young by clubbing, and shotguns. Some cormorants are taken by bald eagles.

Dioxins are very lethal for great blue herons and hence probably cormorants. Dioxins are released by paper mills, none of which are near the Snows. [Source unknown]

Data from King (1989): Concentrations of DDE in cormorant carcasses were 27 times as high as in fish and 57 times as high in cormorant eggs as in fish. Concentrations of PCB were 18 times as high in carcasses and 15 times as high in eggs as in fish.

Data from Gilbertson, et al. (1991): In the Great Lakes basin double-crested cormorants have exhibited chronic impairment of reproduction. In addition to eggshell thinning caused by high levels of DDT and its metabolites, the reproductive impairment is characterized by high embryonic and chick mortality, edema, growth retardation, and deformities. Since the late 40s and early 50s there has been a series of population collapses of colonial fish-eating birds. The first species that showed signs of declining was the double-crested cormorant. By 1962 it ceased to breed in Lake Michigan, and was declining in Lake Superior, Georgian Bay, Lake Huron and Lake Ontario. By the early 1970s the population in the upper Great Lakes was estimated to be fewer than 200 nesting pairs. Only colonies in Lake Erie maintained their numbers into the 1970s. Since the mid 1970s the situation seems to have markedly improved [or worsened, depending on one's loyalties]. However, there is still a high incidence of deformities (1 to 5%) in embryos. Numerous studies point to as relationship between the presence or organochlorine compounds and the demise of the Great Lakes populations of fish-eating birds. In a series of studies in 1986 16% of the cormorant eggs and 20% of all embryos exhibited edema in the upper Great Lakes. With the decline of levels of DDT and DDE there has been a reciprocal increase in eggshell thickness. Eggshell thinning is not considered to be related to GLEMEDS. GLEMEDS has been observed (Ludwig et al.,1988) in Green Bay and Saginaw Bay, the symptoms being then liver enlargement, necrosis, and porphyria, which is not the whole syndrome. GLEMEDS might be associated with certain organohalogen compounds. The presence of large unresorbed yolk sacs in growth-retarded embryos at the time of hatching seems to be the most readily detected sign in these wildlife epizootics. PCBs are concentrated by a factor 25 million in Great Lakes food chains.

Data from Tillitt, et al. (1989): The evidence is strong for at least a partial role for PCHs as causal agents in the reproductive impairment of fish-eating waterbirds from the Great Lakes.

Data from Fox, et al., (1991A and 1991B): cormorants are good biomarkers for contaminents in the Great Lakes ecosystem. The Green Bay area is especially affected. [Is that because of paper mills?] 70 of 31,000 cormorant chicks in the Great Lakes had crossed or deflected bills or different mandible lengths.

Data from McNeil and Leger (1987): They studied reproductive success as a function of nest tree quality vs strong winds. [Finding is not in the abstract!]

Data from Vaughn Weselon, et al. (1983): During the 1960's double-crested cormorants breeding on Lake Huron experienced a decline in numbers and an elevation in body and egg contaminant burdens. In 1972 colonies were small, suffered high egg breakage and loss (95%) and nearly total reproductive failure (.06 to .11 young per nest). Level of DDE averaged 14.5 ppm and PCB's 23.8 ppm in the eggs. Lake Huron cormorants are now recovering.

4.6 Population

Data from Hobson, Knapton, and Lysack (1989): In 1979 there were 9053 nests and 17 colonies. In 1987 there were

35,181 nests and 37 colonies. [From these numbers one can calculate the percentage increase of nests per year and colonies per year.] These authors believe that the increased abundance of cormorants on their lake is due, in part, to the increased abundance of forage fish, which is a result of increased and excessive commercial exploitation of large predatory fish.

Data from Harris et al. (1987): In the Firth of Forth, Scotland, there are many kinds of seabirds. The numbers of cormorants were stable after colonization, following a saturation type of curve.

Data from Birt, et al, (1987): Seabird populations are limited by food supplies during the breeding season. Chicks might not get enough food to survive if food fish are sufficiently depleted.

Data from Scharf and Shugart (1981): The U. S. Great Lakes population of cormorants in 1977 was 157 in three colonies, a 26% increase over 1976. There was a 454% increase from 1977 to 1981. There were in 1981 714 nests at 12 colonies on four of the Great Lakes. None of their birds were in the Les Cheneaux Islands.

Data from Peterjohn (1991): Double-crested cormorants continued to set records for sightings, with 3000 at Rend Lake, IL, October 7 (1990), and 1000 to 2600 at 6 other sites in Iowa, Missouri, Illinois, and northwest Ohio. Flocks of 100-500+ coirmorants were noted at many locations where they were formerly rare.

Data from Findholt (1988): From one active nest in 1928 double-crested cormorants increased to 629 pairs in 9 colonies in 1983 and then to 1477 nesting pairs in 18 colonies by 1986.

Data from MacDonald (1987): Cormorant breeding population had increased from 1865 pairs in 1969-70 to 4455 pairs in 1985-86.

Data from Craven and Lev (1987): In these Lake Superior islands the cormorant colony increased from 17 pairs in 1978 to 289 pairs in 1985.

Data from Price and Vaughn-Weseloh (1986): From 1974 to 1982 Double-Crested Cormorants nesting on Lake Ontario increased from approximately 22 to 770 pairs, showing an average annual rate of increase of 56%.

Data from Blokpoel and Harfenist (1986): Double-credted cormorants increased from 81 nests at two colony sites to 569 nests at 7 colony sites, North Channel, Lake Huron, Canada.

Data from Desgranges, et al. (1984): 12000 pairs of double-crested cormorants nested in Quebec in 1979. They were divided among 43 colonies. Three quarters of the colonies and four fifths of the nests are currently found on islands, both in trees, on the ground, and on the face of cliffs. They are becoming more protected, so populations keep going up.

Data from Campo et al. (1993): Over the entire Great Lakes system total growth of cormorant breeding colonies since 1972 was 40% per year (Ludwig 1984).

Data from M. Clymer (1993): In April-May 1993 1300-2000 cormorants were observed in the Snows. This is about when perch spawn.

Data from meeting at Anggio's, 5/10/93: 11-40%/yr population growth.

Data from M. Clymer (but also reported elsewhere, in the literature): The minimum population in Wisconsin when DDT was at its peak in the environment, was 66 breeding pairs.

Data from Jim Ludwig: Cormorants over the U.S. gain population at 15-63%/yr.

Data from John Trapp: He guesses there are 750,000 cormorants in North America today.

Source? Data from M. Clymer: The cormorant problem was severe in Oklahoma by 1989. In 1991 the state legislature termed them a nuisance.

Data from 10/7/93 Meeting Minutes: 2000 nesting pairs were seen in the Snows in a survey.

93 MDNR aerial survey ✓ Data from M. Clymer: A survey found a peak population on August 20, 1993 consisting of 6614 cormorants in the area including St. Martin's Bay, Les Cheneaux Islands, and Drummond Island. The peak in Les Cheneaux alone was 2761.

Data from M. Clymer: Cormorants in Michigan have been growing at the rate of 15% per year for 15 years.

Data from Detroit News, 9 May 1993: Estimated 50,000 cormorants in the Snows alone. In 1940 there were only 1000 nesting pairs in the Great Lakes. They were killed down to 125 nesting pairs by 1972 in the Great Lakes. In 1992 on Little Galloo Island in Lake Ontario there were 100,000 cormorants.

Data from Pittman Letter to Editor of St. Ignace News, 11 Feb 93: There were 50,000 cormorants in the Great Lakes in 1992.

Data from Robert Montgomery in Bassmaster Magazine: He said that the U.S. cormorant population is 300,000, of which 100,000 are in Lake Ontario, Lake Oneida, and the St. Lawrence River area. He quotes Al Schiavone who said that there are 5400 nesting pairs on Little Galloo Island and that they are 10% of the U.S. population.

5. Zooplankton

5.1 Food and Feeding

Data from Wu (1991): During June through August in western Lake Erie a shift from edible algae limitation to young of the year fish predation can account for the dynamic pattern of Daphnia galeata mendotae populations. Daphnia selectively grazes edible algae, with high grazing in early summer, resulting in a very low level of edible algae in midsummer, which made cladocerans decline then.

5.2 Predation upon Zooplankton

Data from Wu (1991): Growth of yellow perch declines when the zooplankton population declines (See 5.1 herein). This keeps the perch vulnerable to predators.

Data from Mills and Forney (1981): It can be the perch which knock down Daphnia populations in late summer, forcing themselves to eat more of other things.

Data from Prout, et al. (1990): In Oneida Lake when age-0 yellow perch biomass exceeds 20 kg/hectare, the daphnid population collapses.

Data from Arts and Sprules (1989): age 0+ yellow perch can have a large impact on populations of the cladoceran Holopedium.

5.3 Growth

5.4 Behavior

5.5 Mortality

5.6 Population

Data from Evans and Jude (1986): Inshore region Daphnia populations have changed little since the late 1880's. At different times there have tended to be different dominant Daphnia species. Before 1982 Daphnia retrocurva and Daphnea galeata were the dominant species of Daphnia in offshore Lake Michigan.

Data from Prout, et al. (1990): In Lake Oneida the zooplankton community in 1980 was dominated by calenoids (45-77%), whereas Daphnia pulex was generally the second most abundant organism (5-28%). The total zooplankton biomass reached nearly 0.4 mg/l in early August, declined abruptly in September, but rose to 0.17 mg/l in early October. Yellow perch fed heavily upon the abundant Daphnia pulex population, which represented 80-100% of the biomass in yellow perch stomachs in July-September. As daphnids disappeared, perch shifted to a diet of the amphipod Gammarus sp., which they didn't like as much.

Data from Wu and Culver (1992): Total zooplankton abundance in Lake Erie fluctuated, with a peak in June and a continuous decline until mid-July, both inshore and offshore. Cladoceran populations fluctuated quite similarly to total zooplankton.

6. Phytoplankton

7. Ecosystem and Perch Fishery Data

7.1 Artificial Reefs

Data from Danehy et al. (1991): ..."artificial reef development in the Great Lakes is still in its infancy as a fishery management technique".

8. References

Arts, M. T., and Sprules, W. G., Use of Enclosures To Detect the Contribution of Particular Zooplankton To Growth of Young-of-the-Year Yellow Perch (Perca flavescens Mitchell), Oecologia, vol 81, no 1, pp 21-27, 1989.

Birt, V. L., et al., Ashmole's Halo: Direct Evidence for Prey Depletion by a Seabird, Marine Ecology Progress Series, vol 40, pp 205-208, 1987.

Blokpoel, H., and Harfenist, A., Comparison of 1980 and 1984 Inventories of Common Tern, Caspian Tern, and Double-crested cormorant colonies in the Eastern North Channel, Lake Huron, Ontario, Canada, Colonial Waterbirds, vol 9, no 1, pp61-67, 1986.

Campo, J. J., Thompson, B. C., Barron, J. C., Telfair, R. C. II, Durocher, P., and Gutreuter, S., Diet of Double-Crested Cormorants Wintering in Texas, J. Field Ornithol., vol 64, no 2, pp 135-144, Spring 1993.

Clady, M., Crustacean Zooplankton Populations and Concurrent

Survival of Larval Yellow Perch in Oneida Lake, New York Fish and Game Journal, vol 24, no 1, Jan. 1977(A).

Clady, M., Distribution and Relative Exploitation of Yellow Perch Tagged on Spawning Grounds in Oneida Lake, N. Y. Fish Game J., vol 24,no 2, pp 168-177, 1977(B).

Clymer, A. B., The Timetable of Life: The Timing of Events in the Lives of Organisms, in press, 1994.

Coble, D. W., Fish Populations in Relation to Dissolved Oxygen in the Wisconsin River, Trans. Am. Fish. Soc., vol 111, no 5, pp 612-623, 1982.

Confer, J. L., and Lake, G. J., Influence of Prey Type on Growth of Young Yellow Perch (Perca flavescens), Casn. J. Fish. Aquat. Sci., vol 44, no 11, pp 2028-2033, 1987.

Confer, J. L., and O'Bryan, L. M., Changes in Prey Rank and Preferences by Young Planktivores for Short-term and Long-term Ingestion Periods, Can. J. Fish. Aquat. Sci., vol 46, no 6, pp 1026-1032, 1989.

Costa, H. H., The Food and Feeding Chronology of Yellow Perch (Perca flavescens) in Lake Washington, Intern. Rev. Gesamt. Hydrobiol., vol 64, no 6, pp 783-793, 1979.
Danehy, R. J., Ringler, N. H., and Gannon, J. E., Influence of Nearshore Structure on Growth and Diets of Yellow Perch (Perca flavescens) and White Perch (Morone americana) in Mexico Bay, Lake Ontario, J. Great Lakes Res., vol 17, no 2, pp 183-193, 1991.

Craven, S. R., and Lev, E., Double-Crested Cormorants in the Apostle Islands, Wisconsin, USA: Population Trends, Food Habits, and Fishery Depredations, Colonial Waterbirds, vol 10, no 1, pp 64-71, 1987.

Cucin, D., and Faber, D. J., Early Life Studies of Lake Whitefish (Coregonus clupeaformis), Cisco (Coregonus artedii), and Yellow Perch (Perca flavescens) in Lake Opeongo, Ontar io, Ontario Fisheries Technical Report Series, No 16, 1985.

Danehy, R. J., Ringler, N. H., and Gannon, J. E., Influence of Nearshore Structure on Growth and Diets of Yellow Perch (Perca flavescens) and White Perch (Morone americana) in Mexico Bay, Lake Ontario, J. Great Lakes Research, vol 17, no 2, pp 183-193, 1991.

DesGranges,J. L., Chapdelaine, G., and Dupuis, P., Nesting Sites and Dynamics of Double-Crested Cormorants in Quebec, Can. J. Zool.,vol 62, no 7, pp 1260-1267, 1984. (In French)

Dorr, J. A., Substrate and Other Environmental Factors in Reproduction of the Yellow Perch (Perca flavescens), Ph D

Dissertation, University of Michigan, 1982.

Evans, M. S., and Jude, D. J., Recent Shifts in Daphnia Community Structure in Southeastern Lake Michigan: A Comparison of the Inshore and Offshore Regions, Limnol. Oceanogr., vol 31, no 1, pp 56-67, 1986.

Findholt, S. L., Status, Distribution and Habitat Affinities of Double-Crested Cormorant Nesting Colonies in Wyoming, Colonial Waterbirds, Vol 11, no 2, pp 245-251, 1988.

Forney, J. L., Some Observations on Cormorant-Fish Interactions in Oneida Lake, publication unknown, pp 8-13, some time after the 1993 field season. [He is at the Cornell Biological Field Station]

Fox, G. A., et al., Reproductive Outcomes in Colonial Fish Eating Birds: A Biomarker for Developmental Toxicants in Great Lakes Food Chains, I. Historical and Ecotoxicological Perspectives, J. Great Lakes Res., vol 17,, no 2, pp 153-157, 1991A.

Fox, G. A., et al., as above, II. Spatial Variation in the Occurrence and Prevalence of Bill Defects in Young Double-Crested Cormorants in the Great Lakes, J. Great Lakes Res., vol 17, no 2, pp 158-167, 1991B.

Gilbertson, M., Kubiac, T., Ludwig, J., and Fox, G., Great Lakes Embryo Mortality, Edema, and Deformities Syndrome (GLEMEDS) in Colonial Fish-eating Birds: Similarity to Chick Edema Disease, J. Toxicol. Environ. Health, vol 33, no 4, pp 455-520, 1991.

Hansen, M. J., and Wahl, D. H., Selection of Small Daphnia pulex by Yellow Perch Fry in Oneida Lake, New York, Trans. Amer. Fisheries Soc., vol 110, pp 64-71, 1981.

Harris, M. P., Wanless, S., and Smith, R. W. J., The Breeding Seabirds of the Firth of Forth, Scotland, Proc. Royal Soc. of Edinburgh,,,vol 93B,pp 521-533, 1987.

Hartman, K. J., and Margraf, F. J., Effects of Prey and Predator Abundances on Prey Consumption and Growth of Walleyes in Western Lake Erie, Trans. Amer. Fish Society, vol 121, no 2, pp 245-260, 1992.

Hayes, D. B., Distribution, Diet and Growth of Two Coexisting Populations of Yellow Perch (Perca flavescens) and White Sucker (Catostomas commersoni), M.S. Thesis, Michigan State University, 1988.

Hobson, K. A., Knapton, R. W., and Lysack, W., Population, Diet and Reproductive Success of Double-Crested Cormorants Breeding on Lake Winnipegosis, Manitoba, in 1987, Colonial

Waterbirds, vol 12, no 2, pp 191-197, 1989.

Kallemeyn, L. W., Correlations of Regulated Lake Levels and Climatic Factors with Abundance of Young-of-the-Year Walleye and Yellow Perch in Four Lakes in Voyageurs National Park, N. Amer. J. Fish. Manage., vol 7, no 4, pp 513-521, 1987.

Kayes, T. B., and Calbert, H. E., Effects of Photoperiod and Temperature on the Spawning of Yellow Perch (Perca flavescens), presented at meeting of World Mariculture Society, Honolulu, HI, 22 Jan. 1979.

King, K. A., Food Habits and Organochlorine Contaminants in the Diet of Olivaceous Cormorants in Galveston Bay, Texas, Southwestern Naturalist, vol 34, no 3, pp 338-343, 1989.
Knight, R. L., Margraf, F. J., and Carline, R. F., Piscivory by Walleyes and Yellow Perch in Western Lake Erie, Trans. Am. Fish. Soc., vol 113, no 6, pp 677-693, 1984.

Lyons, J. D., Walleye Predation, Yellow Perch Abundance, and the Population Dynamics of an Assemblage of Littoral-Zone Fishes in Sparkling Lake, Wisconsin, Ph D Dissertation, University of Wisconsin, Madison, 1984.

Lyons, J., and Magnuson, J. J., Effects of Walleye Predation on the Population Dynamics of Small Littoral Zone Fishes in a Northern Wisconsin Lake, Trans. Am. Fish. Soc., vol 116, no 1, pp 29-39, 1987.

MacDonald, R. A., The Breeding Population and Distribution of the Cormorant in Ireland, Irish Birds, vol 3, no 3, pp 405-416, 1987.

McNeil, R., and Leger, C., Nest Site Quality and Reproductive Success of Early and nesting Double-Crested Cormorants, Wilson Bull., vol 99, no 2, pp 262-267, 1987.

Mills, E. L., and Forney, J. L., Energetics, Food Consumption, and Growth of Young Yellow Perch in Oneida Lake, New York, Trans. Am. Fish. Soc., vol 1!0, no 4, pp 479-488, 1981.

Ney, J. J., A Synoptic Review of Yellow Perch and Walleye Biology, Amer. Fisheries Society, Special Publication, vol 11, pp 1-12, 1978.

Nielsen, L. A., Effect of Walleye (Stizostedion vitreum vitreum) Predation on Juvenile Mortality and Recruitment of Yellow Perch (Perca flavescens) in Oneida Lake, New York, Can. J. Fish.Aquat. Sci., vol 37, no 1, pp 11-19, 1980.

Parrish, D. L., and Margraf, F. J., Interactions between White Perch (Morone americana) and Yellow Perch (Perca flavescens) in Lake Erie as Determined from Feeding and Growth, Can. J. Fish. Aquatic Sci., vol 47, pp 1779-1787, 1990.

Parrish, D. L., and Margraf, F. J., Growth Responses of Age0 White Perch and Yellow Perch from Field-Enclosure Experiments, Hydrobiologia, vol 254, pp 119-123, 1993.

Peterjohn, B. G., Midwestern Prairie Region [bird sightings], American Birds, Spring 1991, vol 45, no 1, pp 108-113.

Pilon, C., Burton, J., and McNeil, R., Reproduction of the Great Cormorant and the Double-Crested Cormorant in the Iles de la Madeleine, Quebec, Canadian J. of Zoology, vol 61, pp 524-530, 1983. (In French)

Price, I. M., and Vasughn-Weseloh, D., Increased Numbers and Productivity of Double-Crested Cormorants, Phalacrocerax auritus, on Lake Ontario, Canadian Field-Nat., vol 100, no 4, pp 474-482, 1986.

Prout, M. W., Mills, E. L., and Forney, J. L., Diet, Growth, and Potential Competitive Interactions between Age-0 White Perch and Yellow Perch in Oneida Lake, New York, Trans. Amer. Fisheries Soc., vol 119, pp 966-975, 1990.

Schaeffer, J. S., and Margraf, F. J., Food of White Perch (Morone americana) and Potential for Competition with Yellow Perch (Perca flavescens) in Lake Erie, Ohio J. Sci., vol 86, no 1, pp 26-29, 1986.

Scharf, W. C., and Shugart, G. W., Recent Increases in Double-crested Cormorants in the United States Great Lakes, American Birds, vol 35, no 6, pp 910-911, 1981.

Shuter, B. J., and Post, J. R., Climate, Population Viability, and the Zoogeography of Temperate Fishes, Trans. Am. Fish. Soc., vol 119, no 2, pp 314-336, 1990.

Starr, C. J., The Performance of Stunted and Unstunted Yellow Perch (Perca flavescens) Fed Practical Diets, M. S. Thesis, Michigan State University, 1989.

Tillitt, D. E., Ankley, G. T. and Giesy, J. P., Planar Chlorinated Hydrocarbons (PCHs) in Colonial Fish-Eating Waterbird Eggs from the Great Lakes, Marine Environ. Res., vol 28, nos 1-4, pp 505-508, 1989.

Timmons, T. J., Food of a Southeastern United States Population of Yellow Perch, Perca flavescens (Mitchill), in West Point Lake, Alabama-Georgia, J. Tenn. Acad. Sci., vol 59, no 3, pp 54-57, 1984.

Vaughn Weselon, D., Teeple, S. M., and Gilbertson, M., Double-Crested Cormorants of the Great Lakes: Egg-laying Parameters, Reproductive Failure, and Contaminant Residues in Eggs, Can. J. Zool., vol 61, no 2, pp 427-436, 1983.

Weisberg, S. B., and Janicki, A. J., Summer Feeding Patterns of White Perch, Channel Catfish, and Yellow Perch in the Susquehanna River, Maryland, J. Freshwater Ecology, vol 5, no 4 pp 391-405, 1990.

Wu, L., Trophic Interactions in a Large-Lake Ecosystem: Ontogeny of Fish Diet, Zooplankton Summer Dynamics, and Phytoplankton Succession, Ph.D. Dissertation, The Ohio State University, 1991.

Wu, L. and Culver, D. A., Ontogenetic Diet Shift in Lake Erie Age-0 Yellow Perch (Perca flavescens): A Size Related Response to Zooplankton Density, Can. J. Fish. Aquat. Sci., vol 49, pp 1932-1937, 1992.