

**The effects of endocrine-disrupting chemicals  
on survivorship and fecundity.**

**A potential cause for extinction?**

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**Abstract:**

Wildlife and laboratory studies indicate the potential for endocrine-disrupting chemicals to disrupt the reproductive and developmental health of various species. These chemical agents, in turn, effect survivorship and fecundity on vulnerable amniotic species including alligators, fish, otters, and rats. Research has shown devastating effects on certain populations exposed to high concentrations of endocrine-disrupting chemicals. Biological and abiotic factors play important roles in influencing species vulnerability to extinctions. The ability for Natural Selection to evolve adaptive traits and is minimal and unreported in the species noted above thus resulting in declining population density and species diversity. The threat of the effects of endocrine-disrupting chemicals poses a major concern and its influence on extinction is difficult to determine.

This project will show endocrine and reproductive abnormalities of amniotes when exposed to endocrine-disrupting chemicals. Furthermore, this paper will show, through wildlife and laboratory studies, that endocrine-disruptors have a broad and negative effect on the reproductive systems of alligators, otters, turtles, birds, fish and later humans. In addition, wildlife impact studies will show the decline in several populations is a result of their exposure to endocrine-disrupters. Endocrine-disruptors are unique from other evolutionary forces in that they directly effect an organisms ability to survive and reproduce, therefore, evolutionary patterns can be observed.

Though much of the evidence has toxicological implications, the effects of endocrine-disrupting chemicals on evolutionary patterns can be studied; specifically, increased extinction rates of both small populations and populations spread over a large geographical area. The extent of the effects of endocrine-disrupting chemicals on fecundity and survivorship varies between regions, indicating a relationship between environment and the toxic agents. Endocrine-disrupting chemicals may arise in various ways and can be found everywhere in the environment.

## **BACKGROUND**

Endocrine-disruptors come from a variety of man made sources, such as pesticides, plastics, pharmaceuticals, ordinary household chemicals, and industrial chemicals. They alter the hormonal functions of various species by acting as sex hormones, which prevent normal hormonal binding and breakdown of natural hormones (Colborn et al. **1993**). Specific effects found in wildlife and laboratory studies on mammals, reptiles, amphibians and fish include abnormal blood hormone levels, reduced fertility, altered sexual behavior, modified immune system, masculinization of females, feminization of males, undescended testicles, reduced penis size and testis, altered bone density and structure, cancers of the male and female reproductive tract, and lastly, malformed fallopian tubes, uterus and cervix. The fact that these man made endocrine-disruptors have a long half life in the environment and can accumulate within an organism poses a potential threat to the survival and fitness of most amniotic species (Stone **1994**). This broad effect results from a homology shared among amniotes.

If other non-endocrine environmental influences are involved in increased extinction rates, then particular, endocrine-related patterns of morphological or developmental changes should not be observed. These patterns would include masculinization of females, feminization of males, reduced penis

size and testis, high anti-thyroid responses and other devastating effects. Other environmental influences that can effect extinction rates are destruction of habitat, disappearance of food source, dramatic changes in climate, heavy predation, and other human-induced factors such as over hunting. The fact that endocrine-disrupting chemicals specifically targets the reproductive systems of various organisms in specific ways allows us to predict distinct abnormal patterns in development and morphology. When such environmental factors disrupt development, an organism's ability to reproduce and survive is impaired and its success as a species declines. The extinction rates of several amniotic species would be enhanced. Controlled laboratory experiments that both, accounted for these environmental influences or omitted these factors, identified endocrine-disruptors as the main mechanism for reproductive instability. Since amniotic organisms share a common and thus similarly functioning endocrine pathways, it can be predicted that many related species will be effected by endocrine-disrupting chemicals.

#### EVIDENCE

Several wildlife and laboratory studies provide convincing evidence for reproductive abnormalities caused by endocrine-

disrupting chemicals. In one of these studies, the reproductive development of alligators from a contaminated and from a controlled lake in Florida was examined. Females, in the contaminated lake, exhibited abnormal ovarian morphology with large numbers of polyovular follicles and polynuclear oocytes. Male juvenile alligators had significantly depressed testosterone concentrations as well as poorly organized testes and abnormally small phalli (Guillette et al. 1994). As predicted, estimated numbers of juvenile alligators decreased dramatically in comparison to controlled lakes (Figure 1).

Wildlife and lab studies in fish species in the Gulf of Mexico and the Great Lakes also have confirmed reproductive and endocrine abnormalities. Such abnormalities include development of male sex morphological characters in females, modification of anal fins into ganopodium in females, enlarged thyroids, lower fertility compared to other populations and high embryo mortality (Davis et al. 1992). Once again, environmental investigators have reported reduced number of species in these regions.

The effects of endocrine-disrupting chemicals have been observed in otters(mammals). Some toxic agents may be transferred to milk by simple diffusion across blood vessels in the mammary glands. This, in turn, creates a pathway of exposure to the

nursing animal (Williams and Davis 1995:130). Once again, declining population size has been evident in regions where these chemicals are at dangerous levels.

Laboratory studies of rats further substantiates the effects of endocrine-disrupting chemicals released in the environment. Rats were fed diets containing the Great Lake fish indicated earlier and, as a result, thyroid enlargement and decreased reproductive success was observed (Figure 2). The data provided does in fact suggest a strong correlation between endocrine-disrupting chemicals and serious abnormalities in the endocrine and reproductive systems of various species. Also, it's important to note that endocrine-disrupting chemicals are passed down through the food chain.

Several factors were involved in areas where the effects of endocrine-disrupting chemicals were the most damaging. These environmental factors include climatic change, competitive exclusion, and predation.

The synergistic effect between endocrine-disrupting chemicals and other environmental influences were observed. The American alligator was listed as an endangered species in the early 1970's. However, populations in areas of the southeastern

United States grew rapidly after federal protection. Studies have shown that populations in Florida have grown at a stable rate. However, one area, Lake Apopka showed a dramatic decline during the 1980s that continues. The population density of Lake Apopka, at present, continues at one tenth of that, reported in the late 1970s (Guillette et al, 1990). Research has linked the Tower Chemical Company to the decline in alligator population and has provided the best clue for reproductive failure in Lake Apopka (Woodard et. al., 1991).

In another study, previously mentioned, investigators have reported reduced numbers of species, indicators of physiological stress, biochemical responses, behavioral changes and reproductive inhibition in fishes surviving in the area near the Kraft Mill Effluent, which includes the Fenholloway River (Owens, 1991). This river, located in northeast Florida, represents the worst case scenario. In a geographic region with moderately high aquatic species bio diversity, the Fenholloway river is distinctly impoverished in fish species down river from the Kraft Mill Effluent entry point Davis & Bortone, 1992) Davis and Bortone (1992) also noted that each entering tributary stream, spring or peripheral pool was rich in fish species. However, in the confluences of the entering tributaries, fish collected contained mixtures of masculinized and unaffected

fish. These "control" populations did not have similar effects as the fish in **the** confluences!

## CONCLUSION

**It is** evident that the nature of extinctions depend upon environmental conditions. Previous documentation has been noted regarding population extinctions including competitive exclusion, predation, and climatic change (Parsons 1993). Environmental stress is an important, though not exclusive, element in the occurrence of variation. For natural selection to be effective, variance must **be** inherited and available at times of environmental change(Parsons 1993). The relevance of abiotic **stress on** evolutionary change has not been entirely studied. Earlier discussion regarding the process of adaptation has lead to conclusions that physical factors are less important than interactions among organisms. It is difficult to determine which factor has **more importance regarding adaptations since environmental situations vary among differing populations.** However, the study of extinction patterns allows us to gain a closer idea of how certain abiotic factors interact in evolutionary history. The type of stress and its effect on an organism determines the direction of evolution.

What determines a species' vulnerability to extinction? In many cases biological predisposition determines a species' vulnerability to extinction. Adaptations that are suitable for certain environments may not be advantageous in response to change. Another type of species biologically predisposed to extinction consists of species already becoming extinct from natural causes. A third adaptation that can lead to extinction is K-selected. Such populations have a conservative performance geared to a stable environment (Humphrey 1985:7-30).

It is obvious through wildlife and laboratory studies that the effects of endocrine disrupting chemicals do affect fecundity and survivorship among several species even though their modes of action vary. However, the possibility for mass extinction has not been seriously addressed. What is known about endocrine-disrupting chemicals is that they do under certain conditions affect the fecundity and survivorship of many species. In areas contaminated with high concentrations of endocrine-disrupting chemicals the probability for adaptations to arise are near zero. Research has indicated that the stress induced by endocrine-disruptors is powerful enough to prevent natural selection to introduce new adaptation, thus leading to drastic population declines in various species (Dold 1996). Furthermore, species haven't had time to evolve defense mechanisms against something cooked up in a test tube only 30 or 40 years ago (Dold 1996). For example, the disappearance of boreal toads from the

mountains of Colorado didn't have sufficient time to evolve defense mechanisms against the powerful effects of endocrine-disrupting chemicals.

Despite the fact that extinctions are of great importance to evolution, we know little about its role in life history (Raup 1984:145-156). We have predicted that over time patterns of extinction will increase, however we are limited in our ability to predict to what extent extinction patterns will increase. The mechanisms of extinction are not entirely understood but it is from these occurrences, though man induced, that we can gain a better understanding of evolutionary patterns regarding extinctions. In most of the studies noted, it is apparent that in populations where there was the sharpest decline in population there was some other biological or abiotic stress present in the environment. In conclusion, the evidence has proven that endocrine-disrupting chemicals have severe effects on development and endocrine and reproductive systems of an organism however, other abiotic agents are required for extinction. Endocrine-disruptors don't act alone on the environment and as man introduces new stresses on the environment such as destruction of habitat, the struggle to survive becomes increasingly difficult for a species.

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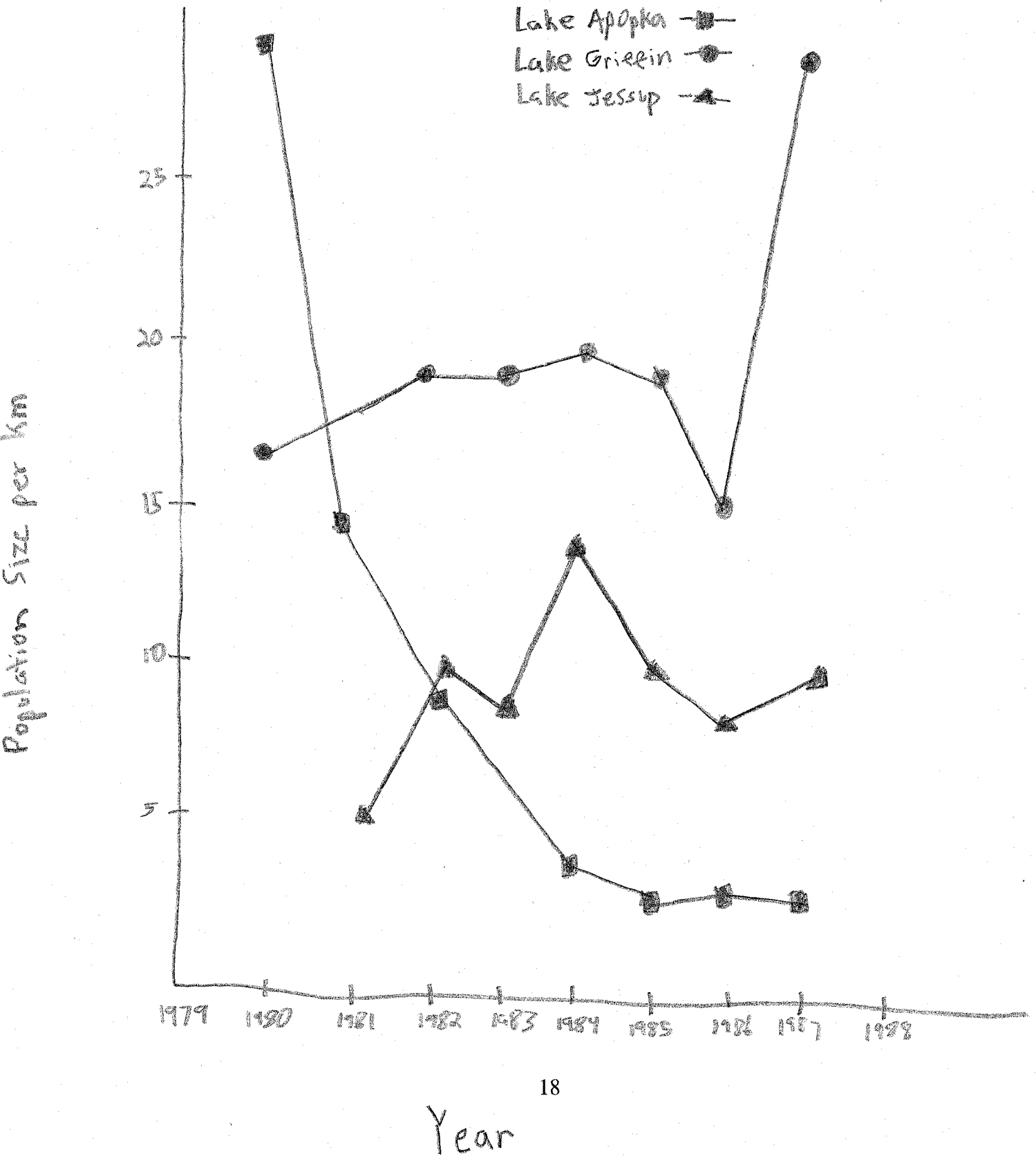
## FIGURE 1

Estimated numbers of juvenile alligators per kilometer of shore line on lakes Apopka, Griffin, and Jessup, Florida, during transformed night-light counts, adjusted for water level and presented on an untransformed scale. Redrawn from Woodward et al (10). A decrease in the population size of juvenile alligators is evident in Lake Apopka. Endocrine-disrupting chemicals are extensively found in this lake as opposed to Lakes Griffin and Jessup respectively. Coincidentally, the Tower Chemical Company is responsible for a chemical spill of a pesticide mixture primarily composed of endocrine-disrupting chemicals. As a result, endocrine and reproductive disorders were reported. Hence, fecundity and survivorship was severely effected, increasing the extinction rate of the alligator species in Lake Apopka.

The rise in population density during the late 1980's in Lakes Griffin and Jessup respectively are attributed to human interference, for example, alligator farming to increase species density.

Lastly, the biphasic curve in Lake Apopka is attributed to man-induced efforts in cleaning the lake as well as migration of other alligator species in the lake.

# Figure 1



**TABLE 1**

Hepatosomatic index (HSI), and N-demethylase activity (ND), B[a]P hydroxylase activity (BPH), and cytochrome P-450 content (CP) in male rats fed diets of coho salmon from either the Pacific Ocean, or one of the Lakes Ontario, Erie, or Michigan, or rat chow for 80 days. Evidently, reduced thyroid function and reproductive and developmental abnormalities were observed in rats that were fed fish from the Great Lakes. Hence, it is evident that endocrine-disrupting chemicals are passed through the food chain and the fitness of many species may be severely impacted.

**TABLE 1**

Diet/Source of Salmon	HSI	NO	BPH	CP
Rat Chow	3.3 ± .20	2.5 ± .50	2.9 ± .40	4.1 ± .70
Pacific Ocean	3.3 ± .20	3.3 ± .60	3.7 ± .70	4.1 ± .20
Lake Ontario	4.2 ± .30*	5.1 ± .20**	14.1 ± .40**	9.1 ± .10**
Lake Erie	3.8 ± .10	4.4 ± .50*	5.0 ± .60*	5.2 ± .30**
Lake Michigan	4.0 ± .30	6.2 ± .40**	12.5 ± 1.2**	7.5 ± .60**

1 Salmon were collected from the 1978 spawning run and 30% diets were used.

2 expressed as % body weight.

3 nol. ECHO formed per mg protein per min;

4 expressed as nol. B[a]P metabolized per mg protein per 10 minutes;

5 expressed as nmol per 10 mg protein.

\*,\*\* **Significantly different from the Pacific Ocean salmon-fed group.**