● PESTICIDES, HORMONES, AND WILDLIFE IN THE PACIFIC NORTHWEST

POLLUTION'S LEGACY IN OUR BACKYARD

During the last decade, biologists have collected a staggering quantity of information about the way that synthetic chemicals disrupt the hormone systems of wildlife. Called endocrine disrupters, these chemicals cause changes in behavior, sexuality, and the ability of animals to reproduce. Many pesticides, but particularly the organochlorine insecticide DDT, act as endocrine disrupters.

While problems in animals from other parts of the country have received more publicity, a variety of Pacific Northwest species appear to be impacted by endocrine-disrupting pesticides. These include minks, river otters, albatross, whelks, falcons, frogs, eagles, deer, and herons.

These animals teach us important lessons. It takes decades to completely understand the impacts of chemicals that upset hormone systems. We may never know the full impacts of some currently-used, less persistent pesticides. With stakes as high as they are, the case for promoting alternatives to pesticides has never been stronger.

BY CAROLINE COX

By now, almost all of us have seen them on our television screens: alligators from a contaminated Florida lake with shrunken and otherwise abnormal genitals,[1] Beluga whales from the St. Lawrence estuary suffering from frequent tumors and high concentrations of "a complex mixture of ubiquitous pollutants,"[2] and Atlantic dolphins, contaminated with high levels of chlorinated hydrocarbons, dying from virulent infections to which the toxins have made them susceptible.[3]

These animals paint a chilling picture of a world that has somehow become so out of balance that the fundamental life processes of birth, growth, and death no longer can follow a normal path. We are chilled because we see that our own lives lose some of their richness and depth when fellow species suffer. We are also chilled because wildlife can indeed act as our "canaries in a coal mine" alerting us to hazards to our own health about which we have only a glimmer of understanding.

What could cause these abnormalities in so many different wildlife species? Scientists hypothesize that many of the problems are related to disruption of the endocrine system, the collection of glands and hormones (chemical messengers) that regulate growth, development, behavior, and sexuality. Symptoms of hormone disruption are varied, but most often are related to reproduction. Because much of the development that occurs as humans and other animals mature is a one-way street, disruptions that occur in young animals will often be manifested for the rest of the animals' life.

Certain synthetic chemicals, including many widely-used pesticides, can disrupt the functioning of the endocrine system by mimicking natural hormones or by acting as inhibitors of a particular enzyme or receptor protein in the system. The orga-

Vera Wong

Young male river otters in the Lower Columbia River exposed to endocrine-disrupting contaminants show delayed sexual development. One young otter with high levels of organochlorine insecticides had no testes at all.

Caroline Cox is JPR's editor.

nochlorine insecticide DDT is probably the most well-studied example. The purpose of this article is to bring knowledge of these problems home to the Pacific Northwest. It looks at wildlife that is, so to speak, in NCAP's "backyard." Are pesticides disrupting the endocrine systems of wildlife in the Northwest and throwing their hormones out of balance? What important lessons can these animals teach us?

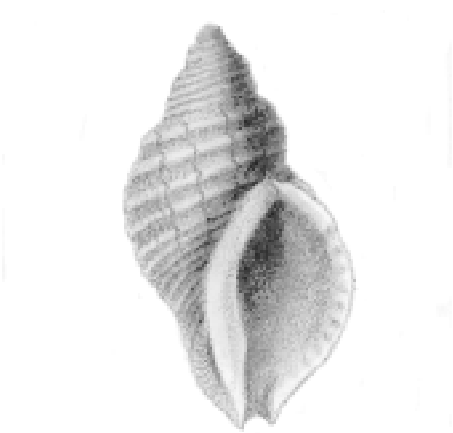
Detective Work: River Otters and Disappearing Mink

Mink, once relatively common in the Lower Columbia River (between Portland, Oregon and the mouth of the Columbia), have decreased in number dramatically: one trapper reported an 85 percent decrease over a twenty year period. Biologists at the U.S. Fish and Wildlife Service (FWS) believe that the mink may have been effectively extirpated from the area because of exposure to contaminants, most likely polychlorinated biphenyls (PCBs). Mink are "extremely sensitive to PCBs and perhaps the most sensitive mammalian species."[4] PCBs were widely used in the U.S. until the 1970s in transformers, as heat transfer fluids, in inks, as "inert" ingredients in pesticides, and a variety of other uses.[5] Their persistence and ability to bioaccumulate mean that they still contaminate water, soil, and wildlife.

Documenting this problem has not been easy. It is difficult to study the mink in the Lower Columbia because so few of them now live there. Instead, they have focused their work on the river otter. While similar to mink in some aspects of their life history, river otter are less sensitive to contaminants and are relatively abundant.[4]

During the winter of 1994-1995, the FWS collected otter carcasses from trappers and found surprising results. Even in young otters (between 8 and 10 months old) concentrations of a variety of organochlorine insecticides (DDE, hexachlorocyclohexane, heptachlor, dieldrin, and mirex), PCBs, dioxins, and furans were all higher than in otters trapped in the relatively less polluted Coast Range in western Oregon.[4]

The length and weight of the baculum (the bone inside of the penis) of Lower Columbia young males was significantly less than those from the Coast Range. Testes averaged about 1/5 the size, but because of the small sample size, the difference was not statistically significant. In addition, the sperm producing structures in the testes of these animals showed no evidence of sperm production, while those from the Coast Range were normal. Older otters from both areas looked normal, so that the effect of the contaminants seemed to be delayed development. However, as the biologists pointed out, "We do not know if age class 2+ [the older otters] male reproductive organs were functioning normally."[4]



Whelks' sexual development is permanently altered by exposure to the pesticide tributyltin.

No testes at all were found in one young otter, who also had the highest concentrations of most organochlorines and PCBs and many of the dioxins and furans measured. High levels of contamination were also associated with enlarged livers and spleens in older animals.[4]

Phthalate esters and alkylphenols, two classes of compounds that are known to cause endocrine-disrupting effects in other species, were not included in this study. Both are used as "inert" ingredients in pesticides as well as in plastics and certain detergents. Researchers hope to include them in the second phase of this study.[4]

Nothing is Remote Enough: Albatross in the North Pacific

Albatross spend most of their lives at sea. The black-footed albatross is found in the waters off the Pacific Northwest coast. It roams across vast distances in the northern Pacific, but nests on islands in the mid-Pacific Ocean. There are large nesting populations on the Midway atoll, east of the Hawaiian Islands.[6,7]

Biologists studying the birds with support from the U.S. Environmental Protection Agency (EPA) discovered that although the birds "forage on the open ocean far from continental pollution sources," they have not escaped persistent, endocrine-disrupting toxic compounds. DDT-related compounds in the black-footed albatross were just under two parts per million, near the threshold concentrations known to cause eggshell thinning in birds. Crushing of weakened eggs accounted for 2/3 of egg hatching failures. Deformed embryos have also been found by the research team.[6]

Black-footed albatross feed on flying fish and their eggs which are relatively high on the marine food chain. The DDT-related chemicals in the albatross appear to come from "a large fresh plume coming off the coast of Southeast Asia."[6] Based on the ratios of DDT to its breakdown products, one of the biologists studying the Midway albatross commented: "This is not old stuff that's been around for 20 years." An age of one or two years is more likely.[6]

DDT and related chemicals are not the only endocrine-disrupting contaminant in the albatross. Concentrations of PCBs, dioxins, and furans were near or above the thresholds known to cause adverse effects in other fish-eating bird species. Preliminary field data from Midway Island showed that black-footed albatross were suffering from high rates of embryo death and lower rates of egg hatching than albatross species that eat lower down on the food chain.[7]

Pesticides, Sex, and Whelks

Whelks (marine snails) around the world have been damaged by the endocrine-disrupting pesticide tributyltin (TBT). TBT is used as an anti-fouling agent in marine paints and as an anti-stain and mildew agent in household paints.[8] When exposed to TBT at a critical stage of development, female whelks develop male genitalia, a condition called imposex. TBT bioconcentrates, so that concentrations in plants and ani-

mals are higher than the concentrations in the water in which they live. Bioconcentration factors for TBT as high as 30,000 have been measured.[9] Concentrations of TBT in water as low as 1 part per trillion have induced imposex in molluscs.[10] The imposex condition is permanent so that if the whelk moves later in life into clean water, normal anatomy is not restored.[11]

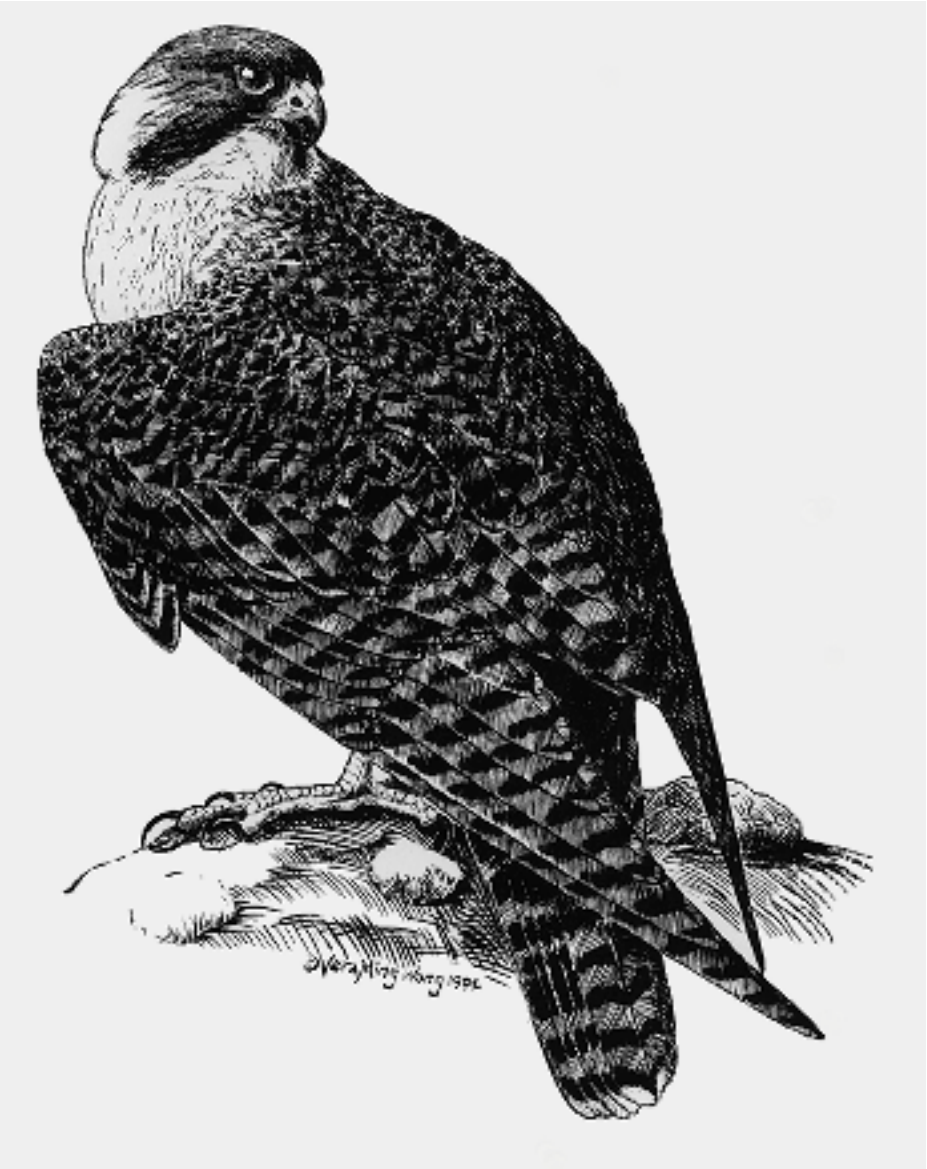
Surveys in 1989 of imposex in whelks around Vancouver Island, Puget Sound, and the west coast of Washington found that imposex was astonishingly common. At collection sites that were within a kilometer of a marina or harbor, all female whelks showed imposex. These sites included Seattle, Tacoma, Port Angeles, and Victoria. At only two sites were no cases of imposex found. In "remote" areas in the Olympic National Park, imposex frequencies varied between 30 and 80 percent.[12]

TBT's registered uses on small boats with hulls not made of aluminum were cancelled in 1988, but other uses continue.[13] Recent (1993) sampling of three sites near Victoria, British Columbia indicates that imposex continues: all females showed imposex at two of the three sites and imposex frequency was over 90 percent at the third site.[14]

Can Falcons Return from Extinction's Precipice?

Peregrine falcon populations were nearly brought to extinction by DDT use earlier in this century. Cancelling DDT's uses in the U.S. allowed some populations of peregrines to recover, but not those in coastal California. DDE contamination of eggs remains relatively high: a recent study found that residues were about 60 percent of the level that biologists have calculated cause population decline. PCBs contaminate the same eggs and the toxicity of these chemicals, together with the effects of some dioxins and furans which also contaminate the eggs, appears to be causing the reproduction failure.[15]

Other falcons suffer similar problems. The prairie falcon is about ten times more sensitive to DDT than the peregrine. Surprisingly, it was less affected by DDT's ubiquitous use. This is because it eats prey that are lower on the food chain, and therefore DDT residues do not have the opportunity to bioconcentrate as much as they would for the peregrine. A study of prairie falcons from Pinnacles National Monument in Central California and some other California eyries found that eggs from three of the seven nests studied were contaminated with DDT breakdown products at levels higher than the levels known to cause population declines in prairie falcons. No eggs successfully hatched at these three nests, while 13 out of 19 eggs hatched at nests where contamination levels were lower. High levels of hexachlorobenzene were also found in some of eggs from failed nests.[16]



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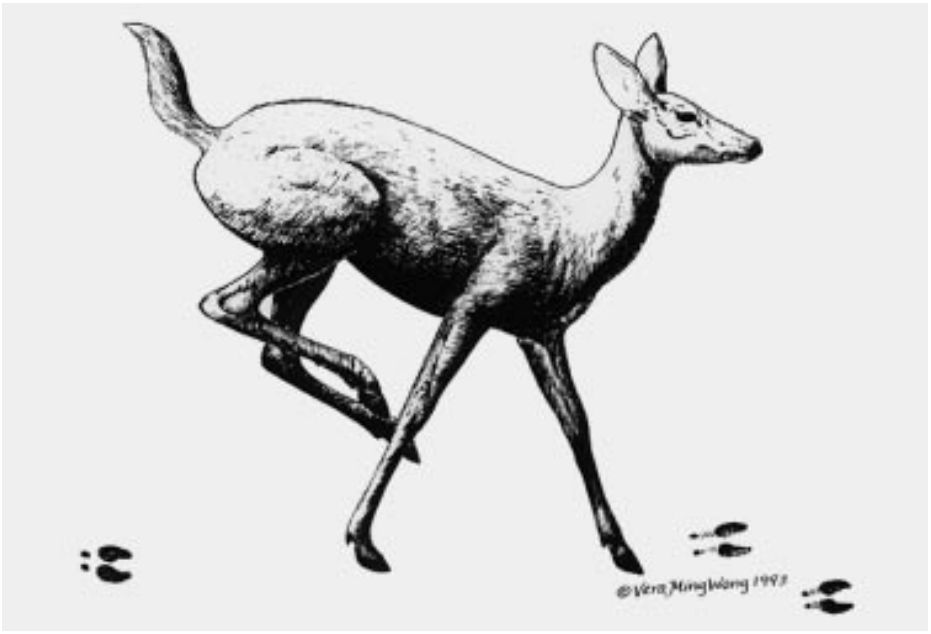
Use of the organochlorine insecticide DDT drove the peregrine falcon to the verge of extinction 25 years ago. Levels of DDT and its breakdown products remain high in peregrines, as well as in the related prairie falcon, nesting in central California.

Frogs Raise More Questions than Answers

Since the end of the 1980s herpetologists have reported worldwide declines in amphibian populations, especially frogs and toads. Local or regional extinctions of some species have been recorded. Pacific North-



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Young deer near Stevensville, Montana, were found this year with missing genitals and misplaced udders. A wildlife rehabilitator in the area suspects exposure to some of the pesticides used on nearby mint fields may be the cause of the deformities.

west amphibians have not escaped this problem. The western toad, the Yosemite toad, the northern leopard frog, the spotted frog, the Cascades frog, the foothill yellow-legged frog, and the red-legged frog are includee-in this somber and lengthy list of disappearing northwest species.[17]

The causes of this decline are often unknown and doubtless multiple: disease, introduction of predatory bullfrogs or fish, dambuilding, acid rain, increased ultraviolet radiation, and pesticides have all been implicated.[17] A particularly striking example of the potential problems caused by pesticides and other agricultural chemicals comes from the Klamath Basin Natural Wildlife Refuges, straddling the border between Oregon and California. Laboratory studies showed that a 96-hour exposure of developing frog eggs to agricultural drainwater caused "severely deformed" embryos.[18]

The Health of Eagles, a National Symbol

Bald eagles, probably the United States' most famous bird, are also at the mercy of endocrine disrupting pesticides. In the Columbia River estuary, eagle nesting success has been noticeably low, "poor and variable" when compared to other areas of Oregon and Washington. A U.S. Fish and Wildlife Service study found that eagles were contaminated with DDE (a major breakdown product of DDT), PCBs, and the notorious dioxin 2,3,7,8-TCDD. High concentrations of DDE and PCBs were associated with "marked" thinning of the eagles' eggshells and a reduced number of eaglets produced per eagle nest. Young nestlings (8 to 10 weeks old) had detectable levels of DDE and PCBs, as did several species of fish typically used as food by eagle parents.[19]

The biologists concluded that the eagles are being contaminated by DDE in the sediments, waters, and food chains of the Columbia River estuary. The DDE is present in this enormous estuary, the "sump" for an awe-inspiring 260,00 square miles, seven states and a Canadian province, because of DDT's heavy agricultural use in orchard, farm, and forest land in the 1940s, 1950s, and 1960s. Another possibility is that migratory birds bring DDE contamination with them from their wintering grounds in Central and South America. The DDT is added to PCB contamination, much of which comes from equipment in the Columbia's hydroelectric dams, and dioxin contamination, coming from a variety of sources. It is clear that the researchers were correct when they wrote, "Efforts to understand and develop solutions to pollution problems in the Columbia River should focus on the entire river basin."[19]

A more recent study found that eagles in the Lower Columbia "continue to accumulate DDE and total PCBs at concentrations associated with limited productivity."[20] In addition, "dioxin and related compounds are contributing to the reduced reproductive success."[20]

Mystery Deer in the Bitterroot Valley, Montana

Judy Hoy is a wildlife rehabilitator in Stevensville, Montana. In order to feed her carnivorous patients, she collects road-killed deer from along the highways. Last spring, she was startled to find a young male deer with a missing scrotum. Since then she has found 16 more deer with the same deformity, as well as two baby does with misplaced udders. Along the stretch of road between Corvallis and Florence, Montana, she found only one normal young deer this summer. The problem appeared to have been caused during a particular time period, because Hoy has found no older deer with similar problems.[21]

Although there is no information yet about what might be causing these deformities, Hoy believes that they could be related to an increased use of pesticides on the mint fields in the area. The case has attracted attention because many cases of pesticide-related reproductive problems in wildlife are seen in carnivores who eat high on the food chain. In this case, deer, who are herbivores, were affected. The Montana Department of Fish, Wildlife, and Parks is now investigating and has arranged for chemical analysis of some of the deer.[21]

Great Blue Herons: Similar Problems

Herons are frequent residents of estuaries throughout the Pacific Northwest but appear "not to be reproducing at sustainable levels."[22] A study of two Puget Sound heron populations, one at Dumas Bay near Tacoma and the other at Samish Island near Bellingham found that DDE levels were high in eggs from both areas. Concentrations of DDE at Dumas Bay "surpass concentrations reported to cause

reproductive problems in waterbirds." PCBs, hexaclorobenzene, and pentachlorobenzene were also found. The researchers were surprised that eggs from Samish Island, a rural area relative to Dumas Bay, had organochlorine contamination. They believe that the contamination resulted from "widespread use" in the agricultural areas surrounding Samish Island during the 1950s and 1960s.[22]

Taking Action

Looking at the research done to date about pesticides and endocrine-disruption in Pacific Northwest wildlife leaves many questions unanswered. It's a complex problem, and one that will need years of study before scientists will feel comfortable saying that they accurately understand all the interacting factors. What the evidence to date points to, though, is that problems are significant and deserve immediate action. Here are some steps that you can take now:

• Write to EPA. Thanks to the tireless work of World Wildlife Fund biologist Theo Colborn and many others, endocrine-disruption is receiving national attention. The Food Quality Protection Act, passed by Congress this year, requires EPA to consider endocrine disruption in its regulation of pesticides. Letters from all of us reminding EPA to implement the law stringently are important. One particularly important problem that EPA needs to hear from us about is the issue of endocrine-disrupting "inert" ingredients in pesticides (those that are claimed as trade secret by the manufacturers). Many of the chemicals that have caused problems in wildlife (PCBs, alkylphenols, phthalate esters) have been or are used as "inerts" in pesticide products.

• Emphasize the *prevention* of pest problems. There is an important lesson to be learned from the recent work showingthat pesticides and other toxins are disrupting wildlife hormone systems. PCBs were first commercially produced in the 1920s, DDT in the 1940s, and tributyltin in the 1960s. Decades passed before we had any idea of the kinds of problems they were causing for wildlife and the magnitude of these problems. Even when our regulatory system restricts or ends the use of these poisons, problems continue. The only sure way to keep similar problems from occurring in the future is to take a precautionary approach and focus on preventing pest problems rather than using toxic chemical controls. Pesticides that are not produced or used cannot wreak havoc with wildlife hormones.

• Buy organically-grown food. About three-quarters of the pesticides used in the U.S. are used in agriculture. If you are concerned about the way that some of these chemicals have disrupted wildlife endocrine systems, a tangible way to demonstrate your concern is to buy organic food. Using nonchemical pest management techniques in your home is another important step.

In the End

Looking at how pesticides, particularly DDT, have affected the hormone systems of wildlife is a humbling experience. DDT first began to be used about half a century ago. Astonishingly enough we are still, after fifty years, in the process of understanding the full impacts of this chemical on wildlife. And the impacts of DDT should be *easy* to understand. DDT is persistent and accumulates in body tissues so that a single measure of contamination levels in an animal gives a pretty good idea about cumulative lifetime exposure. Exposure levels can then be correlated with reproductive success or other impacts of concern.

What about all the other pesticides that might have effects that seem related to endocrine-disruption? It may be extraordinarily difficult to establish proof of cause and effect. Many pesticides are not persistent, and not accumulative, so that an affected animal would carry no "signal" of the cause of its problems. We don't have the luxury of waiting until proof of cause and effect is firmly at hand. We know problems exist. Promoting pesticide alternatives is the only way to safeguard our wildlife's future.

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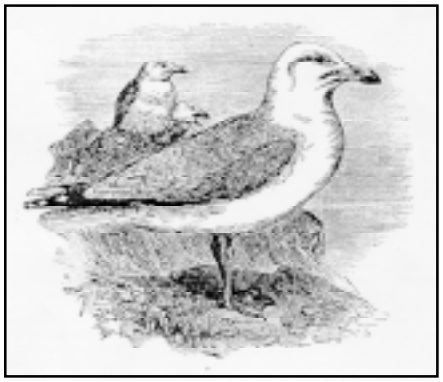
ENDOCRINE DISRUPTION RESEARCH: AN INTERVIEW WITH MICHAEL FRY

Dr. D. Michael Fry, an avian science professor at the University of California, Davis, was one of the first to document the relationship between pesticides and endocrine disruption in wildlife. In 1978 Fry had a hypothesis that DDT was disrupting the developmental process in California condors. Documenting disruption in condors was difficult, so Fry turned instead to gulls on the Channel Islands just off the California coast.

On Santa Barbara Island, 15 percent of the nests were attended by female-female pairs instead of usual male-female pairs. These female-female nest pairs are frequently referred to as the island's "lesbian gulls." Fry thought the breeding anomalies could be caused by DDT. Specifically, o,p'-DDT (one form of the organochlorine insecticide DDT) can be converted to a xenoestrogen (a synthetic chemical which acts like the hormone estrogen). Fry documented that the fish the Santa Barbara Island gulls were feeding on were contaminated with DDT. The high level of DDT seemed to chemically neuter the male embryos, causing a lack of males in the population.

The United States banned DDT in 1972, but because DDT is pervasive and persistent, many years passed before concentrations in the gull eggs decreased and male embryos were no longer being feminized. Pelican and cormorant populations had suffered eggshell thinning due to exposure to DDT, but by 1975 the pelican and cormorant populations were recovering. However, since the gulls suffered from feminization, their populations were disrupted for a generation longer, until 1983. Today DDT still impacts some bird species in the Channel Islands. Peregrine falcons and bald eagles feed at a higher level in the food web than gulls, thus these species will continue to be exposed to toxic levels of DDT for another ten years.



Funding for further study of these problems has been nonexistent. Recently, especially with the publication of Theo Colborn's book *Our Stolen Future*, more attention has been given to endocrine disruption. Funding for wildlife research is increasing. The U.S. Environmental Protection Agency (EPA) recently funded six out of ten research proposals examining endocrine disruption including Fry's.

Currently, Fry serves on the National Academy of Sciences Panel on Hormone Active Agents in the Environment and EPA's Endocrine Disrupter Screening and Testing Committee. Fry's present research involves examining the effects of known endocrine disrupters to see what critical stages of avian development are susceptible to endocrine disruption. He is looking at bird species that at birth are both feathered and self-feeding, or naked and blind. Fry thinks that bird species, especially songbirds, that are fed as nestlings are also being impacted by endocrine disrupters in the environment.

Regulation of endocrine disrupting substances and pesticides is vastly inadequate. Fry mentioned several regulatory problems and other areas of concern. The Federal Insecticide, Fungicide, and Rodenticide Act only requires multigenerational rodent studies that are inadequate to detect if a pesticide effects the endocrine system of rodents, much less that of other animals or humans.

With over 80,000 chemicals in commerce, the prospects of regulation are daunting. In California agriculture alone over 752,000 pounds of alkylphenols were used in 1993. Alkylphenols are "inert" ingredients (those that are called trade secrets by pesticide manufacturers) that are used as surfactants. In isolation these compounds are weakly estrogenic, but in combination estrogenicity may increase. Fry feels that the implications for birds are particularly important. Birds are exceptionally sensitive to estrogenic substances because estrogens control sexual differentiation in birds, whereas mammals are more sensitive to androgens (male sex hormones).

On the brighter side, Fry considers EPA to be on top of things and acting proactively in responding to *Our Stolen Future*. Congress asked EPA to look at estrogenic compounds, but EPA is setting up guidelines for screening and testing of endocrine disrupters in general. The Chemical Manufactures Association and the Chlorine Council are pressuring EPA to restrict the focus to only estrogenic substances. EPA invited 30 different stakeholders including representatives from industry, regulatory community, academia, and the environmental community to help develop screening and testing guidelines. Fry thinks that EPA intends to begin the process of managing endocrine disrupters; these efforts represent a positive start in protecting wildlife populations.

—Samantha McCarthy

Samantha McCarthy is a member of NCAP's board of directors from Davis, California.