



## **DIELDRIN**

- Dieldrin, the second most commonly used agricultural pesticide in the U.S. in the 1960s (after DDT) and banned in the U.S. in 1987, is an acutely toxic carcinogenic and endocrine-disrupting compound. It also decreases the effectiveness of the immune system, reduces reproductive success, and causes neurological problems.
- Dieldrin is classified as a persistent, bioaccumulative, and toxic (PBT) compound by the EPA. More information about the toxic effects of dieldrin can be found at <http://www.atsdr.cdc.gov/tfacts1.html> or <http://www.epa.gov/pbt/pubs/aldrin.htm>.
- In Pear Lake at Sequoia, dieldrin concentrations in 1 of 10 fish exceeded the USEPA human consumption cancer screening value for recreational fishermen.
- At Pear and Emerald Lakes, Sequoia, the average concentration of dieldrin in fish exceeded the USEPA human consumption cancer screening value for subsistence fish consumption.
- Lake sediment cores taken in this study provide a history of contaminant deposition over time. In Sequoia, sediment cores from Pear Lake show a decrease in dieldrin after it was first banned then a recent increase in dieldrin in the last decade. Emerald Lake cores show a slight presence of dieldrin between 1960 and 1970's, then at levels below detection limit since banning (in 1987).
- Concentrations of many current-use pesticides and historic-use pesticides (including dieldrin) in snow were high at Sequoia.
- Concentrations of dieldrin in fish at some parks including Sequoia were markedly higher in than in farmed Atlantic Salmon and wild Pacific salmon.
- The USEPA cancer screening threshold for dieldrin is based on a 1:100,000 cancer risk for adults eating 2.3 meals of fish per month (recreational) or 19 meals of fish per month (subsistence) that are over the threshold<sup>1</sup>.
- To compare the risk level of dieldrin concentrations in fish with other parts of the country; 39% of fish at all sites (urban, agricultural, mixed use, and undeveloped) and 5.3% of fish at undeveloped<sup>2</sup> sites sampled across the U.S. from 1992-2001 by the USGS as part of the National Water Quality Assessment Program<sup>3</sup>, exceeded the dieldrin human health fish consumption threshold<sup>4</sup>.

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<sup>1</sup> Contaminant health thresholds do not accurately assess all contaminant risk (other contaminants weren't measured (e.g., dioxins, furans) and likely change the risk profile). Additionally, these thresholds do not individualize risk (everyone has different risks and body burdens), and they do not characterize fish eating benefits, which likely outweigh contaminant risks for some people.

<sup>2</sup> NAWQA's definition of "undeveloped" sites allows up to 5% urban land use and up to 25% agricultural land use within the watershed--so these sites are not necessarily pristine.

<sup>3</sup> Percentages presented may be overestimations for two reasons: NAWQA (and WACAP) calculates contaminants in whole fish rather than edible fish tissue, while EPA determines human health thresholds based on contaminants only in edible fish tissue. Additionally, most NAWQA fish taxa sampled are not necessarily species that are typically consumed by people, but those with a high likelihood of containing contaminants (e.g., bottom-feeders).

<sup>4</sup> The distinction between recreational and subsistence fish consumption is not made due to high detection limits.



## DDT

- DDT, an insecticide banned in the U.S. in 1972, is a known endocrine-disrupting compound. It is a probable human carcinogen, damages the liver, temporarily damages the nervous system, reduces reproductive success, can cause liver cancer, and damages the reproductive system.
- Sum DDTs (including p,p'-DDE) are classified as persistent, bioaccumulative, and toxic (PBT) compounds by the EPA. More information about the toxic effects of DDT (including DDE and another byproduct, DDD) can be found at <http://www.atsdr.cdc.gov/tfacts35.html> or <http://www.epa.gov/pbt/pubs/ddt.htm>.
- At Pear and Emerald Lakes, Sequoia, the average concentration of DDT in fish exceeded the USEPA human cancer risk for subsistence fish consumption (i.e., adults eating 19 meals of these fish per month).
- In Pear Lake at Sequoia, DDT concentrations in 2 of 10 fish exceeded the piscivorous bird (kingfisher) health threshold and 3 of 10 fish exceeded the piscivorous bird (kingfisher) health threshold at Emerald Lake, Sequoia.
- Lake sediment cores taken in this study provide a history of contaminant deposition over time. Sediment cores from Pear Lake show a sharp presence of DDT beginning in 1950, and a decrease since then. Emerald Lake cores exhibit a similar pattern although the presence is far less magnified.
- DDT concentrations in fish from Sequoia were higher than those in many fish reported elsewhere in the world, including sites in Africa where DDT is used for mosquito control. Concentrations in fish were comparable to fish collected from alpine lakes in Canada.
- The USEPA cancer risk threshold for DDT is based on p,p'-DDE, the form of DDT most frequently detected in the fish, and a 1:100,000 cancer risk for adults eating 2.3 meals of fish per month (recreational) or 19 meals of fish per month (subsistence) that are over the threshold<sup>5</sup>.
- To compare the risk level of DDT (i.e., p,p'-DDE) concentrations in fish with other parts of the country; 14% of fish at all sites (urban, agricultural, mixed use, and undeveloped) and 4.8% of fish at undeveloped<sup>6</sup> sites sampled across the U.S. from 1992-2001 by the USGS as part of the National Water Quality Assessment Program<sup>7</sup>, exceeded the DDT (i.e., p,p'-DDE) human health recreational fish consumption threshold. Sixty-one percent

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<sup>5</sup> Contaminant health thresholds do not accurately assess all contaminant risk (other contaminants weren't measured (e.g., dioxins, furans) and likely change the risk profile). Additionally, these thresholds do not individualize risk (everyone has different risks and body burdens), and they do not characterize fish eating benefits, which likely outweigh contaminant risks for some people.

<sup>6</sup> NAWQA's definition of "undeveloped" sites allows up to 5% urban land use and up to 25% agricultural land use within the watershed--so these sites are not necessarily pristine.

<sup>7</sup> Percentages presented may be overestimations for two reasons: NAWQA (and WACAP) calculates contaminants in whole fish rather than edible fish tissue, while EPA determines human health thresholds based on contaminants only in edible fish tissue. Additionally, most NAWQA fish taxa sampled are not necessarily species that are typically consumed by people, but those with a high likelihood of containing contaminants (e.g., bottom-feeders).



of fish at all sites and 34% of fish at undeveloped sites exceeded the DDT (i.e., p,p'-DDE) human health subsistence fish consumption threshold.

## MERCURY

- While mercury is a naturally occurring element, human activities have greatly increased the amount of mercury currently cycling in the atmosphere, soils, lakes, and streams due to fossil fuel combustion (coal-burning), steel and lime production, smelting, petroleum refining, and mercury cell chlor-alkali production.
- Toxic effects of (methyl-) mercury include reduced reproductive success, impaired growth and development, behavioral abnormalities, reduced immune response and decreased survival. The forms of mercury are classified as a persistent, bioaccumulative, and toxic (PBT) by the EPA. More information about the toxic effects of mercury can be found at <http://www.atsdr.cdc.gov/cabs/mercury/> or <http://www.epa.gov/mercury/about.htm>.
- Mercury concentrations in 2 of 10 fish at Pear Lake (Sequoia) exceeded the human health threshold.
- The average concentration of mercury in fish exceeded both the piscivorous bird (kingfisher) and mammal (mink) health thresholds at Pear and Emerald Lakes, Sequoia. The average concentration of mercury in fish also exceeded the otter health threshold at Pear Lake, while mercury concentrations in 5 of 10 fish at Emerald Lake exceeded the otter health threshold.
- Lake sediment cores taken in this study provide a history of contaminant deposition over time. Mercury profiles are similar in both lakes in that they increase in the late 1800s and have since stabilized at 100% enrichment.
- With few local or regional sources of mercury emissions upwind of Sequoia, mercury concentrations in the snow were generally low, producing only moderate fluxes of mercury deposition.
- The contaminant health threshold for mercury is applied to the general population of adults eating 2.3 meals of fish per month.
- The human threshold is 300 ng/g wet weight (USEPA, 2001), and is based on methyl-Hg in the fillet for a general population of adults with 70 kg body weight and 0.0175 kg fish intake per day. 95-100% of Hg in fish is methyl-Hg (Bloom, 1992), and 300 ng/g in the fillet is equivalent to 185 ng/g ww whole body methyl-Hg (Peterson et al., 2007). Contaminant health thresholds in piscivorous animals (wildlife) are based on 100% fish in the diet for whole body total Hg, as determined by Lazorchak et al., (2003).
- Previous studies show that mercury in fish is strongly influenced by watershed and food web characteristics, and that the interplay among these variables is complex and varies in unpredictable ways.



## CHLORDANE

- Chlordane, a pesticide banned for use in the U.S. in 1988, likely causes cancer and may cause liver cancer, can cause behavioral disorders in children if they were exposed before birth or while nursing, and harms the endocrine system, nervous system, digestive system, and liver.
- Chlordane is a persistent, bioaccumulative, and toxic (PBT) pollutant targeted by EPA. See <http://www.atsdr.cdc.gov/tfacts31.html> or <http://www.epa.gov/pbt/pubs/chlordane.htm> for more information.
- No chlordane levels in fish exceeded piscivorous wildlife or human health thresholds at Sequoia.
- Concentrations of many current-use pesticides and historic-use pesticides (including chlordanes) in snow were high at Sequoia.
- Compared to fish collected from several alpine lakes in Canada, WACAP fish were significantly lower in chlordanes (and HCHs) (only ~ ¼ of the concentration), likely reflecting differences in SOC exposure.

## Endocrine Disrupting Compounds (INTERSEX)

- Intersexuality (male and female reproductive structures in the same fish) can be used as an indicator of endocrine-disrupting contaminants such as dieldrin and DDT. The presence of an egg yolk precursor protein (vitellogenin-- Vtg) in the blood of male fish, normally found in mature female fish and used in egg production, is also another biomarker indicative of a chemical effect.
- “Intersex” was not found in fish at Sequoia, however it was found in fish from the Rocky Mountain NPs (the first known examples of fish from “pristine” areas to exhibit these signs of potential reproductive dysfunction). Due to the small sample size, cause-and-effect linkages were not established.

## PAHs

- Polycyclic Aromatic Hydrocarbons (PAHs) are primarily by-products of incomplete combustion. These combustion sources are numerous, including natural sources such as wildfires, industrial processes, transportation (vehicle exhaust, fuel spills), energy production (burning coal) and use, food preparation (grilling meats), smoking tobacco, and disposal activities such as open trash burning.
- Some PAHs (e.g., benzo(a)pyrene) are PBT chemicals and suspected to cause cancer and developmental, reproductive, and neurological effects. See <http://www.epa.gov/pbt/pubs/benzo.htm> for more information on benzo(a)pyrene.
- PAHs were not detected at levels of concern at Sequoia.



## PBDEs

- Polybrominated diphenylethers, or PBDEs, are often used as flame retardants in furniture foam and camping equipment, plastics for TV cabinets, consumer electronics, wire insulation, back coatings for draperies and upholstery, and plastics for personal computers and small appliances. While important for safety, there is growing evidence that PBDEs persist in the environment and accumulate in living organisms, as well as toxicological testing that indicates these chemicals may cause liver toxicity, thyroid toxicity, and neurodevelopmental toxicity. See <http://www.atsdr.cdc.gov/tfacts68-pbde.html> for more information on the toxic effects of PBDEs.
- No PBDE levels in fish exceeded human health thresholds for recreational or subsistence fishing. Wildlife health thresholds have not been established for PBDEs, thus the lack of comparison for kingfisher, otter, and mink.
- PBDE fluxes were below the method detection limits in the surficial sediment at SEKI (only exceeded at ROMO).
- Concentrations of PBDEs in WACAP fish from all eight core parks were approximately 3 times higher than concentrations in fish from similar alpine environments in Europe.

## PCBs

- Polychlorinated biphenyls (PCBs) have been used widely as coolants and lubricants because they do not easily burn and are good insulators. While the manufacturing of PCBs in the U.S. stopped in 1977, present sources of PCBs may include organic wastes burned at municipal and industrial incinerators, hazardous waste sites, etc.
- PCBs are persistent, bioaccumulative, and toxic (PBT) pollutants that have been targeted by EPA, and they are the leading chemical risk from fish consumption. They are a probable human carcinogen, can damage the stomach, cause skin irritation, liver and kidney damage, and thyroid gland injuries. See <http://www.atsdr.cdc.gov/cabs/pcb/> or <http://www.epa.gov/pbt/pubs/pcbs.htm> for more information.
- Human health risks from eating PCBs in WACAP fish were not calculated because WACAP did not measure the same chemicals as the PCB human health thresholds.
- No PCB levels in fish exceeded piscivorous wildlife health thresholds.
- PCBs were detected in sediment profiles at Sequoia. Pear Lake had a particularly high PCB value at the surface of the core, which suggests a recent increase in flux of PCBs to the lake.



**Current-Use Pesticides (CUPs): ENDOSULFANS, CHLORPYRIFOS, DACTHAL, g-HCH**

- Total endosulfans (sum of ENDO I, ENDO II, and ENDO S), g-HCH (lindane), chlorpyrifos (CLPYR), and dacthal (DCPA) were among the most commonly detected current-use pesticides and are markers for recent agricultural sources.
  - Endosulfan is a contact poison used to control insects on food crops, and is also a wood preservative. ENDO causes neurotoxic effects and is an endocrine disruptor.
  - Chlorpyrifos is a broad-spectrum CUP used on cockroaches, grubs, flies, termites, etc. It is toxic to the nervous system, but it is unknown whether it is a carcinogen in humans.
  - Dacthal is an herbicide used on annual grasses and weed species in a wide range of vegetable crops. About one-half of the use of DCPA in the US is for homes and gardens. Effects on the liver have been documented, but toxicological concerns in humans are unknown.
  - Lindane (g-HCH) is a CUP used as a pre-planting seed treatment in the U.S., after most other agricultural uses were restricted in 1983. Potential health effects include effects on the liver and the nervous, cardiovascular, and immune systems.
- Concentrations of the above current-use pesticides (and historic-use pesticides) in snow were high at Sequoia.
- No health consumption thresholds for concentrations of CUPs in fish at Sequoia were exceeded.
- The median value of CUPs in fish at Sequoia was typically above the median value for the range of all WACAP fish.