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STATUS AND ASSESSMENT OF CHESAPEAKE BAY WILDLIFE CONTAMINATION.

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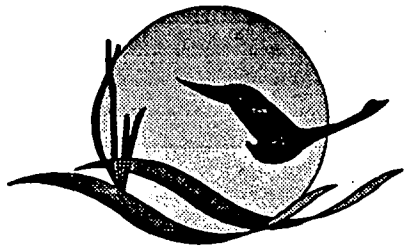

Chesapeake Bay Program

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Status and Assessment of Chesapeake Bay Wildlife Contamination

Chesapeake Bay Program

Basinwide Toxics Reduction Strategy Reevaluation Report

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Abstract: As an integral component of its priority setting process, the Chesapeake Bay Program's Toxics Subcommittee has sought the expertise of Chesapeake Bay researchers and managers in developing a series of Chesapeake Bay toxics status and assessment papers. In the report, evidence for historical and current contaminant effects on key bird species, mammals, reptiles and amphibians which inhabit the Chesapeake Bay basin is examined. For each group of wildlife species, a general overview of effects caused by specific toxic substances is followed by detailed accounts of contaminant effects on selected species.

Status and Assessment of Chesapeake Bay Wildlife Contamination

Basinwide Toxics Reduction Strategy
Critical Issue Forum Report
to the Chesapeake Bay Program
Toxics Subcommittee

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INTRODUCTION

As an integral component of its priority setting process, the Chesapeake Bay Program's Toxics Subcommittee has sought the expertise of Chesapeake Bay researchers and managers in developing a series of Chesapeake Bay toxics status and assessment papers. The purpose of each paper is to document and assess the current state of understanding of the identified potential Chesapeake Bay toxics issue in order to answer the following questions:

1. Do the conclusions from a critical review of existing monitoring data and research findings give us reason to believe the identified potential toxics issue is causing or can cause an impact on the Chesapeake Bay system, on a baywide, regional or local scale?

2. If not, is that because a) there is insufficient data from which to draw solid conclusions, or b) currently there is no basis for concern?

3. If there are insufficient data from which to draw solid conclusions, identify the additional data/research needs required to answer the question of whether or not there is an impact.

4. If there is reason to believe there is an impact or a significant potential for impact, define the magnitude and extent of the (potential) impact.

The "Status and Assessment of Chesapeake Bay Wildlife Contamination" paper focuses on a critical review of available data and information for evidence of impacts on Chesapeake Bay basin birds, mammals, reptiles and amphibians through exposure and uptake of toxic substances. Information presented here was extracted, in part, from a comprehensive review by two of the authors, Heinz and Wiemeyer, of the impacts of toxic substances on Chesapeake Bay target waterfowl, raptor and wading bird species originally published in the Habitat Requirements for Chesapeake Bay Living Resources - Second Edition (Funderburk et. al. 1991). The findings, conclusions and recommendations reported here were presented and reviewed as part of the "Chesapeake Bay Wildlife Critical Issue Forum" held in Annapolis, Maryland in November1 1991 (Appendix A). Prior to publication, this report was peer reviewed by the Chesapeake Bay Program's Scientific and Technical Advisory Committee.

In this paper, evidence for historical and current contaminant effects on key bird species, mammals, reptiles and amphibians which inhabit the Chesapeake Bay basin is examined. For each group of wildlife species, a general overview of effects caused by specific toxic substances is followed by detailed accounts of contaminant effects on selected species.

BIRDS

Historical Contaminant Effects

There is little doubt that in the past, organochlorine pesticides, and possibly other toxic substances, caused adult mortality and reproductive impairment in waterbirds in the Chesapeake Bay. Lead poisoning, the result of ingestion of spent lead shot used by hunters, also may have reduced survival. Various environmental contaminants have adversely impacted populations of birds using the Chesapeake Bay by reducing survival and reproductive success. The major classes of toxic substances of concern are organochlorines (including pesticides such as DDT and its metabolite DDE, dieldrin, and kepone), metals (principally lead and cadmium), oil, organophosphorus and carbamate insecticides (such as Abate and Furadan which are cholinesterase inhibitors), herbicides and polychlorinated biphenyls (PCBs).

Lethal Effects

Dieldrin

Dieldrin has been identified as a cause of mortality of several species of birds in the Chesapeake Bay region. Cattle egrets found dead in 1978 near Bozman in Talbot County, Maryland, and great blue herons, one from near Jamestown, Virginia in 1970 and another from Mason Neck National Wildlife Refuge, Virginia, in 1974 were listed as cases of possible dieldrin poisoning (Ohlendorf et al. 1981). In a series of papers that reported pesticide residues in bald eagles, dieldrin was listed as the likely cause of death of five bald eagles in the Chesapeake Bay (Reichel et al. 1969; Mulhern et al. 1970; Belisle et al. 1972; Cromartie et al. 1975; Prouty et al 1977; Kaiser et al. 1980; Reichel et al. 1984). Given the difficulty in finding birds killed by environmental contaminants and the irregular nature of the reporting process, it is likely that many more birds died from exposure to toxic substances than were reported.

Carbofuran

Carbofuran-related mortalities have been reported throughout the Chesapeake Bay region. The granular formulation Furadan 15G, commonly applied on corn, has been associated with the deaths of bald eagles, American kestrels, red-tailed hawks, and many species of songbirds (Stinson, personal communication, 1991).

Reproductive Effects

Organochlorine Pesticides

Organochlorine pesticides probably had a greater impact on reproduction of birds than on adult survival. DDE was largely responsible for the decline of bald eagle reproduction in the Chesapeake Bay into the 1970s. In a nationwide survey, the highest levels of most organochlorines were recorded in bald eagle eggs from the Chesapeake Bay (Wiemeyer et al. 1984). DDE concentrations have been measured in peregrine falcon eggs from the Bay region that were above critical levels which resulted in nest failure (Peakall et al. 1975).

Likewise, osprey numbers began to decline in the Chesapeake Bay in the 1950s and did not begin to increase until the early 1970s (Ames 1966; Wiemeyer 1971; Reese 1975; Henny 1977; Reese 1977). Organochlorine pesticides, especially DDE, were believed responsible for population declines of ospreys in

the Bay (Wiemeyer et al. 1988).

An estimated 15% of the barn owl population nesting in offshore duck blinds on the Maryland side of the lower Potomac River in 1972 and 1973 contained levels of organochlorines, mostly DDE and dieldrin, that may have been high enough to harm their reproduction (Klaas et al. 1978). DDE also may have impaired the reproductive success of east coast black ducks in the late 1950s and into the 1960s. The more heavily contaminated areas were New York, New Jersey, and Massachusetts, but effects in the Chesapeake Bay in the 1950s cannot be ruled out (Longcore and Stendell 1983). In addition, there may have been other species that were not studied whose reproduction was affected by DDE.

Although it has a short half-life and a comparatively low toxicity to birds, Abate (an organophosphorus pesticide used as a mosquito larvicide in marshes bordering the Chesapeake Bay) caused a surprising degree of reproductive impairment when fed to breeding adult mallards and their young at 1 ppm on a dry-weight basis (Franson et al. 1983).

Kepone

Other toxic substances may have affected avian reproduction in the Chesapeake Bay but their effects may have gone unnoticed. Kepone, which was manufactured at Hopewell, Virginia, and was dumped into the James River during production, is an example. Contamination of the tidal portion of the river was so severe that all shellfishing and finfishing was banned for several years. Kepone residues ranged from 2.4 to 36 parts per million (ppm) on a wet-weight basis in the livers of great blue herons collected from Hog Island Wildlife Refuge in 1976 and 1977 (Huggett and Bender 1980). Kepone also was elevated in the tissues and eggs of a few bald eagles, especially those collected near the James River in the 1970s (Stafford et al. 1978; Wiemeyer et al. 1984; U.S. Fish and Wildlife Service 1990).

Based on circumstantial evidence, the loss of all breeding pairs of bald eagles from the James River from 1975 to 1978 might have been related in part to kepone contamination (C.U.S. Fish and Wildlife Service 1982). A few osprey eggs from areas near the James River contained elevated kepone levels (Stafford et al. 1978; Wiemeyer et al. 1988). Unfortunately, there have been no laboratory or field studies to aid in the interpretation of these kepone residues.

Spill Effects

The Chesapeake Bay has been contaminated with oil on a number of occasions when accidents occurred during its transport (Perry et al. 1978). The birds most likely to be exposed to oil include various species of waterfowl, grebes, and loons, although exposure of a variety of other species including bald eagles and ospreys may also occur (Albers 1984; Piatt et al. 1990). Oiling of plumage may result in deaths from exposure and drowning, whereas ingestion can cause generally sublethal effects on physiology (Albers 1984). An additional danger is the transfer of small amounts of oil from plumage to eggs which may be lethal to embryos (Albers 1984). Lighter refined petroleum products such as No. 2 fuel oil and gasoline are far more toxic than heavier petroleum products such as bunker C. Nonpoint sources of oil pollution from boating activities and urban runoff are probably greater than spills. Damage to and disruption of bird habitats by oil pollution may cause displacement of populations and reductions of important foods (Albers 1984).

Historical Contaminant Effects on Key Species

Bald Eagle

The major decline in the Chesapeake Bay bald eagle population that occurred in the 1950s, continuing into the 1970s, resulted primarily from exposure to organochlorine pesticides used in agriculture and for mosquito control. Both a major reduction in reproductive success, primarily due to DDE, and direct mortality of adult bald eagles, principally due to dieldrin, were involved. For bald eagles to survive and reproduce in the Chesapeake Bay, their eggs should contain an average of no more than 2 ppm DDE, 0.3 ppm dieldrin, or 5 ppm PCBs on a wet-weight basis.

Bald eagle eggs collected after they failed to hatch from Chesapeake Bay nests during the 1970s contained mean concentrations of about 10 ppm DDE, 1 ppm dieldrin, and 25 ppm PCBs, plus other organochlorine pesticides and their metabolites. The concentrations in eggs collected from the Chesapeake Bay region during 1973-1979 were among the highest for any bald eagle population in the U.S. DDE, dieldrin, and PCBs were of greatest concern. Concentrations were significantly lower in 1980-1984 (about 4.5 ppm DDE, 0.3 ppm dieldrin, and 15 ppm PCBs) than in 1973-1979. During the later period, the population began to increase and reproductive success returned to normal. Elevated DDE residues ($\geq$ 4 ppm) in bald eagle eggs have been most closely related to poor production of young and eggshell thinning. However, PCBs and other toxic substances also have been related to these factors, but this is probably due to the fact that where DDE is high, these other chemicals are also high (Wiemeyer et al. 1984; Wiemeyer et al., In Preparation).

Tissues of bald eagles found dead in the Chesapeake Bay region have been analyzed for organochlorine pesticides and PCBs. Six of 19 bald eagles that were found dead or dying in the Chesapeake Bay region from 1966 to 1977 had lethal or highly elevated concentrations ($\geq$ 4 ppm) of dieldrin in brain, but concentrations rapidly declined thereafter (Mulhern et al. 1970; Belisle et al. 1972; Cromartie et al. 1975; Prouty et al. 1977; Kaiser et al. 1980; Reichel et al. 1984; U.S. Fish and Wildlife Service 1982; U.S. Fish and Wildlife Service 1990).

Metals do not appear to have been involved in the decline or poor reproductive success of Chesapeake Bay bald eagles. Mercury residues in eggs were about one-tenth those associated with reductions in reproductive success in other species (Wiemeyer et al. manuscript in preparation; Wiemeyer et al. 1984). Four bald eagles from the greater Chesapeake Bay region are known to have died of lead poisoning; however, three were found dead far from the Bay (U.S. Fish and Wildlife Service 1990). High lead concentrations in eagles ($\geq$ 10 ppm in liver on a wet-weight basis is an indication of lead poisoning) are the result of ingestion of lead pellets from hunter-killed or crippled prey, primarily waterfowl, and not from contamination of the environment from other sources (Pattee and Hennes 1983).

Other toxic substances such as carbamate and organophosphorus pesticides have been implicated in the mortality of bald eagles in the Chesapeake Bay region (U.S. Fish and Wildlife Service 1990). However, the eagles were not exposed through the aquatic food chain, but rather from consumption of illegally poisoned baits or eating terrestrial animals that had ingested the toxicants from illegal use or their use in normal agricultural practices. Excessive mortality from exposure to and uptake of these toxic substances may have slowed recovery of the population. Restrictions on the use of some chemicals, such as carbofuran, may prove beneficial to bald eagles and other species.

Osprey

Reproductive success of the Chesapeake Bay osprey population was reduced by the adverse effects of organochlorine pesticides, primarily DDE. However, the degree of the impact was generally far less serious than that found for bald eagles. Direct mortality caused by agricultural chemicals was not detected.

Osprey eggs that were collected from a number of areas around the Chesapeake Bay in the 1960s and 1970s contained about 3 ppm DDE, 3-10 ppm PCBs, and several other organochlorine pesticides at lower concentrations (Wiemeyer et al. 1975; Wiemeyer et al. 1988). Eggshell thinning in some samples approached levels (> 15%) that have been associated with egg breakage and, in turn, with poor reproduction and population declines (Anderson and Hickey 1972; Lincer 1975; Wiemeyer et al. 1988).

Of all the toxic substances found in osprey eggs, DDE has been most closely associated with eggshell thinning and appeared responsible for negative effects on reproduction (Wiemeyer et al. 1988). Although PCB concentrations in eggs generally exceeded those of DDE, PCBs were not associated with adverse effects on shell thickness and production of young. Trends in organochlorine concentrations in eggs have been variable, but levels in general have been stable or declining (Wiemeyer et al. 1988; Audet et al. unpublished manuscript). Concentrations of organochlorine pesticides generally declined in tissues of ospreys found dead around the Chesapeake Bay during the 1970's and early 1980's, while PCB concentrations remained unchanged (Wiemeyer et al. 1987).

Various elements, including chromium, copper, zinc, arsenic, cadmium, mercury, and lead, do not appear to have had an adverse effect on Chesapeake Bay ospreys. Concentrations in tissues of birds found dead around the Bay generally were normal (Wiemeyer et al. 1980; Wiemeyer et al. 1987). Although few data are available on the synergistic effects among different toxic substances, harmful synergistic effects on birds are unlikely at the levels of these elements in the Chesapeake Bay.

Canvasback

Knowledge of the effects of various toxic substances, especially metals, to canvasbacks is incomplete. There is no evidence to date that canvasbacks have suffered direct toxic effects from any environmental contaminants in the Chesapeake Bay.

Except for seaducks, canvasbacks had the highest levels of cadmium in liver and among the highest in kidney of all ducks. Lead, in contrast, was not especially high in canvasbacks compared to dabbling ducks and seaducks. Zinc and copper were not especially different than in other ducks, and were not considered harmful (DiGiulio and Scanlon 1984). Cadmium concentrations in canvasbacks were generally below those found in a laboratory study to be associated with lesions in kidneys (White et al. 1978). However, a small percentage of canvasback livers had greater than 7 ppm cadmium, a level associated with changes in energy metabolism in mallards (DiGiulio 1982). Lead in foods might be a greater source of lead for canvasbacks than lead shot (DiGiulio and Scanlon 1984). In another study using blood lead levels and a blood enzyme assay to estimate exposure of Chesapeake Bay canvasbacks to lead, it was concluded that foods were more of a cause of elevated lead than the ingestion of lead shot (Dieter 1979). The relatively recent switch in the diet of canvasbacks from submerged aquatic vegetation to clams was not believed to increase exposure to lead or cadmium. In fact, the levels of both metals were generally higher in plants than in clams (DiGiulio and Scanlon 1985). Organochlorine pesticide and PCB levels in Chesapeake Bay canvasbacks collected in 1973 and 1975 were believed to be in a safe range when compared to levels known to affect survival and reproduction (White et al. 1979).

Organochlorine and mercury levels in canvasback eggs collected from the prairie pothole region of the United States and Canada in 1972 and 1973 were generally below those believed to affect reproduction (Stendell et al. 1977). Although canvasbacks do not nest around the Chesapeake Bay, levels of mercury and many organochlorines in eggs, owing to the slow rates of elimination of these substances, would reflect exposure on both the breeding and wintering ground.

One cannot rule out the possibility of physiological and other sublethal effects of toxic substances on canvasbacks that could indirectly alter survival or reproduction. For example, lighter Chesapeake Bay canvasbacks have been shown to have lower over-winter and annual survival probabilities. If exposure to a toxic substance affected body weight, survival could be affected (Haramis et al. 1986). However, the most likely reason why canvasbacks might be underweight would not be toxic substances, but reductions in the abundance of submerged aquatic vegetation in the Bay, and even this more likely connection has not been proven. The question of whether cadmium could be altering the energy metabolism of a small percentage of Chesapeake Bay canvasbacks remains unanswered.

Black duck

Apart from lead shot poisoning, which should decrease with the switch to steel shot, toxic substances do not appear to be a threat to black ducks in the Chesapeake Bay. This conclusion is tempered by the lack of a complete inventory of the effects of toxic substances on waterfowl in the Bay.

Black ducks and other dabbling ducks generally had higher lead concentrations than seaducks and diving ducks, attributable to the higher densities of spent shot in areas inhabited by the dabbling ducks. In contrast to canvasbacks, lead through the food chain was not considered as important a route as lead shot for black ducks. Cadmium, zinc, and copper in black ducks were below levels believed to be harmful to birds (DiGiulio and Scanlon 1984).

Measurements of organochlorines in black ducks from the Chesapeake Bay date back to a survey of eggs collected in 1964 (Reichel and Addy 1968). Compared to DDE levels in black ducks collected from states such as New York, New Jersey, and Massachusetts, eggs from the Chesapeake Bay were fairly clean. Coupled with the results of subsequent surveys in 1971 and 1978, these findings indicate that it is unlikely that organochlorine pesticides or PCBs posed a hazard to black ducks, at least since the egg surveys began, and these chemicals are even less likely to be a problem today (Reichel and Addy 1968; Longcore and Mulhern 1973; Haseltine et al. 1980).

Chesapeake Bay black ducks were also part of the duck wing monitoring program for pesticides and PCBs, which started in 1965 and lasted into the 1980s. As pools of wings were analyzed from each state, it is impossible to be certain where in Maryland and Virginia black duck wings came from, but reasonable to assume that many came from the Chesapeake Bay basin. As with the black duck egg surveys, the wing surveys showed that black ducks from the Chesapeake Bay region contained lower levels of most organochlorine pesticides and PCBs than black ducks from states such as Massachusetts, New York, and New Jersey. Moreover, organochlorine pesticides and PCBs have steadily declined in black duck wings collected in the Chesapeake Bay region (Heath 1969; Heath and Hill 1974; White and Heath 1976; White 1979; Cain 1981; Prouty and Bunck 1986).

Wood duck

There is very little information on concentrations and effects of environmental contaminants on wood ducks in the Chesapeake Bay basin. However, much of the information listed in the sections on other ducks

is applicable to some extent to wood ducks.

Several metals were measured in wintering Chesapeake Bay basin wood ducks collected generally from fresh water marshes bordering tributaries of rivers entering the Bay. Except for lead, which was higher in wood ducks than in other ducks, concentrations of metals were lower than or about equal to levels in other ducks from the Bay basin. Lead was the only metal in wood ducks that was considered high enough to be associated with sublethal impacts, such as physiological changes. For wood ducks, and other species of dabbling ducks (mallards, black ducks, and pintails), lead shot ingestion was considered the probable cause of elevated lead in liver. Lead through the food chain was not considered to pose a significant hazard (Scanlon et al. 1980; DiGiulio and Scanlon 1984).

Redhead

There were no publications describing contaminant levels in redheads from the Chesapeake Bay basin, but the information presented for other ducks is generally applicable to this species as well.

Wading Birds

There is too little information on contaminant levels and effects in wading birds in the Chesapeake Bay region to make a clear assessment of possible adverse effects. A survey of PCBs and organochlorine pesticides in the brains and carcasses of wading birds found dead along the Chesapeake Bay and its tributaries was conducted in the late 1960's and 1970's. Except for two great blue herons in which dieldrin levels in the brain were in a potentially dangerous range, concentrations of these toxic substances in several great blue herons, green-backed herons, and snowy egrets were too low to have been the cause of death. Two cattle egrets were reported to have died of dieldrin poisoning (Ohlendorf et al. 1981). In the early 1970s, residues of PCBs and organochlorine pesticides in the eggs of green-backed herons and cattle egrets from the Potomac River were below levels believed to affect reproduction (Ohlendorf et al. 1979).

MAMMALS

Contaminant Effects

Whether populations or communities of wild mammals within the Chesapeake Bay basin have been or are now being adversely affected by exposure to toxic substances is a question that cannot be fully answered at this time due to a lack of data. However, studies published to date do not suggest that there are baywide or regional impacts.

Contaminant Residues

Organochlorines

Elevated residues of kepone were reported in raccoons (Bryant et al. 1978), and in white-footed mice, (Terman and Huggett 1980) collected from the James River region. Concentrations in raccoons were elevated by an order of magnitude but were still less than 0.1 ppm (wet, dry, or lipid weight not indicated). Actual concentrations in white-footed mice were not given. Although significantly lower concentrations were found in approximately 70% of mice trapped at a reference site 4.8 miles inland. Mammalian top carnivores

that eat fish, such as the river otter or mink, were not studied in relation to kepone.

Each year from 1945 through 1949, DDT was applied at 2 pounds per acre to Patuxent River riparian habitat on the U.S. Fish and Wildlife Service's Patuxent Wildlife Research Center near Bowie, Maryland. White-footed mice showed no significant difference in trapping rates before and after application (Stickel 1946, 1951). Residue concentrations in tissues were not measured and possible long-term effects were not studied.

Concentrations of organochlorine insecticides and PCBs (polychlorinated biphenyls) were reported in little brown bats from North East, Maryland, on the Chesapeake Bay (Clark and Prouty 1976). DDE, dieldrin, and PCBs were found at maximum mean amounts of 1.80, 1.01, and 3.22 ppm (wet weight) in carcasses, amounts far below any known harmful level. At Montpelier Barn in Laurel, Maryland, carcass concentrations of DDE (5.32 ppm) and PCBs (4.99 ppm) in big brown bats and of DDE (3.00 ppm) and PCBs (11.6 ppm) in little brown bats were higher than those at North East (Clark and Prouty 1976) but still far below any concentration known to be harmful.

Ranch-reared mink are extremely sensitive to PCBs, and dietary dosages of only 0.64 ppm (wet weight) prevented nearly all reproduction (Platonow and Karstad 1973, Aulerich and Ringer 1977, Jensen et al. 1977). O'Shea et al. (1981) found mean PCB concentrations in livers of wild Maryland mink similar to amounts in ranch mink whose reproduction had failed. Some of these Maryland mink were from the Chesapeake Bay basin. Mean concentrations of DDE, oxychlordane, heptachlor epoxide, and dieldrin were all less than 0.5 ppm (wet weight) in livers of the same animals (O'Shea et al. 1981). The Maryland mink came from trappers and no effort was made to get animals from areas where trappers do not normally collect.

Two Atlantic bottlenose dolphins collected from Maryland and Virginia contained a maximum of 80 ppm (lipid weight) of DDE, 6 ppm dieldrin, and 195 ppm PCBs in their blubber (Kuehl et al. 1991). The brain of one contained 45 ppm PCBs. The authors suggested that some of the residues could cause immunosuppression but they present no data to support this claim. Otherwise, these concentrations are not believed to be high enough to cause lethal or reproductive effects.

Organochlorines and metals

Among muskrats analyzed from the contaminated lower Elizabeth River, from the less contaminated upper Elizabeth River, and from the uncontaminated Nansemond River, 22 of 35 carcasses contained polynuclear aromatic hydrocarbons, but all but 3 compounds were below the quantitation limit of 0.03 ppm dry weight) (Halbrook 1990). Only trace amounts (< 1 ppm dry weight) of organochlorine compounds were found. Among toxic metals measured in kidneys, nickel was highest (0.05 ppm dry weight) in muskrats from the lower Elizabeth River, selenium (5.31 ppm) was highest in muskrats from the upper Elizabeth River. The author concluded that the environmental contaminants reduced body and spleen weights through depression of immunological function; however, reproduction and population density were not affected.

Heavy metals

High lead concentrations were found in several small mammal species associated with the high traffic volume of Baltimore-Washington Parkway near Laurel, Maryland (Clark 1979). Estimates of daily lead intake were high enough, when compared to studies of domestic mammals, to suggest possible mortality or

reproductive effects in short-tailed shrews, little brown bats, and meadow voles. Whether these effects ever occurred in these populations or whether these mammals have become genetically resistant to lead through selection is not known.

River otters showed median concentrations of lead in bone and cadmium in kidney from large samples (78 to 221 animals) from the tidewater Virginia region along the Chesapeake Bay only as high as 2.95 ppm (dry) for lead and 0.15 ppm (dry) for cadmium with no known harmful effects (Anderson-Bledsoe and Scanlon 1983). Population and reproductive parameters were not investigated.

Eight of approximately 104 mink from areas adjacent to the Chesapeake Bay contained lead concentrations of 3 or more ppm (dry weight) in their bones, and 4 contained cadmium at 2 or more ppm (dry weight) in their kidneys (Ogle et al. 1985). These authors did not attribute any harmful effects to these metals, however, possible effects on population and reproduction parameters were not studied.

Anticholinesterases

Methomyl (Lannate) applied with the organochlorine toxaphene to soybeans near the Chesapeake Bay at Deltaville, Virginia, caused significant depression (11-12%) of brain cholinesterase activity in feral house mice up to 3 days after spraying (Montz et al. 1983). Only mice capable of being baited into live-traps were sampled so those most seriously affected were presumably not sampled. Under these conditions, serious effects on this and other mammal species could have been missed.

Granular carbofuran had no measurable effect on blood cholinesterase activity or on population levels, body weight, movement, hematocrit, or liver function of white-footed mice in agricultural fields of the U.S. Department of Agriculture's Beltsville Agricultural Research Center near Laurel, Maryland (Albers et al. 1990). Again the study included only animals healthy enough to be trapped, but the lack of any apparent effect suggests there were none.

While conducting criminal investigations of bird mortalities, U.S. Fish and Wildlife Special Agent Frank Kuncir (Kuncir, Personal Communications) documented 21 events between 1983 and 1989 in which carbofuran, parathion, famphur, malathion, or an unidentified avicide killed 8 wild mammal species in Chesapeake Bay basin counties of Delaware, Maryland, and Virginia. Carbofuran killed raccoons (13 events); opossums (4 events); red foxes (4 events); muskrats (1 event); white-tailed deer (1 event); river otters (1 event); and, unidentified squirrels (1 event). Parathion killed gray foxes (1 event); and, red foxes (1 event). Famphur killed raccoons (1 event); malathion killed raccoons (1 event); and, an avicide killed raccoons (1 event). Agent Kuncir believes this to be only a small fraction of the mortality that regularly occurs. Note also that this recorded mortality involves only larger mammals. Mortality in small species such as mice, shrews, and bats must be orders of magnitude higher because these small species occur in much higher population densities, because dead individuals disappear much more rapidly, and because when they are found dead they are given much less consideration.

REPTILES

CONTAMINANT EFFECTS

The adverse effects of toxic substances on reptiles in the Chesapeake Bay basin, and on reptiles in general, are not well known. Species population sizes and population trends are largely unknown except for occasional studies of local reptile populations (e.g., Stickel 1978). The findings from published studies, summarized below, describe general effects of toxic substances on reptiles. Data from Chesapeake Bay are provided when available.

Organochlorines

Extensive use of organochlorine pesticides in the 1950s, 1960s, and early 1970s resulted in numerous reports of the lethal effects of these sustances on reptiles across the United States (Hall 1980). Subsequent reports emphasized the residues of organochlorine pesticides, PCBs, dioxins, and furans (Stone et al. 1980, McKim and Johnson 1983, Ryan et al. 1986, Ford and Hill 1991, Bishop et al. 1991). The effects of PCBs, dioxins, or furans on reptiles have never been firmly established, although limited evidence implies that these substances could cause deformities and delayed hatching in eggs of the snapping turtle (Bishop et al. 1991).

Organophosphates and carbamates

A study of the effects of four organophosphorus pesticides on a lizard showed that effects were more similar to birds and mammals than amphibians and fish (Hall and Clark 1982). The LD 50 of parathion to the Caspian terrapin was comparable to the established range for birds and mammals (15 mg/kg vs 5-50 mg/kg), but susceptibility to cholinesterase inhibition was less than that of two species of birds similarly tested (Yawetz et al. 1983). No other studies of the effects of cholinesterase-inhibiting pesticides on reptiles are known.

Metals

Reptiles, particularly turtles, will accumulate metals from metals-contaminanted environments, but there are no documented cases of wild reptiles dying from metals poisoning (e.g., Albers et al. 1986, Ohlendorf et al. 1988). The physiological and behavioral responses of reptiles to metals exposure have not been determined.

Oil spills

Spilled petroleum can kill adult reptiles. Various species of reptiles were killed by a spill of bunker C fuel oil in the St. Lawrence River (E.S. Smith, New York Department of Environmental Conservation, Albany, NY, unpublished report). Petroleum is often found in the mouth and on the external surface of sea turtles, leading to concerns about the effects of oil ingestion and surface fouling (Witham 1978, Hall et al. 1983). Mechanisms of toxicity for oil ingestion or external oiling have not been determined. Turtle embryos could die or develop abnormally when exposed to oiled nest substrate (T.H. Fritts and M.A.

McGehee, USFWS, Denver Wildlife Research Center, Denver, CO, unpublished report).

Population Impacts

An evaluation (1970-75) of the effects of 20 years (1949-69) of wildlife exposure to chemical warfare agents [anticholinesterase compounds (G-agents and VX), anticholinergic compounds (incapacitating agents, e.g., BZ), tissue destroying compounds (vesicants, e.g., mustard, nitrogen mustard, lewisite, phosgene oxime), lung irritants (phosgene, chlorine), oxidative metabolism inhibitors (blood agents, e.g., hydrogen cyanide and cyanogen chloride), irritants (riot control agents CS, DM, and CN), and screening and signaling smokes (FS, FM, and WP)] on Carroll Island in the upper Chesapeake Bay produced evidence of population effects for a reptile species. The population of the spotted turtle was 40% lower on the exposed than on the unexposed portion of the island and young animals (1-7 yrs old) were twice as abundant on the exposed portion as on the unexposed portion (Ward 1979). The latter finding indicates a growing population, presumably recovering from the effects of previous chemical tests. A box turtle population in the Patuxent River drainage was studied from 1945 to 1975. The population declined by more than 50%, mostly between 1965 and 1975. The reason for the decline is unknown but habitat change might have been a contributing factor (Stickel 1978).

AMPHIBIANS

Overall, there is insufficient information information on the current statur of amphibian populations, and very limited research or residue analysis collected regionally from which to assess either the actual or potential adverse effects from toxic substacnes on amphibians within the Chesapeake Bay. However, based on limited field data collected in other areas of the U.S., and in other countries, it is known that amphibians are sensitive to metals and organochlorine pesticides. The following section, therefore, represents research done outside of the Chesapeake Bay area.

Metals

Heavy metals are believed to be the most acutely toxic chemicals to amphibians as a group (Power et al. 1989). Green frogs, American bullfrogs, and toads collected on a relatively undisturbed wildlife refuge in Maryland were analyzed for metal residues. Adults accumulated high levels of copper, whereas tadpoles accumulated lead, zinc, copper, cobalt, cesium, strontium, iron, magnesium and, to a lesser extent, cadmium (Hall and Mulhern 1984).

Laboratory research substantiates uptake and concentration of low levels of cadmium from the environment, and increased antibody titers and synthesis of metallothionein, both of which may incur some protection from subsequent metal exposure (Woodall 1988; Zettergren et al. 1991). Metal induced responses to sublethal exposure include reduced fecundity (Kanamadi and Saidapur 1991), increased incidence of abnormal limb regeneration (Chang et al. 1976; Manson and O'Flaherty 1978), loss of equilibrium and erratic swimming (Khangarot and Ray 1987; Muino et al. 1990). Susceptibility of amphibians during embryonic development has been reported for copper, mercury, zinc (Birge et al. 1977), cadmium and lead (Dawson et al. 1988; Perez-Coll et al. 1988).

Bullfrog and green frog tadpoles collected from highway drainage ditches along the upper Coastal Plain contained lead levels up to 270 ppm. These elevated lead levels were positively correlated to sediment concentrations and average daily highway traffic volume (Birdsall et al. 1986). Lead interferes with normal

embryonic development (Perez-Coll et al. 1988) and may alter locomotor activity, learning acquisition and memory in the bullfrog and the green frog (Taylor et al. 1990).

What effects metals may have at the population level are not known. A reduction in the presence of 16 amphibian species near a zinc smelter in Pennsylvania (Beyer, 1988) may have been the result of an interaction between habitat disturbance and elevated concentrations of zinc and cadmium in the soil. Unfortunately, no amphibian residues were available.

Organochlorines

Residues of DDE, DDD, dieldrin and chlordane metabolites were detected in aquatic Neuse River waterdogs collected in North Carolina. Average residue levels were correlated to size of individual specimens and to geographic locations: specimens collected on the Coastal Plains were found to have higher levels of pesticide than those collected along the Piedmont Plateau (Hall et al. 1985). Chlorinated hydrocarbons cause extensive and debilitating tissue damage (Osborn et al. 1981) and result in a characteristic hyperactive behavior in the amphibians studied (Cooke 1970, 1972, 1973, 1979; Marchal-Segault and Ramade 1981; Juarez and Guzman 1984). Cyclodienes are toxic to amphibian eggs, tadpoles and subadults (Mulla 1963; Sanders 1970; Hall and Swineford 1980; Juarez and Guzman 1984).

PCB residues in the Neuse River waterdog were elevated throughout all regions in North Carolina where they were found (Hall et al. 1985). PCB exposure results in elevated post-hatch mortality in the leopard frog (*Rana pipiens*) and toads (Birge et al. 1978).

Anticholinesterases

Although amphibians show a stage-specific response to organophosphorus compounds (Mohanty-Hejmadi and Dutta 1981), they seem resistant to acute anticholinesterase inhibition (Wang and Murphy 1982). Laboratory studies screening for response to exposure to anticholinesterase agricultural chemicals predict low field mortality under current application rates (Edery and Schatzberg-Porath 1960; Mulla et al. 1963; Llamas et al. 1985). However, with the increased awareness due to concern for declining amphibian populations, tadpole die-offs observed in areas following agricultural spray applications are now being reported.

Herbicides

An early field study with atrazine (Hazelwood 1970) reported reproductive effects on a frog population. Laboratory studies conducted on anurans indicate a wide range of toxicity levels and responses, depending on test conditions, species (Linder et al. 1990), life stage (Jordan et al. 1977) and class of herbicides (Sanders 1970; Paulov 1977; Dial and Bauer 1984; Dial and Dial 1987; Linder et al. 1990). Although the LC 50 concentrations estimated by many of these studies exceed the field application rates, changes in behavior, impaired growth, and delayed development have been observed at levels far below application rates (Scorgie and Cooke 1979). Sensitivity of those amphibians tested indicates a response similar to some freshwater fish (Scorgie and Cooke 1979; Zaffaroni et al. 1986). Increased reliance on herbicides has caused growing concerns for the potential for dermal absorption among tadpoles and some adults, and for the overall persistence of herbicides concentrated in agricultural drainage ditches and wetland border vegetation and sediments (Linder et al. 1990). There are no data reported on herbicide effects specifically for Chesapeake Bay amphibians.

Other

Very little information is known on the sensitivity of amphibians to pyrethroid insecticides (Smith and Stratton 1986). Recent laboratory studies indicate these compounds may be toxic to anurans when present in low concentrations in the water (Jolly et al. 1978; Paulov 1990).

Aquatic anurans may be susceptible to exposure to low levels of oil and petroleum products. Responses include reduced survival and growth, increased incidence of deformities (Pyastolova and Danilova 1987), and behavioral abnormalities (McGrath and Alexander 1979).

Although no data have been collected along the Cheapeake Bay, reports from Poland indicate that amphibian populations in the field are experiencing extensive mortality among larvae exposed to high concentrations of nitrogen fertilizers (Berger 1989).

RESEARCH AND ASSESSMENT NEEDS

Birds

- o Develop a more complete list of toxic substances and concentrations in birds and their eggs as the first step in assessing direct effects of exposure to toxic substances on birds in the Chesapeake Bay basin.

- o When toxic substances are already known to occur at elevated levels in plants or animals eaten by birds, these substances should be measured in representative birds.

- o When new toxic substances are discovered at elevated levels, and information does not already exist on their toxicity to birds, laboratory and field research should be initiated.

  - In some cases, laboratory tests to determine tissue and egg residues associated with harm to health, survival, and reproduction may suffice.

  - In cases where residues appear to be in a dangerous range, field research should be conducted to relate residues to the reproductive success of one or more species that nest in the Chesapeake Bay basin.

- o The significance of lead derived through the food chain by canvasbacks and seaducks still needs continued study although lead poisoning in puddle ducks should decrease in the near future with the substitution of steel shot for lead shot.

- o Additional research is needed to determine the impact of the liquid formulation of carbofuran.

- o Wildlife mortality due to exposure to diazinon has continued at selected sites in the Chesapeake Bay basin even after its discontinued use on golf courses and sod farms. Investigations of urban and residential uses of diazinon in these areas should be conducted to determine whether these are contributing to its continued presence.

- o Research is needed to determine potential effects of high cadmium residues in seaducks on health and reproduction.

- o Additional field and laboratory research is needed to confirm the results of a laboratory reproductive study on Abate which showed an unidentified detrimental effect on ducklings or on maternal behavior.

- o Measurement of the effects of toxic substances on a growing colony of black-crowned night-herons nesting in the Patapsco River estuary should be undertaken (Erwin et al., in press). These herons feed in some of the most industrialized parts of the harbor. It would seem that if a fish-eating species of bird were going to be affected by exposure to toxic substances somewhere in the Chesapeake Bay, it might be these herons. Considerable nationwide research has already been conducted to determine how the black-crowned night-heron could be used in a monitoring program to measure contaminant levels and effects in estuarine systems.

- o Research into the construction of storm water retention ponds and other wetlands in urban areas and

the resultant build up of toxic substances in these small urban wetlands and potential impacts on wildlife should be conducted. These man-made wetlands are being used to prevent sediments and toxic substances from reaching the Chesapeake Bay (Adams et al. 1986). When properly designed, these wetlands attract many kinds of birds. The benefits of a reduction in toxic substances entering the Chesapeake Bay may be offset by an increase in toxic substances in many of these small, urban wetlands.

Mammals

- Research is needed to determine the potential for adverse impacts on mink populations due to exposure to and uptake of PCBs.

- Investigations are needed to determine the extent of mortality in mammals - especially species of fox-size and smaller - that result from primary or secondary poisoning by anti-cholinesterase pesticides. Evaluation of this problem would involve use of radiotelemetry so that all individuals of a sample can be recovered after each spray application, studying many spray events, and extrapolating the results over all of the appropriate agricultural acreage for a given chemical and crop.

Reptiles

- Basic research on the adverse effects on reptiles from exposure to and uptake of toxic substances within the Chesapeake Bay region is needed. Emphasis should be placed on cholinesterase-inhibiting pesticides and metals. Habitat modification caused by herbicides, fertilizers, and sewage effluents also merits evaluation for their potential to reduce reptile populations. Monitoring reptiles for population changes and contaminant burdens in areas of rapidly increasing human activity would focus the research effort on locations that offer the most potential for demonstrating the effects of these activities.

Amphibians

- Establish amphibian monitoring stations throughout the Chesapeake Bay regions. Field monitoring should include both aquatic and terrestrial searches. The information needed at this time includes basic ecology including habitat use and abundance.

- Conduct residue analyses on species collected from point source locations, following (or upstream and downstream from) a contaminant release. Standardized assays, such as FETAX (Frog Embryo Teratogenesis Assay - *Xenopus*) may be applicable in the future, but at this stage, information is needed on what the effects are on the more common and indigenous species in the field.

- Test amphibian response within a mesocosm, chronically exposing animals to contaminant mixtures and allowing the system to proceed over a complete cycle. Such a mesocosm may provide a more realistic test when dealing with species which remain in a contaminated area and which interact with this environment for a long segment of their life cycles.

- Record effects observed at sublethal as well as at lethal concentrations in all testing and monitoring of contaminant effects. Many of the chemical screening studies to date infer that unless levels higher than the recommended field application rates are applied, no mortality is predicted. However, responses

such as altered swimming behavior, impaired growth and development observed at contaminant concentrations far below lethal levels may be detrimental to the individual or population in the field.

FINDINGS AND CONCLUSIONS

Birds

Apart from isolated examples of possible continuing contaminant effects on individual species of birds, there is little evidence suggesting that toxic substances in the Chesapeake Bay are currently posing a serious hazard to birds, at least from direct toxicity. Monitoring of toxic substances in waterbirds should continue, especially in the most contaminated areas of the Bay. However, the direct impact of these pollutants on birds is probably less important than the indirect effects on habitat caused by excess nutrients, suspended sediments, and possibly herbicides. The loss of submerged aquatic vegetation in the Bay is perhaps the best example of an indirect effect of pollutants on waterfowl abundance and distribution.

Others have come to much the same conclusion. In a review of organochlorine pollutants and birds in the Chesapeake Bay, Ohlendorf (1981) advised, "In the Chesapeake Bay, attention should be focused on fish-eating birds, primarily bald eagles and ospreys, but it is unlikely that organochlorines will represent a serious threat to these species, or others of the Chesapeake Bay region". In another review paper, dealing with continuing organochlorine pesticide and PCB problems in the 1980's, Fleming et al. (1983) and others listed many potential problems across the United States, but none in the Chesapeake Bay.

Perry (1987) concluded, "Although some of the studies of pollutants in Chesapeake Bay waterfowl have shown some cause for concern, in general, pollutants in tissue and eggs of waterfowl are below levels normally considered to cause adverse effects. Monitoring of toxic substances in waterfowl should continue, especially in the most contaminated areas of the Bay, but the direct impact of these pollutants on birds is probably less important than the indirect effects on waterfowl habitat from pollutants such as nutrients, suspended sediments, and perhaps herbicides."

In the most recent review of contaminant effects on birds in the Chesapeake Bay, Ohlendorf and Fleming (1988) stated, "In the Chesapeake Bay high levels of cadmium and lead in seaducks, lead in dabbling ducks, and DDE in some ospreys and bald eagles are the current avian contaminant issues."

Although organochlorine pesticides and perhaps PCBs, affected birds in the Chesapeake Bay in the past, there is little evidence indicating they are still causing great harm. Certain metals, such as lead and cadmium, may be a problem for canvasbacks and other ducks, but more research on effects is needed. A search for other toxic substances, such as selenium and industrial pollutants, is warranted in birds. The most harmful effects may be indirect ones on food supplies, such as the reduction in submerged aquatic vegetation. Research on contaminant effects on avian foods should guide and accompany efforts to mange restoration of birds within the Chesapeake Bay basin.

Mammals

Existing data from the published studies do not indicate any adverse impact of toxic substances on Chesapeake Bay mammal populations or communities. However, these data were not collected with this objective in mind, and there has been no study directed at answering related questions. There appear to be at least two areas of concern: the potential for adverse impacts on mink populations due to exposure to

PCBs; and mortality of mammals--especially species of fox-size and smaller--that results from primary or secondary poisoning by anti-cholinesterase agricultural chemicals.

Reptiles

Information on the effects of toxic substances on reptiles found in the Chesapeake Bay basin is limited to the knowledge that reptiles were frequently killed by organochlorine pesticide applications during the 1950s, 1960s, and early 1970s; the effects of other toxic substances on Bay reptiles are mostly unknown. Inferences must be drawn from observations and studies performed elsewhere on the same or other reptiles. Existing data on the effects of toxic substances on reptile populations are too limited to draw any conclusions about effects on current Bay basin reptile populations. Information on the effects of cholinesterase-inhibiting pesticides and metals, and population trends of key species, are needed to improve our understanding of the effects of environmental contaminantion on reptiles of the Bay watershed.

Amphibians

Very little is known on the current status of amphibian populations from which to assess either the actual or potential adverse effects from toxic substances on amphibians within the Chesapeake Bay. Residue analyses obtained from species inhabiting the Chesapeake Bay Basin indicate that amphibians do accumulate metals, organochlorines and PCBs. Although amphibians may appear resistant to many chemicals at levels known to be lethal to other vertebrates, changes in amphibian behavior and early development may in fact be more sensitive indicators of contaminant effects.

APPENDIX A

Chesapeake Bay Program Toxics Subcommittee
CHESAPEAKE BAY WILDLIFE CONTAMINATION
CRITICAL ISSUE FORUM SUMMARY

Annapolis, Maryland
November 15, 1991

Welcome and Introductions

Ray Fritz welcomed the forum participants. He explained that this forum is one of a series of forums the Chesapeake Bay Program will be holding to assess the status and magnitude of existing and potential Bay toxics issues. He mentioned that the wildlife contamination critical issue forum was being sponsored by the U.S. Fish and Wildlife Service and the Chesapeake/Potomac Regional Chapter of the Society of Environmental Toxicology and Chemistry on behalf of the Chesapeake Bay Program Toxics Subcommittee.

Critical Issue Forum Objectives

Rich Batiuk briefly described the objectives of the wildlife contamination critical issue forum as:

- Assessing existing research and monitoring data on wildlife contamination in the Bay area;
- Determining whether this data indicate existing or potential toxic impacts to the Bay ecosystem;
- If so, then identify the next steps needed to define the magnitude and extent of the toxic impact(s);
- If not, then identify the type of information needed to make this assessment; or,
- Determine that there is no present toxic contamination problem.

A single Status and Assessment of Chesapeake Bay Wildlife Contamination Paper will be produced and reviewed by forum participants and the Chesapeake Bay Program's Scientific and Technical Advisory Committee. The final status and assessment paper will be presented to the Toxic Subcommittee for integration into the 1992 reevaluation of the Basinwide Toxics Reduction Strategy.

Presentation of the Status and Assessment of Chesapeake Bay Bird Contamination Paper

Gary Heinz and Stanley Wiemeyer presented their findings from their review of available literature on contamination of Chesapeake Bay waterfowl, raptors and wading birds. Generally, birds are susceptible to a wide range of contamination due to their vast feeding habits and also their migratory nature which also makes it difficult to assess or isolate toxic effects on a local level.

Historic contaminant problems have been identified with certain organochlorine pesticides such as dieldrin, kepone and DDE, a metabolite of DDT which have caused mortality of adult birds and impaired reproduction. Lead poisoning from ingestion of lead shot has reduced survival as well. With the banning of these pesticides and lead shot, observed toxic effects have significantly decreased or are no longer observed.

Recent, isolated examples of direct toxic impacts of contaminants on individual species of birds have been recorded. These include:

- o bald eagle deaths caused by consumption of illegally poisoned baits and terrestrial animals which had ingested carbofuran;
- o diazinon consumption effects on mallards, doves and robins in Virginia urban areas;
- o elevated DDE tissue concentrations in peregrine falcons and bobwhite quail; and
- o bird botulism from feeding from stormwater containment ponds.

Other major classes of contaminants of concern are oils, organophosphorus and carbamate pesticides, herbicides, and polynuclear aromatic hydrocarbons (PAHs).

Laboratory results can be invaluable in identifying potential toxic concentrations of pollutants. This work is essential to developing a more complete list of the wide range of contaminants to which birds may be exposed. Additional field and laboratory research is needed to confirm initial findings of toxic impact levels from exposure to individual chemicals or ambient concentrations of contaminants in water, sediments and prey species. Research and assessment needs identified included:

- o further studies to determine the significance of elevated tissue levels lead, cadmium and selenium;
- o additional research on Abate (an organophosphorus pesticide used for mosquito control in marshes) exhibiting reproductive impairment on adult mallards and ducklings upon consumption;
- o industrial contaminant concentration effects on black-crowned night herons in the Patapsco River estuary;
- o effects from the concentration of toxic substances in storm water retention ponds and other urban wetland areas on the wildlife species, especially birds; and,
- o when new toxic substances or persistent degradation products are discovered at elevated levels, and information does not exist on their toxicity to birds, then laboratory and field research should be initiated to determine body burden levels and whether existing population concentrations are approaching these effect levels.

On a regional scale, the direct impacts of toxic substances on birds is probably less important than the indirect effects on habitat caused by excess nutrients, suspended sediment, and possibly herbicides (i.e. the loss of submerged aquatic vegetation).

Presentations by Other Wildlife Contaminant Review Papers

Reptiles

Pete Albers presented his findings from a search of published literature on effects toxic substances on reptiles in the Chesapeake Bay basin. In general, toxic effects on reptiles and population sizes and trends are not well known. Thirty-four species of reptiles were identified in Maryland and the District of Columbia in 1945; nearly all occur in the Bay basin. Additional species probably occur in the Susquehanna River basin in Pennsylvania and in northeastern Virginia. A local box turtle population in the Patuxent River basin declined more than 50% from 1965 to 1975. The cause of this decrease is unknown but habitat change might have been a contributing factor.

Organochlorine pesticides, used extensively in the 1950s through the early 1970s, caused the death of many reptiles throughout the United States. Organophosphate pesticides had effects on reptiles that were more similar to birds and mammals than amphibians and fish. Petroleum can kill adult reptiles but the mechanism of death is unknown. Discarded plastic debris has become a serious menace for marine turtles because of ingestion of plastic objects and entanglement in fishing gear and plastic rings.

Several species of turtles have been found to be tolerant of highly polluted habitats; high levels of metals, PCBs, dioxins, and furans were accumulated. However, Carroll Island, an island in the upper Chesapeake Bay used for testing chemical warfare agents for 20 years, suffered a 40% reduction in the spotted turtle population on the exposed portion of the island. The presence of a high proportion of young turtles several years after testing ceased indicated that the population was recovering.

Research and assessment needs identified include:

- o information on the effects of cholinesterase-inhibiting pesticides and metals, including dose-response data;
- o effects on reptile populations of habitat modifications caused by herbicides, fertilizers, and sewage effluents; and
- o population studies of key species in areas of rapidly increasing human activity.

Amphibians

Paula Henry presented her findings on the contamination effects on amphibians in the Chesapeake Bay basin. There is virtually no information to assess whether amphibian populations are being affected by contaminants in the Bay basin. Unless a species is classified as endangered or threatened, there are no official counts or monitoring programs for baseline population data. No residue analyses have been conducted in contaminated areas in the Bay basin. Unlike the high visibility some wildlife populations have, amphibian 'die-offs' may not be noticed due to rapid predation.

An extensive study in 1975 identified thirty-two of the 40 Maryland amphibian species in the Bay basin. These species reside in a variety of moist or wet conditions during their life history.

The varying life stages of amphibians (egg-embryo-larvae-adult) make it difficult to determine uniform responses of a species to a given chemical. Heavy metals are among the most toxic of chemicals. Limited data indicate that even at low concentrations, metal bioaccumulation should be of concern because they not only causes abnormal development of the affected amphibian, but also because they may accumulate to levels lethal to higher food chain organisms. The high fat content of early life stages predisposes amphibians to bioaccumulation of persistent chemicals, resulting in some cases in mortality at metamorphosis. Chlorinated hydrocarbons have exhibited hyperactivity and debilitating tissue damage in amphibians. The extensive use of DDT in the 1950s almost lead to the elimination of adult frogs in certain areas, and similar results have been observed with tadpoles from dieldrin exposure. Recent concern has focused on the effects of herbicide absorption through the skin of amphibians from agricultural spray drift exposure.

Presently, there is not sufficient data to determine the sensitivity of amphibians to ambient levels of toxic substance in the Chesapeake Bay basin. Research and assessment recommendations include:

- o establish monitoring stations throughout the Bay basin to assess habitat use, abundance and community structures;
- o conduct residue analyses on species at selected sites to assess effects from point source locations (amphibians are limited geographically); and,
- o conduct chronic exposure studies to assess complete life stage toxic effects due to ambient mixtures of chemicals.

Mammals

Harry Coulombe discussed the paper summarizing the effects of environmental contaminants on mammals in the Chesapeake Bay basin authored by Donald Clark. Available mammalian toxicity data do not indicate any major impact of chemicals on Bay mammal populations or communities. However, mink have been identified as being highly sensitive to PCBs and dioxin, and there is concern over the elevated levels of PCBs being detected in mink livers in Maryland. Reduced body and spleen weights have been recorded in muskrats from the Elizabeth River. Agricultural applications of organophosphorus and carbamate pesticides (carbofuran, parathion, famphur, malathion, or another unidentified avicide have been responsible for the death of twenty-one mammals between 1983-89. Actual total deaths due to these pesticides are believed to be orders of magnitude higher when less visible, smaller mammal species are considered.

In the past, very little research has been directed to answer the contaminant exposure questions that are now beginning to be asked. Unfortunately, no fish eating carnivores were studied to determine the effect of the kepone contamination of the James River. Future research should be designed to assess community toxic effects from exposure to ambient concentrations of toxic substances. Specific recommendations include:

- o investigating the extent to which PCB exposure has effected mink populations; and,
- o determine the community effects from primary or secondary poisoning by anti-cholinesterase (organophosphorus and carbamate) agricultural chemicals.

Forum Summary and Follow-up

Ray Fritz and Rich Batiuk summarized the major discussions from the forum. They described followup to the forum as consolidating the four wildlife contamination papers into a single status and assessment paper, preparing a written summary of the critical issue forum and presenting both documents to the Toxics Subcommittee for approval and publication as Chesapeake Bay Program documents.

Chesapeake Bay Program Toxics Subcommittee
Chesapeake Bay Wildlife Contamination
Critical Issue Forum
Annapolis, Maryland
November 15, 1991

List of Participants

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Nancy Rybitski	Virginia Institute of Marine Sciences
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3175
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