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Proceedings of the Expert Consultation Meeting on Mink and Otter, Windsor, Ontario, March 5 and 6, 1991

Great Lakes Science Advisory Board. Ecological Committee

Canada. Department of the Environment

Ontario. Ministry of Natural Resources

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Sponsored by Environment Canada and Ontario Ministry of Natural Resources

Proceedings of the Expert Consultation Meeting on Mink and Otter

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Great Lakes Science Advisory Board's Ecological Committee
Report to the International Joint Commission

Proceedings of the Expert Consultation Meeting on Mink and Otter

Edited by

Ed M. Addison
Glen A. Fox
Michael Gilbertson

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Acknowledgements

The sponsors of this workshop are grateful to acknowledge Chris Wren, Irene O'Connell, Steve Driker and Myrna Reid for having organized the workshop and having made it an enjoyable experience for all; to Chris Mason for his wit, critical assessment and for extending to us the benefit of his experience; to all the other participants for their enthusiasm and to R. Groleau and M.R. Lacroix who typed this document, and Bruce Jamieson for graphic design.

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1.0 Summary

On March 5 and 6, 1991, the Biological Effects Subcommittee of the International Joint Commission, the Canadian Wildlife Service and the Ontario Ministry of Natural Resources co-hosted a roundtable on mink *(Mustella vison)* and river otter *(Lutra canadensis)*. The objectives of the workshop were (1) to consolidate existing information on the status of mink and otter in the Great Lakes basin, (2) to identify factors that affect their populations, with a focus on the role of persistent toxic substances in reproductive impairment (3) to assess the usefulness of mink and otter as biological indicators of ecosystem health in the Great Lakes basin, particularly in the shoreline wetlands and (4) to assess the usefulness of mink and otter as reliable indicators of improvement in the water quality of the Great Lakes.

Mink and otter were discussed as possible biological indicators because of their position in the food web, and in the case of mink, their known extreme sensitivity to PCBs and related toxic substances. As consumers of fish and other aquatic prey, these two mammals are subject to high levels of environmental contaminants, which bioconcentrate up aquatic food chains.

1.1 Background

Mink occupy a wide variety of freshwater wetland habitats, where their numbers reflect the abundance of permanent wetlands with ample shorelines and emergent vegetation. Such habitats are also important for muskrats, whose bank burrows provide denning sites for mink and whose abundance can provide an index of habitat suitability. Mink are generalists and prey on locally-available food sources, including fish, amphibians, waterfowl and muskrat. The river otter is able to adapt to diverse aquatic habitats but prefers areas of riparian vegetation adjacent to rivers, streams, lakes and other wetland areas. Beaver create foraging and denning sites for otter. Unlike the mink, the river otter is a specialist, feeding almost entirely on aquatic prey, primarily fish.

As early as 1965, it was shown that diets containing fish from Lake Michigan were causing reproductive failure in ranch mink. It was later shown that this situation was attributable to PCBs, rather than rancidity, mercury or DDT and other chlorinated hydrocarbon insecticides. Numerous toxicological studies have since shown the ranch mink to be the most sensitive mammalian species to PCBs, PBBs, HCB and TCDD. Since fish and other aquatic prey in Great Lakes wetlands are contaminated with these chemicals, mink that live in shoreline habitats may be exposed to toxicologically-significant amounts of PCBs.

1.2 Data on changes in numbers and distribution

If PCBs and related toxic substances are present in the food web of wild mink and have affected their survival and/or reproduction, we would expect to see changes in mink populations where the risk of exposure to these substances is high. If wild mink populations have been affected by environmental contaminants, and if the closely-related otter has a similar sensitivity and exposure to contaminated foods, it is likely that river otter populations have also been affected.

The only available measure of the relative abundance of mink and otter are the harvest statistics. However, these data are potentially confounded by several variables including demand, fur prices, weather, and trapping experience, methods and effort. In addition, harvest statistics usually do not provide good geographical resolution and therefore do not allow for the evaluation of population trends in those areas with the highest risk of contaminant exposure, which are the shorelines of the Great Lakes and their tributaries. Detailed harvest records have been kept for fur bearers on the Upper Mississippi River National Wildlife Refuge in Wisconsin from 1939 to 1988. Mink numbers were patterned differently than were muskrat, beaver and racoon, declining steeply between 1959 and 1968 and have now recovered to less than half their earlier numbers while muskrat and racoon numbers are relatively high. The continued trapping of mink at very low population levels by relatively high numbers of trappers did not prevent a slow but distinct population recovery. This extensive data set suggests that the decline in mink harvest was not related to fur price or habitat quality. In Ohio, where mink harvests were monitored for each county from 1981 to 1986, the harvest was substantially lower in the counties bordering Lake Erie than in the adjacent counties remote from Lake Erie. A trapper survey conducted in Wisconsin in 1990 suggested that traps set more than one mile from Green Bay were twice as likely to catch mink as were those set along the Green Bay and Fox River shoreline and that trapping success on these shorelines was the lowest of any area surveyed in the state.

The Ontario mink harvest began to decline in the mid-1950s and was lowest in the early 1970s, recovering somewhat in the 1980s. This temporal trend is remarkably similar to that seen in populations of several fish-eating and predatory birds. Although the muskrat harvest was also depressed during this period, the depression was less severe. A similar trend was seen in Wisconsin but not in Ohio. A recent study of Ontario mink and muskrat harvests from 1970 to 1984 suggested that where the risk of PCB exposure was known to be high, significantly fewer mink were harvested than in areas where the risk of PCB exposure was known to be low. In contrast, the high risk areas did not necessarily have lower muskrat harvests. However, the harvest records would only allow these designated areas to be resolved at the level of townships. There was no discrimination among some low risk and high risk habitats.

In general, inland tributaries which support healthy otter populations become relatively devoid of otter as they approach Lake Michigan. There have been no otter harvested along the entire Lake Michigan shorelines of Wisconsin and Michigan, including Green Bay, the Saginaw Bay region of Lake Huron, and much of the Lake Superior shorelines of Michigan and Minnesota. In a recent three-year study in New York state, biologists were unable to find otter along the Lake Ontario shoreline.

1.3 Disease and environmental factors

There are a number of biological factors which may influence the distribution and abundance of mink and otter in the Great Lakes basin. These include the quantity and quality of habitat, parasites and disease. Diseases such as canine distemper and infestation with the giant kidney worm may, alone or in concert with habitat constraints and/or environmental contaminants, affect the survival of these species. Mink are very susceptible to botulism. There is experimental evidence that suggests that cold temperatures, in combination with chemical contaminants, increase mortality.

1.4 The role of toxic substances

Burdens of PCBs in most mink collected from Great Lakes shorelines are sufficient to induce adverse effects on reproduction in ranch mink. PCB levels in mink from New York state were significantly correlated with concentrations in fish on a restricted geographic scale. The presence of mirex, photomirex and high concentrations of PCBs in mink captured along tributaries of Lake Ontario suggests that spawning fish transport biologically-significant amounts of these contaminants upstream.

In two studies where PCB burdens of mink and otter caught in the same regions were compared, the burdens in otter exceeded those in mink. Similarly, in four studies comparing mercury burdens in mink and otter caught in the same regions, the burdens of otter generally exceeded those of mink. These data are consistent with the larger proportion of fish and other aquatic prey in the diet of otter. PCB levels of otter captured in New York were correlated with concentrations in fish on a restricted geographic scale. Because there have been no controlled studies of the effects of PCBs on otter, it is not possible to determine the levels of contaminants in food or tissues that are associated with adverse effects. Current evaluations are based on those for ranch mink, assuming equal sensitivity.

Although the introduction of the pesticide, dieldrin, coincided with the decline of the otter population in Britain, there are a number of lines of evidence that suggest PCBs are a more likely cause. On reviewing water pollution studies and the distribution of otter in Europe, Dr. Christopher Mason has concluded that "the evidence from these studies strongly implicates the role of PCBs in the decline of otter populations."

1.5 Conclusions and research needs

The purpose of the Great Lakes Water Quality Agreement is to restore and maintain the integrity of the waters of the basin ecosystem. The Agreement states that the "discharge of any or all persistent toxic substances be virtually eliminated." One operational approach to defining "virtual elimination" is to develop indicators of the absence of toxicity in very sensitive species representing the diversity of ecosystems within the basin. The mink is the freeliving mammal most sensitive to toxic substances such as PCBs and TCDD and its diet provides an integrated exposure to contaminants in shoreline wetlands. The chemical sensitivity of the otter is unconfirmed, but its largely piscivorous diet is more directly reflective of the nearshore aquatic environment. Thriving populations of mink and otter could serve as biological indicators of the health of shoreline wetlands of the Great Lakes basin and of success in achieving the "virtual eliminat ion" of persistent toxic substances from these systems. However, their utility for this purpose may be limited by a variety of potentially-confounding biotic and abiotic factors.

The participants concluded, however, that before a reliable operational biomonitoring program using mink and otter could be developed and employed, further research would be needed. There was a strong consensus that, at the present time, resources allocated for this purpose should be oriented toward research on mink, and that efforts should be focused on those populations inhabiting the shorelines of the Great Lakes and their tributaries. Toward these goals, research in the following areas would be needed to fill the gaps in knowledge:

- Development of field survey techniques useful for the assessment of distribution, abundance and reproductive health of these species, and the validation of contaminant contents of scats as a non-destructive measure of contaminant burden in free-ranging mink
- The distribution and abundance of mink (and otter) along Great Lakes shorelines and the age structure of these populations
- The distribution of suitable mink (and otter) habitat in the Great Lakes basin, past and present
- The relationship between habitat quality and population and harvest data;
- The incidence and effects of disease and parasites in mink (and otter) populations in the basin
- The constituents of an typical diet for mink (and otter) inhabiting Great Lakes shorelines
- Whether the physiological and pathological responses of ranch mink are equivalent to those in wild mink, especially as they relate to reproduction, and the sensitivity of otter, relative to mink, to PCBs and related chemicals
- The physiological and biochemical responses of these species to chemical stressors, which could be measured in free-living mink and otter, as indicators of the restoration of the integrity of the waters of the Great Lakes Basin Ecosystem.

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2.0 Abstracts of Presentations

2.1 Overview of the Biology, Population Status and Sensitivity to Chemicals of Mink and Otter

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Following outbreaks of reproductive failure on commercial mink ranches utilizing Great Lakes fish as feed, laboratory toxicology experiments showed that mink are particularly susceptible to organochlorine chemicals, especially PCBs and dioxins. There are indications that wild mink and otter populations have been adversely affected by the presence of chemical contaminants in the Great Lakes. This discovery has led to suggestions to utilize mink and otter as biological monitors of Great Lakes water quality.

Mink are opportunistic feeders, that will feed upon prey in proportion to availability and susceptibility to predation. Common prey groups include fish, amphibians, crustaceans, small mammals and birds. As an opportunistic feeder, a mink may derive only a portion of its diet from aquatic food items. Further work is required to assess accurately the food habits of mink in the Great Lakes basin to determine their actual exposure to contaminants.

Otters are primarily piscivores, with at least 90% of their food being composed of fish. Fish species will be consumed in direct proportion to their availability and vulnerability.

Evidence is presented from harvest data regarding the population status of mink and otters in certain locations around the Great Lakes. There are several factors that limit the value of harvest data such as habitat quantity and quality. Data on the mink harvest in Ohio are reported on a county basis. A comparison of trapping returns between 1982 and 1987 of mink taken from more highly-contaminated counties bordering Lake Erie were consistently lower (380 animals per year) than those from counties removed from Lake Erie (850 animals per year). Harvest data on mink in all of Ontario show an overall decline during the past four decades. In contrast, the overall harvest of otter has steadily increased. Information collected by the Ontario Ministry of Natural Resources suggests that harvest levels of mink are lower along the shores of Lake Ontario where animals are potentially exposed to chemicals than they are in inland or "non-exposed" areas. Evidence was also presented on the harvest data for otters taken from four New York state counties adjacent to Lake Ontario. The harvest data from these counties taken between 1959 and 1988 show that between 1960 and early 1970, the number remained stable but has since increased. This increase is consistent with improved water quality in Lake Ontario during the past 15 years.

The harvest studies in Ohio, New York and Ontario have not been thoroughly evaluated and comparison of habitat quality among proposed "chemically exposed" and "non-exposed" animal populations. In addition to habitat, harvest levels are subject to a variety of influences, such as trapper effort, pelt price and natural population fluctuations, that are quite distinct from the effects of chemicals.

Extensive laboratory experiments have demonstrated that mink are affected by concentrations of chemicals frequently encountered in Great Lakes fish. If wild mink were feeding extensively on such contaminated fish there is little question that reproductive performance, and ultimately population numbers would be affected.

However, prior to utilizing mink or otters as biological indicators of Great Lakes water quality, a substantial amount of basic research pertaining to habitat, food habits and population status must be undertaken.

2.2 Fur Trapping Records from the Upper Mississippi River Wildlife and Fish Refuge, 1939 - 1988

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Office of Refuge Biology, La Crosse Wisconsin

Fur harvest records of the Upper Mississippi River National Wildlife and Fish Refuge (UMRNWFR) 1939 and 1988 were studied to determine factors affecting furbearers. The average catch per trapper provided an index to population size for the muskrat *(Ondatra zibethica)*, beaver *(Castor canadensis)*, raccoon *(Procyon lotor)* and mink *(Mustela vison)*. Populations of each of these species seemed not to be affected adversely by trapping. Average catch per trapper (A), average price (B), total trappers (C), total caught (D) and dollar value (E) were analyzed by linear and partial correlations for muskrats (nearly all trappers caught muskrat). Seven of the ten sets (A to E) were correlated ($\underline{P}<0.05$), but A-B, A-E and B-D were not. With partial correlations the strongest associations were B-E, A-D, A-C (negative), and C-D. The higher the number of trappers, the fewer muskrats each caught; this finding implies competition which could be controlled by management. During the latter half of the 1939-88 period, trapper numbers were higher than earlier, thus muskrat population indices may actually have been conservative then. Total muskrats caught was most strongly associated with total trappers and average catch per trapper (population size). Muskrat fur price was linked to trapper numbers in linear correlation, but only weakly and negatively associated with total trapper numbers in partial correlations. Value (total dollars) of the muskrat harvest was controlled chiefly by price and secondarily by numbers caught. The average number of trappers was 1,061 annually. The average trapper annually caught 103 muskrats, 1.7 beavers, 0.9 mink and 1.0 raccoon, benefiting by $260/season from 1939 to 1988 (>$12 million total).

Mink numbers were patterned differently than the other furbearers; mink declined steeply during the 10-year period 1959-68, probably because of river pollution (Figure 1). Currently, mink have recovered to less than half of earlier levels, while muskrat, beaver and raccoon populations are relatively high in population size. There is no indication that trapping has adversely affected numbers of any of these furbearers; continued trapping of mink at very low population levels by relatively high numbers of trappers did not prevent a slow but distinct population recovery. UMRNWFR fur harvest is a substantial part of that in four bordering states, indicating that refuge habitats are highly productive. There is no reason to think that mink habitats have deteriorated seriously, but some island erosion and sedimentation in backwaters is occurring.

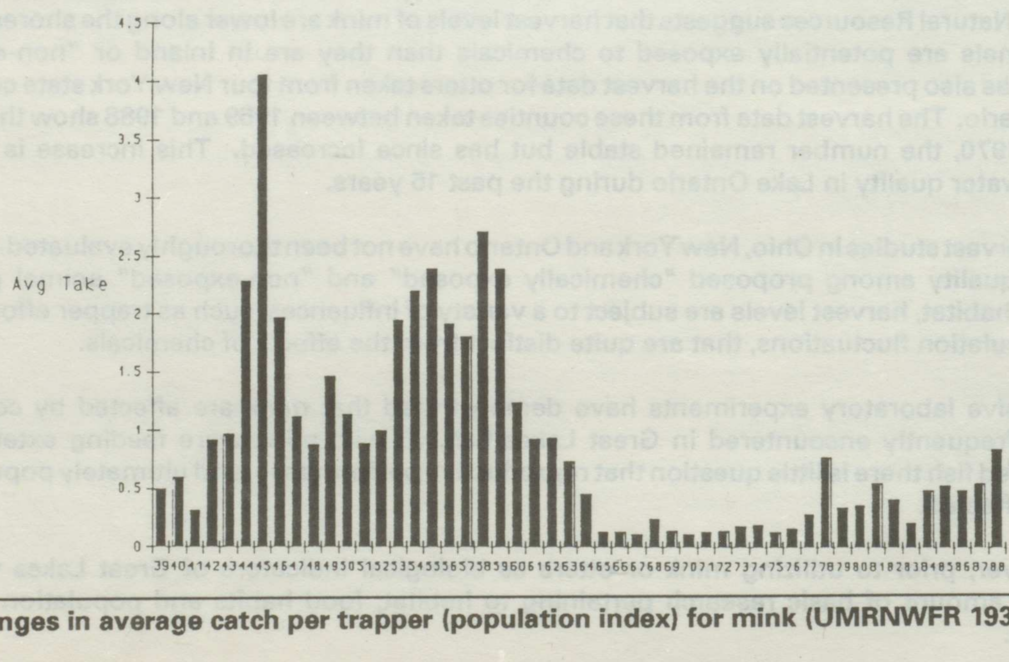

FIGURE 1. Changes in average catch per trapper (population index) for mink (UMRNWFR 1939-1988)

In an effort to explain the mink decline, data were sought from the Departments of Natural Resources in states adjoining the UMRNWFR. Although the Minnesota mink harvest cannot be statistically distinguished from that of the UMRNWFR during the period of decline, Iowa and Wisconsin populations did not decline 1959-68 (Figure 2). Mink carcasses from the Mississippi River and from upland situations in Minnesota were collected for analysis of heavy metals and PCBs; this study is being conducted under the direction of Keren Ensor, Minnesota Pollution Control Agency. Analyses are incomplete at this time, but preliminary data support our supposition that the mink decline was caused by river pollution.

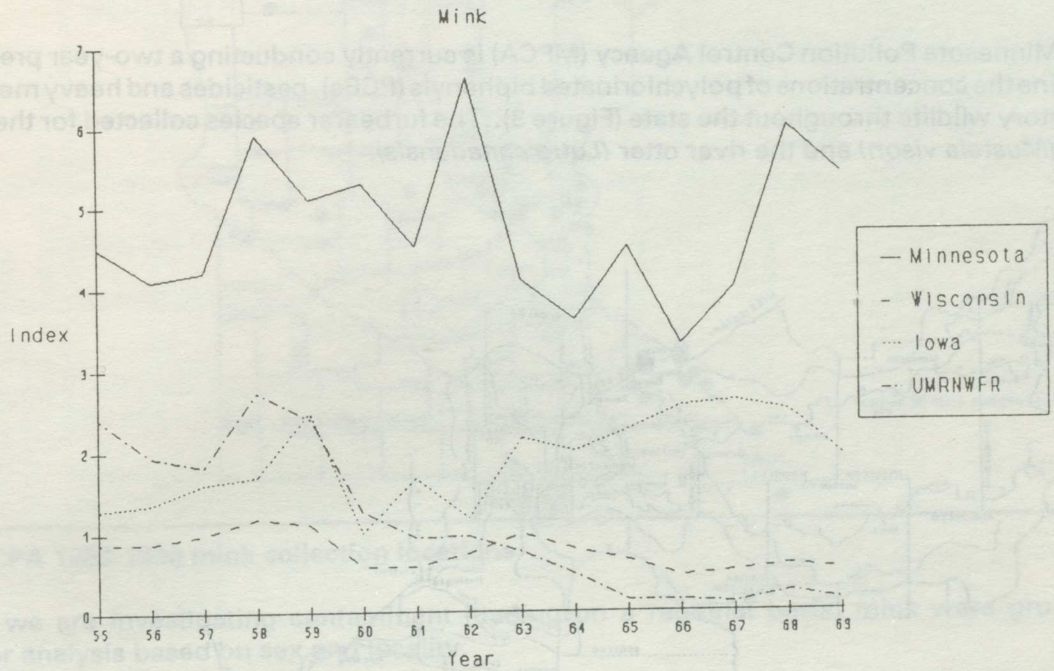

FIGURE 2. Trends in mink population indices for three states adjoining UMRNWFR, 1955-1969

2.3 Minnesota Pollution Control Agency, 1989 - 1991 "Contaminants in Minnesota Wildlife" Study

Keren E. Ensor
Minnesota Pollution Control Agency
Water Quality Division, Assessment and Planning, St. Paul, Minnesota

The Minnesota Pollution Control Agency (MPCA) is currently conducting a two-year preliminary study to determine the concentrations of polychlorinated biphenyls (PCBs), pesticides and heavy metals in resident and migratory wildlife throughout the state (Figure 3). The furbearer species collected for the study include the mink *(Mustela vison)* and the river otter *(Lutra canadensis)*.

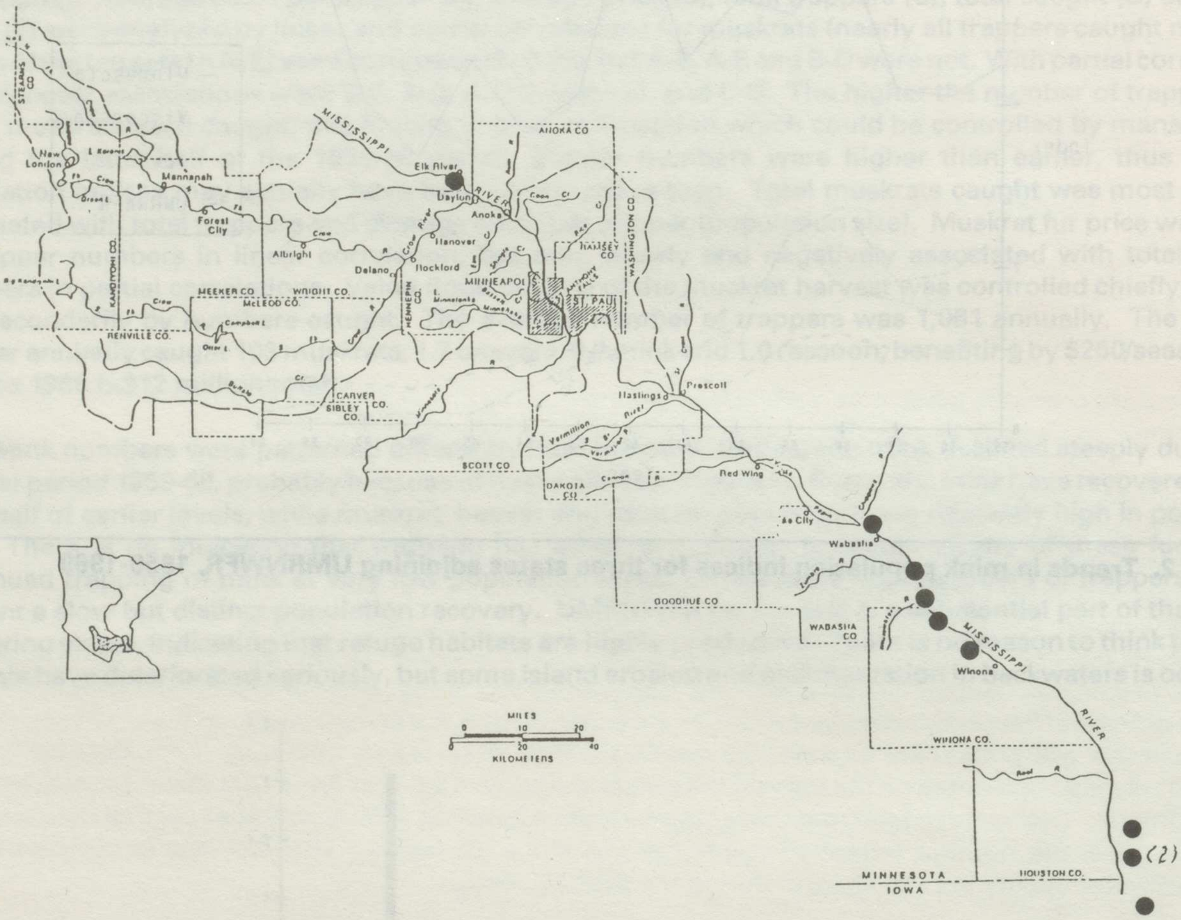

FIGURE 3. Map of upper Mississippi River study area

Mink carcasses were collected throughout the state by Minnesota trappers during the 1989-1990 trapping season (Figure 4). River otter collections were limited to the northeast regions of the state (based on Minnesota Department of Natural Resources trapping regulations). Composites of river otter for the study will be limited (4-5 composites) due to the minimum number of otters trapped by participating trappers. Otter concentrations will not be addressed here since composite analytical results have not yet been reported.

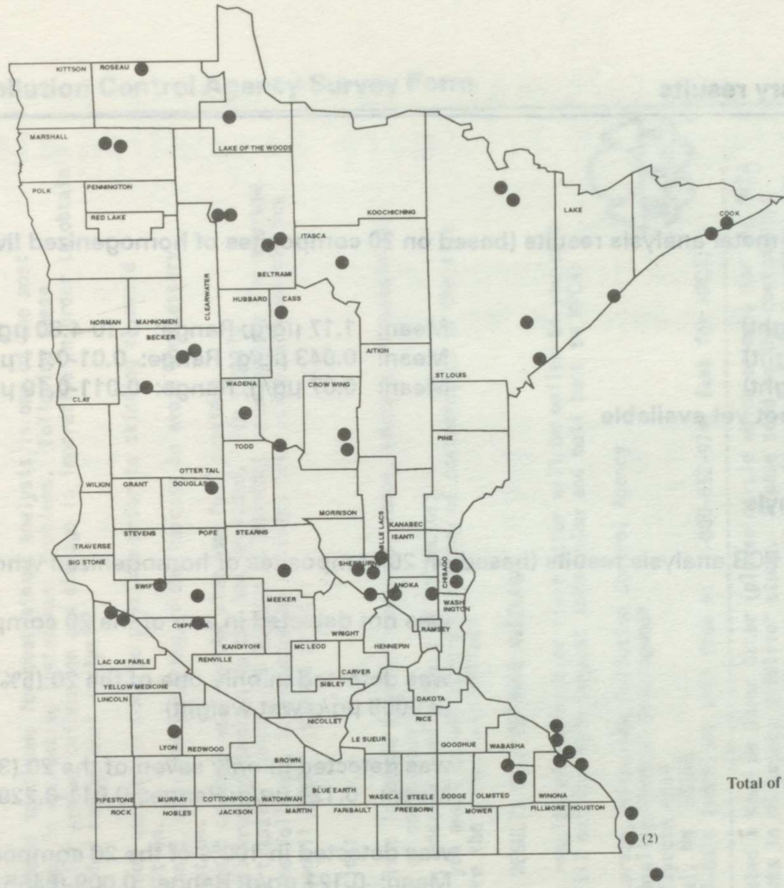

FIGURE 4. MCPA 1989-1990 mink collection locations

Because we are investigating contaminant loading on a regional basis, mink were grouped into composites for analysis based on sex and locality.

TABLE 1. Contaminants analyzed, tissues analyzed method of analyses, detection limits

1. **Metals - analyzed composites of homogenated livers**

Method of Analysis and Detection Limit:

Mercury (Hg):	cold vapor AAS (0.01 ppm)
Selenium (Se):	volatile hydride generation with AAS (0.01 ppm)
Arsenic (As):	volatile hydride generation with AAS (0.01 ppm)
Lead (Pb):	nonflame AAS with graphite furnace (0.01 ppm)
Cadmium (Cd):	nonflame AAS with graphite furnace (0.05 ppm)
Chromium (Cr):	nonflame AAS with graphite furnace (0.05 ppm)

2. **PCBs - analyzed composites of homogenated whole carcasses**

PCB analysis for liver homogenates was not possible due to analytical work being performed at two different laboratories: one for metals, one for PCBs and organochlorines (OCs). Limitations in liver volume did not allow enough sample material for both metals and PCB analyses.

Method of Analysis and Detection Limit:
EPA "Comstar" method (Burkhard and Weiniger, 1987) (5-10 ppb)

3. **Organochlorine pesticides - analyzed composites of homogenized whole carcasses**

DDT and metabolites, chlordane and metabolites, dieldrin, aldrin, endrin, hexachlorobenzene, heptachlor epoxide, gamma and alpha BHC (5-10 ppb)

TABLE 2. Preliminary results

Metals

Preliminary mink metal analysis results (based on 20 composites of homogenized liver) (see Figure 3):

Total	
Hg (µg/g wet weight)	Mean: 1.17 µg/g; Range: 0.10-4.80 µg/g
Pb (µg/g wet weight)	Mean: 0.043 µg/g; Range: 0.01-0.11 µg/g
Cd (µg/g wet weight)	Mean: 0.07 µg/g; Range: 0.011-0.19 µg/g

Note: As, Se, Cr not yet available

Polychlorinated Biphenyls

Preliminary mink PCB analysis results (based on 20 composites of homogenized whole carcasses):

Aroclor 1242	was not detected in any of the 20 composites
Aroclor 1248	was detected in only one of the 20 (5%) composites; (0.0005 µg/g wet weight)
Aroclor 1254	was detected in only seven of the 20 (35%) composites; Mean: 0.121 µg/g; Range: 0.011-0.229 µg/g
Aroclor 1260	was detected in 100% of the 20 composites; Mean: 0.121 µg/g; Range: 0.009-0.455 µg/g
Total PCBs (µg/g wet weight)	Mean: 0.151 µg/g; Range: 0.009-0.455 µg/g
Total PCBs (µg/g lipid weight)	Mean: 1.986 µg/g; Range: 0.13-6.78 µg/g

Upper Mississippi River PCB results:

The Upper Mississippi River is known for PCB contamination based on surface water, bottom sediment sampling, and fish flesh sampling. In addition, PCBs have settled out and accumulated in the bottom sediments of Spring Lake and Lake Pepin (see map). Therefore, concern over the possible effects of PCBs on the mink population in the Upper Mississippi basin led to an intensive mink collection along the river directly above the Twin Cities and along the river below the Twin Cities (approximately river mile 850 to 679) for the MPCA wildlife contaminant study. Ten mink composites (n=32 individuals) were obtained during the 1989 trapping season. An additional four 1990 Mississippi River mink composites are currently being analyzed. The preliminary total PCB results of the 1989 Mississippi River mink composites (again, analyzed whole homogenized carcasses) are as follows:

Total PCBs (µg/g wet weight)	Mean: 0.182 µg/g; Range: 0.026-0.455 µg/g
Total PCBs (µg/g lipid weight)	Mean: 2.624 µg/g; Range: 0.33-6.78 µg/g

These values represent the highest PCB concentrations found in the initial 1989 statewide mink contaminant results.

Organochlorine (OC) pesticides	OC pesticides analytical results are not available at this time.

A final report will be available in January 1991. If you are interested in receiving a copy of the report, please make a request to Keren Ensor at the address shown on the participant list.

FIGURE 5. Minnesota Pollution Control Agency Survey Form

MINK AND RIVER OTTER
CARCASSES NEEDED

Furtrappers! We need your help and cooperation! The Minnesota Pollution Control Agency (MPCA) is conducting a statewide survey to determine the extent of contaminant loading in wildlife populations. Because the Mink and River Otter are favored furbearers of the state, the MPCA would like to obtain whole carcasses (pelt not included) of these mammals from specific areas of the state where the animals are found. If you choose to donate a Mink or River Otter from your trapping, the animal will become an important part of the 1989-1991 statewide survey that will aid in determining the health and welfare of Minnesota's furbearer population.

IF YOU WOULD LIKE TO PARTICIPATE:

Please refer to the list below which identifies where the specific collection locations are needed for the MPCA study. If you are interested in participating in the study, please inform Keren Larson (phone # below) how many packages of materials (one needed per animal) you may need as well as what location you plan to trap. (If you signed up at the annual August meeting in Litchfield, there is no need to contact her again.) Please allow 3 weeks notice.

WHERE COLLECTIONS NEED TO BE MADE:

Collections must be limited to furbearers collected within the state. However, collections in the proximities of rivers (i.e., Mississippi, Red) on adjacent state lines is also acceptable. We would like to obtain several different collections along lakeshores, streambanks, marshes and riverbanks that border the following rivers:

NOTE: River otter collections will be limited to north of U.S. Hwy 10.

(a) Mississippi River - (1) above the Twin Cities;
(2) in the 7-county metro area;
(3) Pools 2-3;
(4) Pools 3-4;
(b) St. Louis River and Duluth Harbor;
(c) Minnesota River;
(d) Rainy River;
(e) Pigeon River;
(f) St. Croix River; and
(g) Lake Superior shoreline;

NUMBER OF SAMPLES NEEDED PER LOCATION

We would like to obtain 5 mink or 2-3 otters (same sex) per collection location (species will differ depending on location). Because we are investigating contaminant loading on a regional basis, we will be grouping samples of the animals (same species and sex) sharing a common location into composite samples.

MATERIALS NEEDED FOR COLLECTION:

Necessary supplies that will be made available to Minnesota Trappers Association participants (please request one package per animal):

(a) aluminum foil - to wrap carcass in;
(b) plastic bag - to place foil-wrapped carcass in;
(c) index card - to record essential information;
(d) instructions for collections.

Other supplies not provided:

(a) pencil - to record information on index card;
(b) freezer - to temporarily store sample until shipping.

HOW TO COLLECT:

The collection of specimens for contaminant analysis is one of the most important steps in evaluating contaminant problems. Following these instructions for proper collection and storage is imperative in order to obtain good samples for contaminant analysis.

1. Please keep carcass as cool as possible prior to skinning to avoid decomposition.
2. Once skinned, minimize handling of the carcass to avoid unnecessary contamination.
3. Wrap skinned carcass well in the aluminum foil provided.
4. Place foil-wrapped carcass in the bag provided. Tie tightly.
5. Cool and transfer carcass AS QUICKLY AS POSSIBLE to a freezer for storage.
6. Record the following information on an index card using an indelible ink pen or pencil (NOTE: please print):

(a) species;
(b) sex;
(c) specific location (county, township, range, section (if possible);
(d) date of collection;
(e) name, address, and phone # of collector;
(f) Are you aware of any specific history of contaminants in the site where the animal was killed?

CONTAMINANT RESULTS WILL BE MADE AVAILABLE

Contaminant results of the mink or river otter will be mailed to you upon request. Fill out the MPCA request form below and mail back to MPCA:

Keren Larson, Minnesota Pollution Control Agency
Water Quality/Program Development
520 Lafayette Road
St. Paul, MN 55155
612/296-6074 (work) or toll free #: 1-800-652-9747 (ask for MPCA)

I have donated a Mink or River Otter (please circle which animal) for the MPCA "Contaminants in Minnesota Wildlife" study. Please send me the contaminant analysis results for my furbearer when available (approximately 6 months) to:

Name ______________________________

Address ______________________________

____

Phone number : (   ) ______________________________

2.4 Mink and Otter in New York State: Contaminants and Prelimary Population Studies

R.E. Foley, T. Martin and G. Caputo
New York State Department of Environmental Conservation
Hale Creek Field Station, Gloversville, New York

Organochlorine and metal levels in wild mink *(Mustela vison)* and river otter *(Lutra canadensis)* of New York State were measured in adipose and liver tissues collected between 1983 and 1985. Residues of polychlorinated biphenyl (total Aroclor 1254/1260), p,p'-DDE, HCB, dieldrin, mirex, photomirex, Hg, Cd and Pb were detected. Significantly greater concentrations of organochlorine residues (on a lipid basis) were found in mink living near water bodies known to be contaminated with PCB (Hudson River and within 8 km of Lake Ontario), and in otter living near the Hudson River. Currently, a set of liver samples are undergoing congener-specific PCB and dioxin analyses, and AHH induction assays.

Otters (n=63) were sampled from the eastern lake plains (ELP), west Adirondack Mountains (WAM), northeast Adirondack Mountains (NAM) and the Hudson River Valley (HR). After combining all otter, the residues in livers (geometric mean / S.E.) were: PCB, 0.4 / 0.06; DDE, 0.024 / 0.003; HCB, 0.003 / 0.039; dieldrin, 0.004 / 0.039; Hg, 2.14 / 0.04; Cd, 0.08 / 0.10 and Pb, 0.32 / 0.001 (ppm, wet weight). Data that were less than the detection limit (DL) are included in these calculations as DL/2. PCBs and DDE were significantly higher (by a factor of four) in otter from HR than from other areas of the state. The highest PCB level in liver tissue was 7.3 ppm. The otter harvest in New York is currently estimated to be 1,000 animals. The population has been expanding in number and in geographical area in recent years.

Mink (n=109) were sampled from ELP, WAM, NAM, HR, the Appalachian Plateau (AP) and from within 8 km of Lake Ontario (LO). Residues in liver (geometric mean / S.E.) were: PCB, 0.3 / 0.06; DDE, 0.03 / 0.06; HCB, 0.002 / 0.032; dieldrin, 0.006 / 0.06; Hg, 1.85 / 0.03; Cd, 0.16 / 0.06 and Pb, 0.27 / 0.001 (ppm, wet weight). PCBs ranged from 0.1 - 37.6 ppm. Mirex, photomirex and oxychlordane were found in several animals at low concentrations. Significantly higher residues of PCB were found in animals from HR and LO than from elsewhere in the state. Mirex and photomirex (contaminants found only in Lake Ontario) were found in several mink from watersheds around the east end of LO. The presence of mirex, photomirex and high levels of PCBs in mink captured along tributaries of the lake suggests that upstream transport occurs from the lake to the watersheds so that contaminants are available for uptake by terrestrial species in the watershed. PCB levels in several wild mink were similar to those that caused reproductive problems in controlled-feeding studies conducted by researchers at Michigan State University. The 1986-87 annual harvest was approximately 13,000.

New York biologists have developed a winter track survey technique which relies on the nocturnal movement of mink. We applied this technique to measure the presence of this species in stream habitats near the Hudson River and Lake Ontario. Streams were surveyed after one night of no snowfall, which had been preceded by a snowfall of at least one centimeter. Stream-road intersections (SRI) within 8 km of the river and lake were surveyed one time between December 15, 1990 and February 15, 1991 for the presence of mink (tracks, scat). A total of 447 SRIs were identified in HR and LO, but 140 had poor habitat characteristics and were eliminated as candidates for the survey. Of 307 SRI with habitat likely to support mink, we visited 45 in LO and 70 in HR. The presence of mink was documented at 11.1% and 12.8% of the LO and HR survey sites, respectively. Mink tracks were found at the mouths of tributaries to the Hudson River and within one mile of Lake Ontario. Early data summaries showed that mink were present more frequently in stream habitats within 4 km than in stream segments that were 4 to 8 km from these water bodies. This phenomenon suggested that distances greater than 8 km be used when comparing the presence/absence of mink near contaminated water bodies.

2.5 Comparison of Ontario Mink and Muskrat Harvest from Areas Differing in Potential PCB Contamination

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We studied mink and muskrat harvests in several townships in Ontario from 1970 to 1985. We compared the number of mink and muskrat harvested by each trapper for each year in four study areas. The two high PCB-risk study areas were townships adjacent to Lakes Erie and Ontario and the St. Lawrence River. The two low PCB-risk study areas were nearby townships removed from the Great Lakes and areas in central Ontario.

The combined mink harvest in the two high PCB-risk areas was significantly lower than that of the two low risk areas during 12 of the 15 years. The mean number of muskrats per trapper, on the other hand, was significantly different in only seven of the 15 years and in three of these years it was the high PCB-risk areas that had the higher muskrat harvest. This phenomenon suggests that lower mink harvests in the high PCB risk areas did not reflect poorer wetland habitat.

The second phase of this study will compare PCB levels in 78 mink from townships bordering Lakes Erie and Ontario and the St. Lawrence River with inland townships.

2.6 A Preliminary Assessment of the Threat Posed to Wisconsin Mink by Environmental Contaminants

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Wisconsin trappers are not required to tag or turn in mink carcasses. Therefore, it is not possible to determine from harvest records whether Wisconsin mink subpopulations which are exposed to environmental contaminants have declined. There is, however, anecdotal evidence that the exposure of mink to contaminants may be great enough to cause an effect on population in some regions of Wisconsin. A mink found dead on Green Bay's west shore had liver total PCB concentrations of 5.7 ppm (U.S. FWS, Unpubl. data). A wild mink collected along the Sheboygan River in Wisconsin in 1986 had PCB levels in its muscle tissue of 5.4 ppm (Table 3; Unpubl. data, Wisconsin DNR Wildlife Contaminant Monitoring Program). Muscle or liver concentrations of about 5 ppm total PCBs are associated with mortality in ranch mink (Aulerich and Ringer, 1977). A pooled muscle sample of four mink, collected 1.5 miles from Green Bay on the Oconto River, contained 1.9 ppm total PCB, while another pooled muscle sample from two carcasses collected 10 miles upstream from Green Bay on the Oconto River, contained 2.3 ppm total PCBs. Five other carcasses collected from sites which did not have PCB-contaminated fish, had PCB concentrations in their tissues at or below the detection level (0.20 ppm), including one from the backwaters of Pool 5 on the Mississippi River and one each from Columbia, Green Lake, Jackson and Langlade Counties. Dieldrin and DDE were the only organochlorine pesticide metabolites detected in the mink carcasses and those occurred in the Oconto County carcasses at concentrations <0.5 ppm in the muscle samples. Liver mercury levels ranged from 0.08 - 1.60 ppm total mercury (Unpubl. data, Wisconsin DNR, Wildlife Contaminant Monitoring Program).

areas, likely indicating a difference in the quality of mink habitat between these areas (muskrat are less common in Vilas and Oconto Counties). The trapping success index of the Green Bay and Fox River region was below that of both control regions and of the other Special Survey regions. Of greatest interest was the discovery that traps set >1 mile from Green Bay (Marinette and Oconto Counties) were twice as likely to catch mink as those set along the Green Bay and Fox River shoreline (based on the trapper success index). As stated previously, fish from Green Bay and the Fox River have maximum PCB concentrations second only to those in the Sheboygan River (a U.S. EPA Superfund site) in Wisconsin.

TABLE 4. Results of 1990 Wisconsin mink trapper survey

REGION	NUMBER OF TRAPPERS	NO. OF MINK TRAPPED	TRAPPING EFFORT	SUCCESS INDEX
		CONTROL AREAS		
Vilas and Oneida	90	359	37,181	0.0097
Inland Marinette and Oconto Counties (>1 Mile inland from Green Bay)	98	542	35,970	0.0151
		AREAS OF CONCERN		
Within one mile of Green Bay and Fox River shoreline	26	63	8,475	0.0074
Lake Superior	43	161	12,599	0.0128
Lake Michigan	36	146	12,726	0.0115
Wisconsin River	53	204	21,651	0.0094
Mississippi/St. Croix Rivers	33	91	7,167	0.0127

The limitations of using survey data (respondent versus nonrespondent bias, recall bias, etc.) to assess population status is ackowledged. However, because of the biases likely to occur in each region and because of the magnitude of the difference in the success index between Green Bay and the counties adjacent to it, we conclude that the population of mink is likely lower along the Green Bay and Fox River shoreline than it is >1 mile inland in adjacent counties. We are currently developing a study plan which will allow us to compare the number of mink and their population structure (sex and age ratios) along Green Bay and the Fox River with the same information for the inland population.

Proposed Study Plan

We are currently developing a protocol for investigating the apparent difference in the abundance of mink along the Green Bay and Fox River shoreline as opposed to the inland habitats. We are also assessing the use of mink as a monitor of microcontaminant remediation efforts for microcontaminants in Green Bay. Under a Great Lakes-wide program of the International Joint Commission, lower Green Bay has been identified as one of 43 Areas Of Concern. By monitoring the contaminant burden and population status of top predators (such as mink) in the Green Bay estuary, long-term trends in ecosystem contamination and the effectiveness of remediation can be established.

TABLE 5. PCB concentrations of fish sampled in Wisconsin consumption advisory areas, 1980-1990

Maximum fish total PCB concentrations (fresh wt.)

Concentration	Waterways
5.0 - 10.0 ppm	Wisconsin River (Wood, Adams, Juneau, Portage Counties); Mississippi River (Crawford, Vernon, La Crosse, Trempeleau Counties); Most of Lake Michigan and Lake Superior shoreline
10.0 - 20.0 ppm	Lake Michigan (Kewaunee and Sheboygan Counties); Mississippi River (Pierce, Pepin, Buffalo Counties)
20.0 - 30.0 ppm	Green Bay estuary; Lake Michigan (Door County)
30.0 - 50.0 ppm	Lower Fox River; Milwaukee River
> 50.0 ppm	Sheboygan River

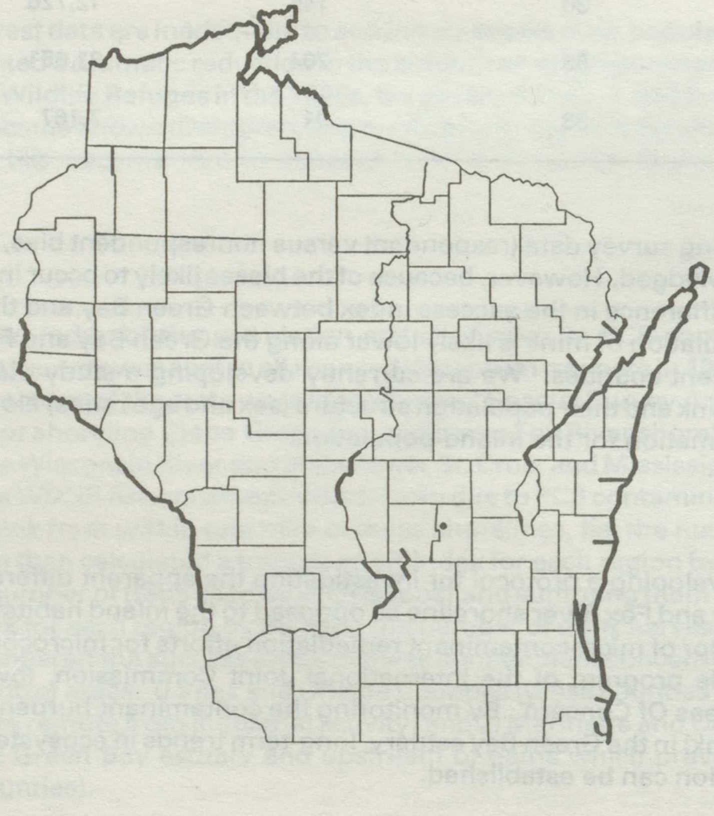

FIGURE 6. Wisconsin waterways with organochlorine fish consumption advisories, 1989

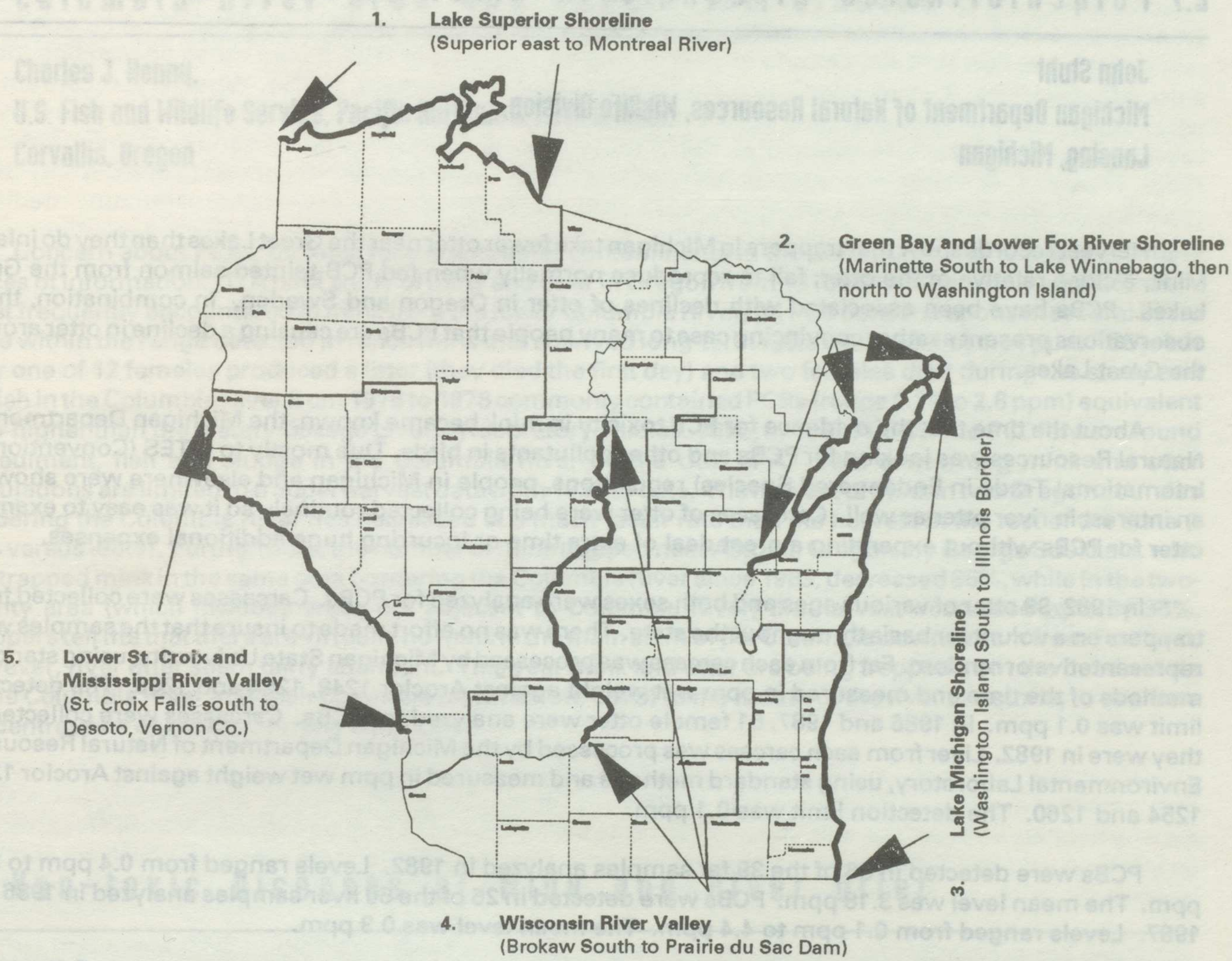

FIGURE 7. Mink special survey regions

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2.7 Polychlorinated Biphenyls in River Otter from Michigan

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Harvest records show that trappers in Michigan take fewer otter near the Great Lakes than they do inland. Mink, a close relative of the otter, fail to reproduce normally when fed PCB-tainted salmon from the Great Lakes. PCBs have been associated with declines of otter in Oregon and Sweden. In combination, these observations present a rather convincing case to many people that PCBs are causing a decline in otter around the Great Lakes.

About the time that the evidence for PCB toxicity in mink became known, the Michigan Department of Natural Resources was looking for PCBs and other pollutants in birds. Due mostly to CITES (Convention on International Trade in Endangered Species) regulations, people in Michigan and elsewhere were showing an interest in river otter as well. Carcasses of otter were being collected routinely so it was easy to examine otter for PCBs without expending a great deal of extra time or incurring huge additional expenses.

In 1982, 39 otter of various ages and both sexes were analyzed for PCBs. Carcasses were collected from trappers on a volunteer basis throughout the state. There was no effort made to insure that the samples were representative or random. Fat from each carcass was processed by Michigan State University, using standard methods of the time and measured in ppm wet weight against Aroclor 1248, 1254 and 1260. The detection limit was 0.1 ppm. In 1986 and 1987, 51 female otter were analyzed for PCBs. Carcasses were collected as they were in 1982. Liver from each carcass was processed by the Michigan Department of Natural Resources Environmental Laboratory, using standard methods and measured in ppm wet weight against Aroclor 1248, 1254 and 1260. The detection limit was 0.1 ppm.

PCBs were detected in 36 of the 39 fat samples analyzed in 1982. Levels ranged from 0.4 ppm to 38.5 ppm. The mean level was 3.18 ppm. PCBs were detected in 25 of the 50 liver samples analyzed in 1986 and 1987. Levels ranged from 0.1 ppm to 4.4 ppm. The mean level was 0.3 ppm.

The detection of PCBs in otter was not surprising. Levels were generally low and comparable to those detected in other studies. There appeared to be differences in levels between regions but there was no obvious association between the levels of PCBs and the Great Lakes. Levels were generally higher in females and younger animals. Several females had PCB levels in their livers similar to those seen in mink that failed to reproduce after being fed PCBs.

2.8 Chemicals in Mink and River Otter from the Columbia River Area and Population Studies

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Concern about PCBs, dioxins, furans and other contaminants in the Columbia River is based on many pieces of information: (1) A pilot study of mink and otter in Oregon from 1978 to 1979 showed that PCBs were most frequently encountered in mink from the lower Columbia River; (2) PCB concentrations in several livers were within the range detected in ranch mink that survived long-term tests with a diet of 0.64 ppm PCBs, but only one of 12 females produced a litter (they died the first day) and two females died during the study and (3) fish in the Columbia River from 1976 to 1978 commonly contained PCBs (range 0.24 to 2.8 ppm) equivalent to or higher than the dietary dosage given in laboratory studies. Also, in 1987 PCDDs and PCDFs were found in sediment, fish and sludge in the Columbia River by the U.S. EPA. Data concerning mink and otter populations are limited to trapper harvest data from 1949 to date. The harvest of mink in two Oregon counties bordering the Columbia River has decreased at a much faster rate than the harvest in the rest of the state (-84% versus -58%). Furthermore, the number of mink trapped near Astoria, Oregon, by George Soukkala, who has trapped mink in the same area bordering the Columbia River since 1963, decreased 85%, while in the two-county area (which includes areas not adjacent to Columbia River) the harvest decreased by only 35%. Trappers tell me that there are virtually no mink in the main stem of the Columbia downstream from Portland; however, river otter seem fairly abundant. This year mink and otter are being trapped from the headwaters of the Columbia River in British Columbia (John Elliott, CWS) to the mouth of the river at Astoria, to evaluate concentrations of dioxins, furans and PCBs.

2.9 Non-toxic Diseases of Mink and River Otter

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Although there is considerable information on diseases of mink reared for fur and limited data on diseases of captive river otter, very little is known about diseases and their impact in wild populations of these species. According to Eagle and Whitman (1987), the role of diseases and parasites as mortality factors in wild mink is not documented. Similarly, Linscombe et al. (1982) stated that a wide variety of diseases of ranched mink are not known to affect wild populations significantly. This phenomenon seems as much an effect of a paucity of studies, rather than the result of firm knowledge.

It is unlikely that diseases resulting from feeding practices, inbreeding and intensive management of farmed mink will manifest themselves in wild populations. However, farmed mink do reflect the susceptibility of the species to infectious and parasitic diseases, some of which may be indigenous to mink or may circulate among populations of other wild carnivores to which mink may be exposed. Knowledge of life-cycles and the potential for organ or tissue damage by some species of parasites permits speculation on parasites which may be potentially pathogenic under some circumstances. Intensive management has highlighted areas where non-infectious factors may affect on fecundity, recruitment and mortality of mink.

Canine distemper is a morbillivirus infection with a host range encompassing much of the Carnivora, including mustelids (Budd 1981). Mink are exquisitely susceptible to this disease, which may cause extensive mortality on mink ranches and has been reported in wild mink (Monson and Stone, 1976). **Mink Virus Enteritis** is caused by a parvovirus closely related to **Feline Panleukopenia Virus** (FPL). First recognized in ranched mink at Fort William, Ontario in 1947, it may be a mutant of FPL. It may cause devastating losses among farmed mink, if vaccination is not practised (Pearson and Gorham, 1987a). Whether it occurs among wild populations is unknown; similar parvoviruses do infect wild Canidae and Felidae, among which they do cause some local mortality (Addison et al. 1987). **Aleutian Disease** is caused by a different parvovirus (Aasted 1985). Though it will infect other species (Kenyon et al. 1978), it seems to be indigenous to mink. It may cause reproductive failure, interstitial pneumonia in kits and premature mortality as the result of immune-mediated disease. Mink are susceptible to **Rabies**, but it is not known to affect populations. **Influenza pneumonia** has occurred in ranched mink; it may in one case have been avian in origin (Englund et al. 1986). **Transmissible Mink Encephalopathy** is a scrapie-like spongiform encephalopathy, which likely results from transmission of the infectious particle in slaughterhouse waste, rather than being a disease indigenous to mink (Pearson and Gorham, 1987b).

Significant bacterial infections of ranched mink include *Pseudomonas* **pneumonia** (Long and Gorham, 1981) and *Campylobacter* **enteritis and abortion** (Hunter et al. 1986). The latter is likely transmitted by the consumption of infected chicken offal and is unlikely to occur in wild mink. *Staphylococcus* infections and empyema mainly occur in mink with Chediak-Higashi syndrome, an inherited defect in leucocyte function.

Among nematode parasites of wild mink, *Dioctophyma renale*, the giant kidney worm and *Dracunculus insignis*, the Guinea worm are the most obvious, but neither is considered to have a significant impact on health. A variety of other helminth parasites occur in wild mink (Linscombe et al. 1982), but few are likely to be significant pathogens. **Toxoplasmosis** (Pridham 1961) and **coccidiosis**, primarily due to *Eimeria vison* (Myers et al. 1980), are protozoan infections pathogenic to farmed mink; the latter may have the potential to cause kit mortality among wild mink.

Mink are extremely susceptible to **botulism**. Since this disease, caused by a bacterial exotoxin elaborated by organisms proliferating in nutrient-rich anaerobic environments, is seasonally prevalent in marshy habitats and lake margins in the Great Lakes basin, wild mink may be exposed in local areas, though an effect on wild populations has not been recognized. Congenital/hereditary diseases, which are common in domestic mink, are the product of inbreeding and are unlikely to be manifest among wild populations.

Mink are susceptible to infertility due to factors interfering with fertilization, with blastocyst survival during the period of delayed implantation and with implantation and fetal survival. Pertubations during the reproductive period are avoided by mink ranchers and Aleutian Disease may have its effect on fertility during the pre-implantation period. Low birth weight (<8.0 gm) is strongly associated with still birth or early postnatal death. Environmental stressors at whelping may influence perinatal mortality in wild mink (Burns 1964, cited in Linscombe et al. 1982). Disturbance of the female during the early perinatal period may result in cannibalism or abandonment. Mastitis and metabolic illness (nursing sickness) in females may cause mortality of dam and/or litter. Mustelids in general, and mink in particular, are prone to stress-related gastric haemorrhage, which may result in death. This result should be borne in mind in any studies involving live-trapping, handling or holding of wild mink. Death might occur after release, in the case of trap-and-release studies.

Diseases of river otter are very poorly known. Otter are susceptible to **Canine distemper** (Geisel 1979) and antibody to **Feline Viral Rhinotracheitis, Feline calicivirus** and **parvovirus** cross-reacting with FPL has been found in otters captured from the wild (Hoover et al. 1985a). Pneumonia is reported as a common cause of death in captive otters and jaundice, speculatively associated with *Leptospira* infection, has been reported. A large number of parasites are reported in otter (Toweill and Tabor, 1982); only a few are potentially pathogenic and none have been demonstrated to be significant in the wild population. River otter have a very long period of delayed implantation and as such may be particularly susceptible to factors injuring the blastocyst. **Salmonellosis** and a variety of other opportunistic infections have been reported in otters captured for translocation (Hoover et al. 1985b), possibly reflecting secondary infection in stressed animals. Mortality in otter involved in translocation programmes varies from 5-45% (Melquist and Dronkert, 1987). How much is a function of the stress of the procedure and how much is due to the effects of inadequate habitat or other factor operating after release, is unknown.

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2.10 Current Status of Information Regarding Mink in Ontario

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The Ontario fur harvest records and an unpublished set of data on parasites and demography are the currently available information on mink populations in Ontario. Both sets are of limited use in evaluating mink as a possible indicator of the toxicological health of the Great Lakes.

The fur harvest data consist of the location and number of mink harvested per annum. The chief problem with these data is the coarseness of the spatial units used for the trapping location of the mink. These vary from approximately 10,000 - 50,000 ha for agricultural southern Ontario. Other factors limiting the usefulness of these data include unknown effects of changing fur prices, inclusion of ranch fur in harvest totals and changes in trapping techniques over time.

The second data set describes information on 2,000 - 3,000 mink collected from 1960 to 1969. Although mink were collected throughout Ontario, the majority are from central Ontario. Data include age and sex structure, size of mink and presence of parasites. Because these data were collected exclusively to evaluate possible effects of helminth parasites on mink, they are of limited use for toxicological considerations.

It has been, and will continue to be, logistically difficult to monitor changes and establish possible causes of changes in the mink populations of Ontario. To soundly evaluate mink as an indicator of toxicological health, we recommend clear recognition of the limitations of current data. Future evaluation of mink as an indicator species requires progression from the reductionist approach of past research on wild mink to a multi-disciplined, "ecosystem-oriented" approach.

2.11 Reproductive Performance of Mink Fed Saginaw Bay Carp

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Planar polychlorinated hydrocarbons (PCHs) have been implicated as a cause of the declining populations of wild mink and otter throughout the Great Lakes region. The objective of this study was to determine the effects of PCH-contaminated prey on the reproductive performance and survival of mink. Carp collected from Saginaw Bay, Michigan, containing 8.4 ppm total polychlorinated biphenyls (PCBs) were substituted for marine fish at levels of 0, 10, 20 or 40% of the diet. The H4IIE rat hepatoma cell bioassay was used to determine TCDD equivalents (TCDD-EQs) of the complex mixture of PCHs in the carp to predict the relative potency of the dietary PCHs. The diets were fed to mink prior to and during the reproductive period. The total quantities of PCBs and TCDD-EQs ingested by mink fed 0, 10, 20 or 40% carp over the 85-day treatment period were 0.34, 13.2, 25.3, and 32.3 mg PCBs/mink and 22.9, 356, 661, and 1019 ng TCDD-EQs/mink, respectively. The consumption of mink feed and body weight gains during the trial were inversely proportional to the PCB content of the diet. Expressed as a percentage of brain weight, livers, kidneys, spleens and lungs showed a general dose-dependent increase in weight. Histopathologic examination of the livers showed periportal and vacuolar hepatocellular lipidosis in the mink fed 40% carp. Total hepatic PCB concentrations in the carp-fed groups were significantly different from control values and increased in a dose-dependent manner. The females fed 40% carp whelped the fewest number of kits, all of which were stillborn or died within 24 hours. Kit survival in the 10 and 20% carp groups was significantly reduced at three and six weeks of age, compared with the controls. A LOAEL of 0.134 mg PCBs/kg body weight/day (3.60 ng TCDD-EQs/kg body weight/day) was determined. The results of this study confirm the extreme sensitivity of mink to PCHs and lend support to the suspicion that PCHs may be responsible for the marked decline in mink populations in certain areas adjacent to the Great Lakes.

2.12 Effects of *In-Utero* Exposure to Polychlorinated Biphenyls on Chemical Communication in Neonatal Ranch Mink

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Hypertrophic cervical apocrine sweat glands appear to be unique to members of the Mustelidae. In the newborn mink kit, the gland is visible as a high area of thickened skin on the dorsal neck, extending from the occiput to the thorax. The secretory product is abundant and may be seen macroscopically as dried, honey-colored crusts on the skin surfaces. The gland enlarges during the first two weeks of life and then regresses. The coincidence of glandular regression and weaning is a phenomenon which has only been noted in members of the Mustelidae. The transitory presence of the cervical gland during the neonatal period argues for a role in maternal interaction with the kits.

Our preliminary behavioral studies, in which several parameters of maternal reaction were monitored following exposure of the lactating females to secretions collected from the cervical glands, suggest that the glandular secretions may influence maternal recognition of the young. In view of the documented pathological effects of PCBs on the mammalian integument, including the atrophy of sebaceous glands, mink kits exposed to PCBs *in-utero* may develop cutaneous lesions, which could interfere with secretion and/or production of the putative semiochemicals, which assist in maternal recognition. Failure to nurse would readily explain the wasting disease observed in litters from mink fed PCB-contaminated feed.

We found that both the development of the cervical apocrine gland and the growth rate was affected in kits born to female ranch mink receiving 1 ppm Aroclor 1254 in their diet from two weeks post breeding until whelping, a period of approximately 45 days. The reduction in gland size in the first two weeks of life was greater than could be attributed to the effects of body size alone. The effect on the glandular development was greatest in the first two weeks of life, the time when in the normal kit, the gland is maximally active. Not only were the glandular units reduced in size, but the area of epithelial cell cytoplasm was significantly reduced.

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2.13 Role of Contaminants in the Decline of the European Otter

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Forty years ago the otter *(Lutra lutra)* was widely distributed through most of Europe. Populations then went into sharp decline. An analysis of hunting data in England and Wales (otters were hunted for sport with dogs until 1978) indicated that the decline began in the late 1950s and continued over the following two decades.

Following several local surveys in England in the mid-1970s, which showed the otter population to be in a parlous state, national surveys of the British Isles were carried out in the late 1970s. These involved locating signs of otters (mainly scats, known in Britain as spraints) in a 600 m stretch of riverbank. Nearly 11,000 sites were surveyed. Otters were found to be widespread in Ireland and most of Scotland, severely depleted in much of Wales and absent from large areas of central, eastern and southern England (where overall only 6% of sites were positive). Repeat surveys seven years later gave some evidence of expanded distribution in central Scotland, Wales and western England, but of a further decline in eastern England, where the native population may now be extinct.

During the 1980s, field surveys for otters have been carried out in a number of European countries. With the results of questionnaire surveys from the rest, we now have a reasonably good view of the distribution in Europe. Populations are thriving only on Atlantic seaboards (Norway, Scotland, Ireland, south-west France, Portugal and western Spain) and in south-east Europe (especially Greece). Populations are severely depleted in countries with high industrial output or downwind of such countries. This situation suggests that both local and air-borne sources of pollution may be important in the decline.

It has been suggested that dieldrin was the cause of the decline in Great Britain, for the introduction of this agrochemical appeared to coincide with a decrease in hunting success; other factors were ruled out. No analytical data were presented to support this view. Continental workers stress the significance of PCBs, which are more toxic to mink than is dieldrin. Perhaps we should be considering contaminants as a "toxic suite," for we know very little about additive or synergistic effects. Mercury, for example, has been shown to act synergistically with PCBs to reduce pup survival in mink. Although analyses of British otters have shown only a few individuals with mercury at levels of concern (when considered alone) mercury and PCB concentrations tend to be correlated and fish in Britain are widely contaminated with mercury; 25% of a large sample of eels had Hg concentrations in flesh more than 0.3 ppm fresh weight, the EEC standard for human consumption of fish, while eel livers had yet higher concentrations.

Swedish experiments have demonstrated reproductive failure in mink when PCB concentrations in muscle exceed 50 mg kg^{-1} lipid. Mean concentrations in otters exceed this value in samples from Sweden (population threatened), the Netherlands (extinct since 1989) and East Anglia, England (wild population probably extinct since 1989). In Ireland, otters are thriving and PCB levels are low, but some otters utilize habitat in cities, such as Cork, and mean concentrations there are greater than 50 ppm. Otters with high concentrations of PCBs in Cork and East Anglia have been disoriented prior to death, consistent with organochlorine (OC) poisoning. Two otters from East Anglia had symptoms similar to the adrenocortical hyperplasia described in Baltic seals. Evidence generally points to the significant role of PCBs in the European otter decline, while bearing in mind the possible combined effects of contaminants.

Because of the general dearth of otter tissues available for analysis (the species is fully protected through most of Europe), we have been developing techniques for the analysis of spraints for OCs. Large sample numbers are then possible to achieve and catchments can be "fingerprinted" for OCs. In upland areas where otters are thriving, mean PCB and total OC pesticide concentrations in spraints are both less than 5 mg kg^{-1}

lipid. As populations expand downstream from these strongholds into the lowlands, both mean PCB and pesticide loads almost double; they are at a similar level in East Anglia samples (mainly from a restocked population of otters). Whereas the lower reaches of western rivers may receive recruitment of young otters from clean waters upstream, East Anglian rivers rise in lowlands and are often contaminated at their headwaters. In the Clyde estuary, Scotland, "fingerprinting" has shown elevated PCB concentrations associated with urbanization, a marine sewage sludge dumping site, a nuclear submarine base, an oil storage facility and ferry terminals.

Dutch experiments with mink have shown that a diet containing 0.25 ppm PCB results in reproductive failure, while 0.025 ppm depresses reproduction in long- term experiments. An otter eats 1 kg of food per day so that concentrations of PCBs in fish can be more or less directly related to daily intake. Eels from rivers in the United Kingdom not holding otters had mean PCB concentration of 0.55 ppm; eels from rivers still supporting otters had a mean PCB level of 0.08 ppm. Eels from an East Anglian river judged suitable for a reintroduction programme had a mean PCB level of 0.21 ppm. Such concentrations are probably typical of the region and bode ill for the future of this reintroduction.

In addition to contamination, habitat destruction has been rife over much of Europe and probably lowers the carrying capacity of freshwaters for otters. There are local problems with acidification and mine drainage, while small populations become vulnerable to random mortality factors, such as road kills and drowing in nets. All of these phenomenon must be considered in the development of a conservation strategy.

3.0 Results of Workshop Discussions

Agencies responsible for virtual elimination programs in the Great Lakes basin need reliable indicators to evaluate their effectiveness in controlling discharges of persistent toxic substances. Participants at the workshop were asked a series of questions about the suitability of mink and otters as indicators of ecosystem quality in the Great Lakes basin. Table 6 comprises the results of a poll of the participants concerning the adequacy of existing field data concerning whether to recommend the mink or otter as an indicator species.

TABLE 6. Attendees' assessment of adequacy of existing field data

	MINK	OTTER
Population status	No	No
Harvest data	Yes	Yes
Disease data	No	No
Parasite data	Some	Some
Population structure	Some	Some
Range	Yes	No
Diet (exposure)	No	No
Tissue levels	Some	Some
Distribution	Some	Some
Density	No	No

Table 7 (page 27) is a tabulation of the responses of the participants to a series of questions on the current state of knowledge of mink and otter as ecosystem quality indicators.

Table 8 (page 28) comprises the answers to the question: "What do you need to know before the mink and otter could be recommended as an ecosystem indicator of virtual elimination of persistent toxic substances in the Great Lakes basin?"

TABLE 7. Attendees' assessment of current state of knowledge of mink and otter as Ecosystem Quality Indicators

QUESTION	MINK YES	MINK NO	OTTER YES	OTTER NO
Is sufficient known about the status of the mink and otter in the Great Lakes basin to make it a useful indicator?	7	15	2	20
Is sufficient known about the factors affecting the status of the Great Lakes mink and otter populations to make them reliable indicators of quality improvement?	5 1-factors affecting status 1-about each other	14	2	18
What kind of data or parameters do we need to monitor for mink and otter population status?	• Population dynamics/age structure/demographic data versus time • Disease/immunology • Environmental influences • Field exposure • Food habits/diet composition/contamination in forage • Reproductive success/recruitment • Tissue residue data • Population distribution/presence, absence maps • Trapping data (long term) • Release studies/capture-recapture • Determine censusing techniques (perhaps scat) • Measures of biomarkers • Measure most toxic contaminants in the Great Lakes • Sensitivity of species and phases of reproduction • Effect of human pressures on wildlife population • Scat index or sign index			
Is sufficient known about the toxicological effects of chemicals on mink and otter?	9	4 •almost marginal •just barely •need more data	1	17
What agencies/groups should be responsible for monitoring programs?	• States/provinces; federal; universities • Private groups (especially trappers) • OMNR; OMOE; DNR • CWS; U.S. FWS			

TABLE 8. What do we need to know?

1.	Survey methods for assessing the distribution abundance of mink and otter on Great Lakes shorelines
2.	The distribution of mink around the Great Lakes
3.	Habitat distribution
4.	Relationship between habitat (quality) and population/harvest
5.	Diet of mink and otter inhabiting Great Lakes shorelines and tributaries
6.	Population structure and reproductive success
7.	Incidence/effects of disease/parasites in natural mink and otter populations
8.	Coincident with looking at responses, measure potential causes, for example: • PCBs • Canine distemper • Parasite burden
9.	Resolve apparent difference between mink and otter relations in England and on Columbia River
10.	Sources of funding for furbearer research related to water quality

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