FRASER RIVER ACTION PLAN

Assessment of Potential Indicator Species For Monitoring Environmental Contamination Of The Fraser River Basin, British Columbia

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Prepared for:

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ABSTRACT

Fifty seven species of amphibians, birds and mammals, were considered as potential indicators of chemical contamination in the aquatic component of the Fraser River Basin, British Columbia. A list of criterion were applied to rank the suitability of each species. Criteria were based on published knowledge and the practicality of sample collection. Criteria included: 1) fundamental attributes of residency, distribution, abundance and diet; 2) current understanding and documentation of natural history, such as home range, habitat, migration and historic abundance; 3) the ease of collection samples; 4) the suitability of each species for laboratory study; and 5) knowledge availability pertaining to contaminant research. The suitability of each species, expressed as a score out of 19, was based on how well it fulfilled each selection criteria. The highest score attained for mammals was 19 for the River Otter. For the birds, the highest scores were 16 for the Great Blue Heron and 15 for the Osprey. The scores for amphibians were notably lower than those of mammals and birds. The highest score attained was 12 for the Rough-skinned Newt.

The results reflect differences in the availability of information and the extent to which various species have been studied. Therefore, it is possible that low scoring species may be upgraded when missing information is acquired. This project was the first attempt at evaluating indicator species for the Fraser River Basin, and although higher scores are significant, results are not exclusive and should serve as a guide only. When designing a contaminant monitoring program and attempting to select the most appropriate indicator species, consideration must be given to individual program objectives, specific contaminant chemistry, and any relationships of the latter with a particular species' ecology.

RÉSUMÉ

On a relevé cinquante-sept espèces de mammifères, d'oiseaux et d'amphibiens susceptibles de servir d'indicateurs de la contamination chimique de l'environnement aquatique du bassin du Fraser, en Colombie-Britannique. Pour évaluer l'adéquation de chaque espèce et les classer, on a utilisé une liste de critères qui reposent sur les connaissances publiées et l'aspect pratique du prélèvement d'échantillons. Les critères retenus comprenaient: 1) caractères fondamentaux de résidence, de répartition, d'abondance et de régime alimentaire; 2) les connaissances actuelles et les documents existants sur l'histoire naturelle, comme le domaine vital, l'habitat, la migration et l'abondance antérieure; 3) la facilité de prélèvement des échantillons; 4) l'adéquation de chaque espèce en vue des études en laboratoire, et 5) la disponibilité des connaissances se rapportant aux recherches sur les contaminants. L'adéquation de chaque espèce, exprimée sous forme d'une note sur 19, était fonction de la façon dont l'espèce respectait chacun de critères de sélection. Dans le cas des mammifères, la loutre de rivière a reçu un 19, soit la note la plus élevée. Chez les oiseaux, les notes les plus élevées étaient de 16 pour le grand héron, et de 15, pour la balbuzard. Chez les amphibiens, les notes étaient particulièrement plus basses que celles des mammifères et des oiseaux, le triton rugueux s'étant vu attribuer 12, note la plus élevée pour ce groupe.

Les résultats témoignent de différences au niveau de la disponibilité de l'information et de l'ampleur de l'étude des différentes espèces. Il est donc possible de revoir à la hausse la note des espèces mal classées lorsqu'on connaîtra les données manquantes. Ce project représente la première tentative d'évaluation des espèces indicatrices du bassin du Fraser, et bien que des notes élevées soient importantes, les résultats ne sont pas exclusifs et ne doivent servir qu'à orienter les choix. Lorsque l'on conçoit un programme de surveillance des contaminants et que l'on essaie de choisir les espèces indicatrices les plus appropriées, il faut tenir compte des objectifs de chaque programme, des propriétés chimiques du contaminant et de tout rapport entre ce contaminant et l'écologie des espèces visées.

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1. INTRODUCTION

Scientists face a difficult task when attempting to select the most appropriate indicator species to monitor for the presence or effects of environmental contaminants. The ideal indicator species should possess certain qualities relevant to the goals of a contaminant monitoring program. First, it should reside throughout the study region with individuals completing life cycles within a comparatively small area. There should be adequate documentation of the species' ecology, with references to diet, nesting behaviour and historic abundance. For practical purposes, locating and collecting of samples must be relatively easy without involving unnecessary disturbance to the surrounding ecosystem and its inhabitants. Finally, it is also highly desirable that the species (or other closely related species), be amenable to captive breeding and rearing as this would facilitate its controlled study over successive generations.

An investigator must also be able to relate the species' ecology with contaminant chemistry. This is necessary to determine first, which species to monitor, and second, the type of sample to collect. For example, when monitoring a contaminant which accumulates in river or lake-bed sediments, a benthic invertebrate may be a better choice over a surface-dwelling predator. Similarly, it is important that the most relevant form of a sample be collected (eggs, tissues, blood, etc.). There may be little value in a tissue sample from a migratory bird immediately following its return from a distant habitat. However, in a few weeks, examination of residues in chicks of the same species may provide a better indication of local environmental contaminant levels.

There have been a few studies describing criteria used in the selection of indicator species (Moore, 1966; Butler *et al.*, 1971; Ryder and Edwards, 1985; Noble and Elliott, 1986; Hebert *et al.,* 1993). The purpose of this study was to develop an adapted criteria list specifically for use in contaminant monitoring within the aquatic ecosystem of the Fraser River Basin, British Columbia. Based on the extent to which a species met criteria requirements, it was possible to derive a list ranking the capability of a range of resident avian, mammalian, and amphibian species to serve as indicators of basin contamination. It should be emphasized that the results of this study are not comprehensive and that species scores should serve only as a guide in any selection process.

2. METHODS

2.1 Study Species and Area

Fifty-seven species from the taxonomic classes Aves, Mammalia, and Amphibia, were selected for consideration as potential indicators of environmental contamination. All of the species currently breed within the Fraser River Basin and all are part of the aquatic food chain. Herbivores were generally avoided as there is less evidence supporting

bioaccumulation of chemical contaminants at this trophic level. For the purpose of this report the study area included all rivers, lakes and water systems draining into the Fraser River upstream of the confluence with the Pitt River (Map 2.1).

2.2 Selection Criteria

Criteria used in this study were adapted from Hebert *et al.* (1993) with modifications specific to the aquatic ecosystem of the Fraser River Basin. An attempt was made to develop an objective set of criteria based on the availability of published information on each species, and the feasibility of sample collection. Criteria were not designed to be sensitive to details such as variations in sample size, and/or sensitivity of individual species to specific contaminants. In addition, care was taken to objectively judge each species without discrimination or influence based on any kind of associations. For example, a potential indicator species could be endangered, or possibly revered and protected for symbolic reasons (e.g. the Bald Eagle). It may also be of economic importance and necessary for the livelihood of indigenous people.

Selection criteria were divided into five categories: 1) fundamental ecological attributes; 2) understanding and documentation of ecology; 3) ease of sample collection; 4) suitability for laboratory study; and 5) knowledge pertaining to other contaminant research. How well a species fulfilled each category's requirements was quantified by systematically answering its constituent questions and arriving at a numerical score. A high final score implied that the species in question would be valuable as an indicator of pollution for the aquatic ecosystem of the Fraser River Basin.

Criterion 1 pertains to the most basic ecological attributes inherent to a species. Criteria 2 - 5 are an indication of the amount of research and documentation that exists for a species. As scores in these criteria are based on available information, once missing data is identified, it is quite possible that another in-depth literature search, or a subsequent study may be all that is necessary to improve on a score. Each criterion category is presented along with comments on its relevance, and a short explanation for the score given. While most questions were answered as either yes (1) or no (0), some required a more subjective answer within a range of possible scores. If information was insufficient to judge, the species scored zero by default. In many instances there was no easy yes or no answer. For each species, a synopsis of the information used to arrive at a score is provided in Appendices 1 - 3.

Criterion 1 - Fundamental Ecological Attributes

1a **Is the species a year-round resident of the Fraser Basin?**
Species which reside year-round within the Fraser Basin are preferable to migratory species which may return to the basin following exposure to contaminants elsewhere. Resident species were scored as one.

1b **Does the species have a broad distribution within the Fraser Basin?**

Species with limited range were judged less useful than those found throughout the basin. The Fraser Basin was divided into three regions based on general climatic differences and major geographic landforms (Map 2.1):

1) Northern Region: Approximating the Sub-Boreal Interior ecoprovince, encompassing all river and lake systems north of a line running west from Quesnel and a second line running south-east from Quesnel through the town of Clearwater;

2) Central Region: Approximating the Central and Southern Interior, extending south to the town of Hope;

3) Coastal Region: Encompassing all the Fraser River drainage downstream of Hope, inclusive of Harrison Lake and the Lillooet River.

Species found in one, two or three regions were scored zero, one or two respectively.

1c **Is the species common in the Fraser Basin?**

The more common a species, the more useful it is as an indicator of environmental contamination. Unfortunately, it is very difficult to singularly define abundance relative to all species. Occurrence records for bird species, as reported by Campbell *et al.* (1990) in The Birds of British Columbia were used as a measure of abundance. Species were considered common (a score of one) if a minimum of 20 individuals were sighted per day, per site. Amphibians and mammals, as well as birds not yet covered in The Birds of British Columbia, were scored based on anecdotal statements from other sources as cited in the appendices.

1d **Proportion of diet within the aquatic food web.**

Scoring in this category was difficult as, for most species, diet information was very limited with food preferences available only to the Family level. In order for a species to be useful as an indicator, it was deemed that more than half of the diet must be aquatic, and carnivorous. If a species had less than 50% of its diet within the animal component of the aquatic food web, it scored a zero. It is not unusual for different life stages (especially amphibians) of the same species to have highly distinct diets. For this reason, if the diet of either adults or young consisted of greater than 50% aquatic animals, the score was one; whereas, if both life stages were predominantly aquatic predators, the maximum score given was two.

Criterion 2 - Understanding and Documentation of Ecology

2a **Has the home range of the species been described?**
Knowledge of a species' foraging range is necessary to accurately relate its contaminant burden with known or unknown sources of pollutants. Most species are much more mobile when not breeding. The size of a home range is usually relative to the size of the species; larger animals tend to cover larger areas when foraging. Due to the limited availability of documentation, any information describing home range size resulted in a score of one. It is also very important to consider the home range of an indicator species within the context of the objectives of any proposed contaminant monitoring study.

2b **Is the habitat used by the species well documented?**
An animal's choice of habitat is based on cost-benefit relationships which optimally balance a number of habitat requirements such as availability of food sources, risk of predation, and adequate protection provided by a shelter. In addition, a habitat can become less desirable compared to a similar one if it is polluted. The conspicuous absence of a species from an area where it would be expected to live, is a definite sign of some environmental disturbance. Organisms may move in or out of an area if they are more or less tolerant of pollution relative to competitor species. Knowledge of an animal's habitat requirements is thus very important to understand why or why not an animal occurs in a certain area. References describing habitat preferences at the detail of ecosection (sub-regional ecosystems) or greater resulted in score of one.

2c **Is the reproductive biology of the species well documented?**
Information on where and when a species breeds is helpful when trying to locate an animal to collect a particular form of sample. A species received a score of one if any references to its gestation or incubation periods and/or dates of breeding were available.

2d **Is the migration behaviour of the species well documented?**
A migratory species may be exposed to local contaminants as well as those encountered during its annual route. Therefore, an understanding of its migratory behavior helps to distinguish between local versus distant sources of contaminant burdens or effects. Any references describing a species' migratory behavior (e.g. spring arrival and fall departure times) resulted in a score of one. Non-migratory species were also given a score of one. Only in cases where absolutely no information was available, was a zero assigned.

2e **Is there information on the historic abundance of the species?**
Historic information on the abundance and distribution of an indicator species is necessary in order to monitor the long-term effects of environmental contamination. References to past population estimates (as described in systematic surveys or sightings in specified areas), prior to 1980 or during the period between 1980 and

the present, resulted in a score of one. A score of two was given if abundance estimates in both time periods were available. General statements about increasing or decreasing populations or habitat ranges, some with no temporal references, were included as comments and cited, but not considered in the scoring process.

Criterion 3 - Ease of Sample Collection

3a **Can nests or animals be easily located?**
A species that is very difficult to locate, would not be suitable for use as an indicator. Colonial nesting species, species which accept artificial nest boxes, those with clearly visible nests, and those described in the literature as easy to locate, were all given a score of one.

3b **Are samples easy to collect?**
For practical reasons, an indicator species should be easy to locate, and the act of sampling should not cause a disturbance to other organisms or the environment. Based on personal communications with wildlife service personnel (Appendices 1-3), and some published references, a subjective score of zero or one was assigned.

Criterion 4 - Suitability for Laboratory Study

4a **Has captive rearing been reported?**
Having the option to study a species in captivity is very useful when attempting to quantify the biological effects of specific contaminants. Species known to have been maintained in captivity were scored as one.

4b **Has captive breeding been reported?**
As a continuation of 4a, a laboratory population may be valuable when monitoring a contaminant for long-term toxic effects such as mutagenicity or, more importantly, reproductive toxicology including developmental effects, i.e., teratogenicity. Species known to have been successfully bred in captivity were scored as one.

Criterion 5 - Knowledge Pertaining to Other Contaminant Research

5a **Is there any historical documentation of this species associated with a particular contaminant burden(s) within the Fraser Basin?**
To determine the existence of any trends or temporal relationships in contaminant loadings, historical records must be studied for comparison with current contaminant levels. There may be archives of residue analysis data, or in some

cases actual tissue samples may be banked. Any baseline information of this kind was considered useful and warranted a score of one.

5b **Has this species been useful as an indicator of contamination in other regions?**
It is always valuable to compare methods as well as results from contaminant monitoring studies conducted in other regions. References of this type resulted in a score of one for the species.

5c **Have biological effects for this species in response to particular contaminants been studied?**
Has the species been studied such that we have a reasonable understanding of the biological consequences of exposure to broad classes of contaminants? If published data were available documenting quantitative dose-response relationships to a contaminant or class of contaminants, a species was given a score of one.

2.3 Literature Search and Annotated Bibliography

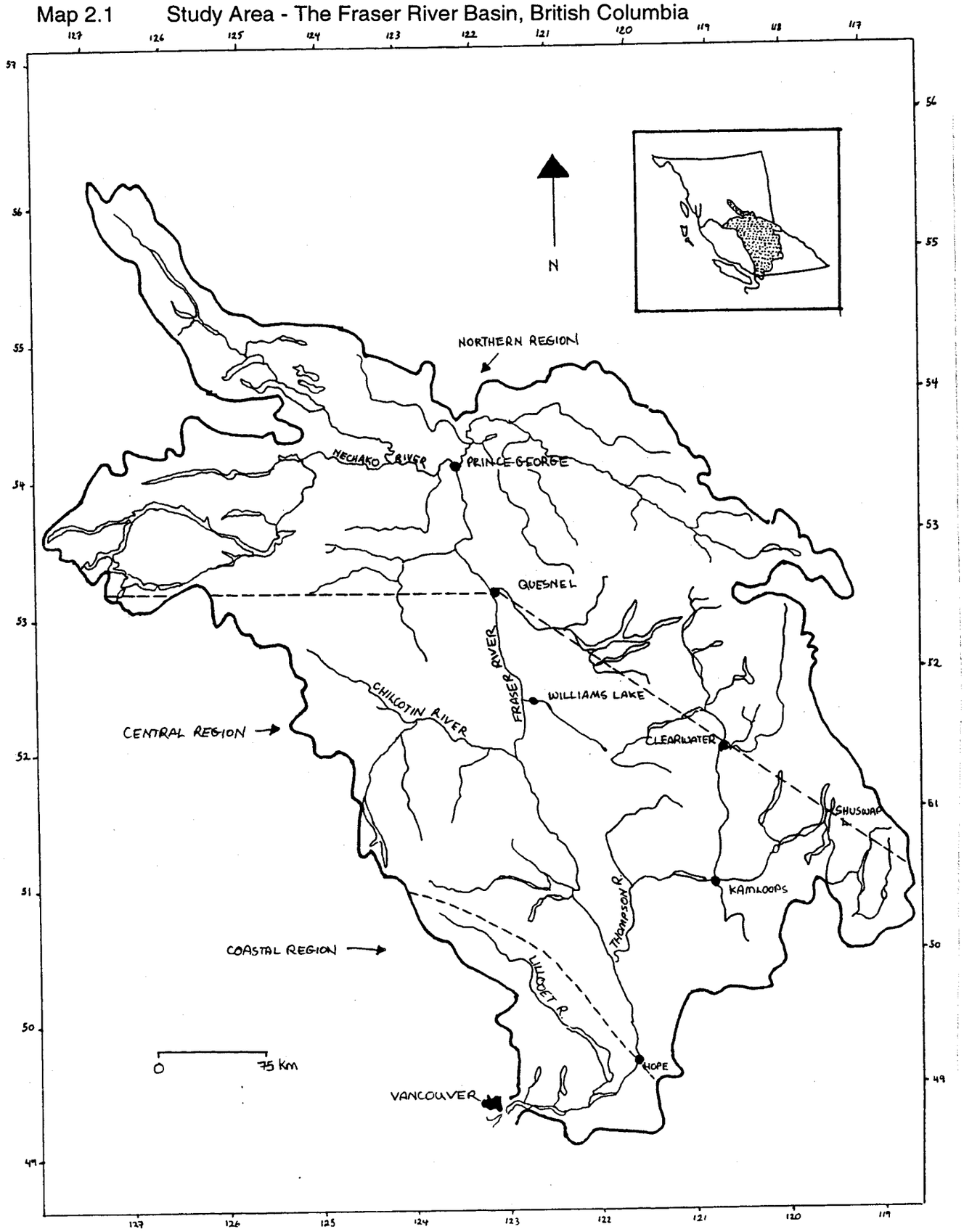
In this study, for each candidate indicator species, both published and unpublished material was reviewed for studies examining basic ecology and/or biological effects. The information presented in this report was retrieved from the following computer data bases:

- Biological and Agricultural Index - 1985 to present
- Biosis - 1985 to present
- Heep Index - 1985 to present
- Silver Platter 3.11 - January 1991 to January 1993

Additional information was obtained from the Toxicology Task Force (Philomath, Oregon), the reference collection at the Ministry of Environment, Lands and Parks library in Victoria, and during interviews with Provincial and Federal Biologists and private Biological Consultants. All references were alphabetically compiled by first author in the bibliography. Most of the works include either the author's abstract, keywords, or a brief written summary. A bibliographic index was arranged by species, and divided into four broad subject areas: 1) General Biology; 2) Contaminant Residue Studies; 3) Biological Effects; and 4) Additional Contaminant Information. References may be located by following alpha-numeric codes listed in the index.

In order to avoid duplication, the bibliographic index does not include amphibian citations found in Harfenist *et al*.'s comprehensive review (1989).

Map 2.1 Study Area - The Fraser River Basin, British Columbia



3. RESULTS AND DISCUSSION

3.1 Criterion 1 - Fundamental Ecological Attributes

Evaluation based on the components of criterion 1 resulted in twenty avian, four mammalian, and five amphibian species scoring four or greater out of a possible maximum of six (Tables 3.1 - 3.3; Subtotal column). Three species, the Common Merganser, Hooded Merganser, and the River Otter all obtained a "perfect" score of six. Relatively high scores of five or six were given to six birds and two mammals in contrast to amphibians which never scored above four.

Amphibians tended to score low in fundamental ecological attributes for a number of reasons (Table 3.1). In many cases, there was insufficient information on their distribution and abundance within the basin. Orchard (1984) provided some mapped data consisting of isolated sightings in select locations. Frequently these spot locations consisted of only one specimen. As all amphibian species satisfied criterion 1a (an important requirement for an ideal indicator species), it would not be unreasonable to improve scores by conducting systematic searches for amphibians throughout the Fraser Basin. Another reason for the low scores was that adult amphibians consume a largely terrestrial diet (Table 3.4).

Birds appeared to be the most studied and understood of the three classes examined. Unlike the amphibians and many of the mammals, most birds are migratory and therefore do not satisfy criterion 1a (Table 3.2). Of the species found year-round within the Fraser Basin and also consuming mainly aquatic animals (Table 3.5), the American Dipper received only a five because there was not enough information to judge it as common (criterion 1c). The Western Grebe's low score of three was due to its limited distribution and abundance, and the fact that it breeds in colonies in very restricted areas. The Tree Swallow, although considered an indicator species in other regions, did not appear as suitable for the Fraser Basin. It received a low score of four which could be upgraded by one point with a better understanding of its abundance.

Among the larger fur-bearing mammals, the River Otter, Mink and Muskrat are all year-round residents (criterion 1a), widely distributed (criterion 1b), and abundant (criterion 1c); however, only the River Otter received the maximum score of six (Table 3.3). The Mink and Muskrat, as a result of an exclusively herbivorous and mainly terrestrial based diet respectively, scored lower in criterion 1d.

The majority of bats scored poorly on fundamental ecological attributes (Table 3.3), with the exception of the Little Brown Myotis which scored 12. This reflected a general lack of knowledge in all areas. For many of the species, it was not known whether they migrate or hibernate and, as with amphibians, distribution and abundance (criteria 1b and 1c) data was limited to point locations of known roosts. In addition, many bat species rely on terrestrial food sources and therefore scored low in the diet

Table 3.1 -- AMPHIBIANS -- Indicator species criteria scores received by 15 species of amphibians which inhabit the aquatic component of the Fraser River Basin, British Columbia.

SPECIES	INDICATOR SPECIES CRITERIA																	
	Fundamental Ecological Attributes					*Ecological Information Documented*							*Ease of Collection*		*Suitability for Lab Study*		*Contaminant Knowledge Available*			
	Yr. round resident	*Broad distribution*	*Abundance*	*% Aquatic diet*		*Habitat range*	*Habitat type*	*Reproduction*	*Migratory*	*Historic abundance/ distribution*	*Easy to locate*	*Easy to collect*	*Captive rearing*	*Captive breeding*	*Residue history*	*Other regions*	*Biological effects*	**Total**
	1a	**1b**	**1c**	**1d**	**sub total**	**2a**	**2b**	**2c**	**2d**	**2e**	**3a**	**3b**	**4a**	**4b**	**5a**	**5b**	**5c**	
Rough-skinned Newt	1	1	0	2	**4**	0	1	1	1	0	1	1	1	0	0	1	1	**12**
Pacific Treefrog	1	2	1	0	**4**	0	1	1	0	0	1	1	1	0	0	1	1	**11**
Long-toed Salamander	1	2	0	1	**4**	0	1	1	1	0	1	1	1	0	0	0	0	**10**
Western Toad	1	2	1	0	**4**	0	1	1	0	0	1	0	1	0	0	1	1	**10**
Wood Frog	1	1	1	0	**3**	0	1	1	0	0	1	1	1	0	0	1	1	**10**
Northwestern Salamander	1	0	0	1	**2**	0	1	1	1	0	1	1	1	0	0	1	1	**10**
Bullfrog	1	0	0	0	**1**	0	1	1	0	0	1	1	1	1	0	1	1	**9**
Green Frog	1	0	0	0	**1**	0	1	1	0	0	1	1	1	1	0	1	1	**9**
Spotted Frog	1	2	1	0	**4**	0	1	1	0	0	1	0	0	0	0	0	0	**7**
Tailed Frog	1	1	0	0	**2**	0	1	1	0	0	1	1	0	0	0	0	0	**6**
Great Basin Spadefoot Toad	1	0	0	0	**1**	1	1	1	1	0	1	0	0	0	0	0	0	**6**
Red-legged Frog	1	0	0	0	**1**	0	1	1	0	0	1	1	1	0	0	0	0	**6**
Pacific Giant Salamander	1	0	0	1	**2**	0	1	1	1	0	0	0	0	0	0	0	0	**5**
Ensatina	1	1	0	0	**2**	0	1	1	1	0	0	0	0	0	0	0	0	**5**
Western Redback Salamander	1	0	0	0	**1**	0	1	1	1	0	0	0	0	0	0	0	0	**4**
Maximum Possible Score	1	2	1	2	**6**	1	1	1	1	2	1	1	1	1	1	1	1	**19**

Table 3.2 -- BIRDS -- Indicator species criteria scores received by 27 species of birds which inhabit the aquatic component of the Fraser River Basin, British Columbia.

SPECIES	INDICATOR SPECIES CRITERIA																	
	Fundamental Ecological Attributes					*Ecological Information Documented*							*Ease of Collection*		*Suitability for Lab Study*		*Contaminant Knowledge Available*		
	Yr. round resident	*Broad distribution*	*Abundance*	*% Aquatic diet*		*Habitat range*	*Habitat type*	*Reproduction*	*Migratory*	*Historic abundance/ distribution*	*Easy to locate*	*Easy to collect*	*Captive rearing*	*Captive breeding*	*Residue history*	*Other regions*	*Biological effects*	**Total**
	1a	**1b**	**1c**	**1d**	**sub total**	**2a**	**2b**	**2c**	**2d**	**2e**	**3a**	**3b**	**4a**	**4b**	**5a**	**5b**	**5c**	
Great Blue Heron	0	1	1	2	**4**	1	1	1	1	2	1	1	1	0	1	1	1	**16**
Osprey	0	2	0	2	**4**	1	1	1	1	1	1	1	1	0	1	1	1	**15**
Bald Eagle	0	2	0	2	**4**	1	1	1	1	0	1	1	1	1	1	1	1	**15**
Common Merganser	1	2	1	2	**6**	0	1	1	1	0	1	1	1	0	0	1	1	**14**
Bufflehead	0	2	1	2	**5**	1	1	1	1	0	1	1	1	1	0	1	0	**14**
Tree Swallow	0	2	0	2	**4**	1	1	1	1	0	1	1	1	0	1	1	1	**14**
Common Goldeneye	1	2	0	2	**5**	1	1	1	1	0	1	0	1	0	0	1	1	**13**
Red-necked Grebe	0	1	1	2	**4**	1	1	1	1	2	1	1	0	0	0	1	0	**13**
Eared Grebe	0	1	1	2	**4**	1	1	1	1	2	1	1	0	0	0	1	0	**13**
Western Grebe	1	0	0	2	**3**	1	1	1	1	2	1	1	1	0	0	1	0	**13**
Hooded Merganser	1	2	1	2	**6**	0	1	1	1	0	1	1	0	0	0	1	0	**12**
Barrow's Goldeneye	0	2	0	2	**4**	1	1	1	1	0	1	1	1	0	0	0	0	**11**
Belted Kingfisher	0	2	0	2	**4**	1	1	1	1	0	1	0	1	0	0	1	0	**11**
Horned Grebe	0	2	0	2	**4**	0	1	1	1	0	1	1	0	0	0	1	0	**10**
Violet-green Swallow	0	2	0	0	**2**	0	1	1	1	0	1	1	1	1	0	1	0	**10**
Red-winged Black Bird	0	2	0	0	**2**	1	1	1	0	0	1	1	1	0	0	1	1	**10**
Pied-billed Grebe	0	2	1	2	**5**	0	1	1	1	0	0	1	0	0	0	0	0	**9**
Common Loon	0	2	0	2	**4**	1	1	1	1	0	1	0	0	0	0	0	0	**9**
Lesser Scaup	1	1	1	1	**4**	0	1	1	1	0	0	1	0	0	0	1	0	**9**
Ruddy Duck	0	2	1	1	**4**	0	1	1	1	0	0	0	1	0	0	1	0	**9**
American Dipper	1	2	0	2	**5**	0	1	1	1	0	0	0	0	0	0	0	0	**8**
White-winged Scoter	0	1	1	2	**4**	0	1	1	1	0	0	0	0	0	0	1	0	**8**
Canvasback	1	1	1	0	**3**	0	1	1	1	0	0	1	0	0	0	1	0	**8**
Redhead	1	1	0	0	**2**	0	1	1	1	0	0	1	0	0	0	1	1	**8**
Ring-necked Duck	0	2	0	0	**2**	0	1	1	1	0	0	1	0	0	0	1	1	**8**
Harlequin	0	2	0	2	**4**	0	1	1	1	0	0	0	0	0	0	0	0	**7**
Cliff Swallow	0	2	0	0	**2**	0	1	1	1	0	1	0	0	0	0	0	0	**6**
Maximum Possible Score	1	2	1	2	**6**	1	1	1	1	2	1	1	1	1	1	1	1	**19**

Table 3.3 -- MAMMALS -- Indicator species criteria scores received by 15 species of mammals which inhabit the aquatic component of the Fraser River Basin, British Columbia.

SPECIES	INDICATOR SPECIES CRITERIA																	
	Fundamental Ecological Attributes					*Ecological Information Documented*							*Ease of Collection*		*Suitability for Lab Study*		*Contaminant Knowledge Available*		
	Yr. round resident	*Broad distribution*	*Abundance*	*% Aquatic diet*		*Habitat range*	*Habitat type*	*Reproduction*	*Migratory*	*Historic abundance/ distribution*	*Easy to locate*		*Easy to collect*	*Captive rearing*	*Captive breeding*	*Residue history*	*Other regions*	*Biological effects*	**Total**
	1a	**1b**	**1c**	**1d**	**sub total**	**2a**	**2b**	**2c**	**2d**	**2e**	**3a**	**3b**	**4a**	**4b**	**5a**	**5b**	**5c**	
River Otter	1	2	1	2	**6**	1	1	1	1	2	1	1	1	1	1	1	1	**19**
Mink	1	2	1	0	**4**	1	1	1	1	2	1	1	1	1	1	1	1	**17**
Little Brown Bat	0	2	1	2	**5**	0	1	1	1	0	0	1	1	0	0	1	1	**12**
Muskrat	1	2	1	0	**4**	1	1	1	1	2	1	1	0	0	0	0	0	**12**
Big Brown Myotis	1	2	0	0	**3**	1	1	0	1	0	1	1	0	0	0	1	1	**10**
Yuma Myotis	0	1	0	2	**3**	1	1	1	0	0	0	1	1	0	0	0	0	**8**
California Myotis	0	1	1	0	**2**	0	1	0	0	0	1	1	0	0	0	1	0	**6**
Long-legged Myotis	0	2	0	0	**2**	0	0	1	1	0	0	1	0	0	0	1	0	**6**
Western Small-footed Myotis	1	0	0	1	**2**	0	1	0	1	0	1	0	0	0	0	0	0	**5**
Western Long-eared Myotis	0	2	0	0	**2**	0	1	0	0	0	1	0	0	0	0	1	0	**5**
Townsend's Big-eared Bat	1	1	0	0	**2**	0	1	1	1	0	0	0	0	0	0	0	0	**5**
Fringed Myotis	1	0	0	0	**1**	0	1	1	1	0	0	1	0	0	0	0	0	**5**
Silver-haired Myotis	0	2	0	0	**2**	0	1	0	0	0	0	0	0	0	0	1	0	**4**
Hoary Bat	0	1	0	0	**1**	0	0	1	0	0	0	0	0	0	0	0	0	**2**
Spotted Myotis	0	0	0	0	**0**	1	1	0	0	0	0	0	0	0	0	0	0	**2**
Maximum Possible Score	1	2	1	2	**6**	1	1	1	1	2	1	1	1	1	1	1	1	**19**

Table 3.4 -- AMPHIBIANS -- Summary of aquatic diet information for 15 amphibian species inhabiting the aquatic component of the Fraser River Basin, British Columbia.

SPECIES	Age Class			Components						
	Adult	Young	% of Aquatic Animals in Diet	Plants	Detritus	Aquatic / Terr. Invertebrates	Aquatic Insects	Terrestrial Insects	Amphibian	Fish
Rough Skinned Newt	x	x	>50		x	x	x	x		
Northwestern Salamander	x		0		x			x		
		x	>50		x	x		x		
Long-toed Salamander	x		0		x		x			
		x	100		x	x		x		
Pacific Giant Salamander	x		0		x		x	x		
		x	>50			x	x	x	x	
Ensatina Salamander	x	x	0		x		x			
Western Redback Salamander	x	x	0		x		x			
Tailed Frog	x		<50		x	x	x			
		x	0	x						
Great Basin Spadefoot Toad	x		0				x			
		x	<50	x	x			x		
Western Toad	x		0				x			
		x	0	x	x					
Pacific Treefrog	x		<50			x	x			
		x	0	x	x					
Red-legged Frog	x		0		x		x			
		x	0	x	x					
American Bullfrog	x		<50					x	x	
		x	0	x	x					
Green Frog	x		<50					x	x	
		x	0	x	x					
Spotted Frog	x		<50				x	x		
		x	0	x						
Wood Frog	x		0		x		x			
		x	0	x	x					

Table 3.5 -- BIRDS -- Summary of aquatic diet information for 27 avian species inhabiting the aquatic component of the Fraser River Basin, British Columbia.

SPECIES	Age Class			Components of Diet						
	Adult	Young	% of Aquatic Animals in Diet	Plants	Aquatic / Terr Invertebrates	Aquatic Insects	Terrestrial Insects	Amphibian	Fish
Common Loon	x	x	100		x				x
Pied-billed Grebe	x	x	100		x			x	x
Horned Grebe	x	x	100		x	x			x
Red-necked Grebe	x		>50		x	x	x	x	x
		x	>50			x	x		
Eared Grebe	x	x	100		x	x		x	x
Western Grebe	x		100		x	x		x	x
		x	100			x			
Great Blue Heron	x	x	>50		x			x	x
Canvasback	x		<50	x	x	x			
		x	<50	x		x			
Redhead	x	x	<50	x		x			
Ring-necked Duck	x	x	<50	x	x	x			
Lesser Scaup	x		<50	x	x				
		x	>50		x	x			
Harlequin	x	x	100		x	x			x
White-winged Scoter	x	x	>50	x	x	x			
Common Goldeneye	x	x	>50		x	x			
Barrow's Goldeneye	x	x	>50		x	x			
Bufflehead	x	x	>50		x	x			
Hooded Merganser	x	x	100		x	x			x
Common Merganser	x		100						x
		x	100			x			x
Ruddy Duck	x	x	>50		x	x			
Osprey	x	x	100						x
Bald Eagle	x	x	>50						x
Belted Kingfisher	x	x	>50		x			x	x
Tree Swallow	x	x	>50			x	x		
Violet-green Swallow	x		?			x	x		
Cliff Swallow	x	x	?	x		x	x		
American Dipper	x	x	100		x				x
Red-winged Blackbird	x	x	?	x	x	x	x		

criterion, while others were given a zero because their diet had not been sufficiently documented.

3.2 Species Scores Resulting from all Criteria

When all criteria (1 - 5) were considered together, it quickly became evident that some species scored poorly because they had not been extensively researched and very little was actually known about them (Tables 3.1- 3.3; Appendices 1-3, for detailed species accounts). This is especially true with the amphibians and bats where the highest score in each case was only 12, as compared to the River Otter which obtained a maximum score of 19. Second to the River Otter was the Mink (17), followed by the Great Blue Heron (16), and the Osprey and Bald Eagle (both scored 15).

In general, amphibians scored well in criteria 3a and 3b as they are relatively easy to collect. Due to the small required size of habitat, many amphibians already have been, or may successfully be raised and bred in captivity (criterion 4). Some species scores were limited because published descriptions of captive rearing could not be located. It is of interest that no previous environmental contaminant studies on amphibians have been conducted in the Fraser Basin, while they have in other regions (criterion 5). A FRAP-funded study is currently underway to assess the effects of agricultural pollutants on amphibian breeding in the Sumas River drainage basin. This study is expected to be completed by the spring of 1998.

The Great Blue Heron scored 16, and appeared to be the bird species with the greatest potential for use as an indicator. The Osprey and Bald Eagle also scored high, both scoring 15. Two of three other bird species scoring 14, could be upgraded to 15 if a sample were collected for contaminant analysis. For example, the Common Merganser (14), had already scored a maximum of six in criterion 1- fundamental ecological attributes. Research examining its home range (criterion 2a), a search for unpublished records on its historic abundance (criterion 2e), and a contaminant residue analysis study would raise its score to 18. A similar situation occurs with the Hooded Merganser. Its even lower score of 12 reflects the lack of knowledge in the area of captive breeding and its uncommon use as an indicator in environmental contaminant monitoring (criterion 5).

Judgment on criterion 3 was more complicated for waterfowl as samples could feasibly be collected during three life stages (egg, juveniles, and adults), and that each life stage could occur in a different habitat. In an attempt to standardize, waterfowl were scored according to the ease of collecting eggs. If allowances are made for juveniles or adults to be collected by trapping or shooting from a distance, there is room to upgrade a few species, especially those nesting in very concealed or inaccessible locations. To this date, only four of the bird species (Great Blue Heron, Osprey, Bald Eagle, Tree Swallow), have been selected for environmental contaminant monitoring programs within the Fraser Basin (criterion 5a). A contaminant residue survey examining tissue samples from a broad range of bird species may provide the information necessary to raise most scores by another point.

Aside from the River Otter and Mink, most species of mammals scored below ten. The Little Brown Myotis is worthy of some further study. Although it received a score of twelve, it could easily be upgraded by four points if: a) its home range is examined (criterion 2a); b) abundance surveys are conducted (criterion 2e); c) bat houses are erected and roost sites are catalogued (criterion 3a); and d) samples are collected for baseline contaminant residue analysis (criterion 5a). In general, all bats will score low in criterion 3b, as sampling tends to be invasive and disruptive.

3.3 Aquatic Diet Information

The score for criterion 1d is one of the more significant, and deserves further discussion. It represents whether or not 50% of a given species' diet falls within the aquatic food chain. It also takes into account the unique diet needs of young versus adults. The main reason for such considerations has to do with the mechanisms of contaminant exposure.

Aside from direct contact with harmful chemicals, organisms can indirectly be exposed to compounds through their diet. Contaminants, including some heavy metals (e.g. cadmium), and persistent organochlorines can bioaccumulate in animal tissues (muscle, bone, organ), and when one organism is consumed by another, the contaminant is passed along the food chain to the higher trophic level. As a result of successive biomagnification, organisms at the top of the food chain tend to have the greatest contaminant burdens. Hence, it is extremely important to identify a species' position in the food chain and to examine what proportion of its diet, at different life stages, is of aquatic, as opposed to terrestrial origins. For example, young American Bullfrogs consume plants and detritus, while adults feed on other amphibians and fish that are one or two trophic levels up on the food chain. Collecting a sample of bullfrog tadpoles may reveal a very different contaminant profile when compared to the results from a sample of adults.

For each of the classes, summaries of aquatic diet information are presented in Tables 3.4, 3.5 and 3.6.

Table 3.6 -- MAMMALS -- Summary of aquatic diet information for 15 mammalian species inhabiting the aquatic component of the Fraser River Basin, British Columbia.

SPECIES	Age Class		Components of Diet						
	Adult	Young [1]	% of Aquatic Animals in Diet	Plants	Aquatic / Terr. Invertebrates	Aquatic Insects	Terrestrial Insects	Amphibian	Fish
Big Brown Bat	x		0			x			
Spotted Bat	x		0			x			
Silver-haired Bat	x		<50		x	x			
Hoary Bat	x		<50		x	x			
California Myotis	x		<50		x	x			
Western Small-footed Myotis	x		>50		x	x			
Western Long-eared Myotis	x		<50		x	x			
Little Brown Myotis	x		>50		x	x			
Fringed Myotis	x		<50		x	x			
Long-legged Myotis	x		<50		x	x			
Yuma Myotis	x		>50		x				
Townsend's Big-eared Bat	x		<50			x			
Muskrat	x		0	x					
River Otter	x		>50				x		x
Mink	x		<50		x		x		x

1. *Mammalian young are suckled, therefore, their diet was not differentiated from that of adults.*

4.0 CONCLUSIONS

The choice of an appropriate indicator species for a particular contaminant in the aquatic ecosystem requires integrating the criteria information available in Tables 3.1 - 3.3, the aquatic diet information summarized in Tables 3.4 - 3.6, and the more detailed references of Appendices 1 - 3. In order to do this, the investigator must posses a knowledge of the chemical characteristics of a compound (or class of compounds) within an ecological context.

The selection process described in this study is meant for use as a guide only. Before any decision can be made on an indicator species, sufficient information about the chemistry of the contaminant in question is prerequisite, as well as an idea of the objectives of the project or monitoring scheme proposed. In addition, it is emphasized that poor scores do not necessarily reflect unsuitability, and species with such scores should not be hastily disregarded. In fact, should an investigator examine what information is missing, determine the significance of it, and proceed to acquire the data, an initially unattractive species may actually prove to be quite useful as an indicator of contamination.

With a few exceptions, the information in this report used to develop the ranking criteria, and included in the Annotated Bibliography, is dated prior to December 31, 1993. At the time of compiling this report, with respect to the information provided on the Tree Swallow, it was known that the Canadian Wildlife Service would begin sample collection and analysis in the spring of 1994. The collection of osprey and eagle data also continued into 1996 and 1997, respectively. It is highly recommended that the report be periodically reviewed and amended to include the most current research findings.

GLOSSARY

benthic A collective term used to describe organisms inhabiting the bed of aquatic ecosystems.

bioaccumulation A process by which contaminants are ingested and retained as a consequence of rate of intake being greater than rate of loss from the body, resulting in increasing levels of toxic substances over time with continued exposure.

biological effects Any identifiable and quantifiable biological changes resulting as a consequence of exposure to the harmful effects of chemical, physical, or biological agents.

biomagnification A cumulative increase in the concentration of a persistent substance in successively higher levels of the food chain.

dose-response The relationship between concentration of a chemical and the effects of an organism.

ecology The study of the interactions of organisms with their physical environment and with each other and of the results of such interactions.

ecoprovince An ecological unit of ecosystem classification and mapping developed for British Columbia to provide a systematic view of the broad geographic relationships of the province; common scale of presentation = 1: 7 000 000

ecosection An area with minor physiographic and macroclimatic or oceanographic variation; common scale of presentation = 1: 2 000 000 (See ECOPROVINCE)

ecosystem The organisms in a community plus the associated abiotic factors with which they interact.

food chain The system of trophic (feeding) levels found within a biotic community. Organisms within the levels are related to one another as prey and predator.

food web A set of linked food chains, through which energy and materials move within a particular ecosystem.

indicator species An animal species whose presence (or state of health), is used to indicate the presence or absence of a contaminant, or as a measure of ecological conditions or changes occurring in the environment.

life cycle The entire span of existence of an organism from time of zygote formation, through progressive series of changes or developments, until it itself reproduces.

mutagenic The property of a chemical that causes the genetic characteristics of an organism to change in such a way that future generations are permanently affected.

natural history The natural development of an organism over a period of time.

roost A place where birds (or bats) customarily rest.

teratogenic The capacity of a chemical to form congenital (birth) defects.

toxicology The branch of science devoted to the study of poisons, including their mode of action, effects, detection and counter-measures.

trophic level A position occupied in the food web by organisms feeding on the same general type of food.

APPENDIX 1

CLASS AMPHIBIA

Species are ordered taxanomically as follows:

ROUGH-SKINNED NEWT *Taricha granulosa*

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
Found along the Fraser River as far up as Lillooet (Orchard 1984).

1c. **Common in the Fraser Basin?**
No, occurs only on the coast and up the Fraser Valley as far as Lillooet (Orchard 1984).

1d. **Proportion of diet within the aquatic food web.**
Females feed on a variety of terrestrial arthropods (Orchard 1984). Males and larvae eat aquatic insects, crustaceans, worms and tadpoles (Orchard 1984).

2a. **Has the home range of the species been described?**
No.

2b. **Habitat selection is well documented?**
Mixed forests usually near permanent ponds or swamps. They prefer open woods with plenty of deadfall and leaf litter. They do not like dense damp cedar forests but prefer coastal Douglas-fir and Western Hemlock. Adult females hibernate on land while males are mostly aquatic. Males may be found in lakes, ponds, fresh water marshes and slow-moving streams (Orchard 1984).

2c. **Breeding biology is well understood?**
During the breeding season females move down stream to where the males are located. Breeding occurs in early spring in shallow ponds, bogs, swamps and lakes. Eggs are laid shortly after mating and are attached singly to aquatic plants. The larvae eat small aquatic invertebrates and may take one or two seasons to transform (Green and Campbell 1984; Orchard pers. comm.1994).

2d. **Migration behaviour is well documented?**
Large numbers will migrate to breeding sites on warm rainy nights in spring (Orchard pers. comm.1994). Where busy roads intersect migration routes adult females and transformed juveniles are killed in great numbers (Orchard 1984).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
Breeding sites should be easy to locate (Orchard pers. comm. 1994).

3b. **Can samples be easily collected?**
Eggs are laid on the edges of sticks, they are pea-sized clumps and should be possible to find (Orchard pers. comm.1994).

4a. **Captive rearing possible and well understood?**
Yes, this has been mentioned in Orchard (1984) but there are no details.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Willis and Valett 1971; Willis *et al*. 1976 and Willis and Valett 1978, reviewed in Harfenist *et al*. 1989).

5c. **Have biological effects for this species been studied?**
Yes (Willis and Valett 1971; Willis *et al*. 1976 and Willis and Valett 1978, reviewed in Harfenist *et al*. 1989).

NORTHWESTERN SALAMANDER ***Ambystoma gracile***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
No, this species is limited to Vancouver Island the coast range and up the Fraser Valley as far east as Hope (Orchard 1984; Green and Campbell 1984).

1c. **Common in the Fraser Basin?**
No, common only on Vancouver Island and in the coast mountains of B.C. (Orchard 1984).

1d. **Proportion of diet within the aquatic food web.**
The diet of the metamorphosed adult is not well documented. It is believed that adults eat slugs and soft bodied invertebrates. Diet of larvae and neotenes seems to be better known. They feed on larval freshwater clams, leeches, water fleas, seed shrimp, sideswimmers, adult and larval flies, larval dragonflies, damselflies and tadpoles (Orchard 1984).

2a. **Has the home range of the species been described?**
No.

2b. **Habitat selection is well documented?**
Metamorphosed adults are not often seen. They seem to prefer dense forest margins and pond banks but probably spend most of their time hidden underground beneath leaf litter or rotten logs. Larvae and neotenic adults (larvae which have developed sexually without transforming) are found in permanent lakes or ponds and slow-moving streams generally with soft bottoms (Orchard 1984).

2c. **Breeding biology is well understood?**
Metamorphosed adults migrate to ponds or lakes in early spring to breed. They require permanent or semi-permanent water. Breeding sites are usually devoid of fish which would feed on the eggs and larvae. Egg masses are laid around submerged twigs or stems and are very large - the size of a baseball. Eggs hatch in about three months. Empty jelly masses can still be seen in late summer. Larvae take a year to reach metamorphose if they do at all.

2d. **Migration behaviour is well documented?**
Metamorphosed adults migrate from dense forest habitat to nearby water to breed between March and June. Larvae take a year to reach metamorphosis after which they leave the water. Juveniles leave the water between March and October (Orchard 1984).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
Locating egg masses, larvae and neotenes should be quite easy (Orchard pers. comm. 1994).

3b. **Can samples be easily collected?**
Yes (Orchard pers. comm.1994).

4a. **Captive rearing possible and well understood?**
Yes (Geen *et al*. 1986, reviewed in Harfenist *et al*. 1989).

4b. **Captive breeding possible and well understood?**
Insufficient information

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Geen *et al*. 1986, reviewed in Harfenist *et al*.1989).

5c. **Have biological effects for this species been studied?**
Yes (Geen *et al*.1986 reviewed in Harfenist *et al*.1989).

LONG-TOED SALAMANDER ***Ambystoma macrodactylum***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
Yes (Green and Campbell 1984; Orchard 1984), however, Orchard (1984) states that the range limits of the three subspecies that reside in B.C. are poorly defined.

1c. **Common in Fraser Basin?**
Not often seen outside of the breeding season because they spend large amounts of time underground (Green and Campbell 1984). As they are not commonly encountered it is difficult to say whether they are common or not.

1d. **Proportion of diet within the aquatic food web.**
Adults feed on terrestrial arthropods such as snail and invertebrates. Larvae feed on aquatic insect larvae, larval clams and predacious cannibalism has also been observed (Orchard 1984).

2a. **Has the home range of the species been described?**
Mild humid climates - this species is not bound to breeding in permanent water and may range far from it (Orchard 1984).

2b. **Habitat selection is well documented?**
These are the most adaptable salamanders native to B.C.. Where conditions are dry or cold they are likely to remain near to permanent water (Orchard 1984). They prefer damp areas at forest margins where there is lots of cover and generally not far from standing water. Breeds in shallow permanent ponds with aquatic vegetation (Green and Campbell 1984) except where conditions are mild and humid in which case they may use non permanent bodies of water (Orchard 1984).

2c. **Breeding biology is well understood?**
Mating activity occurs in early spring (March) when weather is wet, often before ice on breeding ponds has fully melted. Soon after mating female will lay eggs (Green and Campbell 1984). Eggs are sometimes laid singly but usually in small clumps attached to underwater vegetation (Orchard pers. comm.1994). Eggs hatch in two to three weeks. Larvae may over-winter in pond and transform the following summer. They take two to three years to mature (Green and Campbell 1984). If conditions become dry, larvae may undergo an induced metamorphosis (Orchard 1984).

2d. **Migration behaviour is well documented?**
Timing of migration to breeding sites by metamorphosed adults, and later of metamorphosed larvae from water to land, are triggered by suitable temperature and moisture thresholds. These conditions will of course vary considerably from one season to the next but also from one area of the Fraser Basin to another. Migrations occur at night, during or after a rain (Orchard pers. comm. 1994).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
Finding metamorphosed adults would be very difficult as they spend most of their time underground except during the breeding season. They are the most highly terrestrial of all the salamanders in B.C.. Larvae are in pools of water until metamorphosis. Their size can range considerably depending on when the eggs were laid, and on temperature and food availability. No neotenic stage.

3b. **Can samples be easily collected?**
Yes, (Orchard pers. comm. 1994).

4a. **Captive rearing possible and well understood?**
Yes, it is possible and has been done, but it is not well documented (Orchard pers. comm.).

4b. **Captive breeding possible and well understood?**
Not documented.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

PACIFIC GIANT SALAMANDER ***Dicamptodon ensatus***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
No, the species is confined to the Chilliwack River drainage system (Orchard 1984).

1c. **Common in Fraser Basin?**
No, occurs only in the lower Fraser Valley at Cultus and Chilliwack Lakes.

1d. **Proportion of diet within the aquatic food web.**
Metamorphosed adults will feed on slugs, insects, frogs, other salamanders, garter snakes and occasionally small mammals. Larvae and neotenic adults prey on other terrestrial and aquatic insects, sculpins, salmonids and amphibian larvae (Orchard 1984; Green and Campbell 1984).

2a. **Has the home range of the species been described?**
No.

2b. **Habitat selection is well documented?**
The Pacific Giant Salamander is the only stream-dwelling salamander in B.C. It is associated with cold permanent streams, rivers and lakes surrounded by unlogged mature Douglas-fir and Big-leaf Maple forests on the slopes of hills and mountains. These salamanders rarely venture far from clear, fast-flowing creeks and usually hide under logs or rocks by streams (Green and Campbell 1984). Larvae hide under stones in streams, rivers and lakes and forage by night (Orchard 1984).

2c. **Breeding biology is well understood?**
Breed in spring. Eggs are laid in water where they are deposited in underground springs. Eggs are colourless and the female usually remains with them until they hatch in the fall (Orchard 1984). Larvae are aquatic and grow slowly and may transform in their second or third year or they may remain as neotenes. Neoteny is very common in this species, in fact metamorphosed adults are comparatively rare (Orchard pers. comm. 1994).

2d. **Migration behaviour is well documented?**
Non-migratory.

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
No, locating egg masses would be very difficult and very disruptive, however, collecting larvae or neotenes might be possible.

3b. **Can samples be easily collected?**
Collecting eggs would be very difficult. Collecting larvae and neotenes would be possible, however, the species is 'red listed' which may mean that collecting specimens would not be appropriate at all.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

ENSATINA SALAMANDER ***Ensatina eschscholtzii***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
No.

1c. **Common in the Fraser Basin?**
No, only up the Fraser River until just past Hope (Orchard 1984).

1d. **Proportion of diet within the aquatic food web.**
Sowbugs, mites, earthworms, spiders and many other types of insects (Orchard 1984).

2a. **Has the home range of the species been described?**
No.

2b. **Habitat selection is well documented?**
Never resorts to water. Prefers damp Douglas-fir forests with loose well-drained substrate (Orchard 1984).

2c. **Breeding biology is well understood?**
Mating seems to occur in early spring. Eggs are laid in late spring. These are clusters of colourless eggs. They are placed in underground chambers or in rotted logs. One parent broods the eggs all summer. The eggs hatch in fall and are fully developed (Green and Campbell 1984; Orchard pers. comm. 1994).

2d. **Migration behaviour is well documented?**
Non-migratory.

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
Seems like it could be quite difficult to find enough individual nests.

3b. **Can samples be easily collected?**
Would likely be highly disruptive since the female broods the eggs.

4a. **Captive rearing possible and well understood?**
Not documented.

4b. **Captive breeding possible and well understood?**
Not documented.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

WESTERN REDBACK SALAMANDER ***Plethodon vehiculum***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
No.

1c. **Common in the Fraser Basin?**
No, occurs mainly on the coast and only up the Fraser Valley as far as Hope (Orchard 1984).

1d. **Proportion of diet within the aquatic food web.**
Not well documented. Feeds on soft-bodied invertebrates that inhabit forest floor (Orchard 1984).

2a. **Has the home range of the species been described?**
No.

2b. **Habitat selection is well documented?**
Strictly ground dwelling, does not resort to water to breed. Occurs in cool damp, dark locations on the forest floor such as beneath boards, logs and rocks. They retreat into cavities where they can avoid drying out. It is also in such cavities that they nest (Orchard 1984).

2c. **Breeding biology is well understood?**
Nest in cavities where they are protected from desiccation. Eggs are attended by at least one parent until they hatch. Juveniles emerge as fully formed adults. Breeding occurs in March until May and juveniles hatch out in September (Orchard 1984).

2d. **Migration behaviour is well documented?**
Non-migratory.

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
Locating nest cavities could be difficult and highly disruptive.

3b. **Can samples be easily collected?**
It would not be easy to sample eggs and juveniles because of the difficulty in finding them. It might be possible, however, to locate adults by pitfall trapping.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

TAILED FROG ***Ascaphus truei***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
Limited to the coastal and central regions of the Fraser Basin. With the exception of one location in the interior, Tailed Frogs occur along the Fraser River only as far up as the junction of the Thompson and Fraser Rivers (Orchard 1984; Green and Campbell 1984).

1c. **Common in Fraser Basin?**
No.

1d. **Proportion of diet within the aquatic food web.**
Adults eat terrestrial and aquatic insects including snails, pseudoscorpions, ticks, mites, spiders, centipedes, millipedes. Tadpoles feed on algae and diatoms which they scrape from the rocks of mountain streams (Orchard 1984; Green and Campbell 1984).

2a. **Has the home range of the species been described?**
Not well known, however, metamorphosed adults must move up and down stream along the banks to account for complete colonisation of streams above and below waterfalls (Orchard pers. comm. 1994).

2b. **Habitat selection is well documented?**
Inhabits mountain streams in undisturbed forests. They require cold, clear, unsilted water. During the day they are most often found under rocks by the stream or in small rivulets, they wander off through the forest on rainy days (Green and Campbell 1984; Orchard 1992).

2c. **Breeding biology is well understood?**
Breed in the fall. Sperm remain viable in the females oviduct until many months later. Egg laying in fact does not occur until the following mid-summer. Eggs are laid under stones in stream beds. The tadpoles can cling with great force to the rocks in the stream and they are able to negotiate the swiftest currents. Tadpoles take two, or possibly even three, years to transform into frogs. They reach maturity in seven years (Green and Campbell 1984; Orchard 1992).

2d. **Migration behaviour is well documented?**
Metamorphosed adults will forage terrestrially along small rivulets that extend into the forest during rainy conditions (Orchard 1984). No other details.

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
Should be quite easy to find tadpoles. Generally there are several generations in one stream because the tadpoles take three years to reach metamorphosis. Finding eggs would be next to impossible without being highly disruptive (Orchard pers. comm 1994).

3b. **Can samples be easily collected?**
Collecting tadpoles would be fairly easy (Orchard pers. comm. 1994).

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

GREAT BASIN SPADEFOOT TOAD *Scaphiopus intermontanus*

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
No, only in the Okanagan and Nicola valleys and as far north as 70 Mile House in the Cariboo region (Green and Campbell 1984).

1c. **Common in Fraser Basin?**
No, this species is threatened (Orchard 1984; Orchard 1992).

1e. **Proportion of diet within the aquatic food web.**
Diet of the adult is not well known although they are known to consume insects (Orchard 1984). The tadpoles feed voraciously on anything organic including algae, aquatic plants, dead fish, other tadpoles and even their own faeces (Green and Campbell 1984).

2a. **Has the home range of the species been described?**
Has not been measured but they generally seem to be within calling distance of spawning sites (2 km) (Orchard pers. comm 1994).

2b. **Habitat selection is well documented?**
Open woodlands, meadow, sage or bunchgrass prairie. It is unable to live in true desert. Often found near permanent lakes or ponds but will range far afield to higher elevations (Green and Campbell 1984).

2c. **Breeding biology is well understood?**
Breeds in early summer in temporary pools or the shallows of lakes when conditions are adequate. These are alkaline or saline pothole lakes without fish populations (Orchard 1992). Generally they will wait for a rain before breeding. The males call in choruses (Green and Campbell 1984). Females lay their black eggs in clumps in shallow water (Orchard pers. comm. 1994). The tadpoles transform in

about six weeks to toadlets 20 to 25mm long and reach maturity in two to three years (Green and Campbell 1984).

2d. **Migration behaviour is well documented?**
Outside the breeding season they spend at lot of time underground. Migration is initiated by a temperature:rain threshold and by the mating call of the male. Hearing the call causes other toads to begin migrating to the spawning site (Orchard pers. comm. 1994).

2e. **Information on historic abundance?**
They are known to have been abundant at several localities in the Ponderosa pine - bunchgrass biogeoclimatic zone (Orchard 1984) but their numbers are declining due to several factors including destruction of breeding habitat by cattle and four-wheel drive vehicles (Orchard 1992).

3a. **Can nests or animal be easily located?**
Chorusing males should make locating breeding sites relatively easy, however, breeding may not occur every year if there is not enough rain and warm temperatures (Orchard pers. comm.1994).

3b. **Can samples be easily collected?**
May be difficult. The eggs are not conspicuous and tend to be scattered. If the water is muddy then finding them would be even more difficult. It would be best to be on site when breeding occurs (Orchard pers. comm. 1994).

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

WESTERN TOAD *Bufo boreas*

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
Yes.

1c. **Common in Fraser Basin?**
Yes (Orchard 1984).

1d. **Proportion of diet within the aquatic food web.**
Adults feed on spiders, centipedes, and crustaceans but 95% of their diet is insects. Tadpoles feed on bottom detritus and algae (Orchard 1984).

2a. **Has the home range of the species been described?**
No.

2b. **Habitat selection is well documented?**
This species is primarily terrestrial and only resorts to water for a short period in the spring to breed (Orchard 1984). Found in fields, forests or meadows. They will roam quite far from standing water but prefer damp conditions. They do not occur in urban areas but they do well in rural farming districts (Green and Campbell 1984).

2c. **Breeding biology is well understood?**
In spring they congregate at small ponds or pools to breed. Prefer shallow water with a sandy bottom. They can use temporary pools beside rivers or lakes because the tadpoles transform within a season (Orchard 1984). Eggs are laid in long strings entwined among submerged vegetation. There are two strings of eggs laid per female. A single female can produce more than 12,000 eggs (Orchard pers. comm. 1994). Tadpoles develop rapidly and transform into 10 mm toadlets in about six to eight weeks. In mid-summer tadpoles and toadlets aggregate in large numbers around the banks of the breeding ponds (Green and Campbell 1984).

2d. **Migration behaviour is well documented?**
Not studied in B.C.

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
Should be possible to locate breeding sites (Orchard pers. comm. 1994).

3b. **Can samples be easily collected?**
Collecting eggs may be site dependent, eggs may be carried along by the currents as they are laid or they may settle near the bottom of ponds. The eggs themselves are small and black (Orchard pers. comm. 1994).

4a. **Captive rearing possible and well understood?**
Yes (Johnson and Prine 1976; Porter and Hakanson 1976 reviewed in Harfenist *et al*. 1989).

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Mulla 1962; Mulla *et al*. 1963; Johnson and Prine 1976; Porter and Hakanson 1976, reviewed in Harfenist *et al*. 1989).

5c. **Have biological effects for this species been studied?**
Yes (Mulla 1962; Mulla *et al*. 1963; Johnson and Prine 1976; Porter and Hakanson 1976 reviewed in Harfenist *et al*. 1989).

PACIFIC TREEFROG ***Hyla regilla***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
Yes (Orchard 1984).

1c. **Common in Fraser Basin?**
Yes (Orchard 1984).

1d. **Proportion of diet within the aquatic food web.**
Adults eat crawling and flying insects. Tadpoles feed on algae, diatoms and detritus (Green and Campbell 1984).

2a. **Has the home range of the species been described?**
No.

2b. **Habitat selection is well documented?**
Treefrogs breed in shallow ponds early enough in the season that the breeding ponds are not likely to dry out. This species will inhabit open woodlands or forest margins and will tolerate agricultural and suburban areas. In the summer they will travel some distance from water (Green and Campbell 1984; Orchard 1984).

2c. **Breeding biology is well understood?**
Breed in shallow ponds. Onset of breeding is temperature related (6 to 8°C). When other frogs hear the male mating call they are attracted. Eggs are laid on grass

stocks. Tadpoles turn into tiny frogs in two to three months (Orchard pers. comm.1992).

2d. **Migration behaviour is well documented?**
Not well documented.

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
Males have a loud mating call which can be heard for several kilometres. This could help in locating breeding sites (Orchard pers. comm. 1994).

3b. **Can samples be easily collected?**
Finding clusters of eggs should be fairly easy. Each egg in the mass is usually yellow on top and brown on the bottom (Orchard pers. comm. 1994).

4a. **Captive rearing possible and well understood?**
Yes (Johnson 1980 reviewed in Harfenist *et al*. 1989).

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Johnson 1980 reviewed in Harfenist *et al*.1989).

5c. **Have biological effects for this species been studied?**
Yes (Johnson 1980 reviewed in Harfenist *et al*.1989).

RED-LEGGED FROG ***Rana aurora***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
No, they occur in the coastal region of the Fraser Valley as far up as Chilliwack (Orchard 1984).

1c. **Common in Fraser Basin?**
No.

1d. **Proportion of diet within the aquatic food web.**
Adults feed at night terrestrially on small insects and other forest invertebrates. Tadpoles feed on aquatic vegetation, detritus and algae (Green and Campbell 1984).

2a. **Has the home range of the species been described?**
No.

2b. **Habitat selection is well documented?**
Forest-dwelling frogs. Live in water or at water margin (Green and Campbell 1984).

2c. **Breeding biology is well understood?**
Breeding season starts soon after they emerge from hibernation in mid-February or March. Males call underwater; eggs are laid in large masses as much as one foot in diameter. Tadpoles turn into froglets by mid-summer and mature in two to three years (Orchard pers. comm. 1994).

2d. **Migration behaviour is well documented?**
Not documented.

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
Locating breeding sites should be fairly easy because where they occur they are quite common. Egg mass should be easy to spot because of their size (Orchard pers. comm. 1994).

3b. **Can samples be easily collected?**
Yes.

4a. **Captive rearing possible and well understood?**
Yes (Orchard 1984).

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

AMERICAN BULLFROG ***Rana catesbeiana***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
No.

1c. **Common in Fraser Basin?**
No, occurs in the Fraser Valley as far up as Chilliwack (Orchard 1984).

1d. **Proportion of diet within the aquatic food web.**
Adults will eat anything including young birds, mice, fish and smaller bullfrogs. Tadpoles are largely vegetarian but will scavenge carrion (Orchard pers. comm.1994).

2a. **Has the home range of the species been described?**
No.

2b. **Habitat selection is well documented?**
Entirely aquatic and rarely leave the weedy heavily vegetated permanent ponds and lakes that they inhabit. They are extremely wary during the day (Green and Campbell 1984).

2c. **Breeding biology is well understood?**
Prolonged breeding season beginning in late spring and extending through the summer. Males have a loud distinctive mating call (Green and Campbell 1984). Eggs are laid in huge floating masses as much as 3 ft across. Tadpoles take four years to mature (Orchard pers. comm. 1994).

2d. **Migration behaviour is well documented?**
Not documented.

2e. **Information on historic abundance?**
Species was introduced.

3a. **Can nests or animal be easily located?**
Yes, the males distinctive call should make locating breeding sites quite easy. Egg masses should be highly visible. Tadpoles may be difficult to distinguish from Red-legged Frogs until they have reached their maximum size when they are far larger than any other species of tadpole in B.C. (Orchard pers. comm. 1992).

3b. **Can samples be easily collected?**
Yes (Orchard pers. comm.1994).

4a. **Captive rearing possible and well understood?**
Yes (Orchard 1992).

4b. **Captive breeding possible and well understood?**
Yes (Orchard 1992).

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (see Harfenist *et al*. [1989] for a review of all contaminant studies prior to 1988 and Shuytema *et al*. 1991).

5c. **Have biological effects for this species been studied?**
Yes (see Harfenist *et al*. [1989] for a review of all contaminant studies prior to 1988 and Shuytema *et al*. 1991).

GREEN FROG ***Rana clamitans***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
No, occurs in the Fraser Valley only as far up as Hope (Orchard 1984).

1c. **Common in Fraser Basin?**
No.

1d. **Proportion of diet within the aquatic food web.**
Diet is similar to the American Bullfrog (Orchard 1984).

2a. **Has the home range of the species been described?**
No.

2b. **Habitat selection is well documented?**
Species is strictly aquatic requiring permanent water (Orchard 1984). Usually found in ponds, drainage ditches (Green and Campbell 1984).

2c. **Breeding biology is well understood?**
Species has a lengthy breeding season that continues through the late spring and early summer. Eggs are laid in floating masses. Tadpoles winter in the pond and transform the following summer into frogs (Green and Campbell 1984).

2d. **Migration behaviour is well documented?**
Insufficient information.

2e. **Information on historic abundance?**
Species was introduced.

3a. **Can nests or animal be easily located?**
Males have a distinctive call which should be helpful in locating breeding sites.

3b. **Can samples be easily collected?**
Egg masses are large and should be quite visible.

4a. **Captive rearing possible and well understood?**
Yes, this species is often sold in pet stores (Green and Campbell 1984).

4b. **Captive breeding possible and well understood?**
Yes, this species is often sold in pet stores (Green and Campbell 1984).

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (see Harfenist *et al*.1989 for a review of all contaminant studies prior to 1988 and Taylor *et al*. 1990; Strickler-Shaw and Taylor 1990; Lacki *et al*. 1992; and Berrill *et al*. 1993).

5c. **Have biological effects for this species been studied?**
Yes (see Harfenist *et al*.1989 for a review of all contaminant studies prior to 1988).

SPOTTED FROG *Rana pretiosa*

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
Yes.

1c. **Common in Fraser Basin?**
Yes (Orchard 1984).

1d. **Proportion of diet within the aquatic food web.**
Tadpoles feed on filamentous algae and leafy plants (Orchard 1984). Adults feed on insects, pillbugs, spiders, and tadpoles and froglets of other species (Green and Campbell 1984).

2a. **Has the home range of the species been described?**
No.

2b. **Habitat selection is well documented?**
This species is highly aquatic and is always associated with permanent ponds, small lakes, creeks, rivers and marshes (Orchard 1984). They can be found at the edge of any suitable standing water. They are tolerant of cold waters. They only leave water during rainy periods and even then only rarely (Orchard 1984).

2c. **Breeding biology is well understood?**
Breed in the early spring before ice has fully disappeared from the surface of the breeding ponds. Breeding is quite short, lasting for only a couple of weeks (Green and Campbell 1984). Eggs are laid in communal masses at the surface of the water. They are large loose gelatinous masses (Orchard pers. comm. 1994).

2d. **Migration behaviour is well documented?**
Not well documented.

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
Males have a mating call although it is low in pitch and volume and has little carrying power, nonetheless it may be useful in locating breeding sites (Orchard pers. comm. 1994).

3b. **Can samples be easily collected?**
Eggs are laid in communal masses, however they may be obscured by emergent vegetation which grows up quickly once ice has completely disappeared from the water (Orchard pers. comm. 1994).

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

WOOD FROG ***Rana sylvatica***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
Yes, the most widespread amphibian in Canada (Green and Campbell 1984).

1c. **Common in Fraser Basin?**
Yes (Orchard 1984).

1d. **Proportion of diet within the aquatic food web.**
Adults are terrestrial feeder eating mainly insects and other invertebrates. Tadpoles feed on detritus and algae (Orchard 1984).

2a. **Has the home range of the species been described?**
No.

2b. **Habitat selection is well documented?**
Forests, fields, muskegs though usually not far from water. Highly tolerant of cold weather. Quite terrestrial and will forage far from water (Green and Campbell 1984).

2c. **Breeding biology is well understood?**
Breeds in early spring before ice has melted. Breeding occurs in shallow clear ponds (Green and Campbell 1984). Eggs are laid in globular masses. They may be attached to sticks and plants or lay freely in the water (Orchard pers. comm. 1994). The tadpoles grow quickly and transform into frogs by mid-summer (Green and Campbell 1984).

2d. **Migration behaviour is well documented?**
Like most amphibians it is an explosive breeder waiting for suitable conditions. Suitable conditions may of course vary substantially from one region of the province to another (Orchard pers. comm. 1994).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
Males have a mating call which may be helpful in locating breeding sites, however, the call may be heard for only a week or so. In summer Wood Frogs may be found in grasses near the margins of waterways (Orchard pers. comm. 1994).

3b. **Can samples be easily collected?**
Should be easy to find egg clusters in shallow water (Orchard pers. comm. 1994).

4a. **Captive rearing possible and well understood?**
Yes (Gosner and Black 1957 reviewed in Harfenist *et al*. 1989; Tome and Plough 1982; Kams 1984; Pierce *et al*. 1984; Freda and Dunson; Dale *et al*. 1985; Clark and LaZerte 1985; and Pierce and Harvey 1987)

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (see Harfenist *et al*. 1989 for a review of all contaminant studies prior to 1988 and Berrill *et al*. 1993).

5c. **Have biological effects for this species been studied?**
Yes (see Harfenist *et al*. 1989 for a review of all contaminant studies prior to 1988).

APPENDIX 2

CLASS AVES

Species are ordered taxanomically as follows:

COMMON LOON ***Gavia immer***

1a. **Present in the Fraser Basin year-round?**
Most migrate to coastal areas to winter. Species is rare to uncommon in the southern interior in the winter (Campbell *et al.* 1990).

1b. **Broad distribution?**
Yes, it occurs throughout the Fraser Basin, although the Thompson-Okanagan and Fraser Plateau and Basin appear to be the centre of abundance (Campbell *et al.* 1990).

1c. **Common in the Fraser Basin?**
Species is an uncommon to fairly common breeder throughout the province (Campbell *et al.* 1990).

1d. **Proportion of diet within the aquatic food web.**
Fish are the primary diet particularly during the breeding season but invertebrates, especially crustaceans, are also consumed. Young are fed small fish and aquatic invertebrates (Ehrlich *et al.* 1988).

2a. **Has the home range of the species been described?**
In a study in northeastern Minnesota, Titus and Vandruff (1981) found breeding Common Loons exhibiting territoriality. Density was estimated to be about one adult per 35 ha.

2b. **Habitat selection is well documented?**
Breeds most often on large and small lakes in both forested and open regions; occasionally breeds in sloughs, marshes, lagoons and near rivers (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Monogamous, both parents incubate eggs and later tend the young (Ehrlich *et al.* 1988). Nests are on the ground usually on main shores of water bodies. Sometimes they are built over partially submerged logs, trees and muskrat pushups or amongst emergent marsh vegetation. Nests consist of heaped masses of aquatic vegetation. They range in size from 30 to 74 cm in diameter. Eggs are laid between mid April and late July although most are laid between late May and mid June (Campbell *et al.* 1990). Clutches are small usually one to two eggs (Ehrlich *et al.* 1988). Eggs are incubated for about 29 days (Campbell *et al.* 1990). Eggs hatch asynchronously. Downy chicks are carried on their parents back. Chicks are fledged in 75 to 80 days (Ehrlich *et al.* 1988).

2d. **Migration behaviour is well documented?**
Yes. Fall migration from interior breeding sites to coastal areas begins in late August although peak migration occurs in the first half of October. Major wintering

areas are the northern end of the Strait of Georgia, off the Fraser River delta, and at the east end of Juan de Fuca Strait. Spring migration to breeding sites begins in late March with the peak migration occurring from late April to early May.

2e. **Information on historic abundance?**
No, however, the Common Loon appeared on the Blue List in 1980 and 1981, with the exception of British Columbia, it has largely been extirpated from it's breeding range in the Pacific Northwest. In British Columbia it is still listed as a species of special concern because of the impact of disturbance from powerboats on breeding success and because of the unknown potential impact of acid rain (Campbell *et al.* 1990).

3a. **Can nests or animals be easily located?**
Finding nests should be relatively easy since this species nests on the ground and in fairly open areas.

3b. **Can samples be easily collected?**
Common Loons are sensitive if not intolerant to disturbance (Titus and Vandruff 1981).

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

PIED-BILLED GREBE ***Podilymbus podiceps***

1a. **Present in the Fraser Basin year-round?**
Most migrate to coastal freshwater areas (Campbell *et al.* 1990).

1b. **Broad distribution?**
Yes, occurs through the Fraser Basin.

1c. **Common in the Fraser Basin?**
Species is fairly common to common. The centre of breeding abundance is the southern interior and the Chilcotin-Cariboo (Campbell *et al.* 1990).

1d. **Proportion of diet within the aquatic food web.**
Aquatic insects are a primary part of the diet during the breeding season, but fish, snails and frogs are also eaten (Ehrlich *et al.* 1988).

2a. **Has the home range of the species been described?**
Insufficient information.

2b. **Habitat selection is well documented?**
Nests in wetland habitat with shoreline vegetation of reeds, rushes, sedges and grasses or patches of such vegetation offshore. Prefers freshwater marshes, ponds and shallow lakes. Nests are built on the water and attached to stands of emergent vegetation. Nests are sometimes free-floating. Nest are built where water depth ranges from 0.2 to 2m. Most in locations up to 18 m from shore (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Species is monogamous and both parents incubate and later raise the young. (Ehrlich *et al.* 1988). Eggs are laid between May and early June and are incubated for 23 days. Clutches range in size from five to seven eggs. Chicks are carried on the adults backs. Fledging period is unknown (Campbell *et al.* 1990).

2d. **Migration behaviour is well documented?**
Pied-billed Grebes migrate to interior ice-free lakes as early as mid-March but the peak movement in southern areas is mid-April. The onset of autumn migration to coastal areas is influenced by weather in the interior migration occurs from early September through October (Campbell *et al.* 1990).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animals be easily located?**
No, it would be very hard to find nests. These birds nest in lakes which are virtually enclosed in vegetation such as cattails and bulrushes (Breault pers. comm. 1994).

3b. **Can samples be easily collected?**
Pied-billed Grebes tend to leave their nests and eggs covered though unattended for prolonged periods (Campbell *et al.* 1990) which may be advantageous for egg sampling.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

HORNED GREBE *Podiceps auritus*

1a. **Present in the Fraser Basin year-round?**
No, most birds migrate to the coast or to the south eastern interior to winter (Campbell *et al.* 1990).

1b. **Broad distribution?**
Yes, a widespread breeder throughout the province, although the centre of breeding abundance is Chilcotinotin-Cariboo Basin and the Thompson-Okanagan Plateau (Campbell *et al.* 1990).

1c. **Common in the Fraser Basin?**
The Horned Grebe is an uncommon to fairly common breeder in the interior east of the coast mountains (Campbell *et al.* 1990).

1d. **Proportion of diet within the aquatic food web.**
During the breeding season aquatic insects and crustaceans are the primary items in the diet. During winter the diet consists mostly of fish and crustaceans (Ehrlich *et al.* 1988).

2a. **Has the home range of the species been described?**
Insufficient information.

2b. **Habitat selection is well documented?**
Prefers to nest on small freshwater lakes and marshes usually where vegetation is present. Nests sites are found in both open and forested sites. Nests are built in shallow water and are attached to submerged vegetation. Bulrushes are preferred but cattails, sedges, rushes and horsetails are also used. Water depths range from 15cm to 2m and most nests are about 8m from shore although some may be as much as 30m from shore (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Monogamous, both parents incubate and raise the young. Generally this species is a solitary breeder but loose colonies of three to 20 pairs have been observed in the Chilcotin-Cariboo Basin. Eggs are laid between mid-June and early July although

eggs may be found in early May and in mid-August. Clutches range between one and eight eggs although most have four or five. Eggs are incubated for 25 days (Campbell *et al.* 1990). Young are fledged by 45 to 60 days (Ehrlich *et al.* 1988).

2d. **Migration behaviour is well documented?**
Yes, autumn migration to wintering grounds begins in late August and peaks in late September and October. Important wintering areas include Clayoquot Sound, western and southern Strait of Georgia, Fraser River estuary, Haro Strait on the coast and Okanagan Lake, Kootenay Lake, Lower Arrow Lake and the Columbia River in the southern interior. Spring migration to breeding sites occurs in April and May (Campbell *et al.* 1990).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animals be easily located?**
Yes, these birds nests in emergent vegetation around open lakes so that it is quite easy to spot nests (Breault pers. comm. 1994).

3b. **Can samples be easily collected?**
Yes, it is easy to approach nests and collect eggs, however, these birds are sensitive to disturbance. It would be best to not attempt egg collections before three weeks (incubating) to reduce the risk of nest abandonment (Breault pers. comm. 1994).

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Vermeer *et al.* 1993; Ulfvens 1986).

5c. **Have biological effects for this species been studied?**
No.

RED-NECKED GREBE ***Podiceps grisegena***

1a. **Present in the Fraser Basin year-round?**
Most migrate to coastal B.C. a few winter in the southern interior (Campbell *et al.* 1990).

1b. **Broad distribution?**
Yes, a widespread breeder (Campbell *et al.* 1990).

1c. **Common in Fraser Basin?**
The Red-necked Grebe is uncommon to very common throughout the basin.

1d. **Proportion of diet within the aquatic food web.**
Feed on small fish, aquatic and land insects and their larvae, tadpoles, salamanders, crustacmollusksIluscs and aquatic worms. In marshes and small lakes, fish are a minor part of the diet. Chicks fed mainly insect larvae (Palmer 1962).

2a. **Has the home range of the species been described?**
During the breeding season, Red-necked Grebes usually defend a territory 75 to 125m along a shoreline, or a shallow lake of at least 10 acres. Breeding pairs are mainly confined to their territories from the time the clutch is complete until the end of rearing. Once young are fledged, however, the birds range much further (Palmer 1962).

2b. **Habitat selection is well documented?**
Yes. Sheltered usually shallow freshwater lakes with emergent and submergent vegetation in both open and forested regions. Require at least 50 to 60 m of open water for take off (Ohanjanian 1986). Nests are built on floating platforms of vegetation among or at the edge of emergent vegetation in lakes and marshes (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Eggs are laid between May and August with most laid in June. Clutches usually have two to four eggs. Eggs are incubated for 22 to 23 days by both parents (Ehrlich *et al.* 1988). Chicks are precocial. Initially young are fed near the nest by the parents. Chicks are fledged in 56 to 70 days (Campbell *et al.* 1990).

2d. **Migration behaviour is well documented?**
Yes. Migrate to the south coast of B.C. in late September and return to interior breeding sites in April (Campbell 1990).

2e. **Information on historic abundance?**
Yes. In Campbell *et al.* (1990) there are survey results from the major breeding concentrations in British Columbia dating from 1916 to 1987.

3a. **Can nests or animals be easily located?**
Yes, these birds nest in emergent vegetation around open lakes making it quite easy to spot nests (Breault pers. comm. 1994).

3b. **Can samples be easily collected?**
Yes, it is easy to approach nests and collect eggs, however, these birds are sensitive to disturbance. It would be best to not attempt egg collections before three weeks (incubating) to reduce the risk of nest abandonment (Breault pers. comm. 1994).

4a. **Captive rearing possible and well understood?**
No (Breault pers. comm. 1994).

4b. **Captive breeding possible and well understood?**
No (Breault pers. comm. 1994).

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (De 1987).

5c. **Have biological effects for this species been studied?**
No.

EARED GREBE ***Podiceps nigricollis***

1a. **Present in the Fraser Basin year-round?**
Most birds move to coastal B.C., Washington, Idaho and Montana to winter (Campbell *et al*. 1990).

1b. **Broad distribution?**
Yes.

1c. **Common in the Fraser Basin?**
Fairly widespread common to very abundant. Chilcotin-Cariboo is the centre of abundance. Breault *et al*. (1988) estimates 1700 to 4500 breeding pairs from his survey of 419 lakes in the southern interior, central interior, Okanagan/Kamloops area and the Peace River.

1d. **Proportion of diet within the aquatic food web.**
Mostly aquatic insects and larvae, also fish, crustaceans, molluscs, amphibians and feathers (Ehrlich *et al.* 1988).

2a. **Has the home range of the species been described?**
Breeding Eared Grebes remain on the lake where they have nested until the young are fledged (Palmer 1962).

2b. **Habitat selection is well documented?**
Often shallow sheltered freshwater marshes, ponds and lakes with moderate to heavy growth of emergent vegetation. Water bodies are usually greater than 4 ha. Nest on floating platforms of vegetation in lakes and marshes (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
They are colonial, nesting in colonies as large as 1,000 pairs. Eggs are laid mostly in June although they may be laid as early as mid May or as late as mid August. Clutch size ranges from one to eight eggs with most having three to four eggs. Eggs are incubated for 20.5 to 21.5 days by both parents. Chicks are fledged at 21 days (Campbell *et al.* 1990).

2d. **Migration behaviour is well documented?**
Winters on the coast of B.C. and small numbers winter in southern B.C. from Shuswap Lake south through the Okanagan valley. Some also winter in Washington, Idaho and Montana. Birds that appear in the southern portion of the province in April have likely arrived from Washington, Idaho and Montana. In autumn, the migration probably occurs in September. A. Breault (cited in Campbell *et al.* 1990) suggests that there are probably three waves of migrants: non-breeders, successful breeders and abandoned young (Campbell *et al.* 1990).

2e. **Information on historic abundance?**
All historical nesting records are compiled in Breault (1988). These cover the southern interior, the central interior and the Okanagan/Kamloops area with the earliest records dating back to the 1930's. The information is, however, quite fragmented so that it is not possible to get an overview of breeding abundance from any period (Breault 1988).

3a. **Can nests or animals be easily located?**
Yes, nests are quite easy to locate because these birds nests in emergent vegetation in fairly open lakes. Furthermore Breault (1988) has conducted a detailed survey of suitable nesting lakes in the southern interior, central interior, Okanagan/Kamloops area and Peace River. Each of the lakes surveyed which had nests are described in Breault (1988).

3b. **Can samples be easily collected?**
Yes, it is easy to approach nests and collect eggs, however, these birds are sensitive to disturbance. It would be best to not attempt egg collections before three weeks (incubating) to reduce the risk of nest abandonment (Breault pers. comm. 1994).

4a. **Captive rearing possible and well understood?**
No (Breault pers. comm. 1994).

4b. **Captive breeding possible and well understood?**
No (Breault pers. comm. 1994).

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Barnum and Gilmer 1988; Olson and Welsh 1993; Palawski *et al.* 1992).

5c. **Have biological effects for this species been studied?**
No.

WESTERN GREBE ***Aechmophorus occidentalis***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
No, localised at breeding sites at Duck Lake (Creston), Kootenay Lake, Okanagan Lake, Shuswap Lake (Campbell *et al.* 1990).

1c. **Common in the Fraser Basin?**
No, they are only common at colony sites which are few.

1d. **Proportion of diet within the aquatic food web.**
Yes. Mainly fish (81% by composition almost 100% by weight), opportunistic when hunting fish. Also eat salamanders, crustaceans, polychaete worms, grasshoppers and a variety of aquatic insects. Feed young feathers from first day. Feed young smaller food items than they usually eat e.g. insect larvae. Feed young until about eight week. (Storer and Nuechterlein 1992).

2a. **Has the home range of the species been described?**
Yes. During incubation adults may range several kilometres from nest site to forage. During brooding, generally restricted to the body of water upon which the colony is established (Storer and Nuechterlein 1992).

2b. **Habitat selection is well documented?**
Yes. Breeds on freshwater lakes and marshes with extensive areas of open water bordered by emergent vegetation. Breeding areas contain open water of at least several square kilometres (Storer and Nuechterlein 1992).

2c. **Breeding biology is well understood?**
Nests in colonies with nests 2.0 to 3.9m apart. Egg laying begins before nest is completed. Both members of pair stay near nest and defend it (Storer and Nuechterlein 1992). Eggs laid in April, but in B.C. colonies there can be so much

disturbance associated with power boats and recreational fishing that relaying is common. Thus clutches can be found as late as August. Clutches contain one to seven eggs with most having three to four. Eggs are incubated by both parents for about 24 days (Campbell *et al.* 1990). Once hatched the chicks climb upon parent's back, parents then wander away from nest with young to feed. Chicks are back brooded for two to four weeks. Chicks fed by the non brooding parent. Chicks fed by parents until eight weeks of age (Storer and Nuechterlein 1992).

2d. **Migration behaviour is well documented?**
Yes, most migrate to coastal B.C. although some stay in the southern interior of B.C.. Migration to wintering areas begins mid-September and spring migration to breeding sites occurs late April to early May (Campbell *et al.* 1990).

2e. **Information on it's historic abundance ?**
Yes, historical information on breeding sites. There is sporadic breeding survey data from 1933 to 1987. Historically there were seven breeding sites in B.C. now there are only four of which only Shuswap Lake is in the Fraser Basin. The decline in colony numbers is attributable to industrial development, recreational activity and unstable water levels (Campbell *et al.* 1990).

3a. **Can nests or animals be easily located?**
Yes, these birds nests in emergent vegetation around open lakes so that it is quite easy to spot nests (Breault pers. comm.1994).

3b. **Can samples be easily collected?**
Yes, it is easy to approach nests and collect eggs, however, these birds are sensitive to disturbance. It would be best to not attempt egg collections before three weeks (incubating) to reduce the risk of nest abandonment (Breault pers. comm. 1994).

4a. **Captive rearing possible and well understood?**
Yes,but quite difficult. Methods are described in Ratti (1977).

4b. **Captive breeding possible and well understood?**
No.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Henny *et al.* 1990).

5c. **Have biological effects for this species been studied?**
No.

GREAT BLUE HERON ***Ardea herodias***

1a. **Present in the Fraser Basin during all life stages?**
Most birds move to the Fraser Delta which has the largest wintering population, the largest wintering population in the interior is in the Okanagan Valley (Campbell *et al.* 1990).

1b. **Broad distribution?**
Yes.

1c. **Common in the Fraser Basin?**
Common in the Fraser lowlands, this is the centre of abundance, but they are fairly common and a widespread breeder in the southern interior (Campbell *et al.* 1990).

1d. **Proportion of diet within the aquatic food web.**
Yes, mostly fish but also amphibians, invertebrates, reptiles, small mammals and birds (Butler 1992).

2a. **Has the home range of the species been described?**
Generally nesting colonies are located within 2.3 to 6.5km of a productive feeding area (Butler 1992).

2b. **Habitat selection is well documented?**
This species is remarkably adaptable, feeding mostly in slow moving or calm freshwater but also in tidal flats and occasionally fields. Colony sites are usually in mature forests of mixed deciduous and coniferous trees (Poplar, Western White Pine, and Ponderosa Pine have been used). Most nests are located 17 to 30m above the ground (Campbell *et al.* 1990; Butler 1992).

2c. **Breeding biology is well understood?**
Yes, birds begin to return to colony sites in the interior in late March. Eggs are laid between April and mid June (Campbell *et al.* 1990). Clutch sizes range from one to eight eggs with most having three to five eggs. Eggs are incubated by both parents for 27 to 28 days. Brooding of young is carried out by both parents and both parents feed chicks. Fledging period is about 60 days but fledged offspring continue to return to the nest for a further three weeks to receive food from parents (Butler 1992).

2d. **Migration behaviour is well documented?**
Pacific coast population appears to be non migratory but some post-breeding dispersal occurs (Butler 1992).

2e. **Information on it's historic abundance?**
Yes, there is sporadic colony survey data from 1941 to 1982. Prior to 1947 they were known to breed in coastal areas but only two sites were known in the interior.

The number of colony sites in the interior has increased over the years although the magnitude of this increase is not known (Campbell *et al.* 1990).

3a. **Can nests or animals be easily located?**
Large colonies can often be easily located by noting where herons congregate to feed. Small colonies and those located in upland forests may be more difficult, but on the coast there has been much success at locating colonies (personal observation).

3b. **Can samples be easily collected?**
Egg collecting can, and has been done successfully, but requires an experienced tree climber. The timing of the collection is critical to reduce the chance of nest or colony abandonment as a result of the disturbance. Collection of chicks has not been attempted because of the tendency for chicks to jump out of the nest upon approach (personal observation).

4a. **Captive rearing possible and well understood?**
Yes (Bennet *et al.* 1992).

4b. **Captive breeding possible and well understood?**
No.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
Yes, in the Chilliwack area (P. Whitehead pers. comm.).

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Blus and Henny 1981; Bayer 1982; Nosek and Faber 1982; Fitzner *et al.* 1982; Heinz *et al.* 1984; Dowd *et al.* 1985; Fleming *et al.* 1985; Blus *et al.* 1985a; Blus *et al.* 1985b; Riley *et al.* 1986; Leighton 1988; Fitzner *et al.* 1988; Elliott *et al.* 1989; Gray 1989a; Gray 1989b; Gray 1991; Henschel *et al.* 1991; Kennedy *et al.* 1991; Speich *et al.* 1992; MacIntosh *et al.* 1993).

5c. **Have biological effects for this species been studied?**
Yes (Zinkl *et al.* 1981; Fleming *et al.* 1985; Elliott *et al.* 1989; Bellward *et al.* 1990; Elliott *et al.* 1991; Bennett *et al.* 1992; Sanderson and Bellward 1993).

CANVASBACK *Aythya valisineria*

1a. **Present in the Fraser Basin year-round?**
Yes, although some migrate to the coast in fall.

1b. **Broad distribution?**
No, centre of breeding abundance is in Chilcotin-Cariboo.

1c. **Common in the Fraser Basin?**
Yes, centre of abundance is the Chilcotin-Cariboo.

1d. **Proportion of diet within the aquatic food web.**
Yes, 80.6% of food is vegetation with pondweed the most important food source. The remaining 19.4% of the diet mollusc and insects. Juvenile diet comprised 64.4% vegetation and 35.6% insects. Insects consumed included caddisfly (Trichoptera) larvae and cases, midge (Chironomidae) larvae, nymphs of mayflies (Ephemerida), dragonflies and damselflies (Odonata), water boatman (Corixidae), back swimmers (Notonecta) and water striders (Gerris) (Palmer 1976).

2a. **Has the home range of the species been described?**
Insufficient information.

2b. **Habitat selection is well documented?**
Freshwater and alkali lakes, marshes and ponds. Lakes are used most often. Shorelines have extensive marshes or are bordered by dense emergent vegetation. Alkali ponds are used mainly as brood ponds. Nests are situated in dense stands of emergent vegetation (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Yes. Eggs are laid in May. Clutch size ranges from three to 14 eggs with most having eight to 10 eggs. Eggs are incubated by the female for 24 to 29 days (Ehrlich *et al.* 1988). Male leaves once the clutch is laid. Chicks are fledged in 56 to 68 days. Young often move from natal pond to adjacent ponds that may have less cover but are richer in food (Campbell *et al.* 1990).

2d. **Migration behaviour is well documented?**
Yes. Many remain in the southern interior to winter, others migrates to coastal B.C. and also south towards wintering grounds in California. Fall migration is quite protracted, late August to November. Spring migration to breeding areas in the interior of B.C., March to mid April (Campbell *et al.* 1990).

2e. **Information on historic abundance?**
No, but migrant and wintering populations have been declining for past 30 years due largely to habitat loss (Bellrose [1976] and Tate and Tate [1982] cited in Campbell *et al.* 1990).

3a. **Can nests or animals be easily located?**
Ehrlich *et al.* (1988) states that nests are well concealed suggesting it may be difficult to locate nests.

3b. **Can samples be easily collected?**
If the nest is found collecting eggs should be easy, however, Ehrlich *et al.*(1988) states that nests are often parasitized by Redheads.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Di and Scanlon 1984; Miles and Ohlendorf 1993).

5c. **Have biological effects for this species been studied?**
No.

REDHEAD ***Aythya americana***

1a. **Present in the Fraser Basin year-round?**
Yes, the Redhead is the only duck to winter in larger numbers in the interior than on the coast (Campbell *et al.* 1990).

1b. **Broad distribution?**
Yes.

1c. **Common in the Fraser Basin?**
Fairly common breeder, there are an estimated 7,000 breeders in B.C.(Campbell *et al.* 1990).

1d. **Proportion of diet within the aquatic food web.**
On an annual basis, a herbivorous diet appears to predominate. In summer adults eat mainly animal matter (aquatic invertebrates and insect larvae) . Juveniles eat vegetation and animal matter in about the same amounts but in late summer and fall plant food predominates (90% vegetation, 10% aquatic insects mainly grasshoppers, and nymphs of damselflies (Cottam 1939 cited in Palmer 1976) but also midge larvae and caddisfly larvae (Bartonek and Hickey 1969 cited in Palmer 1976). The diet of chicks is not documented.

2a. **Has the home range of the species been described?**
The female leads chicks to better feeding areas and they may make several moves. Eventually the female abandons the chicks at three to five weeks after hatching (Palmer 1976).

2b. **Habitat selection is well documented?**
Yes. Breeds on shallow lakes, marshes and sloughs from 330 to 1000m elevation. Most nest on lakes with emergent vegetation on the shoreline or a larger expanse

of emergent marsh (73%; n=242). Nests are situated in dense stands of emergent vegetation (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Wide laying period, between April 28 and July 27. Clutch sizes are difficult to determine because of the semi-parasitic habits of Redheads. Redheads will lay their eggs in the nests of other waterfowl including other Redheads. Incubation period is 24 days. Fledging period ranges from 56 to 73 days (Campbell *et al.* 1990) Redheads have low reproductive success due mostly to their parasitic behaviour (Palmer 1976).

2d. **Migration behaviour is well documented?**
Winters in the southern interior of B.C. and on the coast, but band recoveries suggest that most birds reared in B.C. migrate south to southern California and Mexico. Autumn migration begins in early September, peaks in the second half of October and continues until November. Spring migration to breeding sites begins in mid February in southern B.C. and continues until mid-May (Campbell *et al.* 1990).

2e. **Information on historic abundance?**
Yes, historical changes have been documented in the Okanagan Valley, east Kootenays, west Kootenays and Creston area but not in the Fraser Basin (see Campbell *et al.* 1990).

3a. **Can nests or animals be easily located?**
Nest are concealed in emergent vegetation which may make them difficult to locate.

3b. **Can samples be easily collected?**
Collecting eggs from nests should be relatively easy although there is no information on the effects of human disturbance. Sampling fledged young of the year might be more practical.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Tarshis and Rattner 1982; Flickinger *et al.* 1984).

5c. **Have biological effects for this species been studied?**
Yes (Flickinger *et al.* 1984).

RING-NECKED DUCK ***Aythya collaris***

1a. **Present in the Fraser Basin year-round?**
Most migrate to the coast and to the southern U.S.A. to winter, some remain in the southern interior (Campbell *et al.* 1990).

1b. **Broad distribution?**
Yes.

1c. **Common in the Fraser Basin?**
Widespread but uncommon to fairly common breeder in B.C. (Campbell *et al.* 1990). Bellrose (1976) estimated a breeding population of almost 28,000 birds in B.C.

1d. **Proportion of diet within the aquatic food web.**
Adults eat more vegetable matter than juveniles and chicks. Young are fed mostly invertebrates especially during the first two to three weeks. (Ehrlich *et al.* 1988). Stomachs of juveniles taken in July contained 63% vegetable matter and 37% animal matter comprising insects of the orders, Anisoptera, Trichoptera, Zygoptera, Hemiptera, and Coleoptera. Stomachs of downy chicks contained 48.7% animal matter, caddisflies (Trichoptera), beetles (Chrysomelidae, Haliplidae, Curculionidae, Elateridae), bugs (Gerridae, Corixidae), nymphs of dragonflies (Anisoptera) and damselflies (Zygoptera). From ducks collected in the fall and winter, the diet consisted of 81.5% vegetable matter, 18.5% animal matter. Diet of birds during spring, summer and fall was similar, 88% vegetable and 12% animal. Animal matter consumed includes nymphs of damselflies and dragonflies (Odonata), larvae and cases of caddisflies (Trichoptera), larvae of midges (Chironomidae), water boatmen (Corixidae), diving beetles (Dytiscidae), mollusc, gastropods (Goniobasis, Nertina, Mitrella, Planorbis, Amnicola) and pelecypods, miscellaneous fish, water mites, crabs, water fleas, amphipods and annelid worms (Palmer 1976).

2a. **Has the home range of the species been described?**
Insufficient information.

2b. **Habitat selection is well documented?**
Yes. Breeds on freshwater lakes, marshes, ponds and sloughs often in wooded situations mainly from 300m to 1200m. They seem to prefer waters that are slightly acidic where yellow waterlily covers much of the surface. Nests are in stands of emergent vegetation or on grassy clumps in varying degrees of concealment. Nest may be located over water or on the ground (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Yes. Dates for clutches ranged from May 21 to July 18. Clutch size ranges from five to 12 eggs with 50% having nine or 10 eggs. Incubation period is about 25 to 29 days and incubating is done by the female although the male remains in attendance through incubation and sometimes until hatching (Campbell *et al.* 1990; Ehrlich *et al.* 1988). Chicks are fledged at 49 to 56 days (Ehrlich *et al.* 1988). Ring-necked ducks are gregarious even during the breeding season and will often flock in common areas (Palmer 1976).

2d. **Migration behaviour is well documented?**
Yes. Winter on the coast and in the southern interior of B.C. Autumn migration begins between the end of September to mid October. Spring migration to interior B.C. breeding sites begins in February (Campbell *et al.* 1990).

2e. **Information on historic abundance ?**
Prior to 1947 the Ring-necked duck was not known to breed north of the Bulkley Valley. Now, however, it is known to occur north to the Yukon border (Campbell *et al.* 1990).

3a. **Can nests or animals be easily located?**
Could be difficult to locate nests.

3b. **Can samples be easily collected?**
If the nest is found, collecting an egg should be relatively easy, however, there is no information on how well these birds tolerate disturbance. Collecting young of the year once they have fledged for blood sampling could be relatively easy and less likely to cause disturbance.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Di and Scanlon 1984).

5c. **Have biological effects for this species been studied?**
Yes (Mautino and Bell 1986; Blancher and McAuley 1987).

LESSER SCAUP *Aythya affinis*

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
Yes.

1c. **Common in the Fraser Basin?**
Yes, widespread breeder, fairly common to very common. The centre of breeding abundance is the Chilcotin-Cariboo. 50,000 breeders in B.C. (Campbell *et al.* 1990).

1d. **Proportion of diet within the aquatic food web.**
Aquatic plants (60%) and invertebrates (40%), although invertebrates are taken mainly during the breeding season, in fact 90% of the juvenile diet is invertebrates: caddisflies, dragonflies, damsel flies, water boatmen, midges, beetles and crustaceans (Cottam 1939 cited in Palmer 1976).

2a. **Has the home range of the species been described?**
Insufficient information.

2b. **Habitat selection is well documented?**
Yes, breeds near freshwater and alkaline lakes (70% n=867), marshes, sloughs and ponds from 300 to 1400m. Most nests were on islands (42%) followed by farmland (28% including hay and alfalfa meadows, rangelands and cereal grain fields). Nests in agricultural areas are occasionally destroyed during mowing. Other nest sites included wet sedge meadows, peninsulas and wooded groves. Most nest are concealed in dense clumps of grass including agricultural crops or thick growths of emergent vegetation (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Lesser Scaups are semi-colonial. There are three records of two active nest within 3m of each other from B.C. (Campbell *et al.* 1990). Eggs are laid as early as May 2 and well into August. Clutch size ranges from one to 22 eggs with most having eight to 10 eggs. Lesser Scaups do experience brood parasitism e.g. Redhead. Incubation is 21 to 27 days. Aggression between female parents often results in the adoption or loss of young resulting in brood amalgamation. Fledgling period is between 45 and 50 days. Males desert when incubation begins. Soon after hatching young are led to water (Campbell *et al.* 1990; Ehrlich *et al.* 1990).

2d. **Migration behaviour is well documented?**
Yes, spring migration from coastal areas and from the southern interior begins in late February but most birds do not appear on their breeding grounds until April.

Main autumn migration occurs from mid-September through October (Campbell *et al.* 1990).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animals be easily located?**
May be difficult to find since they tend to conceal their nests well. Nests on land may be the easiest to locate.

3b. **Can samples be easily collected?**
It should be very easy to collect eggs from nest located on land. Once the chicks hatch they are led to water. It may be more practical to collect blood samples from fledged young of the year.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Di and Scanlon 1984; Smith *et al.* 1986).

5c. **Have biological effects for this species been studied?**
No.

HARLEQUIN DUCK ***Histrionicus histrionicus***

1a. **Present in the Fraser Basin year-round?**
No.

1b. **Broad distribution?**
No, only a few breeding areas (from distribution map in Campbell *et al.* 1990).

1c. **Common in the Fraser Basin?**
Widespread but uncommon (Campbell *et al.* 1990).

1d. **Proportion of diet within the aquatic food web.**
Diet is almost entirely animal with vegetation taken accidentally. In inland areas diet is made up largely of Diptera larvae and pupae while in coastal areas the diet includes crustaceans, bivalves and fish eggs. Dietary items identified have

included: Crustaceans (Hemigrapsus, Pagurus, Dermaturus, Petrolisthes, Cancer, Oxyrhyncha, Pachycheles, Mesidotea), mollusc (Chiton, Lacuna, Littorina, Margarites, Acmaea, Mitrella, Odostomia, Buccinum, Natica, Bittium, Nassarius, Mytilus), echinoderms (Strongylocentrotus), fishes (Cottidae, Salmo) and fish eggs, miscellaneous (nereid worms, ascidians, bryozoans, sea spiders, hydroids), insects, nymphs of stone flies (Plecoptera), water boatmen (Croxidae), midges (Chronomidae) (Palmer 1976).

2a. **Has the home range of the species been described?**
Insufficient information.

2b. **Habitat selection is well documented?**
No. There are only two breeding records for the central interior of the province, so that habitat selection is unclear. Rivers, creeks and glacial streams at elevations above 1000m. (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Breed near interior rivers, creeks and glacial streams often at elevations in excess of 1000m. Only four nest records for all of B.C. Males desert females at start of incubation (Campbell *et al.* 1990). Eggs are incubated for 28 to 30 days and chicks are fledged by 60 to 70 days (Ehrlich *et al.* 1990). Fledging rates are low 50 - 70% (Palmer 1976).

2d. **Migration behaviour is well documented?**
Winter on the sea along the coast of B.C. Spring migration is difficult to pinpoint because of the large numbers of non-breeders on the coast but generally breeders begin to appear in the interior around mid-April. The number of males on the coast begins to outnumber females by late May and becomes most apparent by early July as males leave incubating females and move to the ocean to moult (Campbell *et al.* 1990).

2e. **Information on historic abundance ?**
No.

3a. **Can nests or animals be easily located ?**
No, only four nesting records in all of B.C.

3b. **Can samples be easily collected ?**
See above.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

WHITE-WINGED SCOTER ***Melanitta fusca***

1a. **Present in the Fraser Basin year-round?**
No.

1b. **Broad distribution?**
Yes.

1c. **Common in the Fraser Basin?**
Common to fairly common breeder, 17,000 breeders in B.C. (Campbell *et al.* 1990)

1d. **Proportion of diet within the aquatic food web.**
Chiefly mollusc, crustaceans, aquatic plants, insects and occasionally fish. Examination of 819 stomachs of adults showed 94% animal and 6% vegetable matter. Stomach contents of four juveniles showed similar percentages. Mollusc (Ostrea, Pecten, Venus, Mya, Thais, Protothaca, Mytilus, Macoma, Tellina, Siliqua, Cardium, Nassarius, etc.) 75.3%; crustaceans (Hemigrapsus, Cancer, Neopanope, Hexapanopeus, Pagurus) 13.2%; insects (larvae of caddisflies, dragonflies, lacewings, and midges, grasshoppers) 2.5%; fishes (Porichthys, Moxocephalus, Ammodytes, Heterostomata) 1.7%; sand dollars, sea urchins, starfish and brittle star (Palmer 1976).

2a. **Has the home range of the species been described?**
Insufficient information.

2b. **Habitat selection is well documented?**
Nests on freshwater lakes and ponds in relatively open country in the central plateau region of B.C. Nests on alkaline lakes in the Chilcotin-Cariboo and occasionally in bullrush sloughs. Some particular lakes seem to be more important than others. Fletcher and Stum Lakes in the Chilcotin Plateau, 103 and 105 Mile lakes in the Chilcotin-Cariboo Basin. Only two nests have ever been found in B.C. (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Only two nests have been found in B.C. Eggs are laid between May and July and incubation is 25 to 28 days. Brood parasitism does occur with females laying eggs

in the nests of other White-winged Scoters and other species of ducks (Campbell *et al.* 1990). Clutches of greater than 12 eggs are the result of more than 1 female. Females brood chicks for 12 to 24 hours after hatching. Most broods have seven to 12 young. Fledging period is 63 to 75 days (Ehrlich *et al.* 1988) but young become independent of the female at about one week of age. At this point, the female will often leave her week old chicks and fly to moulting areas in salt water (mid August) (Campbell *et al.* 1990). White-winged Scoters breed later than any other duck. Females show strong nest site tenacity (Ehrlich *et al.* 1988).

2d. **Migration behaviour is well documented?**
Not all White-winged Scoters that winter on the B.C. coast breed nearby, but generally these birds migrate to the coast in autumn to winter. Autumn migration is difficult to pinpoint because of the large number of White-winged Scoter that occur year round on the coast. Spring migration, marked by the arrival of breeding pairs on interior lakes, occurs in mid May. Males migrate to the coast soon after incubation begins (June?) females follow in early autumn and young of the year leave the interior before freeze up in the first weeks of November (Campbell *et al.* 1990).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animals be easily located?**
Nests may be difficult to find as only two have been found in B.C.

3b. **Can samples be easily collected?**
See above. May be more practical to consider sampling fledged young of the year.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Di and Scanlon 1984).

5c. **Have biological effects for this species been studied?**
No.

COMMON GOLDENEYE ***Bucephala clangula***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
Yes.

1c. **Common in the Fraser Basin?**
Widespread though uncommon breeder (Campbell *et al.* 1990). Bellrose (1976) estimated 20,000 breeders though Campbell *et al.* (1990) believed this estimate to be very high.

1d. **Proportion of diet within the aquatic food web.**
Insects form a large part of the diet on freshwater while crustaceans form a large part of the diet on salt water. Animal matter constitutes 74% of the diet in adults and 84% of the diet in juveniles. Juveniles eat mainly insects. Insects consumed include larvae of caddisflies (Trichoptera), water boatmen (Corixidae), nymphs of dragonflies and damselflies (Odonata), mayflies (Ephemeridae) saltflies (Ephydra) and beetles (Coleoptera) (Palmer 1976).

2a. **Has the home range of the species been described?**
While accompanied by young, the female remains in a limited area. Once the female leaves, however, the fledged young may move as well (Palmer 1976).

2b. **Habitat selection is well documented?**
Yes. Nest near lakes, rivers and associated flood plains, sloughs, ponds and creeks usually with woody margins, from 180 to 1550m. Common Goldeneyes will nest in nest boxes when they are available. Natural sites include tree cavities. Nests are generally 3.5 to 5.5m off the ground and are usually about 90m from water (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Eggs are laid as early as April 1 and into late June. Clutch sizes generally have six to eight eggs. Soon after the onset of incubation, males desert the females and fly to moulting areas (Campbell *et al.* 1990). Incubation lasts about 30 days. Broods with more than 12 chicks are likely the result of brood amalgamation resulting from aggressive encounters between females. Chicks fledge in 56 to 60 days. When nest sites are scarce, females will parasitize each other resulting in clutches often greater than 30 eggs! Young remain in nest for 24 to 42 hours, after the female and brood leaves for nearby water (Ehrlich *et al.* 1988).

2d. **Migration behaviour is well documented?**
Common Goldeneyes migrate to the coast and to the southern interior of B.C. to winter. Many of them also move south to winter. Bellrose (1976) reported only

1,248 Common Goldeneyes wintering in B.C.. Christmas Bird Counts have suggested over 5,000 wintering birds. Autumn migration is late in the interior as many birds stay until freeze-up. Spring migration begins in late February as birds arrive on interior lakes in early March (Campbell *et al.* 1990).

2e. **Information on historic abundance?**
The Common Goldeneye appears to have expanded it's range in some areas but in other areas to now be outnumbered by Barrow's Goldeneye (see Campbell *et al.* 1990.)

3a. **Can nests or animals be easily located?**
Since Common Goldeneyes will take readily to nestboxes, finding nests could be very easy.

3b. **Can samples be easily collected?**
Sampling eggs in nestboxes could be quite easy, however, Common Goldeneyes are apparently easily disturbed from their eggs during incubation and clutch abandonment is common. Sampling fledged young of the year might be more practical.

4a. **Captive rearing possible and well understood?**
In their review of this criteria with Common Goldeneye, Hebert *et al.* (1993) indicated that this species has been reared in captivity.

4b. **Captive breeding possible and well understood?**
No (Hebert *et al.* 1993).

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Falandysz 1982a; Barrett and Barrett 1985; Falandysz 1986; Smith *et al.* 1986; Zicus *et al.* 1988; Foley and Batcheller 1988; Eriksson *et al.* 1989; Swift *et al.* 1993).

5c. **Have biological effects for this species been studied?**
Yes (Eriksson 1984; Desgranges and Rodrique 1985; Eriksson 1987; Blancher and McAuley 1987; Mallory *et al.* 1993).

BARROW'S GOLDENEYE ***Bucephala islandica***

1a. **Present in the Fraser Basin year-round?**
Most winter on the coast (Campbell *et al.* 1990).

1b. **Broad distribution?**
Yes, a widespread breeder throughout the interior of B.C. (Campbell *et al.* 1990).

1c. **Common in the Fraser Basin?**

Fairly common in the southern portion of the region becoming rare to only locally fairly common north of the Chilcotin-Cariboo (Campbell *et al.* 1990). Pre-breeding estimates indicate 70,000 to 126,000 Barrow's Goldeneyes in B.C. (Bellrose 1976).

1d. **Proportion of diet within the aquatic food web.**

Diet it similar to the Common Goldeneye but apparently more insects are consumed, 78% of the diet is animal matter with a large part of it being insects and the rest crustacean and mollusks. Among juveniles 98% of the diet consisting of animal matter mainly insects (Cottam 1939 cited in Palmer 1976). Generally insects and their larvae are important in freshwater, and mollusc and crustaceans are important in saltwater habitats. Animal matter consumed: Insects: nymphs of damselflies and dragonflies (Odonata), larvae and cases of caddisflies (Trichoptera), water boatmen (Corixidae), back swimmers (Notonecta), larvae of midges (Chironomus), aquatic beetles and larvae (Dytiscidae) 36.4% Mollusc: (Mytilus edulis mainly, Littorina, Lacuna) 19.2%, crustaceans: amphipods mainly, isopods and crayfishes (Astacus) 17.7%; fishes, sculpins (Cottidae) mainly 1.1%, water mites (Hydracarina), sea urchins, starfish, earthworms, marine worms, hydroids and freshwater sponges 3.3% (Palmer 1976).

2a. **Has the home range of the species been described?**

A brood territory is maintained until the chicks can fly (about six weeks). If repeatedly disturbed, however, the territory may be abandoned and a new one established. In addition, chicks will frequently move between territories as a result of brood amalgamation (Palmer 1976).

2b. **Habitat selection is well documented?**

Lakes associated with aspen parkland, open Ponderosa Pine forests, farmland, rangelands and alpine meadows as well as wetter, closed, coniferous forests including sub-alpine regions from 300 to 1830m elevation. Alkaline lakes are preferred, occasionally will nest near rivers and ponds. They will readily accept nest-boxes and other man made structures (barn loft). Natural cavities include woodpecker cavities and crows nests. Nests are near or over water, or at the edge of a wetland. Most nests are between 2 and 3 m off the ground. Savard (1986) showed that suitable nest sites are a limiting factor in certain areas (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**

Pair bond lasts over successive years although the male deserts the female during incubation (Ehrlich *et al.* 1988). Eggs are laid between March and early July. Clutch sizes are mostly six to 10 eggs. Clutches larger than this are likely the result of two females (one female dumping her eggs in the nest of another) . The incubation period ranges between 29 and 34 days (Campbell *et al.* 1990). Young remain in nest for 24 to 36 hours after which they are led to water. Chicks are fledged in 56 days (Ehrlich *et al.* 1988).

2d. **Migration behaviour is well documented?**
Birds migrate to the coast and to southern B.C. to winter. Autumn migration begins in October with large flocks developing on the coast by late October. Spring migration to breeding sites begins in mid March (Campbell *et al.* 1990).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animals be easily located?**
Since Barrow's Goldene take readily to nestboxes, finding nests could be quite easy. Finding juveniles and adults during the breeding season should also be fairly easy since many of the breeding areas are known.

3b. **Can samples be easily collected ?**
Finding eggs from nestboxes would be quite easy, however, there is no information on how well Barrow's Goldeneye tolerate disturbance. Sampling young of the year once they have fledged might be easier.

4a. **Captive rearing possible and well understood?**
Yes, captive rearing of young is referred to by Palmer (1976), but there are no details given.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have bioeffect relationships between this species and contaminants been studied?**
No.

BUFFLEHEAD ***Bucephala albeola***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
Yes, widespread breeder.

1c. **Common in the Fraser Basin?**
Fairly common to locally very common (Campbell *et al.* 1990). 70,000 to 100,000 breeders in B.C. (Bellrose 1976).

1d. **Proportion of diet within the aquatic food web.**
Yes, 70 to 90% of the diet consists of aquatic insects, shrimp and snails. Downie chicks feed more on aquatic insects. The diet of older juveniles does not differ appreciably from that of the adult (Palmer 1976).

2a. **Has the home range of the species been described?**
Female will lead chicks over land to suitable water where they will stay for five to six wks at which point the chicks are fledged.

2b. **Habitat selection is well documented?**
Yes, lakes and occasionally on rivers, sloughs and ponds in the aspen parklands, interior Douglas fir forests, open Ponderosa Pine forests, farmland, rangelands from 300 to 1430m. They will use nest-boxes but seem to prefer natural cavities, mostly those created by Northern Flickers. The most commonly reported natural site is in Trembling Aspen. Most nests are near the edge of a wetland, although sometimes they may be as much as 200m from water. Most nests are 60 cm to 3 m from the ground (Campbell *et al.* 1990). Strong fidelity to nest sites (Ehrlich *et al.* 1988).

2c. **Breeding biology is well understood?**
Long-term pair bond, although male deserts female during incubation (Ehrlich *et al.* 1988). Eggs are laid between late April and late July. Clutches are generally seven to nine eggs. Larger clutches are the result of more than one female (Campbell *et al.* 1990). Eggs are incubated for 28 to 33 days. Chicks stay in the nest for 24 to 36 hours after which they move to water. Broods larger than 12 chicks are likely the result of brood amalgamation resulting from aggressive encounters between females or sometimes just by accident. Chicks are fledged in 49 to 56 days (Ehrlich *et al.* 1988).

2d. **Migration behaviour is well documented?**
Yes, migrate to coastal B.C. and the southern interior of B.C. to winter, although many of the birds reared in B.C. actually winter along the Pacific coast south to California. Males leave incubating females in May and June. Females and young of the year remain on interior lakes until freeze up, leaving in October and November. Spring migration to breeding sites occurs in April (Campbell *et al.* 1990).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animals be easily located?**
Finding nests could be fairly easy since they often occur in the same habitat as Barrow's Goldeneyes and they will use nest boxes. Finding females with young of the year could also be fairly easy since many of the lakes and wetlands used during the breeding season area known.

3b. **Can samples be easily collected?**
Yes, collecting eggs could be fairly easy from nest boxes and probably also from natural cavities since most are no more than 3 m off the ground, however, there is no information on the tolerance of Buffleheads to disturbance. Collecting young of the year might be more practical.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Di and Scanlon 1984; Di and Scanlon 1981; Foley 1992).

5c. **Have biological effects for this species been studied?**
No.

HOODED MERGANSER ***Lophodytes cucullatus***

1a. **Present in the Fraser Basin year-round?**
Yes, they are very common in certain areas of the southern interior near Campbell River (Campell *et al.* 1990).

1b. **Broad distribution?**
Yes, but the centre of breeding abundance in the southwestern portion of the province (Bellrose 1976). Elsewhere they are sparsely distributed.

1c. **Common in the Fraser Basin?**
Not that common, there are only an estimated 2,000 to 4,000 breeders (Bellrose 1976).

1d. **Proportion of diet within the aquatic food web.**
Yes, in general they consume less fish than the other two merganser species. Approximately 44% of the diet consists of small fish. Overall, animal matter makes up 96% of the diet and includes small fish, aquatic insects and crayfish (Palmer

1976). There is no information on the diet of chicks or whether their diet differs significantly from that of the adults.

2a. **Has the home range of the species been described?**
Insufficient information.

2b. **Habitat selection is well documented?**
Yes, breeding habitat includes mainly fresh but occasionally brackish water sites, usually with wooded shorelines. Habitats include rivers, lakes, marshes, streams, beaver ponds and sloughs. Hooded Mergansers will take readily to nestboxes and will use them whenever available. Nests are usually 4 to 15 m from the ground (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Yes. Eggs are laid between mid March and June. Clutch sizes are usually eight or nine eggs. Much larger clutches are the result of egg dumping by other females (Campbell *et al.* 1990). Eggs are incubated for about 33 days. Males desert females during incubation. Chicks fledge in about 71 days (Ehrlich *et al.* 1988).

2d. **Migration behaviour is well documented?**
Spring migration is not clear, wintering birds have usually left the coast by the end of April. In summer males leave the incubating females to unknown wintering grounds and then move to the coast in the autumn. Autumn migration is a gradual dispersal in October and November (Campbell *et al.* 1990).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animals be easily located?**
Yes, finding Hooded Mergansers should be easy as they will use nest boxes. Finding adults and young of the year on nearby water should be fairly easy too. No information on sensitivity to disturbance.

3b. **Can samples be easily collected?**
Yes, collecting eggs from nes boxes would be quite easy. Collecting young of the year and adults should be fairly easy too.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Zicus *et al.* 1988).

5c. **Have biological effects for this species been studied?**
No.

COMMON MERGANSER ***Mergus merganser***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
Widespread breeder (Campbell *et al.* 1990)

1c. **Common in the Fraser Basin?**
Fairly common to common (Campbell *et al.* 1990), 8,000 to 12,000 breeding mergansers in B.C., most are Common Mergansers (Bellrose 1976).

1d. **Proportion of diet within the aquatic food web.**
Yes, feeds largely on fish taking whatever species are most readily available. Ducklings at first feed almost entirely on aquatic insects with fish appearing in their diet as they grow older and can dive (Palmer 1976).

2a. **Has the home range of the species been described?**
No, female abandons young when they are half grown. Once on their own, the brood begin to move downstream perhaps in pursuit of larger prey (Palmer 1976).

2b. **Habitat selection is well documented?**
Near freshwater along forested shores of lakes, steams, rivers. Most nests are along the shoreline of freshwater lakes or on the banks of rivers. Some are on islands in lakes. Some nests are in tree cavities while others are on the ground (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Eggs are laid between March and late May. Clutches usually contain eight to 10 eggs. Males leave for moulting areas during incubation (Campbell *et al.* 1990). Eggs are incubated for 28 to 35 days. Chicks are fledged after 65 to 70 days. Where suitable nests are not available egg dumping occurs. Ducklings stay in the nest for 24 to 48 hours. Deserted broods join female tended broods (Ehrlich *et al.* 1988).

2d. **Migration behaviour is well documented?**
Winters on the coast of B.C. and in the southern interior of B.C.. In spring, herring spawning sites on the coast are frequented. During autumn salmon spawning rivers

are frequented. Spring migration in the interior begins soon after ice break up with the main movement occurring in April and early May. Autumn migration in the interior occurs in November (Campbell *et al.* 1990).

2e. **Information on it's historic abundance?**
No.

3a. **Can nests or animals be easily located?**
Nests in nest-boxes would be easy to find, nests on the ground and in natural cavities might be more difficult.

3b. **Can samples be easily collected?**
Collecting eggs from nests should be relatively easy since nests appear to be accessible, however, there is no information on how Common Mergansers tolerate disturbance. Catching fledged young of the year might be more practical.

4a. **Captive rearing possible and well understood?**
Yes, captive rearing is mentioned in Palmer (1976) but no details are given, also Wood and Hand (1985).

4b. **Captive breeding possible and well understood?**
In their review of the Common Merganser, Hebert *et al.* (1993) concluded that captive breeding has not been undertaken.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Hansen and Kraul 1981).

5c. **Have biological effects for this species been studied?**
Yes (Eriksson 1984; Eriksson 1987).

RUDDY DUCK ***Oxyura jamaicensis***

1a. **Present in the Fraser Basin year-round?**
Very rare in winter in the B.C. interior (Campbell *et al.* 1990).

1b. **Broad distribution?**
Yes, widespread breeder (Campbell *et al.* 1990).

1c. **Common in the Fraser Basin?**
Fairly common to very common breeder, (Campbell *et al.* 1990), 15,000 birds breed in the Chilcotin-Cariboo (Bellrose 1976).

1e. **Proportion of diet within the aquatic food web.**
Most aquatic insect larvae, also aquatic snails, other invertebrates. Food obtained by straining from soft substrate ooze. Invertebrates eaten include: larvae of midges, caddisflies, water boatmen, dragonfly and damsel fly nymphs (Palmer 1976).

2a. **Has the home range of the species been described?**
No. Female deserts young when they are half grown and chicks can fly at six weeks (Palmer 1976).

2b. **Habitat selection is well documented?**
Prefers freshwater lakes, ponds, sloughs and marshes deeper than 2m, with emergent vegetation such as bulrushes and cattail for nesting cover. It seems to prefer areas with slightly shorter and sparser dead vegetation rather than taller and denser green vegetation. Most nests are over water that is 0.25 to 0.4m deep. They were situated in cattail, bulrushes and sedge borders, 2 to 33m from open water. Most nests were attached to emergent vegetation and many were concealed by vegetation pulled over the nest, giving it a basket-shaped appearance. Some nests are free-floating (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Eggs are laid between May and August with most laid in June and July. Clutches usually contain five to nine eggs. Males leave soon after incubation starts (Campbell *et al.* 1990). Eggs are incubated for about 23 days. Ruddy Ducks appear to parasitize and intraspecific parasitism is higher than interspecific parasitism (Ehrlich *et al.* 1988). Ruddies have been known to lay their eggs in nests of American Bittern, Northern Pintail, Canvasback, Redhead, Lesser Scaup and American Coot (Campbell *et al.* 1990). Chicks are fledged in 42 to 49 days. Ducklings are soon capable divers but are quite helpless on land (Ehrlich *et al.* 1988).

2d. **Migration behaviour is well documented?**
Most migrates to protected bays along the southern mainland and Vancouver Island. Autumn migration to these wintering sites occurs mainly in late September through October. Spring migration to breeding sites occurs mainly in late April through to the third week of May but it can begin as early as late February (Campbell *et al.* 1990).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animals be easily located?**
It could be difficult to find nests easily because they are concealed in emergent vegetation. Finding females with broods or fledged young of the year might be easier.

3b. **Can samples be easily collected?**
Egg collection could be difficult. Collecting fledged young of the year might be more practical.

4a. **Captive rearing possible and well understood?**
Yes, captive rearing is mentioned by Palmer (1976) but no details are given.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Di and Scanlon 1984; Barnum and Gilmer 1988).

5c. **Have biological effects for this species been studied?**
No.

OSPREY *Pandion haliaetus*

1a. **Present in the Fraser Basin year-round?**
No.

1b. **Broad distribution?**
Yes. Widespread breeder throughout the Basin (Campbell *et al.* 1990).

1c. **Common in Fraser Basin?**
Uncommon to fairly common in southern third of province, rare north of latitude 56° (Campbell *et al.* 1990).

1d. **Proportion of diet within the aquatic food web.**
Yes. Feeds almost exclusively on fish. In the Fraser Basin they are known to feed on suckers, whitefish, trout and black bullhead (Machmer and Ydenberg 1990; Steeger *et al.* 1992). Most fish eaten are 11 to 30 cm weighing up to 1 kg. Parents deliver about 4.6 fish/day to broods of two chicks and 5.6 fish/day to broods of three chicks (Palmer 1988).

2a. **Has the home range of the species been described?**
In B.C. most nest sites are located near to water where one can be quite certain they are feeding. They are opportunists and are energy efficient and not likely to travel further than they need to find food (Machmer pers. comm. 1994).

2b. **Habitat selection is well documented?**
Yes. Trees or elevated structures over or near lakes (65%), rivers (25%) or marine shores (9%). Occasionally nests may be as much as 4 km from water source (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Yes. Monogamous. Lays two to four eggs. During laying, the female is fed by the male. Eggs are incubated by both parents for 32 to 43 days. Eggs laid as early as April 17 and as late as the end of June. Female does most of the brooding of the young with the male bringing food to the nest. Chicks are fledged in 48 to 59 days of hatching (Ehrlich *et al.* 1988; Campbell *et al.* 1990).

2d. **Migration behaviour is well documented?**
Yes. Migrate to southern U.S.A., Chile and Argentina. Southward migration occurs mainly during the last two weeks of September. The main influx of Osprey to the interior of B.C. occurs in mid April although they can arrive as early as February (Campbell *et al.* 1990).

2e. **Information on historic abundance?**
Nest sites have been mapped and some records kept on occupancy for contaminant studies in the Fraser Basin (Steeger and Machmer 1991; Machmer and Steeger 1992).

3a. **Can nests or animals be easily located?**
Yes. Single large nests. Very visible and tend to return in subsequent years to nests so that nest sites can be mapped out for future reference. Many nests along the Fraser, Thompson and Nechako Rivers have been mapped as part of Osprey contaminant monitoring study (Machmer and Steeger 1992).

3b. **Are samples easy to collect?**
Yes. Eggs have been successfully collected and blood sampling of chicks has been done successfully (Steeger *et al.* 1992; Machmer and Steeger 1992).

4a. **Captive rearing possible and well understood?**
Osprey chicks can be reared in captivity but only for brief periods as they are susceptible to respiratory infections (Machmer pers. comm. 1994).

4b. **Captive breeding possible and well understood?**
No.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
Yes, at nests along the Nechako and Fraser Rivers near Prince George, the Fraser River near Quesnel, and the Thompson River between Shuswap Lake and Spences Bridge (Steeger and Machmer 1991; Machmer and Steeger 1992; Whitehead pers. comm.).

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Ohlendorf 1981; Wiemeyer and Cromartie 1981; Levenson and Koplin 1984; Littrel 1986; Wiemeyer *et al.* 1987; Wiemeyer *et al.* 1988; Noble and Elliott 1990; Henny *et al.* 1991; Steidl *et al.* 1991a; Wiberg *et al.* 1992; Audet *et al.* 1992; Ewins and Bishop 1993; Noble *et al.* 1993).

5c. **Have biological effects for this species been studied?**
Yes (Eriksson 1984; Eriksson 1986; Henny *et al.* 1991; Steidl *et al.* 1991b; Presser and Ohlendorf 1987).

BALD EAGLE ***Haliaeetus leucocephalus***

1a. **Present in the Fraser Basin year-round?**
Some birds are year round residents, most migrate to the coast during winter. Juveniles wander the farthest (Campbell *et al.* 1990). In a midwinter (January 10, 1988) survey of Bald Eagles in British Columbia, 8400 eagles were counted and of these only 96 were recorded from the southern interior of British Columbia (Farr and Dunbar 1988).

1b. **Broad distribution?**
Yes.

1c. **Common in the Fraser Basin?)**
No. Uncommon but they do occur throughout the Fraser Basin.

1d. **Proportion of diet within the aquatic food web.**
Highly diverse and adapted to food availability. Fish, however, make up at least half their diet, followed by birds and then mammals. Coots are the most commonly eaten bird perhaps because are easy to catch. Food is acquired by: 1) stealing, 2) scavenging, and 3) hunting. Nestlings fed in the nest are brought five to six items per day (Stalmaster 1987).

2a. **Has the home range of the species been described?**
Although they have a nesting territory (1 - 2 km) they may well forage outside this area (Stalmaster 1987).

2b. **Habitat selection is well documented?**
Yes. Tall trees, usually conifers, but they will nest in deciduous and mixed woodlands. Nest trees are near seashores, lakes, large rivers and marshes. Most nest trees have unobstructed views of surrounding area with a food source nearby. Often nest on islands in rivers and lakes and also on river banks (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Yes. Maintain exclusive breeding territories of 1 to 2 km^2. Monogamous and maintain long term pair bonds. Within the breeding territory there are often several

nests which are used in alternate years. Each year the nest to be used is added to. Following nest preparation one to three eggs are laid. Eggs are usually laid in April and are incubated for about 35 days. Eggs are rarely left unattended. Chicks are fed for the first 6-7 wks after which time the chicks feed themselves of the food they are offered. Male does most of the early hunting mostly because the female is incubating unhatched eggs and brooding hatched chicks. Chicks are fledged 10 to 12 weeks after hatching (Stalmaster 1987).

2d. **Migration behaviour is well documented?**
Yes. Most birds move to the coast to winter although many remain in the interior. Migration in autumn seem correlated with commencement of salmon spawning on the coast and in the interior. In the interior the winter distribution of Bald Eagles is dependent on open water and the availability of waterfowl especially American Coot (Campbell *et al.* 1990).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animals be easily located?**
Yes. Nests are highly visible. Typically a pair will have several nests in their territory and they rotate among the nests annually. Nests can be mapped out for future reference (J.E. Elliott and I.E. Moul pers. comm.).

3b. **Are samples easy to collect?**
Yes. Requires a tree climber, but eagles do not seem to attack during egg collections or during blood sampling of chicks (personal observation). However, eagles are unlikely to lay replacement eggs. If only one egg is removed they will not relay. If all eggs are removed there is a chance relaying might occur if the eggs were removed during the first week of incubation (Stalmaster 1987).

4a. **Captive rearing possible and well understood?**
Yes.

4b. **Captive breeding possible and well understood?**
Yes.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
Yes. Eggs and blood samples of chicks have been collected from Agassiz to the Strait of Georgia (J.E. Elliott pers. comm.)

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Ohlendorf 1981; Wiemeyer *et al.* 1984; Franson *et al.* 1985; Gray 1989a; Gray 1989b; Noble and Elliott 1990; Grubb *et al.* 1990; Gray 1991; Kozie and Anderson 1991; May 1993; Noble *et al.* 1993; Anthony *et al.* 1993; Wiemeyer *et al.* 1993).

5c. **Have biological effects for this species been studied?**
Yes (May 1983; Franson *et al.* 1985; Colborn 1991; Kozie and Anderson 1991; Anthony *et al.* 1993).

BELTED KINGFISHER ***Ceryle alcyon***

1a. **Present in the Fraser Basin year-round?**
No.

1b. **Broad distribution?**
Yes, where ever nest sites are available (Campbell *et al.* 1990).

1c. **Common in the Fraser Basin?**
No, uncommon (Campbell *et al.* 1990).

1d. **Proportion of diet within the aquatic food web.**
Primarily feed on fish, but occasionally take aquatic invertebrates, amphibians, reptiles, insects, young birds, mice and, rarely, berries. Young are fed regurgitant (Ehrlich *et al.* 1988).

2a. **Has the home range of the species been described?**
No information about Kingfishers in B.C., however, in Ontario they do not maintain small home ranges (Hebert *et al.* 1993).

2b. **Habitat selection is well documented?**
Usually near watercourses along natural or man-made cutbacks including roads, railways river and lakeshore banks. Nests are excavated in sand or clay banks. Burrows are generally 1 to 2.4m in depth. Most burrows are 1.2 to 24m above the base of the bank with most occurring between 1.5 and 6m. Entrance diameters range from 9 to 13cm (Campbell *et al.* 1990).

2c. **Breeding biology is well understood?**
Eggs are laid between March and June. Clutch sizes range between two and seven eggs (Campbell *et al.* 1990). Eggs are incubated for about 23 days by both parents. Chicks remain in the nest for 30 to 35 days. After fledging, parents teach young to fish. Dead meals are dropped into the water below perched young who must dive for them. At 10 days post-fledging young are capable of catching live prey and are forced from the parental territory. Territory sizes are inversely related to food abundance. During non-breeding season Belted Kingfishers are solitary (Ehrlich *et al.* 1988).

2d. **Migration behaviour is well documented?**
Mostly winter on the B.C. coast although small numbers winter in the southern interior of the province. Spring migration to breeding sites in the interior begins as

early as March although the main movement is in April. Autumn migration occurs in August in the north and in September/October further south (Campbell *et al.* 1990).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animals be easily located?**
Nests should be fairly easy to spot although they may be widely distributed.

3b. **Can samples be easily collected?**
Burrows are 1 to 2.4m in depth and this could make it very difficult to sample eggs or chicks. In their report, Hebert *et al.* (1993) concluded that collecting samples in Ontario would be difficult.

4a. **Captive rearing possible and well understood?**
In their review of the Belted Kingfisher, Hebert *et al.* (1993) noted that captive rearing was possible and sufficiently understood.

4b. **Captive breeding possible and well understood?**
No, according to Hebert *et al.* (1993) captive breeding has not been attempted.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Heinz *et al.* 1984; Landrum *et al.* 1993).

5c. **Have biological effects for this species been studied?**
No information.

TREE SWALLOW *Tachycineta bicolor*

1a. **Present in the Fraser Basin year-round?**
No.

1b. **Broad distribution?**
Yes.

1c. **Common in the Fraser Basin?**
Probably, but insufficient information.

1d. **Proportion of diet within the aquatic food web.**
Diet 50-90% aquatic insects (Quinney and Ankey 1985; Blancher and McNichol 1988).Nestlings are fed Diptera (46%), Homoptera (26%), Ephemeroptera (11%), Odonata (5%), Coleoptera (4%), Mollusca (4%), Aranae (2%), Psocoptera (1%),

Hymenoptera (1%), plus traces of Hemiptera, Neuroptera, Trichoptera and Lepidoptera (Robertson *et al.* 1992).

2a. **Has the home range of the species been described?**
Yes, during incubation and nestling phases birds tend to maintain small home ranges of 2 to 3 km (females), 4 to 5 km (males). Prior to incubation they may forage up to 60km from the nest site (Robertson *et al.* 1992).

2b. **Habitat selection is well documented?**
Open areas usually near water, including fields, marshes, shorelines, and wooded swamps with standing dead trees that provide nesting cavities. Will readily use nest boxes (Robertson *et al.* 1992). South facing preferred over north facing cavities (Lumsden 1986). Require substantial open areas around nest site . Scarcity in grass pastures due to competition with Mountain Bluebirds (Robertson *et al.* 1992).

2c. **Breeding biology is well understood?**
Generally nest in aggregations. Mainly monogamous. Sometimes the same pair breeds in consecutive years. This is a result of strong nest site tenacity rather long-term pair bonding. Pair formation begins soon after females arrive on breeding grounds. Egg laying begins early May in many populations although reported as early as April 19. Not sure what dates might be in the B.C. interior. Females lays one egg per day. Clutch size ranges from four to six eggs. Eggs are incubated by the female for 11 to 19 days. Nestlings remain in the nest for about 18 to 22 days. During this time both parents feed them. Food is carried in the bill and throat by the parents. Average size of food bolus is 28g dry mass. Late in the nestling phase single large insects are brought. Each parent makes 10 to 20 feeding trips per hour (Robertson *et al.* 1992).

2d. **Migration behaviour is well documented?**
Migration to wintering grounds begins soon after the breeding season (August). Winters in the southern U.S.A. and central America. Spring arrival times on breeding grounds generally earlier than other swallow species - March to early April (Robertson *et al.* 1992).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animals be easily located?**
Since this species will take readily to nest boxes, finding nests will be easy.

3b. **Can samples be easily collected?**
Sampling of eggs and nestlings has been done successfully (Shaw 1983; DeWeese *et al.* 1985; Bishop *et al*. 1992; Elliott *et al.* 1993).

4a. **Captive rearing possible and well understood?**
Yes, in their review of the Tree Swallow, Hebert *et al.* (1993) stated that captive rearing is possible and well understood.

4b. **Captive breeding possible and well understood?**
Yes, in their review of the Tree Swallow, Hebert *et al.* (1993) stated that captive breeding is possible and well understood.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
Yes, the Canadian Wildlife Service planned to collect eggs and/or chicks for contaminant analysis during the 1994 season (Phil Whitehead pers. comm.).

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Shaw 1983; DeWeese *et al.* 1985; Zach and Mayoh 1986; Diamond 1987; Kraus 1989; Bishop *et al.* 1992; Ankley *et al.* 1993; St. *et al.* 1993; Zach *et al.* 1993; Elliott *et al.* unpubl.).

5c. **Have biological effects for this species been studied?**
Yes (Zach and Mayoh 1986; Blancher and McAuley 1987; Blancher and McNichol 1988; Louis and Barlow 1993; Zach *et al.* 1993).

VIOLET-GREEN SWALLOW ***Tachycineta thalassina***

1a. **Present in the Fraser Basin year-round?**
No.

1b. **Broad distribution?**
Yes.

1c. **Common in the Fraser Basin?**
Probably, but there is insufficient information.

1d. **Proportion of diet within the aquatic food web.**
Difficult to ascertain from the available information. Hemiptera 36% (mostly leafhoppers and leafbugs), Diptera 23%, Hymenoptera (mostly ants, also wasps and wild bees), Coleoptera 11%. Little information on food of young. Nestlings are fed by parents soon after hatching, apparently females do most of the feeding (86%). Feeding trips by parents are made every two minutes in the morning slowing in the afternoon to intervals of several hours (Brown *et al.* 1992).

2a. **Has the home range of the species been described?**
No information.

2b. **Habitat selection is well documented?**
Open deciduous, coniferous and mixed woodlands, including ponderosa pine and quaking aspen. Shares breeding habitat with the Tree Swallow but often found in more open habitat: rock crevices or holes in dirt banks. Nests in cavities of various sites, including trees, cliffs and nest boxes. Less common but also recorded are nests in stream-sided cutbanks and old nests of Cliff and Barn Swallows. Prefers trees in open areas e.g. open grove or woodland edge. Nest boxes 3 to 5 m off the ground are used (Brown *et al.* 1992).

2c. **Breeding biology is well understood?**
Colonial nester commonly nesting in colonies up to 25 nest but isolated pairs have been reported. Eggs laid one per day until clutch complete, four to six eggs. Eggs are incubated for about 15 days by the female. The eggs rarely hatch all on one day. Nestlings remain in the nest for 23 to 24 days but chicks remain dependent on the parents for some time after fledging (Brown *et al.* 1992).

2d. **Migration behaviour is well documented?**
Winters from the Imperial Valley and lower Colorado Valley and coast in California and south to Guatemala, El Salvador and Honduras. Migration to wintering grounds starts soon after the breeding season ends (August). Spring arrival at breeding sites probably late March (Brown *et al.* 1992).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animals be easily located?**
Yes, especially those in nestboxes.

3b. **Can samples be easily collected?**
Yes, nestlings and eggs could easily be collected from nestboxes.

4a. **Captive rearing possible and well understood?**
Not documented.

4b. **Captive breeding possible and well understood?**
Not documented.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (DeWeese *et al.* 1986).

5c. **Have bioeffect relationships between this species and contaminants been studied?**
No.

CLIFF SWALLOW *Hirundo pyrrhonota*

1a. **Present in the Fraser Basin year-round?**
No.

1b. **Broad distribution?**
Yes.

1c. **Common in Fraser Basin?**
Insufficient information.

1d. **Proportion of diet within the aquatic food web.**
Almost entirely insects but occasionally gorges on berries (Ehrlich *et al.* 1988).

2a. **Has the home range of the species been described?**
Insufficient information.

2b. **Habitat selection is well documented?**
Open country, savanna especially near running water. Build nests on the underside of bridges or culverts, on cliffs, wall under eaves or other vertical surfaces (Ehrlich *et al.* 1988).

2c. **Breeding biology is well understood?**
This species is monogamous. They nest in colonies occasionally 1,000+ pairs. Lay four to six eggs. Eggs are incubated by both parents for 14 to 16 days. Nestlings are fledged after 21 to 24 days. Both parents rear young (Ehrlich *et al.* 1988).

2d. **Migration behaviour is well documented?**
Winter in South America from Paraguay and central and southeast Brazil to Argentina (Ehrlich *et al.* 1988). There is no information on dates of migration to and from the Fraser Basin but it is probably similar to other swallow species.

2e. **Information on historic abundance?**
No.

3a. **Can nests or animals be easily located?**
Yes, colonies of mudplaster nests should quite visible.

3b. **Can samples be easily collected?**
Might be difficult to sample eggs or chicks because of ; 1) the small size of the nest hole opening, and 2) the nest itself may be fairly fragile so that attempts to remove eggs and nestlings could result in destruction of nest.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

AMERICAN DIPPER ***Cinclus mexicanus***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
Yes, throughout B.C.

1c. **Common in the Fraser Basin?**
Insufficient information.

1d. **Proportion of diet within the aquatic food web.**
Aquatic invertebrates and small fish (2" -3") (Ehrlich *et al.* 1988).

2a. **Has the home range of the species been described?**
Insufficient information.

2b. **Habitat selection is well documented?**
Mountain streams at various elevations up to timberline; usually fast-moving streams that remain open in winter but sometimes mountain ponds or lakeshores. Builds nests on ledges, rocky niche or crossbeams under bridges or similar supports (Godfrey 1986). Sometimes builds nest near or behind waterfalls (Cannings *et al.* 1987). Nest is a bulky dome-shaped structure with an outer shell of moss and some grass. There is an entrance hole on the side (Godfrey 1986).

2c. **Breeding biology is well understood?**
Apparently lays four to five eggs which are incubated for about 16 days (Godfrey 1986). Eggs are laid as early as the second week of April and probably the last week of May (Cannings *et al.* 1987).

2d. **Migration behaviour is well documented?**
Move downstream to areas where water stays open year-round (November). Then by February have begun to move back to breeding sites (Cannings *et al.* 1987).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animals be easily located?**
Might be difficult to find and there is no information on densities.

3b. **Can samples be easily collected?**
Could be difficult since nests have only small openings.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No but see references on the European Dipper (*Cinclus cinclus*).

5c. **Have biological effects for this species been studied?**
No but see references to the European Dipper (*Cinclus cinclus*).

RED-WINGED BLACKBIRD ***Agelaius phoeniceus***

1a. **Present in the Fraser Basin year-round?**
No.

1b. **Broad distribution?**
Yes.

1c. **Common in the Fraser Basin ?**
Probably but there is insufficient information.

1d. **Proportion of diet within the aquatic food web.**
Difficult to ascertain from the available information. Insects and spiders, grasses and seeds. The breeding season is the only time when animal matter exceeds plant matter in their diet (Bendell and Weatherhead 1982). Young fed insects exclusively (Ehrlich *et al.* 1988). In a study in Ontario, Lepidopteran larvae from grasses and legumes predominated during the nestling period. Later Orthopterans

predominated. Other invertebrates eaten included spiders, isopods and snails (Bendell and Weatherhead 1982).

2a. **Has the home range of the species been described?**
Yes, males defend territories during the breeding season.

2b. **Habitat selection is well documented?**
Freshwater and brackish marshes, riparian habitats, fields. Builds nests near or over water usually in emergent vegetation or shrubs (Ehrlich *et al.* 1988).

2c. **Breeding biology is well understood?**
Polygynous, strongly territorial, male defends a territory, females nest in territory. Three to four eggs are laid and incubated by the female for 10 to 12 days. Both sexes tend the young. Young are able to fly after 11 to 14 days and can swim at five to six days. Are parasitized by cowbirds (Ehrlich *et al.* 1988).

2d. **Migration behaviour is well documented?**
Migrate south to U.S.A. and as far south as Costa Rica (Ehrlich *et al.* 1988).

2e. **Information on it's historic abundance?**
Insufficient information.

3a. **Can nests or animals be easily located?**
Yes nests can be easily located for sampling (Bishop *et al.* 1992)

3b. **Can samples be easily collected?**
Yes eggs and chicks can be easily collected (Bishop *et al.* 1992)

4a. **Captive rearing possible and well understood?**
Yes (Stickel *et al.* 1984a; Stickel *et al.* 1984b; Hienz and Sach 1987; Hill and Murray 1987; Avery and Nelms 1990; Avery and Decker 1991; Avery and Decker 1992; Avery *et al.* 1993;).

4b. **Captive breeding possible and well understood?**
No (Hebert *et al.* 1993).

5a. **Is there historic information on contaminant burdens in the Fraser Basin ?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Holler and Schafer 1982; Powell 1983; Schafer and Jacobson 1983; Stickel *et al.* 1983; Stone *et al.* 1984; Flickinger *et al.* 1984; Balcomb *et al.* 1984a; Balcomb *et al.* 1984b; Stickel *et al.* 1984a; Stickel *et al.* 1984b; Lacombe *et al.* 1986; Lacombe *et al.* 1987; Clark *et al.* 1988; Avery and Decker 1991; Koster *et al.* 1992; Bishop *et al.* 1992; Ankley *et al.* 1993;).

5c. **Have biological effects for this species been studied?**

Yes (DeWeese *et al.* 1983; Flickinger *et al.* 1984; Custer *et al.* 1985; Beyer *et al.* 1988; Meyer *et al.* 1990; Hart *et al.* 1991; Meyer *et al.* 1992; Meyer *et al.* 1993).

APPENDIX 3

CLASS MAMMALIA

Species are ordered taxanomically as follows:

BIG BROWN BAT ***Eptesicus fuscus***

1a. **Present in the Fraser Basin year-round ?**
Yes, it hibernates (Nagorsen and Brigham 1993).

1b. **Broad distribution?**
Yes, northern limit in B.C. is not known (Nagorsen and Brigham 1993).

1c. **Common in the Fraser Basin ?**
Probably common but not sufficiently documented.

1d. **Proportion of diet within the aquatic food web.**
Regarded as a generalist, hunts over water, forest canopy and along roads in clearings and around street lights in urban areas. Beetles are an important part of their diet but also eats moths, termites, carpenter ants and lacewings. Young are nursed (Nagorsen and Brigham 1993).

2a. **Has the home range of the species been described?**
Information from the Okanagan indicates this species will travel at least 4km between feeding areas and night roosts (Nagorsen and Brigham 1993).

2b. **Habitat selection is well documented?**
Occurs in arid grasslands and interior and coastal forests. Roosts in buildings but also in tree cavities and rock crevices. Is less tolerant of high temperatures than other species and will leave a roost site if temperatures exceed 35°C (Nagorsen and Brigham 1993).

2c. **Breeding biology is well understood?**
No, mating is thought to occur in autumn and winter. Scant data from B.C. suggests young are born in June but birth dates and development can be quite variable among roost sites. Young can fly at 18 to 35 days.

2d. **Migration behaviour is well documented?**
Hibernate usually no more than 80 km from summer sites.

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located ?**
Since this species tends to roost in buildings it might be fairly easy to locate animals.

3b. **Can samples be easily collected?**
Would need to collect individuals or else take large numbers of blood samples from trapped individuals. Repeated disturbance at a nursery colony would probably not be appropriate.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Henny *et al*. 1982; Clark and Krynitsky 1983; Clark 1986).

5c. **Have biological effects for this species been studied?**
Yes (Clark 1986).

SPOTTED BAT ***Euderma maculatum***

1a. **Present in the Fraser Basin year-round?**
Not known, there is only one hibernation record from Utah (Nagorsen and Brigham 1993).

1b. **Broad distribution?**
Distribution poorly known, recent evidence of this bat in the Williams Lake area suggests there may be localised populations throughout the dry interior (Nagorsen and Brigham 1993).

1c. **Common in the Fraser Basin?**
No, this is a rare bat (Nagorsen and Brigham 1993).

1d. **Proportion of diet within the aquatic food web.**
Forages over Ponderosa Pine forests, hay fields and marshes adjacent to lakes. Diet is believed to consist of medium-sized moths. Young are nursed (Nagorsen and Brigham 1993).

2a. **Has the home range of the species been described?**
Will move as far as 10 kilometres between day roost and feeding areas (Nagorsen and Brigham 1993).

2b. **Habitat selection is well documented?**
Associated with arid desert terrain. Typically roost sites are in crevices in steep cliff faces (Nagorsen and Brigham 1993).

2c. **Breeding biology is well understood?**
Very little information. Scant information suggests mating occurs in fall. Based on one pregnancy record for B.C., young are believed to be born in late June early July (Nagorsen and Brigham 1993).

2d. **Migration behaviour is well documented?**
No information at all, although suspected to hibernate locally (Nagorsen and Brigham 1993).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
With so few records for B.C. it seems unlikely that individuals and or roost sites could be found easily. Furthermore the species is on the provincial Blue List.

3b. **Can samples be easily collected?**
See 3a.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

SILVER-HAIRED BAT ***Lasionycteris noctivagans***

1a. **Present in the Fraser Basin year-round?**
Not known. There is evidence to suggest that the species migrates to the U.S.A. throughout most of it's range, however, this may not be the case in British Columbia, where conditions may be mild enough in some areas to allow over wintering. Most records of this species in B.C. are from May and early autumn. These sightings may be individuals preparing to migrate south or individuals from more northern parts of the range arriving to winter. There are a few records of hibernating individuals from the interior (Nagorsen and Brigham 1993).

1b. **Broad distribution?**
Yes, occurs throughout the interior north to the Spatsizi Plateau and east to the Peace River. It also occurs on the coast north to Rivers Inlet and also on most islands (Nagorsen and Brigham 1993).

1c. **Common in the Fraser Basin?**
Not well enough known.

1d. **Proportion of diet within the aquatic food web.**
Hunts at tree top level and over water. Exploits whatever insects are available including moths, midges, leafhoppers, caddisflies, flies, beetles, ants and termites. Young are nursed for about three weeks (Nagorsen and Brigham 1993).

2a. **Has the home range of the species been described?**
Not documented.

2b. **Habitat selection is well documented?**
Associated with forests and grasslands. Species is generally regarded as a tree bat. Information on roost sites is scant for B.C. but individuals have been found under the bark of trees, in crevices in trees, abandoned woodpecker holes and in birds nests (Nagorsen and Brigham 1993).

2c. **Breeding biology is well understood?**
No. Generally roost individually, even maternity colonies are small (one to eight females). No maternity colonies have been found in B.C. Mating is thought to occur in autumn. Females give birth to two young. Young develop quickly and can fly by three weeks of age.

2d. **Migration behaviour is well documented?**
No, there may be some movement of individuals either out of British Columbia and southward and/or a southward movement of individuals from northern parts of their range into southern B.C. (Nagorsen and Brigham 1993).

2e. **Information on it's historic abundance?**
No.

3a. **Can nests or animal be easily located ?**
Since individuals roost alone or in very small groups locating animals at roost sites could be quite difficult, furthermore roost sites are not well characterised in B.C.. Perhaps individuals could be captured by mist netting or trapping over water (Fenton *et al*. 1980).

3b. **Can samples be easily collected?**
Would need to trap individuals and take blood samples. It may be difficult to locate enough individuals in a reasonable period of time.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Henny *et al*. 1982).

5c. **Have bioeffect relationships between this species and contaminants been studied?**
No.

HOARY BAT*Lasiurus cinereus*

1a. **Present in the Fraser Basin year-round ?**
No, circumstantial evidence strongly suggests this species is migratory (Nagorsen and Brigham 1993).

1b. **Broad distribution?**
In B.C. it occurs along the coast and in the interior north to Williams Lake and east to the Rocky Mountains (Nagorsen and Brigham 1993).

1c. **Common in the Fraser Basin?**
Little is known about this species in B.C. (Nagorsen and Brigham 1993).

1d. **Proportion of diet within the aquatic food web.**
Feeds on large insects. Hunts at tree top level in open areas such as fields and forest clearings. Bulk of diet consists of large moths, beetles, dragonflies. Less common items include, midges and flies. Young are nursed for several weeks (Nagorsen and Brigham 1993).

2a. **Has the home range of the species been described?**
Not documented.

2b. **Habitat selection is well documented?**
Associated with a variety of forested and grassland habitats in the province. Tendency to roost in trees. Details of roost site characteristics are not available for B.C.

2c. **Breeding biology is well understood?**
No breeding data from B.C.. Males are solitary and females roost only with their young and do not congregate in colonies. In other areas, young are born in June and nursed through July. Normally females leave their young at the roost while they hunt but they can carry their young for the first week. Typically give birth to twins. Development is slower than with other species. By five weeks the young are capable of sustained flight and the family remains together for several more weeks (Nagorsen and Brigham 1993).

2d. **Migration behaviour is well documented?**
Seems to be migratory although the exact winter range of the B.C. population is not known. Generally populations in the Pacific Northwest appear to migrate to southern California or Mexico to winter (Nagorsen and Brigham 1993).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
No, roost individually and roost sites are not well known in B.C.

3b. **Can samples be easily collected?**
Would need to trap individuals and take blood samples. It may be difficult to locate enough individuals in a reasonable period of time.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have bioeffect relationships between this species and contaminants been studied?**
No.

CALIFORNIA MYOTIS ***Myotis californicus***

1a. **Present in the Fraser Basin year-round?**
Probably, although no hibernating colonies have been found in B.C. (Nagorsen and Brigham 1993).

1b. **Broad distribution?**
Yes (see map in Nagorsen and Brigham 1993).

1c. **Common in the Fraser Basin?**
Yes (Nagorsen and Brigham 1993).

1d. **Proportion of diet within the aquatic food web.**
Feeds at night. Hunts mostly over the surface of lakes although it will also hunt in forest canopy. In the Okanagan, it feeds mainly on caddisflies with moths, flies and beetles taken in minor amounts. Young are nursed, but for how long is not documented (Nagorsen and Brigham 1993).

2a. **Has the home range of the species been described?**
Not documented.

2b. **Habitat selection is well documented?**
Arid grasslands, humid coastal forests and montane forests. Uses rock crevices, tree cavities, spaces under the bark of trees, mine tunnels, buildings and bridges for summer day roosts (Nagorsen and Brigham 1993).

2c. **Breeding biology is well understood?**
Mating occurs in autumn but beyond this the breeding biology is poorly documented. A few records of pregnant females suggests young are born in late June/early July (Nagorsen and Brigham 1993).

2d. **Migration behaviour is well documented?**
Believed to be non-migratory but hibernating colonies have not been found in B.C.

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
It would be possible to capture animals by mist net or bat trap (Fenton *et al*. 1980; Nagorsen and Brigham 1993) but one would need to know where to set nets or traps.

3b. **Can samples be easily collected?**
Individuals weigh only 3.3 to 5.4 grams so one would either need to collect individuals or collect large numbers of blood samples. It may be difficult to collect enough samples within a reasonable period of time.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Henny et al. 1982).

5c. **Have biological effects for this species been studied?**
No.

WESTERN SMALL-FOOTED MYOTIS *Myotis ciliolabrum*

1a. **Present in the Fraser Basin year-round?**
Yes (Nagorsen and Brigham 1993).

1b. **Broad distribution?**
No, was believed to be restricted to the Okanagan and Similkameen valleys but recent surveys in the dry interior indicate they are somewhat more widespread (Nagorsen and Brigham 1993).

1c. **Common in the Fraser Basin?**
No (Nagorsen and Brigham 1993).

1d. **Proportion of diet within the aquatic food web.**
Diet is only reported for the Okanagan where these bats feed primarily on caddisflies and also eat flies, beetles and moths. Young are nursed, but for how long is not documented (Nagorsen and Brigham 1993).

2a. **Has the home range of the species been described?**
Not documented.

2b. **Habitat selection is well documented?**
Live near cliffs and rock outcrops in arid valleys and badlands. In summer it roosts in cavities in cliffs, boulders, vertical banks on talus slopes and under rocks. It prefers small protected crevices. Small caves, abandoned mine adits and buildings serve as night roosts (Nagorsen and Brigham 1993).

2c. **Breeding biology is well understood?**
No. Mating probably occurs in autumn before hibernation. Females usually have single young. Based on a small number of samples, young are probably born from mid-June to mid-July. Newborns weigh 1 gram (Nagorsen and Brigham 1993).

2d. **Migration behaviour is well documented?**
Non-migratory, usually hibernate alone (Nagorsen and Brigham 1993).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
It would be possible to capture animals by mist net or bat trap (Fenton *et al*. 1980; Nagorsen and Brigham 1993) but one would need to know where to set nets or traps.

3b. **Can samples be easily collected?**
These are the smallest bat in B.C. weighing only 2.8 to 5.5 grams. Sampling would require either taking whole individuals or large numbers of blood samples. Collecting individuals would likely be unethical as this species is on the provincial Blue List.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

WESTERN LONG-EARED MYOTIS ***Myotis evotis***

1a. **Present in the Fraser Basin year-round?**
Not known for certain whether they hibernate locally.

1b. **Broad distribution?**
Yes, they are widespread in British Columbia (Nagorsen and Brigham 1993).

1c. **Common in the Fraser Basin?**
Not documented.

1d. **Proportion of diet within the aquatic food web.**
Food habits have not been studied in B.C. From other regions, it appears to be a flexible feeder, eating airborne insects as well as gleaning insects from vegetation

or off the ground. Young are nursed perhaps up to a month (Nagorsen and Brigham 1993).

2a. **Has the home range of the species been described?**
Not documented.

2b. **Habitat selection is well documented?**
Found in a wide range of habitats from arid grasslands and Ponderosa Pine forests to humid coastal and montane forests. In summer it uses buildings or climbs under the bark of trees to roost during the day (Nagorsen and Brigham 1993).

2c. **Breeding biology is well understood?**
No. Maternity colonies are small (five to 30 individuals) and are usually located in buildings. Presumably mating occurs in autumn or early winter. Based upon a few records it is suggested that young are born in late June or early July (Nagorsen and Brigham 1993).

2d. **Migration behaviour is well documented?**
Believed to be non-migratory but there are no winter records for the province (Nagorsen and Brigham 1993).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
It could be difficult to locate day roosts or maternity colonies and the impact of disturbance is not documented. It would be possible to capture animals by mist net or bat trap (Fenton *et al*. 1980; Nagorsen and Brigham 1993) but need to know where to set nets or traps.

3b. **Can samples be easily collected?**
One would have to collect many individuals or else take a lot of blood samples. Finding enough individuals in a reasonable period of time could be difficult.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Henny *et al*. 1982).

5c. **Have biological effects for this species been studied?**
No.

LITTLE BROWN MYOTIS *Myotis lucifugus*

1a. **Present in the Fraser Basin year-round?**
Probably but not known for certain.

1b. **Broad distribution?**
Yes, inhabits most of North America as far north as the tree-line. It is found throughout all of B.C. (Nagorsen and Brigham 1993).

1c. **Common in the Fraser Basin?**
The Little Brown Myotis is considered to be the most widespread and abundant bat species in British Columbia (Nagorsen and Brigham 1993).

1d. **Proportion of diet within the aquatic food web.**
In British Columbia diet has only been studied in the Okanagan. Aquatic insects such as midges, caddisflies and mayflies are major prey items although moths, beetles and other kinds of flies are also taken. Diet changes seasonally with midges predominating in the spring and caddisflies and mayflies important during the summer (Nagorsen and Brigham 1993). This species seems to prefer to feed over calm water rather than over turbulent water where water noise may interfere with prey detection (Frenckell and Barclay 1987). Young are nursed for three weeks after which they can fly and consume the adult diet.

2a. **Has the home range of the species been described?**
Not documented.

2b. **Habitat selection is well documented?**
Occurs in a wide range of habitats from arid grasslands and Ponderosa Pine forest to humid coastal forest and northern boreal forest (Nagorsen and Brigham 1993). Summer roosts are in buildings and other man-made structures, tree cavities, rock crevices caves and under bark.

2c. **Breeding biology is well understood?**
In summer sexes live separately, females congregate in large nursery colonies that can contain hundreds or even thousands of individuals. Mating occurs in late summer or early autumn. The gestation period is 50 to 60 days. Young are born between mid June and mid July. Within three weeks the young are able to fly and to eat solid food (Nagorsen and Brigham 1993).

2d. **Migration behaviour is well documented?**
They do hibernate, but the whereabouts of most of the British Columbia population is not known. In other regions they are known to migrate 50 to 200km between hibernation sites and summer roosts (Nagorsen and Brigham 1993).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
It is extremely difficult to distinguish this bat from the Yuma Myotis, in some cases the only definitive means of identification is an examination of the skull (Nagorsen and Brigham 1993; Harris pers. comm. 1993). Finding a nursery colony might be possible but it may not be appropriate to disturb these individuals. It would be possible to capture animals by mist net or bat trap (Fenton *et al*. 1980; Nagorsen and Brigham 1993) but one would need to know where to set nets or traps.

3b. **Can samples be easily collected?**
One would need to collect individuals or else take large numbers of blood samples. Repeated disturbance at a nursery colony would probably not be appropriate.

4a. **Captive rearing possible and well understood?**
Yes, captive rearing has been done (Aldridge 1986) but no details are provided.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Clark and Stafford 1981; Clark and Krynitsky 1983; Clark and Prouty 1984; Clark 1986; Clark and Rattner 1987; Clark *et al*. 1991).

5c. **Have biological effects for this species been studied?**
Yes (Clark and Rattner 1987; Clark *et al*. 1991).

FRINGED MYOTIS ***Myotis thysanodes***

1a. **Present in the Fraser Basin year-round?**
This species probably hibernate in the Fraser Basin though hibernation sites not well known. Evidence from other regions suggests it migrates short distances from it's summer range to winter range (Nagorsen and Brigham 1993).

1b. **Broad distribution?**
No, located principally in the dry interior from Osoyoos to the Chilcotin River and in the Williams Lake region (Nagorsen and Brigham 1993).

1c. **Common in the Fraser Basin?**
No, species is on the provincial Blue List (Nagorsen and Brigham 1993).

1d. **Proportion of diet within the aquatic food web.**
Diet data are from the Okanagan. Feeds along the edges of streams and rivers. Feeds on moths, flies, beetles, leafhoppers, lacewings, crickets and harvestmen. The presence of flightless insects in the diet indicates that some prey are gleaned from foliage. Young are nursed for about three weeks (Nagorsen and Brigham 1993).

2a. **Has the home range of the species been described?**
Not documented.

2b. **Habitat selection is well documented?**
Generally associated with arid grasslands and Ponderosa Pine - Douglas-fir forests. Virtually nothing is known about roost site characteristics in B.C.. In other areas it roosts in caves, mines, rock crevices and buildings (Nagorsen and Brigham 1993).

2c. **Breeding biology is well understood?**
One maternity colony is known in an attic in Vernon. Males roost separately during the spring and summer. Details of reproduction are not known for B.C. Young are probably born in late June or early July. Young develop quickly and are capable of limited flight at 17 days. By 21 days they have attained adult size.

2d. **Migration behaviour is well documented?**
Believed to hibernate since they accumulate body fat as do other species. There are only two records of hibernating individuals. Seems they hibernate alone. Information from other areas suggests they may travel short distances between summer and winter sites (Nagorsen and Brigham 1993).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
Locating nursery colonies would be difficult since only one is known of in B.C. Alternatively one could capture animals by mist net or bat trap (Fenton *et al*. 1980; Nagorsen and Brigham 1993) but one needs to know where to set nets or traps.

3b. **Can samples be easily collected?**
One would need to collect individuals or else take large numbers of blood samples. Repeated disturbance at a nursery colony would probably not be appropriate. This species is on the provincial Blue List (Nagorsen and Brigham 1993).

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

LONG-LEGGED MYOTIS ***Myotis volans***

1a. **Present in the Fraser Basin year-round?**
Probably hibernates in the Fraser Basin, however, there are no winter records from B.C. (Nagorsen and Brigham 1993).

1b. **Broad distribution?**
Yes, occurs in the interior as far north as Atlin and east to Cranbrook and Mount Revelstoke National Park (Nagorsen and Brigham 1993).

1c. **Common in Fraser Basin?**
Not known although it is quite widespread (Nagorsen and Brigham 1993).

1d. **Proportion of diet within the aquatic food web.**
Opportunistic hunter takes aerial insects over water, forest clearings, among trees and above forest canopy. About 75% of diet is moths but also eats termites, spiders, flies, beetles, leafhoppers and lacewings. Young are nursed but for how many weeks is not documented (Nagorsen and Brigham 1993).

2a. **Has the home range of the species been described?**
Not documented.

2b. **Habitat selection is well documented?**
Inhabits arid range land of the interior but also humid coastal and montane forests. Roost site information from the western United States indicates they use buildings,

crevices in rocks, cliffs, fissures in the ground and the bark of trees for summer roosts (Nagorsen and Brigham 1993).

2c. **Breeding biology is well understood?**
Maternity colonies are located in attics, fissures in the ground and under bark. Only two colonies have been found in B.C.. Males roost separately. Mating occurs in late August or September before the bats enter hibernation. Reproductive data for B.C. are scant. Young are probably born in late June and July (Nagorsen and Brigham 1993).

2d. **Migration behaviour is well documented?**
Non-migratory, although there are no winter records from B.C. of hibernating individuals (Nagorsen and Brigham 1993).

2e. **Information on it's historic abundance?**
No.

3a. **Can nests or animal be easily located?**
Locating nursery colonies would be difficult since only two are known of in B.C.. Alternatively one could capture animals by mist net or bat trap (Fenton *et al*. 1980; Nagorsen and Brigham 1993) but one needs to know where to set nets or traps.

3b. **Can samples be easily collected?**
Would need to collect individuals or else take large numbers of blood samples. Repeated disturbance at a nursery colony would probably not be appropriate.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Henny *et al*. 1982).

5c. **Have biological effects for this species been studied?**
No.

YUMA MYOTIS ***Myotis yumanensis***

1a. **Present in the Fraser Basin year-round?**
Winter whereabouts of Yuma bats in B.C. is not known (Nagorsen and Brigham 1993).

1b. **Broad distribution?**
Yes, occurs in the interior as far north as Williams Lake and east to Nelson. It also occurs on the coast as far north as Kimsquit and inhabits many islands (Nagorsen and Brigham 1993).

1c. **Common in the Fraser Basin?**
Insufficient information.

1d. **Proportion of diet within the aquatic food web.**
Strongly associated with water (Harris pers. comm. 1993) more so than any other species. Feeds on aquatic insects, mayflies, caddisflies and midges are the major prey. Midges are the main prey in spring, caddisflies and mayflies are the main prey in summer. Young are nursed but the number of weeks is not documented (Nagorsen and Brigham 1993).

2a. **Has the home range of the species been described?**
At Squilax near Shuswap Lake where there was a large maternity colony, individuals have been known to fly more than 4km to forage over rivers and lakes (Harris pers. comm. 1993; Nagorsen and Brigham 1993). Unfortunately, the church where the bats had established a maternity colony burnt down in February 1994.

2b. **Habitat selection is well documented?**
Generally restricted to elevations below 730 metres. Inhabits coastal forests, Ponderosa Pine - Douglas Fir forests and arid grasslands. In summer it usually roosts in buildings and other man-made structures in close proximity to water (Nagorsen and Brigham 1993).

2c. **Breeding biology is well understood?**
Maternity colonies can be very large. One of the largest colonies was in an old church at Squilax. It comprised 1500 to 2000 females. They also roost in caves and in trees but colonies in these situations are much smaller. Males roost separately. Young are born in early June and mid July. Mating occurs in autumn. Maternity colonies are usually deserted by late summer or early autumn (Nagorsen and Brigham 1993).

2d. **Migration behaviour is well documented?**
Probably non-migratory but the whereabouts of winter hibernicula are not known (Nagorsen and Brigham 1993).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
It can be extremely difficult to distinguish this species from the Little Brown Myotis. The Squilax colony would have been an obvious location, however, disturbance in the colony would be of concern (Harris pers. comm. 1993). Alternatively one could capture animals by mist net or bat trap (Fenton *et al*. 1980; Nagorsen and Brigham 1993) out over waterways where they are known to feed (Harris pers. comm. 1993).

3b. **Can samples be easily collected?**
Would need to collect individuals or else take large numbers of blood samples from trapped individuals (Harris pers. comm. 1993). Repeated disturbance at a nursery colony would probably not be appropriate .

4a. **Captive rearing possible and well understood?**
Yes, they have been reared in captivity (Aldridge 1986) but there are no details given.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

TOWNSEND'S BIG-EARED BAT *Plecotus townsendii*

1a. **Present in the Fraser Basin year-round?**
Yes, this is one of the few species that has been found consistently hibernating in B.C. They are relatively sedentary, moving 10 to 65 km between summer roosts and winter hibernation sites (Nagorsen and Brigham 1993).

1b. **Broad distribution?**
Widespread in southern British Columbia. Occurs on Vancouver Island and in the interior as far north as Williams Lake (Nagorsen and Brigham 1993).

1c. **Common in the Fraser Basin?**
Although it is widespread it is also on the provincial Blue List because of it's sensitivity to human disturbance (Nagorsen and Brigham 1993).

1d. **Proportion of diet within the aquatic food web.**
Food habits have not been studied in British Columbia. In the western United States, small moths form most of the diet, but they also eat lacewings, dung beetles, flies and sawflies. Young are nursed but the number of weeks is not documented (Nagorsen and Brigham 1993).

2a. **Has the home range of the species been described?**
Not documented.

2b. **Habitat selection is well documented?**
Occurs in a variety of habitats from coastal forests to arid grasslands of the interior. Roost sites are not well known in British Columbia, but in the United States it uses caves, old mines and buildings as summer day roosts (Nagorsen and Brigham 1993).

2c. **Breeding biology is well understood?**
Females establish nursery colonies during summer, males roost separately. Only one nursery colony has been found in B.C., on Vancouver Island. Mating occurs from November to February usually at the winter roosts. Gestation is 50 to 100 days. Gestation duration is controlled largely by temperature. In the interior of B.C., young are probably born in mid July. Young mature quickly and are capable of flight at three weeks, and are full size by four weeks (Nagorsen and Brigham 1993).

2d. **Migration behaviour is well documented?**
Non-migratory (Nagorsen and Brigham 1993).

2e. **Information on historic abundance?**
No.

3a. **Can nests or animal be easily located?**
Summer roosts are not well known in British Columbia although winter hibernicula are. Unfortunately this species is highly sensitive to human disturbance.

3b. **Can samples be easily collected?**
This species is particularly sensitive to human disturbance, females will permanently abandon a traditional summer roost if disturbed (Nagorsen and Brigham 1993). Mist netting or trapping at night while they are feeding might be one method of capturing animals for sampling.

4a. **Captive rearing possible and well understood?**
Insufficient information.

4b. **Captive breeding possible and well understood?**
Insufficient information.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

MUSKRAT ***Ondatra zibethicus***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
Yes, occurs throughout British Columbia east of the coast mountains. West of the coast mountains it occurs on Vancouver Island, Denman Island and Graham Island where it has been introduced (Stevens and Lofts 1988).

1c. **Common in the Fraser Basin?**
There is no estimate of their numbers in B.C. although they are believed to be abundant (Stevens and Lofts 1988). Populations where studied tend to fluctuate cyclically (Boutin and Birkenholz 1987).

1d. **Proportion of diet within the aquatic food web.**
Muskrat are primarily herbivores. They consume shoots, roots, bulbs and leaves of aquatic plants. Where available, cattails and bulrushes are preferred and may constitute as much as 80% of their diet. In some cases they will also eat clams, mussels, fish and other animal matter (Boutin and Birkenholz 1987). Young are nursed up to 21 days and are weaned by four weeks (Perry 1982).

2a. **Has the home range of the species been described?**
Muskrats do maintain home ranges and most movements are restricted to their home ranges. Home range sizes seem to vary from 7 to 448m. Home range size probably depends on habitat quality and on population density (Boutin and Birkenholz 1987).

2b. **Habitat selection is well documented?**
Live and feed in wetlands and other aquatic habitats with fresh emergent vegetation such as ponds, slow moving permanent riverine habitats. Prefer areas with fairly stable water levels and water that is deep enough so that the bottom does not freeze in winter (Boutin and Birkenholz 1987; Stevens and Lofts 1988).

2c. **Breeding biology is well understood?**
Live in family units. Gestation is 28 to 30 days. In the southern U.S.A. Muskrats breed year-round, but farther north the breeding season becomes increasingly restricted. In areas where there is ice, breeding begins soon after ice breakup. Litters range in size from three to nine young. Litter size tends to increase above three with latitude (Boutin and Birkenholz 1987). Young are raised in nesting houses which reach above and below the water. They also use burrow systems which they excavate in stream banks. Stable water levels are important for bank nesting Muskrat (Stevens and Lofts 1988). Juveniles disperse in the spring as adults establish breeding territories.

2d. **Migration behaviour is well documented?**
Non-migratory, however, young of the year disperse in spring when breeding territories are being established and many may disperse over large distances. In autumn there is also some dispersal as young of the year locate suitable wintering habitat (Boutin and Birkenholz 1987).

2e. **Information on historic abundance?**
There is limited information on historic numbers which could be gleaned from provincial trapping records. Trapping records, however, will also reflect changes in economic conditions which affect pelt prices and hence trapping effort at various times.

3a. **Can nests or animal be easily located?**
Apparently locating Muskrat nesting houses or smaller feeding houses is possible as these are very visible. However, it may be more practical to rely upon trappers to collect carcasses.

3b. **Can samples be easily collected?**
Collecting carcasses from trappers would be easiest.

4a. **Captive rearing possible and well understood?**
No information available.

4b. **Captive breeding possible and well understood?**
No information available.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
No.

5b. **Has this species been used in contaminant studies in other regions?**
No.

5c. **Have biological effects for this species been studied?**
No.

RIVER OTTER ***Lontra canadensis***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
Yes (Stevens and Lofts 1988).

1c. **Common in the Fraser Basin?**
Yes, however they are more common along coastal shorelines (Stevens and Lofts 1988). There are estimated to be between 15,000 and 30,000 River Otter in B.C. (Munro and Jackson 1979).

1d. **Proportion of diet within the aquatic food web.**
Feed primarily on fish. They will also eat amphibians, small birds and rarely small mammals (Gilbert and Nancekivell 1982; Stevens and Loft 1988). In lake habitats they may prey extensively on moulting waterfowl (Gilbert and Nancekivell 1982). Pups are nursed but begin to consume prey items by two months, however, weaning does not occur until three months (Melquist and Hornocker 1983; Melquist and Dronkert 1987).

2a. **Has the home range of the species been described?**
Otters do maintain home ranges, generally males have larger ranges than females and most ranges are overlapping. In a study in Idaho, home ranges were quite variable in size ranging between 8 and 78 km along shorelines. Home range size is dependent on prey availability, habitat, weather conditions, topography, the reproductive cycle and conspecifics (Melquist and Hornocker 1983).

2b. **Habitat selection is well documented?**
Require proximity to aquatic habitat where they feed. May be riverine or lacustrine habitat. Their dens are located close to water in sheltered spots such as cavities among tree roots, hollow logs, old beaver lodges or under a rock (Stevens and Lofts 1988).

2c. **Breeding biology is well understood?**
Sexual maturity is not reached until two years of age. Breeding occurs in late spring after parturition. Parturition occurs over at least a two month period, March, April. Litters of two to three are most common. Pups emerge from the natal den after two months. At three months pups can travel well enough to leave the natal site and the family moves to an area of abundant prey where the pups learn hunting skills. The female and pups remain together for at least seven to eight months and sometimes until just prior to the birth of the a new litter (Melquist and Dronkert 1987).

2d. **Migration behaviour is well documented?**
Non-migratory.

2e. **Information on historic abundance?**
There is limited information on historic numbers which could be gleaned from provincial trapping records. Trapping records, however, will also reflect changes in economic conditions which affect pelt prices and hence trapping effort at various times.

3a. **Can nests or animals be easily located?**
Yes, most studies investigating contaminant levels in wild populations have relied upon trappers to collected carcasses (Henny *et al*. 1981; O'Shea and Kaiser 1981; Somers *et al*. 1987; Wren *et al*. 1988; Whitehead pers. comm. 1993).

3b. **Can samples be easily collected?**
Yes, see 3a.

4a. **Captive rearing possible and well understood?**
Yes, River Otter have been reared in captivity (Melquist and Dronkert 1987).

4b. **Captive breeding possible and well understood?**
Yes, River Otter have been bred in captivity (Melquist and Dronkert 1987).

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
Yes (Whitehead pers. comm. 1993).

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Cumbie 1975; Henny *et al*. 1981; O'Connor and Nielsen 1981; O'Shea and Kaiser 1981; Wren *et al*. 1986; Somers *et al*. 1987; Foley *et al*. 1988; Wren *et al*. 1988; Whitehead pers. comm. 1993).

5c. **Have biological effects for this species been studied?**
No.

MINK ***Mustela vison***

1a. **Present in the Fraser Basin year-round?**
Yes.

1b. **Broad distribution?**
Yes (Stevens and Lofts 1988).

1c. **Common in the Fraser Basin?**
Yes, there are estimated to be 50,000 to 100,000 mink in British Columbia (Munro and Jackson 1979).

1d. **Proportion of diet within the aquatic food web.**
Among inland populations diet includes mice, hares, birds, muskrat, fish, amphibians and crustaceans (Stevens and Lofts 1988). In an analysis of scats, Gilbert and Nancekivell (1982), found that mink living in northeastern Alberta generally selected prey on the basis of availability but small mammal remains were most common. Near streams, 42.6% of the scats examined contained fish, 83.6% contained small mammals, 16.4% contained birds and 8.2% contained insects. Near lakes, 31.4% of the scats contained fish, 63.6% contained small mammals, 32.9% contained birds and 35.0% contained insects. Mink living in freshwater habitats hunt along shorelines and among emergent vegetation. Young are nursed for three weeks. By 37 days the young are eating prey items (Eagle and Whitman 1987).

2a. **Has the home range of the species been described?**
There is no information on home range sizes from the Fraser Basin, however, it is known that mink do defend home ranges. On Vancouver Island home ranges have been measured linearly. Males averaged 0.72 km, females averaged 0.41 km (Hatler 1976). In general, range size is inversely proportional to quality of local hunting (Stevens and Lofts 1988).

2b. **Habitat selection is well documented?**
Found in wetland habitats and near the banks of slow permanent riverine, lacustrine and pond habitat (Stevens and Lofts 1988).

2c. **Breeding biology is well understood?**
Litter size ranges from one to eight young. Timing of the breeding season is influenced by photoperiod and generally varies along a latitudinal gradient. Breeding occurs between January and April and pregnancy lasts is 40 to 79 days. Mink kits weigh 6 to 10g at birth (Eagle and Whitman 1987). Parturition occurs in late April/early May in nests in available shelter in burrows along river banks (excavated by other animals e.g. muskrat), or in stumps or hollow logs in adjacent forest (Stevens and Lofts 1988).

2d. **Migration behaviour is well documented?**
Non-migratory, although juveniles disperse between July and September. Juvenile mink may disperse as much as 18km from their natal site (Eagle and Whitman 1987).

2e. **Information on historic abundance?**
There is limited information on historic numbers which could be gleaned from provincial trapping records. Trapping records, however, will also reflect changes in economic conditions which affect pelt prices and hence trapping effort at various times.

3a. **Can nests or animals be easily located?**
Yes, most studies investigating contaminant levels in wild populations of mink have relied upon trappers to collected carcasses (O'Shea and Kaiser 1981; Henny *et al*. 1981; Proulx *et al*. 1987; Wren *et al*. 1988; Whitehead pers. comm.1993).

3b. **Can samples be easily collected?**
Yes, see 3a.

4a. **Captive rearing possible and well understood?**
Yes, (Jensen *et al*. 1977; Aulerich *et al*. 1988; Hochstein *et al*. 1988; Crum *et al*. 1993).

4b. **Captive breeding possible and well understood?**
Yes, mink are routinely bred in captivity for their fur.

5a. **Is there historic information on contaminant burdens in the Fraser Basin?**
Yes (Whitehead pers. comm. 1993).

5b. **Has this species been used in contaminant studies in other regions?**
Yes (Cumbie 1975; Jensen *et al*. 1977; O'Connor and Nielsen 1981; O'Shea and Kaiser 1981; Henny *et al*. 1981; Norheim *et al*. 1984; Wren *et al*. 1986; Mason and MacDonald 1986; Proulx *et al*. 1987; Wren *et al*. 1988; Foley *et al*. 1988; Hochstein *et al*. 1988; Aulerich *et al*. 1988; Crum *et al*. 1993; Whitehead pers. comm. 1993)

5c. **Have biological effects for this species been studied?**
Yes (Aulerich *et al*. 1973; Aulerich *et al*. 1974; Wobeser *et al.* 1976a; Wobeser *et al*. 1976b; Jensen *et al*. 1977; Borst and Lieshout 1977; Wren *et al.* 1987a; Wren *et al*. 1987b; Aurelich *et al*. 1988; Hochstein *et al*. 1988; Wren 1991; Aulerich *et al*. 1991; Bonna *et al*. 1991; Crum *et al*. 1993).

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- Biological references — O10

GREAT BASIN SPADEFOOTED TOAD
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A1) Aldridge, H. 1986. Manoeuvrability and ecological segregation in the Little Brown (*Myotis lucifugus*) and the Yuma (*M. yumanensis*) bats (Chiroptera: Vespertilionidae). Can. J. Zool. 64: 1878-1882.

Summary: In the laboratory, the abilities of two species of bats to negotiate a series of obstacles while flying was measured. The Little Brown Bat performed better than the Yuma Bat. Differences in performance were attributed to wing loading and wingspan differences between the two species.

A2) Ankley, G.T., G.J. Niemi, K.B. Lodge, H.J. Harris, D.L. Beaver, D.E. Tillitt, T.R. Schwartz, J.P. Giesy, P.D. Jones and C. Hagley. 1993. Uptake of planar polychlorinated biphenyls and 2,3,7,8-substituted polychlorinated dibenzofurans and dibenzo-p-dioxins by birds nesting in the lower Fox River and Green Bay, Wisconsin, USA. Arch. Environ. Contam. Toxicol. 24: 332-344.

Abstract: The uptake of persistent polychlorinated hydrocarbons (PCHs) by four avian species was investigated at upper trophic levels of two aquatic food chains of the lower Fox River and Green Bay, Wisconsin (USA). Accumulation of total and specific planar polychlorinated biphenyls (PCBs), polychlorinated dibenzofurans (PCDFs), polychlorinated dibenzo-p-dioxin (PCDDs), and H4IIE rat hepatoma cell bioassay-derived 2, 37, 8-tetrachlorodibenzo-p-dioxin equivalents (TCDD-EQ) was evaluated in Forster's tern (*Sterna forsteri*) and Common Tern (*Sterna hirundo*) chicks, and in Tree Swallow (*Tachycineta bicolor*) and Red-winged Blackbird (*Agelaius phoeniceus*) nestlings from colonies nesting in several locations within the watershed. Concentrations of the PCHs were greatest in eggs and chicks of the two tern species, less in the tree swallows and least in the Red-winged Blackbirds. Young of all four species accumulated total PCBs, PCB congeners 77, 105, 126, and 169, and TCDD-EQ. The young birds also accumulated small concentrations of several 2, 3, 7, 8-substituted PCDF and PCDD congeners. Uptake rates for certain of the PCHs for the Forster's Tern chicks were: 15 mug/day for total PCBs, 70, 200, 6.5, and 0.14 ng/day for PCB congeners 77, 105, 126, and 169, respectively, and 270 pg/day for TCDD-EQ. Principal components analysis revealed that the patterns of PCH concentrations in the sample were influenced by species of bird, their age (or length of exposure) and nesting location. Collectively, our findings demonstrate that exposure of avian species to contaminants derived from aquatic food chains can be characterized and quantified for the purposes of ecological risk assessment.

A3) Anthony, R.G., Garrett M.G. and C.A. Schuler. 1993. Environmental contaminants in bald eagles in the Columbia River estuary. J. Wildl. Manage. 57(1): 11-17.

Abstract: Eggs blood and carcasses of Bald Eagles (*Haliaeetus leucocephalus*) and fish were collected and breeding success of eagles was monitored in the Columbia River estuary, 1980-87, to determine if contaminants were having an effect on productivity. High levels of DDE, PCBs and 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) were found in eggs, blood from adults and 2 eagle carcasses. Detectable levels of DDE and PCB's were found in blood of nestlings indicating they were exposed to these contaminants early in life. Increasing concentrations of DDE, PCB's and mercury age also indicate accumulation of these contaminants. High levels of DDE and PCB's were associated with eggshell thinning (x=10%) and with productivity (x=0.56 young/ occupied site) that was lower than that of healthy populations. DDE and PCB's had a deleterious effect on reproduction of bald eagles in the estuary. The role dioxins play in eagle reproduction remains unclear. Probable sources of these contaminants include dredged river sediments and hydroelectric dams. Proper management of each may reduce the amount of contaminants released into the Columbia River estuary.

A4) Audet, D.J., D.S. Scott and S.N. Wiemeyer. 1992. Organochlorines and mercury in Osprey eggs from the eastern United States. J. Raptor Res. 26: 219-224.

Abstract: Organochlorine and mercury concentrations were determined in Osprey eggs collected from Maryland, Virginia, and Massachusetts (USA) during 1986-87. DDE concentrations were significantly different among locations. Median DDE concentrations did not decline significantly in eggs from Glenn L. Martin National Wildlife Refuge, Maryland, between 1973 and 1986. The median DDE residue for eggs from Martin Refuge in 1986 surpassed the value associated with 10% eggshell thinning, but was below the value associated with production of 1.0 young per active nest, a level assumed to represent a stable population. DDD, DDT, dieldrin, PCB, and mercury residues in all eggs appeared insignificant with regard to potential effects on shell thickness or reproduction. DDE and PCB residues were lower in eggs collected in 1986-87 than in those collected in the 1970s for each area. DDD, DDT, and dieldrin were not detected in Martin Refuge eggs in 1986, representing a significant reduction since 1973. DDD, DDT, and dieldrin levels in Massachusetts and Virginia eggs in 1986-87 were similar to those in eggs from the 1970s for each state. Mercury residues in eggs from Martin Refuge may be increasing and although not significant in this study, may warrant future monitoring.

A5) Aulerich, R.J., R.K. Ringer and S. Iwamoto. 1973. Reproductive failure and mortality in mink fed on Great Lakes fish. J. Reprod. Fertil. Suppl. 19: 365-376.

Keywords: feeding, reproduction, feed study

A6) Aulerich, R.J., R.K. Ringer and S. Iwamoto. 1974. Effects of dietary mercury on mink. Arch. Environ. Contam. Toxicol 2: 43-51.

Keywords: mink, diet, feed study

A7) Aulerich, R.J., S.J. Bursian and A.C. Napolitano. 1988. Biological effects of epidermal growth factor and 2,3,7,8-tetrachlorodibenzo-p-dioxin on developmental parameters of neonatal mink. Arch. Environ. Contam. Toxicol. 17: 27

Summary: Newborn mink kits were administered 0.1 ug TCDD/kg body weight, 1 ug TCDD/kg body weight, 10 ug epidermal growth factor (EGF)/kg body weight, or 50 ug EGF/kg body weight by intraperitoneal injection (10 ml/kg body weight) for 12 consecutive days to compare the effects of TCDD and EGF on body weight gains, time of eyelid opening, tooth eruption, and pelage development. Mortality exceeded 50% at the higher doses of both TCDD and EGF, while at the lower doses, TCDD and EGF caused a significant reduction of body weight gains. Additionally, EGF caused a significant decrease in the time of eyelid opening and retarded growth and development of the fur of the treated kits. TCDD had no discernible effects on the time of eyelid opening or hair growth. The time of tooth eruption was not significantly affected by either compound.

A8) Aulerich, R.J., S.J. Bursian, R.H. Poppenga, W.E. Braselton and T.P. Mullaney. 1991. Toleration of high concentrations of dietary zinc by mink. J. Vet. Diagn. Invest. 1991 Jul;3(3): 232-7

Abstract: Adult and kit male and female natural dark Ranch Mink (*Mustela vison*) were fed a conventional diet supplemented with 0, 500, 1,000, or 1,500 ppm zinc, as ZnSO4.7H2O, for 144 days. No marked adverse effects were observed in feed consumption, body weight gains, haematologic parameters, fur quality, or survival. Zinc concentrations in liver, kidney, and pancreas of the mink increased in direct proportion to the zinc content of the diet. Histopathological examination of the livers, kidneys, and pancreata revealed no lesions indicative of zinc toxicosis. The results indicate that mink can tolerate at least 1,500 ppm dietary zinc, as ZnSO4.7H2O, for several months without apparent adverse effects.

A9) Avery, M.L. and C.O. Nelms. 1990. Food avoidance by red-winged blackbirds conditioned with a pyrazine odour. Auk 107: 544-549.

Abstract: Brown rice treated with 2-methoxy-3-methylpyrazine (one of a family of compounds reported to function as warning odours in nature) was not repellent to test groups of four Red-winged Blackbirds (*Agelaius phoeniceus*). But, after pairing with methiocarb, an illness-inducing agent, the odour of methylpyrazine was an effective conditioned stimulus that reduced the birds' rice consumption. Furthermore, rice consumption

remained suppressed even after pyrazine was no longer present. A combination of red dye plus pyrazine odour proved no more effective a conditioned stimulus than red dye alone. Furthermore, the colour seemed to interfere with the birds' ability to use the odour as a conditioned stimulus. Consequently, there was no residual suppression of rice consumption by groups exposed to the methiocarb- colour-pyrazine treatment as was demonstrated by the groups exposed to just methiocarb plus pyrazine.

A10) Avery, M.L. and D.G. Decker. 1991. Repellency of fungicidal rice seed treatments to Red-winged Blackbirds. Journ. Wildl. Man. 55: 327-334.

Abstract: We evaluated the feeding responses of male Red-winged Blackbirds (*Agelaius phoeniceus*) to rice seed treated with fungicidal compounds in a series of 2-cup, 1-cup, and flight pen trials. Of the materials tested, Kocide SD, a fungicide containing 30% copper hydroxide, was the most effective. Although this chemical caused mortality (due to haemolytic anemia) when applied at relatively high concentrations in the 1-cup test, birds consistently avoided it without ill effects in 2-cup and flight pen trials. Applied at the currently registered label rate, Kocide may safely and effectively repel birds feeding on newly planted rice. Currently registered fungicides and other pesticides may offer new alternatives for bird damage control.

A11) Avery, M.L. and D.G. Decker. 1992. Repellency of cinnamic acid esters to captive Red-winged Blackbirds. J. Wildl. Man. 56: 800-805.

Abstract: Each year, blackbirds cause millions of dollars of damage to newly planted rice in the southern United States. Currently, there is no product registered as a bird repellent rice seed treatment, so we conducted 2-cup feeding trials with individually caged male red-winged blackbirds (Agelaius phoeniceus) to test the repellency of methyl cinnamate and ethyl cinnamate, two naturally occurring esters of cinnamic acid. While ethyl cinnamate was moderately deterrent, consumption of treated rice was virtually eliminated by a 1.0% (g/g) application of methyl cinnamate. Additional effort should be given to understanding the chemical and physiological bases of repellency of feeding deterrents such as methyl cinnamate as well as to the development of these materials as bird management tools.

A12) Avery, M.L., D.G. Decker, D.L. Fischer and T.R. Stafford. 1993. Responses of captive blackbirds to a new insecticidal seed treatment. J. Wildl. Manage. 57: 652-656.

Abstract: Development of new repellent chemicals specifically to control crop damage by birds may be cost-prohibitive. Instead, the use of compounds developed for other pest control needs may be more practical. Thus, we conducted 2-cup feeding trials with singly caged Red-winged Blackbirds (*Agelaius phoeniceus*) and Brown-headed Cowbirds (*Molothrus ater*) to test the repellency of a new seed treatment insecticide, imidacloprid (proposed common name for Miles Incorporated NTN33893). Both redwings and cowbirds were strongly deterred ($P < 0.05$) from feeding on rice seed treated with imidacloprid at 620 and 1,870 ppm. When applied to wheat seed, imidacloprid effectively reduced ($P < 0.05$) consumption by redwings at rates as low as 165 ppm. We noted treatment-related effects such as ataxia and retching in some birds exposed to the highest treatment levels, but such effects were transitory. Videotapes indicated that imidacloprid was not a sensory repellent or irritant to birds. We conclude that avoidance of imidacloprid-treated food is a learned response mediated by post-ingestion distress. Although developed and envisioned as a broad spectrum, systemic insecticide, imidacloprid also appears to have promise as a bird repellent seed treatment.

B1) Balcomb, R., C.A. Bowen Ii, D. Wright and M. Law. 1984a. Effects on wildlife of at-planting corn applications of granular carbofuran. J. Wildl. Manage. 48: 1353-1359.

Abstract: Application, at planting, of a granular formulation of the insecticide carbofuran to 195 ha of corn resulted in wildlife mortalities in Frederick County, Maryland (USA), in April and May 1980. Systematic field searches within 96 h of treatment revealed 6 dead songbirds (order Passeriformes), five of which contained residues of carbofuran ranging from 1.6-17.0 ppm (gastrointestinal tract and liver combined). As American Robin (*Turdus migratorius*) and a Mallard (*Anas platyrhychos*) were observed exhibiting symptoms consistent with carbofuran poisoning. A dead White-footed Mouse (*Peromyscus leucopus*) found 24-h post-treatment contained 15.1 ppm carbofuran. The pesticide was detected in 10 of 12 Common Grackles (*Quiscalus quiscula*) shot at the site (gastrointestinal tract and liver: $x = 0.75$ ppm, SE = 0.19), suggesting extensive sublethal exposure among birds feeding in treated fields. Captive House Sparrows (*Passer domesticus*) and Red-winged Blackbirds (*Agelaius phoeniceus*) were orally administered carbofuran granules; dosage as low as one granule resulted in fatalities with both species. Given the extensive annual use of granular carbofuran (> 4 USA, numerous wildlife mortalities are likely.

B2) Balcomb, R., R. Stevens and C. Bowen. 1984b. Toxicity of 16 granular insecticides to wild-caught songbirds. Bull. Environ. Contam. Toxicol. 33: 302-307.

Key Words: *Passer domesticus, Agelaius phoeniceus*, mortality, food chain

B3) Barclay, R.M. 1991. Population structure of temperate zone insectivorous bats in relation to foraging behaviour and energy demands. J. Anim. Ecol. 60: 165-178.

Summary: The foraging behaviour and prey distribution of two temperate zone species of insectivorous bats in an area of the eastern slopes of the Rocky Mountains (Canada) was studied. Only male Little Brown Bats occurred in the low ambient temperature and low insect abundance area. By contrast, both male and female Western Long-eared Bats occurred. The Western Long-eared Bat exhibited a more flexible foraging strategy than the Little Brown Bat. It is suggested that because of a flexible foraging strategy, female Western Long-eared Bats which have much higher energy demands than males of either species are able to inhabit the area.

B4) Barnum, D.A. and D.S. Gilmer. 1988. Selenium levels in biota from irrigation drain-water impoundments in the San Joaquin Valley, California, USA. Lake Reservoir Manage. 4: 181-186.

Key Words: *Ruppia maritima, Gambusia affinis, Oxyura jamaicensis, Podiceps nigricollis, Anas clypeata*, corixidae, wastewater

B5) Barrett, J. and C.F. Barrett. 1985. Wintering Goldeneye (B*ucephala clangula)* in the Moray Firth, Scotland, UK. Scot. Birds 13: 241-249.

Key Words: feeding, sewer, outfall, water pollution, sex ratio, seasonality

B6) Bayer, R.D. 1982. Great Blue Heron (*Ardea herodias*) egg shell thickness at Oregon USA estuaries. Wilson Bull. 94: 198-201.

Key Words: pesticides

B7) Bellrose, F.C. 1976. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, Pennsylvania. 540 pp.

B8) Bellward, G.D., R.J. Norstrom, P.E. Whitehead, J.E. Elliott, S.M. Bandiera, C. Dworschak, T. Chang, S. Forbes, B. Cadario, L.E. Hart, and K.M. Cheng. 1990. Comparison of polychlorinated dibenzodioxin levels with hepatic mixed-function oxidase induction in Great Blue Herons. J. Toxicol. Environ. Health 30: 33-52.

Abstract - As part of the Canadian Wildlife Service monitoring of Great Blue Herons in British Columbia, eggs were collected from three colonies with low, intermediate, and high levels of PCDD and PCDF contamination: Nicomekl, Vancouver, and Crofton, respectively. One egg from each nest was used for chemical analysis by GC-MS; the others were hatched. Liver

microsomes were prepared from the heron chicks and used for determination of cytochrome P-450-dependent activities. No erythromycin N-demethylase activity was found in any sample. Ethoxyresorufin O-dealkylase activity in the Nicomekl group was similar to that in pigeons, a control altricial species. The ethoxyresorufin activity in the herons from the Crofton colony was 2.6-fold higher than in the Nicomekl group. The Vancouver colony was intermediate. No difference among the three heron colonies was found in pentoxyresorufin O-dealkylase activity, although levels were 20-33 times that in the pigeon. Chemical analysis was carried out on paired heron eggs. Vancouver and Crofton eggs contained 13.5 and 21 times the levels of 2,3,7,8-TCDD compared to the Nicomekl group. The Crofton eggs contained higher levels of several other contaminants also. A highly significant correlation (p less than .001) was found between ethoxyresorufin O-dealkylase and 2,3,7,8-TCDD concentrations. The correlation coefficient did not change when ethoxyresorufin O-dealkylase was compared to total chemical contamination using several toxic equivalency factors. Multiple regression analysis resulted in only one predictor variable for ethoxyresorufin O-dealkylase: 2,3,7,8-TCDD.

B9) Bendell, B.E. and P.J. Weatherhead. 1982. Prey characteristics of upland breeding Red-winged Blackbirds. Can. Field Naturalist. 96(3): 265-271.

Abstract: Neck-collar food samples collected from Red-winged Blackbird (*Agelius phoeniceus*) nestlings from two agricultural upland sites indicated that Lepidopteran larvae from grasses and legumes predominated during the main nestling period but were later replaced by adult Orthopterans. Sampling of prey abundance indicated that Red-winged Blackbirds were preying selectively on species characterized as cryptically coloured, slow-moving, diurnal, foliage feeders. Overall, insects from 27 families in nine orders as well as spiders, isopods, snails and grain were represented.

B10) Bennett, D.C., V.A. Bowes, M.R. Hughes and L.E. Hart. 1992. Suspected sodium toxicity in hand-reared Great Blue Heron (*Ardea herodias*) chicks. Avian Dis. 36: 743-8.

Abstract - Sodium toxicity was suspected in hand-reared Great Blue Heron (*Ardea herodias*) chicks fed herring frozen in brine (seawater). Affected chicks were lethargic with stiff legs that extended to the posterior, and breathing was labored. Chicks regurgitated food or refused to eat. All chicks that were fed herring exclusively and eight of the 10 chicks fed a mixed diet (herring and salmonids) died, whereas all chicks fed only salmonids survived. Renal lesions ranged from mild to marked generalized nephrosis, which was characterized by degeneration and necrosis of the proximal convoluted tubular epithelium and dilation of the distal convoluted tubules and collecting ducts. These observations suggest that fish frozen in brine is unsuitable food for hand-rearing of young herons.

B11) Berrill, M., S. Bertram, A. Wilson, S. Lotis, D. Bringam and G.C. Stromber. 1993. Lethal and sublethal impacts of pyrethroid insecticides on amphibian embryos and tadpoles. Environ. Toxicol. Chem. 12:525-539.

Abstract: Amphibian populations are potentially sensitive to aquatic contaminants such as pesticides. We exposed embryos and larvae of five amphibians (the frogs *Rana sylvatica, Rana pipiens, Rana clamitans*; and the toad *Bufo Americanus*; the salamander *Ambystoma maculatum*) to one or both of the pyrethroid pesticides permethrin and fenvalerate. Concentrations ranged from 0.01ppm to 2ppm, and exposures lasted 22 or 96 hours. No significant mortality of embryos, anuran tadpoles, or salamander larvae occurred during or following exposure to pyrethroids. However, tadpoles and salamander larvae responded to prodding not be darting away but by twisting abnormally. Both effects may result in greater vulnerability to predation. Recovery of normal avoidance behaviour occurred more rapidly at 20 than at 15 °C and following exposure to lower concentrations of the pesticide. indicating both temperature and dose effects. Tadpoles exposed later in development did not feed for a period of days following exposure but were still capable of metamorphosis. Of the five tested species, *Ambystoma maculatum*, a tadpole predator, was particularly sensitive. An amphibian community is therefore likely to be sensitive to low-level contamination events.

B12) Beyer, W.N., J.W. Spann, L. Sileo and J.C. Franson. 1988. Lead poisoning in six captive avian species. Arch. Environ. Contam. Toxicol. 17: 121-130.

Key Words: protoporphyrin, delta, aminolevulinic acid, dehydratase, liver, kidney, heart, *Colinus virginianus, Agelaius phoeniceus, Molothrus ater*, *Otus asio, Quiscalus quiscula, Anas platyrhynchos*

B13) Bishop, C.A., A.A. Chek, M.D. Koster, D. Hussel and K. Jock. 1992. Chlorinated hydrocarbons and mercury in sediments, Red-wing Blackbird (*Agelaius phoeniceus*) eggs and Tree Swallow (*Tachycineta bicolor*) eggs and nestlings from wetlands in the Great Lakes-St. Lawrence River Basin. Unpubl. Manuscr. pp 33.

B14) Blancher, P.J. and D.G. McAuley. 1987. Influence of wetland acidity on avian breeding success. McCabe, R.E.0: 628-635.

Key Words: A*ythya collaris, Anas rubripes,* B*ucephala clangula, Tyrannus tyrannus, Tachycineta bicolor*

B15) Blancher, P.J. and D.K. McNichol. 1988. Breeding biology of Tree Swallows in relation to wetland acidity. Can. J. Zool. 66: 842-849.

Abstract: We examined aspects of the breeding biology of Tree Swallows (*Tachycineta bicolor*) in relation to pH, presence or absence of fish, and dissolved organic carbon concentration in 51 wetlands adjacent to nest boxes northeast of Sudbury, Ontario. Wetland pH was positively related to swallow clutch size, the total volume of eggs in the clutch (clutch volume), the number of fledglings per successful nest, and several measures of nestling size and growth. Swallows breeding near wetlands where fish are present laid earlier, but had smaller eggs and clutch volumes and slower growth of primary feathers than swallows breeding near fishless wetlands. Organic carbon concentrations were poorly related to the reproduction of swallows. These results are discussed in relation to possible mechanisms for the effects of wetland acidity on avian reproduction.

B16) Blus, L.J. 1984. DDE in birds eggs: Comparison of two methods for estimating critical levels. Wilson Bull. 96: 268-276.

Abstract: The sample egg technique and eggshell thickness-residue regression analysis were comparatively evaluated as tools in estimating critical levels of DDE in birds' eggs that seriously affect reproductive success and population starts. In comparing critical values of DDE that were derived from the two methods, the estimates were lower using the sample egg technique for both the Brown Pelican (3 mug/g vs. 8 mug/g) and the Black-crowned Night Heron (12 mug/g vs. 54 mug/g) assuming a critical value of eggshell thinning at 20%. Extension of the regression line beyond the eggshell thickness-DDE residue data base is likely to result in spurious critical values of DDE. When sufficient thickness and residue data are available for estimating critical values of DDE from the regression equation, the estimates are meaningful but are likely to inflated because adverse effects unrelated to eggshell thinning such as parental behaviour and embryotoxicity unrelated to eggshell deficiencies are not taken into account. Establishing critical levels of pollutants in eggs and tissues is a necessary procedure in assessing effects of these chemicals on individuals and populations of sensitive species. There are inherent difficulties in quantifying the effects of any pollutant on population trends and declines in productivity. The sample egg technique is apparently a more sensitive method for estimating critical levels of DDE, but some subjective interpretation is required for results obtained by both methods.

B17) Blus, L.J. and C.J. Henny. 1981. Suspected Great Blue Heron (A*rdea herodias*) population decline after a severe winter in the Colombia basin, USA. Murrelet 62: 16-18.

Key Words: organochlorines, polychlorinated biphenyl, pollution, residues, brain

B18) Blus, L.J., C.J. Henny and A.J. Krynitsky. 1985. Organochlorine-induced mortality and residues in Long-billed Curlews (N*umenius americanus*) from Oregon, USA. Condor 87: 563-565.

Key Words: *Ardea herodias,* insecticide, pollutant, pesticide, chlordane, heptachlor, dieldrin, reproductive impairment, non-target organism

B19) Blus L.J., C.J. Henny, A. Anderson and R.E. Fitzner. 1985. Reproduction, mortality and heavy metal concentrations in Great Blue Herons from three colonies in Washington and Idaho. Colonial Waterbirds. 8 (2): 110-116

Summary: Eggs from nests, hatchlings and eggs with advanced embryos on the ground, and pre-fledgling young of Great Blue Herons (*Ardea herodias*) were collected at three nesting colonies in Washington and Idaho. Two colonies were located near areas extensively polluted with heavy metals from mining or smelting activities. The third colony, at the Hanford Reservation, Washington was located some distance from point sources of heavy metal pollution. Heavy metals in heron samples were generally low and were all below concentrations known to induce mortality or adversely affect reproductive success. Breeding herons apparently fed near their colonies in areas removed from the sites of heaviest contamination, but birds in the Lake Chatcolet colony in Idaho were preying on fish containing as much as 6 ug/g lead.

B20) Bonna, R.J., R.J. Aulerich, S.J. Bursian, R.H. Poppenga, W.E. Braselton and G.L. Watson. 1991. Efficacy of hydrated sodium calcium aluminosilicate and activated charcoal in reducing the toxicity of dietary aflatoxin to mink. Arch. Environ. Contam. Toxicol. 20(3):441-7

Abstract - Mink were fed diets that contained 0, 34, or 102 ppb (micrograms/kg) aflatoxins with or without 0.5% hydrated sodium calcium aluminosilicate (HSCAS) and/or 1.0% activated charcoal (AC) for 77 days. Consumption of the diet that contained 34 ppb aflatoxins was lethal to 20% of the mink, while 102 ppb dietary aflatoxins resulted in 100% mortality within 53 days. The addition of AC to the diet containing 102 ppb aflatoxins reduced mortality and increased survival time of the mink while the addition of HSCAS, alone or in combination with AC, prevented mortality. Histologic examination of livers and kidneys from the mink demonstrated liver lesions ranging from extremely severe in mink fed 102 ppb aflatoxin to mild to moderate in those that received 34 ppb aflatoxins. The addition of HSCAS and/or AC to the diets that contained 102 ppb aflatoxins reduced or essentially eliminated histopathologic lesions in the livers. No histopathologic alterations associated with the dietary treatments were observed in the kidneys.

B21) Borst, H.A. and C.G. Lieshout. 1977. Phenylmercuric acetate intoxication in mink. Tijdschr Diergeneesk 102: 495-503.

Keywords: mink, contaminated feed, phenyl mercury, accidental exposure

B22) Boumphrey, R.S., S.J. Harrad, K.C. Jones and D. Osborn. 1993. Polychlorinated biphenyl congener patterns in tissues from a selection of British birds. Arch. Environ. Contam.Toxicol. 25: 346-352.

Abstract: A large selection of polychlorinated biphenyl (PCB) congeners was determined in tissues from several British bird species including three sea birds, four birds of prey, and herons (*Ardea cinerea*). The congener signatures were consistent between different tissues of the same individual, but varied within and between species. Congeners 138, 153, and 180 were dominant in most samples. Nevertheless, SIGMAPCB values were wide ranging (0.02-105 mug/g wet weight) and also differed considerably in subsamples of different tissues from individual birds. Applying recently reported toxicity equivalency factors (TEFs) for non-ortho, mono-ortho, and di-ortho substituted PCBs to liver concentrations of such congeners, it appears that the mono-ortho congeners 105 and 118 make a high contribution to TEFs when their toxicities are weighted by concentration. The study highlights that caution is needed when interpreting data on contaminants in wildlife, but suggests that careful sampling will reduce the many variables which can give rise to differing congener patterns and SIGMAPCB values.

B23) Boutin, S. and D.E. Birkenholz. 1987. Muskrat and Round-tailed Muskrat. In: M. Novak, J.A. Baker, M.E. Obbard and B. Malloch (eds.) Wild Fur-bearer Management in North America. Min. Natur. Res., Ontario. pp. 316-324.

Summary: A comprehensive review of the natural history of muskrat and a detailed discussion of management issues.

B24) Breault, A.M., K.M. Cheng and J.L. Savard. 1988. Distribution and abundance of Eared Grebes (*Podiceps nigricollis*) in British Columbia. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia. Tech. Rep. Ser. No. 51.

Summary: The historic and current distribution of breeding Eared Grebes (*Podiceps nigricollis*) in British Columbia is summarised. Nesting records were found for 46 lakes. Current distribution was studied in 1985 and 1986 when lakes were surveyed in the Central and Southern Interior, Peace River and Okanagan/Kamloops areas. Thirty-four lakes with previous breeding records were revisited but only 19 were still used. Twenty-seven new breeding lakes were documented. The total breeding population on all lakes surveyed approached 3,000 pairs. Due to a few large breeding lakes, the Peace River and the Southern

Interior jointly accommodate 50% of the known provincial population even though they comprise only 20% of the breeding lakes.

B25) Breault, A.M. and J.L. Savard. 1991. Status report on the distribution of Harlequin Ducks in British Columbia. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia. Tech. Rep. Ser. No. 110.

B26) Brown, C.R., A.M. Knott and E.J. Damrose. 1992. Violet-green Swallow. In: The Birds of North America, No. 14. A. Poole, P. Stettenheim and F. Gills (eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornthithologists' Union.

B27) Brown, T.G., C.D. Levings, L. Rzen and E. White. (in press). Survey of piscivorous birds of the Nechako and Stuart Rivers, BC. Can. Manu. Rep. Ser., 43pp.

Summary: Counts and observations of birds within the Nechako and Stuart rivers were made between May and October, 1991 to examine the impact of reduced flow and altered temperatures on predation of juvenile Chinook Salmon. A total of 10,500 birds were counted from a drifting boat on 4 surveys of 241 km of river. Canada Geese (*Branta canadensis*) and Mallards (*Anas platyrhynchos*) were the most abundant species. Common Mergansers (*Mergus merganser*) (55%), and Belted Kingfishers (*Ceryle alcyon*) (13%) accounted for the majority of piscivorous birds on the Nechako River. When all bird predation on juvenile salmon was considered in a simple feeding model, we estimated that Common Mergansers and Belted Kingfisher could account for the majority of the juvenile chinook consumed by birds (89% and 10% respectively).

B28) Brunstroem, B. and L. Reutergardh. 1986. Differences in sensitivity of some avian species to the embryotoxicity of a PCB, 3,3',4,4'-tetrachlorobiphenyl, injected into the eggs. Environ. Pollut. Ser. A 42: 37-45.

B29) Bunck, C.M., J.W. Spann, O.H. Pattee and W.J. Fleming. 1985. Changes in eggshell thickness during incubation implications for evaluating the impact of organochlorine contaminants on productivity. Bull. Environ. Contam. Toxicol. 35: 173-182.

Key Words: Mallard, Black-crowned Night Heron, American Kestrel, Barn Owl, Screech Owl, DDE

B30) Burger, A.E. 1991. Status report on Western Grebes in British Columbia. Report to the Wildlife Branch, Environment B.C., Victoria

B31) Burger, J. and M. Gochfeld. 1985. Comparisons of nine heavy metals in salt gland and liver of Greater Scaup (*Aythya marila*), Black Duck (*Anas*

rubripes) and Mallard (*Anas platyrhynchos*). Comp. Biochem. Physiol. C. Comp. Pharmacol. Toxicol. 81: 287-292.

Key Words: liver salt, gland, cadmium, cobalt, chromium, copper, lead, mercury, manganese, nickel, zinc, New Jersey, USA

B32) Burger, J. and M. Gochfeld. 1993. Heavy metal and selenium levels in feathers of young egrets and herons from Hong Kong and Szechuan, China. Arch. Environ. Contam. Toxicol. 25: 322-7.

Abstract - Several species of herons and egrets frequently nest in colonies in areas where humans also concentrate. Since the birds feed on intermediate-sized fish that themselves concentrate pollutants, they can be used not only to assess the levels of contaminants in avian tissues but as indicators of contaminants in the environment. The concentration of heavy metals and selenium in the breast feathers of fledgling Black-crowned Night Herons (*Nycticorax nycticorax*) and Chinese Pond Herons (*Ardeola bacchus*) from the Tu Jing Yan heronry outside Chengdu, Szechuan Province in China; and from fledgling Black-crowned Night Heron, Little Egret (*Egretta garzetta*), Great Egret (*Egretta alba*) and Cattle Egret (*Bubulcus ibis*) from the Mai Po heronry in Hong Kong, were determined. Breast feathers were also collected from adult Great Egrets in Hong Kong. Adult Great Egrets had significantly higher levels of all heavy metals than did young Great Egrets. There were no significant interspecific differences in metal levels among the young at Szechuan China, except for chromium (Pond Herons had higher levels). There were significant differences among the young nesting at Hong Kong for all metals examined. Great Egrets had lower, and Night Herons had higher, levels of lead than the other young. Night Herons also had the highest levels of cadmium, manganese, and selenium compared to the other young. Great Egret chicks had the lowest mercury levels, while Little Egret had the highest levels. Lead levels for all the birds in both Hong Kong and Szechuan were among the highest in the world, and this was attributed to the continued use of leaded gasoline.

B33) Burton, F.G., M. Marquis and S.G. Tullett. 1986. A note on eggshell porosity, nest humidity and the effects of DDE in the Gray Heron (*Ardea inerea*). Comp. Biochem. Physiol. C. Comp. Pharmacol. Toxicol. 85: 25-32.

Key Words: Agricultural, insecticide, metabolism, thinning, incubation

B34) Butler, R.W. 1992. Great Blue Heron. A. Poole, P. Stettneheim, and F. Gill (series eds.). The Birds of North America, No. 25. Academy of Natural Sciences, Philadelphia, PA, and American Ornithologists Union, Washington, D.C.

B35) Butler P.A., L. Andren, G.J. Bonde, A. Jernelov and D.J. Reish.1971. Monitoring Organisms. In: FAO Technical conference on marine pollution and its effects on living resources and fishing, Rome, 1970. Report of the seminar on methods of detection, measurement and monitoring of pollutants in the marine environment. pp. 101-112. FAO Fisheries Reports No. 99 Suppl. 1.

B36) Butler, R.W., B.G. Stushnoff and E. McMackin.1986. The birds of the Creston Valley and southeastern British Columbia. Canadian Wildlife Service. Occ. Pap. No. 58. pp.37.

C1) Calabrese, E.J., R.J. Aulerich and G.A. Padgett. 1992. Mink as a predictive model in toxicology. Drug Metab. Rev. 24 (4):559-78

Abstract: This paper reviewed the biomedical and toxicological database concerning the use of mink as a predictive model of human responses. It is concluded that substantial information exists on the mink genetics, physiology, metabolism, nutritional requirements, and susceptibility to infectious disease; and provides a foundation upon which interspecies extrapolation may be considered. In addition, information on the response of mink to several dozen toxic substances revealed that mink respond in a qualitatively and quantitatively similar manner to other more commonly employed species as well as humans. Our conclusion does not infer that mink should be used routinely in toxicological testing for estimation of human responses. However, it indicates that toxicological data from this species may be a useful complement in risk assessment processes based upon data obtained from traditionally employed models such as rats and dogs.

C2) Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser and M.C.E. McNall. 1990. The Birds of British Columbia. Volume 1: Nonpasserines. Published by the Royal British Columbia Museum in association with Environment Canada, Canadian Wildlife Service. 514pp.

C3) Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser and M.C.E. McNall. 1990. The Birds of British Columbia. Volume 2: Nonpasserines. Published by the Royal British Columbia Museum in association with Environment Canada, Canadian Wildlife Service. 636pp.

C4) Cannings, R.A., R.J. Cannings and S.G. Cannings. 1987. Birds of the Okanagan Valley, British Columbia. Royal British Columbia Museum, Victoria. 420 pp.

Summary: Provides brief accounts of the natural history, distribution and seasonal occurrence of birds inhabiting the Okanagan Valley of British Columbia.

C5) Carlile, D.W. and R.E. Fitzner. 1984. Use of Fauna as Biomonitors. Govt. Reports Announcements & Index 02: TD3:

Abstract - Five criteria by which to evaluate the suitability of faunal species as biomonitors are proffered. The criteria which should be considered include: species response to environmental condition, distribution of species, cost of biomonitoring, precision of measurements and ease of maintaining a monitoring system. As an example, the criteria are used in assessing the utility of using nesting Great Blue Herons as biomonitors of fate and effects of environmental contaminants. Emphasis is placed on a method of determining optimal sampling based on cost and precision of measurements of environmental condition. Heron excreta, collected from nine colonies throughout the arid, Mid-Columbia region of Washington, was analyzed to determine levels of specific pollutants. Analyses of variance components were conducted and estimates of within and among- colony variance in levels of selected pollutants are provided. From such variance estimates, numbers of colonies and samples within colonies needed to obtain precise estimates of pollutant levels are determined. The costs of each aspect of sampling are accounted for and are incorporated into a cost function to estimate the cost of sampling. Costs associated specifically with colonies and those attributed to samples within colonies are related to estimates of among and within-colony variation in pollutant levels. This enables determination of the most cost-effective allocation of sampling effort. This method of associating precision and cost is also applied to counts of fledglings for assessment of effects. (ERA citation 08:052255) Renewable resources inventory for monitoring changes and trends meeting, Corvallis, OR, USA, 15 Aug 1983.

C6) Clark, D.R., Jr. 1986a. Toxicity of methyl parathion to bats mortality and coordination loss. Environ. Toxicol. Chem. 5: 191-196.

Keywords: *Myotis lucifugus*, *Mus musculus*, *Eptesicus fuscus,* mouse, Little Brown Bat, Big Brown Bat, brain, cholinesterase, insecticide

C7) Clark, D.R. Jr., and C.J. Stafford. 1981. Effects of DDE and polychlorinated biphenyl (Aroclor 1260) on experimentally poisoned female Little Brown Bats (*Myotis lucifugus*): Lethal brain concentrations. J. Toxicol. Environ. Health 7: 925-934.

Abstract: Adult female Little Brown Bats (*Myotis lucifugus*) were collected in a church attic in North East, Cecil County, Maryland (USA). Mealworms (*Tenebrio molitor*) containing organochlorine pollutants were fed to the bats as follows: five bats were dosed at 480 ppm DDE, 12 at 150 ppm DDE, five at 1000 ppm polychlorinated biphenyl (PCB; Aroclor 1260) and 12 at 15 ppm PCB. Bats (seven) were fed untreated mealworms. The objective was to elevate brain levels of DDE and PCB to lethality and measure these concentrations. During 40 days of dosage, one DDE-dosed bat and two PCB-dosed bats died after exhibiting prolonged tremoring that characterized organochlorine poisoning. After dosage, surviving bats were starved to

elevate brain levels of toxicants and three additional DDE-dosed bats tremored before dying. Mean brain concentration of DDE diagnostic of death was estimated as 603 ppm (range, 540-670 ppm). This mean was 16-18% higher than means for Mexican Free-tailed Bats (*Tadarida brasiliensis*) and Common Grackles (*Quiscalus quiscula*) and may indicate less sensitivity. Lethal brain concentrations of Aroclor 1260 were 1300 and 1500 ppm. Values were higher than values (Aroclor 1254) for Brown-headed Cowbirds (*Molothrus ater*). During starvation, DDE-dosed bats lost weightmounts of stored DDE caused increased metabolic rates of nonfeeding bats, as during hibernation or migration, the result could be premature energy depletion and increased mortality.

C8) Clark, D.R. Jr., and A.J. Krynitsky. 1983. DDE in brown and white fat of hibernating bats. Environ. Pollut. Ser. A Ecol. Biol. 31: 287-300.

Abstract: Samples of brown and white fat from hibernating bats (Big Brown Bat [*Eptesicus fuscus*], Little Brown Bat [*Myotis lucifugus*] and Eastern Pipistrelle [*Pipistrellus subflavus*]) collected in western Maryland, USA, were analyzed to determine lipid and DDE content. Amounts of brown fat, expressed as percentages of total bat weight, were the same for all three species. Lipid content of brown fat was significantly less. Lipids of brown fat contained significantly higher (28%) concentrations of DDE. In a mixed-species sample of 14 bats, concentrations of DDE increased exponentially in brown and white fat as white fat reserves declined. Brown fat facilitated arousal from hibernation by producing heat through rapid metabolism of triglycerides. The question was raised whether organochlorine residues, such as DDE, may have been concentrated and then liberated in lethal amounts by the processes of hibernation and arousal.

C9) Clark, D.R. Jr., and R.M. Prouty. 1984. Disposition of dietary dieldrin in the Little Brown Bat (*Myotis lucifugus*) and correlation of skin levels with body burden. Bull. Environ. Contam. Toxicol. 33: 177-183.

Keywords: soil, pollution, neurotoxicity, insecticide

C10) Clark, D.R. Jr., A.S. Wenner and J.F. Moore. 1986. Metal residues in bat colonies Jackson County, Florida, USA 1981-1983. Fla. Field Nat. 14: 38-45.

Keywords: *Myotis grisescens, Myotis austroriparius,* cadmium, guano, tissue, residue, heavy metals, metal pollution

C11) Clark, D.R., Jr. and B.A. Rattner. 1987. Orthene toxicity to Little Brown Bats (*Myotis lucifugus*), acetylcholinesterase inhibition, coordination loss and mortality. Environ. Toxicol. Chem. 6: 705-708.

Keywords: *Mus musculus*, methyl parathion, organophosphorus insecticide, serum, cholinesterase, environmental pollution

C12) Clark, D.R. Jr., F.M. Bagley and W.W. Johnson. 1988. Northern Alabama colonies of the endangered Gray Bat (*Myotis grisescens*), organochlorine contamination and mortality. Biol. Conserv. 43: 213-226.

Key Words: A*gelaius phoeniceus*

C13) Clark, D.R. Jr., E.F. Hill and P.F. Henry. 1991. Comparative sensitivity of Little Brown Bats (*Myotis lucifugus*) to acute dosages of sodium cyanide. Twenty First Annual North American Symposium On Bat Research, Austin, Texas, USA. October 33: 68.

Keywords: *Peromyscus leucopus, Mus musculus, Anas platyrhynchos,* mines, Arizona, California, Nevada, USA

C14) Clark, K L. and B.D. LaZerte. 1985. A laboratory study of the effects of aluminium and pH on amphibian eggs and tadpoles. Can. J. Fish. Aquatic. Sci. 42: 1544-1551.

C15) Clawson, R.L. 1991. Pesticide contamination of endangered gray bats and their prey in Boone, Franklin, and Camden Counties, Missouri. Trans. Mo. Acad. Sci. 25: 13-19.

Abstract: Endangered Gray Bat (*Myotis grisescens*) colonies in Boone and Franklin counties, Missouri, were examined for contamination by chlorinated hydrocarbon pesticides during 1988 and 1989. Insects were collected in these counties, plus Camden County, to determine possible sources of pesticide contamination. Guano samples, dead Gray Bats, and insect samples from all study sites showed detectable levels of dieldrin and hepatachlor epoxide, compounds associated with gray bat mortality in earlier studies. One of two juvenile Gray Bat carcasses collected in the study contained 3,500 ppb pp'DDE/dieldrin, a level sufficiently high to have caused its death. Pesticide levels of the guano samples collected in this study ranged from below detection limits to 212 ppb pp'DDE/dieldrin, from 2.7 to 42 ppb hepatochlor epoxide, and from below detection limits to 111 ppb technical chlordane. These levels were lower than those of samples collected in the early 1980s. Insect samples contained levels of contamination that ranged from below detection limits to 625, 92, and 702 ppb pp'DDE/dieldrin, heptachlor epoxide, and technical chlordane, respectively. These likewise were lower than those collected in previous

studies. Despite apparently lower levels in the environment, however, chlorinated hydrocarbon pesticides continue to affect the endangered Gray Bat.

C16) Colborn, T. 1991. Epidemiology of Great Lakes Bald Eagles. J. Toxicol. Environ. Health 33: 395-453.

Abstract: Historical data are provided to support the hypothesis that organochlorine chemicals introduced into the Great Lakes ecosystem following World War II are the cause of reproductive loss among Bald Eagles (*Haliaeetus leucocephalus*) in the basin. This is supported with data on concurrent population fluxes of extrabasin North American Bald Eagle populations and the European White-tailed Sea Eagle (*Haliaeetus albicillus*) where the same chemicals were produced and released. Organochlorine chemicals appear as a unique stress on Great Lakes Bald Eagle populations when compared with stresses on successful populations of Bald Eagles continentwide. Shoreline birds bear significantly higher concentrations of these persistent toxics than inland birds. Association between contaminated prey and elevated concentrations of PCBs, DDT, and DDE in Great Lakes Bald Eagles are presented. A fledging ratio is used to support the hypothesis that maternal prezygotic exposure affects the viability of embryos and chicks. The ratio of the mean number of fledglings per successful territory to the mean number of fledglings per active territory, when the numerator is greater than 1.4, provides an index of exposure to contaminants by parental animals and affected offspring. When the ratio is greater than two, parental exposure to organochlorine chemicals should be considered. The adverse effects of pre-zygotic exposure to the same contaminants in other animal species dependent upon Great Lakes fish, and extra-basin Bald Eagle populations dependent upon contaminated fish, provide consistency to the argument. The mechanism of action of the organochlorine chemicals further strengthens the causal argument indicting DAT, DDE, and PCBs. A strong association between DAT/DDE and Bald Eagle reproductive success is provided. However, the role of PCBs is not ruled out. Only data for total PCB concentrations in Bald Eagle tissue are available, and until specific PCB congeners are quantified there will be uncertainty concerning PCB's role in the Great Lakes Bald Eagle's lack of success.

C17) Corrao, A., E. Catalano and B. Zava. 1985. Destructive effects of chlorinated pesticides on a bats colony: Chiroptera. Mammalia 49: 125-130.

Keywords: M*yotis myotis, Miniopterus schreibersi,* DAT

C18) Crum, J.A., S.J. Bursian, R.J. Aulerich, D. Polin and W.E. Braselton. 1993. The reproductive effects of dietary heptachlor in mink (*Mustela vison*). Arch. Environ. Contam. Toxicol. 24. 156-164.

Summary: Adult female mink were fed diets containing 0 (control), 6.25, 12.5 and 25 ppm (ug/g) technical grade heptachlor prior to and throughout the reproductive period (181 days) to evaluate the effects of heptachlor consumption on reproduction and offspring viability and to assess the extent of placental and mammary transfer of heptachlor epoxide to mink offspring. 67% and 100% mortality occurred in the 12.5 and 25 ppm groups. No kits were born in the 25 ppm group as all females died. In the 12.5 ppm group, kits weighed significantly less than the controls and survival to three weeks was significantly reduced. Even among the 6.25 ppm kits, weight gain at 3 to 6 weeks was significantly less than the controls. The LCD50 for the 181-day exposure period for females was 10.5 ppm heptachlor and the LOAEL, based on reduced kit growth was 6.25 ppm.

C19) Cumbie, P.M. 1975. Mercury levels in Georgia otter, mink, and freshwater fish. Bull. Environ. Contam. Toxicol. 14: 193-196.

Keywords: mink, otter, prey, residue study

C20) Custer, T.W., E.F. Hill and H.M. Ohlendorf. 1985. Effects on wildlife of ethyl and methyl parathion applied to California USA rice fields. Calif. Fish Game 71: 220-224.

Key Words: *Triops longicaudatus, Lepus californicus, Anas platyrhynchos, Phasianus colchicus, Fulica americana, Agelaius phoeniceus,* brain cholinesterase

D1) De, S.K. 1987. Organochlorines predators and reproductive success of the Red-necked Grebe in southern Manitoba, Canada. Condor 89: 460-467.

Key Words: *Podiceps grisegena, Procyon lotor,* human activities, DDE, PCB, nesting loss, renesting, egg inviability, fledging success, population decline, North America

D2) Desgranges, J.L. and J. Rodriguez. 1985. Influence of acidity and competition with fish on the development of ducklings in Quebec, Canada. International Symposium On Acidic Precipitation, Muskoka, Ontario, Canada. September

Key Words: *Anas rubripes, Bucephala clangula, Salvelinus fontinalis*, growth, acid rain

D3) Deweese, L.R., L.C. Mcewen, L.A. Settimi and R.D. Deblinger. 1983. Effects on birds of fenthion aerial application for mosquito control. J. Econ. Entomol. 76: 906-911.

Abstract: Effects on birds of an aerial application of fenthion, a potent organophosphorus cholinesterase (ChE)-inhibiting insecticide, were assessed on four study sites 1.8 to 3.6 km^2 in size. These sites were located within 121.5 km^2 of wet meadows treated with 47 g of fenthion (AI) per ha in ultralow-volume formulation. Assessment methods were searches for sick or dead birds, measurements of brain ChE activity in specimens found dead or collected alive at different time intervals, and counts of bird populations. After treatment, 99 birds and 15 mammals were found sick or dead; 106 of these were on one site. Brain ChE activity in dead birds was depressed sufficiently to indicate that death was caused by an anti-ChE substance. Brain ChE activity in three common bird species collected alive showed the greatest reduction two days postspray. Two of these species had ChE activity that was still significantly ($P < 0.05$) depressed 15 days postspray. Bird populations declined most where mortality was heaviest. Fenthion sprayed for mosquito control was life threatening to many birds inhabiting treated meadows. (The following species were studied: *Anas platyrhynchos*, *A. acuta, Porzana carolina, Charadrius vociferus, Steganopus tricolor, Eremophila alpestris, Sturnella neglecta, Xanthocephalus xanthocephalus, Agelaius phoeniceus, Euphagus cyanocephalus, Molothrus ater, Passerculus sandwichensis, Marmota flaviventris, Lepus townsendii, Sylvilagus nuttallii, Spermophilus richardsonii, Peromyscus* sp. and *Erethizon dorsatum*).

D4) Deweese, L.R., R.R. Cohen and C.J. Stafford. 1985. Organochlorine residues 4and eggshell measurements for Tree Swallows (*Tachycineta bicolor*) in Colorado, USA. Bull. Environ. Contam. Toxicol. 35: 767-775.

Key Words: DDE, mortality, nesting failure, age

D5) Deweese, L.R., L.C. Mcewen, G.L. Hensler and B.E. Petersen. 1986. Organochlorine contaminants in passeriformes and other avian prey of the Peregrine Falcon (*Falco peregrinus*) in the Western USA. Environ. Toxicol. Chem. 5: 675-694.

Key Words: *Tachycineta thalassina, Tachycineta bicolor, Charadrius vociferus, Euphagus cyanocephalus,* DDE, polychlorinated biphenyls, hexachlorocyclohexane, heptachlor epoxide, oxychlordane, dieldrin, toxaphene, mortality, carcass fat

D6) Di, G.R. and P.F. Scanlon. 1981. Heavy metal concentrations in ducks wintering in the lower Chesapeake Bay region USA. 38th Northeast Fish And Wildlife Meeting, Virginia Beach, Va., USA, April 38: 111-112.

Key Words: *Anas platyrhynchos, Anas americana, Anas rubripes, Clangula hyemalis, Bucephala albeola,* vegetation, invertebrate, cadmium, copper, lead, zinc, liver, kidney, bone

D7) Di, G.R. and P.F. Scanlon. 1984. Heavy metals in tissues of waterfowl from the Chesapeake Bay, USA. Environ. Pollut. Ser. A. Ecol. Biol. 35: 29-48.

Abstract: Concentrations of Cd, Pb, Cu and Zn were measured in 774 livers, 266 kidneys and 271 ulnar bones from 15 species (Mallard, Black Duck, Pintail, Gadwall, American Wigeon, Green-winged Teal, Wood Duck, Ring-necked Duck, Greater Scaup, Bufflehead, Canvasback, Lesser Scaup, Ruddy Duck, Oldsquaw, White-winged Scoter) of ducks obtained from the Chesapeake Bay region. A major purpose of this study was to elucidate relationships between food habits and tissue accumulations of heavy metals in Chesapeake Bay waterfowl. Liver and kidney concentrations of Cd were highest among two carnivorous sea-duck species, *Clangula hyemalis* and *Melanitta deglandi*. Pb concentrations in tissues were generally highest in largely herbivorous species, such as *Anas platyrhynchos, A. rubripes* and *A. strepera*. Spent shot may have been an important source for tissue burdens of Pb in these ducks. No marked trends were observed between food habits and tissue concentrations of the nutrient elements, Cu and Zn.

D8) Diamond, A.W. 1987. Impacts of acid rain on aquatic birds. Acid Rain Symposium 12: 245-254.

Key Words: G*avia immer, Anas rubripes, Tachycineta bicolor, Cinclus cinclus,* heavy metal, toxicity, aluminum, mercury, food chain, disruption, growth, reproduction

D9) Dittmann, J., M. Altmeyer, K. Dmowski, J. Kruger, P. Muller and G. Wagner. 1990. Mercury concentrations in a White-tailed Eagle (*Haliaeetus albicilla*) from the vicinity of Warsaw, Poland. Environ Conserv 17: 75-77.

Key Words: feather

D10) Douthwaite, R.J. 1982. Changes in Pied Kingfisher (*Ceryle rudis*) feeding related to endosulfan pollution from Tsetse Fly control operations in the Okavango Delta, Botswana. J. Appl. Ecol. 19: 133-142.

Abstract: Diet, feeding behaviour and number of Pied Kingfishers were monitored on the Mochaba River in Botswana when the area was treated with aerosols of endosulfan (6-12 g/ha) to kill Tsetse Flies. The diet comprised fish of 28-112 mm (mean 62 mm) total length and 0.2-19.1 g (mean 4.1 g) weight. Cichlids predominated, selectivity increasing with length. Kingfishers were attracted to fish kills where they fed faster, eating

debilitated fish. The local fish population was substantially reduced by leaking endosulfan at one spray; kingfisher feeding rates fell and some birds left the area. The total concentration of endosulfan in the brains of three birds shot two weeks after the final spray was 0.2 mug/g wet weight, similar to levels found in fish. When spraying ended feeding rates had fallen from about 13 g ha-1 to about 6 g ha-1, possibly because the availability of fishing perches and open water were reduced. The kingfisher population in the study area had apparently survived and numbers at a communal roost were steady.

D11) Douthwaite, R.J. 1992. Effects of DDT on the Fish Eagle (*Haliaeetus vocifer*) population of Lake Kariba in Zimbabwe. Ibis 134: 250-258.

Abstract: Twenty clutches were collected from nests of Fish Eagles (*Haliaeetus vocifer*) at Lake Kariba, Zimbabwe, and a small dam nearby in 1989-90. Unaltered DDT, and metabolites DDD and DDE, were found in every egg. Mean levels of SIGMADDT(=DDT+DDD+DDE) generally varied from 14 to 49 mg/kg dry weight per clutch, but 113-223 mg/kg dry weight were found in clutches from the eastern end ot the lake and the mouth of the Sengwa River. SIGMADDT and DDE levels were significantly correlated with the Ratcliffe Ind eggshell thickness. Comparison with museum specimens showed that the Ratcliffe Index has declined by 11% since 1936-41 due to a significant fall in shell weight. Eggshell thinning exceeded 20% at the eastern end of the lake. Aerial surveys in 1987 and 1990 found that hatching success along the southern lakeshore exceeded 72%, but chicks were seen in fewer than half the nests at the eastern end. However, the density of breeding pairs was greatest here. Residue levels have increased by about 8% since 1980, rinsing more steeply in areas recently sprayed for tsetse fly control and falling in others. The threat from DDT may now be receding as regional use has declined and will end, tsetse fly control, by 1995. None was used for this purpose in 1991. Mercury levels in adult birds were very high and may pose a significant risk. The breeding population may be limited by availability of safe nest sites. Chicks are sometimes eaten by people. Settlement along the lakeshore is increasing and safe sites are becoming scarcer as dead trees in the lake collapse and large trees onshore are destroyed by elephants.

E1) Eagle, T.C. and J.S. Whitman. 1987. Mink. In: M. Novak, J.A. Baker, M.E. Obbard and B. Malloch (eds.). Wild Fur-bearer Management in North America. Min. of Natur. Res., Ontario. pp. 615-624.

Summary: A comprehensive review of the natural history of mink and a detailed discussion of management issues.

E2) Ehrlich, P.R., Dobkin D.S. and D. Wheye. 1988. The Birders handbook. A field guide to the natural history of North American birds. Simon & Schuster Inc. New York. 785 pp.

E3) Elliott, J. E., R.W. Butler, R.J. Norstrom and P.E. Whitehead. 1989. Environmental contaminants and reproductive success of Great Blue Herons (*Ardea herodias*) in British Columbia, Canada, 1986-1987. Environ. Pollut. 59: 91-114.

E4) Elliott, J.E., P.E. Whitehead, R.J. Norstrom, S.M. Bandiera, L.E. Hart, K.M. Cheng and G. D. Bellward. 1991. Monitoring chlorinated hydrocarbon exposure in Great Blue Herons by using mixed-function oxidases. Sixth International Symposium on Responses of Marine Organisms to Pollutants, Part 35: 204-205.

Key Words: *Ardea herodias,* contamination, pollution

E5) Elliott, J.E., P.A. Martin, T.W. Arnold and P.H. Sinclair. Unpubl. Organochlorines and reproductive success of birds in orchards and non-orchard areas of central British Columbia, Canada, 1990-91. 25 pp.

Key Words: mercury, lead, cadmium, polychlorinated dibenzodioxin, polychlorinated dibenzofuran, organochlorine, pesticide, Vancouver Island

E6) Emery, R.M., D.C. Klopper, D.A. Baker and J.K. Soldat. 1981. Potential radiation dose from eating fish exposed to actinide contamination. Health Phys. 40: 493-510.

Abstract: Maximum potential for transporting actinides to man via fish consumption was studied. The study took place in U-Pond (Richland, WA, USA), a nuclear waste pond. It had concentrations of 238U, 238Pu, 239.240Pu and 241Am that were approximately three orders of magnitude greater than background levels. Fish living in the pond contained higher actinide concentrations than those observed in fish from other locations. Experiments were performed in U-Pond to determine maximum quantities of actinides that could accumulate in fillets and whole bodies of two centrarchid fish species (*Lepomis macrochirus, Micropterus salmoides*). Doses to hypothetical consumers were estimated by assuming that actinide behavior in their bodies was similar to that defined for standard man by the International Commission on Radiological Protection. Results indicated that highest concentrations occurring in bluegill or bass muscle after more than one year exposure to the pond would not be sufficient to produce a significant radiation dose to a human consumer, even if he ate 0.5 kg (1 lb)

of these fillets every day for 70 yr. Natural predators (heron or coyote), having lifetime diets of whole fish from U-Pond, would receive less radiation dose from the ingested actinides than from natural background sources.

E7) Eriksson, M.O. 1984. Acidification of lakes: Effects on waterbirds in Sweden. Ambio 13: 260-262.

Abstract: The decline in abundance of fish in acidified lakes affects the bird fauna according to the feeding habits of the species in question. Ducks feeding on aquatic insects are favored by the reduced competition with fish for common prey. Goldeneye in particular exploit the increased populations of highly mobile insects which turn up in lakes with reduced densities of fish. Among fish-eating birds such as divers and mergansers, which search for prey while swimming with their eyes below the surface, there is a compensation for the reduced abundance of fish prey by a concomitant increase in water transparency which makes remaining fish easier to detect. Other species, such as Osprey and terns, do not benefit from the increased visibility as their diving depths limit them to fish in the uppermost meter of water. In addition to exposure to ecological changes resulting from acidification, birds are also increasingly exposed to metal pollutants, which increase in acidified waters. Among passerine birds, impaired reproductive success has been related to breeding in territories close to the shore where they are exposed to Al by feeding on emerging insects. Generally, the waterbird fauna in the type of lake which is susceptible to acidification is comparatively sparse. But for some species, such as divers and Osprey, a considerable proportion of the total European populations breed at such waters and it is of international importance for the preservation of these species that people are concerned with the effects of lake acidification.

E8) Eriksson, M.O. 1986. Fish delivery production of young and nest density of Osprey (*Pandion haliaetus*) in southwest Sweden. Can. J. Zool. 64: 1961-1965.

Key Words: juvenile, acid rain, acidification, lake, mortality, maturation

E9) Eriksson, M.O. 1987. Liming of acidified lakes in southwestern Sweden - short-term effects on waterbird densities. Wildfowl 38: 143-149.

Key Words: *Gavia arctica, Mergus merganser, Anas platyrhynchos, Anas crecca, Bucephala clangula*

E10) Eriksson, M.O., L. Henrikson and H.G. Oscarson. 1989. Metal contents in liver tissues of non-fledged Goldeneye (*Bucephala clangula*) ducklings: a

comparison between samples from acidic circumneutral and limed lakes in south Sweden. Arch. Environ. Contam. Toxicol. 18: 255-260.

Key Words: air pollution, water pollution, water chemistry, toxicokinetics, acid precipitation

E11) Ethier, T. 1993. Survey methods for swallows and swifts in British Columbia. Mininstry of Environment, Lands and Parks, Wildlife Branch, Victoria. Unpubl. Manusc. 32 pp.

E12) Euliss, N.H. Jr., R.L. Jarvis and D.S. Gilmer. 1989. Carbonate deposition on tail feathers of Ruddy Ducks using evaporation ponds. Condor 91: 803-806.

Abstract: Substantial carbonate deposits were observed on rectrices of Ruddy Ducks (*Oxyura jamaicensis*) collected during 1982-1984 on evaporation ponds in the San Joaquin Valley, California. Carbonate deposits were composed of about 75% aragonite and 25% calcite, both polymorphous forms of CaCO3. Significantly more carbonate deposits were observed on Ruddy Ducks as length of exposure to agricultural drain water increased, during the 1983-1984 field season when salt concentrations in the ponds were higher, and in certain evaporation-pond systems.

E13) Evans, D.L. 1982. Status reports on 12 raptors. US Fish Wildl. Serv. Spec. Sci. Rep. Wildl. 0: 1-68.

Abstract: The distribution, ecology, management and status of 12 species of raptors are compiled largely from the literature, and an extensive bibliography on each species. Earlier declines in the Bald Eagle (*Haliaeetus leucocephalus*), Cooper's Hawk (*Accipiter cooperii*), Merlin (*Falco columbarius*), Osprey (*Pandion haliaetus carolinensis*), Peregrine Falcon (*F. peregrinus*) and the Sharp-shinned Hawk (*A. striatus velox*) appear to have ended with restrictions on organochlorine biocide use and most populations appear to be recovering. Continued use of organochlorine biocides in South and Central America has the potential of negating this positive trend. Depletion of fisheries due to acid rain may pose a future threat to bald eagle and osprey populations in some regions. Loss of essential habitat has affected declines in the Caracara (*Caracara cheriway*) and Western Burrowing Owl (*Athene cunicularia hypugaea*) and the disappearance of the northern Aplomado Falcon (*F. femoralis septentrionalis*) from the southern USA. Most populations of the Ferruginous Hawk (*Buteo regalis*), Marsh Hawk (*Circus cyaneus hudsonius*) and Prairie Falcon (*F. mexicanus*) appear stable; habitat loss is the most critical factor in population changes.

E14) Evans, S.W. and H. Bouwman. 1992. DDT levels in the blood of Pied Kingfishers (*Ceryle-rudis*) from Kwazulu, South Africa. Wilson, R.T.0: 611-616.

Key Words: human food web, household pest

E15) Ewins P.J. and C.A. Bishop. 1993. Monitoring uptake of chlorinated hydrocarbons in migrant Opsrey: eggs or chick plasma? Society of Environmental Toxicology and Chemistry, Fourteenth Annual Meeting, Houston, Texas. December 1993.

F1) Falandysz, J. 1986. Organochlorine compounds in tissues of Goldeneye, Velvet Scoter, Eider and Coot wintering in Gdansk Bay, Poland 1975-1976. Bromatol Chem. Toksykol 19: 55-60.

Key Words: *Bucephala clangula, Melanitta fusca, Somateria mollissima, Fulica atra*, muscle, liver, adipose tissue, starvation, weather conditions, hexachlorobenzene, alpha hexachlorocyclohexane, beta hexachlorocyclohexane, gamma hexachlorocyclohexane, polychlorinated biphenyls

F2) Falandysz, J. and P. Szefer. 1982a. Chlorinated hydrocarbons in diving ducks wintering in Gdansk Bay, Baltic Sea. Sci. Total Environ. 24: 119-128.

Abstract: The levels of HCB (hexachlorobenzene fungicide), alphaBHC, gamma-BHC, DDT (plus analogs) and PCB (polychlorinated biphenyl) were determined in adipose fat from seven species of diving ducks (*Aythya fuligula, A. marila, Bucephala clangula, Clangula hyemalis, Melanitta fusca, M. nigra, Somateria mollissima*) at their winter quarters in the southern Baltic. PCB, SIGMADDT and HCB were detected in all samples. PCB was highest, followed by SIGMADDT and HCB. Residues of gamma-BHC were detected in four of 129 samples, but for all samples from the Long-tailed Duck, only levels of alpha-BHC were positive. Differences between HCB, SIGMADDT and PCB residue levels between males and females of the Scaup duck were statistically insignificant ($P < 0.01$).

F3) Falandysz, J. and P. Szefer. 1982b. Chlorinated hydrocarbons in fish-eating birds wintering in the Gdansk Bay, Baltic Sea, Poland, 1980-1981. Mar. Pollut. Bull. 13: 132-135.

Abstract: Samples of the chlorinated hydrocarbon content in adipose tissue of fish-eating birds wintering in the south Baltic showed high concentrations of PCB (polychlorinated biphenyl) compared with SIGMADDT, HCB (hexachlorobenzene fungicide), alpha- and gamma-BHC. The Great Crested

Grebe had 4-fold higher PCB SIGMADDT ratios than specimens taken during 1975-1976.

F4) Farr, A.C.M. and D.L. Dunbar. 1988. British Columbia's 1988 midwinter Bald Eagle survey. Ministry of the Environment, Surrey, B.C. 34 pp.

F5) Fenton, M.B., C.G. van Zyll De Jong, G.P. Bell, D.B. Campbell and M. Laplante. 1980. Distribution, parturition dates and feeding of bats in south-central British Columbia. Can. Field-Nat. 94(4): 416-420.

Summary: Bat surveys were carried out during the summer of 1979 in the Similkameen and Okanagan Valleys, British Columbia. Distribution and feeding behaviour of bats was determined by monitoring their echolocation calls. Ten species were captured including the Fringed Bat and the Pallid Bat. Feeding behaviour and habitat use by some species is described.

F6) Findholt, S.L. 1985. Status and distribution of herons, egrets, ibises and related species in Wyoming, USA. Colon. Waterbirds 7: 55-62.

Key Words: *Botaurus lentiginosus, Ardea herodias, Egretta thula, Nycticorax nycticorax, Plegadis chihi, Eudocimus albus, Ixobrychus exilis, Mycteria americana*, human disturbance, breeding, historical record, organochlorine contamination

F7) Fitzner, R.E., W.H. Rickard and W.T. Hinds. 1982. Excrement from heron colonies for environmental assessment of toxic elements. Environ. Monit. Assess. 1: 383-386.

Abstract: Excrement cast from Great Blue Heron nests was collected during the nesting period of 1978, from four colonies in Washington and Idaho (USA). Cheesecloth strips placed on the ground beneath the nests served as excrement collecting devices. Chemical analysis for Pb, Hg and Cd were performed on dried samples. Pb was the most abundant trace metal found in heron debris. The Idaho colony at Lake Chatcolet had an average concentration of 46 ppm in the beneath-nest samples and 6 ppm in control samples. A heron colony near Tacoma, Washington, had beneath-nest samples averaging 28 ppm and control samples averaging 20 ppm. Two colonies located in the interior region of Washington had substantially lower concentrations of Pb. The difference observed between colonies was attributed to their association with a polluted watershed (Chatcolet colony), an interstate highway (Tacoma colony) and an unpopulated, largely agricultural area (inland Washington).

F8) Fitzner, R.E., L.J. Blus, C.J. Henny and D.W. Carlile. 1988. Organochlorine residues in Great Blue Herons from the northwestern United States. Colonial Waterbirds 11(2): 293-300.

Absract: We collected eggs or young Great Blue Herons (*Ardea herodias*) from eight nesting colonies in the northwestern United States from 1977 through 1982. Subadults were collected at three estuarine areas in Puget Sound in 1981 and dead young or adults were collected at various localities. Nearly all samples analyzed contained residues of DDE and polychlorinated biphenyls (PCBs); small residues of 10 other organic contaminants were detected infrequently. Maximum residues (wet weight) in eggs were 26 ug/g DDE and 13ug/g PCBs. Livers of adults from Puget Sound contained up to five ug/g PCBs. Maximum residues of DDE and PCBs in livers of prefledgling Great Blue Herons from three colonies were only 0.45 and 1.20 ug/g. respectively. Maximum residues in whole bodies of hatchlings found dead at Lake Chatcolet, Idaho were 21 ug/g DDE and 11ug/g PCBs. On a colony basis, eggshell thinning averaged from 4 to 13%. Multiple regression analysis indicated that DDE and PCBs accounted for 26 and 3%, respectively, of the variability in eggshell thickness. There was no evidence that any of the organochlorines detected were related to lethal or serious sublethal effects.

F9) Fleming, W.J., B.P. Pullin and D.M. Swineford. 1985. Population trends and environmental contaminants in herons in the Tennessee Valley, USA 1980-1981. Colon. Waterbirds 7: 63-73.

Key Words: biosis, copyright, biol. abs., RRM, *Ardea herodias, Nycticorax nycticorax, Butorides striatus*, pesticide, polychlorinated biphenyl, chromium, DDT, nesting success, egg shell thickness, mercury

F10) Flickinger, E.L., D.H. White, C.A. Mitchell and T.G. Lamont. 1984. Monocrotophos and dicrotophos residues in birds as a result of misuse of organophosphates in Matagorda County, Texas (USA). J. Assoc. Off. Anal. Chem. 67: 827-828.

Abstract: About 1100 birds of 12 species, Red-winged blackbird (*Agelaius phoeniceus*), Great-tailed Grackle (*Quiscalus mexicanus*), Brown-headed Cowbird (*Molothrus ater*), Mourning Dove (*Zenaida macrours*), Eastern Meadowlark (*Sturnella magna*), Vesper Sparrow (*Pooecetes gramineus*), Common Snipe (*Gallinago gallinago*), Blue-winged Teal (*Anas discors*), Mottled Duck (*Anas fulvigula*), Common Moorhen (*Gallinula chloropus*), Redhead (*Aythya americana*) and Ruddy Turnstone (*Arenaria interpres*) died from organophosphate poisoning in Matagorda County on the Texas Gulf Coast in March and May 1982. Birds died from feeding on rice seed that was illegally treated with dicrotophos or monocrotophos and placed near rice fields as bait to attract and kill birds. Brain acetylcholinesterase inhibition of affected birds averaged 87% (range 82-89%), and contents of gastrointestinal tracts contained residues of dicrotophos (5.6-14 ppm) or monocrotophos (2.1-13 ppm). Rice seed collected at mortality sites contained 210 ppm dicrotophos or 950 ppm monocrotophos. Mortality from dicrotophos poisoning continued for almost 3 wk. The practice of illegally

treating rice seed with either of the two organophosphates appears to be infrequent but widespread at present.

F11) Foley, R.E. 1992. Organochlorine residues in New York waterfowl harvested by hunters in 1983-1984. Environ. Monit. Assess. 21: 37-48.

Abstract: Thirteen organochlorine compounds were detected in fat and breast muscle tissues of Canada Goose and five species of ducks that were shot by sportsman in New York. Residues of DDE and PCB occurred most frequently and were postively identified along with DDT,hepatochlor epoxide, trans-nonachlor, and hexachlorobenzene. Compounds that were detected but not positively confirmed by mass spectrometry were dieldrin, mirex, heptachlor, chlordane, oxychlordane, and endrin. Wood Duck (*Aix sponsa*) and Canada Goose (*Branta canadensis*) had significantly lower levels of DDE and PCB than Black Duck (*Anas rubripes*), Mallard (*Anas platyrhynchos*), Scaup (*Athys* sp.), and Bufflehead (*Bucephala albeola*). Birds collected from Long Island and the Hudson River-Lake Champlain corridor carried highest concentrations.

F12) Foley, R.E. and G.R. Batcheller. 1988. Organochlorine contaminants in Common Goldeneye wintering on the Niagara River. J. Wildl. Manage. 52(3): 441-445.

Abstract: We collected adult male Common Goldeneye (*Bucephala clangula*) near their time of arrival on wintering grounds (Nov.-Dec.) (n=26) and just prior to spring migration (Feb.-Mar.) (n=24) from the Upper Niagara River (UNR), New York, to identify and measure organochlorine contaminants in fat tissues. Detectable concenatrations of polychlorinated biphenyl (PCB), dichlorodiphenyldichloroethylene (DDE), dieldrin, hexachlorobenzene (HCB), oxychlordane, and heptachlor epoxide (HE) were found in adult birds. Polychlorinated biphenyl, dieldrin, HCB amd HE increased ($P<0.05$) in adults between the two sample periods. In a group of hatching-year (HY) birds sampled in November-December (n=27), organochlorine residues were less than those of adults from the same period ($P<0.001$). Contaminants known to occur in prey items (e.g. crustaceans, gastropods, insects, pelecypods, fish, and annelids) are probably the major source of exposure for common goldeneye on the Niagara River.

F13) Foley, R.E., S.J. Jackling, R.J. Sloan and M.K. Brown. 1988. Organochlorine and mercury residues in wild mink and otter. Comparison with fish. Environ. Toxicol. Chem. 7: 363-374.

Keywords: *Mustela vison, Lutra canadensis*, polychlorinated biphenyl, mercury , p,p'-DDE, insecticide, Lake Ontario, New York, residue study

F14) Forbes, L.S. 1984. The nesting ecology of the Western Grebe in British Columbia. Can. Wildl. Serv. Rep., Delta, B.C. 20pp.

F15) Forbes, L.S. 1985. The feeding ecology of the Western Grebe breeding at Duck Lake, British Columbia. M.Sc. thesis, University of Manitoba, Winnipeg. 72 pp.

F16) Franson, J.C., E.J. Kolbe and J.W. Carpenter. 1985. Famphur toxicosis in a Bald Eagle (*Haliaeetus-leucocephalus*). J. Wildl. Dis. 21: 318-320.

Key Words: *Hypoderma* spp., cattle, secondary poisoning, insecticide

F17) Frenckell, B. von and R.M.R. Barclay. 1987. Bat activity over calm and turbulent water. Can. J. Zool. 65: 219-222.

Summary: Compared the foraging activity of Little Brown Bats over calm pools and fast-flowing riffles in southwestern Alberta. Bat activity was measured by frequency of echolocation clicks. Insect abundance was measured with sticky traps. Bats were more active over calm pools even though prey abundance did not differ between the two types of sites. Water noise at riffles may decrease the efficiency with which bats can detect targets.

G1) Garrett, M.G., J.W. Watson and R.G. Anthony. 1993. Bald Eagle home range and habitat use in the Columbia River estuary. J. Wildl. Manage. 57(1):19-27.

G2) Georgi, M.E., M.S. Carlisle and L.E. Smiley. 1986. Giardiasis in a Great Blue Heron (*Ardea herodias*) in New York State, USA: another potential source of waterborne giardiasis. Am. J. Epidemiol. 123: 916-917.

Key Words: cross transmission, host specificity, necropsy

G3) Gerrard, J.M., E. Dzus, G.R. Bortolotti and P.N. Gerrard. 1993. Waterbird population changes in 1976-1990 on Besnard Lake, Saskatchewan: Increases in loons, gulls, and pelicans. Can. J. Zool. 71: 1681-1686.

Abstract: Declines in Common Loon (*Gavia immer*) populations associated with increasing human use of lakes have been reported from many areas of North America. In the present report we describe a lake in northern Saskatchewan, Besnard Lake, where there has been a substantial increase in the number of loons, from about 85 in 1976-1979 to about 165 in 1990. A comparison was made with numbers of other birds associated with water. Increases were also seen in American White Pelicans (*Pelecanus erythrorhynchos*), Osprey (*Pandion haliaetus*), Great Blue Herons (*Ardea herodias*), Herring Gulls (*Larus argentatus*), Ring-billed Gulls (*L. delawarensis*), and Bonaparte's Gulls (*L. philadelphia*). No change was seen in mergansers (*Mergus merganser* and *M. serrator*), Bald Eagles (*Haliaeetus leucocephalus*), or Common Terns (*Sterna hirundo*). The period 19760-1990

has also seen increased human use on Besnard Lake. The reason for increased loon numbers is uncertain, but could possibly be related to an increase in the numbers of small fish in Besnard Lake as a result of increased fishing pressure disproportionately removing the larger, predatory fish.

G4) Gilbert, F.F. and E.G. Nancekivell. 1982. Food Habits of mink (*Mustela vison*) and otter (*Lutra canadensis*) in northeastern Alberta. Can. J. Zool. 60: 1282-1288.

Summary: Scats of mink (*Mustela vison*) and River Otter (*Lutra canadensis*) in northeastern Alberta were collected from two drainage systems and analysed to determine diet. In general diet differed in different habitat types according to type of water body. In a habitat dominated by lakes, brook stickleback (*Culaea inconstans*) was the most frequently encountered food item in scats of both species. In a habitat dominated by streams, brook stickleback remained important in the otter diet while among mink, varying hare (*Lepus americana*) became the primary food item by frequency of occurrence and mammalian items were, in general, significantly ($P < 0.01$) more frequent among mink. The frequency of avian remains in otter scats was very high and probably reflected high utilisation of breeding and moulting waterfowl.

G5) Glahn, J.F., A.R. Stickley, Jr., J.F. Heisterberg and D.F. Mott. 1991. Impact of roost control on local urban and agricultural blackbird problems. Wildl. Soc. Bull. 19: 511-522.

Key Words: *Quiscalus quiscula, Agelaius phoeniceus, Molothrus ater, Sturnus vulgaris*, agricultural pest, urban pest, sprinkler system, surfactant application, field, method analysis, Kentucky, Alabama USA

G6) Glooschenko, V., J. Jones, C. Hebert and D. Haffner. 1990. Comparison of southern Ontario mink harvest from sites of high/low PCB contamination. Society of Environmental Toxicology and Chemistry, Eleventh Annual Meeting, Arlington, VA. Nov. 1990.

G7) Gochfeld, M. and J. Burger. 1987. Heavy metal concentrations in the liver of three duck species: influence of species and sex. Environ. Pollut. 45: 1-16.

Key Words: *Anas rubripes, Anas platyrhynchos, Aythya marila*, Raritan Bay, New Jersey, USA

G8) Godfrey, W.E. 1986. Birds of Canada. Revised Edition. National Museum of Canada, Ottawa.

Summary: Provides a brief account of distribution and natural history of birds in Canada.

G9) Gray, R.H. 1989a. Monitoring Fish, Wildlife, Radionuclides and Chemicals at Hanford, Washington. Govt. Reports Announcements & Index 16: TD3.

Abstract: Concern about the effects of potential releases from nuclear and non-nuclear activities on the US Department of Energy's Hanford Site in southeastern Washington has evolved over four decades into a comprehensive environmental monitoring and surveillance program. The program includes field sampling, and chemical and physical analyses of air, surface and ground water, fish, wildlife, soil, foodstuffs, and natural vegetation. In addition to monitoring radioactivity in fish and wildlife, population numbers of key species are determined, usually during the breeding season. Data from monitoring efforts are used to assess the environmental impacts of Hanford operations and calculate the overall radiological dose to humans onsite, at the Site perimeter, or residing in nearby communities. Chinook salmon (*Oncorhynchus tshawytscha*) spawning in the Columbia River at Hanford has increased in recent years with a concomitant increase in winter nesting activity of Bald Eagles (*Haliaeetus leucocephalus*). An elk (*Cervus elaphus*) herd, established by immigration in 1972, is also increasing. Nesting Canada Geese (*Branta canadensis*) and Great Blue Heron (*Ardea herodias*), and various other animals, e.g., Mule Deer (*Odocoileus hemionus*) and Coyotes (*Canis latrans*) are common. Measured exposure to penetrating radiation and calculated radiation doses to the public are well below applicable regulatory limits. 35 refs., 4 figs. (ERA citation 14:021835) Biennial symposium: issues and technology in the management of impacted wildlife, Glenwood Springs, CO, USA, 6 Feb 1989.

G10) Gray, R.H. 1989b. Overview of a Comprehensive Environmental Monitoring and Surveillance Program: The Role of Fish and Wildlife. Govt Reports Announcements & Index 08: TD3:

Abstract: Concern about the effects of potential releases from nuclear and non-nuclear activities on the US Department of Energy's Hanford Site in southeastern Washington has evolved over four decades into a comprehensive environmental monitoring and surveillance program. The program includes field sampling, and chemical and physical analyses of air, surface and ground water, fish and wildlife, soil, foodstuffs, and natural vegetation. In addition to monitoring radioactivity in fish and wildlife, population numbers of key species are determined, usually during the breeding season. Data from monitoring efforts are used to assess the environmental impacts of Hanford operations and calculate the overall radiological dose to humans onsite, at the Site perimeter, or residing in nearby communities. Chinook salmon spawning in the Columbia River at

Hanford has increased in recent years with a concomitant increase in winter nesting activity of Bald Eagles (*Haliaeetus leucocephalus*). An elk (*Cervus elaphus*) herd, established by immigration in 1972, is also increasing. Nesting Canada Geese (*Branta canadensis*) and Great Blue Heron (*Ardea herodias*), and various other animals, e.g., mule deer (*Odocoileus hemionus*) and Coyotes (*Canis latrans*) are common. Measured exposure to penetrating radiation and calculated radiation doses to the public are well below applicable regulatory limits. (ERA citation 14:000264) American Fisheries Society annual meeting, Albuquerque, NM, USA, 13 Oct 1988.

G11) Gray, R.H. 1991. Long-term environmental monitoring at Hanford, Washington. Govt. Reports Announcements & Index 10: TD3.

Abstract: Environmental monitoring has been an ongoing activity on the US Department of Energy's Hanford Site in southeastern Washington for over 45 years. Objectives are to detect and assess potential impacts of Site operations (nuclear and non-nuclear) on air, surface and ground water, foodstuffs, fish, wildlife, soils and vegetation. Data from monitoring efforts are used to calculate the overall radiological dose to humans working on site or residing in nearby communities. In 1988, measured Hanford Site perimeter concentrations of airborne radionuclides were below applicable guidelines. In addition to monitoring radioactivity in fish and wildlife, population numbers of key species are determined. Chinook salmon (*Oncorhynchus tshawytscha*) spawning in the Columbia River at Hanford has increased in recent years with a concomitant increase in winter roosting activity of Bald Eagles (*Haliaeetus leucocephalus*). An elk (*Cervus elaphus*) herd, established by immigration in 1972, is increasing. The Hanford Site also serves as a refuge for Canada Goose (*Branta canadensis*) and Great Blue Heron (*Ardea herodias*), and various plants and other animals, e.g., (*Odocoileus hemionus*) and Coyote (*Canis latrans*). 32 refs., four figs. Superfund '90: 11. annual national conference and exhibition of the Hazardous Materials Control Research Institute, Washington, DC (USA), 26-28 Nov 1990. Sponsored by Department of Energy, Washington, DC.

G12) Green D.M. and R.W. Campbell. 1984. The Amphibians of British Columbia. Royal British Columbia Handbook No. 45. 100pp.

Summary: Provides a description of the distribution and natural history of amphibians inhabiting British Columbia.

G13) Grubb, T.G., S.N. Wiemeyer and L.F. Kiff. 1990. Eggshell thinning and contaminant levels in Bald Eagle eggs from Arizona, 1977 to 1985. Southwestern Naturalist 35: 298-301.

Abstract: The mean eggshell thickness of 11 eggs of Bald Eagles (*Haliaeetus leucocephalus*) and 21 samples of eggshell fragments (n = 32) collected from 14 nests in Arizona during 1977 to 1985 was 0.539 mm, 8.8% thinner than the pre-1947 (pre-DDT) mean for eggs from southern California and Baja California, Mexico. Eleven eggs analyzed for contaminants contained slightly elavated concentrations of DDE (3.3 ppm wet weight) and mercury (0.14 ppm). Productivity of sampled pairs was low but improving. The predictive equations of Wiemeyer *et al*. (1984) were also verified.

H1) Hansen, S.G. and I. Kraul. 1981. Shell thickness and residues of dieldrin, DDE and polychlorinated biphenyl in eggs of Danish Goosanders (*Mergus merganser*). Ornis. Scand. 12: 160-165.

Abstract: Eggs of Danish Goosanders (44) collected from 1973-1976 were examined for shell thickness and residues of the persistent organochlorines: dieldrin, DDE and PCB (polychlorinated biphenyl). A thinning ofcknes of eggs from 1973-1976 compared to eggs from 1870-1933 occurred and the following levels of the quantitated chemicals were found (arithmetic means and ranges in mg kg-1 on wet weight basis): dieldrin 0.12 (not detectable-0.48), DDE 3.9 (0.8-8.6) and PCB 13.5 (4.0-22.2). Both the shell thickness and the residues show a tendency of decrease (1973-1976). No significant correlations between the chemical residues and the shell thickness could be found. It is suggested that the actual registrated amounts of organochlorinated hydrocarbons are too small to affect the shell thickness and by this way of no influence on the size of the breeding population. The possibility of a correlation between these residues and the decreased breeding population observed during the years from 1938 to 1973-1976 is discussed.

H2) Harfenist, A., T. Power, K.L. Clark and D.B. Peakall.1989. A review and evaluation of the amphibian toxicological literature. Tech. Rep. Ser. No. 61. Headquarters Canadian Wildlife Service. pp.222

Summary: This is a comprehensive review of the published literature on levels and effects of environmental contaminants on amphibians up to 1988. Each study is summarised in a series of tables; acute toxicity, other laboratory studies, field studies and residue data. Summaries include species, life stage, contaminant, dose/level, affect.

H3) Harris, M.L., C.A. Bishop and J.P. Bogart. 1993. Northern Leopard Frog (*Rana pipiens*) and Green frog (*Rana clamitans*) population fitness within a pesticide-influenced wetland community. Presented at the Fourteenth Annual Meeting of the Society of Environmental Toxicology and Chemistry (SETAC), held in Houston Texas, 14-18 November 1993. (Poster).

Summary: Growth rates, physical features and EROD induction were measured in caged tadpoles in apple orchards and in laboratory specimens. Guthion, a commonly sprayed pesticide produced significant growth inhibition, smaller snout-vent length and significant EROD induction in the study animals.

H4) Hart, L.E., K.M. Cheng, P.E. Whitehead, R.M. Shah, R.J. Lewis, S.R. Ruschkowski, R.W. Blair, D.C. Bennett, S.M. Bandiera, R.J. Norstrom *et al*. 1991. Dioxin contamination and growth and development in Great Blue Heron embryos. J. Toxicol. Environ. Health 32: 331-44.

Abstract: A Great Blue Heron colony located near a pulp mill in British Columbia failed to fledge young in 1987, with a concurrent sharp increase in polychlorinated dibenzo-p-dioxin (PCDD) and polychlorinated dibenzofuran (PCDF) levels in their eggs. In 1988 we tested the hypothesis that the PCDD and PCDF contamination caused reproductive failure by increasing mortality of the heron embryos in ovo. Pairs of Great Blue Heron eggs were collected from three British Columbia colonies with low, intermediate, and high levels of dioxin contamination: Nicomekl, Vancouver, and Crofton, respectively. One egg of each pair was incubated under laboratory conditions at the University of British Columbia (UBC) while the other egg was analyzed for PCDDs and PCDFs. All incubated eggs were fertile. All eggs from the Nicomekl colony hatched, while 13 of 14 eggs from Vancouver and 12 of 13 eggs from Crofton hatched. Subcutaneous edema was observed in four of 12 chicks from Crofton and two of 13 chicks from Vancouver. No edema was seen in the chicks from Nicomekl. There was a small, but significant, negative regression of plasma calcium concentration, yolk-free body weight, tibia length, wet, dry, and ash weight, beak length, and kidney and stomach weight of the hatched chicks on the tetrachlorodibenzo-p-dioxin (TCDD) level of the paired eggs. Fewer down follicles were present on the heads of TCDD-contaminated chicks. Hence while dioxins did not cause mortality of the heron embryos in ovo, the depression of growth and the presence of edema are suggestive that dioxins at the levels found in the environment have an adverse effect on the development of great blue heron embryos.

H5) Haseltine, S.D., G.H. Heinz, W.L. Reichel and J.F. Moore. 1981. Organochlorine and metal residues in eggs of waterfowl nesting on islands in Lake Michigan off Door County, Wisconsin, USA, 1977-78. Pestic. Monit. J. 15: 90-97.

Abstract: One egg from each of 114 Red-breasted Merganser (*Mergus serrator*) nests in 1977 and 92 nests in 1978 was collected and later analyzed for organochlorines, polybrominated biphenyls (PBB), polychlorinated styrenes (PCS) and metals. One egg was also collected from each of the dabbling duck nests located. Egg (29) were analyzed for organochlorines and metals in 1977; 10 eggs were analyzed in 1978. All merganser eggs contained DDE, polychlorinated biphenyls (PCB) and

dieldrin; all but one egg collected in 1978 contained DDT. DDE and PCB levels had declined since 1975 to a geometric mean of 7.4 ppm DDE and 20 ppm PCB in 1977 and 7.6 ppm DDE and 19 ppm PCB in 1978. Dieldrin residues in eggs had not declined from 1975 levels; the geometric mean was 0.78 ppm in 1977 and 0.76 ppm in 1978. Other organochlorines were present at low levels. Hg residues averaged > 0.50 ppm in merganser eggs and had not declined since 1975. Other metals were present at low levels. Dabbling ducks had lower organochlorine and Hg residues than mergansers; DDE and PCB were the only organochlorines present in the majority of eggs. Geometric means of PCB and DDT in dabbling duck eggs did not exceed 2.0 and 1.0 ppm, respectively. PBB and PCS were detected only in a few merganser eggs at low levels. Eggshell thickness for Red-breasted Merganser eggs averaged 0.359 mm in 1977 and 0.355 mm in 1978, which was 2-3% below pre-1946 thicknesses. Mallard (*Anas platyrhynchos*) eggshell thicknesses averaged 0.331 mm in 1977 and 0.337 mm in 1978.

H6) Hatler, D.F. 1976. The coastal mink on Vancouver Island, British Columbia. Ph.D thesis, University of British Columbia, Canada.

Summary: A study of the natural history of mink on coastal Vancouver Island. The author describes diet, foraging strategies, population characteristics (proportion of males, females and juveniles), the mating season, population densities and home range patterns.

H7) Hayes, J.P. and J.W. Caslick. 1984. Nutrient deposition in cattail stands by communally roosting blackbirds and starlings. Am. Midl. Nat. 112: 320-331.

Abstract: Nutrient additions to five cattail (*Typha* spp.) stands in central New York State (USA) from droppings of roosting Red-winged Blackbirds (*Agelaius phoeniceus*), Common Grackles (*Quiscalus quiscula*), Brown-headed Cowbirds (*Molothrus ater*) and European Starlings (*Sturnus vulgaris*) are reported. Bird numbers were estimated by counting birds as they left their roosts in the morning. Red-winged Blackbirds were mistnetted as they entered a roost and were held until morning in cages lined with aluminum foil of known mass to determine the quantity of droppings excreted per bird-night. These data were used to develop a regression model to predict, from existence energy, the quantity of excreta input per bird per night. The amounts of N, P and K in the excreta were measured for Red-winged Blackbirds fed a simulated Aug. diet and a simulated Oct. diet. Red-winged blackbird droppings averaged 9.2% N, 1.41% P and 1.35% K. Nightly excretions of N, P and K averaged 59, 9.0 and 8.7 mg for a 39.0-g female and 75, 12 and 11 mg for a 56.0-g male. Nutrient loadings from blackbirds and starlings to the most densely populated roosts ranged up to 28, 4.3 and 4.1 kgf N, P and K, respectively. These nutrient loadings are

greater than those coming into the stands via precipitation and may be of similar magnitude to runoff loadings in some systems.

H8) Hebert, C.E., C.A. Bishop and D.V. Weseloh. 1993. Evaluation of wetland biomonitors for the Great Lakes: A review of contaminant levels and effects in five vertebrate classes. Tech. Rep. Ser. No. 182. Can. Wildl. Serv., Ontario Region. pp103.

H9) Heidmann, W.A., A. Buethe, M. Beyerbach, R. Loehmer and S.H. Ruessel. 1989. Chlorinated hydrocarbons of some bird species breeding in the inland of Lower Saxony, West Germany. J. Ornithol. 130: 311-320.

Key Words: Tree sparrow, House Martin, White Stork, Heron, Rook, Mallard, egg, liver, migration, food web

H10) Heinz, G.H., S.D. Haseltine, W.L. Reichel and G.L. Hensler.1983. Relationships of environmental contaminants to reproductive success in Red-breasted Mergansers (*Mergus serrator*) from Lake Michigan. Environmental Bulletin. 32: 211-232.

Abstract: In 1977 and 1978 we studied Red-breasted Mergansers (*Mergus serrator*) nesting on islands in northwestern Lake Michigan to determine whether environmental contaminants were having effects on reproduction. Seventeen contaminants were measured in randomly chosen eggs from 206 nests under study. Using a variety of statistical approaches, we looked for effects of individual contaminants and combination of contaminants on reproductive measurements such as nest desertion, failure of eggs to hatch, death of newly hatched ducklings, percentage hatching success, number of ducklings leaving the nest and eggshell thickness. We also looked for relationships between the levels of some contaminants in blood samples of 39 incubating females and reproductive success. A small degree of eggshell thinning was attributed to DDE and a few other statistical tests were significant, but no contaminant or combination of contaminants we measured seemed to have a pronounced effect on aspects of reproduction we followed.

H11) Heinz, G.H., D.M. Swineford and D.E. Katsma. 1984. High polychlorinated biphenyl residues in birds from the Sheboygan River, Wisconsin (USA). Environ. Monit. Assess. 4: 155-162.

Abstract: Organochlorine residues were measured in the carcasses and, in some cases, brains and stomach contents of four species of birds (Great Blue Heron, Belted Kingfisher, Solitary Sandpiper, Spotted Sandpiper) collected along the Sheboygan River, Wisconsin during 1976-1980. Polychlorinated biphenyls (PCB) were high in all samples and were the

contaminants of greatest concern. Carcass residues ranged from 23-218 ppm PCB on a wet weight basis; these were levels associated with reproductive impairment in laboratory studies with some birds. Food items in the stomachs of collected birds contained 12-58 ppm PCB, indicating a heavy contamination of food sources. The brain of one bird contained 220 ppm PCB, a level that was not in the lethal range but was high. Birds feeding in the contaminated portions of the Sheboygan River may have been harmed by high PCB levels.

H12) Henny, C.J., L.J. Blus, S.V. Gregory and C.J. Stafford. 1981. PCB's and organochlorine pesticides in wild mink and river otters from Oregon. Worldwide Furbearer Conference Proceedings. August 3-11 1980. J.A. Chapman and D. Pursley (eds.) Worldwide Furbearer Conference Inc. pp 1763-1780.

Summary: Mink and river otters were collected during the trapping season in Oregon in 1978 - 1979. Liver samples were analysed for PCBs and organochlorine pesticides. PCB residues were most frequently encountered in both species from the Lower Columbia River. PCB residues measured in mink liver were as high as those reported in liver tissue from experimental female mink fed PCB contaminated feed (0.64 ppm) for 160 days. Furthermore, analysis of fish from the Columbia River revealed PCB levels ranging from 0.24 to 2.8 ppm which is equivalent to or higher than the experimental doses. River otter livers contained even higher levels of PCBs. Population declines of both mink and river otter resulting from PCB contamination may have occurred and may still be occurring along the Lower Columbia River.

H13) Henny, C.J., C. Maser, J.O. Whitaker, Jr. and T.E. Kaiser. 1982. Organochlorine residues in bats after a forest spraying with DDT. Northwest Sci. 56: 329-337.

Abstract: Background levels of DDT and its metabolites (SIGMADDT) were low or not detected in five species (*Myotis evotis, M. volans, M. californicus, Lasionycteris noctivagans, Eptesicus fuscus*) of forest-dwelling bats in northeastern Oregon (USA), i.e., areas not sprayed with DDT in 1974. Other organochlorine pesticides were rarely found and no polychlorinated biphenyls (PCB) were detected at any time. Four of five species of bats showed significant changes in SIGMADDT residues in their carcasses following the single DDT spray application. *M. californicus* and *M. volans* showed the highest postspray carcass residues, 6.90 and 6.21 ppm (wet wt), respectively. *L. noctivagans* and *E. fuscus* also showed an increase; *M. evotis* exhibited no significant postspray change. By 1977 (3 yr postspray), residues declined and only *M. californicus* and *M. volans* contained levels that were significantly above those in the nonspray (control) area. It is uncertain whether elevated residue levels resulting from the DDT spray

project adversely affected any bats. An attempt to relate bat carcass SIGMADDT residues to food habits, through analysis of stomach contents, yielded no clear relationships.

H14) Henny, C.J., L.J. Blus, A.J. Krynitsky and C.M. Bunck. 1984. Current impact of DDE on Black-crowned Night Herons (*Nycticorax nycticorax*) in the Intermountain West (USA). J. Wildl. Manage. 48: 1-13.

Abstract: Organochlorine contamination was studied in eight Black-crowned Night Heron (*Nycticorax nycticorax*) populations nesting in Washington, Oregon and Nevada (USA) in 1978-1980. DDE was detected in 220 eggs sampled; eggshell thickness was negatively correlated with residues of DDE and polychlorinated biphenyls (PCB). Other contaminants were detected in : 35% of the eggs. Except for the two Columbia River colonies in which local DDE contamination was a probable compounding factor, a strong north-south clinal pattern of DDE residues among colonies existed. Southern colonies were most contaminated, and productivity was below population maintenance in one colony (Ruby Lake). At DDE levels in eggs > 8 ppm, clutch size and productivity decreased, and the incidence of cracked eggs increased. No evidence of breeding-ground DDE-DDT contamination was found except along the Columbia River.

H15) Henny, C.J. and R.G. Anthony. 1987. Bald Eagle and Osprey. Pendleton, B. G. 0: 66-82.

Key Words: review, western USA, distribution, reproductive performance, disturbances, habitat deterioration, environmental contaminants, wildlife management, reintroduction, Pacific States, Bald Eagle recovery plan

H16) Henny, C.J., L.J. Blus and R.A. Grove. 1990. Western Grebe, *Aechmophorus occidentalis*, wintering biology and contaminant accumulation in Commencement Bay, Puget Sound, Washington (USA). Can. Field Nat. 104: 460-472.

Abstract: Western Grebes wintering at the head of Commencement Bay (bordering the waterways) accumulated significant amounts of mercury, arsenic, DDE, PCBs, chlordanes, and perhaps cadmium and HCB between 17 October 1985 and 6 February 1986. No change in selenium or lead was detected, but copper declined significantly. Western Grebes were likely to accumulate even higher levels of certain contaminants because they remained in Commencement Bay for an additional three months afer the final collection. Remige moult and bursa length were used to separate five individuals believed to represent one age class, from the remainder of the October collection. These birds, perhaps nonbreeders spending one continuous year in Puget Sound, contained the five higher PCB, five of the eight highest DDE, and two of the three highest mercury concentrations. No

evidence was found in the literature to suggest the contaminant concentrations we reported would adversely impact the Western Grebe population. As expected, lipid content of carcasses increased significantly from October (15.5%) to February (28.8%).

H17) Henny, C.J., L.J. Blus, D.J. Hoffman, R.A. Grove and J.S. Hatfield. 1991. Lead accumulation and Osprey production near a mining site on the Coeur d'Alene River, Idaho (USA). Arch. Environ. Contam. Toxicol. 21: 415-424.

Abstract: Mining and smelting at Kellogg-Smelterville, Idaho, resulted in high concentrations of lead in Coeur d'Alene (CDA) River sediments 15-65 km downstream, where Ospreys (*Pandion haliaetus*) nested. Adult and nestling ospreys living along the CDA River had significantly higher lead concentrations than those at Lake Coeur d'Alene (intermediate area) or Pend Oreille and Flathead Lakes (reference areas). Lead concentrations in fish collected from the sandy areas paralleled those found in Ospreys. Inhibition of blood delta-aminolevulinic acid dehydratase (ALAD) activity and elevation of protoporphyrin concentration provided evidence of lead exposure. In adult Ospreys, ALAD activity was negatively correlated with lead in blood (r = -0.57), whereas protoporphyrin was positively correlated with lead in blood (r = +0.40). Neither hemoglobin nor hematocrit was adversely affected by the relatively modest lead concentrations found in the blood. Pronounced accumulation of lead by adults or young could ultimately result in behavioral abnormalities or death, both of which would reduce productivity of the nesting osprey population. We did not observe death related to lead, behavioral abnormalities, or reduced productivity during this 1986-87 study. Despite some lead-induced biochemical changes in blood parameters, Ospreys produced young at nearly identical rates in the three study areas; these rates were among the highest ever reported in the western United States. Post-fledging survival of Ospreys exposed to lead early in life remains an unknown. Lead does not biomagnify in the food chain as do organochlorine pesticides and mercury and several Osprey behavior traits reduce the potential for the species to accumulate critical levels of lead. Swans, which feed at a lower trophic level, continue to die from environmental lead in the region.

H18) Henshel, D.S., K.M. Cheng, R. Norstrom, P. Whitehead and J.D. Steeves. 1991. Morphometric and histologic changes in brains of Great Blue Heron hatchlings exposed to PCDDs preliminary analyses. W.G. Landis, J. S. Hughes and M. A. Lewis (eds.) 0: 262-277.

Key Words: *Ardea herodias*, egg contamination, polychlorinated benzo-p-dioxins, polychlorinated dibenzofurans, polychlorinated biphenyls

H19) Herold, H. 1990. Freshwater fishing source of food and contributor to a healthy environment. Z. Binnenfisch 37: 301-305.

Key Words: fish, carp, trout, frog, turtle, larvae, Osprey, Marsh Harrier, Kite, Bittern, industrial economics, eutrophication consequence, nitrogen, phosphorus, hazardous waste, toxicity, fish mortality, pond pisciculture, river sewage, purification, sedimentation, organic substance, clay, iron, heavy metal, polychlorinated biphenyl

H20) Hienz, R.D. and M.B. Sachs. 1987. Effects of noise on pure-tone thresholds in blackbirds (*Agelaius phoeniceus* and *Molothrus ater*) and pigeons (*Columba livia*). J. Comp. Psychol. 101: 16-24.

Abstract: Blackbirds and pigeons were trained to detect tones in quiet and in broadband noise by using positive-reinforcement techniques. In Experiment 1, thresholds in noise were obtained in blackbirds as a function of both tone frequency and noise intensity for a pulsed noise masker (noise gated on and off with tone). For blackbirds, critical ratios (the ratio of the power of the just-detectable tone in noise to the power of the noise masker) obtained in pulsed noise showed no consistent relation to tone frequency. For pigeons, on the other hand, critical ratios obtained in continuous noise increased by about 3 dB/octave across their range of hearing, being similar to known critical ratio functions for cats and humans. In Experiment 2, critical ratios in blackbirds obtained with both continuous noise and pulsed noise were compared. Blackbird critical ratios were more stable in continuous noise and averaged 4 dB lower than critical ratios in pulsed noise. The blackbird critical ratio function obtained with continuous noise was similar to the known critical ratio function of another avian species, the parakeet. Thus, small birds appear to have atypical critical ratio functions, compared with pigeons and other vertebrates.

H21) Hill, E.F. and H.C. Murray. 1987. Seasonal variation in diagnostic enzymes and biochemical constituents of captive Northern Bobwhites and passerines. Comp. Biochem. Physiol. B. Comp. Biochem. 87: 933-940.

Key Words: *Colinus virginianus, Sturnus vulgaris, Agelaius phoeniceus, Quiscalus quiscula*, hematologic parameters, dehydrogenases, aminotransferases, creatine, kinase, acetylcholinesterase, toxicology, reproduction

H22) Hochstein, J.R., R.J. Aulerich and S.J. Bursian. 1988. Acute toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin to mink. Arch. Environ. Contam. Toxicol. 17:33-37.

Summary: The effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) on adult male mink were assessed. TCDD was administered as a single oral dose (0, 2.5, 5.0 and 7.5 ug/kg body weight) and the mink were observed for 28 days. There was a dose-dependent decrease in feed consumption with corresponding weight loss. Gross necropsy revealed mottling and discoloration of the liver, spleen and kidneys and at higher doses, brain, kidney, heart, thyroid and adrenal glands were enlarged. The results indicate that mink are among the most sensitive species to TCDD and that they can serve as a valuable model to study the impact of environmental dioxins on carnivorous mammalian species

H23) Hoffman, D.J., G.J. Smith and B.A. Rattner. 1993. Biomarkers of contaminant exposure in Common Terns and Black-crowned Night Herons in the Great Lakes. Environ. Toxicol. Chem. 12: 1095-1103.

Abstract: Morphological and biochemical indexes of contaminant exposure were examined in hatching Common Terns (*Sterna hirundo*) and Black-crowned Night Herons (*Nycticorax nycticorax*) from industrialized and non-industrialized locations in the Great Lakes. In 1984, naturally incubated, pipping Common Tern and Black-crowned Night Heron embryos collected from industrialized locations exhibited smaller femur-length-to-body-weight ratios, elevated hepatic microsomal aryl hydrocarbon hydroxylase (AHH) activities, and lower hepatic DNA concentrations ($P < 0.05$). In addition, a high incidence of subcutaneous edema was noted in pipping herons ($P < 0.01$). In 1985, reduced hatching success was observed for laboratory-incubated Common Tern eggs collected from the industrialized sites, compared to non-industrialized sites ($P < 0.01$). Day-old hatchlings exhibited reduced femur-length-to-body-weight ratio, developmental anomalies, and elevated hepatic AHH activity ($P < 0.05$). For hatching Common Terns studied in 1984 and 1985, femur-length-to-body-weight ratio was inversely related to AHH activity ($r = -0.67$, P : 0.05) and inversely related to log-transformed PCB concentrations ($r = -0.70$, P : 0.05) of unincubated eggs from the same colony. The activity of AHH in hatching terns was also directly related ($r = 0.71$, P : 0.05) to log-transformed PCB concentrations in unincubated eggs. Other examined contaminants, including DDE, other organochlorine pesticides, and mercury, were not directly related to these effects.

H24) Hoffman, D.J., B.A. Rattner, C.M. Bunck, A. Krynitsky, H.M. Ohlendorf and R.W. Lowe. 1986. Association between PCBs and lower embryonic weight in Black-crowned Night Herons in San Francisco Bay. J. Toxicol. Environ. Health. 19: 383-391.

H25) Holler, N.R. and E.W. Schafer, Jr. 1982. Potential secondary hazards of avitrol baits to Sharp-shinned Hawks (*Accipiter striatus*) and American Kestrels (*Falco sparverius*). J. Wildl. Manage. 46: 457-462.

Key Words: heep, copyright: biol abs., *Peromyscus* sp, *Coturnix coturnix, Agelaius phoeniceus*, horse meat, 4 amino pyridine, crop protection, acute oral toxicity, predation, mortality, behavior

H26) Hussell, D.J.T. and T.E. Quinney. 1986. Food abundance and clutch size of Tree Swallows (*Tachycineta bicolor*). Ibis 129:243-258.

J1) Jensen, S., J.E. Kihlstrom, M. Olsson, C. Lundberg and J. Orberg. 1977. Effects of PCB and DDT on mink (*Mustela vision*) during the reproductive season. Ambio. 6: 239.

J2) Jensen, W.I. and J.P. Allen. 1981. Naturally occurring and experimentally induced castor bean (*Ricinus communis*) poisoning in ducks (*Anas platyrhynchos*). Avian. Dis. 25: 184-194.

Abstract: Castor bean (*Ricinus communis*) poisoning caused the death of several thousand ducks in the Texas (USA) panhandle in the fall and winter months, 1969-1971. Signs of intoxication resembled those of botulism, except for mucoid, blood-tinged excreta. The most common lesions were severe fatty change in the liver, widely distributed internal petechial hemorrhages or ecchymoses and catarrhal enteritis. Nearly intact castor beans were found in the stomach of one duck during field necropsy. Fragments of seed coat resembling castor bean were found in the stomachs of 10 of 14 ducks examined in the laboratory. Clinical signs and postmortem lesions observed in wild ducks were induced experimentally in mallards (*A. platyrhynchos*) by force-feeding intact castor beans. Toxicity titrations were erractic but the LD50 appeared to be between 3-4 seeds. Mouse toxicity test, used to detect Clostridium botulinum toxin the blood serum of intoxicated ducks, was negative in every case. Hemagglutination and precipitin tests failed to detect castor bean in extracts of excreta or intestinal contents of experimentally intoxicated ducks.

K1) Kalinowski, S.A., R.C. Martin and L.D. Cooper. 1982. Grays Harbor and Chehalis River Improvements to Navigation Environmental Studies. Wildlife Studies at Proposed Disposal Sites in Grays Harbor, Washington. Govt. Reports Announcements & Index 15: TD3:

Abstract: A 15-month study to inventory wildlife resources on four proposed terrestrial dredged material disposal sties and one intertidal disposal site was initiated. Major emphasis was placed on inventorying birds and mammals to assess the value of these areas to wildlife. Amphibians, reptiles, and plants received less emphasis. Seven species of amphibians and three species of reptiles were captured on fill sites 16, 17, and 18 during this study. The Spotted Frog and Dunn's Salamander have been reported only rarely in Grays Harbor County. Most individuals of these two groups of animals would be killed by disposal of dredge materials on these sites. At

least 46 species of waterbirds use the main channel and sloughs proximal to the Cosmopolis Reach of the Chehalis River. Mallards and scaup were the most common waterfowl; highest numbers were seen during winter. Areas preferred by waterfowl were river marshes and upper reaches of sloughs. Large numbers (more than 200) of Western Grebes, gulls and diving waterfowl used the Cosmopolis Reach during all seasons. During dredging, direct impacts to waterfowl and bald eagles would be negligible; most observations were 5 kms or more upstream from proposed dredging activity. Impacts (i.e. decreased hunting success due to suspended particulates) to diving birds would be minimized by dredging between August and October, when numbers of birds are lowest. Dredging during ebb tides would result in sediments disturbed by dredging flowing into the harbor.

K2) Kennedy, S.W., A. Lorenzen, C.A. James and R.J. Norstrom. 1991. Ethoxyresorufin-o-deethylase erod and porphyria induction in chicken embryo hepatocyte cultures a new bioassay of PCB PCDD and related chemical contamination in wildlife. Eleventh International Symposium on Chlorinated Dioxins and Related Compounds: 23-27.

Key Words: *Larus argentatus, Ardea herodias*, water, pollution effects, chicken embryo, hepatocytes bioaccumulation, halogenated aromatic hydrocarbons, polychlorinated biphenyls, UK

K3) Klaesson, P. 1989. The ocean's fishing birds. Larsson, E. Naturskyddsforeningens Arsbok 0: 68-75.

Key Words: Osprey, Guillemot, Least Tern, Gannet, Shag, fish oil, environmental toxicology

K4) Knight, R.L., P.J. Randolph, G.T. Allen, L.S. Young and R.J. Wigen. 1990. Diets of nesting Bald Eagles, *Haliaeetus leucocephalus*, in western Washington (USA). Can. Field Nat. 104: 545-551.

Abstract: We analyzed food remains collected at Bald Eagle (*Haliaeetus leucocephalus*) nests from three regions in Washington: San Juan Islands, Olympic Peninsula, and Puget Sound. Of 1198 items collected, 53% were birds, 34% were fish, 9% were mammals, and 4% were invertebrates. Fish were more abundant at nests in the San Juan Islands and Puget Sound than at nests on the Olympic Peninsula. Overall, mammals were not important; however, the Old World Rabbit (*Oryctolagus cuniculus*) was a common food species for eagles in the San Juan Islands. Forty-two prey items were

identified during 212 hours of direct observations at three eagles nests. This allowed a comparison of prey delivered to nests with prey found beneath these nests and indicated that birds were over-represented in prey collections beneath nests and fish were over-represented in prey carried to nests. Two important Bald Eagle food items, the Glaucous-winged Gull (*Larus glaucescens*) and Old World Rabbits were analyzed for DDE and PCBs; the former showed detectable levels of both.

K5) Koonz, W.H. and P.W. Rakowski. 1985. Status of colonial waterbirds nesting in southern Manitoba, Canada. Can. Field Nat. 99: 19-29.

Key Words: *Pelecanus erythrorhynchos, Phalacrocorax auritus, Larus delawarensis, Podiceps nigricollis, Aechmophorus occidentalis, Sterna hirundo, Sterna caspia, Ardea herodias, Larus pipixcan, Larus argentatus, Sterna forsteri, Nycticorax nycticorax*, human abundance, history, breeding population decline, management education, protection, pesticide threat

K6) Koster, M.D., D.V. Weseloh and P. Ng. 1992. Pesticide exposure of birds breeding in vegetable crops in Ontario, Canada. The British Crop Protection Council. Brighton Crop Protection Conference: Pests And Diseases, Vols 0: 817-822.

Key Words: biosis, copyright: biol abs. RRM, *Hirundo rustica, Agelaius phoeniceus,* DDE, cholinesterase activity

K7) Kozie, K.D. and R.K. Anderson. 1991. Productivity, diet and environmental contaminants in Bald Eagles nesting near the Wisconsin shoreline (USA) of Lake Superior. Archives of Environmental Contamination and Toxicology. 20(1): 41-48.

Abstract: Bald Eagles (*Haliaeetus leucocephalus*) nesting in the Apostle Islands National Lakeshore and along the Wisconsin shoreline of Lake Superior produced an average of 0.8 young/occupied nest and had an average nest success of 57% during 1983-1988, compared to 1.3 young/occupied nest and 77% nest success in inland Wisconsin. Contaminant levels in nesting Bald Eagle carcasses collected from nests near Lake Superior were higher than those collected inland, suggesting local contamination. Prey remains collected at nests consisted of fish (50%); birds, primarily Herring Gulls (*Larus argenntatus*) (48.4%); and mammals (1.2%). Organochlorine and polychlorinated biphenyl (PCB) residues were present at low levels (DDE hivin x = 0.07 mu-g/g wet wt, PCB: hivin x = 0.21 mu-g/g wet wt) in fish. Herring Gulls contained higher concentrations (DDE: hivin x = 5.5 mu-g/g wet wt, PCB: hivin x = 16.95 mu-g/g wet wt) and appear to be the major source of elevated contaminant levels in Bald Eagles nesting near Lake Superior.

K8) Kraus, M.L. 1989. Bioaccumulation of heavy metals in pre-fledgling Tree Swallows (*Tachycineta bicolor*). Bull. Environ. Contam. Toxicol. 43: 407-414.

Keywords: industrial waste, pollution, ecology, environmental surveillance

K9) Kuroda, N. 1985. Lake Tega the former home of waterfowl on opening of Yamashina Institute at new site, Abiko Chiba Prefecture, Japan. J. Yamashina Inst. Ornithol. 17: 3-8.

Keywords: *Aythya ferina,* Snow Goose, Canada Goose, Canvasback duck, Long-tailed Duck Ruddy, Shelduck, Coot, Moorhen, Reed Bunting, Green Pheasant, Ural Owl, rice cultivation, conservation, water pollution

L1) Lacki, M.J., J.W. Hummer and H.J. Webster. 1992. Mine-drainage treatment wetland as habitat for herptofaunal wildlife. Environ. Manage. 16(4): 513-520.

Summary: Land reclamation techniques that incorporate habitat features for herptofaunal wildlife have received little attention. We assessed the suitability of a wetland, constructed for the treatment of mine-water drainage, for supporting herptofaunal wildlife from 1988 through 1990 using diurnal and nocturnal surveys. Natural wetlands within the watershed were also monitored for comparison. The treatment wetland supported the greatest abundance and species richness of herptofauna among the sites surveyed. Abundance was a function of the frog density, particularly Green Frogs (*Rana clamitans*) and the Pickerel Frog (*R. palustris*), while species richness was due to the number of snake species found. Whole-body assays of Green Frog and Bullfrog (*R. catesbeiana*) tissues showed no differences among sites in uptake of iron, aluminum and zinc; manganese levels in samples from the treatment wetland were significantly lower than those from natural wetlands. These results suggest that wetlands established for water quality improvement can provide habitat for reptiles and amphibians, with the species composition dependent on the construction design, the proximity to source populations, and the degree of acidity and heavy-metal concentrations in the drainage waters.

L2) Lacombe, D., A. Cyr and J. M. Bergeron. 1986. Effects of the chemosterilant ornitrol on the nesting success of Red-winged Blackbirds. J. Appl. Ecol. 23: 773-780.

Keywords: *Agelaius phoeniceus*, pesticide, vertebrate, pest, crop, industry

L3) Lacombe, D., P. Matton and A. Cyr. 1987. Effect of ornitrol on spermatogenesis in Red-winged Blackbirds. J. Wildl. Manage. 51: 596-601.

Keywords: *Agelaius phoeniceus*, testicular weight, germinal epithelium, ingestion, chemosterilant, photostimulation

L4) Landrum, C.L., T.L. Ashwood and D.K. Cox. 1993. Belted Kingfishers as ecological monitors of contamination: A review. Govt. Reports Announcements & Index 24: TD3:

Abstract: Aquatic systems serve as transport pathways and reservoirs for most of the contaminants known to be present on the Oak Ridge Reservation (ORR). Organisms that live in aquatic systems accumulate some of these contaminants from their food and directly from the water or sediment. A wide array of terrestrial organisms feeds on aquatic organisms and may accumulate contaminants from aquatic prey. The Belted Kingfisher (*Ceryle alcyon*) is a piscivorous and territorial avian species that may be a suitable monitor of contaminant accumulation at specific sites on the ORR. A kingfisher collected on White Oak Lake in 1991 had a (sup 137)Cs concentration of 568 pCi/g in muscle tissue, which exceeds levels found in any other waterfowl collected from the lake. An investigation into the efficacy of using the kingfisher as an ecological indicator of aquatic contaminants on the ORR was initiated in late August 1992. The primary objective of this study was to acquire information concerning the ecology of the kingfisher to determine how the species could be used within the framework of the Biological Monitoring and Abatement Program at Oak Ridge National Laboratory (ORNL). A second important objective of the study was to examine the possible somatic and reproductive effects of polychlorinated biphenyls (PCBs), Hg, and various radioactive contaminants on piscivorous birds by reviewing pollution ecology studies conducted on those species. Environmental Sciences Division Publication No. 4017. Sponsored by Department of Energy, Washington, DC.

L5) Leighton, F.A. 1988. Some observations of diseases occurring in Saskatchewan, Canada wildlife. Blue Jay 46: 121-125.

Keywords: House Sparrow, gull, Great Blue Heron, goose, salmonellosis, starvation, pesticide poisoning, necrotizing enteritis

L6) Leonard, M.L. and M.B. Fenton.1983. Habitat use by Spotted Bats (*Euderma maculatum*, Chiroptera: Vespertilionidae): roosting and foraging behaviour. Can. J. Zool. 61: 1487-1491.

L7) Levenson, H. and J.R. Koplin. 1984. Effects of human activity on productivity of nesting Ospreys (*Pandion haliaetus*). J. Wildl. Manage. 48: 1374-1377.

Keywords: chlorinated hydrocarbon, fledgling

L8) Littrell, E.E. 1986. Shell thickness and organochlorine pesticides in Osprey (*Pandion haliaetus*) eggs from Eagle Lake, California, USA. Calif. Fish Game 72: 182-185.

Keywords: polychlorinated biphenyl, chlordane, heptachlor, BHC, DDT, insecticide, nontarget organism

L9) Louis, V.L. and J.C. Barlow. 1993. The reproductive success of Tree Swallows nesting near experimentally acidified lakes in northwestern Ontario. Can. J. Zool. 71: 1090-1097.

Abstract: We examined a number of reproductive parameters of Tree Swallows (*Tachycineta bicolor*) breeding near experimentally acidified lakes in northwestern Ontario. We found that near acidified lakes, eggs were smaller in certain dimensions, hatching success was lower (and by definition fewer nestlings fledged per nest box), certain nestling body characters were smaller 4 days posthatch, nestling wing length was shorter near time of fledging, and growth functions were different from those near unmanipulated reference lakes. These results are consistent with earlier findings that calcium-rich food items needed for egg production by laying females and growth of nestlings are more scarce at acidified lakes than at nonacidic reference lakes, and that potentially toxic metals accumulate to higher concentrations both in the chironomids that swallows consume and in nestling swallows at acidified lakes. Our results clearly show that even nonaquatic organisms are affected by acidification of freshwater ecosystems.

L10) Lumsden, H.G.1986. Choice of nest boxes by Tree Swallows, *Tachycineta bicolor*, House Wrens, *Troglodytes aedon*, Eastern Bluebirds, *Sialia sialis*, and European Starlings, *Sturmus vulgaris*. Can. Field Natur. 100(3): 343-349.

M1) Machmer, M. and R.C. Ydenberg. 1990. Weather and foraging energetics in Osprey. Can. J. Zool. 68: 40-43.

M2) Machmer, M. and C. Steeger. 1992. PCDDs and PCDFs in Osprey foraging in the Fraser, Thompson and Columbia River systems. 25pp. Canadian Wildlife Service, Delta, B.C.

M3) MacIntosh, D.L., G.W. Suter and F.O. Hoffman. 1993. Model of the PCB and mercury exposure of mink and Great Blue Heron inhabiting the off-site environment downstream from the US Department of Energy Oak Ridge Reservation. Environmental Restoration Program. Govt. Reports Announcements & Index 08: TD3:

Abstract: This report presents a pair of wildlife exposure models developed for use in investigating the risks to wildlife of releases of mercury and PCBS. The species modeled are the Great Blue Heron and mink. The models may be used to estimate the exposure experienced by mink and herons, to help establish remedial action goals and to identify research needs. Because mercury and PCBs bioaccumulate through dietary uptake, the models simulate the food webs supporting the two species. Sources of contaminants include surface water, sediment, sediment pore water, and soil. The model are stochastic equilibrium models. Two types of variance in the input parameters are distinguished: stochastic variance among individual mink and herons and ignorance concerning true parameter values. The variance in the output due to stochastic parameters indicates the expected variance among the receptors. The variance due to ignorance indicates the extent to which the model outputs could be unpaved by additional sampling and measurement. The results of the models were compared to concentrations measured in Great Blue Heron eggs and nestlings from colonies on the Clinch and Tennessee Rivers. The predicted concentrations agreed well with the measured concentrations. In addition, the variances in measured values among individuals was approximately equal to the total stochastic variance predicted by the models. Environmental Sciences Division Publication 3934. Sponsored by Department of Energy, Washington, DC.

M4) Mallory, M.L., P.J. Weatherhead, D.K. McNicol and M.E. Wayland. 1993. Nest site selection by Common Goldeneyes in response to habitat features influenced by acid precipitation. Ornis. Scand. 24: 59-64.

Abstract: The choice of nest sites is an important component of breeding behavior because it can influence reproductive success. We examined the effects of habitat quality on nest site selection by Common Goldeneyes (*Bucephala clangula*) in an acid-stressed area near Sudbury, Ontario. Females used fishless wetlands more often prior to incubation, and nested more frequently in nest boxes erected on these wetlands. Within fishless wetlands, female goldeneyes preferred boxes on wetlands that were more isolated from other waterbodies. We conclude that goldeneyes selected high quality, fishless wetlands because these habitats provide an abundant supply of invertebrate foods needed for reproduction.

M5) Mason, J.R. 1989. Avoidance of methiocarb-poisoned apples by Red-winged Blackbirds. J. Wildl. Manage. 53: 836-840.

Keywords: *Agelaius phoeniceus*, bird repellant, methyl anthranilate, calcium carbonate, learning, chemical cue, crop protection

M6) Mason, J.R., A.H. Arzt and R.F. Reidinger. 1985. Avfail in color avoidance learning by Starlings (*Sturnus vulgaris*) and Red-winged Blackbirds (*Agelaius phoeniceus*). J. Comp. Psychol. 99: 403-10.

Abstract: Certain unconditioned stimuli (UCS) in flavor avoidance learning sometimes become ineffective after pairings with relatively stronger UCS. This failure of avoidance learning (avfail) has been demonstrated only with rodents. The present investigations were conducted to determine whether avfail might also occur with avian species, the food selection of which is guided primarily by visual cues. In Experiment 1, Starlings were given pairings of methiocarb (a relatively weak UCS) and LiCl (a relatively strong UCS). In Experiment 2, Red-winged Blackbirds were given pairings of two concentrations of methiocarb (relatively weak and relatively strong UCS, respectively). Pairings were followed by a conditioning trial (UCS gavage in the presence of a color cue) and two-choice tests. Conditioned avoidance was always observed except when methiocarb preceded LiCl and when the low preceded the high methiocarb dose in preconditioning pairings. Experiment 3 demonstrated that UCS habituation could not account for the results of Experiments 1 and 2. The data reflect avfail in the visual modality, and a biological implication of the results is that birds may not learn strong avoidance of aposematic prey containing varied levels of toxicant.

M7) Mason, C.F. and S.M. MacDonald. 1986. Levels of cadmium, mercury and lead in Otter and Mink feces from the UK. Sci. Tot. Environ. 53: 139-146.

Keywords: *Lutra lutra, Mustela vison*, fish, prey, Britain, Greece, fecal analysis, residue study

M8) Mason, J.R. and W.R. Bonwell. 1993. Evaluation of turpentine as a bird-repellent seed treatment. Crop. Prot. 12: 453-457.

Abstract: These experiments explored the repellency of turpentine to Brown-headed Cowbirds (*Molothrus ater*), Common Grackles (*Quisculus quiscula*) and Red-winged Blackbirds (*Agelaius phoeniceus*). Phytotoxicity of turpentine to treated seeds also was assessed. Concentrations as low as 0.13% (w/w) were repellent to cowbirds in both one-cup and two-cup tests. However, grackles and red-wings showed no avoidance of turpentine concentrations as high as 5.0%. No concentration was phytotoxic. Although turpentine apparently does not interfere with seed germination, it has limited value as a bird-repellent seed treatment.

M9) Mason, C.F. and A.B. Madsen. 1993. Organochlorine pesticide residues and PCBs in Danish Otters (*Lutra lutra*). Sci. Total Environ. 133(1-2):73-81

Abstract: Tissues (71 liver, 2 muscle) of 73 otters found dead in Denmark between 1980 and 1990 were analyzed for organochlorine pesticide residues and PCBs. Geometric means of contaminant concentrations were generally low, but some Otters had PCB concentrations considered to be of concern; a greater proportion of these came from isolated populations away from the main population centre in Limfjord. Animals dying of unknown causes had greater concentrations of PCBs than those dying by drowning or in traffic accidents. Adults had significantly higher concentrations of PCBs. Contaminant concentrations were strongly intercorrelated. Concentrations of DDE and PCBs declined significantly during the study period. A sample of Otter spraints (faeces) collected in 1990 had low mean concentrations of contaminants. It is concluded that current concentrations of organochlorine pesticide residues and PCBs are unlikely to pose a threat to Otter populations.

M10) Mason, C.F. and S.M. Macdonald. 1993a. Impact of organochlorine pesticide residues and PCBs on Otters (*Lutra lutra*): a study from western Britain. Sci. Total Environ. 138(1-3):127-45

Abstract: A study of Otter (*Lutra lutra*) populations and levels of organochlorine (OC) pesticide residues and PCBs in Otter droppings (spraints) was made on eight stretches of river in three catchments in Wales and West Midland England. Population and contaminant levels were compared against target values. The Otter populations (as measured by an index) remained stable on one stretch over 11 years, while they increased rapidly to equilibrium on four other stretches. The three lower stretches of rivers showed more erratic trends and on only one stretch did the index exceed, occasionally, the target value. Marking intensity at spraint sites was also lower at the three lowland sites. Concentrations of dieldrin, DDE and PCBs were significantly greater in spraint samples from the three lowland stretches. Over 50% of samples from the three lowland stretches had OC concentrations above the maximum allowable concentration, whereas most samples from the upland stretches had concentrations below the 'no effects level'. It is suggested that the colonization, by otters, of their former lowland range is inhibited by OC contamination of their food chain but, if contaminant levels can be reduced, spread will occur rapidly.

M11) Mason, C.F. and S.M. MacDonald. 1993b. Impact of organochlorine pesticide residues and PCBs on Otters (*Lutra lutra*) in eastern England. Sci. Total Environ. 138 (1-3):147-60

Abstract: A study of Otter (*Lutra lutra*) populations and levels of organochlorine (OC) pesticide residues and PCBs in otter faeces (spraints) was made on rivers in East Anglia, England. Population and contaminant levels are compared against target values. It is thought that the native otter population was almost extirpated during the study period. The current population must derive largely, if not entirely, from captive-bred animals introduced since 1983. Its range has expanded little and population levels, measured as an index, were generally low. Concentrations of OC pesticides and PCBs were similar to those of lowland stretches of western rivers;

however, samples had a smaller proportion of dieldrin and a greater proportion of PCBs. Overall 44% of samples had concentrations of contaminants exceeding the 'level of concern'. It is considered that contamination, especially by PCBs, remains a factor influencing otter populations, which may not be viable in East Anglia without repeated releases of captive-bred animals.

M12) Massi, A., C. Fossi, L. Lari, C. Leonzio, S. Casini and G. Ferro. 1991. Effect of the use of organophosphorus insecticides on the level of blood esterases in Swallow (*Hirundo rustica*). Riv. Ital. Ornitol. 61: 101-106.

Abstract: In July 1989 a Swallow population nesting in several cowsheds in Piedmont (northern Italy) was examined in order to assess the effect of organophosphorus insecticides on the levels of serum B-esterases, carboxylesesterase (Ce) and butyrylcholinesterase (BChe). Two sets of blood samples were taken the day before and the day after the cowshed treatment with commercial insecticides containing azametiphos, an organophosphorus compound. The spectrophotometrical analysis showed a decrease of 58% and 36% for Ce and BChe respectively. In birds these interactions could cause neurological abnormalities and other sublethal effects, due to lacking of A-esterases involved in organophosphorus compounds detoxification. The results also showed the reliability in the field of this method, which does not involve the suppression of birds, for the determination of environmental stress due to the presence of esterase inhibitors.

M13) Mautino, M. and J.U. Bell. 1986. Experimental lead toxicity in the Ring-necked Duck. Environ. Res. 41: 538-45.

Abstract: Ring-necked Ducks (*Aythya collaris*) were administered a single lead shot by gastric intubation. At weekly intervals over a 7-week period, the birds were weighed and blood samples obtained for measurement of hematocrit, free erythrocyte protoporphyrin (FEP), blood lead and delta-aminolevulinic acid dehydratase (delta-ALAD) activity. The birds were fluoroscoped weekly to ensure that the pellets had been retained. Blood lead concentrations peaked one week after dosing at a concentration of 7.75 micrograms/ml and then fell to control levels by Week 4. FEP concentrations in the treated ducks also peaked one week after dosing at levels which were roughly 1200% of control concentrations. The return of FEP concentrations to normal paralleled blood lead. ALAD activity was inhibited by approximately 85% by Week 1; however, there was a gradual but steady recovery of ALAD activity through Week 7. Four of the treated birds died within 2 to 3 weeks of lead administration. Physical signs of lead toxicity were maximal 7 to 10 days postdosing and included ataxia, loss of body weight, impaction of the upper gastrointestinal tract, and bile green diarrhea.

In surviving birds, overt signs of toxicity declined with time and all birds appeared normal by Week 7.

M14) May, R.M. 1983. Reproductive success of eagles and organochlorine insecticides. Nature 301:

M15) McKelvey, R. and G.E.J. Smith. 1990. The distribution of waterfowl banded or returned in British Columbia, 1951-1985. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia. Tech. Rept. Ser. No. 79.

M16) Mel'nikov, N. N. 1992. Chlorocarbons and some of their derivatives in the environment. Agrokhimiya 0: 112-119.

Keywords: review, human, plants, animals, Pike, Guillemot, Cormorant, Eider, Osprey, Marsh Harrier, White-tailed Eagle, Gray Seal, Ring Seal, Greenland Seal, Caspian Seal, Guinea-pig, Mouse, Rat, Rabbit, Dog, Hamster, Monkey, acute toxicity, contamination, pollution, adipose tissue, DDT, DDE, DDD, hexachlorobenzene, polychlorodiphenyls, polychlorodibenzofurans, polychlorodibenzodioxins

M17) Melquist, W.E. and M.G. Hornocker. 1983. Ecology of River Otters in west central Idaho. Wildl. Monogr. 83: 1-60.

Summary: River Otter ecology was studied between June 1976 and May 1981. Estimate of population size and density are presented as well as reproductive parameters such as gestation and timing of births, foraging techniques and diet based on scat analysis. Travel routes and dispersal patterns were influenced by food. Otters preferred valleys and stream-associated habitats to mountains, lakes, reservoirs or ponds. Shelter was also a factor in habitat selection. Home ranges overlapped extensively and varied considerably in size from 8-78 km in length. The basic social group and behaviour are also discussed.

M18) Melquist, W.E. and A.E. Dronkert. 1987. River Otter. In*:* M. Novak, J.A. Baker, M.E. Obbard and B. Malloch (eds.). Wild Furbearer Management in North America. Ministry of Natural Resources, Ontario. pp. 627-641.

Summary: A comprehensive review of the natural history of River Otters and a detailed discussion of management issues.

M19) Meyers, S.M., J.L. Cummings and R.S. Bennett. 1990. Effects of methyl parathion on Red-winged Blackbird (*Agelaius phoeniceus*) incubation behavior and nesting success. Environ. Toxicol. Chem. 9: 807-814.

Abstract: Free-living female Red-winged Blackbirds (*Agelaius phoeniceus*) were captured on their nests and given oral doses of 0, 2.37 or 4.21 mg/kg methyl parathion in a propylene glycol carrier during incubation. Birds were

released immediately after dosing and observed for 5 h to document behavioral effects, amount of time spent off the nest after dosing and time spent incubating. Each nest was monitored until nestlings fledged or until all nestlings died or disappeared. For each nest, the time of abandonment, hatching success and fledging success were determined. In addition, prefledging weights were obtained for all nestlings in nests at 8 d after hatch. Although methyl parathion caused ataxia. Lacrimation and lethargy and significantly depressed cholinesterase activity (> 35%) at 4.21 mg/kg, there were no apparent adverse effects on reproduction. Females receiving 4.21 mg/kg methyl parathion were able to return to their nests, resume incbation, successfully hatch their clutch and rear their young. Nestlings of poisoned females did not have significantly different body weights at 8 compared to controls, indicating that methyl parathion did not disrupt the females' ability to forage and deliver adequate food to nestlings. Band returns from the following year indicated that treatment birds returned and nested in nearly the same proportion as did controls and other red-winged blackbirds occupying the ponds. Ther was no induction that a single oral dose of methyl paration (2.37 or 4.21 mg/kg) decreased over-winter survival.

M20) Meyers, S.M., B.T. Marden, R.S. Bennett and R. Bentley. 1992. Comparative response of nestling European Starlings and Red-winged Blackbirds to an oral administration of either dimethoate or chlorpyrifos. J. Wildl. Dis. 28: 400-6.

Abstract: Red-winged Blackbird (*Agelaius phoeniceus*; blackbird) and European Starling (*Sturnus vulgaris*; starling) nestlings were dosed with either 2.0 mg/kg body mass chlorpyrifos, 50.0 mg/kg body mass dimethoate, or a propylene glycol carrier in situ. Four growth measurements (body mass, culmen, tarsus, wing) were recorded from nestlings to determine if these organophosphorus compounds caused perturbations in development at sublethal concentrations. Blackbird nestlings were more sensitive to chlorpyrifos than starling nestlings were more sensitive to dimethoate than blackbird nestlings. This was in contrast to reported adult LD50 values where the reverse was true. Blackbird nestlings were more tolerant of a substantially higher concentration of dimethoate than the adult LD50. The sensitivity of starling nestlings to dimethoate was similar to adults. In contrast, juveniles of both species were more sensitive to chlorpyrifos than adults. After the initial 24 hr, surviving nestlings dosed with either chemical recovered and continued their development. Exposure to dimethoate caused significant depression in starling body mass during the initial 24 hr period. Survivors obtain body mass equal to controls within 48 hr post dosing. The research presented here demonstrates that the simple supposition that passerine nestlings are typically more sensitive to toxins than adults does

not always hold true. It also indicates that sensitivity relationships among adults do not necessarily apply to their nestlings.

M21) Meyers, S.M., B.T. Marden, R.S. Bennett and R. Bentley. 1993. Comparative response of nestling European Starlings and Red-Winged Blackbirds to an oral administration of either Dimethoate or Chlorpyrifos. Govt. Reports Announcements & Index 04: TD3:

Abstract: Red-winged Blackbird (*Agelaius phoeniceus*: red-wings) and European Starling (*Sturnus vulgaris*: starling) nestlings were dosed with either 2.0 mg/kg body weight chlorpyrifos, 50.0 mg/kg body weight dimethoate, or a propylene glycol carrier in situ. The sensitivity to these compounds was compared between species and between adults and young of the same species. In addition, four growth measurements were recorded for nestlings to determine if these organophosphorus compounds caused perturbations in development at sublethal concentrations. Red-wing nestlings were more sensitive to chlorphyrifos than starling nestlings and starling nestlings were more sensitive to dimethoate than red-wing nestlings. In addition, red-wing nestling were more tolerant of a substantially higher concentration of dimethoate than the adult LD50. The sensitivity of starling nestlings to dimethoate was similar to adults. In contrast, both species were more sensitive to chlorpyrifos than adults. After the initial 24 hr, nestlings dosed with either chemical recovered and continued their development. Of the four growth measurements, body weight appeared to be the most important in documenting pesticide-induced growth inhibition. Journal article. Pub. in Jnl. of Wildlife Diseases, v28 n3 p400-406 1992. Sponsored by Corvallis Environmental Research Lab., OR.

M22) Miles, A.K. and H.M. Ohlendorf. 1993. Environmental contaminants in Canvasbacks wintering on San Francisco Bay, California. Calif. Fish Game 79: 28-38.

Abstract: The concentrations of 11 trace elements, 21 organochlorines, 13 polycyclic aromatic hydrocarbons, and 13 aliphatic hydrocarbons were determined in Canvasbacks (*Aythya valisineria*) wintering on San Francisco Bay, California during 1988. With the exception of Se, concentrations of potentially toxic elements were low. Similarly, concentrations of most organic compounds were near or below detection limits. Aliphatic hydrocarbons, PCBs, and DDE were common, but at levels lower than those known to be harmful to waterfowl. Innocuous trace elements (Cu, Fe, and Zn), which are often associated with anthropogenic contamination, occurred at high levels. Concentrations of toxic elements were several times lower and those of benign elements were similar or greater than concentrations reported for

surf scoters (Melanitta perspicillata) or greater scaup (Aythya marila) from San Francisco Bay.

M23) Millard, J.B., F.W. Whicker and O.D. Markham. 1990. Radionuclide uptake and growth of Barn Swallows nesting by radioactive leaching ponds. Health Phys. 58: 429-439.

Abstract: Populations of Barn Swallows (*Hirundo rustica*) nested seasonally near the Test Reactor Area (TRA) radioactive leaching ponds on the Idaho National Engineering Laboratory (INEL). These birds utilized leaching pond arthropods as a food source and contaminated mud for nest construction and thus accumulated radioactive materials. Over 20 fission and activation products were detected in immature and adult TRA birds. The radionuclide exhibiting the highest mean concentration in adult birds was 51Cr, with 16.1 Bq g-1 (435 pCi g-1). Mean concentrations of detectable radionuclides were used to calculate internal dose rates. Approximately 72% of the total dose rate of 219 muGy d-1 (22 mrad d-1) for adult birds was due to 24Na. Swallow thyroids contained a mean 131I concentration of 3330 Bq g-1. An average dose rate to thyroid was calculated to be 4300 muGy d-1 or 450 mGy (45 rad) for the entire breeding season. Data from LiF-700 thermoluminescent dosimeters in swallow nests indicated that average dose rates were 840 muGy d-1 for eggs and 2200 Gy d-1 for nestlings, for a total of 54 mGy (5.4 rad) during the nesting period. The breeding biology and growth rate were investigated for TRA swallows and comparison groups located 15 km and 100 km away. Total mortality rates for comparison group vs. 1976 and 1977 TRA populations were not found to be significantly ($p > 0.9$) different. Nonlinear regression was used to fit individual growth curves and estimate parameters using a logistic model. First clutch TRA swallows were found to have a significantly ($p < 0.05$) lower mean growth rate compared to either the first clutch comparison group or the second clutch of TRA birds. Mean asymptotic weights achieved by immature TRA birds were also found to be significantly ($p < 0.05$) lower than those achieved by comparison group birds. Both growth rate and asymptotic weights for TRA birds were within the normal range reported in the literature. The cause for the statistical difference in growth rate between the comparison group and TRA firstclutch populations could not be determined.

M24) Moller, A.P. 1993. Morphology and sexual selection in the Barn Swallow (*Hirundo rustica*) in Chernobyl, Ukraine. Proc. R. Soc. Lond. Ser. B. Biol. Sci. 252: 51-57.

Abstract: Secondary sexual characters are large structures of great intricacy of design, and there are many ways in which their development can be disrupted. Both somatic and germ-line mutations affecting the expression of secondary sexual characters are likely to be biased and most frequently reduce performance because of the great complexity of characters. I

investigated the degree of fluctuating asymmetry and the incidence of aberrant secondary sexual characters in the monogamous Barn Swallow *Hirundo rustica* in two areas in Ukraine, one near Chernobyl, and the other near Kanev. I predicted that developmental disorders should be more frequent in a recent sample of birds from the Chernobyl area than in samples from other areas, and than in museum samples pre-dating the 1986 contamination event. There were apparently no consistent effects of area or time period on the morphology of Barn Swallows. The level of fluctuating asymmetry in male tail length was considerably elevated in the Chernobyl area in the recent sample, but not in females, and three other morphological variables were unaffected in both sexes. Males with high degrees of asymmetry in their tails bred later than symmetric males. The incidence of aberrant feather morphology in the Chernobyl area was high for tail ornaments of males than for other morphological characters in males, and than for the homologous character of females, and there were no cases of aberrant feathers in the control area or in the museum samples. Males with aberrant tail feathers bred later than other males.

M25) Moore, N.W. 1966. A presticide monitoring system with special reference to the selection of indicator species. J. Appl. Ecol. 3: 261-269.

M26) Munro, W.T. and L. Jackson. 1979. Preliminary mustelid management plan for British Columbia. B.C. Ministry of the Environment, Fish and Wildlife Branch, Victoria, B.C.

Summary: A short report presenting a summary of information on the biology of mustelids and on their economic uses. The report also identifies conflicts between man and mustelids and management problems. A summary management prescription is presented.

N1) Nagorsen, D.W. and R.M. Brigham. 1993. Bats of British Columbia. Royal British Columbia Museum Handbook. UBC Press, Vancouver. 164pp.

N2) Niethammer, K.R., T.S. Baskett and D.H. White. 1984. Organochlorine residues in three heron species as related to diet and age. Bull. Environ. Contam. Toxicol. 33: 491-8.

N3) Noble, J.E. and J.E. Elliott. 1986. Environmental Contaminants in Canadian Seabirds 1968-1985 Trends and Effects. Tech. Rep. Ser. No. 13. Headquarters, Canadian Wildlife Service.

N4) Noble, D.G. and J.E. Elliott. 1990. Levels of contaminants in Canadian raptors, 1966 to 1988: Effects and temporal trends. Can, Field Nat. 104: 222-243.

Abstract: Organochlorine and mercury residue concentrations in eggs and body tissue of twenty-seven species of raptors collected in Canada between 1966 and 1988 are summarized. A few individuals had liver mercury of DDE concentrations at levels associated with poisoning. During the late 1960s and early 1970s levels of DDE in some eggs of Bald Eagles, Osprey, Red-tailed Hawks, Northern Harriers, Merlins, Prairie Falcons, and Great Horned Owls were high enough to cause eggshell thinning. In the 1980s, elevated DDE levels were found in some eggs of Sharp-shinned Hawks, Cooper's Hawks and Merlins. Dieldrin and heptachlor epoxide levels in eggs also exceeded minimum critical levels in a few individuals of a number of species. The significance of the detected concentrations are discussed in relation to the status of those populations. DDE, dieldrin and heptachlor epoxide concentrations in eggs generally declined over the period of sampling. Although some bird-eating raptors are still highly contaminated, population declines in many species can be attributed to a number of factors, including loss of suitable habitat.

N5) Noble, J.E., J.E. Elliott and J.L. Shutt. 1993. Environmental Contaminants in Canadian Raptors 1965-1989. Tech. Rep. Ser. No. 91. Headquarters Canadian Wildlife Service. 224pp.

N6) Nosek, J.A. and R.A. Faber. 1982. Polychlorinated biphenyls and organochlorine insecticides in Great Blue Heron (*Ardea herodias*) and Great Egret (*Casmerodius albus*) eggs from the upper Mississippi River USA. Wiener, J. G., R. 14-15.

Keywords: DDT, mirex, DDD, heptachlor epoxide, DDE, dieldrin, hexachlorobenzene, endrin, chlordane, trans-nonachlor

N7) Norheim, G., T. Sivertsen, E. M. Brevik and A. Froslie. 1984. Mercury and selenium in wild mink *(Mustela vison)* from Norway. Nord. Veterinaermed. 36: 43-48.

Keywords: mercury, methyl mercury, selenium, contamination

O1) O'Connor, D.J. and S.W. Nielsen. 1981. Environmental survey of methylmercury levels in wild mink *(Mustela vison)* and otter *(Lutra canadensis)* from the northeastern United States and experimental pathology of methylmercurialism in the otter. Worldwide Furbearer Conference Proceedings. pp. 1728-1745.

Keywords: methylmercury, otter, pathology, neuron damage, malacia, perivasular cuffing, histopathology, neurotoxicity

O2) Offerhaus, L. 1991. [Halcion: requiem for a kingfisher?]. Ned Tijdschr Geneeskd 135: 2467-9.

O3) Ohanjanian, I.A. 1986. Effects of a man-made dyke on the reproductive behaviour and nesting success of Red-necked Grebes. M.Sc. S.F.U. 83 pp.

O4) Ohlendorf, H.M. 1981. The Chesapeake Bay's USA birds and organo chlorine. Sabol. K. 0: 259-270.

Keywords: raptor, eagle, osprey, hawk, duck, gull, DDT

O5) Ohlendorf, H.M., D.M. Swineford and L.N. Locke. 1981. Organochlorine residues and mortality of herons. Pestic. Monit. J. 14: 125-35.

Abstract: Since 1966, 72 herons found dead or moribund in the field have been analyzed for organochlorine chemicals. In addition, 36 herons were obtained through systematic collections, and carcasses were analyzed to determine sublethal exposure to organochlorines. Brains of birds found dead or moribund were analyzed to determine whether the birds had died of organochlorine poisoning. Residues of DDE were found most frequently (96 of 105 carcasses analyzed), PCBs were second (detected in 90 carcasses), and dieldrin and TDE (detected in 37 and 35 carcasses, respectively) were about equal as third and fourth most frequent. Endrin, mirex, toxaphene, and HCB were found least often (8, 9, 9, and 9 carcasses, respectively). At least one organochlorine was found in each carcass, except for six heron chicks found dead in a Maryland heronry. DDE and PCBs were present in highest concentrations; they exceeded 100 ppm in two birds each. Organochlorine concentrations were almost always higher in adult herons than in immature birds. All birds that had hazardous or lethal concentrations in the brain were adults, and most were Great Blue Herons (*Ardea herodias*). Dieldrin was the chemical most often considered responsible for death. Herons died of suspected DDT and dieldrin poisoning years after the chemicals were banned in the United States. More than 20% of the herons found dead or moribund had lethal or hazardous concentrations of organochlorines in the brain.

O6) Ohlendorf, H.M., K.C. Marois, R.W. Lowe, T.E. Harvey and P.R. Kelly. 1991. Trace elements and organochlorines in Surf Scoters from San Francisco Bay, 1985 (California, USA). Environ. Monit. Assess. 18: 105-122.

Abstract: Surf Scoters (*Melanitta perspicillata*) were collected from six locations in San Francisco Bay during January and March 1985. Overall, mean concentrations of cadmium and zinc were higher in livers of scoters from the southern region of the Bay, whereas mean iron and lead were

higher in those from the northern Bay region. Mean concentrations of arsenic, copper, lead, zinc, aluminum (January only) and iron (January) also differed among individual locations. Mean concentrations of copper and zinc increased, arsenic decreased, and cadmium remained the same between January and March. Selenium and mercury concentrations in scoter livers were not significantly correlated ($P > 0.05$), but cadmium concentrations in livers and kidneys were positively correlated ($P < 0.0001$), and body weight was negatively related to mercury concentration in the liver ($P < 0.05$). Body weight differed among locations but not between January and March. Body weight was correlated with lipid content ($P < 0.0001$). DDE PCBs were each detected in 34 of 36 scoter carcasses. DDE increased significantly between January and March at Richmond Harbor, but PCBs did not differ between January and March at the three locations that could be tested.

O7) Olson, M.M. and D. Welsh. 1993. Selenium in Eared Grebe embryos from Stewart Lake National Wildlife Refuge, North Dakota. Prairie Nat. 25: 119-126.

Abstract: Selenium in 41 Eared Grebe (*Podiceps nigricollis*) eggs, from Stewart Lake National Wildlife Refuge (Stewart Lake), North Dakota, averaged 4.5 mug/g dry weight (range 2.9-6.5 mug/g), and is above the 85th percentile (3.2 mug/g dry weight) of mean concentrations in background investigations of selenium in eggs from the western United States. The best available estimate of hatchability indicated that 16.0% of all grebe eggs examined would not have hatched. No deformities were noted in the examined embryos. Dates of nest initiation spanned 24 days (17 June to 12 July 1991), with peak nest initiation occurring on 3 July. There was no correlation between selenium concentration in eggs and date of nest initiation, suggesting that selenium accumulation in grebes at Stewart Lake reaches equilibrium before egg laying occurs.

O8) Orchard, S.A. 1984. Amphibians and Reptiles in British Columbia: An Ecological Review. Report to Ministry of Forests, Victoria. 268 pp.

Summary: The report presents a introduction to amphibians and reptiles in British Columbia and detailed species accounts. Where information is lacking or scant this is stated clearly. The status of each species is also given.

O9) Orchard, S.A. 1988. Wildlife Habitat Handbooks for the Southern Interior Ecoprovince. Volume 4: Species Notes for Amphibians. Wildlife Habitat Research WHR-31. Wildlife Report No. R-18.

O10) Orchard, S.A. 1992. Amphibian population declines in British Columbia. In: Bishop C.A. and K.E. Pettit (eds.). Declines in Canadian amphibian populations: designing

a national monitoring strategy. Occ. Pap. Number 76, Canadian Wildlife Service. 120pp.

Summary: This paper discusses declines in populations of seven amphibians species native to British Columbia. These species are habitat specialists and declines can be largely attributed to habitat destruction.

O11) Ormerod, S.J. and S.J. Tyler. 1986. The diet of Dippers (*Cinclus cinclus*) wintering in the catchment of the River Wye, Wales (UK). Bird Study 33: 36-45.

Abstract: We studied the diet of Dippers in the River Wye catchment by faecal analysis during the winters of 1983/84 and 1984/85. Diptera, Trichoptera, Ephemeroptera and Plecoptera comprised respectively 34, 23, 18 and 11% of 4650 items recorded from over 350 faecal samples. The Simuliidae (Diptera) and Baetidae (Ephemeroptera) were the commonest macroinvertebrate families recorded despite their small size. Fish and trichopteran larvae comprised respectively an estimated 63 and 19% of the diet by weight. By contrast with Dippers foraging for nestlings, the proportions and reconstructed weights of items appearing in faeces strongly reflected those in stream samples. Birds probably fed opportunistically. Consequently, Dippers feeding on hard water streams ingested more calcium-rich prey than those on soft-water streams. The results are discussed in relation to the infleunce of stream acidity on aspects of Dipper ecology.

O12) Ormerod, S.J., K.R. Bull, C.P. Cummins, S.J. Tyler and J.A. Vickery. 1988. Egg mass and shell thickness in Dippers, *Cinclus cinclus* in relation to stream acidity in Wales and Scotland. Environ. Pollut. 55: 107-121.

Summary: Shell thickness and egg mass were measured in Dipper eggs collected on streams of differing pH in Wales and Scotland. Using regression analysis they showed pH accounted for 7% of the variance in shell thickness and 17% of the variance in egg mass. They also measured aluminium, phosphorus and calcium in invertebrates consumed by the Dipper. Calcium concentrations showed a significant relationship with stream pH in two insect orders. Calcium rich prey were most abundant in circumneutral streams.

O13) Ormerod, S.J. and S.J. Tyler. 1989. Long-term change in the suitability of Welsh streams for Dippers (*Cinclus cinclus*) as a result of acidification and recovery: A modelling study. Environ. Pollut. 62: 171-182.

Abstract: Using a recognized and widely used hydrochemical model, MAGIC, long-term changes in acidity were simulated at 104 sites in the acid sensitive region of upland Wales. Conditions were modelled in the future (2010) under different reductions in sulphate deposition from 0 to 90% of

1984 values. Chemical output from the model was used to simulate change in the chemical suitability of streams for a species of river bird, the Dipper (*Cinclus cinclus*) known to be affected by acidification. According to simulations, only reduction in sulphate deposition by over 50% of 1984 levels prevented decline in the number of streams chemically suitable for Dippers. Greater reductions in deposition in the model permitted some recovery except where conifer forestry occupied acid sensitive catchments. There are several uncertainties with the models in their present form.

O14) Ormerod, S.J. and S.J. Tyler. 1990. Environmental pollutants in the eggs of Welsh Dippers (*Cinclus cinclus*): A potential monitor of organochlorine and mercury contamination in uplant rivers. Bird Study 37: 171-176.

Abstract: Deserted or addled egs (n = 63) were collected from 34 nests of the Dipper Cinclus cinclus in Wales (UK) during 1988, while 14 eggs were collected from eight nests of the Grey Wagtail Motacella cinerea. A minority of eggs contained HCH and HCB, and only one Dipper egg contained mercury, but all or most contained HEOD, DDE and PCBs. Geometric mean concentrations in Dipper eggs were 3.26 p.p.m. lipid for HEOD, 4.51 p.p.m. for DDE, and 17.78 p.p.m.for PCBs. Concentrations in Grey Wagtail eggs were only slightly higher. In seven clutches of three or more Dipper eggs, within clutch variation was greater than between clutch variation. For clutches of two eggs or more, there was significant variation between clutches for HEOD and DEE, but not PCBs. Most variation in DDE levels was due to low values at high altitude sites in upland sheepwalk, whilst high PCB values were found in two afforested catchments. Concentrations of DDE in Dipper eggs were generally lower than those in raptors, but HEOD and PCB levels were similar to or slightly higher than in some raptors in Britain, and insectivorous waterbirds elsewhere. The potentail value of Dippers as indicators of organochlorine contamination in upland rivers is discussed.

O15) Ormerod, S.J. and S.J. Tyler.1991. Exploitation of prey by a river bird, the Dipper (*Cinclus cinclus*) along acidic and circumneutral streams in upland Wales. Freshwater Biology 25: 105-116.

O16) Ormerod, S.J., J. O'Halloran, S.D. Gribbin and S.J. Tyler. 1991. The ecology of Dippers (*Cinclus cinclus*) in relation to stream acidity in upland Wales (UK): Breeding performance, calcium physiology and nestling growth. J. Appl. Ecol. 28: 419-433.

Abstract: (1) We compared the laying dates, clutch size, brood size and nestling growth of Dippers (*Cinclus cinclus*) breeding on acidic and circumneutral Welsh streams in 1985 and 1986. Serum calcium and serum alkaline phosphatase concentrations were measured in nestlings and adults from the wild population in 1988-89. (2) Laying dates were later, clutch and

brood sizes smaller, and nestling growth slower along acidic streams by comparison with circumneutral streams. All differences were significant. Second clutches were absent from acidic streams, but occurred at 20% of circumneutral sites. (3) Though egg-laying was delayed at higher altidues, pH had additional significant effects. Pairs began laying later by 13-22 days at acidic sites than circumneutral sites even after removing the effect of altitude. (4) Reduced clutch size at acidic sites in 1986 could be explained solely by delayed laying, but pH had an additional effect in 1985 and in the combined years' data. (5) Smaller broods at acidic sites could be explained solely by reduced clutch size. (6) Reduced daily mass increase in nestlings at acidic sites could be explained by delayed laying, but reduced tarsal growth was affected by pH at P = 0.06 after accounting for the effects of laying date. (7) Adult mass was significantly lower on acidic streams than on circumneutral streams in the pre-breeding period. The age structure of the population did not differ between the two types of stream, though the sex ratio on acid streams was female biased. (8) Serum calcium was significantly lower in both males and females at acidic sites in the pre-breeding period than at circumneutral sites. At acidic sites only, females had higher serum calcium than males, and showed also elevated serum alkaline phosphatase. Nestling serum calcium was lower at acidic sites only up to eight days after hatching. (9) We discuss our results in relation to the reduced availability of calcium in dipper prey along acidified streams.

O17) Ormerod, S.J. and S.J. Tyler. 1992. Patterns of contamination by organochlorines and mercury in the eggs of two river passerines in Britain and Ireland with reference to individual PCB congeners. Environ. Pollut. 76: 233-243.

Abstract: Unhatched eggs were collected in 1988 and 1990 from nests of the Eurasian Dipper (*Cinclus cinclus*) and the Grey Wagtail (*Motacilla cinerea*) in Wales, eastern Scotland and south-western Ireland (UK). Mercury concentrations in Dipper eggs (geometric means 0.45-0.91 ppm (mug g-1) dry mass) were significantly lower in eastern Scotland than in either south-western Ireland or Wales, where the incidence of detectable residues increased markedly between 1988 (2% of eggs) and 1990 (69%). By contrast, DDE (geometric means 0.63-3.54 ppm in lipid), TDE (< 0.01-1.80 ppm), DDT (< 0.01-0.65 ppm), total PCBs (3.99-10.47 ppm), HEOD (0.39-0.61 ppm) and HCB (0.02-0.13 ppm) were all significantly higher in Scottish eggs than others. Around 33-46% of the total PCB burden in Dipper and Grey Wagtail eggs could be accounted for by six congeners (IUPAC numbers 118, 180, 101, 153, 138 and 170). Amongst these attributable PCBs, Dipper eggs from eastern Scotland were dominated by congener 153 (2,2',4,4',5,5'-hexachlorobiphenyl), whilst Welsh and Irish eggs were dominated by congener 118 (2,3',4,4',5- pentachlorobiphenyl). With the latter exception, all the individual congeners were found at significantly higher concentrations in Scottish eggs than others. Grey

Wagtail eggs were dominated by congeners 118 and 101 (2,2,4,5,5'-pentachlorobiphenyl). In general, these congeners are common, widespread, and dominant components in the eggs of other wild birds for which data are available. Consistent with the low to medium levels of contaminants found in Dipper eggs, there was only slight evidence of any toxic effects. These included moderate shell thinning in relation to increasing DDE, and some evidence that contaminants had contributed to egg failure.

O18) Ormerod, S.J. and S.J. Tyler. 1993. Further studies of the organochlorine content of Dipper (*Cinclus cinclus*) eggs: Local differences between Welsh catchments. Bird Study 40: 97-106.

Abstract: In previous years, we examined the use of deserted and addled eggs of the Dipper (*Cinclus cinclus*) as monitors of the contamination of upland rivers by persistent organochlorines. Here, we examined and interpret differences between the organochlorine content of eggs from adjacent sub-catchments of rivers in Wales. We provide information particularly on individual polychlorinated biphenyls (PCBs), for which few data are available on wild birds generally. There were no significant differences between catchments in egg concentrations of total PCBs, although two individual PCB chemicals (or congeners) showed significant differences in concentration or incidence of occurrence. PCB congener 118 (2,3',4,4',5 Pentachlorobiphenyl) showed a reduction in concentration on a SW-NE gradient through south and mid-Wales reflecting possible sources in the coastal industrial belt. However, significantly elevated concentrations in Irish eggs suggest the possibility of more remote origins to the west. PCB 101 (2,2,4,5,5' Pentachlorobiphenyl) was found significantly more often in eggs from sub-catchments in mid-Wales than from south Wales. Further data on the sources, transport, persistence and ecotoxicity of individual PCB congeners are required before these results can be seen in context. There was a marked reduction in total PCB concentrations in Dipper eggs between 1988 and 1990 which continued into 1991. Significant variation between catchments in HEOD (from the insecticides Aldrin and Dieldrin) reflected land use. Levels in eggs increased significantly where river catchments had high sheep densities. HEOD concentrations in eggs correlated with bacteriological features in river water which were indicators of high stock densities. These patterns are consistent with the former legal or latterly illicit use of Dieldrin in sheepdip, although the concentrations present in Dipper eggs declined between 1988 and 1990. We conclude that, at least within regions, Dipper eggs can aid in the detection of local patterns in the contaminatin of rivers by some persistent organochlorines.

O19) O'Shea, T.J. and T.E. Kaiser. 1981. Polychlorinated biphenyls in a wild mink population. In: Worldwide Furbearer Conference Proceedings. August 3-11, 1980. J.A. Chapman and D. Pursley (eds.).Worldwide Furbearer Conference Inc. pp. 1746-1751.

Summary: Liver, brain and muscle tissue from 32 mink collected in rural western Maryland during winter were analysed for PCB's. Mean residues of PCBs in livers (eight mink had detectable residues) were 1.4 ppm for females and 1.5 ppm for males. These levels are comparable to those reported in the literature for livers of experimental female ranch mink that showed reproductive failure when fed 0.64 ppm PCBs for 160 days. Our findings imply that even in areas with no recognized large-scale PCB pollution, exposure to these widespread contaminants could be sufficient to inhibit reproduction.

P1) Palawski, D.U., W.E. Jones, K. DuBois and J.C. Malloy. 1992. Contaminant Biomonitoring at the Benton Lake National Wildlife Refuge in 1988. Govt. Reports Announcements & Index 04: TD3:

Abstract: Trace element concentrations in sediment samples from Benton Lake National Wildlife Refuge were not elevated relative to the western U.S. geometric mean concentrations. Boron concentrations in aquatic plants approached the concentration of boron in Mallard (*Anas platyrhyncos*) diets that reduced hatching success. Among the three invertebrate taxa sampled, only midge larvae (*Chironomidae*) bioaccumulated selenium. Selenium concentrations in Eared Grebe livers exceeded the levels found in the livers of Mallards that experienced reproductive problems. Four hundred thirty-eight water bird nests were located during nest searches, and 536 eggs were examined from 179 of those nests. A minimum of 8.4% of the eggs laid contained dead embryos, and 0.1% contained abnormal embryos. Rates of embryo death and abnormality were similar to rates of presumably unpolluted natural populations. Mean selenium concentrations in Eared Grebe, Northern Pintail (*Anas acuta*), Mallard, and American Coot (*Fulica americana*) eggs exceeded the 3 micrograms/g dry weight concentration typical of natural background levels. However, only one of three deformed bird embryos had a selenium concentration greater than 3 micrograms/g dry weight. Organochlorine residues in bird eggs did not exceed concentrations believed to be harmless.

P2) Palmer, R.S.1962. Handbook of North American Birds. Volume 1: Loons through Flamingoes. Yale University Press, New Haven.

P3) Palmer, R.S. 1976. Handbook of North American Birds. Volume 3: Waterfowl Part 2. Yale University Press, New Haven.

P4) Palmer R.S. 1988. Handbook of North American Birds. Volume 4: Diurmal Raptors, Part 1. Yale University Press, New Haven.

P5) Perry, R.H.1982. Muskrats (*Ondatra zibethicus* and *Neofiber alleni*) In: Wild Mammals of North America, Biology, Management, and Economics. J.A. Chapman and G.A. Feldhamer (eds.). John Hopkins University Press. pp 284-325.

P6) Piechocki, R. 1987. Winter losses of scaup ducks and their biometric evaluation. Hercynia 24: 121-133.

Keywords: *Aythya ferina, Aythya fuligula, Aythya marila, Somateria mollissima, Clangula hyemalis, Melanitta nigra, Melanitta fusca, Bucephala clangula, Mergus albellus, Mergus serrator, Mergus merganser*, pisces, crustacea, mollusc, fat storage, foraging behavior, starvation, mortality, fat utilization, hypothermia, oil pollution, East Germany

P7) Poole, A.F. 1989. Ospreys: A natural and unnatural history. In: A.F. Poole (ed.). Ospreys: A Natural And Unnatural History. Xviii. Cambridge University Press: Port Chester, New York, USA. 246pp.

Keywords: book, *Pandion haliaetus*, phylogeny classification, distribution, migration, wintering ecology, diet, foraging, nesting, breeding, environmental threats, pollution management

P8) Powell, G.V. 1983. Industrial effluents as a source of mercury contamination in terrestrial riparian vertebrates. Environ. Pollut. Ser. B. Chem. Phys. 5: 51-58.

Abstract: Piscivorous and insectivorous birds (*Butorides stiratus, Anas platyrhynchos, Aix sponsa, Stelgidopteryx ruficollis, Sayornis phoebe, Seiurus motacilla, Agelaius phoeniceus, Melospiza melodia*) and a bat (*Pipistrellus subflavus*) collected along Virginia's (USA) North Fork of the Holston River contained elevated Hb residues. The ubiquitous occurrence of Hg in riparian insectivores implicated aquatic insects as a vehicle for spreading Hg contamination from 1 ecosystem to another and expanded the ecological ramifications of Hg-contaminated industrial effluents.

P9) Pratt, H.M. and D.W. Winkler. 1985. Clutch size, timing of laying and reproductive success in a colony of Great Blue Herons (*Ardea herodias*) and Great Egrets (*Casmerodius albus*). Auk 102: 49-63.

Keywords: DDT, fledging success

P10) Presser, T.S. and H.M. Ohlendorf. 1987. Biogeochemical cycling of selenium in the San Joaquin Valley, California, USA. Environ. Manage. 11: 804-822.

Keywords: Eared Grebe, American Coot, selenate, deformity, embryo death, climate, soil type, irrigation, water pollution

P11) Proulx G., D.V.C. Weseloh, J.E. Elliott, S. Teeple, P.A.M. Anghem and P. Mineau. 1987. Organochlorine and PCB residues in Lake Erie mink populations. Bull. Environ. Contam. Toxicol. 39: 939-944.

Summary: Mink carcasses were collected from trappers in Ontario. Body homogenates were analysed for DDT, DDD, DDE, dieldrin, heptachlor epoxide, HCH, chlorobenzenes, chlordane, mirex and PCB. PCB levels in body homogenates varied from 0.06 to 7.37 ppm on a wet weight basis, and from 0.8 to 117.7 ppm on a lipid weight basis. DDE residues in body homogenates ranged from 0.02 to 0.91 ppm (wet weight) and from 0.26 to 33.7 ppm on a lipid weight basis. The other contaminants all occurred at low levels. The high levels of PCB detected are higher than levels used in experimetal studies showing significant negative effects on mink. The high levels of PCB and DDE measured in this study may have a significant impact in winter when fat stores are mobilized.

P12) Pybus, M.J., D.P. Hobson and D.K. Onderka. 1986a. Mass mortality of bats due to probable blue-green algal toxicity. J. Wildl. Dis. 22: 449-450.

Keywords: *Myotis, Lasiurus cinereus, Anabaena flos aquae, Anas platyrhynchos*, Canadian, lake, toxic, alkaloid identification

P13) Pybus, M.J., D.P. Hobson and D.K. Onderka. 1986b. Mass mortality of bats due to probable blue-green algal toxicity. J. Wildl. Dis. 22: 449-450.

Keywords: *Myotis, Lasiurus cinereus, Anabaena flos aquae, Anas platyrhynchos*, Canadian lake, toxic, alkaloid identification

Q1) Quinney, T.E. and C.D. Ankey. 1985. Prey size selection by Tree Swallows. The Auk. 102(2):245-250.

R1) Ratti, J.T. 1977. Reproductive separation and isolating mechanisms between sympatric dark- and light-phase Western Grebes. Ph.D. thesis, Utah State University, Logan.

Summary: This study investigated the relationship between dark- and light-phase Western Grebes on the Bear River Migratory Bird Refuge in Utah. The objectives of the study were to determine the degree of reproductive isolation between the two phases, identify and analyse isolating mechanisms and clarify the systematic relationship between the two color phases. The study revealed striking and statistically significant differences between the two phases. Mixed pairs occurred in

only 1.2% of the pairs observed (n=1185). Clutch initiation dates differed and chicks of the light-phase developed black-crown feathers 30 to 40 days later than dark-phase chicks. Breeding populations tended to be segregated.

R2) Rendell, W.B. and R.J. Robertson. 1990. Influence of forest edge on nest-site selection by Tree Swallows. Wilson Bulletin. 102(4): 634-644.

R3) Rickard, W.H., W.C. Hanson and R.E. Fitzner. 1982. The nonfisheries biological resources of the Hanford Reach of the Columbia River, Washington, USA. Northwest Sci. 56: 62-76.

Abstract: The Hanford Reach is the only undammed segment of the Columbia River in the USA upstream from Bonneville Dam. The non-agricultural and non-recreational land-use policies imposed by the Department of Energy have permitted the Hanford Site to function as a refugium for wildlife for 35 years. The protection offered by the Hanford Site has been especially important for the Bald Eagle (*Haliaeetus leucocephalus*), Mule Deer (*Odocoileus hemionus*), Coyote (*Canis latrans*), and resident Great Basin Canada Goose (*Branta canadensis moffitti*). Island habitats are especially important for nesting geese and for fawning Mule Deer. Coyotes are important predators upon nesting geese and Mule Deer fawns. Salmon carcasses are an important winter food for Bald Eagles. Riparian plant communities along the Columbia River have been changing in response to changing water level fluctuations largely regulated by power generation schedules at upstream hydroelectric dams. There are no studies presently established to record the response of Columbia River shoreline plant communities to these kinds of fluctuating water levels. The existing information on birds and mammals closely allied with the Hanford Reach of the Columbia River is summarized. High trophic level wild animals are discussed as indicators of chemical contamination of food chains.

R4) Riley, R.G., R.M. Bean, R.E. Fitzner, D.A. Neitzel and W.H. Rickard. 1986. Preliminary survey of polychlorinated biphenyls (PCBs) in aquatic habitats and Great Blue Herons on the Hanford Site. Govt. Reports Announcements & Index 14: TD3.

Abstract: Polychlorinated biphenyls (PCBs), constituents of insulating fluids used in electrical transformers and capacitors, were identified during a preliminary survey of waters, sediments, and fish from five locations on the Hanford Site in southeastern Washington State: Gable Mountain Pond, B Pond, West Pond, White Bluffs Slough on the Columbia River, and a pond on the Wahluke Slope. These aquatic areas are all within the foraging range of Great Blue Herons (*Ardea herodias*) that nest on the Hanford Site. Of those waters that contained PCBs, concentrations were found to be somewhat over 1 ng/L, but less than 20 ng/L, and equal to or less than concentrations reported for other freshwater regions of the United States.

The PCBs in sediments and fish closely resembled the chromatographic profile of Aroclor 1260, a commercial PCB mixture produced in the United States by the Monsanto Company. Concentrations of PCBs detected in the sediments were 10 to 100 times lower than those found in soils and sediments from other areas of the nation. Concentrations of PCBs in fat from Hanford Great Blue Herons ranged from 3.6 to 10.6 ppM, while PCB concentrations in herons from other areas of the Pacific Northwest ranged from 0.6 to 15.6 ppM. Great Blue Herons at Hanford contained PCB isomer distributions closely matching that of Aroclor 1260; Great Blue Herons from other locations contained isomer distributions indicating the presence of a mixture of aroclors. 21 refs., 13 figs., 8 tabs. (ERA citation 11:020975).

R5) Roberts, G. and A. Roberts. 1994. Biodiversity in the Cariboo-Chilcotin Grasslands. Report submitted to the Ministry of the Environment, Lands and Parks, Wildlife Branch, Williams Lake, B.C. 131 pp.

Summary: Non-game wildlife surveys were conducted in 1992 and 1993 in eight main geographical areas; Empire Valley, Gang Tanch, Dog Creek, Alkali Lake, Junction Wildlife Management Area, Riske Creek, Hanceville and Alexis Creek. Surveys focussed on bats, grassland birds, amphibians and reptiles and dominant plant species.

R6) Robertson, R.J. and W.B. Rendell. 1990. A comparison of the breeding ecology of a secondary cavity nesting bird, the Tree Swallow (*Tachycineta bicolor*) in nest boxes and natural cavities. Can. J. Zool. 68: 1046-1052.

R7) Robertson, R.J., B.J. Stutchbury and R.R. Cohen. 1992. Tree Swallow. In: The Birds of North America, No. 11. A. Poole, P. Stettenheim, and F. Gills (eds.). Philadelphia: The Academy of Natural Sciences; Washington, DC: The American Ornthithologists' Union.

R8) Rolev, A.M. 1983. Zinc, copper, lead and cadmium in feathers of Danish Gray Herons, *Ardea cinerea*. Dan. Ornithol. Foren. Tidsskr. 77: 13-24.

Abstract: Feathers consist of keratins, a dead proteinaceous material, especially good at binding metals. In order to study whether the concentration of heavy metals in feathers reflected local enrichment, the Gray Heron (*Ardea cinerea*) was selected, mainly because of its high position within food webs in the Danish fjords. These fjords were recipients of urban, industrial and agricultural discharges of sewage containing heavy metals. Molted wing feathers, collected in some of the biggest heronries in July, 1979, were ultrasonically cleaned before analysis of Zn, Cu, Pb and Cd by atomic absorption spectrophotometry. The results showed a small variation and symmetrical distribution patterns of Zn and Cu concentrations. This suggests the existence of some physiological regulation of these elements. The values of Pb and Cd showed a positively skewed distribution

pattern and a greater variation, which correlated with local enrichment. A heronry at Mariager Fjord and another in Lillebaelt yielded the highest concentration of Pb and Cd. The birds were probably not able to regulate these nonessential elements, and some nonessential heavy metals incorporated in the keratins of feathers grown on the breeding grounds can be used as indicators of environmental enrichment.

R9) Rydell, J. 1987. Bats need churches. Fauna Flora 82: 88-90.

Keywords: biosis, copyright: biol abs., RRM, *Plecotus auritus*, toxicity, chlorinated hydrocarbons, Vastergotland, Sweden

R10) Ryder, R.A. and C.J. Edwards. 1985. A conceptual approach for the application of biological indicators of ecosystem quality in the Great Lakes. Intern. Joint Commission, Windsor, Ontario.

S1) Sanderson, J.T. and G. D. Bellward. 1993. In ovo induction of hepatic microsomal ethoxyresorufin o-deethylase (EROD) by 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD): comparison of four Avian species. Toxicologist 13: 195.

Abstract: The in ovo EROD inducing potency of TCDD, as an indicator of sensitivity to Ah receptor-mediated toxicities, was determined in the Double-crested Cormorant, Great Blue Heron, Pigeon and domestic Chicken. Dose-response curves were produced by injecting eggs into the air sac with varying doses of 3H-TCDD in corn oil, 5-7 days before hatching. After hatching, hepatic microsomal EROD activities were measured in the newborns. Several organs, including liver, were analysed for 3H-TCDD using liquid scintillation counting. Livers contained 6-8% of the total dose in all four avian species. In the heron and cormorant, EROD activity was increased at 3 ug/kg egg. At the highest dose examined, 100 ug/kg, EROD was induced 35- and 22-fold, respectively. TCDD was at least 100-fold more potent an inducer in the domestic chick, a species known to be sensitive to TCDD toxicity. Chick edema was present in the cormorant at 3 ug/kg and in the chick at 0.125 ug/kg. Surprisingly, chick edema was present in the heron at 0.5 ug/kg, before any increase in EROD activity. Edema appears to be a rapid response, which in the heron is more sensitive to TCDD than the induction of P-450 1A1.

S2) Savard, J.L. 1986. Territorial behaviour, nesting success and brood survival of Barrow's Goldeneye and its congener. Ph.D thesis U.B.C. 219pp.

Summary: This study describes and characterizes the intra- and interspecific territorial behaviour of Barrow's Goldeneye and compares it to that of Common Goldeneye and Bufflehead. The study also examines some factors influencing the use of nest boxes by Barrow's Goldeneye and their reproductive success and compares duckling mortality with that in Common Goldeneye and Bufflehead. The main function of territoriality in these species seems to be the provision of an exclusive feeding area for the female and young. The author argues that the evolution of interspecific aggression in the genus *Bucephala* has been favoured by a high level of intraspecific aggression within the genus and significant feeding advantages obtained from the exclusion of competitors. The genus *Bucephala* provides one of the best examples of interference competition in a guild of related competitors.

S3) Savard, J.L. 1987. Causes and functions of brood amalgamation in Barrow's Goldeneyes and Bufflehead. Can. J. Zool. 65: 1548-1553.

S4) Savard, J.L. 1991. Waterfowl in the aspen parkland of central British Columbia. Tech. Rep. Ser. No. 132, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

S5) Schafer, E.W., Jr. and M. Jacobson. 1983. Repellency and toxicity of 55 insect repellents to Red-winged Blackbirds (*Agelaius phoeniceus*). J. Environ. Sci. Health Part A Environ. Sci. Eng. 18: 493-502.

Abstract: A joint research program was initiated in 1997 to investigate the potential avian repellency and toxicity of 55 selected insect repellents originating from or related to naturally occurring chemicals. Seven of the chemicals or extracts tested exhibited avian repellency and two of these were considered to be moderately active, with R50 (analogous to LD50) of 0.237 (trans-asarone) and 0.240% (safrole). None of the 55 chemicals or extracts exhibited acute oral toxicity at : 100 mg/kg to the Red-winged Blackbird (*Agelaius phoeniceus*).

S6) Shaw, G.G. 1983. Organochlorine pesticide and PCB residues in eggs and nestlings of Tree Swallows, *Tachycineta bicolor*, in Central Alberta. Can. Field Natur. 98(2): 258-260.

Abstract: Organochlorine pesticides and PCB residues in eggs and large nestlings were determined for Tree Swallow (*Tachycineta bicolor*) at five locations in central Alberta. Concentrations of dieldrin, pp`- DDD, pp`- DDT, alpha-chlordane, oxychlordane, beta-BHC and HCB were all less than 0.03 ppm. Concentrations of DDE, heptachlor epoxide and PCB's were about 1, 0.1 and 0.5 ppm, respectively, in eggs, and 0.3, 0.02 and 0.1 ppm in nestlings. Total body burden of DDE and PCB's in nestlings were significantly higher than those in eggs at two of the locations, which suggests that adult Tree Swallows still receive some of their organochlorine pesticide and PCB burden in Canada.

S7) Sheffy, T.B. and J.R. Stamant. 1982. Mercury burdens in furbearers in Wisconsin. J. Wildl. Manage. 46: 1117-1120.

Keywords: mink, otter, residue study

S8) Shuytema, G.S., A.V. Nebeker, W.L. Griffis and K.N. Wilson. 1991. Teratogenesis toxicity and bioconcentration in frogs exposed to dieldrin. Arch. Environ. Contam. Toxicol. 21(3): 332-350.

Abstract: Teratogenesis, acute and chronic toxicity, growth and bioconcentrations were investigated in various life stages (embryos, tadpoles, juveniles, adults) of the frogs *Xenopus laevis* (African Clawed Frog), *Rana catesbeiana* (Bullfrog) and *Rana pipiens* (Leopard Frog) exposed to aqueous dieldrin in static-renewal and flow-through systems in a study on the development of wildlife-based water quality criteria.

S9) Smith, V.E., J.M. Spurr, J.C. Filkins and J.J. Jones. 1986. Organochlorine contaminants of wintering ducks foraging on Detroit River sediments. Govt. Reports Announcements & Index 19: TD3:

Abstract: Organochlorine analysis was performed on carcasses of 13 diving ducks from a 1981 wintering population that foraged on contaminated sediments in the lower Detroit River. Mean total PCB concentrations were 10 mg/kg for seven Lesser Scaups (*Aythya affinis*), 11 mg/kg for three Greater Scaups (*A. marila*), and 7.6 mg/kg for three Goldeneyes (*Bucephala clangula*). Highest mean levels of other residues were measured for hexachlorobenzene (1.7 mg/kg) in Goldeneyes, and transnonachlor (0.33 mg/kg) and 4,4'-DDE (1.3 mg/kg) in Greater Scaup. Quantitative analysis of 72 PCB congeners also was applied to water, seston, sediment, benthic oligochaetes, and carp from the same site. Results of a multivariate analysis indicated that ratios of more conservative to less conservative PCBs did not vary significantly among ducks (alpha = .05), but differed from those in carp, oligochaetes, and sediment. Journal article, Pub. in Jnl. of Great Lakes Research 11, n3 p231-246 1985. Prepared in cooperation with Cranbrook Inst. of Science, Bloomfield Hills, MI., and Maine Univ. at Orono.

S10) Somers J.D., B.C. Goski and M.W. Barrett. 1987. Organochlorine residues in Northeastern Alberta Otters. Bull. Environ. Contam. Toxicol. 39: 783-790.

Summary: River Otter carcasses were obtained from trappers in northeastern Alberta. Liver and lipids samples were taken from the carcasses to analyse for Hexachlorobenzene (HCB), Hexachlorocyclohexane (BHC), Hepatachlor, Hepatachlor epoxide (HE), Chlordane, Aldrin, Dieldrin, Endrin, DDT and

derivatives, Mirex, Pentachlorobenzene, Toxaphene, Methoxychlor, Aroclor 1242, 1254, 1260 (PCB) and Polybrominated biphenyls. Only HCB, BHC, DDE and PCB's were detected in lipid. DDD and chlordane and dieldrin were also detected at very low levels in liver. In general levels of all detected compounds ranged between ND and 0.1 ug/g in lipid and 0.01 ug/g in liver.

S11) Speich, S.M., J. Calambokidas, D.W. Shea, J. Peard, M. Witter and D.M. Fry. 1992. Eggshell thinning and organochlorine contaminants in western Washington waterbirds. Colon. Waterbirds 15: 103-112.

Abstract: Within the Puget Sound, Washington (USA), marine environment there are urban-industrial areas with a known variety of pollutants present, including PCB's and DDT/DDE. In 1984 five species of waterbirds were studied for effects of pollutants at urban-industrial sites and in more remote areas of western Washington. No significant thinning was observed in the eggs of Double-crested and Pelagic Cormorants (*Phalacrocorax auritus* and *P. pelagicus*), all taken in remote areas. The same was true of Pigeon Guillemot (*Cepphus columba*) eggs taken in Puget Sound. Significant average eggshell thinning (to 13%) was observed in eggs of Great Blue Herons (*Ardea herodias*) from heronries near agricultural areas. Samples from near urban-industrial areas showed less average thinning (5-7%). The generally low average concentrations of total DDT (0.35-2.22 mug/g, wet weight) in heron eggs probably reflect local contamination from agricultural areas and wind drift from elsewhere. Highest average concentrations of PCBs in heron eggs were in those from Seattle (15.58 mug/g) and Tacoma (5.46 mug/g), the most industrially developed parts of Puget Sound. The largest average amounts of thinning (7-9%) in Glaucous-winged Gull (*Larus glaucescens*) eggs were for colonies in or near the urban-industrial areas of Puget Sound. Average shell thinning in eggs from the remote area colony was less (2%). Concentrations of total DDT in eggs (0.49-1.19 mug/g) do not account for the amount of thinning observed. The levels of the contaminants and the degree of eggshell thinning observed in the study species are all currently below levels associated with reproductive impairment in other studies. There is no current or historical evidence of significant pollution related impairment of reproduction in the study species in western Washington.

S12) St, L.V., L. Breebaart and J.C. Barlow. 1990. Foraging behavior of Tree Swallows over acidified and nonacidic lakes. Can. J. Zool. 68: 2385-2392.

Abstract: We studied the effects of lake acidification on foraging behaviour of Tree Swallows (*Tachycineta bicolor*) at the Experimental Lakes Area in northwestern Ontario (Canada). Predictions suggest that food quantity and (or) food quality may be important factors related to the reproductive success of birds nesting near acidified bodies of water. Therefore, we investigated the extent to which Tree Swallows (aerial insectivores) use the

affected ecosystem as a food resource base. We showed that breeding Tree Swallows foraged on the abundant chironomids emerging at their nest-site lakes before searching for food elsewhere. Chironomid abundance was greatest during the period when Tree Swallows produced their eggs, and declined significantly during periods when Tree Swallows incubated their eggs and fed their nestlings. The data suggest that the reproductive success of Tree Swallows nesting near lakes (and other aerial insectivores that primarily rely on emerging aquatic insects for food) is potentially at risk should changes in the quantity and (or) quality of emerging chironomids result from acidification.

S13) St, L.V. and L. Breebaart. 1991. Calcium supplements in the diet of nestling Tree Swallows near acid sensitive lakes. Condor 93: 286-294.

Abstract: We quantified supplemental sources of calcium in the diet of nestling Tree Swallows (*Tachycineta bicolor*) near acid sensitive lakes in northwestern Ontario (Canada). Among the calcium-rich items brought to nest boxes by adult swallows and ingested by nestlings, fish bones (particularly flat pieces) were most numerous followed by crayfish exoskeleton, clam shell, and bird eggshell in that order. Only 5% of the items eaten were longer than 10 mm, whereas over 29% of the items found in nest boxes were in this size class. We found significantly fewer calcium-rich items in the stomachs of nestlings from acidic lakes than in those from reference lakes, suggesting that items suitable for ingestion may be scarcer there. However, Tree Swallows flew at least 50 to 650 m from their nest-site lake to obtain calcium-rich items. Because lake acidification has reduced numbers of animals providing calcium for Tree Swallows in regions in which many lakes are atmospherically acifidied, the availability of calcium sources for nestlings may be seriously affected.

S14) St, L.V., L. Breebaart, J.C. Barlow and J.F. Klaverkamp. 1993. Metal accumulation and metallothionein concentrations in Tree Swallow nestlings near acidified lakes. Environ. Toxicol. Chem. 12: 1203-1207.

Abstract: Metal accumulation in hepatic and renal tissues of Tree Swallow (*Tachycineta bicolor*) nestlings were studied at acidified and nonacid reference lakes in northwestern Ontario (Canada). Hepatic concentrations of metallothionein (metal-binding proteins, MT) in Tree Swallow nestlings were negatively correlated with pH of the nest-site lake. Combined concentrations of Cu and Zn in the liver were correlated with liver MT concentrations, but Cd was not. Although no overt signs of metal toxicity were observed in nestlings near acid lakes, results clearly provided evidence that metals are transferred from acid lakes to birds and that these metals are correlated with increases in hepatic MT production.

S15) Stalmaster, M. 1987. The Bald Eagle. Universe Books, New York, 227 pp.

S16) Steeger, C. and M. Machmer. 1991. Pilot study on the effect of toxic pupl mill effluents on Ospreys in British Columbia. 22pp. Canadian Wildlife Service, Delta, B.C..

S17) Steeger, C., Esselink H. and R.C. Ydenberg 1992. Comparative feeding ecology and reproductive performance of Osprey in different habitats of southeastern British Columbia. Can. J. Zool. 70: 470-475.

S18) Steidl, R.J., C.R. Griffin and L.J. Niles. 1991. Differential reproductive success of Ospreys in New Jersey (USA). Journ. Wildl. Manage. 55(2): 266-272.

Abstract: To determine factors responsible for low productivity of Osprey (*Pandion haliaetus*) nesting along Delaware Bay, we compared their reproductive success to birds nesting along the Atlantic Coast during 1987 and 1988. Productivity of Ospreys nesting along the Delaware Bay was lower because 50% of all nests initiated failed, whereas only 21% of Atlantic Coast nests failed. Only 50% of all eggs laid in the Bay colony hatched, compared to 69% in the Atlantic Coast colony. Nestling mortality was similar between colonies (26 vs 18% for Delaware Bay and Atlantic Coast respectively) but 21% of those young hatched near the bay were probably preyed upon by Great Horned Owls (*Bubo virginianus*). Although Delaware Bay Ospreys spent considerably more time away from their nests, presumably foraging, than did Atlantic Coast birds, adults from both colonies spent similar amounts of time feeding young, which suggests that food stress did not influence productivity. High frequency of unhatched eggs and thinner eggshells (8% below pre-DDT levels vs. 3% for Atlantic Coast eggs) of Ospreys along Delaware Bay suggest possible exposure to environmental contaminants that may reduce hatching success.

S19) Steidl, R.J., C.R. Griffin and L.J. Niles. 1991a. Contaminant levels of Osprey eggs and prey reflect regional differences in reproductive success. J. Wildl. Manage. 55: 601-608.

Abstract: To determine if contaminants contributed to low hatching success of Opreys (*Pandion haliaetus*) nesting near Delaware Bay (USA), we compared levels of organochlorines, mercury, and lead in addled and randomly collected eggs and potential prey from Delaware Bay to a successful population along Atlantic Coast (>80 km from the Bay colony) and a geographically intermediate population along Maurice River (> 40 km from the Bay colony), a tributary of Delaware Bay. Eggs from Delaware Bay contained significantly higher levels of DDE, DDD, PCB's, dieldrin, and heptachlor epoxide than did Atlantic Coast eggs (P> 0.008) and also had thinner eggshells (P=0.04); eggs from Maurice River had intermediate contaminant levels and eggshell thickness. Contaminant levels in potential prey from each region reflected levels found in eggs, suggesting that Opreys

accumulated on their breeding grounds. Eggshell thickness was most closely correlated with levels of DDD (P=0.002) and DDE (P=0.06) in eggs. With the exception of dieldrin (P=0.003), addled and randomly collected eggs contained similar contaminant levels, although addled eggs contained mirex (P=0.0001) and lead (P=0.04) more frequently. Elevated contaminant levels osprey eggs from Delaware Bay suggest that contaminants from within the Bay contributed to reduced hatching success in this population.

S20) Stevens, V. and S. Lofts. 1988. Wildlife Habitat Handbooks for the Southern Interior Ecoprovince. Volume 1: Species Notes for Mammals. Wildlife Habitat Research WHR-28. Wildlife Report No. R-15.

Summary: This report provides a brief summary of natural history information related to habitat requirements of mammals which occur in the south central interior of British Columbia.

S21) Stickel, L.F., W.H. Stickel, R.A. Dyrland and D.L. Hughes. 1983a. Oxychlordane, HCS-3260 (cis and transchlordane) and nonachlor in birds: Lethal residues and loss rates. J. Toxicol. Environ. Health 12: 611-622.

Abstract: Oxychlordane reached lethal levels in birds given dietary dosages of HCS-3260 (70.75% cis-chlordane and 23.51% trans-chlordane) at six levels from 50-500 ppm. Oxychlordane ranged from 9.4-22.1 ppm in brains of Cowbirds (*Molothrus ater*), Grackles (*Quiscalus quiscula*) and Red-winged Blackbirds (*Agelaius phoeniceus*) that died on dosages of 1.3-4.8 ppm in sacrificed birds, providing a clear diagnostic separation. Among Starlings (*Sturnus vulgaris*), oxychlordane ranged from 5.0-19.1 ppm in brains of birds that died, significantly lower than in the other species, and from 1.4-10.5 ppm in sacrificed birds, overlapping the levels in those that died. Lethal levels began 5.0 ppm, as in a previous study in which oxychlordane itself was fed, but the data from Starlings emphasized the need for confirmatory necropsy findings in diagnosis of poisoning. Nonachlor had a low order of toxicity, killing only one of 12 birds dosed at 100 ppm for 35 days; three others died and one was incapacitated during a short period of food deprivation. Lethal levels of oxychlordane were present in the brains of birds that died. Oxychlordane accumulated in the bodies of birds on dietary dosage of HCS-3260 in proportion to dosage and time, but did not approach equilibrium at the levels (10, 50 and 100 ppm) that were fed. Loss rates of oxychlordane from HCS-3260, oxychlordane or technical chlordane dosages (the last in a previous study) did not differ significantly from each other; respective half-lives were 57, 63 and 74 days. Residues of cis-chlordane in birds fed HCS-3260 were consistently lower than oxychlordane during the

accumulation period and declined abruptly when dosage ceased; individual variation was high.

S22) Stickel, W.H., L.F. Stickel, R.A. Dyrland and D.L. Hughes. 1984a. Aroclor 1254 residues in birds: Lethal levels and loss rates. Arch. Environ. Contam. Toxicol. 13: 7-14.

Abstract: Lethal residues of polychlorinated biphenyls (PCB) were determined experimentally in four species (*Quiscalus quiscula, Agelaius phoeniceus, Molothrus ater, Sturnus vulgaris*) of wild birds given dietary dosage of 1500 ppm Aroclor 1254 until one-half had died, sacrificing the survivors, chemically analyzing the tissues and comparing results in dead birds and survivors. For all species, residues of : 310 ppm in the brain showed increasing likelihood of death from PCB poisoning. Residues in dead birds did not differ among species except for Starlings (*S. vulgaris*), which averaged slightly lower than the others. The species differed in the length of time to 50% mortality and in the levels of PCB in brains at sacrifice. Concentrations in bodies and livers were not diagnostic when expressed on a wet weight basis. On a lipid basis, concentrations of PCB in bodies of dead birds were higher than in sacrificed birds, but in both groups residues increased with time, suggesting that overlapping values were expected. Loss rates were followed in Grackles (*Q. quiscula*) fed 1500 ppm PCB for 8 days, then given untreated feed and sacrificed at intervals of 7, 28, 56, 112 and 224 days. PCB residues were lost from bodies at irregular rates; overall, the rate was estimated at 0.77% per day (half-life 89 days). Residues in brains generally were related to the percentage of body fat, but also showed an irregular pattern.

S23) Stickel, W.H., L.F. Stickel, R.A. Dyrland and D.L. Hughes. 1984b. DDE in birds: Lethal residues and loss rates. Arch. Environ. Contam. Toxicol. 13: 1-6.

Abstract: Lethal brain residues of DDE were determined experimentally in four species (*Quiscalus quiscula, Agelaius phoeniceus, Molothrus ater, Sturnus vulgaris*) of wild birds given dietary dosage of 1500 ppm DDE until one-half had died, then sacrificing the survivors, chemically analyzing the tissues and comparing results in dead birds and survivors. In all species, residues of 300-400 ppm DDE in the brain were considered to show increasing likelihood of death from DDE, confirming results of an earlier study with a single species. Body residues (parts/million wet weight) were not diagnostic, overlapping grossly in dead birds and survivors, but averaging higher in survivors. Body residues (parts/million wet weight) were not diagnostic, overlapping grossly in dead birds and survivors, but averaging higher in survivors. Body residues (parts/million lipid base) were higher in dead birds and did not overlap those in survivors. Loss rate was followed in Grackles fed 1500 ppm DDE for 7 days, then given untreated

feed and sacrificed at intervals of 7, 28, 56 and 112 days. DDE was lost slowly from the bodies, at a rate of 0.30% per day (estimated half-life 229 days). DDE was lost more rapidly from brains, half of the initial concentration being reached in 25 days; concentrations in brains increased thereafter in close correlation with percentage of fat in the body.

S24) Stone, W.B., S.R. Overmann and J.C. Okoniewski. 1984. Intentional poisoning of birds with parathion. Condor 86: 333-336.

Abstract: Intentional poisoning of birds by farmers is not uncommon but is rarely documented and given proper attention. Two recent cases from New York (USA) are illustrative. In the first, at least 5120 birds, mostly Red-winged Blackbirds (*Agelaius phoeniceus*), Common Grackles (*Quiscalus quiscula*) and Brownheaded Cowbirds (*Molothrus ater*) were killed by parathion (an organophosphate insecticide)-treated corn, which was distributed on a truck farm in mid-March. In the second, at least 3196 birds, mostly Common Grackles, Red-winged Blackbirds and European Starlings (*Sturnus vulgaris*), died after ingesting parathion-treated seed spread near unharvested field corn in late March. A Cooper's Hawk (*Accipiter cooperii*), two Red-tailed Hawks (*Buteo jamaicensis*) and an American Kestrel (*Falco sparverius*) were killed in these cases after consuming poisoned icterids. Small numbers of birds in six other species were also killed in these incidents.

S25) Storer, R.W. and G.L. Nuechterlein. 1992. Western and Clark's Grebe. In: The Birds of North America, No. 26. A. Poole, P. Stettenheim and F. Gill (eds.). Philadelphia: Academy of Natural Sciences; Washington, D.C. American Ornithologists' Union.

S26) Strickler-Shaw, S. and D.H. Taylor. 1990. Sublethal exposure to lead inhibits acquisition and retention of discriminate avoidance learning in Green Frog (*Rana clamitans*) tadpoles. Environ. Toxicol. Chem. 9(1); 47-52.

Keywords: behaviour, memory

S27) Stutchbury, B.J. and S. Rohwer. 1990. Molt patterns in the Tree Swallow (*Tachycineta bicolor*). Can. J. Zool. 68: 1468-1472.

S28) Sullivan, J. P. and S. M. Payne. 1988. Aspects of history and nestling mortality at a Great Blue Heron (*Ardea-herodias*) colony, Quetico Provincial Park, Ontario, Canada. Can. Field Nat. 102: 237-241.

Keywords: fish, food item, flight behavior, sibling rivalry, lake acidification, seasonality, population dynamics

S29) Swift, B.L., R.E. Foley and G.R. Batcheller. 1993. Organochlorines in Common Goldeneyes wintering in New York. Wildl. Soc. Bull. 21: 52-56.

Keywords: *Bucephala clangula*, polychlorinated biphenyls, DDE, human consumption, pesticide residues, contaminated food, water pollution, USA

S30) Szefer, P. and J. Falandysz. 1986. Trace metals in the bones of Scaup ducks (*Aythya marila*) wintering in Gdansk Bay, Poland Baltic Sea 1982-1983 and 1983-1984. Sci. Total Environ. 53: 193-200.

Keywords: trachea, sex difference, heavy metal pollution

S31) Szefer, P. and J. Falandysz. 1987. Trace metals in the soft tissues of Scaup ducks (*Aythya-marila*) wintering in Gdansk Bay, Baltic Sea. Sci. Total Environ. 65: 203-214.

Keywords: mollusk, kidney, liver, stomach, lung, bioconcentration, food chain, sex difference, iron, zinc, manganese, copper, lead, cadmium, cobalt, nickel

T1) Tarshis, I.B. and B.A. Rattner. 1982. Accumulation of 14C-Naphthalene in the tissues of Redhead ducks fed oil-contaminated crayfish. Arch. Environ. Contam. Toxicol. 11: 155-9.

Abstract: Crayfish, artificially contaminated with 14C-naphthalene-5% water-soluble fraction of No. 2 fuel oil, were force-fed to one-year-old Redhead ducks to determine the accumulation of petroleum hydrocarbons. The relative distribution of carbon-14 activity in the gall bladder containing bile, and fat were similar, and significantly greater (P less than 0.05) than the activity in the blood, brain, liver, and kidney. There was a significant increase (P less than 0.05) in the disintegrations per minute per gram (dpm/g) in the blood, brain, kidney, and liver between days 1 and 3 of feeding, indicating a progressive accumulation of carbon-14 activity (naphthalene and presumably its metabolites). There was no significant effect of sex or the interaction of the duration of feeding and sex on carbon-14 activity in any of the tissues. The low daily dose of petroleum hydrocarbons (a total of approximately 1.25 mg/day) received by the ducks from the crayfish and the relatively short feeding regimen did not cause any overt signs of toxicity in the ducks.

T2) Taylor, D.H., C.W. Steele and S. Strickler-Shaw. 1990. Responses of Green Frog (*Rana clamitans*) tadpoles to lead-polluted water. Environ. Toxicol. Chem. 9(1): 87-94.

Keywords: behaviour, locomotion, activity

T3) Titus, J.R. and L.W. VanDruff. 1981. Response of the Common Loon to recreational pressure in the Boundary Waters Canoe Area, northeastern Minnesota. Wildl. Monog. 79: 6-59.

Summary: A field study to evaluate the impact of outdoor recreationists upon nesting and brood rearing success of the Common Loon was conducted in the Boundary Waters Canoe Area of northeastern Minnesota during the 1975 and 1976 breeding season. Crews searched for nests, described and monitored known nests, checked on broods, and recorded the location and activity of recreationists in relation to the nesting territories. Nest site data were used to calculate indexes of human use, human impact, disturbance potential, visibility and vegetational cover. The conclusion is that human use of this wilderness area slightly reduces the nesting and brood rearing success of individual pairs in areas of high human impact but because of undisturbed loon pairs or pairs habituated to human use, the size of the adult breeding population during the past 25 years has not declined. The findings of this study should not be applied to loon populations in more developed areas.

T4) Tyler, S.J. 1992. A review of the likely causal pathways relating the reduced density of breeding Dippers *Cinclus cinclus* to the acidification of upland streams. Environ. Pollut. 78: 49-55.

Abstract: Previous work has shown that the breeding density of a bird characteristics of upland streams, the Dipper (*Cinclus cinclus*), is markedly reduced at low pH in both Wales and Scotland (UK). Populations also declined when streams became more acidic. Evidence of causal explantation for these relationships is that: (1) Food quantity is reduced in acidic streams, and important prey, including those rich in calcium, are scarce; (2) Blood chemistry in pre-breeding birds differs between acid and circumneutral streams, with plasma calcium reduced in those breeding at low pH. Skeletal sources of calcium are probably limited; (3) The time spent foraging by pre-breeding birds on acidic streams is markedly increased, even though overall energy costs on acidic streams is markedly increased, even though overall energy costs on acidic and circumneutral streams are similar. Body condition is inferior to birds on circumneutral streams are similar. Body condition is energy costs of acidic and circumneutral streams; (4) Egg laying is significantly delayed on acidic streams irrespective of and effect on laying of altitude, and clutch and brood sizes are significantly reduced; (5) Eggs on lighter and shells thinner at low pH; (6) Chick growth is reduced at low pH; (7) Contamination by heavy metals and persistent organochlorines is low in the population on acidic streams and cannot explain the impaired breeding performance. None of these features can exclude the possibilities that acidic streams either hold population of poor quality birds, which show the above features, or that acidity affairs the

breeding ecology of all dippers that attempt to breed at low pH. The qualitative outcome of these two alternatives is identical.

U1) Ulfvens, J. 1986. Mercury content in eggs of the Great-crested Grebe (*Podiceps cristatus*) and the Horned Grebe (*Podiceps auritus*) in the archipelago of Korsnas Gulf of Bothnia, Finland. Ornis. Fenn. 63: 92-93.

Keywords: pollution, food chain, breeding season, reproductive success

V1) Van, D.M.E., A.A. Blok and G.G. De. 1982. Winter starvation and mercury intoxication in Gray Herons (*Ardea cinerea*) in the Netherlands. Ardea 70: 173-184.

Abstract: A short cold spell in January and February, 1976 caused a marked mortality among wintering Grey Herons *Ardea cinerea* in the Netherlands. This resulted in the next breeding season in a 19% decrease of the population. Analysis of 41 specimens from the western part of the country revealed the presence of relatively high residues of Hg and Se. In at least 5% of the birds (those with more than 400 ppm) liver mercury residues alone were considered lethal. In 20% of the herons (those with mercury concentrations over 160 ppm) sublethal residues combined with stress from undernourishment and cold weather may have been fatal. The levels found varied widely: liver Hg 1.6-773, liver Se 1.5-23.2, kidney Hg 0.9-700, kidney Se 2.7-14.4 ppm (all values in ppm dry weight). Neither sex, age, condition or breeding experience correlated with residue levels. The accumulation largely took place between the last autumn molt and the cold period of January/February 1976 and was caused by local pollution. With one exception, all herons with more than 160 ppm mercury in the liver were found in a limited area in the north of Nood-Holland (region A). The residues occurring in other rural areas did not differ from those in industrialized regions. These generally remained below 100 ppm. The residues in herons from the northern part of Noord-Holland were 4 to 10 times higher than hitherto observed in other bird species in the Netherlands. The molar ratios of Hg and Se varied between 1 to 10 (kidney) and 15 to 1 (liver). The amount of Hg and Se in the kidney showed linear correlation. The relative amount of Se in the liver declined as the Hg level rose. In most herons both Hg and Se levels were higher in the liver than in the kidneys. The use of fungicides in agriculture was probably the primary source of the high Hg residues in the northern part of Noord-Holland.

V2) Van, D.B.M., F. Blank, C. Heeremans, H. Wagenaar and K. Olie. 1987. Presence of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in fish-eating birds and fish from the netherlands. Arch. Environ. Contam. Toxicol. 16: 149-158.

Keywords: *Phalacrocorax carbo, Ardea cinerea, Podiceps cristatus, Anguilla anguilla*, 2378 pentachlorodibenzofuran, 123678 hexachlorodibenzo-p-dioxin, food chain

V3) Vermeer K., W.J. Cretney, J.E. Elliott, R.J. Norstrom and P.E. Whitehead. 1993. Elevated Polychlorinated Dibenzodioxin and Dibenzofuran Concentrations in Grebes, Ducks and their prey near Port Alberni, British Columbia, Canada. Mar. Poll. Bull. 26(8): 431-435.

Abstract: In 1989, eight estuarine bird species were collected from the Somass River estuary, downstream of the Port Alberni Pulp and Paper Mill. Their livers were analysued for 2,3,7,8-substituted polychlorinated dibenzodioxin (PCDD) and polchlorinated dibenzofuran (PCDF) residues. All birds contained PCDD and PCDF residues, but the highest levels were found in Red-necked (*Podiceps grisegena*) and Western Grebes (*Aechmophorus occidentalis*). Elevated PCDD levels were also detected in *Corophium* amphipods collected in 1991 (present stomachs of most bird species examined) in estuary. The birds may have acquired the PCDDs and PCDFs from eating contaminated *Corophium*.

V4) Vickery, J. 1992. The reproductive success of the Dipper *Cinclus cinclus* in relation to the acidity of streams in south-west Scotland. Freshwater Biol. 28: 195-205.

Abstract: The breeding success of Dippers (*Cinclus cinclus*) was assessed in south-west Scotland over three years and related to the acidity of the streams along which they bred. At sites of high acidity, clutch and brood sizes were significantly smaller than those at sites of lower acidity. Egg weight and the incidence of second clutches increased significantly with pH, but there was no evidence to suggest an effect of acidity on hatching success. The rate at which food was delivered to individual nestlings was significantly lower at acidic than non-acidic sites. Nestling weights and survival were lower at more acidic sites. Reduced brood sizes, low nestling survival and the low incidence of second breeding attempts resulted in a significant reduction in total productivity (number of fledglings produced, per pair, per year) at acidic compared with non-acidic streams. It is suggested that pH-related differences in the invertebrate fauna of streams result in low prey availability for Dippers on acidic streams, leading to reduced productivity.

W1) Westall, M.A. 1988. Osprey. National Wildlife Federation. 0: 22-28.

Keywords: *Pandion haliaetus-carolinensis*, pesticide poisoning, artificial nesting program, distribution status, South Florida, Gulf Coast, Atlantic Coast, interior USA

W2) Wiberg, K., C. Rappe and P. Haglund. 1992. Analysis of bromo-, chloro- and mixed bromochlorodibenzo-p-dioxins and dibenzofurans in Salmon, Osprey and human milk. Chemosphere 24: 1431-1439.

Abstract: Muscle samples from Salmon and Osprey as well as human mothers milk were solvent extracted and cleaned up extensively by chemical digestion followed by chromatography on various adsorbents. Appropriate fractions were analyzed for brominated, chlorinated, and bromochlorinated dibenzo-p-dioxins and dibenzofurans (PBDD/F, PCDD/F and PXDD/F, respectively) by high-resolution gas chromatography/high-resolution mass spectrometry. PCDD/F were found in all samples analyzed, however in no cases were PBDD/F or PXDD/F detected despite low limits of detection, < 1 ppt in most cases.

W3) Wiemeyer, S.N. and E. Cromartie. 1981. Relationships between brain and carcass organo chlorine residues in Ospreys (*Pandion haliaetus*). Bull. Environ. Contam. Toxicol. 27: 499-505.

Keywords: P P' DDE Dieldrin,P P' DDD Heptachlor epoxide, polychlorinated biphenyl, fat, lip, death

W4) Wiemeyer, S.N., T.G. Lamont, C.M. Bunck, C.R. Sindelar, F.J. Gramlich, J.D. Fraser and M.A. Byrd. 1984. Organochlorine pesticide, polychlorobiphenyl and mercury residues in Bald Eagle (*Haliaeetus leucocephalus*) eggs, 1969-1979, and their relationships to shell thinning and reproduction. Arch. Environ. Contam. Toxicol. 13: 529-550.

Abstract: Bald Eagle (*Haliaeetus leucocephalus*) eggs were collected in 14 states (USA) in 1969-1979, and analyzed for organochlorine pesticides, polychlorobiphenyls and Hg. Moderate shell thinning occurred in eggs from several areas. Eggs from the Chesapeake Bay (Maryland, USA) area contained the highest residue levels of most organochlorines. DDE was detected in all eggs; other organochlorines were detected less frequently. Hg levels were highest in eggs from Maine (USA). Eight contaminants were significantly negatively correlated with shell thickness or reproduction at sampled breeding areas; DDE was most closely related to these factors. Production of young was near normal at breeding areas when DDE was : 3 ppm (wet wt); reproductive failure approached 100% for those breeding areas where DDE in eggs was >15 ppm. Five ppm DDE was associated with 10% shell thinning. The other contaminants that were associated with these factors were also highly correlated with DDE; their impact appeared minor in relation to those of DDE.

W5) Wiemeyer, S.N., S.K. Schmeling and A. Anderson. 1987. Environmental pollutant and necropsy data for Ospreys from the eastern United States, 1975-1982. J. Wildl. Dis. 23: 279-91.

Abstract: Twenty-three Ospreys (*Pandion haliaetus*) found dead or moribund in the eastern United States during 1975-1982 were necropsied and selected tissues were analyzed for organochlorines and metals. Major causes or factors contributing to death were trauma, impact injuries, and emaciation. DDE was detected in 96% of the osprey carcases, DDD in 65%, DDT and heptachlor epoxide in 13%, dieldrin, oxychlordane, and cis-nonachlor in 35%, cis-chlordane in 52%, trans-nonachlor in 45%, and PCB's in 83%. Carcasses of immature Ospreys from the Chesapeake Bay had significantly lower concentrations of DDE, DDD + DDT, cis-chlordane, and PCB's than carcasses of adults from the same area. Concentrations of some organochlorines in Ospreys from the Chesapeake Bay declined significantly from 1971-1973 to 1975-1982. Significant differences in concentrations of certain metals in the ospreys' livers were noted between time periods, and sex and age groups for birds from the Chesapeake Bay. During 1975-1982, adults had significantly lower concentrations of chromium, copper, and arsenic than immatures and nestlings, and adult males had higher mercury concentrations than adult females. Adult females had lower zinc concentrations in 1975-1982 than in 1971-1973. Immatures and nestlings had higher concentrations of chromium and lead in 1975-1982 than in 1971-1973. A slightly elevated concentration of chromium (1.7 ppm) or arsenic (3.2 ppm) was found in the livers of individual ospreys. Several Ospreys had elevated concentrations of mercury in their livers; two Ospreys had more than 20 ppm which may have contributed to their deaths.

W6) Wiemeyer, S.N., C.M. Bunck and A.J. Krynitsky. 1988. Organochlorine pesticides polychlorinated biphenyls and mercury in Osprey eggs 1970-1979 and their relationships to shell thinning and productivity. Arch. Environ. Contam. Toxicol. 17: 767-788.

Keywords: *Pandion haliaetus*, environmental pollution, DDE, DDD, DDT, monitoring, insecticide, bioindicator

W7) Wiemeyer, S.N., C.M. Bunck and C.J. Stafford. 1993. Environmental contaminants in Bald Eagle eggs: 1980-1984 and further interpretations of relationships to productivity and shell thickness. Arch. Environ. Contam. Toxicol. 24(2): 213-227.

Abstract: Bald Eagle (*Haliaeetus leucocephalus*) eggs were collected in 15 states in the United States in 1980-84 and analyzed for organochlorine pesticides, polychlorinated biphenyl (PCBs), and mercury. Data were compared and combined with data from earlier studies to examine trends and refine relationships of contaminants to shell thickness and young production. Moderate shell thinning occurred in eggs from several states. The frequency of occurrence of detectable residues of several contaminants declined during 1969-84. DDE concentrations declined significantly in Wisconsin, Maine, and the Chesapeake Bay region (USA). Some other contaminant residues declined, but usually not significantly. During

1980-84, DDE, PCB, and mercury concentrations were highest in eggs from Maine, whereas most contaminant concentrations were lowest in eggs from Arizona. DDE was most closely related to shell thickness and young production at sampled breeding areas. Fifteen percent shell thinning was associated with 16 mu-g/g DDE (wet wt) for eggs collected early in incubation. Young production was normal when eggs at sampled breeding areas contained lt 3.6 mu-g/g DDE (wet wt), was nearly halved between 3.6 to 6.3 mu-g/g, and halved again when concentrations exceeded 6.3 mu-g/g. Several other contaminants were also associated with poor reproduction and eggshell thinning; however, their impact appeared to be secondary to that of DDE and was probably related to their high correlation with DDE. Data relating contaminant concentrations to mean 5-year production are applicable only to breeding areas where eggs are collected after failure to hatch, because such breeding areas are not representative of all nesting bald eagles in a given population.

W8) Williamson, S.C., C.L. Armour, G.W. Kinser, S.L. Funderburk and T.N. Hall. 1987. Cumulative impacts assessment an application to Chesapeake Bay USA. McCabe, R.E.0: 377-388.

Keywords: Canvasback Duck, vegetation, environmental quality

W9) Winkler, D.W. 1993. Use and importance of feathers as nest lining in Tree Swallows (*Tachycineta bicolor*). The Auk. 110(1):29-36.

W10) Wobeser, G., N.O. Nielsen and B. Schiefer. 1976a. Mercury and mink I. Use of mercury-contaminated fish as a food for Ranch Mink intoxication. Can. J. Comp. Med. 40: 30-33.

W11) Wobeser, G., N.O. Nielsen and B. Schiefer. 1976b. Mercury and mink II. Experimental methyl mercury intoxication. Can. J. Comp. Med. 40: 34-45.

W12) Wood, C.C. and C.M. Hand. 1985. Food-searching behaviour of the Common Merganser (*Mergus merganser*) I: Functional responses to prey and predator density. Can. J. Zool. 63: 1260-1270

W13) Wren, C.D. 1991. Cause-effect linkages between chemicals and populations of Mink (*Mustela vison*) and Otter (*Lutra canadensis*) in the Great Lakes basin. J. Toxicol. Environ. Health 33(4):549-85.

Abstract: Following outbreaks of reproductive failure in commercial ranching operations, laboratory experiments showed that mink are extremely sensitive to organochlorine chemicals, particularly PCBs and dioxins. The purpose of this paper is to test the hypothesis that, since wild mink are exposed to these compounds through consumption of Great Lakes fish, they might exhibit reproductive dysfunction and population declines. The otter, another piscivorous animal, should show the same effects. The available information is reviewed according to five

epidemiological criteria. Harvest data are presented as a surrogate for the population status of mink and otters in certain locations around the Great Lakes. Data from Ohio show that the mink harvest between 1982 and 1987 from contaminated counties bordering Lake Erie was consistently lower (380 animals per year) than those from counties removed from Lake Erie (850 animals per year), suggesting an effect of chemicals on the status of mink populations. Preliminary studies from Ontario also suggest that mink harvest is lower in potentially high PCB exposure areas compared with lower exposure areas. Evidence is also presented on the harvest data for otters taken from four New York State counties adjacent to Lake Ontario and the St. Lawrence River. The harvest data from these four counties show that between 1960 and early 1970 otter harvest remained stable but has since increased. Increased harvest is consistent with improved water quality in Lake Ontario during the past 15 yr. Data relating to strength of association between chemicals and populations of mink and otter are weak and need to be further analyzed. The specificity of the effects of the chemicals on mink reproduction and mortality is well established from toxicological experiments, but there is poor resolution of the information on effects using field data. The strongest case for a causal relationship comes from consideration of the coherence criterion. In conclusion, before a causal link can be drawn between the status of mink and otter populations and exposure to organochlorine chemicals from the Great Lakes, a large amount of research and data analysis needs to be undertaken.

W14) Wren, C.D., P.M. Stokes and K.L. Fischer. 1986. Mercury levels in Ontario Canada Mink and Otter relative to food levels and environmental acidification. Can. J. Zool. 64: 2854-2859.

Keywords: fish, crayfish, diet, heavy metal, pollution, bioindicator, trophic transfer, bioaccumulation, residue study

W15) Wren, C.D., D.B. Hunter, J.F. Leatherland and P.M. Stokes. 1987a. The effects of polychlorinated biphenyls and methylmercury, singly and in combination on mink. II: Reproduction and kit development. Arch. Environ. Contam. Toxicol. 16: 449-454.

W16) Wren, C.D., D.B. Hunter, J.F. Leatherland and P.M. Stokes. 1987b. The effects of polychlorinated biphenyls and methylmercury, singly and in combination, on mink. I: Uptake and toxic responses. Arch. Environ. Contam. Toxicol. 16: 441-447.

Keywords: methylmercury, mink, lab feed study

W17) Wren, C.D., Fischer K.L. and P.M. Stokes. 1988. Levels of lead, cadmium and other elements in Mink and Otter from Ontario, Canada. Environ. Pollut. 52: 193-202.

Abstract: Concentrations of Pb, Cd, Cu, Ni, Fe, Zn, Mn, Ca, P, Mg, and S were measured in tissues of Mink (*Mustela vison*) and River Otter (*Lutra canadensis*) from five areas of Ontario, Canada. Bone Pb levels in both species were lowest in animlas from collection sites most remote from industrial activity and atmospheric deposition pollutants. Mean liver and kidney Cd levels were also different between collection sites and may reflect natural and/or anthropogenic sources. Copper levels in liver were elevated in both species from the heavily Cu-contaminanted Sudbury region. However, tissue levels did not reflect environmental loading of other metals, such as Fe, Ni and Zn, in the Sudbury area. This may be a function of effective homeostatic regulation in mammals, or low potential for biomagnification of these elements.

Z1) Zach, R. and K.R. Mayoh. 1986. Gamma irradiation of Tree swallow (*Tachycineta bicolor*) embryos and subsequent growth and survival. Condor 88: 1-10.

Abstract: Tree Swallow (*Tachycineta bicolor*) eggs from 35 nests, 7 to 8 days into incubation, were acutely exposed to gamma-radiation doses of about 0.4, 0.8, 1.6 or 3.2 Gy in the laboratory. The naturally incubated eggs were hatched in the laboratory and the young returned to the nests for raising by parents. Transport controls were treated identically, but not irradiated; box controls were left undisturbed in the nests. The overall mean hatching and fledging successes were 92.8% and 71.8%, respectively, predation and harsh weather. Observed statistics and fitted parameters from the Richards model both indicated depressed growth in the 1.6-Gy and 3.2-Gy nestlings. Radiation exposure increased incubation time and depressed body mass and foot and primary-feather lengths at fledging. Box controls had shorter incubation times and greater hatching body masses than transport controls, suggesting experimental stress factors other than radiation exposure. Data from a few nests showed that chronic doses of about 1.0 Gy but not fledging, success. It also depresses growth far more severely than a 3.2-Gy acute dose. Since Tree Swallow embryos appear to be less sensitive to external gamma-radiation exposure than man, existing protective measures for man should be satisfactory for birds.

Z2) Zach, R., J.L. Hawkins and S.C. Sheppard. 1993. Effects of ionizing radiation on breeding swallows at current radiation protection standards. Environ. Toxicol. Chem. 12: 779-786.

Abstract: A field study was carried out involving breeding Tree Swallows (*Tachycineta bicolor*) to see whether human protection standards are adequate for birds, as implied by an International Commission on

Radiological Protection 1977 assumption. The swallows were provided with a grid of nest boxes with radiation levels up to 45 times the background level, or 6 muGy/h. Swallows were permitted to settle freely in the boxes for breeding, regardless of radiation level. The breeding performance was exceptionally high and was not influenced by experimental radiation exposure. The results were similar for the growth performance of nestlings. Thus numerous, apparently healthy, young were raised to fledging in a radiation environment that corresponded to an annual dose of up to 50 mSv, which is the current limit for human occupational exposure. The corresponding limit for the public is lower, at 5 mSv/a. The results show that swallows are not affected during the nesting season by radiation doses above the limits for humans, provided birds and humans share a similar radiation environment.

Z3) Zicus, M.C., M.A. Briggs and R.M. Pace III. 1988. DDE, PCB and mercury residues in Minnesota Common Goldeneye and Hooded Merganser eggs 1981. Can. J. Zool. 66: 1871-1876.

Keywords: *Lophodytes cucullatus, Bucephala clangula, Aix sponsa*, eggshell, DDT, pesticide, polychlorinated biphenyls, mortality, Ratcliffe index

Z4) Zinkl, J., D.A. Jessup, A.I. Bischoff, T.E. Lew and E.B. Whelldon. 1981. Fenthion poisoning of wading birds. J. Wildl. Dis. 17: 117-120.

Abstract: Low brain and serum cholinesterase activity were found in several species of wading birds (*Egretta thula, Casmerodius albus, Ardea herodias*). The area from which these birds were taken had recently been sprayed with the organophosphorous insecticide fenthion (O, O-dimethyl O-(4-(methylthio)-m - tolyl) phosphorothioate). Analysis of stomach contents and water samples revealed residues of fenthion. Fenthion caused lethal cholinesterase depression.