

THE HEALTH STATUS OF WATERFOWL
POPULATIONS IN A DESIGNATED AGRICULTURAL
AREA OF THE FRASER DELTA - 1980

by

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PREFACE

This study was jointly sponsored by the B. C. Ministry of Environment, Fish and Wildlife Branch; the B. C. Ministry of Agriculture and Food, Crop Protection Branch; and the Canadian Wildlife Service, Delta.

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ABSTRACT

Aerial and ground surveys were conducted on agricultural land of the Fraser River Delta, British Columbia, Canada, between October, 1980 and March, 1981 to determine the effects of agricultural practices on health of waterfowl. No duck kills attributable to agricultural practices were detected (one hawk was recovered dead with a high level of fensulfothion insecticide in its gut). Ten times more ducks fed on fields at night than during the day. Fields in the Municipality of Surrey were more heavily used by ducks than fields in the Municipalities of Delta or Richmond. No organophosphate and only trace amounts of organochlorine pesticides were detected in bird tissues but lead, copper and cadmium levels in some bird tissues were high.

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¹The appendices are not included with this report. To view the appendices please contact the B.C. Ministry of Environment library in Victoria.

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1.0 INTRODUCTION

The Fraser River delta is a major stop-over area for migratory waterfowl of the Pacific flyway. During fall migration, over 100,000 waterfowl may be found in the saltwater bays, foreshore and lowlands of the delta (Burgess, 1970).¹ Approximately half this number will remain in the area throughout the winter. When food sources are depleted on the bays and foreshores they can move onto the agricultural fields to feed.

The Fraser River delta and floodplains of the Nicomekl and Serpentine Rivers are primarily agricultural land. Agricultural practices attempt maximum crop production here year round. Insecticides used in crop protection play an important role in achieving the high quantity and quality of produce grown.

During the past eight years, there have been six major duck kills in the Fraser River delta area attributable to agricultural insecticides. In the years 1973, 1974, 1975 and 1977, 1,400 ducks, mostly Mallards, Pintails, Wigeons and Green-winged Teals, were poisoned by the misuse of the insecticide carbofuran in potato and turnip fields. In 1979, approximately 120 Mallards, Pintails and Green-winged Teal were killed by the misuse of fensulfothion.

¹Burgess, T. E., 1970. Foods and Habitat of Four Anatinids Wintering of the Fraser Delta Tidal Marshes. M.Sc. Thesis, University of British Columbia.

This study was initiated in response to these duck kills to assess the health status of the Fraser delta waterfowl. An attempt has been made to understand the circumstances by which an insecticide may become a hazard to ducks and how that hazard may be reduced.

2.0 OBJECTIVES

The purpose of this study was to more fully understand the relationship between bird mortality and agricultural practices in the Fraser River delta. The specific objectives were:

- to determine the number and distribution of waterfowl within the study area during fall migration and winter.
- to determine the extent and cause of bird mortality.
- to study the feeding behavior and movement patterns of waterfowl.
- to determine which commonly used insecticides may pose a hazard to waterfowl.
- to determine the pattern of insecticide use within the study area.
- to determine insecticide residue levels in soil, water and vegetation.
- to determine the general state of health of birds in the study area and specifically to assess background levels of pesticides and heavy metal residues in bird tissues.
- to determine the efficacy of some waterfowl scare devices.

3.0 THE STUDY AREA

The study area consisted of the lowlands, foreshore, and intertidal areas of the Municipalities of Surrey, Delta and Richmond (Figure 1).

Areas of Surrey included the lowlands of the Serpentine and Nicomekl Rivers and the foreshore and waters of Mud Bay. Areas of Delta included Westham Island, the foreshores and waters of Boundary Bay and Ladner. Areas of Richmond included the lowlands south of the Steveston Highway.

The entire study area was surveyed regularly by aircraft. More intensive ground monitoring of agricultural fields was carried out in Richmond, Westham Island, and Ladner only.

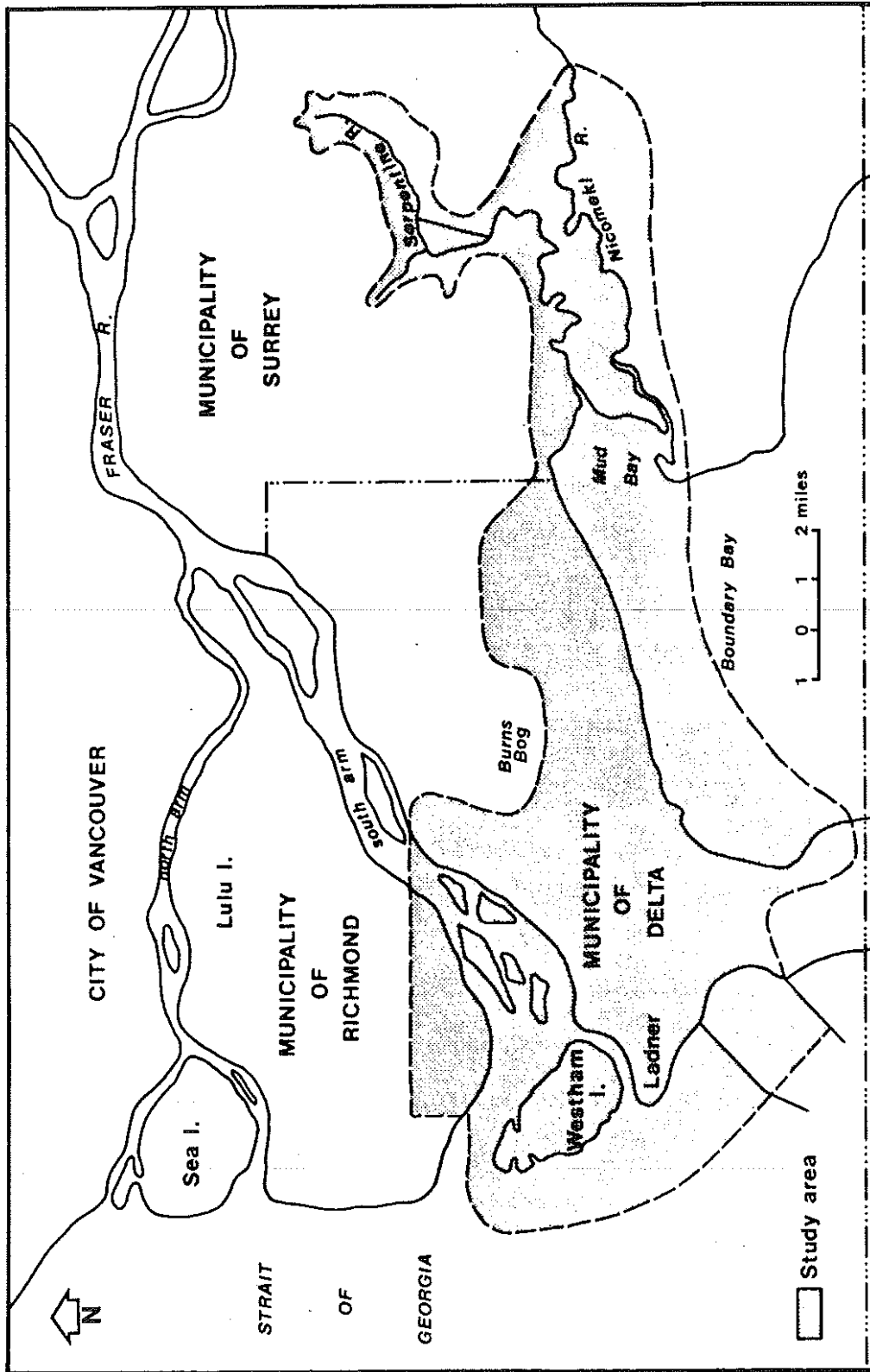


Figure 1. THE STUDY AREA

4.0 STUDY METHODS

Study methods are presented as two parts, waterfowl studies and insecticide studies. These are outlined in turn:

4.1 WATERFOWL STUDIES

The waterfowl studies involved field surveys, observation of waterfowl behavior and assessment of waterfowl scare techniques.

4.1.1 Field Surveys

Fields were surveyed to determine waterfowl numbers and distributions and to locate bird kills. Aerial and ground surveys were used; the combination provided both extensive and intensive monitoring of the study area.

Aerial Surveys: The aerial surveys covered Boundary Bay, Roberts Bank, and the lowland agricultural fields of south Richmond, Delta and Surrey. The area was flown twice weekly, weather permitting, from October 15, 1980 through March 9, 1981, using a high-wing aircraft. The flight route is shown in Figure 2. The surveys were flown at a ground speed of approximately 145 kmh and at an altitude of 80 meters over water and 150 meters over agricultural land. Waterfowl numbers, locations and field types were noted.

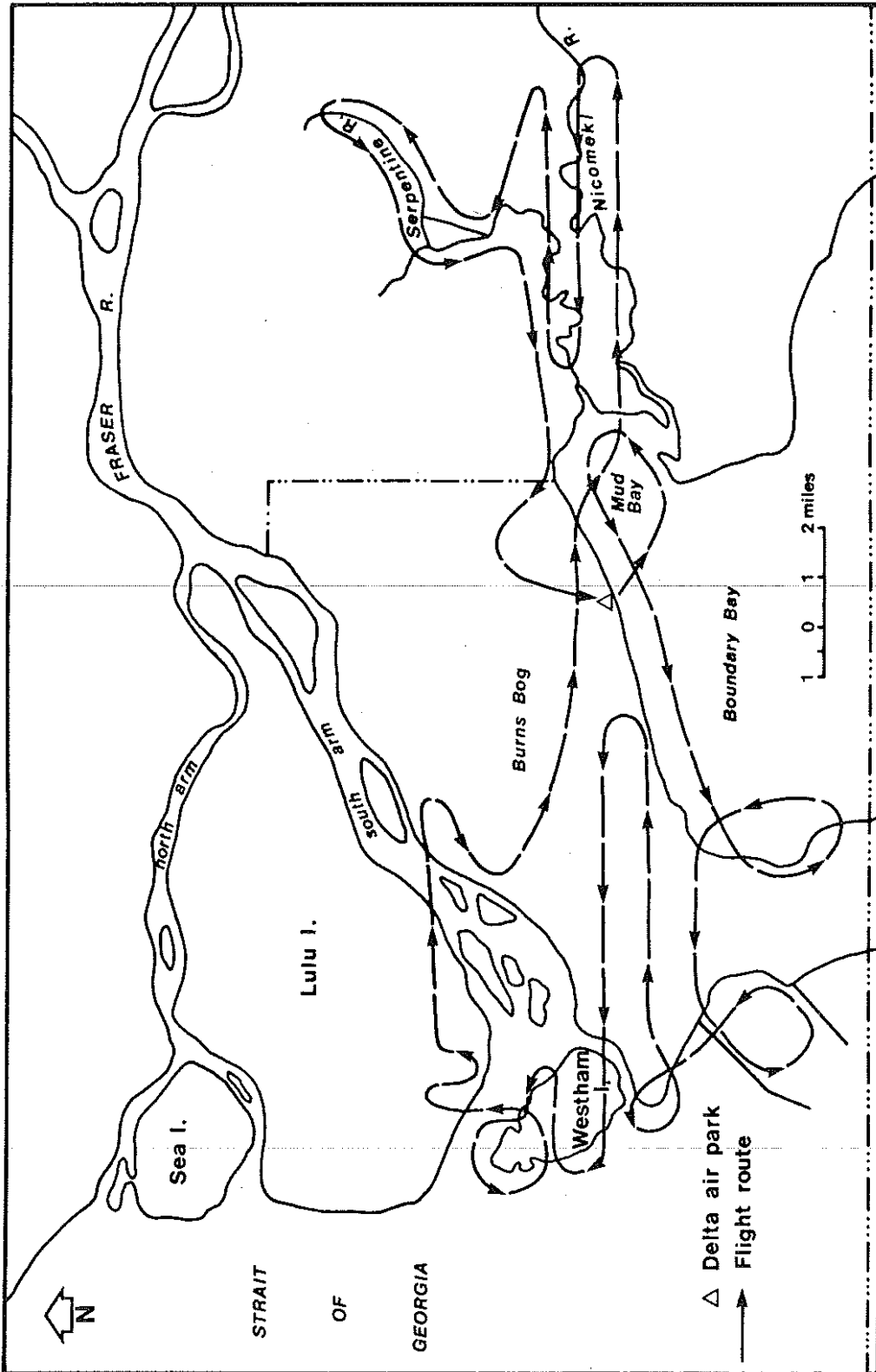


Figure 2. THE AERIAL CENSUS ROUTE

Identification of duck species was not possible during aerial surveys due to flight altitudes and distance of flocks. Boundary Bay and Roberts Bank counts tallied birds as being either swan, Canada goose, snow goose, or waterfowl (which included dabbling and diving ducks, coots and scoters). Agricultural field counts tallied birds as being swan, Canada goose, snow goose, or ducks (dabblers).

Estimates of waterfowl numbers and location of flocks on Boundary Bay and Roberts Bank were noted directly onto maps. The location of each sighting on agricultural fields was numbered on a flight map and the corresponding estimate and field type recorded on tape. Flight tapes were transcribed following each flight.

The locations of feather clusters were noted and later ground checked to determine the species of the bird killed.

Ground Surveys: Ground surveys were carried out to provide information concerning day and night agricultural field use by waterfowl and to locate bird kills.

Day field surveys of waterfowl were conducted between December 1980, and February 1981, along a specified route (Appendix 1). This route was planned to provide a wide coverage of field types within south Richmond and west Delta.

Waterfowl counts were made using a Bushnell Spacemaster II Zoom 20X-45X spotting scope. Observations recorded were field location and type, and waterfowl numbers. Field locations were numbered on a route map and a corresponding data sheet with field type and waterfowl number was attached.

Night field surveys were made with two observers, each with a powerful, hand-held spotlight. A vehicle was driven along the survey route at approximately 20 kmh while the fields on both sides were scanned. The field location, field type, and number of waterfowl observed were recorded. The effective scanning distance using spotlights was up to 180 meters.

The search for bird kills was carried out randomly and occasionally by the field technician, retriever dogs and local hunting and naturalist groups. Agricultural fields were systematically searched on foot and any evidence of waterfowl use and mortality was noted. Labrador retrievers were used to intensively search agricultural fields in south Richmond and Delta. Fields selected for these searches were usually covered with thick crop stubble. Eleven local hunting clubs and naturalist groups were notified of the study and asked to report any waterfowl or raptor kills. A copy of this letter and a list of the clubs contacted are given in Appendix 3.

4.1.2 Waterfowl Behavior

The behavior of waterfowl on agricultural fields was studied to determine feeding habits and movement patterns. Observations were made throughout the study period in Richmond and Delta.

Feeding behavior was observed during the day and night. Day observations were made using the 20X-45X spotting scope, a Smith and Wesson Star-Tron Night Vision Scope was used for night observations. Field types and food materials eaten were recorded. A cannon net and cloverleaf trap were used to capture birds for crop and gizzard analyses. Crippled birds found on fields were also retrieved for analysis.

Waterfowl movement within the study area was determined from field observations and bird marking studies. The field observations were made during the day and night ground surveys and aerial surveys described in Section 4.1.1. As well, ducks were trapped in a cloverleaf trap, leg banded, wing tagged, and released at the capture site. Wing tags were fluorescent red or yellow flagging tape attached to the base of the wing by knotting, stapling, looping, or some combination. Left or right wings and red or yellow tags were used to distinguish fields and dates of capture. Searches were made of Richmond and Delta to locate tagged birds.

4.1.3 Waterfowl Scare Devices

The efficacy of several devices for preventing waterfowl from landing on agricultural fields was assessed. Some of these were tried by growers and others were tested by the field technician. Devices evaluated by growers included rifles, cracker shells, propane exploder cannons, scarecrows, and fencing. The field technician evaluated streamers and reflectors, and flashing lights.

4.2 INSECTICIDE STUDIES

The insecticide studies involved the determination of soil insecticides in use, insecticide residue levels in soil, water and vegetation, and general state of health of waterfowl.

4.2.1 Determination of Soil Insecticides Used

Grower interviews in Delta and Richmond were conducted to determine which insecticides were used in the study area. A list of growers was supplied by the B.C.M.A.F. and is given in Appendix 4.

4.2.2 Determination of Insecticide Residue Levels

Soil, water and vegetation samples were collected from fields in Richmond and Delta to determine insecticide residue levels. These fields were selected on the basis of insecticide treatment histories and expected or observed waterfowl use. Most of this information was obtained from grower interviews.

Soil samples were collected using a soil auger. Cores, 15 x 25 cm, were taken from within rows every ten paces along a route that transected the field several times, crossway to the rows. The soil was air dried until it could be mixed thoroughly and a one-half kilogram sub-sample was taken for analyses. Samples were submitted to the B. C. Environmental Laboratory located at the University of British Columbia for insecticide residue analyses.

Composite 3.8 litre samples of field and ditch water were collected for insecticide residue analyses at the B. C. Environmental Lab.

Individual and composite samples of various types of vegetation from several fields were submitted for insecticide analyses at the B. C. Environmental Laboratory.

4.2.3 Determination of General State of Health of Waterfowl

Groups of waterfowl were sampled throughout the study period and submitted for postmortem examination and tissue analysis to determine the general health of the birds and the background levels of insecticides and heavy metals in their tissues. Birds submitted for postmortem analyses were:

(1) normal birds, 4-6 birds per group, sacrificed in September, December, January and February, and (2) dead or crippled birds found within the study area.

Bird specimens submitted for laboratory analyses were tagged as described in Appendix 5. Postmortem analyses were performed at the BCMAF Abbotsford Veterinary Laboratory and at the Agriculture Canada Animal Pathology Laboratory. Heavy metal analyses was carried out at the Abbotsford Veterinary Laboratory and at the Environmental Laboratory. Insecticide analyses was undertaken at the B. C. Environmental Laboratory.

5.0 RESULTS AND DISCUSSION

5.1 WATERFOWL STUDIES

5.1.1 Waterfowl Number and Distribution

Aerial surveys: Twenty-eight aerial surveys were attempted between October 15, 1980 and March 9, 1981. Seven were only partly completed due to weather. The Boundary Bay surveys are presented in Appendix 6, the Roberts Bank surveys in Appendix 7, and the agricultural field surveys in Appendix 8. The aerial survey results are tabulated in Appendix 9. About 80,000 - 90,000 waterfowl were estimated to be in the study area on any one day between October 1980 and March 1981. This included both dabbling and diving ducks, although divers likely made up less than 10% of the total since flight surveys over Boundary Bay and Roberts Bank were made close to shore.

The proportion of waterfowl on agricultural land compared to the total is summarized in Table I. Figure 3 illustrates these proportions. Between October and mid-February there was about 4,000 - 5,000 dabbling ducks on agricultural fields during the day, the number increased to 20,000 - 25,000 between February 16 and March 9 during the day. The increase was probably related to the close of duck hunting season in the Lower Mainland at the end of January.

TABLE I THE PROPORTION OF WATERFOWL OBSERVED ON AGRICULTURAL LAND EXPRESSED AS A PERCENTAGE OF THE TOTAL OBSERVED DURING AERIAL COUNTS FROM OCTOBER, 1980 TO MARCH, 1981

| DATE | TOTAL WATER- FOWL OBSERVED | PERCENT ON AGRICULTURAL FIELDS |
|-------------|-------------------------------|-----------------------------------|
| October 27 | 69,600 | 0 |
| 30 | 33,732 | 1 |
| November 5 | 105,760 | 1 |
| 11 | 106,320 | 2 |
| December 12 | 89,250 | 8 |
| 15 | 92,405 | 5 |
| 18 | 111,505 | 7 |
| 23 | 108,884 | 3 |
| January 6 | 70,945 | 10 |
| 9 | 91,600 | 9 |
| 13 | 69,850 | 4 |
| 19 | 106,364 | 2 |
| 24 | 112,870 | 1 |
| 27 | 84,465 | 4 |
| February 3 | 73,098 | 10 |
| 6 | 79,050 | 6 |
| 10 | 58,345 | 5 |
| 16 | 87,670 | 24 |
| 20 | 79,185 | 31 |
| 26 | 124,785 | 29 |
| March 9 | 69,580 | 22 |

Oct. 27 - Feb. 10

\bar{X} = 4.6

S.D. = 3.3

VAR. = 10.2

n = 17

Feb. 16 - Mar. 9

\bar{X} = 26.5

S.D. = 4.2

VAR. = 13.3

n = 4

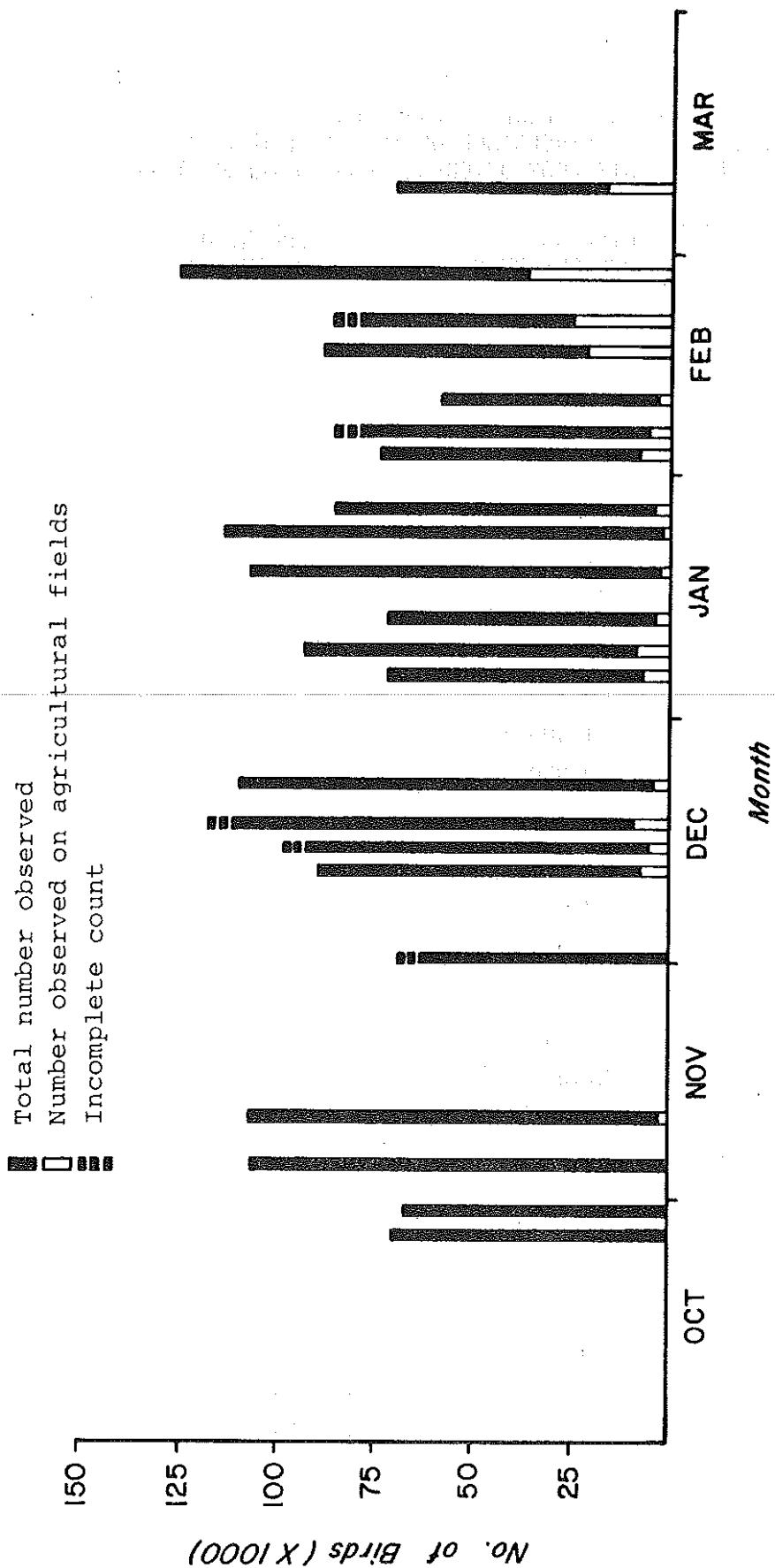


Figure 3. TOTAL NUMBER OF WATERFOWL OBSERVED WITHIN STUDY AREA AND PROPORTION OBSERVED ON AGRICULTURAL FIELDS DURING AERIAL FLIGHTS FROM OCTOBER, 1980 TO MARCH, 1981.

Appendix 10 outlines the distribution of dabbling ducks sighted on agricultural land in Richmond, Delta, and Surrey as a percentage of the total number observed during aerial surveys. The actual numbers sighted on the agricultural fields in Richmond, Delta and Surrey are graphed in figures 4, 5 and 6. During the day, approximately 85% of the waterfowl were on Boundary Bay and Roberts Bank, (60% on Boundary Bay, 25% on Roberts Bank). Ten percent were located on wildlife sanctuaries (Alaksen, Serpentine Fen), and 5% were on agricultural land.

Figure 7 illustrates the relative numbers of dabbling ducks observed on the agricultural fields in Richmond, Delta and Surrey from November through February. Figure 8 outlines the accumulated sightings of waterfowl in fields during aerial surveys from October 1, 1980 to March 31, 1981. An average of 55% of ducks sighted on agricultural fields occurred in Surrey, 32% in Delta, and 13% in Richmond. Bird use of agricultural fields in Surrey and Delta increased after mid-February, whereas use of fields in Richmond declined. This was probably a result of B.C. Hydro crews working in an area of high waterfowl use in Richmond. Westham Island (excluding Alaksen wildlife area) received little waterfowl use during the day.

Reasons for Surrey fields receiving the majority of duck use may include more standing field water, more worked fields

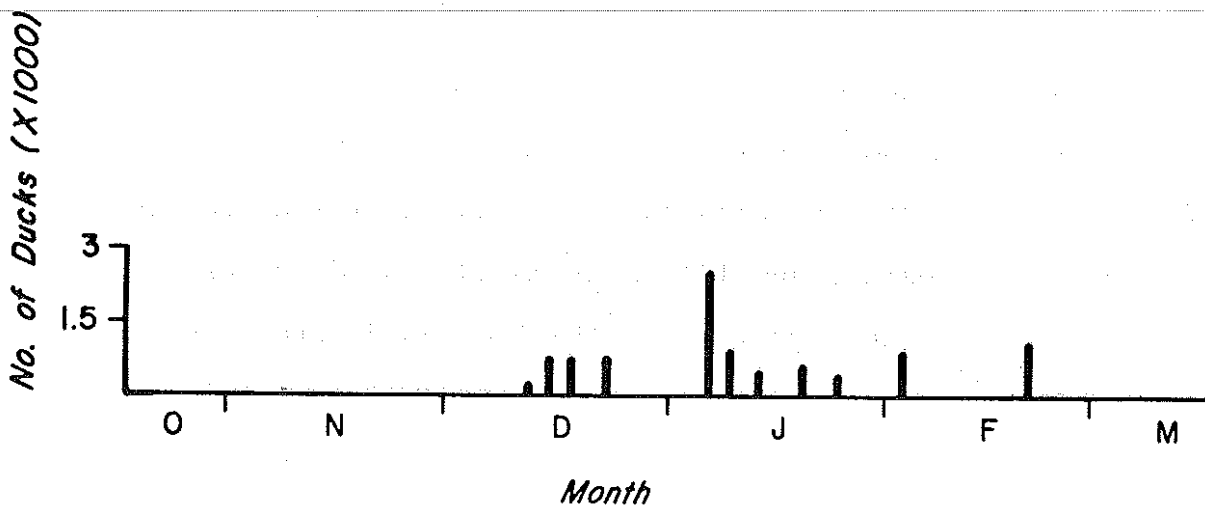


Figure 4.

AERIAL COUNTS OF DABBLING DUCKS ON AGRICULTURAL FIELDS IN RICHMOND FROM OCTOBER 1, 1980 TO MARCH 31, 1981.

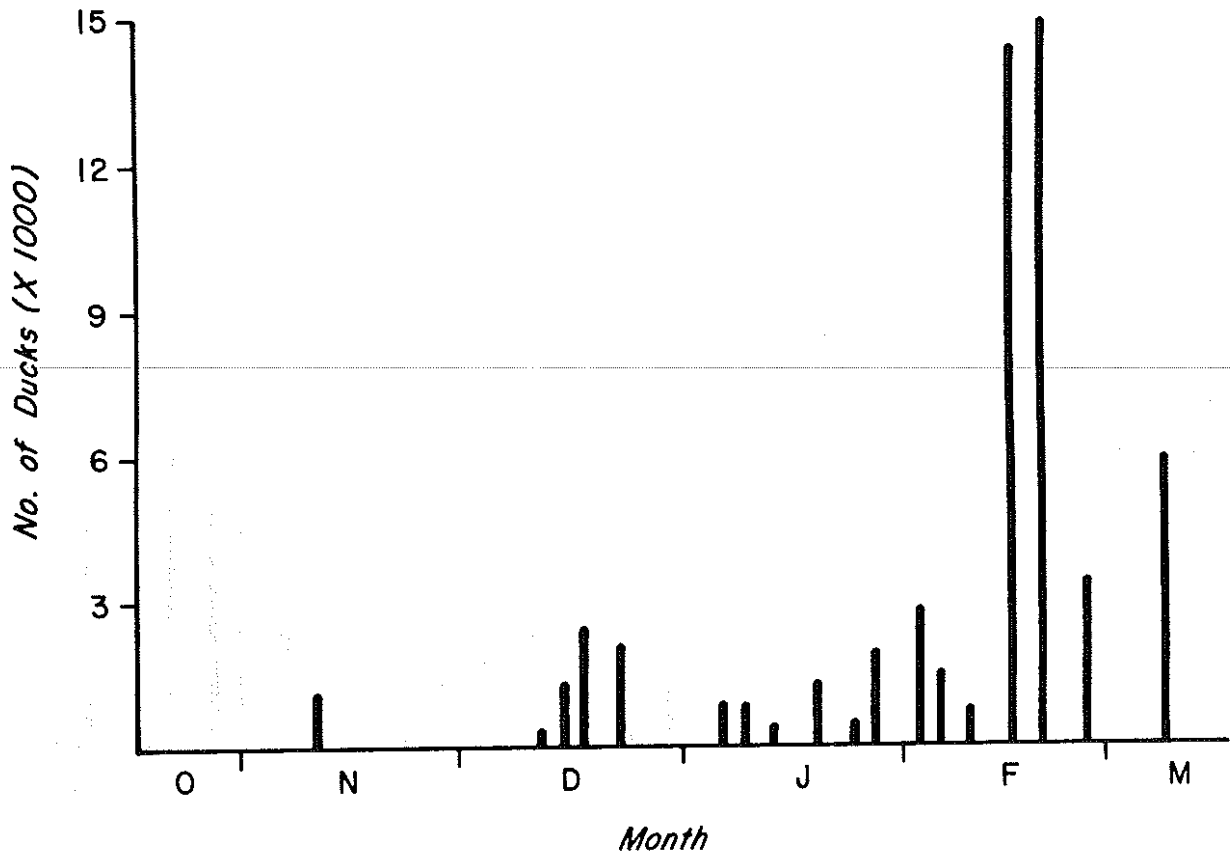


Figure 5.

AERIAL COUNTS OF DABBLING DUCKS ON AGRICULTURAL FIELDS IN DELTA FROM OCTOBER 1, 1980 TO MARCH 31, 1981.

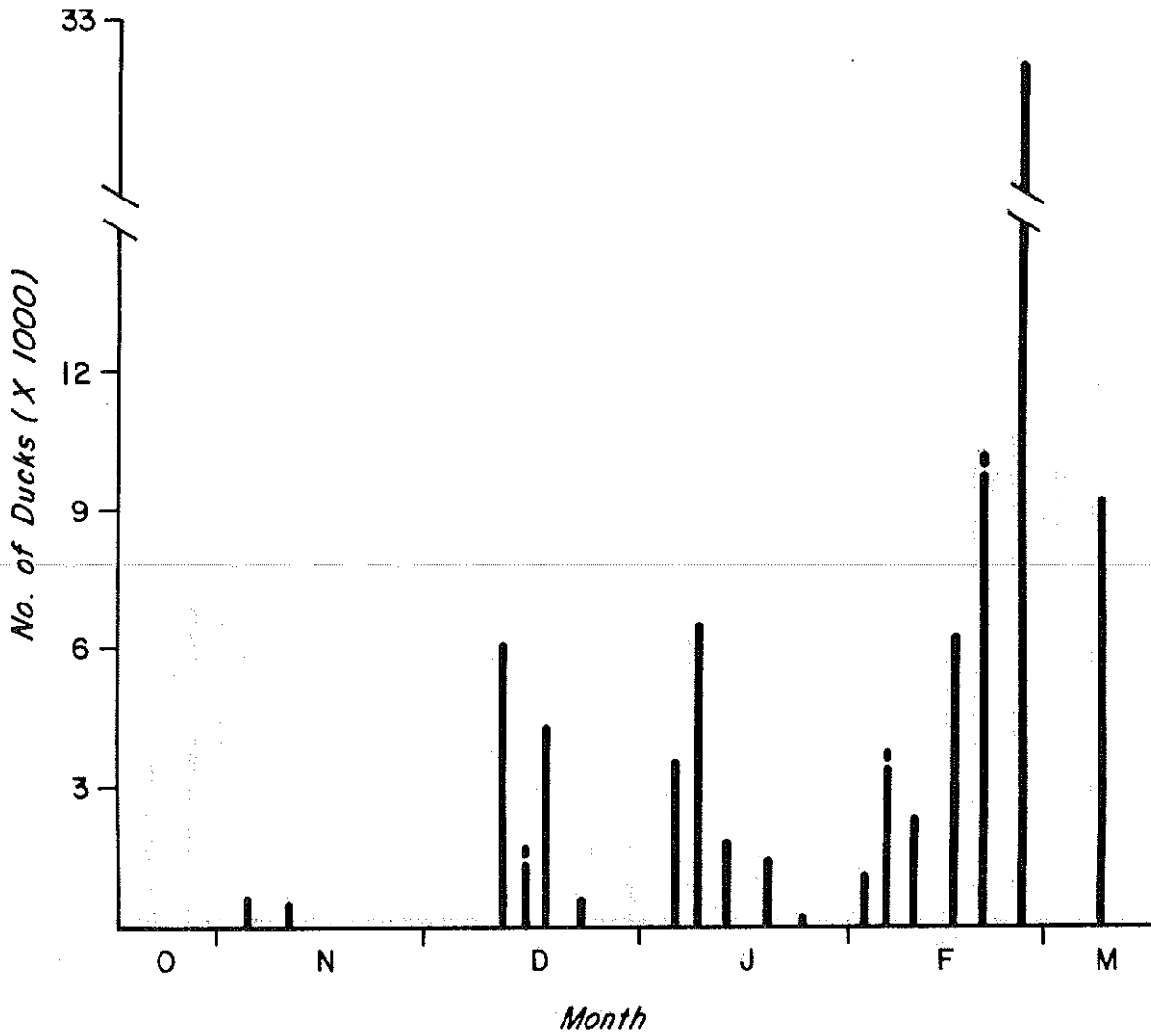


Figure 6.

AERIAL COUNTS OF DABBLING DUCKS ON AGRICULTURAL FIELDS IN SURREY FROM OCTOBER 1, 1980 TO MARCH 31, 1981.

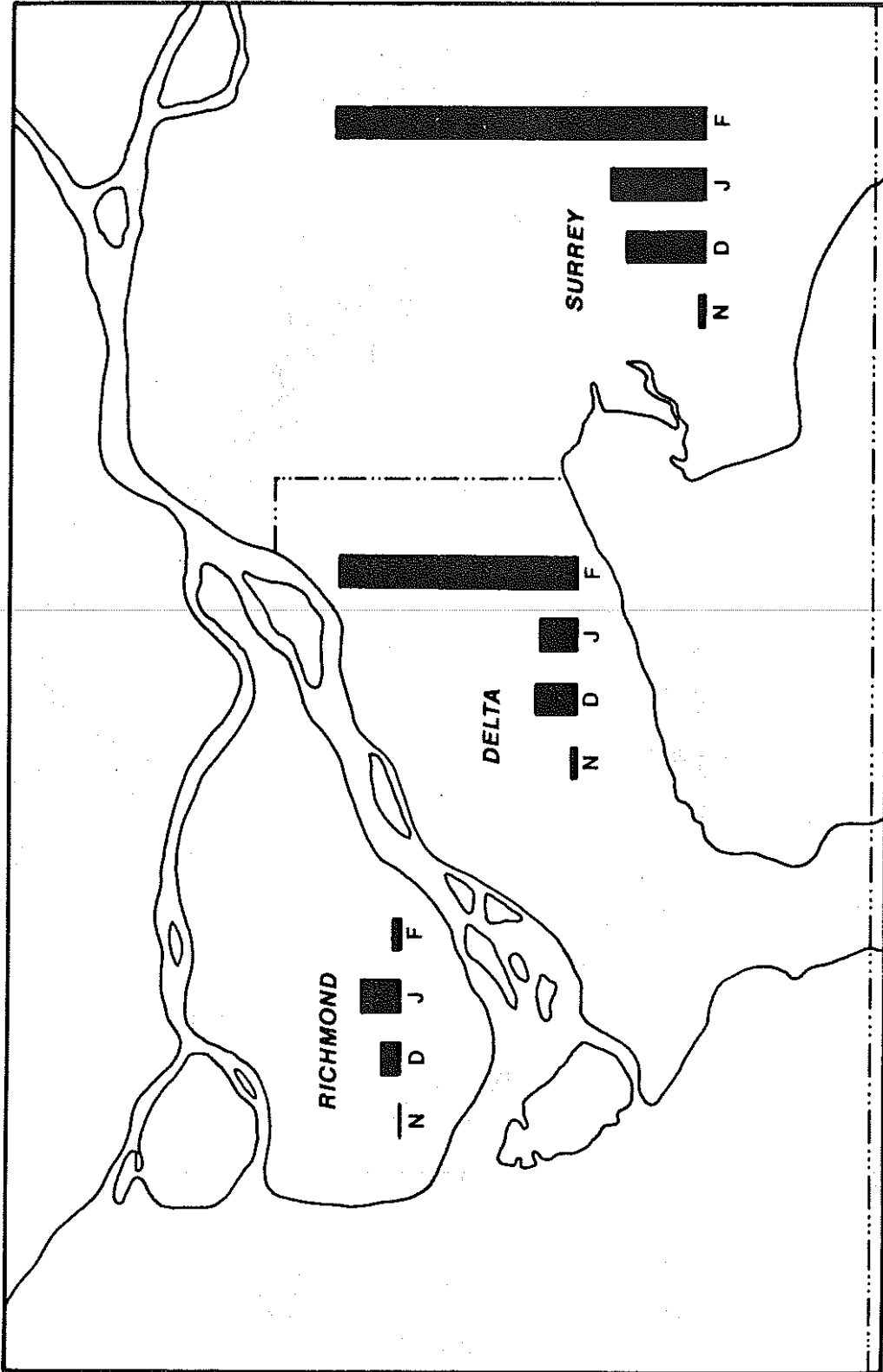


Figure 7. RELATIVE NUMBERS OF DUCKS IN AERIAL COUNTS ON AGRICULTURAL FIELDS IN RICHMOND, DELTA, AND SURREY FROM NOVEMBER 1, 1980 TO FEBRUARY 28, 1981.

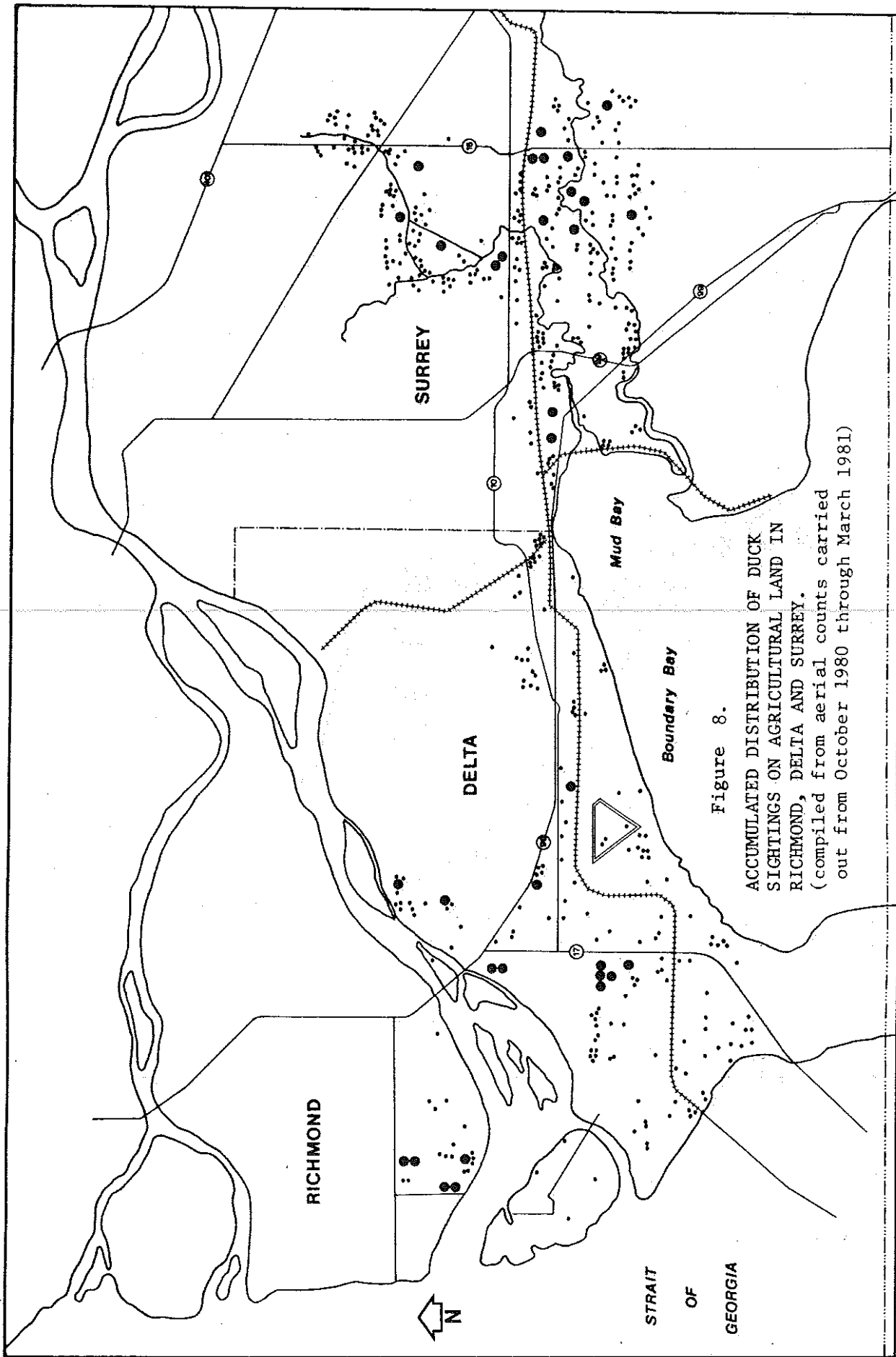


Figure 8.

ACCUMULATED DISTRIBUTION OF DUCK
SIGHTINGS ON AGRICULTURAL LAND IN
RICHMOND, DELTA AND SURREY.
(compiled from aerial counts carried
out from October 1980 through March 1981)

• Single sighting

● 10 sightings

(ploughed, disced, etc.), proximity of Serpentine and Nicomekl Rivers for loafing, feeding, and security, and differences in hunting pressures.

Ground Surveys: Six day field surveys and nine night field surveys were made between December, 1980 and February, 1981. The day survey data is presented in Appendix 11 and summarized in Appendix 12; and the night survey data is presented in Appendix 13 and summarized in Appendix 14.

Figure 9 illustrates the difference between day and night use of agricultural fields in Richmond and Delta. Night field use by ducks is about 10 times greater than day field use. Since aerial surveys showed an average of 5,000 ducks on the fields of Surrey, Delta, and Richmond during the day, it is possible that as many as 50,000 ducks were feeding on agricultural fields at night.

5.1.2 Bird Mortality

No duck kills were found during aerial searches. Six feather clusters were sighted and were confirmed on the ground to be gull carcasses.

One hundred thirteen fields in Richmond and Delta were searched on the ground, 35 using retriever dogs. The ground search findings are summarized in Appendix 15; and the dog search findings in Appendix 16.

Twenty-two duck carcasses were found on 15 fields (one field had 6, two fields had 2 each, and twelve fields had 1 each). Four of the carcasses were located by the dogs. All of the carcasses were either too decomposed or scavanged to be suitable for laboratory analyses. It is unlikely the

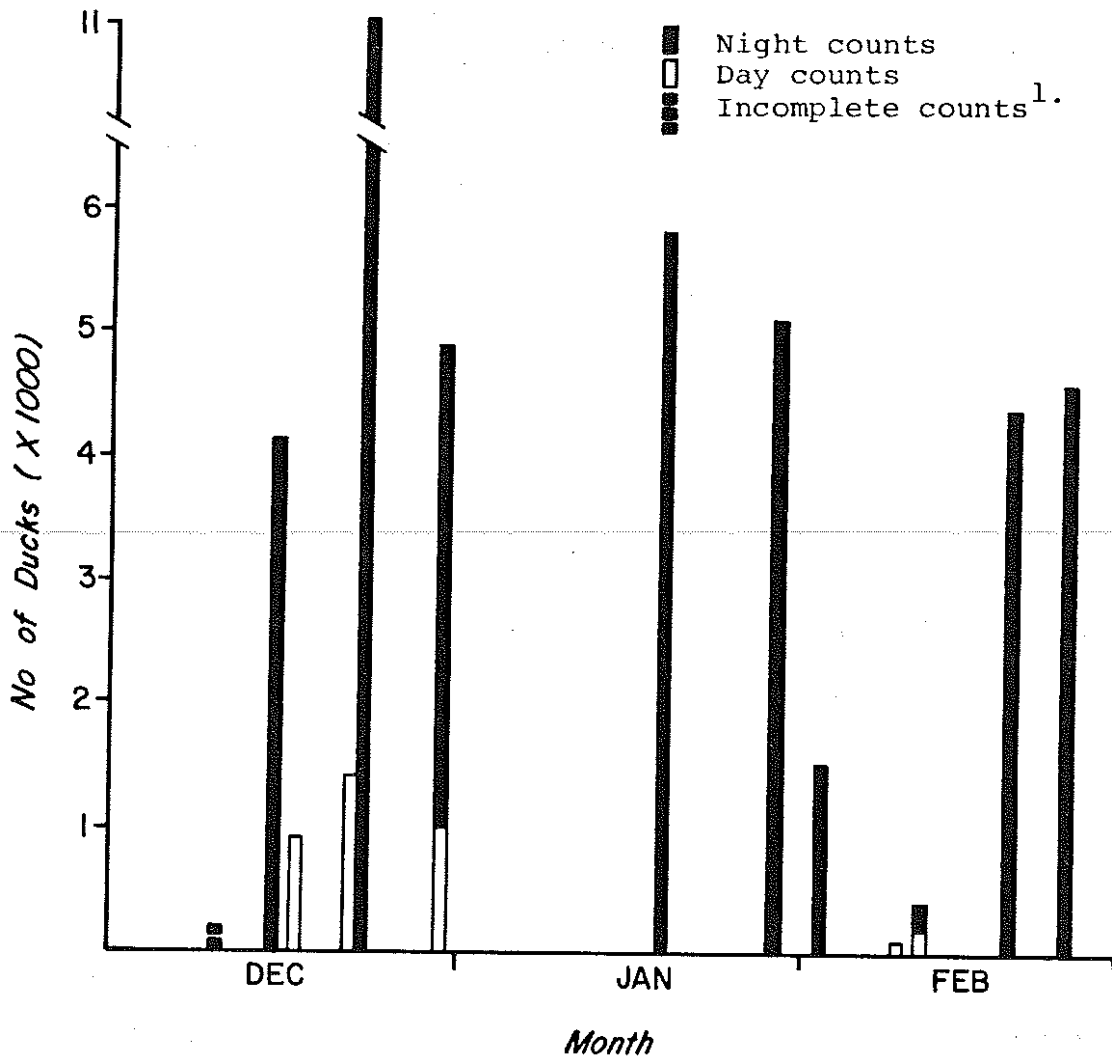


Figure 9.

NUMBER OF DUCKS OBSERVED ON AGRICULTURAL FIELDS IN DELTA AND RICHMOND DURING NIGHT AND DAY FIELD COUNTS, DECEMBER, 1980 TO FEBRUARY, 1981.

¹. Data was generated from flight surveys not completed as a result of poor weather.

deaths were caused by agricultural insecticides. Other factors such as hunting, predation, parasites, disease and heavy metal poisoning were more likely the cause of death. Six duck carcasses were found on a field in Richmond, contaminated with sewage from an adjacent sewage treatment plant.

One dead hawk was located. Analysis results indicate the bird likely died from fensulfothion poisoning.

A kill of from 15 - 20 birds (dabbling and diving ducks and seagulls) on the Boundary Bay foreshore was reported November 11, 1980. The laboratory investigations found the cause of death was Aspergillosis, a fungal infection.

One dead barn owl on Iona Island, Richmond was reported by the hunting and naturalist clubs. It was too decomposed for laboratory analyses.

There are several possible explanations why no waterfowl kills attributable to insecticides was detected during the study period: (1) no insecticide misuse occurred; (2) greater grower awareness to hazards and proper use of granular insecticides resulted in better agricultural practices; (3) less granular insecticides were used in study area than in past; and (4) 30% more precipitation than average during the winter of 1980/81 caused faster breakdown of granular formulations.

5.1.3 Waterfowl Feeding Behavior

The field types used by dabbling ducks during aerial surveys (Appendix 18), day field surveys (Appendix 19), and night field surveys (Appendix 20), are summarized in Table 2. A total of 1,089 waterfowl sightings on fields were noted. Waterfowl were most commonly seen on ploughed, ploughed potato, and pastured fields respectively 36, 22 and 17 percent of all field types inspected. Ninety-two percent of the fields inspected possessed standing water, 63% of those were described as flooded. During waterfowl hunting season, 85% of the ducks in the study area were found on Boundary Bay and Roberts Bank during the day, these birds were resting as opposed to feeding. Ground surveys indicated that night use of agricultural fields was ten times greater than day use. The majority of ducks using the fields at night arrived after dusk and departed again before dawn.

Observations of feeding habits showed that Mallard and Pintail ducks were often found together in mixed flocks whereas Wigeon were usually in separate homogeneous flocks. Food preferences probably dictate these associations, Wigeon preferring to graze and Mallard and Pintail preferring to dabble. Mallard and Pintail were observed feeding on the fields during the day more often than Wigeon. Wigeon appeared to prefer feeding at night. Green-Winged Teal were rarely seen on fields.

TABLE 2 The agricultural field types used by dabbling ducks during aerial, day field, and night field surveys, October 1980 through March 1981.

| FIELD TYPE | % USE |
|---------------------|-------|
| Ploughed | 36 |
| Potato (Ploughed) | 22 |
| Pasture | 17 |
| Corn | 6 |
| Hay | 5 |
| Grain Stubble | 4 |
| Cole Crop | 4 |
| Fall Rye | 2 |
| Other ^{1.} | 4 |
| | 100 |

1. Includes pumpkin, turf, scrub, strawberry, and unspecified fields.

Throughout the winter months, dabbling ducks fed on a variety of food materials on agricultural fields in the study area. The crop and gizzard contents of 14 birds were examined to identify materials eaten. The data are presented in Appendix 21. Table 3 lists some of the food materials. Mallard, Pintail and Wigeon were observed eating during the winter months on agricultural fields in Richmond and Delta. Potato, corn, and grain fields were most attractive to Mallard and Pintail. Wet pasture was also popular. Wigeon favoured pasture, clover, fall rye, and the foliage of over-wintering cole crops. Wigeon were also observed occasionally feeding on potatoes.

Mallard, Pintail, and to a lesser extent, Wigeon were observed digging into the soil while feeding on waste potatoes. As a result, some potato fields were pockmarked with small holes up to 4 or 5 inches deep. Ducks likely use the same techniques while searching for seeds in the soil. In this way granular insecticides in the soil could be picked up by feeding ducks.

5.1.4 Waterfowl Movement Patterns

Day and night field counts of ducks indicate that night use was much greater than day use (Figure 9). During the evening, Mallard, Pintail, Wigeon and Green-winged Teal moved onto the agricultural fields from resting areas in Boundary Bay, Roberts Bank, and wildlife sanctuaries and by dawn most of the birds returned to these resting areas.

TABLE 3 Some food materials¹ seen to be eaten by Mallard, Pintail, and Wigeon ducks during the winter months on agricultural fields in Richmond and Delta.

| Mallard | Pintail | Wigeon |
|------------------------|------------------------|--------------------------------------|
| Weed seeds | Weed seeds | Weed seeds |
| Waste corn | Waste corn | Waste corn |
| Barley, oat stubble | Barley, oat stubble | Barley, oat stubble |
| Millet | Millet | Millet |
| Grasses | Grasses | Turf, grasses |
| Potato | Potato | Clover |
| Cabbage | | Fall rye |
| Turnip | | Over-winter cauliflower leaves |
| | | Over-winter turnip leaves |
| | | Potato |

1. Not in order of preference or importance.

Observations of duck flight directions suggest that Surrey fields receive ducks mainly from Boundary Bay, and Richmond mainly from Roberts Bank. Delta received ducks from both areas. The extent of duck movement between Roberts Bank and Boundary Bay could not be determined. During night field surveys, numerous small duck flights were heard. It could not be determined whether these ducks were moving between agricultural fields and offshore areas or from field to field.

After hunting season closed, day use of agricultural fields increased approximately five times. An increase in duck flights to and from fields during the day was also noticed.

Twenty-six ducks on 5 different occasions were tagged and released between January 16 and February 13, 1981. The tagging data is given in Appendix 22, the tagged bird sighting in Appendix 23. Birds from two different tagging groups were sighted on the fields where they had been tagged 10 days previous. Another bird was sighted on two occasions on the field where it had been tagged and on an adjacent field on two other occasions over an eleven day period. Twenty-seven days after tagging, a bird was sighted in Reifel Island, about 2.4 km west of where it was tagged. A tagged bird was released from the Fraser River dike approximately 270 meters from the field of capture; four days later it was sighted on the field of capture.

An assessment of the bird tagging method showed that of the eight caged Mallards tagged at the Serpentine Fen waterfowl reserve in Surrey, all had removed their tags within 18 hours. This data is included in Appendix 22. It may be that when confined, the birds spend more time working at removing the tag than when free. The wing tags were not always easy to spot. Possibly narrow neck collars made from the same material and stapled or taped would be more visible and less temporary.

Tagging studies demonstrated that ducks do return to the same fields but not consistently. Instead, they appear to frequent a group of fields in an area for a period of time, leaving when food supplies become depleted, weather becomes unfavourable, or human activity discourages use. Some birds had a strong attraction to the field they were using. Even the stress of capture and tagging did not discourage them.

5.1.5 Waterfowl Scare Devices

Interviews with growers (Appendix 26) indicated that rifles and shotguns shooting cracker shells were effective scare methods but time-consuming. These devices were usually used during times of heavy crop depredation, day and night.

Scarecrows constructed of wood and old clothes had limited use because waterfowl soon became accustomed to them (Appendix 26). It was suggested that their effectiveness may be increased by constructing arms that moved with the wind, and by moving the scarecrows around the field regularly. At least two scarecrows per hectare was recommended.

Propane cannons manufactured by electro-Purivox, Germany, were used with considerable success according to growers (Appendix 26) on Westham Island. After cannons were placed in two problem areas on Westham Island in December, 1980, further crop depredation was minimal. One "Double John" propane cannon was found to be effective for 5-10 hectares of crop for ducks. Geese, however, appear to adjust to propane cannons. The use of rifles, shotguns and scarecrows appears to enhance the effectiveness of the propane cannons.

Streamers and reflectors were assessed between February 13-26 on a field in Richmond. The device appeared to function reasonably well but only for the area actually covered by the devices. Ducks did not feed near the streamers and reflectors during the day for at least 5 days. However, there was evidence of night feeding within the protected area, as soon as 3 or 4 days after placement (Appendix 24).

Ten flashing construction site barriers were positioned on the same field as the reflectors and streamers for 7 nights commencing February 19. During this time no evidence of feeding was observed (Appendix 24). Streamers, reflectors or flashing lights appear to be suitable scare devices on a temporary basis near residential areas until a more permanent method could be employed such as fencing or ploughing.

A combination of a 305 mX 1.22 m snow-fence erected by the B.C.M.A.F. and bright colored streamers completely halted crop depredation on a small cauliflower test plot on Westham Island. Fencing was the most effective of the methods examined but is only suitable for small enclosures, it otherwise becomes too costly.

An effective, low cost method of keeping waterfowl off farmland would be welcomed by farmers. These scare techniques would also be useful to the wildlife manager for keeping waterfowl off fields suspected of chemical contamination. Waterfowl scare techniques must be effective at night as well as day.

5.1.6 Crop Depredation Reports

Throughout December 1980 and January 1981 several occurrences of crop damage by waterfowl mainly to over-wintering cole crops were reported by growers on Westham Island, Delta. Wigeons caused most of the damage. Canada geese apparently caused some damage as well. Crop depredation reports brought to the attention of the study technician are included in Appendix 25.

Wigeons feed in large dense flocks, this behavior would contribute to economic crop damage.

5.2 INSECTICIDE STUDIES

The insecticide study results and discussion are presented in three parts: (1) the insecticides used in the study area, (2) insecticide residue levels, and (3) investigations concerning health of waterfowl.

5.2.1 Insecticides Used in the Study Area

Twenty-three Delta and Richmond farmers were interviewed, providing insecticide information on 79 fields. The farm information data sheets are filed in Appendix 26. The locations of the 79 fields are indicated in figure 10. The interviews provided information on insecticide use in the study area, although accurate information concerning application rates and dates was not always available. Some growers kept written records while others relied upon memory.

Tables 4 and 5 summarize the insecticide use information gathered during grower interviews. Table 4 provides a summary of which insecticides were used by crop and Table 5 offers the number of hectares to which the particular insecticides were applied. Only two granular insecticides, chlorfenvinphos and fensulfothion, were used by the growers interviewed. Some growers stated that they no longer used granulars because of reported problems in the past relating to waterfowl kills. Granular chlorfenvinphos was used on only 1 field, while fensulfothion was used on eight. Approximately four times as much liquid fensulfothion was used as the granular form.

Endosulfan, applied to 265.6 hectares of potatoes, was the most widely used insecticide in the study area. Endosulfan was applied to 180 hectares in Ladner. Methamidophos applied to 180.8 hectares of cabbage, cauliflower and potatoes was the second most widely used insecticide. Methamidophos was applied to 136 hectares in Ladner. The third most common insecticide used in the study area was fensulfothion (L) which was applied to 91.4 hectares of cabbage, cauliflower and turnip.

A list of insecticides which may be hazardous to birds, based on LD₅₀ values, would include: aldicarb, carbofuran, chlorfenvinphos, demeton, diazinon, disulfoton, fensulfothion, fonophos, methamidophos, methomyl, methoxychlor, mevinphos, and parathion (Appendix 28). Of these, only carbofuran, diazinon, fensulfothion, methamidophos and mevinphos were used by growers in the study area (Table 4 and 5).

Background information on the insecticides encountered within the study area was compiled for inclusion into the appendices of this report. This information includes:

- 1) insecticide registrations (partial) and technical information (Appendix 27).
- 2) insecticide toxicity values of Mallard (Appendix 28).
- 3) insecticide use information including formulations, application methods and frequencies (Appendix 29).
- 4) amounts of insecticide sold in B.C. during 1978 and 1979 (Appendix 30).

TABLE 4. The Insecticides Encountered and the Number of Crops each was used on in Richmond & Delta¹.

| Insecticide | Potato | Cabbage | Cauli. | Turnip | Chinese Radish | Total |
|---------------------|--------|---------|--------|--------|----------------|-------|
| carbofuran | | 1 | 1 | 1 | | 3 |
| chlorfenvinphos (G) | | | 1 | | | 1 |
| diazinon | | 4 | 2 | 1 | | 7 |
| dimethoate | 1 | 1 | 1 | | | 3 |
| endosulfan | 26 | 4 | 2 | | | 32 |
| fensulfothion (L) | | 11 | 7 | 8 | | 26 |
| fensulfothion (G) | | 3 | 1 | 3 | 1 | 8 |
| malathion | | 2 | 2 | 1 | | 5 |
| maneb | 2 | | | | | 2 |
| methamidophos | 12 | 7 | 2 | | | 21 |
| mevinphos | | 3 | 2 | | | 5 |
| naled | | 5 | 2 | | | 7 |

¹For fields for which insecticide history is known.

TABLE 5 The Number of Fields and Approximate Number of Hectares to Which Each Insecticide was Applied in Richmond and Westham Island and Ladner, Delta¹.

| Insecticide | Richmond | | Delta | | | | Total | |
|---------------------|----------|------|--------------|------|--------|-------|-------|-------|
| | | | Westham Isl. | | Ladner | | | |
| | No. | Ha. | No. | Ha. | No. | Ha. | No. | Ha. |
| carbofuran | 2 | 1.6 | 0 | 0 | 1 | 10.0 | 3 | 11.6 |
| chlorfenvinphos (G) | 0 | 0 | 1 | 4.0 | 0 | 0 | 1 | 4.0 |
| diazinon | 4 | 16.8 | 2 | 7.2 | 0 | 0 | 6 | 24.0 |
| dimethoate | 2 | 6.4 | 1 | 8.0 | 0 | 0 | 3 | 14.4 |
| endosulfan | 10 | 50.0 | 6 | 35.2 | 14 | 180.4 | 30 | 265.4 |
| fensulfothion (L) | 12 | 37.5 | 7 | 20.4 | 5 | 33.6 | 24 | 91.6 |
| fensulfothion (G) | 6 | 15.6 | 2 | 3.2 | 0 | 0 | 8 | 18.8 |
| malathion | 5 | 9.2 | 0 | 0 | 0 | 0 | 5 | 9.2 |
| maneb | 0 | 0 | 1 | 8.8 | 1 | 14.0 | 2 | 22.8 |
| methamidophos | 5 | 10.4 | 4 | 34.4 | 11 | 136.0 | 20 | 180.8 |
| mevinphos | 0 | 0 | 0 | 0 | 3 | 11.6 | 3 | 11.6 |
| naled | 0 | 0 | 0 | 0 | 5 | 39.6 | 5 | 39.6 |

¹. For fields for which insecticide history is known.

5.2.2 Insecticide Residues

Fields sampled in Richmond and Delta to determine insecticide residue levels are listed in Tables 6 and 7. The location of these fields is illustrated in Figure 10. The insecticide residues found were not hazardous to ducks.

Insecticide concentrations existing in the nine soil samples collected between November 28, 1980 and January 29, 1981 are summarized in Table 8. Little change in the soil concentrations of fensulfothion granular occurred over the period of sampling. Soil data sheets are available in Appendix 31 and laboratory reports are available in Appendix 32. Soil sample conductivity, pH and type were assessed by the B.C.M.A.F. and the data is available in Appendix 33. All soil insecticide concentrations are below toxic levels for a Mallard duck. For example, for the highest detected fensulfothion residue level of 3.95 ppm, a Mallard would have to ingest approximately 300 - 400 grams of soil (dry weight) to receive a lethal dose.

Insecticide concentrations existing in the thirteen water samples collected between November 28, 1980 and January 29, 1981 are summarized in Table 9. Only trace amounts of the insecticides occurred in the water.

TABLE 6 The Fields in Delta and Richmond From
Which Soil and Water Samples Were Collected
For Insecticide Residue Analyses.

| Field No. | Location | Crop | Insecticides Used |
|-----------|----------|----------------------------|---|
| 003 | Delta | over-winter cabbage | fensulfothion (SC) |
| 012 | Delta | chinese radish | fensulfothion (15G) |
| 020 | Richmond | turnips | fensulfothion (15G) fensulfothion (L) diazinon (WP) |
| 034 | Delta | over-winter cauliflower | chlorfenvinphos (10G) |
| 043 | Richmond | cauliflower | carbofuran (L) malathion 1000 |
| 071 | Richmond | potato | endosulfan (L) |

TABLE 7 The Fields in Richmond and Delta From Which Vegetation Samples Were Collected For Insecticide Residue Analyses.

| Field No. | Location | Vegetation Sample |
|-----------|--------------|--|
| 003 | Westham Isl. | over-winter cabbage leaf groundsel |
| 004 | Westham Isl. | over-winter cauli. leaf over-winter cauli. head |
| 012 | Westham Isl. | chinese radish leaf chinese radish root |
| 020 | Richmond | chickweed turnip leaf |
| 034 | Westham Isl. | chickweed corn spurry over-winter caul. leaf |
| 042 | Richmond | cauliflower head cabbage head |
| 056 | Delta | turnip root |
| 063 | Richmond | cabbage head |
| 071 | Richmond | potato |

TABLE 8 The Soil Insecticide Analyses Results Including Expected Concentrations at Time of Application.

| Field No. | Insecticide | Date of Applic. | FIRST SAMPLING | | SECOND SAMPLING | |
|-----------|--------------------|-----------------|----------------|------|-----------------|------|
| | | | Date | PPM | Date | PPM |
| 034 | chlorfenvinphos G* | July | 28 Nov. '80 | 0.03 | 21 Jan. '81 | -- |
| 012 | fensulfothion G* | July | 28 Nov. '80 | 0.49 | 21 Jan. '81 | 0.48 |
| 003 | fensulfothion LC** | August | 3 Dec. '80 | 3.95 | 21 Jan. '81 | 3.01 |
| 020 | fensulfothion G* | June | 5 Dec. '80 | 1.92 | 21 Jan. '81 | 1.82 |
| 071 | endosulfan 4E | August | 29 Jan. '81 | 0.07 | -- | -- |

* Granules - Expected concentration at time of application: 32.4 ppm in 15 cm bands, 2.5 cm depth, (6.4 ppm in 15 cm bands, 15 cm depth).

** Liquid drench - Expected concentration at time of application:

16.2 ppm in 15 cm bands, 2.5 cm depth,
(2.7 ppm in 15 cm bands, 15 cm depth).

TABLE 9 The Insecticide Analysis Results For Water Samples Collected in Richmond and Delta

| Field No. | Sample Type | FIRST SAMPLING | | SECOND SAMPLING | |
|-----------|-------------|----------------|-------------------------------|-----------------|--------------------------------|
| | | Date | Results (PPM) | Date | Results |
| 034 | Field | Nov. 28/80 | 0.02 chlorfenvinphos | Jan. 21/81 | 0.02 chlorfenvinphos |
| 034 | Ditch | Nov. 28/80 | 0.0003 chlorfenvinphos | Jan. 21/81 | (not detected) chlorfenvinphos |
| 012 | Field | Nov. 28/80 | 0.005 fensulfothion | Jan. 21/81 | 0.01 fensulfothion sulphone |
| 003 | Field | Dec. 3/80 | 0.01 fensulfothion | -- | -- |
| 003 | Ditch | -- | -- | Jan. 21/81 | (not detected) fensulfothion |
| 043 | Field | Dec. 3/80 | L.008 ¹ carbofuran | Jan. 21/81 | (not detected) carbofuran |
| 020 | Field | Dec. 5/80 | 0.004 fensulfothion | Jan. 21/81 | 0.057 fensulfothion sulphone |
| 071 | Field | Jan. 29/80 | -- | -- | -- |

¹The letter 'L' refers to the level of sensitivity to which the test was carried with no residue detected.

Sample data sheets are available in Appendix 34 and laboratory reports are available in Appendix 35. Carbofuran was not detected, since cauliflower roots were only dipped in carbofuran solution at time of planting. The practice is not recommended by the B.C.M.A.F. since it increases the exposure of workers to the insecticide at the time of planting.

Insecticide concentrations existing in twenty-three vegetation samples from ten fields collected between November 28, 1980 and February 17, 1981 are summarized in Table 10. Sample data sheets are available in Appendix 36 and laboratory reports are available in Appendix 37. Trace quantities of chlorfenvinphos and fensulfothion were detected in only two of the samples.

TABLE 10 The Insecticide Analysis Results For Vegetation Collected in Richmond and Delta.

| Field No. | Sample Type | FIRST SAMPLING | | SECOND SAMPLING | |
|-----------|--------------------------|----------------|-----------------------------|-----------------|----------------------|
| | | Date | Results (PPM) | Date | Results (PPM) |
| 034 | chickweed | Nov. 28/80 | L 1. chlorfenvinphos | Jan. 21/81 | 0.03 chlorfenvinphos |
| 034 | corn spurry over-winter | Nov. 28/80 | L 1. chlorfenvinphos | Jan. 21/81 | L 1. chlorfenvinphos |
| 034 | cauli. leaf chinese | Jan. 21/81 | L 1. chlorfenvinphos | -- | -- |
| 012 | radish leaf chinese | Nov. 28/80 | L 0.8 fensulfothion | Jan. 21/81 | 0.81 fensulfothion |
| 012 | radish root over-winter | Dec. 5/80 | L 1. fensulfothion | -- | -- |
| 003 | cabbage leaf | Dec. 3/80 | L 0.8 fensulfothion | Jan. 21/81 | L 0.8 fensulfothion |
| 003 | groundsel | Dec. 3/80 | L 0.8 fensulfothion | Jan. 21/81 | L 0.8 fensulfothion |
| 020 | chickweed | Dec. 5/80 | L 1.45 fensulfothion | Jan. 21/81 | L 0.8 fensulfothion |
| 020 | turnip leaf | Dec. 5/80 | L 0.8 fensulfothion | Jan. 21/81 | L 0.8 fensulfothion |
| 042 | cauli. head | Dec. 5/80 | (no analysis) carbofuran | -- | -- |
| 042 | cabbage head | Dec. 5/80 | (no analysis) carbofuran | -- | -- |
| 071 | potato | Jan. 29/81 | L 0.8 fensulfothion | -- | -- |
| 071 | potato | Jan. 29/81 | L 0.04 endosulfan | -- | -- |
| 063 | cabbage head over-winter | Jan. 30/81 | L 0.8 fensulfothion | -- | -- |
| 004 | cauli. head | Feb. 11/81 | L 1. malathion | -- | -- |
| 004 | over-winter | Feb. 11/81 | L 0.8 fensulfothion | -- | -- |
| 056 | cauli. leaf | Feb. 17/81 | L 0.1 diazinon | -- | -- |
| 056 | turnip root | Feb. 17/81 | L 0.1 diazinon | -- | -- |

The letter 'L' refers to the level of sensitivity to which the test was carried with no residue detected.

5.2.3 Health of Waterfowl Investigations

Postmortem examinations and tissue analysis for insecticides and heavy metals were conducted on 30 birds. Twenty birds were sacrificed as normal specimens, 5 birds were dead upon receipt and four birds were sacrificed as ailing specimens. The birds and the analyses conducted are presented in Table 11.

Postmortem examinations were conducted on 26 birds, a summary of these examinations is presented in Table 12. Laboratory reports are available in Appendix 39. The 20 normal bird (Mallard ducks) examinations provided no unusual findings, 3 ducks were infested with thorny-head worms, Acanthocephalan sp, 2 with tapeworms, Tetrameres sp, 2 with intestinal fluke worms and eggs and 1 duck was infested with roundworm eggs. Two of the remaining 6 birds died of Aspergillosum fungal infection, 1 appeared to die of gunshot wounds and 3 died or were ill of unknown causes.

The parasite infestations found were not considered particularly detrimental to the general health of the birds, but in combination with other factors, such as disease or malnutrition, could be harmful. It is likely that some of the isolated kills found during the winter were a result of hunter crippling. Once crippled, birds became more susceptible to other mortality factors such as parasites, predators, and severe weather conditions. Aspergillosum was also found to be a bird health hazard in the study area.

TABLE 11 Bird Samples Submitted For Laboratory Analyses

| Sample No. | Spec. Type 1. | Species | Tissue | Analyses ² | Lab ³ |
|----------------|---------------|------------|--------------------|-----------------------|------------------|
| 09-04-00-01..4 | B | Mallard | | P.M. | A |
| | | | Liver | Metals | A |
| | | | Liver, Kidney | P.C.B. | E |
| | | | Muscle, Fat | P.C.B. | E |
| 10-20-01-01 | A | Coot | | P.M. | A |
| | | | Gut Content | O.P. | E |
| | | | Muscle | O.C. | E |
| 11-05-00-01 | A | Can. Goose | Liver | Metals | E |
| | | | Gizzard content | O.P. | E |
| | | | Muscle | O.C. | E |
| 11-06-01-01 | K | Mallard | | P.M. | A |
| 11-10-02-01,2 | K | Mallard | | P.M. | A |
| 12-11-00-01..6 | B | Mallard | | P.M. | V |
| | | | Kidney, Liver, Fat | Metals | E |
| | | | Kidney, Liver, Fat | O.P. | E |
| | | | Kidney, Liver, Fat | O.C. | E |
| 12-16-01-01 | A | Mallard | Kidney | Metals | E |
| | | | Liver | O.P. | E |
| | | | Fat | O.C. | E |
| 01-14-01-01 | A | Coot | Kidney | Metals | E |
| | | | Liver | O.P. | E |
| | | | Fat | O.C. | E |

TABLE 11 (cont'd)

| Sample No. | Spec. Type 1. | Species | Tissue | Analyses ² | Lab ³ |
|----------------|---------------|---------|--------------------|-----------------------|------------------|
| 01-27-00-01..6 | B | Mallard | | P.M. | V |
| | | | Kidney, Liver | Metals | E |
| | | | Kidney, Liver | O.P. | E |
| 01-30-01-01 | K | Hawk | | O.C. | E |
| | | | Fat | O.C. | E |
| | | | Kidney | P.M. | A |
| 01-30-01-01 | K | Hawk | | Metals | E |
| | | | Gut Content, Liver | O.P. | E |
| | | | Fat | O.C. | E |
| 01-30-01-02 | K | Gull | | P.M. | A |
| | | | Kidney | Metals | E |
| | | | Gut Content, Liver | O.P. | E |
| 02-12-00-01..4 | B | Mallard | | P.M. | A |
| | | | Kidney | Metals | E |
| | | | Gut Content, Liver | O.P. | E |
| 02-12-00-05 | B | Wigeon | | O.C. | E |
| | | | Muscle, Fat | O.C. | E |
| | | | Liver | Metals | E |
| 02-12-00-05 | B | Wigeon | | O.P. | E |
| | | | Gut content | O.P. | E |
| | | | Muscle | O.C. | E |

1. Specimen types: B (Base-line); K (Kill); A (Ailing).

2. Analyses: metals (Heavy metals); O.C. (Organochlorine insecticides)
O.P. (Organophosphate insecticides); P.C.B. (Polychlorinated biphenyls);
P.M. (Postmortem examination).

3. Labs: A (Agriculture Canada); E (Ministry of Environment);
V (Abbotsford Veterinary).

TABLE 12 The Postmortem Results For Bird Specimens
Submitted for Analyses

| <u>Sample No.</u> | <u>Species</u> | <u>S.T.</u> ¹ | <u>Lab</u> ² | <u>Results</u> |
|-------------------|----------------|--------------------------|-------------------------|--|
| 09-04-00-01..4 | Mallard | B | V | Normal (Base-line samples) |
| 10-20-01-01 | Coot | A | A | Normal appearing |
| 11-06-01-01 | Mallard | K | A | Gunshot; 1 leadshot in gizzard |
| 11-10-02-01,2 | Mallard | K | A | Aspergillosis |
| 12-11-00-01..6 | Mallard | B | V | Normal; 2 birds harbour <u>Tetrameres</u> <u>sp.</u> Tapeworm. (Base-line samples) |
| 01-27-00-01..6 | Mallard | B | V | Normal (Base-line samples) 2 birds infected with <u>Acanthocephalon sp.</u> worms. |
| 01-30-01-01 | Hawk | K | A | Well-fleshed; cause of death unknown |
| 01-30-01-02 | Gull | K | A | Emaciated; cause of death unknown |
| 02-12-00-01..4 | Mallard | B | A | Normal (Base-line samples); some <u>Acanthocephalon sp.</u> , Intestinal Fluke, and Nematode Infestations. |

1. Specimen Types: B(Base-line); K(Kill); A(Ailing)

2. Labs: V(Abbotsford Veterinary); A(Agriculture Canada)

The tissues of 26 birds were analyzed for insecticide residues, a summary of these results is presented in Table 13. Laboratory analyses reports are available in Appendix 40. Trace levels of organochlorine insecticides were detected in tissues of 10 of 23 normal birds. Levels did not exceed 0.36 ppm in fat tissue. A hawk had 3.2 ppm fensulfothion in its gut contents and likely died from insecticide poisoning.

Trace levels of organochlorine insecticides such as DDT are not uncommon in waterfowl tissue since they accumulate in the food chain and are readily stored in fat. The low levels found, however, suggest that organochlorines are not a hazard to birds in the study area. Chronic organophosphate residue contamination is not a problem with waterfowl since these insecticides are not stored or accumulated in tissues.

The tissues of 26 birds were analyzed for heavy metals. The results of these analyses are presented in Table 14. Laboratory reports are presented in Appendix 41. Table 15 outlines the toxicity of four heavy metals to Mallards.

Tissue concentrations of heavy metals from the normal birds varied widely. Four birds taken in September, 1980, had apparently normal metal levels. In December, however, a similar group of six birds possessed a high mean level of lead, 11 ppm, in their kidneys. In January, 1981, of six birds, one bird possessed high copper levels, 218 ppm, in its liver and another bird had high lead levels, 13 ppm, in its liver. Five birds taken in February showed normal metal levels.

TABLE 13 The Insecticide Analyses Results¹ for Bird Samples Submitted (PPM. Dry Wt.)

| Sample No. | Species | Tissue | S.T. ² | PP-DDT | DDE | DDD | fensulfothion | bromacil ³ | dieldrin |
|----------------|---------|--------------|-------------------|--------|------|------|---------------|-----------------------|----------|
| 09-04-00-01..4 | Mallard | Muscle, Fat | B | 0.003 | | | | | |
| " | Mallard | Kidney | B | 0.003 | 0.01 | | | | |
| " | Mallard | Liver | B | 0.003 | | | | | |
| 12-11-00-01,5 | Mallard | Liver | B | | 0.01 | 0.01 | | | |
| 03,4 | Mallard | Liver | B | | 0.01 | | | | |
| 01..6 | Mallard | Kidney | B | | 0.01 | 0.01 | | | |
| 01..5 | Mallard | Fat | B | 0.09 | 0.23 | | | | |
| 01-30-01-01 | Hawk | Gut contents | K | | | | 3.2 | 2.51 | |
| 01-27-00-03 | Mallard | Fat | B | | | | | | 0.03 |
| 04 | Mallard | Fat | B | | | | | | 0.36 |

1. Only positive findings are listed here. Refer to lab reports for negative findings.
2. Specimen Types B (Base-line); K (Kill); A (Ailing)
3. bromacil is a Herbicide.

TABLE 14 The Heavy Metal Analyses Results (PPM; Dry Wt.)².

| Sample No. | Species | Tissue | Specij. Type | Lab ⁴ | Pb | Cd | Mn | Cu | Zn | Fe | As | Hg ¹ | Cr | K | Mg | Ca | Ni | Mo |
|---------------|------------|------------|--------------|------------------|------|------|-----|------|------|------|-----|-----------------|----|------|-----|-----|----|-----|
| 09-04-00-01 | Mallard | Liver | B | V | 2.14 | 0.58 | 2.4 | 19.0 | 22.6 | 250 | | | | | | | | |
| -02 | " | " | B | | 1.40 | 0.91 | 3.5 | 28.9 | 43.0 | 265 | | | | | | | | |
| -03 | " | " | B | | 0.40 | 0.20 | 2.5 | 14.7 | 32.3 | 173 | | | | | | | | |
| -04 | " | " | B | | 3.65 | 0.16 | 2.2 | 50.8 | 30.8 | 152 | | | | | | | | |
| (01,2,3,4) | " | Muscle,fat | B | E | L1.2 | L1. | | | 35 | | | L.05 | | | | | | |
| 11-05-00-01 | Can. Goose | Liver | A | E | L10. | 2 | | 107 | 227 | | L5. | | | | | | | |
| 12-11-00-01,5 | Mallard | Liver | B | E | L10. | 4 | 11 | 59 | 100 | 3560 | L5. | | | 9940 | 645 | 139 | | 3 |
| 3,4 | " | Liver | B | E | L10. | L1. | 14 | 44 | 114 | 6140 | L5. | | | 1130 | 753 | 127 | | 6 |
| -01..6 | " | Kidney | B | E | L1. | 16 | 13 | 28 | 99 | 829 | L5. | | | 1320 | 867 | 263 | | 4 |
| -01..5 | " | Fat | B | E | L10. | L1. | 1 | L1. | 1 | 65 | L5. | | | 288 | 35 | 26 | | L1. |
| 12-16-01-01 | Mallard | Kidney | A | E | 276 | 2 | | 22 | 95 | | L5. | | | | | | | |
| 01-14-01-01 | Coot | Kidney | A | E | L13. | L1. | | 17 | 78 | L7. | | | | | | | | |
| 01-27-00-01 | Mallard | Liver | B | E | L10. | 2 | | 129 | 113 | | L5. | | | | | | | |
| -02 | " | " | B | E | L10. | L1. | | 218 | 97 | | L5. | | | | | | | |
| -03 | " | " | B | E | L10. | 1 | | 71 | 93 | | L5. | | | | | | | |
| -04 | " | " | B | E | L10. | 6 | | 35 | 96 | | L5. | | | | | | | |
| -05 | " | " | B | E | L10. | 1 | | 38 | 99 | | L5. | | | | | | | |
| -06 | " | " | B | E | L10. | 2 | | 53 | 88 | | L5. | | | | | | | |
| -01 | " | Kidney | B | E | L10. | 6 | | 14 | 75 | | L5. | | | | | | | |
| -02 | " | " | B | E | L13. | 1 | | 20 | 75 | | L7. | | | | | | | |
| -03 | " | " | B | E | L10. | 7 | | 14 | 79 | | L5. | | | | | | | |
| 01-30-01-01 | Hawk | Kidney | K | E | L11. | L.1 | | 9 | 71 | | L5. | | | | | | | |
| 01-30-01-02 | Gull | Kidney | X | E | L10. | 10 | | 15 | 208 | | L5. | | | | | | | |
| 02-12-00-01 | Mallard | Kidney | B | E | L10. | 9 | | 29 | 96 | | L5. | | | | | | | |
| -02 | " | " | B | E | L11. | 8 | | 83 | 116 | | L6. | | | | | | | |
| -03 | " | " | B | E | L10. | 5 | | 13 | 81 | | L5. | | | | | | | |
| -04 | " | " | B | E | L10. | 7 | | 26 | 87 | | L5. | | | | | | | |
| 02-12-00-05 | Wigeon | Liver | B | E | L10. | 2 | | 116 | 135 | | L5. | | | | | | | |

1. Wet Weight

2. The letter 'L' refers to the level of sensitivity to which the test was carried with no residue detected.

3. Specimen types: B (base-line); K (kill); A (ailing).

4. Labs: V (Abbotsford veterinary); E (Ministry of Environment); A (Agriculture Canada).

TABLE 15 Trace Mineral Toxicity Levels For Mallard

| <u>Mineral</u> | <u>Tissue</u> | <u>Levels (PPM)</u> | | |
|------------------------|---------------|---------------------|-------------|--------------|
| | | <u>Normal</u> | <u>High</u> | <u>Toxic</u> |
| Copper ^{1.} | Liver | 10-60 | 25-140 | |
| Lead ^{1.} | Liver | 0.05-0.5 | | 10-64 |
| | Kidney | 0.1-1.0 | | 8-40 |
| Vanadium ^{1.} | Liver | 0.013-0.080 | 0.540-0.760 | |
| | Kidney | 0.0007-0.002 | 0.230-0.320 | |
| Cadmium ^{2.} | Liver | 0.379-0.493 | | |
| | Kidney | 1.922-1.986 | | |

1. Veterinary trace mineral deficiency and toxicity information preliminary version. January 1980
British Columbia Ministry of Agriculture and Food
Veterinary Laboratory, Abbotsford, British Columbia.
2. White and Finley, 1978, in Whitehead, P.M. and Whitehead, P.E.
Cadmium in the Environment and its impact on Birds.
Canadian Wildlife Service Report.

The significance of the heavy metal levels generally, and the elevated lead and copper cannot be interpreted because reference data is not available.

6.0 CONCLUSIONS

Waterfowl Numbers and Distributions

1. The population of waterfowl in the study area remained relatively constant between October 1980 and March 1981, averaging 80,000 - 90,000 birds.
2. Only a small portion of the population, 4,000 - 5,000 birds, utilized the agricultural fields during the day during duck hunting season, October to mid-February. Day field use increased considerably to 20,000 - 25,000 birds once hunting season was closed in mid-February.
3. Night use of agricultural fields by ducks was estimated at 10 times greater than day use, which suggests that as many as 50,000 ducks may have been feeding on agricultural fields at night.
4. Open hunting season was the major cause of the reduction of waterfowl use of agricultural fields during the day.
5. Surrey agricultural fields received the most duck use, probably due to the greater amount of standing water compared to Delta and Richmond. The Serpentine and Nicomekl Rivers also attracted birds to the Surrey area.
6. Richmond agricultural fields received the least bird use, due to the limited number of agricultural fields and the greater intensity of human activity.

Bird Mortality

1. Twenty-two duck carcasses were found on 15 of 113 fields, it was not possible to determine cause of death.
2. No duck kills were attributed to agricultural practices, however, one hawk likely died of fensulfothion poisoning.

Waterfowl Feeding Behavior

1. Some ducks returned to the same field or group of fields to feed throughout the winter months. Ducks trapped and removed from a field upon release returned to the same field.
2. Day feeding ducks preferred wet ploughed fields.
3. Mallard, Pintail, and Wigeon all made extensive use of agricultural crops for food during the winter months.
4. Mallard, Pintail, Wigeon and Canada geese will dig into the soil with their beaks while feeding. During this process granular insecticides could be picked up and ingested.
5. Wigeon appear to cause the greatest damage to overwintering cole crops and fed mostly at night.

Insecticides Used in the Study Area

1. Only two granular insecticides, chlorfenvinphos and fensulfothion, were used in the study area according to interviewed growers.
2. In order of use, endosulfan, fensulfothion, and methamidophos were the most common insecticides applied to crops in the study area.
3. Endosulfan and methamidophos were mostly used in Delta; fensulfothion was mostly used in Richmond.
4. Broadcast spraying was the most common method of insecticide application. Carbofuran, an insecticide potentially hazardous to birds, was used only as a seedling preplant dip. This procedure is not recommended by B.C.M.A.F. because of the increased exposure of workers to the insecticide during planting.

Waterfowl Scare Devices

1. Propane cannons are the most practical and efficient scare devices examined, especially when used with occasional shooting and scarecrows.

Insecticide Residues

1. Soil insecticide residue levels were within expected breakdown limits and were below levels toxic to waterfowl.
2. Granular fensulfothion demonstrated a slower degradation rate than did the liquid form.
3. Insecticide residue levels in water were below levels toxic to waterfowl.
4. Ditch water residue levels were lower than field water levels.
5. Most vegetation sampled possessed no detectable levels of insecticides.
6. Low levels of organochlorine insecticides were detected in waterfowl tissues.
7. Background levels of lead, copper, and cadmium in some waterfowl were high and may constitute a hazard to the health of waterfowl.

7.0 RECOMMENDATIONS

1. Continued monitoring of the study area for bird kills in future winters, with a greater emphasis on Surrey fields may further a greater understanding of what hazards are posed to waterfowl by agricultural practices.
2. Government agencies should further develop a joint plan of action to follow in the event of a bird kill on agricultural land which should include: the availability of waterfowl deterrent device, facilities for field detoxification and a practical definition of action responsibilities amongst the relevant government agencies.
3. Further studies are needed to determine if heavy metals pose a hazard to waterfowl health.
4. Continued liason with growers concerning the impact of various agricultural practices, such as granular insecticides, would be beneficial.

SUMMARY

Bird Mortality - 1980

1. Twenty-two duck carcasses were found on 15 of 113 fields; it was not possible to determine cause of death.
2. A duck kill of 15 - 20 birds on Boundary Bay, found in November, was caused by Aspergillosis.
3. No duck kills were attributed to agricultural practices; however, one hawk likely died of fensulfothion poisoning.

Health of Waterfowl Investigations - 1980

1. All waterfowl sacrificed and inspected as part of a base-line study appeared to be normal and healthy.
2. Aspergillosis infection appears to be a major mortality factor for waterfowl.
3. Minor parasitic infestations were found in 10 percent of waterfowl specimens examined. Spiny-headed worms (Acanthocephalon sp.) were most common followed by tapeworms (Tetrameres sp.) and flukes.
4. No detectable level of organophosphate insecticides were found in the 15 waterfowl analyzed.
5. Low levels of organochlorine insecticide residues were detected in 2 of 20 birds analyzed.
6. Lead, cadmium and copper levels were apparently high in the birds sacrificed for analyses.
7. There was a very wide range in iron levels detected in bird livers.

Insecticides Used in the Study Area - 1980

1. Only granular soil insecticides, chlorfenvinphos (Birlane) and fensulfothion (Dasanit), were known to be used in the study area.
2. Chlorfenvinphos was applied on one field and fensulfothion (G) on eight.
3. The most commonly used insecticide sprays by area treated were, in order, endosulfan (Thiodan), methamidophos (Monitor), and fensulfothion.
4. Insecticides were applied to fields in the following frequency order: endosulfan, fensulfothion (L), methamidophos, fensulfothion (G), diazinon, malathion, naled, carbofuran, dimethoate, mevinphos, maneb and chlorfenvinphos.

Insecticide Residues - 1980

1. All insecticide residue levels in soil, water or vegetation were below toxic levels for waterfowl.
2. All soil samples analyzed contained detectable insecticide residue levels.
3. Insecticide residue levels in water were lower than in soil; ditch water residue levels were lower than field water residues.
4. Chlorfenvinphos residue levels in field water were only slightly lower than in soil.
5. Chlorfenvinphos and fensulfothion residues in chickweed and chinese radish tops indicate that these compounds are translocated and stored in some plants.
6. All residue levels in vegetation were below toxic levels for waterfowl.

Waterfowl Number and Distribution - 1980

1. About 80,000 - 90,000 waterfowl resided in the study area between late October and early March.
2. Approximately 60% and 25% of these birds were found respectively on Boundary Bay and Roberts Bank during the day.
3. Approximately 10% of the study area waterfowl were found on wildlife sanctuaries during the day (Alaksen and Serpentine Fen).
4. An average of 4,000 - 5,000 dabbling ducks used the agricultural fields during the day during waterfowl hunting season; an average of 20,000 - 25,000 used the agricultural fields during the day after hunting season closed.
5. Surrey, Delta and Richmond received respectively 55, 32 and 13 percent of the duck use during the day.
6. Westham Island agricultural fields in Delta received little duck use during the day (excluding Alaksen waterfowl area).
7. The duck population using agricultural fields at night during hunting season was estimated to be 50,000.
8. Ducks utilizing fields at night arrive after dusk and leave before dawn.

Waterfowl Feeding Behavior - 1980

1. Eighty-five percent of ducks rest on Boundary Bay and Roberts Bank during the day. Fifteen percent rest on sanctuaries and five percent rest on agricultural land during the day.
2. At night ducks move on agricultural fields in order to feed.

3. Some ducks returned repeatedly to the same field or group of fields.
4. Standing water and food availability appeared to be the major attractants for waterfowl. Wet, ploughed fields were most attractive to ducks during the day.
5. Mallard and Pintail ducks were usually together in loose flocks whereas Wigeon tended to be in dense homogenous flocks.
6. Wigeon fed at night more often than Mallard or Pintail.
7. Wigeon appeared to be responsible for most of the damage to overwintering crops.
8. Green-winged Teal were rarely seen on the fields during the day.
9. Potato, corn, and waste grain were most commonly used as food by Mallard and Pintail. Grass, clover, fall rye, and overwintering cole crops were favored by Wigeon.
10. Ducks were rarely seen in harvested cole crop fields.

Waterfowl Scare Devices - 1980

1. To protect crops a functional scare technique must be effective at night as well during day.
2. Fencing was the best waterfowl deterrent for small enclosures (less than 1,500 sq. meters).
3. Propane exploders function well day and night, especially in conjunction with occasional shooting and scarecrows.
4. Flashing lights, and reflectors and streamers are only temporary deterrents to waterfowl (about 1 week).
5. Shooting, live ammunition or cracker shells, is only effective while being carried out and not as a long term solution.

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