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AVIAN RADIOECOLOGY ON A
NUCLEAR POWER STATION SITE

Technical Progress Report

Period Covered: 1 July, 1973 - 30 June, 1974

Submitted to the

Division of Biomedical & Environmental Research

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by the

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TECHNICAL PROGRESS REPORT

I. Summary

The period covered by this technical progress report saw a number of significant changes in the operation of the radioecology project as compared to its earlier operations under the sponsorship of the Boston Edison Company. The new, more sensitive whole-body counting chamber was designed, constructed and installed. Sampling intensity was increased and the trapping sites were carefully re-studied to ensure their continued validity as specimen sources. All aspects of the program were assessed to refine and codify techniques and procedures to ensure long-term effectiveness. Research data for the reporting period includes the quantification of ^{137}Cs body burdens demonstrating unique population groupings dependent on geographic location over a relatively small area. There was also the probable detection of ^{131}I on three separate occasions possibly related to a reactor shut-down and accompanying pressure-vessel opening.

Presented below are complete descriptions of the new counting chamber, the field activities, and the radioecological measurement data for the reporting period.

II. Counting Equipment

The new whole-body counting chamber was designed by the project staff in conjunction with the fabricating contractor. Basic layout and performance data were generated by the staff, while implementation and detailing were the responsibility of the fabricators.¹ All assembly materials were radioassayed prior to use in construction.

1. Bio-Nuclear Measurements, Ipswich, Mass.

The chamber is formed of 6061-T651 aluminum plate, 6.3mm thick, fabricated to form a cubical enclosure the internal dimensions of which are 48cm. Allowing for the intrusions of the detector mounts and the sample holder supports, the useful sample volume is 25cm in diameter by 48cm long. The aluminum plate structure is surrounded by electrolytic copper sheeting 0.8mm thick. Standard 5cm x 10cm x 20cm lead bricks are used to surround the aluminum/copper cave to a minimum wall thickness of 10cm. Specially milled pieces and a carefully designed construction plan ensure that no through cracks exist in the shielding. A steel outer jacket structure encloses the entire assembly and provides structural integrity. Access to the cave is via a horizontally swinging door which is shielded in the same manner as the chamber itself. The door is 20" square, providing a 2 1/2" minimum overlap around the 15" square opening to the cave interior. The motion of the door is pneumatically damped in both directions.

The moveable carriers for the four scintillation detectors, located in the chamber vertical midplane at the diagonals, allow external positioning of the detectors inside the cave to maximize geometric efficiency. Indexing positions are provided for the standard sample carriers used in the cave, but intermediate detector positions are available as well. Lead-filled aluminum structural pieces are used to cap any openings in the detector mounting assemblies which might otherwise provide an unshielded path to the cave interior.

In order to minimize airborne contamination arising from the laboratory's below-ground location, in addition to the vapor barriers and inter-wall spacing described in the original proposal, a $0.25\text{m}^3/\text{min}$ air compressor has been installed which draws air from a location above the laboratory building. The air inlet is approximately 11m above ground level at the laboratory, and is about 3m. above ground level referenced to the highest point within 1/2 mile. The compressed air is passed through a filter assembly with a 99.95% retention efficiency for particles $>0.6\mu\text{m}$ prior to entering the chamber. This air flow maintains the cave at a positive pressure with respect to the rest of the laboratory, and leakage around the chamber access door provides a flow rate of about one cave-volume per minute.

Four $7.5\text{cm} \times 7.5\text{cm}$ NaI(Tl) scintillation crystals are used, arranged in quadrature about the sample holder horizontal center line. The detector crystals are separated from their phototubes by light pipes of pure NaI 5cm thick. The photomultiplier tubes used are RCA 8054. The entire assemblies have been constructed using low background and low noise materials.

As compared with our first counting chamber (two $7.5 \times 7.5\text{cm}$ standard NaI(Tl) detectors in a cave with 5cm lead shielding) the new chamber shows significant reduction in total background count rate, in the ^{40}K count rate, and the expected increase in sensitivity from the two additional detectors. Figure 1 illustrates comparative background spectra from the two chambers. Table 1 lists background count rates for various energy regions using the new cave. Note that the count rate

Figure 1. Comparative Background Spectra

Curve A. New Whole-Body Counter
Curve B. Old Whole-Body Counter

varies slightly with detector position in the cave, increasing as the crystals approach each other or the chamber walls.

Table 1. Background Count Rates for the New Whole-Body Counter

	Energy Range (MeV)				<u>Upper limit</u>		<u>Lower limit</u>		
	0.25 2.50	0.305 0.335	0.345 0.380	0.640 0.690	0.730 0.770	0.810 0.855	1.090 1.140	1.150 1.200	1.425 1.495
Detector Position ^a	CPM	CPM	CPM	CPM	CPM	CPM	CPM	CPM	CPM
II	842	41	40	26	19	18	12	11	11
III	875	38	37	24	19	18	12	11	10
IV	886	48	48	28	23	21	11	11	13

a. Position I not used. Position II used for smallest specimens (crystals closest together). Position IV for largest specimens (crystals closest to chamber walls). Position III is an intermediate position.

The performance of the multi-crystal spectrometer has exceeded its resolution specifications. Ordered to a resolution of 7.5%, the four crystals have proven to have a measured system resolution of 7.3% with an observed range of 7.15% to 7.45%, and excellent long-term stability. All four phototubes are driven by a single Harshaw NV-25 power supply feeding a Harshaw NV-21 high voltage divider. The ± 5 kV panel meter of the voltage divider has been replaced with a 0-1kV 3 1/2 digit digital voltmeter to allow setting the detector voltages to within 1 volt in cases where shutdowns or changes have been necessary.

Sensitivity in terms of radionuclide detection limits has been measured for five radionuclides. These data are presented in Table 2. A ^{226}Ra spectrum is shown in Figure 2 to illustrate the resolution of the system.

Figure 2. ^{226}Ra Source in New Whole-Body Counter

III Field Data

The design, construction and start-up of the new whole-body counting system together with two periods of analyzer downtime, one of which was due to a faulty cable on the new point plotter, of necessity detracted somewhat from field efforts. In addition, the re-evaluation of the suitability of each trapping site resulted in the suspension of work at one control site, the opening and subsequent closing of a third site on the reactor station property, and the development of a new primary control site, all of which lessened the expected total of avian specimens processed.

The closing of our original control site at Scusset Beach was necessitated by two factors. Located as it is on a state-owned public beach reservation recently opened up to long-term use by motor campers, vandalism was becoming a problem. Secondly, the area was coming under increasing pressure from hunters using the reservation during the upland game-bird season as well as some illegal out-of-season hunting activity, endangering the field biologists working at the site. It was with considerable reluctance that we suspended the use of this site, since a significant portion of the resident avian population had been banded during the first two years of the program. In addition, its location, immediately adjacent to an expanding oil-fuel power generating station made it of considerable environmental interest. However, the drawbacks associated with its use made it necessary to abandon it and seek a more stable control site. Certain net support hardware remain in

place at the Scusset site, buried and inconspicuous, so that if it should prove of extreme interest to reopen the site in spite of its problems, we can do so and can recreate the exact trapping geometry that was used in the past.

Taking advantage of the opportunities afforded us by our expanded field biologist staff, it was decided to open a third trapping site on the 517-acre reactor station property. A site was selected to provide a habitat as different as possible from the two other sites on the station, and the necessary netting devices were installed. Unfortunately, although prior observation had suggested otherwise, this mixed pitch-pine and white oak habitat proved to be nearly devoid of trappable avifauna. After extensive experimentation, the site was abandoned. A search of the reactor station property continues with the goal of finding and developing a viable third site.

We were especially fortunate to be offered the use of trapping sites on a large (800 acre) fenced, patrolled private farm site approximately twelve miles south of the reactor site and four miles west of the abandoned Scusset control site. A very wide diversity of habitats is available at this location and initial trapping sites were selected and set up during September and October of 1974. Initial results have been good, and absolute freedom from vandalism is ensured. Sufficient habitat variation exists within the bounds of the controlled area such that we should be able to orient our activities in such a way as to maximize the catch of any population type determined to be of par-

ticular interest from our work at the reactor site (excepting marine species). There is no present indication of any future events which might alter either the status or character of this new control area, nor of our continued access to it.

The Manomet Bird Observatory is also now being used as a control site on a regular basis, especially in the winter months when a trapping program allows access to a stable resident population of blue jays, quail and various species of sparrows. During the spring, summer and fall, the primary goal of the netting activities at the Observatory itself is to band the maximum possible number of migrants. To this end, the nets are generally open twenty-four hours a day. Under these conditions the resident population quickly learns of the nets and avoids them. We are thus denied repetitive access to the resident population. This shyness factor generally does not develop when using traps, however, so when traps are in use in the winter, the repeat statistics become favorable at the Headquarters site.

Figure 3 shows both the location of the abandoned control site and the new site as well as their relationship to the reactor and Observatory Headquarters sites. Figure 4 shows the location of the unsuccessful trapping site on the reactor property and the two sites which have been in use since the inception of the project.

Notwithstanding the difficulties enumerated above, the project field staff was able to capture and band over 2500 birds during this reporting period. Over 700 birds were handled more than once for au

Figure 3. Reactor, Observatory and Control Site Locations

Figure 4. Reactor Station Trapping Sites

overall repeat proportion of 23%. The opening of two new netting sites of necessity diluted the repeat population, but as the resident populations at these new areas are processed the repeat rate should rise to equal that which we experience at the other established sites. Eighty-eight species were banded. A number of interesting individuals including two Brewster's Warblers were netted. Many blue jays banded at the reactor site in 1971 were recaptured during 1973 although very few of these 1971 birds were seen during 1972. There had been a general indication of fewer blue jays seen in the New England area during 1972, and this one year gap in our own population adds more information to this as-yet-unexplained phenomenon.

The radionuclide measurement phase of the program suffered somewhat more than the field trapping activities because of the various changes in equipment and trapping sites. Even so, 655 avian specimens were measured. Forty-four species were represented in this total. Three hundred and fifty birds were measured for the first time, and 145 of these birds were handled at least twice. Some individuals were radioassayed for the sixth or seventh time. Individuals of 20 species were measured as dead specimens. Table 3 lists the avian species handled by the project during the reporting period.

As was pointed out in the original proposal, mammalian specimens provide a source of additional data and are especially useful due to their relatively greater density as compared with birds. We therefore measured mammals on a time-available basis. In addition to our

<u>AOU #</u>	<u>SPECIES</u>	<u>USE CODE</u>	<u>AOU #</u>	<u>SPECIES</u>	<u>USE CODE</u>
047	Black-backed Gull	3	608	Scarlet Tanager	1
051	Herring Gull	3	614	Tree Swallow	3
117	Cannet	3	617	Rough-winged Swallow	2
159	Common Eider	3	619	Cedar Waxwing	2
166	Surf Scoter	3	624	Red-eyed Vireo	2
172	Canada Goose	3	626	Philadelphia Vireo	2
202	Blk.-crowned Night Heron	3	631	White-eyed Vireo	2
228	Woodcock	1	636	Black & White Warbler	2
270	Black-bellied Plover	1	641	Blue-winged Warbler	2
289	Bobwhite (quail)	1	641.2	Brewster's Warbler	2
300	Ruffed Grouse	3	645	Nashville Warbler	2
309.1	Ring-necked Pheasant	1	648	Parula Warbler	2
332	Sharp-shinned Hawk	1	650	Cape May Warbler	2
343	Broad-winged Hawk	1	652	Yellow Warbler	2
360	American Kestrel	1	654	Blk-throated Blue Warbler	2
372	Saw-whet Owl	1	655	Myrtle Warbler	2
387	Yellow-billed Cuckoo	1	657	Magnolia Warbler	2
388	Black-billed Cuckoo	2	659	Chestnut-sided Warbler	2
393	Hairy Woodpecker	2	660	Bay-breasted Warbler	2
394	Downy Woodpecker	1	661	Blackpoll Warbler	2
412	Yellow-shafted Flicker	1	667	Blk-throated Green Warbler	2
417	Whip-poor-will	1	671	Pine Warbler	2
420	Common Nighthawk	2	672	Palm Warbler	2
444	Eastern Kingbird	1	673	Prairie Warbler	2
452	Great Crested Flycatcher	1	674	Ovenbird	2
456	Pheobe	2	675	Northern Waterthrush	2
461	E. Wood Pewee	2	679	Mourning Warbler	2
463	Yellow-bellied Flycatcher	2	681	Northern Yellowthroat	2
466	Traill's Flycatcher	2	683	Yellow-breasted Chat	1
467	Least Flycatcher	2	685	Wilson's Warbler	2
477	Blue Jay	1	686	Canada Warbler	2
493	Starling	1	687	American Redstart	1
495	Brown-headed Cowbird	2	688.2	House Sparrow	2
498	Red-winged Blackbird	1	704	Catbird	1
507	Baltimore Oriole	1	705	Brown Thrasher	1
511	Common Grackle	1	718	Carolina Wren	2
517	Purple Finch	2	721	House Wren	2
528	Common Redpoll	2	722	Winter Wren	2
529	American Goldfinch	2	726	Brown Creeper	2
542	Savannah Sparrow	2	727	White-breasted Nuthatch	2
546	Grasshopper Sparrow	2	731	Tufted Titmouse	1
558	White-throated Sparrow	1	735	Blk-capped Chickadee	2
559	Tree Sparrow	2	748	Golden-crowned Kinglet	2
560	Chipping Sparrow	2	749	Ruby-crowned Kinglet	2
563	Field Sparrow	2	755	Wood Thrush	1
567	Slate-colored Junco	2	756	Veery	2
581	Song Sparrow	1	757	Gray-cheeked Thrush	2
584	Swamp Sparrow	2	758	Swainson's Thrush	2
585	Fox Sparrow	2	759	Hermit Thrush	2
587	Rufous-sided Towhee	1	761	Robin	1
593	Cardinal	1			
598	Indigo Bunting	2			

USE CODE: 1. Banded & Radioassayed
2. Banded Only
3. Radioassayed Only (usually a dead specimen)

Table 3. Avian Species Processed During Reporting Period

casual sampling which consisted mainly of gathering road kills and those small mammals caught in our bird traps which were located on the ground, an associate of the principal investigator conducted a trapping program in conjunction with a thesis project which gave us access to a stable woodchuck population. (See Section VI, Publications for further information). Table 4 lists the mammalian species processed.

Table 4. Mammalian Species Radioassayed

Opossum	Grey Fox	Rabbit (cottontail)
Snowshoe Hare	Grey Squirrel	Woodchuck
Meadow Vole	Raccoon	Feral Cat

IV. Radionuclide Data

The results from the radionuclide measurements may conveniently be divided into three sections. First, data, principally in tabular form, concerning the general radionuclide levels found in various avian species. These data have not yet been subject to detailed statistical analysis. Secondly, a discussion of the findings concerning ^{137}Cs is presented, and finally, the apparent detection of ^{131}I is discussed.

IV. A. General Results

Table 5 lists radionuclide data for selected species measured since the new whole-body counting system began operating in mid-September, 1973. The tabular entries are of four types. Where data so permit, mean, standard deviation and ranges are indicated for those

Species	n	Weight (g)		⁵¹ Cr (0.305-0.335MeV)				¹³¹ I (0.345-0.380MeV)			
		mean	SD	mean	SD	max	min	mean	SD	max	min
Bobwhite (<u>Colinus virginianus</u>)	70	185.5	33.0	<2SD _b	--	7.8SD _b	<2SD _b	0.06	0.05	0.19 ₊ 0.01	<0.01 ^a
Blue Jay (<u>Cyanocitta cristata</u>)	66	88.4	7.1	<2SD _b	--	6.6SD _b	<2SD _b	<0.06	--	0.24 ₊ 0.06	<0.06 ^a
Catbird (<u>Dumetella carolinensis</u>)	46	37.9	3.2	<2SD _b	--	<2SD _b	--	<0.15	--	0.59 ^Q ₊ 0.15	<0.15 ^a
Rufous-sided Towhee (<u>Pipilo erythrophthalmus</u>)	22	39.5	8.7	<2SD _b	--	<2SD _b	--	<0.14	--	0.66 ^Q ₊ 0.14	<0.14 ^a
Brown Thrasher (<u>Toxostoma rufum</u>)	21	70.7	6.2	<2SD _b	--	2.5SD _b	<2SD _b	<0.08	--	0.24 ₊ 0.08	<0.08 ^a
White-throated Sparrow (<u>Zonotrichia albicollis</u>)	21	26.1	3.0	<2SD _b	--	<2SD _b	--	<0.21	--	0.33 ^Q ₊ 0.21	<0.21 ^a
Red-winged Blackbird (<u>Agelaius phoeniceus</u>)	14	67.8	4.3	<2SD _b	--	4.0SD _b	<2SD _b	<0.08	--	<0.08 ^a	--
Robin (<u>Turdus migratorius</u>)	13	72.4	5.6	2.3SD _b	1.9SD _b	4.4SD _b	<2SD _b	<0.08	--	0.42 ₊ 0.08	<0.08 ^a
Mourning Dove (<u>Zenaidura macroura</u>)	9	141.0	9.6	<2SD _b	--	<2SD _b	--	<0.04	--	0.09 ₊ 0.04	<0.04 ^a
Wood Thrush (<u>Hylocichla mustelina</u>)	4	53.5	2.7	<2SD _b	--	<2SD _b	--	<0.10	--	<0.10 ^a	--
Song Sparrow (<u>Melospiza melodia</u>)	3	23.1	3.6	<2SD _b	--	<2SD _b	--	<0.24	--	0.38 ^Q ₊ 0.24	<0.24 ^a
Baltimore Oriole (<u>Icterus galbula</u>)	2	40.0	0.7	<2SD _b	--	<2SD _b	--	<0.14	--	<0.14 ^a	--

(a) System detection limit @ 95% Confidence limit (1.96 background SD above background)

(b) Quantities expressed in pCi/g or in multiples of background observed Standard Deviation (SD)

(Q) Questionable data (SD_b) Background Standard Deviation

Table 5 Radionuclide Body-Burden Data

Species	n	Weight (g)		¹³⁴ Cs (0.580-0.630MeV)				¹³⁷ Cs (0.640-0.690MeV)			
		mean	SD	mean	SD	max	min	mean	SD	max	min
Bobwhite (<u>Colinus virginianus</u>)	70	185.5	33.0	1.7SD _b	1.2SD _b	11SD _b	<2SD _b	0.20	0.14	0.71±0.03	<0.03 ^a
Blue Jay (<u>Cyanocitta cristata</u>)	66	88.4	7.1	<2SD _b	--	7.0SD _b	<2SD _b	0.46	0.32	1.22±0.04	<0.04 ^a
Catbird (<u>Dumetella carolinensis</u>)	46	37.9	3.2	<2SD _b	--	4SD _b	<2SD _b	<0.17	--	1.13±0.17	<0.17 ^a
Rufous-sided Towhee (<u>Pipilo erythrophthalmus</u>)	22	39.5	8.7	<2SD _b	--	<2SD _b	--	0.22	0.31	0.97±0.16	<0.16 ^a
Brown Thrasher (<u>Toxostoma rufum</u>)	21	70.7	6.2	<2SD _b	--	4.6SD _b	<2SD _b	0.10	0.19	0.47±0.09	<0.09 ^a
White-throated Sparrow (<u>Zonotrichia albicollis</u>)	21	26.1	3.0	<2SD _b	--	5.0SD _b	<2SD _b	<0.25	--	0.52±0.25	<0.25 ^a
Red-winged Blackbird (<u>Agelaius phoeniceus</u>)	14	67.8	4.3	<2SD _b	--	3.2SD _b	<2SD _b	<0.10	--	0.11±0.10	<0.10 ^a
Robin (<u>Turdus migratorius</u>)	13	72.4	5.6	2.9SD _b	5.3SD _b	9SD _b ^Q	<2SD _b	0.17	0.29	1.25±0.09	<0.09 ^a
Mourning Dove (<u>Zenaida macroura</u>)	9	141.0	91.6	<2SD _b	--	4.9SD _b	<2SD _b	<0.05	--	<0.05 ^a	--
Wood Thrush (<u>Hylocichla mustelina</u>)	4	53.5	2.7	<2SD _b	--	<2SD _b	--	<0.12	--	0.14±0.12	<0.12 ^a
Song Sparrow (<u>Melospiza melodia</u>)	3	23.1	3.6	<2SD _b	--	<2SD _b	--	<0.28	--	<0.28 ^a	--
Baltimore Oriole (<u>Icterus galbula</u>)	2	40.0	0.7	<2SD _b	--	<2SD _b	--	<0.16	--	0.27±0.16	<0.16 ^a

(a) System detection limit @ 95% Confidence limit (1.96 background SD above background)

(b) Quantities expressed in pCi/g or in multiples of background observed Standard Deviation (SD)

(Q) Questionable data (SD_b) Background Standard Deviation

Table 5 Radionuclide Body-Burden Data (continued)

Species	n	Weight (g)		⁹⁵ Zr- ⁹⁵ Nb (0.730-0.770MeV)				⁵⁴ Mn (0.810-0.855MeV)			
		mean	SD	mean	SD	max	min	mean	SD	max	min
Bobwhite (<i>Colinus virginianus</i>)	70	185.5	33.0	2.2SD _b	1.5SD _b	5SD _b	<2SD _b	<0.02	--	0.05+0.02	<0.02 ^a
Blue Jay (<i>Cyanocitta cristata</i>)	66	88.4	7.1	<2SD _b	--	4SD _b	<2SD _b	<0.04	--	0.09+0.04	<0.04 ^a
Catbird (<i>Dumetella carolinensis</i>)	46	37.9	3.2	<2SD _b	--	2.9SD _b	<2SD _b	<0.10	--	0.14+0.10	<0.10 ^a
Rufous-sided Towhee (<i>Pipilo erythrophthalmus</i>)	22	39.5	8.7	<2SD _b	--	4.1SD _b	<2SD _b	<0.10	--	0.16+0.10	<0.10 ^a
Brown Thrasher (<i>Toxostoma rufum</i>)	21	70.7	6.2	<2SD _b	--	4.5SD _b	<2SD _b	<0.06	--	<0.06 ^a	--
White-throated Sparrow (<i>Zonotrichia albicollis</i>)	21	26.1	3.0	<2SD _b	--	<2SD _b	--	<0.05	--	<0.05 ^a	--
Red-winged Blackbird (<i>Agelaius phoeniceus</i>)	14	67.8	4.3	<2SD _b	--	3.1SD _b	<2SD _b	<0.06	--	0.12+0.06	<0.06 ^a
Robin (<i>Turdus migratorius</i>)	13	72.4	5.6	<2SD _b	--	2.4SD _b	<2SD _b	<0.05	--	<0.05 ^a	--
Mourning Dove (<i>Zenaidura macroura</i>)	9	141.0	9.6	<2SD _b	--	3.4SD _b	<2SD _b	<0.03	--	<0.03 ^a	--
Wood Thrush (<i>Hylocichla mustelina</i>)	4	53.5	2.7	<2SD _b	--	<2SD _b	--	<0.07	--	<0.07 ^a	--
Song Sparrow (<i>Melospiza melodia</i>)	3	23.1	3.6	<2SD _b	--	<2SD _b	--	<0.17	--	<0.17 ^a	--
Baltimore Oriole (<i>Icterus galbula</i>)	2	40.0	0.7	2.7SD _b	--	3.1SD _b	--	<0.10	--	<0.10 ^a	--

(a) System detection limit @ 95% Confidence limit (1.96 background SD above background)

(b) Quantities expressed in pCi/g or in multiples of background observed Standard Deviation (SD)

(Q) Questionable data (SD_b) Background Standard Deviation

Table 5 Radionuclide Body-Burden Data (continued)

Species	n	Weight (g)		^{110m}Ag (0.865-0.905MeV)				^{65}Zn (1.090-1.140MeV)			
		mean	SD	mean	SD	max	min	mean	SD	max	min
Bobwhite (<i>Colinus virginianus</i>)	70	185.5	33.0	<2SD _b	--	2.2SD _b	<2SD _b	<0.16	--	0.46 _{+0.16}	<0.16 ^a
Blue Jay (<i>Cyanocitta cristata</i>)	66	88.4	7.1	<2SD _b	--	3.2SD _b	<2SD _b	<0.33	--	0.63 _{+0.33}	<0.33 ^a
Catbird (<i>Dumetella carolinensis</i>)	46	37.9	3.2	<2SD _b	--	<2SD _b	--	<0.77	--	1.62 _{+0.77}	<0.77 ^a
Rufous-sided Towhee (<i>Pipilo erythrophthalmus</i>)	22	39.5	8.7	<2SD _b	--	<2SD _b	--	<0.73	--	1.85 _{+0.73}	<0.73 ^a
Brown Thrasher (<i>Toxostoma rufum</i>)	21	70.7	6.2	<2SD _b	--	<2SD _b	--	<0.41	--	0.53 _{+0.41}	<0.41 ^a
White-throated Sparrow (<i>Zonotrichia albicollis</i>)	21	26.1	3.0	<2SD _b	--	<2SD _b	--	<1.11	--	1.25 _{+1.11}	<1.11 ^a
Red-winged Blackbird (<i>Agelaius phoeniceus</i>)	14	67.8	4.3	<2SD _b	--	<2SD _b	--	<0.43	--	0.75 _{+0.43}	<0.43 ^a
Robin (<i>Turdus migratorius</i>)	13	72.4	5.6	<2SD _b	--	<2SD _b	--	<0.40	--	0.73 _{+0.40}	<0.40 ^a
Mourning Dove (<i>Zenaidura macroura</i>)	9	141.0	9.6	<2SD _b	--	<2SD _b	--	<0.21	--	0.32 _{+0.21}	<0.21 ²
Wood Thrush (<i>Hylocichla mustelina</i>)	4	53.5	2.7	<2SD _b	--	<2SD _b	--	<0.54	--	<0.54 ^a	--
Song Sparrow (<i>Melospiza melodia</i>)	3	23.1	3.6	<2SD _b	--	<2SD _b	--	<1.26	--	<1.26 ^a	--
Baltimore Oriole (<i>Icterus galbula</i>)	2	40.0	0.7	<2SD _b	--	<2SD _b	--	<0.73	--	<0.73 ^a	--

(a) System detection limit @ 95% Confidence limit (1.96 background SD above background)

(b) Quantities expressed in pCi/g or in multiples of background observed Standard Deviation (SD)

(Q) Questionable data (SD_b) Background Standard Deviation

Table 5 Radionuclide Body-Burden Data (continued)

Species	n	Weight (g)		⁶⁰ Co (1.150-1.200)				⁴⁰ K (1.425-1.495MeV)			
		mean	SD	mean	SD	max	min	mean	SD	max	min
Bobwhite (<u>Colinus virginianus</u>)	70	185.5	33.0	<0.04	--	0.10±0.04	<0.04 ^a	0.40	0.09	0.59±0.06	<0.06 ^a
Blue Jay (<u>Cyanocitta cristata</u>)	66	88.4	7.1	<0.08	--	0.14±0.08	<0.08 ^a	0.37	0.20	0.81±0.12	<0.12 ^a
Catbird (<u>Dumetella carolinensis</u>)	46	37.9	3.2	<0.19	--	0.58±0.19	<0.19 ^a	0.39	0.52	1.51±0.28	<0.28 ^a
Rufous-sided Towhee (<u>Pipilo erythrophthalmus</u>)	22	39.5	8.7	<0.18	--	0.40±0.18	<0.18 ^a	0.39	0.52	1.45±0.27	<0.27 ^a
Brown Thrasher (<u>Toxostoma rufum</u>)	21	70.7	6.2	<0.10	--	<0.10 ^a	--	0.29	0.21	0.71±0.15	<0.15 ^a
White-throated Sparrow (<u>Zonotrichia albicollis</u>)	21	26.1	3.0	<0.27	--	<0.27 ^a	--	<0.42	--	0.42 ^a	--
Red-winged Blackbird (<u>Agelaius phoeniceus</u>)	14	67.8	4.3	<0.10	--	<0.10 ^a	--	0.37	0.14	0.64±0.16	<0.16 ^a
Robin (<u>Turdus migratorius</u>)	13	72.4	5.6	<0.10	--	<0.10 ^a	--	0.47	0.31	1.35±0.15	<0.15 ^a
Mourning Dove (<u>Zenaida macroura</u>)	9	141.0	9.6	<0.05	--	<0.05 ^a	--	0.27	0.23	0.50±0.08	<0.08 ^a
Wood Thrush (<u>Hylocichla mustelina</u>)	4	53.5	2.7	<0.13	--	0.31±0.13	<0.13 ^a	<0.32	--	0.81±0.20	<0.20 ^a
Song Sparrow (<u>Melospiza melodia</u>)	3	23.1	3.6	<0.31	--	<0.31 ^a	--	<0.45	--	<0.45 ^a	--
Baltimore Oriole (<u>Icterus galbula</u>)	2	40.0	0.7	<0.18	--	<0.18 ^a	--	<0.27	--	0.57±0.27	<0.27 ^a

- (a) System detection limit @ 95% Confidence Limit (1.96 background SD above background)
 (b) Quantities expressed in pCi/g or in multiples of background observed Standard Deviation (SD)
 (Q) Questionable data (SD_b) Background Standard Deviation

Table 5 Radionuclide Body-Burden Data (continued)

Species	n	Weight (g)		¹⁴⁰ Ba- ¹⁴⁰ La (1.560-1.630MeV)			
		mean	SD	mean	SD	max	min
Bobwhite (<u>Colinus virginianus</u>)	70	185.5	33.0	<2SD _b	--	12.2SD _b ^Q	<2SD _b
Blue Jay (<u>Cyanocitta cristata</u>)	66	88.4	7.1	<2SD _b	--	6SD _b ^Q	<2SD _b
Catbird (<u>Dumetella carolinensis</u>)	46	37.9	3.2	<2SD _b	--	2.6SD _b	<2SD _b
Rufous-sided Towhee (<u>Pipilo erythrophthalmus</u>)	22	39.5	8.7	2.1SD _b	2.1SD _b	6SD _b	<2SD _b
Brown Thrasher (<u>Toxostoma rufum</u>)	21	70.7	6.2	<2SD _b	--	<2SD _b	--
White-throated Sparrow (<u>Zonotrichia albicollis</u>)	21	26.1	3.0	<2SD _b	--	<2SD _b	--
Red-winged Blackbird (<u>Agelaius phoeniceus</u>)	14	67.8	4.3	<2SD _b	--	<2SD _b	--
Robin (<u>Turdus migratorius</u>)	13	72.4	5.6	<2SD _b	--	3.7SD _b	<2SD _b
Mourning Dove (<u>Zenaidura macroura</u>)	9	141.0	9.6	<2SD _b	--	<2SD _b	--
Wood Thrush (<u>Hylocichla mustelina</u>)	4	53.5	2.7	<2SD _b	--	<2SD _b	--
Song Sparrow (<u>Melospiza melodia</u>)	3	23.1	3.6	<2SD _b	--	2.7SD _b	<2SD _b
Baltimore Oriole (<u>Icterus galbula</u>)	2	40.0	0.7	<2SD _b	--	<2SD _b	--

(a) System detection limit @ 95% Confidence limit (1.96 background SD above background)

(b) Quantities expressed in pCi/g or in multiples of background observed Standard Deviation (SD)

(Q) Questionable data (SD_b) Background Standard Deviation

Table 5 Radionuclide Body-Burden Data (continued)

species handled in sufficient numbers to justify such treatment.

Secondly, for those species groups too small to allow valid statistical treatment, mean and maximum values only are given. Thirdly, for those radionuclides for which the system was calibrated but which were not detected, maximum possible values (equivalent to system detection limits) are given. Finally, in the case of those radionuclides for which calibration phantoms had not yet been received at the time of this report, measurement data are presented in terms of observed background standard deviations.

As Table 5 indicates, ^{131}I , ^{137}Cs , ^{95}Zr - ^{95}Nb , ^{65}Zn , and ^{40}K were detected in one or more species and the data are such that we may be reasonably confident about the actual presence of these materials. We can be somewhat less confident about the detection of ^{51}Cr , ^{134}Cs , ^{54}Mn , ^{60}Co , and ^{140}Ba - ^{140}La , although indications are that these radionuclides probably were detected in some individuals. It appears that $^{110\text{m}}\text{Ag}$ was not detected at any time. More sophisticated spectrum analysis procedures are necessary to further refine these data. We are presently at work on these aspects of the data analysis problem.

It is interesting to compare the ^{137}Cs data from quail and blue jays in contrast with that of red-winged black birds and mourning doves. Except for the blue jay, these birds are essentially granivorous /insectivorous birds, and are almost totally granivorous during the winter and early spring when insects are unavailable. Further, we must draw a careful distinction in that blue jays as a species are omnivorous but that individuals or geographic groups may, due to relative levels of

food accessibility, become essentially sustained by a relatively narrow range of food types. In our study region, during the winter months, the blue jays do, in fact, become almost totally granivorous, and thus we may consider them together with the quail, red-wings, and mourning doves. Examination of Table 5 shows that red-wings and mourning doves have a uniformly lower radiocesium body-burden than do quail or jays; in fact, the highest recorded red-wing is just a bit more than one half the mean value for the quail and less than one fourth that of the jays. The mourning doves in turn are less than half the value of the red-wing. We hope to be able to intensively monitor this relationship as the food habits of the jays, quail and red-wings becomes increasingly more insectivorous as the breeding season approaches, while that of the dove remains essentially wedded to seeds.

The relatively frequent occurrence of statistically significant maxima for ^{95}Zr - ^{95}Nb even though population means remain below system detection limits reflects the transient and short-lived nature of this nuclide which is detected for a limited period after atmospheric nuclear tests, usually those conducted by the Peoples Republic of China.

Finally, it should be noted that the calibration data for ^{40}K were obtained using a vial containing KCl. Although this does not represent an accurate avian phantom, the relative levels of ^{40}K in the various species may be of interest. Phantoms using ^{40}K accurately distributed in equivalent avian mass are under fabrication and the data will be further refined. The determination of lean body mass (LBM) may be attempted as a means of contributing to the knowledge of avian fat buildup mechanisms, a uniquely interesting avian phenomenon.

IV. B. ^{137}Cs Levels In Birds

Detectable levels of ^{137}Cs in birds trapped at the various project sites have been routine since the beginning of the program. However, the detection limits of our original whole-body counter were such that, although we could establish that the ^{137}Cs levels were highly variable, we could make no meaningful statements about either general population levels of ^{137}Cs or the magnitude and/or rate of change within a single individual, because so many individuals showed detectable body burdens on initial measurements, and showed none on recapture, or the reverse. The greatly improved sensitivity of the new counting system has overcome this problem.

Figure 5 illustrates the temporal variations in ^{137}Cs body-burdens in a number of blue jays trapped repeatedly over extended intervals. As mentioned earlier in this report the unexplained disappearance of most blue jays during the winter of 1972 causes a gap in the data, but examination of the figure will show that large changes have occurred in some individuals over relatively short periods. See, for example bird number 101382598 which shows a radiocesium body burden drop of about a factor of six within 23 days, while bird number 101382595 shows a similar drop, but adds a subsequent partial recovery. Data taken from a single blue jay kept in captivity for eleven days and fed on corn showing no detectable radiocesium (0.01pCi/g) indicate that the biological half-life of ^{137}Cs in the blue jay is 6-7 days.

The occurrence of apparent ^{131}I , detailed below, led to the suggestion that increased radiocesium levels might be expected to accompany

Figure 5. Illustration of Temporal Variations in ^{137}Cs Body-Burdens in Blue Jays.

any reactor-associated elevation of radioiodine levels. Sample groupings with respect to trapping site were made for blue jays and quail and the body burden statistics for each group calculated. Quail taken from the trapping sites on the nuclear power station property showed (a) that there is a difference in ^{137}Cs body burdens between the two trapping sites, although the difference is not significant at the 2SD level; and (b) that quail taken from the observatory site two miles SE of the reactor site show, in general, three to four times less radiocesium. Had we been limited only to birds from these three sites, one might be led to suggest that some reactor-associated phenomenon was causing the elevated levels, for the three sites are quite similar in vegetation, meteorology, and avian food sources. The ^{131}I data would have served to materially reinforce such suggestions.

However, quail taken from the Buzzards Bay control site, twelve miles south of the Pilgrim Nuclear Power Station, show a mean ^{137}Cs body burden approximately three times greater than those of the reactor site birds. Examination of the blue jay data groupings show similar results except that the two reactor site populations are indistinguishable from each other. A summary of these data are presented in Table 6.

Table 6. Radiocesium Body Burdens in Quail and Blue Jays - Grouped by Trapping Sites.

Location ^a	Species	n	Mean	¹³⁷ Cs SD	Body Burden (pCi/g)	
					min.	max.
AA	Quail	9	0.06	0.04	0.03	0.14
AB	Quail	18	0.15	0.07	0.03	0.25
AC	Quail	31	0.28	0.06	0.03	0.40
AK	Quail	2	0.59	0.04	0.56	0.62
AA	Blue Jay	8	0.13	0.08	0.07	0.29
AB	Blue Jay	26	0.38	0.21	0.07	0.77
AC	Blue Jay	16	0.36	0.23	0.09	0.78
AK	Blue Jay	9	0.95	0.22	0.51	1.23
AA	Both	17	0.10	0.07	0.03	0.29
AB	Both	44	0.29	0.20	0.03	0.77
AC	Both	47	0.30	0.15	0.03	0.78
AK	Both	11	0.89	0.25	0.51	1.23

- a. Location AA is the MBO Headquarters site.
Locations AB & AC are on the nuclear power station property, and AK is the Buzzards Bay control site.
See Figures 3 & 4 for location maps.

An effort seeking to establish possible reasons for this radiocesium distribution is underway. Soil and food samples have been taken from each site for analysis. A large group of red-winged black birds and mourning doves which had just arrived on the Buzzards Bay site at the end point of their northward migration has been banded. It is planned to carefully monitor these birds throughout their stay on their summer territory. Although quite similar in food habits to quail and blue jays, the red-wings and mourning doves had very low levels of ¹³⁷Cs when first measured, usually at or below the detection limits. Another factor under consideration is the meteorology of the Buzzards Bay site as compared to the reactor and Observatory sites. The influence on the local weather caused by the extreme water temperature differential between the two ends of the Cape Cod Canal, which is immediately adjacent

to the Buzzards Bay site, may cause an increased incidence of thunder storms with their characteristic upper atmospheric turbulence. This might influence the local fallout pattern. The Scusset control site should be subject to similar disturbances if they exist, and we are considering reopening the site for purposes of comparison.

IV. C. Apparent Detection of ^{131}I .

In early January of 1974, radionuclide activity which appeared to be increased levels of ^{131}I was found in blue jays and quail trapped on the site of the Pilgrim Nuclear Power Station. Radioiodine was detected in 40 of the 52 individuals trapped on the reactor site between 1/1/74 and 2/14/74. Thirty-six individuals of the group of birds in which radioiodine was detected had activity levels $>2.58\text{SD}$ above background. The highest recorded ^{131}I body burden was $0.24 \pm 0.06 \text{pCi/g}$. During the same period, four quail and two blue jays were trapped at the Observatory's Headquarters site two miles SE of the reactor; none of these individuals showed detectable ^{131}I . In addition, during the period between 11/1/73 and 12/31/73, nineteen blue jays and quail were trapped at the reactor trapping sites. In this latter group only two blue jays showed indications of ^{131}I activity as much as 1.96SD (95% confidence limit) above background, and neither activity was greater than 2.58SD (99% confidence limit) above background.

There were three occasions on which ^{131}I was apparently detected. The first occurred on 7 January, 1974, possibly correlated with the opening of the Pilgrim Station reactor pressure vessel on 1/4/74 for repair and refuelling. During the period 1/4/74 to 1/8/74 snowfall

covered a good deal of the birds' natural food supply. The second and third occurrences of ^{131}I detection (1/16 - 1/21 and 2/13 - 2/14) were associated with rising temperatures and melting snow cover, indicating a possibility that the source of the radioiodine was made available again to the birds at these times. The radiation monitors at the Pilgrim Station had shown no indication of unusual activity releases during this whole period.

In addition to the tentative identification of ^{131}I by its gamma-ray spectrum (0.364 MeV), further confirmation was attempted by decay measurements on one sacrificed specimen. The observed value for the half-life of 9.3 ± 2 days is not inconsistent with the true ^{131}I value of 8.06 days, especially at these low levels of activity.

A complication in all of these measurements is the apparent transit time of the activity through the avian gastrointestinal tract which has been determined by our measurements to be on the order of six hours or less. The fact that birds are normally caught in small groups, coupled with the 100-min counts presently in use means that many birds are held in captivity for periods which are long with respect to this apparent transit time prior to being counted. Thus the measured activity might well have been a good deal lower in these late-measured birds than the true environmental level. Attempts to measure ^{131}I activity in the excreta were unsuccessful, possibly due to the volatility of the iodine or its compounds and/or inadequate methods of excrement collection in use at the time.

Measurements indicated that the activity was not detectable in melted snow cover taken from the trapping sites nor was it found in either wipes of the outer feather surfaces or in measurements of the feathers themselves, seemingly ruling out any cloud immersion phenomena. In one dissected specimen, separate measurements were made of the whole bird, of the feathers, the crop and its contents, the remaining gastrointestinal tract, the thyroid and surrounding tissues, and of the remaining carcass. The GI tract sample showed the bulk of the ^{131}I activity while none of the remaining samples showed any radioiodine activity above system detection limits. The carcass measurements accounted for essentially all of the measured ^{137}Cs and ^{40}K activity in the bird.

All the evidence suggests that ^{131}I was detected in a number of birds resident on the reactor site possibly coincident with the opening of the reactor pressure vessel for servicing and refuelling. The release of any activity in gaseous form due to the opening of the primary containment vessel would be expected to be through the building vent system which exhausts at a point 150' above mean sea level (msl) rather than the normal gaseous release pathway which is via the main vent stack at +400' msl. The main vent stack is of course used during normal power operations. The building-release point, being 250' lower than the stack-release point might be expected to produce very different diffusion characteristics, especially taking into account the semi-bowl shaped nature of the site when referenced to this +150' msl release height. It appears that the activity detected in the birds was neither an external contamination nor an inhalation phenomenon, but was, in fact ingested activity. It also appears that the ingested activity passed

through the gastrointestinal tract very rapidly as is the characteristic of food material in most small birds.

The possibility that the detected activity might have been radium from gravel eaten by the bird (a normal avian habit necessary for digestion) which was passing through with a six hour time period, and that the measured decay rate of 9.3 ± 2 days was merely coincidental was considered. Careful studies of the spectra in comparison with ^{226}Ra spectra and comparative measurements of soil samples indicate that this possibility may safely be discarded, especially since no activity was detected in the crop and crop contents of the sacrificed bird. In addition, examination of fecal matter and discussions with MBO staff ornithologists suggest little evidence of such a rapid turnover of gizzard gravel contents.

However, the very low levels of activity together with the lack of holding and metabolic facilities and the electronics necessary to operate our second (original) whole-body counter prevented a more efficient and thorough investigation of these occurrences and prevent us from making any more positive identification of the ^{131}I activity than that suggested above.

V. Principal Investigator's Time Commitment

The Principal Investigator spent approximately 8-10% of his time on the project (Contract #AT(11-1)-2308) during the period 1 July, 1973 through 1 December, 1973. Due to the research results, that percentage began to increase quite substantially after 1 December, and it is expected that the budgeted figure of 15% will be approximately correct when the entire contract period (FY'74) is averaged.

VI. Publications

A. Papers Submitted

Hamill, R. & Kunz, T. "A Dual Purpose Device for Marking & Holding Live Woodchucks".

Submitted to Journal of Wildlife Management

B. Papers Published

Salvadori, A. & Youngstrom, K. "A System Survey of a Bird Observatory; Part I. A Recording Form for Banding Data".

Published in Bird Banding, Vol. 44 No. 4, Autumn 1973

C. Papers to be Presented

Maletskos, C.J., Youngstrom, K.A., & Levy, C.K. "Repetitive Nondestructive Assessment of Environmental Radionuclides in Recapturable Wild Birds".

Accepted for presentation at the annual meeting of the Health Physics Society, Houston, Texas, 7-11 July, 1974.

Youngstrom, K., Levy, C., & Maletskos, C. "Banding Techniques Used in Avian Radioecology Research Program".

Accepted for presentation at annual meeting of Northeastern & Eastern Bird Banding Associations, Plymouth, Mass. 31 May - 2 June, 1974.

Hamill, R. & Levy, C.K., "Nondestructive Repetitive Measurements of Environmental Gamma-Emitting Radionuclides in Wild Marmots".

Submitted for presentation at 5th International Congress of Radiation Research, Seattle, Washington, 14-20 July, 1974.