TENNESSEE VALLEY AUTHORITY

CHATTANOOGA, TENNESSEE 37401
400 Chestnut Street Tower II

March 20, 1985

Director of Nuclear Reactor Regulation
Attention: Ms. E. Adensam, Chief
Licensing Branch No. 4
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Ms. Adensam:

In the Matter of the Application of	)	Docket Nos. 50-390
Tennessee Valley Authority	)	50-391

Please refer to your letter dated February 27, 1985, which transmitted the staff's comments to the proposed Offsite Dose Calculation Manual (ODCM) for Watts Bar Nuclear Plant transmitted to you by letter dated October 16, 1984. These comments were discussed in a TVA/NRC telephone conference call on February 20, 1985. Enclosed is the requested information with the exception of Figure 1.3 concerning the Gaseous Radwaste Treatment System and Figure 2.1 concerning the Liquid Radwaste Treatment System. These will be submitted by March 27, 1985.

If you have any questions concerning this matter, please get in touch with K. Mali at FTS 858-2682.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

J. A. Domer

J. A. Domer
Nuclear Engineer

Sworn to and subscribed before me
this 20 day of March 1985

L. Cheryl Clark
Notary Public
My Commission Expires 6/24/86

Director of Nuclear Reactor Regulation March 20, 1985

Enclosure
cc: U.S. Nuclear Regulatory Commission (Enclosure)
Region II
Attn: Mr. J. Nelson, Grace, Regional Administrator
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30323

ENCLOSURE

Response to Watts Bar Nuclear Plant

Proposed ODCM Concerns

$$X_i = \sum_{j=1}^{9} \sum_{k=1}^{7} (2/\pi)^{1/2} \frac{f_{jk} Q_i P}{\Sigma_{zk} u_j \; (2\pi x/n)} \left[\exp(-\lambda_i x/u_j)\right][VFF] \quad (1)$$

where

X_i = air concentration of radionuclide i, µCi/m³.

f_{jk} = joint relative frequency of occurrence of winds in windspeed class j, stability class k, blowing toward this exposure point, expressed as a fraction.

Q_i = average release rate of radionuclide i, µCi/s.

P = fraction of radionuclide remaining in plume, Figure 1.1.

Σ_{zk} = vertical dispersion coefficient for stability class k which includes a building wake adjustment,

$\Sigma_{zk} = (\sigma_{zk}{}^2 + cA/\pi)^{1/2}$, where σ_{zk} is the vertical dispersion coefficient for stability class k (m), c is a building shape factor (c=0.5), and A is the minimum building cross-sectional area (1630 m^2), m.

u_j= midpoint value of wind speed class interval j, m/s.

x = downwind distance, m.

n = number of sectors, 16.

λ_i = radioactive decay coefficient of radionuclide i, s^{-1}.

$2\pi x/n$ = sector width at point of interest, m.

VFF = adjustment factor for valley flow (Table 1.4). Taken from NUREG/CR-2919.

For determining the total body dose rate

$$D_{TB} = \sum_i X_i \, DFB_i \quad (1.2)$$

where

D_{TB} = total body dose rate, mrem/yr.

X_i = air concentration of radionuclide i, µCi/m^3.

DFB_i = total body dose factor due to gamma radiation, mrem/yr per µCi/m^3 (Table 1.5).

2. Ground Contamination

For determining the ground concentration of any nuclide:

$$G_i = 3.15 \times 10^7 \sum_{k=1}^{7} \frac{f_k \quad Q_i \quad DR}{(2\pi x/n)\ \lambda_i} \quad (1-\exp - (\lambda_i \quad t_b)\ (VFF) \qquad (1.5)$$

where:

G_i = ground concentration of radionuclide i, $\mu Ci/m^2$.

k = stability class.

f_k= joint relative frequency of occurrence of winds in stability class k blowing toward this exposure point, expressed as a fraction.

Q_i= average release rate of radionuclide i, $\mu Ci/s$.

DR = relative deposition rate, m^{-1} (Figure 1.2).

x = downwind distance, m.

n = number of sectors, 16.

$2\ \pi x/n$ = sector width at point of interest, m.

λ_i = radioactive decay coefficient of radionuclide i, yr^{-1}.

t_b = time for buildup of radionuclides on the ground, 35y.

3.15×10^7 = s/yr conversion factor.

For determining the critical organ dose rate from ground contamination:

$$D_{THG} = (8,760)(1 \times 10^6) \sum_i G_i\ DFG_i \qquad (1.6)$$

where:

D_{THG} = critical organ dose rate due to ground contamination, mrem/yr.

G_i = ground concentration of radionuclide i, $\mu Ci/m^2$.

VFF = adjustment factor for valley flow (Table 1.4). Taken from NUREG/CR-2919.

3. Milk Ingestion

For determining the concentration of any nuclide (except H-3) in and on vegetation:

$$CV_i = 3{,}600 \sum_{k}^{7} \frac{f_k\ Q_i\ DR}{(2\pi\ x\ /n)} \left[\frac{r(1-\exp(-\lambda_{Ei}\ t_e))}{Y_v \lambda_{Ei}} + \frac{B_{iv}\ (1-\exp(-\lambda_i\ t_b))}{P\ \lambda_i}\right] \boxed{VFF} \tag{1.7}$$

where:

CV_i = concentration of radionuclide i in and on vegetation, µCi/kg.

k = stability class.

f_k = frequency of this stability class and wind direction combination, expressed as a fraction.

Q_i = average release rate of radionuclide i, µCi/s.

DR = relative deposition rate, m^{-1} (Figure 1.2).

x = downwind distance, m.

n = number of sectors, 16.

$2\pi x/n$ = sector width at point of interest, m.

r = fraction of deposited activity retained on vegetation, 0.47.

λ_{Ei} = effective removal rate constant, $\lambda_{Ei} = \lambda_i + \lambda_w$, where λ_i is the radioactive decay coefficient, h^{-1}, and λ_w is a measure of physical loss by weathering (λ_w = .0023 h^{-1}) for particulates and 0.0017 for iodines.

t_e = period over which deposition occurs, 720 h.

Y_v = agricultural yield, 1.18 kg/m².

B_{iv} = transfer factor from soil to vegetation of radionuclide i (Table 1.6).

λ_i = radioactive decay coefficient of radionuclide i, h^{-1}.

t_b = time for buildup of radionuclides on the ground, 3.07×10^5 h (35yr).

P = effective surface density of soil, 240 kg/m².

3,600 = s/h conversion factor.

VFF = adjustment factor for valley flow (Table 1.4). Taken from NUREG/CR-2919.

For determining the concentration of H-3 in vegetation:

$$CV_T = 1 \times 10^3 \, X_T \, (0.75)(0.5/H) \qquad (1.9)$$

where:

CV_T = concentration of H-3 in vegetation, µCi/kg.

X_T = air concentration of H-3, µCi/m³.

0.75 = fraction of total plant mass that is water.

0.5 = ratio of tritium concentration in plant water to tritium concentration in atmospheric water.

H = absolute humidity of the atmosphere, g/m³.

1×10^3 = g/kg conversion factor.

For determining the concentration of any nuclide in cow's milk:

$$CM_i = CV_i \, FM_i \, Q_f \exp(-\lambda_i t_f)$$

D_{TH1} = thyroid dose rate due to inhalation, mrem/yr.

D_{THG} = thyroid dose rate due to ground contamination, mrem/yr.

D_{THM} = thyroid dose rate due to milk ingestion, mrem/yr.

The maximum dose rate calculated in this step will be used in step 2 with the following dose rate limits (10 CFR 20):

Total body = 500 mrem/yr

Skin = 3,000 mrem/yr

Maximum organ = 1,500 mrem/yr

Step 2a (Initial Setpoints)

For the determination of initial setpoints, the above limits are divided by the appropriate dose calculated in step 1 yielding,

$$\frac{\text{Dose limit}}{\text{Dose step 1}} = R$$

This ratio, R, represents how far above or below the guidelines this step 1 calculation was. Multiplying the original source term by R will give release rates that should correspond to the dose limits given above. Step 1 is redone using the adjusted source terms to ensure that this is the case.

Appropriate release rate limits in µCi/sec for each nuclide and release point will be provided to plant personnel for use in establishing monitor setpoints. The setpoints in counts per minute for each gaseous effluent monitor will be established using plant instructions.

The general equation used by plant personnel in establishing setpoints in cpm from release rate limits in µCi/sec is as follows:

$$C = \frac{Q \times E \times S \times 60}{V \times 28320}$$

where c = monitor setpoint, cpm

Q = release rate limit, µCi/sec

e = detector efficiency, cpm/µCi/cc

S = safety factor; 0.2 for system without automatic isolation, 0.5 for systems with automatic isolation

60 = sec/min

28320 = cc/ft^3

V = flowrate past the detector, cfm

Step 2b (Release Mix Specific Setpoints)

When release mixes are known, setpoints are based on the dose methodology given in Step 1, disregarding the design source term mix. Using a normalized source term for each nuclide (r_i), nuclide specific dose rates (D_i) are determined independently for each nuclide using Step 1 methodology. Dividing the appropriate dose rate limit above by the nuclide specific dose rate, D_i, yields,

$$\frac{\text{Dose Rate Limit}}{D_i} = R_i$$

This ratio, R_i, represents how far above or below the guidelines the nuclide specific dose rate (D_i) is. Multiplying the nuclide specific source term (r_i) by R_i will give the maximum normalized allowable release rate for nuclide i, RR_i.

For a known mixture of nuclides the release rates, rr_i, must be such that:

$$\sum \left(\frac{rr_i}{RR_i} + \ldots \frac{rr_n}{RR_n} \right) < 1$$

Appropriate release rate limits in µCi/s for each nuclide and the release point will be provided to plant personnel for use in establishing monitor setpoints. The setpoints in counts per minute for each gaseous The general equation used by plant personnel in establishing setpoints in cpm from release sites in µCi/sec is the same as that used in step 2a. The physical and technical description, location, and identification number for each gaseous radiation detector is contained in plant documentation.

1.2 Monthly Dose Calculations

Dose calculations will be performed monthly to ensure that the dose rate is unrestricted areas due to gaseous effluents from the reactor at the site will be limited to the following values:

TABLE 1.4

WBN - Receptor[a] LOCATION DATA

	POINT	SECTOR	DISTANCE (M)	ELEVATION (M)	CHI-OVER-Q (S/M**3)	D-OVER-Q (1/M**2)	VALLEY FLOW FACTOR
1	SITE BOUNDARY	N	1100.	71.	1.42E-05	3.11E-08	4.00
2	SITE BOUNDARY	NNE	1100.	22.	1.97E-05	6.98E-08	4.00
3	SITE BOUNDARY	NE	1100.	4.	1.43E-05	2.99E-08	4.00
4	SITE BOUNDARY	ENE	1100.	-9.	1.62E-05	2.21E-08	4.00
5	SITE BOUNDARY	E	1100.	-9.	2.12E-05	2.93E-08	4.00
6	SITE BOUNDARY	ESE	1100.	-9.	1.57E-05	2.56E-08	4.00
7	SITE BOUNDARY	SE	1100.	-9.	2.64E-05	3.60E-08	4.00
8	SITE BOUNDARY	SSE	1100.	-9.	1.84E-05	2.94E-08	4.00
9	SITE BOUNDARY	S	1100.	-9.	1.33E-05	3.27E-08	4.00
10	SITE BOUNDARY	SSW	1100.	-9.	1.27E-05	3.54E-08	4.00
11	SITE BOUNDARY	SW	1100.	-9.	1.28E-05	2.72E-08	4.00
12	SITE BOUNDARY	WSW	1100.	-2.	1.91E-05	2.83E-08	4.00
13	SITE BOUNDARY	W	1100.	10.	1.27E-05	1.98E-08	4.00
14	SITE BOUNDARY	WNW	1100.	45.	3.79E-06	5.29E-09	4.00
15	SITE BOUNDARY	NW	1100.	46.	6.73E-06	9.22E-09	4.00
16	SITE BOUNDARY	NNW	1100.	23.	1.01E-05	1.68E-08	4.00
17	NEAREST RESIDENT	N	2035.	28.	3.57E-06	7.11E-09	2.50
18	NEAREST RESIDENT	NNE	2770.	10.	2.48E-06	7.56E-09	2.00
19	NEAREST RESIDENT/GARDEN	NE	3380.	0.	1.19E-06	1.95E-09	1.70
20	NEAREST RESIDENT	ENE	2305.	0.	3.08E-06	3.59E-09	2.20
21	NEAREST RESIDENT/GARDEN	E	3150.	4.	2.12E-06	2.29E-09	1.80
22	NEAREST RESIDENT/GARDEN	ESE	4615.	4.	8.62E-07	7.99E-10	1.40
23	NEAREST RESIDENT	SE	1500.	0.	1.38E-05	1.80E-08	3.30
24	NEAREST RESIDENT/GARDEN	SSE	1535.	4.	9.27E-06	1.42E-08	3.30
25	NEAREST RESIDENT/GARDEN	S	1615.	0.	5.82E-06	1.36E-08	3.10
26	NEAREST RESIDENT/GARDEN	SSW	1920.	4.	3.73E-06	9.66E-09	2.70
27	NEAREST RESIDENT	SW	4305.	16.	6.73E-07	1.03E-09	1.50
28	NEAREST RESIDENT/GARDEN	WSW	2150.	0.	4.31E-06	5.65E-09	2.40
29	NEAREST RESIDENT/GARDEN	W	3000.	0.	1.40E-06	1.78E-09	1.90
30	NEAREST RESIDENT	WNW	1535.	22.	1.87E-06	2.54E-09	3.30
31	NEAREST RESIDENT/GARDEN	NW	3035.	-9.	7.39E-07	8.11E-10	1.90
32	NEAREST RESIDENT/GARDEN	NNW	4460.	10.	5.07E-07	5.96E-10	1.50
33	GARDEN	N	4460.	10.	6.98E-07	1.11E-09	1.50
34	GARDEN	NNE	3770.	28.	1.27E-06	3.55E-09	1.60
35	GARDEN	ENE	3305.	0.	1.44E-06	1.50E-09	1.70
36	GARDEN	SE	3075.	-8.	2.75E-06	2.94E-09	1.80
37	GARDEN	WNW	2615.	0.	5.60E-07	6.63E-10	2.10
38	MILK COW ADULT	E	4805.	30.	9.26E-07	8.54E-10	1.40
39	MILK COW ADULT	E	7300.	0.	4.53E-07	3.45E-10	1.20
40	MILK COW TEEN	ESE	5995.	7.	5.62E-07	4.65E-10	1.30
41	MILK COW CHILD	SSW	2150.	22.	2.32E-06	7.08E-09	2.40
42	MILK COW CHILD	SW	2460.	0.	2.07E-06	3.78E-09	2.10
43	MILK COW ADULT	S	2535.	0.	2.06E-06	4.32E-09	2.10
44	MILK COW ADULT	SSW	2535.	0.	1.95E-06	4.68E-09	2.10
45	MILK COW ADULT	SW	2650.	0.	1.77E-06	3.17E-09	2.00
46	MILK COW CHILD	WSW	2460.	0.	3.13E-06	3.93E-09	2.10
47	MILK COW ADULT	W	7150.	37.	2.70E-07	2.42E-10	1.20
48	MILK COW INFANT	WNW	5460.	52.	1.25E-07	1.14E-10	1.30
49	MILK COW ADULT	NW	7580.	16.	1.34E-07	1.02E-10	1.20
50	MILK COW ADULT	WNW	7560.	16.	7.39E-08	5.82E-11	1.20
51	MILK COW ADULT	NW	7455.	22.	1.37E-07	1.05E-10	1.20
52	MILK GOAT ADULT	WSW	5610.	10.	6.27E-07	5.90E-10	1.30
53	MILK GOAT ADULT	NE	3380.	0.	1.19E-06	1.95E-09	1.70

[a] Based on the "Land Use Survey Around Watts Bar Nuclear Power," October 22, 1984, memorandum from J. M. Ransom to E. A. Belvin. Meteorological data is based on the January 1975 to December 1978 JFD contained in Table 1.3 of this ODCM. Valley Flow Factors are based on NUREG/CR-2919 values.

$$f_1(b_1R_1-1) + (b_2R_2-1) + f_3 (b_3R_3-1) + f_4 (b_4R_4-1) \leq F \qquad (2.5)$$

$$b_1 = \frac{S_1}{P_1} \qquad (2.6)$$

$$b_2 = \frac{S_2}{P_2} \qquad (2.7)$$

$$b_3 = \frac{S_3}{P_3} \qquad (2.8)$$

$$b_4 = \frac{S_4}{P_4} \qquad (2.9)$$

For example, for 2 release points and minimum dilution flow this becomes,

$$f_1(\frac{S_1}{P_1} \times R\,1) -1 + f2 \; (\frac{S_2}{P_2} \times R2\,) -1 < 20{,}000 \qquad (2.10)$$

2.2.2 Setpoint Calculation

Setpoints for the effluent monitors are calculated using the following:

$$S_j = b_j \sum C_{ij} \times MSi \qquad (2.10a)$$

where:

MS_i = Monitor sensitivity for radionuclide i, cpm per µCi/ml.

2.2.3 Post-Release Analysis

A post-release analysis will be done using actual release data to ensure that the limits specified in Section 2.1.1 were not exceeded.

A composite list of concentrations (C_i), by isotope, will be used with actual liquid radwaste (f) and dilution (F) flow rates (or volumes) during the release. The data will be substituted into Equation 2.3 to demonstrate compliance with the limits in Section 2.1.1. This data and setpoints will be recorded in auditable records by plant personnel.

2.3 Dose

2.3.1 RETS Requirements

Specification 3.11.1.2 of the Radiological Effluent Technical Specifications (RETS) requires that does or dose commitment to an individual from radioactive material in liquid effluents released to unrestricted areas from each reactor shall be limited:

a. During any calender quarter to < 1.5 mrem to the total body and to < 5 mrem to any organ, and

b. During any calendar year to ≤ 3 mrem to the total body and to ≤ 10 mrem to any organ.

To ensure compliance, cumulative dose calculations will be performed at least once per month according to the following methodology.

2.3.2 Monthly Analysis

Principal radionuclides will be used to conservatively estimate the monthly contribution to the cumulative dose. If the projected dose exceeds the above limits, the methodology in Section 2.3.3 will be implemented.

The 22 nuclides (listed below), based on Sequoyah Nuclear Plant historical release data, contribute more than 95 percent of the dose to the total body and the most cricital organs for both the water and fish ingestion pathways. The critical organs considered for fish ingestion are the gastrointestinal tract (GIT), bone, thyroid, and liver. Critical organs considered for water ingestion are the GIT, bone, and thyroid.

H-3	Co-58	SR-90	Cs-134
Na-24	Co-60	Zr-95	Cs-136
Cr-51	Z_n-65	Nb-95	Cs-137
Mn-54	Sr-89	Mo-99	I-133
Fe-55		Tc-99m	I-131
Fe-59		Ag-110m	
		Sb-124	

A conservative calculation of the monthly dose will be done according to the following procedure. First, the monthly operating report containing the release data will be obtained and the activities released of each of the bove 22 radionuclides will be noted. This information will then be used in the following calculations.

2.3.2.1 Water Ingestion

The dose to an individual from ingestion of water is described by the following equation.

$$D_j = \frac{1}{.95} \sum_{i=1}^{22} (DCF)_{ij} \times I_{ij}, \text{ rem} \qquad (2.11)$$

where:

D_j = dose for the jth organ from 22 radionuclides, rem

j = the organ of interest (bone, GIT, thyroid, and total body).

.95 = conservative correction factor, considering only 22 radionuclides.

2.3.2.2 Fish Ingestion

The dose to an individual from the consumption of fish is described by Equation 2.11. In this case the activity ingested of the i^{th} radionuclide (I_i) is described by

$$I_i = \frac{A_i \quad B_i \quad M_{ij}}{Fd\ (7.34 \times 10^{10})}, \ \mu Ci \qquad (2.14)$$

A_i = Activity released of the i^{th} radionuclide during the month, µCi

B_i = effective fish concentration factor of i^{th} radionuclide $\frac{\mu Ci/g,}{\mu Ci/mL}$ see attached as Table 2.2.

M_{ij} = amount of fish eaten monthly by maximum individual corresponding to age group selected for the critical DCF_{ij} above (adult: 1750 gµ child: 575 gµ Regulatory Guide 1.109).

F = average river flow rate at Watts Bar Dam for month (cubic feet per second)

d = fraction river flow available for dilution (0.10)

7.34×10^{10} = conversion from cubic feet per second to milliliters per month.

Considering the conversion factor from rem to mrem ($x10^3$), the dose equation then becomes

$$D_j = \frac{1.43 \times 10^{-7}}{F} \sum_{i=1}^{22} A_i \cdot B_i \cdot (M \cdot DCF)_{ij}, \ mrem \qquad (2.15$$

2.3.2.3 Recreation

The total body dose to an individual via the shoreline recreation pathway is described by the following equation. For this calculation, the total dose is estimated based on a calculation for Co-58, Co-60, C_s-134, and C_s-137. These four nuclides are expected to contribute over 95 percent of the recreation dose.

$$D = \frac{1}{0.95} \sum_{i=1}^{4} \frac{[\ (RDCF)_i \xi_i \quad 67],\ \text{mrem}}{8760} \quad \frac{4}{} \qquad (2.16)$$

D = dose to the total body from plant releases, mrem

$\frac{1}{0.95}$ = conservative correction factor for considering only 4 radionuclides

$RDCF_i$ = shoreline recreation dose commitment factor for the i^{th} radionuclide (mrem/yr per $\mu Ci/cm^2$). See attached table 2.3. (Note: For Cs-137, the dose commitment factor for its daughter, Ba-137m, is assumed.)

ξ_i = concentration of i^{th} radionuclide in shoreline sediment ($\mu Ci/cm^2$), as described by the following equation (based on equation A-5 in Regulatory Guide 1.109).

$$\xi_i = 100 \ .\ RHL_i \ .\ C_i \ .\ W\ [1 - \exp(- \quad i \ .\ t)] \qquad (2.17)$$

where:

100 = transfer constant defined in Regulatory Guide 1.109

RHL_i = radiological half-life of the i^{th} radioisotope, days from Table 2.1

λ_i = concentration of i_{th} radionuclide in the Tennessee River, $\mu Ci/mL$. $\mu C_i = A_i/(F\ .\ d\ .\ 7.34 \times 10^{10})$

A_i = activity released of i^{th} radionuclide during the month, μCi.

F = average river flow at Watts Bar Dam for the month cubic feet per second

d = fraction of river flow available for dilution (0.10)

7.34×10^{10} = conversion from cubic feet per seond to milliliters per month.

W = shoreline width factor (0.3 for a lake shore, per table A-2 Regulatory Guide 1.109)

λ_i = decay constant of the i^{th} radionuclide

3.0 Radiological Environmental Monitoring

3.1 Monitoring Program

An environmental radiological monitoring program shall be conducted as described in Tables 3.1 and 3.2 and in Figures 3.1, 3.2, 3.3, and 3.4 shall be conducted. Results of this program shall be reported in accordance with Technical Specifications.

The atmospheric environmental radiological monitoring program shall consist of 10 monitoring stations from which samples of air particulats, atmospheric radioiodine, rainwater, and heavy particle fallout shall be collected.

The terrestrial monitoring program shall consist of the collection of milk, soil, ground water, drinking water, and food crops. In addition, direct gamma radiation levels will be measured in the vicinity of the plant.

The reservoir sampling program shall consist of the collection of samples of surface water, sediment, and fish.

Deviations are permitted from the required sampling schedule if specimens are unobtainable (for example: because of hazardous conditions), sample unavailability, or to malfunction of sampling equipment. If the latter, every effort shall be made to complete corrective action prior to the end of the next sampling period.

3.2 Detection Capabilities

Analytical techniques shall be such that the detection capabilities listed in Table 3.3 are achieved.

DCF_{ij} = adult ingestion dose commitment factor for the j^{th} organ from the i^{th} radionuclide rem/µCi, see attached as Table 2.1.

I_{ij} = monthly activity ingested of the i^{th} radionuclide by the critical age group for the jth organ, µCi.

I_{ij} is described by

$$I_{ij} = \frac{A_i \; V_{ij} \; (30)}{Fd \; (7.34 \times 10^{10})} \quad \mu Ci \qquad (2.12)$$

where:

A_i = activity released of ith radionuclide during the month, µCi.

V_{ij} = maximum individual water consumption rate corresponding to the age group selected for the critical DCF_{ij} above (Adult: 2000 mL/d, Child: 1400 mL/dµ Regulatory Guide 1.109)

30 = days per month

F = average river flow rate at Watts Bar Dam for the month (cubic feet per second)

d = fraction of river flow available for dilution (0.10) (E. E. Driver to R. B. Maxwell, Watts Bar Nuclear Plant Dispension, December 3, 1984)

$\times 10^{10}$ = conversion from cubic feet per seond to milliliters per month.

nsidering the conversion factor from rem to mrem ($\times 10^3$), the dose uation then becomes

$$D_j = \frac{4.30 \times 10^{-6}}{F} \sum_{i=1}^{22} (V \cdot DCF)_{ij} \cdot A_i \text{, mrem} \qquad (2.13)$$

t = buildup time in sediment, assumed 15 years, per Regulatory Guide 1.10

67 = assumed monthly exposure time for maximum individual, h

$= 500\ \frac{h}{yr}$ (~10 h/week) $^{\circ}0.4$ (fractional exposure for quarter) _ 3 (months/quarter)

8760 = conversion from year to hours.

0.1 = conversion factor, m^2 . ml/cm^2 . 1

The dose equation then becomes:

$$D = \frac{1}{F}\ (0.0138\ A_{Co-60} + 0.00024\ A_{Co-58} + 0.00412 A_{c5-134} \quad (2.18)$$

$$+ 0.00684\ A_{Cs-137})$$

2.3.2.4 Monthly Summary

Calendar quarter doses are first estimated by summing the doses calculated for each month in that quarter. Calendar year doses are first estimated by summing the doses calculated for each month in that year. However, if the annual doses determined in this manner exceed or approach the specification limits, doses calculated for previous quarters with the methodology of Section 2.3.3 will be used instead of those quarterly doses estimated by summing monthly results. An annual check will be made to ensure that the monthly dose estimates account for at least 95 percent of the dose calculated by the method described in Section 2.3.3. If less than 95 percent of the dose has been estimated, either a new list if principal isotopes will be prepared or a new correction factor will be used. The latter option will not be used if less than 90 percent of the total dose is predicted.

2.3.2.5 Dose Projections

In accordance with specification 3.11.1.3, dose projections will be performed. This will be done by averaging the calculatd dose for the most recent month and the calculated dose for the previous month and assigning that average dose as the projection for the current month.

2.3.3 Quarterly and Annual Analysis

A complete analysis utilizing the total estimated liquid releases for each calendar quarter will be performed and reported as required in Section 6.9 of the Technical Specificaitons. This analysis will replace previous estimates calculated using Section 2.3.2 methodology and will also include an approximation population doses.

TABLE 3.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Sample Locations*	Sampling and Collection Frequency	Type and Frequency of Analysis
3. WATERBORNE			
a. Surface	TRM 529.3 TRM 523.1 TRM 517.9 (Figure 3.4)	Collected by automatic sequential-type sampler** with composite sample collected over a period of ≤ 31 days	Gamma scan of each composite. Composite for tritium, 89Sr and 90Sr at least once once per 92 days
b. Ground	1 sample adjacent to plant (Table 3.2 and Figure 3.3, Station W-1)	Collected by automatic sequential-type sampler with composite sample collected over a period at ≤ 31 days	Gamma scan of each composite. Composite for tritium at least once per 92 days
	1 sample from ground water source upgradient (Table 3.2 and Figure 3.3, Station M-1)	Grab sample once per 31 days	Gamma scan once per 31 days. Composite for tritium at least once per 92 days.
c. Drinking 3 (Figure 3.4)	1 sample at the first potable surface water supply downstream from the plant (TRM 503.8, Figure 3.4)	Collected by automatic sequential-type sampler** with composite sample collected over a period of ≤ 31 days.	
	1 sample at a control location (TRM 529.3[a], Figure 3.4)		Gross beta and gamma scan of each composite. Composite for tritium, 89Sr, and 90Sr at least once per 92 days
4. AQUATIC			
a. Sediment	TRM 532.1, Figure 3.4 TRM 532.1, Figure 3.4	At least once per 184 days	Gamma scan 89Sr, and 90Sr analyses of each sample
b. Sediment from shoreline	TRM 513, Figure 3.4 TRM 530, Figure 3.4	At least once per 184 days	Gamma scan on each sample

[a]The sample collected at TRM 503.8 is taken from the raw water supplyµ therefore, the upstream surface water sample will be considered the control sample for drinking water.

TABLE 3.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Sample Locations*	Sampling and Collection Frequency	Type and Frequency of Analysis
5. INGESTION			
a. Milk	1 sample from milk producing animals in each of 1-3 areas indicated by the cow census where doses are calculated $\leq$ 0.5 m rem/year. (Table 3.2 and Figure 3.1). If samples are unavailable from an area, doses to that area will be estimated by projecting the doses from concentrations detected in milk from other areas or by sampling vegetation where milk samples are not available.	At least once per 15 days	^{131}I analysis of each sample Gamma scan, ^{89}Sr, and ^{90}Sr at least once per 31 days
b. Fish[b]	1 sample each of a commercially and a recreationally important species from Nickajack. Chickamauga, and Watts Bar Reservoirs (Figure 3.4)	At least once per 184 days.	Gamma scan on edible portions. 89 Sr, 90 Sr
c. Vegetation	Samples from atmospheric monitoring statins and the dairy farms from which milk is obtained (Table 3.2 and Figure 3.1)	At lease once per 92 days	Gamma scan on edible portions, 89 Sr, 90 Sr
d. Food Products	1 sample each of principal food products grown at private gardens and/or farms in the immediate vicinity of the plant. 1 sample of each of the foods grown at distances of greater than 10 miles from the plant	Annually at time of harvest. The type of foods available for sampling will vary. Following is a list of typical foods which may be available: Cabbage and/or lettuce Corn, Green Beans, Potatoes, Tomatoes	Gamma scan on edible portion

[b] Within the reaches of the reservoirs in the vicinity of WBN, invertebrates typically collected (such as clams and plankton) are scarce and difficult to obtain. Moreover, the most dominate species, Asiatic Clams, are not used as a food service in this region. Therefore, sampling of these species will not be required.

TABLE 3.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Sample Locations*	Sampling and Collection Frequency	Type and Frequency of Analysis
1. AIRBORNE			
a. Particulates	4 samples from locations (in different sectors) at or near the site boundary (LM 1, 2, 3, and 4)		
	4 samples from communities approximately 3 to 10 miles distant from the plant (PM 2, 3, 4, and 5)	Continuous sampler operation with sample collection at least once per 7 days	Gross beta, following filter change. Composite by location for gamma scan at least once per 31 days and for ^{89}Sr, and ^{90}Sr at least once per 92 days
	2 samples from control locations greater than 10 miles from the plant (RM 2 and 3)		
b. Radioiodine	Samples from same locations as air particulates	Continuous sampler operation with filter collection at least once per 7 days	^{131}I at least once per 7 day
c. Fallout	Samples from same locations as air particulates	Heavy particulate fallout collected continuously on gummed acetate paper with paper collection at least once per 31 days	Gross beta following collection
d. Rainwater	Samples from same locations as air particualtes	Rainwater collected continuously with composite samples analyzed at least once per 31 days	Gamma scan, ^{89}Sr, ^{90}Sr at least once per 31 days
e. Soil	Samples from same locations as air particulates	Once per 3 years	Gamma scan, ^{89}Sr, ^{90}Sr once each 3 years
2. DIRECT	(Figures 3.2 and 3.3) 35-40 locations with at least 2 dosimeters for continuously measuring and recording dose rate at each location	At least once per 92 days	Gamma dose at least once per 92 days

Response to NRC question on TVA's use of a straight line dispersion model, without flow adjustment factors, to calculate χ/Q and D/Q values in the Watts Bar Nuclear Plant (WBN) Offsite Dose Calculation Manual (ODCM)

As discussed in a telephone conversation with Nuclear Regulatory Commission (NRC) staff on February 20, 1985, TVA agreed to adopt the NRC's calculations of χ/Q and D/Q values for inclusion in the WBN ODCM. These values were obtained with the NRC's XOQDOQ code using default adjustment factors provided in NUREG/CR-2919. However, as a result of a 1984 land use survey in the Watts Bar area, many of the critical receptor distances have changed from the distances currently used in the ODCM and in the NRC calculations. To obtain new χ/Q and D/Q values, the TVA straight line model was run with the new receptor distances and with default factors based on the curve provided in NUREG/CR-2919 (figure 3.2).

TVA's adjusted χ/Q and D/Q values from the new model run are very consistent with the values calculated by the NRC. At the site boundary distance (1100m), ratios of the TVA χ/Q values to the NRC values range from about 1.0 to 1.1. Ratios of D/Q values at the same distance range from about 0.9 to 1.0.

The effect of the adjustment factors for other critical receptors at greater distances was also examined. For ease of comparison, default adjustment factors (from NUREG/CR-2919) were applied to χ/Q and D/Q values at six old receptor points that are the same as those used in the NRC calculations. Distances for the points selected were about 2000m, 5000m, and 6000m. Directions for these points ranged from north clockwise through south-southwest. Ratios of TVA values to NRC values for these receptor points were in the range 1.0 to 1.2 for χ/Q values and were about 1.0 for D/Q values, respectively.

These results indicate close agreement between χ/Q and D/Q values calculated by the NRC code and those calculated by the TVA model when the flow adjustment factors from the NUREG are used.

Fish Movement in Reservoirs

Attached is chapter 3 of a TVA report, "Browns Ferry Nuclear Plant Pre-operational Fisheries Resources Report," published in May 1978. This chapter discusses fish movements in Wheeler Reservoir and shows a fair amount of movement. Unfortunately, it does not deal with Smallmouth Buffalo movement, in part because insufficient data were obtained on this species. This serves to illustrate the point that Smallmouth Buffalo are not readily available at all locations and times.

CHAPTER 3

RECAPTURE AND MOVEMENT OF FIVE TAGGED FISH SPECIES

W. A. Hubert

The tagging and movement study was initiated to provide baseline information on fish movements within Wheeler Reservoir prior to the operation of Browns Ferry Nuclear Plant. Of particular interest was information concerning recovery percentages, redistribution following tagging, and movements of fish past the nuclear plant site.

In the past, tagging studies have been performed on several TVA storage impoundments (Manges 1950a, 1950b; Chance 1955), but especially on Norris Reservoir in eastern Tennessee (Eschmeyer 1942, Schumacher and Eschmeyer 1942, Cady 1945, Dendy 1945, Haslbauer 1945, Eschmeyer and Haslbauer 1946, and Haslbauer and Manges 1949). Tagging on TVA mainstream impoundments was limited to early work on Wheeler and Guntersville Reservoirs (Miller and Bryan 1947, Miller 1950) and was designed to estimate sport fish harvests rather than fish movements.

3.1 Materials and Methods

Most fish were collected for tagging in 3 m trap nets. Electrofishing was used to a very limited extent in some areas to increase sample size. Trap nets were set in overbank and deep-water areas at Tennessee River Mile (TRM) 283, 285, 287, 293, and (above the plant site) at 298. In 1969, a deep-water trap net at TRM 296 was set in addition to those listed; however, its use was discontinued in later years. Tagging began in February 1969 and continued through April 1972, but, in order to minimize mortality, fish were tagged only during cool weather.

Fish selected for tagging were taken from the trap net and placed in a 2,300 l. (600 gallon) aerated water tank on the boat. The total length and weight of each fish were recorded, and a numbered, color-coded Floy FD-67F anchor tag was inserted into the musculature on the left side near the posterior end of the dorsal fin. Each tag was also imprinted with the words "Return-TVA." After tagging, fish were immediately released in the location of capture.

Post cards were distributed to area bait, boat, and tackle dealers for use by sport fishermen in reporting tag returns. The majority of the information was obtained from this source. Some tag returns also came from commercial fishermen and TVA sampling.

3.2 Results

A total of 17 species was tagged and released during the four-year period. Only five species were tagged or recaptured in sufficient numbers to allow meaningful interpretation of the data. These species were: channel catfish (*Ictalurus punctatus*), blue catfish (*Ictalurus furcatus*), flathead catfish (*Pylodictis olivaris*), white crappie (*Pomoxis annularis*), and white bass (*Morone chrysops*). A total of 5,452 specimens of these five species was tagged with 219 (4.01 percent) known recaptures (Table 3.1).

3.2.1 Analysis of Recovery Percentages

The tagging study provided information on the proportion of recovery for each of the five species, as well as variations in recovery proportions between years and between release sites. Chi-square analysis was utilized to evaluate the recovery proportions between species, years, and release sites (Schumacher and Eschmeyer 1942). A statistically significant difference

Table 3.1. Percent and number of tagged fish recovered according to species, with corresponding expectation of recovery on the hypothesis that the same proportion of all species should be recovered.

Species	Recaptured			Number Tagged and Released
	Percent Observed	Number Observed	Number Expected	
Channel catfish	1.65	34	82	2057
Blue catfish	2.26	12	21	530
Flathead catfish	6.97	50	29	717
White crappie	8.49	95	45	1118
White bass	2.72	28	41	1030
Total	4.01	219	218	5452

Chi-square = 108.61, 4 df, $P < 0.0005$.

x^2 (.05, 4) = 9.49

in recovery proportions was observed between species, years, and release sites. The recapture proportions were similar for channel catfish, blue catfish, and white bass (1.65, 2.26, and 2.72 percent, respectively); substantially higher percentage of returns occurred for flathead catfish and white crappie (6.97 and 8.49 percent, respectively).

Among the four sample years, three years produced relatively consistent proportions of returns (range 3.84 - 5.14 percent for all species combined. However, in 1971, a significantly smaller proportion (1.94 percent, Table 3.2) was recovered. Tag recoveries for the five release sites also differed significantly (Table 3.3). A larger than expected number of returns (6.43 percent) from TRM 283 was a major contributor to the variation.

3.2.2 Distance and Direction Moved Following Tagging

Data on distance moved between tagging and recapture in relation to specified time intervals showed a high degree of variation among the five species (Tables 3.4-3.8). These data were analyzed from the standpoint of "What proportion of a given species will be recaptured within a specified time interval and distance?" (Schumacher and Eschmeyer 1942). Multiple regression analysis was utilized to determine the influence of distance and time when predicting the cumulative proportion of fish recaptures. Sufficiently high regression coefficients were obtained to justify the use of models in the form

$$P = b_0 + b_1 (\log D) + b_2 (\log T)$$

where D is the waterline distance in km between the points of release and recapture, T is the number of days between release and recapture, and P is the cumulative proportion of recapture within distance D and time interval T. The equations for each species are as follows:

Table 3.2. Percent and number of tagged fish (all species combined) recovered from each year of tagging, with corresponding expectation of recovery under the hypothesis that the proportion recovered from year to year did not differ significantly.

Year	Recaptured: Percent Observed	Recaptured: Number Observed	Recaptured: Number Expected	Number Tagged and Released
1969	5.14	83	65	1616
1970	5.12	60	47	1171
1971	1.94	27	56	1389
1972	3.84	49	51	1276
Total	4.02	219	219	5452

Chi-square = 23.57, 3 df, $P < 0.005$.

x^2 (.05, 3) = 7.81

Table 3.3. Percent and number of tagged fish recovered from each release site, with corresponding expectation recovery under the null hypothesis that the proportion recovered did not differ for release sites.

Release Site (TRM)	Recaptured			Number Tagged and Released
	Percent Observed	Number Observed	Number Expected	
283	6.43	34	21	529
285	3.19	25	31	783
287	4.11	90	88	2191
293	4.07	44	43	1082
298	3.00	26	35	867
Total	4.01	219	218	5452

Chi-square = 11.34, 4 df, $0.025 > P > 0.01$

x^2 (.05, 4) = 9.79

Table 3.4. Frequency distributions of recaptured channel catfish according to number of days between release and recapture, and line-of-sight distances between points of tagging and release.

Water-line Distance (km)	Days at liberty 0-9	10-24	25-49	50-99	100-199	200-399	400+	Total
0-5	9	5	2				1	17
5-10	5		2	1				8
10-15			1	1		1		3
15-20	1		1					2
20-25	1		1					2
25-30		1		1				2
Total	16	6	7	3		1	1	34

Table 3.5 Frequency distributions of recaptured flathead catfish according to number of days between release and recapture, and line-of-sight distances between points of tagging and release.

	Days at liberty							
Water-line Distance (km)	0-9	10-24	25-49	50-99	100-199	200-399	400+	Total
0-5	10	13	2	3	6			34
5-10	1	1	1	1				4
10-15	2		4	2				8
15-20				1				1
20-25		1						1
25-30					1			1
65-70				1				1
Total	13	15	7	8	7			50

Table 3.6. Frequency distributions of recaptured blue catfish according to number of days between release and recapture, and line-of-sight distances between points of tagging and release.

	Days at liberty							
Water-line Distance (km)	0-9	10-24	25-49	50-99	100-199	200-399	400+	Total
0-5	1	2	2	1				6
5-10	2		1					3
10-15					1			1
15-20				2				2
Total	3	2	3	3	1			12

Table 3.7. Frequency distributions of recaptured white crappie according to number of days between release and recapture, and line-of-sight distances between points of tagging and release.

Water-line Distance (km)	Days at liberty							
	0-9	10-24	25-49	50-99	100-199	200-399	400+	Total
0-5	14	4	1	5	8	2	3	37
5-10	5	4	3	8	5	1		26
10-15	1		3	2	1		2	9
15-20			1	5		1		7
20-25				2	4	1		7
25-30			1		2			3
35-40							1	1
40-45					1			1
50-55			1		1			2
85-90					1			1
128			1					1
Total	20	8	11	22	23	5	6	95

Table 3.8. Frequency distributions of recaptured white bass according to number of days between release and recapture, and line-of-sight distances between points of tagging and release.

Water-line Distance (km)	Days at liberty							
	0-9	10-24	24-49	50-99	100-199	200-399	400+	Total
0-5	1			1				2
5-10					2			2
10-15					1			1
15-20		1	1	1	1	1		5
20-25			1	6	3	1		11
25-30					1			1
30-35			1					1
35-40		1		1				2
50-55			1					1
75-80				1				1
90-95			1					1
Total	1	2	5	10	8	2		28

Channel catfish $P = 0.258 + 0.568\ (\log D) - 0.044\ (\log T);\ r^2 = 0.94$

Blue catfish $P = 0.647 + 0.344\ (\log D) - 0.087\ (\log T);\ r^2 = 0.82$

Flathead catfish $P = 0.086 + 0.920\ (\log D) - 0.104\ (\log T);\ r^2 = 0.74$

White crappie $P = 0.548 + 0.392\ (\log D) - 0.117\ (\log T);\ r^2 = 0.75$

White bass $P = 0.003 + 0.666\ (\log D) - 0.144\ (\log T);\ r^2 = 0.67$

The graphs of the equations were plotted as distance versus time for 50, 80, and 95 percent of the recoveries (Figures 3.1-3.6). These relationships illustrated considerable variation of movement between species. For example, within 50 days from the time of release, 80 percent of the blue catfish recoveries were estimated to be within 7.4 km of their site of release, whereas 80 percent of the white bass recoveries were calculated to be within 36.6 km of their release site. A relative comparison of the distance moved versus time between species indicated that the three catfish species were the most sedentary while white bass moved most extensively (Figure 3.6). The movement of white crappie was intermediate between the catfishes and white bass.

Of the 219 fish tagged and released, 82 percent left the release site, and of these, over 56 percent moved downstream. Contingency analysis indicated that direction of movement was not independent of fish species. Of the three catfish species studied, flathead catfish showed the greatest deviation from the expected values. Flathead apparently showed a greater tendency to move in neither direction than either channel or blue catfish. White bass showed the greatest departure from the expected response. This species showed proportionately less tendency to remain near the point of capture and greater tendency to move downstream than the other species (Table 3.9).

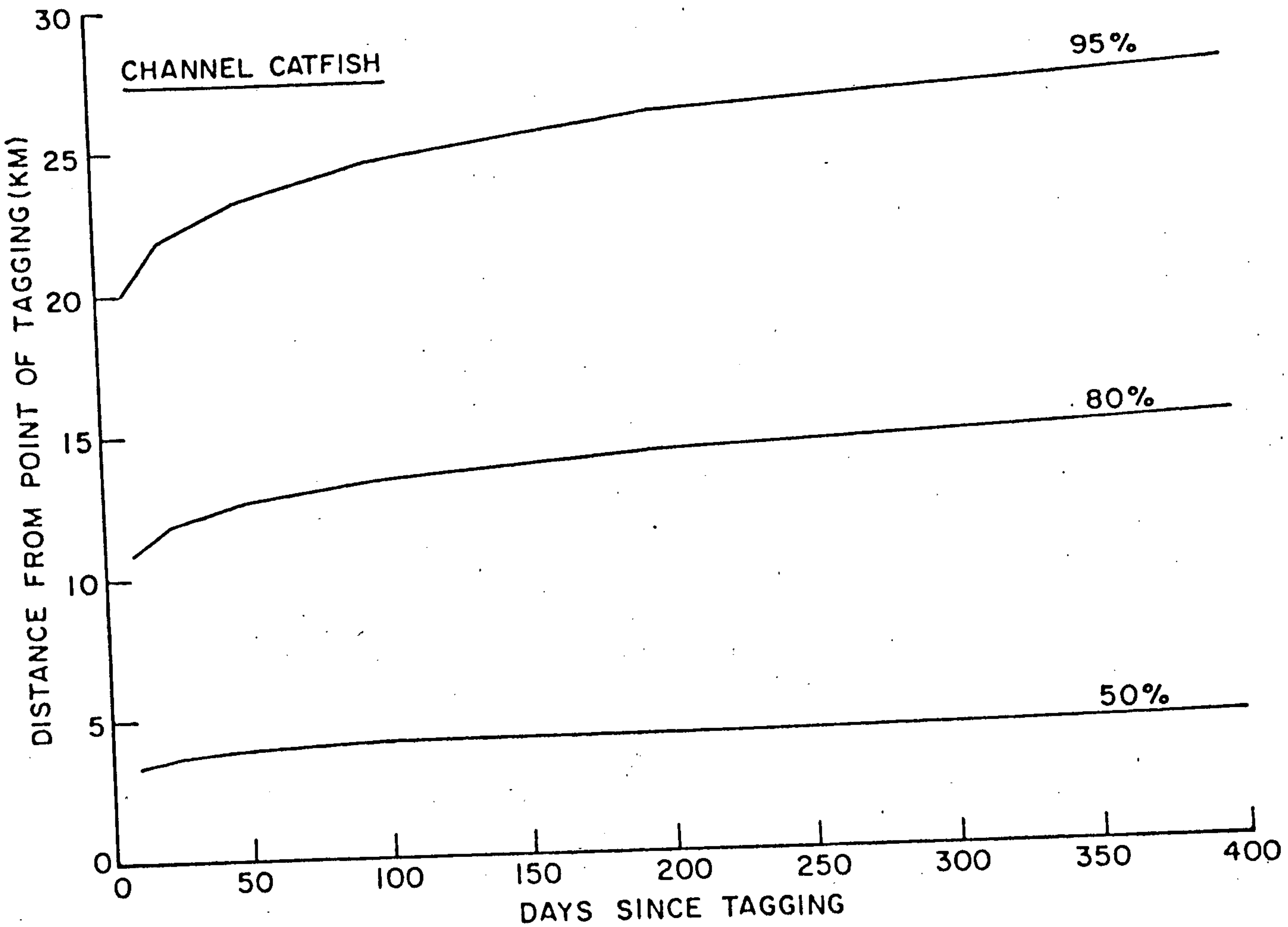

Figure 3.1. Calculated redistribution of channel catfish (based on 34 recaptured fish) in terms of straight-line distance from point of tagging and time since release. Curves represent the specified percentage of tagged fish expected to be captured within x days at a distance of y kilometers or less from the point of release.

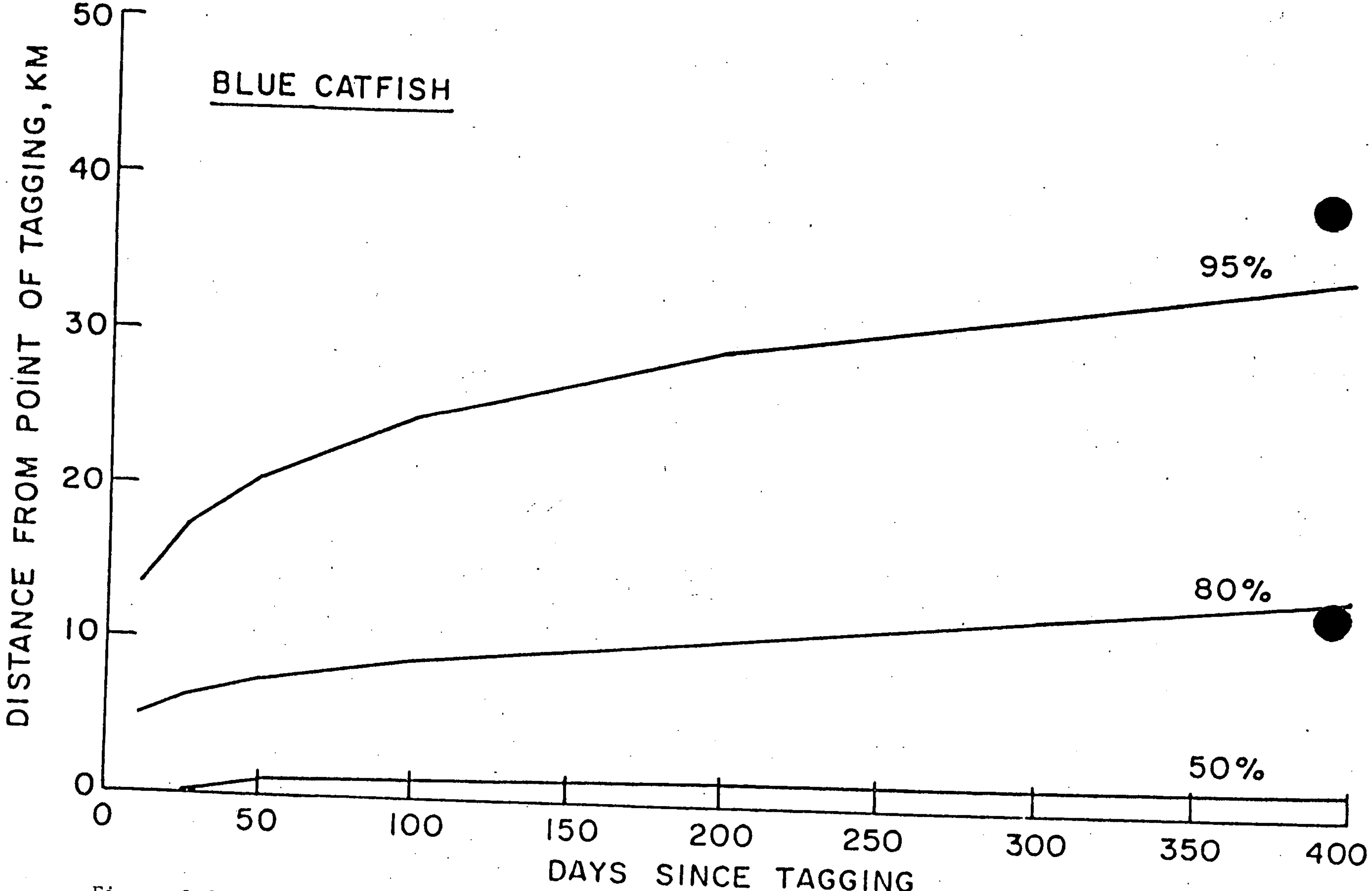

Figure 3.2. Calculated redistribution of blue catfish (based on 12 recaptured fish) in terms of straight-line distance from point of tagging and time since tagging. Curves represent the specified percentage [illegible]

...straight-line distance from point of tagging.
and time since tagging. Curves represent the specified percentage

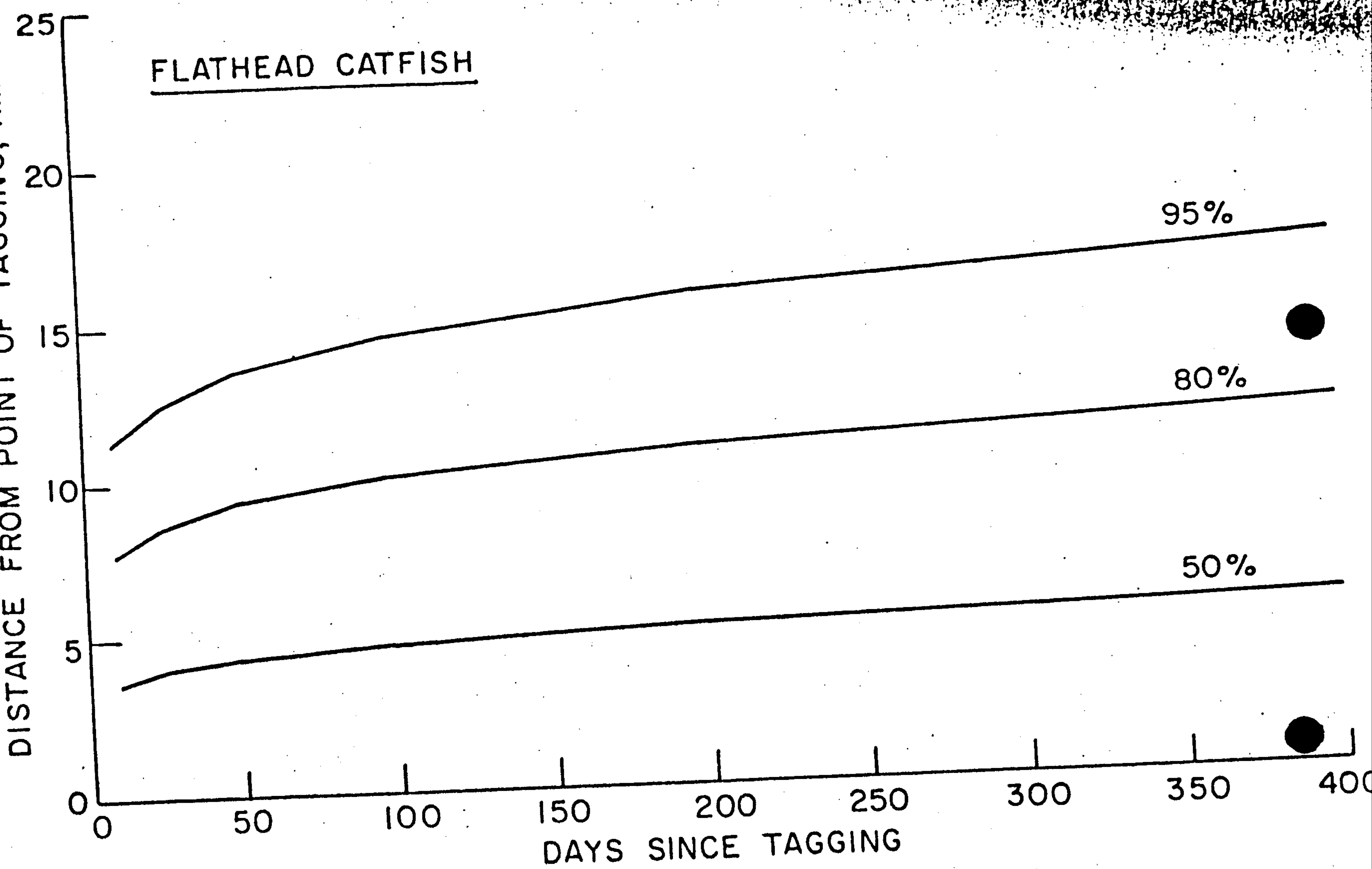

Figure 3.3. Calculated redistribution of flathead catfish (based on 50 recaptured fish) in terms of straight-line distance from point of tagging, and time since tagging. Curves represent the specified percentage of tagged fish expected to be captured within x days at a distance of y kilometers or less from the point of release.

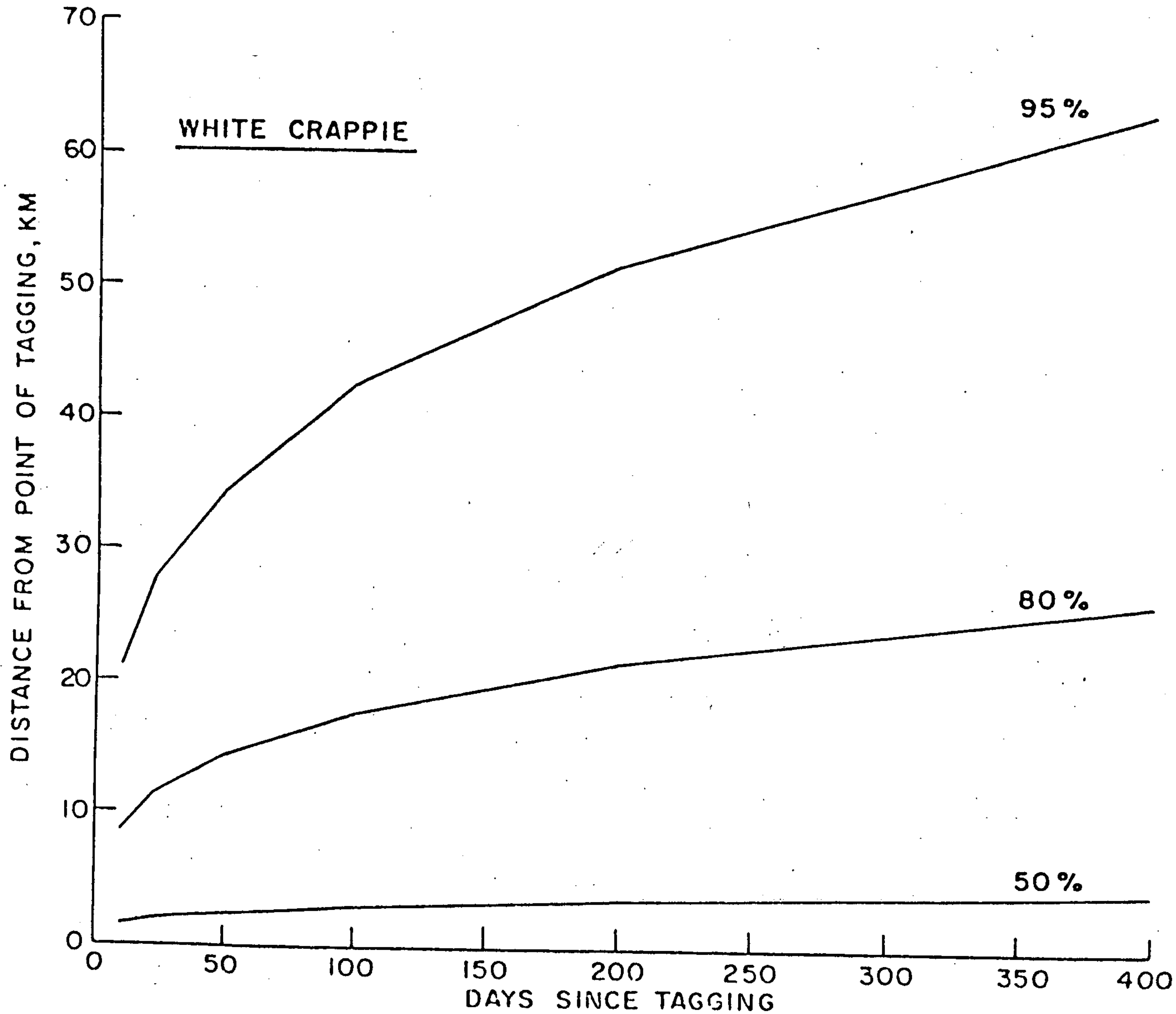

Figure 3.4. Calculated redistribution of white crappie (based on 95 recaptured fish) in terms of straight-line distance from point of tagging [illegible]

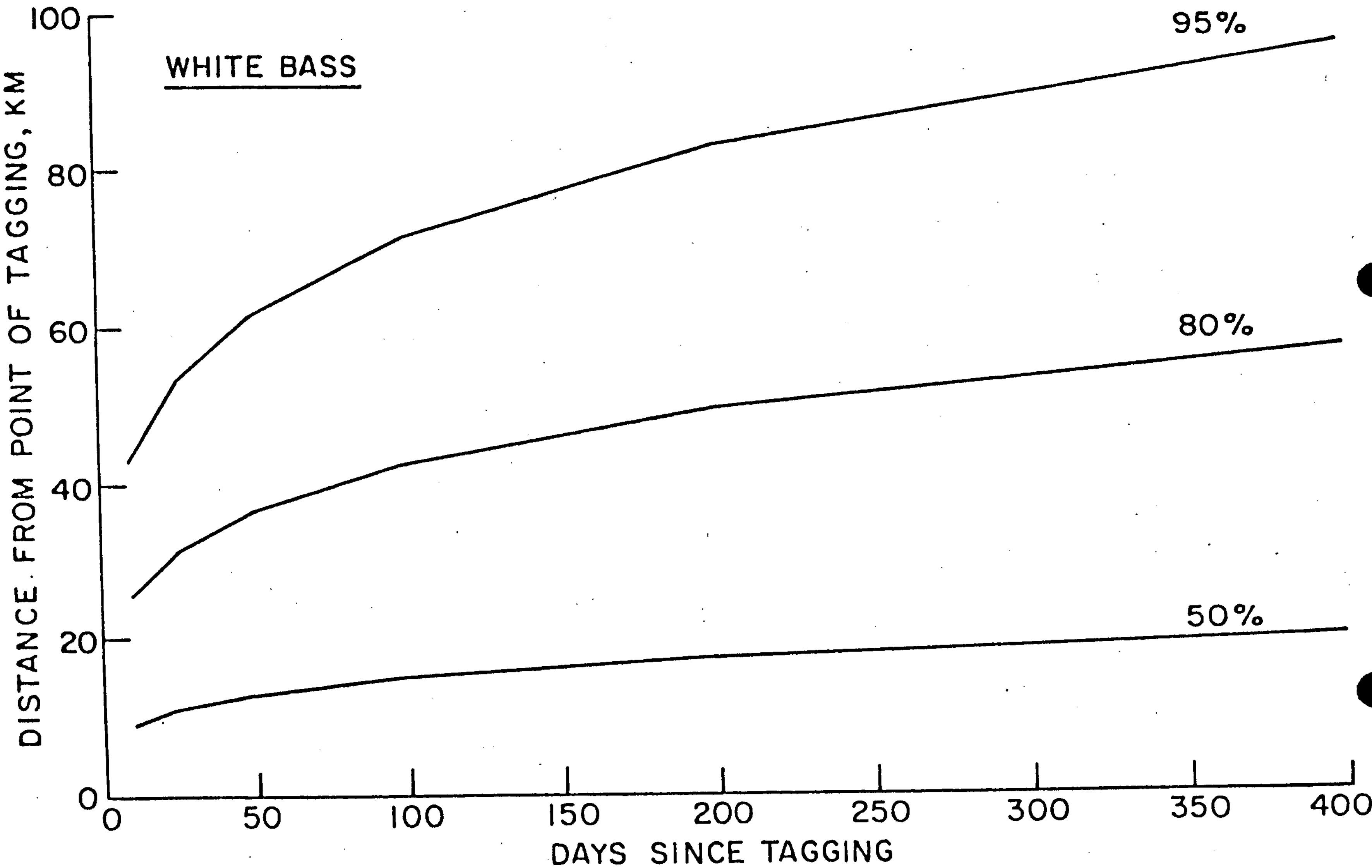

Figure 3.5. Calculated redistribution of white bass (based on 28 recaptured fish) in terms of straight-line distance from point of tagging, and time since tagging. Curves represent the specified percentage of tagged fish expected to be captured within x days at a distance of y kilometers or less from the point of release.

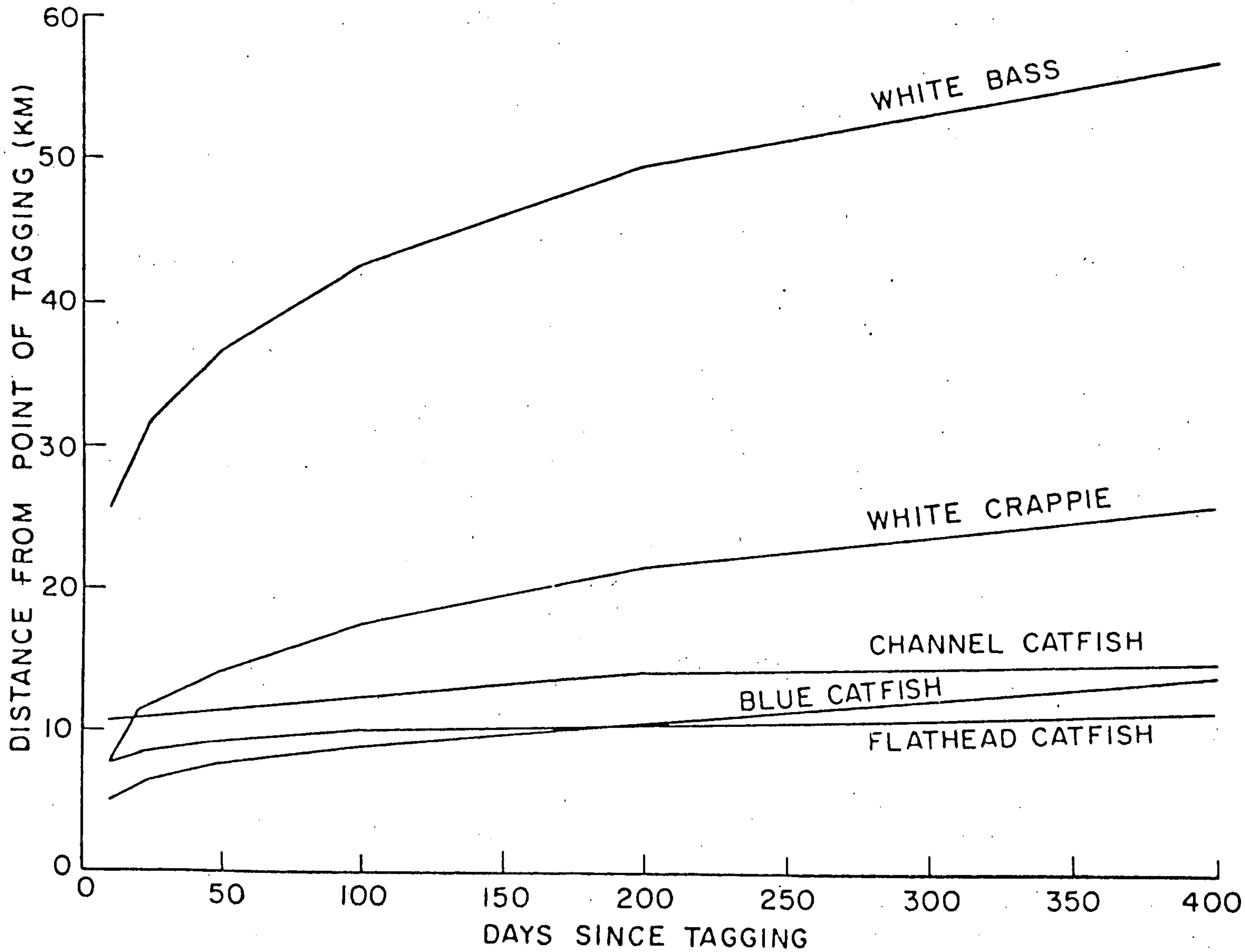

Figure 3.6. Calculated redistribution of five fish species in terms of straight-line distance from point of tagging, and of time since tagging. Curves represent 80 percent of the specified percentage of tagged fish expected to be [illegible] within [illegible] days [illegible]

Table 3.9. Distribution of 219 recaptured fish according to species and direction of movement.

Direction of Movement	Channel Catfish		Blue Catfish		Flathead Catfish		White Crappie		White Bass		Total	
	Observed	X^2	Observed	X^2	Observed	X^2	Observed	X^2	Observed	X^2	Observed	X^2
Upstream	14	0.29	4	0.02	19	0.08	35	0.04	6	1.58	78	2.01
Neither up nor downstream	5	0.18	3	0.34	14	2.92	16	0.77	1	3.18	39	7.39
Downstream	15	0.04	5	0.06	17	1.70	44	0.00	21	7.86	102	6.66
TOTAL	34	0.51	12	0.42	50	4.70	95	0.81	28	9.62	219	16.06

Chi-square = 16.06, 8 d.f.

X^2 (0.05, 8 d.f.) = 15.51

3.2.3 Species Movement Past the Plant Site.

Fish recaptures after moving past the plant site from each release area are presented in Table 3.10. This table includes all fish whose line-of-sight distance between the points of release and recapture would have them passing the plant site. Of 195 recaptured fish released below the plant site, 18 (9 percent) had moved upstream past the plant site. Of 24 recaptured fish released above the plant site, 6 (25 percent) had moved downstream past the plant site. Fish movements past the nuclear plant were highly variable among the five species. The returns ranged from none for blue catfish to 1.2 percent for white crappie.

Table 3.10. Proportion and number of tagged fish recovered after moving past the nuclear plant site according to species and release site.

Species	Release Site (TRM)	Recaptured Past the Plant Site		Number Tagged and Released
		Number	Proportion	
Channel catfish	283	0	0.0000	283
	285	1	0.0021	469
	287	1	0.0015	639
	298	2	0.0051	385
Blue catfish	283	0	0.0000	119
	285	0	0.0000	60
	287	0	0.0000	118
	298	0	0.0000	122
Flathead catfish	283	1	0.0101	99
	285	0	0.0000	112
	287	0	0.0000	182
	298	0	0.0000	126
White crappie	283	2	0.0338	59
	285	0	0.0000	160
	287	7	0.0107	652
	298	4	0.187	213
White bass	283	0	0.0000	32
	285	0	0.0000	93
	287	6	0.0076	784
	298	0	0.0000	60

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FISH MOVEMENT IN RESERVOIRS

Considering the diverse assemblage of fish species in most reservoirs, it is generally recognized that duration and extent of movement varies substantially among and within species groups. Also, differences in physical conditions among reservoirs may result in a species showing dissimilar movement patterns. Major factors influencing movement are spawning, food search, light, temperature, and dissolved oxygen.

Although definitive movement studies for several species within any single TVA mainstream reservoir such as Chickamauga are lacking, collective observations from throughout the system provide a broad baseline for evaluating fish movement. Although some species are relatively sedentary (e.g., bluegill), most species move extensively. For example, numerous tagging studies on sauger (Percidae) during the 1950's and 1960's, showed that this species commonly moved more than 25 miles. In Guntersville Reservoir, smallmouth buffalo moved an average minimum distance of seven miles and the maximum was 56 miles (Wrenn, 1968). In Watts Bar Reservoir, Martin et al., (1964) reported that this species moved an average distance of 11.2 miles. Monitoring studies in Wheeler Reservoir (Browns Ferry Nuclear Plant) showed substantial movement by white crappie and white bass. In general, and especially near the Watts Bar Nuclear Plant the primary directive factor for fish movement is location of spawning grounds.

CTS:TJS
2/22/85

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