

# Evaluating Risks from Fish Consumption in the Housatonic River: Probabilistic Assessment

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## Abstract

We conducted point and probabilistic risk assessments for the consumption of fish in the Housatonic River. The probabilistic analyses consisted of Monte Carlo simulation (with both one-dimensional and microexposure event analyses), dependency bounds analyses, probability bounds analyses, and a comparison of the results of a probability bounds analysis with a 2 dimensional Monte Carlo approach. The exposure distributions were based on the same datasets from which the point estimate exposure parameters were derived. The Monte Carlo analyses assumed strict independence between all variables and indicated the expected variability of the risk. A dependency bounds analysis was used to relax the assumptions of independence and explore risks from ingestion under other dependency assumptions. The probability bounds analyses used intervals to comprehensively bound the uncertainty in the distribution of the risk indicated by the Monte Carlo simulations. Sensitivity analyses were conducted to quantify the contributions of variability and/or uncertainty of each exposure parameter to the risk estimates. The ingestion rate usually contributed the largest amount of variance in the models examined.

## Outline of analyses

### Probabilistic analyses

- One-dimensional (1D) and Microexposure Event modeling (MEE)
- Cancer risk and non-cancer risk
- Monte Carlo simulation (MC) variability only
- Probability Bounds analysis (PBA) variability, uncertainty
- Dependency bounds analysis (DBA)

Analyses indicated in blue are discussed in this presentation

## Input variables

| Variable             | Symbol            | Units    | Min,Max    | Central Estimate | Std. Dev | MC Distribution | P-box          |
|----------------------|-------------------|----------|------------|------------------|----------|-----------------|----------------|
| Concentration        | $C_{\text{fish}}$ | mg/kg    | 10.8, 13.9 | 13.9             | -        | point est.      | interval       |
| Cooking loss         | $LOSS$            | unitless | 0, 1       | 0.26             | 0.18     | mixture         | mixture        |
| Bake                 |                   |          | 0.05, 0.67 | 0.22             | 0.112    | lognormal       | MMMS           |
| Broil                |                   |          | 0.02, 1    | 0.19             | 0.18     | T-lognormal     | MMMS           |
| Pan fry              |                   |          | 0.04, 0.9  | 0.24             | 0.15     | lognormal       | MMMS           |
| Deep fat fry         |                   |          | 0.15, 1    | 0.44             | 0.17     | T-lognormal     | MMMS           |
| Adult intake rate    | $EFIR_A$          | g/day    | 0.03, 647  | 8.5              | 13.6     | EDF             | ENV EDF        |
| Child intake rate    | $EFIR_C$          | g/day    | 0.015, 324 | 4.25             | 6.8      | EDF             | ENV EDF        |
| Adult ingestion rate | $IR_A$            | g/meal   | 142, 340   | 227              | -        | triangular      | interval       |
| Child ingestion rate | $IR_C$            | g/meal   | 70.9, 170  | 113.5            | -        | triangular      | interval       |
| Exposure frequency   | $EF$              | meal/yr  | 0.03, 490  | 13.1             | 22.2     | decon. EDF      | ENV decon. EDF |
| Fraction ingested    | $FI$              | unitless | 0.1, 1     | 0.48             | 0.27     | EDF             | MMMS           |
| Adult exposure dur.  | $ED_A$            | yr       | 1, 64      | 29               | 20       | T-lognormal     | MMMS           |
| Child exposure dur.  | $ED_C$            | yr       | 1, 6       | 3.5              | 1.4      | uniform         | interval       |
| Adult body weight    | $BW_A$            | kg       | 39, 119    | 72               | 15       | lognormal       | lognormal      |
| Child body weight    | $BW_C$            | kg       | 12, 23     | 17               | 2.3      | lognormal       | lognormal      |

Variables indicated in red are needed for MEE modeling and are not discussed in this presentation.

## Monte Carlo methods

- Precise point estimate
- Empirical distribution function (EDF)
- Precise distribution function
  - Lognormal
  - Truncated lognormal
  - Uniform
  - Triangular (MEE models only)
- Stochastic mixture of distributions

## Probability bounding methods

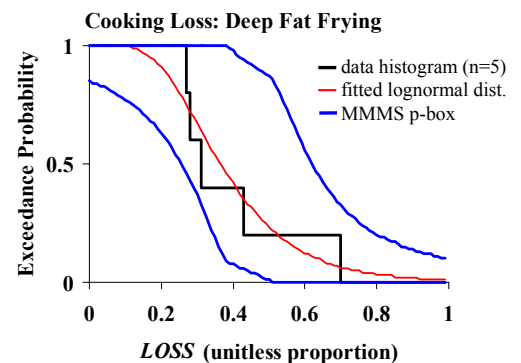
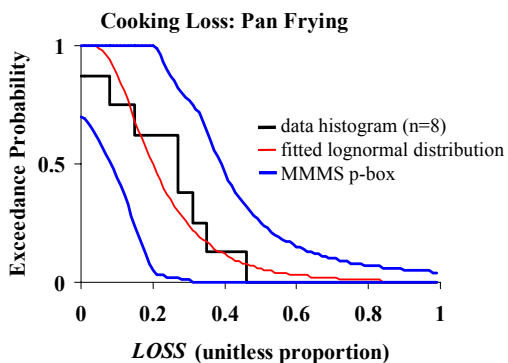
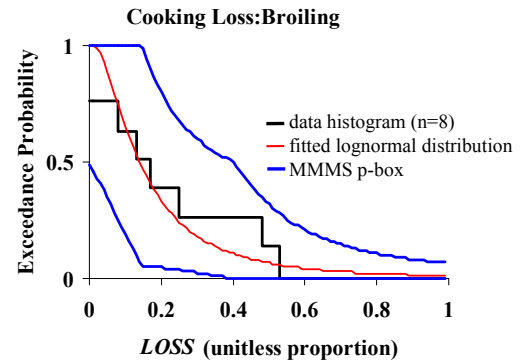
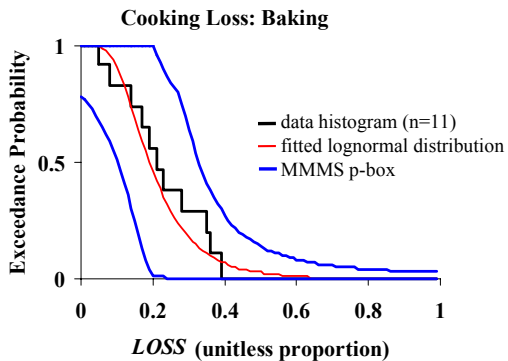
- Interval (Min, Max)
- MMMS (Min, Max, Mean, Std.Dev)
- Envelope of EDFs
- Stochastic mixture of MMMS
- Precise distribution function (lognormal)

## Concentration in fish ( $C_{\text{fish}}$ )

- MC used the EPC for four fish species (combined).  
95% UCL used to “account for uncertainty”.  
Using the UCL is intended to prevent underestimation.
- PBA used the interval: [mean, EPC].  
Assumes the sample mean  $\leq$  the true mean.  
EPA is concerned with not underestimating the mean.

## LOSS data

| Bake   | Ref  | Broil | Ref  | Pan fry | Ref  | Deep fat fry | Ref  |
|--------|------|-------|------|---------|------|--------------|------|
| 5      | (8)  | 0     | (7)  | 46      | (4)  | 74           | (7)  |
| 16     | (7)  | 53    | (11) | 7.5     | (2)  | 31           | (12) |
| 34     | (11) | 7.5   | (2)  | 35      | (13) | 35           | (13) |
| 7.5    | (2)  | 24    | (15) | 31      | (15) | 32           | (14) |
| 27     | (9)  | 12    | (1)  | 15      | (1)  | 47           | (3)  |
| 20     | (1)  | 16    | (15) | 27      | (5)  |              |      |
| 35     | (13) | 47    | (5)  | 0       | (3)  |              |      |
| 22     | (15) | 0     | (3)  | 27      | (10) |              |      |
| 13     | (15) |       |      |         |      |              |      |
| 39     | (5)  |       |      |         |      |              |      |
| 18     | (6)  |       |      |         |      |              |      |
| Median | 20   | 14    |      | 27      |      | 35           |      |
| Mean   | 22   | 20    |      | 24      |      | 44           |      |



## Cooking method weights

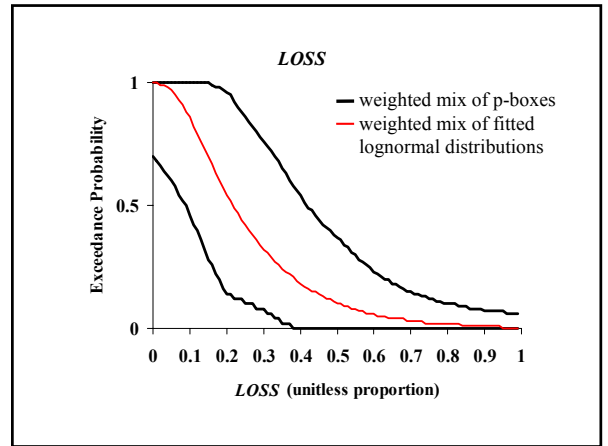
Data

| Method                  | %    |
|-------------------------|------|
| Frying (pan & deep fat) | 62.1 |
| Baking                  | 17.9 |
| Broiling                | 16.4 |
| Soup                    | 2.0  |
| Poaching                | 0.9  |
| Microwaving             | 0.9  |
| Raw                     | 0.6  |
| Boiling                 | 0.2  |

96.4%

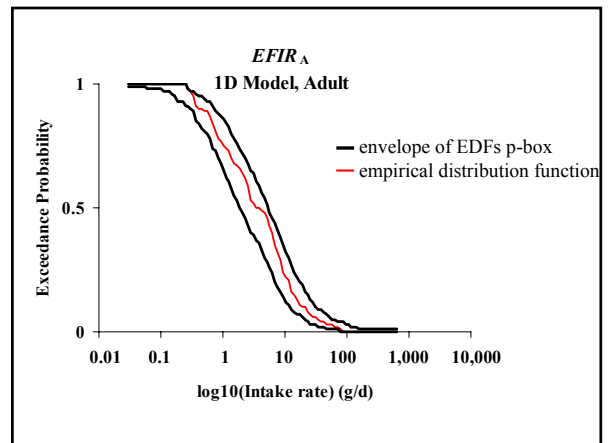
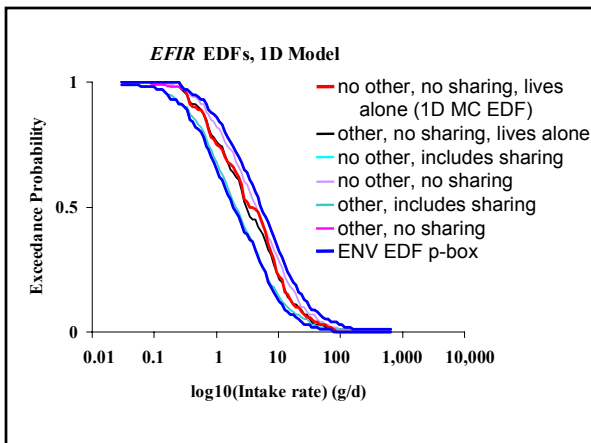
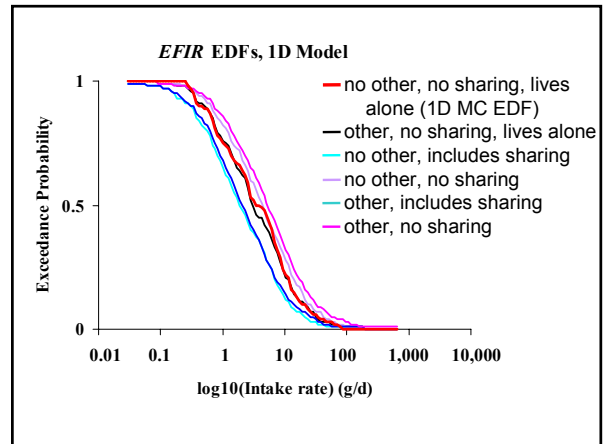
Decision

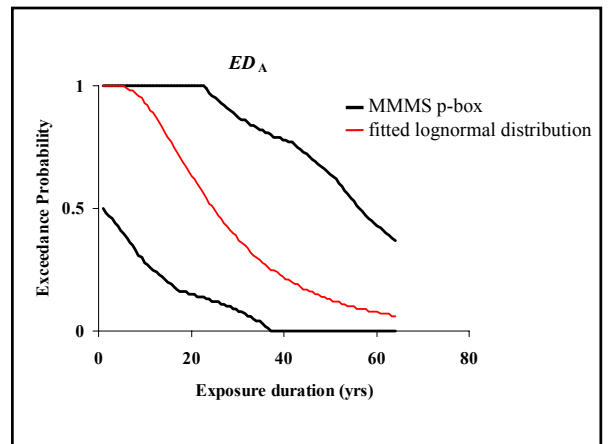
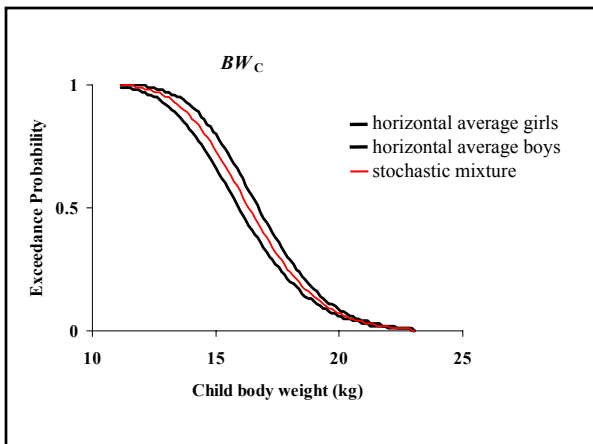
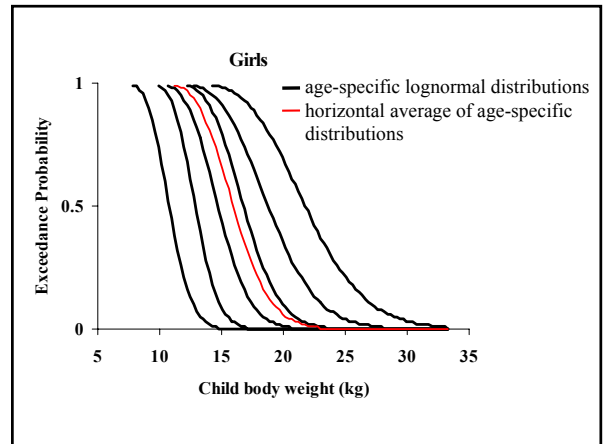
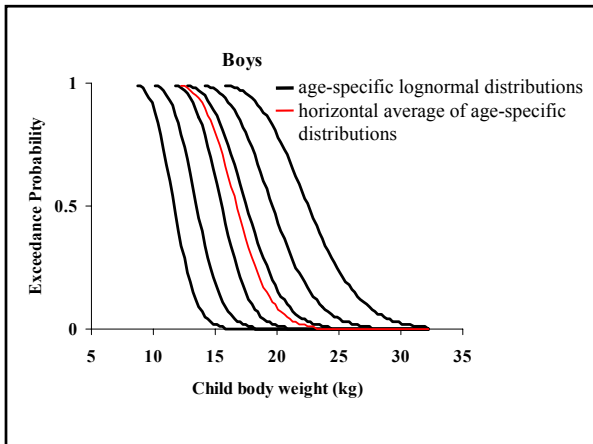
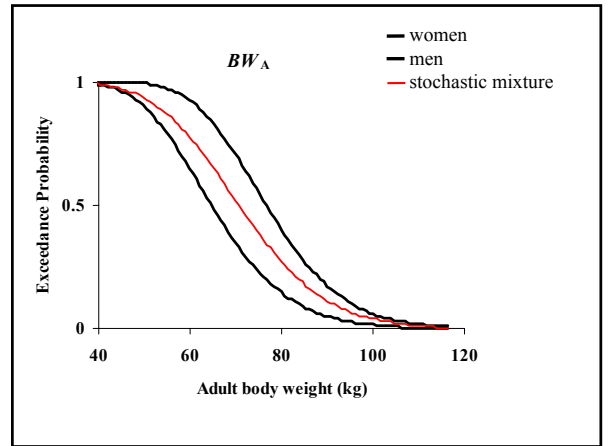
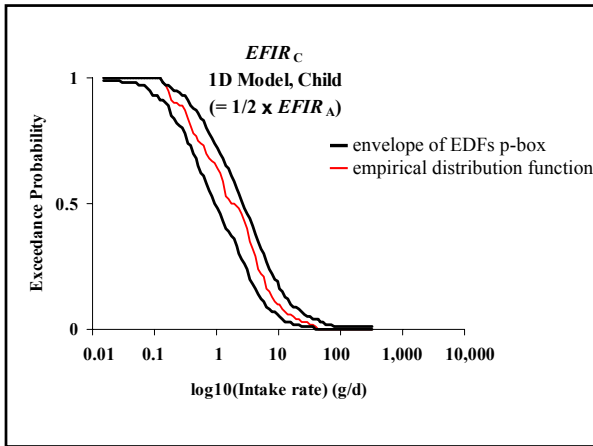
| Method          | %  |
|-----------------|----|
| Pan frying      | 40 |
| Deep fat frying | 20 |
| Baking          | 20 |
| Broiling        | 20 |



## 1D model intake rate

- 1D model uses data from the Maine Angler Survey to model intake rate.
- The survey measured grams of game fish consumed per household per day (g/d).
- The data was stratified:
  - Did you consume fish from “other” sources?
  - Did you eat shared fish?
  - Do you live alone?
    - If not, intake rate divided by number in household.







## References (2)

Cooking Loss weights and EFIR data sources:

ChemRisk. 1992. *Consumption of Freshwater Fish by Maine Anglers*. 24 July 1992.  
 ChemRisk. 1995. *Evaluating the Impact of Cooking Processes on the Level of PCBs in Fish*. Prepared for General Electric Company. January 1995.

Body weight distribution data sources:

Brainard J and Burmaster D.E. 1992. Bivariate distributions for height and weight of men and women in the United States. *Risk Analysis* 12: 267-275.  
 Burmaster, D.E. and E.A.C. Crouch 1997. Lognormal distributions for body weight as a function of age for males and females in the United States, 1976-1980. *Risk Analysis* 17(4):499-505.

ED data source:

MDPH (Massachusetts Department of Public Health). 2001. Letter from Suzanne K. Condon, Assistant Commissioner of the Bureau of Environmental Health Assessment to Bryan Olson, U.S. Environmental Protection Agency, Region I. Tables with Hunting Information for Individual Family Members Who Reported Hunting Birds from the HRA, PCB Exposure Assessment Study, Volunteer Study, and Hotline Study and Calls from Individuals Concerned about Hunting after Hearing about the PCB Duck Advisory. 21 August 2001.

FI data sources:

Barry, T.J. 1988. *An Angler Survey and Economic Study of the Housatonic River Fishery Resource*. Connecticut Department of Environmental Protection, Bureau of Fisheries, Hartford. Final Report.  
 ChemRisk. 1992. *Consumption of Freshwater Fish by Maine Anglers*. 24 July 1992.  
 Ebert, E.S., S.H. Su, T.J. Barry, M.N. Gray, and N.W. Harrington. 1996. Estimated rates of fish consumption by anglers participating in the Connecticut Housatonic River Creel Survey. *North American Journal of Fisheries Management* 16:81-89.

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end

## Cancer models

1-D model:

$$Dose = \frac{C_{fish} \times (1 - LOSS) \times FI \times CF \times \left( \frac{ED_C \times EFIR_C}{BW_C} + \frac{ED_A \times EFIR_A}{BW_A} \right)}{AT}$$

Microexposure model:

$$Dose = \frac{CF}{AT} \left[ \left( \frac{ED_C}{BW_C} \times \text{mean}(FI \times EF) \times Z_C \right) + \left( \frac{ED_A}{BW_A} \times \text{mean}(FI \times EF) \times Z_A \right) \right]$$

where

$$Z_j = \text{mean}(C_{fish} \times (1 - LOSS) \times IR_j)$$

for  $j = C$  (child) or  $A$  (adult)

### Dependencies Modeled with Dependency Bounds Analysis

|      | C | LOSS | IR | EF | FI | ED |
|------|---|------|----|----|----|----|
| LOSS | I |      |    |    |    |    |
| IR   | I | I    |    |    |    |    |
| EF   | I | I    | ?  |    |    |    |
| FI   | I | I    | I  | I  |    |    |
| ED   | I | I    | ?  | I  | I  |    |
| BW   | I | I    | ?  | I  | I  | ?  |

“I” indicates independence assumed, “?” indicates possible dependency relationship. Definitions for variable abbreviations are given in the text.