

Tri-State Monitoring of Sr-90 in Fish

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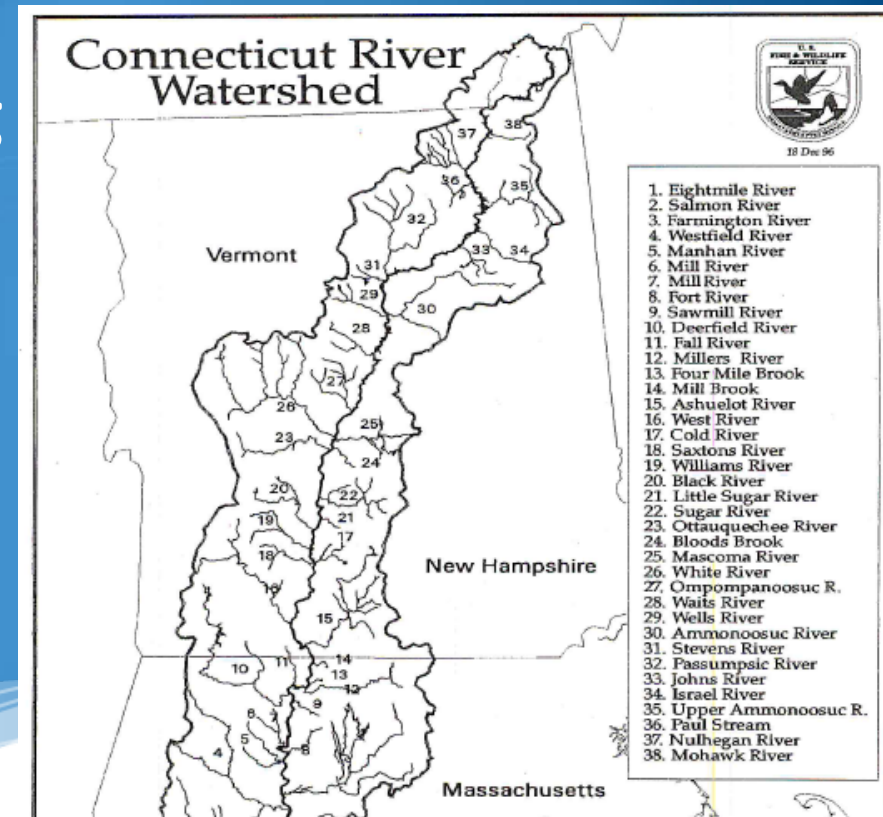
NH Dept. of Health and Human Services

Division of Public Health Services

Public Health Laboratories

Tri-State Monitoring of Sr-90 in Fish

- New Hampshire Division of Public Health Services, Department of Health and Human Services
- Vermont Department of Health (VDH)
- Massachusetts Department of Public Health, Bureau of Environmental Health
- FDA/Winchester Engineering and Analytical Center



Why was the study done?



- **Sr-90 bioaccumulates in Fish muscle and bone**
- **NY study have shown Sr-90 accumulation in fish**
- **Strontium-90 in a Connecticut River fish, 2010**
 - Sr-90 level in a fish sampled from the Connecticut River in 2010 detected higher than background activity, but still below the FDA level of concern for ingestion.
- **Background level study needed**
 - New Hampshire, Vermont, and Massachusetts decided to study the background levels of Sr-90 in their water bodies, especially those not connected to the Connecticut River watershed.
- **Joint study undertaken**
 - Winchester Engineering and Analytical Center (WEAC) performed the radioanalyses
 - New Hampshire sent three batches for analysis

Where does Sr-90 come from

- One of several radionuclides in the environment due to
 - Chernobyl (1986)
 - Fukushima (2011)
 - Nuclear weapons use and testing (1945 – 1980)
 - Other man-made releases (e.g., DOE sites and military installations.)



Sources of man-made radionuclides in the environment

- Permitted releases from nuclear power plants and other nuclear facilities
- Unmonitored releases from nuclear power plants and other nuclear facilities



NRC file photo

Sr-90 in the environment

- Half life: approximately 29 years
- Chemically similar to Calcium (Both Group IIA elements)
- Dissolves in water
- Emits a beta particle with no gamma radiation, as it decays to Yttrium-90 (also a beta-emitter) which in turn decays to stable Zirconium
- Moderately mobile in soil, but site-dependent

GROUP	
1 IA	2 IIA
1 1.0079 H HYDROGEN	
3 6.941 Li LITHIUM	4 9.0122 Be BERYLLIUM
11 22.990 Na SODIUM	12 24.305 Mg MAGNESIUM
19 39.098 K POTASSIUM	20 40.078 Ca CALCIUM
37 85.468 Rb RUBIDIUM	38 87.62 Sr STRONTIUM
55 132.91 Cs CAESIUM	56 137.33 Ba BARIUM
87 (223) Fr FRANCIUM	88 (226) Ra RADIUM

Health Effects of Sr-90

- Sr-90 moves similar to calcium in the body (“bone seeker”)
- Damages bone marrow & decreased blood cell counts
 - Low red blood cell counts may result in anemia
 - Low white blood cell counts may reduce ability to fight infection
- The most common test for exposure to Sr-90 is a urine bioassay (for internal contamination)

Radionuclides produced & globally dispersed in above ground weapons testing

Radionuclide	Half-life	Fission Yield (%)	Global release (PBq) ^a
¹³¹ I	8.02 days	2.9	675,000
¹⁴⁰ Ba	12.75 days	5.18	759,000
¹⁴¹ Ce	32.50 days	4.58	263,000
¹⁰³ Ru	39.26 days	5.2	247,000
⁸⁹ Sr	50.53 days	3.17	117,000
⁹¹ Y	58.51 days	3.76	120,000
⁹⁵ Zr	64.02 days	5.07	148,000
¹⁴⁴ Ce	284.9 days	4.69	30,700
⁵⁴ Mn	312.3 days		3,980
¹⁰⁶ Ru	373.6 days	2.44	12,200
⁵⁵ Fe	2.73 years		1,530
¹²⁵ Sb	2.76 years	0.4	741
³ H	12.33 years		186000 ^b
²⁴¹ Pu	14.35 years		142 ^c
⁹⁰ Sr	28.78 years	3.5	622
¹³⁷ Cs	30.07 years	5.57	948
¹⁴ C	5,730 years		213 ^b
²⁴⁰ Pu	6,563 years		4.35 ^c
²³⁹ Pu	24,110 years		6.52 ^c

^a Corresponds to total globally dispersed fission energy of atmospheric tests of 160.5 Mt or fusion energy of 250.6 Mt (excludes releases associated with local and regional deposition)

^b Because of mobility and half-lives of ³H and ¹⁴C, the release is associated with a total fusion energy of 251 Mt.

^c Estimated from ratios to ⁹⁰Sr in global deposition.

Adapted from UNSCEAR 2000

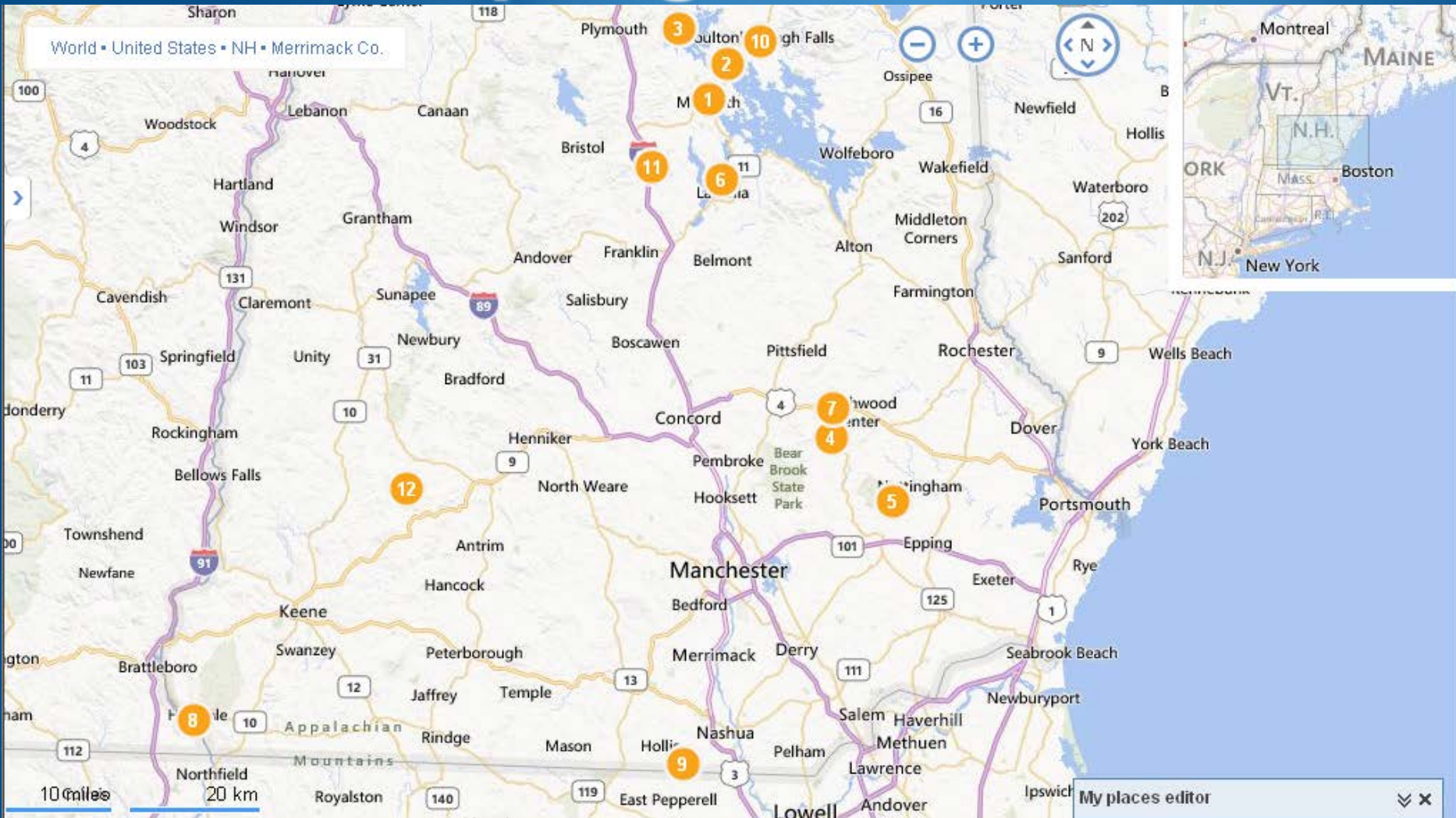
Reason for Selecting Large-Mouth Bass in NH

- The method required 500g (1.1 lbs) of sample to meet data quality objective, we were asked to get 2 lbs/fish so that the edible portion would be at least 1.1 lbs.
- NH Fish and Game thought large mouth bass would give us the best chance at hitting that 2 lb. mark.

Large-Mouth Bass from NH



NH Sampling Locations



Fish sampling locations in NH: (1) Meredith (Lake Winnepesaukee) (2) Center Harbor (Lake Winnepesaukee), (3) Holderness (Squam Lake), (4) Deerfield (Pleasant Lake), (5) Nottingham (Pawtuckaway Lake), (6) Laconia (Opechee Lake), (7) Northwood (Northwood Lake), (8) Hinsdale (the Connecticut River), (9) Nashua/Hollis (the Nashua River), (10) Moultonborough (Lees Pond), (11) Sanbornton (Hermit Lake), (12) Stoddard (Highland Lake)

Fish (Bass) Sampling Rounds

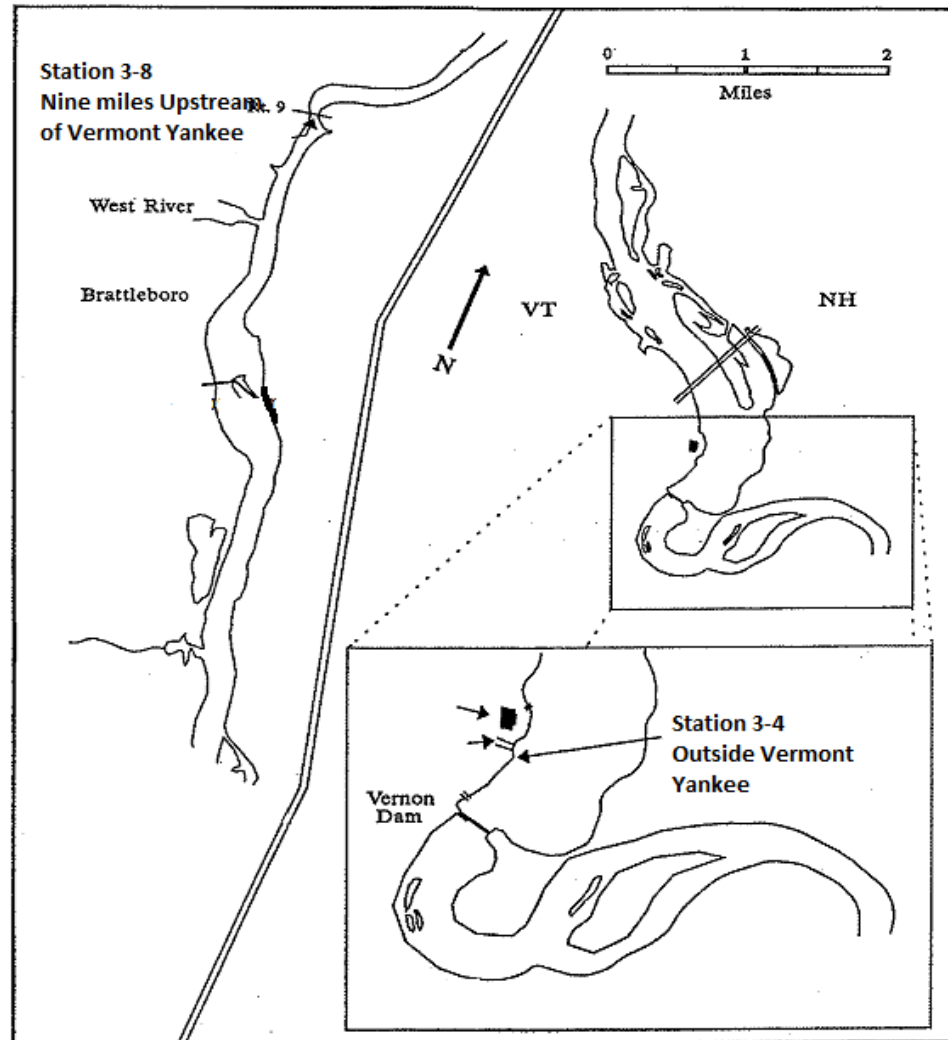
Collection Date	Location	No. of Sample Collected	Distance from Nuclear Stations*
5/11/2012 5/16/2012	Hermit Lake (Sanbornton)	30	71 (VY), 60 (SS)
9/22/2012	Nashua River (Hollis)	3	50 (VY), 37 (SS)
9/22/2012	Lake Winnepesaukee (Meredith)	3	80 (VY), 62 (SS)
9/22/2012	Connecticut River (Hinsdale)	2	5 (VY), 86 (SS)
9/22/2012	Lake Winnepesaukee (Center Harbour)	3	83 (VY), 64 (SS)
9/22/2012	Squam Lake (Holderness)	3	80 (VY), 69 (SS)
9/22/2012	Pleasant Lake (Deerfield)	3	70 (VY), 30 (SS)
9/23/2012	Pawtuckaway Lake (Nottingham)	3	73 (VY), 21 (SS)
9/23/2012	Opechee Lake (Laconia)	2	74 (VY), 53 (SS)
9/26/2012	Northwood Lake (Northwood)	3	70 (VY), 30 (SS)
9/26/2012	Highland Lake (Stoddard)	3	32 (VY), 64 (SS)
5/6/2013	Lee's Pond (Moultonborough)	30	88 (VY), 63 (SS)

* Crow flight distance from Vermont Yankee (VY) and Seabrook Station (SS)

Vermont's Radiological Fish Testing Pre-2010

- **Surveillance near Vermont Yankee for 40+ years**
- **Fish collected from 2 locations in the Connecticut River (stations 3-4 & 3-8)**
- **Tested 'whole' fish by gamma spectrometry at Health Department Laboratory**
- **Cesium-137 and potassium-40 routinely detected**

Vermont Yankee Connecticut River Fish Sampling Stations



Vermont Yankee Fish Sampling Stations on the Connecticut River: Stations 3-4 and 3-8

Vermont's Radiological Fish Testing

- Identification of an unmonitored release of tritium in January 2010 led to increased surveillance. Increase in both number of samples and types of tests performed
- Connecticut River samples still taken, sent to contract laboratory, tested as edible/inedible fractions
- Requested MDA of 5.0 pCi/kg for strontium-90 in both fractions to match regional data study
- Fish will be tested by gamma spectroscopy and strontium-90

Vermont's Radiological Fish Testing 2010-2012

Test	Method	Approximate MDA (pCi/kg)
Gamma Spectrometry	EPA 901.1 Mod/DOE HASL 300	5 to 10 (based on cesium-137)
Iron-55	DOE RESL Fe-1 Modified	1250
Nickel-63	DOE RESL Ni-1 Modified	300
Strontium-89	EPA 905.0 Modified	Varied
Strontium-90	EPA 905.0 Modified	50.0
Wet weight reporting		

Vermont's Radiological Fish Testing 2010-2012

- Primarily largemouth, smallmouth bass, but yellow perch, bluegill and pumpkinseed also tested
- 500g-1000g, may composite fish if needed
- Edible portions: filets
- Inedible: bones, guts, scales, skull



Largemouth bass



Smallmouth bass



Pumpkinseed

2010-2012 Vermont Fish Sample Results (all)

Radionuclide	Edible Portion Average (pCi/kg)	# detects/ n	Inedible Portion Average (pCi/kg)	# of detects/ n
Potassium-40	3050	31/31	2480	31/31
Cesium-137	27.8	8/31	21.8	5/31
Strontium-90	< MDA - 58.0	1/46	69.2	25/46

No iron-55, nickel-63, or strontium-89 detected

Strontium-90 MDA generally ranges from 35-50 pCi/kg

2010-2012 Vermont Fish Sample Results (location)

Radionuclide	CT River Edible Average (pCi/kg)	Franklin County Edible (n=2)	CT River Inedible Average (pCi/kg)	Franklin County Inedible (n=2)
Potassium-40	3070	2630	2490	2310
Cesium-137	19.4	52.8	14.0	33.6
Strontium-90	< MDA - 58.0	< MDA	70.5	54.6

2010-2012 Vermont Fish Sample Results

- **No radionuclides solely associated with nuclear power plant operations were detected in CT River fish**
- **More data of background levels of cesium-137 and strontium-90 in the northeast is needed**

Vermont Background Study Fish

- About 30 samples of fish were collected at 2 lakes in Rutland County, Vermont in September 2012
- Edible fish species were collected: bluegill, brown bullhead, pumpkinseed, northern pike, large-, smallmouth and rock bass.



Pumpkinseed



Largemouth Bass



Smallmouth Bass



Northern Pike



Brown Bullhead



Yellow Perch

Vermont Fish Collection Sites

Franklin County, VT
2 samples
Fall 2011

Lake Carmi

Rutland County, VT
30+ samples
Fall 2012

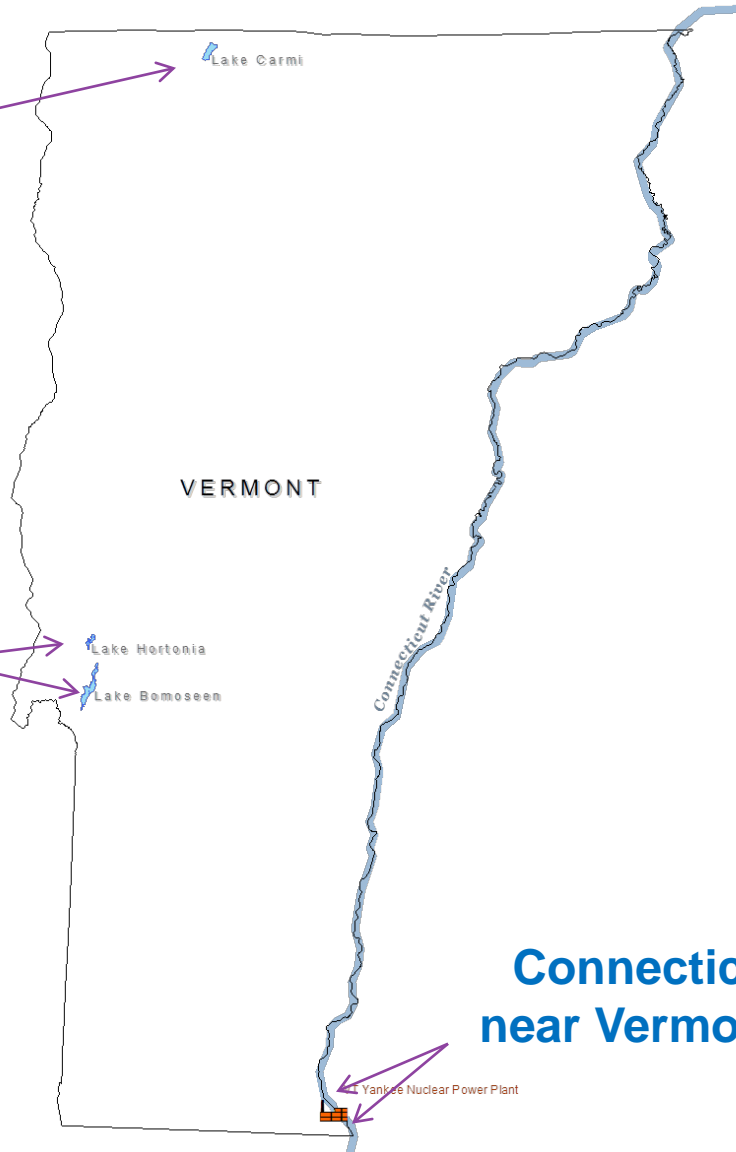
Lake Hortonia

Lake Bomoseen

Connecticut River

Connecticut River Stations
near Vermont Yankee--routine

Yankee Nuclear Power Plant





Massachusetts Department of Public Health Bureau of Environmental Health

- The Massachusetts Department of Public Health, Bureau of Environmental Health (MDPH/BEH) initiated an environmental sampling program in the Massachusetts communities that comprise the Vermont Yankee Nuclear Power Station Emergency Planning Zone (EPZ).
- This environmental monitoring program is a collaborative effort between BEH's Environmental Toxicology Program (ETP) and Radiation Control Program (RCP).
- This monitoring program includes collection of sediment, surface water, fish, vegetation, milk, food crops, air.
- The MDPH/BEH RCP Massachusetts Environmental Radiation Laboratory (MERL) has the capacity to analyze these samples for typical radionuclides associated with power station operations, in particular gamma emitters such as cesium 137, using gamma spectroscopy.



Massachusetts Department of Public Health Bureau of Environmental Health

- The first round of MDPH/BEH fish collection was carried out in October 2013.
- MERL will analyze the samples with gamma spectroscopy analysis and send split samples to FDA/WEAC for hard-to-detect analysis (including analysis for Sr-90).
- Results will be part of Massachusetts routine monitoring and will also be incorporated into the multi-state effort to study Sr-90 in fish.

MDPH/BEH contact:

Tom Hinchliffe

617 624 5757

Tom.Hinchliffe@state.ma.us

WEAC Method: RN-method 2.0

Sample is weighed, ashed and digested in nitric acid



Sample soln. Is placed in a sep. funnel with nitric acid equilibrated with tributylphosphate which separates Sr-90 and Y-90



After removal of iron and rare earths by fluoride and hydroxide ppts.the purified Y-90 is deposited on a glass fiber filter and counted on a low background internal gas-flow proportional counter.



The concentration of Sr-90 is equal to the concentration of Y-90 determined.

NH Results

- Hermit Lake:
 - The average concentration for the 30 fish from this lake was 0.16 Bq/Kg with a stdv. of 0.09 and a cv of 56%.
- Bass Fishing Derbies:
 - The average concentration for the 28 fish collected from the 10 fishing derbies was 0.200 Bq/Kg with a stdv. of 0.226 and a cv of 113%.

Results: (cont.)

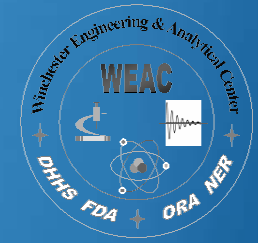
- Lee's Pond:
 - The average concentration for the fish from this pond was 0.485 Bq/Kg with a stdv. of 0.695 and a cv of 144%.
- The average for these three is 0.290 Bq/Kg.
- The average for Vermont was 0.163 Bq/Kg.
- A NY study had 1 fish out of 30 that tested above the DL. The result for this was 0.296 Bq/Kg.

Sr-90 DIL (Derived Intervention Level)

All Components of the Diet

160 Bq/Kg

Source: FDA CPG Sec. 560.750 Radionuclides in Imported Foods – Levels of concern



NH State First Batch Sample Analytical Result

NH State sample #	FDA Sample #	Cs-137 (Bq/Kg)	Cs-137 MDC (Bq/Kg)	Cs-137 Uncertainty (Bq/Kg, 2 sigma)	Sr-90 Activity Concentration (Bq/Kg)	Sr-90 MDC (Bq/Kg)	Sr-90 Uncertainty (Bq/Kg, 2 sigma)
A203833012 & A203833019	760035 (edible)	ND	2.70	NA	0.185	0.111	0.074
	760035 (inedible)	ND	2.37	NA	12.6	0.111	0.666
A203833018	760052 (edible)	5.59	1.74	1.41	0.148	0.111	0.074
	760052 (inedible)	ND	3.03	NA	13.2	0.111	0.666
A203833015	760084 (edible)	27.2	2.55	4.00	0.185	0.111	0.074
	760084 (inedible)	14.9	2.40	2.44	13.0	0.148	0.777



Summary

- First tri-state study to determine background levels of Sr-90 in fish was successful
- May Fish were collected from different water bodies to have an idea of what the background (radiation baseline) looks like
- It is important that no inedible portions (bones) are mixed with edible portions when preparing the samples as Sr-90 accumulates there!

Award

- This project won the FDA 2013 Office of Regulatory Affairs Honor Award for Scientific Collaboration of the Year!

Acknowledgement

- **Winchester Engineering and Analytical Center**
- Kelly Garnick, Thomas Scott, Christine Karbiwnyk, Abdurrafay Shareef, Joanne Hill, Marshall Harris & Cong Wei
- **Vermont Dept. of Health - William Irwin**
- **New Hampshire State Fish and Game**
- **MA DPH/BEH – Tom Hinchliffe**
- **NH Bass tournament coordinators and the club members who helped to catch the fish**
- **NH PHL employees who collected fish from fishing derbies throughout the state**
- **NH Radiological Health section.**

Questions???