Mid-Columbia River Fish Toxics Assessment

Columbia Toxics Reduction Workgroup meeting
Portland, Oregon
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What we'll cover today:

- Study design, analytes
- Field sampling
- Screening values (SVs) for human health and ecological receptors
- Results: river miles exceeding SVs
- What's next

Why study the mid-Columbia?

Past work indicating elevated toxic contaminants:

- USGS studies, NAWQA and others
- Bi-State
- CRITFC
- Hanford

Known toxics issues:

- fish consumption advisories

  mercury, PCBs, DDTs

- 303d listings

  mercury, PCBs, DDTs, other pesticides, dioxins

(Combined with the relative lack of information about this reach compared with the upper and lower sections)
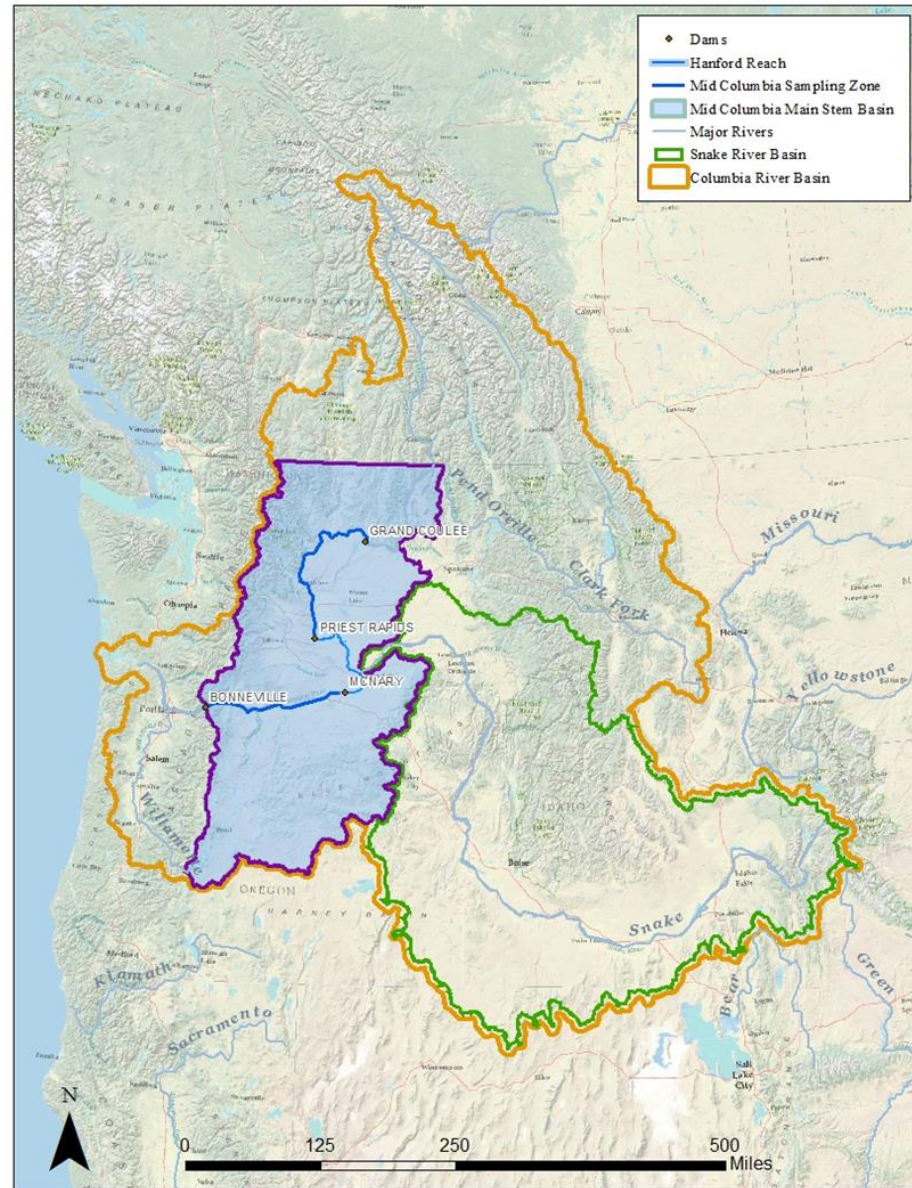
Mid-Columbia Project Area

Study area:

400 mile reach

Grand Coulee Dam
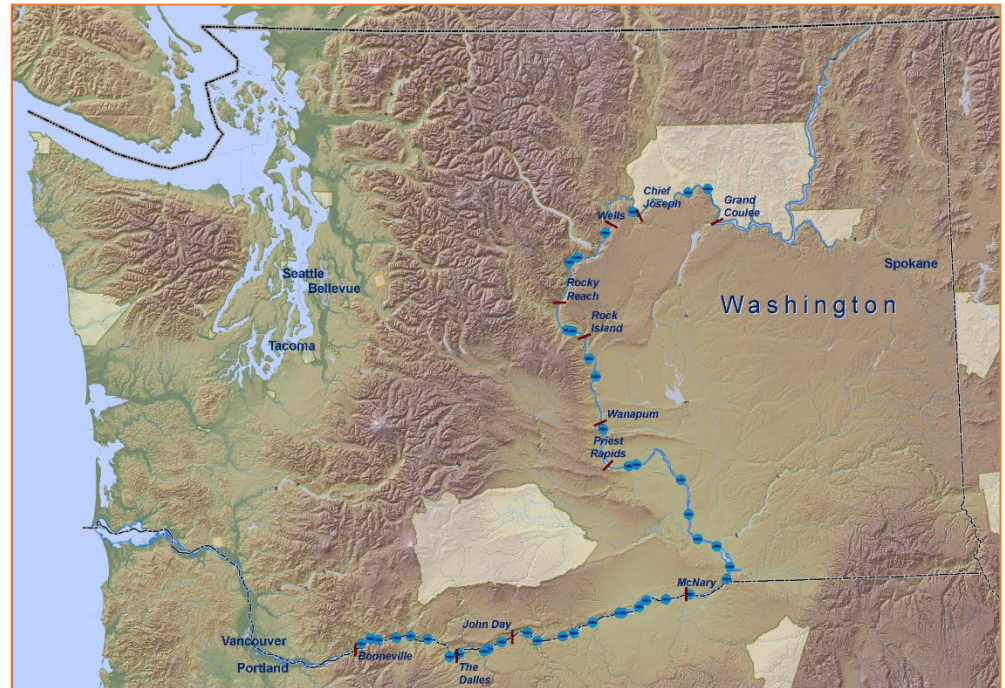downstream to Bonneville Dam

Study Design overview

Stratified-random design:

- uses small number of sites to describe the large river reach
- allows us to express the 'extent' of any stressor/analyte (in %)
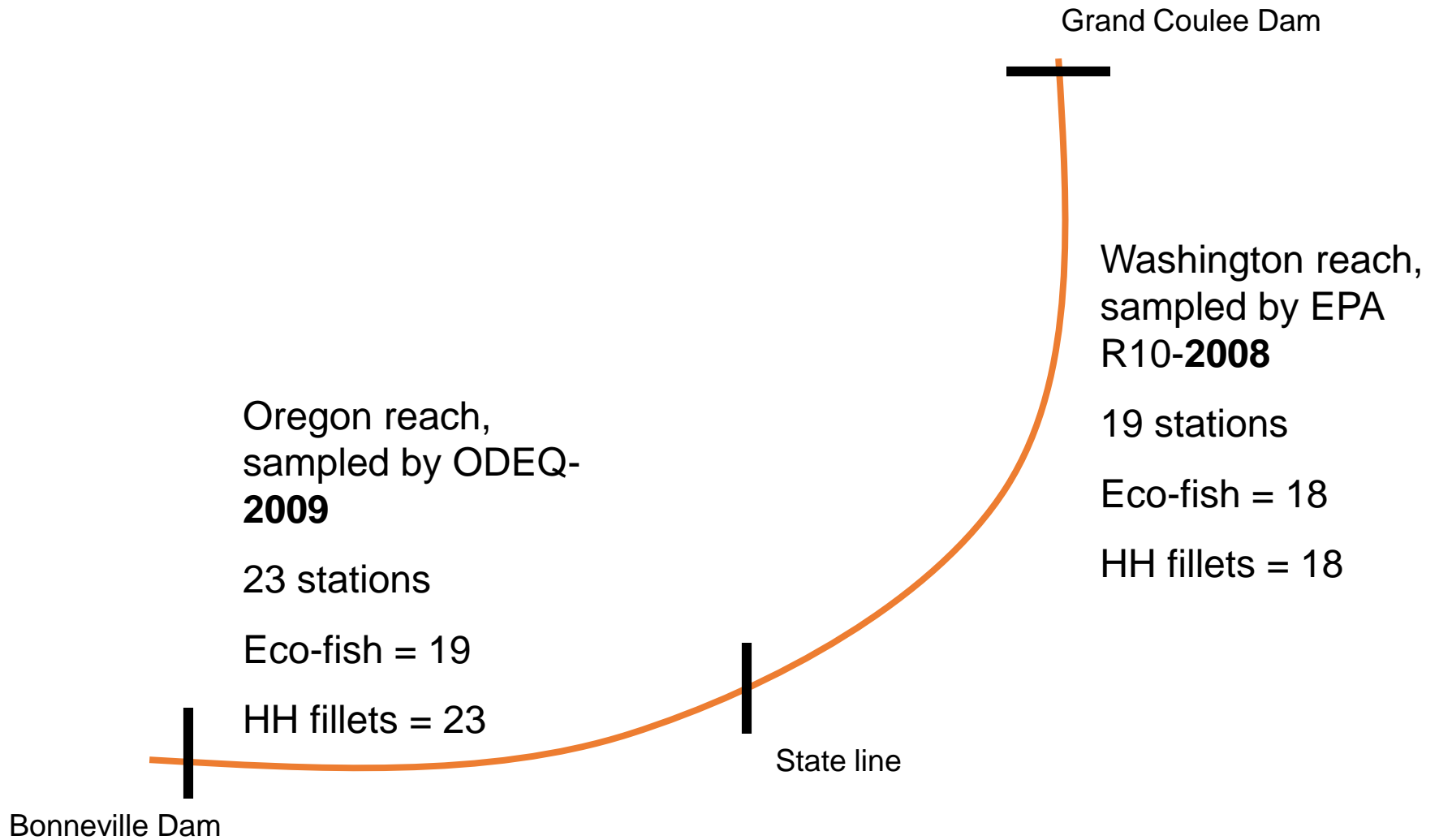- statistical confidence is 'built in'.

Sites Sampled:

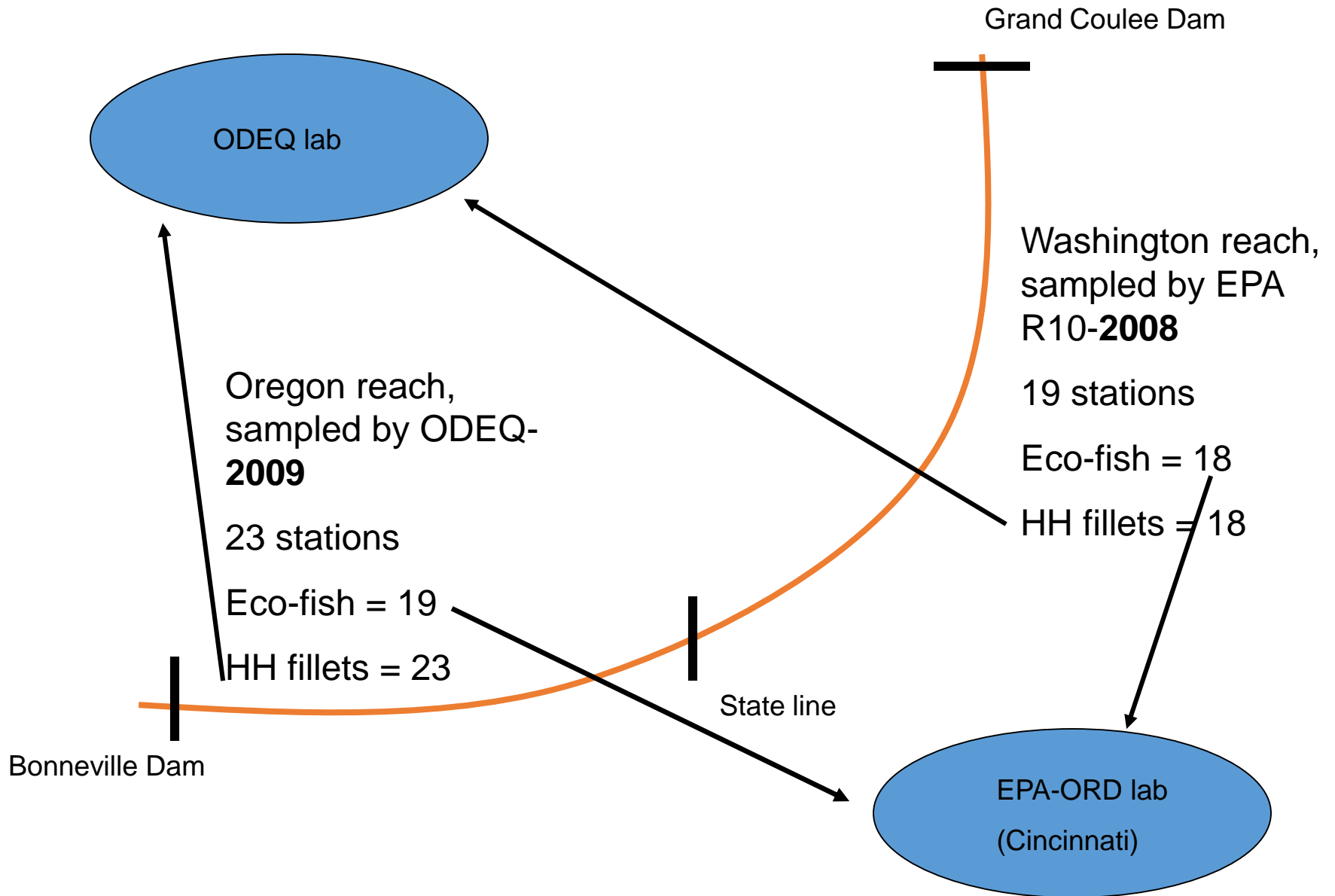   42 sites total
    19 in WA
    23 in OR

Field Sampling example
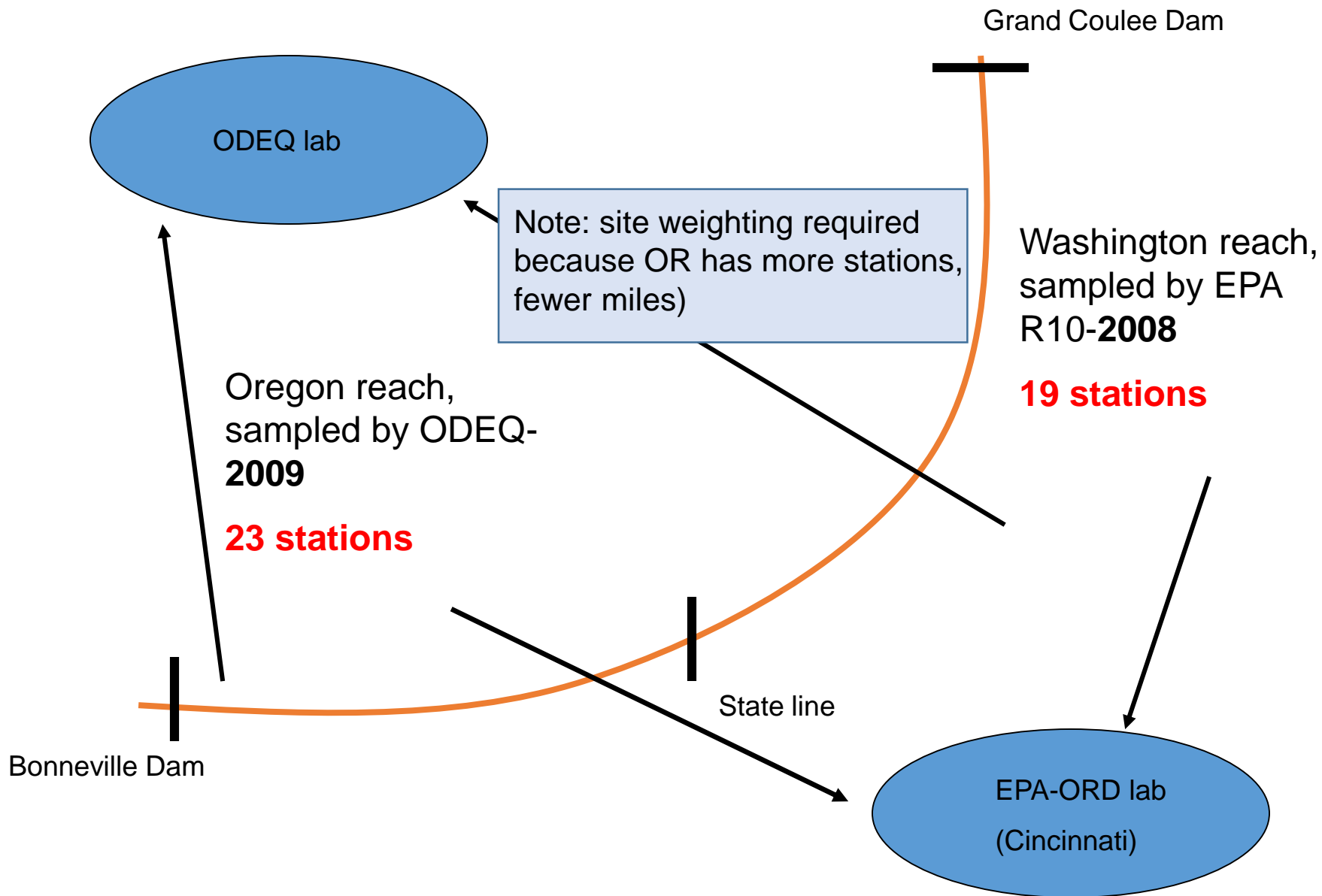# (site 63, Vernita Bridge)

Grand Coulee Dam

Washington reach, sampled by EPA R10-**2008**

19 stations

Eco-fish = 18

HH fillets = 18

Oregon reach, sampled by ODEQ-**2009**

23 stations

Eco-fish = 19

HH fillets = 23

State line

Bonneville Dam

(Oregon also sampled 8 hand-picked stations, mostly from tributaries)

Grand Coulee Dam

ODEQ lab

Washington reach, sampled by EPA R10-**2008**

19 stations

Eco-fish = 18

HH fillets = 18

Oregon reach, sampled by ODEQ-**2009**

23 stations

Eco-fish = 19

HH fillets = 23

State line

Bonneville Dam

EPA-ORD lab

(Cincinnati)

(Eco-fish metals analysis from EPA Manchester lab)

Grand Coulee Dam

ODEQ lab

Note: site weighting required because OR has more stations, fewer miles)

Washington reach, sampled by EPA R10-**2008**

19 stations

Oregon reach, sampled by ODEQ-**2009**

23 stations

State line

Bonneville Dam

EPA-ORD lab

(Cincinnati)

(Eco-fish metals analysis from EPA Manchester lab)

Tissue Analytes

- PCB congeners, ECO-fish (21) (ASE/ECD)
- PCB congeners, HH fish (172) (HRGC/HRMS)
- DDT and metabolites (6) (ASE/ECD)
- Other chlorinated pesticides (17 ECO, 20 HH) (ASE/ECD)
- PBDE congeners, ECO-fish (8)   (GC/ECD)
- PBDE congeners, HH fish (34) (HRGC/HRMS)
- Mercury and Selenium (ICP)
- Trace metals (ECO-fish only) (ICPMS)
- Dioxins and furans (fillet samples only) (HRGC/HRMS)

approaches for analysis:

- extent of contaminants
  (reach-wide descriptive statistics)

- comparison to screening values
  (CDFs to describe exceedances in % river length)

- spatial patterns / comparisons *(ongoing)*

Fish sampling:

Two fish samples collected per site using daytime electrofishing:

• Human health endpoint -   Resident predator species, consumed by humans, composites of 5 similar-sized adults (fillets)

• Ecological endpoint – Resident omnivores, <200mm length, prey items to other fish species and wildlife. Composite of at least 5 similar-sized fish, with minimum of 200g of tissue collected (whole body)

Human Health (fillet) samples

HH samples were collected at 41 of the sites.
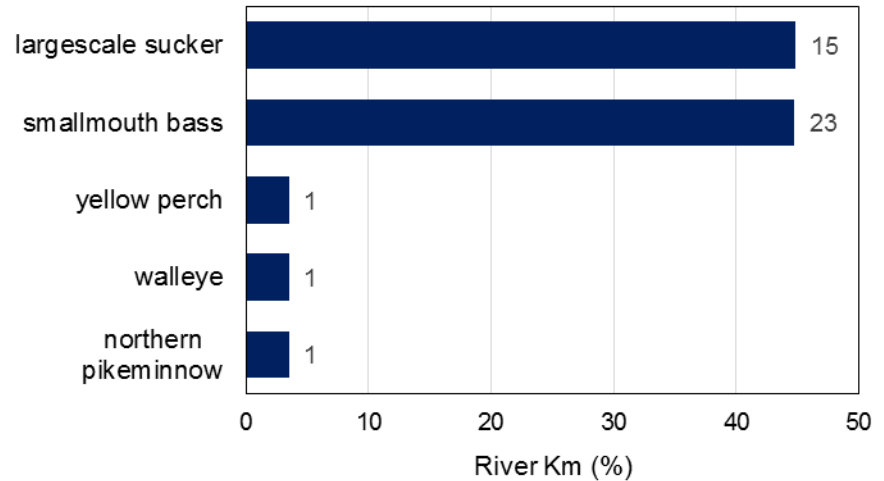
Percent of river length represented by the species sampled for HH-endpoint tissue. Numbers in bars are actual sample counts.

Largescale suckers and smallmouth bass represent 90% of the survey river miles

Eco-Fish (whole body) samples

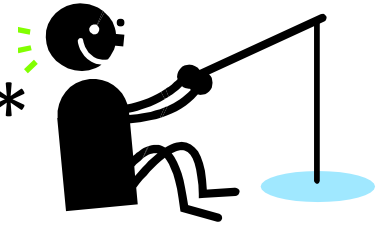Eco samples were collected at 37 of the sites.
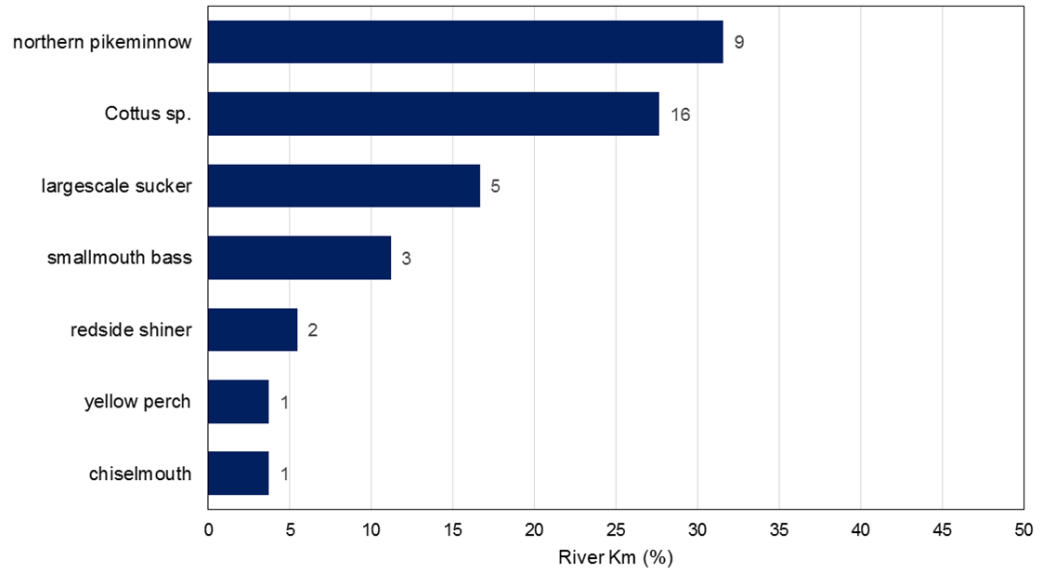
Percent of river length represented by the species sampled for eco-endpoint tissue. Numbers in bars are actual sample counts.

Pikeminnow, sculpins, and small largescale suckers represent 76% of the survey river miles

Screening values : Human Health*

- 2 endpoints: cancer** and non-cancer
- 2 consumption rates, "general population" and "high consumer"

general population rate   =59.7 g/day
                           = 2 meals/week at 8 oz/ meal
                           = Am. Heart Assoc. recommendation

high fish consumer rate   = 175 g/day
                           = 2013 revision, OR WQ standards

* calculations provided by Dave McBride, WA Dept of Health, based on toxicity data from USEPA and ATSDR
** at excess cancer rate 1/1,000,000
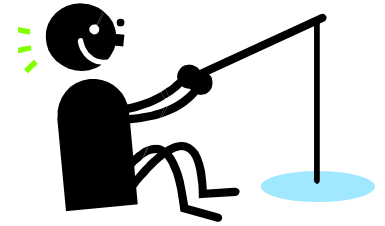
- Each contaminant that exceeded screening values will be discussed:

- Summary statistics

- Detections

- Screening values

- Exceedances of screening values (SVs)

For fillet samples, contaminants to focus on are

- Mercury

- PCBs

- DDTs and other chlorinated pesticides
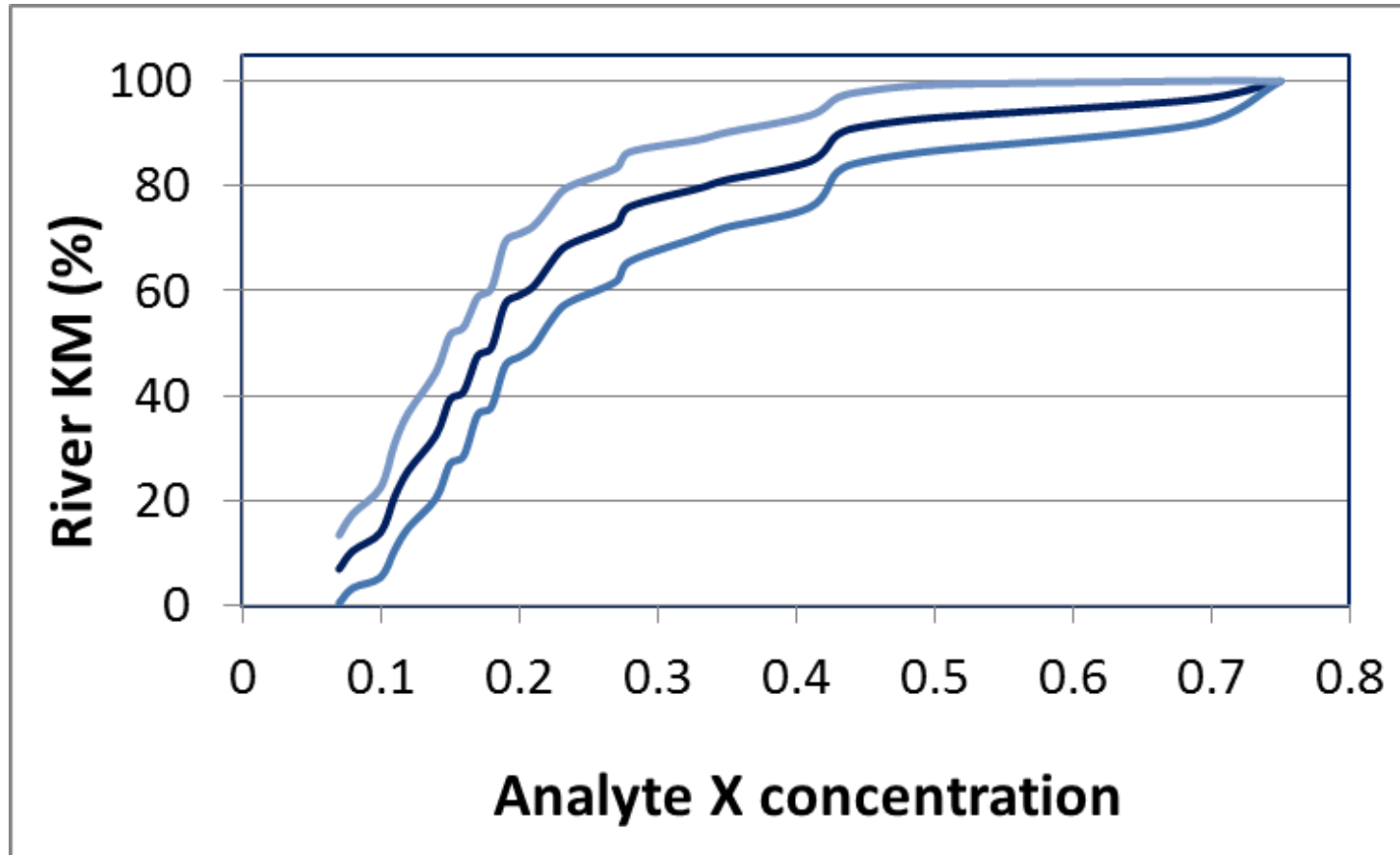
(plus a brief discussion of PBDEs, dioxins/furans)
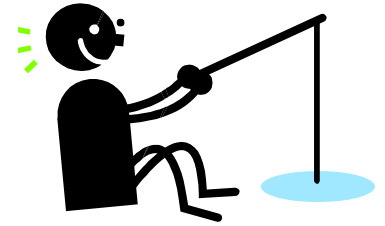
But first, intro to a favorite EMAP tool, the CDF:
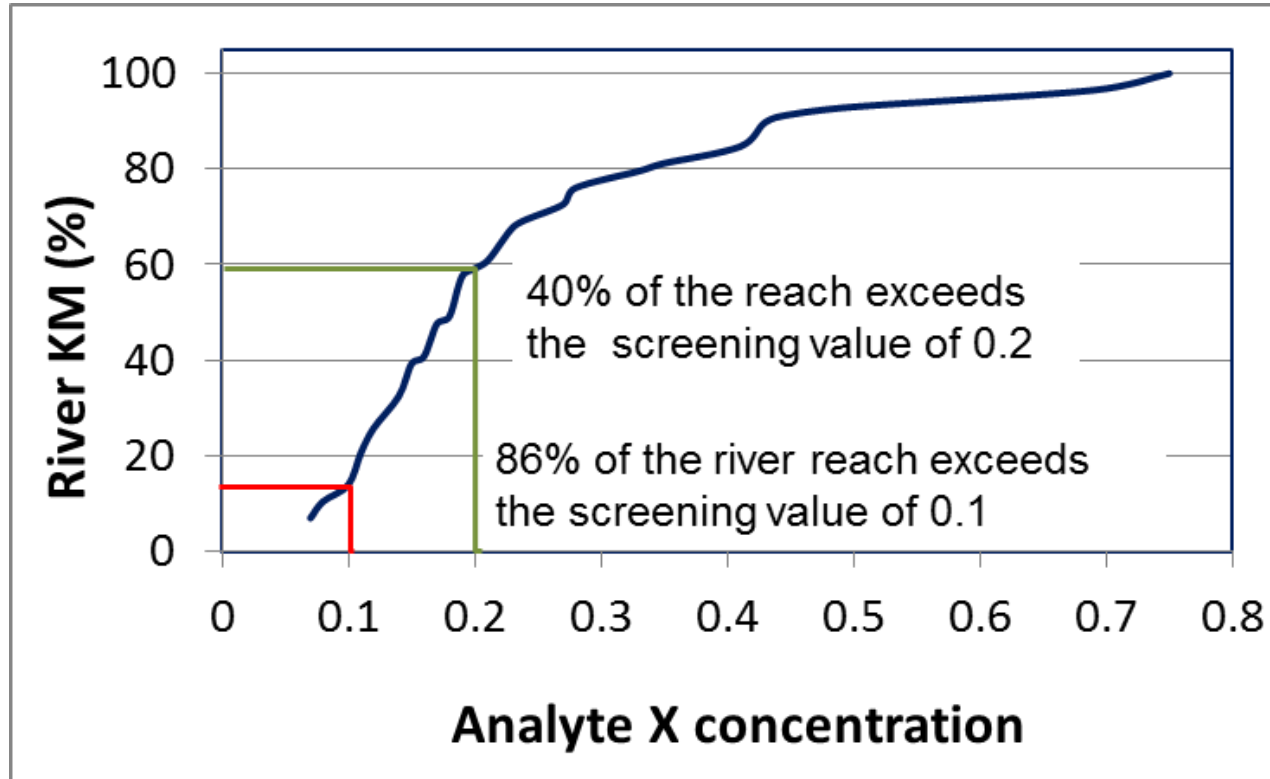
Can use the same dataset to answer different questions
        (using different thresholds of interest, for example)

(you can even look at the confidence intervals)

Expression of uncertainty/confidence is "built in"

Mercury

• Hg was found in all fillets (100% of the river miles)

Analyte	Units	Mean	Median	Min.	Max.	Std.Dev.	Non-detects (% Obs.)
Mercury, total	mg/Kg, wet wt	0.24	0.19	0.07	0.8	0.17	0

Screening value (non-cancer)   River miles that exceed SV

General population SV = 0.101 mg/kg   86%

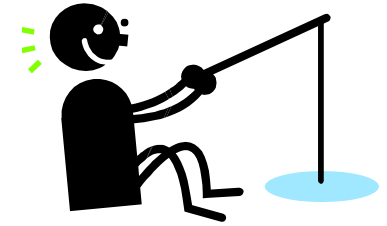High consumer SV = 0.03 mg/kg   100%

PCBs
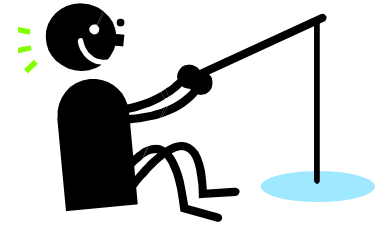
Widely detected by any definition:

133 of the 153 congeners analyzed were detected in the MCRT

All fillet samples had detectable PCBs (100% of MCRT)

Analyte	Units	Mean	Median	Min. detected value	Max.	Std. Dev.	Non-detects (%)
Sum_PCBs	ng/Kg	20985.47	12408.92	1372.15	85265.8	22950.85	0

PCBs

Analyte	General Population (ng/kg)	% RM above SV	High Consumer (ng/kg)	% RM above SV
	Cancer Screening Value			
PCBs (Total)	586.3	**100**	200.0	**100**
	Non-cancer Screening Values*			
PCBs (Total)	23450.6	**25.8**	8000.0	**58.5**
PCBs (Total)	30150.7	**20.7**	10285.7	**53.4**

*There are two non-cancer SVs for PCBs, one for immune effects, and one for developmental
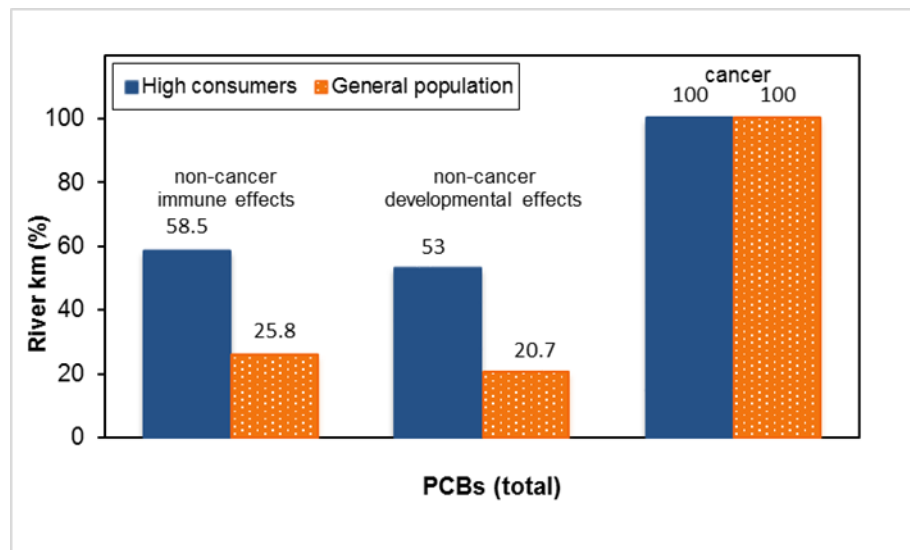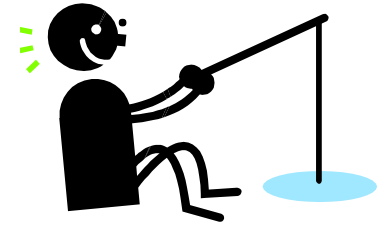
DDTs
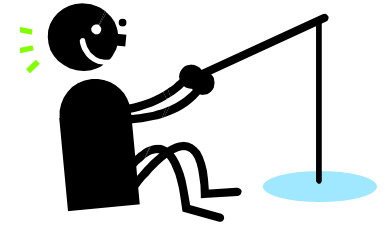
- Summary stats

Analyte	Units[1]	Mean	Median	Min.	Max.	Std.Dev.	Non-detects (% Obs.)
2,4`-DDD	ng/Kg	1905.22	479.00	15.80	6980.0	2252.14	0
2,4`-DDE	ng/Kg	519.53	201.00	19.90	1770.0	549.55	0
2,4`-DDT	ng/Kg	311.39	127.00	15.00	1180.0	334.81	0
4,4`-DDD	ng/Kg	13216.97	3770.00	189.00	47200.0	15352.13	0
4,4`-DDE	ng/Kg	64676.67	31300.00	2650.00	226000.0	65711.19	0
4,4`-DDT	ng/Kg	2675.85	1010.00	98.60	11100.0	3044.10	0
DDT Total	ng/Kg	83305.63	43620.90	3191.30	289553.0	86491.65	0

Summary statistics were calculated with non-detects set to zero. 'Non-detect percent observations' refers to the percent of samples analyzed not the percent of inference RM.

DDT Total is the sum of the six metabolites

- DDTs were detected in all fillet samples, representing 100% of the MCR

DDTs

- Total DDTs and DDE exceed cancer SVs for both the general population and high fish consumers across the MCR (95-100% of the river miles for both groups)

- DDD and DDT also exceed cancer SVs across much of the reach for both the general population and high fish consumers, but exceedances are less extensive
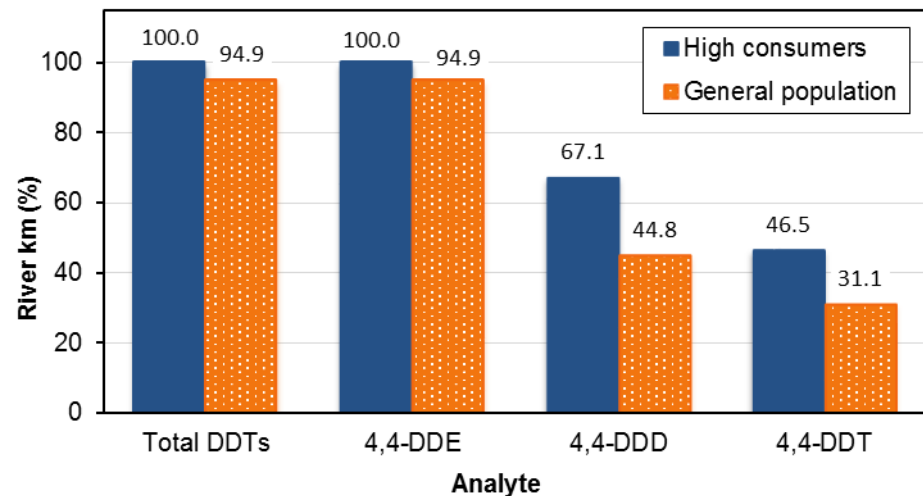
# *Other chlorinated pesticides*

(those with exceedances)
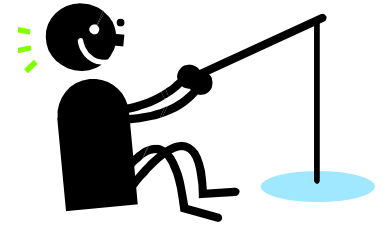
- Four other chlorinated pesticides exceed human health screening values. All four were detected at 100% of the sample sites

Analyte	Units	Mean	Median	Min. detected value	Max.	Std. Dev.	Non-detects (% Obs.)
Chlordane Total	ng/Kg	689.50	511.60	60.69	2871.0	693.06	0
Dieldrin	ng/Kg	171.94	87.10	13.40	1050.0	216.77	0
Heptachlor epoxide	ng/Kg	38.85	24.10	2.81	152.0	37.75	0
Hexachlorobenzene	ng/Kg	336.82	239.00	103.00	1120.0	245.10	0

Other chlorinated pesticides

(SVs for the four with exceedances)
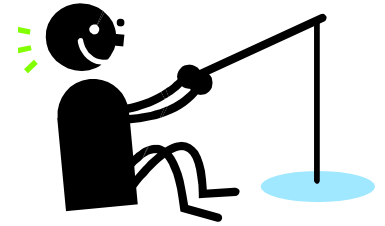
Analyte	General population (ng/kg)	% rkm above SV	High consumer (ng/kg)	% rkm above SV
	Cancer screening value			
Chlordane (total)*	3350.1	0.0	1142.9	**16.9**
Dieldrin*	73.3	**66.9**	25.0	**91.7**
Heptachor Epoxide*	128.8	**3.5**	44.0	**23.9**
Hexachlorobenzene*	732.8	**8.6**	250.0	**46.5**

Results: Other chlorinated pesticides
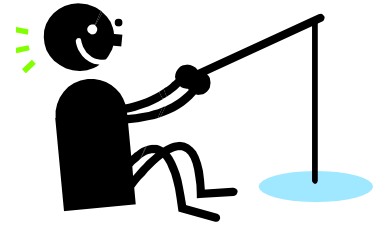
- Four other chlorinated pesticides exceed screening values (cancer risk) for human health for both the general population and high fish consumers

- Dieldrin exceedances are most extensive of these, covering 67%-92% of the river miles (general population / high fish consumers)

- Total chlordane exceeds only the high consumer SV (16.9% river miles)
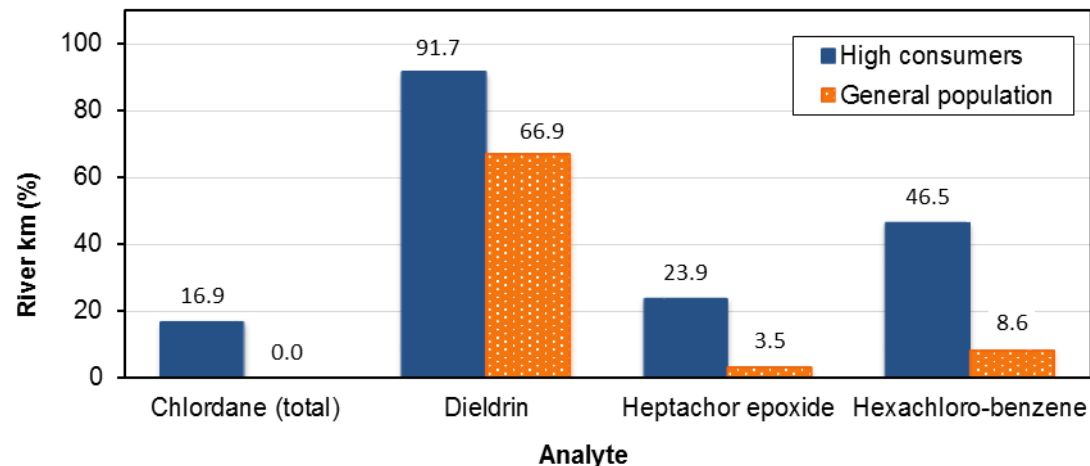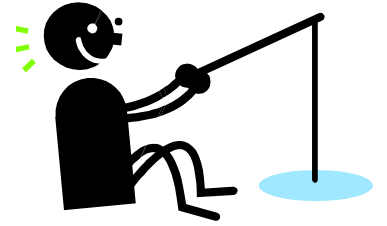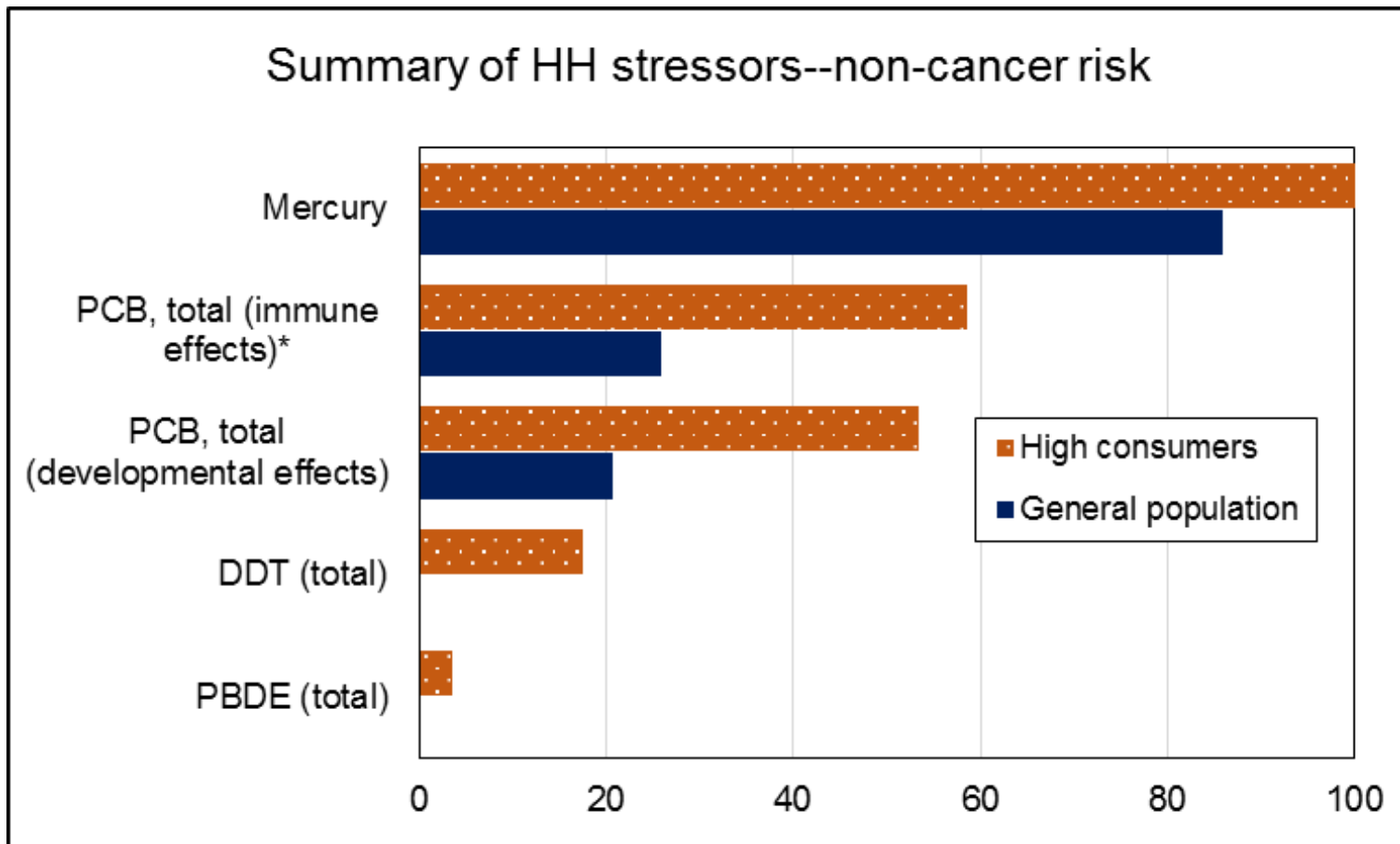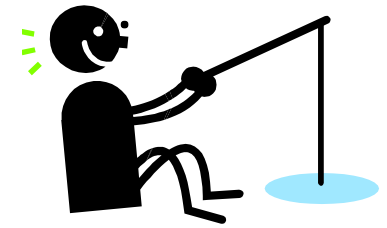
Results: PBDEs

- Ubiquitous: (100% of the samples had detects for many of the PBDEs)

- None of the analytes with screening values were detected

Results: Dioxins and furans

- Rarely detected *(detected in approximately 2% of the river miles for most D&F analytes, range of non-detects was 73-100%)*

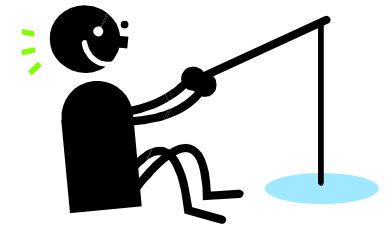- None of the analytes with screening values were detected

Summary:
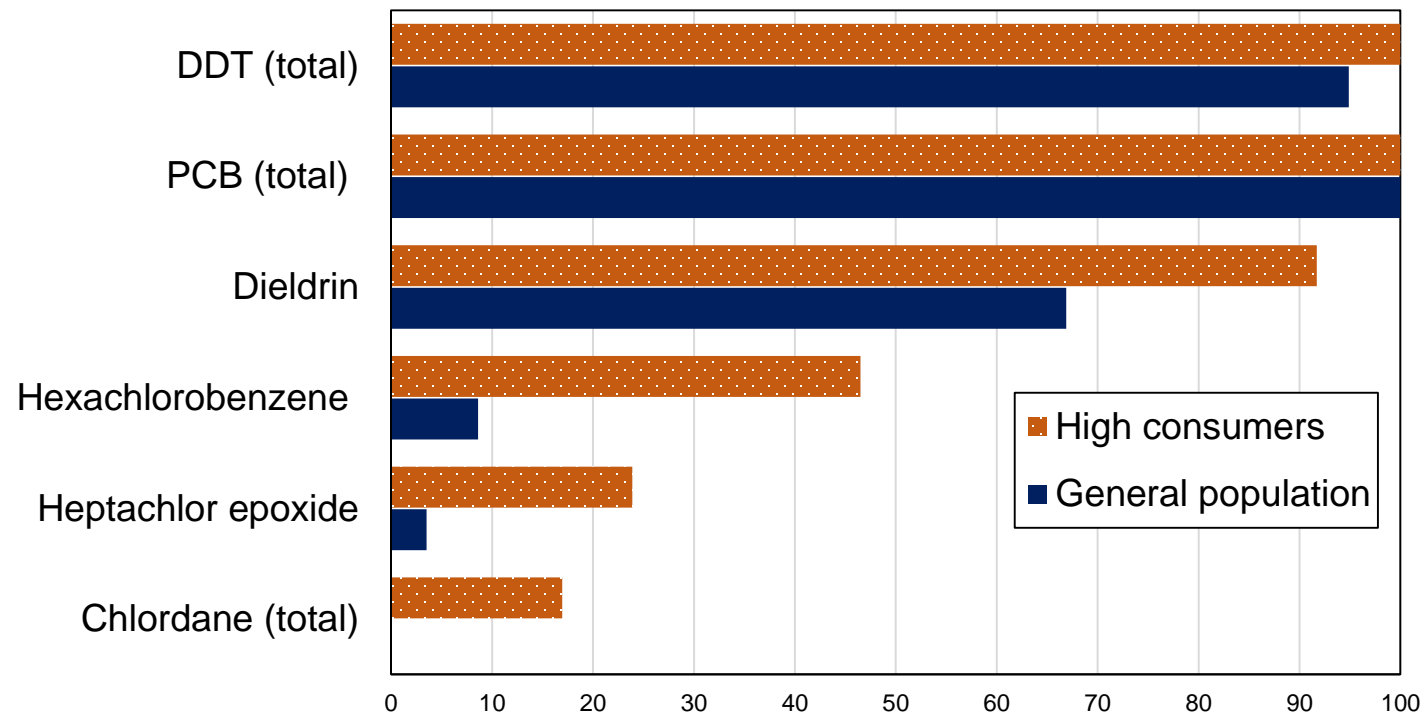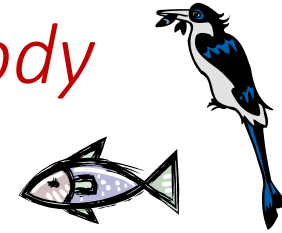exceedances of Human Health screening values (% of river length)

Summary of HH stressors--non-cancer risk

Summary of HH stressors--cancer risk

Category	Value

DDT (total)

PCB (total)

Dieldrin

Hexachlorobenzene

Heptachlor epoxide

Chlordane (total)

High consumers
General population
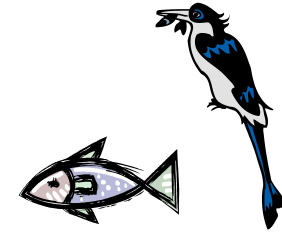
0   10   20   30   40   50   60   70   80   90   100

On to ECO-fish Results from whole body samples...

mercury, other trace metals, PCBs, DDTS and other pesticides, PBDEs

Screening values : Ecological

We used two types of tissue screening values for ecological receptors

- *"General aquatic" SVs: Based on protecting the fish (or other aquatic species) themselves*
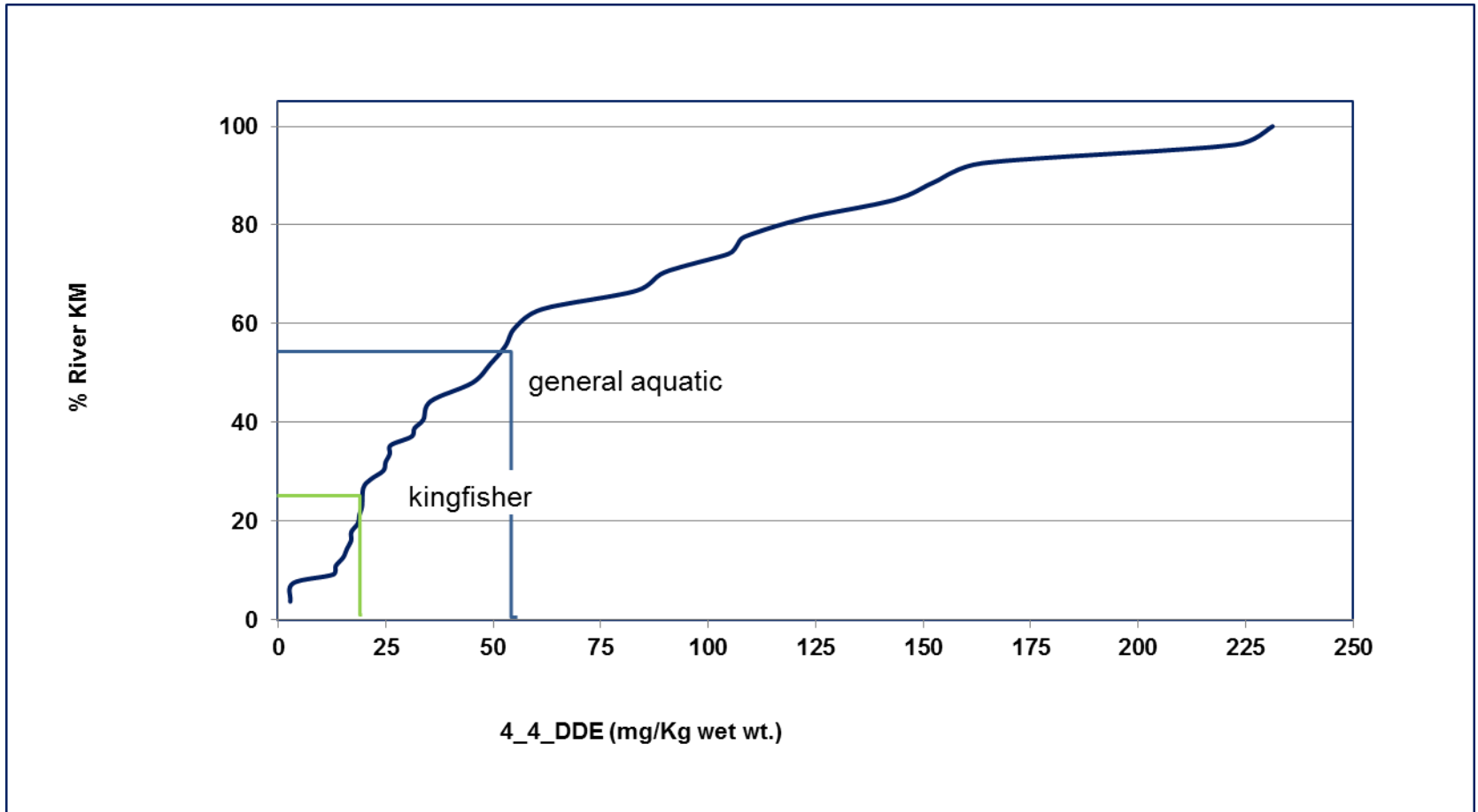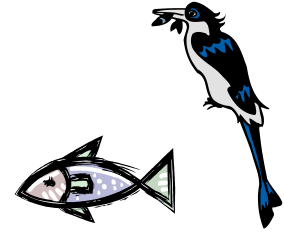
    designed to provide the same level of protection to aquatic species as EPA's water quality criteria for aquatic life –protect 95% of aquatic genera from adverse effects on survival, reproduction and growth.

    Method from Dyer et al, 2000, additional chemicals from Shephard, personal comm. 2014
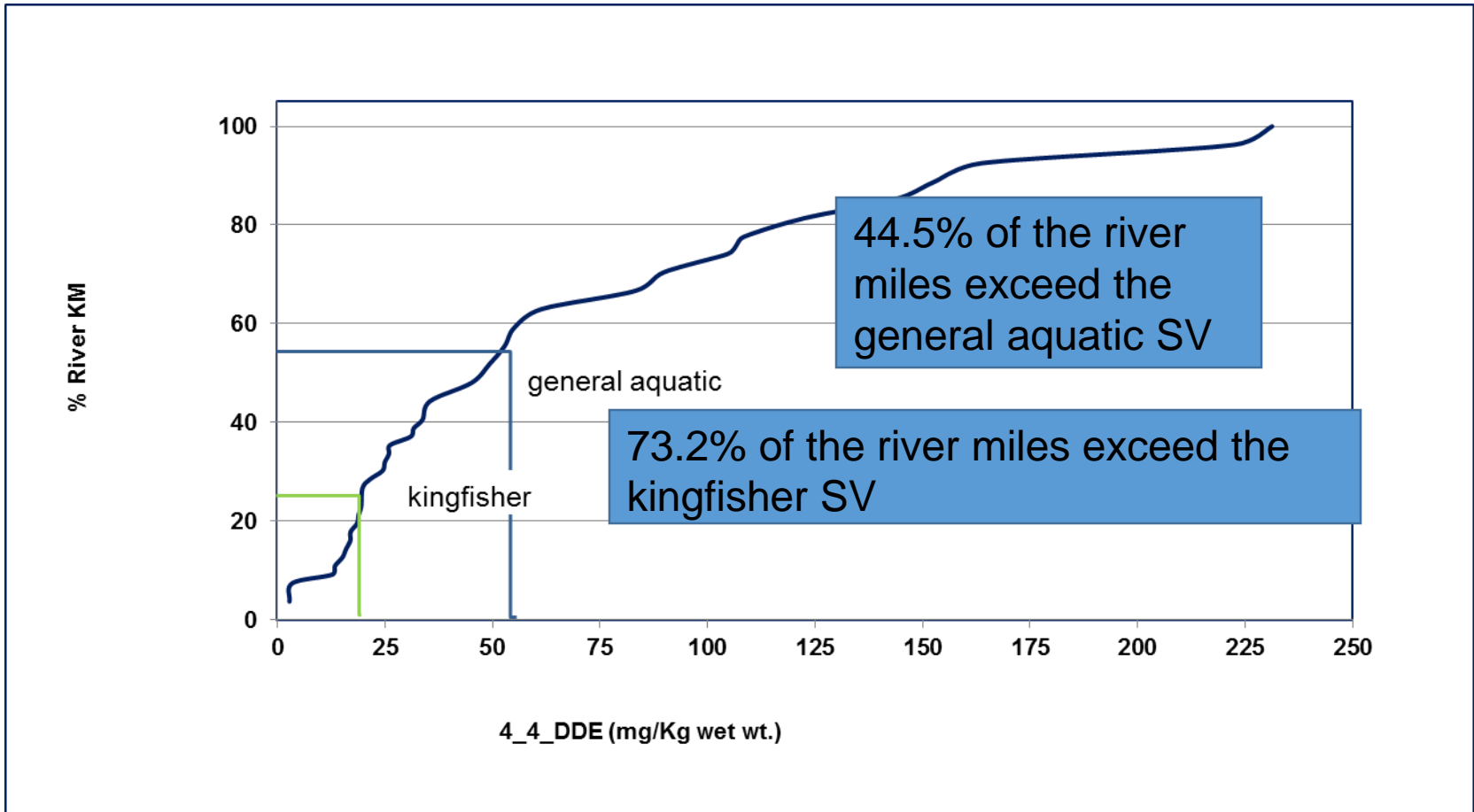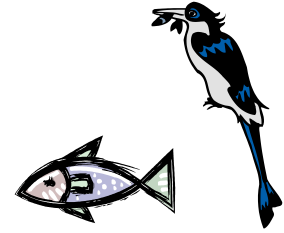
- *"Wildlife" SVs: Based on protecting animals that consume fish, which includes predatory fish, fish-eating wildlife, and fish-eating birds*

    Method from USEPA Great Lakes Water Quality Initiative, and described in Lazorchak et al, 2003
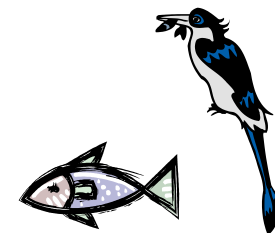
# *Example CDF : Ecological*

Example CDF : Ecological

44.5% of the river miles exceed the general aquatic SV

73.2% of the river miles exceed the kingfisher SV

Results: Mercury

- *Mercury was detected in all the ECO-fish samples*

Analyte	Units[1]	Mean	Median	Min.	Max.	Std.Dev.	Non-detects (% Obs.)
Mercury	ug/kg	37.13	31.06	13.29	118.20	20.47	0

- Only the general aquatic screening value *(0.06 mg/kg)* was exceeded (in 6.9% of the river miles)
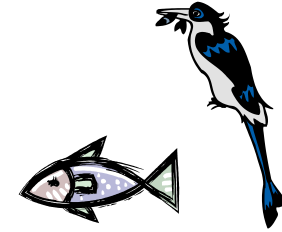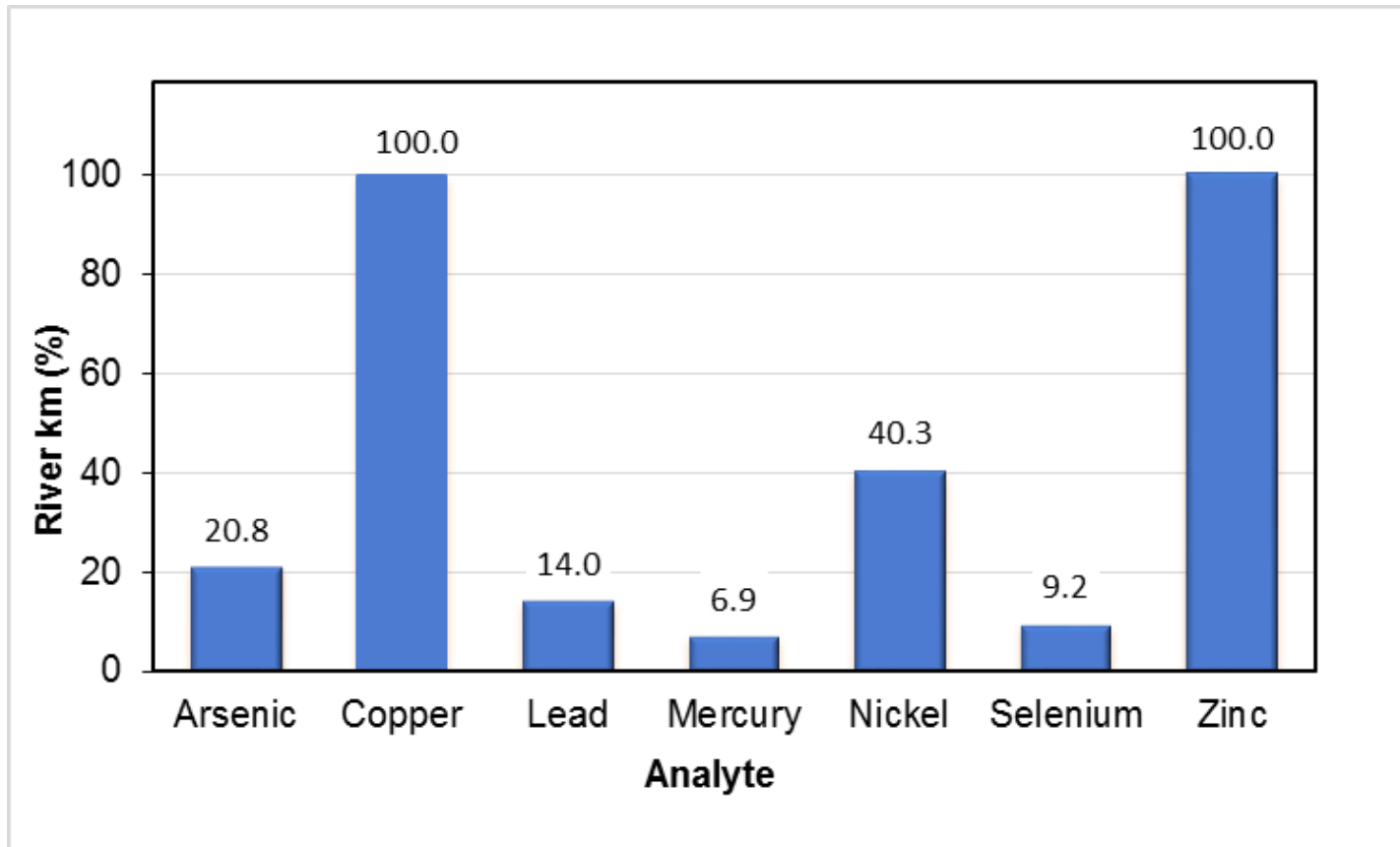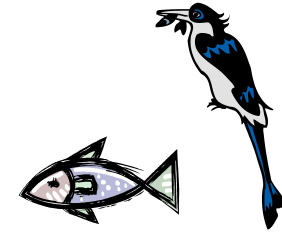
Results: trace metals

- Widely detected (naturally occurring at low concentrations)

- Several metals exceeded the general aquatic screening values, None exceeded wildlife SVs

  The most extensive exceedances were for zinc, copper, and selenium
  (all over 98% of the river miles)

  Less extensive were exceedances of SVs for nickel (40.3%), arsenic (20.8%), lead (14%), and mercury (6.9%)
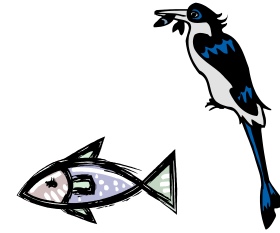
  Cadmium and chromium did not exceed any ecological SVs

Results: Hg and other metals

Screening value exceedances (general aquatic) for trace metals in eco-endpoint fish

Results: PCBs

- *Some (4) congeners were detected in all eco-samples, while others were not detected in any*

- There were no exceedances of the general aquatic or wildlife screening values

Analyte List	Screen type	Screening Value (mg/kg)	SV exceedances % RM
PCB_sum	otter	0.180	0.0
PCB_sum	mink	0.130	0.0
PCB_sum	kingfisher	0.440	0.0

Note: data are for 21 out of 209 congeners

Results: DDTs and other pesticides
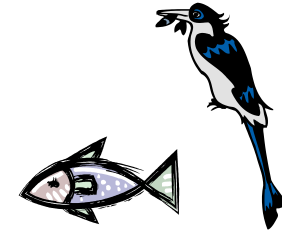
DDT and related compounds were ubiquitous and showed the most widespread ecological SV exceedances (of organic analytes)

Analyte	Units[1]	Mean	Median	Min. detected value	Max.	Std.Dev.	Non-detects (% Obs.)
2,4'-DDD	ng/g	1.33	0.95	0.22	5.44	1.47	32
4,4'-DDD	ng/g	12.79	9.66	0.32	41.72	11.97	0
2,4'-DDE	ng/g	0.66	0.52	0.20	2.02	0.62	32
4,4'-DDE	ng/g	71.22	49.27	2.81	231.22	63.84	0
2,4'-DDT	ng/g	0.28	0.25	0.21	1.23	0.27	38
4,4'-DDT	ng/g	0.69	0.60	0.12	2.13	0.59	16
DDT Total	ng/g	86.96	59.41	3.13	269.76	76.28	0

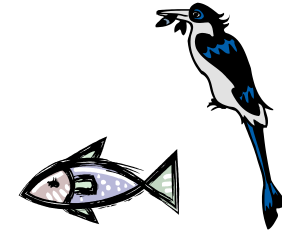Total DDT and DDE exceeded the general aquatic SV (**55.6%** and **44.5%** river miles)

The kingfisher SV was exceeded for total DDT in **85.6%** of the river miles, for DDE in **73.2%**, and for DDD in **18.7%**

Results: DDTs and other pesticides
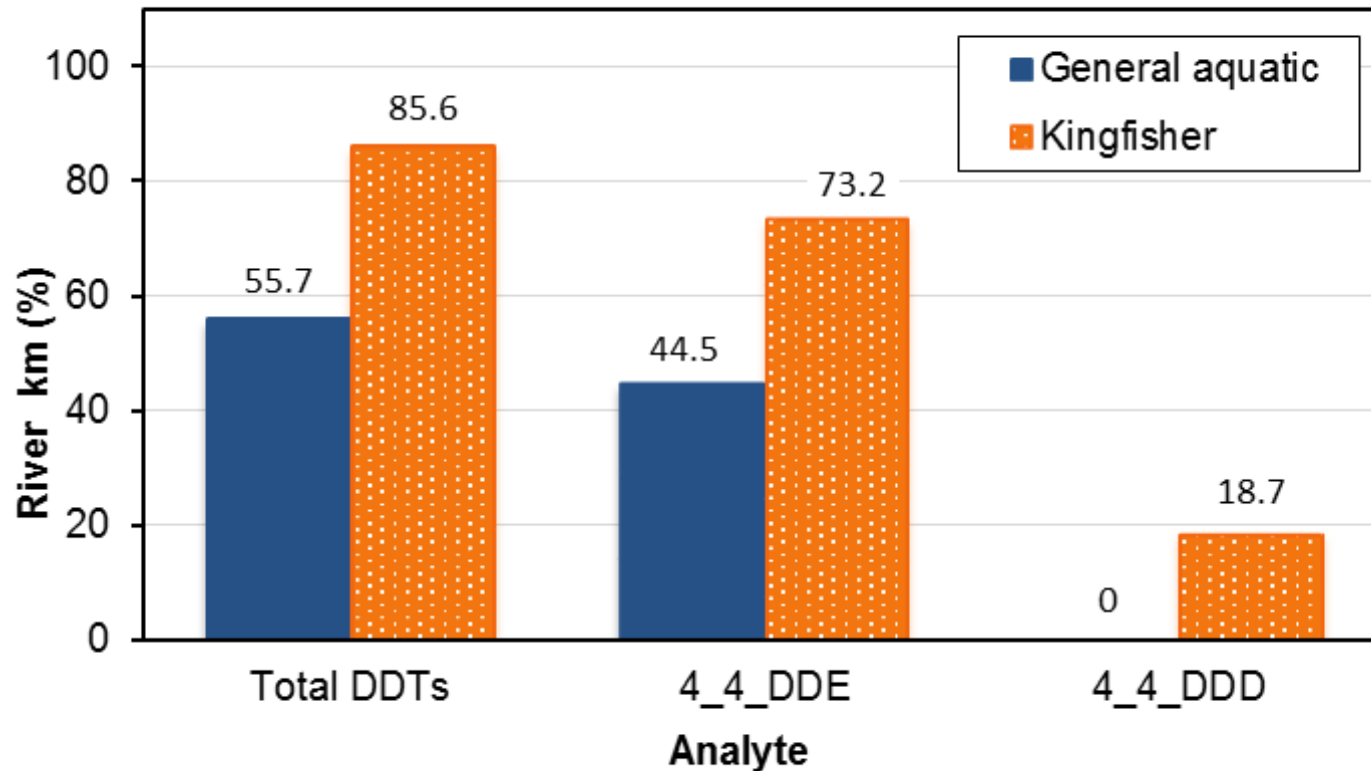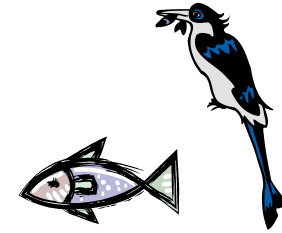
Total chlordane was the only other pesticide to exceed an ecological SV (for kingfisher, over **3.7%** of the river miles)

Results: PBDEs

- The most common congeners were widely detected *(81-97% RM)*

| Analyte	Units[1]	Mean	Median	Min. detected value	Max.	Std.Dev.	Non-detects (% Obs.)
PBDE #47	ng/g	5.16	4.53	2.75	13.51	2.6	3
PBDE #66	ng/g	0	0	0	0	0	100
PBDE #99	ng/g	0.16	0	0.31	1.73	0.38	84
PBDE #100	ng/g	0.91	0.83	0.41	3.18	0.63	19
PBDE #138	ng/g	0	0	0	0	0	100
PBDE #153	ng/g	0	0	0	0	0	100
PBDE #154	ng/g	0	0	0	0	0	100
PBDE #183	ng/g	0	0	0	0	0	100
PBDE Total[3]	ng/g	6.23	5.25	0.54	16.69	3.15	na

- The only ecological SVs we had were for mink and kestrel
- The SV for kestrel was exceeded in 5.5% of the river length

Summary: *contaminants exceeding ecological screening value concentrations in whole fish samples*
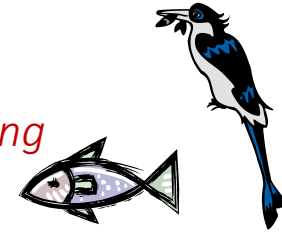
Summary of eco-endpoint stressors
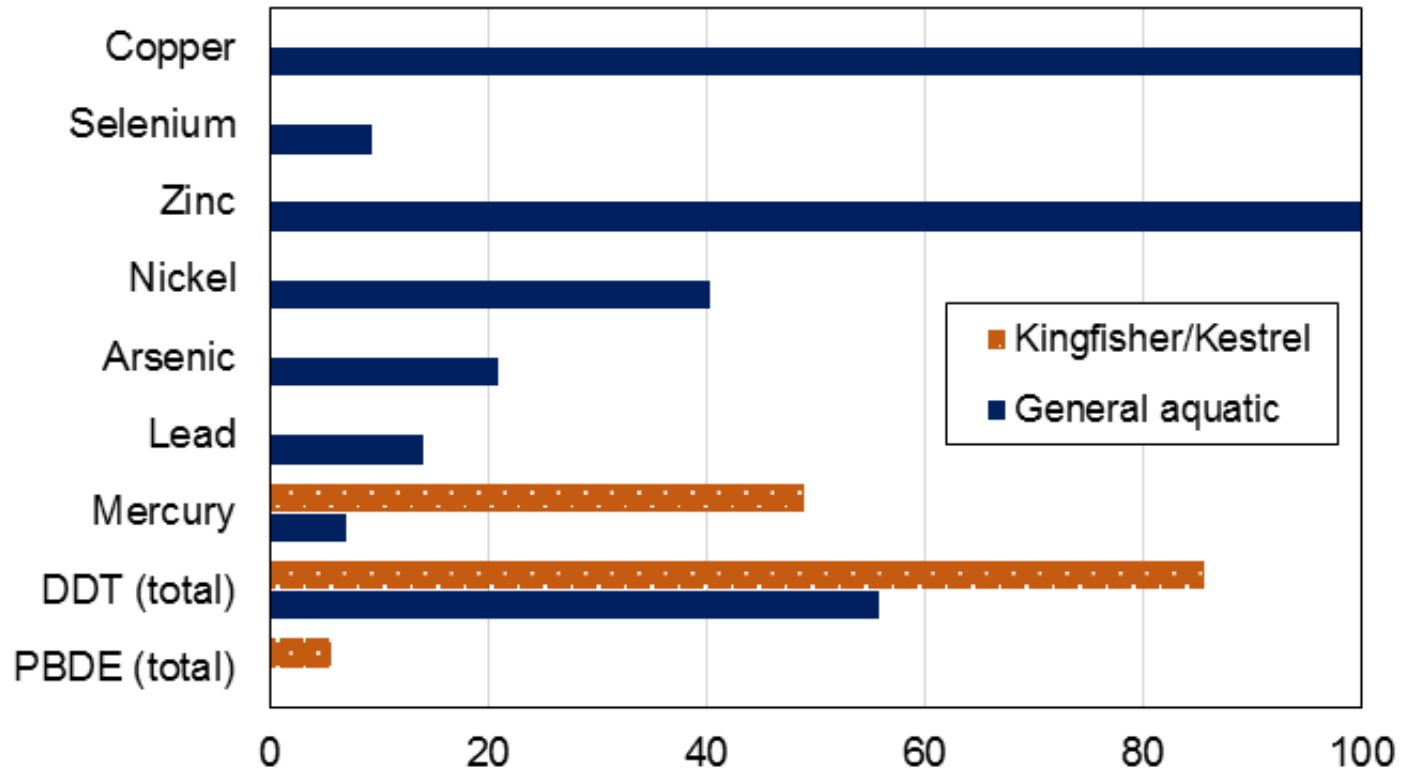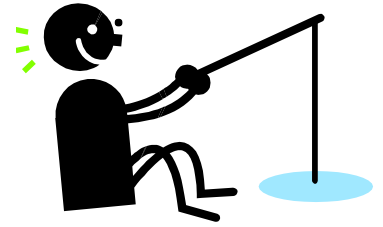
Conclusions (human health):

Toxic contaminants of concern in the mid-Columbia main stem tend to be the "usual suspects"

Mercury, PCBs, and DDTs are everywhere and they tend to exceed SVs for cancer (PCBs and DDTs) or other effects (Hg) in 75-100+ % of the river length

Dieldrin is also widespread and exceeds cancer SVs in 67-92% of the MCR, and a few other chlorinated pesticides exceed SVs in a smaller portion of the river

PBDEs are everywhere, but not at concentrations above current SVs
Dioxins and furans are rarely detected

The list of toxic chemicals of concern is almost the same regardless of which of the two consumption rates is used to develop the screening values

Conclusions (ecological):
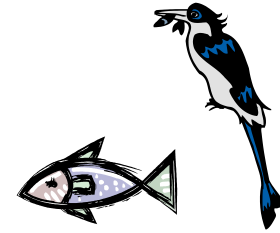
Avian wildlife (kingfisher/kestrel) screening values were lower than those for mink and otter and were the only wildlife SVs to be exceeded in the MCR

DDT (total) was the most widespread kingfisher exceedance at 85.6% RM, based mostly on DDE (exceeded 73.2% RM)

DDT (total) SVs for general aquatic life were exceeded in somewhat fewer river miles,

but show widespread exceedances for several **metals**

Pesticide SVs other than DDTs were not exceeded

PBDE SV for kestrel was exceeded locally

Next?

Continue looking at spatial patterns, comparing with other data

Review draft soon!

L. Edmond and Herger, L. 2015. Mid-Columbia River Fish Toxics assessment: EPA Region 10 Report, EPA-910-R-XXX-XXX, US Environmental Protection Agency, Region 10, Seattle, Washington

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