ENVIRONMENTAL JUSTICE: UNIQUE EXPOSURE PATHWAYS AND DISPROPORTIONATE EXPOSURES IN LOW INCOME, MINORITY, NATIVE AMERICAN, AND OTHER POPULATIONS: OUTLIERS MATTER

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2. UMDNJ-Robert Wood Johnson Medical School
3. Consortium for Risk Evaluation with Stakeholder Participation & Environmental and Occupational Health Sciences Institute
Environmental Justice Issue

- Environmental hazards, exposures, and risks are not uniformly distributed
- Multiple biologic and social risk factors intersect, placing some people at high risk,
- Low income, minority status, and age may create unique exposure circumstances that place some individuals groups at disproportionately high risk
OBJECTIVES

• 1) Review exposure pathways and distributions normally examined by risk assessors.

• 2) Identify and discuss populations with high end exposures and unique exposure pathways.

• 3) Provide a framework for identifying unique pathways and outliers.
## Transformation of EPA Risk Assessment Approaches

<table>
<thead>
<tr>
<th>Old</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Source</td>
<td>Multiple Sources</td>
</tr>
<tr>
<td>Single Media-focused</td>
<td>Multi-media Focused</td>
</tr>
<tr>
<td>Single Pathway</td>
<td>Multiple Pathways</td>
</tr>
<tr>
<td>Single Route of Exposure</td>
<td>Multiple Routes of Exposure</td>
</tr>
<tr>
<td>Single Endpoint</td>
<td>Multiple Endpoints</td>
</tr>
<tr>
<td>Central Decision-making</td>
<td>Community Cumulative Risk</td>
</tr>
<tr>
<td>Command and Control</td>
<td>Community-based Decision-making</td>
</tr>
<tr>
<td>One-Size-Fits-All Response</td>
<td>Flexibility in Achieving Goals</td>
</tr>
<tr>
<td>Single Stressor Risk Reduction</td>
<td>Case-Specific Responses</td>
</tr>
<tr>
<td></td>
<td>Holistic Reduction of Risk</td>
</tr>
</tbody>
</table>

IDENTIFICATION OF COMMUNITY

Tools and Methods

information, strategies, exposure models, data bases, analytic methods, GIS

EPA’s Risk Paradigms
Intersecting Vulnerability Attributes

STAKEHOLDERS

Poverty
Minorities
Youth
Tribal nations
Psychosocial Stress
Inadequate health care/access
Exposure to noise
Exposure to violence
Education
Minority status
Income
Modify effects of chemicals
IDENTIFICATION

National Databases
- Literature
- Case studies

Community instigated
- Recognized Populations
RISK ASSESSMENTS: TRADITIONAL VERSUS ENVIRONMENTAL JUSTICE RISK ASSESSMENTS

Cumulative risk assessment for multiple hazards

Traditional risk assessment examines exposure to a given contaminant (e.g. lead, mercury, PCBs), including one or several exposure pathways (top), but environmental justice communities are often exposed to multiple contaminants, with multiple pathways that lead to complex, cumulative exposures.
<table>
<thead>
<tr>
<th>Pathways of Exposure</th>
<th>AIR</th>
<th>WATER</th>
<th>SOIL/DUST</th>
<th>FOOD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inhalation</strong></td>
<td>MAJOR ROUTE</td>
<td>Showering (volatiles)</td>
<td>MAJOR ROUTE</td>
<td></td>
</tr>
<tr>
<td><strong>Ingestion</strong></td>
<td>Deposition on food</td>
<td>MAJOR ROUTE</td>
<td>MAJOR ROUTE toddlers also</td>
<td>MAJOR ROUTE</td>
</tr>
<tr>
<td><strong>Dermal</strong></td>
<td></td>
<td>Some organics through showers or swimming</td>
<td>Some organics from muds and slurries</td>
<td></td>
</tr>
</tbody>
</table>
Main Pathways of Exposure for Human Risk Assessment.

Source 

- Air-borne Pollutants 
- Direct Contact 
- Food and Water 
- Medicinal 
- Ingestion 
- Dermal 
- Injection 

Receptor
Expanded Conceptual Approach

- INHALATION
  - Resident exposure from factories
  - Volatile household pesticides
  - Sweat baths for native tribes
  - Contaminants on parents clothes
  - Mercury and others used for culture or religion
  - Volatile contaminants from polluted water when showering or recreating (fish, swim)

- DERMAL
  - Cosmetics or medicinals (soil, plant, animal products)
  - Showering or swimming
  - Contaminants on clothes (occupational, gardening)

- INGESTION
  - Self-caught fish/shellfish, wildlife, bird eggs
  - Wild herbs, roots, berries
  - Soil by children or adults or on foods, toys, other objects
  - Self-caught fish or game given to EJ communities
  - High one-meal exposures (feasts, picnics, fish fries)
  - High rates of one type of contaminated food

- INJECTION
  - Intentional injection of plant or animal extracts
  - Tattoos
<table>
<thead>
<tr>
<th><strong>INHALATION</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Resident exposure from factories</td>
</tr>
<tr>
<td>Contaminants on parents clothes</td>
</tr>
<tr>
<td>Volatile household pesticides</td>
</tr>
<tr>
<td>Sweat baths for native tribes</td>
</tr>
<tr>
<td>Mercury and others used for culture or religion</td>
</tr>
<tr>
<td>Volatile contaminants from polluted water when showering or recreating (fish, swim)</td>
</tr>
</tbody>
</table>

**Air-borne pollutants**
INGESTION

Self-caught fish/shellfish, wildlife, bird eggs

Wild herbs, roots, berries

High one-meal exposures
(feasts, picnics, fish fries)

Self-caught fish or game given to EJ communities

Soil by children, adults, foods, toys & other objects

High rates of one type of contaminated food
DERMAL INJECTION

Showering or swimming

Contaminants on clothes (occupational, gardening)

Cosmetics or medicinals (soil, plant, animal products)

INJECTION

Intentional injection of plant or animal extracts

Medicinal

Tattoos
Potentially Unique Exposure Pathways Developed for Environmental Justice Communities
Consumptive Uses (Ingestion)

- Daily and seasonal consumption patterns
- Wild-caught or gathered foods
- Unusual commercial foods or herbs
- Commercial foods vs. wild foods by biota species and parts
- Daily and seasonal preparation patterns for wild foods or unusual commercial foods
- Unusual consumption patterns by group, age, gender, or season
- Intermittent of high exposures: single meal or single day consumption [feasts, fish fries, socials]
- Inadvertent consumption patterns (e.g. children eating dirt)
- Geophagy (deliberate soil ingestion)
TYPES OF FACTORS TO CONSIDER

Hunting
- Preparation for hunting
- Hike to hunting site
- Canoe or boat to site
- Conducting scouting trips
- Setting traplines
- Building blinds
- Capturing or killing prey
- Field dressing of meat
- Hauling our food
- Butchering
- Drying or smoking
- Preparing hides or skins
- Returning remains to nature
- *Are products for food, drink, implements, medicine, cosmetics, or ceremonies
- *What are the terrain types or aquatic conditions?
- *Are game butchered on site or brought back to land or to a village?
- *What are the exertion levels, and time spent in each activity?
- *What are the total pathways of each activity (inhalation, dermal, ingestion)
TYPES OF FACTORS TO CONSIDER

Fishing
Preparations for fishing
Canoe or boat to site
Hike to collecting site
Building piers
Making/repairing nets
Making/repairing poles
Construct drying racks
Fishing activity itself (from shore or boat)
Cleaning or storing fish
Drying & storing fish
Returning remains to nature

*What are the products involved?
*What are the terrain types to get there, and the aquatic conditions for fishing?
*Are fish butchered on site or brought back to camp or a village?
*Are there gut contents of consideration
*What are the exertion levels and time spent in each activity?
*What are the total pathways of each activity?
Maintenance and Cosmetic Uses

- Tribal sweat baths
- Sand or soil or plant material for maintenance or cosmetics
- Usual commercial materials for cosmetics
- Unique substances for cultural practices (e.g., mercury)
- Temporal patterns: daily & seasonal, frequency, duration
Medicinal, Religious and Cultural Uses

• Types of medicine and healing practices
• Species, types, seasonality and exposure from herbs or other medicines
• Potential roles of commercial medicinals in relation to self-gathered herbs
• Types and frequencies of religious events or ceremonies
• On-site, non-consumptive uses, (eg. Vision Quests or Dream Quests)
• Folk/Cultural Medicines (i.e. Ayurvedic, mercury)
• Temporal patterns: daily & seasonal, frequency, duration
• Lifestyle exposures: alcohol, tobacco, pharmaceutical
Cultural uses of Mercury

• Mercury---elemental
  – Widely available in “botanica” stores
  – In northeast cities primarily Afro-Caribbean
  – Global issue: mercury used also among Asian Indian, Andean Indians etc

• Superstitious & good luck
  – Sprinkled in new cars and on new babies
  – Carried in pocket to bring “love”

• Quasi-religious practices and healing

• Residual mercury may affect subsequent tenants
Examples

Asian Herbal Medicines
(Ayurvedic) lead (64% of samples)
(Ayurvedic) mercury (64%)
(Ernst 2002) arsenic (41%)
(Ernst 2002) cadmium (9%)

Chinese medicines
(Ernst & Thompson 2001) mercury
cadmium
arsenic
copper
thallium

Mexican medicines
(Bose et al. 1983) azarcon
(Bose et al. 1983) lead
Eco-cultural Dependency Webs and Eco-cultural Attributes as Exposure Pathways

Occupational exposures
- Unique exposures and co-exposures
- Take-home exposures

Non-point source exposures (inhalation)
- Air pollution
- Traffic and roadways
- Hazardous waste sites/landfills

Building-related exposures (inhalation, ingestion)
- Housing age and condition
- School age and condition
- Pesticides, lead, mold
- Residences above or next to small industrial sources
- Residences as workplaces (solvents, ceramics, recycling)
Unique Pathways
Examples of high-end exposures

MICHAEL GOCHFELD
AND
JOANNA BURGER
Environmental Justice

• Original conception
  – Poor or minority neighborhoods clustered around exposure sources
  – Industries, hazardous waste sites, etc.

• Poor communities singled out for LULU’s
  – LULUs=locally unwanted land uses

• Poor people could only afford contaminated neighborhoods

• Increasingly EJ applies to groups that may be spatially dispersed
NJ is a poster child for fenceline residences
SOME SPECIAL POPULATIONS covered in our paper

- Native Americans
- Farms, farmers, farm workers and farm neighbors
- Migrant Workers
- Urban Poor: unemployed, underemployed
- Urban gardeners
- Conditions of Residences
- Conditions of Schools
- Conditions of Neighborhoods
- Pica and geophagy
- Cultural Uses of Mercury
Children: unique exposures

- Hand to mouth behavior
- Soil ingestion estimates (the risk driver)
- Lead exposure (& housing)
- Pesticide exposure pathways
- Mercury exposure pathways (canned tuna)
- Asthma in urban children
Fish consumption

• Risk assessment default assumptions
• High end fish consumers (health reasons)
• Recreational fishers
• “Subsistence” fishers
• Native American scenarios
Additional pathways & co-exposures

• Consumptive Resource Use
• Non-consumptive Resource Use
• Maintenance and Cosmetic
• Smoking and demography
• Medicinal, Religious and Cultural
• Hazardous occupational exposures
• Eco-cultural Dependency Webs and Eco-cultural Attributes
Different Exposure Distributions
A, b, c = ‘normal’, d = ‘lognormal’ and e = strongly skewed
### Age Specific Estimates of Soil Ingestion by Children (mg/day)

<table>
<thead>
<tr>
<th>Age</th>
<th>EPA IEUBK defaults</th>
<th>Kimbrough et al. 1984</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1 year</td>
<td>85</td>
<td>0-9 months=0</td>
</tr>
<tr>
<td>1-4 years</td>
<td>135</td>
<td>9-18 months=1</td>
</tr>
<tr>
<td>4-5 years</td>
<td>100</td>
<td>18-42 months=10000</td>
</tr>
<tr>
<td>5-6 years</td>
<td>90</td>
<td>42-60 months=1000</td>
</tr>
<tr>
<td>6-7 years</td>
<td>85</td>
<td>Not specified</td>
</tr>
<tr>
<td>Distribution Values for Soil Ingestion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Median soil ingestion value</strong></td>
<td>14 mg/day</td>
<td></td>
</tr>
<tr>
<td><strong>Range of median soil ingestion estimates</strong></td>
<td>1-103 mg/day</td>
<td></td>
</tr>
<tr>
<td><strong>Median of the upper 95\textsuperscript{th} percentile of the 64 daily ingestion values</strong></td>
<td>252 mg/day</td>
<td></td>
</tr>
<tr>
<td><strong>Range of average daily ingestion</strong></td>
<td>1-2268</td>
<td></td>
</tr>
<tr>
<td><strong>Median of 64 subjects daily average ingestion</strong></td>
<td>75 mg/day</td>
<td></td>
</tr>
<tr>
<td><strong>Upper 95% of the average daily soil ingestion</strong></td>
<td>1751 mg/day</td>
<td></td>
</tr>
</tbody>
</table>

Stanek and Calabrese 1995
<table>
<thead>
<tr>
<th>Ingestion value</th>
<th>IEUBK(^2) Default of 135 mg/day</th>
<th>Upper 95(^{th}) percentile of median values(^1)</th>
<th>Upper 95(^{th}) percentile of all subjects(^1)</th>
<th>Pica at 7.7 g/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometric mean blood lead (ug/dl)</td>
<td>2.3</td>
<td>3.4</td>
<td>11.3</td>
<td>25</td>
</tr>
<tr>
<td>% exceeding 10 ug/dl</td>
<td>0.1%</td>
<td>1%</td>
<td>60%</td>
<td>98%</td>
</tr>
</tbody>
</table>

1=Stanek and Calabrese (1995)  
2=EPA Integrated Exposure Uptake Biokinetic Model
### Contact Behavior of Infants and Children in Texas.

Videotaping (mean hourly frequency). Mean Events/Hour ± Standard Deviation

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Infants</th>
<th>1 yr olds</th>
<th>2 yr olds</th>
<th>Preschool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand to mouth</td>
<td>19.8 ± 14.5</td>
<td>15.8 ± 8.7</td>
<td>11.9 ± 9.3</td>
<td>22.1 ± 22.1</td>
</tr>
<tr>
<td>Object to mouth</td>
<td>24.4 ± 11.6</td>
<td>9.8 ± 6.3</td>
<td>7.8 ± 5.8</td>
<td>10.1 ± 12.4</td>
</tr>
<tr>
<td>Food to mouth</td>
<td>10.8 ± 9.0</td>
<td>17.2 ± 14.0</td>
<td>14.7 ± 10.9</td>
<td>15.7 ± 11.8</td>
</tr>
<tr>
<td>Videotaping</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Time on floor</td>
<td>11 ± 10</td>
<td>8 ± 5</td>
<td>9 ± 4</td>
<td></td>
</tr>
</tbody>
</table>

Black et al. 2005
Children’s Pesticide Exposure

- Working in fields
- Accompanying parents into fields
- Take-home exposure on clothing
- Cross-contamination of pails
- Household uses of pesticides
- Pesticide residues on foods
- Playing on or with pesticide packaging
## Linguistic Problem for Assessment

Percent of farm workers who self-report their English skill levels as “not at all” or “well”

<table>
<thead>
<tr>
<th></th>
<th>U.S.-born non-Hispanic</th>
<th>U.S.-born Hispanic</th>
<th>Foreign born Hispanic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Speak</td>
<td>Read</td>
<td>Speak</td>
</tr>
<tr>
<td>Not at all</td>
<td>0%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>Well</td>
<td>98%</td>
<td>93%</td>
<td>66%</td>
</tr>
</tbody>
</table>

1. There was essentially no difference between Mexican and Central Americans in English skill level

From NAWS 2005
Fish Are Not Created Equal

- Variable Levels of harmful contaminants
- Variable Levels of beneficial Omega-3’s
- Variable Levels of microbial contamination
- Variable Desirability (taste, sport)

Variables a Result of:
- Fish species
- Habitat & location
  - General
  - Specific
- Size & Age of fish

Variety of fish on Adak, Alaska
Fishers differ as well
RISK BALANCING FOR FISH

• Low fat protein source
• Locally available in many places
• Omega-3 (PUFAs) & selenium

BUT
• High methylmercury, PCBs, PFOAs

• Low and moderate consumption: benefit > harm
• High end consumers  harm > benefit
  – Modify amount of intake
  – Modify species selected

• CLINICAL OBSERVATIONS---10 MEALS PER WEEK
ENVIRONMENTAL JUSTICE
Fish consumption (kg/year)

- Recreation: 52 g/day, 19 kg/year
- Subsistence: 137 g/day, 50 kg/year

8% of Whites & 24% of Blacks eat >50 kg

Burger et al. 1999 Risk Analysis 19:427
# EXPOSURE DATA FOR ADULTS BY PERCENTILE: SOUTH CAROLINA

<table>
<thead>
<tr>
<th>Age</th>
<th>Sample Size</th>
<th>% Who</th>
<th>Mean (Range)</th>
<th>Median</th>
<th>75th %</th>
<th>90th %</th>
<th>95th %</th>
<th>99th %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild-caught Fish</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32 &amp; under</td>
<td>145</td>
<td>77</td>
<td>32.6 (0.63-412)</td>
<td>14.2</td>
<td>37.6</td>
<td>66.5</td>
<td>123</td>
<td>216</td>
</tr>
<tr>
<td>33 to 45</td>
<td>159</td>
<td>77</td>
<td>71.3 (7.52-902)</td>
<td>18.8</td>
<td>67.6</td>
<td>177</td>
<td>354</td>
<td>590</td>
</tr>
<tr>
<td>over 45</td>
<td>150</td>
<td>78</td>
<td>44.0 (0.35-538)</td>
<td>20.0</td>
<td>44.4</td>
<td>100</td>
<td>164</td>
<td>286</td>
</tr>
</tbody>
</table>

*Wilcoxon X²*  
3.86 (NS)

Hitting the High-end
HIGH END CONSUMERS AREN'T ALWAYS MINORITY OR SUBSISTENCE---

-Oak Ridge TN

Amount of Fish Eaten Per Year (kg)

Percent

=200 g/day (7oz)

Black
White
<table>
<thead>
<tr>
<th>TYPE</th>
<th>Daily intake Grams/day</th>
<th>Kg/year</th>
<th>Daily Intake of MeHg for a fish with 0.3 ppm (ug/day)</th>
<th>Daily MeHg per kg body wgt (assume 70kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MINORITY</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delaware (KCARD 1994)</td>
<td>Black = 15 Asian = 6 Hispanic = 3</td>
<td>5.5 2.2 1.1</td>
<td>4.5 1.8 0.9</td>
<td>.06 .03 .01</td>
</tr>
<tr>
<td>Michigan (West et al. 1992)</td>
<td>Native American=24.3 Black=20.3 Whites = 17.9</td>
<td>8.9 7.4 6.5</td>
<td>7.3 6.1 5.4</td>
<td>.10 .09 .08</td>
</tr>
<tr>
<td>New Jersey (Burger 2002a)</td>
<td>Asian = 52 Hispanic = 41 White = 27 Black = 23</td>
<td>19.0 15.0 9.9 8.4</td>
<td>15.6 12.3 8.1 6.9</td>
<td>.22 .18 .12 .10</td>
</tr>
<tr>
<td>South Carolina (Burger et al. 2001)</td>
<td>Black male=70 Black female=48 White male=38 White female=26</td>
<td>25.6 17.5 13.9 9.5</td>
<td>21.0 14.4 11.4 7.8</td>
<td>.30 .21 .16 .11</td>
</tr>
<tr>
<td>SanDiego Bay, CA (Moya 2004)</td>
<td>Asian = 82 Filipino = 50 Hispanic = 24 Caucasian = 11</td>
<td>29.9 18.3 8.8 4.0</td>
<td>24.6 15.0 7.2fs 3.3</td>
<td>.35 .21 .10 .05</td>
</tr>
<tr>
<td>Asian and Pacific Islanders, Washington (Sechena et al. 2003)</td>
<td>117.2 42.8</td>
<td>35.2</td>
<td>.50</td>
<td></td>
</tr>
<tr>
<td>TYPE</td>
<td>Average Daily Intake Grams/day</td>
<td>Kg/year</td>
<td>Daily MeHg Intake for a fish with 0.3 ppm (µg/day)</td>
<td>Daily MeHg per kg body wgt (assume 70kg)</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------------</td>
<td>---------</td>
<td>-----------------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>EPA population</td>
<td>6.5</td>
<td>2.4</td>
<td>1.9</td>
<td>.03</td>
</tr>
<tr>
<td>EPA Default (EPA 2000)</td>
<td>17.5</td>
<td>6.4</td>
<td>5.2</td>
<td>.08</td>
</tr>
<tr>
<td>EPA 2008 8 oz/wk = 32g/day</td>
<td>32</td>
<td>11.8</td>
<td>9.6</td>
<td>.14</td>
</tr>
<tr>
<td>EPA for subsistence fishers (EPA 2000)</td>
<td>142.4 (165.5)</td>
<td>51.8 (60.2)</td>
<td>42.6</td>
<td>.61</td>
</tr>
<tr>
<td>Amerindians – ( and Currie 1993 Men – 19 Women – 14)</td>
<td>6.9</td>
<td>5.1</td>
<td>5.7</td>
<td>.08</td>
</tr>
<tr>
<td>Native American – (West et al.1992)</td>
<td>24.3</td>
<td>8.9</td>
<td>7.3</td>
<td>.10</td>
</tr>
<tr>
<td>Tulalip and Squaxin Tribes, , Toy et al. 1996)</td>
<td>60.72a</td>
<td>22.2</td>
<td>18.2</td>
<td>.26</td>
</tr>
<tr>
<td>Columbia River () tribes (CRITFC 1994)</td>
<td>63.2</td>
<td>23.1</td>
<td>19.0</td>
<td>.27</td>
</tr>
<tr>
<td>Anishinaabe, (DeWeese et al. 2009)b</td>
<td>15.1 (Dec)</td>
<td>5.5</td>
<td>4.5</td>
<td>.06</td>
</tr>
<tr>
<td>– median for 1950s (Walker and Pritchard 1999)</td>
<td>350</td>
<td>128</td>
<td>105</td>
<td>1.5</td>
</tr>
<tr>
<td>(99th percentile) (CRITFC 1994)</td>
<td>389</td>
<td>142</td>
<td>117</td>
<td>1.7</td>
</tr>
<tr>
<td>CTUIR traditional rate (Harris and Harper 1997)</td>
<td>454</td>
<td>156</td>
<td>136</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Both fish and shellfish.
Calculated from high rate for April for the tribe (X 227 g/meal).
refers to what tribal members ate historically before contamination and other factors both suppressed the fish populations and rendered the fish high in contaminants such that fish consumption was lowered.0
### Traditional Subsistence or Lifeways

#### Consumption Patterns (g/day)

<table>
<thead>
<tr>
<th>TRIBE</th>
<th>Fish/shellfish</th>
<th>Game/Meat</th>
<th>Vegetable</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yakama Nation, Washington</td>
<td>150</td>
<td>245</td>
<td>264</td>
<td></td>
</tr>
<tr>
<td>Elmo Pomo,</td>
<td>200</td>
<td>200</td>
<td>1103</td>
<td>36</td>
</tr>
<tr>
<td>Washoe Tribe</td>
<td>200</td>
<td>220</td>
<td>1906</td>
<td>40</td>
</tr>
<tr>
<td>coastal</td>
<td>514</td>
<td>286</td>
<td>404</td>
<td>148</td>
</tr>
<tr>
<td>CTUIR</td>
<td>620</td>
<td>125</td>
<td>1225</td>
<td>125</td>
</tr>
<tr>
<td>High fish diet</td>
<td>1060</td>
<td>150</td>
<td>1600</td>
<td></td>
</tr>
<tr>
<td>High game</td>
<td>250</td>
<td>935</td>
<td>1600</td>
<td></td>
</tr>
</tbody>
</table>

8 ounces = 226 grams

Harper et al. 2008
ALEUTIAN ISLAND FOOD SURVEY RESULTS

1. Villagers regularly use 59 kinds of wild resources
2. Villagers used 19 kinds of fish, 13 kinds of marine invertebrates, 12 kinds of birds and eggs, and 11 kinds of mammals (includes Sea Lion)
3. Households used an average of 23 kinds of wild resources
4. 95% gave away some of their catch
5. Percent of all households using:
   a. Sockeye Salmon = 95%
   b. Halibut and Cod = 95%
   c. Octopus = 90%
   d. Chitons = 85%
   e. Dolly Varden = 75%
   f. King Crab = 75%
## Direct Exposure from Confederated Tribes of the Umatilla Indian Reservation

<table>
<thead>
<tr>
<th>Direct Pathway</th>
<th>Default Suburban</th>
<th>Rural Gardener</th>
<th>Subsistence Forager</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inhalation (m³/day)</strong></td>
<td>20m³</td>
<td>25m³</td>
<td>30m³</td>
</tr>
<tr>
<td><strong>Drinking water ingestion (L/day)</strong></td>
<td>2L/d</td>
<td>3L/d</td>
<td>3L/d + 1 L for sweat lodge</td>
</tr>
<tr>
<td><strong>Soil ingestion (mg/d)</strong></td>
<td>50-100 mg/d</td>
<td>300 mg/d</td>
<td>400mg/d</td>
</tr>
<tr>
<td><strong>Exposure frequency days/year</strong></td>
<td>Up to 365 days</td>
<td>Up to 365 days</td>
<td>365 days/24 hrs</td>
</tr>
<tr>
<td><strong>Exposure duration</strong></td>
<td>30 years</td>
<td>70 years</td>
<td>70-75 years</td>
</tr>
<tr>
<td><strong>Body weight</strong></td>
<td>70 kg</td>
<td>70 kg</td>
<td>70 kg</td>
</tr>
</tbody>
</table>

CTUIR 2004
Exposure Information Needed from Dietary Studies to Allow Adequate Risk Assessment

Consumption patterns
- Number of meals per week (mean, median, maximum, percentiles up to 99)
- Size of the meals (mean, median, maximum, percentiles up to 99)
- Composition of those meals (species of fish, game, plant, herb)
- Parts eaten (for fish, shellfish, and game)
- Size of the fish eaten (means, range)
- Method of cooking (and skin off or on)

Individual status
- Age, gender, ethnicity
- Pregnancy or child-bearing age
- Nutritional status
- Other compromising characteristics

Exposure Duration
- Lifetime exposure
- Acute or peak exposure (many meals in a short period of time)

Temporal patterns
- Differences in consumption patterns by age group
- Differences in consumption patterns by season (and month)
- Differences in consumption patterns by changing mores
- Total years of exposure
Precautionary Action

• More research is always needed
• More research will always be wanted
• But the words “more research is needed should not be used as an excuse for failure to take actions.”
• We need to invoke precaution while our science base is maturing.
• Link to the national POLLUTION PREVENTION initiative (P2)
• International Environmental Justice
  – Our hazards are being exported to poor communities in other countries
INTERACTIONS AMONG PROXIMATE RISK FACTORS

- Lack of Information
- Vulnerability to exposure
- Susceptibility to toxicity
- Lack of Access to Health Care

High Risk
INTERACTIONS AMONG RISK FACTORS

- Limited Communication
- Psychosocial stressors
- Low income/hazardous jobs
- High exposure(S)

Vulnerable
ACKNOWLEDGEMENTS

• Over the thirty years that we have been studying exposures and health issues among special populations with unusual high exposure pathways we have benefited from discussions, insights, and advice from numerous colleagues in our universities, in the Consortium for Risk Evaluation with Stakeholder Participation under which our Department of Energy/American Indian research has been conducted, and in our Environmental and Occupational Health Sciences Institute.

• For the present papers we appreciate the advice and input from M. Callahan, O. Nweke, and R. Lorenzana. Also B. Harper and S. Harris. Our dedicated laboratory and office staff C. Jeitner, S. Shukla, T. Pittfield, M. Donio, and T. Cirillo were helpful as always.

• Over the years our research has been funded by the Environmental Protection Agency, Department of Energy (through the Consortium for Risk Evaluation with Stakeholder Participation, AI # DE-FG 26-00NT 40938 and DE-FC01-06EW07053), Nuclear Regulatory Commission (NRC-38-07-502M02), and NIEHS (P30ES005022), the Department of the Interior, the New Jersey Department of Environmental Protection, and EOHSI.