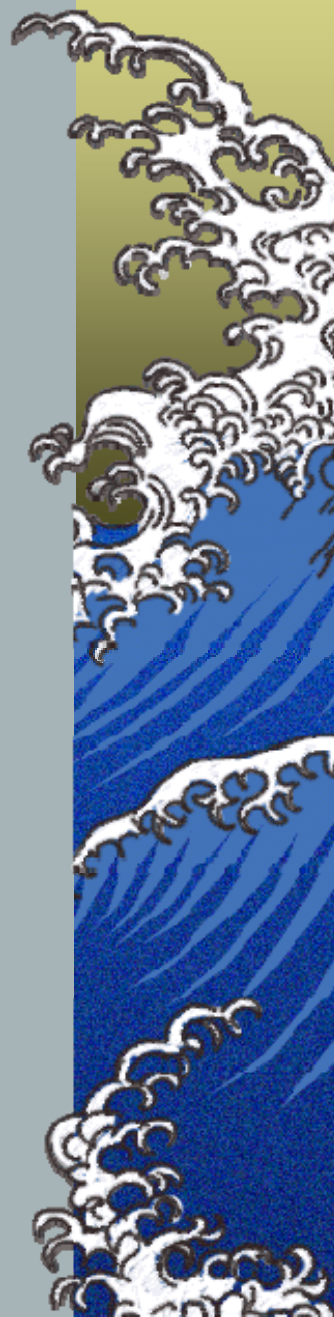
Development of Fish* Consumption Rates for Use in MTCA Surface Water Cleanup Level Equations at Sites Impacting the Duwamish River and Elliott Bay



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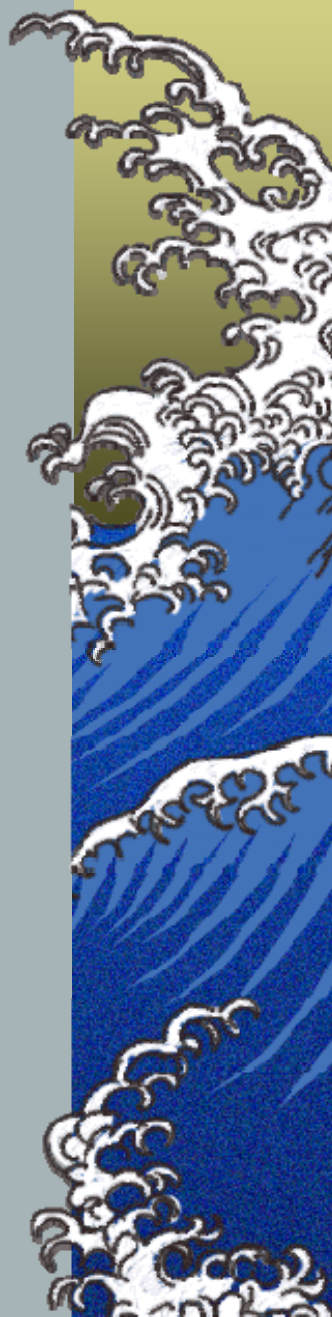
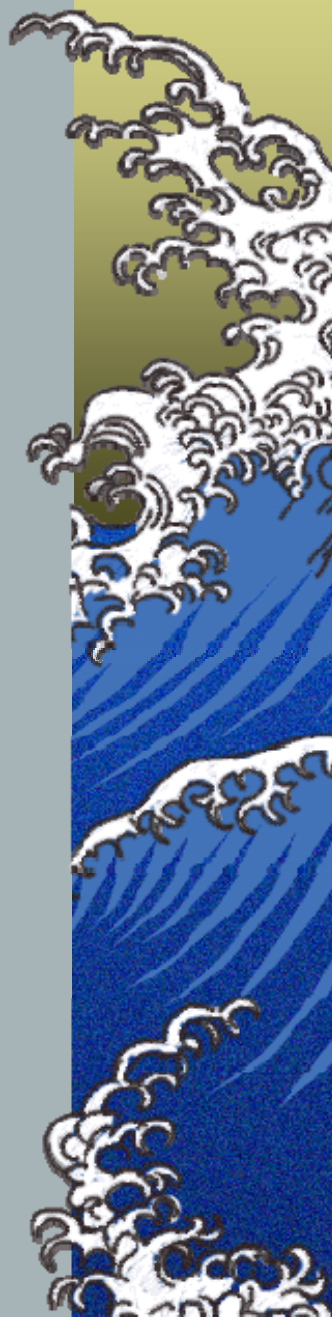
- *Catherine O'Neill, Seattle University School of Law*
- *Nayak Polissar, MWLSC**

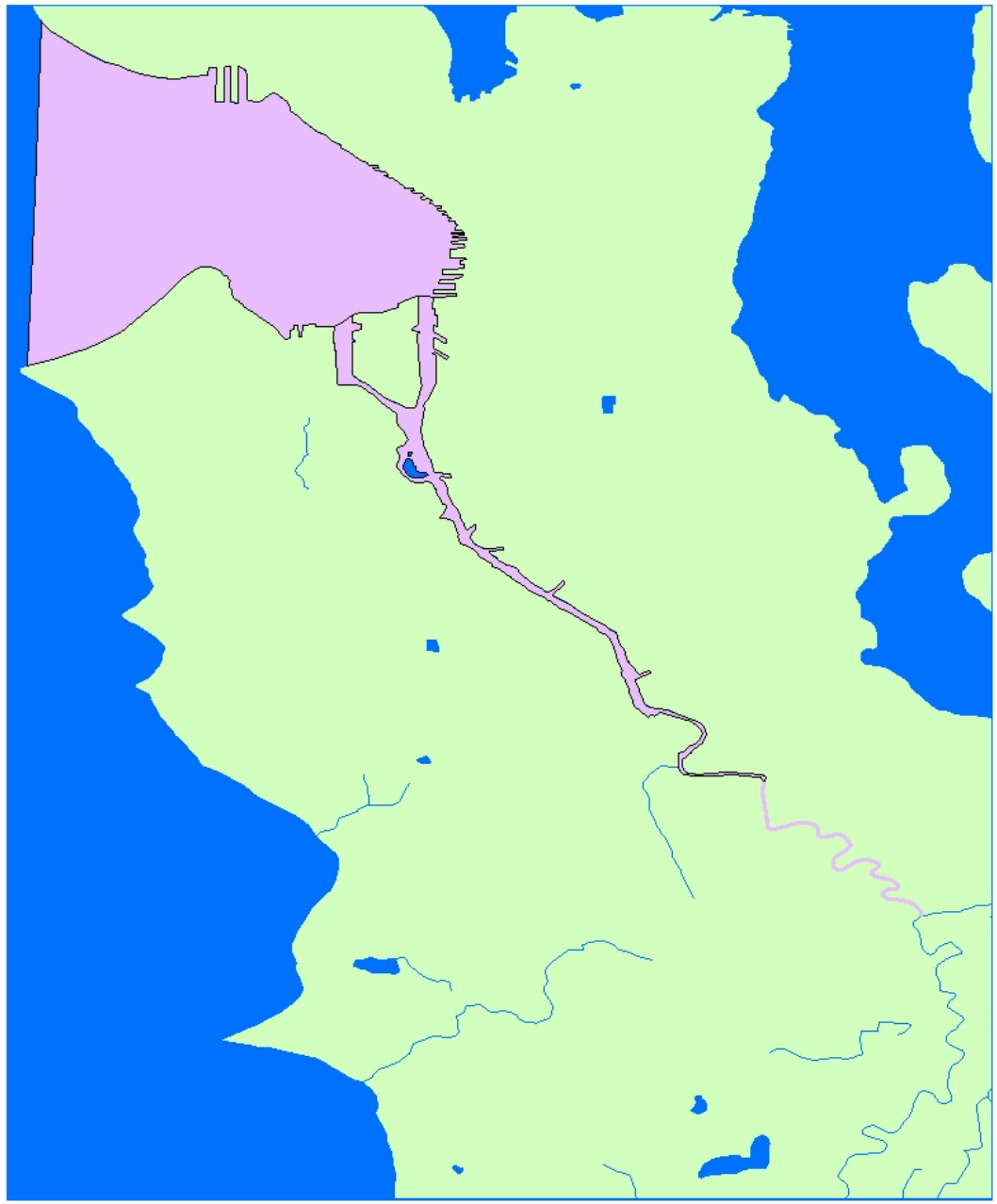
**MWLSC = The Mountain-Whisper-Light Statistical Consulting*



Why are we here?

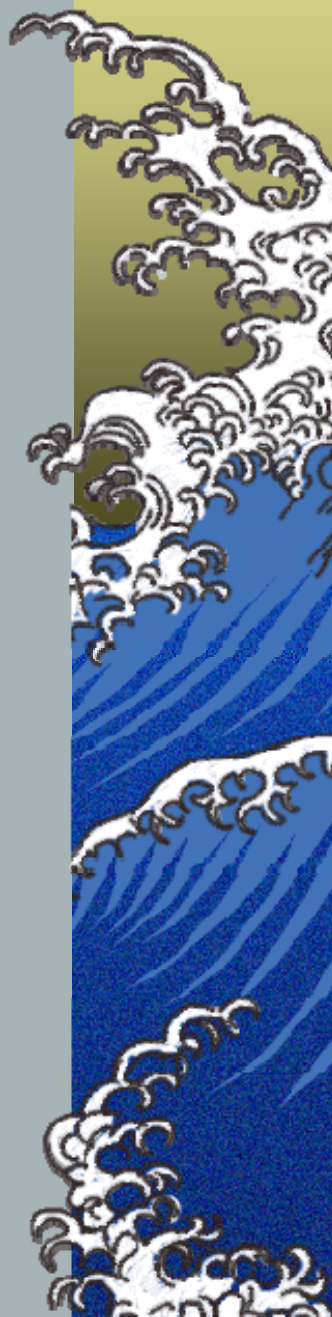
- Ecology cleanup sites releasing contaminants to the Duwamish River and Elliott Bay
- Fish may accumulate site-related contaminants, and humans may be exposed to these contaminants via fish consumption
- Asians & Pacific Islanders (API)s reside in the vicinity of the Duwamish River and consume seafood that has been harvested from the Duwamish River and Elliott Bay.
- API fish consumption rates are greater than the MTCA fish consumption rate used to compute surface water cleanup levels (SWCUL)s
- Ecology wishes to use a higher fish consumption rate to develop SWCULs protective of APIs who might consume fish from the Duwamish and Elliott Bay





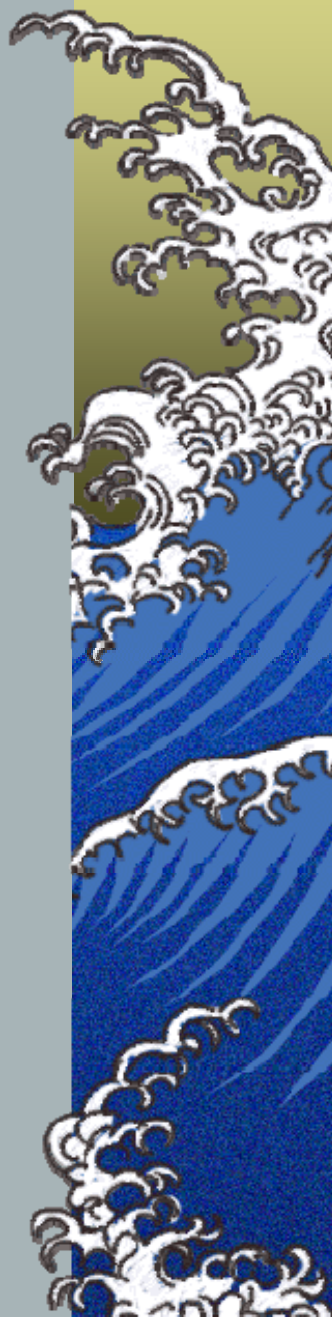
Presentation outline

- Process for modifying MTCA exposure parameters
- MTCA surface water cleanup level equation
- Rationale for Ecology and EPA concerns about current rate's protectiveness
- Fish consumption surveys and the API study
- Approach used to develop API fish consumption rates



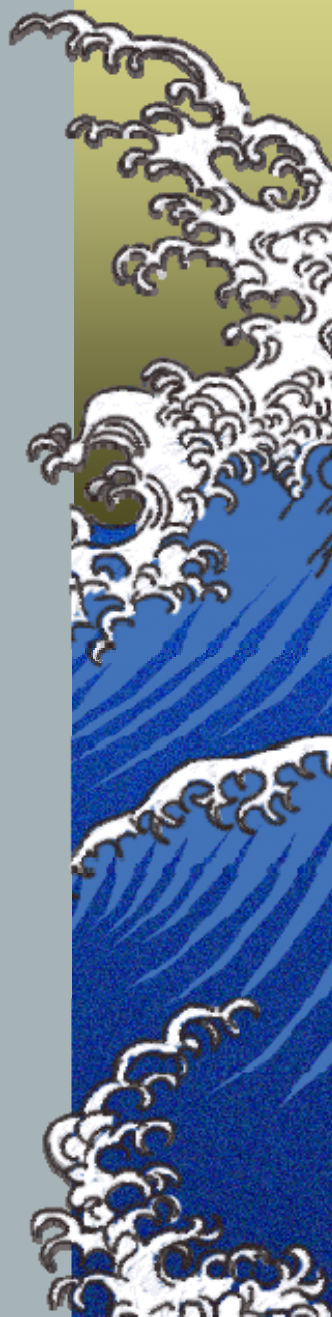
Presentation outline (continued)

- Discussion of assumptions used in fish consumption rate analysis
- Evaluation of uncertainty in fish consumption rate
- API body weight
- Rationale for analysis choices
- Recommended exposure parameter values.



Process for modifying MTCA exposure parameters

- MTCA [WAC 173-340-708(10)] allows for modification of certain exposure parameters on a site-specific basis when necessary to protect human health.
- Modification of some exposure parameters, including fish consumption rates, requires consultation with EPA, WADOH and the SAB. [WAC 173-340-702 (15)].



MTCA surface water cleanup levels

$$CUL\ (\mu g/L) = \frac{(RISK \times \mathbf{ABW} \times AT \times UCF1 \times UCF2)}{CPF \times BCF \times \mathbf{FCR} \times \mathbf{FDF} \times ED}$$

Where:

CPF = Carcinogenic Potency Factor

RISK = Acceptable cancer risk level

ABW = Average body weight, (70 kg)

AT = Averaging time (75 years)

UCF1 = Unit conversion factor (1,000 ug/mg)

UCF2 = Unit conversion factor (1,000 grams/liter)

BCF = Bioconcentration factor (liters/kilogram)

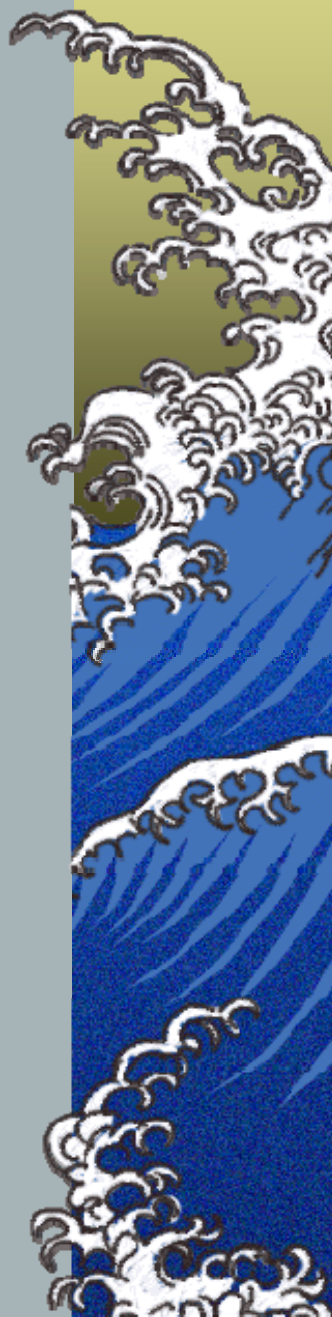
FCR = Fish consumption rate (54 grams/day)

FDF = Fish diet fraction (0.5) (unitless)

ED = Exposure duration (30 years)

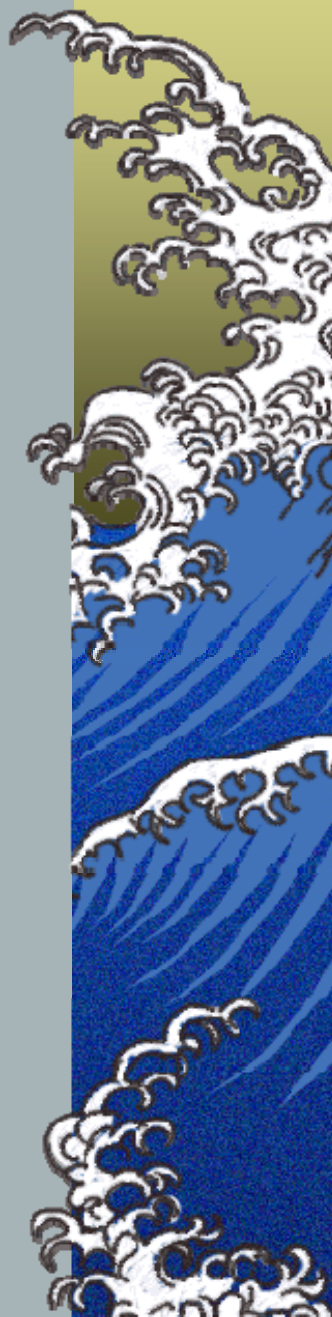
Site-related contamination, water quality and fish consumption risks

- Site-related contaminants may discharge to surface water via groundwater, runoff or sediments
- Humans consuming fish that have accumulated contaminants are at risk

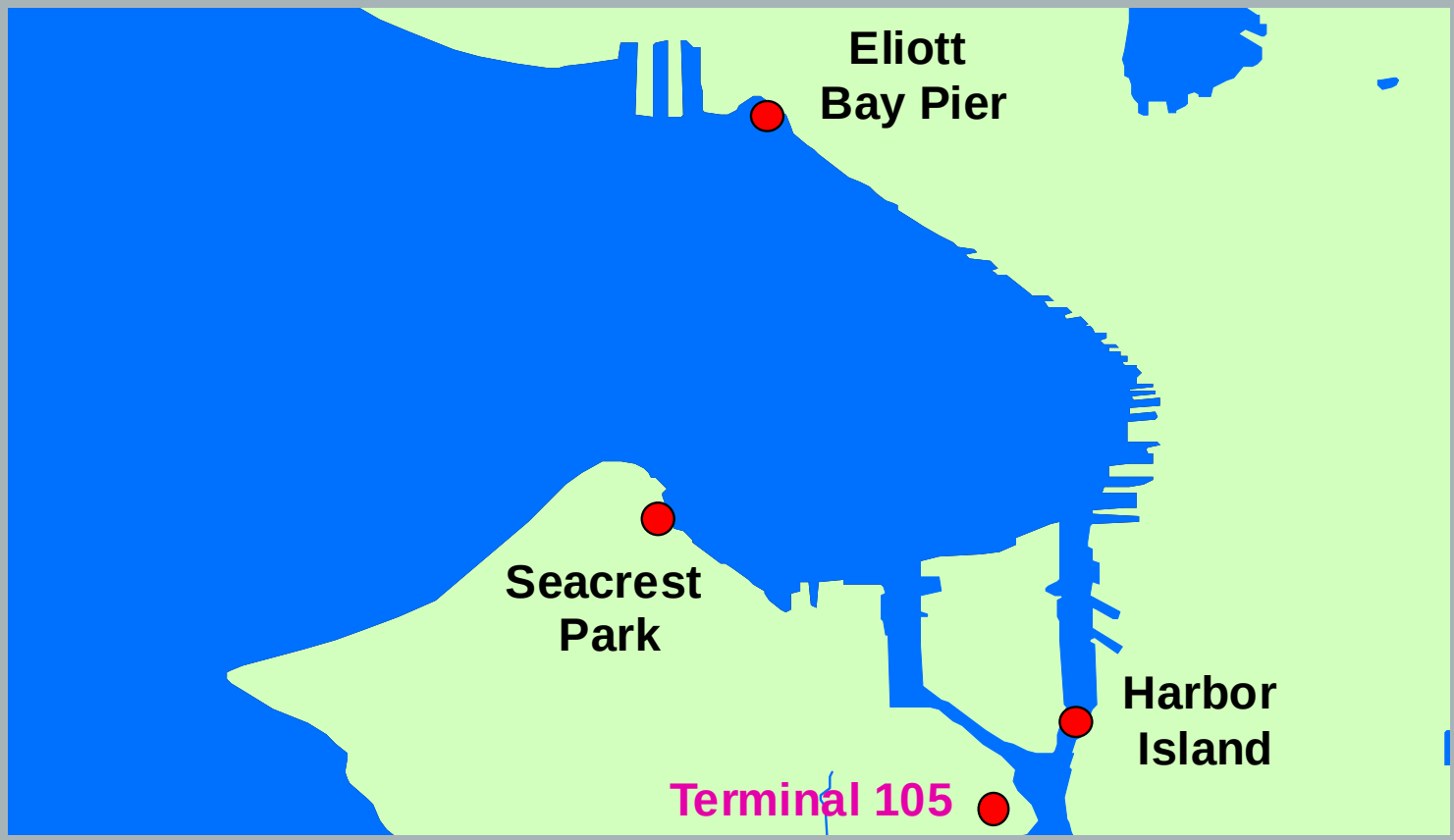


MTCA consumption rate protectiveness concerns

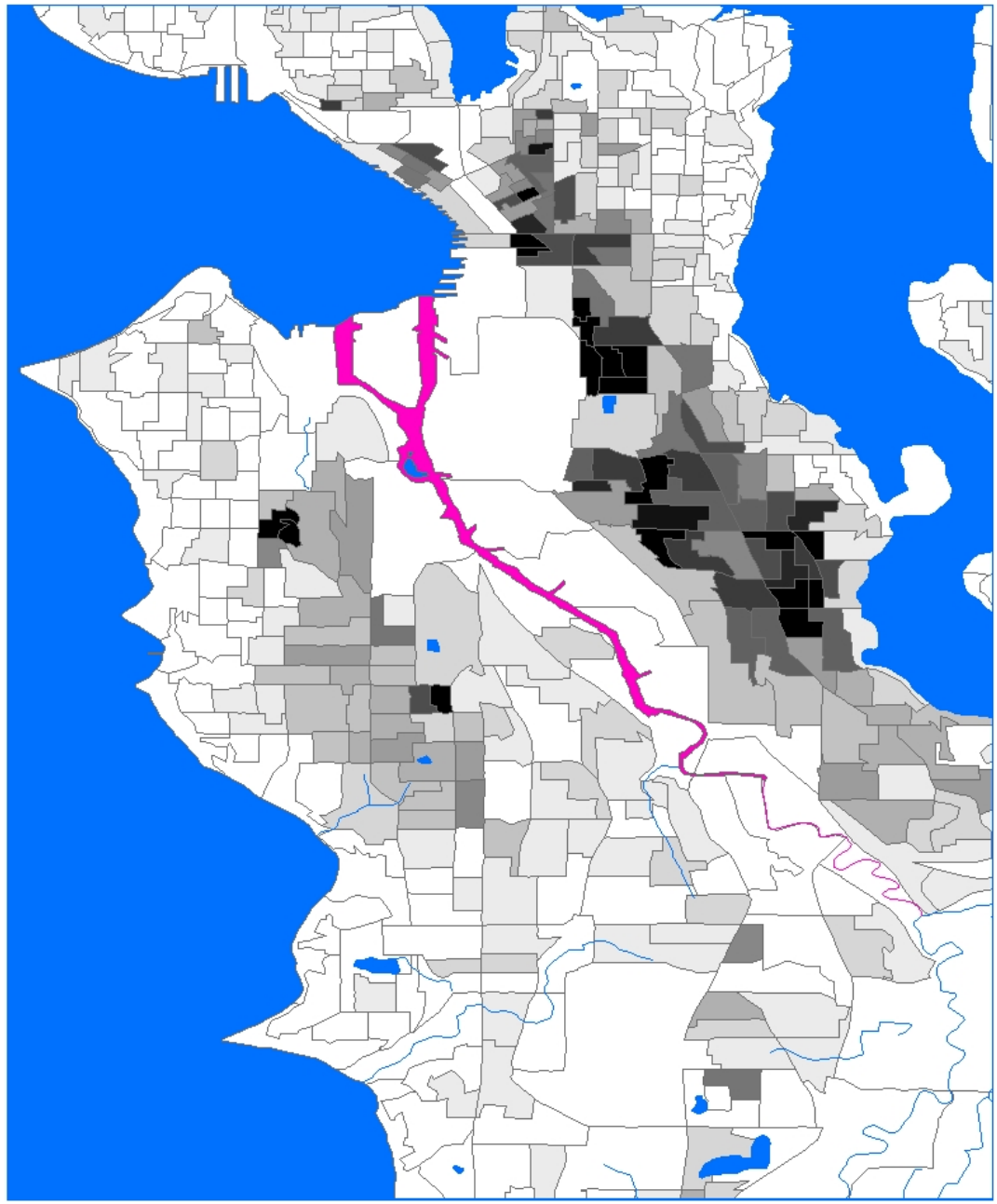
- APIs consume seafood from the Duwamish area and Elliott Bay (King County, 1998; NOAA 1985 & 1987; McCallum, 1985)
- A large number of APIs reside in King County, including areas bordering the Duwamish River (e.g., Georgetown; 2000 U.S. Census)
- 1999 API fish consumption study indicates APIs consume more fish than Ecology's default rate



King County Seafood Consumption Survey, 1998

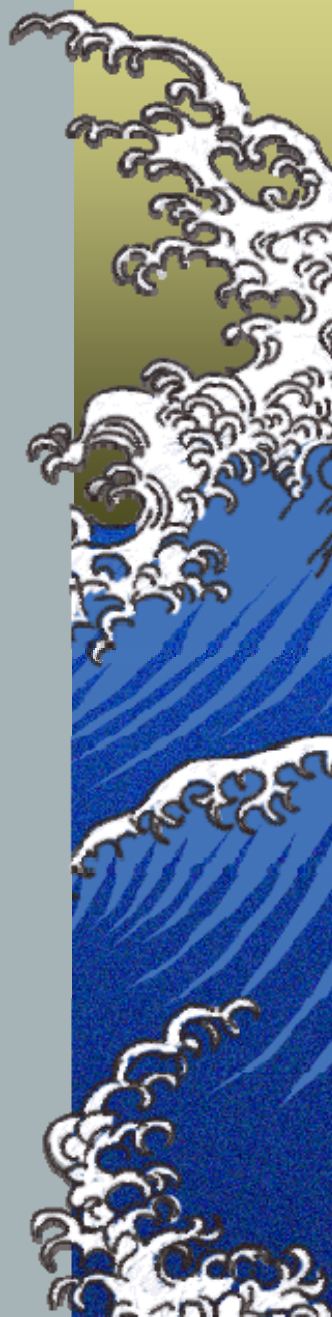


King County API population is 197,000, 11.3% of total. (2000 U.S. census)



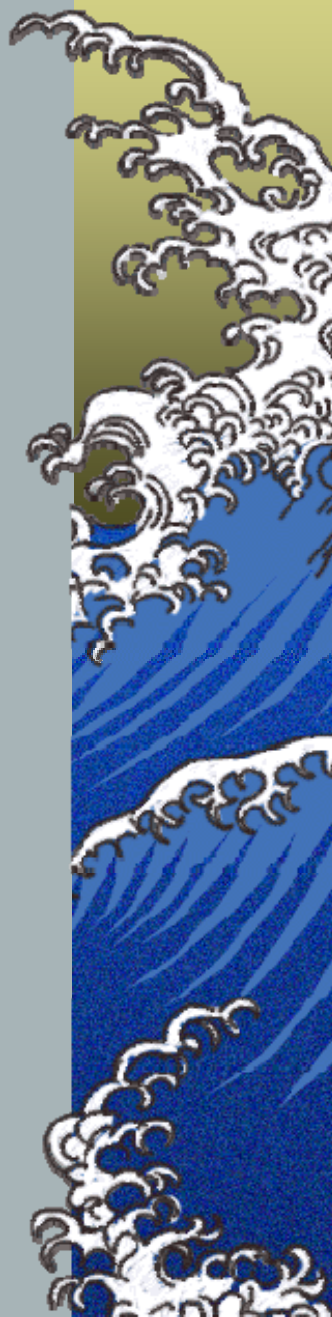
Creel vs. Personal Interview Surveys

- Creel: Interviews done in the field, catch inspected
- Personal interview: Interviews done in a non-field setting



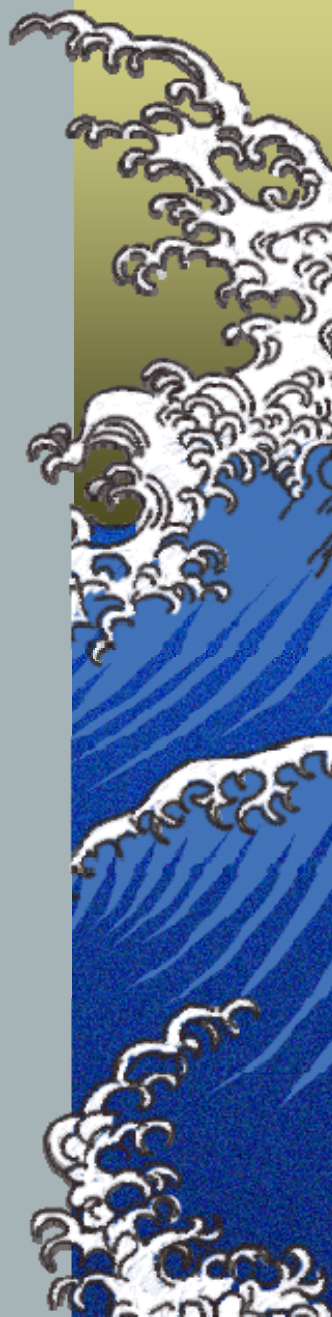
Creel surveys

- Individuals interviewed a function of who's fishing (i.e. selection bias), can over sample frequent anglers
- Months and hours covered
- Language barriers & fear of authorities issues when interacting with ethnic minorities.
- Interviews only collect information between the time an individual starts fishing and time of interview
- Interviewee can feel burdened
- Quantification of portion size difficult



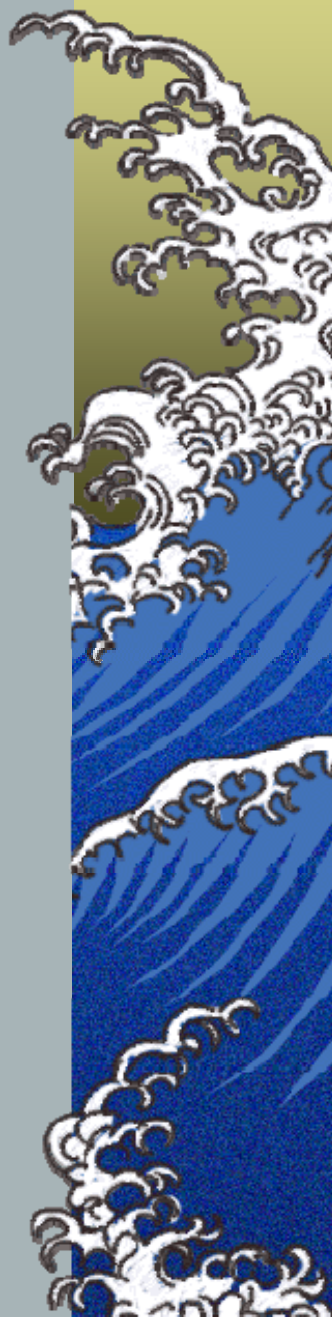
Personal interview surveys

- Can select a random sample of the group to be surveyed
- Can assess fish consumption throughout the year
- Some uncertainty associated with recall that can be quantified with repeat interviews
- Can be done in environments that are comfortable for ethnic minority interviewees
- Use of models and other aids to quantify portion size easier than for creel surveys



Strengths of the Sechena et al. 1999 API study

- Personal interview survey
- Interviewers trained
- Survey pilot tested and refined
- Randomization included in participant selection
- Interviewers were trusted members of the ethnic communities being surveyed

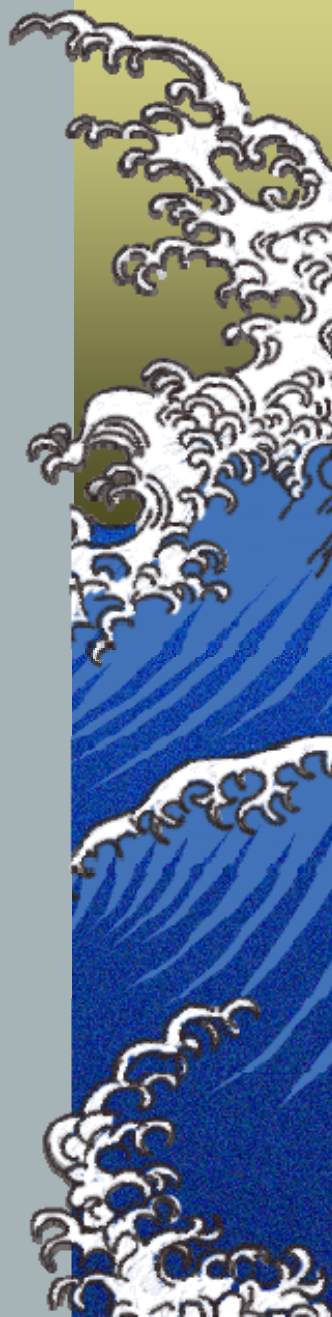


API total fish consumption, Sechena et al. 1999

Statistic (percentile or mean)	Grams fish & shellfish consumed per day
10%	30
25%	47
50%	86
75%	136
90%	246
Mean	114

Factors considered in consumption rate development:

- Reasonable maximum exposure media contact (e.g. fish consumption rate),
  95th percentile (EPA 1989)
- Fish consumers only
- Correction for consumption recorded on a cooked tissue basis
- Fraction affected by source = fraction harvested from King County



Using the API study to describe King County API seafood consumption

- Adjusting study results (i.e. weighting) so that they are reflective of King County on the basis of API ethnic composition.
- Computation of consumption rates
- Coupling weighting and consumption rates to derive percentiles of consumption.

API ethnic composition of study participants vs. King County

- Upper percentile rates to be developed for APIs as a whole due to sample size considerations.
- Percentages of ethnic groups in study and King County differ.
- Study participant ingestion rates need to be "weighted" to reflect the ethnic composition of King County and so that conclusions about King County fish consumption can be drawn.

Weighting

The weight (w_i) or percentage of the King Co. population represented by a participant's ingestion rate is a function of:

- The percentage of the population consisting of a participant's ethnic group, P_i.
- The number of individuals surveyed within a participant's ethnic group, n_i.

$$\text{Weight } (w_i) = P_i / n_i$$

Fish consumer-only weighting refinements

- Number of individuals per ethnic group (n_i) becomes the number of fish consumers per ethnic group (n_{ci}).
- Percentage of the population consisting of an ethnic group (P_i) becomes the percentage of fish consumers within an ethnic group (P_{ci}).

$$\text{Weight } (w_i) = P_{ci} / n_{ci}$$

Determining the percentage of fish consumers in the population (P_{ci})

- No census data to compute P_{ci}
- Can estimate P_{ci} using the fraction of seafood consumers (f_c) from API study data.
- f_c is the ratio of the number of consumers to the number of non-consumers
- P_{ci} estimated using $f_c * P_i$.
- f_c could be calculated for data for each ethnic group (n_{ci} / n_i) or for all study data (n_c / n).
- Statistical test indicated pooled data best.

Weighting factor for members of a particular ethnic group

$$w_i = P_{ci} / n_{ci} = (P_i * f_c) / n_{ci}$$

Where $f_c = n_c / n$

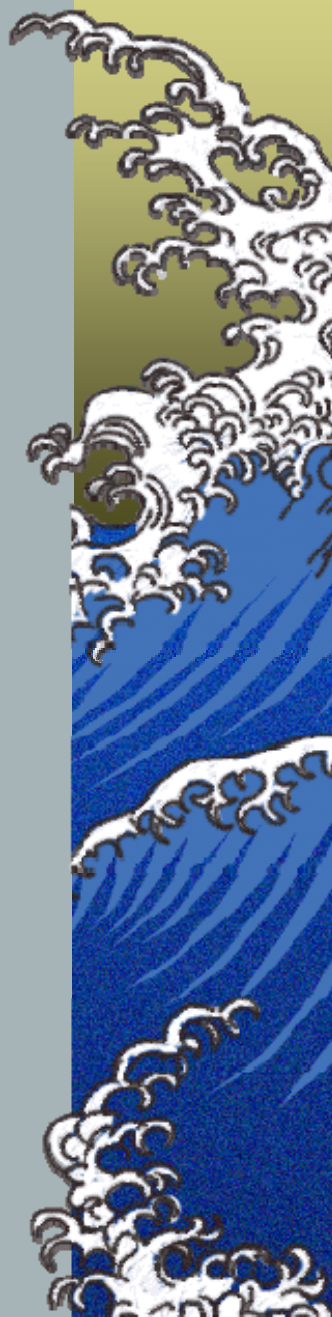
Normalized weighting factor

- To develop consumption rate percentiles, the sum of the weighting factors for all API study participants needs to be scaled to equal 100% (i.e. normalized).
- Ethnic group specific weighting factors divided by the sum of the weighting factors for all consumers

$$w_{i\ normalized} = (P_i * f_c / n_{ci}) / \Sigma (P_i * f_c / n_{ci})$$

Potential flaw in weighting methodology

- Weighting methodology used may be inappropriate for small sample sizes.
- Data set of API consumers sufficiently large enough to use this weighting methodology correctly.



Computing fish ingestion rates

$$IR = (IR_A + IR_P + IR_B + IR_S + IR_F) * BW$$

Or

$$IR = \sum_{i=1}^{n} (IR_i) * BW$$

Where:

IR = total fish ingestion rate in grams per day for a study participant

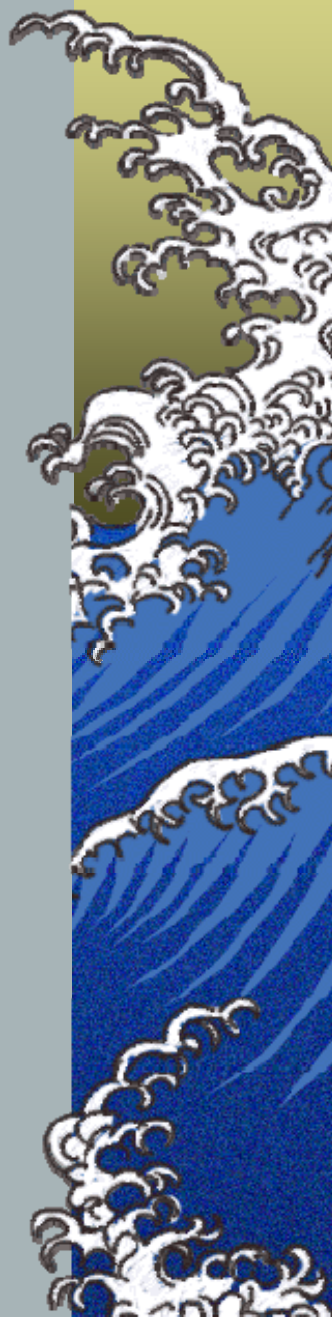
$IR_{subscript}$ = species group: A= anadromous, P=pelagic, B=benthic, S=shellfish, F=freshwater

BW = body weight in kilograms

Incorporating fraction from source

Study recorded amount of seafood obtained from various sources:

- Harvested in King County
- Harvested outside King County
- Purchased in grocery stores
- Consumed in restaurants



Incorporating fraction from source

$$IR = \sum_{i=1}^{n} (IR_i * F_{i\ King\ Co}) * BW$$

Where:

IR = total fish ingestion rate in grams per day for a study participant

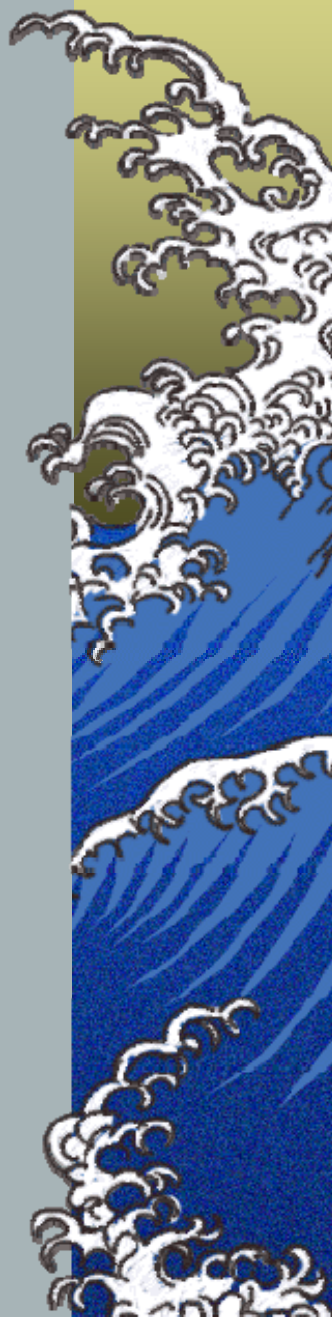
IR_i = species group ingestion rate in grams per kilogram per day

BW = body weight in kilograms

F_i = fraction of seafood harvested from King Co

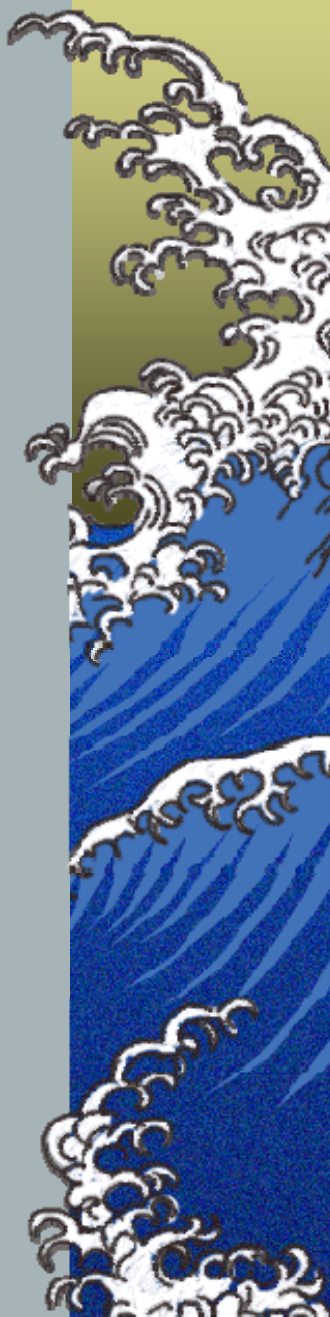
Fraction from the source

- Incorporated on an individual basis at the species group level.
- Site specific



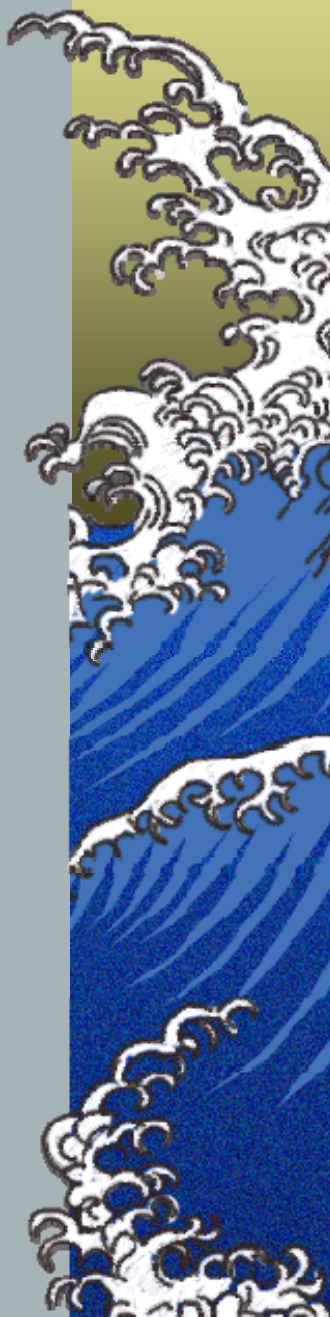
Use of cooked and uncooked shellfish tissue weights in the API study

- API study recorded shellfish consumption on an uncooked and cooked basis
- Certain shellfish steamed to facilitate removal of edible tissue for weighing
- Cooked tissue weights associated with models and used to derive consumption rates.



Why adjust consumption to an uncooked basis?

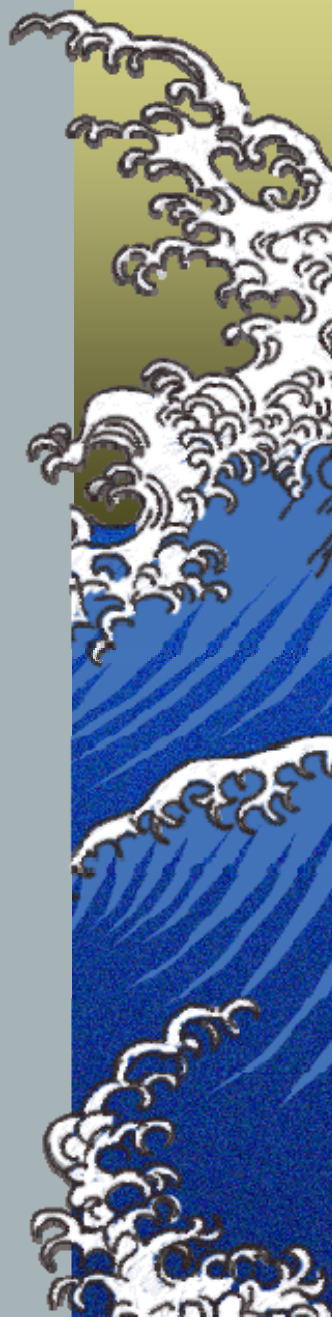
- Lower cooked tissue weights translate into lower consumption rate estimates (i.e. consumption rate is biased low)
- Risk assessment uses contaminant concentration data from uncooked samples
- Important that concentration and consumption are both on the same basis (EFH 1997)
- Effect of different cooking techniques on weight and contaminant concentration vary



Correction of ingestion rate for cooking weight loss

$$\text{Correction factor (CF)} = \frac{\text{portion weight}_{\text{uncooked}}}{\text{portion weight}_{\text{cooked}}}$$

$$IR_{uncooked} = CF * IR_{cooked}$$



What data are available on shellfish cooking weight loss?

- USDA (1975) found weight losses of 25% for shucked raw oysters and 50% for shucked scallops.
- EPA (2005) observed weight losses upon steaming of shucked of:
  - 23.5% +/- 2.5% for shucked mussels
  - 37.4% +/- 1.1.%for shucked oysters
- API study data used to derive a weight loss of 18% for crab

Participant shellfish consumption rate corrected for cooking

$$IR_{shellfish} = \sum_{i=1}^{n} (IR_{cooked\ species\ i}) * CF + IR_{crab} * CF_{crab} + \sum_{i=1}^{n} (IR_{uncooked\ species\ i})$$

25% loss scenario: CF is 1 1/3

50% loss scenario: CF is 2

Crab loss of 18% used in both scenarios

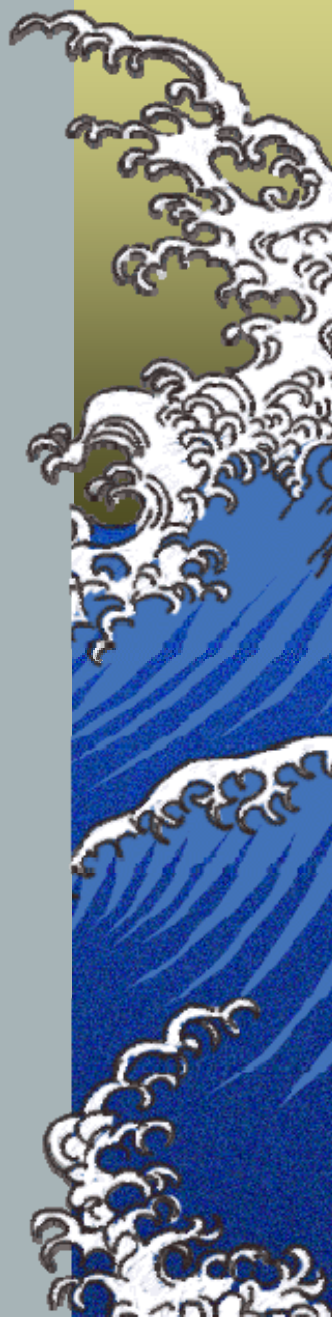
Consumption rate summary

$$IR = \sum_{i=1}^{n} (IR_i * F_{i\ \text{King County}}) * BW$$

$$IR_{shellfish} = \sum_{i=1}^{n} (IR_{\text{cooked species } i}) * CF$$

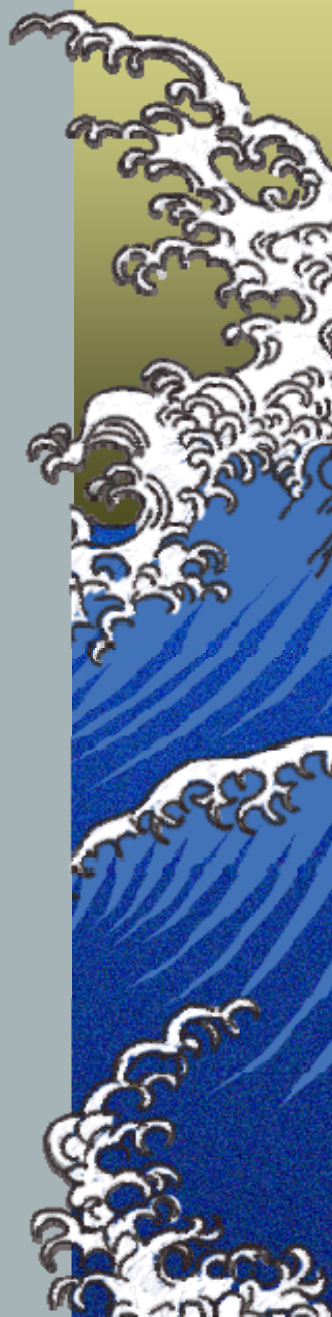
$$+ IR_{crab} * CF_{crab}$$

$$+ \sum_{i=1}^{n} (IR_{\text{uncooked species } i})$$



Developing percentiles

- Ingestion rates rank ordered from lowest to highest.
- Weighting factor summed to develop a cumulative percentage distribution.
- Ingestion rates with cumulative weights bracketing the 95^{th} percentile identified.
- Linear interpolation performed between rates bracketing the 95^{th} percentile.



Developing percentiles

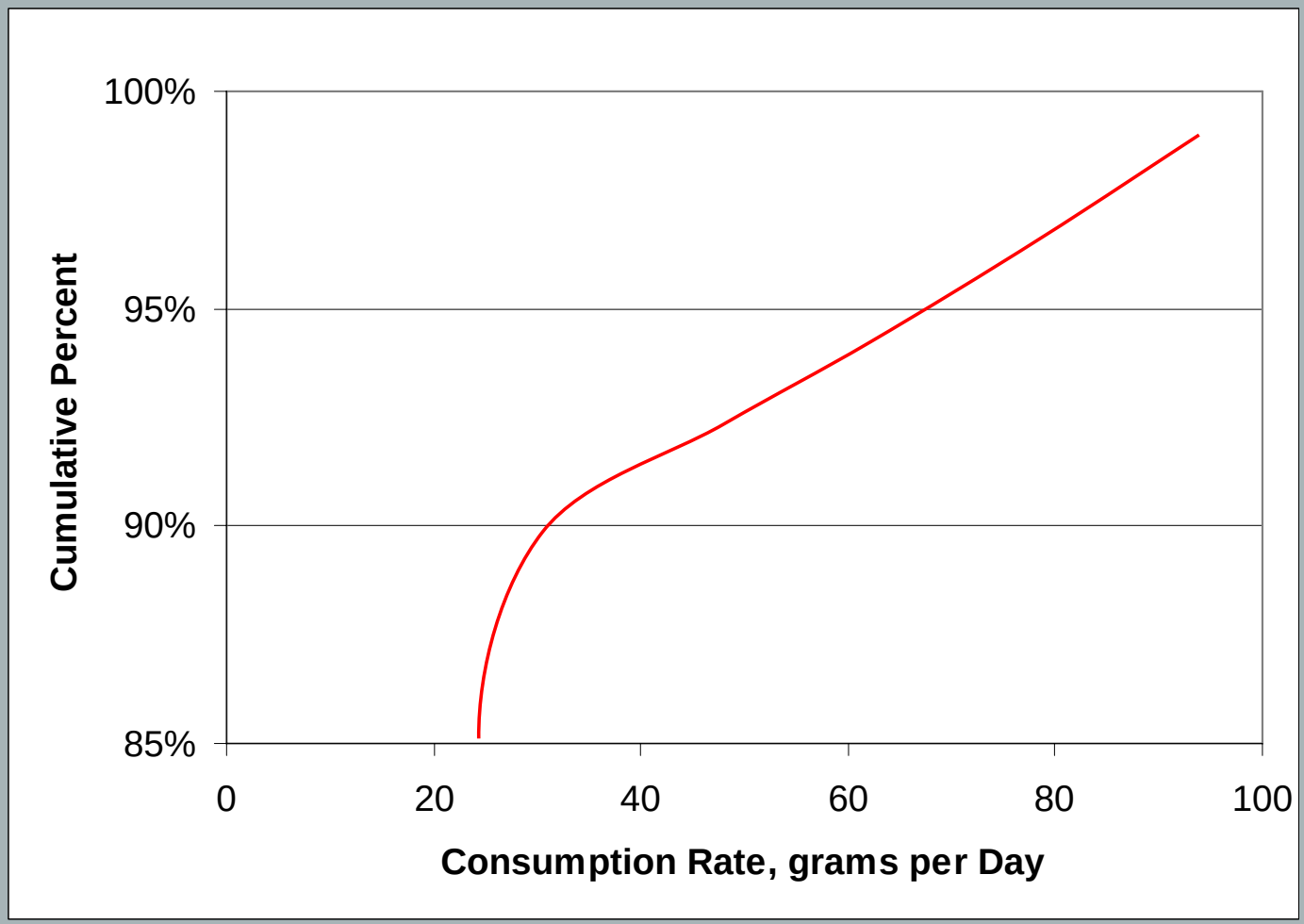
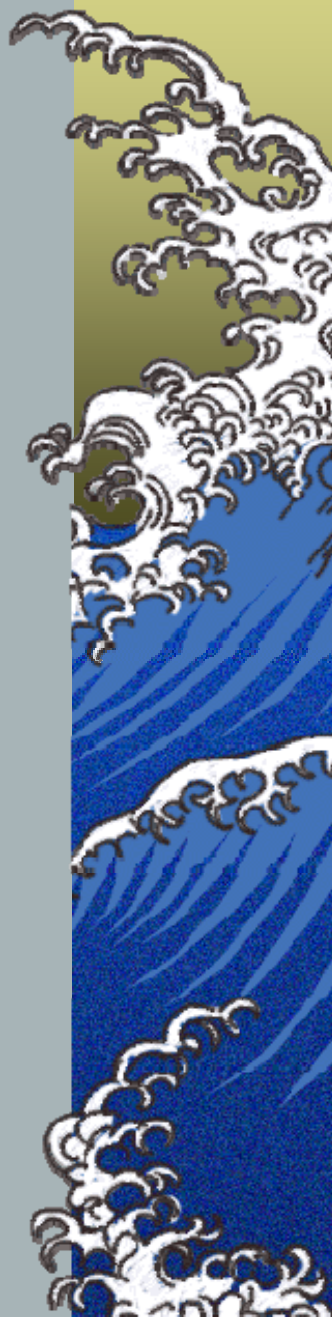


Table 3: Computation of 95th percentile consumption rates for individuals harvesting seafood from King County (no correction for cooking)

Individual	Ethnicity	Statistical Weight, (w_{0i})	Cumulative Percent	Seafood Consumption Rate, g/day
AV10	Cambodia	0.0036	0.4%	0.16
JR62	Vietnamese	0.0180	2.2%	0.31
AR28	Cambodia	0.0036	2.5%	0.57
…				
EV35	Korean	0.0118	94.2%	35.2
FV01	Laotian	0.0025	94.4%	48.3
CR30	Filipino	0.0142	95.9%	48.5
ER14	Korean	0.0118	97.0%	49.2
FR13	Laotian	0.0025	97.3%	57.5
DR03	Japanese	0.0106	98.3%	75.3
DV09	Japanese	0.0106	99.4%	77.6
AV13	Cambodia	0.0036	99.8%	81.0
FR15	Laotian	0.0025	100.0%	196.6

Assumptions

- The seafood consumption behavior of the API study population is representative of King County resident API seafood consumption.
- U.S. Census data are appropriate to use to weight API study results so that they represent King County seafood consumers.

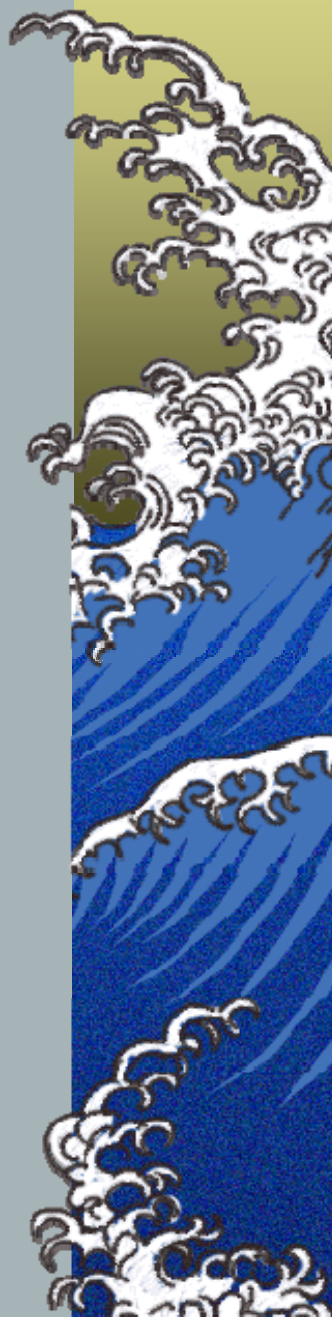


Factors that may cause seafood consumption of API study sample and adult King County API population to differ

Item	Sample	King Co.
Generation	1st and 2nd	Not restricted
Gender mix	50:50	Potentially different
Effect of disqualification and respondent selection methodology	Volunteers responding to ads, organization rosters	All individuals
Ethnic group	10 study groups	Study groups + more

Conclusions: API study sample and King County API fish consumption differences

- Can't quantify effect of differences.
- Good basis for believing some factors have minimal effects.
- Reasonable to use seafood consumption behavior of API study sample to represent behavior of King County APIs.



Factors affecting use of U.S. census data to weight API study results

How would census percentages of API groups change if they were based on a population with the characteristics of the API study?

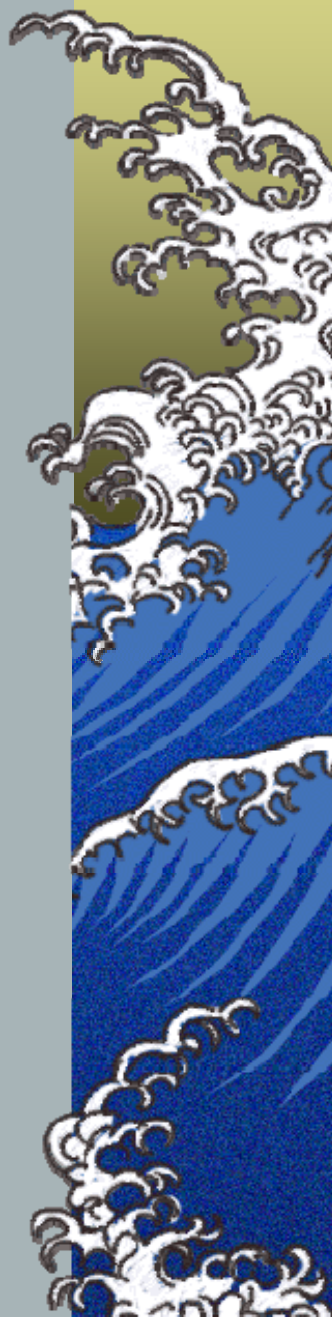
Factor	**Study**	**U.S. Census**
Age	18+	All ages
Generation	1st or 2nd generation	All generations
Seafood consumer?	All consumers	Consumers and non consumers

Conclusions: Factors affecting use of U.S. census data to weight API study results, conclusions

- Can't quantify impact
- Good basis for believing effects are minimal, though effect of generational difference is unknown.
- Reasonable to use U.S. census data to weight API study results

Quantification of uncertainty

- Done using bootstrap technique.
- Addresses fraction of consumer and consumption rate uncertainty.
- 999 resamples of all original data *with replacement* to fill ethnic group quotas
- For each resample, a new fraction of consumers value and set of weights were computed.
- Percentiles then computed for each resample
- 95% confidence interval about a percentile based on the 0.025 and the 0.0975 quantiles of the 999 resamples.

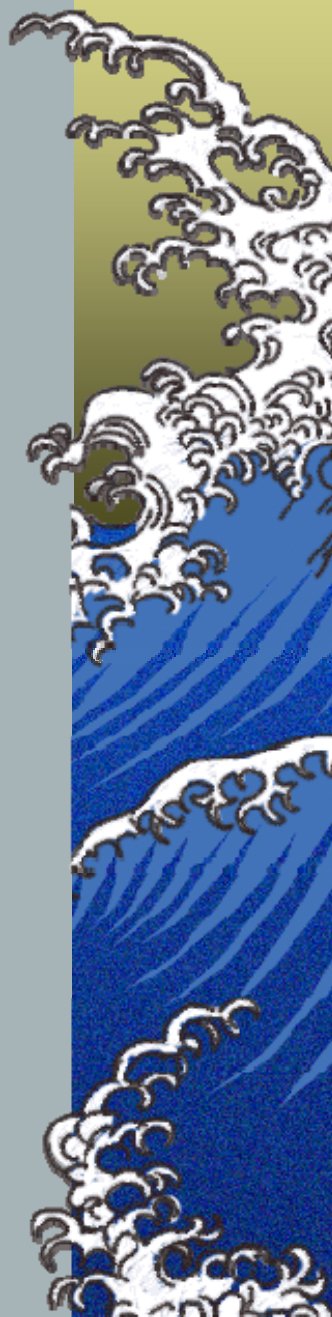


Original Data	Resample #:				
Hmong	1	2	3	...	999
1	4	1	3	...	3
2	1	2	1	...	5
3	5	4	2	...	2
4	2	2	3	...	1
5	5	5	4	...	5
Samoan					
1	6	4	2	...	8
2	4	3	8	...	10
3	5	6	5	...	3
4	7	10	5	...	4
5	6	2	3	...	8
6	6	10	6	...	2
7	5	7	6	...	8
8	10	4	3	...	1
9	8	5	4	...	5
10	4	5	1	...	3
▪ ▪ ▪ Total: 202					

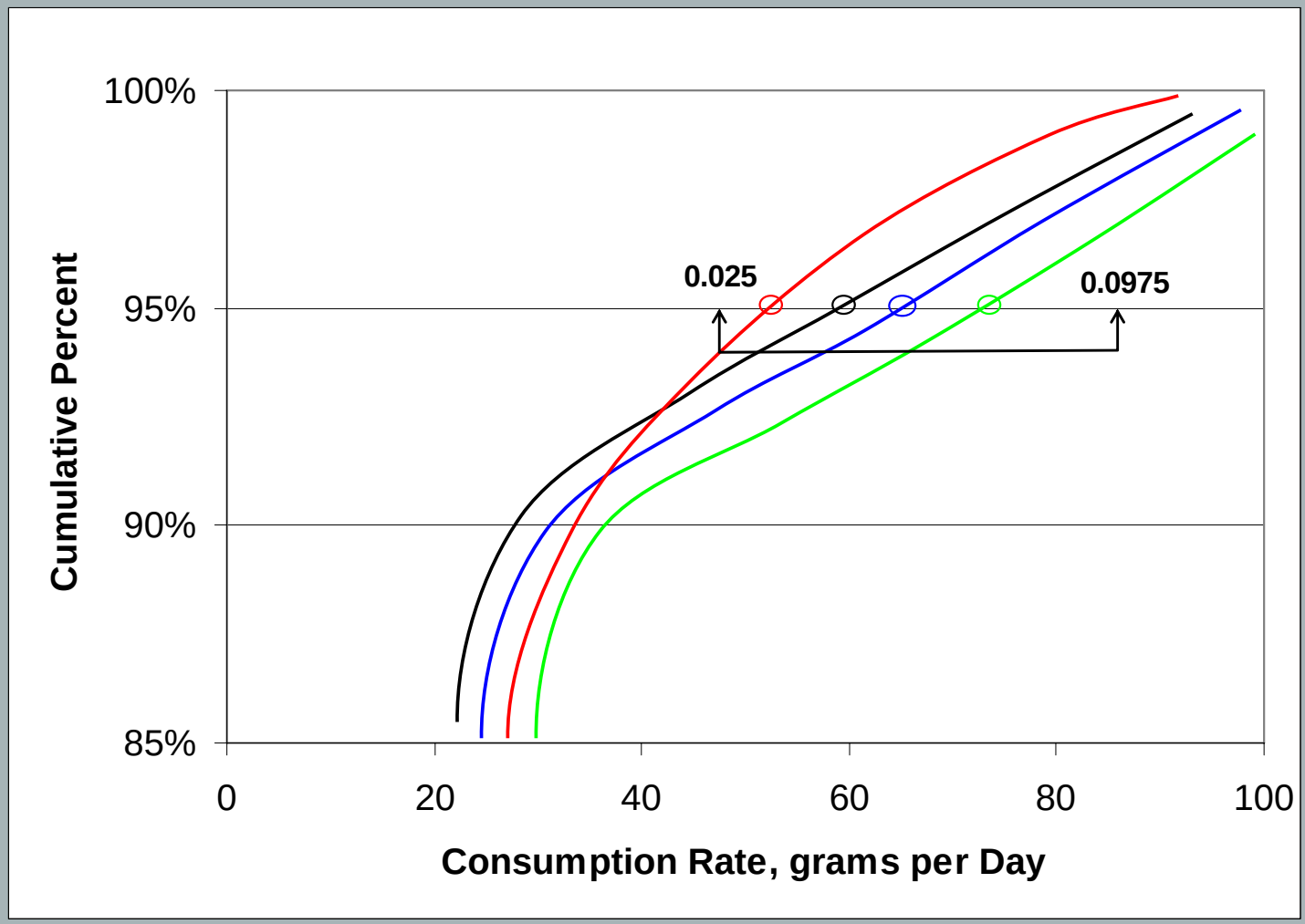
# of consumers:	4	5	6	...	6
Fraction of consumers:	0.3	0.4	0.5	...	0.5

Consumer:

Non-consumer:



Quantification of uncertainty



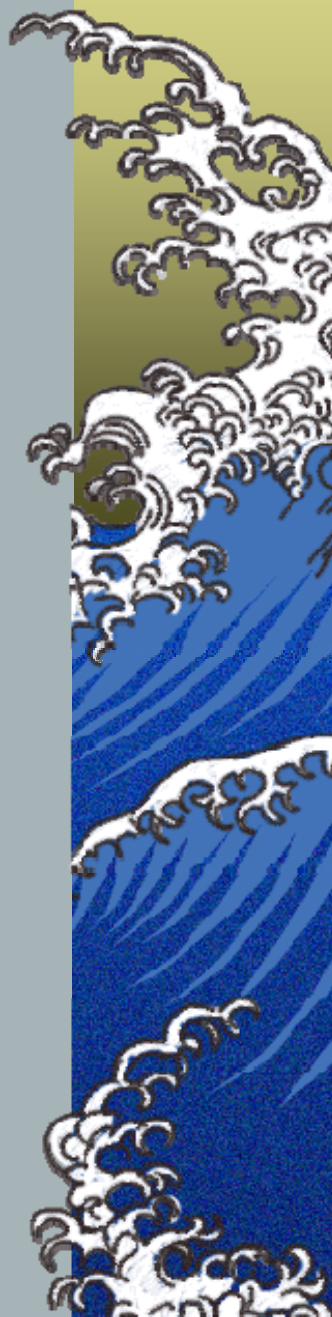
Quantification of uncertainty, results

Variability evaluated for consumption of all seafood harvested from King County using cooking weight loss of 0, 25% and 50%.

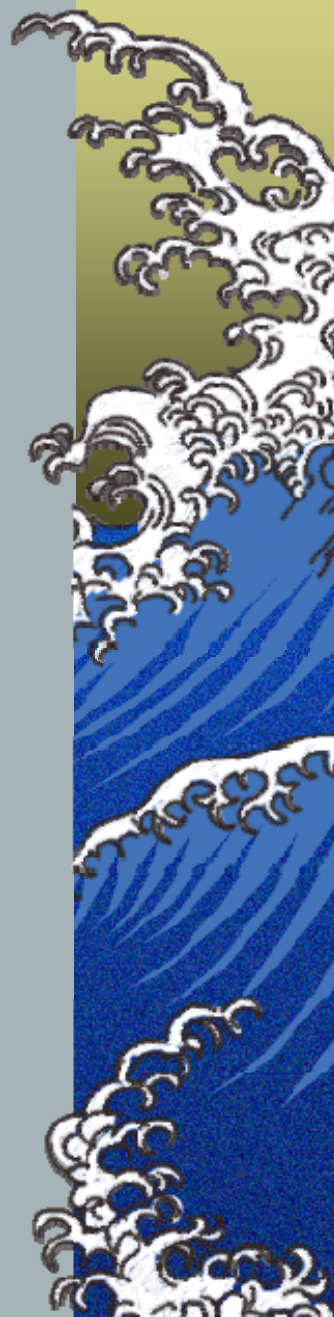
% Cooking Loss	Median				90th percentile				95th percentile			
	Est.	*SE*	*LCB*	*UCB*	*Est.*	*SE*	*LCB*	*UCB*	*Est.*	*SE*	*LCB*	*UCB*
0	5.7	0.9	3.8	7.4	22.2	6.9	17.4	48.3	48.4	11.7	21.8	72.0
25	5.7	1.1	3.9	8.1	24.3	11.2	20.1	53.1	53.1	13.8	24.2	78.9
50	5.8	1.5	4.3	9.2	26.7	13.5	22.6	61.2	61.1	15.0	26.7	84.1

Body weight

- API body weight evaluated using
  - averages w/o weighting
  - Weighting factors for consumption of all seafood harvested from King Co.
- Average body weight of 63 kg computed in both cases



Rationale & recommendations



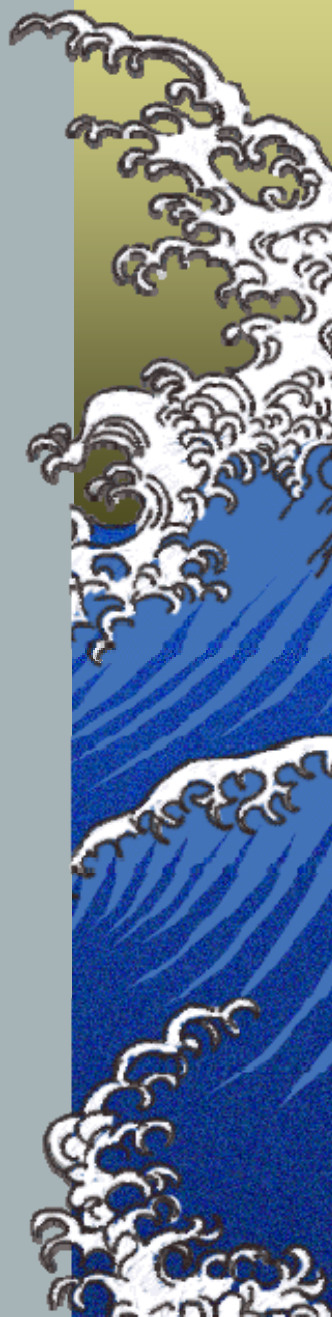
Proposed source fraction = King County harvested fraction

- King Co. larger than the area of application.
- **However:**
  - Pollutants and fish are mobile.
  - Individuals may obtain their fish from small regions.
  - Fish harvested in King Co. might be obtained in groceries or restaurants
  - Consumption of fish from King Co. lower due to resource contamination perceptions

Washington DOH Duwamish fish consumption warnings

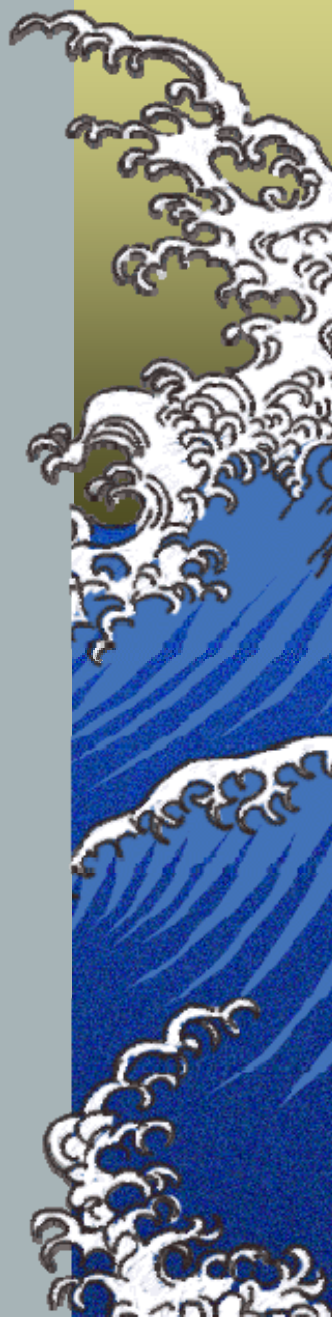
Rejected source-fraction options

- Total consumption rate:
  - Overly conservative
  - Fish from groceries & restaurants not likely affected by site-related contaminants
- Fraction harvested anywhere: Harvest area too large to all be affected by site contamination



Cooking weight loss uncertainty

- Believe 25% and 50% cooking loss correction factors are reasonable and supported by existing data.
- Average of the percentiles derived using these correction factors represents a plausible way to deal with cooking weight loss uncertainty.

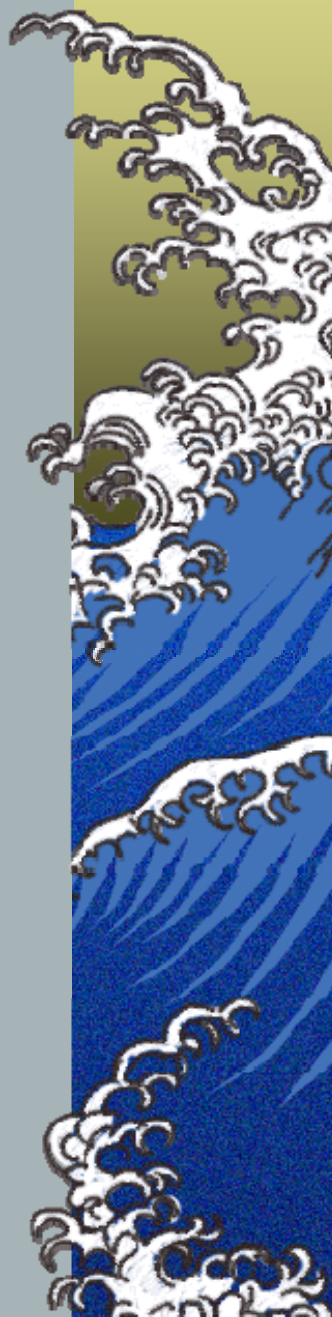


Recommended API consumption rates for risk analysis in g/day

Consumption Rate Category	Percentile		
	50	90	95
All species harvested from King County	5.8	25.5	57.1
Non-anadromous species harvested from King County	6.6	33.4	57.3
All species harvested anywhere	6.9	49.1	76.3
Non-anadromous species harvested anywhere	7.1	54.2	72.3
Total API fish consumption rate (regardless of source)	77.8	236.4	305.7

Recommendations

- Recommended fish ingestion rate for MTCA sites that contribute contamination to the Duwamish or Elliott Bay, is the average of the 95th percentile consumption rates for all King Co. harvested seafood based on cooking correction factors of 25 and 50%: 57 g/day.
- Recommended body weight: 63 kg.



MTCA SAB charge: Are the following recommendations within a range of scientific defensibility?

To protect the API population who may eat fish harvested from the Duwamish River and Elliott Bay, the MTCA surface water cleanup level equation for sites that contribute contaminants to these water bodies should be modified as follows:

1. Replace the MTCA fish consumption rate of 54 g/day and fish diet fraction of 0.5 (effective consumption rate of 27 g/day) with an effective fish consumption rate of 57 g/day (derived using the fraction of fish harvested from King County by APIs) and a fish diet fraction of 1.0.
2. Use an average body weight for the API population of 63 kg, derived from the Schena et al. 1999, study.