

# Mercury in Fish

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# *What You Need to Know About Mercury in Fish and Shellfish*

**2004 EPA / FDA Advice For:**

**Women Who Might Become Pregnant  
Women Who are Pregnant  
Nursing Mothers  
Young Children**

EPA and FDA. 2004. What you need to know about Mercury in Fish and Shellfish. March 2004. [www.cfsan.fda.gov/~dms/admehg3.html](http://www.cfsan.fda.gov/~dms/admehg3.html)

# Joint 2004 EPA-FDA Consumer Advisory for Mercury\*

- Advisory for pregnant women, nursing mothers and young children.
- Avoid eating swordfish, sharks, king mackerel and tilefish.
- Limit all fish consumption to 2 meals/week.
- Limit tuna\*\* consumption to 1 meal/week.

\*FDA and EPA. 2004. What you need to know about Mercury in Fish and Shellfish. March 2004. [www.cfsan.fda.gov/~dms/admehg3.html](http://www.cfsan.fda.gov/~dms/admehg3.html)

\*\*Refers to larger tuna and canned albacore.

# Is there consensus on mercury advisories?

- NO
- Agencies disagree on the safe Reference Dose (safe daily intake)
- The Reference Dose is the basis of advisories on fish consumption

# Wide range of guidance for safe tuna consumption.

FOR: Pregnant women

EPA/FDA	1	meal/week
WHO	2.3	meals/week
ATSDR*	3	meals/week
Seychelles Study**	12	meals/week

\*Agency for Toxic Substance and Disease Registry

\*\*Myers et al., 2003. Prenatal methyl mercury exposure from fish consumption in the Seychelles child development study. Lancet 361: 1686-1692.

# Guidance for safe yellowfin tuna consumption for pregnant women.

<u>Country</u>	<u>Ave Seafood Consump.</u>	<u>Advice</u>
USA	16 lb/person/year	1 meal/wk*
Hawaii	41 lb/per/year	1 meal/2wk**
Japan	154 lb/person/year	no limit***

\*2004 US EPA/FDA Advisory

\*\* 2003 Hawaii Dept of Health Advisory

\*\*2005 Japan MHLW Advisory (bottlenose dolphin 1 meal every 2 months; pilot whale 1 meal every 2 weeks; sperm whale 1 meal per week; no restriction on Minke or other baleen whales)

# What might be good to know about the Mercury Advisory?

- Advisory contains a 1,000% Safety Factor
- The consumption guidance is not the "*brightline*" between safe and toxic dietary exposure.
- Advisory (Reference Dose) was not based on dietary exposure to mercury in fish.





# Toxicological Effects of Methylmercury

*"Methylmercury (MeHg), one organic form of Hg, can accumulate up the food chain in aquatic systems and lead to high concentrations of MeHg in predatory fish<sup>1</sup>. . . ." National Research Council, 2000*

<sup>1</sup>In this report, the term "fish" includes shellfish and marine mammals, such as pilot whales, that are consumed by certain populations.



# Key Poisoning Events\* & Studies\*\*

- \*Minamata, Japan      Hg polluted fish/shellfish
- \*Iraq                      Hg treated wheat seed
- \*\*Faroe Islands              pilot whale
- \*\*New Zealand              shark ("fish & chips")
- \*\*Seychelles Is.              variety of ocean fish

# Have mercury poisoning outbreaks ever happened from eating Open Ocean Fish?

- NO
- There has never been an outbreak of mercury poisoning from eating pelagic fish, including tuna, swordfish and others.

# Has mercury poisoning ever happened from eating other types of fish?

- YES. Severe mercury poisoning occurred in *Minamata and Niigata, Japan* in the 1950's and 1960's.
- Fish were contaminated by Hg from chemical factory wastes (5.6 - 35.7 ppm)
- Case of severe, uncontrolled industrial pollution, not natural sources.

# Other evidence about mercury effects from "fish"?

- *Faroe Islands Study*\*: women & children exposed to mercury from "fish"
- Study found subtle learning defects in children correlated with umbilical cord blood mercury level.
- Basis of reference dose. Most advisories use this study to limit fish consumption.

\*NRC. 2000. Toxicological effects of methylmercury. National Academy Press.



# Pilot Whales are not Fish!

- Problem with *Faroe Islands Study*\*
- Women ate cod and haddock (very low 0.05 ppm MeHg)
- Some women ate large amounts of pilot whale during pregnancy
- Pilot whale meat has high levels of MeHg (2-3 ppm) and cadmium.
- Pilot whale blubber has high levels of PCB's.

\*Steuerwald et al., 2000. Maternal seafood diet, methyl mercury exposure and neonatal neurological function. J Pediatrics 136:599-605.

# Faroese Health Advisory

- Based on the study findings, the Faroe Islands Health authorities advise...
- Adults: no more than 1 meal of pilot whale per month
- Women: avoid eating pilot whale meat during pregnancy
- No restriction on eating fish

# Is there evidence about the safety of open ocean fish?

- *Seychelle Islands Study*\*
- Fish consumption very high (12 meals/wk).
- Fish include skipjack, yellowfin, wahoo, jacks and barracuda (ave Hg = 0.3 ppm)
- No whale meat in diet.
- No evidence of negative health effects in children tested up to age 9.

\*Myers et al., 2003. Prenatal methyl mercury exposure from fish consumption in the Seychelles child development study. Lancet 361: 1686-1692.

# 2007 ALSPAC\* Study UK

- Life style study, including diet
- Largest study to date on fish consumption
- Over 8,000 women and children pairs
- Children's test scores increased with increasing fish consumption by mothers (omega-3 fatty acids)
- Regardless of dietary mercury.
- **EATING FISH IS GOOD FOR BABY!**

\*Avon Longitudinal Study of Parents and Children (Hibbeln, et al., 2007 Lancet)



# Avoiding Fish Caused Harm!

- ALSPAC Study\* in UK 2007.
- Children born to women that ate 2 fish meals or less per week (EPA/FDA guidance) were more likely to be in lowest 25% of cohort group for verbal IQ and other developmental scores.
- Health educators and physicians need to consider these results...and "do no harm"

\*Avon Longitudinal Study of Parents and Children (Hibbeln, et al., 2007 Lancet)

# FDA Risk Benefit Assessment

- Health risk and benefits of fish consumption are being assessed by FDA
- FDA Draft Report concludes that eating at least 2 meals of fish per week provides health benefits
- Watch for final report and outcome.
- Possible re-evaluation of EPA/FDA Guidance for fish consumption.

# The real danger to babies

- Mercury advisories may scare women to avoid eating fish and place babies at risk.
- Depriving babies of healthy fish oils can adversely affect brain and vascular development.

# Conclusions

- "Dose makes the Poison"
- Mercury is toxic at high levels.
- A growing body of evidence indicates it is not toxic at low levels found in open ocean fish.



# Conclusions

- The type of food containing mercury impacts the toxicity
- "Whales are not fish"

# What is the difference between OCEAN FISH and PILOT WHALE?



# Selenium protects against mercury

Mercury poisoning has not occurred with foods with more selenium than mercury.

Mercury is the only substance known that can sequester selenium in brain tissue.

The molar ratio of mercury and selenium is superior risk factor over mercury alone.

# Selenium

- Selenium was first known as a toxin.
- Essential antioxidant function was discovered in 1957.
- Considered an essential trace mineral.
- Daily Value for adults 55 mcg/day
- Tolerable Upper Limit is 400 mcg/day



# Selenium in Ocean Fish

17 of the top 25 food sources of selenium in the American diet are seafood (USDA 2009. Natl. Nutrient Database for Standard Reference).

<u>Hawaii Fish</u>	<u>Mean Selenium</u>
Yellowfin tuna	125 mcg/100g
Bigeye tuna	99 mcg/100g
Albacore tuna	88 mcg/100g
Swordfish	39 mcg/100g

Source: Kaneko and Ralston 2007. Selenium and Mercury in Pelagic Fish in the Central North Pacific near Hawaii. Biol Trace Elem Res 119:242-254.

# Selenium Health Benefits

- Essential antioxidant effects (ex. glutathione peroxidase)
- Anti-cancer effects (ex. prostate)
- Promotes immune system function
- Metal detoxification (ex. mercury)

# Mercury Toxic Effects

- Mercury toxicity impairs selenoenzyme activities in brain leading to oxidative damage.
- Brain selenoenzyme activities are normally unstoppable (Se is conserved).
- Fetal brain is very sensitive to maternal MeHg exposure.

# Selenium's protective effects

- Yellowfin tuna was first shown to protect against mercury toxicity in 1972\*.
- Se has been shown to protect against mercury toxicity in all species studied. No similar studies on humans.
- Se to Hg molar ratios may explain why ocean fish have not caused mercury poisoning and why subtle effects were seen when pilot whale meat was eaten during pregnancy.

\*Source: Ganther et al., 1972 Selenium: relation to decreased toxicity of methylmercury added to diets containing tuna. *Science* 175: 1122.

# Selenium Mercury Interactions

- Hg - Sulfur binding affinity is very strong (stab. coef.  $10^{39}$ ). Hg binds to sulfur containing amino acids in protein.
- Hg - Se binding affinity is a million times stronger (stab. coef.  $10^{45}$ ). Hg and Se form mercury selenide (inert).

# Mechanism of Mercury Toxic Effects

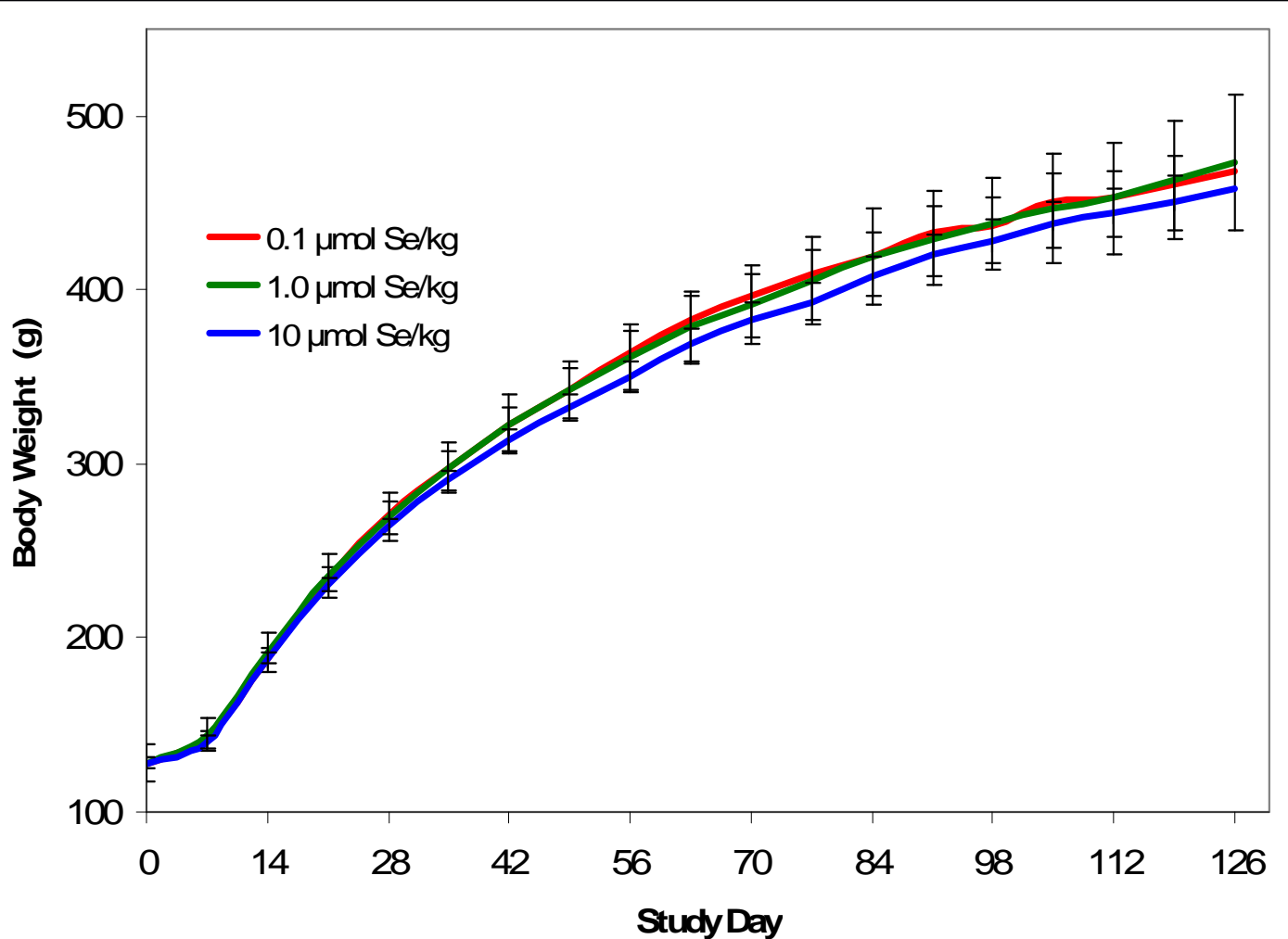
- Old thinking: Mercury is toxic by itself.
- New thinking: Mercury sequesters Selenium, leading to Se deficiency.
- Proposed Mechanism of Mercury Toxicity:  
Loss of selenium-dependent enzyme action due to mercury-dependent selenium sequestration.

# Recent Studies on Se-Hg Interactions in Mice

- Drs Nick Ralston, L Raymond and L Blackwell, Energy and Environmental Research Center, U North Dakota
- Studying Health Effects of Metals
- Controlled Diet Studies to evaluate Health Effects of Mercury in relationship to Selenium status.
- Results: Have re-confirmed protective effects and found therapeutic effects of Se on Hg toxicity.



# EFFECTS OF DIETARY SELENIUM ON GROWTH



Low,  
Normal and  
Rich Se  
diets.

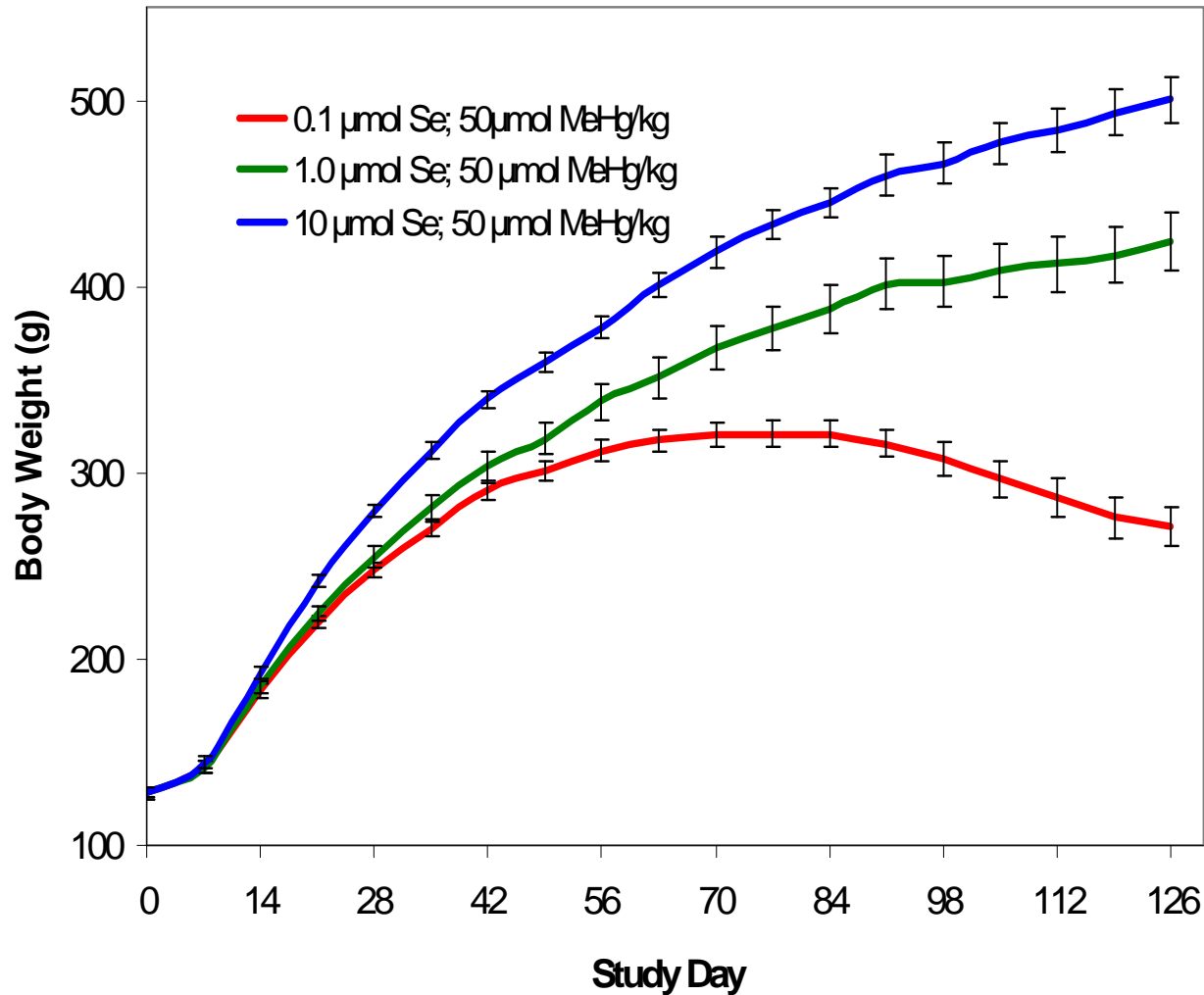
No  
difference  
in growth  
rates

Ralston, NVC, JL Blackwell and LJ Raymond, 2007. Dietary selenium protects against mercury toxicity in rats. *Biological Trace Element Research* 119 (3): 228 -241

# MeHg-Se Molar Ratios in the rat diets

- Each diet contained 10 ppm MeHg (50  $\mu$ moles/kg)
- Low Se diet: MeHg to Se Molar Ratio..... 500:1
- Normal Se diet: MeHg to Se Molar Ratio... 50:1
- Rich Se diet: MeHg to Se Molar Ratio..... 5:1

# SELENIUM'S PROTECTIVE EFFECT AGAINST MERCURY (10 ppm)



5:1 MeHg-Se:  
normal growth

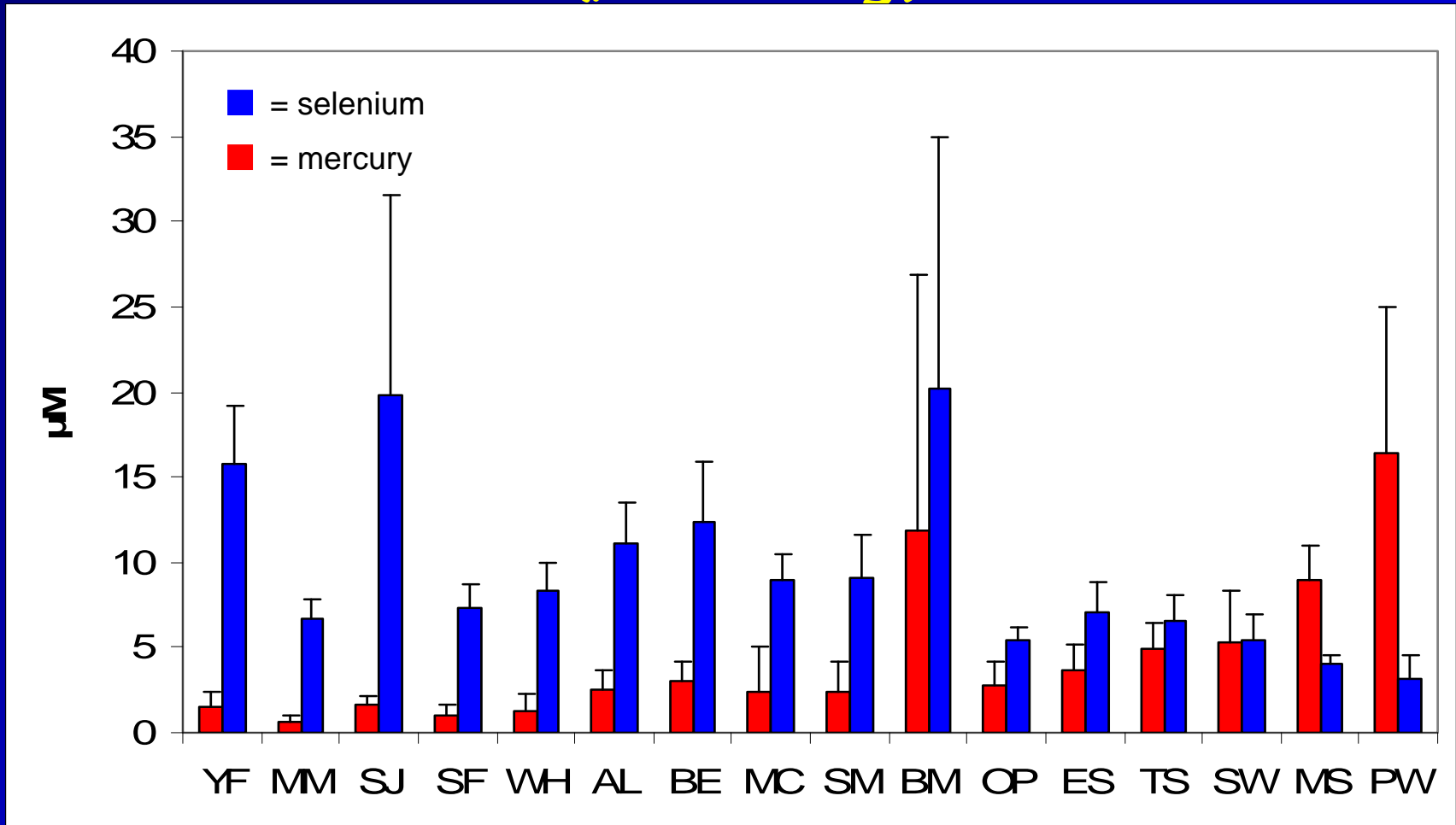
50:1 MeHg-Se:  
decreased growth, no motor defects

500:1 MeHg:  
greatly decreased growth, severe motor defects, mortalities

# Risk Assessment of Dietary Mercury

- Selenium to Mercury Molar Ratios key to risk assessment.
- Current method of only considering Mercury concentration is incomplete and inadequate.
- Se Health Benefit Value (SeHBV) has been proposed as the seafood safety measure.

# Mercury and Selenium in Hawaii Fish ( $\mu\text{mole}/\text{kg}$ )



YF=Yellowfin; MM=Mahimahi; SJ=Skipjack; SF=Spearfish; WH=Wahoo; AL=Albacore; BE=Bigeye; MC=Monchong; SM=Striped Marlin; BM=Blue Marlin; OP=Opah; ES=Escolar; TS=Thresher shark; SW=Swordfish; MS=Mako Shark; PW=Pilot whale

Kaneko, JJ and NVC Ralston 2007. Selenium and Mercury in Pelagic Fish in the Central North Pacific Ocean near Hawaii. Biological Trace Element Research 119 (3): 242-254. (NOAA Award No. NA05NMF4521112)

# Choose wisely

Hawaii Bigeye Tuna  
Sashimi YES!



Toothed Whale  
Meat NO!



Photos: John Kaneko