

# 2009 Working Se TMDL Documents

## Proposed Numeric Targets



Regional Water Quality Control  
Board – Santa Ana Region

Workshop 2  
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# Purpose

- Provide a brief overview of the proposed numeric targets
- Provide information on how the fish tissue numeric target was selected
- Provide information on how the bird egg tissue numeric target was selected

# Proposed Numeric Targets

Primary, tissue-based numeric targets based on:

- Proposed Se SSOs:
  - Fish tissue: 5  $\mu\text{g}$  Se/g dry weight (as whole body fish tissue composites)
  - Bird egg tissue: 8  $\mu\text{g}$  Se/g dry weight (in individual bird eggs)

Proposed secondary, water column-based numeric target based on:

- California Toxics Rule (CTR) criterion for selenium in freshwater (currently, the legally applicable water quality objective): 5  $\mu\text{g}/\text{L}$  total recoverable Se

# Proposed Numeric Targets

Primary Tissue Targets ( $\mu\text{g/g}$ dry weight)		Secondary Water Column Target ( $\mu\text{g/L}$ )
Fish Tissue	Bird Egg Tissue	Freshwater
5	8	5

- ❖ *Upon USEPA approval of the tissue-based SSOs for selenium, the CTR-based secondary target will become ineffective and the primary, tissue-based targets will become the final numeric TMDL targets*

# Proposed Fish Tissue Target

- Background Se concentrations (no effects level concentrations) in whole-body fish range from <math><1-4 \mu\text{g/g dw}</math> (typically <math><2 \mu\text{g/g dw}</math>)
- Se concentrations associated with minimal effects are slightly higher (<math>4-6 \mu\text{g/g dw}</math>)
- In 1998 the USDOL's selenium guidelines identified a toxicity threshold range of <math>4-6 \mu\text{g/g Se dw}</math> in whole body fish
- In 2005, USFWS staff concluded that an appropriate toxicity threshold range for freshwater fish was <math>4-5 \mu\text{g/g dw}</math> (also as whole body fish)



### Threshold Values for Selenium Effects in Fish Based on Selenium Concentrations in Whole-Body Fish Tissue

Tissue Concentration (µg/g, dw)	Location	Effect/Threshold	Reference(s)
<1-4 (whole-body) (typically <2)	Synthesis <sup>1</sup>	Background	USDOJ, 1998
4-12 (whole-body)	Synthesis	Range of concern; toxicological and reproductive effects a certainty if upper limit exceeded/whole-body	Engberg et al., 1998
4 (whole-body)	Synthesis	Maximum allowable concentration (protective of reproduction)	Lemly, 2002
5-7 (whole body)	Synthesis	Diagnostic residues for reproductive impairment (deformity or mortality of larvae/fry); applies to centrarchids, fathead minnows, salmonids, percichthyids	Lemly, 1998
4-8 (whole-body)	Synthesis	Reproductive impairment (10% effect level) in sensitive species (perch, bluegill, salmon)	USDOJ, 1998; Presser et al., 2004
4-6.5 (whole-body)	Lab and synthesis	Growth and survival (swim-up Chinook salmon larvae)	Hamilton et al., 1990; Hamilton 2002, 2003
3.6-8.7 (whole-body)	Field	Survival (razorback sucker larvae)	Hamilton et al., 1996, 2005a, b; Hamilton, 2002, 2004
3.96-4.98 (whole body)	Field and lab	Reproductive impairment (deformities) in Northern Pike embryos (1% effect concentration or EC <sub>01</sub> ) as calculated from egg and muscle selenium concentrations	Muscateleo et al., 2006
5.85 (whole-body)	Lab	40% overwinter mortality in juvenile bluegill (winter stress)	Lemly, 1993a
8 cold-water (whole-body) 9 warm-water (whole-body)	Synthesis	Recommended toxicity guidelines (10% effect level)	DeForest et al., 1999
7.91 (whole-body) 5.85 (whole-body)	Synthesis	Draft criterion, winter stress conditions; a concentration of 5.85 µg/g dw measured in the summer or fall would trigger repeated monitoring in the winter	USEPA, 2004

<sup>1</sup> Threshold value is based on the review/integration (synthesis) of results from several field and/or laboratory studies.

# Proposed Fish Tissue Target

- Muscatello et al. (2006) calculated two statistically rigorous estimates of a 1% effect concentration ( $EC_{01}$ ) for selenium in northern pike (*Esox lucius*):
  - 3.96  $\mu\text{g Se/g dw}$  and 4.98  $\mu\text{g Se/g dw}$
  - Estimated range is similar to other estimates of toxicity thresholds in freshwater fish (USDOI/USFWS)
  - The upper end of this range (5  $\mu\text{g Se/g dw}$ ) was judged by USFWS staff as an appropriately protective level for fish species in the Newport Bay watershed
- ❖ Also expected to be a fully protective dietary concentration for birds in the watershed
  - In mallards (a species sensitive to Se) 5  $\mu\text{g Se/g dw}$  would range from a 10-25% effects level ( $EC_{10-25}$ ) for egg hatchability

# Proposed Fish Tissue Target

To summarize:

- Single concentration ( $5 \mu\text{g Se/g dw}$ ) applicable to all fish species (fresh or saltwater)
  - Applied to whole body fish tissue composite samples
- Low- to no-effect concentration protective of fish reproduction
- Also protective as a dietary concentration for birds that eat fish



# Proposed Bird Egg Tissue Target

- Selenium concentrations in eggs are most useful for evaluating potential reproductive impairment
- Reduced hatching success is considered the most sensitive, reliable endpoint for effects



# Proposed Bird Egg Tissue Target

- Mean background selenium concentrations (no effects level concentrations) in bird eggs are generally at concentrations  $<3 \mu\text{g Se/g dw}$  (typically  $1.5\text{-}2.5 \mu\text{g Se/g dw}$ , with individual eggs  $<5 \mu\text{g Se/g dw}$ ).
- Effects levels range from  $6\text{-}7 \mu\text{g Se/g dw}$  to  $14 \mu\text{g Se/g dw}$  (reduced hatchability in black-necked stilts)

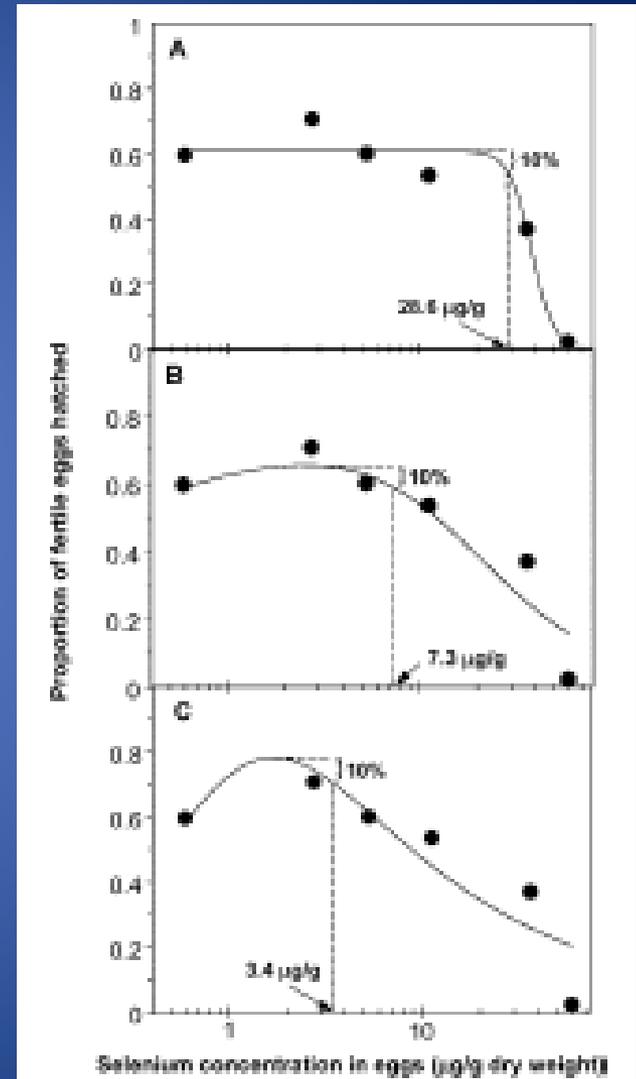


## Threshold Values for Reproductive Effects in Birds from Selenium Based on Se Concentrations in Bird Eggs

Level/Status	Concentration (µg/g, dw)	Effects	Comments	References
Background	Mean < 3.0 (typically 1.5-2.5); individual eggs <5	None	Concentrations may be higher in marine birds	Ohlendorf and Harrison, 1986; Skorupa and Ohlendorf, 1991; USDOl, 1995; Eisler, 2000
Adequate	0.66-5.0 (0.20-1.5 ww)	Nutritional needs are met for poultry	Lower dietary concentrations are marginal or deficient, and diets must be fortified	Puls, 1988
High	5.0-16 (1.5-5.0 ww)	Levels are excessive and upper end of range may be toxic to poultry	Poultry are relatively sensitive to effects of selenium	Puls, 1988
Toxic	>8.2 (>2.5 ww)	Reduced egg hatchability and teratogenic effects in embryos/chicks	Poultry are relatively sensitive to effects of selenium	Puls, 1988
Reproductive impairment	6-7 (about 1.8-2.1 ww)	EC <sub>10</sub> on a clutch-wise (or hen-wise) basis and EC <sub>10</sub> on egg-wise basis	Based on results of extensive field studies of black-necked stilts	Skorupa, 1996, 1999
Reproductive impairment	3.4-7.7	EC <sub>10</sub> for reduced egg hatchability (Brain-Cousens model [3.4 µg/g] and log-logistic <sup>2</sup> model [7.7 µg/g])	Based on results of one laboratory study with mallards, assuming hormetic effects	Beckon et al., 2008
Reproductive impairment	9.0	EC <sub>0.2</sub> for impaired clutch viability	Based on results of one laboratory study with mallards, using linear regression analysis	Lam et al., 2005
Reproductive impairment	12 (95% CI = 9.7-14)	EC <sub>10</sub> for reduced egg hatchability	Based on results of six laboratory studies with mallards, using hockey stick analysis	Adams (pers. comm.; see Ohlendorf 2007)
Reproductive impairment	12 (95% CI = 6.4-16)	EC <sub>10</sub> for reduced egg hatchability	Based on results of six laboratory studies with mallards, using logistic regression analysis	Ohlendorf, 2003
Reproductive impairment	14	EC <sub>10.3</sub> for reduced egg hatchability	Based on results of extensive field studies of black-necked stilts	Lam et al., 2005

# Proposed Bird Egg Tissue Target

- Mallards are more sensitive to the reproductive effects of selenium than shorebirds (e.g., black-necked stilts and American avocets)
  - Beckon et al. (2008) calculated a potential 10% effect concentration ( $EC_{10}$ ) range for selenium in mallards of  $3.4 \mu\text{g/g dw}$  to  $7.7 \mu\text{g/g dw}$



# Proposed Bird Egg Tissue Target

- The range of plausible  $EC_{10}$ s overlaps the true no effects concentration (NEC) for many data sets
  - USFWS staff judged the upper end of the range identified by Beckon (7.7 or 8  $\mu\text{g/g dw}$ ) as sufficiently protective of the bird species that live or forage in the Newport Bay watershed



❖ *USFWS judged it protective of T&E species as well*



# Proposed Bird Egg Tissue Target

- Studies of the endangered California clapper rail (a close relative of the endangered light-footed clapper rail) found no direct effect on reproduction at concentrations averaging as high as  $7.4 \mu\text{g Se/g dw}$  in eggs
- California least tern is a piscivorous bird, which may be less sensitive to selenium than mallards or shorebirds



# Proposed Bird Egg Tissue Target

To summarize:

- The proposed numeric target of 8 ug/g Se dw in bird egg tissue is a no- to low-effect concentration
- Is applicable to all bird species (including resident and migratory birds) that live or forage in the Newport Bay watershed
  - Including threatened and endangered species
- Would be applied to individual bird eggs



