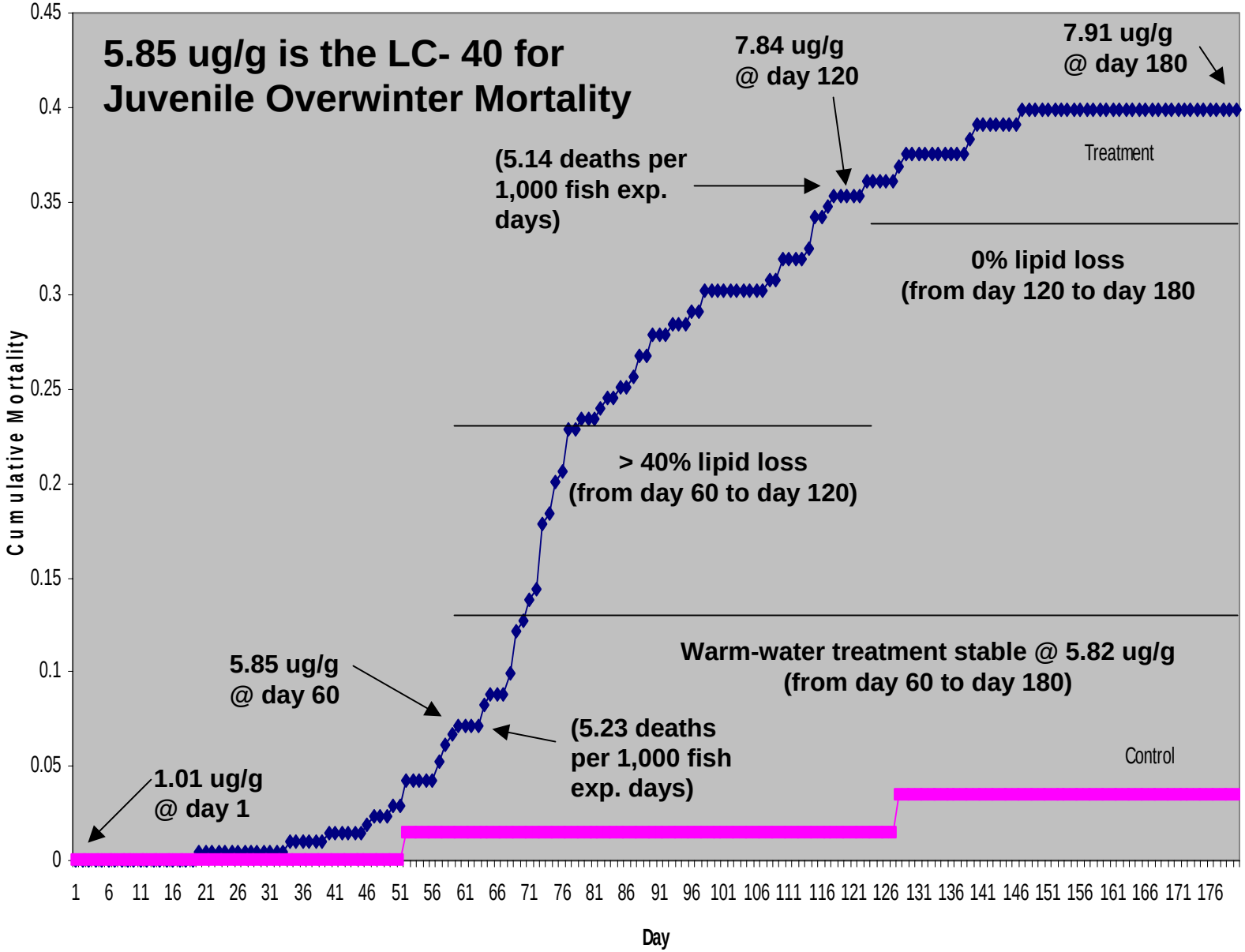
LEMLY RAW DATA

Cold + Se Treatment Day	Fish at Start	Fish at End	Fish Exposure Days	Dead Fish	Dsurv	Cmort
50	205	204	204.5	1	0.995122	0.028572
51	204	204	204	0	1	0.028572
52	204	201	202.5	3	0.985294	0.042858
53	201	201	201	0	1	0.042858
54	201	201	201	0	1	0.042858
55	201	201	201	0	1	0.042858
56	201	201	201	0	1	0.042858
57	201	199	200	2	0.99005	0.052381
58	199	197	198	2	0.98995	0.061905
59	197	196	196.5	1	0.994924	0.066667
60	196	195	195.5	1	0.994898	0.071429
Whole-body Se = 5.85 ug/g			**30 fish removed**			
61	165	165	165	0	1	0.071429
62	165	165	165	0	1	0.071429
63	165	165	165	0	1	0.071429
64	165	163	164	2	0.987879	0.082684
65	163	162	162.5	1	0.993865	0.088312
66	162	162	162	0	1	0.088312
67	162	162	162	0	1	0.088312
68	162	160	161	2	0.987654	0.099567
69	160	156	158	4	0.975	0.122078
70	156	155	155.5	1	0.99359	0.127706
			3825	**20**		
			5.23 mortalities per	**1,000 Exp.**	**Days**	

Lemly winter-stress results

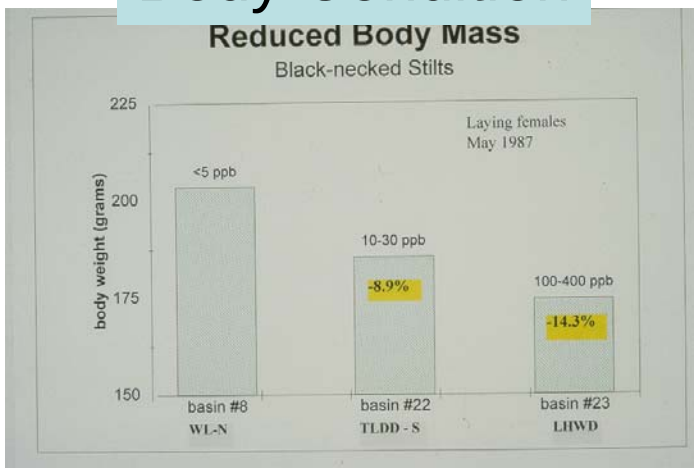


Endpoints [2]

- Habitat Value…
- … measured via classic Darwinian fitness
- (A) Survival & Growth
- (B) Reproduction

Adult Fitness Endpoints

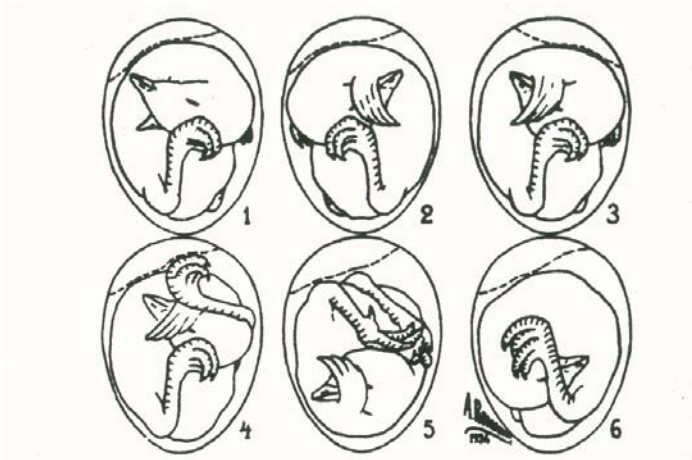
Body Condition

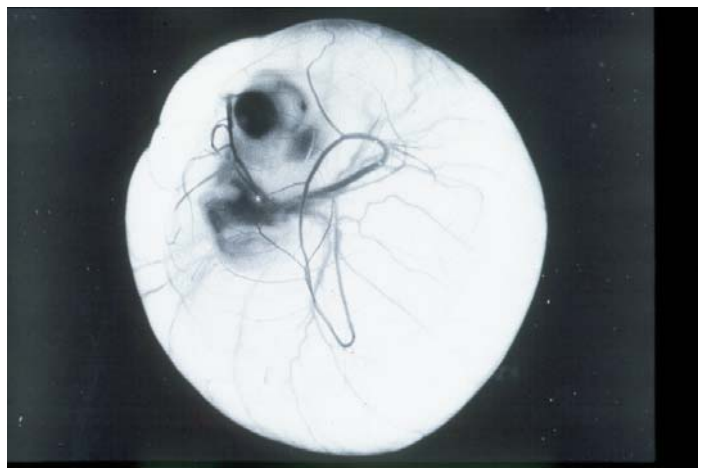


Feather Loss

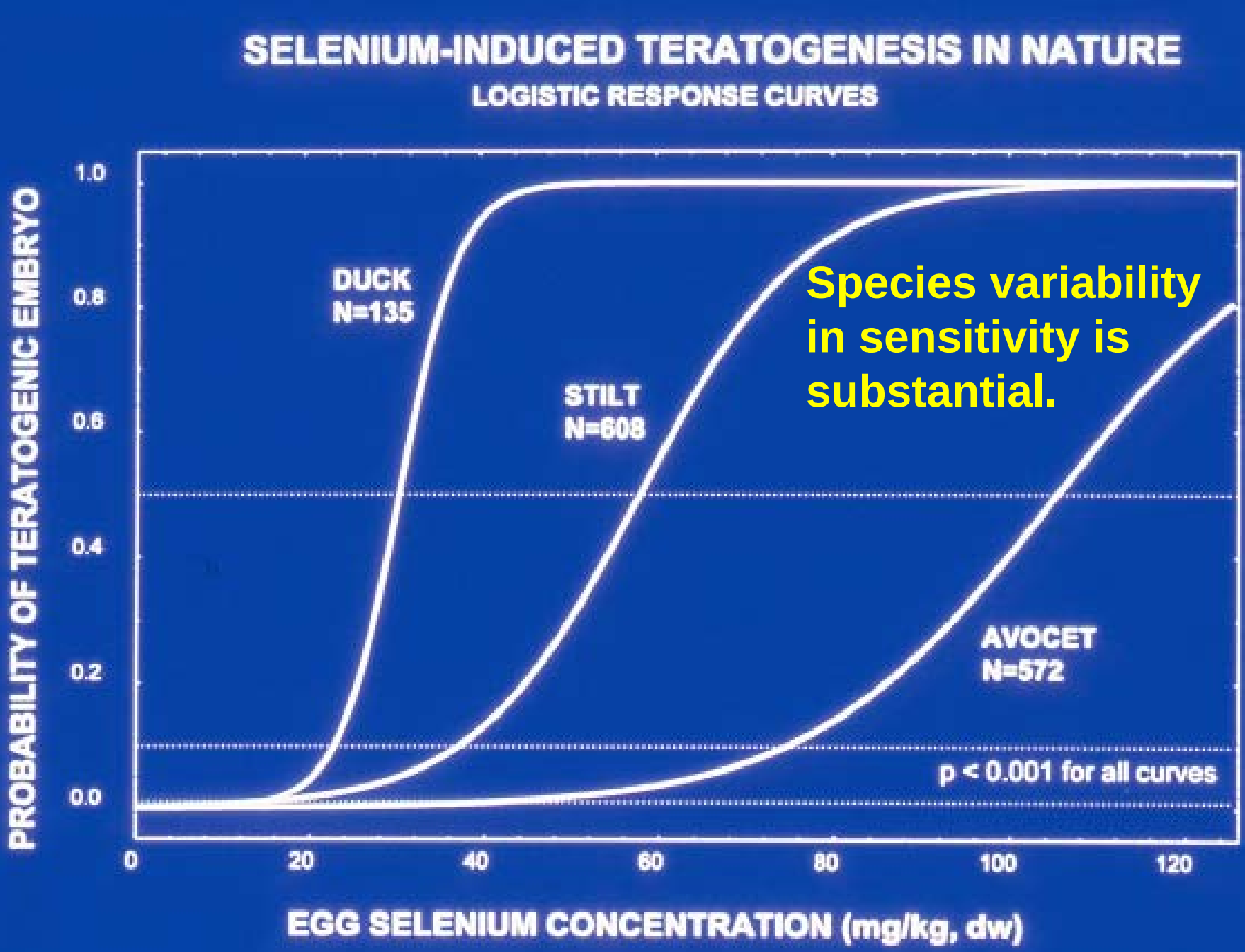
Gross Morphology

Embryotoxicity – Hatchability [1]

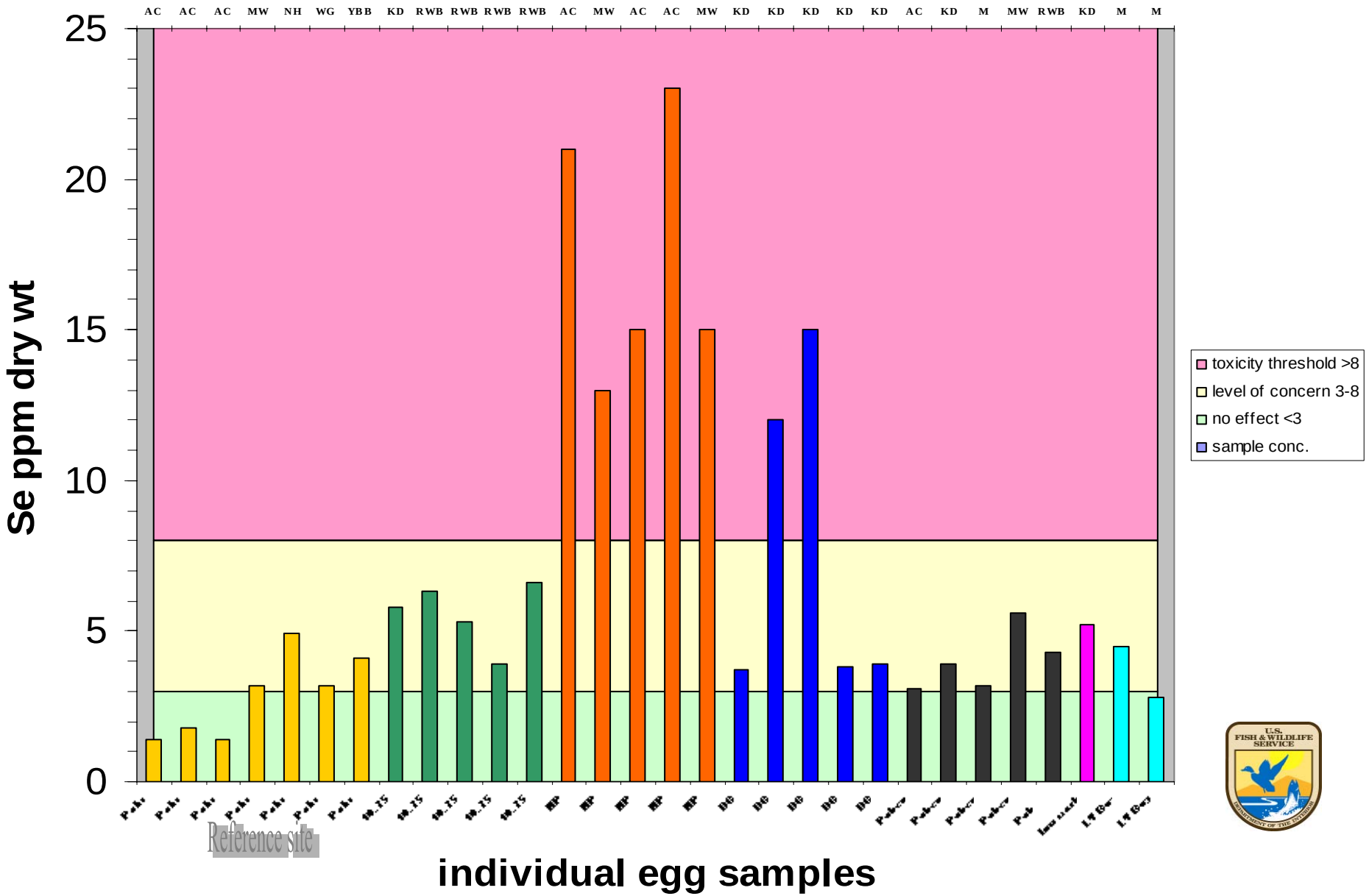




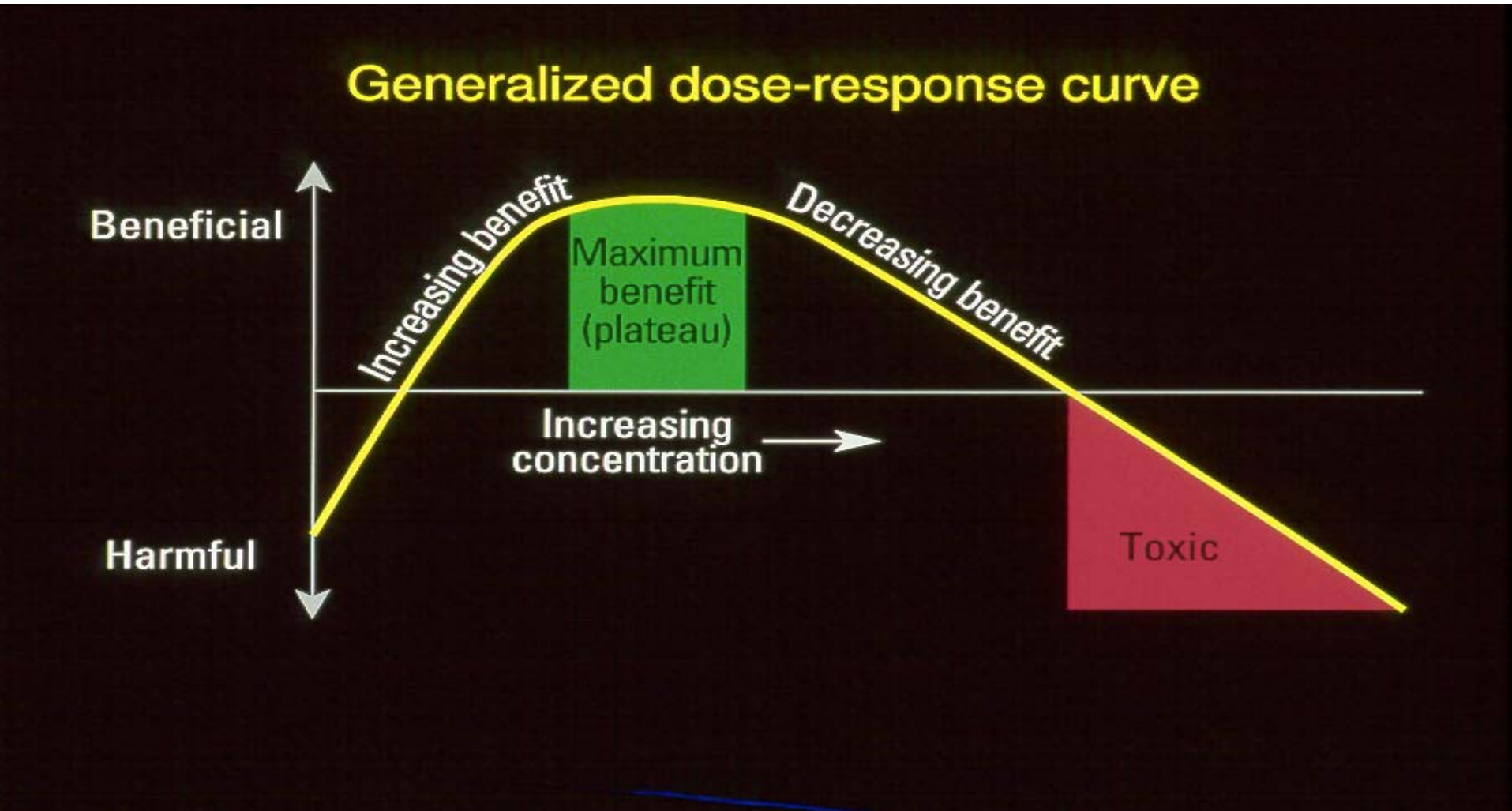
Embryotoxicity – Terata [1]


SELENIUM-INDUCED TERATOGENESIS IN NATURE
LOGISTIC RESPONSE CURVES
PROBABILITY OF TERATOGENIC EMBRYO
1.0
0.8
0.6
0.4
0.2
0.0
DUCK
N=135
STILT
N=608
AVOCET
N=572
Species variability in sensitivity is substantial.
p < 0.001 for all curves
0
20
40
60
80
100
120
EGG SELENIUM CONCENTRATION (mg/kg, dw)

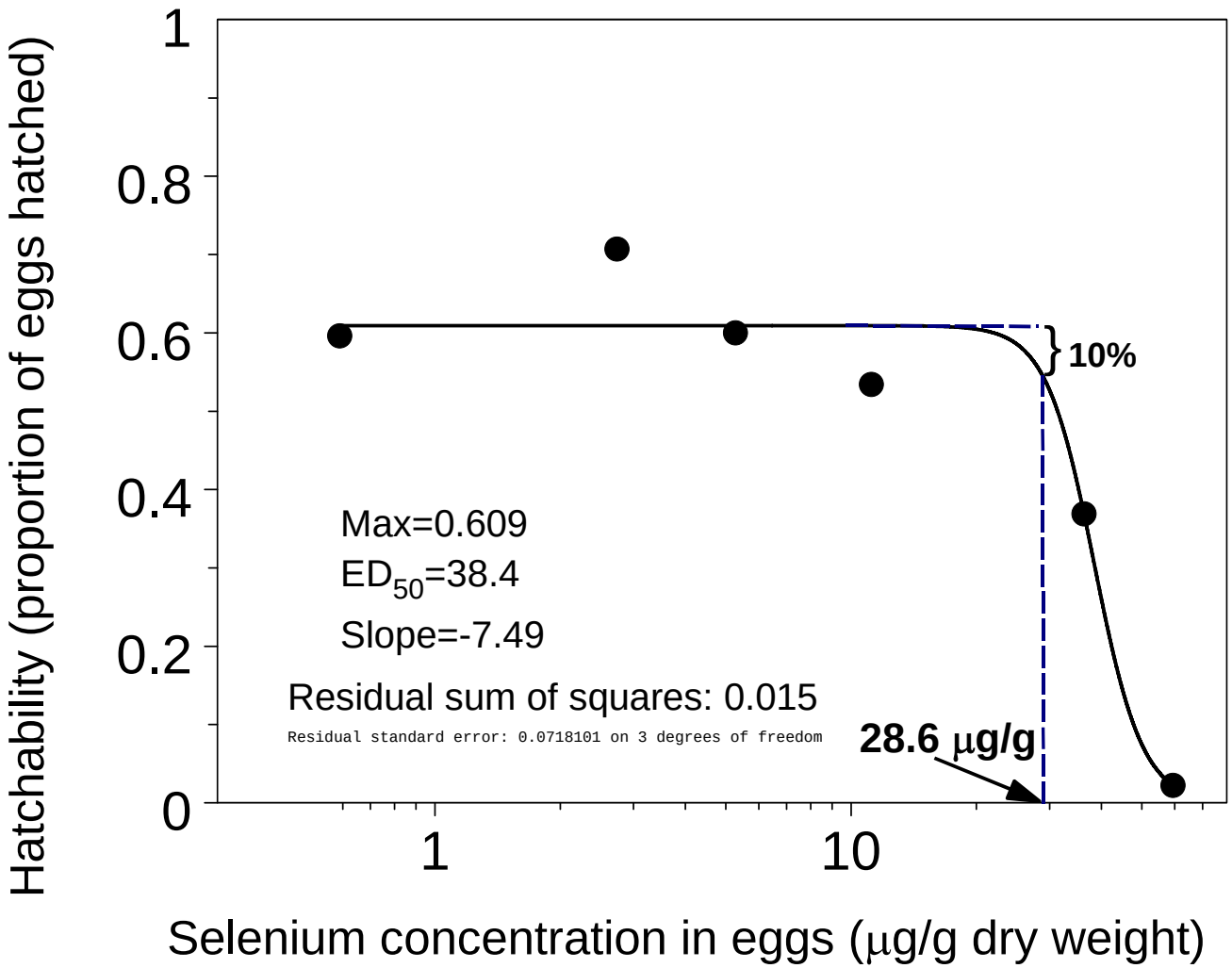
2003 Wash Bioassessment - Se in Bird Eggs ppm dw



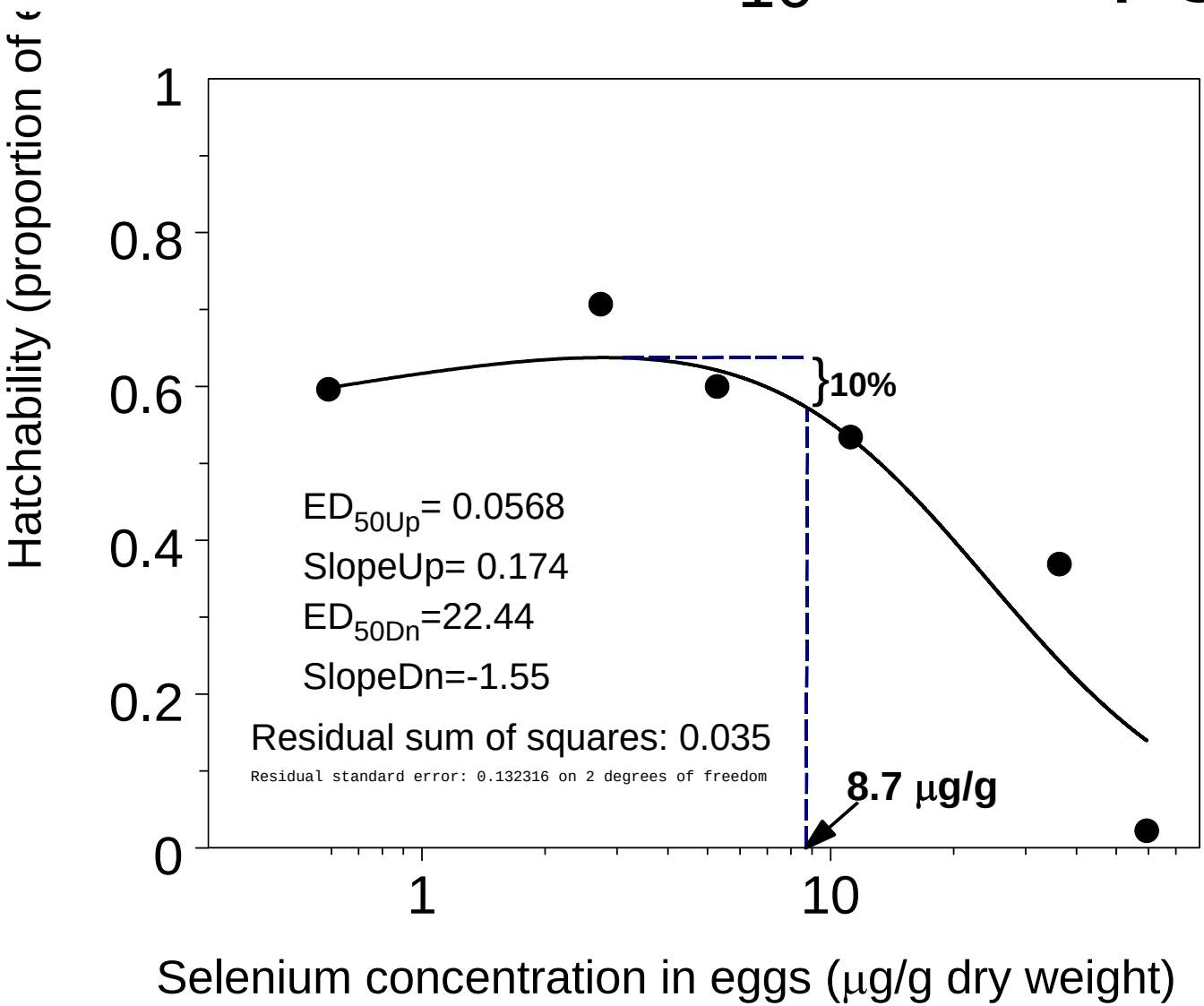
- **SELENIUM IS HORMETIC**
- **THE BENEFICIAL RANGE IS VERY NARROW**



Logistic: EC_{10} = 28.6 µg/g



Beckon *et al*.: EC_{10} = 8.7 µg/g

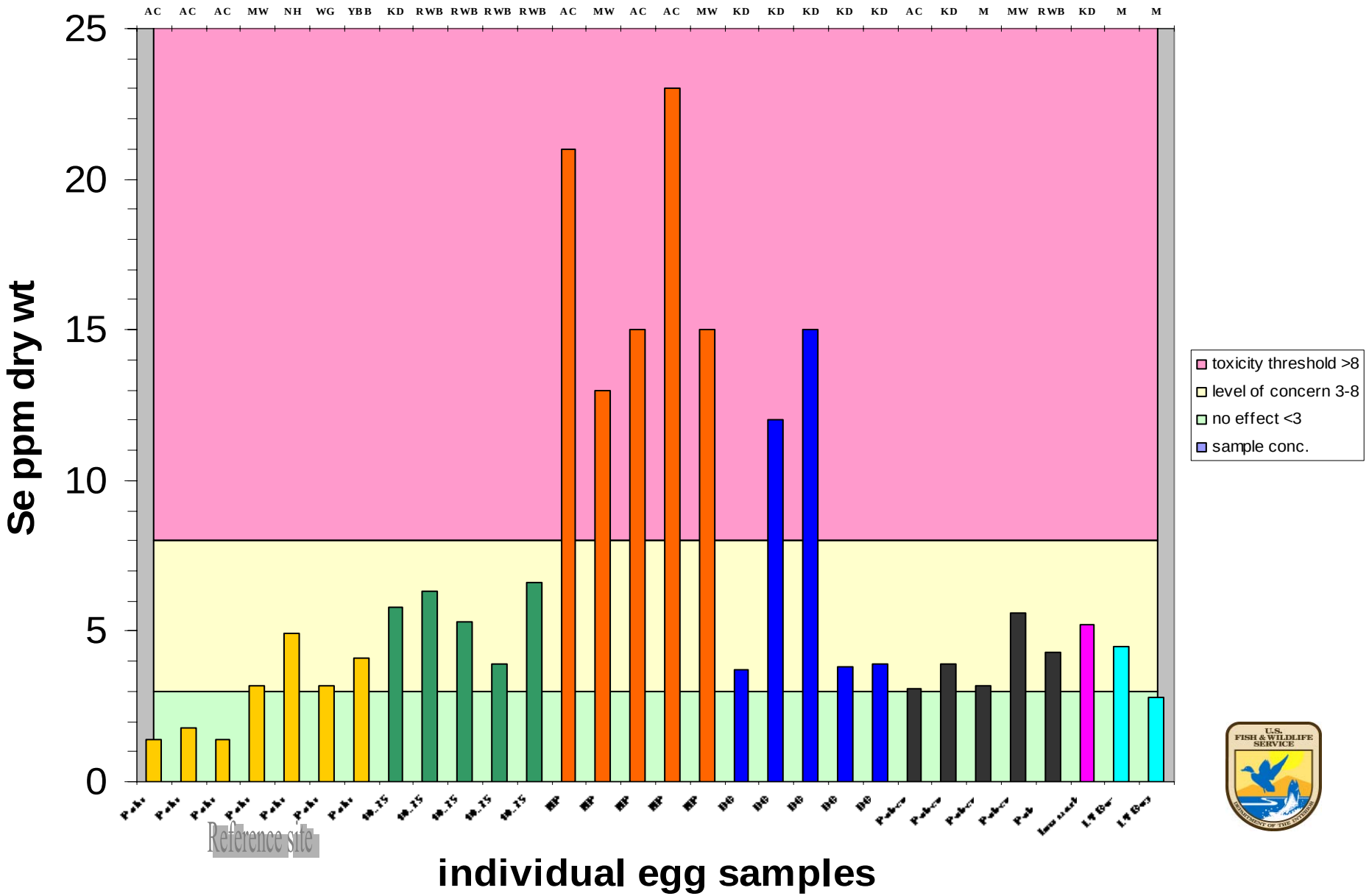


Hatchability of Eggs in Controlled Experiments with Captive Mallards

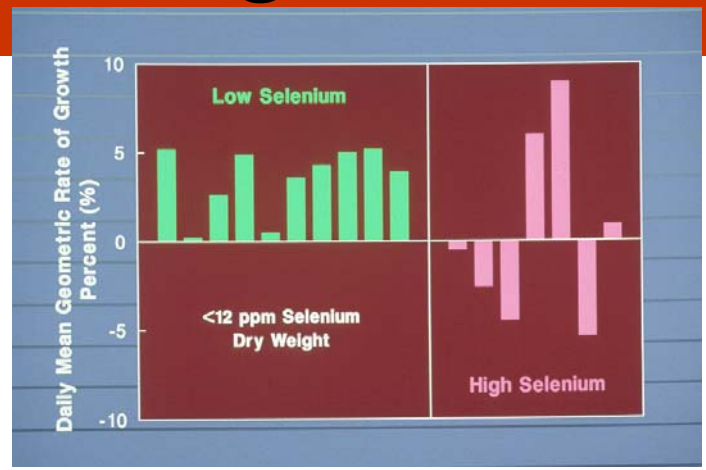
- **EC_{10} = 12.5 ug/g**
- **EC_{01} = 5.7 ug/g**

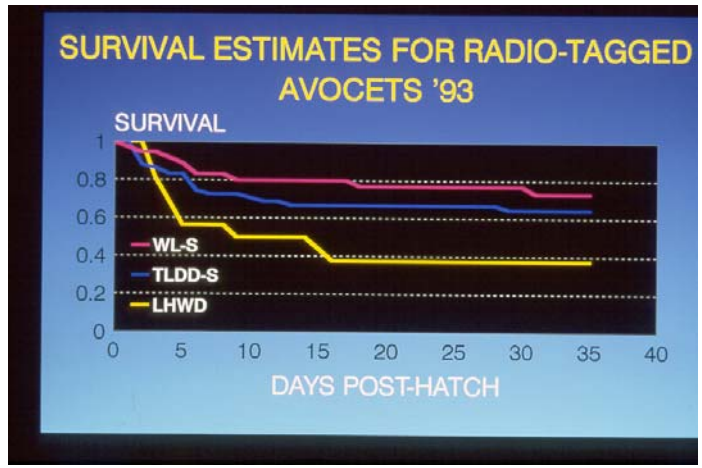
Ohlendorf (2003)

2003 Wash Bioassessment - Se in Bird Eggs ppm dw



Post-hatch Vigor



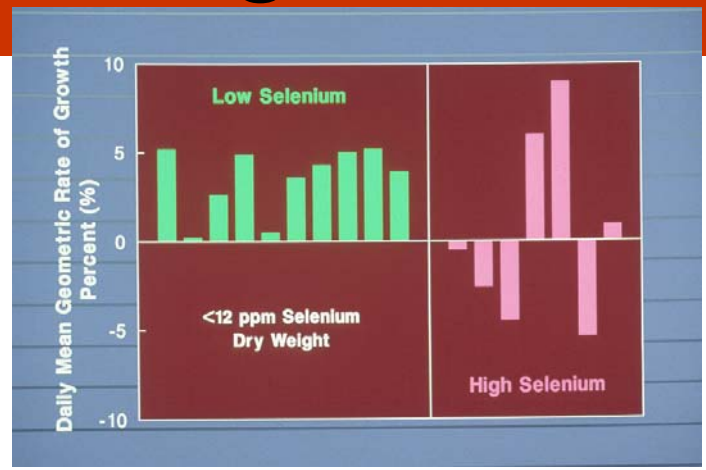


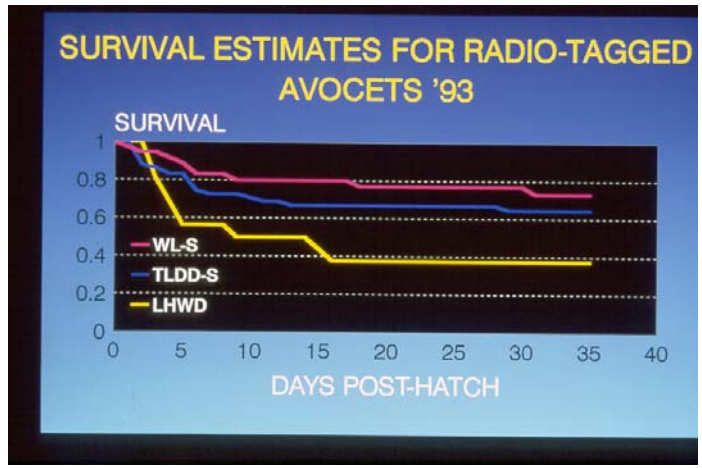
Best predictor of successful fledging is growth rate in first five days post hatch

Greater than 80% of all reproductive impairment at KR was post hatch

Nonetheless, this endpoint remains poorly documented; & likely highly interactive

Post-hatch Vigor





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Resolving Uncertainty

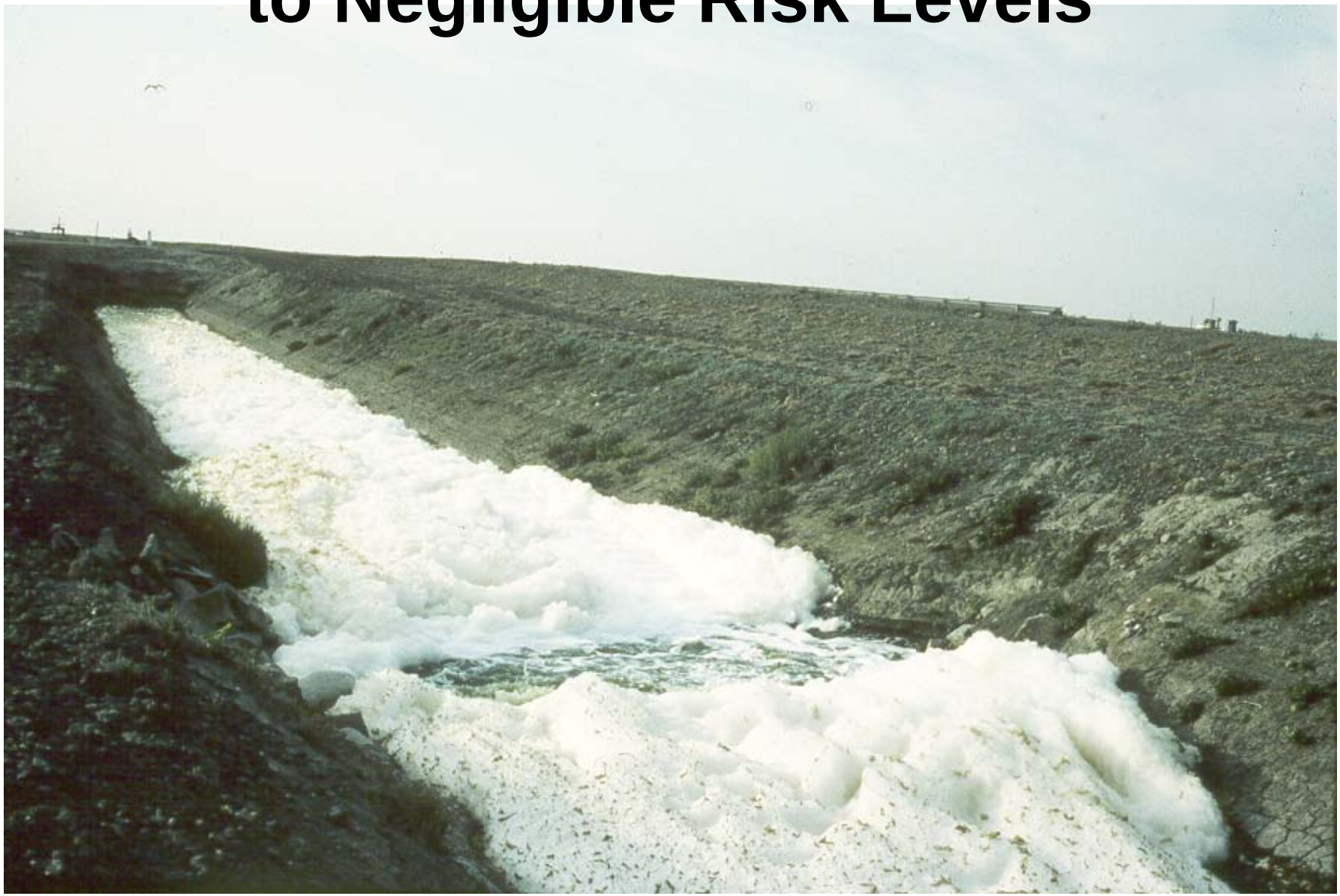
Some options:

Clean-up environment to a level known to be universally safe.

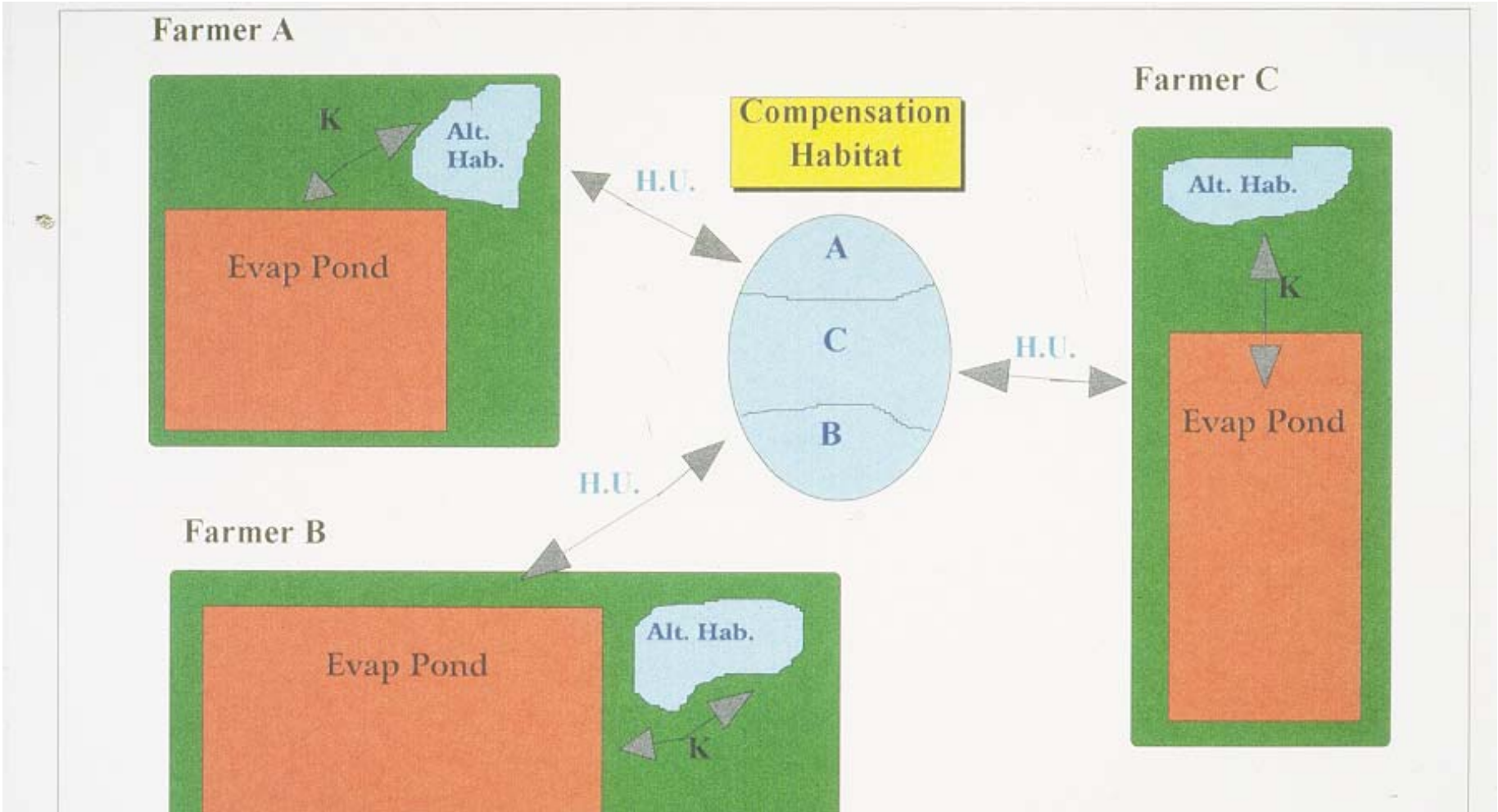
Collect more data on egg hatchability, post-hatch effects, and nonbreeding effects and mitigate according to site-specific findings.

Live with site-specific uncertainty and mitigate based on probable impacts extrapolated from exposure data and existing [non-site-specific] effects data.

Management I: Reduce Se Loading to Negligible Risk Levels

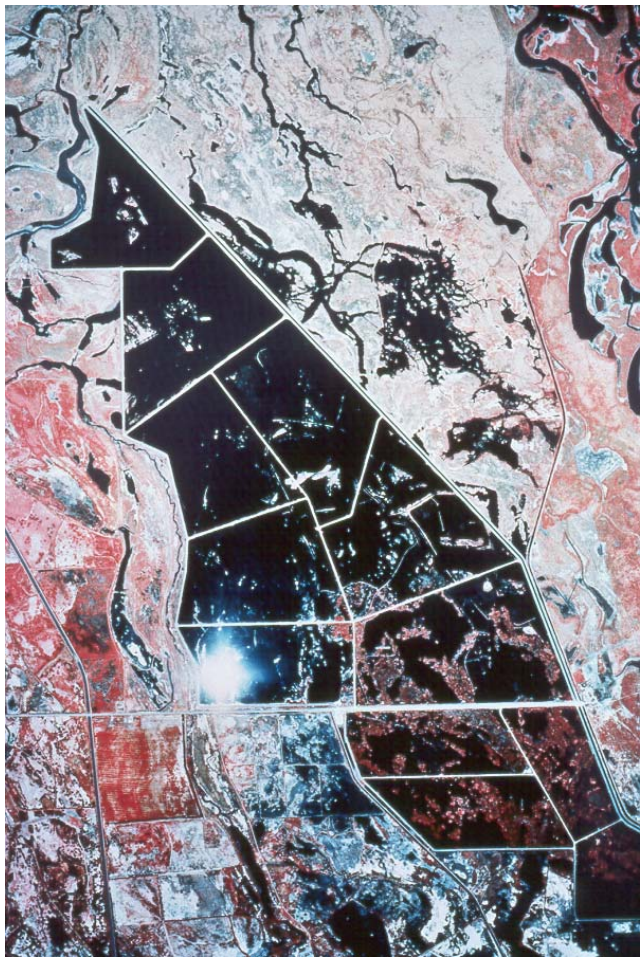


Management II: Mitigate and Compensate to Create Landscape Assimilative Capacity



Management III: Shift Contamination from High Risk Aquatic Food Web to Lower Risk Terrestrial Food Web

Management I/III: Kesterson

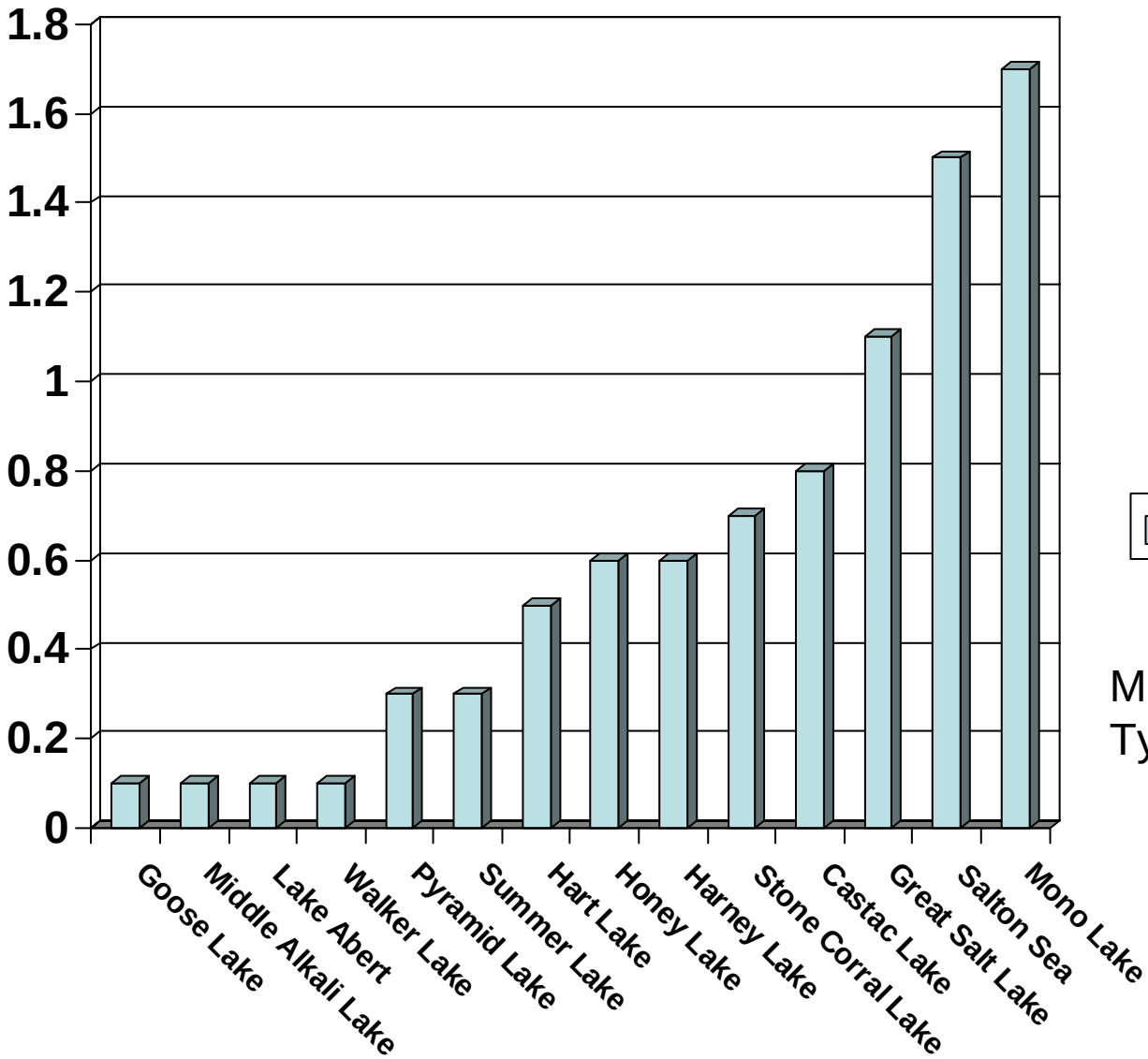


Management IV: Bird Free

Regulatory Snafu?

Draft fish-tissue based Se criteria are based solely on Fish Tox data, but will be applied to aquatic invertebrates in fishless water bodies. Proposed criterion of 7.9 ug/g, dw, is far above the dietary EC-10 for mallards (4.9 ug/g, dw), thus the proposed criterion will not be adequately protective of many closed basin water bodies and the dense populations of water birds they attract.

Inland Saline Lakes Survey for Selenium: CA, OR, NV, UT



Median = 0.6
Typical Freshwater < 0.4

CRWQCB 1990