Intake Screening Study

Length-Specific Probabilities of Screen Entrainment of Larval Fishes Based on Head Capsule Measurements

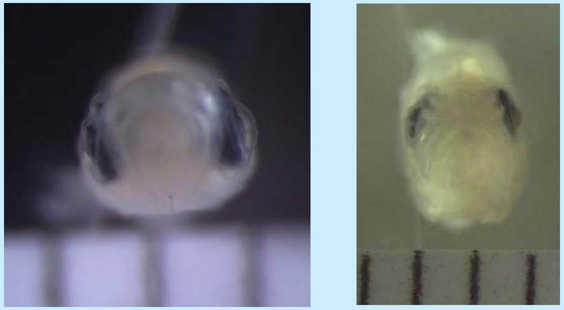
Prepared for:
Bechtel Power Corporation JUOTC Project

California State Water Resources Control Board
Once-Through Cooling Policy
Nuclear-Fueled Power Plant Special Studies

John Steinbeck
Tenera Environmental
San Luis Obispo, CA
jsteinbeck@tenera.com

Research Questions

- **What are the actual <u>minimum</u> dimensions of larval fishes typically entrained?**
- **How does intake screen slot/mesh size reduce the entrainment probability for various fish species ?**



Background

Data Sources

- Analyses were completed for 15 taxonomic categories (taxa) of fish larvae from data collected at 8 CA power plants

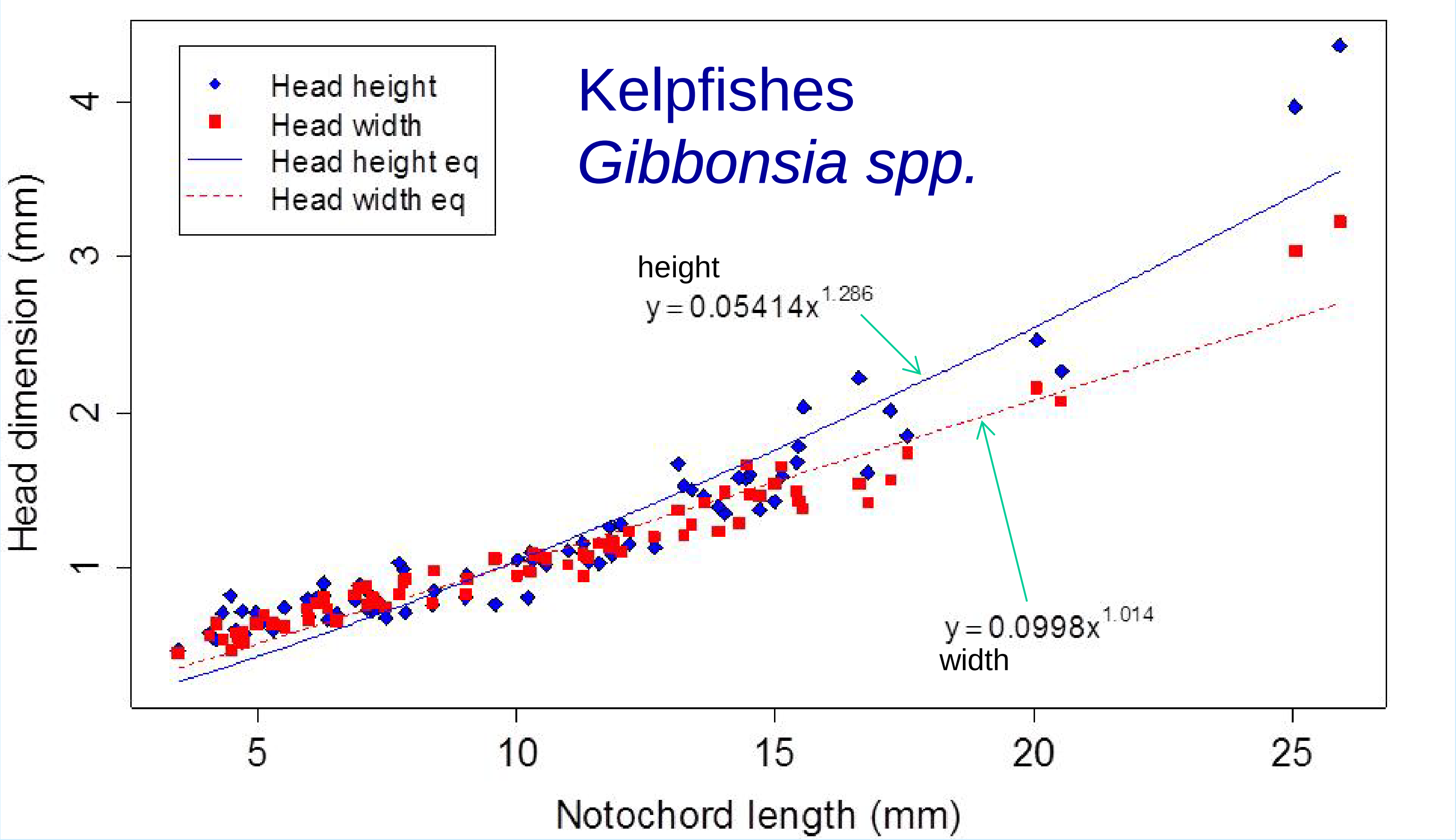
Moss Landing
Diablo Canyon
Scattergood
El Segundo
Redondo
Haynes
Harbor
South Bay

Background
Fish Larvae Analyzed

Common name	Taxon (included species)
anchovies	*Engraulis mordax*
blennies	*Hypsoblennius* spp.
cabezon	*Scorpaenichthys marmoratus*
clingfishes	*Gobiesox* spp.
croakers	*Genyonemus lineatus, Seriphus politus*
flatfishes	*Citharichthys stigmaeus, Paralichthys californicus*
gobies	*Acanthogobius flavimanus,* CIQ goby complex, *Rhinogobiops nicholsii*
kelpfishes	*Gibbonsia* spp.
monkeyface prickleback	*Cebidichthys violaceus*
Pacific barracuda	*Sphyraena argentea*
pricklebacks	Stichaeidae
rockfishes	*Sebastes* spp.
sea basses	*Paralabrax* spp.
sculpins	*Artedius* spp., *Orthonopias triacis*
silversides	*Atherinops affinis, Atherinopsis californiensis, Leuresthes tenuis*

Background
Analysis Example

Nonlinear regression where *head capsule = a(length)^b*, where *a* and *b* are the resulting coefficients for the model.



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Background
Conclusions of Regression Analysis

- **Different models must be used for head height (depth) and width**
- **Variation around data shows that head dimension varies at each length**
- **This variation needs to be considered in determining screening efficiency**

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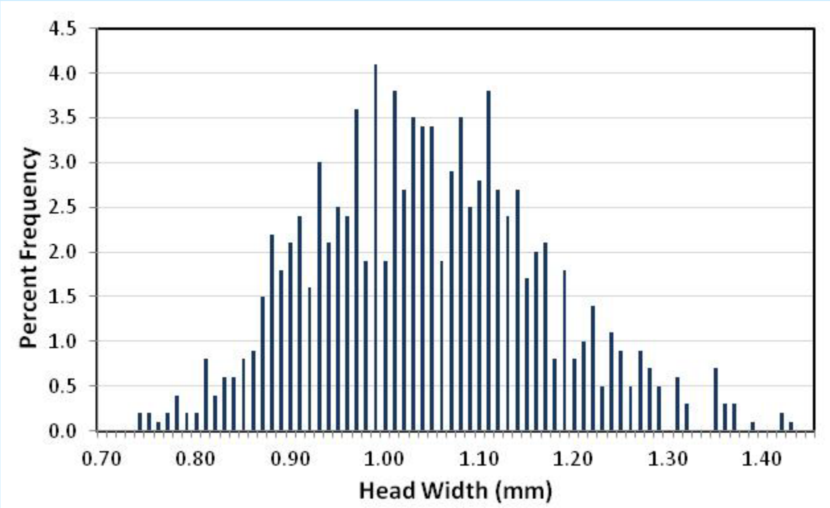
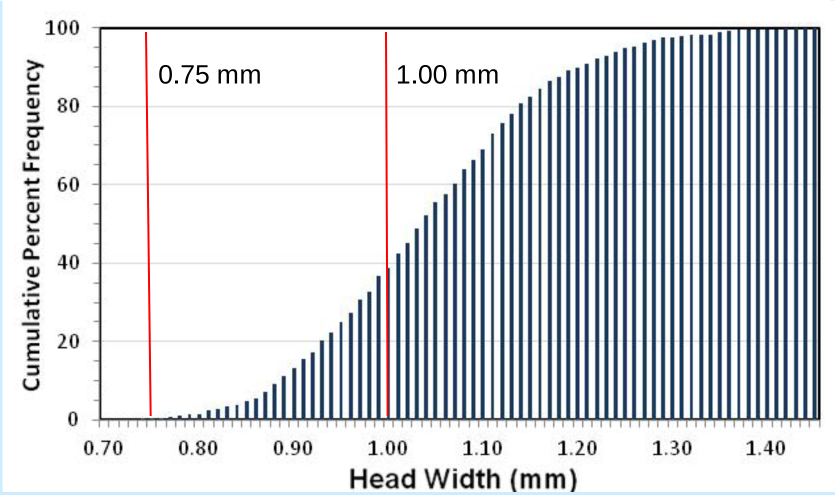
Methods

- Using results from regression analyses, estimate the potential efficiency of different screen slot/mesh sizes at reducing entrainment for those 15 fish species
- Based on the variation in head capsule at each length, generate range of values using measures of variation (SE) for regression coefficients
- 10,000 random estimates of head depth and width were computer-generated at each length for each taxon
- Proportion of data exceeding sizes of mesh were used as the estimate of efficiency

Results - 1

- **Using example for kelpfishes – 1,000 head widths at length of 10 mm generated using coefficients for *a* and *b* and associated std. errors.**
- **Cumulative frequency shows that very few 10 mm larvae entrained at slot/mesh size of 0.75 mm, but ~40% at 1.00 mm**





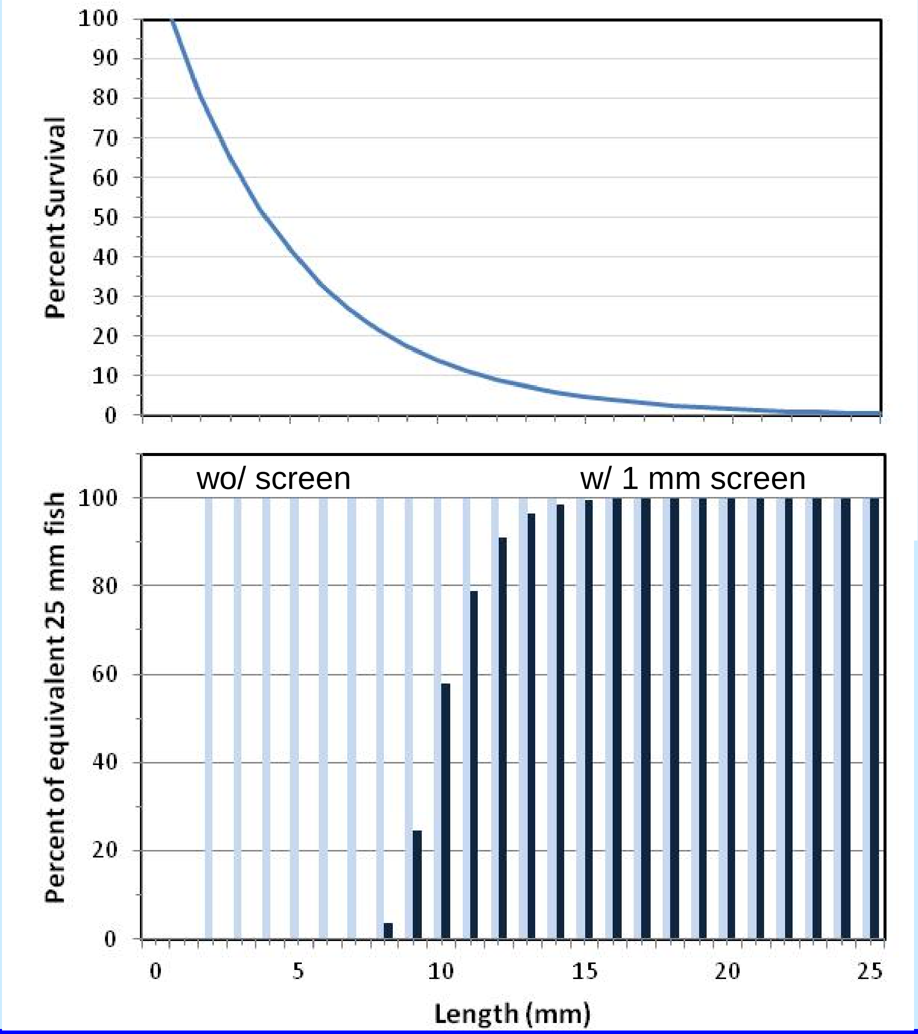
Results - 2

Results are used to generate probabilities of entrainment for each mm length category for each taxon (results for kelpfishes shown here) for various slot/mesh dimensions

Notochord	Screen Slot Dimension (mm)					
Length (mm)	0.75	1	2	3	4	6
2	1	1	1	1	1	1
3	1	1	1	1	1	1
4	1	1	1	1	1	1
5	1	1	1	1	1	1
6	0.9785	1	1	1	1	1
7	0.7781	0.9991	1	1	1	1
8	0.4144	0.9614	1	1	1	1
9	0.1584	0.7541	1	1	1	1
10	0.0499	0.4207	1	1	1	1
11	0.0158	0.2112	1	1	1	1
12	0.0046	0.0889	0.9999	1	1	1
13	0.0014	0.0369	0.9995	1	1	1
14	0.0004	0.0144	0.9945	1	1	1
15	0	0.0059	0.9772	1	1	1
16	0	0.0022	0.9309	1	1	1
17	0	0.0006	0.8369	0.9999	1	1
18	0	0.0002	0.7064	0.9999	1	1
19	0	0	0.5438	0.9993	1	1
20	0	0	0.4057	0.9968	1	1
21	0	0	0.2738	0.9899	1	1
22	0	0	0.1748	0.9769	0.9999	1
23	0	0	0.1052	0.9513	0.9999	1
24	0	0	0.0619	0.9071	0.9997	1
25	0	0	0.0367	0.8458	0.9988	1

Results - 3

- Assuming constant survival over range of lengths (age), the numbers of larvae at each length will result in the same number of equivalent 25 mm fish
- This allows the proportions across the size range to be averaged to estimate average effects on population (e.g., kelpfishes using 1 mm screen)



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Results – 4
(reduction of 20-25 mm fishes relative to open intake)

		Percentage Reduction in Mortality by Slot Opening Width					
Taxon	Size Range	0.75 mm	1 mm	2 mm	3 mm	4 mm	6 mm
kelpfishes	2–25 mm	73.33	64.60	24.80	1.39	0.01	0.00
sculpins	2–25 mm	85.92	81.19	64.57	49.88	36.17	14.05
flatfishes	1–25 mm	78.71	72.74	51.35	32.90	18.67	4.51
monkeyface prickleback	3–25 mm	75.73	62.16	12.78	0.53	0.01	0.00
combtooth blenny	2–20 mm	81.90	72.12	32.54	8.41	1.45	0.03
clingfishes	2–20 mm	83.09	75.88	48.96	27.18	13.23	2.62
anchovies	2–25 mm	55.42	45.19	5.49	0.00	0.00	0.00
croakers	1–20 mm	81.88	74.79	46.07	17.46	1.63	0.00
gobies	1–25 mm	74.61	66.52	35.73	8.34	0.19	0.00
silversides	2–25 mm	76.01	68.49	34.84	3.00	0.00	0.00
Pacific barracuda	1–20 mm	68.21	53.24	15.84	4.43	1.30	0.13
rockfishes	2–25 mm	74.58	66.97	41.67	21.42	10.11	2.23
cabezon	2–25 mm	79.24	70.24	39.11	20.27	10.45	2.90
sea basses	1–25 mm	84.13	79.78	59.86	40.99	22.73	0.06
pricklebacks	3–25 mm	80.52	57.91	4.01	0.10	0.00	0.00
Average % Reduction		76.89	67.45	34.51	15.75	7.73	1.77

% reduction of numbers of larvae would be much less

Conclusions

- **Highly species dependent**
  - **Larval head dimensions**
  - **Frequency distributions**
- **Results are likely to be conservative — actual performance is expected to be much better than theoretical estimates**
  - **Larvae are unlikely to be entrained head first**
  - **Models do not account for screen hydrodynamics**

Notes on Methodology

- **Results using actual size distributions of larvae collected at a facility are likely to provide different results**

- **Modeling approach used here may be preferred as it addresses all lengths potentially subject to entrainment, and does not reflect potential sampling biases due to sampling frequency**

Questions?

John Steinbeck
Tenera Environmental
jsteinbeck@tenera.com
805-541-0310