Final Report on Pacific Herring (*Clupea pallasi*) Test Development and Validation - with an Appendix on Herring Embryo Temperature Tolerance Comparisons between West Coast Stocks

Revised September 2012
Ecology Publication No. 11-10-086
https://fortress.wa.gov/ecy/publications/publications/1110086.pdf

Ecology and WWU began developing herring toxicity tests in 2000.

- The effort has cost close to $870,000 so far.
- Ecology provided 45% of the funds, industry provided 40%, and 15% came from grants.
- Dr. Paul Dinnel at the Shannon point Marine Center was the lead scientist.
- The effort has produced:
  - a 96-hour acute survival test
  - an embryo survival & development test
  - a larval 7-day survival & growth test.

In addition to the Ecology report, the method development was published:

Dinnel, P.A., D.P. Middaugh, N.T. Schwarck, H.M. Farren, R.K. Haley, R.A. Hoover, J. Elphick, K. Tobiason, R.R. Marshall. 2011. Methods for Conducting Bioassays Using Embryos and Larvae of Pacific Herring, *Clupea pallasi.* Arch Environ Contam Toxicol *60:290–308.*

Background

- The Cherry Point stock declined from nearly 15,000 tons of spawning biomass in 1973 to just above 800 tons in 2000.
- Stock size then rose gradually until 2007 when it began declining again and dropped below 800 tons in 2010.

Cherry Point Recruitment

- Recruitment is the number of first time spawners and a direct measure of the success of reproduction 2-3 years earlier.
- Averaged 2121 tons from 1974 to 1995.
- 1994 had a record recruitment of 4076 tons.
- Recruitment dropped steeply in 1996 and only averaged 755 tons from 1996 to 2001.
- Recruitment in 2004 was only 22 tons.
- Herring deposit eggs nearshore where human activities can affect environmental quality.

Herring Testing in Permits

- Even though evidence points to malnutrition and disease as being key factors in the Cherry Point herring decline, Ecology included herring toxicity testing in permits in order to rule out effluent toxicity as a factor in the decline in recruitment.
- Herring testing has also been put into permits for municipal wastewater plants near Cherry Point and into industry permits in other locations with vulnerable herring stocks.
- Industries have been routinely monitoring effluent since 2007 using the 96-hour herring acute survival test.

Standards for Validity

- We agreed with industry from the beginning that a herring test would be considered to be validated for regulatory use when a commercial lab demonstrated the ability
  - to get a consistent test organism response when exposed to the same toxicant in repeated tests.
  - to detect as statistically significant a minimum of a 40% difference in survival, development, or growth between a control and treatment groups.

Results of Validation Exercise

- The herring test results generally met the validation standards and are similar to results from standard EPA tests.
- Three commercial labs have validated one or more of the herring tests. One of these labs closed but the others can fill the gap.
- Regular effluent monitoring with the herring 96-hour acute test has been successfully performed since 2007.

Lesser Uses of Herring Tests

- The variability of effluent toxicity requires more frequent monitoring than is possible with herring given the limited spawning season and limited availability even during the spawning season.
- Labs have experience with using the EPA standard toxicity tests in toxicity identification evaluations.
- The EPA tests are best for effluent monitoring when EPA test sensitivity can account for the sensitivity of herring.

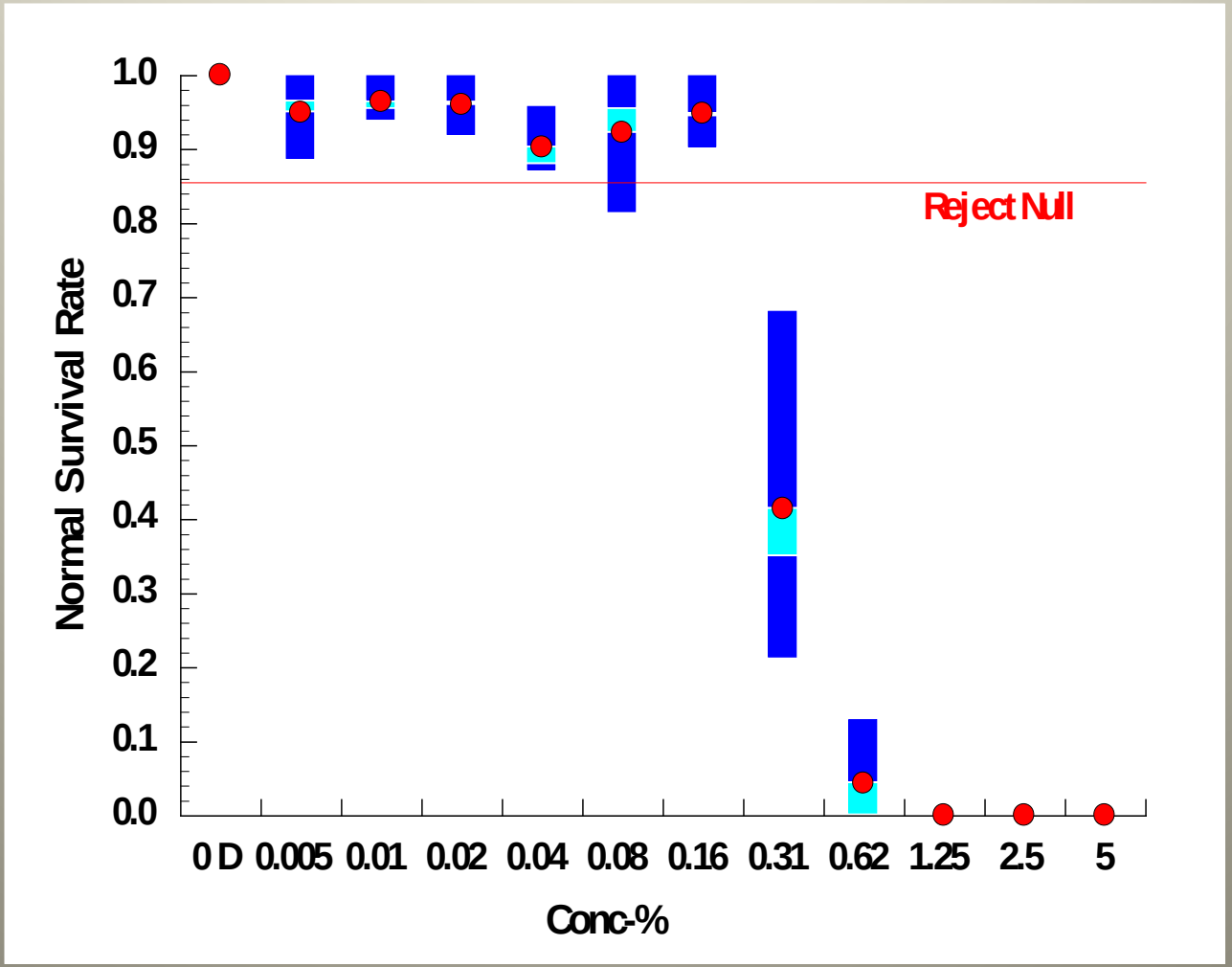
Best Use of Herring Tests – Environmental Monitoring

- Evaluate shoreline conditions (water, groundwater, and sediment) not only for their own sake but as a surrogate for all forage fish.
- Determine the effectiveness of spill cleanup.
- Look for substances of concern such as creosote and algal toxins.
- Locate the sources of water quality impairment – See next slide.

Abnormality Rates in Herring Outplants in the 1990s

location	stations numbered north to south	average % abnormal
s. of Al smelter pier	7	54.3
ravine	8	43.0
s. of oil refinery pier	10	40.8
n. of oil refinery pier	9	40.2
gravel pier	5	38.7
Neptune Beach	11	38.7
Sandy Point	12	35.1
n. of Al smelter pier	6	34.6
Viewpoint	2	30.8
n. of oil refinery pier	3	30.7
s. of oil refinery pier	4	27.8
Point Whitehorn	1	25.4
lab controls		29.4

Example – creosote saturated seawater



Current Extent of Herring Testing

Herring tests have now been used in

- reference toxicant testing
- effluent monitoring
- testing environmental samples
- evaluating ballast water biocides
- examining creosote toxicity
- assessing dinoflagellate toxicity
- comparing the embryo temperature tolerance of different West Coast herring

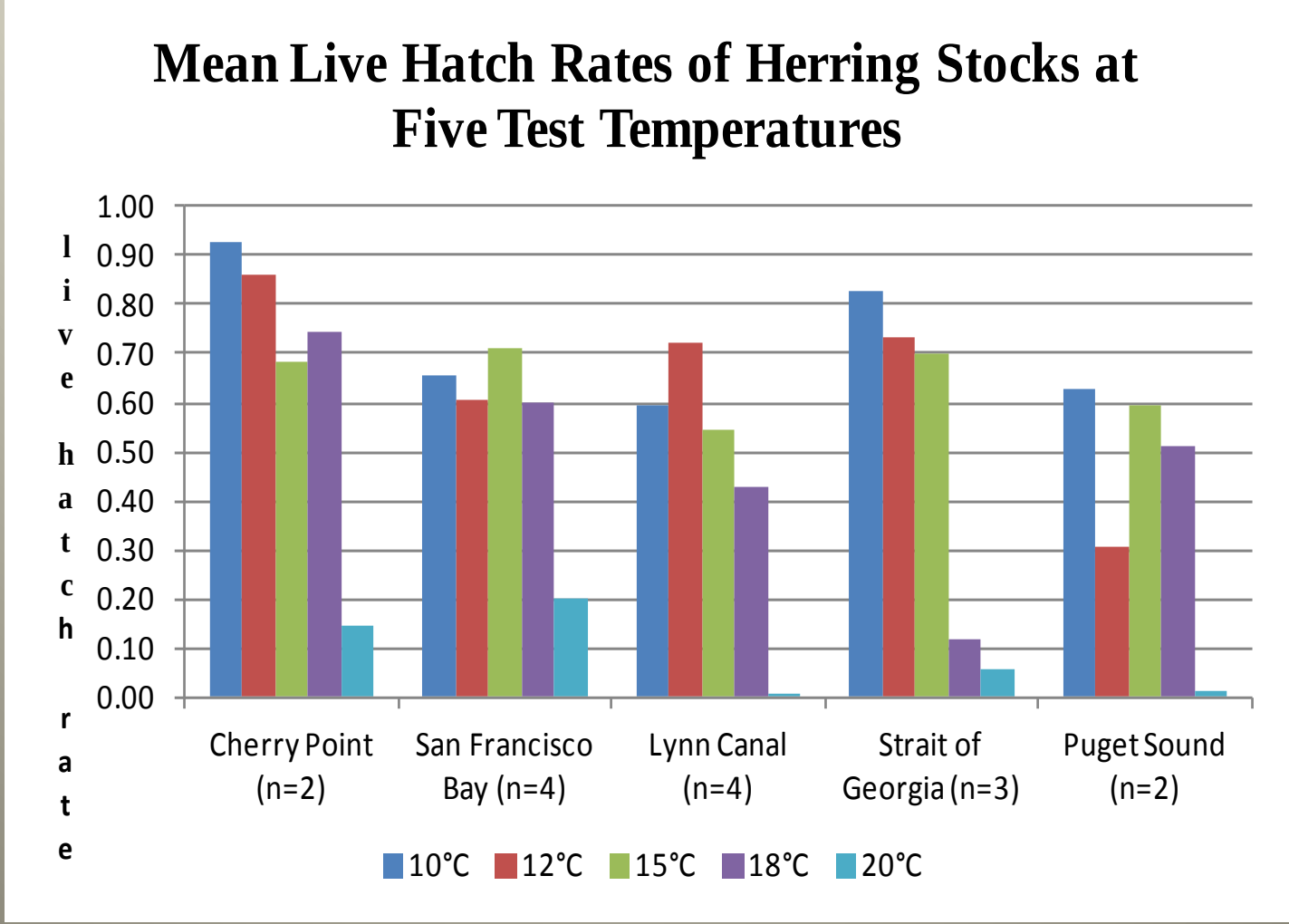
Herring Temperature Tolerance

- The Cherry Point herring spawn in late spring raising concern about warm temperatures having a role in the decline in recruitment.
- However, they may have acquired tolerance for the warm temperatures common during their spawning season.
- Herring spawn in shallow water and the intertidal zone and eggs can be exposed to heat through water, air, or sunlight.
- The degree of heat exposure will vary between herring stocks depending on the latitude and time of year for spawning.
- It made sense to test the hypothesis that Cherry Point herring are more tolerant of heat than other regional herring by comparing the temperature tolerance of embryos from stocks spawning from San Francisco to Alaska.

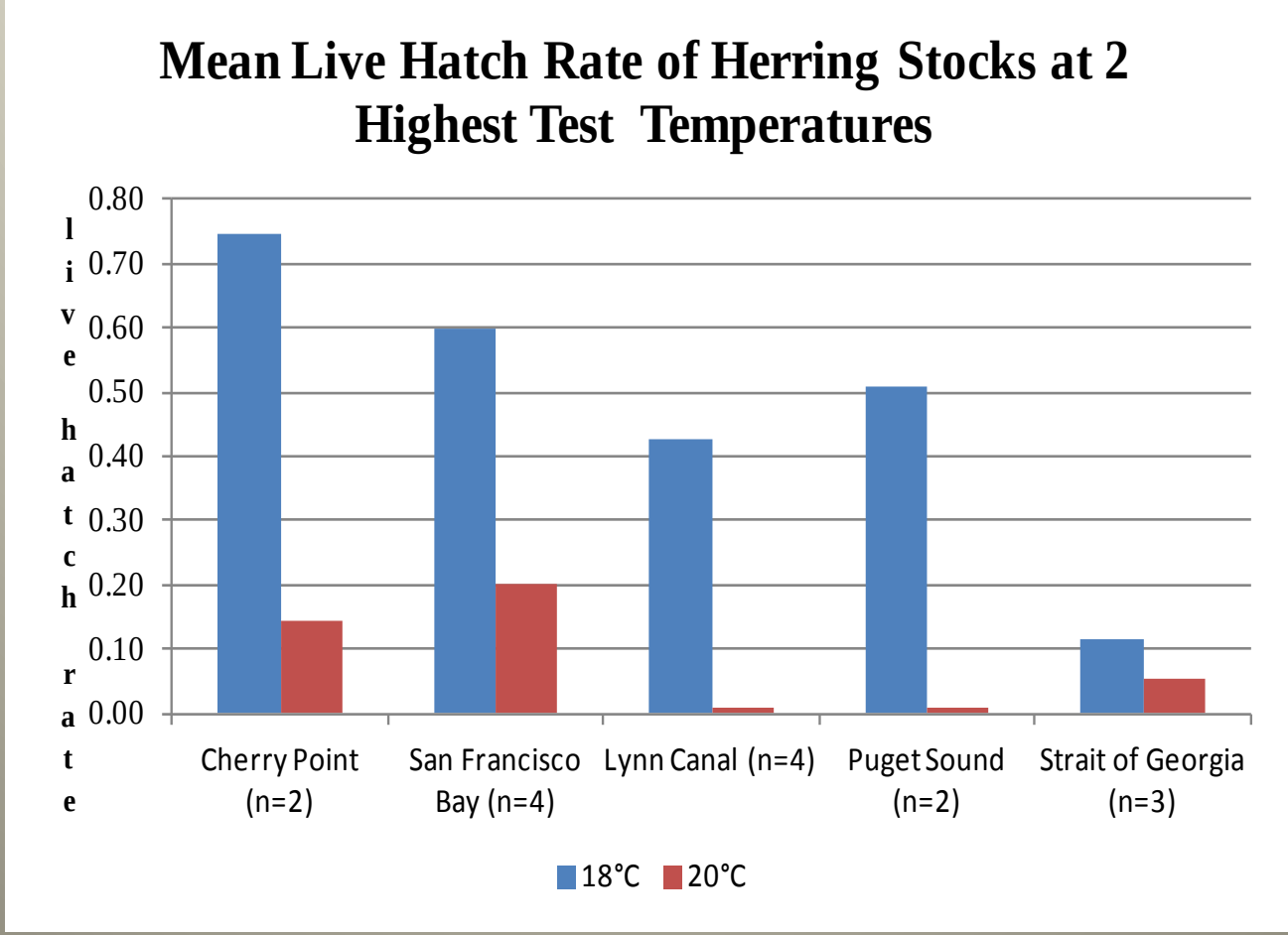
Temperature Tolerance Test Method

- Due to the variety of toxicity test species and protocols used routinely, commercial testing labs must be able to test on any given day at multiple test temperatures.
- The ripe fish we were receiving from all along the West Coast gave us an opportunity to test newly fertilized herring embryos to determine a temperature-response relationship for different stocks.
- The temperature tolerance test method followed the same protocol as for the herring embryo survival & development test except that replicates of four test chambers were held in separate incubators at 10°, 12°, 15°, 18°, and 20° C.
- If enough of temperature-response relationships can be generated to perform statistics, then analysis could reveal whether embryos from different herring stocks have varying tolerance for warm temperatures related to spawning location or timing.

All Temperatures Tested



Focus on Higher Temperatures



Conclusions

- We had too few test results from most stocks to run good statistics and make definite conclusions.
- Some results from comparing responses at 18° and 20°C showed Cherry Point herring to have temperature tolerance similar to San Francisco Bay herring and to be more tolerance than the other WA, BC, and AK herring stocks tested.
- The strongest results showed the San Francisco Bay and Lynn Canal herring to be significantly different in heat tolerance.

Better Conclusion

- More temperature tolerance testing is needed, and all of the stocks involved in this study should be brought up to a minimum of four tests a piece.
- In addition, it is important to determine whether the differences seen in temperature tolerance are due to genetics or to environmental conditioning.
- The information may prove to be a key consideration for resource management in a changing climate.

Fiction is better than life.

- In 2005 Bellingham author, Clyde W. Ford, published a novel entitled ***Red Herring***.
- The novel was inspired by plight of the Cherry Point herring and the test development efforts and the story contains a lot of local flavor.
- Mr. Ford actually interviewed Dr. Paul Dinnel and put a pretty good description of the Shannon Point Marine Center into the otherwise completely fictitious novel.