Loss of genetic integrity in hatchery steelhead despite juvenile-based broodstock and wild integration: conflicts in production and conservation

Dan Bingham, Ben Kennedy, Kyle Hanson, and Christian Smith

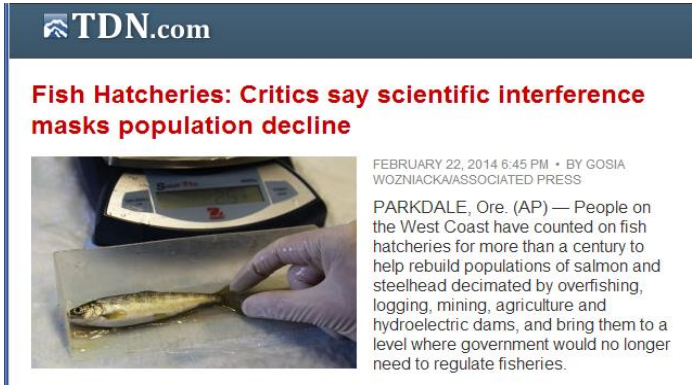
Acknowledgements

- This work is part of a broader study: “Natural Reproductive Success and Demographic Effects of Hatchery-Origin Steelhead in Abernathy Creek, Washington conducted by P. Crandell, J. Holmes, J. McLaren, J. Poole, D. Hawkins, M. McGlauflin, B. Adams, J. Von Bargen, L. Godfrey, A. Gannam, R. Twibell, W. Simpson, K. Steinke, R. Glenn, J. Anderson, J. Samagaio, A. McNamee, K. Ostrand, D. Campton, W. Simpson, W. Gale and R. Glenn.

- The Washington Department of Fish and Wildlife provided assistance with sample collection.

Conflicts between production and conservation

- Many agencies are facing litigation for harm caused by hatchery fish.
- "Maximizing offspring production and minimizing the loss of genetic variation are often viewed as separate and competing goals."–*Fiumera et al. 2004*
- Can alternative practices be used to produce hatchery fish that retain the genetic characteristics of endemic populations?



TDN.com

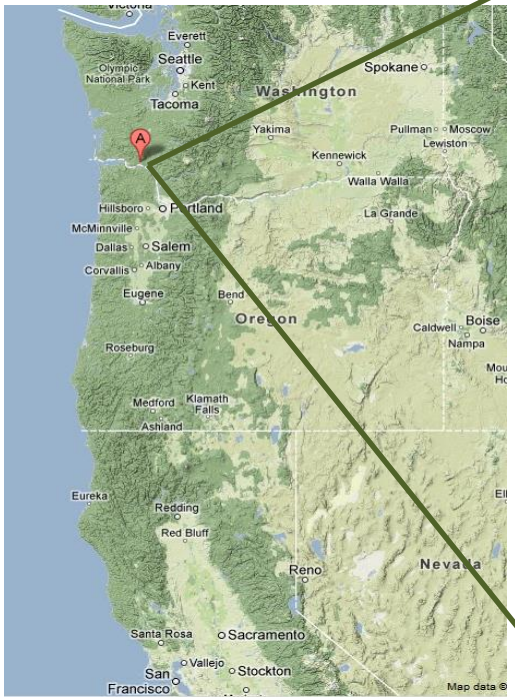
Fish Hatcheries: Critics say scientific interference masks population decline

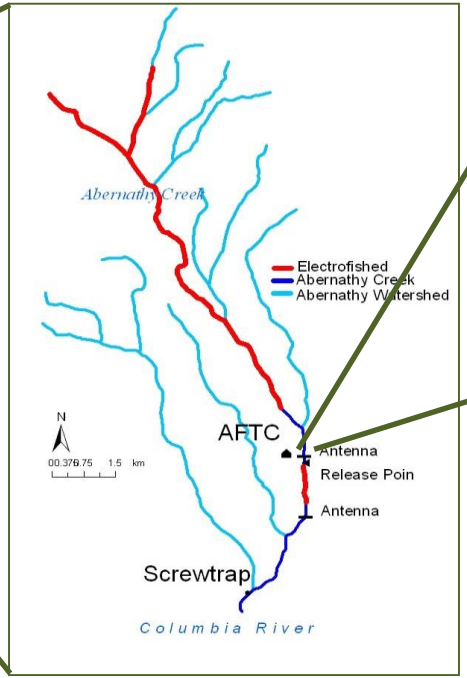
FEBRUARY 22, 2014 6:45 PM • BY GOSIA WOZNIACKA/ASSOCIATED PRESS

PARKDALE, Ore. (AP) — People on the West Coast have counted on fish hatcheries for more than a century to help rebuild populations of salmon and steelhead decimated by overfishing, logging, mining, agriculture and hydroelectric dams, and bring them to a level where government would no longer need to regulate fisheries.

"presence of hatchery fish lowers the number of offspring produced by wild populations, disrupts local adaptations, and leads to loss of genetic diversity."

Abernathy Fish Technology Center





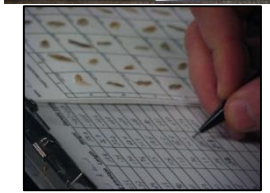
- **Production goal:** 20,000 1-year steelhead smolts annually
- **Conservation goal:** provide demographic boost while maintaining genetic profile of endemic population

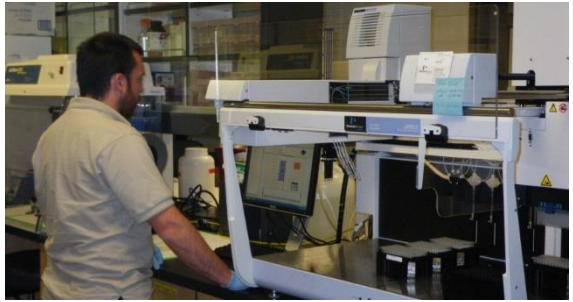
Methods 1: Culture

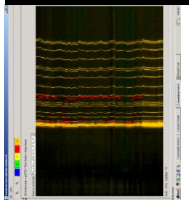
- Broodstock of captivity-reared **endemic juveniles**.
- Subsequent **integration** of wild adults in broodstock**.**
- Spawning / rearing protocols designed to prevent reductions in hatchery effective population size.

Methods 2: Genetic analysis

- Sample captive broodstock and wild and hatchery juveniles over nine years.
- Analyze 10 genetic markers in all samples.
- Compare genetic diversity, effective size, and population structure among collections.





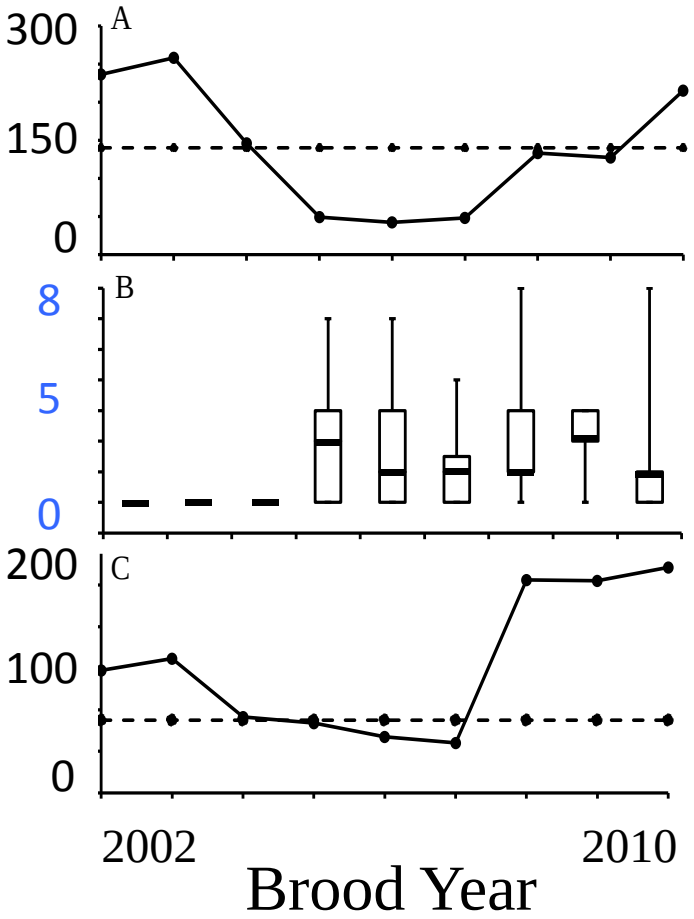


Broodstock management: What was planned versus what occurred.

Number of spawners

Mates per spawner

Number of Families



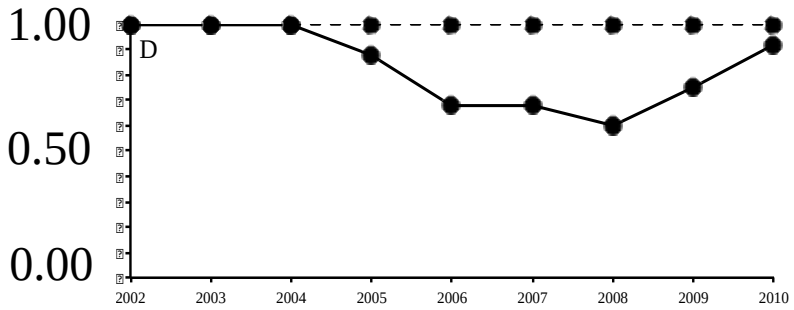
140 spawners planned

1 mate per spawner planned (pairwise, monogamous)

70 families planned

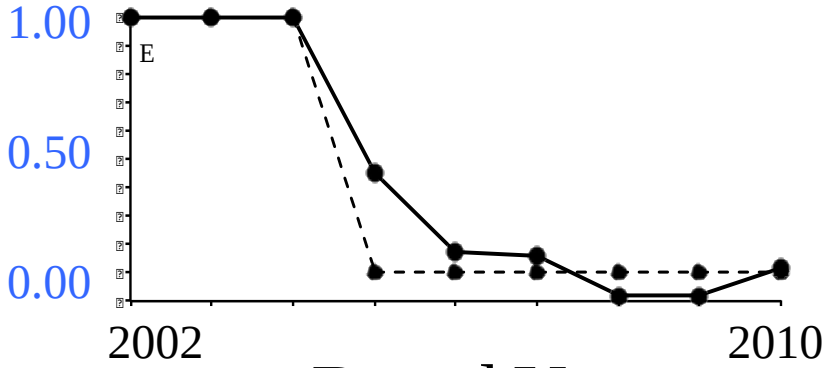
Broodstock management: What was planned versus what occurred.

Sex ratio



1-to-1 sex-ratio planned

Proportion wild



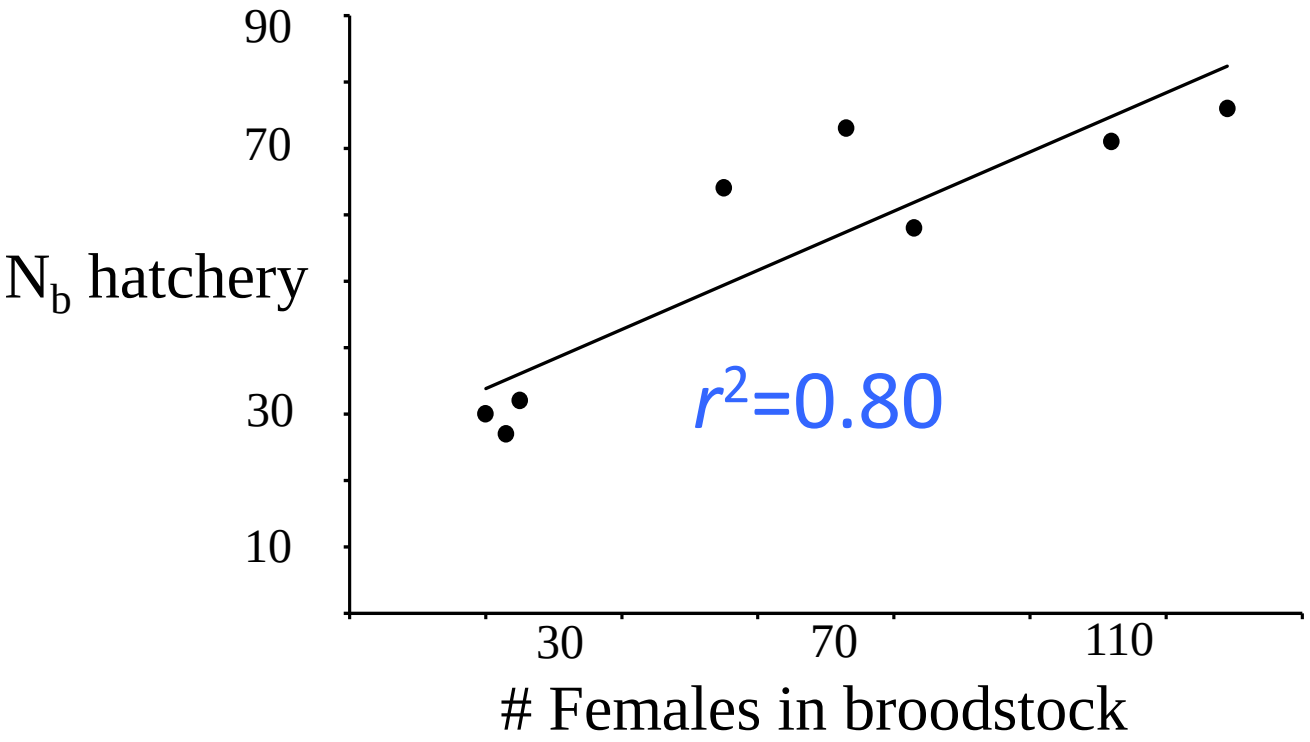
10% wild planned

Brood Year

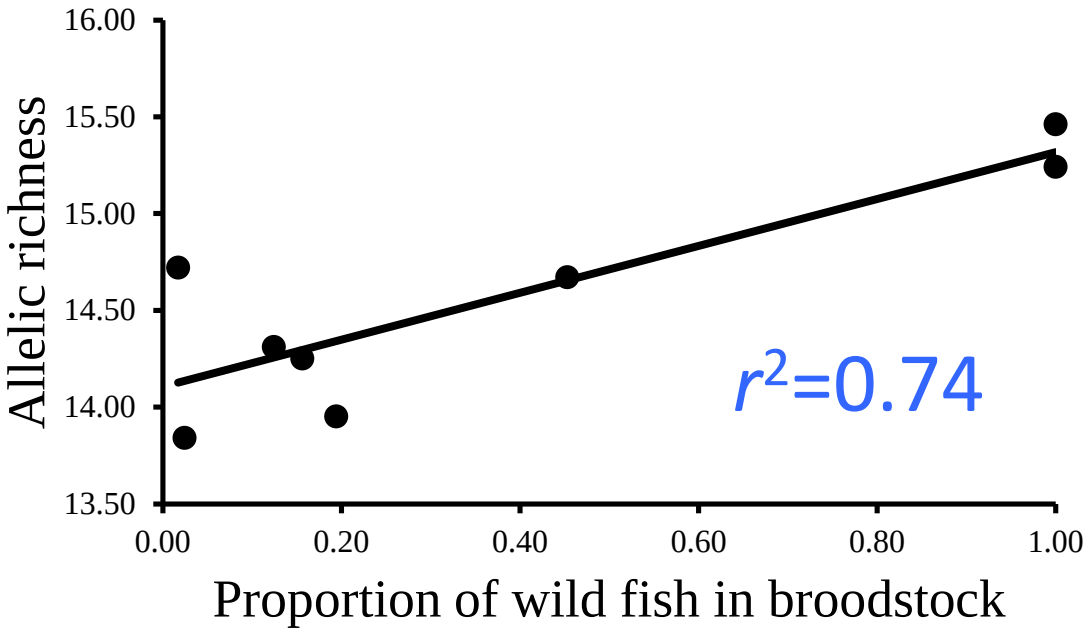
Production goal was met in 6 of 9 years

Brood Year	Number of smolts
2002	29,724
2003	20,009
2004	19,049
2005	17,660
2006	24,190
2007	19,657
2008	24,538
2009	21,222
2010	20,491

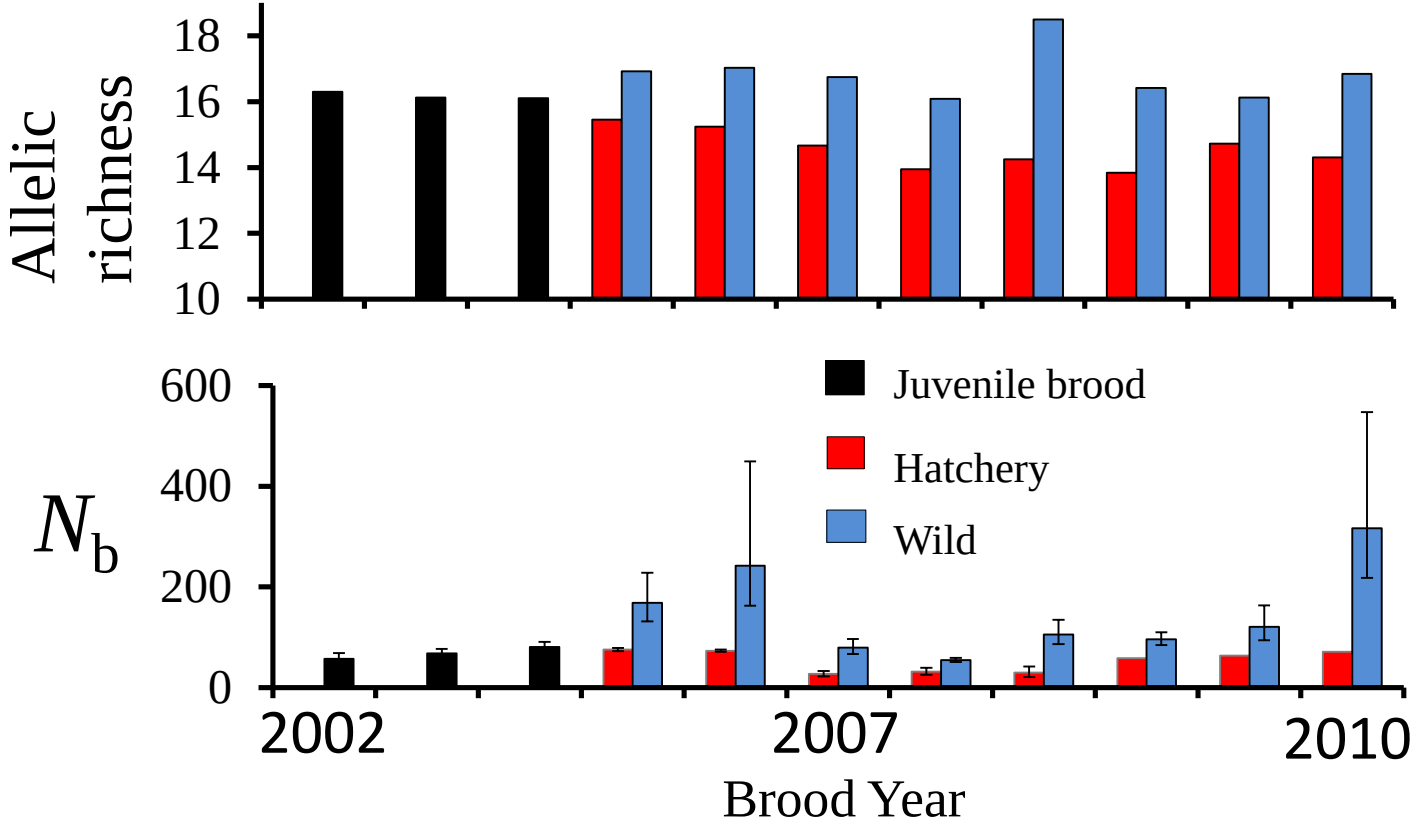
Relationship between broodstock size and effective size



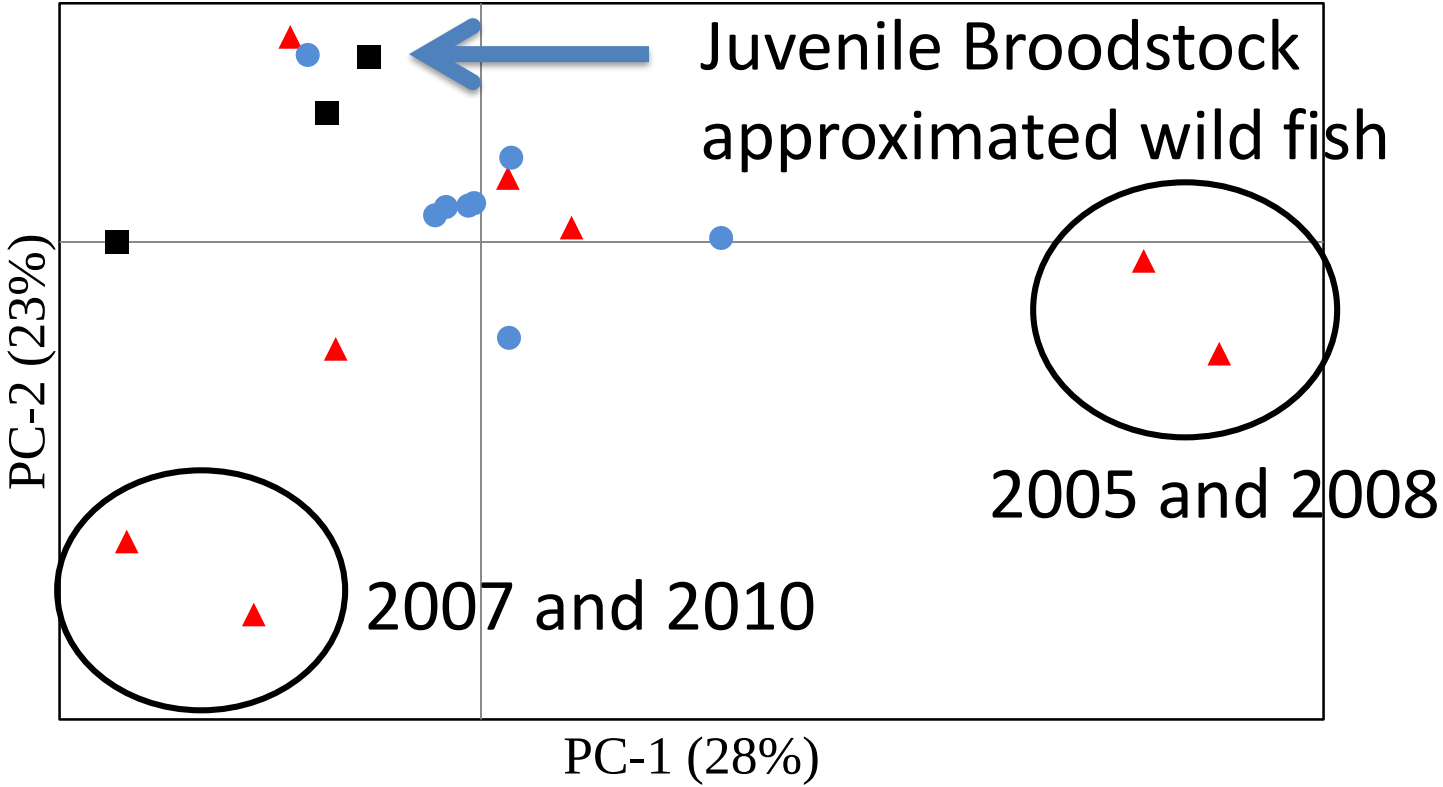
Relationship between proportion of wild fish in broodstock and genetic diversity in hatchery offspring



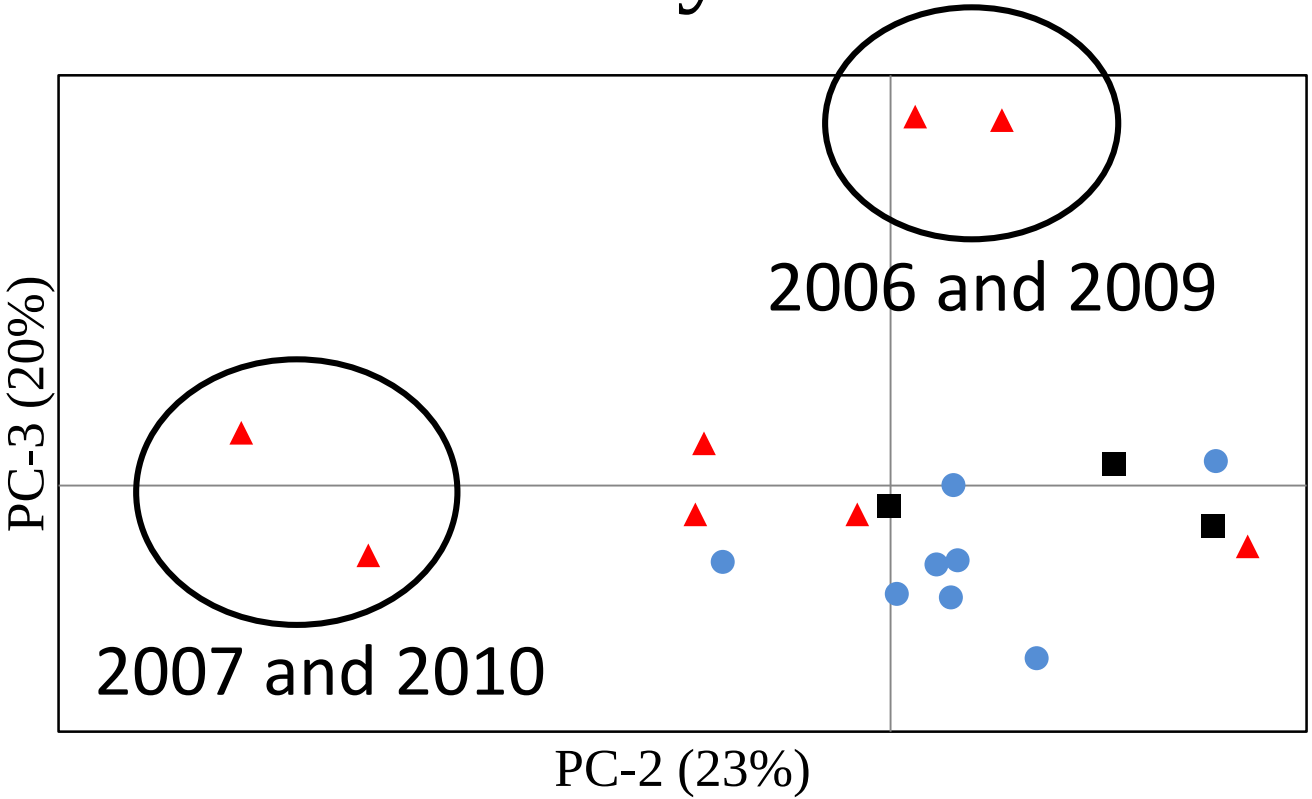
Decreased diversity and N_e in hatchery fish



Hatchery fish diverged from wild fish



Temporal population structure in hatchery fish



Conclusions

- The hatchery effectively met production goals, but wild-type genetic integrity of hatchery fish was degraded every year.
- Despite substantial conservation efforts, hatchery steelhead rapidly diverged from the wild component.
  - Increased drift, inbreeding, and temporal structure
- 60% reduction in the effective number of breeders in the hatchery.
- Data not shown, but substantial reduction in reproductive success of hatchery fish relative to wild.

Conclusions

- Increasing broodstock size and proportion of wild fish in broodstock both reduced genetic drift.
- The juvenile-based broodstock represented an adequate *sample* of genetic variation, but the mating design did not emulate the effective number of breeders that spawned naturally in Abernathy Creek.

Conclusions

- Spawning protocols should be based on both realistic expectations for the availability of spawners and on scientific theory: for example, partial factorial designs.
- If conservation issues are determined to be the most important issue for hatchery propagation, then production goals may need to be forfeited.

Questions

Dan Bingham
bingham@roguebio.com
www.roguebio.com
360-207-4705