Evaluation of genetic Ne of Delta Smelt provides hope for recovery

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Acknowledgements and Collaborators

- Scott Blankenship and Gregg Schumer
  - Project coordination, data collection and genotyping

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GENIDAQS
aquatic species sampling, simplified

THE METROPOLITAN WATER DISTRICT of SOUTHERN CALIFORNIA

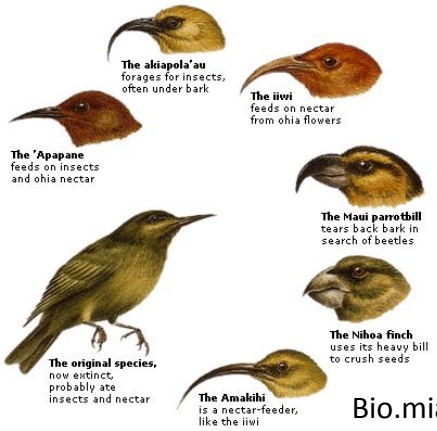
SFCWA
State and Federal Contractors Water Agency

Central question:

What is the (known) extent of genetic threats to Delta Smelt?

Genetic diversity

- Why do we care about genetic diversity?
  - Natural selection acts on genetic variation
  - Genetic variation allows adaptation to a changing environment



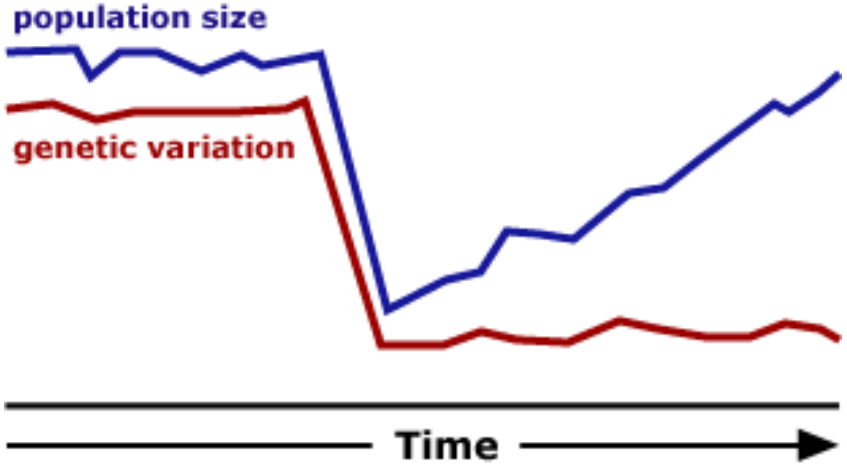
Bio.miami.edu

- Inbreeding and drift remove diversity
- Immigration or mutation add diversity

Genetic diversity and conservation

- Recognized by the IUCN as one of three forms of biodiversity deserving conservation

A large population reduced in size loses diversity



Population size can rebound more quickly than genetic diversity

Image: evolution.berkeley.edu

Effective population size (N_e)

- Allows us to predict loss of diversity using the relationship between forces that add genetic diversity (mutation), and forces that remove diversity (drift)
- N_e = size of an **ideal** population that loses heterozygosity (due to drift or inbreeding) at the same rate as the **real** population
- **Ideal** population (hypothetical)
  - Random mating, infinite population size, no migration, mutation or selection

Lowering N_e

- Departures from an ideal population lower the N_e of a **real** population

Life history

Demography

In other words…

- If an **real** population loses genetic diversity at the same rate as an **ideal** population of 100, the **real** population has an N_e of 100.

- **Even if there are 1,000 individuals in the real population**

N_e/N

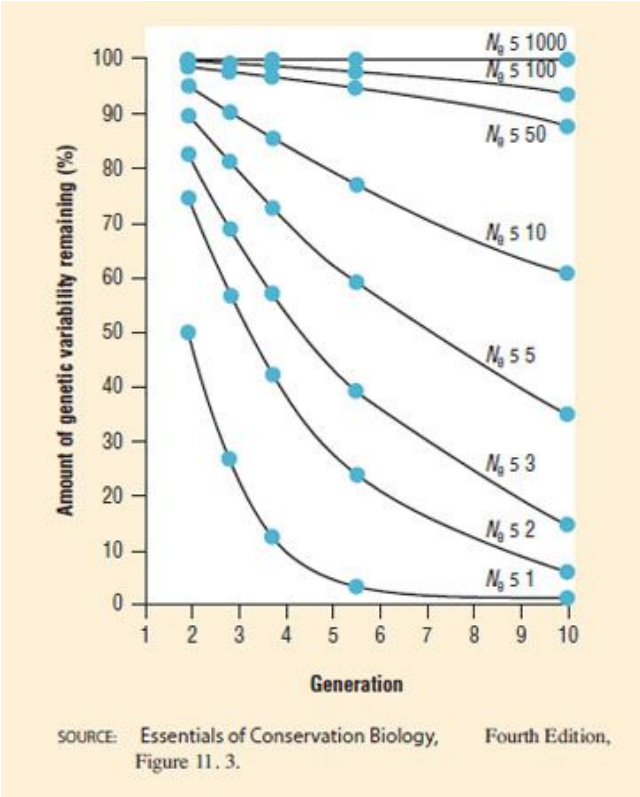
- N_e in **real** population typically far lower than N
  - Avg is 0.1
  - If N_e is 1,000, N is 10,000

- But relationship is uncertain and population-specific

- Highly fecund species (fish, oysters, shrimp) typically have far lower N_e/N ratios
  - 10^{-3} - 10^{-6} (Frankham 1995)

N_e and conservation

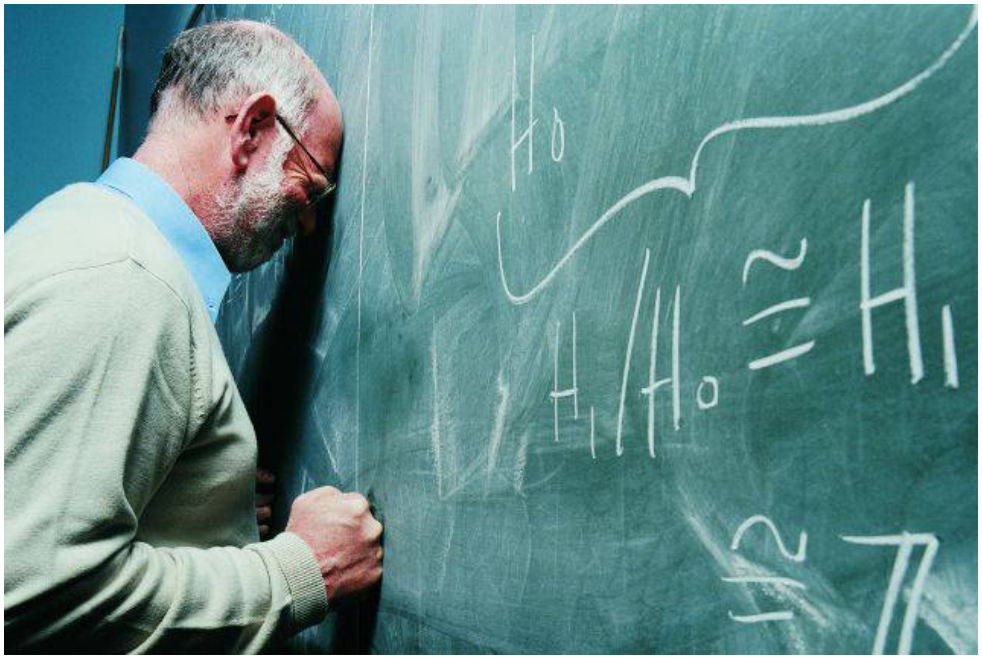
Populations with N_e > 1,000 will maintain nearly 100% of genetic variation over 10 generations



SOURCE: Essentials of Conservation Biology, Fourth Edition, Figure 11. 3.

However…

"(N_e) is arguably both the most important and the most difficult to evaluate directly" (Waples 1989)



N_e Estimators

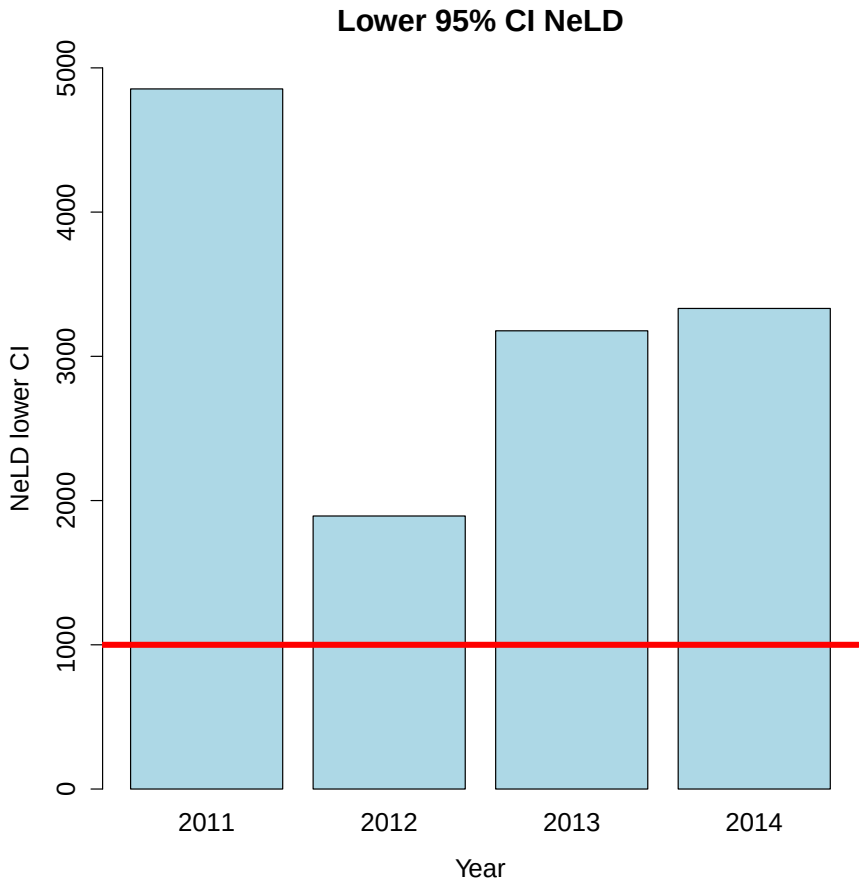
- N_{eLD}
  - Measured with single sample
- N_{eV}
  - Measured between two time points
  - Can decline and recover more rapidly
- In a large, stable population – values will be similar

Methods

- Genotyped 2,628 samples from surveys (FMWT, SKT, EWS, GES) from 2011-2014
- 12 microsatellites (Fisch et al. 2009)
- Estimated N_{eLD} and N_{eV} for each cohort

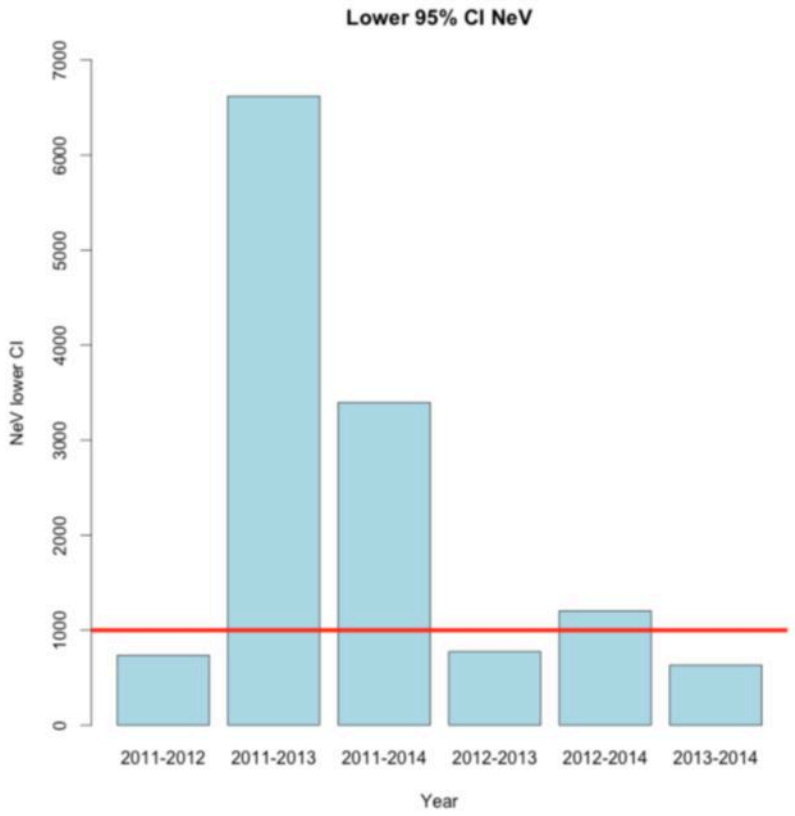
Results: N_{eLD}

- Upper 95% confidence intervals all ∞
- Reporting lower 95% CI



Results: N_{eV}

- N_{eV}
  - Some lower 95% CI values below 1,000 threshold



Interpretation

- Delta Smelt are not *immediately* threatened by reduced evolutionary potential
  - **But** they are *near* the threshold

- Genetic factors are probably not the main reason for Delta Smelt decline
  - Environmental and demographic threats are far greater

Interpretation

- Delta Smelt are recoverable!
  - Don't get the the point of no return
- Another piece of the puzzle

How **not** to use this information

- Short-term data set!
  - N_e and diversity were likely **far greater** before collapse
- Do not use N_e to inform water operations in real time
  - Requires tissue samples and genetic analysis
  - Lag time between demographic changes and changes in N_e

Suggestions

- Focus on maximizing abundance
  - Will allow maintenance and prevent further loss of diversity
- Alternative ways to monitor Delta Smelt
  - Smeltcam
  - eDNA
- Coordinate with other data sets – otoliths, gene expression, contaminants, biomarkers

Future work in our lab

- More powerful genetic monitoring and long-term data set
  - Genomic data
  - Use historic samples (at least from the 1990's)
  - Determine genetic basis for residency, sex marker
- Longfin smelt coastwide structure
  - Stay tuned!

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Questions?