Management of genetic resources in the federally endangered Rio Grande silvery minnow, *Hybognathus amarus*

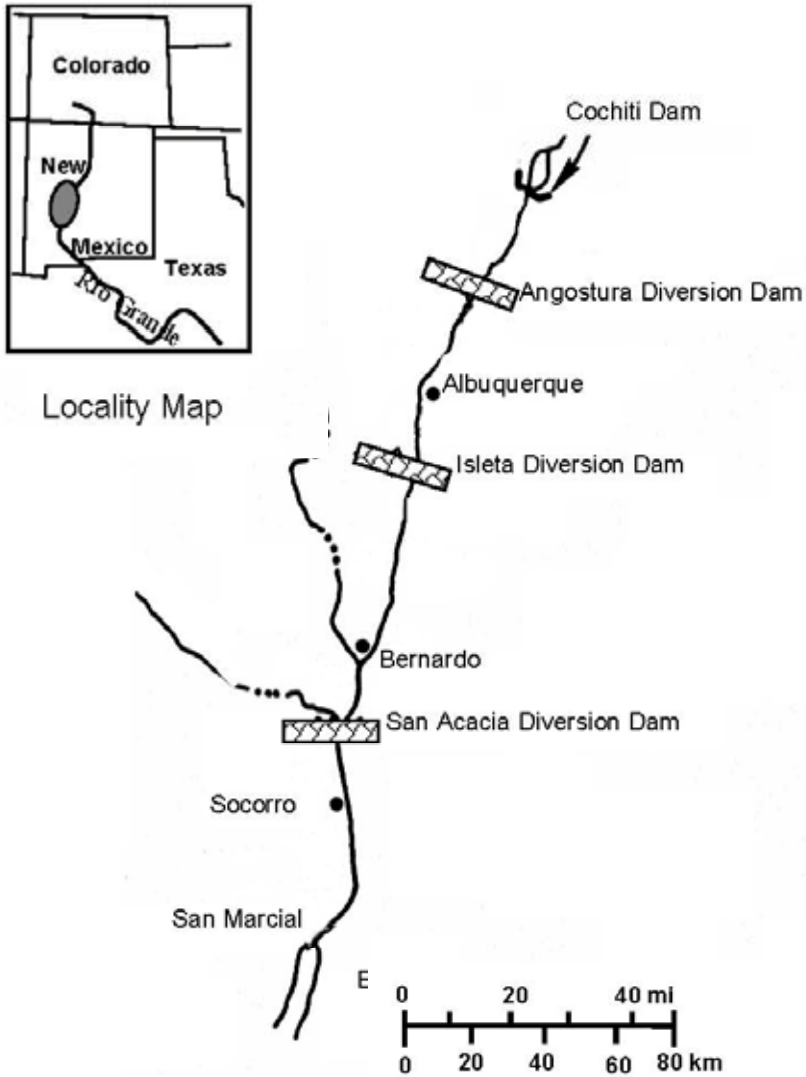
Thomas F. Turner and Megan J. Osborne

THE UNIVERSITY of NEW MEXICO

Rio Grande silvery minnow - *Hybognathus amarus*

- Dramatically reduced abundance/Geographic Range
- Short generation time (G = 1.22 years)
- Pelagic eggs and larvae
- Captive propagation
- Drifting egg recovery
- Refugial populations

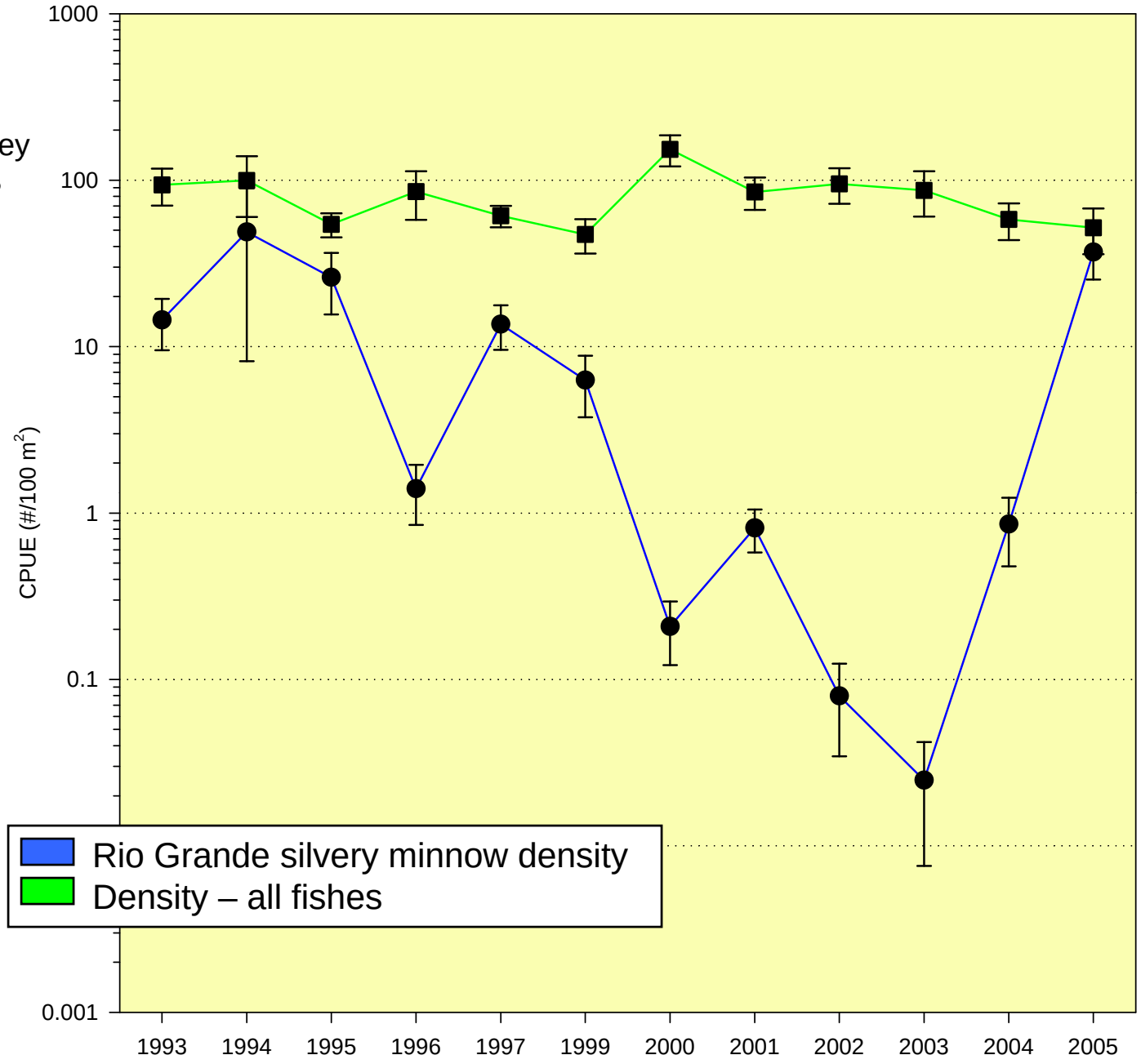
Rio Grande – New Mexico, USA



San Acacia Diversion Dam

2004 8 24

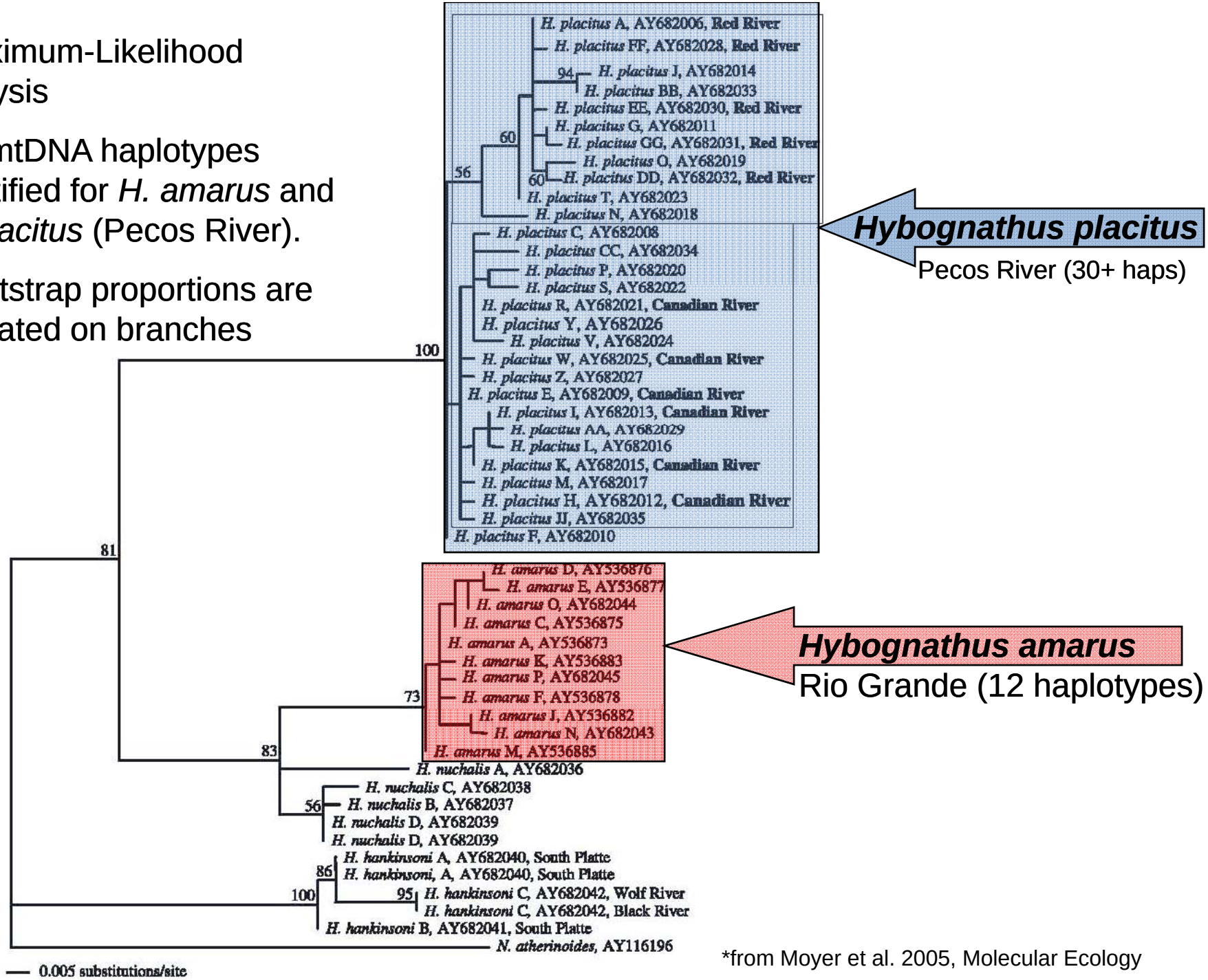
Data and Figure courtesy of R.K. Dudley & S. P. Platania, MSB Fishes



Sampling Design

- Analysed individuals for 10 microsatellite loci and one mtDNA locus.
- Adult individuals sampled over eight generations (1999-2006), and over 10 localities representing the current geographic range of the species.
- Sampling conducted to evaluate temporal genetic diversity and estimate the genetic effective population size to adult census size ratio (N_e/N)

- Maximum-Likelihood analysis
- All mtDNA haplotypes identified for *H. amarus* and *H. placitus* (Pecos River).
- Bootstrap proportions are indicated on branches

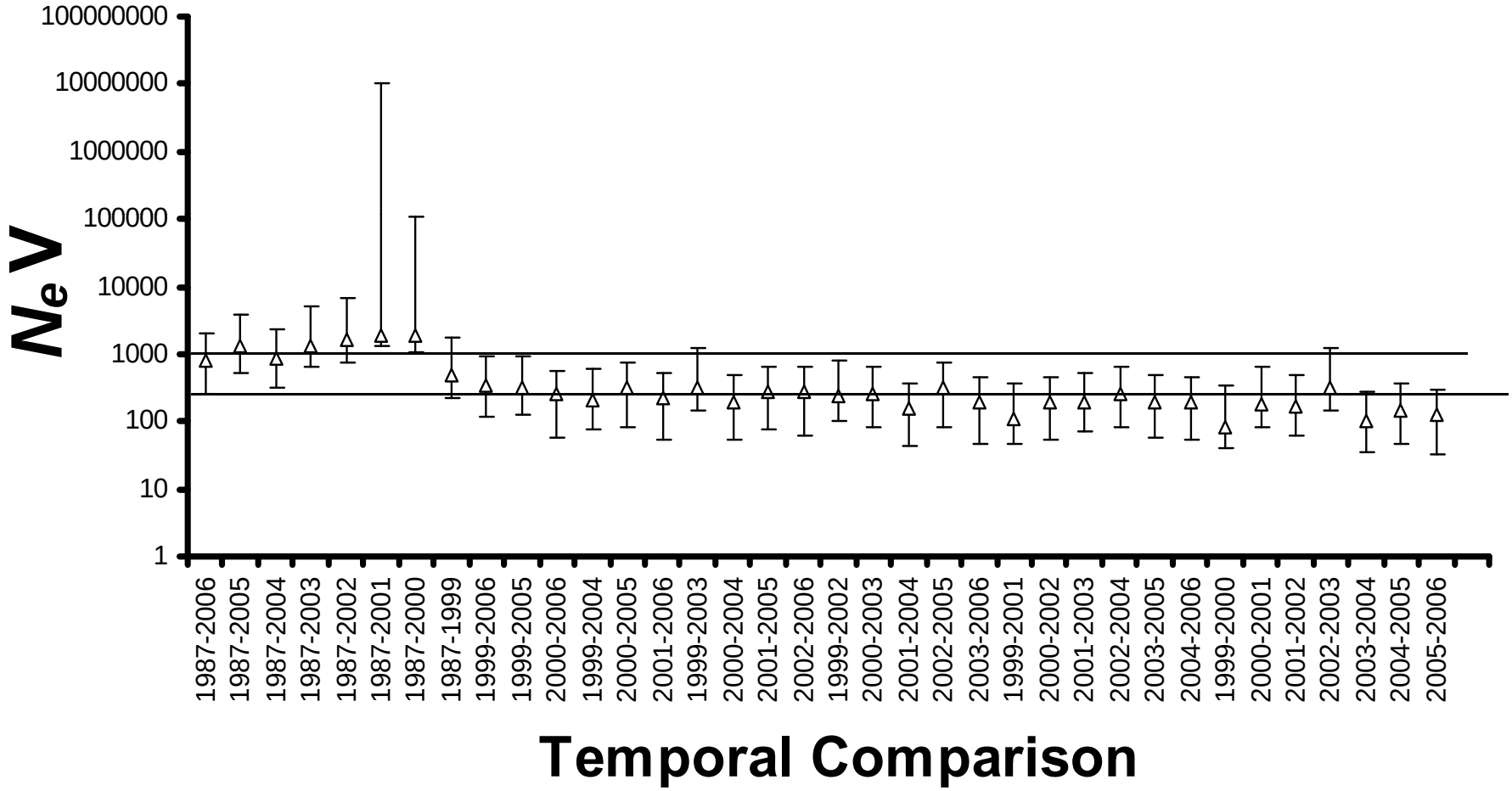


*from Moyer et al. 2005, Molecular Ecology

Spatial Structure – Adults

Year Class	F_{SC}	Localities	Total pairwise	Number significant	Type I Error
2000	-0.001	4	6	0	0.30
2001	**0.001***	2	1	1	0.05
2002	**0.008***	7	21	9	1.05
2003	0.008	3	3	1	0.15
2004	**0.020***	4	6	5	0.30
2005	**0.003***	6	15	6	0.75
2006	**0.004***	8	28	10	1.40
	5/7		80	32	4

Variance Effective size (N_{eV})



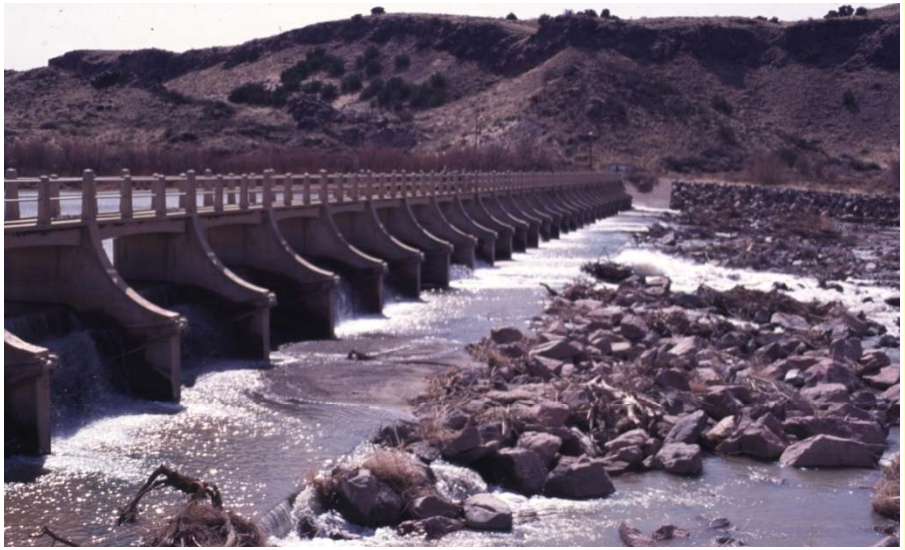
Reproductive Success

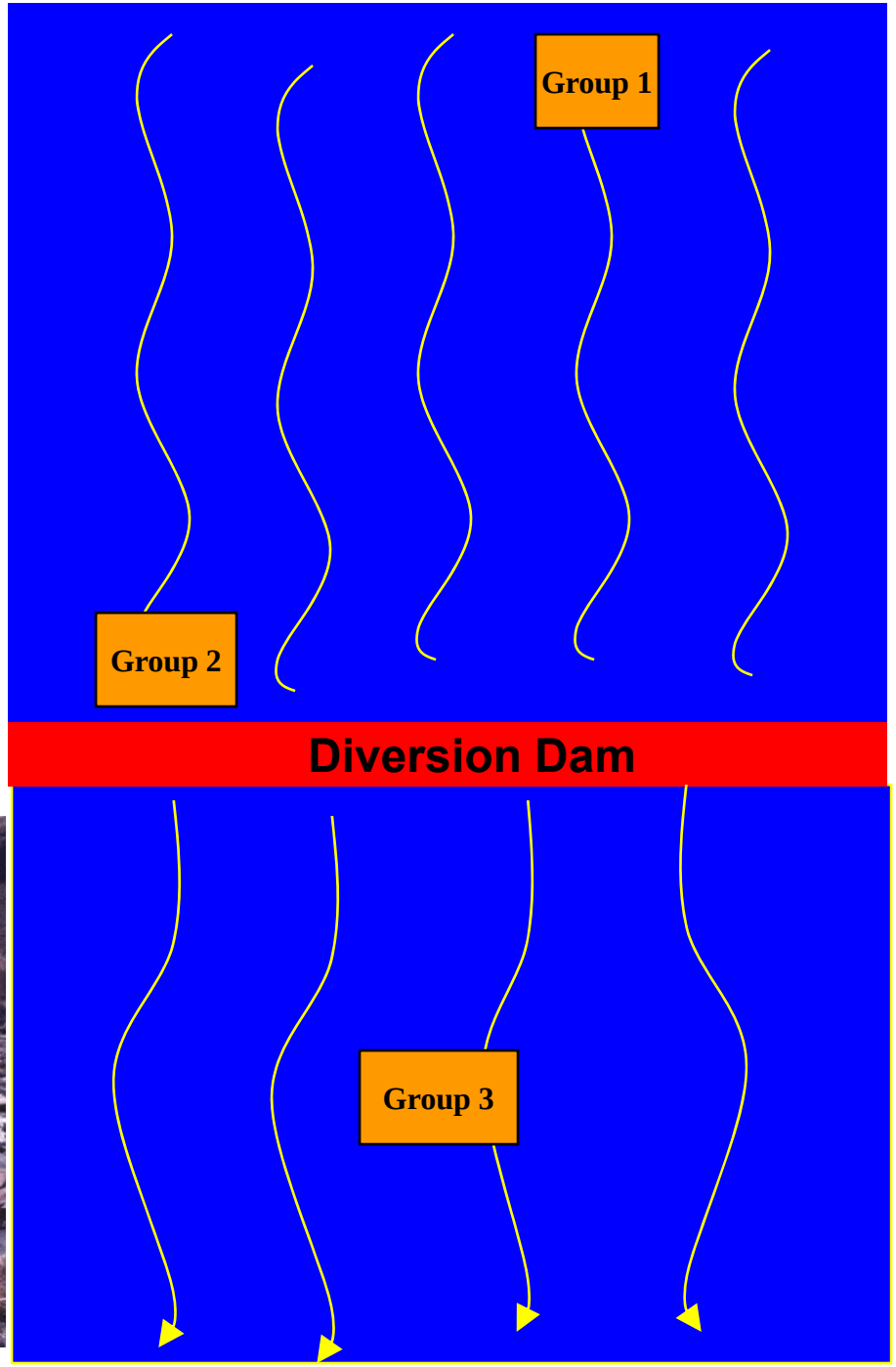
Dispersive Larvae

Group 1 > Group 2

Larval Retention

Group 1 = Group 2





The interaction of habitat fragmentation and life history for lowering N_e: A viable hypothesis?

- Present day N_e/N << pre-fragmentation N_e/N (Alò & Turner 2005)

- RGSM eggs drift in genetically discrete groups (Osborne et al. 2005). May reflect spatially discrete spawning aggregations

- Ecologically and evolutionarily similar species in unfragmented, but otherwise similar habitats do not show lowered N_e/N (Turner et al. 2006)

Goals of Propagation & Genetics Workgroup

- Hold sufficient numbers to repopulate the species (we have argued roughly 500,000 reproductively capable adults)
- Maximize production and number of distinct propagation facilities (Biopark, Dexter, NMSU, ISC)
- Maximize genetic diversity, effective population size, minimize inbreeding and VRS
- Avoid Ryman-Laikre effect to extent possible

Captive Propagation and Rearing

Maintenance of captive broodstock

Rearing wild-caught eggs

Captive Spawning of RGSM

Small body size imposes limits on spawning techniques

Three experimental approaches:

(1) Pairwise matings

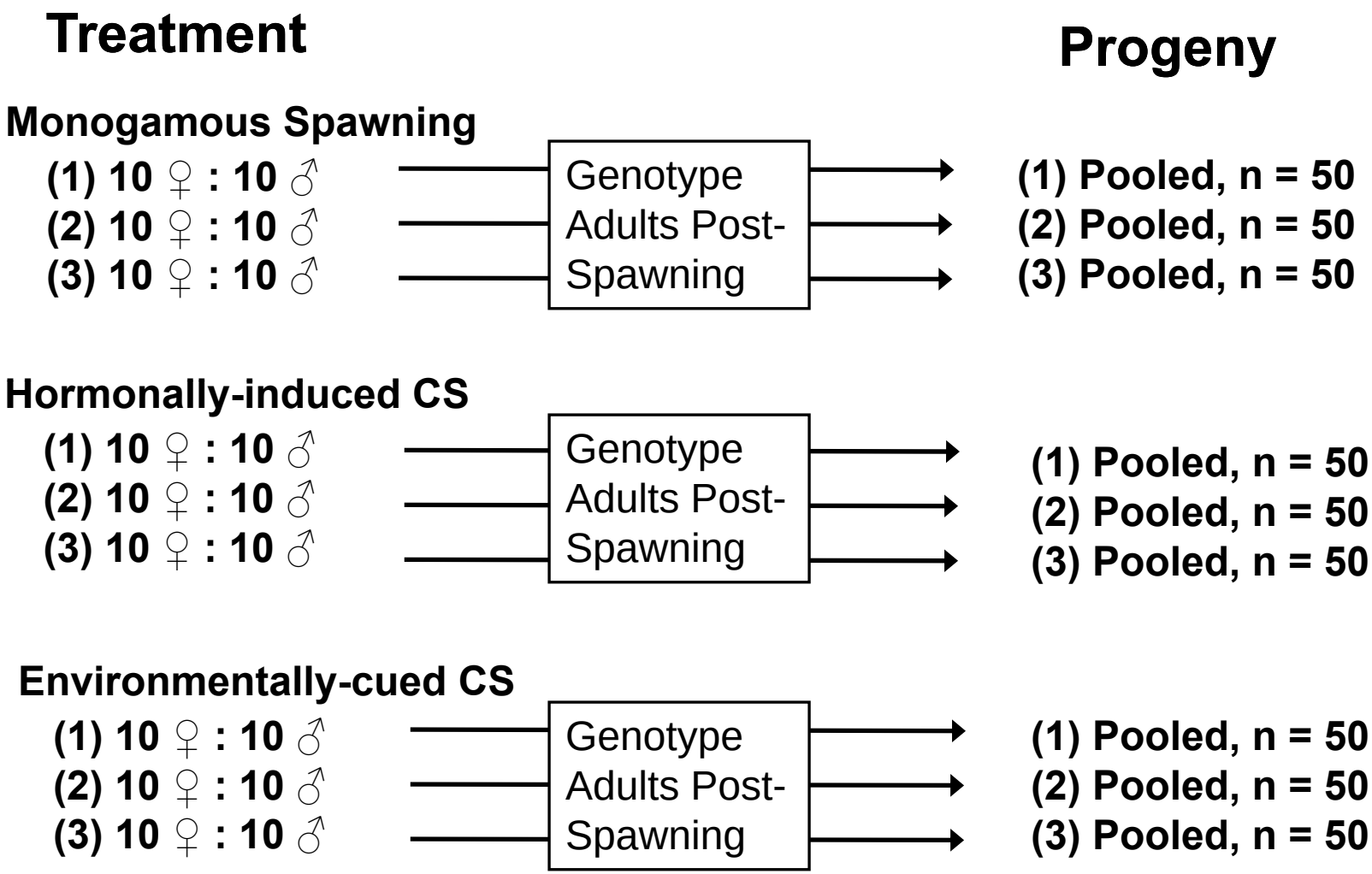
(2) Hormonally-Induced communal spawning

(3) Environmentally-Induced Communal Spawning

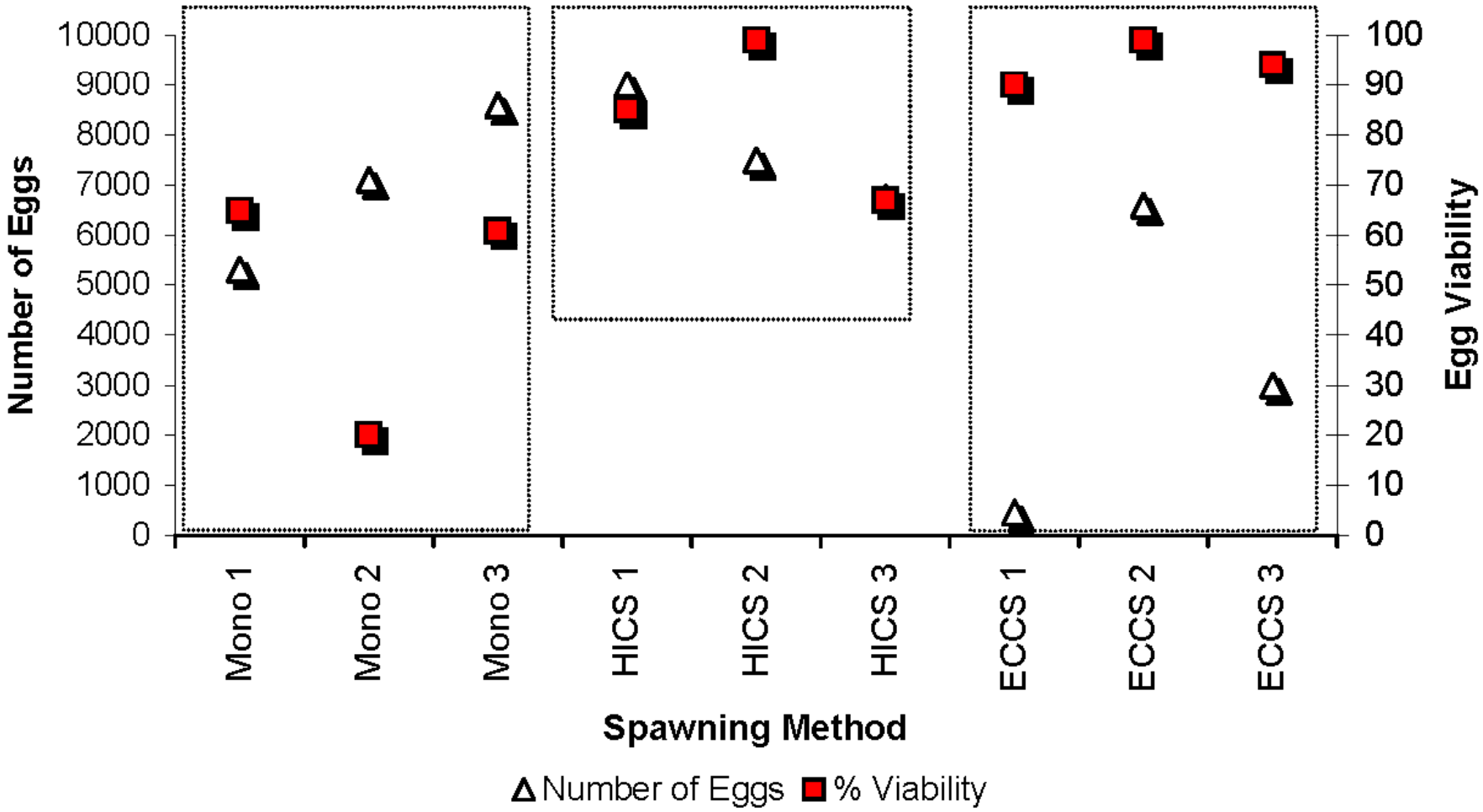
Targets:

Maximize production and viability; N_e

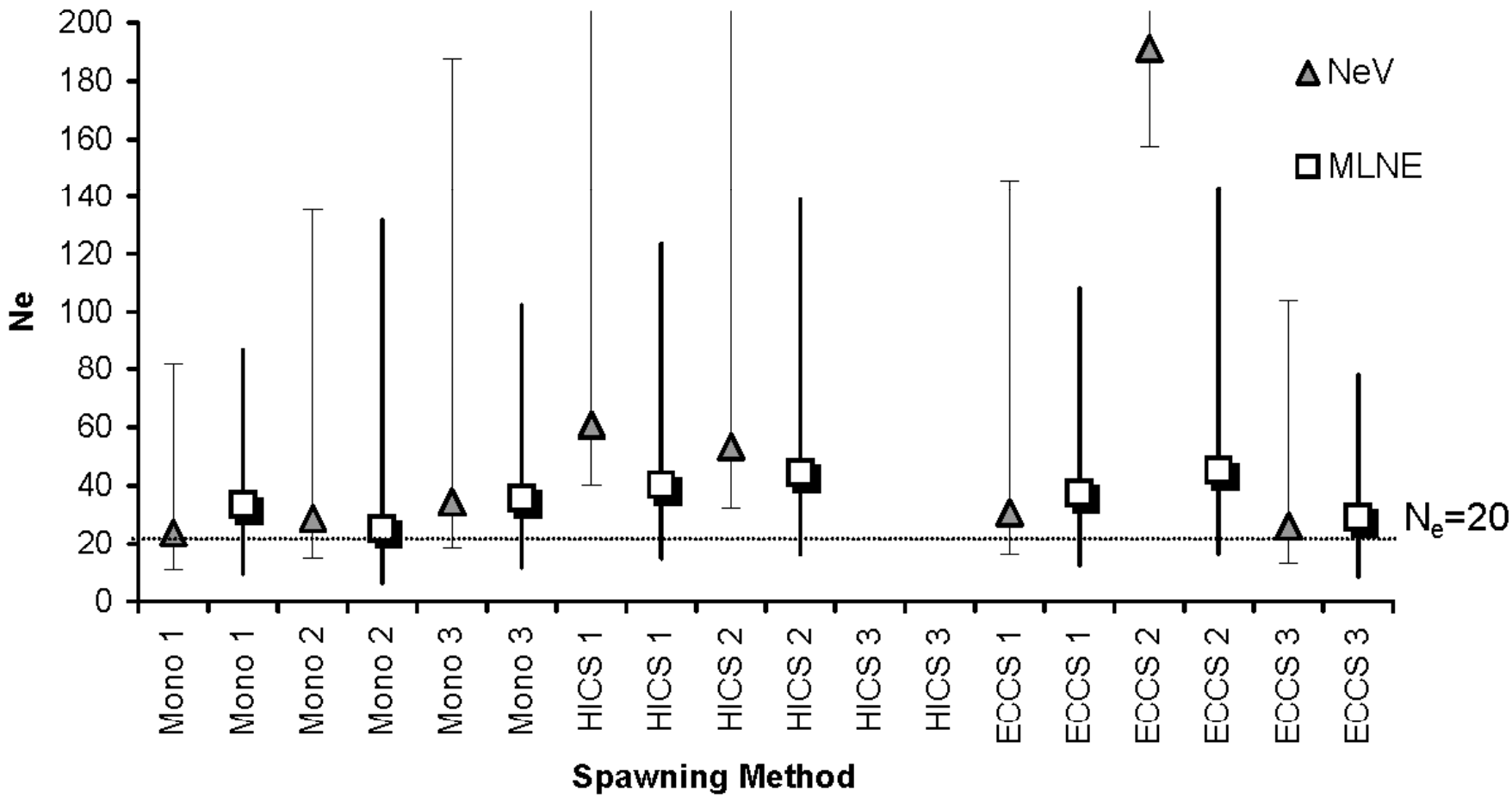
Minimize loss of diversity; variance family size


Treatment
Progeny
Monogamous Spawning
(1) 10 ♀ : 10 ♂
(2) 10 ♀ : 10 ♂
(3) 10 ♀ : 10 ♂
Genotype Adults Post-Spawning
(1) Pooled, n = 50
(2) Pooled, n = 50
(3) Pooled, n = 50
Hormonally-induced CS
(1) 10 ♀ : 10 ♂
(2) 10 ♀ : 10 ♂
(3) 10 ♀ : 10 ♂
Genotype Adults Post-Spawning
(1) Pooled, n = 50
(2) Pooled, n = 50
(3) Pooled, n = 50
Environmentally-cued CS
(1) 10 ♀ : 10 ♂
(2) 10 ♀ : 10 ♂
(3) 10 ♀ : 10 ♂
Genotype Adults Post-Spawning
(1) Pooled, n = 50
(2) Pooled, n = 50
(3) Pooled, n = 50

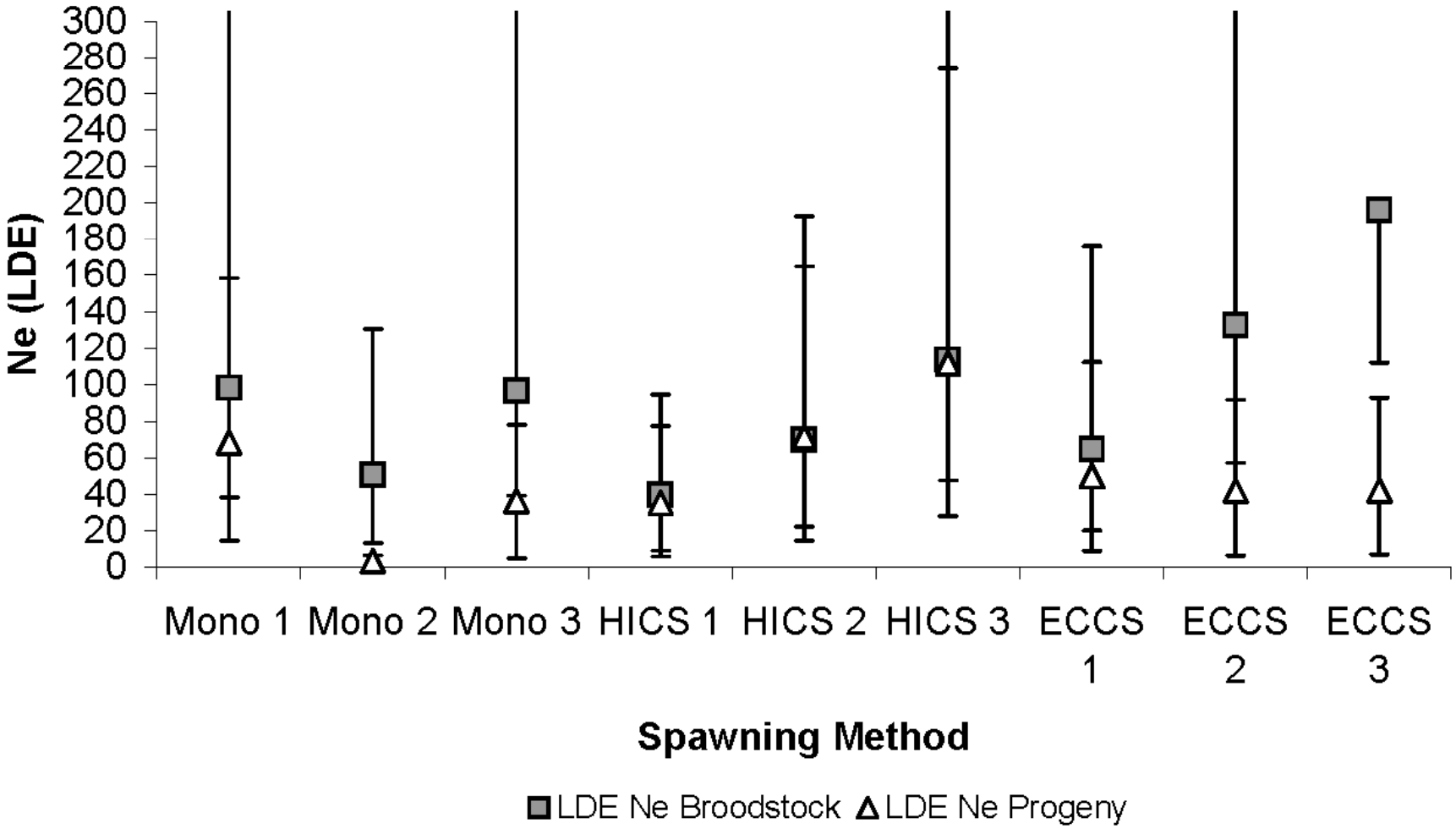
Production and Viability of Eggs
Captive Spawning Experiment

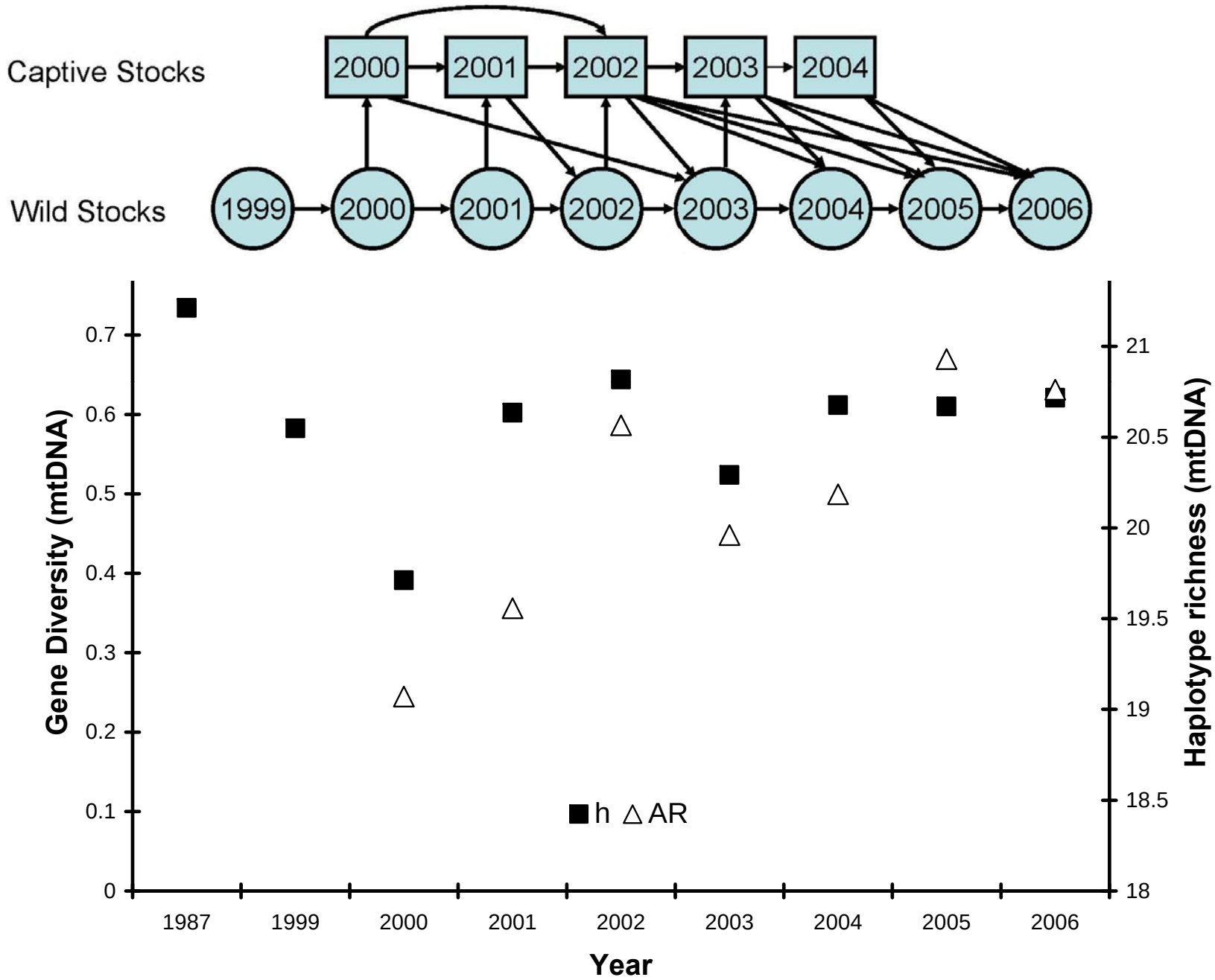


Variance Effective Size - Progeny

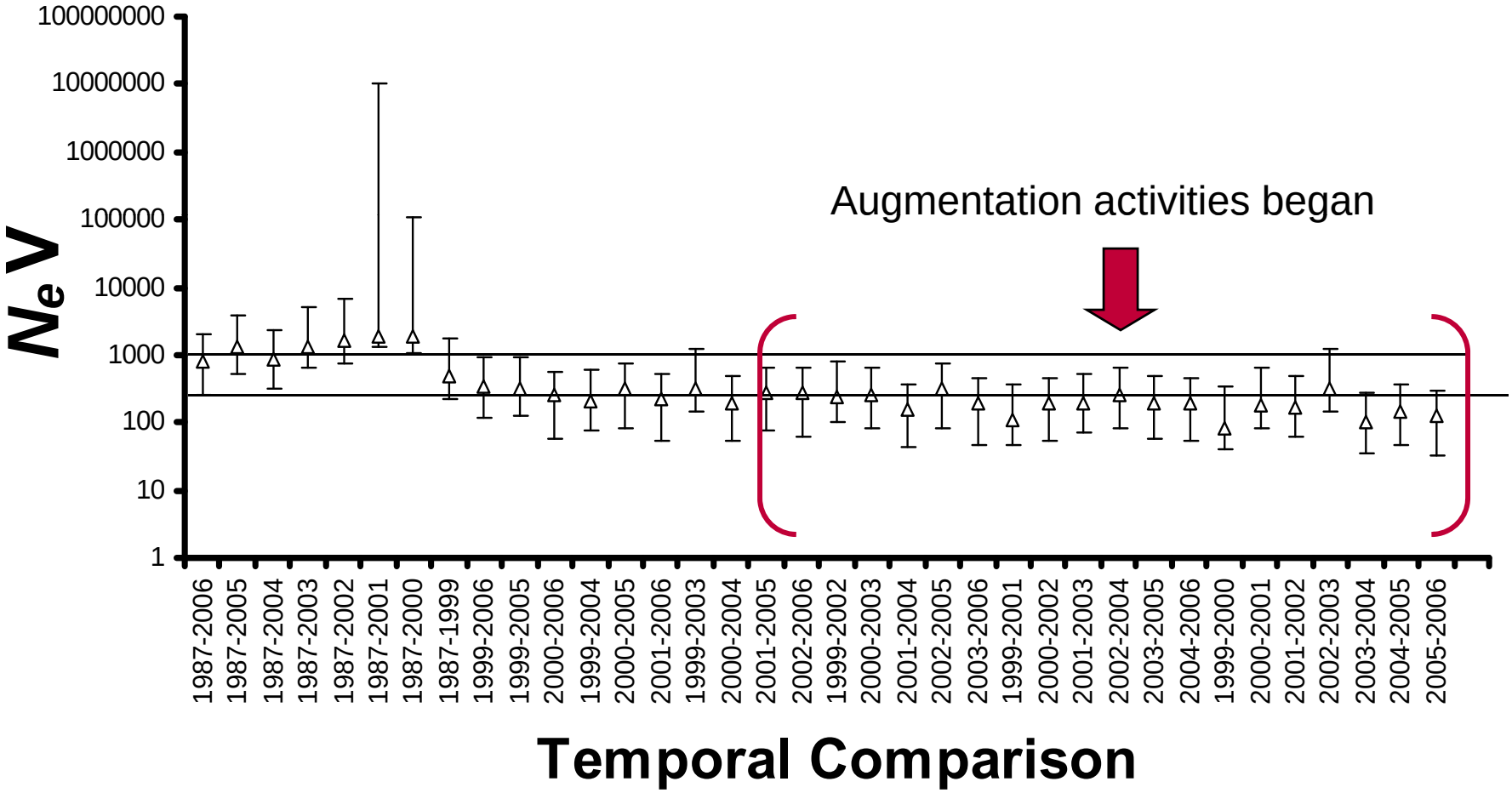


N_e (LDE - Waples & Do 2007): Parents & Progeny




Captive Stocks
2000
2001
2002
2003
2004
Wild Stocks
1999
2000
2001
2002
2003
2004
2005
2006
Gene Diversity (mtDNA)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Haplotype richness (mtDNA)
21
20.5
20
19.5
19
18.5
18
h
AR
1987
1999
2000
2001
2002
2003
2004
2005
2006
Year

Effective size (N_e)



Conclusions

- An interaction between early life history and habitat fragmentation exerts strong effects on the trajectory of genetic diversity in Rio Grande silvery minnow.
- Wild stocks exhibit local spawning aggregrations, high variance in reproductive success, and low genetic effective size
- Repatriates reared from wild-caught eggs appear to best reflect natural levels of genetic diversity – egg collection must encompass entire spawning period

Conclusions - 2

- Hormone-induced communal spawning appears to synchronize reproduction and maximize (or minimize) target metrics relative to other approaches
- Augmentation has increased genetic diversity in wild RGSM stocks but not variance effective size.
- Captive propagation and augmentation do not appear to be sufficient to halt long-term declines in genetic diversity; rather, they insure against catastrophic loss.
- Deterministic processes are an open question

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