Development of a Hatchery and Genetic Management Plan for Delta Smelt (*Hypomesus transpacificus*)

DECEMBER 6TH, 2017

deltacouncil.ca.gov

Daphne Gille, Melinda Baerwald, Ted Sommer, Tien-Chieh Hung, and Mandi Finger

Decline of Delta Smelt

1980s – Population decline

1993 – Listed as threatened (state & federal ESA)

2009 – Uplisted to endangered (state ESA)

Ubiquitous in the Delta

Low densities in east and south Delta

2015 – First zero value Summer Townet Survey

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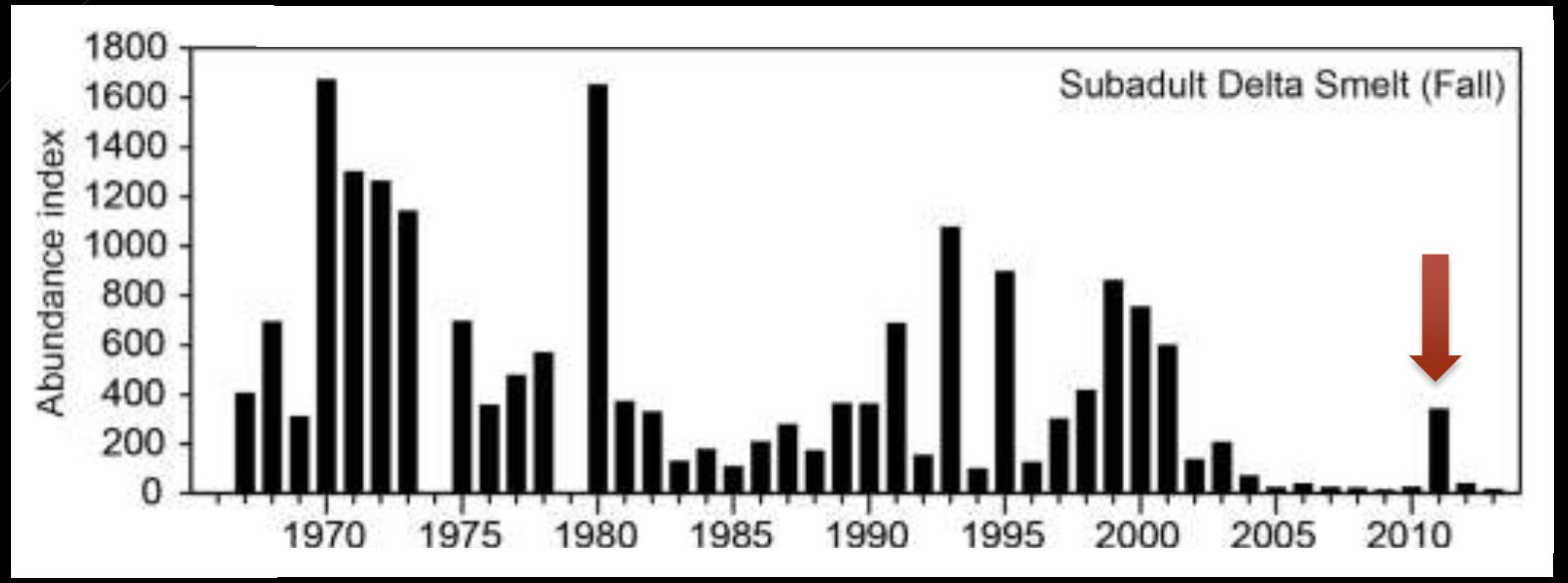
Causes of decline: multi-factorial and dynamic, ultimately human alteration of the Delta ecosystem

Decline of Delta Smelt



IEP 2015

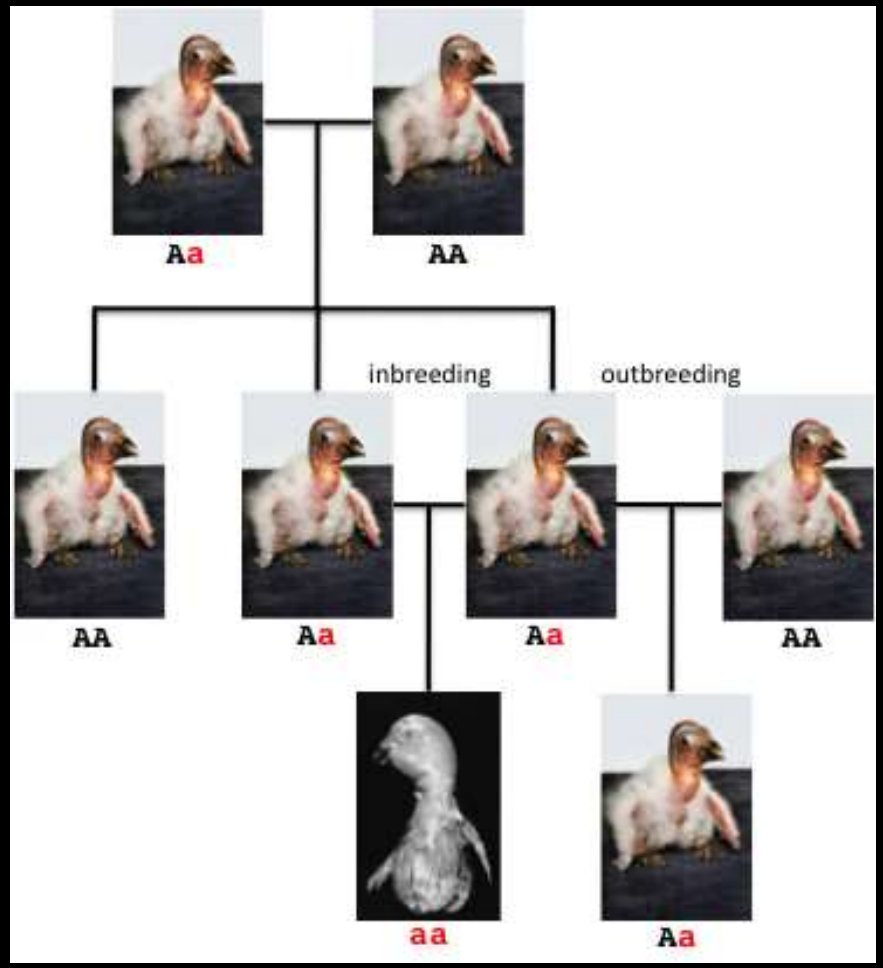
- In 2011, following a wet year, short-lived increase in Delta Smelt abundance
- Delta Smelt show resilience when conditions are favorable
- Habitat restoration is underway (completed before extinction?)

Refuge population at the FCCL

- Use cultured fish to bolster wild population in the short term
- Refuge population established in 2008 at FCCL using wild fish
- Safeguard against extinction and provide fish for research

Importance of genetic management

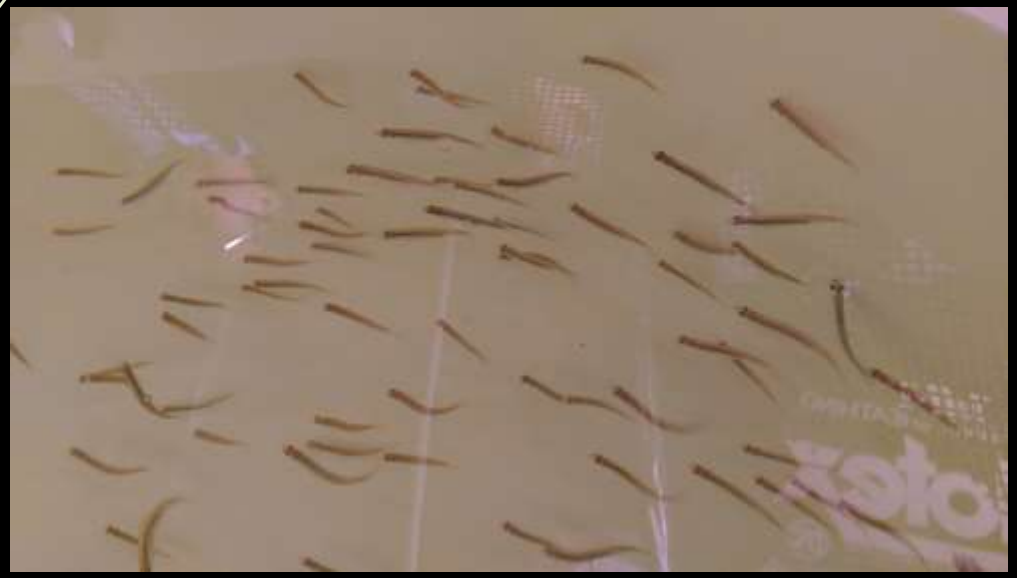
- Genetic management at the FCCL is in place (later)
- Genetic diversity = raw material for natural selection acts
- Greater genetic diversity = greater adaptive potential
- Loss of genetic diversity can lead to inbreeding and reduced fitness effects



Ralls et al. (2000); media.oregonlive.com

Hatchery and genetic management plan

- An HGMP will provide guidance and best practices for population supplementation and reintroduction
- Tool if/when such action is necessary (dictated by managers)
- Recommendations for the Fish Technology Center (FTC) and conservation hatchery (Rio Vista, CA)



Hatchery and genetic management plan

Purpose: guide for conservation hatcheries to preserve genetic diversity and defend against negative effects of artificial propagation

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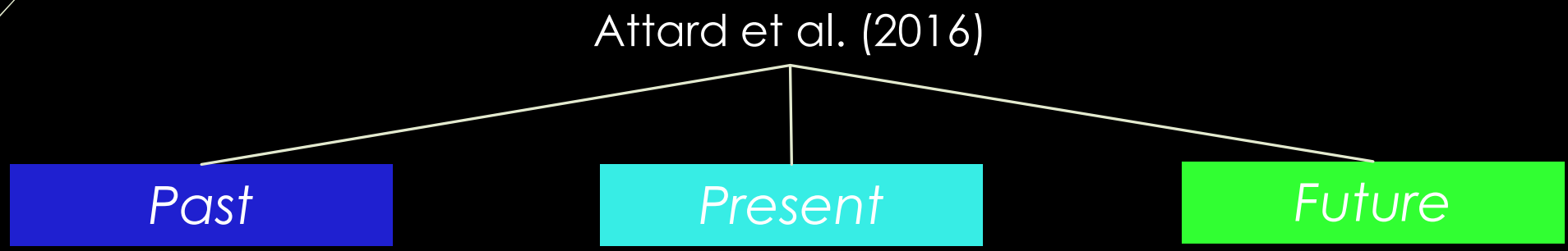

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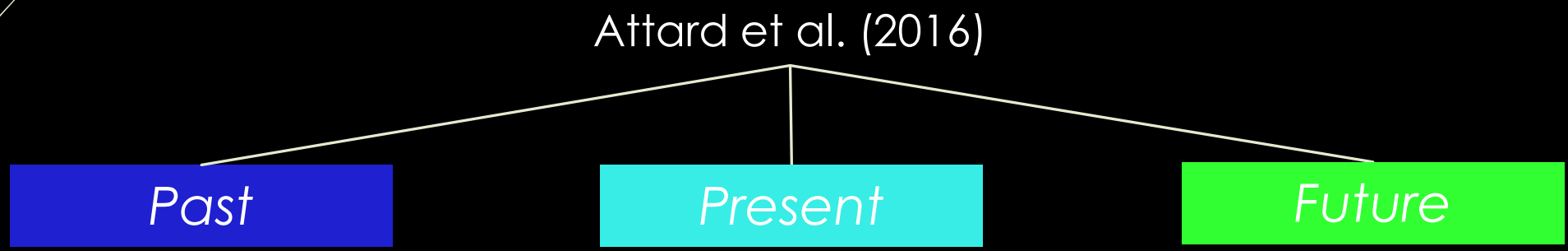

- History of species decline
- Wild population structure

Hatchery and genetic management plan

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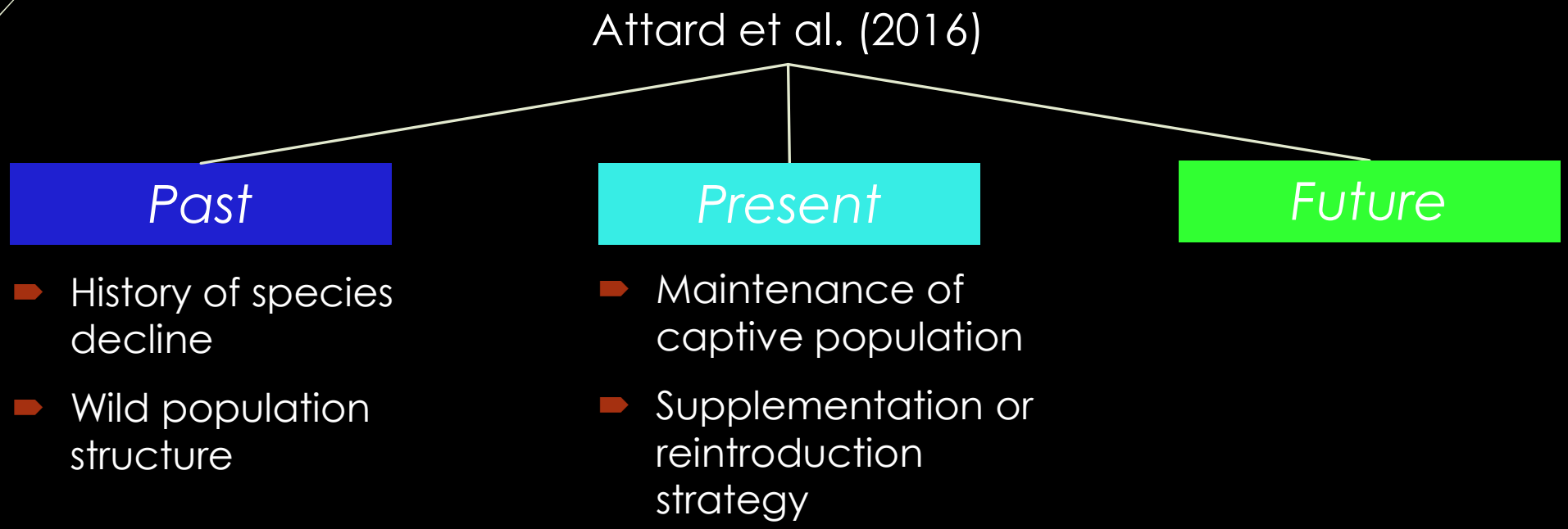

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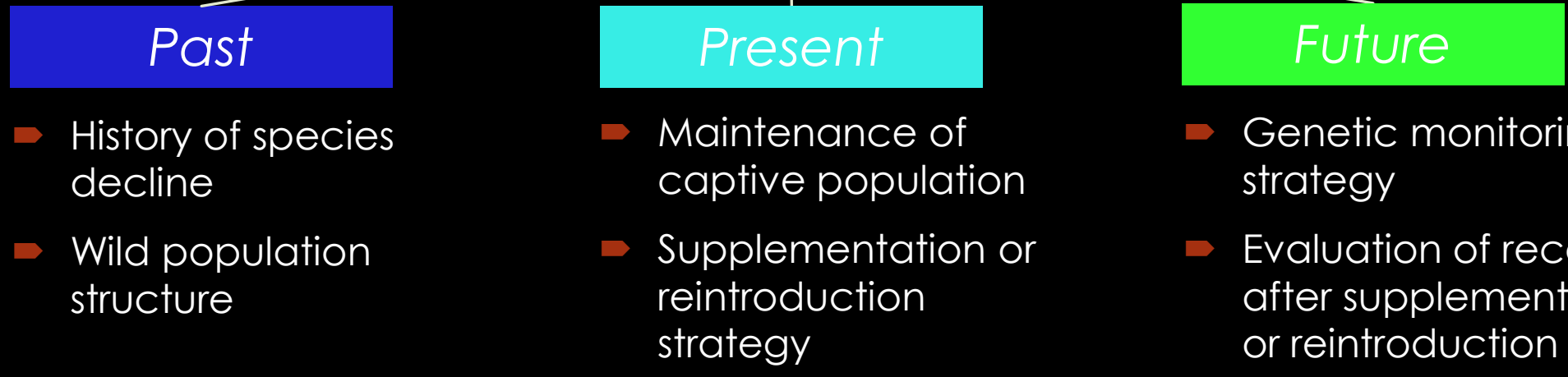
Attard et al. (2016)



Past

Hatchery and genetic management plan

Fisch et al. (2011)

- 15 microsatellite markers
- 2003, 2005, 2007 & 2009

Past

Hatchery and genetic management plan

Fisch et al. (2011)

- 15 microsatellite markers
- 2003, 2005, 2007 & 2009
- No reduction in genetic diversity

Table 1 Sample size, allelic richness, levels of heterozygosity and the inbreeding coefficient of all delta smelt sampled in five regions throughout their range in the San Francisco Bay-Delta over four sampling years

	2003						2005						2007						2009					
	N	A_R	H_O	H_E	*HW*	F_{IS}	*N*	A_R	H_O	H_E	*HW*	F_{IS}	*N*	A_R	H_O	H_E	*HW*	F_{IS}	*N*	A_R	H_O	H_E	*HW*	F_{IS}
Region																								
Suisun Bay	11	12	0.83	0.82	0	−0.01	31	12	0.79	0.81	0	0.03	–	–	–	–	–	–	15	12	0.82	0.83	0	0.01
Montezuma Slough	15	12	0.83	0.84	0	0.01	114	13	0.82	0.84	0	0.02	91	13	0.82	0.83	0	0.01	91	13	0.82	0.83	1	0.01
Lower Sacramento River	93	12	0.82	0.82	0	0.01	42	12	0.82	0.82	1	0.01	42	13	0.79	0.83	0	0.04	151	13	0.82	0.83	2	0.01
Cache Slough Complex	57	12	0.81	0.82	1	0.01	87	13	0.79	0.83	0	0.04	60	13	0.83	0.83	0	−0.01	–	–	–	–	–	–
Deep Water Ship Channel	–	–	–	–	–	–	42	13	0.77	0.83	4	0.07	143	13	0.82	0.84	3	0.02	108	12	0.82	0.80	0	0.03
All populations pooled		20	0.82	0.83		0.01		21	0.80	0.83		0.034		21	0.82	0.83		0.015		21	0.81	0.83		0.02
Total	176				1		316				5		336				3		365				3	

N number of individuals, A_R allelic richness[a]; H_O observed heterozygosity, H_E expected heterozygosity, *HW* number of loci with significant Hardy–Weinberg disequilibrium[b], F_{IS} inbreeding coefficient

[a] Allelic richness (A_R) based on a minimum sample size of 156 diploid individuals for the pooled value compared between years and on 20 diploid individuals when compared within and between years for each region

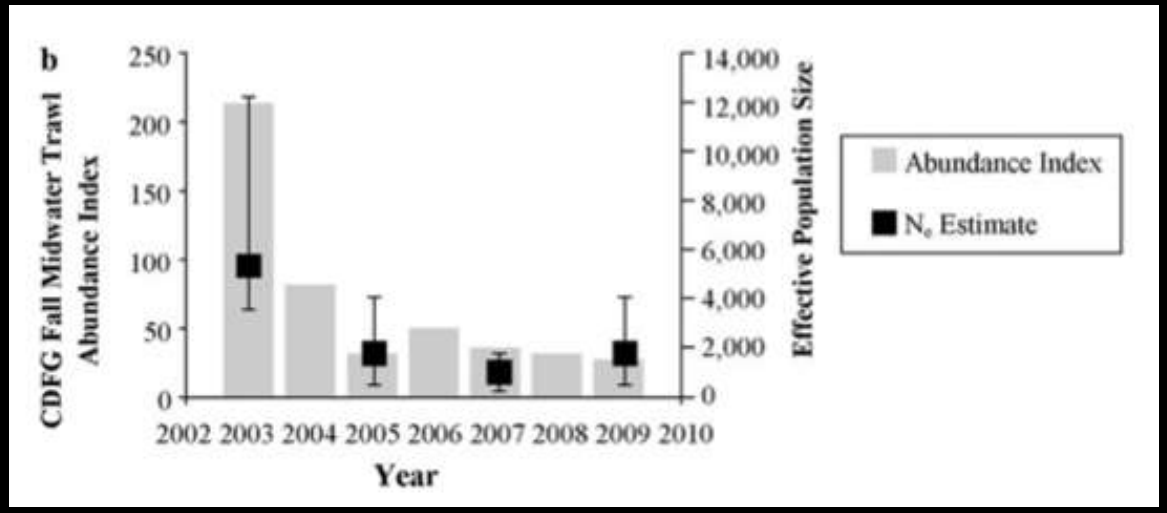
[b] Statistically significant at $P < 0.05$ after Bonferroni correction

Past

Hatchery and genetic management plan

Fisch et al. (2011)

- 15 microsatellite markers
- 2003, 2005, 2007 & 2009
- No reduction in genetic diversity
- Lack of population structure
- Persistent bottleneck
- Decline in effective population size



Past

Hatchery and genetic management plan

Topics to be covered in the HGMP:

- Update wild population genetics
- Use SNP markers and high throughput sequencing
- Improve resolution of indices of genetic diversity
- Evaluate functional genetic diversity/adaptation to captivity

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Conserv Genet (2017) 18:1011–1022
DOI 10.1007/s10592-017-0949-3

RESEARCH ARTICLE

Selection and genetic drift in captive versus wild populations: an assessment of neutral and adaptive (MHC-linked) genetic variation in wild and hatchery brown trout (*Salmo trutta*) populations

Tamara Schenekar[1] · Steven Weiss[1]

Present

Hatchery and genetic management plan

Genetic management plan for the FCCL (Finger and May 2015):

- Captive spawning initiated in 2008 (F_{10} in 2017)
- Controlled mate selection
- Minimize kinship and preserve genetic diversity

Present

Hatchery and genetic management plan

Genetic management plan for the FCCL (Finger and May 2015):

- Captive spawning initiated in 2008 (F_{10} in 2017)
- Controlled mate selection
- Minimize kinship and preserve genetic diversity

Incorporate wild breeders

Equalize family size

Present

Hatchery and genetic management plan

- Collect ~100 wild Delta Smelt annually
- Tag ripe individuals, fin clips to GVL
- Genotype at 12 microsatellite loci
- Pedigree reconstruction/parentage
- Recommendations to minimize kinship and represent the greatest number of pair crosses from previous year
- Combine equal numbers of fertilized eggs from 8 families per tank

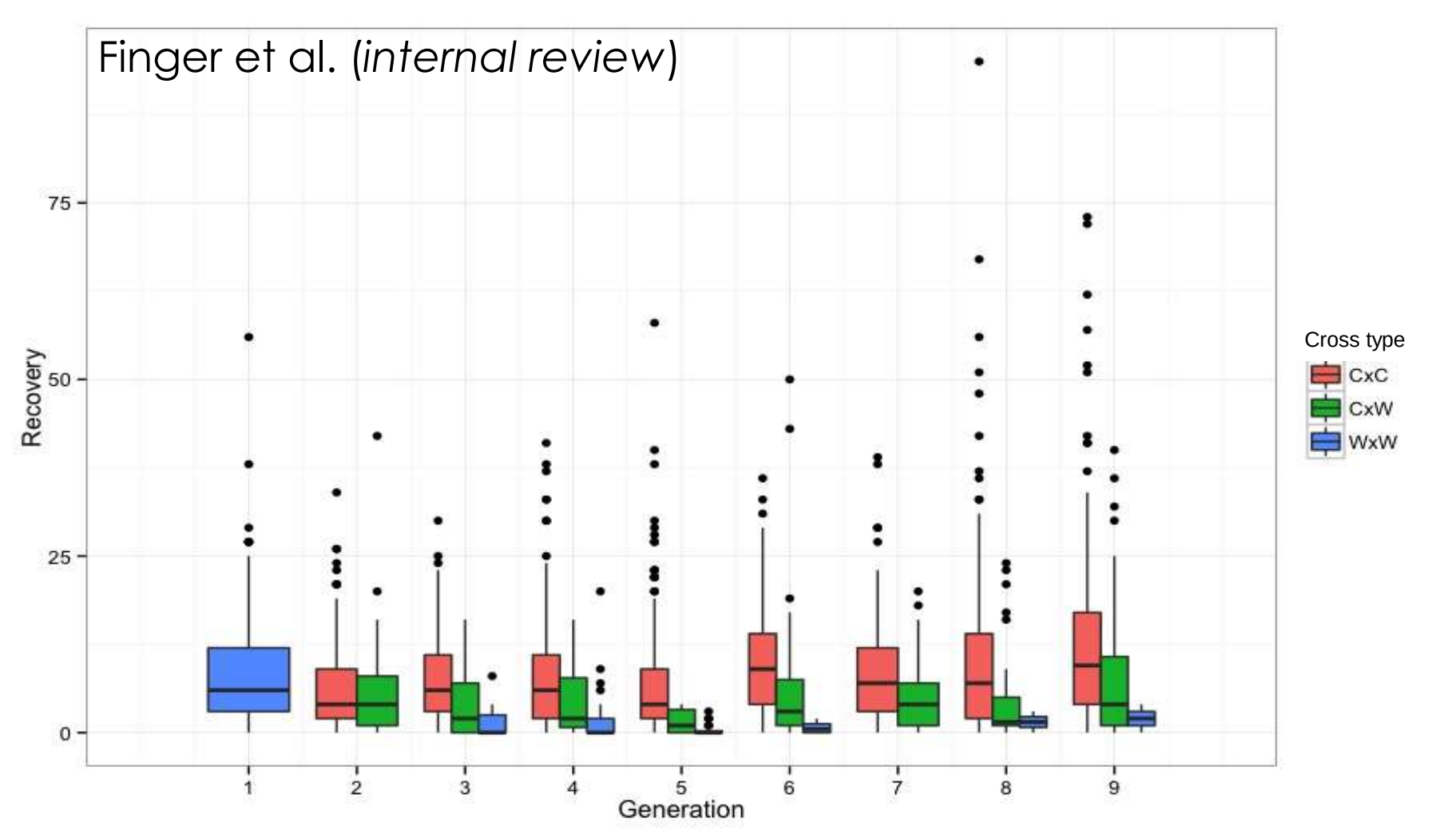
Present

Hatchery and genetic management plan

- Low pairwise F_{ST} among generations (-0.0001 to 0.006) comparing wild, cultured, and total refuge population
- High effective population size (Mean $N_e/N = 0.81$)
- Low mean inbreeding (0.0008)
- Evidence of domestication selection (lower fitness in wild)

Present

Hatchery and genetic management plan



Present

Hatchery and genetic management plan

Topics to be covered in the HGMP:

Minimize domestication selection (alter current protocol)

- Minimize time spent in hatchery (minimal ancestry)
- Release at egg stage (Wakasagi hatching frames)
- Increase wild fish representation (spawn wild >1x, unrelated)
- Aim for mid-level effective population size (slow selection)
- Enriched environment
- Life skills training (e.g., predator avoidance)
- Soft release/acclimatization

15.plala.or.jp/niru_04/houryu.html

Present

Hatchery and genetic management plan

Topics to be covered in the HGMP:

Refuge population at the FTC and the conservation hatchery (Rio Vista, CA; partnership with UC Davis)

- Adapting genetic management practices for FTC, scale up
- Depends upon availability of wild fish

Present

Hatchery and genetic management plan

Topics to be covered in the HGMP:

Population supplementation and reintroduction strategy

- Work with agency partners, establish goals
- Identification of adequate habitat is associated with success

Future

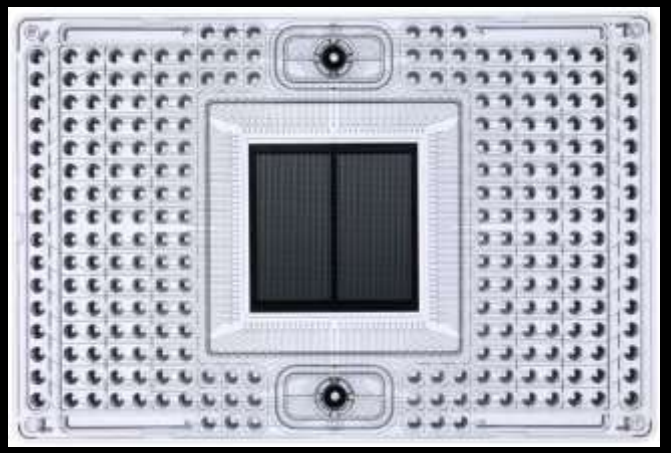
Hatchery and genetic management plan

Topics to be covered in the HGMP:

Genetic monitoring strategy

Lew et al. (2015)

- RADseq to identify SNPs
- 96.96 Fluidigm SNP panel
- 100% assignment
- Low cost (~$11/sample)



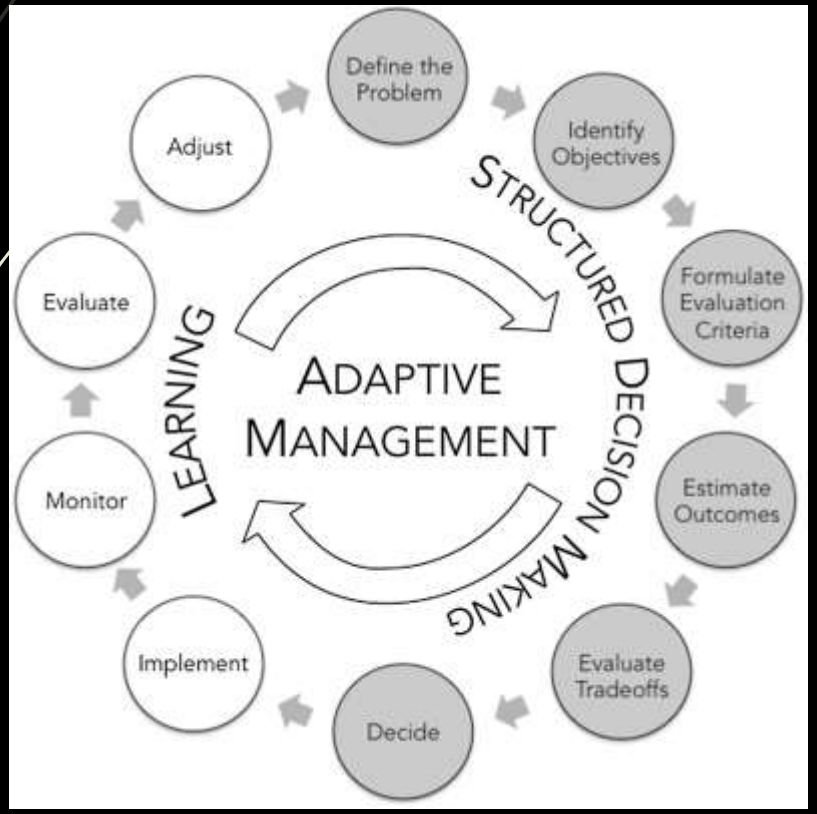
fluidigm.com

Future

Hatchery and genetic management plan

Topics to be covered in the HGMP:

Evaluation of recovery after supplementation or reintroduction



Birgé et al. (2016)

- Genetic comparisons between released, captive, and wild populations
- Assess survival/abundance, recruitment, diversity, inbreeding, and potential connectivity
- Practice adaptive management, learn from our mistakes

Delta Smelt HGMP in Summer 2019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Questions?