



Identification of Individual Cultured Delta Smelt Using Visual and Automated Analysis of Natural Marks



Marade Sandford¹, Wan-Ru Yang¹, Tien-Chieh Hung¹, Gonzalo Castillo², Galen Tigan¹, Luke Ellison¹, Erwin Van Nieuwenhuyse³

¹Fish Conservation and Culture Lab, UC Davis, Byron, CA
²U.S. Fish and Wildlife Service, Lodi FWS Office, Lodi CA
³U.S. Bureau of Reclamation, Bay-Delta Office, Sacramento, CA

Conclusions

- The percentage of correct visual matching in the 2013 sessions was higher than the 2014 sessions. This could be due to the number of days between sessions (nearly 56 days in 2013 and 90 days in 2014).
- The pigmentation patterns changed more as the fish matured, making it easier to make accurate matches as their spots stabilized as they get older and reached maturity.
- TinEye automated matching was not as accurate as visual matching, but had the benefit of being far less time consuming and had the ability to do comparisons among a larger data pool.
- Pigmentation generally became less apparent under the high light treatment, leading to a marginally lower percent of automated recognition relative to fish under low light.

Methods

- Conducted 3 photo sessions in 2 fish groups (Jan-May 2013 and Oct-Apr 2014/15, hereafter 2013 and 2014 sessions). First photo session included adults in 2013 and subadults in 2014. Tested effect of low and high light treatments for matching in the 2014 sessions.
- Used the dorsal head area to evaluate natural marks using visual (naked eye) and automated image recognition (TinEye's Match Engine API).
- Photos for visual matching were unedited dorsal images (UDI; Fig. 1A). Photos used for TinEye were cropped (Figs. 1B, 1C and 1D).
- Evaluated whether the cropped area-of-interest (Fig. 1C) would improve automated matching relative to DHA (Fig. 1B) and AOI5 (Fig. 1D).

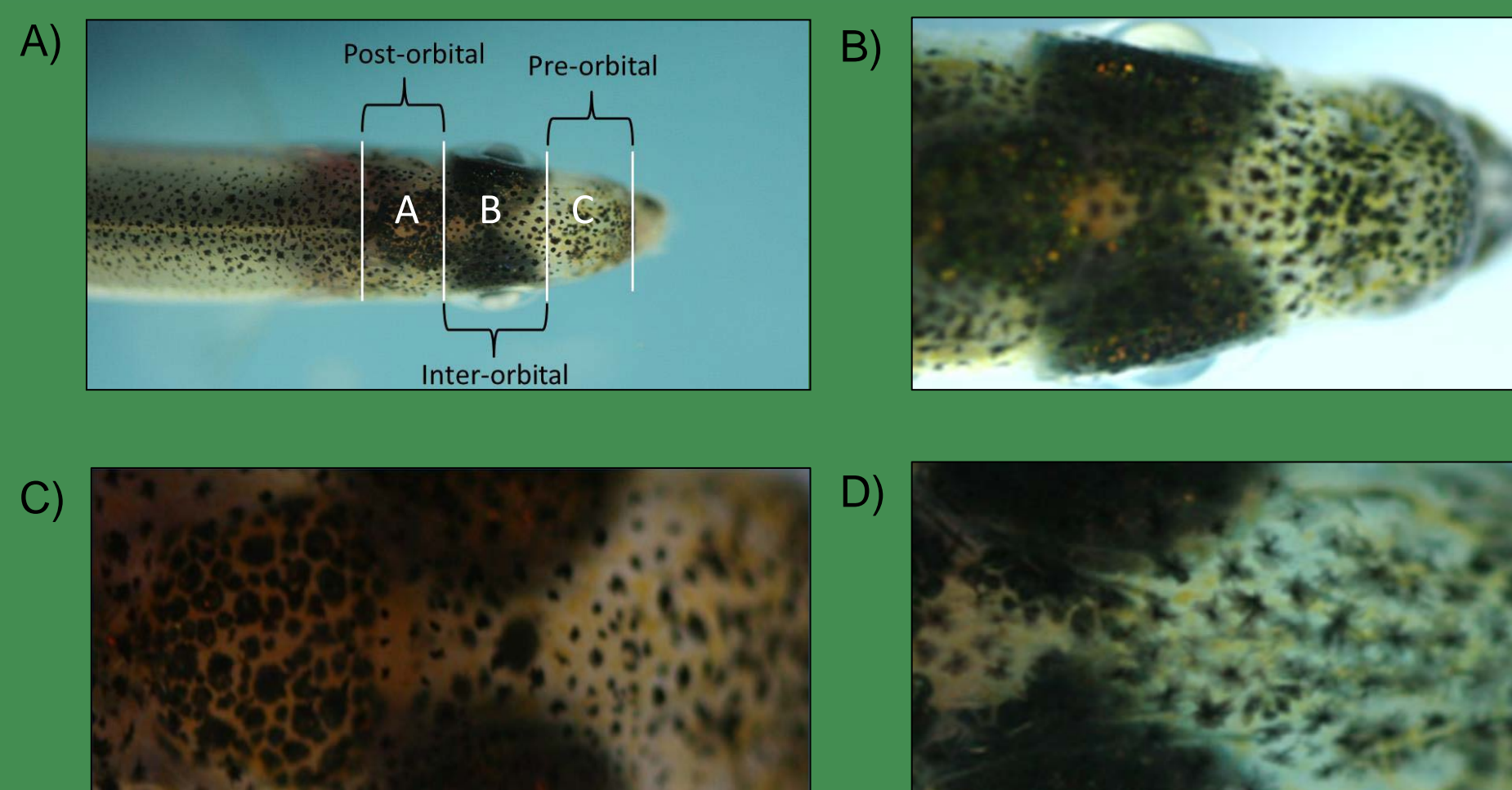


Figure 1. Areas used for photo matching: (A) UDI: AOI A, B and C and areas behind the head; (B) DHA: AOI A, B, C; (C) cropped AOI: cropped AOI A, B, C; and (D) AOI5: cropped AOI B and C.

Data/Results

- Shorter intervals between photo sessions (nearly 56 days in 2013 and 90 days in 2014) resulted in higher percent correct matching for both visual recognition (100% in 2013 and 70-100% in 2014; Table 1) and automated recognition (59-89% in 2013 and 19-33% in 2014; Figure 2).
- Pigmentation generally became less apparent under the high light treatment, leading to a marginally lower percent of automated recognition relative to fish under low light (Tables 3 and 4).
- TinEye correct matching ranged from 13.3% to 92.9% while visual matching ranged from 70-100%.
- TinEye match rate was higher for AOI5 (93.3%) than for cropped AOI (80%) for Session 1 vs. 2, but similar match rates were found for Session 2 vs. 3, (Table 2).

Table 1. Percent correct visual matching for 2013 and 2014.

	2013	2014
Sessions 1-2	100%	83%
Sessions 2-3	100%	100%
Sessions 1-3	100%	70%*

*Data from one tester. All other scores are for both testers.

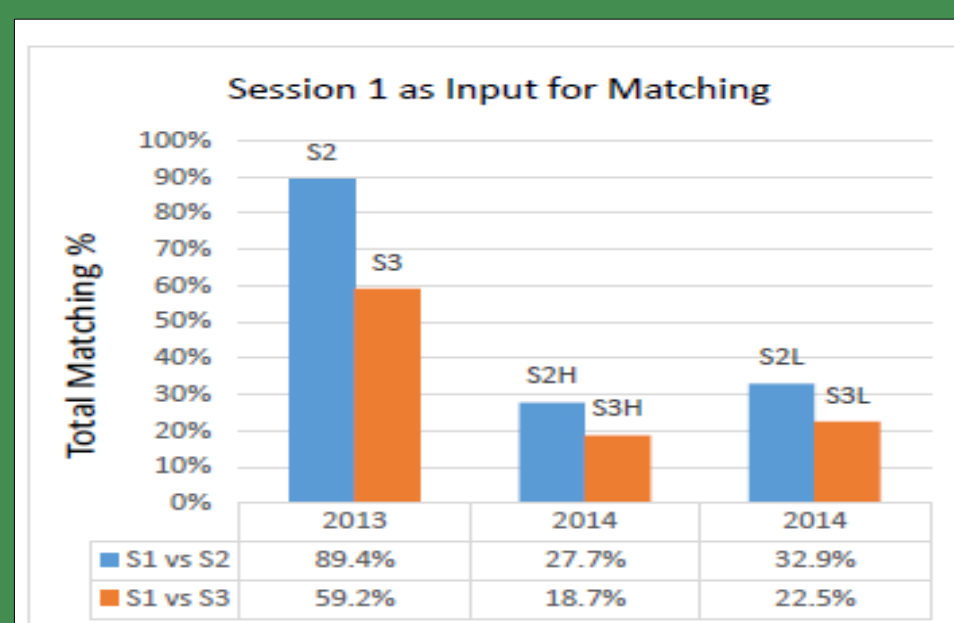


Figure 2. Percent matching for all fish in 2013 and 2014 sessions using automated matching based on AOI5.

Table 3. High light treatment comparison between visual and TinEye matching for the 2014 sessions.

2014 High Light	Session 1 vs. Session 2			
	Tester-G (UDI)	TinEye (Cropped AOI)	Tester-M (UDI)	TinEye (Cropped AOI)
# sample compared	15	15	15	15
# sample matched	13	4	13	2
# wrong match	2	0	2	0
# unmatched	0	11	0	13
% matched	86.7%	26.7%	86.7%	13.3%
% wrong match	13.3%	0.0%	13.3%	0.0%
% unmatched	0.0%	73.3%	0.0%	86.7%

Table 4. Low light treatment comparison between visual and TinEye matching for the 2014 sessions.

2014 Low Light	Session 1 vs. Session 2			
	Tester-G (UDI)	TinEye (Cropped AOI)	Tester-M (UDI)	TinEye (Cropped AOI)
# sample compared	15	15	15	15
# sample matched	12	5	12	5
# wrong match	3	0	3	1
# unmatched	0	10	0	9
% matched	80.0%	33.3%	80.0%	33.3%
% wrong match	20.0%	0.0%	20.0%	6.7%
% unmatched	0.0%	66.7%	0.0%	60.0%

Table 2. Comparisons between DHA, cropped AOI, and AOI5 and bad photos using TinEye.

2013	2013 Session 1 vs. Session 2		2013 Session 2 vs. Session 3	
	Cropped AOI	AOI5	Cropped AOI	AOI5
# sample compared	30	30	30	30
# sample matched	24	28	29	28
# wrong match	0	0	0	0
# unmatched	6	2	1	2
% matched	80.0%	93.3%	96.7%	93.3%
% wrong match	0.0%	0.0%	0.0%	0.0%
% unmatched	20.0%	6.7%	3.3%	6.7%

2014 15 High light and 15 low light photos	2014 Session 1 vs. Session 2		2014 Session 1 vs. 2 (bad pictures)	
	DHA	Cropped AOI	Cropped AOI	AOI5
# sample compared	30	30	30	30
# sample matched	10	6	14	7
# wrong match	0	0	0	0
# unmatched	20	24	16	23
% matched	33.3%	20.0%	46.7%	23.3%
% wrong match	0.0%	0.0%	0.0%	0.0%
% unmatched	66.7%	80.0%	53.3%	76.7%

Implications/Recommendations

- Our results suggest natural marks may be more reliable to track cultured Delta Smelt at the adult stage than from the sub-adult to adult stage.
- Natural marks could be beneficial to identify and track Delta Smelt in the wild, and be far less invasive than tagging.
- TinEye did not match as many fish and was not as accurate as visual matching, but did reveal better results as the fish got older and reached maturity. TinEye is much more efficient and can run through thousands of photographs in seconds versus the time consuming visual methods that may take hours to match individuals. TinEye was also able to match poor quality photos (bad photos), while the visual matchers had a difficult time.
- Applications of natural marks in wild fish requires further testing as preliminary observations revealed significantly lower DHA pigmentation in field-caught adult Delta Smelt, suggesting higher light exposure in the Estuary.

Acknowledgements

Thank you to the staff at FCCL who tagged and maintained all of the fish used in this study, and the Bureau of Reclamation who sponsored this project.

Contact:

Gonzalo Castillo
 gonzalo_castillo@fws.gov