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Spatial and temporal patterns in use by native and non-native fish larvae of a recently flooded island in the Sacramento-San Joaquin River Delta

Mike Marshall, Heather Webb, & Rick Wilder, U.S. Fish & Wildlife Service, Stockton, CA <mike_j_marshall@fws.gov>

Introduction

As a result of a massive flooding event in 1997, the levees of Liberty Island, an artificial agricultural island in the lower Yolo Bypass, breached, flooding the interior of the island. The levees have not been repaired and the island has returned passively to a more natural "wetland" state.

Between 2003 and 2005, the Stockton Fish and Wildlife Office monitored abundances of larval fish in the interior of the island. There were four primary goals:

1. Assess abundances of native and non-native larval fish in tidally influenced areas compared to continuously submerged areas.
2. Assess abundances of native and non-native fish in areas with high wind and wave disturbance compared to more protected areas.
3. Determine intra- and inter-annual patterns of native versus non-native larval fish.
4. Determine whether the two sampling techniques used in our monitoring, light traps and 500 µm larval trawl nets, yield similar results.

Methods

We split the island into four zones that varied by observed tidal influence and observed wind/wave disturbance (Fig. 1). The northern portion experiences tidal inundation while the southern portion is continuously submerged. Because the predominant wind direction is west to east; samples from the east side of the island should be disturbed, while sites on the west side should be less disturbed.

We sampled at multiple sites throughout the island from March-May in 2003, February-June in 2004, and March-June in 2005.

Light traps were used in 2003 and 2004 (Fig. 2A). Traps were placed in the water for approximately 1 hour on each sampling date. Catch per unit effort (CPUE) is expressed as catch per sampling hour.

Larval trawls were used in 2004 and 2005 (Fig 2B). Trawling occurred both at night and during the day. Two trawl nets with 500 µm nylon mesh were towed on either side of a boat for 5-10 minutes. CPUE was calculated as catch per m^3 of water sampled, which was determined using a flow meter attached to one of the nets.

For both sampling techniques, fish were placed immediately in 10% formalin solution and returned to the lab for identification to species level. (Fig. 3).

Fig 3. Technique for identifying larval fish in the laboratory.

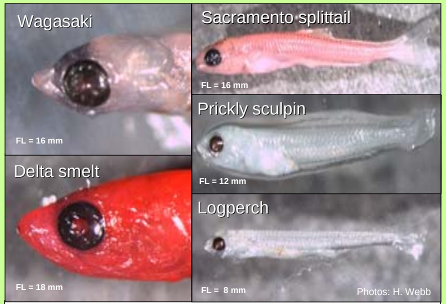

Fig. 4. Examples of larval fish collected during study.

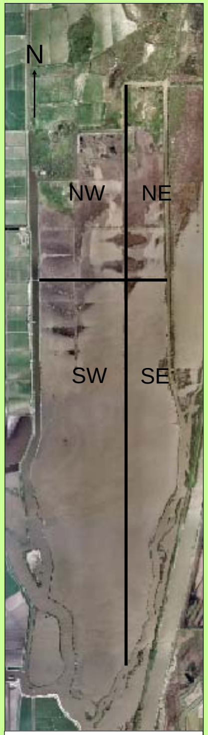

Fig. 1. Map of Liberty Island.

Results

A total of 24,057 larval fish in at least 26 known and unknown species were caught during sampling (Fig. 4; Table 1). The most common species, the native prickly sculpin, *Cottus asper*, accounted for 33% of all individuals caught. Seven of the 10 most abundant species and 37% of all larval individuals identified were native species.

In 2004, both light traps and larval trawls were conducted concurrently. Of the 23 species collected, 13 were captured by both gear types. Catches of inland silversides, logperch, and longfin smelt, were all disproportionately higher in light traps compared to larval trawls.

Temporal patterns

CPUE varied by nearly an order of magnitude in light traps between 2003 and 2004 (Fig. 5). Values of CPUE in larval trawls, however, were similar between 2004 and 2005. Peak CPUE of native fish was earlier in the year (March for both years using both gear types) than that of non-native fish (May-June in both years using both gear types).

Spatial patterns

During 2003, light trap sampling indicated that both natives and non-natives were more common on the western side of the island in the south (Fig. 6). In 2004, natives were more abundant in the southeast quadrant. Non-native fish were more abundant in the northwest.

Patterns in fish abundance in larval trawls were similar to those in light traps in 2004: native fish were more abundant in the southeast region; non-natives were more common in the northwest. In 2005, natives were more abundant in the northeast while non-natives were more abundant in the southeast.

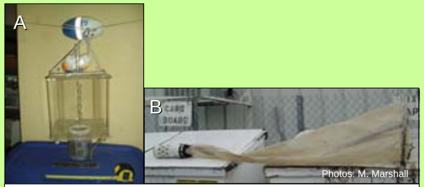

Fig. 2. Sampling gears used for monitoring: (A) light traps and (B) larval trawl nets.

Table 1. Fish species caught by gear type and year in order of total abundance. Green = native, red = non-native.

Fish Species	Light trap			Trawl			Total
	2003	2004	Sub-total	2004	2005	Sub-total	
Prickly sculpin, *Cottus asper*	778	3068	3846	602	3496	4098	7944
Threadfin shad, *Dorosoma petenense*	4	344	348	130	5811	5941	6289
Inland silversides, *Menidia beryllina*	1	3491	3492	99	1472	1571	5063
Striped bass, *Morone saxatilis*	10	299	309	112	968	1080	1389
Common carp, *Cyprinus carpio*	8	73	81	32	546	578	659
Logperch, *Percina macrolepida*	17	399	416	8	135	143	559
Delta smelt, *Hypomesus transpacificus*	206	79	285	5	95	100	385
Shimofuri goby, *Tridentiger bifasciatus*	0	8	8	21	264	285	293
American Shad, *Alosa sapidissima*	0	17	17	0	239	239	256
Sacramento splittail, *Pogonichthys macrolepidotus*	10	62	72	10	140	150	222
Crappie sp., *Pomoxis sp.*	0	118	118	0	101	101	219
Longfin smelt, *Spirinchus thaleichthys*	161	18	179	1	7	8	187
Sacramento sucker, *Catostomus occidentalis*	19	0	19	0	51	51	70
Golden Shiner, *Notemigonus crysoleucas*	0	47	47	0	15	15	62
Yellowfin goby, *Acanthogobius flavimanus*	24	12	36	18	3	21	57
Black Crappie, *Pomoxis nigromaculatus*	0	3	3	0	19	19	22
White catfish, *Ameiurus catus*	0	0	0	0	19	19	19
Hitch, *Lavinia exilicauda*	1	6	7	0	10	10	17
Goldfish, *Carassius auratus*	0	2	2	0	6	6	8
Three-spine stickleback, *Gasterosteus aculeatus*	0	1	1	2	3	5	6
White crappie, *Pomoxis annularis*	0	0	0	0	5	5	5
Channel catfish, *Ictalurus punctatus*	0	0	0	1	2	3	3
Sacramento blackfish, *Orthodon microlepidotus*	3	0	3	0	0	0	3
Wagasaki, *Hypomesus nipponensis*	0	1	1	0	2	2	3
Bluegill, *Lepomis macrochirus*	0	0	0	1	1	2	2
Chinook salmon, *Oncorhynchus tshawytscha*	0	1	1	1	0	1	2
Fathead minnow, *Pimephales promelas*	0	1	1	0	0	0	1
Unidentified minnow, Family Cyprinidae	155	94	249	0	3	3	252
Unidentified centrarchid, *Family* Centrarchidae	0	2	2	0	11	11	13
Unidentified fish	0	0	0	1	46	47	47
Total	1397	8146	9543	1044	13470	14514	24057

Major findings

1. Relative abundances of native fish larvae were greatest in the south (continuously submerged); abundances of non-native fish larvae were greatest in the north (tidally influenced). One explanation is that differences in tidal influence between north and south drive differences in predominant substrata. Many native species prefer rocky substrate (Moyle 2000), which is predominantly found in the southern half of the island. Many non-natives prefer aquatic vegetation (Moyle 2000), which is predominantly found in the north part of the island.
2. Relative abundances of native fish larvae were greatest in the east (disturbed by wind and waves), whereas abundance of non-native fish larvae was greatest in the west (protected). One explanation is that the timing of peak abundance of native versus non-native larvae affects spatial distribution. Wind and, therefore, wind swell, are stronger in spring (March-April) when natives are most abundant. This wind and wave action may sweep native larvae towards the east side of the island.
3. Native fish abundance peaks earlier in the year than non-natives. This pattern was also observed by Marchetti & Moyle (2000) and is likely due to differences between native and non-native environmental spawning cues. Native fishes tend to spawn during periods of higher flow and lower water temperature, typically February-April, whereas non-native fishes tend to spawn later in the year in response to warmer temperatures (Moyle 2000).
4. In 2004, the only year in which both gear types were used concurrently, gross temporal and spatial patterns in CPUE of native and non-native species were similar between light traps and larval trawls. However, there was only moderate overlap of species (13 of 23) between gear types. Marchetti & Moyle (2000) found similar results and suggest that traps and trawls may target different species because each species has unique life history traits that influence their affinity for different gear types.

Literature Cited

Marchetti MP, PB Moyle. 2000. Spatial and temporal ecology of native and introduced fish larvae in lower Putah Creek, California. Env. Biol. Fish. 58: 75-87.

Moyle PB. 2000. Inland fishes of California, 2nd ed. University of California Press, Berkeley.

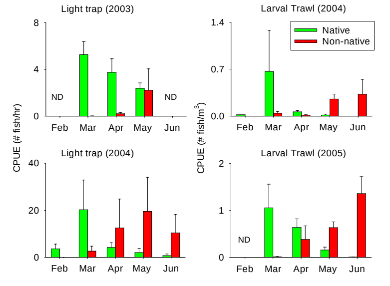

Figure 5. Temporal patterns in CPUE of larval fish. ND = No Data. Note change in scale among panels.

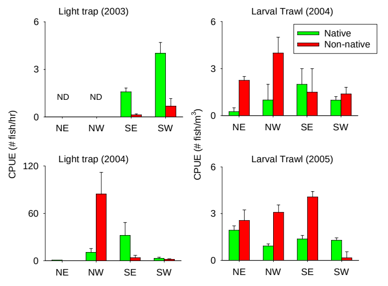

Figure 6. Spatial patterns in CPUE of larval fish. ND = No Data. Note changes in scale among panels.