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Ichthyofauna of the Los Angeles River

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Ichthyofauna of the Los Angeles River

The Los Angeles River is a highly modified urban system. Upper tributaries of the watershed are located in Angeles National Forest and are in a relatively natural state, but below the forest boundary the tributaries and the mainstem consist of a series of completely channelized sections with a concrete bottom that includes a low-flow channel and vertical walls, sections where there are graded berms and a substrate that was either not stabilized with a concrete substrate, or where enough sediment has accumulated to provide a "soft-bottom" with vegetation, boulders, and variation in flow, and off-channel impoundments. Here we provide the results of fish surveys and both professional and community-contributed citizen science observations collected from 2007-2020 that document the presence of 29 species, of which six, found either in upper reaches (sections of the river with similar habitat and hydrologic characteristics) or in the estuary, are native to the river. To accompany these data, we also provide a novel classification schema identifying the unique reaches of the LA River.

Keywords

Los Angeles River, urban, fish, exotic species, restoration, citizen science, volunteer science

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INTRODUCTION

The Los Angeles River drains a 2160.05 km^2 watershed in the nation's second largest metropolitan region. Its upper tributaries begin in the transverse San Gabriel, Santa Monica, and Santa Susana Mountains. The floodplain of the river drops 2133 m in 64 km (Gumprecht 2001) and hosts a variety of hydrologic conditions along its 82 km, from cool, clear, spring-fed mountain tributaries, through a broad alluvial plain and kilometers of concrete channel, down to its estuarine connection to the Pacific in the City of Long Beach (Figure 1).

The watershed is home to approximately 9 million people living in 43 separate cities.[1] Conservation and recreation lands in the watershed include national park (Santa Monica Mountains National Recreation Area), forest (Angeles National Forest), and monument (San Gabriel Mountains National Monument) as well as state lands including two state parks (Rio de Los Angeles and LA River State Historic Park), as well as regional and local parks. The mainstem river flows through 14 cities and portions of the unincorporated County of Los Angeles, with the City of Los Angeles housing the longest stretch. The channel of the mainstem is primarily managed for flood protection by the US Army Corps of Engineers and the LA County Department of Public Works.

Located in an arid Mediterranean climatic region, portions of the river would flow only underground in the summer months prior to hydromodification. During winters, especially those influenced by El Nino Southern Oscillation (ENSO) or Atmospheric River events, large portions of the alluvial plain are inundated. This seasonal inundation resulted in the river switching channels and emptying to the ocean to the east, in what is now the estuary of the San Gabriel River, or far to the west, along the course of Ballona Creek. Once the floodplain was developed and modified by modern human inhabitants, devastating flood events could occur resulting in loss of human life and property (Gumprecht 2001). The threat of flooding led to the large-scale channelization of the river course along its route today.

Other than estuarine and upper watershed species still present today, native fishes in the Los Angeles River above saline influence inhabited the mainstem until major modifications began, with some species last observed in the 1920's-40's, and a few potentially persisting until the 1990s (Swift and Siegel 1993). Eastern headwaters of the river have all or a substantial portion of flow derived from natural water sources (rainwater and springs). Interest in restoring the middle and lower sections of the river (below the boundary of Angeles National Forest) as habitat and a public amenity gained momentum in the 1980's, and by 2020, efforts were underway to plan river revitalization and restoration including designing ways to restore fish passage through downtown Los Angeles (Drill and Post 2022). In order to inform restoration planning, we began characterizing the existing fish community in portions of the river where the banks are hardened but enough substrate remains to support the development of some riparian canopy and some instream heterogeneity amenable to fish presence. We report the results of a series of fish surveys, and innovative ways to observe fish present, conducted from 2008 to 2020 (see Methods below).

[1] https://dpw.lacounty.gov/wmd/watershed/la/, accessed 9/3/20

Ichthyofauna native to the LA River include Arroyo Chub (*Gila orcutti*), California Killifish (*Fundulus parvipinnis*), Western Brook Lamprey (*Lampetra richardsoni*) (Culver and Hubbs 1917), Pacific Lamprey (*L. tridentata*), Santa Ana Speckled Dace (*Rhinichthys osculus*), Santa Ana Sucker (*Catostomus santaanae*), Steelhead/Rainbow Trout (*Oncorhynchus mykiss)*, and Unarmored Three-Spine Stickleback (*Gasterosteus aculeatus williamsoni*) (Swift and Seigel 1993), as well as a variety of estuarine species. Arroyo Chub, Rainbow Trout, Santa Ana Speckled Dace, and Santa Ana Sucker persist in small populations in headwater streams. The lower estuary still supports a number of native estuarine species including California Killifish, Northern Anchovy (*Engraulis mordax*), Striped Mullet (*Mugil cephalus*) and Topsmelt (*Atherinops affinis*).

Here we provide a checklist (see Table 2) to the fish fauna found in the mainstem Los Angeles River through multiple studies conducted by the authors over a period of investigation from 2008 to 2020. We also provide a classification system for the LA River, identifying ecologically and hydrologically unique reaches (sections of the LA River). This can be used by future studies to standardize classification of LA River reaches, and aggregate future studies with historic studies conducted at varying spatial scales.

METHODS

A variety of approaches were used to document fish species present in the river. Data sources included: 1) field studies by the authors using scientific methods described below; 2) grant and consultancy reports; 3) peer reviewed publications; 4) iNaturalist observations by community members; 5) publicly available social media posts; and 6) photos from local anglers. This study focused on identifying all species occurring in the river and not the quantification of fish population sizes. We defined an occurrence as an observation of a fish species at a specific time and sampling site. Multiple individuals may have been observed but would still be defined as a single occurrence – however, finding that same species at a different sampling site on the same day would count as a separate occurrence.

Field methods included typical ichthyological methods such as using a short seine, depletion block nets, and electrofishing. Surveys were conducted throughout representative microhabitats of the river in an effort to comprehensively identify all species present. Microhabitats were selected by visual evaluation of the habitat and reflects sample sites in all habitats that could support fish. Additional literature searches were performed to collate all available observations both historic and recent. Surveys in the upper portion of the Glendale Narrows, conducted in 2007, utilized a 4.6 m x 1.8 m, 3.2 mm seine; 9.2 m x 4.6 m, 3.2 mm seine; a 3.2 mm mesh dipnet, and a wire cage minnow trap baited with tuna (Swift et al. 2008). Seine pulls were conducted in open water and around/under banks of vegetated islands. Quantitative surveys were conducted in 2016 in the Sepulveda Basin immediately upstream of the Sepulveda Dam. These surveys utilized depletion fishing techniques, in which two 10 m x 2 m blocking nets were pulled out perpendicular from the shore at each end. Next, the two nets were pulled together to form a triangle, trapping any fish inside. Two teams with 3 m x 1 m seines walked carefully to the apex of the triangle and pulled from the apex towards the shore, then back and forth throughout the enclosed area. This was repeated until three consecutive pulls were empty.

Additional field surveys were conducted as part of instructional activities at California State University - Los Angeles during the fall semesters from 2014-2018. Field trips were held at the lower end of the Glendale Narrows. River microhabitats were opportunistically sampled with a single 12B Smith-Root backpack electroshocker. Backpack electrofishing is a commonly used method to non-lethally sample freshwater fishes (Zale et al 2013). The method uses electrical current to temporarily stun fish and is readily used to assess freshwater fish diversity and abundance. This sampling protocol was not meant to quantify fishes in specific reaches (e.g. depletion) but to determine presence of species. We could not conduct full depletion sampling due to the size of the river and other logistic constraints. Distinct microhabitats (e.g. runs, riffles, pools) were sampled in short increments of approximately 5-10 minutes to determine species found specifically in these microhabitats. All electroshocking was done with permission from CDFW (SC-7388) and an animal care protocol from Cal State Los Angeles (#1001-02). For surveys conducted in 2014 and 2015 in the soft-bottom reach at the estuary in Long Beach[2] we attempted to use blocking nets but were unsuccessful, and instead relied on volunteers from a local fishing group to determine species present. These volunteers used standard and fly rods with a variety of baits.

We relied on the LA River fishing community to contribute data from additional reaches. We enlisted the help of volunteer anglers through planned volunteer field days and fishing derbies held in 2014 and 2016[3]; through the community science platform iNaturalist. We created and promoted a project entitled *Fish of the LA River - Peces del Río de Los Angeles.*[3] iNaturalist observations that were not user-defined as part of the project but were located in the watershed were incorporated using the umbrella project feature of the platform. For all iNaturalist observations, only verified entries with the *Research Grade* distinction were considered. Raw locations of these observations were retained and were not altered or corrected. Species that commonly hybridize and that cannot be definitively distinguished based on contributed photographs such as Carps (*Cyprinus spp.*) and Tilapia (*Oreochromis spp.*) were grouped and listed at a higher taxonomic level (genus). Occurrences were also documented using still photos or videos (Post 2017) shared through social media. These included observations from which fish could be identified to species and location retrieved from either metadata or by identifying the location through audio and visual clues.

We also collected all published documentation we could find of fish in the river and examined databases such as the California Natural Diversity Database (CNDDB) maintained by the California Department of Fish and Wildlife, and the United States Geological Survey Nonindigenous Aquatic Species database (USGS NAS June 2021).

A classification schema was developed to aggregate fish occurrences and to help visualize how observations were spatially distributed within the Los Angeles River watershed. Hydrologic features that drain into the Los Angeles River were parsed into fourteen distinct

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[2] Dagit, R., Montgomery, E., Burns, J., Blankenship, B., Drill, S., Gossett, R., Bowling, W. P., Thompson, K., and MacAdams, L. (2016). State of the River 3: The Long Beach Fish Study (No. 3; State of the River, p. 65). Friends of the Los Angeles River. https://folar.org/wp-content/uploads/2017/04/FOLAR_Fish_Study_2016.pdf

[3] https://www.inaturalist.org/projects/fish-of-the-la-river-peces-del-rio-de-los-angeles

geographic categories. A simple classification method was developed for the Los Angeles River by identifying distinct waterways and grouping them based on substrate (channelized or soft bottom) as seen in Figure 1 and described in Table 1. By separating channelized from soft bottom reaches, this

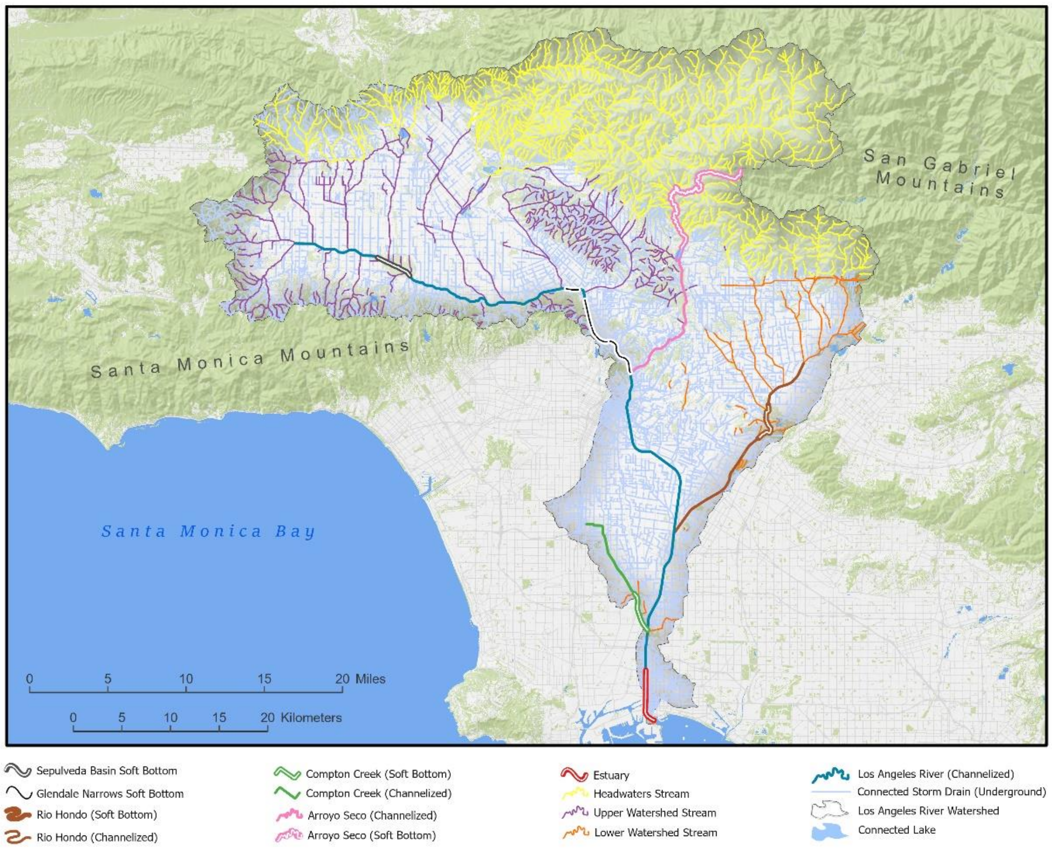

Figure 1. Map of the unique reaches of the Los Angeles River and its tributaries.

Table 1. Unique Reaches of the Los Angeles River and its tributaries as shown in Figure 1.

	Reach Type	Label	Description
1	Sepulveda Basin (Soft Bottom)	SB	Orange Line Busway to Sepulveda Dam
2	Glendale Narrows (Soft Bottom)	GN	Bette Davis Park to Arroyo Seco confluence
3	Arroyo Seco (Soft Bottom)	AS1	Headwaters to 210 Freeway
4	Arroyo Seco (Channelized)	AS2	210 Freeway to confluence with LA River
5	Compton Creek (Soft Bottom)	CC1	Greenleaf Boulevard to confluence with LA River
6	Compton Creek (Channelized)	CC2	South Main Street to Greenleaf Boulevard
7	Rio Hondo (Soft Bottom)	RH1	Rush Street to Whittier Narrows Dam
8	Rio Hondo (Channelized)	RH2	Santa Anita Avenue to Rush Street, Whittier Narrows Dam to confluence with LA River
9	Estuary	E	Willow Street to Long Beach Harbor
10	Headwaters Stream	HW	Upper watershed streams above dams and debris basins
11	Upper Watershed Stream	UW	Flood control channels (concrete) north of confluence with Arroyo Seco
12	Lower Watershed Stream	LW	Flood control channels (concrete) south of confluence with Arroyo Seco
13	Los Angeles River (Channelized)	X	Confluence of Bell Creek/Arroyo Calabasas to Orange Line Busway and Sepulveda Dam to Bette Davis Park, Arroyo Seco Confluence to Willow Street
14	Connected Storm Drain	Z	Underground channel or conduit draining into the LA River
15	Connected Lake	O	Lakes hydrologically connected to LA River

classification considers ecological differences in substrate type without the subjectivity of classifying microhabitats or quantifying disturbance. GIS data were collected from different sources in order to create the classification. The geographic boundary of the Los Angeles River Watershed (Hydrologic Unit Code [HUC 10]: 18070105) was obtained from the USGS Watershed Boundary Dataset (WBD). The National Hydrography Dataset (NHD) was used to visualize waterways that are connected to the Los Angeles River. Hydrologic connectivity between the Los Angeles River and nearby lakes was validated with a spatial boundary dataset (ESRI shapefile) of the LA County Storm Drain system obtained from the Los Angeles County Department of Public Works. The attributes from the same spatial datasets were used to distinguish soft bottom reaches from concrete channelized reaches along with field observations made by Post (2017).

Headwater streams were classified as soft bottom streams that have not been channelized and exist in the northernmost portion of the LA River Watershed. The Estuary of the LA River was bounded by the Willow Street bridge, where a concrete structure prevents tidal effects from extending upstream from that point and delineates the limit of salt or brackish water.

The mainstem Los Angeles River was classified into concrete channel reaches and two large soft bottom reaches (Sepulveda Basin and Glendale Narrows). The Sepulveda Basin and a portion of the Glendale Narrows soft bottom reaches constitute the Los Angeles River

Recreation Zone, where fishing and kayaking are seasonally permitted. Soft bottom reaches in the Glendale Narrows are not continuous, and are separated by concrete and riprap reaches, often covered with intermittent sediment as identified by Post (2017). We included connected lakes in our study area (Figure 2). Numerous fishing lakes such as Echo Park Lake, Hollenbeck Park Lake, and Reseda Park Lake, are connected to the LA River via overflow channels and the LA County storm drain system. This identifies a potential invasion pathway for exotic fish species to enter the LA River.

Figure 2. Map of lakes and waterways (including storm drains) hydrologically connected to the Los Angeles River.

RESULTS

We documented 29 species in 462 occurrences observed from 2007-2020 (Table 2). This includes observations extending from headwaters streams through hydrologically linked waterways to the estuary as shown in Figure 1 and described in Table 1. Table 2 summarizes the number of species identified by author field studies and other sources. Field studies conducted by the authors found 17 of the 29 species identified in the checklist. This accounts for 20.9% (n=97) of the occurrences. Eight native fish species were found, four freshwater species in the upper headwater tributaries among 27 occurrences (5.8% of total) and four native brackish and marine species were found in the lower estuary in seven (1.5%) of the total 462 occurrences. Native species were not found in the middle reaches, tributaries or main stem of the Los Angeles River included connected lakes (Figure 1).

Table 2. Checklist of fish species observed on the Los Angeles River 2007-2020. Data includes fish surveys conducted by the authors; California State University Los Angeles (CSULA), Friends of the Los Angeles River (FOLAR), Resource Conservation District of the Santa Monica Mountains (RCDSMM), and Texas Tech University. The checklist also includes community science data (iNaturalist), online observations (Post and Carter 2021), as well as public domain state and federal data from the California Natural Diversity Database (CNDDB) and US Geological Survey Nonindigenous Aquatic Species Program (USGS NAS). While data from grey literature is referenced, the authors cannot vouch for the validity or accuracy of these data. These datasets include surveys conducted by Bonterra Consulting, ECORP Consulting in partnership with the City of Los Angeles, and the Southwest Resource Management Association (SRMA).

	Common Name	Genus	Species	LA River Watershed Native	Number of Studies	Most Recent Year Observed	CSULA Surveys	FOLAR Fish Studies	FOLAR Fishing Derbies	FOLAR/RCDSMM Surveys	Texas Tech Surveys	iNaturalist (Citizen Science)	Online Observation (Blog, Yo	CNDDB	USGS NAS	Bonterra	ECORP/City of LA	SRMA Surveys	Reaches Observed
							Author Collected Data					Public Data		Gov't. Data		Grey Literature			See Figure 1 and Table 1
1	Alligator Gar	*Atractosteus*	*spatula*		2	2020						X			X				AS2, O
2	Arroyo Chub	*Gila*	*orcutti*	*	4	2020						X		X			X		HW
3	Black Bullhead	*Ameiurus*	*melas*		5	2019	X	X			X	X				X	X		GN, HW, O, SB
4	Bluegill	*Lepomis*	*macrochirus*		1	2020						X							GN, O
5	California Killifish†	*Fundulus*	*parvipinnis*	*	1	2015				X									E
6	Carp	*Cyprinus*	*carpio*		5	2020	X	X	X		X	X	X						AS1, GN, E, O, SB
7	Channel Catfish	*Ictalurus*	*punctatus*		2	2019	X					X							GN, O
8	Convict Cichlid	*Amatitlania*	*nigrofasciata*		2	2017						X			X				O
9	Fathead Minnow	*Pimephales*	*promelas*		4	2016	X	X		X	X						X		E, GN, HW, O, SB
10	Giant Gourami	*Osphronemus*	*goramy*		1	2020						X							O
11	Golden Shiner	*Notemigonus*	*crysoleucas*		1	2016				X									SB
12	Goldfish	*Carassius*	*auratus*		2	2020					X	X							HW, SB, O
13	Green Sunfish	*Lepomis*	*cyanellus*		6	2019	X	X	X		X	X	X			X			GN, HW, O, SB
14	Hybrid Sunfish	*Lepomis*	*macrochirus x cyanellus*		1	2019						X							O
15	Largemouth Bass	*Micropterus*	*salmoides*		4	2020	X	X	X		X	X							GN, O
16	Mississippi Silverside	*Menidia*	*audens*		2	2016	X		X										GN
17	Northern Anchovy†	*Engraulis*	*mordax*	*	1	2016		X											E
18	Pacu	*Colossoma*	*macropomum*		1	2014							X						GN, O
19	Pond Loach	*Misgurnus*	*anguillicaudatus*		2	2020	X					X							GN, RH1
20	Rainbow Trout	*Oncorhynchus*	*mykiss*	*	3	2020						X	X					X	AS1, HW, O
21	Santa Ana Speckled Dace	*Rhinichthys*	*osculus ssp.*	*	3	2020								X		X	X		HW
22	Santa Ana Sucker	*Catostomus*	*santaanae*	*	3	2020								X		X	X		HW
23	Silverside	*Menidia*	*sp.*		1	2020						X							O
24	Sailfin Armored Catfish	*Pterygoplichthys*	*sp.*		7	2019		X		X	X	X	X		X				GN, E, HW, O, SB
25	Striped Mullet†	*Mugil*	*cephalus*	*	2	2020		X				X							E
26	Threadfin Shad	*Dorosoma*	*petenense*		1	2020						X							O
27	Tilapia	*Oreochromis*	*sp.*		5	2019	X	X	X	X	X	X							GN, O, SB, UW, X
28	Topsmelt†	*Atherinops*	*affinis*	*	1	2015		X											E
29	Western Mosquitofish	*Gambusia*	*affinis*		5	2020	X	X	X	X	X	X							AS1, AS2, CC1, E, GN, HW, O, RH2, SB, UW, X
† Denotes Marine, Estuarine, or Brackish Water Specie				**TOTAL SPECIES BY SOURCE**			10	11	7	5	9	20	5	3	4	4	5	1	

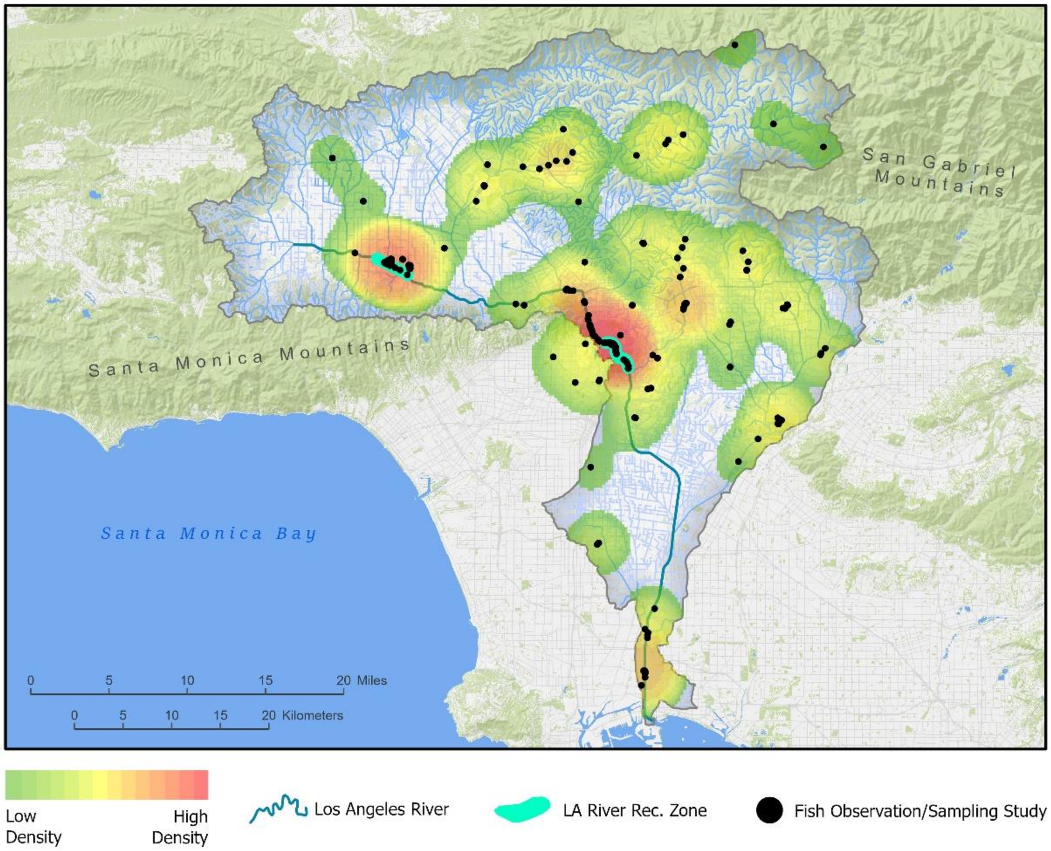

Figure 3. Heatmap (kernel density estimation) depicting the density of fish observations and sampling studies conducted on the Los Angeles River. Note the intense sampling in the soft-bottom reaches of the LA River Recreation Zones.

Community contributed occurrences from iNaturalist (including those from the *Fish of the LA River - Peces del Río de Los Angeles* project) were an important data source. These community contributed observations (n=318) were the largest single source (68.8%) of occurrence data, documenting the presence of 20 fish species (Table 2). Figure 3 shows a Kernel Density Estimation (KDE), a visual analysis or "heatmap" to identify hotspots (dense concentrations) of fish observations. The soft bottom reaches of the Los Angeles River such as the Glendale Narrows, Sepulveda Basin, and to a lesser degree, the estuary, have been heavily sampled. This identifies a possible sampling bias favoring the more easily accessible soft bottom reaches. We addressed this bias using community science where volunteer observers fished in less accessible areas thus expanding the number of microhabitats sampled. Li et al. (2019) reviewed the importance of the contribution of community scientists to the study of urban ecosystems. Here the inclusion of community science data and angler videos provided observations from reaches, connected lakes and microhabitats not previously or easily sampled. These include many of the concrete bottom reaches (Post 2017, Post and Carter 2021). Figure 3 quantifies sampling locations and effort. The middle and lower reaches of the Los Angeles River have been sampled the most due to their diversity of microhabitats (riffles, pools, concrete substrate and soft bottom) and likelihood of high species diversity, as derived from prior studies, and visual observations. These community science observations also provided data from temporal gaps, times between author conducted field studies.

DISCUSSION AND CONCLUSIONS

The dominance of exotic fauna in the river is indicative of the altered hydrologic conditions and in particular, increased temperatures (Mongolo et al. 2017) that likely result from a combination of factors including warm water released from reclamation plants, runoff flowing over impervious concrete and asphalt surfaces, and concrete in the channel itself. The disconnection of the river from cooler groundwater also likely plays a role. Channelization combined with an increase in impervious cover and landscape irrigation runoff means that portions of the river have changed from intermittent to perennial flow. This reduces the competitive advantage of natives adapted to the pre-colonial highly variable hydrograph, thus favoring exotic fishes. The loss of substrate, historic flow regimes, and overall habitat diversity is also conducive to the success of introduced species (Marchetti et al 2006). This works in combination with ample pathways for their introduction to generate an exotic dominated ichthyofauna.

Exotic fish species in the river have had a variety of introduction pathways. Species may have entered the watershed through intentional introduction to California. For example, Mississippi Silverside (*Menidia audens*) were introduced to California in the 1960s for management of nuisance insects, then spread throughout the state (Moyle 1976; Swift et al. 2014). Tilapias (genus *Oreochromis*) were also released into California waters to control mosquitos and nuisance algae (Shapovalov et al. 1959; Downs 1991; Swift et al. 1993; Dill and Cordone 1997a; Dill and Cordone 1997b). Largemouth Bass, Green Sunfish, and Common Carp may have been introduced to “improve” fishing (Dill and Cordone 1997a; Dill and Cordone 1997b). More exotic species may have been released by the public through dumping fish tanks (Padilla and Williams 2004) and similar means.

Native fish species are still present in the LA River, but their distribution is restricted to the more natural conditions found in either the estuary or the upper watershed tributaries. Headwater streams are ecologically significant, as many have more natural sources (rainwater and springs) and support the only remaining habitat for native species such as the Arroyo Chub Santa Ana Speckled Dace and Santa Ana Sucker and steelhead/rainbow trout within the watershed. Equally important for native species is the remaining estuary habitat. Although catch data for this reach is limited, native estuarine species were identified. In the case of Topsmelt, juveniles were observed indicating successful reproduction.

The reach classification schema (Table 1 and Figure 1) we developed can be easily integrated with both prior and future studies. By incorporating connected lakes and waterways into a watershed scale study, the significant role of the storm drain system in connecting legally or illegally stocked waters to the Los Angeles River can be made apparent. This classification facilitates transdisciplinary collaboration, dissemination, and continued exploration of fish observation data for the LA River. Instead of this current checklist being temporally static, this classification allows for ongoing monitoring of fish assemblages by allowing data from varying spatial scales and geographies to be aggregated. Further, this classification aids in understanding sub-watershed scale spatial patterns in fish observations, and to identify sampling bias (unequal sampling effort between reaches) exhibited by prior studies.

Every sampling method exhibits some form of bias. This study represents a comprehensive perspective combining multiple methods with similar results. By incorporating a mixed-methods approach, the checklist produced by this study reflects lower degrees of bias than single-method studies. The methodologies used are considered standard and highly accepted means of quantifying fish assemblages (Hayes et al. 1996, Portt et al. 2006, Zale et al. 2013). A single haul of a seine net can exhibit effectiveness in capturing 75% of midwater species (Pierce et al. 1990, Portt et al. 2006). This supports the confidence of our findings.

While this study represents the most comprehensive study of fish currently present in the Los Angeles River, our checklist cannot be considered completely definitive or inclusive. The Los Angeles River exhibits high rates of exotic releases and introductions, as evidenced by the number of non-native species present. We present the checklist as a list of fish species most representative of the area during the years sampled. Failed introductions of exotic species may go unnoticed or undocumented. The exact rates and occurrences of introductions are also unknown; therefore, it is impossible to quantify all species present. Future studies and ongoing monitoring of exotic introductions are needed to address this.

Our characterization of the existing fish community in the Los Angeles River, compiled from numerous sources and data collection methodologies provides a baseline that can be used to develop criteria for and measure success of ecological restoration of the Los Angeles River. Portions of the river where the banks are hardened but substrate remains that can support the development of enough riparian canopy and instream heterogeneity to support fish presence may be viewed as well or poorly functioning habitat, depending upon societal goals for the river (Drill and Post 2022). The inclusion of habitat in connected lakes is a novel approach that recognizes that this engineered hydrology is an important ecological feature of this urban watershed. We hope this provides an important scientific contribution that can be used to develop and evaluate LA River restoration and revitalization projects.

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