Ecology of piscivorous sport fishes in the San Joaquin River and South Delta

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ABUNDANCE

A total of **2,576 PIT tags** and **1,278 external tags** have been deployed to date (Table 1). Based on recaptured striped bass, from 2019 to 2020, **approximately 83,453** (95% CI: 41,723-168,112) **subadult and adult striped bass** were present in the San Joaquin and Stanislaus rivers (Figure 2). Time-period specific abundances fluctuate between thousands to tens of thousands. Currently we do not have enough recaptures of other species to estimate abundance.

Target Species	PIT Tags (Fyke and Efishing)	External (Disc or T-bar)
Striped bass	1,351	1,058
Largemouth bass	677	27
Smallmouth bass	42	4
Spotted bass	48	8
Catfishes	458	181

Table 1. Total number of PIT and external tags deployed by species since 2019. Total number of PIT tags includes tagging efforts by SJRRP.

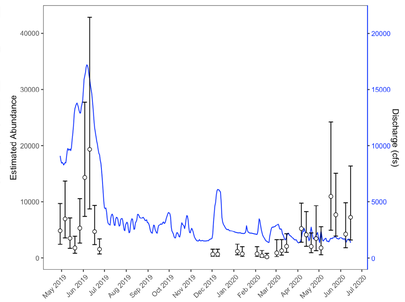


Figure 2. Weekly striped bass abundance estimates based on the POPAN Jolly-Seber estimator using PIT recaptures from electrofishing in the San Joaquin and Stanislaus rivers (FISHBIO) and fyke trapping in the lower (FISHBIO) and upper (SJRRP) San Joaquin River. Discharge (blue line) for the San Joaquin was measured at Vernalis (USGS station 11303500).

MOVEMENT

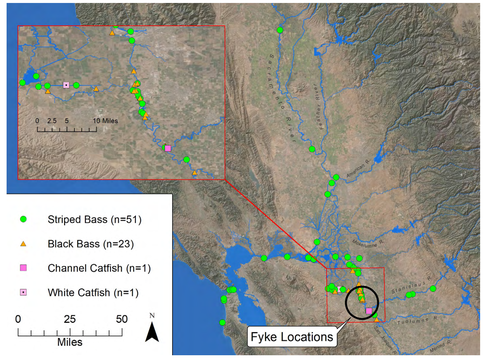


Figure 6. Map of recapture locations of PIT tagged and externally tagged target species.

Recaptured striped bass have been observed in the Pacific Ocean, San Francisco Bay, Sacramento River, and in San Joaquin River tributaries, and are being captured by anglers and other sampling programs year-round (Figure 6). Fewer recaptures of black bass and catfishes have occurred but are consistent with these species being residents in the south Delta and lower San Joaquin River.

FUN FISH FACT

One recaptured fish was originally tagged by NOAA Fisheries as part of the "***Effects of Manipulated Predator Densities and Environmental Variables on Juvenile Salmonid Survival in the lower San Joaquin River***" study (6). This largemouth bass was originally tagged on 5/27/14 in the San Joaquin River. It was 210 mm FL at time of original tagging and 518 mm upon recapture in the San Joaquin River.

ANGLING AND HARVEST

Species	Numbers of tags reported	Proportion released
Striped bass	40	0.25
Largemouth bass	5	1.0
Catfish	2	0.0

Table 4. External disc or t-bar tags reported by anglers and whether or not they were released upon capture.

We acquired data on CDFW's high reward ($100; HR) striped bass tagging program to estimate the reporting rate of our low reward (LR) external tags. Our striped bass tag reporting rate has the following assumptions: 1) HR and LR tags have the same encounter rate, and 2) A reward of $100 is sufficient to achieve a 100% reporting rate. **We estimate that anglers have reported 65% of the LR tags they have encountered,** which provides encouraging evidence of angler participation in the sampling program. Although the number of tags reported is low, largemouth bass are always released but catfish are always harvested (Table 4). Striped bass were released a quarter of the time.

PROGRAM OVERVIEW

Background: Nonnative species now outnumber native species in the Sacramento-San Joaquin Delta (1), and some piscivorous nonnative sport fishes are known to impact the population dynamics of native fishes including listed species such as Chinook salmon and Delta Smelt (2, 3). Improved monitoring is necessary to understand the spatial and temporal variability in the density of predatory fish, including striped bass (*Morone saxatilis*), black bass (*Micropterus* spp.) and catfishes (*Ameiurus* spp. and *Ictalurus* spp.), and how predation risk is influenced by environmental factors (4, 5). Ultimately, this may help to improve management and conservation actions for imperiled native species.

Plate 1. Target species from left to right, striped bass, largemouth bass, and channel catfish.

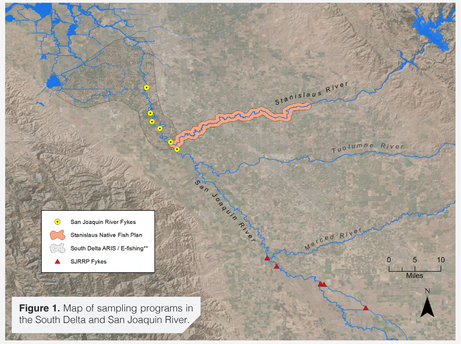


Figure 1. Map of sampling programs in the South Delta and San Joaquin River.

Goal and objectives: Acquire the data necessary to characterize population dynamics of nonnative sport fishes by:

- Developing a monitoring program that adequately samples spatial and temporal trends in populations of nonnative sport fishes in the South Delta and lower San Joaquin River.
- Using mark-recapture techniques to estimate abundance and population vital rates and assess movement dynamics and recreational fishing pressure.
- Collect biological samples to characterize population age structure and diet composition.

This project is part of a larger effort to contribute to improved understanding of the resident fish community structure, abundance, distribution, diet, and habitat associations in the South Delta and lower San Joaquin River, in particular for non-native piscivorous fishes.

Methods:

- Fyke traps
  - 3.0 m or 2.4 m diameter traps fished 24-hours/day Monday–Friday from early March through the end of June, beginning in 2019 (Figure 1).
  - Traps checked daily, all captured fish measured and enumerated.
- ARIS/E-fishing
  - Paired boat electrofishing and DIDSON (ARIS 1800) recording conducted one week per month from December to May.
  - Up to twenty 500-m transects selected each month using a stratified random sampling design.
  - ARIS data reviewed to determine total number of potential predators (fish larger than 200 mm), compared to number of individuals captured during electrofishing to determine feasibility of long-term surveys of predator density using the ARIS.
- Mark-recapture
  - Individuals in good condition >100 mm FL (E-fishing) are tagged with a passive integrated transponder (PIT) tag and released. Individuals >200 mm FL also received an external (disk or t-bar) tag.
  - Information on recaptures was obtained from other research programs and angler reporting.
  - Capture histories of each individual fish were used to assess movement patterns and estimate population abundance of each target species using program Mark.
- Biological samples
  - Stomach contents collected via non-destructive gastric lavage.
  - Scales collected for ageing and growth.

TIMING

- Striped bass captured in the San Joaquin River as early as December and as late as June.
- Striped bass are likely present throughout the basin year-round since they are captured whenever traps are operated (Figure 3).
- Seasonal increases in captured striped bass could indicate spawning migrations.
- All other target species are present year-round.

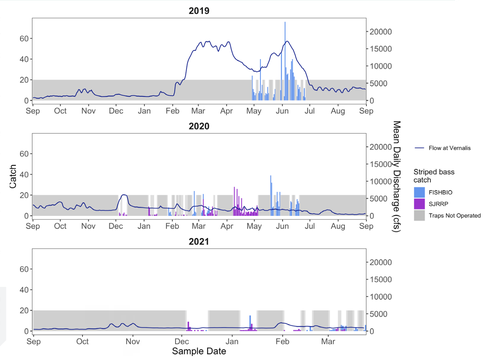


Figure 3. Combined catch of striped bass from fyke trapping and electrofishing in the lower San Joaquin River (FISHBIO) and upper San Joaquin River (SJRRP) with associated flows at Vernalis. Years refer to water years.

AGE/SIZE/SEX COMPOSITION

Scale samples collected during sampling have not yet been analyzed, therefore we used length-at-age relationship from CDFW (https://wildlife.ca.gov/Fishing/Inland/Striped-Bass#35540376-biology) to assign age-classes for striped bass. Regardless of sampling month, the majority of **striped bass captured appear to be in the 2 to 7 year age classes** (Figure 4).

To date, sexing of striped bass individuals has only been performed during spawning season. The sex ratio appears to be skewed towards males (Table 2). Black bass, which are more effectively captured with electrofishing, appear to have bimodal size distributions (Figure 5).

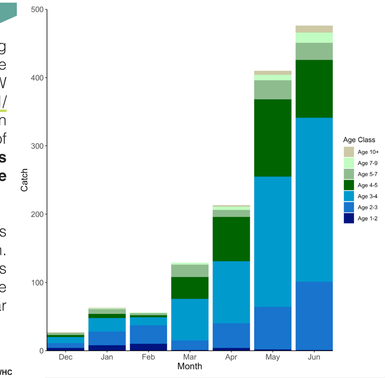
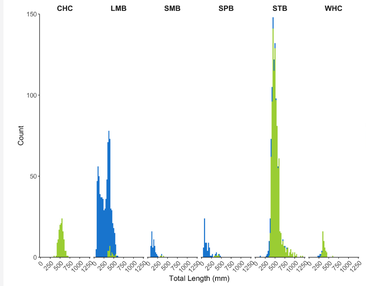


Figure 4. Striped bass age-classes by sampling month captured during Fyke trapping and electrofishing surveys in the South Delta and lower San Joaquin River.



Sex	2019	2020	2021
Female	149	15	11
Male	437	166	15
Undetermined	52	111	8

Table 2. Sex of striped bass captured at the FISHBIO fyke traps. Sex determination was based on ripe individuals expressing gametes.

Figure 5. Length frequency histograms of target species captured during fyke trapping (Fyke) and electrofishing surveys (Efish) in the South Delta and lower San Joaquin River. Species codes are channel catfish (CHC), largemouth bass (LMB), smallmouth bass (SMB), spotted bass (SPB), striped bass (STB) and white catfish (WHC). Total length bins are in 25 mm increments.

FUTURE WORK

We will continue electrofishing surveys and fyke trapping to continue mark-recapture efforts and estimate abundance to track trends in population size over time. Additional genetic identification of fish prey items from electrofishing surveys is needed. Alternative data sets (PIT tag recaptures, external tag recoveries, and acoustic tag studies) can be used in hierarchical models to estimate fishing mortality, survival rates, and characterize movement patterns. We hope to collaborate with CDFW to increase PIT tag recaptures and reporting of external tags, as well as continue collaborating with the SJRRP. We also are planning outreach opportunities to angling groups to increase awareness of external tags and importance of reporting tags.

ACKNOWLEDGEMENTS

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Citations:

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DIET

Stomach contents were collected from target species. Most striped bass samples were collected from the fyke traps, which is the probable reason for the high proportion of empty stomachs. In contrast, most largemouth bass were sampled from electrofishing surveys and had a low percentage of empty stomachs (Table 3). **Genetic identification of fish prey items has identified 13 species** including four native species (Chinook salmon, splittail, Sacramento pikeminnow, and Sacramento sucker). **Based on these samples, striped bass, largemouth bass, and channel catfish are the most piscivorous.**

Species	Number of Stomachs	% Empty	% With fish
Striped bass	327	63%	43%
Largemouth bass	145	6%	40%
Smallmouth bass	16	0%	25%
Spotted bass	13	23%	20%
Channel catfish	58	53%	48%
White catfish	14	71%	0%

Table 3. Diet sample sizes by species collected from fyke trapping and electrofishing in the lower San Joaquin River in 2019 and 2020.