**Supplemental information for:**

Title: Contrasting invasion histories and effects of three non-native fishes observed with long-term monitoring data

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**Complete methods section**

*Study system and data collection*

Fish and aquatic macroinvertebrates were collected using 1-m2, 2-mm mesh throw traps following standardized protocols (Jordan et al. 1997; Dorn et al. 2005) from July 1996 through April 2022. Sampling occurred at 24 sites throughout the Everglades (see Trexler et al. 2001), but here we focus on those in Shark River Slough (6 sites) and Taylor Slough (3 sites) of Everglades National Park, while those in Water Conservation Area 3A (8 sites) serve as a reference region (Fig. 1). Most sites consisted of three 1-ha plots (0.3-ha plots at three Shark River Slough sites), while the two upstream sites of Taylor Slough (TS, MD) consisted of five plots per site, with two of the five plots having shorter hydroperiods (Trexler et al. 2001, 2003). Seven throw-trap samples were collected at each plot during each sampling period, except when wetlands were drying and inaccessible by airboat; helicopters were used when airboats could not and five samples were collected. Our analyses are on plot-level mean densities of small fishes and decapods. Throw-trap samples were collected during five months of each year, starting after the onset of the wet season (begins in June), with wet-season samples collected in July and October, transition period samples collected in December, and dry-season samples collected in February and April. During the driest years, sites were occasionally completely dry during the dry season and/or early wet season and not sampled. Following a standard protocol, animals were removed from throw traps using bar seines and dip nets; vertebrates were euthanized using MS-222 and all animals were fixed in formalin before being transferred to ethanol and identified.

From 1997–2022, most sites/plots were sampled with an airboat-mounted electrofisher to assess large-fish (>8 cm SL) catch-per-unit-effort (CPUE). Plots were sampled four times per year (July, October, January, March) with three transects of five minutes duration (pedal time) (details in Chick et al. 2004, Parkos et al. 2011). Electrofishing was never performed at Shark River Slough site 50 or sites 9 and 10 in Water Conservation Area 3A (Fig. 1), while electrofishing at Shark River Slough site 23 began in 2009. At Taylor Slough sites TS and MD, electrofishing was only performed at the three central/deeper plots. Native fishes were released after processing and non-native fishes were euthanized. Dry-season electrofishing was often limited because airboats could not access sites and/or water levels were too low for sampling (throw-trap sampling continues when accessed by helicopter). To partially overcome limitations of missing dry-season sampling, we created indices of annual predator abundances caught electrofishing by averaging the total number of fish caught across all electrofishing transects during both wet season sampling periods (July, October). These indices were used as predictor variables in analyses.

Densities (# individuals/m2) of the three most common decapod species and nine most common small fishes caught in throw traps between both Shark River Slough and Taylor Slough were our response variables in hydrologic and predator analyses below. For decapods, these species were grass shrimp, Everglades Crayfish (*Procambarus alleni*), and Slough Crayfish (*Procambarus fallax*). Seven fishes were common in both regions: Everglades Pygmy Sunfish (*Elassoma evergladei*), Golden Topminnows (*Fundulus chrysotus*), Marsh Killifish (*Fundulus confluentus*), Eastern Mosquitofish, Least Killifish, Flagfish, and Bluefin Killifish (*Lucania goodei*). Sheepshead Minnows were only common and analyzed in Taylor Slough, and Sailfin Mollies (*Poecilia latipinna*) were only common and analyzed in Shark River Slough, but we display time series data for all species in all regions regardless of if they were analyzed.

*Baseline hydrologic analyses*

Although the drainages are not entirely isolated during high water (surface waters are connected over short-hydroperiod wetlands or through canals and water control structures), we separately investigated effects of hydrologic conditions and non-native species in Shark River Slough, Taylor Slough, and Water Conservation Area 3A due to each region’s respective invasion history (outlined in introduction), hydrology, and other environmental characteristics. We established pre-invasion baseline periods in both Shark River and Taylor sloughs during which we modeled relationships between hydrologic conditions and seasonality and density of our response species, with the subsequent years forming an invasion period (Fig. 3). In Shark River Slough, the baseline period was when jewelfish were absent or rare (1996–2011), while the invasion period was when they were common and abundant from the quantitative samples in the wetland (roughly 2012–2017 but varies by site as defined by ‘presence’ criteria in predator analyses below). Similarly, in Taylor Slough we used the years 1996–2009 as a baseline period, since swamp eels were first detected upstream of our sites in Taylor Slough in 2009; the invasion period in Taylor Slough dataset is roughly 2012–2022, but this again varies by site based on the first swamp eel occurrence at each site (first record in 2012). In Water Conservation Area 3A, the recent invasion of swamp eels and increase in jewelfish densities is insufficient for analysis of these invaders in that region; in this region we used the same baseline period as in Shark River Slough for direct comparison between the two regions and validation of jewelfish effects, which have not previously been looked for and were notably smaller than swamp eel effects (see results).

We modeled the density of each response species (small prey fishes or decapods) separately by region using hydrologic covariates measured at the plot scale (similar covariates in Trexler et al. 2005, Dorn and Trexler 2007). Data from the Everglades Depth Estimation Network (Telis 2006; Liu et al. 2009) were used to estimate hydrological conditions at each plot at the time of sampling: the days since a plot was last dry (DSD; depth <5cm), the length of the last dry season (LDS: number of days water depth was <5cm during the previous dry season), and the average water depth during the 30 or 180 days prior to throw-trap sampling (’30-day depth’ or ‘180-day depth’). Species respond to water depth on different temporal scales, so the better fitting depth measure was used for each species. A layer of dense flocculent material sits at the bottom of the water column such that when the water depth drops below 5 cm the dissolved oxygen levels are too low to support many gilled aquatic animals, and most fish (Trexler et al. 2005). Low-water conditions create an abiotic disturbance (biomass reduction) by killing fish, but also expose them to avian predation, and the seasonal reductions caused by low-water disturbance (sometimes referred to as dry-down) is modeled with the DSD, LDS, and average depth terms in different ways to accommodate the different life histories of the native taxa (Dorn and Trexler 2007; Trexler and Goss 2009). We used a model selection approach that compared the AIC among models using the *dredge* function in the MuMin package v 1.47.1 (Bartoń 2020) to choose the relatively best combination of the three hydrological variables (DSD, either 30- or 180-day depth, LDS), the asymptotic form of recovery from drought (DSD), season (sampling month: July, October, December, February, April), and the interaction between season and LDS, which accounts for either diminishing effects of the previous dry conditions as the water year progresses or lagged population responses (Dorn and Cook 2015). The model with the lowest AIC was chosen as the best model, even if there were competing equally effective models (ΔAIC <2), as our objective was to best account for (model) hydrologic conditions before exploring predator effects. Analyses were mixed-effects models that included plot nested within site as a random effect. Dependent variables were densities of each species and were log-transformed to approximate normal error distributions of the models’ fit; other error distributions (e.g., gamma) typically did not fit (lower log likelihood) or meet the assumptions as well as the gaussian. Independent variables LDS and DSD were log-transformed, while depth was not transformed.

*Predator analyses*

The residuals from the statistical models of hydrologic conditions were used as our response variables during analyses assessing effects of predators during the baseline period. Following the arrival of each non-native predator, we used the *predict* base function in R v 4.2.2 (R Core Team 2022) to generate predictions of prey-species’ density based on observed hydrologic conditions and the most supported models from the baseline period. Then during the invasion period, we generated ‘residuals’ that were calculated as observed minus predicted densities for each prey species (Fig. 3). Native effect sizes (standardized coefficients) provided a range of expected values for native predators beyond hydrology that might be expected of adding another fish of similar impacts. We looked for significantly negative standardized effects that were also larger than those of the native fishes when identifying effects of invasives. This approach was necessary because we were looking for evidence of the invasive species beyond the effects of hydrologic variation and because the presence of swamp eels in Taylor Slough has had dramatic effects that have eliminated the relationships between hydrologic conditions and the life history of several small animal species (Pintar et al. 2023). We assume that our models of hydrologic conditions should continue to predict densities of prey species in the absence of the invasive predators and use them to define our expectations to look for potential predator effects relative to observed densities. Simply applying the hydrologic variables from our baseline models on raw data during the invasion period could result in misrepresented hydrologic or predator effects during the invasion periods.

In addition to the three common non-native species (jewelfish, swamp eels, Mayan Cichlids), we also assessed effects of all combined sunfish (*Lepomis* spp., mostly *L*. *gulosus* electrofishing and *L*. *punctatus* in throw traps, along with *L*. *macrochirus*, *L*. *marginatus*, *L*. *microlophus*; Fig. 2g,h) and the combined three largest predatory fishes (‘top predators’: Bowfin, *Amia calva*; Florida Gar, *Lepisosteus platyrhincus*; and Largemouth Bass, *Micropterus salmoides*; Fig. 2i,j). Three different measures of predator abundance were used in models: annual indices of large fish catch-per-unit-effort (CPUE) from electrofishing (ef) were used for swamp eels, top predators, sunfish, and Mayan Cichlids, while densities of predators from throw data from the current time period (t) and previous time period (t-1) were used for jewelfish, sunfish, and Mayan Cichlids. These different measures were used because electrofishing is the only method that sufficiently measures densities of the three top predators and swamp eels, while jewelfish, which as adults reach larger sizes than some of the small fish species we analyzed, rarely exceed the length cutoffs for quantification with the electrofisher (8-cm minimum standard length) (Chick et al. 1999). For sunfish and Mayan Cichlids, large adults were regularly caught electrofishing while smaller adults and juveniles (SL < 8 cm) were caught in throw traps and may be of similar sizes to adult jewelfish. For both sunfish and Mayan Cichlids, the general patterns of densities over the time series were similar in both throw trap and electrofishing datasets (Fig. 2), but their abundance in the two datasets may represent different predation pressure on our prey species. Larger individuals (electrofishing) may place predation pressure on adults (or all size classes) of the prey species and are limited by only having an annual index, whereas smaller individuals (throw traps) may place predation pressure on juveniles, compete with adults, or exhibit interspecific aggression towards adults. Further, use of throw trap data allows us to assess immediate effects of predators (current time period, t) and effects lagged by one season (2–3-month lag; previous time period, t-1).

We used a consistent approach to analyze predator effects with separate models in Shark River Slough and Taylor Slough: one model of the baseline period (pre-invasion; Fig. 3) and two models of the full dataset: one based on densities of jewelfish and/or swamp eels, and one based on presence/absence of those two species. We used a similar model selection approach to determine the best combination of predator species that explained changes in densities (residuals) of small fishes and decapods beyond what was already accounted for or predicted by hydrologic variables. Though some predator impacts on small fish and decapods co-vary with hydrologic variation (see Trexler et al. 2005; Dorn and Cook 2015), we limited our examination to effects distinguishable after accounting for hydrology, which would indicate effects of non-native predators that are functionally different from those of native predators. During the baseline period, predators included in models were Mayan Cichlids, sunfish, and top predators. For the full dataset, we added densities of jewelfish (Shark River Slough only) and swamp eel CPUE (both sloughs) to this predator list for model selection. In both regions, we assumed that densities of swamp eels were zero up to one year prior to the first swamp eel catch at each site, even if those individual plots were not sampled by electrofishing; the only site where this assumption was not made was Shark River Slough site 50, which was not electrofished and therefore detection of swamp eels there may lag other sites.

In our second analysis of the full dataset, we replaced abundances of swamp eels and jewelfish with a categorical variable of presence/absence to account for the possibility that the abundances could not be perfectly quantified and that their mere presence, even at low densities, could have caused a reduction in native species. For swamp eels, presence was determined as the first sampling period swamp eels were detected at each site (not individual plots); swamp eels have been detected at each site during almost every period since first detection. For jewelfish, presence/absence was determined as the first time they were detected at a site in Shark River Slough during the invasion period (starting in 2012) through when they were last detected at that site before the end of the invasion period (2017). Between first and last detection, jewelfish were assumed to be present at a site even if not recorded (Vander Zanden et al. 2010), as we surmise neither sampling method may have adequately assessed their presence or density at each site. Prior to 2012, jewelfish were treated as being absent at all sites despite sporadic occurrences that we believe represented rapid expansion of a regionally established population, but failure to establish higher and consistent populations in sloughs.

In Water Conservation Area 3A, predator effects were assessed during the corresponding baseline period in Shark River Slough (1996–2011), which included densities of sunfish, top predators, and Mayan Cichlids, but excluded jewelfish and swamp eels due to their historic absence and/or low densities in that region. However, because of the generally small effects of jewelfish observed in Shark River Slough (see results), we then used Water Conservation Area 3A to test for potential time period effects during the core of the jewelfish invasion. We used the time period during which jewelfish were considered present at all sites in Shark River Slough as a categorial variable in Water Conservation Area 3A. Doing so may validate or contest categorical impacts of jewelfish presence/absence in Shark River Slough if concurrent changes of similar magnitude for the same species were observed in both regions. We had no way to test for jewelfish density in Water Conservation Area 3A because they were effectively absent from the region during this timeframe. Model selection for this process was run in the same way as other models, on residuals of hydrologic models with the various predator densities and the jewelfish invasion period for models to select from. We did not run this same test for swamp eel presence because the presence of swamp eels in both regions overlaps during the final years of the dataset, which we otherwise excluded from WCA analyses. However, the jewelfish reference period can be used as a limited comparison for swamp eels in Taylor Slough since it overlaps with a large portion of the time when swamp eels were present in that region.

The electrofishing dataset was limited more than the throw trap dataset because it was not conducted with the same regularity early in the study and because some plots/sites were never sampled by electrofishing. This meant that ~50% of sample periods/plots did not have matching data for both throw trap and electrofishing datasets, restricting the analysis to a smaller sample size. Therefore, predator model selection was conducted in a three-step process. First, we performed model selection on the full dataset using all predator variables mentioned previously. Then, if no non-swamp eel predator abundances from the electrofishing dataset were included in the most supported model from the analysis including all electrofishing data, we re-ran the model selection process only using small predators in throw-traps plus swamp eel electrofishing CPUE, which encompassed more sites due to the assumption of 0 density regardless of sampling mentioned above. Finally, if swamp eel CPUE was not included in the most supported model that included only swamp eels and small predators in throw traps, we re-ran the model selection process using only small predators in throw-traps (all species from electrofishing were excluded) to achieve a final model. The same process was performed for presence/absence analyses, but excluding the second step. Predator models were fit in the same manner as hydrologic models using mixed effects. Model selection for predator models was run with the *step* function in the lmerTest package with a fixed effect α>0.20 excluding terms from the final model. All models were fit by maximum likelihood (using the Satterthwaite method) with the lme4 v 1.1-31 and lmerTest v 3.1-3 packages in R v 4.2.2 (Bates et al. 2015; Kuznetsova et al. 2017; R Core Team 2022). Overall model fit (marginal and conditional *R*2) was determined using the *r.squaredGLMM* function from the MuMIn package v 1.47.1 (Bartoń 2020).

*Jewelfish Analyses*

As a final step in our assessment of the jewelfish invasion of Shark River Slough, we investigated potential factors limiting jewelfish populations from when they were first detected in our dataset (2004) through the year swamp eels were first detected (2019). We first modeled jewelfish responses to hydrologic conditions, selecting the best model from zero-inflated gamma distributions (link=log) because most jewelfish densities were zeros. Plot was nested within site as a random effect, and constant zero-inflation using the glmmTMB package v 1.1.6 (Brooks et al. 2017). Residuals from the best hydrologic model were then used as a response variable to assess potential effects of predators through the same predator model selection process on densities of sunfish, top predators, and Mayan Cichlids from both the throw trap and electrofishing datasets.

**Table S1.** Results of mixed effects models from the parameterization of hydrological effects during the baseline period in Shark River Slough (before peak jewelfish abundance; 1996–2011) for the three most common decapods and eight most common fishes. Coefficients are standardized coefficients. Season indicates the sampling month (categorical variable), depth is the average depth over the prior 30 or 180 days, LDS is the length of the previous dry season, DSD is the days since a plot was last dry (depth < 5 cm). Bold indicates statistical significance (*P* < 0.05).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Coef. | df | F | *P* |
| *Palaemonetes paludosus* (Grass Shrimp) ( = 0.038, = 0.417) | | | | |
| season | 0.028, 0.033, **0.071**, **0.100** | 4, 1307 | 2.5 | **0.041** |
| DSD | **0.094** | 1, 1319 | 7.4 | **0.0068** |
| LDS | **0.060** | 1, 1312 | 6.7 | **0.0098** |
| 30-day depth | **0.068** | 1, 1323 | 4.7 | **0.030** |
| season:LDS | -0.060, **-0.082**, **-0.113**, **-0.114** | 4, 1307 | 4.2 | **0.0024** |
| *Procambarus alleni* (Everglades Crayfish)( = 0.315, = 0.316) | | | | |
| season | -0.059, -0.070, -0.059, -0.046 | 4, 1242 | 1.0 | 0.41 |
| LDS | **0.778** | 1, 619 | 340.3 | **<0.0001** |
| 30-day depth | **0.081** | 1, 359 | 6.5 | **0.011** |
| season:LDS | **-0.169**, **-0.217**, **-0.202**, **-0.251** | 4, 1322 | 15.4 | **<0.0001** |
| *Procambarus fallax* (Slough Crayfish)( = 0.068, = 0.468) | | | | |
| Season | **-0.197**, -0.113, **0.053**, **0.069** | 4, 1309 | 14.5 | **<0.0001** |
| LDS | 0.057 | 1, 1311 | 2.8 | 0.097 |
| DSD | **0.143** | 1, 1317 | 16.6 | **<0.0001** |
| 30-day depth | **0.171** | 1, 1322 | 29.5 | **<0.0001** |
| season:LDS | -0.001, 0.064, 0.005, -0.059 | 4, 1308 | 2.7 | **0.028** |
| *Elassoma evergladei* (Everglades Pygmy Sunfish)( = 0.038, = 0.321) | | | | |
| season | 0.060, **0.116**, **0.135**, **0.080** | 4, 1308 | 3.8 | **0.0046** |
| LDS | **-0.250** | 1, 1312 | 14.1 | **0.0002** |
| DSD | **-0.111** | 1, 1320 | 8.5 | **0.0036** |
| season:LDS | 0.079, 0.072, **0.147**, 0.035 | 4, 1308 | 3.6 | **0.0068** |
| *Fundulus chrysotus* (Golden Topminnow)( = 0.236, = 0.349) | | | | |
| season | **0.086**, **-0.081**, **-0.213**, **-0.253** | 4, 1302 | 32.6 | **<0.0001** |
| LDS | **-0.225** | 1, 1309 | 22.1 | **<0.0001** |
| DSD | **0.305** | 1, 1321 | 72.5 | **<0.0001** |
| season:LDS | -0.010, 0.033, 0.067, **0.084** | 4, 1302 | 2.8 | **0.026** |
| *Fundulus confluentus* (Marsh Killifish) ( = 0.176, = 0.233) | | | | |
| season | -0.049, -0.072, -0.078, **-0.127** | 4, 1323 | 2.7 | **0.029** |
| LDS | **0.156** | 1, 1327 | 80.8 | **<0.0001** |
| 180-day depth | **-0.173** | 1, 1300 | 19.8 | **<0.0001** |
| season:LDS | 0.129, 0.044, -0.041, **0.117** | 4, 1321 | 6.5 | **<0.0001** |
| *Gambusia holbrooki* (Eastern Mosquitofish)( = 0.079, = 0.338) | | | | |
| Season | -0.075, **-0.093**, **-0.195**, **-0.168** | 4, 1308 | 8.6 | **<0.0001** |
| LDS | **-0.114** | 1, 1311 | 11.7 | **0.0006** |
| DSD | **0.262** | 1, 1319 | 46.5 | **<0.0001** |
| 30-day depth | 0.057 | 1, 1325 | 2.7 | 0.10 |
| season:LDS | **0.139**, **0.146**, **0.176**, **0.160** | 4, 1306 | 7.2 | **<0.0001** |
| *Heterandria formosa* (Least Killifish)( = 0.233, = 0.664) | | | | |
| season | 0.041, 0.029, **-0.062**, **-0.094** | 4, 1302 | 13.3 | **<0.0001** |
| LDS | **-0.232** | 1, 1303 | 82.3 | **<0.0001** |
| DSD | **0.376** | 1, 1310 | 165.4 | **<0.0001** |
| 180-day depth | **-0.066** | 1, 1319 | 4.6 | **0.032** |
| *Jordanella floridae* (Flagfish)( = 0.115, = 0.344) | | | | |
| season | -0.000, -0.025, -0.065, **-0.148** | 4, 1312 | 9.0 | **<0.0001** |
| LDS | **0.216** | 1, 1321 | 67.2 | **<0.0001** |
| 180-day depth | **-0.120** | 1, 1320 | 10.3 | **0.0014** |
| *Lucania goodei* (Bluefin Killifish)(0.474, = 0.632) | | | | |
| season | **0.108**, **0.067**, 0.042, 0.020 | 4, 1309 | 4.1 | **0.0027** |
| LDS | **-0.237** | 1, 1311 | 189.9 | **<0.0001** |
| DSD | **0.289** | 1, 1319 | 99.8 | **<0.0001** |
| 180-day depth | **0.180** | 1, 1320 | 38.1 | **<0.0001** |
| season:LDS | **-0.090**, **-0.105**, **-0.074**, -0.041 | 4, 1305 | 3.2 | **0.012** |
| *Poecilia latipinna* (Sailfin Molly)(0.211, = 0.430) | | | | |
| season | 0.023, -0.046, **-0.090**, **-0.112** | 4, 1302 | 4.3 | **0.0017** |
| LDS | 0.109 | 1, 1304 | 2.7 | 0.10 |
| DSD | **0.528** | 1, 1315 | 184.9 | **<0.0001** |
| 180-day depth | **-0.119** | 1, 1325 | 9.2 | **0.0024** |
| season:LDS | **-0.128**, **-0.141**, **-0.119**, **-0.072** | 4, 1298 | 3.6 | **0.0062** |

**Table S2.** Results of mixed effects models from the parameterization of hydrological effects during the baseline period (before swamp eel invasion; 1996–2009) for the three most common decapods and eight most common fishes in Taylor Slough. Parameters were selected based on a model selection procedure described in the methods of the main text. Season indicates the sampling month (categorical variable), depth is the average depth over the prior 30 or 180 days, LDS is the length of the previous dry season, DSD is the days since a plot was last dry (depth < 5 cm). Bold indicates statistical significance (*P* < 0.05).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Coef. | df | F | *P* |
| *Palaemonetes paludosus* (Grass Shrimp): = 0.057, = 0.253 | | | | |
| season | **-0.175**, **-0.348**, **-0.276**, **-0.118** | 4, 762 | 10.1 | **<0.0001** |
| 180-day depth | **0.278** | 1, 633 | 24.6 | **<0.0001** |
| *Procambarus alleni* (Everglades Crayfish): = 0.275, = 0.514 | | | | |
| season | **-0.149**, **-0.229**, **-0.188**, **-0.153** | 4, 762 | 4.5 | **0.0014** |
| LDS | **0.487** | 1, 759 | 42.5 | **<0.0001** |
| DSD | **-0.217** | 1, 760 | 26.6 | **<0.0001** |
| 180-day depth | **0.219** | 1, 762 | 17.8 | **<0.0001** |
| season:LDS | **-0.120**, **-0.186**, **-0.207**, **-0.201** | 4, 758 | 6.5 | **<0.0001** |
| *Procambarus fallax* (Slough Crayfish): = 0.097, = 0.329 | | | | |
| season | **-0.180**, -0.014, **0.151**, 0.032 |  | 11.5 | **<0.0001** |
| DSD | **0.168** |  | 25.3 | **<0.0001** |
| 30-day depth | 0.084 |  | 2.5 | 0.11 |
| *Cyprinodon variegatus* (Sheepshead Minnow): = 0.084, = 0.426 | | | | |
| DSD | **0.118** | 1, 767 | 16.1 | **<0.0001** |
| 30-day depth | **-0.281** | 1, 769 | 94.1 | **<0.0001** |
| *Elassoma evergladei* (Everglades Pygmy Sunfish): = 0.163, = 0.342 | | | | |
| season | 0.074, **0.166**, **0.209**, **0.315** | 4, 763 | 20.4 | **<0.0001** |
| LDS | **-0.318** | 1, 762 | 97.5 | **<0.0001** |
| 180-day depth | **-0.152** | 1,675 | 7.2 | **0.0075** |
| *Fundulus chrysotus* (Golden Topminnow): = 0.340, = 0.409 | | | | |
| season | 0.062, -0.005, **-0.138**, **-0.107** | 4, 725 | 5.0 | **0.0005** |
| LDS | **-0.364** | 1, 765 | 76.0 | **<0.0001** |
| DSD | **0.303** | 1, 765 | 45.6 | **<0.0001** |
| 30-day depth | **-0.114** | 1, 476 | 5.6 | **0.018** |
| *Fundulus confluentus* (Marsh Killifish): = 0.116, = 0.139 | | | | |
| DSD | **-0.317** | 1, 753 | 87.5 | **<0.0001** |
| 30-day depth | **-0.106** | 1, 734 | 9.6 | **0.0020** |
| *Gambusia holbrooki* (Eastern Mosquitofish): = 0.118, = 0.308 | | | | |
| LDS | -0.080 | 1, 767 | 3.6 | 0.059 |
| DSD | **0.193** | 1, 766 | 17.3 | **<0.0001** |
| 180-day depth | **0.138** | 1, 715 | 12.5 | **0.0004** |
| *Heterandria formosa* (Least Killifish): = 0.383, = 0.520 | | | | |
| season | **0.146**, **0.161**, **0.137**, **0.094** | 4, 759 | 3.3 | **0.011** |
| LDS | **0.102** | 1, 767 | 27.1 | **<0.0001** |
| DSD | **0.496** | 1, 764 | 136.7 | **<0.0001** |
| season:LDS | **-0.238**, **-0.282**, **-0.245** **-0.197** | 1, 760 | 8.5 | **<0.0001** |
| *Jordanella floridae* (Flagfish): = 0.086, = 0.109 | | | | |
| season | **-0.289**, **-0.282**, **-0.255**, **-0.325** | 4, 763 | 18.5 | **<0.0001** |
| LDS | **0.107** | 1, 770 | 8.3 | **0.0041** |
| *Lucania goodei* (Bluefin Killifish): 0.618, = 0.738 | | | | |
| season | **0.110**, **0.168**, **0.171**, **0.127** | 4, 762 | 5.9 | **0.0001** |
| LDS | **-0.401** | 1, 759 | 324.9 | **<0.0001** |
| DSD | **0.260** | 1, 761 | 72.9 | **<0.0001** |
| 180-day depth | 0.068 | 1, 731 | 3.4 | 0.068 |
| season:LDS | **-0.101**, **-0.101**, **-0.083**, -0.057 | 4, 759 | 2.1 | 0.074 |

**Table S3.** Results of mixed effects models from the parameterization of hydrological effects in Water Conservation Area 3A during the period corresponding to the baseline period in Shark River Slough (1996–2011) for the two most common decapods and seven most common fishes. Coefficients are standardized coefficients. Season indicates the sampling month (categorical variable), depth is the average depth over the prior 30 or 180 days, LDS is the length of the previous dry season, DSD is the days since a plot was last dry (depth < 5 cm). Bold indicates statistical significance (*P* < 0.05).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Coef. | df | F | *P* |
| *Palaemonetes paludosus* (Grass Shrimp) ( = 0.045, = 0.273) | | | | |
| season | 0.022, -0.026, **-0.081**, -0.055 | 4, 1610 | 3.0 | **0.019** |
| LDS | **0.101** | 1, 1622 | 17.6 | **<0.0001** |
| 30-day depth | **-0.117** | 1, 1615 | 11.5 | **0.0007** |
| season:LDS | **-0.083**, -0.042, 0.060, **0.065** | 4, 1607 | 6.7 | **<0.0001** |
| *Procambarus fallax* (Slough Crayfish)( = 0.124, = 0.169) | | | | |
| season | **-0.124**, 0.065, **0.156**, **0.131** | 4, 1595 | 18.7 | **<0.0001** |
| LDS | **0.065** | 1, 1619 | 5.6 | **0.018** |
| DSD | **0.110** | 1, 1049 | 5.6 | **0.019** |
| 180-day depth | **-0.353** | 1, 867 | 74.7 | **<0.0001** |
| season:LDS | -0.017, 0.044, 0.059, -0.025 | 4, 1625 | 2.3 | 0.057 |
| *Elassoma evergladei* (Everglades Pygmy Sunfish)( = 0.108, = 0.226) | | | | |
| season | **-0.068**, **-0.114**, 0.003, **0.131** | 4, 1597 | 21.8 | **<0.0001** |
| DSD | **0.146** | 1, 1499 | 18.7 | **<0.0001** |
| 180-day depth | **0.114** | 1, 1363 | 7.9 | **0.0049** |
| *Fundulus chrysotus* (Golden Topminnow)( = 0.165, = 0.259) | | | | |
| season | **0.152**, -0.037, **-0.185**, **-0.229** | 4, 1603 | 38.9 | **<0.0001** |
| LDS | **-0.450** | 1, 1621 | 31.3 | **<0.0001** |
| DSD | **0.116** | 1, 1376 | 6.3 | **0.012** |
| 180-day depth | **-0.106** | 1, 1252 | 6.8 | **0.0092** |
| season:LDS | **0.108**, **0.179**, **0.161**, **0.147** | 4, 1610 | 8.1 | **<0.0001** |
| *Gambusia holbrooki* (Eastern Mosquitofish)( = 0.106, = 0.226) | | | | |
| season | **0.162**, 0.041, -0.054, -0.066 | 4, 1609 | 16.6 | **<0.0001** |
| LDS | **-0.457** | 1, 1627 | 7.3 | **0.0069** |
| DSD | **0.077** | 1, 1506 | 7.3 | **0.0069** |
| 180-day depth | **-0.166** | 1, 1434 | 16.2 | **<0.0001** |
| season:LDS | **0.193**, **0.286**, **0.245**, **0.160** | 4, 1611 | 16.6 | **<0.0001** |
| *Heterandria formosa* (Least Killifish)( = 0.239, = 0.381) | | | | |
| season | **0.070**, -0.033, **-0.064**, **-0.094** | 4, 1612 | 6.8 | **<0.0001** |
| LDS | **-0.367** | 1, 1621 | 40.1 | **<0.0001** |
| DSD | **0.150** | 1, 1556 | 11.4 | **0.0008** |
| 30-day depth | **0.210** | 1, 1600 | 41.7 | **<0.0001** |
| season:LDS | -0.002, **0.075**, **0.146**, **0.112** | 4, 1610 | 9.1 | **<0.0001** |
| *Jordanella floridae* (Flagfish)( = 0.288, = 0.346) | | | | |
| season | 0.008, **0.081**, 0.059, -0.044 | 4, 1615 | 4.9 | **0.0007** |
| LDS | 0.007 | 1, 1629 | 4.9 | **0.027** |
| DSD | **-0.189** | 1, 1331 | 18.0 | **<0.0001** |
| 180-day depth | **-0.360** | 1, 1193 | 84.0 | **<0.0001** |
| season:LDS | 0.059, 0.074, 0.061, -0.005 | 4, 1625 | 2.1 | 0.083 |
| *Lucania goodei* (Bluefin Killifish)(0.340, = 0.430) | | | | |
| season | **0.103**, 0.040, **0.067**, **0.061** | 4, 1608 | 3.6 | **0.0064** |
| LDS | **-0.288** | 1, 1623 | 50.1 | **<0.0001** |
| DSD | **0.227** | 1, 1491 | 32.2 | **<0.0001** |
| 180-day depth | **0.181** | 1, 1413 | 26.3 | **<0.0001** |
| season:LDS | -0.009, 0.058, **0.063**, 0.037 | 4, 1610 | 2.5 | **0.040** |
| *Poecilia latipinna* (Sailfin Molly)(0.045, = 0.134) | | | | |
| season | **0.100**, 0.016, -0.015, -0.052 | 4, 1600 | 5.1 | **0.0004** |
| LDS | **-0.103** | 1, 1623 | 1.9 | 0.16 |
| DSD | **0.140** | 1, 1335 | 8.1 | **0.0045** |
| 180-day depth | -0.197 | 1, 1199 | 20.6 | **<0.0001** |
| season:LDS | -0.029, 0.063, 0.065, 0.016 | 4, 1610 | 2.4 | **0.046** |

**Table S4.** Results of models of the effects of predators on the three decapod species in Shark River Slough for each of the three models: Baseline period (1996–2011) and during the entire time series (1996–2022) using Densities or Presence/absence of jewelfish and swamp eels. Coefficients are standardized coefficients. MC indicate effects of Mayan Cichlids; t indicates densities of a predator during the current sampling period; t-1 indicates densities of a predator during the previous sampling period; ef indicates densities of a predator from annual electrofishing indices (all top predator data are electrofishing); p/a indicates presence/absence effects of jewelfish. Bold indicates coefficients different from zero (*P* < 0.05). Because models were performed on residuals of hydrologic analyses/predictions, *R2* here essentially indicates how much of the remaining variation in prey densities is accounted for by predator effects or residual covariation between predators and hydrology.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Coef. | df | F | *P* |
| *Palaemonetes paludosus* (Grass Shrimp) | | | | | |
| Baseline ( = 0.056, = 0.056) | | | | | |
| MC (t-1) | -0.049 | 1, 235 | 1.8 | 0.18 |
| MC (ef) | **0.171** | 1, 346 | 22.5 | **<0.0001** |
| Sunfish (t-1) | **-0.078** | 1, 250 | 4.7 | **0.031** |
| Sunfish (ef) | **0.110** | 1, 552 | 9.4 | **0.0023** |
| Densities ( = 0.092, = 0.115) | | | | | |
| Jewelfish (t) | **-0.056** | 1, 1266 | 4.4 | **0.036** |
| Swamp eels (ef) | **0.263** | 1, 1154 | 93.5 | **<0.0001** |
| Sunfish (t) | **-0.078** | 1, 1260 | 8.1 | **0.0044** |
| Sunfish (ef) | -0.045 | 1, 1015 | 2.6 | 0.11 |
| MC (t-1) | -0.038 | 1, 1265 | 2.0 | 0.16 |
| MC (ef) | -0.036 | 1, 1220 | 1.7 | 0.19 |
| Presence/absence ( = 0.191, = 0.211) | | | | |
| Jewelfish (p/a) | 0.045 | 1, 1527 | 3.8 | 0.052 |
| Swamp eels (p/a) | **0.434** | 1, 1529 | 350.0 | **<0.0001** |
| Sunfish (t) | -0.045 | 1, 1530 | 3.6 | 0.059 |
| *Procambarus alleni* (Everglades Crayfish) | | | | |
| Baseline ( = 0.058, = 0.093) | | | | |
| MC (t-1) | **-0.079** | 1, 730 | 4.7 | **0.030** |
| MC (ef) | **-0.192** | 1, 701 | 27.5 | **<0.0001** |
| Top Preds | **-0.122** | 1, 737 | 11.5 | **0.0007** |
| Densities ( = 0.016, = 0.016) | | | | |
| Jewelfish (t) | -0.052 | 1, 1298 | 3.6 | 0.058 |
| Swamp eels (ef) | -0.037 | 1, 1298 | 1.8 | 0.17 |
| MC (t) | -0.037 | 1, 1298 | 1.7 | 0.19 |
| MC (t-1) | -0.049 | 1, 1298 | 2.9 | 0.087 |
| MC (ef) | **-0.088** | 1, 1298 | 10.1 | **0.0016** |
| Presence/absence ( = 0.036, = 0.037) | | | | |
| Jewelfish (p/a) | **-0.119** | 1, 783 | 18.0 | **<0.0001** |
| Swamp eels (p/a) | **-0.122** | 1, 817 | 19.3 | **<0.0001** |
| MC (t) | -0.050 | 1, 1193 | 3.0 | 0.081 |
| MC (t-1) | **-0.060** | 1, 1124 | 4.4 | **0.037** |
| MC (ef) | **-0.103** | 1, 556 | 14.0 | **0.0002** |
| *Procambarus fallax* (Slough Crayfish) | | | | |
| Baseline ( = 0.023, = 0.023) | | | | |
| MC (t-1) | -0.057 | 1, 744 | 2.4 | 0.12 |
| MC (ef) | 0.048 | 1, 744 | 1.7 | 0.19 |
| Sunfish (t) | **0.079** | 1, 744 | 4.8 | **0.030** |
| Top Preds | **0.103** | 1, 744 | 8.0 | **0.0049** |
| Densities ( = 0.017, = 0.018) | | | | |
| Jewelfish (t-1) | -0.046 | 1, 1229 | 2.8 | 0.090 |
| Swamp eels (ef) | **-0.103** | 1, 1283 | 13.7 | **0.0002** |
| MC (ef) | -0.042 | 1, 798 | 2.3 | 0.13 |
| Sunfish (ef) | 0.047 | 1, 754 | 2.9 | 0.090 |
| Presence/absence ( = 0.049, = 0.049) | | | | |
| Jewelfish (p/a) | **-0.096** | 1, 1298 | 11.9 | **0.0006** |
| Swamp eels (p/a) | **-0.204** | 1, 1298 | 54.7 | **<0.0001** |
| MC (ef) | **-0.055** | 1, 1298 | 4.0 | **0.045** |
| Sunfish (ef) | 0.046 | 1, 1298 | 2.8 | 0.096 |

**Table S5.** Results of models of the effects of predators on the nine small fish species in Shark River Slough for each of the three models: Baseline period (1996–2011) and during the entire time series (1996–2022) using Densities or Presence/absence of jewelfish and swamp eels. Coefficients are standardized coefficients. MC indicate effects of Mayan Cichlids; t indicates densities of a predator during the current sampling period; t-1 indicates densities of a predator during the previous sampling period; ef indicates densities of a predator from annual electrofishing indices (all top predator data are electrofishing); p/a indicates presence/absence effects of jewelfish. Bold indicates coefficients different from zero (*P* < 0.05).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Coef. | df | F | *P* |
| *Elassoma evergladei* (Everglades Pygmy Sunfish) | | | | |  |
| Baseline ( = 0.051, = 0.088) | | | | |
| MC (t) | **-0.172** | 1, 744 | 21.1 | **<0.0001** |
| MC (t-1) | **-0.091** | 1, 744 | 5.8 | **0.016** |
| Sunfish (t) | **-0.105** | 1, 743 | 8.2 | **0.0042** |
| Densities ( = 0.096, = 0.199) | | | | |
| Jewelfish (t) | **0.064** | 1, 1292 | 6.4 | **0.012** |
| Swamp eels (ef) | 0.033 | 1, 1265 | 1.7 | 0.19 |
| MC (t) | **-0.088** | 1, 1287 | 11.4 | **0.0007** |
| MC (t-1) | **-0.090** | 1, 1291 | 12.0 | **0.0005** |
| Sunfish (t) | 0.039 | 1, 1296 | 2.4 | 0.13 |
| Top Preds | **0.244** | 1, 1284 | 79.2 | **<0.0001** |
| Presence/absence ( = 0.100, = 0.213) | | | | |
| Jewelfish (p/a) | **0.113** | 1, 1290 | 18.7 | **<0.0001** |
| Swamp eels (p/a) | **0.058** | 1, 1289 | 5.1 | **0.025** |
| MC (t) | **-0.076** | 1, 1286 | 8.7 | **0.0033** |
| MC (t-1) | **-0.083** | 1, 1290 | 10.1 | **0.0015** |
| Top Preds | **0.240** | 1, 1288 | 76.0 | **<0.0001** |
| *Fundulus chrysotus* (Golden Topminnow) | | | | |
| Baseline ( = 0.020, = 0.026) | | | | |
| MC (ef) | **0.103** | 1, 582 | 7.7 | **0.0058** |
| Sunfish (t) | 0.054 | 1, 646 | 2.1 | 0.15 |
| Sunfish (ef) | -0.053 | 1, 701 | 2.0 | 0.16 |
| Top Preds | -0.069 | 1, 741 | 3.4 | 0.066 |
| Densities ( = 0.019, = 0.036) | | | | |
| Jewelfish (t) | **0.072** | 1, 1292 | 5.7 | **0.017** |
| Jewelfish (t-1) | **-0.062** | 1, 1294 | 4.2 | **0.040** |
| MC (ef) | 0.055 | 1, 1168 | 3.8 | 0.050 |
| Sunfish (t) | **0.073** | 1, 1276 | 6.7 | **0.0097** |
| Sunfish (ef) | -0.049 | 1, 1021 | 2.9 | 0.091 |
| Top Preds | **-0.067** | 1, 835 | 5.0 | **0.026** |
| Presence/absence ( = 0.024, = 0.029) | | | | |
| Jewelfish (p/a) | -0.052 | 1, 1142 | 3.3 | 0.072 |
| Swamp eels (p/a) | **-0.086** | 1, 860 | 9.1 | **0.0027** |
| MC (ef) | 0.046 | 1, 895 | 2.7 | 0.10 |
| Sunfish (t) | **0.080** | 1, 1287 | 7.0 | **0.0081** |
| Sunfish (t-1) | -0.040 | 1, 1271 | 1.8 | 0.19 |
| Sunfish (ef) | **-0.061** | 1, 782 | 4.5 | **0.035** |
| Top Preds | **-0.067** | 1, 335 | 5.2 | **0.023** |
| *Fundulus confluentus* (Marsh Killifish) | | | | |
| Baseline ( = 0.041, = 0.159) | | | | |
| MC (t) | **0.148** | 1, 737 | 16.4 | **<0.0001** |
| Sunfish (t-1) | **-0.123** | 1, 738 | 11.1 | **0.0009** |
| Top Preds | **0.108** | 1, 727 | 9.0 | **0.0027** |
| Densities ( = 0.023, = 0.034) | | | | |
| Swamp eels | **-0.072** | 1, 1297 | 6.8 | **0.0091** |
| MC (t) | **0.086** | 1, 1274 | 9.4 | **0.0022** |
| Sunfish (t) | **0.077** | 1, 1296 | 6.6 | **0.010** |
| Sunfish (t-1) | **-0.059** | 1, 1294 | 3.9 | **0.048** |
| Top Preds | 0.050 | 1, 799 | 2.9 | 0.089 |
| Presence/absence ( = 0.049, = 0.068) | | | | |
| Jewelfish (p/a) | -0.041 | 1, 1257 | 2.0 | 0.15 |
| Swamp eels (p/a) | **-0.178** | 1, 1244 | 39.1 | **<0.0001** |
| MC (t) | **0.087** | 1, 1298 | 9.4 | **0.0022** |
| MC (t-1) | -0.043 | 1, 1297 | 2.2 | 0.13 |
| Sunfish (t) | **0.067** | 1, 1298 | 5.0 | **0.025** |
| Sunfish (t-1) | **-0.066** | 1, 1297 | 4.9 | **0.027** |
| Top Preds | 0.045 | 1, 992 | 2.3 | 0.13 |
| *Gambusia holbrooki* (Eastern Mosquitofish) | | | | |
| Baseline ( = 0.070, = 0.070) | | | | |
| MC (t) | **-0.116** | 1, 744 | 9.9 | **0.0017** |
| MC (t-1) | **-0.151** | 1, 744 | 16.8 | **<0.0001** |
| Sunfish (t) | 0.069 | 1, 744 | 3.4 | 0.064 |
| Sunfish (t-1) | **-0.113** | 1, 744 | 9.3 | **0.0024** |
| Sunfish (ef) | 0.047 | 1, 744 | 1.7 | 0.19 |
| Top Preds | 0.060 | 1, 744 | 2.7 | 0.10 |
| Densities ( = 0.147, = 0.148) | | | | |
| Jewelfish (t) | **-0.211** | 1, 1298 | 56.3 | **<0.0001** |
| Jewelfish (t-1) | **-0.215** | 1, 1289 | 58.3 | **<0.0001** |
| Swamp eels (ef) | 0.049 | 1, 1286 | 3.6 | 0.060 |
| MC (t-1) | 0.036 | 1, 1063 | 1.9 | 0.16 |
| Sunfish (t-1) | **-0.088** | 1, 1060 | 11.4 | **0.0008** |
| Sunfish (ef) | **-0.053** | 1, 830 | 4.0 | **0.046** |
| Presence/absence ( = 0.278, = 0.288) | | | | |
| Jewelfish (p/a) | **-0.515** | 1, 1550 | 562.3 | **<0.0001** |
| Swamp eel (p/a) | **0.074** | 1, 1550 | 11.7 | **0.0006** |
| MC (ef) | -0.028 | 1, 1551 | 1.7 | 0.19 |
| *Heterandria formosa* (Least Killifish) | | | | |
| Baseline ( = 0.074, = 0.075) | | | | |
| MC (t) | -0.060 | 1, 639 | 2.7 | 0.099 |
| MC (t-1) | **-0.093** | 1, 561 | 6.4 | **0.012** |
| Sunfish (t-1) | **-0.078** | 1, 437 | 4.7 | **0.030** |
| Sunfish (ef) | **0.167** | 1, 623 | 21.1 | **<0.0001** |
| Top Preds | **-0.178** | 1, 742 | 24.2 | **<0.0001** |
| Densities ( = 0.113, = 0.150) | | | | |
| Jewelfish (t) | **-0.143** | 1, 1287 | 25.5 | **<0.0001** |
| Jewelfish (t-1) | **-0.208** | 1, 1289 | 53.5 | **<0.0001** |
| MC (ef) | -0.035 | 1, 1250 | 1.7 | 0.19 |
| Sunfish (t) | 0.054 | 1, 1294 | 3.7 | 0.055 |
| Sunfish (t-1) | -0.041 | 1, 1294 | 2.1 | 0.15 |
| Sunfish (ef) | **0.069** | 1, 1230 | 6.3 | **0.012** |
| Top Preds | **-0.090** | 1, 1072 | 9.8 | **0.0018** |
| Presence/absence ( = 0.162, = 0.198) | | | | |
| Jewelfish (p/a) | **-0.388** | 1, 1264 | 216.8 | **<0.0001** |
| Swamp eels (p/a) | **-0.065** | 1, 1207 | 6.2 | **0.013** |
| MC (ef) | **-0.061** | 1, 1251 | 5.4 | **0.020** |
| Sunfish (t) | **0.076** | 1, 1295 | 8.5 | **0.0036** |
| Sunfish (ef) | **0.097** | 1, 1179 | 12.9 | **0.0003** |
| Top Preds | **-0.097** | 1, 971 | 12.4 | **0.0005** |
| *Jordanella floridae* (Flagfish) | | | | |
| Baseline ( = 0.019, = 0.019) | | | | |
| Sunfish (ef) | **0.113** | 1, 744 | 9.2 | **0.0025** |
| Top Preds | 0.062 | 1, 744 | 2.8 | 0.095 |
| Densities ( = 0.065, = 0.099) | | | | |
| Jewelfish (t) | **-0.090** | 1, 1294 | 9.8 | **0.0018** |
| Jewelfish (t-1) | **-0.116** | 1, 1294 | 15.7 | **<0.0001** |
| Swamp eels (ef) | **-0.099** | 1, 1297 | 13.9 | **0.0002** |
| MC (t) | 0.051 | 1, 1298 | 3.6 | 0.059 |
| Sunfish (t) | 0.037 | 1, 1263 | 1.8 | 0.18 |
| Top Preds | **-0.120** | 1, 1214 | 16.9 | **<0.0001** |
| Presence/absence ( = 0.136, = 0.168) | | | | |
| Jewelfish (p/a) | **-0.286** | 1, 1285 | 114.4 | **<0.0001** |
| Swamp eels (p/a) | **-0.237** | 1, 1287 | 79.6 | **<0.0001** |
| Sunfish (t-1) | 0.046 | 1, 1298 | 3.1 | 0.079 |
| Top Preds | **-0.119** | 1, 1209 | 18.5 | **<0.0001** |
| *Lucania goodei* (Bluefin Killifish) | | | | |
| Before ( = 0.101, = 0.104) | | | | |
| MC (t-1) | 0.059 | 1, 571 | 2.8 | 0.096 |
| MC (ef) | **0.163** | 1, 600 | 21.0 | **<0.0001** |
| Sunfish (t) | **0.093** | 1, 614 | 6.9 | **0.0086** |
| Sunfish (ef) | **0.177** | 1, 701 | 24.1 | **<0.0001** |
| Top Preds | **-0.208** | 1, 743 | 33.8 | **<0.0001** |
| Densities ( = 0.070, = 0.140) | | | | |
| Jewelfish (t) | **-0.070** | 1, 1288 | 5.9 | **0.015** |
| Jewelfish (t-1) | -0.054 | 1, 1290 | 3.5 | 0.062 |
| Swamp eels (ef) | **-0.068** | 1, 1250 | 6.3 | **0.012** |
| Sunfish (t) | **0.091** | 1, 1297 | 11.5 | **0.0007** |
| Sunfish (ef) | **0.119** | 1, 1259 | 17.8 | **<0.0001** |
| Top Preds | **-0.172** | 1, 1269 | 34.4 | **<0.0001** |
| Presence/absence ( = 0.060, = 0.137) | | | | |
| Jewelfish (p/a) | -0.051 | 1, 1289 | 3.3 | 0.067 |
| MC (ef) | 0.036 | 1, 1297 | 1.7 | 0.20 |
| Sunfish (t) | **0.088** | 1, 1293 | 9.3 | **0.0023** |
| Sunfish (t-1) | 0.043 | 1, 1293 | 2.2 | 0.14 |
| Sunfish (ef) | **0.130** | 1, 1275 | 21.2 | **<0.0001** |
| Top Preds | **-0.179** | 1, 1259 | 37.1 | **<0.0001** |
| *Poecilia latipinna* (Sailfin Molly) | | | | |
| Baseline ( = 0.119, = 0.123) | | | | |
| MC (t) | -0.069 | 1, 703 | 3.7 | 0.055 |
| MC (t-1) | **-0.111** | 1, 672 | 9.5 | **0.0022** |
| MC (ef) | **0.181** | 1, 623 | 26.6 | **<0.0001** |
| Sunfish (t-1) | -0.054 | 1, 589 | 2.4 | 0.12 |
| Sunfish (ef) | **0.217** | 1, 708 | 38.3 | **<0.0001** |
| Densities ( = 0.127, = 0.152) | | | | |
| Jewelfish (t) | **-0.122** | 1, 1291 | 18.7 | **<0.0001** |
| Jewelfish (t-1) | **-0.145** | 1, 1294 | 26.0 | **<0.0001** |
| Swamp eels (ef) | **-0.151** | 1, 1180 | 33.6 | **<0.0001** |
| MC (ef) | **0.126** | 1, 1237 | 22.4 | **<0.0001** |
| Sunfish (t-1) | **-0.072** | 1, 1287 | 7.5 | **0.0064** |
| Sunfish (ef) | **0.121** | 1, 1044 | 19.6 | **<0.0001** |
| Top Preds | **-0.108** | 1, 1025 | 14.4 | **0.0002** |
| Presence/absence ( = 0.204, = 0.281) | | | | |
| Jewelfish (p/a) | **-0.368** | 1, 1298 | 198.2 | **<0.0001** |
| Swamp eels (p/a) | **-0.250** | 1, 1297 | 92.7 | **<0.0001** |
| MC (t-1) | 0.034 | 1, 1297 | 1.8 | 0.18 |
| MC (ef) | **0.107** | 1, 1298 | 17.8 | **<0.0001** |
| Sunfish (t-1) | -0.045 | 1, 1296 | 1.8 | 0.18 |
| Sunfish (ef) | **0.128** | 1, 1296 | 23.8 | **<0.0001** |
| Top Preds | **-0.100** | 1, 1286 | 13.5 | **0.0002** |

**Table S6.** Results of models of the effects of predators on the three decapod species in Taylor Slough for each of the three models: Baseline period (1996–2009) and during the entire time series (1996–2022) using Densities or Presence/absence of jewelfish and swamp eels. Coefficients are standardized coefficients. MC indicate effects of Mayan Cichlids; t indicates densities of a predator during the current sampling period; t-1 indicates densities of a predator during the previous sampling period; ef indicates densities of a predator from annual electrofishing indices (all top predator data are electrofishing); p/a indicates presence/absence effects of swamp eels. Bold indicates coefficients different from zero (*P* < 0.05).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Coef. | df | F | *P* |
| *Palaemonetes paludosus* (Grass Shrimp) | | | | | | |
| Baseline ( = 0.020, = 0.020) | | | | | | |
| MC (t-1) | 0.077 | 1, 513 | 3.1 | 0.081 |
| Sunfish (t-1) | -0.058 | 1, 513 | 1.7 | 0.19 |
| Sunfish (ef) | -0.078 | 1, 513 | 2.8 | 0.097 |
| Top Preds | **0.111** | 1, 513 | 5.6 | **0.018** |
| Densities ( = 0.046, = 0.087) | | | | | |
| Swamp eels (ef) | **0.194** | 1, 1027 | 39.9 | **<0.0001** |
| MC (t-1) | 0.055 | 1, 1028 | 3.3 | 0.069 |
| Top Preds | -0.050 | 1, 1032 | 2.6 | 0.11 |
| Presence/absence ( = 0.059, = 0.101) | | | | |
| Swamp eels (p/a) | **0.244** | 1, 1370 | 89.6 | **<0.0001** |
| *Procambarus alleni* (Everglades Crayfish) | | | |  |
| Baseline ( = 0.036, = 0.039) | | | | | |
| MC (ef) | **0.103** | 1, 513 | 5.6 | **0.018** |
| Sunfish (t) | 0.065 | 1, 396 | 2.2 | 0.14 |
| Sunfish (t-1) | **0.146** | 1, 427 | 11.0 | **0.0010** |
| Densities ( = 0.051, = 0.063) | | | | | |
| Swamp eels (ef) | **-0.210** | 1, 1077 | 54.4 | **<0.0001** |
| Sunfish (t) | **0.067** | 1, 1206 | 5.6 | **0.018** |
| Presence/absence ( = 0.127, = 0.183) | | | | | |
| Swamp eels (p/a) | **-0.354** | 1, 1392 | 212.3 | **<0.0001** |
| *Procambarus fallax* (Slough Crayfish) | | | | | |
| Baseline ( = 0.020, = 0.020) | | | | | |
| MC (t-1) | 0.077 | 1, 513 | 3.1 | 0.081 |
| Sunfish (t-1) | -0.058 | 1, 513 | 1.7 | 0.19 |
| Sunfish (ef) | -0.078 | 1, 513 | 2.8 | 0.097 |
| Top Preds | **0.111** | 1, 513 | 5.6 | **0.018** |
| Densities ( = 0.167, = 0.227) | | | | | |
| Swamp eels (ef) | **-0.376** | 1, 1047 | 161.8 | **<0.0001** |
| MC (t-1) | 0.039 | 1, 1042 | 2.0 | 0.16 |
| MC (ef) | -0.050 | 1, 1047 | 3.0 | 0.085 |
| Sunfish (ef) | -0.051 | 1, 1045 | 3.0 | 0.085 |
| Top Preds | **0.101** | 1, 1047 | 11.9 | **0.0006** |
| Presence/absence ( = 0.229, = 0.296) | | | | | |
| Swamp eels (p/a) | **-0.478** | 1, 1048 | 313.0 | **<0.0001** |
| MC (t) | **0.055** | 1, 1041 | 4.3 | **0.039** |
| MC (t-1) | **0.070** | 1, 1041 | 7.1 | **0.0079** |
| Sunfish (ef) | **-0.078** | 1, 1045 | 7.8 | **0.0054** |
| Top Preds | **0.078** | 1, 1045 | 7.9 | **0.0051** |

**Table S7.** Results of models of the effects of predators on the eight small fish species in Taylor Slough for each of the three models: Baseline period (1996–2009) and during the entire time series (1996–2022) using Densities or Presence/absence of jewelfish and swamp eels. Coefficients are standardized coefficients. MC indicate effects of Mayan Cichlids; t indicates densities of a predator during the current sampling period; t-1 indicates densities of a predator during the previous sampling period; ef indicates densities of a predator from annual electrofishing indices (all top predator data are electrofishing); p/a indicates presence/absence effects of swamp eels. Bold indicates coefficients different from zero (*P* < 0.05).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Coef. | df | F | *P* |
| *Cyprinodon variegatus* (Sheepshead Minnow) | | | | | |
| Baseline ( = 0.032, = 0.032) | | | | | |
| MC (t-1) | **-0.118** | 1, 513 | 7.2 | **0.0074** |
| MC (ef) | -0.079 | 1, 513 | 3.0 | 0.082 |
| Sunfish (ef) | **0.127** | 1, 513 | 6.9 | **0.0087** |
| Top Preds | -0.080 | 1, 513 | 3.0 | 0.086 |
| Densities ( = 0.043, = 0.074) | | | | |
| Swamp eels (ef) | **-0.070** | 1, 1043 | 4.7 | **0.031** |
| MC (t) | **-0.070** | 1, 1044 | 3.8 | **0.021** |
| MC (t-1) | **-0.110** | 1, 1045 | 13.2 | **0.0003** |
| MC (ef) | -0.057 | 1, 1042 | 3.2 | 0.072 |
| Sunfish (ef) | **0.086** | 1, 1043 | 7.0 | **0.0081** |
| Top Preds | **-0.102** | 1, 1030 | 10.2 | **0.0015** |
| Presence/absence ( = 0.067, = 0.097) | | | | | |
| Swamp eels (p/a) | **-0.192** | 1, 1047 | 39.3 | **<0.0001** |
| MC (t) | -0.052 | 1, 1044 | 3.0 | 0.082 |
| MC (t-1) | **-0.093** | 1, 1045 | 9.6 | **0.0020** |
| Sunfish (ef) | **0.063** | 1, 1038 | 3.9 | **0.048** |
| Top Preds | **-0.113** | 1, 1029 | 12.9 | **0.0003** |
| *Elassoma evergladei* (Everglades Pygmy Sunfish) | | | |  |
| Baseline ( = 0.026, = 0.026) | | | | | |
| MC (t) | **0.121** | 1, 513 | 7.6 | **0.0062** |
| Sunfish (ef) | -0.071 | 1, 513 | 2.3 | 0.13 |
| Top Preds | -0.078 | 1, 513 | 2.7 | 0.097 |
| Densities ( = 0.027, = 0.050) | | | | | |
| Swamp eels (ef) | **-0.120** | 1, 1033 | 14.6 | **0.0001** |
| MC (t) | 0.062 | 1, 1047 | 4.2 | **0.040** |
| Sunfish (t-1) | **0.082** | 1, 1049 | 7.1 | **0.0077** |
| Sunfish (ef) | -0.060 | 1, 1048 | 3.8 | 0.052 |
| Presence/absence ( = 0.045, = 0.070) | | | | | |
| Swamp eels (p/a) | **-0.186** | 1, 1049 | 36.2 | **<0.0001** |
| MC (t) | **0.081** | 1, 1046 | 7.2 | **0.0073** |
| Sunfish (t-1) | **0.067** | 1, 1049 | 4.9 | **0.028** |
| Sunfish (ef) | **-0.073** | 1, 1048 | 5.7 | **0.017** |
| *Fundulus chrysotus* (Golden Topminnow) | | | | | |
| Baseline ( = 0.077, = 0.077) | | | | | |
| MC (t) | **0.121** | 1, 513 | 7.8 | **0.0055** |
| Sunfish (t) | **0.087** | 1, 513 | 4.0 | **0.0045** |
| Sunfish (t-1) | **-0.089** | 1, 513 | 4.3 | **0.039** |
| Sunfish (ef) | **-0.179** | 1, 513 | 15.5 | **<0.0001** |
| Top Preds | **0.192** | 1, 513 | 17.5 | **<0.0001** |
| Densities ( = 0.055, = 0.058) | | | | | |
| Swamp eels (ef) | **-0.145** | 1, 883 | 22.2 | **<0.0001** |
| MC (t-1) | **-0.088** | 1, 1048 | 8.6 | **0.0035** |
| Sunfish (t) | **0.107** | 1, 976 | 12.3 | **0.0005** |
| Sunfish (ef) | **-0.074** | 1, 994 | 5.3 | **0.021** |
| Top Preds | **0.090** | 1, 983 | 8.0 | **0.0047** |
| Presence/absence ( = 0.089, = 0.090) | | | | | |
| Swamp eels (p/a) | **-0.241** | 1, 1043 | 61.1 | **<0.0001** |
| MC (t) | **0.060** | 1, 1048 | 3.9 | **0.050** |
| MC (t-1) | **-0.072** | 1, 1049 | 5.8 | **0.016** |
| Sunfish (t) | **0.082** | 1, 907 | 7.4 | **0.0067** |
| Sunfish (ef) | **-0.086** | 1, 938 | 7.5 | **0.0062** |
| Top Preds | **0.077** | 1, 952 | 6.1 | **0.014** |
| *Fundulus confluentus* (Marsh Killifish) | | | | | |
| Baseline ( = 0.008, = 0.008) | | | | | |
| MC (t) | **0.089** | 1, 683 | 5.4 | **0.020** |
| Densities ( = 0.030, = 0.033) | | | | | |
| Swamp eels (ef) | **-0.128** | 1, 854 | 16.1 | **<0.0001** |
| MC (t) | 0.045 | 1, 1049 | 2.2 | 0.14 |
| MC (ef) | **-0.081** | 1, 1048 | 6.5 | **0.011** |
| Presence/absence ( = 0.053, = 0.056) | | | | | |
| Swamp eels (p/a) | **-0.211** | 1, 1048 | 41.6 | **<0.0001** |
| MC (t) | 0.059 | 1, 1049 | 3.7 | 0.054 |
| MC (t-1) | 0.047 | 1, 1049 | 2.3 | 0.13 |
| MC (ef) | -0.056 | 1, 1047 | 3.1 | 0.080 |
| Sunfish (t-1) | -0.042 | 1, 925 | 1.8 | 0.18 |
| Top Preds | -0.048 | 1, 1048 | 2.5 | 0.11 |
| *Gambusia holbrooki* (Eastern Mosquitofish) | | | | |
| Baseline ( = 0.020, = 0.020) | | | | | |
| MC (t) | 0.077 | 1, 513 | 3.0 | 0.083 |
| Sunfish (ef) | -0.092 | 1, 513 | 3.8 | 0.051 |
| Top Preds | **0.111** | 1, 513 | 5.6 | **0.019** |
| Densities ( = 0.076, = 0.085) | | | | |
| Swamp eels (ef) | **-0.191** | 1, 878 | 36.7 | **<0.0001** |
| MC (t-1) | -0.047 | 1, 1048 | 2.4 | 0.12 |
| MC (ef) | **-0.134** | 1, 1000 | 18.6 | **<0.0001** |
| Top Preds | 0.049 | 1, 961 | 2.6 | 0.11 |
| Presence/absence ( = 0.125, = 0.130) | | | | | |
| Swamp eels (p/a) | **-0.318** | 1, 1048 | 108.2 | **<0.0001** |
| MC (ef) | **-0.084** | 1, 1004 | 7.5 | **0.0063** |
| *Heterandria formosa* (Least Killifish) | | | | | |
| Baseline ( = 0.004, = 0.006) | | | | | |
| Top Preds | 0.066 | 1, 471 | 2.2 | 0.13 |
| Densities ( = 0.061, = 0.100) | | | | |
| Swamp eels (ef) | **0.112** | 1, 1040 | 12.4 | **0.0004** |
| MC (t) | **0.147** | 1, 1045 | 24.2 | **<0.0001** |
| MC (t-1) | **0.112** | 1, 1046 | 14.3 | **0.0002** |
| MC (ef) | **-0.058** | 1, 975 | 3.5 | **0.062** |
| Sunfish (ef) | **-0.071** | 1, 974 | 5.0 | **0.025** |
| Top Preds | **0.065** | 1, 903 | 4.3 | **0.038** |
| Presence/absence ( = 0.069, = 0.103) | | | | |
| Swamp eels (p/a) | **0.150** | 1, 1047 | 21.8 | **<0.0001** |
| MC (t) | **0.135** | 1, 1046 | 20.4 | **<0.0001** |
| MC (t-1) | **0.101** | 1, 1047 | 11.5 | **0.0007** |
| MC (ef) | **-0.078** | 1, 962 | 6.0 | **0.014** |
| Sunfish (ef) | -0.062 | 1, 940 | 3.8 | 0.051 |
| Top Preds | **0.072** | 1, 874 | 5.5 | **0.020** |
| *Jordanella floridae* (Flagfish) | | | | | |
| Baseline ( = 0.036, = 0.036) | | | | | |
| MC (t) | **0.093** | 1, 513 | 4.4 | **0.036** |
| Sunfish (t) | 0.063 | 1, 513 | 2.0 | 0.16 |
| Sunfish (ef) | **-0.114** | 1, 513 | 6.0 | **0.015** |
| Top Preds | **0.134** | 1, 513 | 8.2 | **0.0044** |
| Densities ( = 0.185, = 0.191) | | | | |
| Swamp eels (ef) | **-0.359** | 1, 961 | 144.3 | **<0.0001** |
| MC (t) | **-0.106** | 1, 1049 | 13.9 | **0.0002** |
| MC (ef) | **-0.088** | 1, 1049 | 9.1 | **0.0026** |
| Sunfish (t) | **0.060** | 1, 998 | 4.4 | **0.037** |
| Top Preds | **0.067** | 1, 1047 | 5.6 | **0.018** |
| Presence/absence ( = 0.316, = 0.316) | | | | | |
| Swamp eels (p/a) | **-0.551** | 1, 1037 | 440.3 | **<0.0001** |
| MC (t) | -0.047 | 1, 1045 | 3.4 | 0.067 |
| Sunfish (ef) | **-0.065** | 1, 1031 | 5.9 | **0.016** |
| Top Preds | 0.051 | 1, 1049 | 3.6 | 0.059 |
| *Lucania goodei* (Bluefin Killifish) | | | | | |
| Baseline ( = 0.050, = 0.044) | | | | | |
| MC (t) | 0.084 | 1, 513 | 3.7 | 0.056 |
| Sunfish (t) | **0.094** | 1, 513 | 4.6 | **0.032** |
| Sunfish (ef) | **0.166** | 1, 513 | 14.7 | **0.0001** |
| Densities ( = 0.021, = 0.214) | | | | | |
| Swamp eels (ef) | **0.086** | 1, 1049 | 7.0 | **0.0084** |
| MC (t) | **0.098** | 1, 1027 | 10.6 | **0.0012** |
| MC (ef) | **-0.073** | 1, 1033 | 5.2 | **0.023** |
| Sunfish (t) | 0.060 | 1, 1028 | 3.8 | 0.052 |
| Sunfish (ef) | 0.056 | 1, 1024 | 3.3 | 0.072 |
| Presence/absence ( = 0.018, = 0.175) | | | | | |
| MC (t) | **0.099** | 1, 1021 | 10.6 | **0.0012** |
| MC (t-1) | 0.041 | 1, 1018 | 1.8 | 0.19 |
| MC (ef) | -0.051 | 1, 1030 | 2.8 | 0.096 |
| Sunfish (t) | 0.054 | 1, 1028 | 3.0 | 0.081 |
| Sunfish (ef) | 0.045 | 1, 1026 | 2.1 | 0.15 |

**Table S8.** Results of models of the effects of predators on the two decapod species and seven small fish species in Water Conservation Area 3A during the corresponding baseline period in Shark River Slough (1996–2011). Analyses of the baseline period are of the data from 1996–2011 using predators present in this region; the jewelfish invasion is a test of the jewelfish invasion period from Shark River Slough on the same dataset when jewelfish were present at all sites in Shark River Slough. Coefficients are standardized coefficients. MC indicate effects of Mayan Cichlids; t indicates densities of a predator during the current sampling period; t-1 indicates densities of a predator during the previous sampling period; ef indicates densities of a predator from annual electrofishing indices (all top predator data are electrofishing); p/a indicates presence/absence effects of swamp eels. Bold indicates coefficients different from zero (*P* < 0.05).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Coef. | df | F | *P* |
| *Palaemonetes paludosus* (Grass Shrimp) | | | | |
| Baseline ( = 0.031, = 0.031) | | | | |
| MC (ef) | 0.057 | 1, 772 | 2.5 | 0.11 |
| Sunfish (t-1) | 0.059 | 1, 772 | 2.7 | 0.10 |
| Sunfish (ef) | **-0.148** | 1, 772 | 16.4 | **<0.0001** |
| Top Preds | -0.055 | 1, 772 | 2.3 | 0.13 |
| Jewelfish invasion ( = 0.070, = 0.087) | | | | |
| Jewelfish period | **0.226** | 1, 1210 | 60.2 | **<0.0001** |
| Sunfish (t-1) | **0.063** | 1, 1180 | 5.0 | **0.026** |
| Top Preds | **0.079** | 1, 897 | 6.7 | **0.010** |
| *Procambarus fallax* (Slough Crayfish) | | | | |
| Baseline ( = 0.041, = 0.050) | | | | |
| Sunfish (t) | **0.138** | 1, 523 | 14.2 | **0.0002** |
| Top Preds | **0.136** | 1, 669 | 14.5 | **0.0002** |
| Jewelfish invasion ( = 0.043, = 0.084) | | | | |
| Jewelfish period | **-0.078** | 1, 1243 | 6.4 | **0.012** |
| Sunfish (t) | **0.132** | 1, 1239 | 21.4 | **<0.0001** |
| Sunfish (ef) | **-0.115** | 1, 1243 | 13.4 | **0.0003** |
| Top Preds | **0.100** | 1, 1154 | 9.8 | **0.0018** |
| *Elassoma evergladei* (Everglades Pygmy Sunfish) | | | | |
| Baseline ( = 0.065, = 0.108) | | | | |
| MC (ef) | **-0.104** | 1, 772 | 8.6 | **0.0035** |
| Sunfish (t) | **-0.096** | 1, 755 | 6.8 | **0.0093** |
| Sunfish (ef) | **0.094** | 1, 770 | 6.8 | **0.0091** |
| Top Preds | **0.200** | 1, 746 | 29.6 | **<0.0001** |
| Jewelfish invasion ( = 0.016, = 0.066) | | | | |
| Jewelfish period | **-0.073** | 1, 1228 | 6.1 | **0.013** |
| MC (ef) | -0.053 | 1, 1242 | 3.5 | 0.060 |
| Top Preds | **0.122** | 1, 1160 | 15.5 | **<0.0001** |
| *Fundulus chrysotus* (Golden Topminnow) | | | | |
| Baseline ( = 0.002, = 0.002) | | | | |
| Sunfish (t-1) | -0.042 | 1, 1408 | 2.4 | 0.12 |
| Jewelfish invasion ( = 0.019, = 0.019) | | | | |
| Jewelfish period | **-0.125** | 1, 2034 | 31.9 | **<0.0001** |
| Sunfish (t) | 0.045 | 1, 1588 | 3.6 | 0.058 |
| Sunfish (t-1) | **-0.050** | 1, 1880 | 4.5 | **0.034** |
| *Gambusia holbrooki* (Eastern Mosquitofish) | | | | |
| Baseline ( = 0.015, = 0.015) | | | | |
| Sunfish (t) | 0.057 | 1, 772 | 2.5 | 0.11 |
| Sunfish (ef) | **-0.080** | 1, 772 | 4.9 | **0.027** |
| MC (ef) | **0.087** | 1, 772 | 5.9 | **0.015** |
| Jewelfish invasion ( = 0.042, = 0.058) | | | | |
| Jewelfish period | **-0.109** | 1, 1207 | 12.2 | **0.0005** |
| MC (t-1) | -0.037 | 1, 1238 | 1.7 | 0.19 |
| Sunfish (t) | **0.073** | 1, 1228 | 5.6 | **0.018** |
| Sunfish (t-1) | 0.044 | 1, 1238 | 2.1 | 0.15 |
| Sunfish (ef) | **-0.118** | 1, 1164 | 13.9 | **0.0002** |
| Top Preds | 0.064 | 1, 814 | 4.1 | **0.042** |
| *Heterandria formosa* (Least Killifish) | | | | |
| Baseline ( = 0.028, = 0.035) | | | | |
| MC (t-1) | 0.047 | 1, 772 | 1.7 | 0.19 |
| MC (ef) | **0.099** | 1, 736 | 7.5 | **0.0064** |
| Sunfish (t-1) | -0.061 | 1, 602 | 2.7 | 0.10 |
| Sunfish (ef) | **-0.124** | 1, 771 | 12.0 | **0.0006** |
| Jewelfish invasion ( = 0.029, = 0.068) | | | | |
| Jewelfish period | -0.041 | 1, 1238 | 1.7 | 0.19 |
| MC (ef) | -0.045 | 1, 1235 | 2.5 | 0.11 |
| Sunfish (t) | **0.071** | 1, 1243 | 5.5 | **0.020** |
| Sunfish (t-1) | 0.044 | 1, 1243 | 2.1 | 0.14 |
| Sunfish (ef) | **-0.105** | 1, 1163 | 11.1 | **0.0009** |
| Top Preds | **0.110** | 1, 1108 | 11.7 | **0.0006** |
| *Jordanella floridae* (Flagfish) | | | | |
| Baseline ( = 0.026, = 0.030) | | | | |
| MC (t) | 0.056 | 1, 771 | 2.4 | 0.12 |
| MC (t-1) | 0.057 | 1, 772 | 2.5 | 0.11 |
| MC (ef) | 0.056 | 1, 711 | 2.4 | 0.12 |
| Sunfish (t) | 0.071 | 1, 507 | 3.6 | 0.058 |
| Sunfish (ef) | **-0.091** | 1, 770 | 6.1 | **0.014** |
| Top Preds | -0.056 | 1, 692 | 2.3 | 0.13 |
| Jewelfish invasion ( = 0.053, = 0.103) | | | | |
| Jewelfish period | **-0.173** | 1, 1235 | 35.5 | **<0.0001** |
| Sunfish (t) | **0.141** | 1, 1239 | 24.4 | **<0.0001** |
| Top Preds | 0.045 | 1, 1167 | 2.2 | 0.14 |
| *Lucania goodei* (Bluefin Killifish) | | | | |
| Baseline (0.073, = 0.112) | | | | |
| MC (t) | **0.090** | 1, 766 | 6.6 | **0.010** |
| MC (t-1) | 0.059 | 1, 768 | 2.8 | 0.094 |
| Sunfish (t) | **0.221** | 1, 754 | 34.9 | **<0.0001** |
| Sunfish (ef) | **-0.088** | 1, 771 | 6.1 | **0.014** |
| Top Preds | -0.048 | 1, 743 | 1.7 | 0.19 |
| Jewelfish invasion ( = 0.042, = 0.080) | | | | |
| Jewelfish period | 0.045 | 1, 1242 | 2.1 | 0.15 |
| MC (ef) | -0.044 | 1, 1242 | 2.5 | 0.12 |
| Sunfish (t) | **0.123** | 1, 1243 | 16.4 | **<0.0001** |
| Sunfish (t-1) | **0.065** | 1, 1243 | 4.6 | **0.032** |
| Sunfish (ef) | 0.044 | 1, 1243 | 1.9 | 0.16 |
| Top Preds | **0.082** | 1, 1123 | 6.5 | **0.011** |
| *Poecilia latipinna* (Sailfin Molly) | | | | |
| Baseline (0.013, = 0.022) | | | | |
| Sunfish (ef) | **-0.114** | 1, 767 | 10.2 | **0.0015** |
| Jewelfish invasion ( = 0.016, = 0.016) | | | | |
| Jewelfish period | **-0.095** | 1, 1243 | 9.8 | **0.0018** |
| Sunfish (ef) | -0.056 | 1, 1243 | 3.5 | 0.063 |

**Table S9.** Results of zero-inflated mixed effects model from the parameterization of hydrological effects related to densities of African Jewelfish in Shark River Slough from when they were first detected in the region through the year swamp eels were detected in SRS (2004–2019). Coefficients are standardized coefficients. DSD is the days since a plot was last dry (depth < 5 cm); LDS is the length of the previous dry season; bold indicates coefficients different from zero (*P* < 0.05).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | |  | | *z* | | *P* |
| *Hemichromis letourneuxi* (African Jewelfish)( = 0.106, = 0.233) | | | | | | | | |
| DSD | |  |  | | -2.8 | | **0.0055** | |
| LDS | |  |  | | -2.9 | | **0.0041** | |

**Table S10.** Results of the mixed effect model of the effects of predators on African Jewelfish in Shark River Slough from when jewelfish were first detected in the region through the year swamp eels were detected in SRS (2004–2019). Coefficients are standardized coefficients. MC indicate effects of Mayan Cichlids; t-1 indicates densities of a predator during the previous sampling period; bold indicates coefficients different from zero (*P* < 0.05).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Coef | | | df | | *F* | *P* | |
| *Hemichromis letourneuxi*, African Jewelfish( = 0.037, = 0.051) | | | | | | | | |
| MC (t-1) | | -0.048 | 1, 803 | | 1.9 | | | 0.16 | |
| Top Predators | | **0.185** | 1, 204 | | 23.4 | | | **<0.0001** | |

**Figure S1.** Densities (log-transformed) of the five predatory fishes assessed in this study from 1996–2022 in Water Conservation Area 3A (upstream of Shark River Slough) in the Everglades ecosystem. Study taxa are African Jewelfish (*Hemichromis letourneuxi*; a), Mayan Cichlids (*Mayaheros urophthalmus*; b), Asian Swamp Eels (*Monopterus albus*/*javanaensis*; c), Sunfishes (combined *Lepomis* spp.; d), and combined Top Predators (Bowfin, *Amia calva*; Florida Gar, *Lepisosteus platyrhincus*; Largemouth Bass, *Micropterus salmoides*; e). Points are plot-level densities of throw trap (purple circles) and electrofishing catch-per-unit-effort (blue triangles) data; purple/blue lines indicate mean densities during each sampling period. The dark shaded area corresponds to the period during which swamp eels were detected in this region, which was excluded from analyses of predator effects (Table S10).



**Figure S2.** Plot-level densities (log-transformed) over time and standardized coefficients of effects of predatory fishes on the common decapod and small fish species in Water Conservation Area 3A. Time series data of all species analyzed in Shark River and Taylor sloughs are presented here, but analyses were not performed on three uncommon species. In density plots, the black line is the mean density of all plots during each sampling period; the red line is the mean density predicted by the parameterized hydrologic models from the baseline period (error bars are excluded for clarity). The light shaded area is the jewelfish reference period, corresponding to when they regularly occurred during the boom in Shark River Slough. The dark shaded area is the ‘invasion’ period that correspond to when swamp eels were detected in WCA 3A, which was excluded from analyses (Table S10). Coefficient plots illustrate the mean standardized coefficient (± SE) for effects of predators with *P* < 0.10 included in final models (Table S10). Legend abbreviations: MC = Mayan Cichlid, Sun = Sunfish; Sw Eel = Asian Swamp Eel; t = predator densities during current sampling period; t-1 = predator densities during previous sampling period; ef = index of predator densities from electrofishing. Here, jewelfish presence corresponds to their peak occurrence in Shark River Slough, not presence in WCA 3A; no density analyses were performed in WCA 3A involving jewelfish.



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