Seines and baited remote underwater video document consistent spatiotemporal patterns in nekton communities of subtropical coastal habitats

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ABSTRACT: Monitoring nekton using multiple types of gear over a range of estuarine habitats is necessary for assessing changes in ecosystems, the effects of natural and anthropogenic disturbances, and management related to habitat restoration and protection. To assess the utility of 2 types of gear (seines and baited remote underwater videos [BRUVs]) used in many monitoring programs, nekton community metrics were compared across 3 adjacent, hydrologically distinct coastal basins in Florida Bay (Florida, USA) across seasons (wet vs. dry) and 3 water-years (2016–2019). In these basins, projects are underway to restore freshwater inflow. Spatiotemporal patterns in catch per unit effort and species richness were consistent among types of gear, and nekton assemblages differed significantly among basins. Although similar in size and spatial area, the 3 study basins were notably different in habitat (hydrology, water depth, substrate, submerged aquatic vegetation), and 1 basin exhibited distinct basin-specific trends in nekton community structure and lower nekton abundance and species richness across types of gear. Temporal differences in nekton assemblages reflected seasonal shifts and were strongly affected by the passage of Hurricane Irma in 2017. Although seines and BRUVs revealed similar patterns, seine surveys captured more overall species diversity and prey species, while BRUVs could be used in a greater variety of habitats and documented more predators. These results demonstrate the effectiveness of complementary types of gear in tracking variation in estuarine communities and highlight the importance of a sampling design that successfully monitors species throughout the food web and estuarine seascape.

KEY WORDS: Nekton communities · Estuary · Baited remote underwater video · BRUV · Seines · Florida Bay

1. INTRODUCTION

Estuarine systems consist of a mosaic of habitats subject to different hydrological conditions and support diverse fish and macroinvertebrate (nekton) communities and various life stages of individual taxa (Beck et al. 2001, Nagelkerken & van der Velde 2004, Bradley et al. 2017). Salinity variation due to changes in freshwater inflow has been correlated with the spatial arrangement of subtidal (e.g. seagrass meadows) and intertidal (e.g. mangrove, marsh) vegetated habitats, the structure and function of nekton assemblages, and the recruitment of juvenile fish (Weinstein et al. 1980, Peterson & Ross 1991, Laegdsgaard & Johnson 2001, Jackson et al. 2006, Jelbart et al. 2007, Flaherty-Walia et al. 2015, Stave-

ley et al. 2017, Gilby et al. 2018, Scapin et al. 2018, Schloesser & Fabrizio 2019). Few nekton species, however, are confined to a single type of nursery habitat, and many move across the seascape, taking advantage of the structural complexity (Cocheret de la Morinière et al. 2002, Dorenbosch et al. 2007, Boström et al. 2011, Bradley et al. 2019). As such, the movement of species among habitats, through ontogeny or in response to changes in hydrological conditions, leads to a complex interaction of habitat use over time and space (Jones et al. 2010, Fulford et al. 2011, Kimirei et al. 2011, Sheaves et al. 2015). Understanding the link between spatiotemporal variation in estuarine environmental conditions and nekton assemblage structure has implications for assessing the health of fish populations and conservation, restoration, and hydrological management efforts (Lorenz 1999, Nagelkerken et al. 2015, Sheaves et al. 2015, Carle et al. 2020).

Consistent sampling of estuarine nekton communities using types of gear that can be deployed across the entire seascape can establish valuable baseline metrics for documenting ecosystem changes, evaluating the effects of natural and anthropogenic disturbances, and making management decisions for restoration efforts (Coull 1985, Wolfe et al. 1987, Carle et al. 2020, Schrandt & MacDonald 2020, Clarkson & Beseres Pollack 2021). Valuable long-term fishery-independent data sets from traditional types of gear (predominantly nets such as trawls and seines) are available for many estuarine systems, but the advent of advanced, low-cost camera technology and high availability of user-friendly video software have made it possible to sample and document previously inaccessible habitats and nekton communities (Flaherty-Walia et al. 2023). Haul seines are a well-known and accepted type of gear in fishery monitoring and have been used in Florida (USA) for more than 30 yr in assessing species diversity, abundance, and composition in estuarine fish communities (Tremain & Adams 1995, Flaherty et al. 2014, Schrandt & MacDonald 2020). Seines allow for direct capture of individuals of multiple size classes depending on the length and mesh size of the net. The efficiency of capture, however, depends on escapement as the net is deployed (which decreases with increasing fish size) and retention as the net is hauled (which increases with increasing fish size, Bayley & Herendeen 2000). Baited remote underwater videos (BRUVs) do not have the same limitations as seines as far as escapement, deployment, and bycatch, are inherently low-impact (i.e. in terms of both habitat and target organisms), and have been

used effectively to assess faunal diversity and abundance in coral reef, seagrass, mangrove, and pelagic habitats (Heagney et al. 2007, Bond et al. 2012, Harvey et al. 2012, Delacy et al. 2017, Rees et al. 2018, Langlois et al. 2020). However, sampling with BRUVs has its own set of limitations related to visibility (i.e. turbidity, field of view), determining the effective sampling area (i.e. bait plume effects), and the precision of fish identification (Whitmarsh et al. 2017, Langlois et al. 2020, French et al. 2021).

Several studies have directly compared the efficiency of BRUV sampling to underwater visual censuses by divers (Colton & Swearer 2010, Lowry et al. 2012, Bacheler et al. 2017, Schramm et al. 2020, Cheal et al. 2021), but the few studies comparing nekton monitoring using BRUVs and seines had different results depending on the habitat sampled. In freshwater springs and waterholes, for example, underwater video produced greater species richness, abundance, and diversity than did seining (Ebner & Morgan 2013, Work & Jennings 2019). In surf zones, species assemblages sampled by seines and BRUVs were taxonomically and functionally different (Shah Esmaeili et al. 2021), while in restored mangrove pools, seines outperformed BRUVs by documenting a greater abundance of fish including smaller, cryptic species (Enchelmaier et al. 2020). Maximum species richness was achieved using both conventional netting and video methods (Ebner & Morgan 2013), and it was recommended that both types of gear be used simultaneously to improve understanding of biodiversity (Enchelmaier et al. 2020). The combination of another type of net (trawls) and BRUVs was also more efficient than a single gear type in measuring commonly used indicators of fish assemblage composition in seagrass habitat (French et al. 2021). Since each method has inherent biases, and because earlier studies comparing seines and BRUVs showed conflicting results, careful consideration of the types of gear used is essential in determining how to effectively sample nekton communities in estuarine habitats.

The objective of this study was to evaluate the comparability and complementarity of 2 fishery-independent types of gear, namely seines and BRUVs, in sampling estuarine nekton communities under different levels of freshwater flow. Specifically, we sought to determine whether these types of gear could equally detect and track spatial and temporal variation in nekton communities in a lagoonal estuarine system. Florida Bay is characterized by a complex network of shallow, often intertidal banks (shoals) that isolate its interior and northeastern por-

tions into hydrologically distinct basins (Nuttle et al. 2000). Everglades restoration, the largest hydrological restoration project in the USA (Perry 2004), aims to restore natural patterns of freshwater flow to freshwater and coastal habitats, enhancing reproduction, feeding, and growth of nekton species in Florida Bay (Rudnick et al. 2005). Increased freshwater flow (measured as high salinity variability) has also been found to positively correlate with benthic animal density, biomass, and community structure patterns in northeastern Florida Bay (Montague & Ley 1993, Lorenz 1999, Flaherty et al. 2013). Therefore, an appropriate and comprehensive suite of fishery-independent monitoring gear is needed to assess nekton community patterns as conditions in the study area change due to restoration projects. We hypothesized that data collected with seines and BRUVs would show similar patterns in nekton community metrics (i.e. species richness, abundance, and community structure) associated with season (wet vs. dry) and hydrologic conditions (across years). Furthermore, we expected that spatiotemporal patterns in nekton communities would also be consistent among types of gear and reflect differences across a variety of habitat types.

2. MATERIALS AND METHODS

2.1. Study area

Florida Bay lies between the southern tip of the Florida mainland and the Florida Keys and is the largest estuary in Florida, encompassing approximately 2200 km^2 (Fig. 1). Major sources of freshwater inflow to the bay and patterns of water exchange with the ocean are quite different from those of typical estuarine systems (Cosby et al. 1999, Lee et al. 2008, Herbert et al. 2011). Florida Bay is compartmentalized into a network of 44 basins separated by shallow banks, which restrict water- and wind-driven flow and tidal effects and concentrate the effects of local rainfall and evaporation (Nuttle et al. 2000, Hittle et al. 2001, Lee & Smith 2002). The hydrology of Florida Bay is influenced by the adjacent Gulf of Mexico and Atlantic Ocean (and associated oceanic currents), as well as by freshwater inputs from the Everglades watershed (Lee & Smith 2002, Lee et al. 2006, Briceño et al. 2013). Freshwater inflow into Florida Bay has been heavily altered due to the drainage and impoundment of the Everglades (Marshall et al. 2009, 2011, 2020), which has resulted in changes in habitat and

physicochemical conditions (e.g. seagrass die-off events, chronic hypersalinity in isolated basins, and persistent algal blooms; Hall et al. 1999, 2016, Lee et al. 2006, Kelble et al. 2007).

The 3 adjacent coastal embayments, or basins (Joe Bay, Little Madeira Bay, and Long Sound; Fig. 1), that encompass our study area receive the majority of freshwater flowing into northeastern Florida Bay (Nuttle et al. 2000, Hittle et al. 2001, Marshall et al. 2011, Briceño et al. 2013, ENP 2015), and their nekton communities are distinctive compared with those of the other basins, where salinity is less variable (Ley et al. 1999, Flaherty et al. 2013). Freshwater from upstream marshes, Taylor Slough, and a major water-control canal (C-111) flows into Joe Bay and exits through Trout Creek, which has been estimated to carry as much as 50% of the total measured freshwater flow into Florida Bay (Nuttle et al. 2000, Hittle et al. 2001). Coastal creeks flowing into 2 adjacent basins, Little Madeira Bay and Long Sound, contribute 16 and 25%, respectively, to the total freshwater discharge into northeastern Florida Bay (Hittle et al. 2001). In addition to being in such proximity to one another, these 3 basins are similar in size; Joe Bay is the largest basin, encompassing 28.4 km^2 (Hittle et al. 2001), while Little Madeira Bay and Long Sound are nearly equal in area (9.98 and 8.88 km^2, respectively; Fig. 1).

Few areas in the world contain seagrasses as extensive as those in Florida Bay (Hall et al. 1999 and references therein). Patterns in seagrass density and productivity reflect gradients in sediment depth and macronutrient availability (notably phosphorus), increasing from the northeast to the southwest (Zieman et al. 1989, Fourqurean et al. 1992). Although seagrasses are not as productive in northeastern Florida Bay, *Thalassia testudinum* and *Halodule wrightii* are commonly encountered (Zieman et al. 1989), while *Ruppia maritima* is most common in areas where salinity is seasonally low and salinity variability is high (Strazisar et al. 2015). Of the 3 study basins, Joe Bay has the lowest percentage of submerged aquatic vegetation (SAV, dominated by *H. wrightii*), while Little Madeira Bay has the greatest percentage of SAV cover (dominated by *T. testudinum*) (Herbert et al. 2011).

2.2. Sampling design

A stratified random sampling design was used to select sites for seines (21.3 and 183 m) and BRUVs across Little Madeira Bay, Joe Bay, and Long Sound
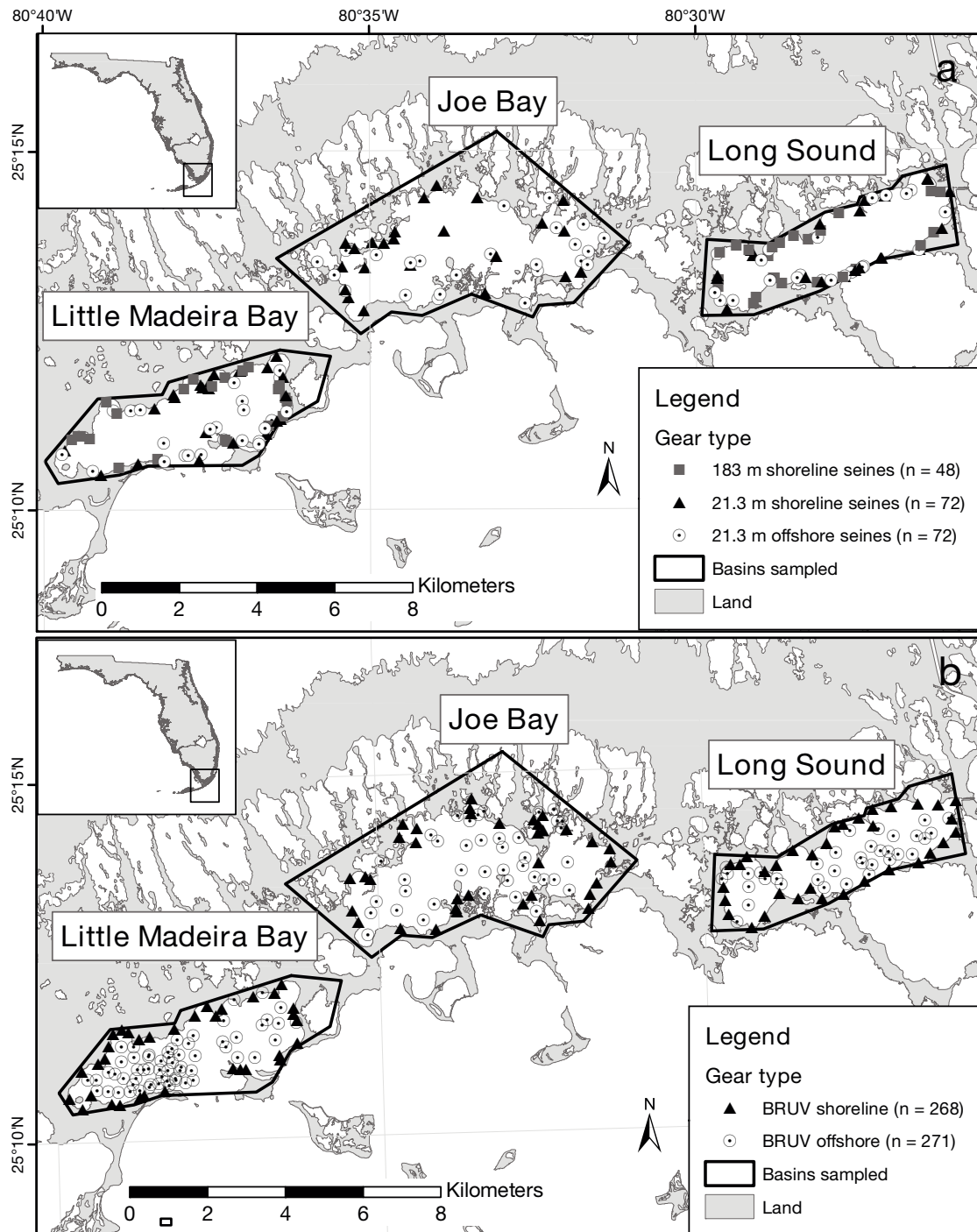
Fig. 1. Sampling sites used for comparative analyses of (a) seines and (b) baited remote underwater video (BRUV) during stratified-random sampling in 3 basins of northeastern Florida Bay, 2016–2019

(Fig. 1; Fig. S1 in the Supplement at www.int-res. com/articles/suppl/m722p037_supp.pdf). For seine site selection, the 3 basins were subdivided by superimposing a cartographic grid with 1 nautical mile (n mile) cells over a chart of the entire system (Flaherty et al. 2013). This grid was further subdivided into microgrid cells using a 10 × 10 cell grid overlay (0.1 n mile on a side). Individual microgrid cells were then randomly selected by depth and habitat (shoreline vs. offshore) for sampling in each basin. The 21.3 m seine was used to sample shallow areas (<1.5 m), which were stratified into 'shoreline' (along

the shoreline) and 'offshore' (>5 m offshore of the shoreline) sites. The 183 m seine was deployed along shorelines with wing depths ≤0.5 m and bag depths ≤2.5 m. When a chosen site could not be sampled with the designated seine (usually because of depth constraints), an alternate site was selected by exiting the original microgrid cell in a randomly selected direction (N, S, E, or W) and moving in a randomly selected spiral (clockwise or counterclockwise) until an appropriate depth and habitat in which to deploy the gear were encountered. For BRUV site selection, a random set of locations to sample was selected in each basin and habitat (shoreline, ≤10 m from shore; offshore, >10 m from shore) using ArcMap 10. Alternate sites were generated for all strata in each basin and were selected when primary sites could not be sampled due to low visibility. A primary site was rejected if a Secchi disk dropped to the bottom could not be seen from the surface. All concurrent BRUV deployments on the same day were separated by at least 100 m to avoid interference from bait attraction between consecutive deployments. No microgrid cells (seines) or selected BRUV locations were sampled more than once per season.

All field sampling was conducted during daytime hours beginning at least 1 h after sunrise and ending at least 1 h before sunset. Sampling was conducted seasonally for 3 water-years from the wet season of 2016 to the dry season of 2019: seines were deployed in October (wet season) and April (dry season) within a 1 wk period, while BRUV units were deployed in December (wet season) and April–May (dry season) over a 2 to 3 wk period. A water-year was defined as a wet season sampling event followed by a dry season sampling event (e.g. water-year 2016 consisted of the 2016 wet season and 2017 dry season). At each BRUV and seine site sampled, hydrological and environmental conditions were collected: water depth (m), water temperature (°C), salinity, dissolved oxygen (mg l^{-1}), sediment depth (cm), and Secchi depth (m). Water quality measurements were collected using a Hydrolab or YSI multiprobe (calibrated each sampling day) at the surface and at 1 m intervals to the bottom and were averaged over the water column to produce 1 value per sample site for data analysis. Sediment depth was measured at the same location as water quality when possible (i.e. when water depth was <1.5 m and sediment depth was <2.0 m). For seines, effort during each sampling event consisted of 4 large-seine deployments along the shoreline in Little Madeira Bay and Long Sound, and in all 3 basins, of 8 small-seine deployments (4 along the shoreline and 4 offshore). For BRUVs, we

attempted to sample at least 12 shoreline and 12 offshore sites in each basin per sampling event. This sampling plan corresponded to a total of 16 large-seine deployments, 48 small-seine deployments, and approximately 180 BRUV deployments in each water-year (Fig. 1; Table A1 in the Appendix).

2.3. Types of gear

2.3.1. Seines

Multiple types of seines were used in sampling, following the protocol of the Fisheries-Independent Monitoring program of the Florida Fish and Wildlife Conservation Commission's (FWC) Fish and Wildlife Research Institute used in several Florida estuaries (McMichael 1991, Flaherty et al. 2013, 2014, FWC 2014). Two seine sizes were used: (1) 21.3 m center-bag (small) seines with 3.2 mm mesh that target small-bodied individuals (generally <100 mm standard length, SL) and (2) 183 m haul (large) seines with 38 mm mesh that sample large-bodied fish (generally >100 mm SL; Fig. S1). This design was chosen for collecting data on small-bodied residents or juveniles, as well as large-bodied resident and transient species from multiple habitats (see Flaherty et al. 2013 for additional sampling details). The small seine was pulled 9.1 m with a width of 15.5 m between the seine poles, sampling an area of approximately 140 m^2. Small seines were deployed (1) parallel to bay shorelines to sample areas with emergent vegetation, mangrove fringes, and beaches and (2) offshore into the prevailing current to sample flats and seagrass beds at least 5 m from the shoreline. The large seine was set by boat in a rectangular shape (approximately 40 × 103 m) along the shoreline and retrieved by hand, sampling an area of approximately 4120 m^2. The large-seine technique (which collected most recreationally important species) was unsuccessful in Joe Bay due to a shallow sediment layer over limestone pinnacles and substantial amounts of mud and algal bycatch not typical in the other basins (Flaherty et al. 2013).

All fish and selected invertebrates (i.e. blue crab *Callinectes sapidus*, horseshoe crab *Limulus polyphemus*, and alpheid and penaeid shrimp) were identified to the lowest practical taxonomic level and counted (Table A1). A subset of each species (10 individuals for small-bodied nekton, 20 individuals for large-bodied nekton) was measured: SL for fish, total length for seahorses, disk width for batoids, precaudal length for sharks, carapace width for swimming

crabs, postorbital head length for penaeid shrimp, and shell height for scallops. A representative sample of each species and any taxa that could not be identified in the field were taken to the laboratory to verify identifications. Certain taxa were not identified to species because of complex and unresolved taxonomy (e.g. silversides *Menidia* spp.; Gilbert 1992) or because they are indistinguishable at small sizes (e.g. mojarras *Eucinostomus* spp. <40 mm SL; Matheson 1983).

2.3.2. BRUVs

BRUV units, consisting of a baited station with cameras, were used in visual surveys to record the arrival and presence of nekton that were attracted to the bait (Bond et al. 2012). For this study, BRUVs were designed to be lightweight, portable, and optimized for shallow-water habitats (Bond et al. 2012, Goetze et al. 2018, Sherman et al. 2018, Speed et al. 2018). Each BRUV system was constructed of a PVC frame (0.75 m long × 0.5 m wide × 0.5 m high) with a PVC pipe marked with black tape at 0.1 m increments extending 0.5 m away from the frame to provide a reference point for measuring underwater visibility and determining the observable area, and to hold a plastic-mesh bait bag (Fig. S1). The distance from the cameras to the bait bag was 0.5 m, and the distance from the cameras to the end of the PVC pole was 1.0 m. Two GoPro Hero 4 cameras were mounted 0.3 m apart on the top of the frame and fixed at a 2° inward-facing angle towards each other to maximize the total field of view and minimize the blind spot between cameras. A stereo camera design allows for maximum visibility and provides an additional recording in case a camera malfunctions during deployment (Langlois et al. 2010, 2020, Letessier et al. 2015). Cameras were programmed to record at 1080-pixel resolution and at 30 frames per second with a wide field of view.

Before each BRUV deployment, the bait bag was packed with a 0.5 kg block of frozen menhaden chum and closed with a plastic zip tie. The cameras were powered on, and the video was stamped with the deployment parameters for that sampling site by filming with both cameras the parameters as written in a field book. BRUVs were retrieved after 90 min of soak time, and each camera was re-supplied with a new memory card and battery for subsequent deployments. A 90 min soak time was chosen because studies have shown that most species will have arrived within 90 min, with no gains in spe-

cies detectability with longer soak times (Santana-Garcon et al. 2014).

The right-hand camera was selected for video analyses unless there was a malfunction in the recording, in which case the left camera was used. For video analyses, 90 min of video were processed in real time using VLC media player 3.0 (VideoLAN) beginning 1 min after the gear had reached the bottom to allow any disturbed sediment to settle. During processing, visibility was recorded on a scale of 0 to 5 based on how much of the PVC pole extending from the BRUV frame was visible (0 = nothing is visible [<0.5 m], 1 = bait bag is visible [~0.5 m], 2 = part of the PVC pole beyond the bait bag is visible [~0.5– 0.7 m], 3 = most or all of the PVC pole beyond the bait bag is visible [~0.7–1.0 m], 4 = visibility extends slightly beyond the PVC pole [~1.0–1.5 m], and 5 = visibility extends far beyond the PVC pole); videos with a visibility score of 0 were excluded from analyses. All visible animals were identified to the lowest possible taxonomic level (Table A1). For each taxon identified, we noted the following metrics: time of first arrival, maximum number of individuals observed in a single frame (MaxN), and time to the observation of MaxN. MaxN is widely used in BRUV sampling as a measure of relative abundance and to avoid repeat counts of the same individuals moving in and out of the field of view (Cappo et al. 2003, Harvey et al. 2007, Campbell et al. 2015).

2.4. Analytical methods

To assess whether various types of gear detected similar patterns of spatiotemporal variation, estimates of abundance and species richness were calculated and compared between seines and BRUVs using univariate permutation tests. Spatial variance was the differentiation across basins, whereas temporal variance focused on seasonality, and secondarily on yearly variation. Multivariate analyses were then conducted to examine assemblage structure as a function of season, year, and basin and in relation to continuous environmental variables and taxa driving nekton community structure.

2.4.1. Environmental conditions

Salinity data from 2000–2019 were downloaded from 3 Everglades National Park continuous-monitoring stations located in the 3 embayments of interest: Little Madeira (25.172° N, 80.632° W), Trout Cove

in Joe Bay (25.213° N, 80.533° W), and Long Sound (25.235° N, 80.457° W) (SFNRC 2019). Average monthly salinity for each water-year (running from August–July) sampled in the present study (2016–2019) was compared to the mean monthly salinity of the past 20 yr (2000–2019).

Water conditions (temperature, salinity, dissolved oxygen) and habitat parameters (water depth, sediment depth) observed during field sampling were compared across basins, seasons, and water-years using principal component analysis (PCA; PRIMER software; Clarke & Warwick 2001, Clarke & Gorley 2006). A PCA was conducted on BRUV and seine data from 2016–2019 to resolve correlated environmental variables (water depth, temperature, salinity, dissolved oxygen, sediment depth) into orthogonal components based on the correlation matrix. Draftsman plots were used to identify variables in need of transformation before they were incorporated into the PCA. Important principal components (PCs, eigenvalues ≥1, up to 3 PCs) were interpreted, and variable loadings and PC scores were estimated for each sample and visualized in 2-dimensional space by basin, season, water-year, and type of gear.

2.4.2. Nekton communities

To more directly compare nekton observed by BRUVs with that collected with the 2 different seine types, BRUV taxa were separated into 2 groups based on body size: small-bodied nekton, such as anchovies, silversides, mojarras, and clupeids, and larger-bodied mesoconsumers and top predators (see Table A1 for taxa in each category). These nekton communities were analyzed separately to facilitate suitable comparisons with the data collected with the 2 seine types; small-bodied nekton (<100 mm SL) are effectively sampled by small seines but are typically not collected in large seines due to the mesh size of the net (Winner et al. 2014). Some taxa, such as *Callinectes sapidus*, were collected in both seine types. Catch per unit effort (CPUE) was calculated as the number of individuals per haul for seines and MaxN for BRUVs. Taxon richness was defined as the number of distinct taxonomic groups, which varied in precision depending on type of gear (Table A1). Overall CPUE and species richness for small-bodied nekton (small seines and BRUVs) and large-bodied nekton (large seines and BRUVs) were compared across basins and seasons (dry vs. wet).

Differences in small- and large-bodied nekton assemblage structure among water-years, basins,

seasons, and habitat strata (shoreline vs. offshore for BRUVs and small seines) were analyzed using multivariate statistics (PRIMER software with PERMANOVA add-on; Clarke & Warwick 2001, Clarke & Gorley 2006, Anderson et al. 2008). Based on shade-plot interpretations, square-root transformations of CPUE (for large-bodied nekton) and fourth-root transformations of CPUE (for small-bodied nekton) were calculated to reduce the influence of numerically dominant species (Clarke & Warwick 2001, Clarke & Gorley 2006, Anderson et al. 2008). Bray–Curtis dissimilarities were calculated on the transformed CPUE data to create a species-resemblance matrix (Bray & Curtis 1957). The statistical significance ($\alpha < 0.05$) and relative importance of season (a fixed factor with 2 levels: wet and dry), basin (a fixed factor with 2 or 3 levels: Long Sound, Little Madeira Bay, and Joe Bay), water-year (a fixed factor with 3 levels: water-years 2016, 2017, and 2018), and habitat stratum (for BRUVs and small seines, a fixed factor with 2 levels: shoreline and offshore) were investigated using permutational multivariate ANOVA (PERMANOVA; Anderson et al. 2008). Analyses included interaction terms pertinent to the study objectives and were conducted using type III sums of squares; p-values were obtained using 9999 permutations under a reduced model. The statistical significance ($\alpha < 0.05$) of pairwise comparisons was determined using PERMANOVA for each main factor separately for all combinations of each spatial (basin) and temporal (water-year, season) factor.

To visualize patterns in assemblage structure, an ordination was constructed using nonmetric multidimensional scaling (nMDS) calculated on the basin by sampling event centroids. Correlation vectors for taxa that contributed >0.6 to similarity patterns of the nekton assemblages were plotted on the nMDS ordination. Groupings between samples were also determined based on 40% similarity levels for seines and 20% similarity levels for BRUVs, calculated using hierarchical clustering (CLUSTER; Clarke & Warwick 2001). Additional nMDS plots were constructed by basin to demonstrate temporal trajectories across sampling seasons and as a function of salinity. A distance-based linear model (DISTLM; Anderson et al. 2008) and redundancy analysis (dbRDA) were used to determine the significance ($\alpha < 0.05$) and visualize the multivariate relationship between the species-resemblance matrix and a combination of associated continuous environmental variables (water depth, temperature, salinity, dissolved oxygen, and sediment depth). Similarity percentages (SIMPER) analy-

ses were conducted to determine which species significantly contributed to differences in community structure among basins, seasons, water-years, and habitat strata.

3. RESULTS

During 2016–2019, 192 seines were deployed across the study area (24 shoreline and offshore seines [21.3 m] in each basin; 24 seines [183 m] each in Little Madeira Bay and Long Sound; Fig. 1a, Table A1). The number of BRUV samples in shoreline and offshore strata averaged 135 per basin across the 3 sampling years, for a total of 539 deployments (Fig. 1b, Table A1).

3.1. Spatiotemporal variation in environmental conditions

When compared to the 20 yr salinity record (2000–2019), salinity of Water-Year 1 (2016–2017) closely followed the average hydrological conditions, while that of Water-Year 2 (2017–2018) was wetter (of lower salinity) than average in all 3 embayments, and that of Water-Year 3 (2018–2019) was slightly drier (of higher salinity) than average across all 3 embayments (Fig. S2). A clear pattern of the lowest salinity in September–October and highest salinity in May–June was evident in all 3 years and all 3 basins, showing that the timing of the wet and dry season did not change over the course of the study and that it did not deviate from the 20 yr average. For the dry season, maximum salinity conditions were similar among the 3 basins, with maxima in May of Year 3 at 36.7 ppt in Joe Bay and 38.4 ppt in Long Sound and a maximum of 37.3 ppt in June of Year 3 in Little Madeira Bay. For the wet season, salinity was lowest in Joe Bay in all 3 years, reaching its minimum, 2.4 ppt, in October of Year 2. Salinity remained substantially higher in Little Madeira Bay than the other 2 embayments during the wet season, with a minimum salinity of 14.2 ppt in October of Year 2. The effects of Hurricane Irma, which passed over the Florida Keys south of Florida Bay as a category 4 storm on 10 September 2017 (Year 2), were most evident in Joe Bay, where average salinity for October of that year (2.4 ppt) dropped well below the long-term average (10.8 ppt).

Within the sampling period, environmental conditions varied seasonally, especially within Joe Bay. The PCA of abiotic data collected during seine and

Table 1. Results of a principal components analysis examining the interrelatedness of environmental metrics quantified during stratified-random sampling using baited remote underwater video and 21.3 and 183 m seines (all types of gear), in northeastern Florida Bay, 2016–2019. **Bold** type indicates factors with high loadings to each principal component (PC)

Variable	PC1	PC2	PC3
Temperature (°C)	**−0.58**	−0.09	0.54
Salinity (ppt)	**−0.54**	−0.42	0.08
Dissolved oxygen (mg l^{-1})	0.49	0.09	**0.66**
Water depth (m)	0.30	**−0.59**	0.37
Sediment depth (cm)	−0.22	**0.68**	0.35
Eigenvalue	1.6	1.32	0.918
% variation	32.1	26.3	18.4
Cumulative % variation	32.1	58.4	76.8

BRUV sampling identified 2 major axes (PCs, eigenvalues ≥1) explaining 58.4% of the environmental variability (Table 1, Fig. 2). The first PC was a measure of seasonal conditions, with negative loadings for temperature and salinity. Conditions in the dry season (April/May) were characterized by higher salinity and temperature and were similar among basins, while conditions in the wet season (October/December) were cooler, less saline, and more distinct among basins, primarily due to low salinity in Joe Bay. The second PC was a measure of habitat differences among basins that had a negative loading for water depth and a positive loading for sediment depth (Table 1). Long Sound was the deepest basin and, like Joe Bay, had a very thin sediment layer over a limestone bottom. Little Madeira Bay was the shallowest basin with the deepest sediments, reflecting the well-documented trend of deeper sediments occurring in shallower areas such as banks (Zieman et al. 1989). Although the third PC had an eigenvalue <1, it showed a large, positive loading for dissolved oxygen. Dissolved oxygen in all basins varied considerably but was well above concentrations considered harmful to fish (<2 mg l^{-1}; Miller et al. 2002). Environmental conditions were consistent among types of gear, but measurements covered a broader range of conditions during BRUV sampling (Fig. 2b), reflecting the increased sample size and diversity of habitats sampled (i.e. deeper, offshore samples).

3.2. Patterns in nekton abundance and richness

A total of 32 905 fishes (of 82 taxa) and 103 invertebrates (4 taxa) were collected during seine sampling,

while 9644 fishes (38 taxa), 145 invertebrates (3 taxa), and 4 reptiles (2 taxa) were observed in BRUV sampling (Table A1). Spatiotemporal patterns in nekton CPUE and species richness were consistent among types of gear, with similar patterns of seasonality and differences among basins detected by seines and BRUVs (Fig. 3). Small-bodied nekton abundance and richness patterns were similar in Little Madeira and Long Sound, but Joe Bay consistently had the fewest species and lowest abundances for both types of gear and across seasons. However, for large-bodied nekton observed with BRUVs, CPUE in Joe Bay was only lower than the other basins in the wet season, and species richness was similar across basins. Seasonal patterns in nekton abundance and species richness were less consistent than basin-scale differences, but both metrics were higher in the dry season (Fig. 3). The exception was small-bodied nekton collected in seines, for which CPUE was more variable overall, and both CPUE and richness were higher in the wet season for Long Sound.

3.3. Spatiotemporal patterns in nekton community structure

Overall, environmental and spatiotemporal trends in nekton community structure across types of gear and size groups were consistent (Table 2, Figs. 4–6). The nekton communities observed in both BRUV and seine sampling differed significantly among basins, seasons, water-years, and (when incorporated) strata for both size groups and types of gear. The importance of (i.e. the percent of variation explained by) these factors varied (Table 2), and large-bodied nekton communities were more variable than were small-bodied nekton communities (Figs. 4 & 5). Basin was overwhelmingly the most important single factor in explaining the variation in most nekton communities (7–15% of the variation; Table 2), and sediment depth was the only environmental factor that explained variability in nekton assemblages for all size groups
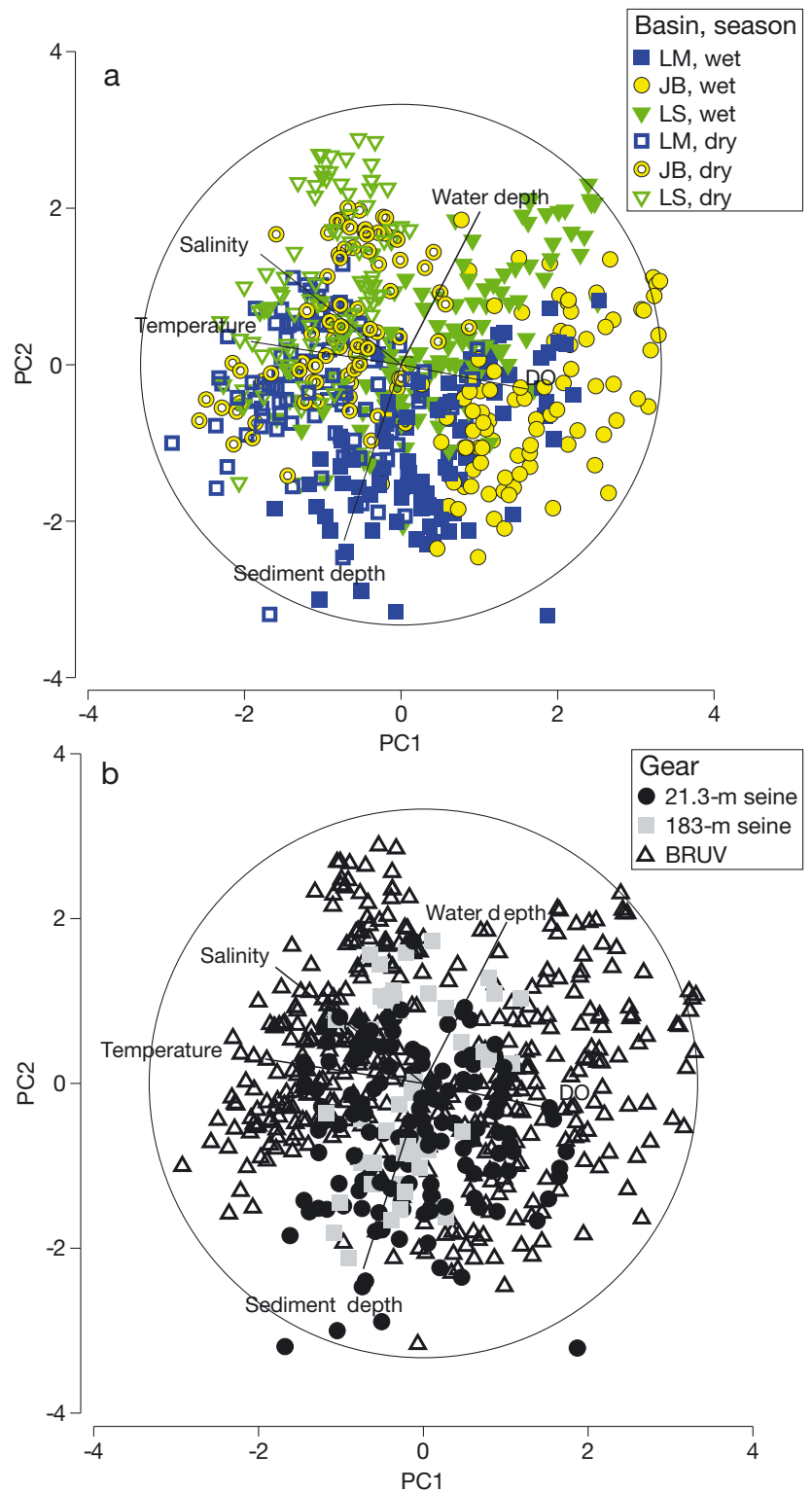

Fig. 2. Ordinations of principal components analysis examining the interrelatedness of environmental metrics collected during 2016−2019 as a function of (a) basin (LM: Little Madeira Bay; JB: Joe Bay; LS: Long Sound) and season, and (b) type of gear. BRUV: baited remote underwater video
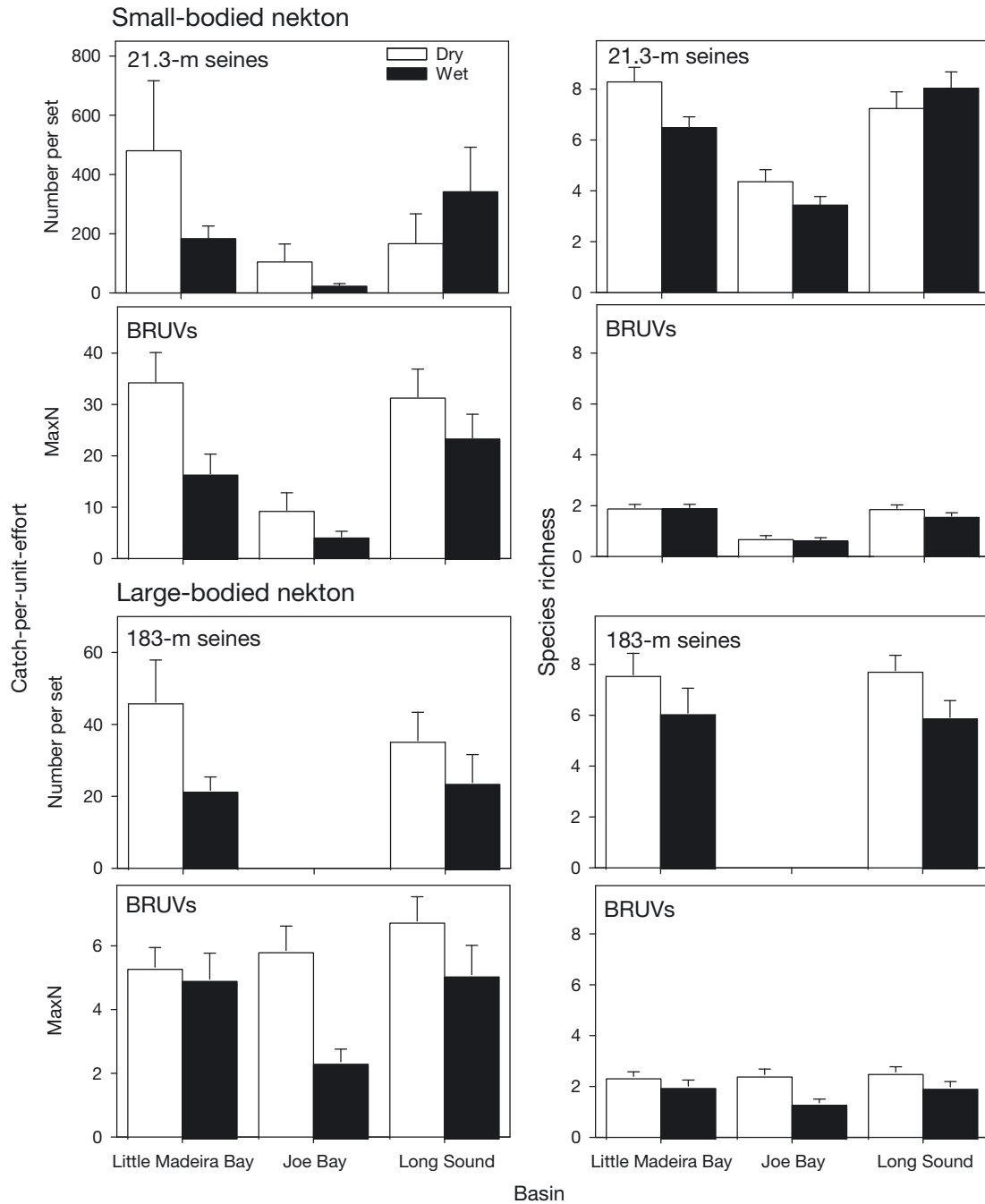
Fig. 3. Mean ± SE estimates of nekton abundance and species richness across all types of gear for small-bodied (21.3 m seines and baited remote underwater videos [BRUVs]) and large-bodied (183 m seines and BRUVs) nekton during 2016–2019, shown across the 3 embayments (Little Madeira Bay, Joe Bay, and Long Sound) and across sampling seasons. Joe Bay was not sampled with 183 m seines

and types of gear (Fig. 6). Season was also important in explaining temporal variation in most nekton communities (3–5% of the variation; Table 2) and was reflected by the influence of salinity and temperature on small-bodied nekton community structure (Fig. 6). Water-year explained more than twice the variation in the large-bodied nekton community (large seines: 3.4%; BRUVs: 4.8%) as in small-bodied nekton communities (small seines: 0.7%; BRUVs: 2.6%) (Table 2). Several taxon-specific patterns were consistent across basins and sampling events, and Gerreidae were important contributors to differences in community structure in both size groups.

Table 2. PERMANOVA results for the analysis of small- and large-bodied nekton assemblages sampled with seines and baited remote underwater videos (BRUVs) in northeastern Florida Bay, 2016–2019, based on the Bray–Curtis dissimilarity matrices as a function of water-year, basin, season, and stratum (shoreline vs. offshore). F: pseudo-F; Sqrt var: square-root component of variation; % var: percent variation. **Bold** text indicates variables that explain high levels of variation, dashes (–) indicate not applicable (no strata for 183 m seines), and p indicates an insignificant variable that has been pooled

Body size	Source	Seines				BRUVs			
		F	p	Sqrt var	% var	F	p	Sqrt var	% var
Small-bodied nekton									
	Water-year	1.61	0.039	4.73	0.73	7.55	<0.001	6.88	2.62
	Season	7.34	<0.001	12.49	**5.08**	4.28	0.004	3.98	0.88
	Basin	13.18	<0.001	21.20	**14.65**	36.40	<0.001	16.08	**14.32**
	Strata	8.23	<0.001	13.34	**5.80**	39.45	<0.001	13.57	**10.20**
	Water-year × season	2.45	<0.001	10.34	**3.48**	7.91	<0.001	9.98	**5.52**
	Water-year × basin	1.51	0.023	7.51	1.84	3.20	<0.001	6.90	2.64
	Season × basin	1.98	0.006	8.50	2.35	1.43	0.200	2.50	0.35
	Season × strata	1.77	0.058	6.15	1.23	9.55	<0.001	9.06	**4.55**
	Basin × strata	1.41	0.108	5.52	0.99	5.79	<0.001	8.30	**3.82**
	Water-year × season × basin	1.84	0.002	13.64	**6.07**	2.97	<0.001	9.20	**4.69**
	Season × basin × strata	p	p	p	p	p	p	p	p
	Residuals and pooled			42.09	57.76			30.18	50.43
Large-bodied nekton									
	Water-year	1.83	0.022	10.72	**3.41**	13.07	<0.001	10.722	**4.79**
	Season	2.24	0.017	10.68	**3.38**	15.16	<0.001	9.5225	**3.78**
	Basin	3.70	<0.001	15.74	**7.35**	10.93	<0.001	9.7582	**3.97**
	Strata	–	–	–	–	68.35	<0.001	20.615	**17.70**
	Water-year × season	1.66	0.045	13.49	**5.40**	2.52	0.005	5.3741	1.20
	Water-year × basin	2.14	0.007	17.71	**9.30**	3.42	<0.001	8.2984	2.87
	Season × basin	2.06	0.039	13.95	**5.77**	2.13	0.020	4.6457	0.90
	Season × strata	–	–	–	–	4.96	<0.001	7.0674	2.08
	Basin × strata	–	–	–	–	4.44	<0.001	8.061	2.71
	Water-year × season × basin	p	p	p	p	1.76	0.018	6.5919	1.81
	Season × basin × strata	–	–	–	–	6.39	<0.001	14.276	**8.49**
	Residuals and pooled			46.97	65.40			34.55	49.71

3.3.1. Small-bodied nekton

Basin was the principal factor in explaining the variation in small-bodied nekton communities (Table 2, small seines [$F_{2,122}$ = 13.2, p ≤ 0.01]: 14.7%; BRUVs [$F_{2,372}$ = 36.4, p ≤ 0.01]: 14.3%), followed by habitat stratum (small seines [$F_{1,122}$ = 8.2, p ≤ 0.01]: 5.8%; BRUVs [$F_{1,372}$ = 39.5, p ≤ 0.01]: 10.2%). Season explained more variation in small-bodied nekton communities in small-seine sampling ($F_{1,122}$ = 7.3, p ≤ 0.01, 5.1%) than in BRUV sampling ($F_{1,372}$ = 4.3, p ≤ 0.01, 0.9%), and, although significant, variation attributed solely to water-year was low (small seines [$F_{2,122}$ = 1.6, p = 0.04]: 0.7%; BRUVs [$F_{2,372}$ = 7.6, p ≤ 0.01]: 2.6%). Significant 2- and 3-way interactions explained an additional 15.0% (small seines) and 21.2% (BRUVs) of variation in nekton communities, but very few of these individual interactions explained more than 5% of the variation (Table 2). Exceptions included (1) the 3-way interaction among water-year, season, and basin (small seines [$F_{4,122}$ =

1.8, p ≤ 0.01]: 6.0%; BRUVs [$F_{4,372}$ = 3.0, p ≤ 0.01]: 4.7%) and (2) 2-way interactions between strata and season and basin for communities observed with BRUVs. Wet- and dry-season nekton communities were significantly different across all basins in water-years 2017 (both types of gear) and 2018 (seine sampling), but differences among water-years were not consistent across basins and seasons (Table S1).

Centroids (i.e. mean community similarities) by season, water-year, and basin in nMDS plots were separated from one another along a gradient of similarity from Little Madeira Bay to Long Sound to Joe Bay, which was the most distinct (Fig. 4). Dry-season communities were generally separated from wet-season communities in each basin; stronger seasonal changes occurred in Joe Bay and were associated with salinity. Pairwise tests indicated that small-bodied nekton communities in Joe Bay were significantly different (p ≤ 0.01 for all pairwise tests) from Little Madeira Bay and Long Sound over all seasons and water-years for both types of gear, except during
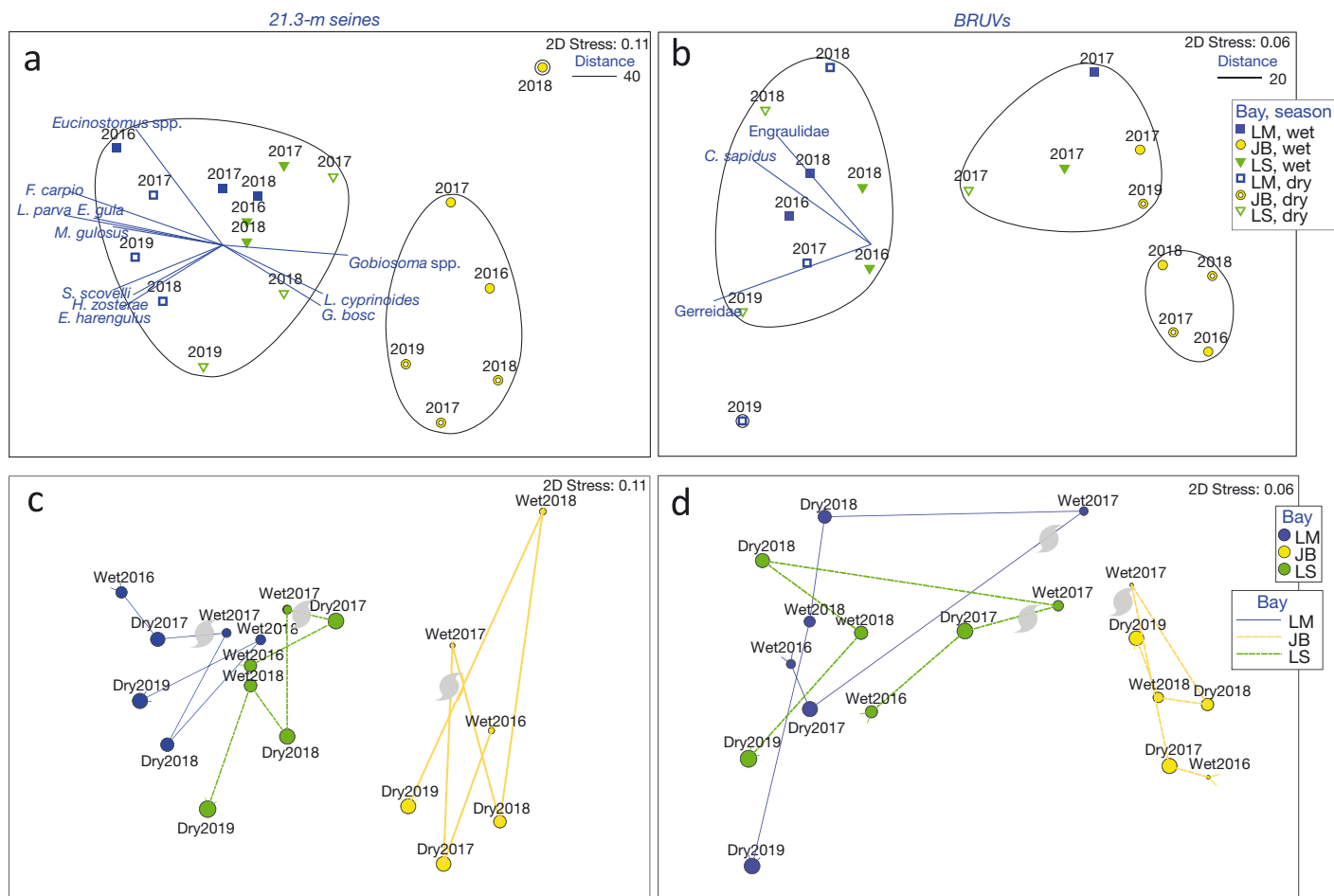
Fig. 4. Nonmetric multidimensional scaling (nMDS) ordinations showing the similarity of small-bodied nekton communities observed during (a,c) small (21.3 m) seine and (b,d) baited remote underwater videos (BRUVs) seasonal sampling events (2016–2019) in Little Madeira Bay (LM), Joe Bay (JB), and Long Sound (LS). For all panels, each symbol represents the centroid of community structure of each basin×season×year sample, and symbols closer together are more similar than those farther apart. Ellipses surrounding symbols denote groups at (a) 40% and (b) 20% similarity; labels indicate year; color and shape indicate basin; filled symbols indicate the wet season; and open symbols indicate the dry season. Overlaid in blue are vectors showing the directionality of correlation for the taxa that drove community differences (correlated >0.6 with the nMDS ordination). The temporal trajectory of samples by basin is shown in (c) and (d). Mean relative salinity for each sampling event is indicated by the sizes of each bubble, and basin is indicated by the line and symbol colors. The hurricane symbol ( ) indicates the timing of Hurricane Irma's passage over the study area in year 2 (10 September 2017)

wet season sampling with BRUVs in 2017 (p > 0.05). Most taxa that were strongly correlated with these differences in community structure were more abundant in Little Madeira Bay, as shown by the direction and length of the correlation vectors (Fig. 4a,b). Small gerreids and Engraulidae were important contributors to differences in community structure among basins for both types of gear (SIMPER analyses; Fig. 7). Small gerreids were more abundant in Little Madeira Bay and Long Sound than in Joe Bay and were responsible for 33.3% (BRUV) and 20.9% (*Eucinostomus* spp., *E. harengulus*, and *E. gula* combined; small seines) of the variation among basins. Engraulidae were abundant in both types of gear

and responsible for 29.1% (BRUVs) and 8.8% (small seines; 1 species: *Anchoa mitchilli*) of the differences among basins, with the lowest abundances again in Joe Bay. A key difference between seine and BRUV samples was the relative importance of taxa from Cyprinodontiformes (*Floridichthys carpio* and *Lucania parva*) and Gobiidae (*Microgobius gulosus, M. microlepis,* and *Lophogobius cyprinoides*); these 2 species groups contributed 21.7 and 14.9% of the variation, respectively, in differences in community structure among basins for seine sampling but were not frequently observed in BRUVs. Cyprinodontiformes were much more abundant in Little Madeira Bay and Long Sound than in Joe Bay, but some gob-
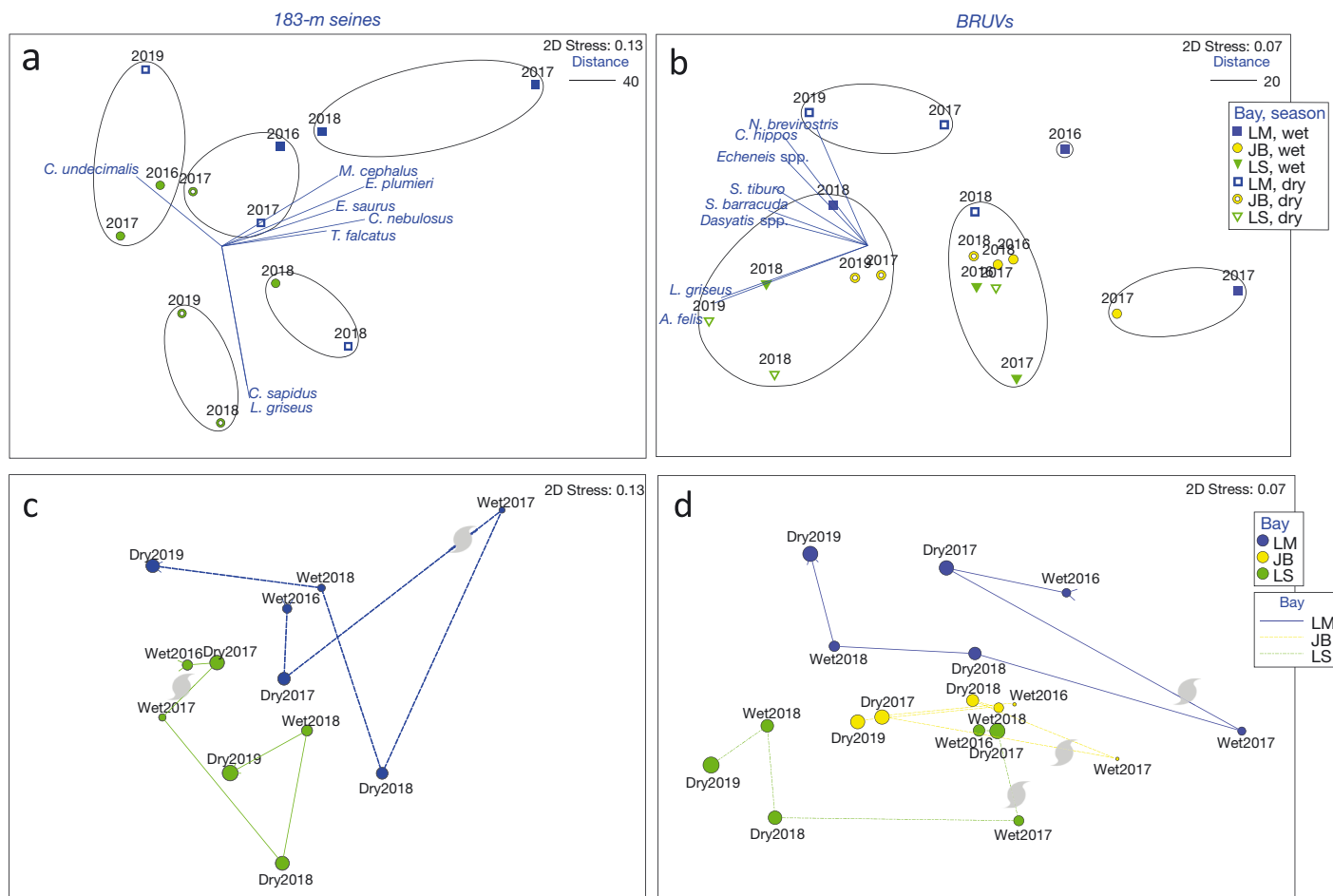
Fig. 5. nMDS ordinations showing the similarity of large-bodied nekton communities observed during (a,c) large (183 m) seine and (b,d) baited remote underwater videos (BRUVs) seasonal sampling events (2016–2019). Other details as in Fig. 4

ies were more abundant (*L. cyprinoides*) or similar in abundance (*M. gulosus*) in Joe Bay than in the other 2 basins.

Although combined in nMDS plots, habitat strata were also important in structuring small-bodied nekton communities, and some of the same taxa (especially Gerreidae and Engraulidae) contributed significantly to those differences (SIMPER analyses). Small gerreids observed in BRUV sampling (31.2% contribution) and 2 gerreid taxa observed in seine sampling (*Eucinostomus* spp., 9.7%; *E. harengulus*, 5.5%) were more abundant along shorelines than in offshore habitats, but *E. gula* (4.3%) was equally abundant in both habitats. Engraulidae (32.1% contribution for BRUVs; 9.8% contribution from *A. mitchilli* for seines) and other schooling species captured in seines (*Menidia* spp., 3.0%) were more abundant along shorelines than in offshore habitats.

Environmental conditions explained 13.5 and 13.3%, respectively, of the variability in the species-resemblance matrices for small-seine and BRUV

deployments (Fig. 6). For small seines, the small-bodied nekton community was associated with salinity (pseudo-F = 7.6, p < 0.01), sediment depth (pseudo-F = 6.2, p < 0.01), temperature (pseudo-F = 3.2, p = 0.15), and water depth (pseudo-F = 2.8, p < 0.01) (DISTLM analyses and BEST solutions based on Akaike's information criterion values). The associated dbRDA for seines explained the variability in the species-resemblance matrix over 4 axes, but most variability could be explained in the first 2 axes (Fig. 6a). Nekton assemblages were strongly associated with basin differences in sediment depth and seasonal changes in salinity (first axis, 6.9% of the variability) followed by temperature (second axis, 3.8% of the variability). For BRUV deployments, the small-bodied nekton community was associated with water depth (pseudo-F = 27.0, p < 0.01), salinity (pseudo-F = 16.2, p < 0.01), sediment depth (pseudo-F = 10.5, p < 0.01), temperature (pseudo-F = 4.4, p < 0.01), and dissolved oxygen (pseudo-F = 1.8, p = 0.15). The associated dbRDA for BRUVs explained the vari-
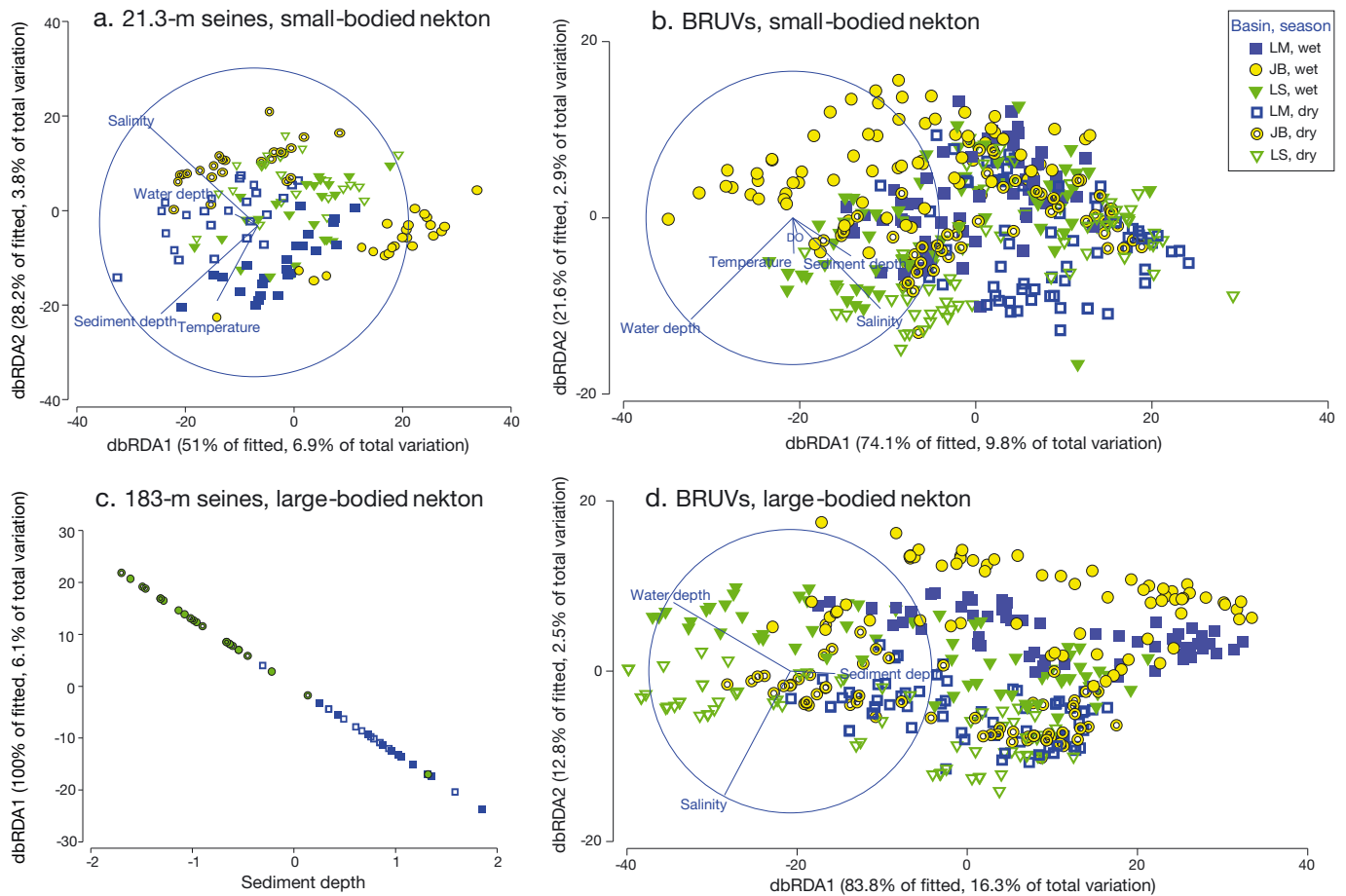
Fig. 6. Ordination plot using distance-based redundancy analysis (dbRDA) and distance-based linear model (DISTLM) analysis showing the continuous variables (vector overlays) significantly associated with (a,b) small- and (c,d) large-bodied nekton assemblages collected during seasonal sampling events (2016–2019) in Little Madeira Bay (LM), Joe Bay (JB), and Long Sound (LS). Seasons are indicated by symbol and basins by color. BRUVs: baited remote underwater videos

ability in the species-resemblance matrix over 5 axes, but, again, most variability was explained by the first 2 axes (Fig. 6b). Nekton assemblages were primarily associated with differences in water depth among basins (first axis, 9.8% of the variability), followed by seasonal changes in salinity (second axis, 2.9% of the variability). In both types of gear, small-bodied nekton communities collected during wet seasons in Joe Bay were the most distinct and most strongly affected by environmental patterns.

3.3.2. Large-bodied nekton

Basin ($F_{1,38} = 3.7$, p ≤ 0.01) and 2-way interactions with basin explained most of the variation in large-bodied nekton communities sampled with large seines (PERMANOVAs, 7.4 and 15.1% of the variation, respectively; Table 2), and, although basin

($F_{2,370} = 10.9$, p ≤ 0.01, 3.8%) was also important in structuring large-bodied nekton communities observed during BRUV sampling, habitat stratum explained the most variability ($F_{1,370} = 68.4$, p ≤ 0.01, 17.7%). Temporal variation in nekton communities was observed as a function of both season (for large seines [$F_{1,38} = 2.2$, p = 0.02]: 3.4%; for BRUVs [$F_{2,370} = 15.1$, p ≤ 0.01]: 3.8%) and water-year (large seines [$F_{2,38} = 1.8$, p = 0.02]: 3.4%; BRUVs [$F_{2,370} = 13.1$, p ≤ 0.01]: 4.8%). Significant 2- and 3-way interactions explained an additional 20.5% (for large seines) and 20.0% (for BRUVs) of the variation in large-bodied nekton communities (Table 2). For large seines, all 2-way interactions explained more than 5% of the variability in large-bodied nekton communities sampled, but, for BRUVs, only the 3-way interaction between season, basin, and habitat stratum ($F_{2,370} = 6.4$, p ≤ 0.01) explained more than 5% of the variation in large-bodied nekton communities (8.5%). In 2017,
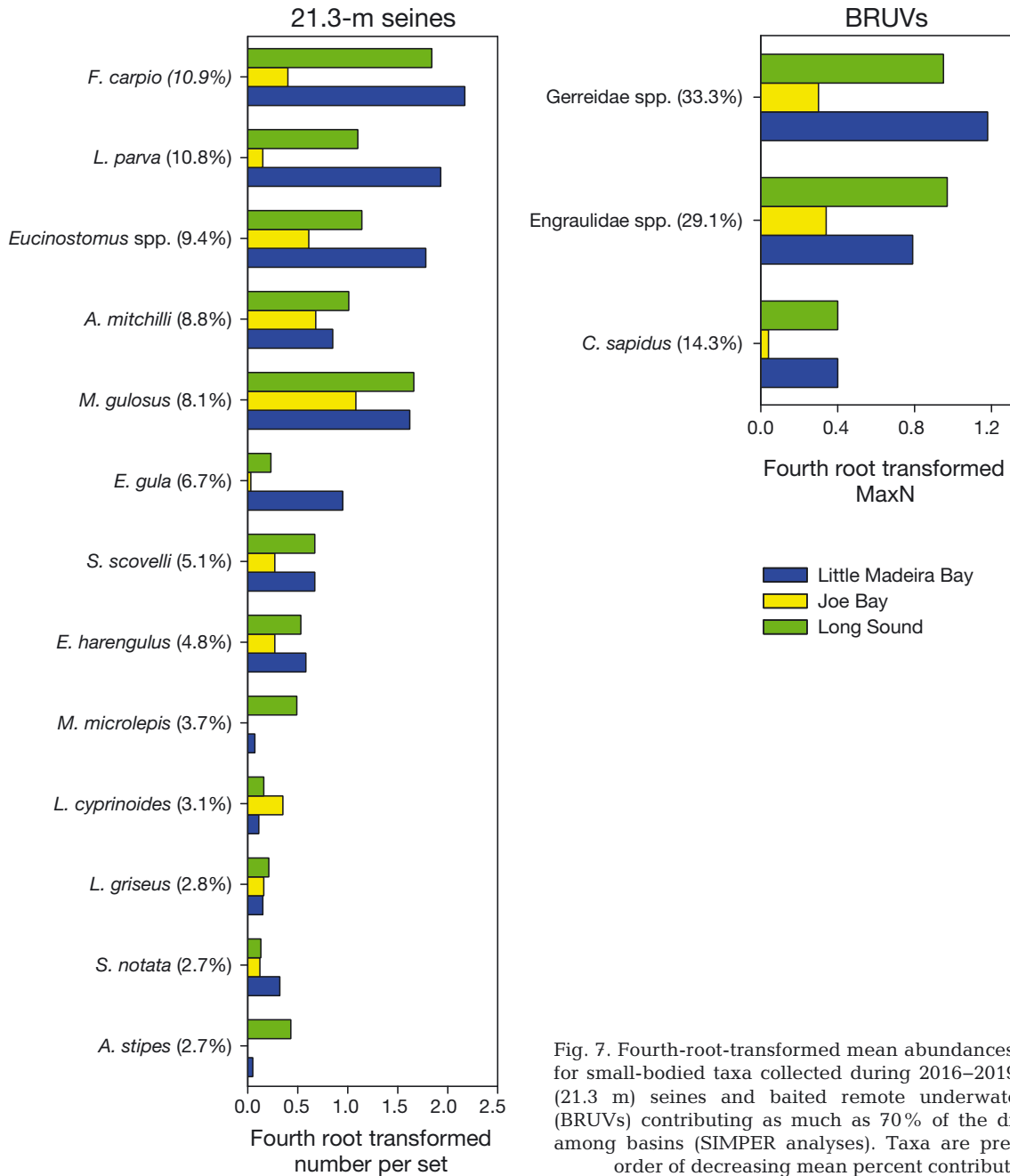
21.3-m seines

BRUVs

Fig. 7. Fourth-root-transformed mean abundances by basin for small-bodied taxa collected during 2016–2019 in small (21.3 m) seines and baited remote underwater videos (BRUVs) contributing as much as 70% of the differences among basins (SIMPER analyses). Taxa are presented in order of decreasing mean percent contribution

pairwise tests (Table S1) indicated that wet- and dry-season nekton communities were significantly different in all basins for BRUV samples and in Long Sound for seine samples ($p \leq 0.01$).

In nMDS plots, community-similarity centroids were again separated by basin. Pairwise tests indicated that large-bodied nekton communities were significantly different across basins for BRUV sampling ($p \leq 0.01$ for all pairwise tests) except for a few isolated sampling events in which Little Madeira and Joe Bay communities did not differ (wet 2016, p =

0.10; dry 2018, $p = 0.91$). In contrast, for seines, Little Madeira and Long Sound communities only differed in 1 sampling event (wet 2017, $p = 0.03$). Most taxa contributing to differences were abundant in Little Madeira Bay as shown by the direction and length of the correlation vectors (Fig. 5a,b). Joe Bay communities observed by BRUVs had less within-basin variability than did the other basins (Fig. 5b). In seine sampling, Gerreidae was again an important family in characterizing patterns in the large-bodied nekton community (Fig. 8). A small-bodied gerreid, *Eucinos-*
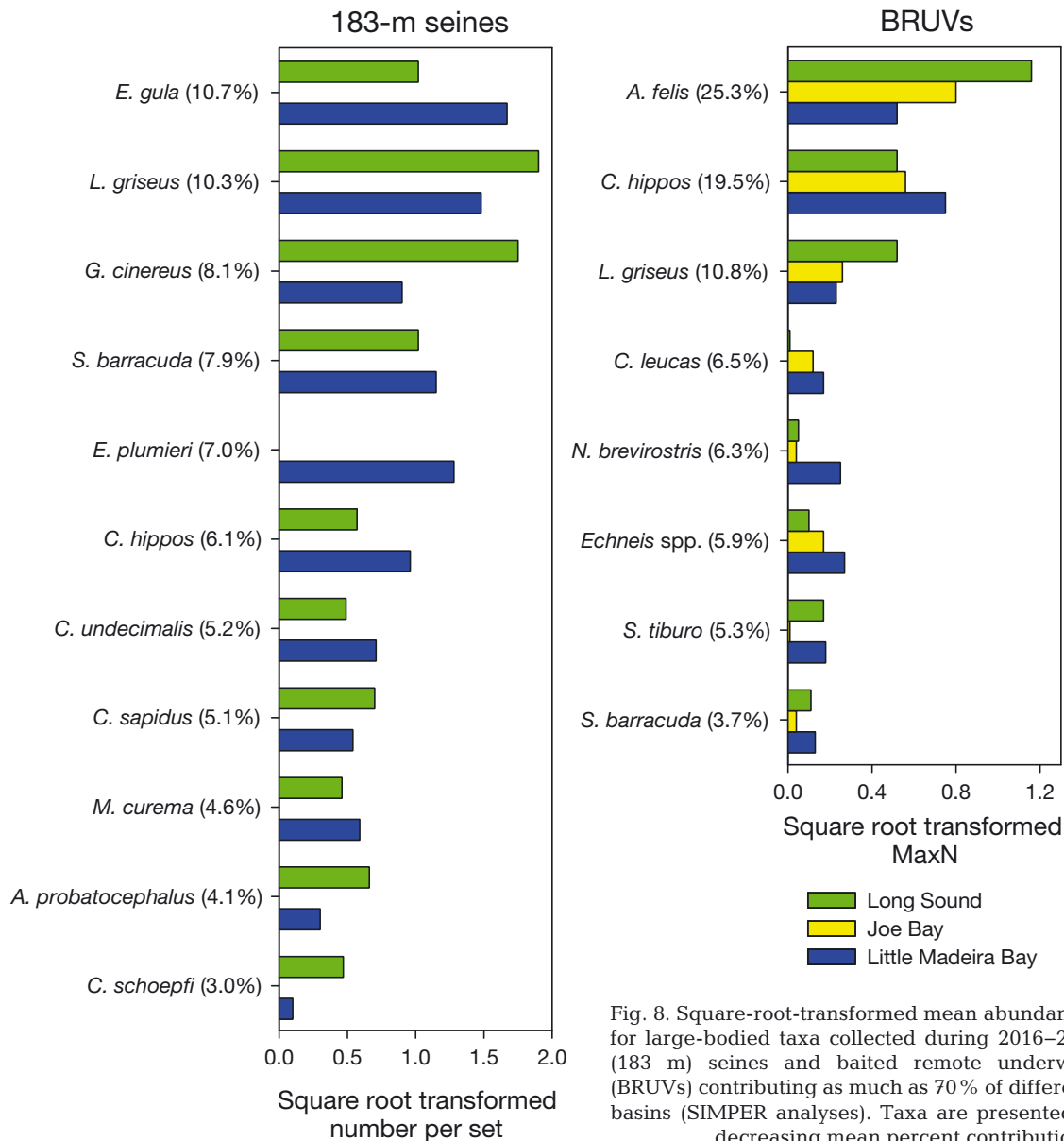
Fig. 8. Square-root-transformed mean abundances by basin for large-bodied taxa collected during 2016–2019 in large (183 m) seines and baited remote underwater videos (BRUVs) contributing as much as 70% of differences among basins (SIMPER analyses). Taxa are presented in order of decreasing mean percent contribution

tomus gula (10.7% contribution), and a large-bodied gerreid, *Eugerres plumieri* (7.0% contribution), were most abundant in Little Madeira Bay, while a similar large-bodied gerreid, *Gerres cinereus* (8.1% contribution), usually associated with more saline waters, was more abundant in Long Sound (Fig. 8). In BRUV samples, large mojarras were observed infrequently and did not contribute significantly to differences in basin community structure. Recreationally important species contributed significantly to community differences under sampling with both types of gear. *Lutjanus griseus* was more abundant in Long Sound than in the other basins (seines: 10.3% contribution, BRUVs: 10.8% contribution; Fig. 8), while *Caranx*

hippos was more abundant in Little Madeira Bay than in other basins (seines: 6.1% contribution, BRUVs: 19.5% contribution; Fig. 8). The abundance of *Sphyraena barracuda* was similar between Long Sound and Little Madeira Bay for both types of gear but was lower in Joe Bay for BRUVs. In addition, for seine sampling, *Centropomus undecimalis* was more abundant in Little Madeira Bay, and *Archosargus probatocephalus* was more abundant in Long Sound, contributing 5.2 and 4.1%, respectively, to basin differences in community structure. Unique to BRUV sampling, several shark species contributed to basin differences (18.1% contribution overall); *Carcharhinus leucas* and *Negaprion brevirostris* were most fre-

quently observed in Little Madeira Bay, while *Sphyrna tiburo* was less abundant in Joe Bay than in the other 2 basins. Although not contributing significantly to basin differences, the threatened American crocodile *Crocodylus acutus* (n(MaxN) = 2) was observed only in Little Madeira Bay, and the endangered smalltooth sawfish *Pristis pectinata* (Carlson et al. 2022) was observed only in Little Madeira Bay (n = 3 in seines, n(MaxN) = 2 in BRUVs) and Joe Bay (n(MaxN) = 2 in BRUVs) (Table A1).

Although incorporated only into BRUV sampling, habitat strata were also important in determining differences among large-bodied nekton communities. *Ariopsis felis* (31.4%) and *C. hippos* (19.3%) contributed the most to differences between strata and were both more abundant in offshore habitats than along shorelines (SIMPER analyses).

Environmental conditions explained 6.15 and 19.5% of the variability in the species-resemblance matrices for large seine and BRUV deployments, respectively. For large seines, sediment depth (pseudo-F = 3.0, p < 0.01) was the only significant factor identified in DISTLM analyses and explained 6.1% of the variability in the species-resemblance matrix along 1 dbRDA axis (Fig. 6c), highlighting the habitat and community differences between Long Sound (shallow sediment layer) and Little Madeira Bay (deep sediment layer). For BRUV deployments, the community structure of large-bodied nekton was significantly associated with water depth (pseudo-F = 58.9, p < 0.01), salinity (pseudo-F = 23.5, p < 0.01), and sediment depth (pseudo-F = 17.7, p < 0.01). The dbRDA explained the variability in the species-resemblance matrix over 3 axes (Fig. 6d); nekton communities were primarily associated with basin differences in water depth (first axis, 16.3% of the variability) and seasonal changes in salinity (second axis, 2.5% of the variability).

3.3.3. Seasonal patterns in nekton communities disrupted by Hurricane Irma

The impacts on hydrology associated with Hurricane Irma during the wet season of 2017 and continuing into the dry season of 2018 overwhelmed many of the seasonal patterns in nekton community structure in each basin (Table S1), where differences among seasons were more pronounced. These differences in community structure are highlighted by the temporal trajectories overlaid on the sampling points for each basin and reinforced by the average salinity observed during each sampling event (i.e. low salinity in the wet season of 2017 for all basins). The wet-season sampling event for 2017 shows a significantly different community structure than other sampling events for Little Madeira Bay (for large seines and BRUVs [small- and large-bodied nekton]) and Joe Bay (for BRUVs [small- and large-bodied nekton]) (Figs. 4c,d & 5c,d). The 2018 dry season also showed a community structure that differed significantly from those shown by other sampling events for Little Madeira Bay (large seines and small-bodied nekton in BRUVs) and appeared to be the beginning of a slight community shift in Long Sound for large-bodied nekton collected with seines and BRUVs (Fig. 5; wet 2016, dry 2017, and wet 2017 are distinct from dry 2018, wet 2018, and dry 2019). Joe Bay communities observed in BRUV sampling showed less variation in community structure among sampling events even though salinity was more variable within that basin (Figs. 4d & 5d).

Several taxon-specific patterns determined differences in nekton communities in the seasons following Hurricane Irma (Table 3). During the wet season of 2017 (1−3 mo post hurricane), nekton communities were characterized by greater abundances of Engraulidae (BRUVs; *A. mitchilli* for small seines) and *E. plumieri* (large seines) and by lower abundances of *L. parva* (small seines), small gerreids (BRUVs), *C. hippos* (BRUVs and large seines), and *C. undecimalis* (large seines) (Table 3). *L. griseus* (BRUVs and large seines), *Ariopsis felis* (BRUVs), and *S. barracuda* (large seines) also contributed substantially to differences in large-bodied nekton community differences, showing lower abundances in the 2017 wet season than in most other sampling events. A large-bodied gerreid, *G. cinereus*, collected in large seines was generally lower in abundance during the 2017 wet season, unlike the similarly sized *E. plumieri*. In the dry season of 2018, Engraulidae were again in high abundance, as were *Callinectes sapidus* (BRUVs and large seines), *Syngnathus scovelli* (small seines), *L. griseus* (large seines), and *E. gula* (large seines). *C. hippos* (BRUVs and large seines) and *S. barracuda* (large seines) were still showing lower abundances in the dry season of 2018, as was *M. gulosus* (small seines).

4. DISCUSSION

Comparisons of seine and BRUV surveys revealed similar spatiotemporal patterns in nekton abundance, richness, and community structure and demonstrated that, although seines documented more

Table 3. Transformed (fourth-root for small-bodied nekton; square-root for large-bodied nekton) mean abundances and average contributions to differences for taxa that contributed as much as 70% of differences among sampling events (SIMPER analyses). Dashes (–) indicate that no individuals of a taxon were collected during a sampling event. Taxa in **bold** were responsible for differences among all sampling-event comparisons. BRUVs: baited remote underwater videos

| Body size | Type of gear | Taxon | Transformed mean abundance by sampling event | | | | | | Average % contribution |
			Wet2016	Dry2017	Wet2017	Dry2018	Wet2018	Dry2019	
Small-bodied nekton									
21.3 m seines		***Floridichthys carpio***	1.83	1.33	1.62	1.21	1.42	1.42	9.98
		***Eucinostomus* spp.**	1.64	1.34	1.49	0.59	1.53	0.47	9.73
		Lucania parva	1.45	1.05	0.89	1.08	0.79	1.11	9.45
		Anchoa mitchilli	0.81	0.69	0.92	1.69	0.66	0.32	9.20
		Microgobius gulosus	1.47	1.76	1.54	1.03	1.41	1.50	8.64
		Syngnathus scovelli	0.26	0.54	0.55	0.84	0.35	0.67	5.18
		Eucinostomus harengulus	0.46	0.62	0.10	0.69	0.23	0.66	5.08
		Eucinostomus gula	0.55	0.56	0.24	0.34	0.25	0.48	4.46
		Menidia spp.	0.07	–	0.24	0.25	–	0.46	4.04
		Microgobius microlepis	0.16	0.50	0.14	0.05	–	0.26	3.89
		Lophogobius cyprinoides	0.22	0.30	0.22	0.14	0.22	0.13	3.37
		Strongylura notata	0.13	0.09	0.28	0.20	0.04	0.39	3.24
		Lutjanus griseus	0.05	0.20	0.17	0.17	0.26	0.19	3.09
		Hippocampus zosterae	–	0.13	0.04	0.18	–	0.39	3.07
		Atherinomorus stipes	0.41	–	0.36	0.07	–	0.14	2.90
		Eucinostomus jonesii	0.05	0.25	0.17	0.05	0.10	–	2.54
		Diplogrammus pauciradiatus	–	0.34	0.05	–	–	–	2.28
	BRUVs	**Gerreidae (small)**	0.85	0.92	0.27	0.72	0.74	1.24	31.90
		Engraulidae	0.56	0.76	0.93	0.84	0.54	0.63	29.67
		Callinectes sapidus	0.29	0.21	0.09	0.61	0.42	0.10	17.56
		Gobiidae	0.07	0.09	0.13	0.16	0.12	0.24	11.45
Large-bodied nekton									
183 m seines		***Eucinostomus gula***	0.66	1.51	0.63	2.86	1.74	0.68	10.98
		Lutjanus griseus	0.98	1.31	0.93	3.46	1.56	1.92	10.39
		Sphyraena barracuda	1.18	1.99	0.59	0.88	1.38	0.48	8.16
		Gerres cinereus	0.82	2.44	0.87	1.10	0.95	1.77	7.60
		Eugerres plumieri	0.33	0.56	1.26	0.57	0.99	0.13	6.86
		Callinectes sapidus	0.35	0.56	0.13	2.19	0.48	–	6.84
		Caranx hippos	1.15	1.18	0.30	0.30	1.08	0.58	6.46
		Mugil curema	0.56	–	0.47	–	1.16	0.97	5.84
		Centropomus undecimalis	0.85	0.90	0.25	0.30	0.43	0.86	5.56
		Mugil trichodon	–	0.79	–	0.35	–	–	4.83
		Archosargus probatocephalus	0.59	0.50	–	0.72	0.55	0.50	4.12
		Chilomycterus schoepfii	0.18	0.52	–	0.72	–	0.30	4.00
		Mugil cephalus	–	–	0.60	–	0.59	–	3.96
		Selene vomer	–	–	0.13	–	–	1.05	3.90
		Diapterus auratus	–	–	0.47	0.22	–	–	3.06
	BRUVs	***Ariopsis felis***	0.35	0.76	0.38	1.00	1.01	1.41	25.40
		Caranx hippos	0.81	0.57	0.14	0.49	0.75	0.79	19.62
		Lutjanus griseus	0.08	0.28	0.12	0.45	0.44	0.63	10.86
		Negaprion brevirostris	0.04	0.19	–	0.09	0.05	0.26	6.32
		Mugilidae	0.24	0.01	0.02	0.00	0.14	–	6.07
		Echeneis spp.	0.10	0.16	0.04	0.23	0.19	0.31	5.99
		Carcharhinus leucas	0.07	0.03	0.10	0.09	0.15	0.13	5.75
		Caranx crysos	0.04	–	0.11	0.21	0.00	–	5.44
		Sphyrna tiburo	0.06	0.18	0.00	–	0.16	0.25	5.36
		Sphyraena barracuda	0.04	0.10	0.02	0.13	0.09	0.17	4.54

diversity, incorporating BRUVs provided additional information for previously inaccessible habitats and for large predators such as sharks. Because results of earlier studies comparing seines and BRUVs differed depending on habitat sampled (Ebner & Morgan 2013, Work & Jennings 2019, Enchelmaier et al. 2020, Shah Esmaeili et al. 2021, Gold et al. 2023), such comparisons are essential for demonstrating the

effectiveness of complementary types of gear in tracking variation in coastal estuarine communities. In the present study, habitat characteristics in spatially and hydrologically distinct basins were the most important drivers influencing nekton abundance, richness, and community structure patterns, as compared to the contributions of season and year. Temporal differences in nekton assemblages reflected seasonal shifts but were strongly affected by a major perturbation within the study period (i.e. Hurricane Irma in 2017). These spatiotemporal trends held true for small-bodied nekton (such as small prey and juvenile fish) as well as large-bodied nekton (recreationally targeted sportfish and sharks). Earlier studies directly comparing nekton communities sampled with seines and BRUVs concentrated on differences in species abundance and richness, were limited by small sample sizes, or did not address whether patterns in those metrics were similar across time and space. In the present study, data collected with seines and BRUVs exhibited similar patterns in small- and large-bodied nekton community metrics across a range of environmental variation, which highlights the importance of a sampling design that monitors species throughout the food web and across the estuarine seascape.

The rich nekton communities of the study area (Florida Bay) include species that are commercially or recreationally important, such as *Farfantepenaeus duorarum* (Browder 1985), *Panulirus argus* (Forcucci et al. 1994, Herrnkind & Butler 1994), *Mugil* spp. (Tilmant 1989), *Lutjanus griseus*, *Cynoscion nebulosus* (Chester & Thayer 1990), and *Centropomus undecimalis* (Ley et al. 1999, Flaherty et al. 2013), as well as many forage fishes (e.g. killifish, mojarras, and gobies) that provide the prey base for some of the economically valuable species (Ley et al. 1994, 1999, Matheson et al. 1999, Flaherty et al. 2013, Lorenz 2014). Fishery-independent throw-trap, ichthyoplankton, seine, and trawl surveys have been completed in different regions of Florida Bay intermittently over several decades (Schmidt 1979, Sogard et al. 1987, Matheson et al. 1999, Thayer et al. 1999, Flaherty et al. 2013, FWC unpubl. data), and a trawl survey, targeting primarily juvenile spotted seatrout *C. nebulosus*, has been conducted consistently over the long-term in the central and western portions of Florida Bay (2004–present; Kearney et al. 2015, Zink et al. 2020, Kelble et al. 2021). The incorporation of a new type of gear (BRUVs) in this study and the potential for direct spatiotemporal comparisons to nekton data previously collected with seines in northeastern Florida Bay provide for additional

ways to critically evaluate patterns in nekton communities.

Two families (Gerreidae and Engraulidae) and a few economically important species (*Caranx hippos*, *L. griseus*, *Sphyraena barracuda*) were responsible for most differences in nekton assemblages, indicating agreement across types of gear. However, as in a South Florida study targeting mangrove habitats (Enchelmaier et al. 2020), seine sampling, compared with BRUV, documented a greater diversity of prey and sportfishes and larger numbers of smaller, cryptic species. Notably, a major difference in small-bodied nekton communities among types of gear was the relative importance of resident prey species of Cyprinodontiformes (*Floridichthys carpio* and *Lucania parva*) and Gobiidae (*Microgobius gulosus*, *M. microlepis*, and *Lophogobius cyprinoides*); these groups contributed substantially to differences in community structure with seine sampling but were not frequently observed with BRUVs. In addition, large gerreids were important in structuring large-bodied nekton communities collected with seines but were infrequently observed during BRUV sampling. Gerreidae (transients) and Cyprinodontiformes (residents) are 2 of the most important and abundant taxonomic groups in Florida Bay (Sogard et al. 1987, Ley et al. 1999, Matheson et al. 1999, Flaherty et al. 2013) and serve as prey for many mesoconsumers, including fish, birds, reptiles, and marine mammals (Hettler 1989, Davis et al. 2005, Torres 2009, Lorenz 2014), so having a good understanding of their patterns of distribution and abundance is vital to understanding ecosystem function and trophodynamics. BRUV observations, however, did include several top predators, including sharks, providing a component that had been lacking in the observed trophodynamic structure of northeastern Florida Bay. Therefore, data collected by seines and BRUVs complemented each other and led to insights on nekton assemblage and ecosystem structure that would not be possible using only one type of gear.

The 3 basins sampled in this study were similar in size and adjacent to one another, so types of gear were compared in a spatially constrained microcosm of environmental impacts. Different hydrological and habitat conditions across basins and seasons allowed for a small-scale examination of how these environmental drivers can be linked to changes in the nekton community. Previous research has correlated increasing sediment depth with decreasing water depth, increased density of *Thalassia testudinum* (Zieman et al. 1989), increased abundance of epibenthic fish on banks (Sogard et al. 1987, 1989), the

occurrence of juvenile spotted seatrout (Chester & Thayer 1990), and the structure of small-bodied nekton communities in northeastern Florida Bay (Flaherty et al. 2013). Although similar in size and spatial area, the 3 study basins exhibited notable differences in these environmental conditions and overall SAV cover; Little Madeira Bay was the shallowest basin with the deepest sediment and highest SAV cover, dominated by *T. testudinum* (Herbert et al. 2011); Long Sound was the deepest basin, and, like Joe Bay, had a very thin sediment layer over limestone bottom; and Joe Bay had the least SAV cover, dominated by *Halodule wrightii* (Herbert et al. 2011). Salinity was consistent among basins during the dry season, but during the wet season it was much lower in Joe Bay than in the other 2 basins due to a large amount of freshwater flow. Overall, the environmental conditions in Joe Bay differed markedly from those in Long Sound and Little Madeira and were reflected in the overwhelmingly distinct basin-specific trends in nekton community structure across types of gear. The fresher, more oligotrophic conditions, shallow sediment depths, and lower SAV cover in Joe Bay might have made habitat there less supportive, especially for small-bodied prey, resulting in poorer foraging for predators. The constrained sampling area of this study facilitated these fine-scale comparisons of nekton communities based on habitat and reduced the inherent variability in comparing the 2 types of gear.

Patterns in overall small-bodied nekton abundance and species richness among basins were consistent among types of gear and driven by lower prey abundance and a distinctly different prey community in Joe Bay than in Little Madeira Bay and Long Sound. Commonly collected small-bodied prey such as Gerreidae (*Eucinostomus* spp. [<40 mm SL], *E. gula, E. harengulus*), Engraulidae (*Anchoa mitchilli*), Cyprinodontiformes (*F. carpio* and *L. parva*), and Syngnathidae (*Syngnathus scovelli* in particular) were notably more abundant in Little Madeira Bay and Long Sound, both of which contain more SAV habitat. A greater proportion of Gobiidae than other prey taxa in Joe Bay could be related to its high proportions of shell, mud, algae, and woody debris and shallow sediment, interspersed with bare limestone substrates. Cryptic Gobiidae species are commonly found in habitats other than SAV, including mud and sand substrates (*M. gulosus*; Schofield 2003, 2004) or mud burrows and crevices in woody debris (*L. cyprinoides*, Darcy 1981, Bouchereau et al. 2012), and *Gobiosoma bosc* use hard substrates such as shell or interstitial rock crevices on which to attach their eggs

(e.g. Lehnert & Allen 2002, Miller et al. 2015). Species-specific differences in habitat use by small-bodied nekton were detected only in the small seines, however, since the BRUVs were not able to detect the breadth of diversity in small prey.

Large-bodied nekton assemblages observed by BRUVs were not as diverse as those in seine samples, but BRUVs did reveal patterns in habitat use by top predators and allowed for sampling of large-bodied nekton within Joe Bay, which could not be sampled by the large seines. The ability to identify taxa to species was again a distinct advantage of sampling with seines, since large-bodied Gerreids, which dominate large-seine samples and are an important prey source, exhibited species-specific differences in distribution and abundance. *Eugerres plumieri* were exclusively captured in Little Madeira Bay, but *Gerres cinereus* were more abundant in Long Sound. Economically important species such as *L. griseus*, *C. hippos*, and *S. barracuda*, however, were easily discerned from samples taken with both types of gear, had similar trends in abundance, and contributed significantly to differences in community structure. *C. undecimalis* (abundant in Little Madeira Bay) and *Archosargus probatocephalus* (abundant in Long Sound) were captured in large enough numbers in seines to contribute significantly to basin differences and reflected the importance of these areas to sportfish species. Flaherty et al. (2013) also reported that Little Madeira Bay harbored proportionately greater numbers of recreationally important species than did other areas of northeastern Florida Bay; these species could be moving in and out of these areas in conjunction with pulses of prey availability. In addition, juveniles of several shark species appeared to use Little Madeira Bay more often than the other 2 basins based on the BRUV surveys. The BRUVs were more effective at documenting these large-bodied, predatory species than the seines, likely because high swimming speeds allowed them to escape capture by seines, whereas the bait on the BRUVs likely attracted them (Harvey et al. 2007).

The temporal structure of communities can be strongly correlated to life history patterns of transient species, seasonal variability in freshwater flow, or disturbance events. Northeastern Florida Bay does not seem to function as a typical estuarine nursery area for smaller juveniles of economically valuable species (Ley et al. 1999, Flaherty et al. 2013), so the nekton communities there are much less seasonal than those in estuaries subject to these recruitment pulses. Overall nekton abundance and richness were generally higher in the dry season, but seasonal pat-

terns in salinity variation and nekton community structure were most pronounced in Joe Bay, which exhibited the lowest average wet-season salinity (10 ppt) and an extreme drop in salinity during Hurricane Irma (to 2.4 ppt). During the wet season of 2017, immediately after the passage of Hurricane Irma, small-bodied nekton communities across northeastern Florida Bay exhibited a distinct shift in community structure characterized by greater abundances of Engraulidae and lower abundances of small gerreids and *L. parva*. Similarly, Zink et al. (2020) observed that small-bodied fish communities in north-central Florida Bay exhibited spatially distinct community shifts during the 4 mo following Hurricane Irma, including a reduction in abundance of Gerreidae and *L. parva* and an increase in *A. mitchilli*. Species-specific differences in the abundance of gerreids were also evident during the wet season of 2017; *E. plumieri* (usually found in less saline waters) were more abundant than in any other season, while *E. harengulus* and *G. cinereus* were less abundant, reinforcing species-specific resource partitioning associated with salinity patterns within Florida Bay, documented earlier (Sogard et al. 1987, Ley et al. 1999, Thayer et al. 1999, Schofield 2004, Flaherty et al. 2013). Two large-bodied fish (*C. hippos* and *C. undecimalis*) were also less abundant in the 2017 wet season, indicating that these highly mobile predators may have moved downstream after the disturbance. Some of these patterns extended into the 2018 dry season. Estuarine fish assemblages are typically quite resilient to hurricane disturbances, but short-term changes in fish communities, possibly resulting from downstream movement induced by enhanced river flow or decreases in dissolved oxygen, can be significant (Greenwood et al. 2006, 2007, Stevens et al. 2006). In the nearby Everglades Shark River system, *C. undecimalis* made large-scale movements downstream in relation to high river stage and low barometric pressure due to Hurricane Irma (Massie et al. 2020). Other movement studies during the passage of hurricanes have documented short-term species movements into deeper waters and expanded foraging areas (Bacheler et al. 2019, Matley et al. 2019). In our study, both types of gear detected a short-term change in nekton communities and a resilience to the disturbances associated with a hurricane direct hit.

Based on results from this study, there are distinct advantages and disadvantages of using seines or BRUVs to monitor estuarine nekton communities (Table 4). Seines are more suitable when sampling turbid, coastal environments where underwater visibility is low and obtaining detailed information on benthic and shoreline habitats sampled is necessary. Seine sampling is also more appropriate for assessing species diversity and obtaining standardized estimates of abundance for each species, since taxonomic identification can be more precise and CPUE can be estimated from a known area swept. In addition, seines should be used when the goals of a study include gathering additional biological information from fishes (e.g. lengths, weights, sex, ages, etc.) and archiving samples for future reference and identification purposes. If the sampling area is large, BRUVs are more suitable because more BRUVs can be deployed than seines over a variety of habitats and in the same amount of time. In particular, BRUVs are appropriate in habitats with deep water, rocky substrates, or excessive detritus (as seen in Joe Bay), or in protected areas in which the habitat is fragile (e.g. coral reefs) or endangered species are present, since BRUVs are noninvasive and less likely than seines to damage habitat or fish. In addition, BRUVs should be used when the goals of the study are to obtain an overview of the fish community assemblage of an area without the need to know the exact species diversity, to document information on fish behavior and species interactions, to monitor shark or other top predator populations, as these large species are not adequately sampled using seines, or to retain a permanent video record of all individuals that encounter the gear. Based on these differences, recommendations for monitoring will vary depending on the study area. For future monitoring of nekton communities in northeastern Florida Bay, we recommend the use primarily of seine surveys, with the use of BRUV surveys in habitats inaccessible to seines (e.g. Joe Bay). The use of seines is a standard method for sampling estuaries throughout Florida, so future seine surveys can be used to compare nekton assemblages in Florida Bay to those in estuaries statewide and to detect decadal patterns in Florida Bay. The seine surveys also encountered more taxa than did the BRUV surveys, and abundance estimates obtained using BRUVs are limited since MaxN is a conservative estimate of abundance. Both methods are low in cost, but seines are more time-consuming to deploy in the field than are BRUVs, while BRUV surveys require extensive processing in the laboratory. The 571 videos processed for this study took approximately 1500 h to process. Even though advances in machine learning and artificial intelligence are being used to develop automated tools for fish monitoring from video data (Ditria et al. 2020, 2021), the management and quality control (i.e. direct identification

Table 4. Assessment of the advantages and disadvantages of using baited remote underwater videos (BRUVs) and seine surveys for sampling nekton communities in coastal environments. Shaded boxes provide advantageous traits for each type of gear

Assessment	Seines	BRUVs
Advantages of both gear types	Cost effective	Cost effective
	Can obtain detailed habitat information on benthic and shoreline habitats	Creates permanent video record of species and habitats
	Can obtain samples for additional analyses (e.g. ageing, genetics, toxicology)	Can be used to assess fish behavior and species interactions
Advantages of seines over BRUVs	Standardized protocols exist, long time series of data available	Still lacks consistent usage protocols; historical data limited
	Can be used in high-turbidity, low-visibility environments	Of limited use in high-turbidity, low-visibility environments
	Results in accurate estimate of effort (i.e. area sampled) and, thus, catch per unit effort	MaxN is only a proxy for abundance; catch per unit effort not easily estimable
	Limited post-collection processing	Time-consuming to watch and process videos
	Can get accurate fish lengths and weights	Time-consuming to get lengths; cannot get weights
	Cryptic species can be identified in the field or taken back to the lab for identification	Small-bodied fishes cannot be easily identified to species
Advantages of BRUVs over seines	Can damage fragile habitat (e.g. coral reefs)	Noninvasive, nondestructive
	Extractive gear (fish are physically handled)	Non-extractive gear
	Can sample only a limited range of water depths dependent on seine size	Can sample greater range of depth than can seines
	Often cannot be used over rocky bottom or where there is much detritus	Can be used in most habitats
	Physically demanding in the field	Quick and easy to deploy and retrieve
	Time-consuming in the field (thus, fewer samples possible)	Allows coverage of large areas in a short time
	Fish size targeted by a range of possible mesh sizes	One type of gear can assess species of all sizes
Disadvantages of both gear types	Requires specialized vessel to deploy larger nets	Requires specialized software to obtain length data
	Builders of standardized nets are difficult to find and keep	Technology changes; storage of video data is costly
	Certain species may be able to avoid the seine	Bait-related biases, including quantifying the area of attraction and species attracted
	Size of fish captured depends on mesh size	Fish observed depends on distance from camera

of less common species) of this technology will still entail significant labor by biologists. These advances could decrease processing time in future BRUV studies but will not replace manual identification in cases of small-bodied fish or if data at the species level are desired. The results of this study demonstrate the effectiveness of complementary types of gear at sampling coastal estuarine communities documenting similar patterns in species assemblages, but the advantages and disadvantages of using seines or BRUVs highlight the need for monitoring programs to carefully select a type of gear (or multiple types of gear) that successfully monitor species throughout their ontogeny and across the estuarine seascape. Since data collected with seines and BRUVs both demonstrated the effect of environmental variation across small- and large-bodied nekton communities, these types of gear could be used in studies of similar estuarine habitat mosaics.

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Appendix

Table A1. Summary of taxa collected by type of gear and stratum during northeastern Florida Bay stratified-random sampling, 2016–2019. Sampling with small (21.3 m) seines and baited remote underwater videos (BRUVs) was stratified by the presence or absence of a shoreline (shore or offshore, respectively); large (183 m) seines were deployed along shorelines. Taxa are summarized by the total number of individuals captured (for seines) and total maximum number of individuals observed in a single frame (MaxN) (for BRUVs). Effort, or the total number of seine hauls or BRUV deployments, is labeled E. Taxa are ordered phylogenetically by order or family and then alphabetically by species. Asterisks (*) mark BRUV taxa used in small-bodied nekton analyses

ORDER or **Family** Species	21.3 m seines Offshore $E = 72$	21.3 m seines Shore $E = 72$	183 m seines Shore $E = 48$	Totals $E = 192$	BRUVs Offshore $E = 271$	BRUVs Shore $E = 268$	BRUVs Totals $E = 539$
Limulidae							
Limulus polyphemus	.	.	.	.	.	2	2
Penaeidae							
Farfantepenaeus aztecus	.	1	.	1	.	.	.
Farfantepenaeus duorarum	1	8	5	14			
Alpheidae*	12	4	.	16	2	1	3
Portunidae							
*Callinectes sapidus**	7	4	61	72	51	82	133
Ginglymostomatidae							
Ginglymostoma cirratum	.	.	1	1	2	19	21
Carcharhinidae							
Carcharhinus leucas	.	.	2	2	17	24	41
Negaprion brevirostris	.	.	.	.	4	51	55
Sphyrnidae							
Sphyrna tiburo	.	.	2	2	30	19	49
Pristidae							
Pristis pectinata	.	1	2	3	2	2	4
Dasyatidae					12	3	15
Dasyatis americana	.	1	1	2	.	.	.
Elopidae							.
Elops saurus	.	1	5	6	27	.	27
Megalopidae							
Megalops atlanticus	.	.	7	7	1	13	14
Albulidae							
Albula conorhynchus	.	1	.	1	.	.	.
Albula spp.	.	1	.	1	.	.	.
Engraulidae*					143	4301	4444
Anchoa mitchilli	620	14171	.	14791	.	.	.
Clupeidae*	.	.	.	.	.	7	7
Harengula jaguana	.	6	.	6	.	.	.
Jenkinsia stolifera	.	2	.	2	.	.	.
Opisthonema oglinum	77	86	.	163	.	.	.
Ariidae							
Ariopsis felis	6	.	9	15	638	69	707
Bagre marinus	.	.	3	3	25	1	26
Synodontidae							
Synodus foetens	.	.	1	1	.	.	.
Batrachoididae							
Opsanus beta	8	15	2	25			.
Mugilidae					1	91	92
Mugil cephalus	.	.	21	21	.	.	.
Mugil curema	.	.	67	67	.	.	.
Mugil trichodon	.	.	29	29	.	.	.
ATHERINIFORMES*	.	1	.	1	72	678	750
Atherinopsidae							
Membras martinica	3	392	.	395	.	.	.
Menidia spp.	.	273	.	273	.	.	.
Atherinidae							
Atherinomorus stipes	3312	1379	.	4691	.	.	.
Hypoatherina harringtonensis	.	4	.	4	.	.	.
Hemiramphidae	.	1	.	1	.	.	.
*Chriodorus atherinoides**	.	2	2	4	131	86	217
Hemiramphus spp.	1	.	.	1	.	.	.
Belonidae	.	.	.	.	.	4	4
Strongylura notata	6	41	4	51	.	.	.
Strongylura spp.	1	.	.	1	.	.	.
Strongylura timucu	.	1	.	1	.	.	.
Tylosurus crocodilus	.	.	10	10	.	.	.
CYPRINODONTIFORMES*	.	.	.	.	27	110	137
Fundulidae							
Lucania parva	1872	737	.	2609	.	.	.
Cyprinodontidae							
Floridichthys carpio	1485	1480	.	2965	.	.	.
Syngnathidae							
Anarchopterus criniger	.	1	.	1	.	.	.
Hippocampus erectus	1	3	.	4	.	.	.
Hippocampus zosterae	24	11	.	35	.	.	.
Syngnathus louisianae	2	.	.	2	.	.	.
Syngnathus scovelli	91	101	.	192	.	.	.

ORDER or **Family** Species	21.3 m seines Offshore E = 72	Shore E = 72	183 m seines Shore E = 48	Totals E = 192	BRUVs Offshore E = 271	Shore E = 268	Totals E = 539
Centropomidae							
Centropomus undecimalis	.	1	49	50	1	10	11
Serranidae							
Diplectrum formosum*	.	.	.	.	2	.	2
Carangidae							
Caranx crysos	.	.	.	.	34	1	35
Caranx hippos	.	.	73	73	291	98	389
Caranx latus	.	.	4	4	.	.	.
Oligoplites saurus*	.	1	2	3	6	4	10
Selene vomer	.	.	57	57	.	.	.
Trachinotus carolinus	.	.	5	5	.	.	.
Trachinotus falcatus	.	.	2	2	.	.	.
Echeneidae	.	.	.	.	38	37	75
Echeneis naucrates	.	.	1	1	.	.	.
Echeneis neucratoides	.	.	1	1	.	.	.
Lutjanidae							
Lutjanus apodus	.	.	.	.	1	.	1
Lutjanus griseus	9	27	249	285	128	158	286
Gerreidae							0
Gerreidae spp. (small)*	.	.	.	.	802	1,209	2011
Gerreidae spp. (large)	.	.	.	.	12	35	47
Diapterus auratus	.	.	8	8	.	.	.
Eucinostomus argenteus	8	10	.	18	.	.	.
Eucinostomus gula	261	212	338	811	.	.	.
Eucinostomus harengulus	62	359	11	432	.	.	.
Eucinostomus jonesii	5	24	2	31	.	.	.
Eucinostomus spp.	664	1300	.	1964	.	.	.
Eugerres plumieri	2	4	103	109	.	.	.
Gerres cinereus	1	7	149	157	.	.	.
Sparidae							
Archosargus probatocephalus	.	1	30	31	2	6	8
Lagodon rhomboides*	1	.	.	1	3	.	3
Sciaenidae							
Cynoscion nebulosus	5	6	4	15	.	.	.
Pogonias cromis	.	.	21	21	1	.	1
Sciaenops ocellatus	.	1	5	6	.	.	.
Cichlidae							
Cichlasoma urophthalmus	1	1	.	2	.	.	.
Blenniidae							
Chasmodes saburrae	2	3	.	5	.	.	.
Labrisomidae							
Paraclinus fasciatus	.	1	.	1	.	.	.
Callionymidae							
Diplogrammus pauciradiatus	15	10	.	25	.	.	.
Gobiidae*	.	.	.	.	51	29	80
Gobiosoma bosc	2	12	.	14	.	.	.
Gobiosoma robustum	10	15	.	25	.	.	.
Gobiosoma spp.	12	10	.	22	.	.	.
Lophogobius cyprinoides	58	27	.	85	.	.	.
Microgobius gulosus	1148	781	.	1929	.	.	.
Microgobius microlepis	113	10	.	123	.	.	.
Ephippidae							
Chaetodipterus faber	.	.	11	11	.	.	.
Sphyraenidae							
Sphyraena barracuda	2	9	134	145	11	26	37
Achiridae							
Achirus lineatus	1	1	3	5	.	.	.
Trinectes maculatus	2	2	.	4	.	.	.
Tetraodontidae							
Sphoeroides nephelus	2	1	4	7	38	9	47
Sphoeroides spengleri	.	.	2	2	.	.	.
Sphoeroides testudineus	.	.	3	3	.	.	.
Diodontidae							
Chilomycterus schoepfii	.	1	21	22	.	.	.
Chilomycterus spp.	1	.	.	1	.	.	.
Trionychidae							
Apalone ferox	.	.	.	.	.	2	2
Crocodylidae							
Crocodylus acutus	.	.	.	.	1	1	2
Totals	**9916**	**21566**	**1526**	**33008**	**2607**	**7186**	**9793**