Chapter 1 Patterns of Zooplankton Consumption by Juvenile and Adult Delta Smelt (Hypomesus transpacificus)

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Chapter 1: Patterns of Zooplankton Consumption by Juvenile and Adult Delta Smelt (*Hypomesus transpacificus*)

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Abstract

Delta Smelt is an imperiled fish species endemic to the upper San Francisco Estuary and associated Sacramento-San Joaquin Delta. Management actions to benefit Delta Smelt include freshwater outflow augmentation, however it is unclear how flow affects Delta Smelt foraging. Our study generated diet information from 1,962 Delta Smelt collected from 2011-2017 to evaluate hypotheses related to the feeding ecology of Delta Smelt among seasons and habitats (salinity) over several years of varying flow conditions in the upper estuary, including 2017, an extremely wet year.

Cyclopoid and calanoid copepods were the numerically dominant prey in the guts of Delta Smelt during most years and seasons and relatively dominant in terms of prey biomass in the guts of Delta Smelt for young juveniles during summer. As Delta Smelt matured, larger prey items such as mysids, amphipods, and larval fishes contributed more to stomach contents, the latter item being important to adults during the spring period only. The wet year of 2017 was dominated by copepods, cladocerans, and amphipods in terms of prey biomass. The importance of amphipods in diet contrasts with prior years, where for most years amphipods were not a large biomass component of Delta Smelt diet including 2011, another wet year. Gut fullness was also higher in 2017, particularly in the low salinity zone (0.5 to 6 ppt) relative to other salinity areas. We found no relationship between gut fullness and condition factor, likely due to these measures operating

on different time scales. Our results revealed that prey categories consumed varied seasonally and among habitats (salinity), yet were similar among recent years.

Introduction

The Delta Smelt *Hypomesus transpacificus* is a small pelagic fish endemic to fresh and brackish waters of the upper San Francisco Estuary (Estuary) and Sacramento-San Joaquin Delta (Delta), California, USA. Though once numerous, Delta Smelt has suffered a long-term decline in abundance associated with changes in habitat conditions in the Estuary (Moyle et al. 2016). The Estuary receives fresh water from the Sacramento and San Joaquin River Delta that flows toward the Pacific Ocean through a series of rivers, channels, and bays. The amount of fresh water flow shifts seasonally from the wet period of winter and spring to the dry period of summer and fall. The tidal mixing of fresh and ocean waters results in a gradient of brackish water, of which the low salinity zone (LSZ; 0.5-6.0 ppt) is important rearing habitat for many young fishes including Delta Smelt (Dege and Brown 2004, Kimmerer et al. 2013). The amount of Estuary fresh water flow is managed by a complex series of reservoir releases and freshwater pumping extraction, both of which influence the location and size of the LSZ (Feyrer et al. 2007, Kimmerer et al. 2013). Habitat features important to Delta Smelt include turbid waters, cool temperatures, and prey availability (Baxter et al. 2015).

Delta Smelt is largely a zooplanktivore that consumes an array of prey that increase in size as the fish matures (Moyle et al. 1992; Feyrer et al. 2003; Mager et al. 2004, Hammock et al. 2019). Delta Smelt larvae hatch at 5-6 mm fork length (FL) (Wang 1986) with feeding starting within about one week of hatching (i.e. ~6 mm FL, Mager et al. 2004). Nobriga (2002) found the smallest Delta Smelt larvae consumed mostly copepod nauplii and copepodites, with larger larvae (~20 mm) switching to mostly adult copepods. The calanoid copepods *Eurytemora affinis* and *Pseudodiaptomus forbesi*, and cyclopoid copepods were the dominant prey consumed with Delta Smelt showing positive selection for both *E. affinis* and *P. forbesi* (Nobriga 2002). Slater and Baxter (2014) showed similar patterns with selection for *E. affinis* and *P. forbesi* extending well into the juvenile life stage during summer. During the summer the authors found *P. forbesi* adults became the major food item by number and weight with *Limnoithona* spp. of noted occurrence as well. During this period, the smaller *Limnoithona* spp. were selected against, but were consumed when at extremely high densities and other prey were limited. Types of prey consumed is also a function of regional differences in availability (Baxter et al. 2015, Hammock et al. 2017). Adult Delta Smelt consume larger zooplankton prey including mysids and larval fishes (Baxter et al. 2015; Hammock et al. 2017). Laboratory feeding experiments show similar patterns with Delta Smelt larvae transitioning to larger copepod prey as fish mature, with selection for larger calanoid copepods *E. affinis* and *P. forbesi* over smaller zooplankton life stages and species (e.g., *Limnoithona* spp.) (Sullivan et al. 2016).

The pelagic foodweb, on which Delta Smelt depends, has undergone radical changes over the last ~50 years. Slater and Baxter (2014) summarized the substantial changes in the prey of Delta Smelt from the 1970s through the 1990s as a result of numerous species introductions. Most notable changes in the upper Estuary and Delta occurred in the late 1980s with new zooplankton species, notably copepods, and the reduction in primary and secondary production following invasion of the bivalve *Potamocorbula amurensis.* The invasions of the Delta by the bivalves

Corbicula fluminea and *P. amurensis* are thought to strongly suppress phytoplankton via grazing and reduce zooplankton abundance through competition and predation. These impacts have had a negative effect on a suite of zooplankton (Winder and Jassby 2011), such as mysids, that are historically important to Delta Smelt (Moyle 2002, Feyrer et al. 2003, Baxter et al. 2015).

The decline of the Delta Smelt population has been attributed in part to changes in the food web (Bennett and Moyle 1996; Moyle 2002; Sommer et al. 2007; Mac Nally et al. 2010; Baxter et al. 2015, Moyle et al. 2016). More specifically, it is thought that Delta Smelt are food limited during the spring through fall periods (Bennett and Moyle 1996; Bennet 2005). Kimmerer (2008) found summer to fall survival was significantly related to calanoid zooplankton biomass in the low-salinity zone (0.5-2.1 psu). Slater and Baxter (2014) suggest low calanoid copepod abundance in August and September may have affected feeding and survival in 2005 and 2006. However, while prey availability is an undoubtedly vital component of Delta Smelt habitat and survival, some uncertainties in this relationship exist.

Outflow-related management actions to benefit Delta Smelt are currently in place or proposed (USFWS 2008; CNRA 2016; Frantzich et al. 2018; Schultz et al. 2018). However, how such actions affect food availability and prey use by Delta Smelt is uncertain. The prevailing hypotheses are that food production, food quality and feeding success for Delta Smelt increases as the salinity field moves seaward, as a function of increased Delta freshwater outflow (USBR 2012; Brown et al. 2014). In this study we examined Delta Smelt collected over a 7-year period to describe prey found in stomachs to address the following questions: (1) Did Delta Smelt have increased feeding success (gut fullness) in 2017 relative to previous years? (2) Was there a relationship between fullness and body condition? (3) How did prey consumption change among seasons (life stages) for Delta Smelt? and (4) Did prey consumption differ among years and habitat (salinity)?

Methods

Study Area. – The study area ranged from San Pablo Bay in the western part of the upper Estuary upstream into the connecting Delta to Stockton on the San Joaquin River, Hood on the Sacramento River, and the Sacramento River Deep Water Ship Channel (Figure 1-1). Daily net freshwater outflow (cfs) past Chipps Island estimates were obtained from the DWR DAYFLOW website (https://water.ca.gov/Programs/Environmental-Services/Compliance-Monitoring-And-Assessment/Dayflow-Data) and summarized as monthly trends among water years, along with the Sac Valley water year index (W = wet, AN = above normal, BN = below normal, D = dry, and C = critically dry). Note that water years in California are October 1-September 30 (e.g. water year 2011 is October 1, 2010-September 30, 2011).

Delta Smelt. – We used Delta Smelt captured during monitoring surveys conducted by the California Department of Fish and Wildlife (CDFW; 2011-2017) and U.S. Fish and Wildlife Service (USFWS; 2017) participating in the Interagency Ecological Program (IEP). CDFW IEP surveys included Summer Townet (STN), Fall Midwater Trawl (FMWT), Spring Kodiak Trawl (SKT), and also a special study in 2014 the Gear Efficiency Survey (GES) (for more details on survey design see Hammock et al. 2017). The USFWS survey Enhanced Delta Smelt Monitoring program (EDSM) begun in 2017 and used a Kodiak Trawl. Fish surveys for CDFW employed a fixed-station design and USFWS surveys used a generalized random-tessellation stratified sampling design (Stevens and Olsen 2004; Starcevich et al. 2016). Temperature (°C), Secchi disk depth (cm), and specific conductivity (µS/cm) were measured from boats at each sampling location. Salinity (parts-per-thousand, ppt) was calculated from specific conductance (uS/cm) corrected to 25°C then using the equation ppt = ((0.36966/(((µS/cm *0.001)^-1.07)-0.00074)*1.28156). Diet data were organized into the following salinity categories <0.5 ppt, 0.5-6.0 ppt, and >6.0 ppt; the Low Salinity Zone (LSZ) recognized as ~0.5-6.0 ppt.

Delta Smelt were preserved in liquid nitrogen on the boats using methods described in Teh et al. (2016) and transferred to University of California at Davis (UCD). Thawed specimens were measured for fork length (mm) and total body weight (g) and then rapidly dissected (~5–10 min per fish). Delta Smelt length-weight data was summarized via a scatterplot and the relationship reported as a power function (Supplement Data: Figures, Figure B1). The gastro-intestinal tract, including esophagus, stomach, and intestine, was preserved in 95% ethanol and sent to CDFW's Diet Study Laboratory for analysis (Stockton, CA). Body weights of 13 fish were not recorded at the start of the study in 2011 as attempts to weigh fish in the field were found too variable, subsequent measures were recorded in the laboratory. We calculated Fulton's condition factor for each fish as follows:

$$K = (W / L^3) * 100{,}000,$$

where W is body weight (g) and L is fork length (mm) (Neumann et al. 2012).

Fullness and Prey Use. – Data related to stomach content identification and fullness largely followed methods in Slater and Baxter (2014) and Hammock et al. (2017). Gastro-intestinal tracts were taken out of vials and rinsed to remove ethanol. The intestine was removed and the stomach was opened to expose contents. Stomach contents were placed in water in a Petri dish and all items were identified to the lowest practical taxon and counted. Intestine contents were not examined as items were heavily digested. In addition to counting items, a length was recorded for mysids, amphipods, and larval fish, when intact. A body length (mm) estimate was assigned to mysids, amphipods and larval fish that were heavily digested or in pieces; assigned lengths were from the intact prey of the same type from the same stomach or same type from a stomach of a fish collected close in time and location (e.g. same station or nearby station). Lengths were recorded for a subset of other zooplankton types, when intact (cumaceans, terrestrial invertebrates, isopods, others). We categorized amphipods as either *Gammarus* spp. or *Corophium* spp. based on distinct body shapes of the genera but did not identify them to species. We determined wet weight of prey in guts by multiplying the count of each prey type by a wet weight estimate (Supplemental Data: Tables, Table A1) or from lengths using length-weight equations for mysids, amphipods, and larval fish (Supplemental Data: Tables, Table A2). Recorded lengths of prey were summarized as scatterplots (Supplemental Data: Figures, Figures B2 and B3). We summed calculated weights of the various prey types for each fish stomach. The calculated weight of prey in stomachs was divided by the total number of prey to generate average prey mass per fish. The various prey categories were grouped by species or genera for a total of 19 categories.

Gut fullness was calculated as stomach content weight as a percentage of body weight (%BW), with wet weight of the stomach contents (g) divided by fish body wet weight (g) multiplied by

100 (Bush 2003). Stomach contents were found in various stages of digestion, so at times only parts of an organism were found (e.g. telson from amphipod). Therefore, the sum of calculated prey weights could exceed actual mass if only parts of prey items are present, or the opposite could occur if materials not enumerated like unidentified animal and plant material were present. Calculated stomach weights and fullness values that exceeded 4% were removed from the analysis (N = 24), as they exceeded double the "full" percentage of 2% and so were believed to be outliers. We assessed the percent fullness and assigned a relative index of fullness rank using the scale 0 = empty, 1 = 1-25% full, 2 = 25-50% full, 3 = 50-75% full and 4 = 75-100% full, similar to Cohen and Bollens (2008). The fullness rank was an additional measure added during the study, so data does not exist for all samples.

We organized data to allow comparison among years for seasons (June-August, September-November, and December-May) that follow closely to gear types used to track the various life stages of Delta Smelt (juveniles, sub-adults, and adults, respectively). Results of diet analysis were reported as percent by number (%N), by weight (%W), and by frequency of occurrence (%FO). Numeric diet data allows examination of prey consumption relative to prey availability, but small numerically abundant prey can outweigh contribution of larger, less frequently consumed prey to the diet. Mass diet data allows examination of patterns relative to stomach fullness, but can overestimate importance of large, less frequently consumed prey. Unidentified animal and plant material were not included in diet by %N, %W, or %FO as these items could not be enumerated.

We used a non-parametric Kruskal-Wallis test to determine whether there were significant differences ($P < 0.05$) in gut fullness across years, salinities, and seasons. A boxplot was generated to show the distribution of calculated fullness (%) values relative to the observed stomach fullness by rank (SYSTAT 13). We used least squares linear regression to assess the relationship between gut fullness and condition factor. A Conover-Iman post-hoc test was applied to test for significance differences among the pairwise comparisons when the Kruskal-Wallis test was significant.

Multivariate analyses were conducted to examine patterns in zooplankton consumption by Delta Smelt from stomach content data among years, habitats (salinity) and seasons using PRIMER 7. Fish with empty stomachs (N = 66) were not included in the multivariate analyses of prey consumption. A square-root transformation was applied to mean diet by percent number, and mean diet by percent weight data, and Bray-Curtis similarity matrices (abundance) were produced. We used one-way Analysis of Similarity (ANOSIM) to test for statistical differences in diet between year, seasons, and salinity ranges. An ANOSIM R value close to zero indicates no difference between groups, an R value close to 1 indicates strong differences between groups, and the maximum value of 1 is the greatest level of dissimilarity possible (Clarke and Warwick 2001, Sampson et al. 2009). We used Non-metric Multidimensional Scaling (NMDS) on the Bray-Curtis matrices to illustrate diet overlap. Similarity Percentage (SIMPER procedure) was used to determine which prey categories contributed to the differences in diets, if any, revealed by ANOSIM. We did use ANOSIM to test for a difference in diet among fish collected by agency (CDFW vs USFWS) and found no significant difference in the global test in diet between agencies (R = 0.075, P = 0.286), so no further analyses for this variable were conducted.

Results

Freshwater outflow as calculated at Chipps Island in the upper Estuary was highly variable during this study. Mean monthly flow followed seasonal trends for the Estuary with wet winters and springs followed by dry summers and falls, with several years of extreme drought (i.e., dry and critically dry water years, 2013-2016), two below normal water years (2012 and 2016), and two wet water years (2011, 2017), one of which (2017) was one of the wettest years on record (Figure 1-2).

Delta Smelt. – There were 1,866 Delta Smelt collected by CDFW studies (2011-2017) and 96 collected by USFWS EDSM (2017) for a total of 1,962 fish that were examined for gut contents (Table 1-1). Feeding incidence was highly positive with some amount of prey present in n=1,896 (98%) stomachs. Delta Smelt in this study were collected at temperatures ranging from 8 to 26 °C, at Secchi depths ranging from 10 to 130 cm, at times between 6 AM and 4 PM, and at salinities from 0.1 to 15.6 ppt, although relatively few Delta Smelt were collected at temperatures above 23 °C or salinities above 8 ppt (Figure 1-3). There did not appear to be a pattern in detection of empty stomachs among each of the environmental variables, as empty stomachs occurred at low frequency across measurements, except a slightly higher frequency of empty stomachs occurred at warmer temperatures (20-21°C) and between 7 AM and 11 AM (Figure 1-3).

Juveniles of each year class were collected beginning in June (mean 36.7 mm FL), although 1 smelt at 32 mm FL was collected in May 2014 (Table 1-2). A general pattern of growth for each year class occurred with increased monthly mean lengths as each year progressed, with some individual months being variable or lower to the previous month due in part to small sample sizes. Adult Delta Smelt were collected through the May of the following year hatch (year class) with a mean length of 73.9 mm FL.

Gut Fullness. – A total of 1,925 Delta Smelt were included in analysis of the fullness. A subset of these fish included assignment of a rank of relative index of fullness (n = 1,200) that was used to place the calculated percent fullness relative to body weight in context of what was observed in stomachs (Figure 1-4). For example, stomachs that appeared “full” (rank 4) occurred over a range of calculated fullness (%) values with the median being 0.89% for “full” stomachs. Stomachs “half-full” had a median value of 0.25% and “3/4 full” were 0.52% (Figure 1-4). Application of this pattern to calculated fullness (%) data would be that Delta Smelt stomachs on average were ¾ to mostly full (Figure 1-5).

There was a significant difference in calculated stomach fullness (%) among years (Kruskal-Wallis = 20.507; $P < 0.003$; Figure 1-5). A post-hoc test revealed fullness was significantly lower in 2013 than 2011, 2012, 2014, 2015, and 2017, but other pairwise combinations of years were not found to be significantly different. There was a significant difference in stomach fullness among salinities (Kruskal-Wallis = 8.583; $P = 0.014$, df = 2; Figure 1-5), with post hoc test of significant differences between <0.5 and 0.5-6 ppt (P =0.009) and also <0.5 and >6 ppt (P = 0.0497), but not between 0.5-6 and >6 ppt ($P = 0.661$). Seasonal fullness was significantly different among June-August, September-November, and December-May (Kruskal-Wallis = 15.649, $P = 0.0004$). Post hoc test results indicated significant differences between June-August and September-November ($P = 0.0004$) and significant differences between September-

November and December-May (P = 0.0002) due to higher September-November fullness, but there was not a significant difference between June-August and December-May (P = 0.761). Fullness (%) differed among hour of collection (Kruskal-Wallis = 202.264, P < 0.0001). Most of the 55 post hoc pairwise comparisons were significantly different, except between 4 PM and 6 AM or 7 AM or between 8 AM and 9 AM, 10 AM, 11 AM, or 1 PM and between 12 PM and 2 PM (Figure 1-5). The extreme high mean value at 3 PM was a small sample size (n=17) with the stomach contents all large prey of amphipods, mysids, cumaceans, and larval fish.

Mean (± SE) fullness (%) was 0.426 (± 0.011) and condition factor (K) was 0.726 (± 0.002). We found no linear relationship (R^2 = 0.0002; df = 1, 1923; P =0.572) between gut fullness and condition factor (Figure 1-6).

General Summary of Diet. – A total of 295,546 items were identified and counted from Delta Smelt stomachs. The number of prey averaged 156 per stomach for fish with food present in guts (n=1,896), with the highest prey count being 2,427 in a single stomach (Figures 1-7A and 1-7B). We found that the maximum number of prey consumed increased as Delta Smelt increased in size from small juveniles up through adults (~55 mm FL), but did not increase among adults, possibly a function of prey size and stomach capacity (Figure 1-7). The number of prey in stomachs appeared to be a function of the size of prey, the stomachs with the most numerous prey also had the lowest mean mass per individual prey item and some of the lowest frequency had the largest mean mass for prey (Figure 1-7A). Number of prey when scaled to stomach fullness saw that both stomachs with numerous small items and also stomachs with few large items had high stomach fullness, but the stomachs with fewer items had lower fullness per individual among fork lengths (Figure 1-7B).

Amphipods ranged in length from 0.5 to 6 mm and were mostly small *Corophium* spp., juveniles of *Americorophium stimpsoni* and *A. spinicorne* (53.7%), with *Gammarus* spp. including *Gammarus daiberi*, *Crangonyx* sp., and *Hyalella* sp. (7.0%) and unidentified amphipods (1.4%) (Figure 81-). Mysids *Hyperacanthomysis longirostris* and unidentified mysids (8.4%) had the widest range of body lengths 0.5-11 mm found in stomachs, with 2/3 of those mysids being 1-3 mm long. Only a few native *Neomysis kadiakensis* (n=5) and *N. mercedis* (n=5) mysids were found in stomachs, compared to hundreds of the introduced *H. longirostris* (n=431). Larval fish (6% of larger prey) ranged in length from 2.0 to 13.9 mm. Pacific Herring *Clupea pallasii* ranged from 5.0 to 10.5 mm, whereas Prickly Sculpin *Cottus asper* ranged from 3.5 to 7.0 mm, Longfin Smelt *Spirinchus thaleichthys* from 3.0 to 7.0 mm, and *Tridentige*r spp. from 2.0 to 3.0 mm (Figure 1-8).

Cyclopoid and calanoid copepods were the numerically dominant prey items in the stomachs of Delta Smelt during most years, salinity ranges, and seasons, with cladocerans dominant in the December-May period in fresh water (Tables 3-5). A pattern was evident that prey use was similar within seasons and salinities among years. During the June-August period juvenile Delta Smelt ate mostly *Pseudodiaptomus* spp. in freshwater (<0.5 ppt) among years (Table 1-3), while in the LSZ (0.5-6 ppt) *Limnoithona* spp. with *Pseudodiaptomus* spp. was also consumed in large numbers (Table 1-4). Juvenile Delta Smelt were less common above 6 ppt. Their diets were more variable, and included *Limnoithona* spp., *Acartiella sinensis*, and *Tortanus* spp. copepods and also demersal invertebrates, amphipods and cumaceans (Table 1-5). Diets during September-November were similar to the previous season with copepods numerically dominant, but the variability in species of copepods increased in freshwater (<0.5 ppt) and LSZ (0.5-6 ppt), notably with an increase in *Pseudodiaptomus* spp. in the fall (Tables 3-4). The few Delta Smelt that were collected in September-November at >6 ppt which primarily consumed copepods and cladocerans with a reduced presence of demersal invertebrates (Table 1-5). During December-May in freshwater (<0.5 ppt), adults shifted to a majority of *Sinocalanus doerrii* with other calanoids, cyclopoids and cladocerans (Table 1-3). Delta Smelt in the LSZ (0.5-6 ppt) shifted consumption to higher percentages of *Eurytemora affinis*, *Acanthocyclops* spp., other cyclopoid copepods, and cladocerans among years (Table 1-4). The December-May high salinity (>6 ppt) diets also included high percentages of *E. affinis* in addition to *Limnoithona* spp. and other cyclopoid copepods and cladocerans (Table 1-5).

In terms of prey mass in the diet of Delta Smelt, cyclopoid and calanoid copepods were dominant for young juveniles during the summer period. Diet by weight for juveniles was more variable as the fish matured with larger prey items such as mysids, amphipods and larval fishes important during several years and the latter being important during the spring period only (Tables 6-8). Similar to diet by number, diet by weight had a pattern of generally consistent prey use among years within seasons and variable among salinity regions, with increased contribution of larger prey (Tables 6-8). Diet by weight for June-August in freshwater (<0.5 ppt) was mostly *Pseudodiaptomus* spp. and *Sinocalanus doerrii* (Table 1-6). During June-August in the LSZ (0.5-6 ppt) diets were more variable with *Pseudodiaptomus* spp., *A. sinensis*, *Tortanus* spp. *Limnoithona* spp, along with mysids and fish and some amphipods contribute by weight (Table 1-7). Diet for June-August at >6 ppt included a greater diversity of prey and larger prey types, such as *Tortanus* spp. copepods, cumaceans and fish (Table 1-8). The “Other” category of 68.5% for June-August 2014 in >6 ppt was due largely to isopods; one fish contained 8 of the total 20 isopods counted among all Delta Smelt stomachs. The September-November period had high percentages of calanoid copepods for diets by weight, *Pseudodiaptomus* spp. the dominant copepod in <0.5 and 0.5-6ppt, but mysids also contributed to diets in fresh water (<0.5 ppt) for several years (Table 1-6). For September-November 2017, we found a substantial amount (>96%) of diet by weight comprised of the amphipods *Gammarus* spp. and *Corophium* spp. in fresh water (<0.5 ppt). This is largely in contrast to prior data from 2011 to 2016, where amphipods were not a large biomass component of Delta Smelt diet even during the other wet year of 2011. Fish during September-November in the LSZ consumed more *Acartiella* sp., other cyclopoids (nearly all cyclopoid copepodites), but also mysids as in the lower salinities (Tables 6-7). The few fish in September-November caught in >6 ppt had variable diets with a mix of copepods, mysids and other items shifting among years as to larger percentages of diet by mass (Table 1-8). Adults during December-May in freshwater consumed high percentages by weight of *S. doerrii*, other copepods, cladocerans, amphipods and larval fish (Table 1-6). Like diet by number, *E. affinis*, *A. vernalis*, cladocerans were major food components by weight in the LSZ in December-May, as were larval fish in several years (Table 1-7). Larval fish identified in stomachs were mostly Pacific Herring (49%), Prickly Sculpin (7%), with a few Longfin Smelt (1%) and gobies of the genus *Tridentiger* spp. (1%), along with unidentified larval fish (41%) due to the state of digestion. Diet by weight during December-May in >6 ppt was highly variable with *E. affinis*, other cyclopoids (mostly unidentified cyclopoid copepodites), cladocerans, amphipods, and cumaceans all contributing differently among years.

Use of prey among individual fish within sample periods, reported as percent frequency of occurrence, revealed prey types contributing in large part to percent by number and by weight were consumed by the majority of individuals (Tables 9-11). This measure of "presence-absence" of the prey types among fish was limited by small sample sizes for some periods. Among periods of large samples of Delta Smelt (n >10), *Pseudodiaptomus* spp. was the most commonly consumed prey among fish in salinities <0.5 and 0.5-6 ppt. There was similarity in prey use among years, but difference among seasons. The December-May period had a greater number of prey used among fish than the other seasons.

Nonmetric multidimensional scaling (NMDS) ordination plots revealed patterns among year, season, salinity, and agency for diet by number (Figure 1-9) and diet by weight (Figure 1-10). One-way ANOSIM statistical global-test showed a significant difference in diet by percent number between groups of months (seasons) ($R = 0.357$, $P = 0.001$) and salinity ranges ($R = 0.332$, $P = 0.001$). Post-hoc pairwise comparisons for seasons revealed December-May diets were strongly dissimilar from June-August ($R = 0.623$) and September-November ($R = 0.546$), whereas diets were similar among June-August and September-November ($R = -0.035$). Post-hoc pairwise comparisons for salinity ranges results appeared to follow a gradient, with significant differences among all pairs with the greatest difference between <0.5 and >6 ($R = 0.6$, $P = 0.001$), with decreasing difference between <0.5 and 0.5-6 ($R = 0.281$, $P = 0.001$) and lastly >6 and 0.5-6 ($R = 0.19$, $P = 0.008$). There was not a significant difference found in the global test in diet between year groups ($R = -0.021$, $P = 0.292$) or agencies ($R = -0.081$, $P = 0.744$). The SIMPER results revealed the dissimilarity among salinities due to mostly *P. forbesi* and *Limnoithona* spp., with other prey (*S. doerrii*, other cyclopoids, cladocerans, *E. affinis*) contributing differently among salinities. The SIMPER results for season dissimilarity was similar in many ways, but the importance of *E. affinis* increased for dissimilarity between December-May to the other seasons.

Diet by percent weight ANOSIM results were similar to that of diet by percent number with significant differences between seasons ($R = 0.293$, $P = 0.001$) and salinity ranges ($R = 0.332$, $P = 0.001$). Post-hoc pairwise comparisons of diet by weight for months revealed December-May diets were strongly dissimilar from June-August ($R = 0.586$) and September-November ($R = 0.395$), whereas diets were similar among June-August and September-November ($R = -0.015$). There was a significant difference between salinity ranges in diet by weight for all groups (<0.5 and 0.5-6 $R = 0.248$, 0.5-6 and > 6 $R = 0.271$, and <0.5 and >6 $R = 0.546$). No significant difference was found in the global test in diet between year groups ($R = 0.042$, $P = 0.189$).

Discussion

This study provides a comprehensive summary of Delta Smelt prey consumption among seasons that are informative of the life stages of Delta Smelt, and how diets vary with salinity across recent years of varying freshwater outflow conditions. We found Delta Smelt to have somewhat consistent and broad diets within seasons and salinities across years, but diets did vary significantly among salinities and seasons within years. This is attributed to the seasonal and regional abundance of zooplankton, most notable with high densities of *P. forbesi* in freshwater during summer and *E. affinis* high densities in LSZ during winter (Hennessy 2017). The most extreme seasonal pattern was consumption of larval fish by adult Delta Smelt in spring, a function attributed to Delta Smelt being large enough to capture and consume fish larvae. Larval fish, such as Pacific Herring and Prickly Sculpin in spring, would convey nutritional benefit as large prey during the energetically demanding spawning period of Delta Smelt (Damon et al. 2016). The duration of spawning periods by native fishes and thus abundance of larvae over a period of time could bestow foraging benefit to adult Delta Smelt. Conditions that allow production of small larvae, thus prey, over longer periods would be advantageous to Delta Smelt. The comparison among years was influenced by variable inter-annual conditions in the Estuary and thus the resulting prey field available to Delta Smelt. For this study, our evaluation was one of several years including comparison of the wet water year of 2017 relative to the other water years that ranged from wet to critically dry.

Based on prior research it was not surprising that this study found copepods dominated the diet of Delta Smelt across years and seasons. Based on stomach contents from the 1970s and 1980s, Delta Smelt were found to rely heavily on copepods with mysids, cladocerans, and amphipods, with the copepods shifting from *E. affinis* in the 1970s to *P. forbesi* in the late 1980s (Moyle et al. 1992), a function of *P. forbesi* becoming dominant after introduction. Findings in the early- and mid-1990s were similar to ours, with seasonal and annual trends of copepods important to diet composition, mostly *Pseudodiaptomus* spp. (Lott 1998). Another similarity to previous findings was the presence of amphipods and larval fish (Lott 1998), but at higher levels for this study than previously found. Herbivorous calanoid copepods (*P. forbesi*, *S. doerrii*, and *E. affinis*) were important components to diet seasonally, consistently among years in freshwater and low salinity zone in the recent period (2011-2017). Smaller *Limnoithona* spp. also made up large portions of diet numerically in recent years, but was not a large contribution to stomach mass in most periods and areas. Seasonal shifts in prey consumed could also be a function of the increasing size of Delta Smelt, which may increase foraging capacity and success. Young Delta Smelt have shown selection against *S. doerrii* (Slater and Baxter 2014), but here we found *S. doerrii* to be a large component of Delta Smelt diet in winter (December-May) in freshwater, possibly a function of improved foraging ability by adults. Along with seasonal production, high mortality of young life stages could limit the numbers of adult *P. forbesi* available as prey. Kimmerer et al. (2018) showed *P. forbesi* nauplii and juveniles experience high mortality in Suisun Bay probably due to clam grazing and predatory copepods which was offset by subsidies from freshwater into Suisun Bay during summer and fall.

While copepods are an undoubtedly important staple of the Delta Smelt diet, prey items that are found to be numerically dominant may be smaller and not reflect the true relative importance of prey biomass to nutritional needs of the fish. The relative benefit of prey types to an organism should include biomass estimates of diet items versus only numerical-related estimates, and indeed larger prey types with more caloric potential are likely to influence the habitat use of an organism within its ecosystem. Conversely, larger items high in caloric value and seemingly of high importance may be uncommon in the environment, inconsistently represented in the diet, or inherently less numerous in the diet due to their size. This concept of size applied to Delta Smelt prey types would place high value on mysids and larval fish, as energetically or nutritionally superior. Smaller crustaceans (i.e. amphipods) have a lower volume of mass per individual with a greater ratio of external chitin relative to mass; chitin is not assimilated by predators (Vijverberg and Frank 1976). The frequency of stomachs with many small prey could be a signal of poor feeding conditions, with greater effort and possibly increased predation risk needed to acquire prey versus collection of a few large prey. The range of prey consumed and percent frequency of occurrence was high with most fish consuming the same types of prey.

Comparison across the seasons revealed that while copepods were still of importance to Delta Smelt diet with respect to biomass, it is clear other food items shared or dominated importance with respect to biomass during certain years and seasons, especially for adult Delta Smelt. Larval fishes were a dominant prey by weight in Delta Smelt diets when data is summed from 2011-2016 and *Gammarus* spp. by weight for 2017. However, a closer look reveals larval fishes were not present in diets of Delta Smelt across many sampling dates and was influenced by seasonal production of larval fish and size of adult Delta Smelt able to capture larger prey (larval fish in stomachs were up to 13.9 mm). That said, the data are suggestive that native fishes that spawn in winter (i.e. Pacific Herring and Prickly Sculpin) produce larvae of importance to the diet of adult Delta Smelt, when they are large enough to consume larval fish. There was evidence of the introduced gobies, *Tridentiger* spp., possibly Shokihaze Goby (*T. barbatus*) and Shimofuri Goby (*T. bifasciatus*) larvae, in stomachs of juvenile Delta Smelt. *Tridentiger* spp. goby larvae in summer have a pelagic period following hatch (~2-3 mm FL) before settling out to a demersal life history around 13-18 mm FL, based on CDFW 20-mm and STN catch patterns. The goby spawning period in summer occurs when the majority of Delta Smelt are juveniles and thus Delta Smelt might not be of size to take advantage of this and other larval fish as food in summer.

Delta Smelt diets did include what is traditionally considered “demersal” prey, such as amphipods and cumaceans. The dominance of *Gammarus* spp. by weight in diet was driven by their relatively high mass per length and numbers consumed in 2017 that was largely not seen in other years. Among amphipods consumed by Delta Smelt, by far the dominant prey was native *Americorophium* spp. of a narrow size range (i.e. copepod sized ~ 1-1.5 mm). *Americorophium* spp. are a tube building amphipod, but we did not observe evidence of tubes debris in stomachs. An interesting observation of gut contents was that there was little to no debris (e.g. sand, silt, and detritus) in Delta Smelt stomachs, as seen in other fishes that forage for benthos along the substrate such as Threadfin Shad *Dorosoma petenense* (Ingram and Ziebell 1983) or as tube or clam siphon nippers such as *Tridentiger* spp. goby (Slater 2005). The absence of debris in stomachs along with the types and size of amphipods found in stomachs are likely evidence of Delta Smelt taking advantage of epi-benthic prey or individuals available in the water column. Cumaceans are also regularly detected by CDFW meso-zooplankton (Clark-Bumpus; CB) nets towed obliquely through the water (CPUE data available at http://www.dfg.ca.gov/delta/data/Zooplankton/CPUE_ZooMap.asp) and provides evidence they would be available to Delta Smelt in the water column.

A surprise finding during the study was of terrestrial insects (e.g. chironomids, flies, aphids, ants, and spiders) in stomachs of Delta Smelt. They occurred in stomachs at a very low frequency and so were reported in the “Other” zooplankton category. Nearly all occurrences were from fish >54 mm FL collected by Kodiak Trawl which sampled adult fish oriented to the surface of the water.

The types of prey found in stomachs was found to be not significantly different among years, but the prey available as herbivorous calanoid copepods was higher in freshwater and the low salinity zone during the wet year of 2017. There was evidence that gut fullness of Delta smelt was higher in 2017 than some other years. It is unclear if this was due to increased availability of prey in the wet year of 2017, or a function of smaller sample sizes available in 2017 across salinities and seasons limiting comparisons. Gut fullness was actually higher in the low salinity zone than other regions. This is similar to the fullness pattern observed in previous related work (Hammock et al. 2017). Our data showed no relationship between gut fullness and fish condition factor. While instantaneous gut fullness may be an indicator of short-term food availability or feeding success, it may not have direct relation to certain health and condition metrics of individuals as these measures are impacted more by a suite of prior conditions experienced by each fish. Fullness as a function of time was similar for two different measures, with higher frequency of empty stomachs and a lower fullness (%) in the early hours of the day. Juvenile and adult Delta Smelt are believed to be a visual predator (Sullivan et al. 2016). Our findings of low stomach fullness in the early hours and then reaching mostly full by late morning could be partly explained by foraging during daylight. Fullness as a measure is dynamic, as fewer items would be needed to reach fullness when eating larger prey or if smaller in size, thus having a smaller stomach to fill.

This study revealed patterns in Delta Smelt diet that were informed by zooplankton data. Zooplankton data can provide trends in prey type and densities relative to the habitat of Delta Smelt. The concurrent fish and zooplankton samples can also provide opportunities for selectivity analysis as to the densities biologically relevant to foraging by Delta Smelt. The importance of copepods was evident from stomach contents and there was associated zooplankton data to look at summer and fall trends for this study, that *Pseudodiaptomus* spp. abundant in summer and fall was a major food item of Delta Smelt. The lack of concurrent zooplankton data for adults during January-May does not allow for close comparison or analysis of selectivity. Added complication to understanding the prey field for adults is the lack of sampling of amphipods and mixed types of larval fish during spring (CDFW Smelt Larval Survey samples January-March). The meso-zooplankton data used is informative of adult copepod sized prey, but might be limited in effective collection of smaller prey (<0.5 mm), such as all life stages of *Limnoithona spp*. The CB net also does not appear efficient in collection of less numerous larger prey such as larval fish and macro-invertebrates. Additional examination of the mysid net for understanding larval fish and macro-zooplankton is warranted to help improve the information regarding the available prey field. Future efforts will look more closely at available prey data and how we might examine selectivity or preference measures by the various life stages of Delta Smelt.

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Tables

Table 1-1. Summary of Delta Smelt Collected by CDFW and USFWS Surveys Among Months and Salinity Ranges (<0.5, 0.5-6, and > 6 ppt) During the Period 2011-2017 that were Examined for Stomach Contents During this Study

Month	Salinity (ppt)	2011	2012	2013	2014	2015	2016	2017	Total
Jan	<0.5		45	40	10	9	4	14	122
	0.5-6		50	22	54	8	3	1	138
	>6		53		6				59
Feb	<0.5		30	11	11	18	3	7	80
	0.5-6		50	18	21	21	2		112
	>6		4						4
Mar	<0.5		65	26	34	4	6	8	143
	0.5-6		10	19	2	1	1		33
	>6								
Apr	<0.5		64	13	16	1	13	4	111
	0.5-6		28	2	2				32
	>6				1				1
May	<0.5		30	4	11	4			49
	0.5-6		3	5	1		1		10
	>6								
Jun	<0.5		49	28	19	4		1	101
	0.5-6		19	32	24			5	80
	>6			7					7
Jul	<0.5			8	2	10		1	21
	0.5-6				9			5	14
	>6			30	8			2	40
Aug	<0.5	42	18	6	30	1		(4)	101
	0.5-6	24	6	4	67			(17)	118
	>6	4		2	1			14	21
Sep	<0.5	8			3			(18)	29
	0.5-6	33		2	67	4		(9)	115
	>6		1	2	1			(2)	6
Oct	<0.5	34	14			1		(36)	85
	0.5-6	12	8	3	9			2 (4)	38
	>6								0
Nov	<0.5	17	2	2					21
	0.5-6	17	9	2			7	(6)	41
	>6	6							6
Dec	<0.5	57	6		38		21		122
	0.5-6	41	5	3	22	1	2		74
	>6	17		5		3	3		28
Total		**312**	**569**	**296**	**469**	**90**	**66**	**160**	**1962**

Notes: USFWS Samples in Parentheses

Table 1-2. Summary of Mean Fork Lengths (mm) of Delta Smelt Collected by CDFW and USFWS Per Month that Were Examined for Stomach Contents During the Period 2011-2017

Month	Salinity (ppt)	2011	2012	2013	2014	2015	2016	2017	Total
Jan	<0.5		63.4	67.3	65.9	61.4	67.0	65.7	65.1
	0.5-6		62.2	70.1	65.8	65.3	70.7	68.0	65.3
	>6		61.6		67.8				62.3
Feb	<0.5		63.3	65.2	66.7	64.7	74.3	68.6	65.2
	0.5-6		63.1	71.1	68.9	67.4	67.5		66.3
	>6		68.0						68.0
Mar	<0.5		65.9	71.2	67.3	69.8	66.3	68.5	67.5
	0.5-6		63.4	75.3	75.0	66.0	65.0		71.1
	>6								
Apr	<0.5		67.9	74.5	68.4	65.0	72.0	77.5	69.5
	0.5-6		68.1	76.0	74.5				69.0
	>6				67.0				67.0
May	<0.5		71.0	78.5	73.5	74.0			72.4
	0.5-6		67.7	77.2	69.0		32.0		71.3
	>6								
Jun	<0.5		35.5	36.0	35.3	31.0		36.0	35.4
	0.5-6		33.8	38.1	31.5			48.4	35.8
	>6			44.3					44.3
Jul	<0.5			46.5	35.5	47.7		46.0	46.0
	0.5-6				45.6			40.4	43.7
	>6			47.6	47.6			45.5	47.5
Aug	<0.5	44.1	51.9	42.0	48.0	47.0		51.5	46.9
	0.5-6	43.6	41.3	48.0	47.7			50.9	47.0
	>6	49.5		46.5	52.0			48.9	48.9
Sep	<0.5	59.4			62.3			50.2	53.8
	0.5-6	49.8		59.5	52.1	58.8		53.0	51.9
	>6		46.0	51.0	63.0			48.0	51.8
Oct	<0.5	54.8	61.4			52.0		57.0	56.8
	0.5-6	57.8	54.3	67.3	54.7			52.9	56.2
	>6								
Nov	<0.5	57.5	67.5	55.0					58.2
	0.5-6	56.9	64.3	64.0			61.9	55.2	59.5
	>6	54.3							54.3
Dec	<0.5	62.3	66.2		60.2		62.2		61.8
	0.5-6	59.4	63.4	62.0	57.5	69.0	65.0		59.5
	>6	57.6		64.2		70.0	68.3		61.3
Total		**54.5**	**60.4**	**58.7**	**55.8**	**61.9**	**65.8**	**55.4**	**58.0**

Note: A single 32 mm FL juvenile Delta Smelt was caught by the SKT in May 2016 and not included in calculation of the total May mean length.

Table 1-3. Diet by Percent Number of Major Prey Categories in Stomachs of Delta Smelt Collected in <0.5 ppt for Months June-August (J-A), September-November (S-N), and December-May (D-M) Among Years 2011-2017

Prey Category	J-A 2011 (42)	J-A 2012 (66)	J-A 2013 (38)	J-A 2014 (47)	J-A 2015 (15)	J-A 2016 (0)	J-A 2017 (2)	J-A 2017* (4)	S-N 2011 (59)	S-N 2012 (16)	S-N 2013 (2)	S-N 2014 (3)	S-N 2015 (1)	S-N 2016 (0)	S-N 2017 (0)	S-N 2017* (53)	D-M 2012 (286)	D-M 2013 (99)	D-M 2014 (81)	D-M 2015 (73)	D-M 2016 (26)	D-M 2017 (51)
	Diet by percent number (%N)																					
Calanoid copepods																						
Eurytemora spp.	0.0	0.0	0.0	0.0	0.1		0.7	0.0	0.0	0.0	0.0	0.0	0.0			0.0	4.1	3.6	3.7	1.0	14.2	2.3
Pseudodiaptomus spp.	71.3	63.0	52.7	59.0	61.5		92.8	22.0	63.5	52.4	18.6	70.2	65.3			63.4	7.4	8.0	6.7	8.5	5.6	0.9
Sinocalanus doerrii	1.7	10.6	5.4	5.9	5.8		0.0	4.1	5.0	8.1	3.5	3.6	2.0			0.0	43.4	26.7	36.2	1.3	54.5	10.8
Acartiella sinensis	0.2	0.0	0.0	0.2	0.0		0.0	4.6	15.4	1.4	0.0	0.0	0.0			6.6	0.3	0.0	0.0	0.0	0.0	0.0
Tortanus spp.	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other calanoids	17.4	7.3	8.9	8.0	6.5		0.0	2.3	3.2	0.5	0.0	3.6	26.7			8.3	6.1	11.7	4.9	5.0	10.2	5.4
Cyclopoid copepods																						
Limnoithona spp.	0.6	11.4	4.7	13.7	9.2		0.0	42.7	2.4	4.2	20.9	16.7	5.0			0.2	0.0	0.0	0.0	0.4	0.2	0.2
Acanthocyclops spp.	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	2.5	5.8	5.0	3.3	2.0	1.2
Other cyclopoids	1.0	1.2	0.1	1.4	4.6		0.7	6.9	1.2	3.2	17.4	2.4	0.0			1.1	10.5	11.9	24.7	35.1	5.5	6.3
Other Copepods																						
Harpacticoids	1.1	0.1	7.1	0.4	0.1		0.0	10.1	1.2	4.6	29.1	0.0	0.0			1.4	1.8	0.2	0.2	0.9	0.6	0.0
Copepod nauplii	2.9	0.3	15.9	2.6	0.3		0.0	2.8	1.5	1.6	8.1	0.0	0.0			0.2	0.0	0.0	0.0	0.2	0.1	0.0
Cladocerans	0.8	2.5	0.9	6.0	6.4		4.6	2.8	1.0	0.0	0.0	2.4	0.0			0.9	13.2	28.9	14.6	41.9	6.1	68.3
Mysids	0.0	0.2	0.1	0.1	0.0		1.3	0.9	1.9	20.6	0.0	0.0	0.0			0.1	0.1	0.1	0.0	0.0	0.0	0.0
Amphipods																						
Gammarus spp.	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.5	0.0	0.0	0.0			13.4	0.3	0.2	0.7	0.2	0.4	0.6
Corophium spp.	0.0	0.1	0.0	0.0	2.2		0.0	0.5	1.7	1.8	1.2	0.0	1.0			2.6	9.1	0.4	0.6	0.3	0.1	0.7
Unidentified amphipods	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.4	0.1	0.0	0.1	0.0	0.0	0.1
Cumaceans	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.2	0.0	0.0	1.2	0.0			0.0	0.2	0.0	0.4	0.1	0.0	0.4
Fish	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.2	0.0	0.1	0.0	0.0	0.5
Other	3.0	3.2	4.1	2.7	3.4		0.0	0.5	1.9	1.2	1.2	0.0	0.0			1.3	0.7	2.6	2.2	1.8	0.5	2.0
Total	100	100	100	100	100		100	100	100	100	100	100	100			100	100	100	100	100	100	100

Note: Each year includes December from the preceding year (e.g. 2012 includes December 2011-May 2012). Number of stomachs with food present in parentheses. No samples (NS) occurred in some years and months reported as blank fields. Fields are shaded darker green with higher percentage values.
* Identifies samples collected by USFWS in 2017

Table 1-4. Diet by Percent Number of Major Prey Categories in Stomachs of Delta Smelt Collected in 0.5-6 ppt for Months June-August (J-A), September-November (S-N), and December-May (D-M) Among Years 2011-2017

	Diet by percent number (%N)																					
Prey Category	J-A 2011 (24)	J-A 2012 (21)	J-A 2013 (32)	J-A 2014 (88)	J-A 2015 (0)	J-A 2016 (0)	J-A 2017 (10)	J-A 2017* (17)	S-N 2011 (61)	S-N 2012 (17)	S-N 2013 (6)	S-N 2014 (75)	S-N 2015 (4)	S-N 2016 (7)	S-N 2017 (1)	S-N 2017* (19)	D-M 2012 (177)	D-M 2013 (71)	D-M 2014 (83)	D-M 2015 (52)	D-M 2016 (8)	D-M 2017 (3)
Calanoid copepods																						
Eurytemora spp.	0.0	0.0	6.2	0.0			0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.0	25.0	5.5	3.8	9.9	61.8	14.1	47.7	47.6
Pseudodiaptomus spp.	4.3	20.7	31.2	9.7			90.0	1.1	11.2	67.2	3.6	42.9	78.7	19.9	75.0	3.7	1.1	0.4	1.5	2.2	1.6	0.2
Sinocalanus doerrii	0.0	1.2	0.0	0.0			0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0
Acartiella sinensis	12.9	1.1	2.3	8.7			0.2	1.9	8.5	10.1	15.9	6.2	1.3	8.0	0.0	1.0	3.3	0.3	1.9	0.4	0.3	0.2
Tortanus spp.	1.2	0.2	0.2	0.0			0.3	0.0	0.2	0.3	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Other calanoids	0.0	1.0	1.0	1.3			2.3	0.1	0.3	0.9	0.6	4.2	14.1	0.3	0.0	1.4	0.4	0.7	9.2	3.5	4.6	4.1
Cyclopoid copepods																						
Limnoithona spp.	76.8	73.7	52.0	65.8			5.6	90.2	4.5	8.1	69.9	38.9	4.0	64.4	0.0	51.6	1.4	0.2	0.6	3.7	12.0	0.2
Acanthocyclops spp.	0.0	0.0	1.0	0.0			0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	4.5	19.7	19.4	5.2	16.7	7.4	10.9
Other cyclopoids	0.0	0.0	1.1	14.0			0.6	5.1	66.7	0.9	8.0	5.9	1.2	4.6	0.0	28.4	36.1	26.1	13.0	48.3	9.5	18.8
Other Copepods																						
Harpacticoids	3.2	0.1	0.2	0.1			0.1	0.7	0.3	0.4	0.4	0.2	0.0	1.1	0.0	0.7	1.1	0.9	0.2	0.2	0.5	0.0
Copepod nauplii	0.3	0.4	0.2	0.1			0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.2	0.3	0.1	0.6	0.0
Cladocerans	0.1	0.0	0.3	0.1			0.1	0.0	2.5	0.0	0.0	0.0	0.3	0.3	0.0	1.4	27.0	38.2	1.2	8.6	9.6	14.2
Mysids	0.4	0.8	1.6	0.1			0.1	0.0	0.5	3.4	1.4	0.2	0.2	0.2	0.0	0.1	0.3	0.3	0.0	0.0	0.1	0.0
Amphipods																						
Gammarus spp.	0.0	0.1	0.0	0.0			0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.3	0.0	0.0	0.1	0.3	0.1	0.0	0.3	0.0
Corophium spp.	0.3	0.1	0.2	0.0			0.4	0.2	0.8	7.4	0.0	0.1	0.2	0.5	0.0	0.1	3.5	0.4	0.2	0.1	2.6	0.2
Unidentified amphipods	0.1	0.0	0.0	0.0			0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0
Cumaceans	0.3	0.0	0.2	0.0			0.0	0.1	0.0	0.1	0.0	0.7	0.0	0.2	0.0	0.2	1.4	1.6	1.9	0.5	3.0	1.7
Fish	0.0	0.1	0.1	0.0			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.9	0.0	0.0	0.0
Other	0.3	0.5	1.7	0.1			0.2	0.4	0.3	0.5	0.1	0.7	0.0	0.0	0.0	0.9	0.2	0.5	1.7	1.5	0.1	2.1
Total	100	100	100	100			100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Note: Each year includes December from the preceding year (e.g. 2012 includes December 2011-May 2012). Number of stomachs with food present in parentheses. No samples (NS) occurred in some years and months reported as blank fields. Fields are shaded darker green with higher percentage values.
* Identifies samples collected by USFWS in 2017

Table 1-5. Diet by Percent Number of Major Prey Categories in Stomachs of Delta Smelt Collected in >6 ppt for Months June-August (J-A), September-November (S-N), and December-May (D-M) Among Years 2011-2017

Prey Category	J-A 2011 (3)	J-A 2012 (0)	J-A 2013 (30)	J-A 2014 (5)	J-A 2015 (0)	J-A 2016 (0)	J-A 2017 (15)	J-A 2017* (0)	S-N 2011 (5)	S-N 2012 (1)	S-N 2013 (2)	S-N 2014 (1)	S-N 2015 (0)	S-N 2016 (0)	S-N 2017 (0)	S-N 2017* (2)	D-M 2012 (74)	D-M 2013 (0)	D-M 2014 (12)	D-M 2015 (0)	D-M 2016 (3)	D-M 2017 (3)
	Diet by percent number (%N)																					
Calanoid copepods																						
Eurytemora spp.	0.0		0.0	0.0			0.0		0.0	0.0	0.0	0.0				0.0	2.0		42.6		85.5	78.2
Pseudodiaptomus spp.	3.7		0.8	0.0			0.1		6.3	0.0	4.3	0.0				0.0	0.3		0.1		0.0	0.0
Sinocalanus doerrii	0.0		0.0	0.0			0.0		0.1	0.0	0.0	0.0				0.0	0.1		0.0		0.0	0.0
Acartiella sinensis	18.5		0.4	0.0			0.1		21.6	0.0	6.4	0.0				0.1	2.4		2.2		0.0	0.0
Tortanus spp.	3.7		3.3	11.1			0.2		1.0	0.0	14.9	69.2				0.0	0.6		2.1		0.0	0.0
Other calanoids	0.0		0.1	0.0			0.0		0.0	0.0	0.0	11.5				0.0	0.9		2.3		2.7	8.2
Cyclopoid copepods																						
Limnoithona spp.	3.7		89.4	0.0			86.5		3.1	100.0	63.8	3.8				91.1	2.5		12.1		0.9	0.4
Acanthocyclops spp.	0.0		0.0	0.0			0.0		1.2	0.0	0.0	0.0				0.0	12.6		6.0		4.2	2.7
Other cyclopoids	0.0		4.4	5.6			12.2		26.3	0.0	0.0	0.0				8.6	55.2		21.1		1.8	8.0
Other Copepods																						
Harpacticoids	3.7		0.2	0.0			0.2		0.2	0.0	8.5	0.0				0.0	2.0		0.5		0.0	0.0
Copepod nauplii	0.0		0.2	0.0			0.3		0.0	0.0	0.0	0.0				0.1	0.1		0.5		0.3	0.1
Cladocerans	0.0		0.0	0.0			0.0		35.0	0.0	0.0	0.0				0.0	19.1		1.2		0.0	0.0
Mysids	7.4		0.1	0.0			0.0		0.0	0.0	2.1	3.8				0.0	0.2		0.0		0.0	0.0
Amphipods																						
Gammarus spp.	0.0		0.0	0.0			0.0		0.0	0.0	0.0	0.0				0.0	0.0		0.1		0.0	0.0
Corophium spp.	25.9		0.1	16.7			0.1		4.4	0.0	0.0	0.0				0.0	0.3		0.6		2.7	0.1
Unidentified amphipods	0.0		0.0	16.7			0.0		0.1	0.0	0.0	0.0				0.0	0.0		0.0		0.0	0.0
Cumaceans	33.3		0.2	5.6			0.0		0.7	0.0	0.0	3.8				0.0	1.3		2.5		1.8	0.1
Fish	0.0		0.1	0.0			0.0		0.0	0.0	0.0	0.0				0.0	0.2		0.0		0.0	0.0
Other	0.0		0.6	44.4			0.3		0.1	0.0	0.0	7.7				0.0	0.2		6.2		0.0	2.0
Total	100		100	100			100		100	100	100	100				100	100		100		100	100

Note: Each year includes December from the preceding year (e.g. 2012 includes December 2011-May 2012). Number of stomachs with food present in parentheses. No samples (NS) occurred in some years and months reported as blank fields. Fields are shaded darker green with higher percentage values.

* Identifies samples collected by USFWS in 2017

Table 1-6. Diet by Percent Weight of Major Prey Categories in Stomachs of Delta Smelt Collected in <0.5 ppt for Months June-August (J-A), September-November (S-N), and December-May (D-M) Among Years 2011-2017

	Diet by percent weight (%W)																					
Prey Category	J-A 2011 (42)	J-A 2012 (66)	J-A 2013 (38)	J-A 2014 (47)	J-A 2015 (15)	J-A 2016 (0)	J-A 2017 (2)	J-A 2017* (4)	S-N 2011 (59)	S-N 2012 (16)	S-N 2013 (2)	S-N 2014 (3)	S-N 2015 (1)	S-N 2016 (0)	S-N 2017 (0)	S-N 2017* (53)	D-M 2012 (286)	D-M 2013 (99)	D-M 2014 (81)	D-M 2015 (73)	D-M 2016 (26)	D-M 2017 (51)
Calanoid copepods																						
Eurytemora spp.	0.0	0.0	0.0	0.0	0.1		0.1	0.0	0.0	0.0	0.0	0.0	0.0			0.0	2.4	2.4	2.1	0.6	6.8	1.1
Pseudodiaptomus spp.	69.2	71.5	65.0	56.1	64.0		65.6	32.9	43.7	2.8	8.7	43.0	81.6			1.3	6.1	7.8	6.2	10.0	4.0	0.6
Sinocalanus doerrii	4.7	17.7	11.4	15.3	9.2		0.0	9.5	4.7	0.7	15.6	14.3	4.0			0.0	44.9	34.1	43.0	2.1	64.4	9.8
Acartiella sinensis	0.8	0.0	0.0	0.6	0.0		0.0	12.1	15.9	0.1	0.0	0.0	0.0			0.3	0.3	0.0	0.0	0.0	0.0	0.0
Tortanus spp.	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.1	0.0	0.0	0.0	0.0
Other calanoids	17.2	3.8	7.0	6.9	4.6		0.0	2.0	1.1	0.0	0.0	6.8	13.2			0.1	4.2	9.3	3.6	5.9	8.5	3.7
Cyclopoid copepods																						
Limnoithona spp.	0.1	1.6	0.6	2.8	1.3		0.0	8.2	0.2	0.0	7.1	5.3	0.8			0.0	0.0	0.0	0.0	0.0	0.0	0.0
Acanthocyclops spp.	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	1.5	4.1	3.3	3.0	1.3	0.6
Other cyclopoids	1.4	0.7	0.1	1.2	4.7		0.4	7.6	0.7	0.2	22.8	4.5	0.0			0.0	4.5	6.4	6.9	27.0	2.6	2.4
Other Copepods																						
Harpacticoids	1.1	0.1	5.9	0.4	0.1		0.0	8.0	0.4	0.1	41.8	0.0	0.0			0.0	0.7	0.1	0.1	0.5	0.2	0.0
Copepod nauplii	0.3	0.0	1.4	0.2	0.0		0.0	0.2	0.0	0.0	1.2	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cladocerans	0.9	1.8	0.9	6.6	4.6		2.8	2.6	0.2	0.0	0.0	3.8	0.0			0.0	8.3	20.2	10.1	34.3	3.8	35.8
Mysids	0.0	0.6	0.6	2.0	0.0		31.2	9.7	30.6	93.8	0.0	0.0	0.0			0.1	1.9	4.4	0.6	0.1	0.0	1.6
Amphipods																						
Gammarus spp.	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	1.1	0.0	0.0	0.0			91.4	4.9	4.2	8.4	4.9	6.2	8.9
Corophium spp.	0.0	0.1	0.0	0.0	1.6		0.0	6.8	0.8	0.8	0.9	0.0	0.5			5.5	9.0	3.9	3.0	1.9	1.1	7.5
Unidentified amphipods	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0			1.2	1.4	0.1	1.2	0.2	0.0	0.2
Cumaceans	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.8	0.0	0.0	22.3	0.0			0.0	0.9	0.1	2.3	0.9	0.2	1.7
Fish	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	7.8	1.2	3.8	0.0	0.0	20.3
Other	4.2	2.0	7.0	7.9	9.9		0.0	0.4	0.9	0.2	1.8	0.0	0.0			0.1	1.3	1.7	5.5	8.3	0.8	5.7
Total	100	100	100	100	100		100	100	100	100	100	100	100			100	100	100	100	100	100	100

Note: Each year includes December from the preceding year (e.g. 2012 includes December 2011-May 2012). Number of stomachs with food present in parentheses. No samples (NS) occurred in some years and months reported as blank fields. Fields are shaded darker blue with higher percentage values.
* Identifies samples collected by USFWS in 2017.

Table 1-7. Diet by Percent Weight of Major Prey Categories in Stomachs of Delta Smelt Collected in 0.5-6 ppt for Months June-August (J-A), September-November (S-N), and December-May (D-M) Among Years 2011-2017

	Diet by percent weight (%W)																					
Prey Category	J-A 2011 (24)	J-A 2012 (21)	J-A 2013 (32)	J-A 2014 (88)	J-A 2015 (0)	J-A 2016 (0)	J-A 2017 (10)	J-A 2017* (17)	S-N 2011 (61)	S-N 2012 (17)	S-N 2013 (6)	S-N 2014 (75)	S-N 2015 (4)	S-N 2016 (7)	S-N 2017 (1)	S-N 2017* (19)	D-M 2012 (177)	D-M 2013 (71)	D-M 2014 (83)	D-M 2015 (52)	D-M 2016 (8)	D-M 2017 (3)
Calanoid copepods																						
Eurytemora spp.	0.0	0.0	6.8	0.0			0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	19.7	8.2	2.5	4.0	19.6	13.7	26.2	35.5
Pseudodiaptomus spp.	11.0	50.9	54.9	25.3			94.4	5.8	20.3	24.0	7.6	48.4	73.6	39.4	80.3	9.5	1.2	0.2	0.6	3.9	1.3	0.3
Sinocalanus doerrii	0.0	3.4	0.1	0.0			0.2	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0
Acartiella sinensis	44.1	3.7	5.5	34.4			0.4	12.6	21.3	4.9	50.4	16.2	2.7	23.0	0.0	3.6	5.2	0.2	1.7	0.9	0.4	0.4
Tortanus spp.	11.2	2.4	1.8	0.0			1.5	0.0	1.3	0.4	0.0	0.0	0.0	1.4	0.0	0.3	0.1	0.2	0.1	0.0	0.0	0.0
Other calanoids	0.0	1.4	0.8	1.5			1.2	0.2	0.2	0.2	0.7	3.6	8.6	0.3	0.0	1.2	0.4	0.4	2.0	4.3	2.2	1.8
Cyclopoid copepods																						
Limnoithona spp.	19.4	16.8	9.4	19.3			0.7	48.0	0.8	0.3	14.9	7.6	0.6	13.6	0.0	16.3	0.2	0.0	0.0	0.7	1.1	0.0
Acanthocyclops spp.	0.0	0.0	1.3	0.0			0.0	0.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0	9.8	16.0	8.1	2.5	22.1	4.6	12.9
Other cyclopoids	0.0	0.0	0.7	15.9			0.5	10.7	37.6	0.2	8.2	4.4	0.8	3.8	0.0	25.3	11.0	4.2	2.4	26.0	2.6	8.0
Other Copepods																						
Harpacticoids	3.4	0.1	0.2	0.1			0.0	1.5	0.2	0.1	0.4	0.2	0.0	1.0	0.0	0.9	0.5	0.2	0.1	0.1	0.2	0.0
Copepod nauplii	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Cladocerans	0.1	0.0	0.2	0.1			0.0	0.0	4.2	0.0	0.0	0.0	0.3	0.4	0.0	3.8	25.9	18.9	0.7	10.4	7.0	21.6
Mysids	5.0	10.1	8.2	2.1			0.8	0.4	6.2	67.2	14.7	9.7	13.4	0.9	0.0	6.2	1.8	7.0	0.8	0.5	7.0	0.0
Amphipods																						
Gammarus spp.	0.0	0.3	0.0	0.1			0.0	0.0	1.3	0.4	1.0	0.9	0.0	6.6	0.0	0.8	2.2	4.3	0.6	0.9	5.6	0.0
Corophium spp.	0.6	0.1	1.9	0.1			0.2	16.1	0.4	1.8	1.3	0.3	0.0	7.6	0.0	9.2	5.0	1.9	1.0	1.6	24.9	0.1
Unidentified amphipods	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.2	0.0	1.3	0.0
Cumaceans	4.0	0.0	2.7	0.5			0.0	2.9	0.3	0.3	0.0	7.8	0.0	2.1	0.0	3.7	9.8	5.6	7.7	5.9	15.8	17.8
Fish	0.0	5.8	0.3	0.0			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.4	44.3	56.3	0.0	0.0	0.0
Other	1.1	5.1	5.2	0.5			0.2	1.6	0.5	0.3	0.8	0.9	0.0	0.0	0.0	1.2	0.5	0.3	3.5	8.8	0.0	1.6
Total	100	100	100	100			100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Note: Each year includes December from the preceding year (e.g. 2012 includes December 2011-May 2012). Number of stomachs with food present in parentheses. No samples (NS) occurred in some years and months reported as blank fields. Fields are shaded darker blue with higher percentage values.
* Identifies samples collected by USFWS in 2017

Table 1-8. Diet by Percent Weight of Major Prey Categories in Stomachs of Delta Smelt Collected in >6 ppt for Months June-August (J-A), September-November (S-N), and December-May (D-M) Among Years 2011-2017

	Diet by percent weight (%W)																					
	J-A	J-A	J-A	J-A	J-A	J-A	J-A	J-A	S-N	S-N	S-N	S-N	S-N	S-N	S-N	S-N	D-M	D-M	D-M	D-M	D-M	D-M
	2011	2012	2013	2014	2015	2016	2017	2017*	2011	2012	2013	2014	2015	2016	2017	2017*	2012	2013	2014	2015	2016	2017
Prey Category	(3)	(0)	(30)	(5)	(0)	(0)	(15)	(0)	(5)	(1)	(2)	(1)	(0)	(0)	(0)	(2)	(74)	(0)	(12)	(0)	(3)	(3)
Calanoid copepods																						
Eurytemora spp.	0.0		0.1	0.0			0.0		0.0	0.0	0.0	0.0				0.0	1.4		24.4		64.6	80.7
Pseudodiaptomus spp.	1.2		2.1	0.0			0.3		7.1	0.0	3.6	0.0				0.0	0.4		0.1		0.0	0.1
Sinocalanus doerrii	0.0		0.0	0.0			0.1		0.1	0.0	0.0	0.0				0.0	0.1		0.0		0.0	0.0
Acartiella sinensis	8.2		1.5	0.0			0.7		31.7	0.0	6.3	0.0				1.5	4.2		4.3		0.0	0.0
Tortanus spp.	4.8		28.0	3.0			0.7		4.5	0.0	37.8	30.6				0.0	2.6		12.0		0.0	0.0
Other calanoids	0.0		0.1	0.0			0.1		0.0	0.0	0.0	2.0				0.0	0.9		1.4		1.4	5.1
Cyclopoid copepods																						
Limnoithona spp.	0.1		25.6	0.0			59.1		0.4	100.0	4.7	0.0				72.0	0.3		1.7		0.1	0.1
Acanthocyclops spp.	0.0		0.0	0.0			0.0		1.0	0.0	0.0	0.0				0.0	11.5		6.0		3.5	4.5
Other cyclopoids	0.0		5.0	0.3			32.8		13.0	0.0	0.0	0.0				26.4	24.0		7.7		0.8	4.8
Other Copepods																						
Harpacticoids	0.5		0.3	0.0			0.6		0.1	0.0	2.5	0.0				0.0	1.1		0.3		0.0	0.0
Copepod nauplii	0.0		0.0	0.0			0.1		0.0	0.0	0.0	0.0				0.0	0.0		0.0		0.0	0.0
Cladocerans	0.0		0.0	0.0			0.0		33.9	0.0	0.0	0.0				0.0	21.1		1.4		0.0	0.1
Mysids	11.4		5.7	0.0			0.0		0.0	0.0	45.0	13.2				0.0	6.8		0.0		0.0	0.0
Amphipods																						
Gammarus spp.	0.0		0.0	0.0			0.0		0.0	0.0	0.0	0.0				0.0	0.0		0.2		0.0	0.0
Corophium spp.	9.3		0.7	6.6			4.6		2.7	0.0	0.0	0.0				0.0	1.2		11.4		16.4	0.4
Unidentified amphipods	0.0		0.0	17.6			0.0		0.0	0.0	0.0	0.0				0.0	0.2		0.4		0.0	0.0
Cumaceans	64.6		3.6	4.0			0.4		4.9	0.0	0.0	7.8				0.0	10.5		22.3		13.2	2.1
Fish	0.0		11.4	0.0			0.0		0.0	0.0	0.0	0.0				0.0	13.5		0.0		0.0	0.0
Other	0.0		15.9	68.5			0.6		0.6	0.0	0.0	46.5				0.0	0.2		6.4		0.0	2.2
Total	100		100	100			100		100	100	100	100				100	100		100		100	100

Note: Each year includes December from the preceding year (e.g. 2012 includes December 2011-May 2012). Number of stomachs with food present in parentheses. No samples (NS) occurred in some years and months reported as blank fields. Fields are shaded darker blue with higher percentage values.
* Identifies samples collected by USFWS in 2017

Table 1-9. Diet by Percent Frequency of Occurrence of Major Prey Categories in Stomachs of Delta Smelt Collected in <0.5 ppt for Months June-August (J-A), September-November (S-N), and December-May (D-M) Among Years 2011-2017

	Diet by percent frequency of occurrence (%FO)																					
Prey Category	J-A 2011 (42)	J-A 2012 (66)	J-A 2013 (38)	J-A 2014 (47)	J-A 2015 (15)	J-A 2016 (0)	J-A 2017 (2)	J-A 2017* (4)	S-N 2011 (59)	S-N 2012 (16)	S-N 2013 (2)	S-N 2014 (3)	S-N 2015 (1)	S-N 2016 (0)	S-N 2017 (0)	S-N 2017* (53)	D-M 2012 (286)	D-M 2013 (99)	D-M 2014 (81)	D-M 2015 (73)	D-M 2016 (26)	D-M 2017 (51)
Calanoid copepods																						
Eurytemora spp.	0.0	3.0	0.0	2.1	6.7		50.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	32.2	50.5	49.4	42.5	88.5	29.4
Pseudodiaptomus spp.	97.6	92.4	97.4	100.0	86.7		100.0	100.0	94.9	62.5	100.0	100.0	100.0			100.0	62.9	62.6	59.3	32.9	80.8	31.4
Sinocalanus doerrii	57.1	72.7	68.4	66.0	66.7		0.0	25.0	33.9	12.5	50.0	33.3	100.0			0.0	55.2	64.6	49.4	13.7	76.9	19.6
Acartiella sinensis	4.8	1.5	2.6	2.1	0.0		0.0	50.0	62.7	25.0	0.0	0.0	0.0			58.5	9.4	1.0	0.0	1.4	0.0	2.0
Tortanus spp.	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.3	1.0	0.0	0.0	0.0	0.0
Other calanoids	69.0	50.0	78.9	53.2	46.7		0.0	50.0	39.0	6.3	0.0	66.7	100.0			49.1	73.1	75.8	65.4	86.3	96.2	60.8
Cyclopoid copepods																						
Limnoithona spp.	9.5	47.0	55.3	72.3	53.3		0.0	75.0	25.4	18.8	100.0	66.7	100.0			3.8	2.8	3.0	6.2	12.3	19.2	13.7
Acanthocyclops spp.	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	57.0	71.7	51.9	71.2	80.8	45.1
Other cyclopoids	45.2	24.2	7.9	29.8	66.7		50.0	75.0	45.8	37.5	100.0	66.7	0.0			24.5	80.4	83.8	66.7	89.0	96.2	58.8
Other Copepods																						
Harpacticoids	16.7	4.5	13.2	27.7	6.7		0.0	25.0	40.7	12.5	100.0	0.0	0.0			15.1	13.6	9.1	13.6	19.2	30.8	3.9
Copepod nauplii	33.3	9.1	26.3	34.0	20.0		0.0	50.0	1.7	6.3	100.0	0.0	0.0			5.7	0.3	1.0	0.0	15.1	7.7	2.0
Cladocerans	35.7	50.0	36.8	61.7	53.3		50.0	25.0	10.2	0.0	0.0	33.3	0.0			11.3	81.1	80.8	67.9	90.4	96.2	78.4
Mysids	0.0	9.1	13.2	14.9	0.0		50.0	25.0	57.6	100.0	0.0	0.0	0.0			3.8	4.5	4.0	4.9	1.4	0.0	3.9
Amphipods																						
Gammarus spp.	0.0	0.0	0.0	0.0	0.0		0.0	0.0	1.7	6.3	0.0	0.0	0.0			60.4	16.4	16.2	37.0	24.7	30.8	35.3
Corophium spp.	0.0	6.1	0.0	0.0	33.3		0.0	25.0	57.6	25.0	50.0	0.0	100.0			47.2	54.2	26.3	44.4	17.8	19.2	29.4
Unidentified amphipods	2.4	0.0	0.0	0.0	0.0		0.0	0.0	3.4	0.0	0.0	0.0	0.0			9.4	8.4	2.0	9.9	4.1	0.0	7.8
Cumaceans	0.0	0.0	0.0	0.0	0.0		0.0	0.0	15.3	0.0	0.0	33.3	0.0			0.0	5.6	1.0	13.6	12.3	3.8	17.6
Fish	0.0	1.5	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	5.6	3.0	4.9	0.0	0.0	13.7
Other	38.1	39.4	36.8	38.3	46.7		0.0	25.0	32.2	18.8	50.0	0.0	0.0			24.5	27.3	38.4	56.8	45.2	34.6	39.2
Maximum	98	92	97	100	87		100	100	95	100	100	100	100			100	81	84	68	90	96	78

Note: Each year includes December from the preceding year (e.g. 2012 includes December 2011-May 2012). Number of stomachs with food present in parentheses. No samples (NS) occurred in some years and months reported as blank fields. Fields are shaded darker red with higher percentage values.
* Identifies samples collected by USFWS in 2017

Table 1-10. Diet by Percent Frequency of Occurrence of Major Prey Categories in Stomachs of Delta Smelt Collected in 0.5-6 ppt for Months June-August (J-A), September-November (S-N), and December-May (D-M) Among Years 2011-2017

	Diet by percent frequency of occurrence (%FO)																					
Prey Category	J-A 2011 (24)	J-A 2012 (21)	J-A 2013 (32)	J-A 2014 (88)	J-A 2015 (0)	J-A 2016 (0)	J-A 2017 (10)	J-A 2017* (17)	S-N 2011 (61)	S-N 2012 (17)	S-N 2013 (6)	S-N 2014 (75)	S-N 2015 (4)	S-N 2016 (7)	S-N 2017 (1)	S-N 2017* (19)	D-M 2012 (177)	D-M 2013 (71)	D-M 2014 (83)	D-M 2015 (52)	D-M 2016 (8)	D-M 2017 (3)
Calanoid copepods																						
Eurytemora spp.	0.0	0.0	40.6	0.0			0.0	0.0	16.4	5.9	0.0	0.0	0.0	0.0	100.0	26.3	62.7	80.3	90.4	75.0	87.5	100.0
Pseudodiaptomus spp.	87.5	71.4	87.5	89.8			90.0	47.1	85.2	82.4	83.3	97.3	75.0	100.0	100.0	78.9	22.6	15.5	32.5	50.0	50.0	33.3
Sinocalanus doerrii	0.0	38.1	3.1	1.1			20.0	0.0	1.6	0.0	0.0	1.3	0.0	0.0	0.0	0.0	5.6	5.6	3.6	0.0	0.0	0.0
Acartiella sinensis	95.8	19.0	21.9	61.4			20.0	82.4	83.6	58.8	66.7	78.7	50.0	100.0	0.0	57.9	28.2	9.9	24.1	28.8	25.0	33.3
Tortanus spp.	58.3	4.8	15.6	0.0			30.0	5.9	23.0	11.8	0.0	0.0	0.0	14.3	0.0	5.3	4.0	7.0	1.2	1.9	0.0	0.0
Other calanoids	0.0	19.0	21.9	30.7			50.0	23.5	24.6	23.5	33.3	56.0	50.0	28.6	0.0	36.8	37.3	35.2	74.7	67.3	75.0	33.3
Cyclopoid copepods																						
Limnoithona spp.	66.7	19.0	56.3	81.8			50.0	94.1	49.2	23.5	83.3	81.3	75.0	71.4	0.0	73.7	17.5	15.5	30.1	44.2	37.5	33.3
Acanthocyclops spp.	0.0	0.0	21.9	1.1			0.0	0.0	11.5	0.0	0.0	0.0	0.0	0.0	0.0	31.6	63.8	85.9	78.3	73.1	50.0	100.0
Other cyclopoids	0.0	0.0	28.1	50.0			50.0	35.3	27.9	23.5	66.7	37.3	25.0	42.9	0.0	78.9	79.1	74.6	85.5	76.9	87.5	100.0
Other Copepods																						
Harpacticoids	58.3	4.8	12.5	9.1			10.0	47.1	39.3	17.6	66.7	20.0	0.0	42.9	0.0	42.1	29.9	9.9	31.3	30.8	25.0	0.0
Copepod nauplii	8.3	9.5	9.4	10.2			0.0	29.4	4.9	0.0	16.7	2.7	0.0	0.0	0.0	36.8	1.7	8.5	18.1	17.3	25.0	0.0
Cladocerans	4.2	0.0	6.3	13.6			10.0	0.0	14.8	0.0	16.7	0.0	25.0	14.3	0.0	31.6	85.9	94.4	55.4	63.5	87.5	66.7
Mysids	20.8	23.8	46.9	8.0			10.0	5.9	42.6	47.1	50.0	14.7	25.0	14.3	0.0	10.5	15.8	12.7	10.8	9.6	12.5	0.0
Amphipods																						
Gammarus spp.	0.0	4.8	0.0	1.1			0.0	0.0	4.9	17.6	16.7	2.7	0.0	28.6	0.0	5.3	7.3	28.2	15.7	15.4	12.5	0.0
Corophium spp.	25.0	4.8	9.4	1.1			10.0	35.3	34.4	47.1	16.7	8.0	25.0	42.9	0.0	15.8	67.8	28.2	33.7	21.2	25.0	33.3
Unidentified amphipods	4.2	0.0	0.0	0.0			0.0	0.0	6.6	5.9	0.0	0.0	0.0	0.0	0.0	0.0	4.5	8.5	6.0	0.0	12.5	0.0
Cumaceans	12.5	0.0	12.5	4.5			0.0	5.9	8.2	5.9	0.0	38.7	0.0	14.3	0.0	26.3	62.7	52.1	69.9	69.2	62.5	66.7
Fish	0.0	4.8	9.4	0.0			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	12.7	19.3	0.0	0.0	0.0
Other	16.7	14.3	21.9	5.7			20.0	23.5	23.0	11.8	33.3	20.0	0.0	0.0	0.0	31.6	14.7	28.2	39.8	61.5	12.5	66.7
Maximum	96	71	88	90			90	94	85	82	83	97	75	100	100	79	86	94	90	77	88	100

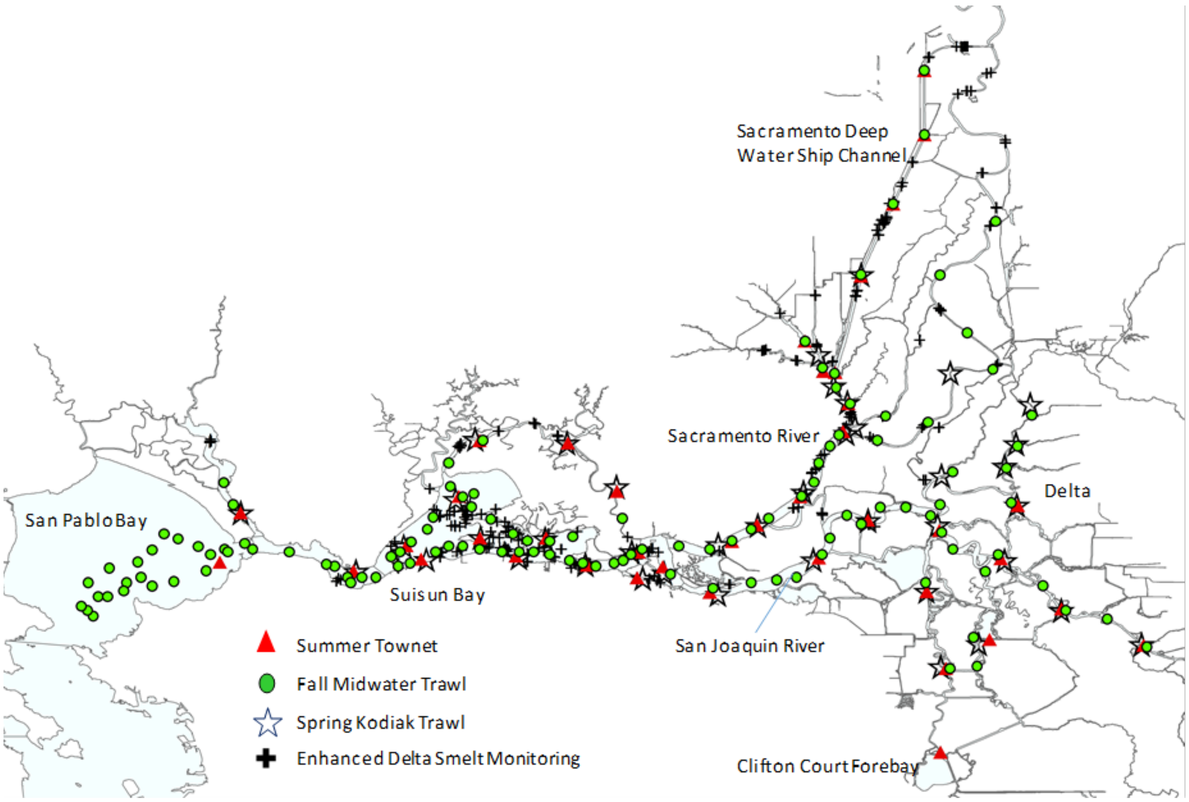
Note: Each year includes December from the preceding year (e.g. 2012 includes December 2011-May 2012). Number of stomachs with food present in parentheses. No samples (NS) occurred in some years and months reported as blank fields. Fields are shaded darker red with higher percentage values.
* Identifies samples collected by USFWS in 2017

Table 1-11. Diet by Percent Frequency of Occurrence of Major Prey Categories in Stomachs of Delta Smelt Collected in >6 ppt for Months June-August (J-A), September-November (S-N), and December-May (D-M) Among Years 2011-2017

	Diet by percent frequency of occurrence (%FO)																					
Prey Category	J-A 2011 (3)	J-A 2012 (0)	J-A 2013 (30)	J-A 2014 (5)	J-A 2015 (0)	J-A 2016 (0)	J-A 2017 (15)	J-A 2017* (0)	S-N 2011 (5)	S-N 2012 (1)	S-N 2013 (2)	S-N 2014 (1)	S-N 2015 (0)	S-N 2016 (0)	S-N 2017 (0)	S-N 2017* (2)	D-M 2012 (74)	D-M 2013 (0)	D-M 2014 (12)	D-M 2015 (0)	D-M 2016 (3)	D-M 2017 (3)
Calanoid copepods																						
Eurytemora spp.	0.0		3.3	0.0			0.0		0.0	0.0	0.0	0.0				0.0	60.8		83.3		100.0	100.0
Pseudodiaptomus spp.	33.3		36.7	0.0			40.0		80.0	0.0	100.0	0.0				0.0	35.1		16.7		0.0	33.3
Sinocalanus doerrii	0.0		0.0	0.0			6.7		20.0	0.0	0.0	0.0				0.0	2.7		0.0		0.0	0.0
Acartiella sinensis	33.3		23.3	0.0			40.0		80.0	0.0	100.0	0.0				100.0	39.2		50.0		0.0	0.0
Tortanus spp.	33.3		60.0	40.0			53.3		80.0	0.0	100.0	100.0				0.0	36.5		33.3		0.0	0.0
Other calanoids	0.0		10.0	0.0			13.3		0.0	0.0	0.0	100.0				0.0	51.4		50.0		66.7	100.0
Cyclopoid copepods																						
Limnoithona spp.	33.3		73.3	0.0			86.7		40.0	100.0	100.0	100.0				50.0	41.9		58.3		66.7	100.0
Acanthocyclops spp.	0.0		0.0	0.0			0.0		20.0	0.0	0.0	0.0				0.0	63.5		83.3		100.0	100.0
Other cyclopoids	0.0		23.3	20.0			86.7		100.0	0.0	0.0	0.0				50.0	97.3		83.3		100.0	100.0
Other Copepods																						
Harpacticoids	33.3		16.7	0.0			46.7		20.0	0.0	50.0	0.0				0.0	63.5		50.0		0.0	0.0
Copepod nauplii	0.0		13.3	0.0			46.7		0.0	0.0	0.0	0.0				50.0	6.8		33.3		33.3	100.0
Cladocerans	0.0		0.0	0.0			0.0		40.0	0.0	0.0	0.0				0.0	93.2		66.7		0.0	33.3
Mysids	33.3		16.7	0.0			0.0		0.0	0.0	50.0	100.0				0.0	24.3		0.0		0.0	0.0
Amphipods																						
Gammarus spp.	0.0		0.0	0.0			0.0		0.0	0.0	0.0	0.0				0.0	0.0		16.7		0.0	0.0
Corophium spp.	33.3		6.7	40.0			26.7		40.0	0.0	0.0	0.0				0.0	40.5		50.0		33.3	66.7
Unidentified amphipods	0.0		0.0	20.0			0.0		20.0	0.0	0.0	0.0				0.0	8.1		8.3		0.0	33.3
Cumaceans	66.7		10.0	20.0			6.7		20.0	0.0	0.0	100.0				0.0	63.5		83.3		66.7	100.0
Fish	0.0		10.0	0.0			0.0		0.0	0.0	0.0	0.0				0.0	10.8		0.0		0.0	0.0
Other	0.0		33.3	40.0			53.3		40.0	0.0	0.0	100.0				0.0	20.3		58.3		0.0	100.0
Maximum	67		73	40			87		100	100	100	100				100	97		83		100	100

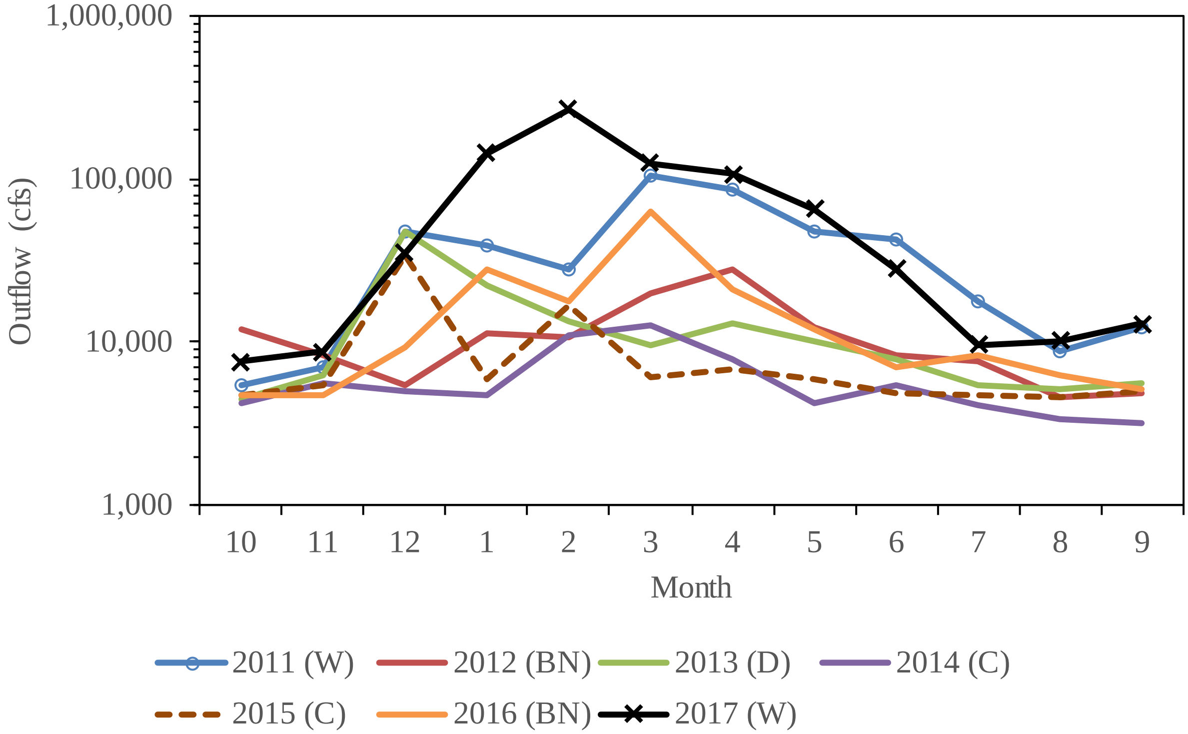
Note: Each year includes December from the preceding year (e.g. 2012 includes December 2011-May 2012). Number of stomachs with food present in parentheses. No samples (NS) occurred in some years and months reported as blank fields. Fields are shaded darker red with higher percentage values.
* Identifies samples collected by USFWS in 2017.

Figures



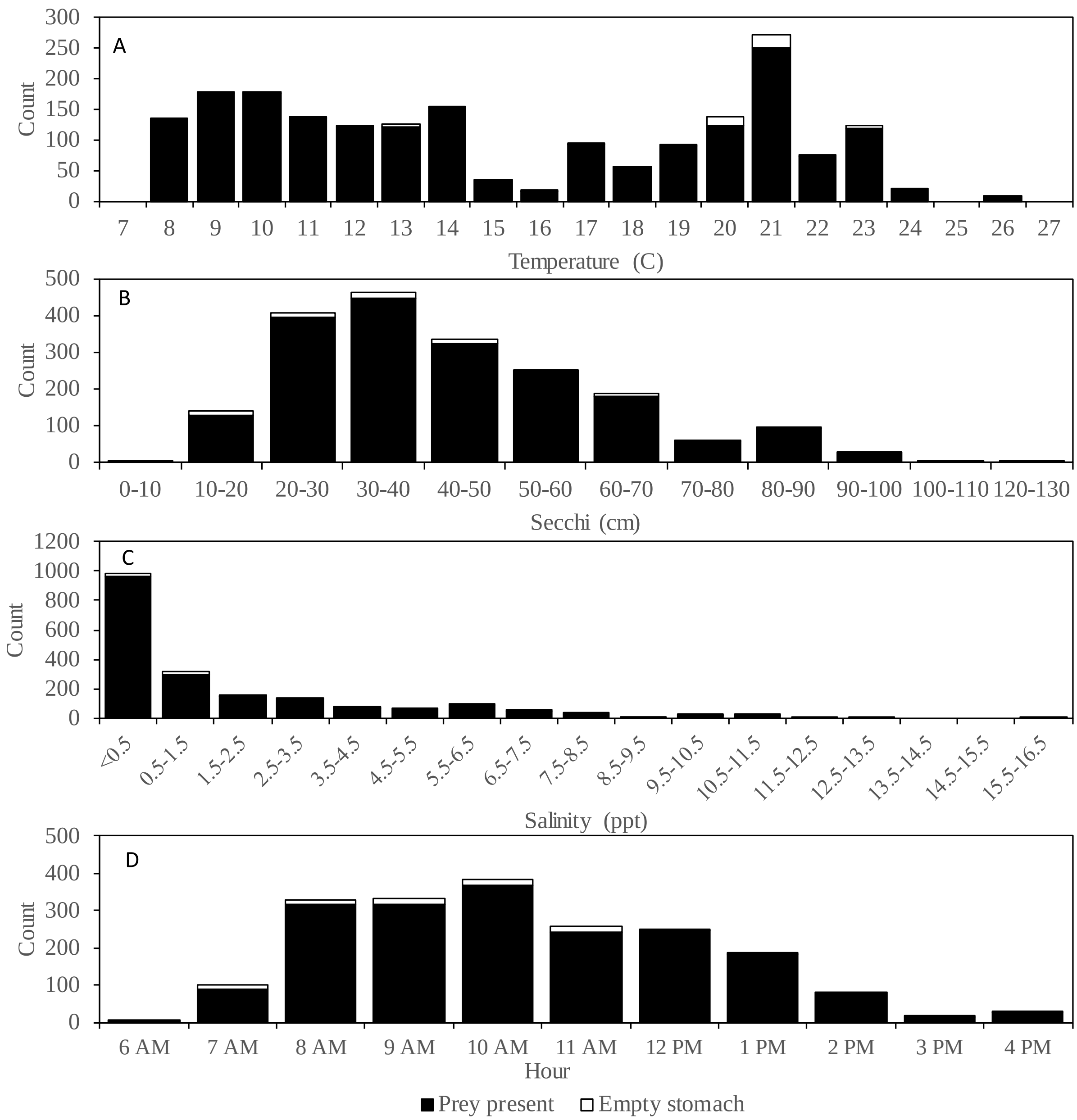
Note: Points include CDFW surveys Summer Townet (red triangle), Fall Midwater Trawl (green circle), and Spring Kodiak Trawl (blue star) with USFWS Enhanced Delta Smelt Monitoring (plus sign).

Figure 1-1. Map of CDFW and USFWS Sampling Locations in the Upper San Francisco Estuary



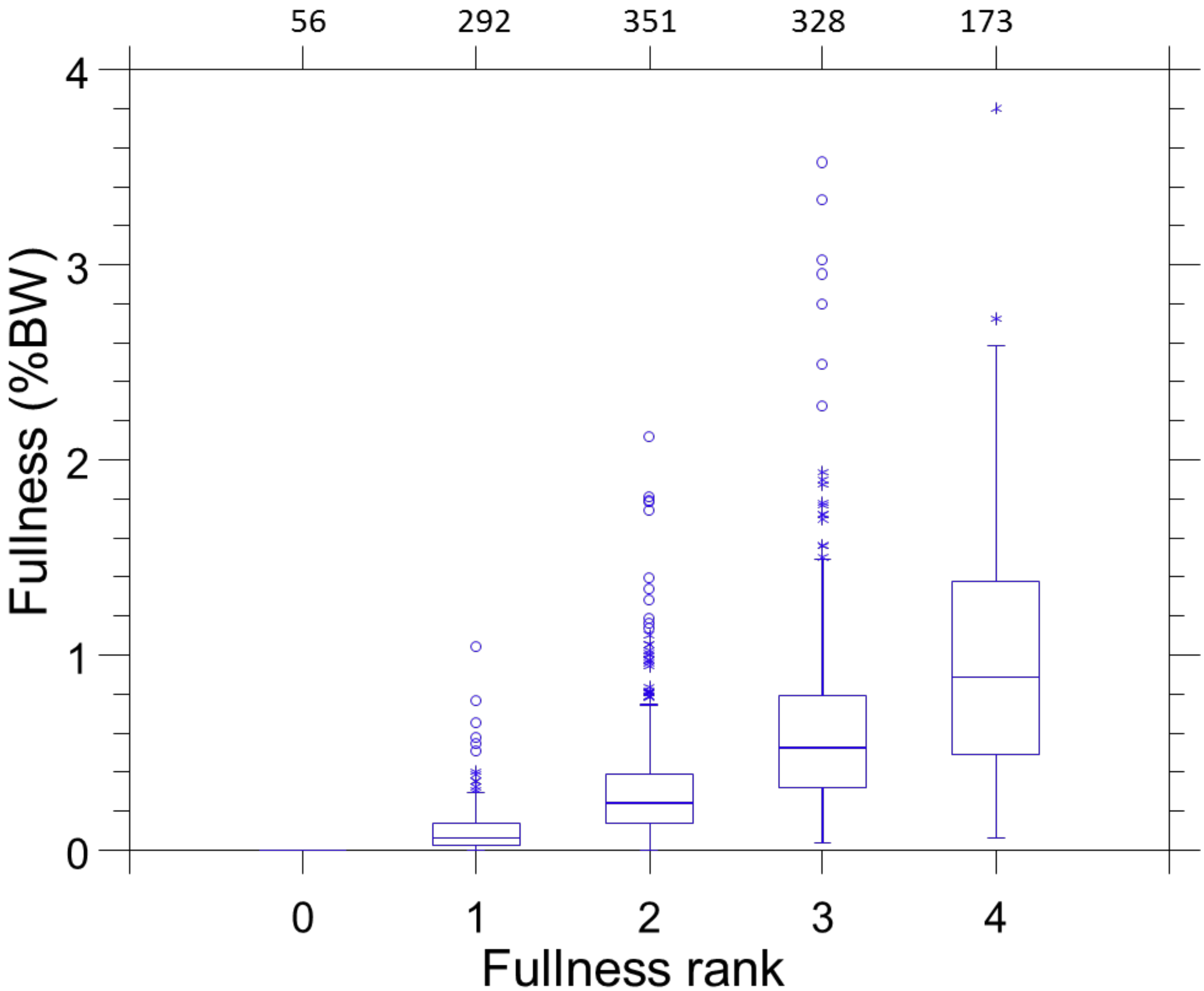
Note: Each water year is January-September, and the preceding October-December (e.g. water year 2011 is October 2010-September 2011). The Sacramento Valley water year index type is in parentheses in legend. Note, figure y-axis is log10 scale.

Figure 1-2. Monthly Mean Freshwater Outflow (cfs) Past Chipps Island for Water Years 2011-2017



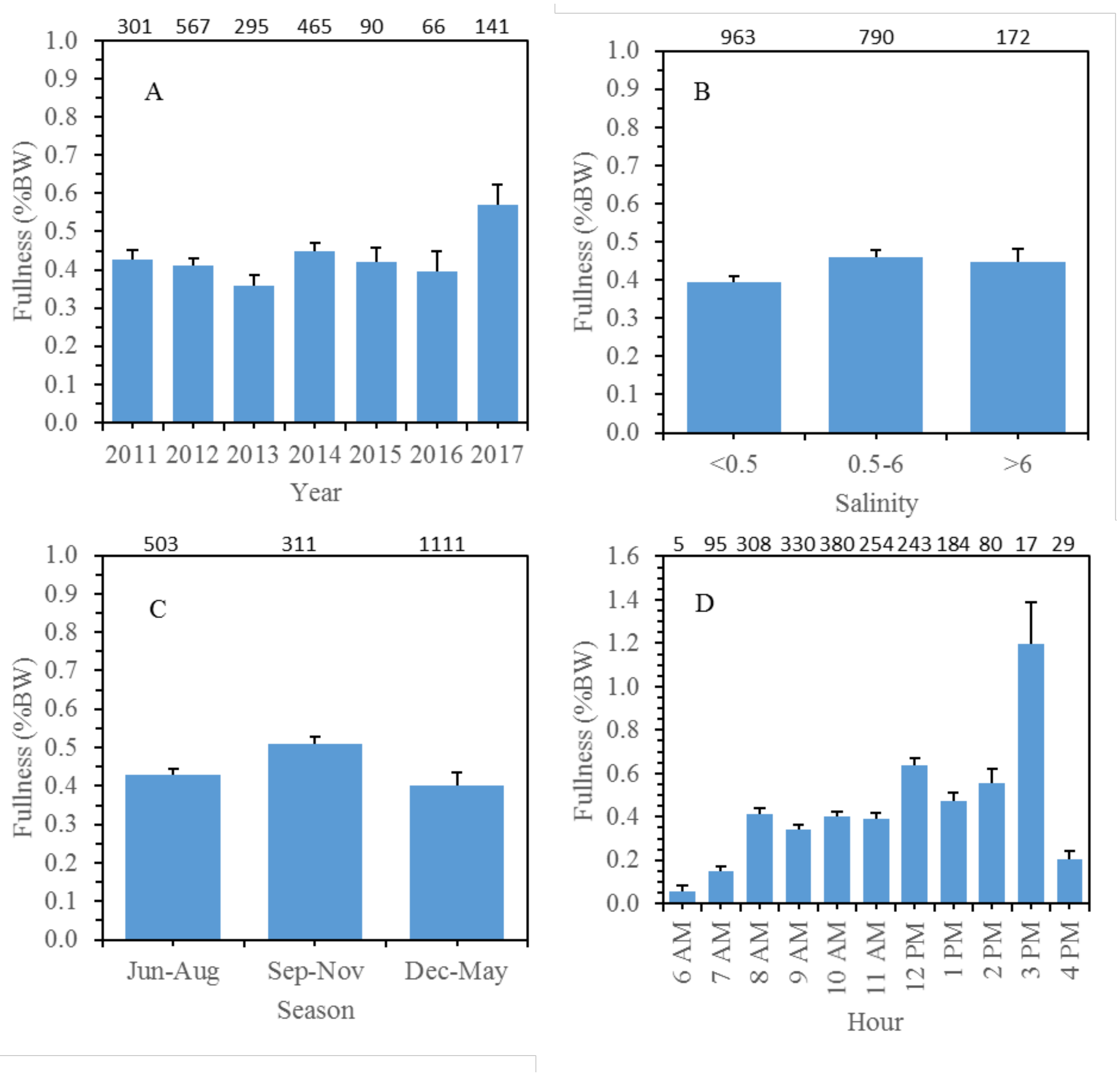
Note: A) Temperature (°C), B) Secchi Disk depth (cm), C) Salinity (ppt), and D) Hour of Collection During 2011-2017 Examined for this Study. Two temperature values were missing.

Figure 1-3. Count of Delta Smelt (N=1,962) with Prey Present in Stomachs or with Empty Stomachs Collected Among Environmental Variables



Note: Only a subset of study samples included visual rank (n = 1,200) with sample size included along top of boxplot. The central vertical line of each box is the median value. The box is the range of the central 50% of values between the 25% and 75% quartiles. The whiskers capture values within 1.5 times the upper 75% and lower 25% quartiles and values exceeding whiskers are asterisks or empty circles.

Figure 1-4. Boxplot of Delta Smelt Gut Fullness (%BW) Per Relative Index of Fullness Using the Scale 0 = Empty, 1 = 25% Full, 2 = 50% Full, 3 = 75% Full and 100% = Full



Note: Sample size included along the top of each bar chart.

Figure 1-5. Mean (±SE) Delta Smelt Gut Fullness (%BW) by A) Year, B) Salinity, C) Season, and D) Hour of collection During 2011-2017 CDFW and 2017 USFWS Surveys

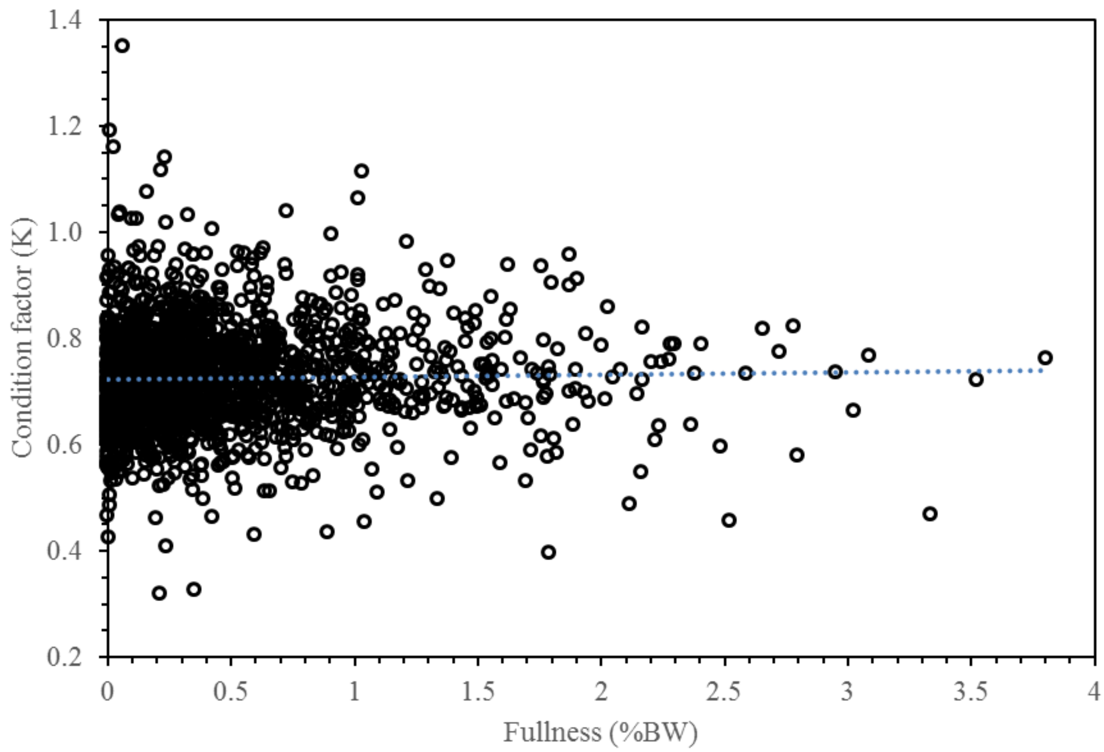
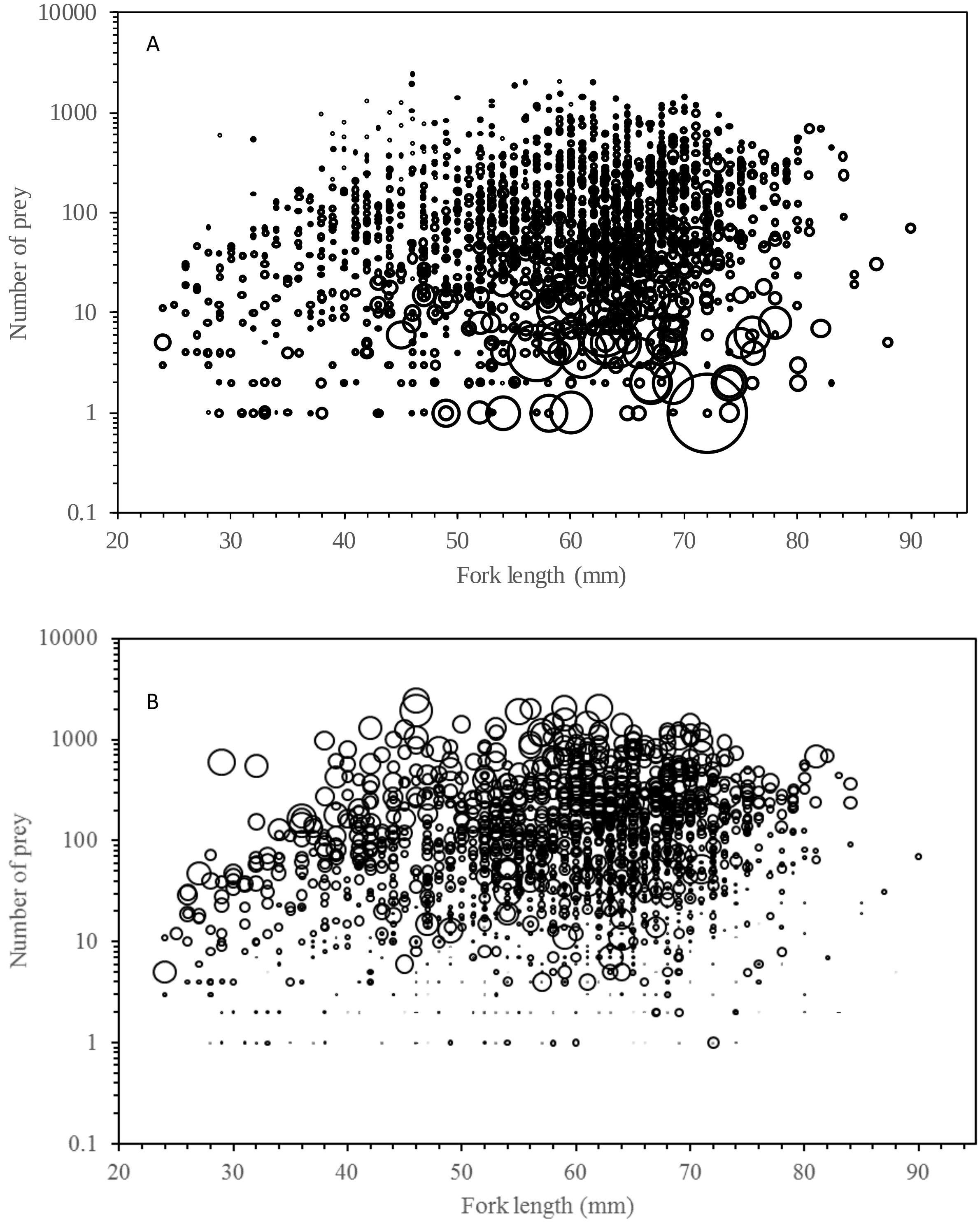
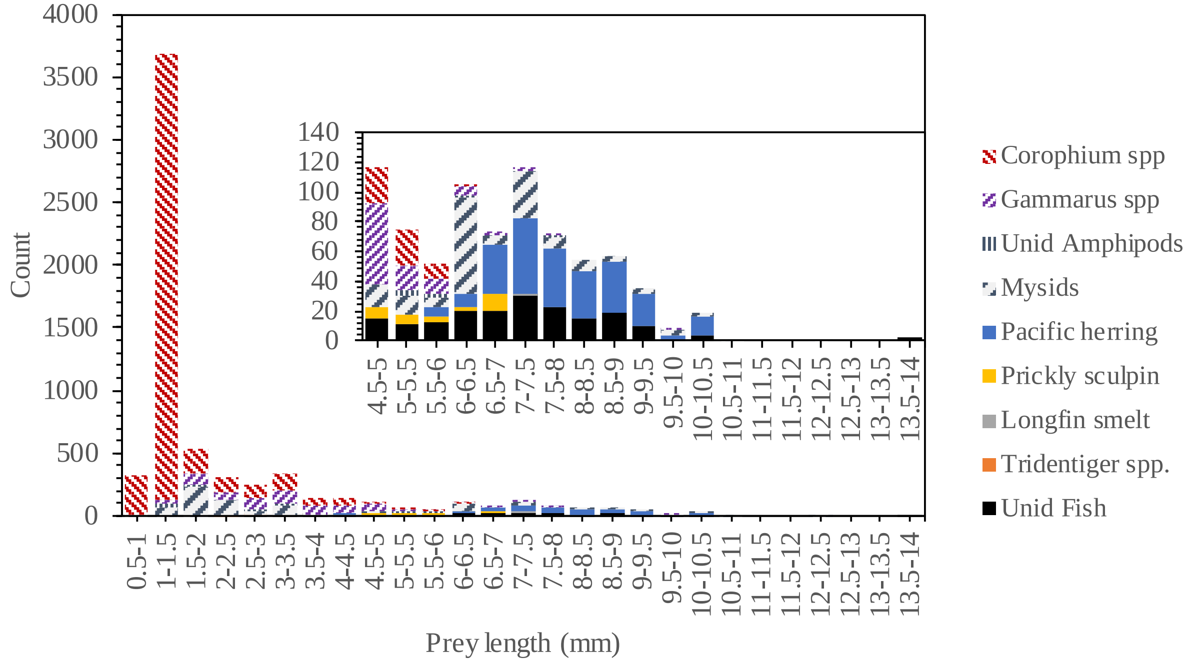


Figure 1-6. Condition Factor Plotted Against Stomach Fullness (%BW) with Linear Regression Fit Line y = -0.0028x + 0.7252, R^2 = 0.0002 for Delta Smelt (N = 1,925) Collected from 2011-2017 CDFW and USFWS Surveys



Note: (N=1,925) with size of bubble representing A) mean mass of prey (bubble scale is 0.00000238 to 0.01085000g) and B) stomach fullness (%BW) with bubble scale 0 to 4. y-axis is $\log_{10}$ scale.

Figure 1-7. Number of Prey in Stomachs Plotted Against Fork Length (mm) for Delta Smelt with Food Present in Guts Collected 2011-2017



Notes: Body lengths (±0.1 mm) were recorded for amphipods, mysids, cumaceans, and larval fish with counts grouped in 0.5 mm length bins. Inset figure is limited to length bins 4.5-14.0 mm to increase visibility of the y-axis scale. Delta Smelt were collected by CDFW and USFWS during 2011-2017.

Figure 1-8. Length-Frequency of Large Prey Found in Stomachs of Juvenile and Adult Delta Smelt During this Study

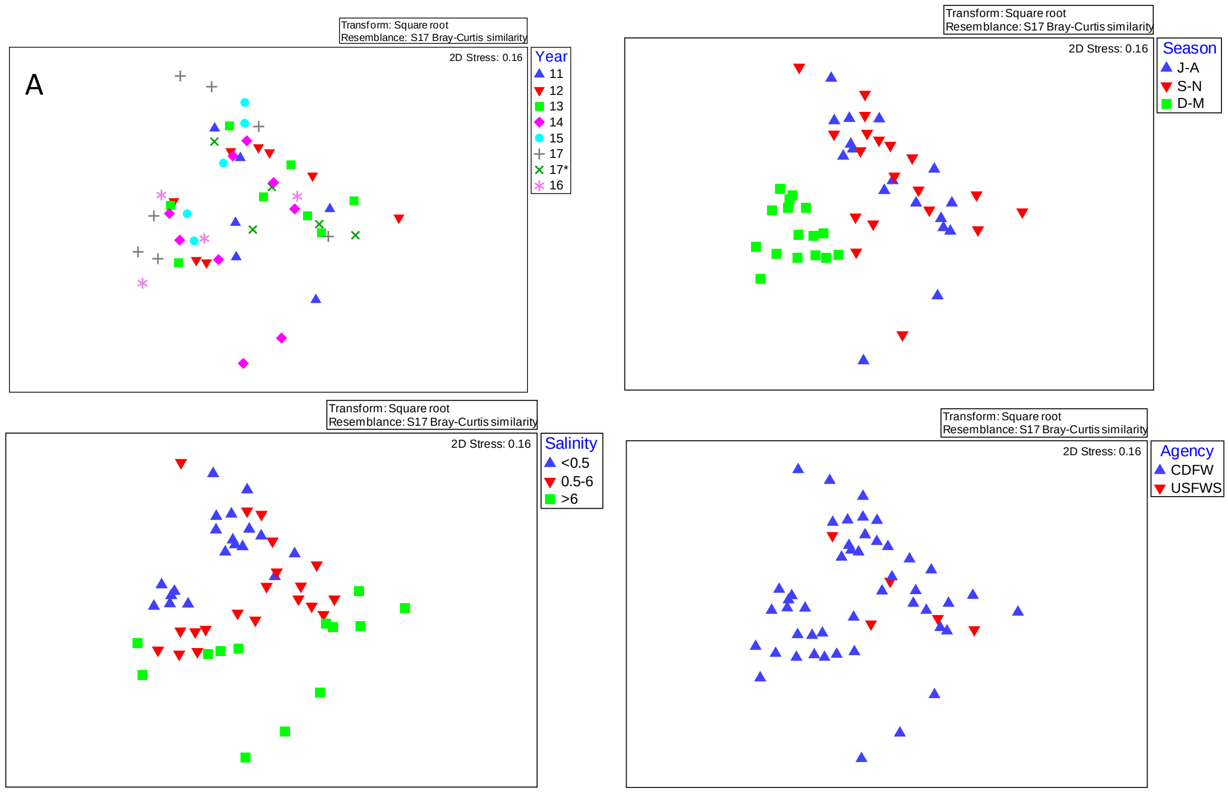


Figure 1-9. Nonmetric Multidimensional Scaling (NMDS) Ordination Plots of Delta Smelt Diet By Percent Number Among A) Year, B) Season, C) Salinity, and D) Agency for the Period 2011-2017

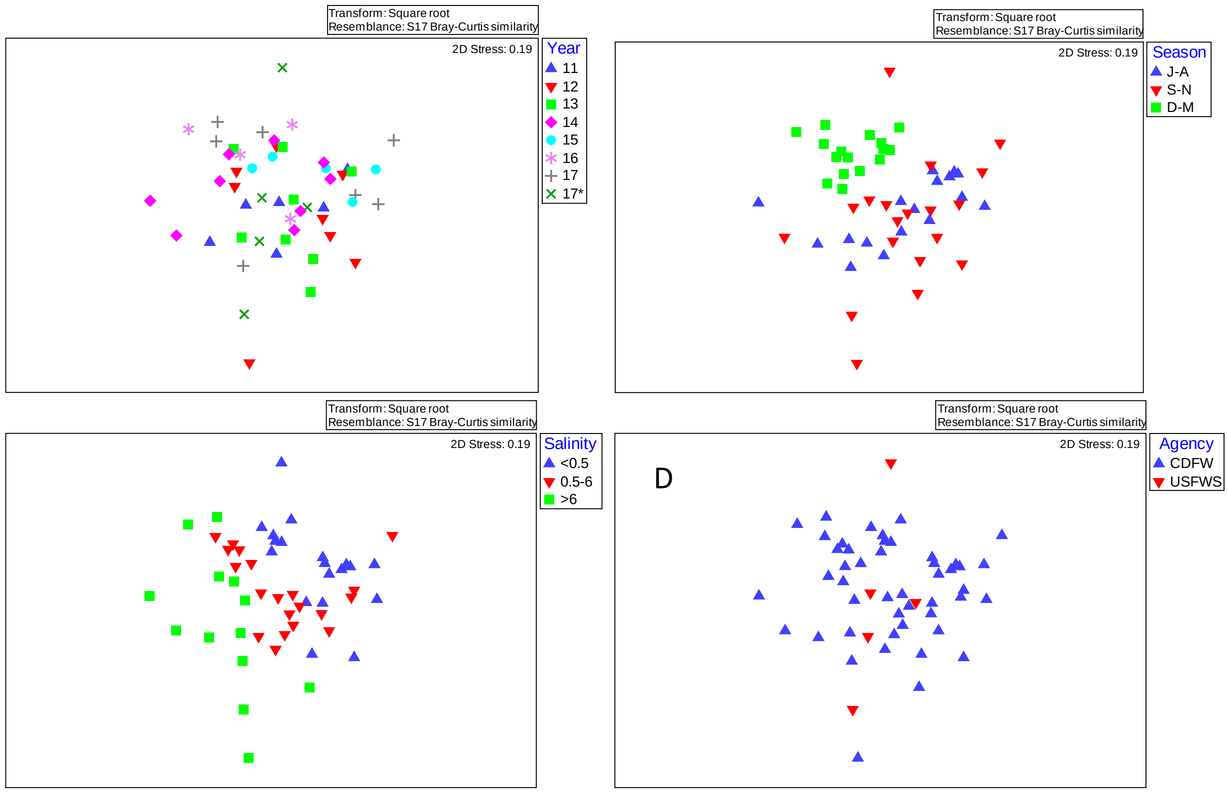


Figure 1-10. Nonmetric Multidimensional Scaling (NMDS) Ordination Plots of Delta Smelt Diet by Percent Weight Among Factors A) Year, B) Season, C) Salinity, and D) Agency

Supplemental Data: Tables

Table A1. Wet weight (µg) Estimates to Calculate Mass of Prey Types Found in Stomachs of Delta Smelt to Determine Diet by Percent Number and Stomach Fullness

Prey Category	Prey Type	Wet Weight (µg)	Source
Calanoid copepods			
Eurytemora spp.	*Eurytemora* spp. nauplii	1.8	Kimmerer 2006
Eurytemora spp.	*Eurytemora* spp. copepodite	10.1	Kimmerer 2006
Eurytemora spp.	*Eurytemora* spp. adult	40.3	Kimmerer 2006
Pseudodiaptomus spp.	*Pseudodiaptomus marinus*	73.3	Kimmerer 2006
Pseudodiaptomus spp.	*Pseudodiaptomus* spp. nauplii	1.8	Kimmerer 2006
Pseudodiaptomus spp.	*Pseudodiaptomus* spp. copepodite	13.7	Kimmerer 2006
Pseudodiaptomus spp.	*Pseudodiaptomus* spp. adult	19.4	CDFW unpublished
Pseudodiaptomus spp.	*Pseudodiaptomus forbesi*	54.9	Kimmerer 2006
Sinocalanus doerrii	*Sinocalanus doerrii* nauplii	2.7	CDFW unpublished
Sinocalanus doerrii	*Sinocalanus doerrii* copepodite	23.6	CDFW unpublished
Sinocalanus doerrii	*Sinocalanus doerrii* adult	70.7	CDFW unpublished
Acartiella sinensis	*Acartiella sinensis* copepodite	27.7	CDFW unpublished
Acartiella sinensis	*Acartiella sinensis* adult	75.3	CDFW unpublished
Tortanus spp.	*Tortanus* spp. copepodite	30.1	CDFW unpublished
Tortanus spp.	*Tortanus* spp. adult	219.6	CDFW unpublished
Tortanus spp.	*Tortanus dextrilobatus*	219.6	From Tortanus spp. adult
Other calanoids	*Acartia* spp. copepodite	11.4	Kimmerer 2006
Other calanoids	*Acartia* spp. adult	71.9	CDFW unpublished
Other calanoids	*Diaptomus* spp. copepodite	11.4	Kimmerer 2006
Other calanoids	*Diaptomus* spp. adult	73.3	Kimmerer 2006
Other calanoids	Unidentified calanoid	27.6	CDFW unpublished
Other calanoids	Calanoid copepodite	13.8	CDFW unpublished
Other calanoids	*Osphranticum* spp.	36.6	From Unidentified calanoid
Other calanoids	Other calanoid	36.6	Kimmerer 2006
Cyclopoid copepods			
Limnoithona spp.	*Limnoithona* spp. juvenile	0.5	Kimmerer 2006
Limnoithona spp.	*Limnoithona* spp. adult	5.6	CDFW unpublished
Acanthocyclops spp.	*Acanthocyclops* spp.	38.2	CDFW unpublished
Other calanoids	*Oithona davisae* adult	4.2	Kimmerer 2006
Other calanoids	*Oithona* spp. juvenile	1.1	Kimmerer 2006
Other calanoids	Other cyclopoid	44.4	CDFW unpublished
Other calanoids	UnID cyclopoid	21.7	CDFW unpublished
Other calanoids	cyclopoid copepodite	13.7	Kimmerer 2006
Other copepods			
Harpacticoid copepods	Harpacticoids	22.7	CDFW unpublished
Copepod nauplii	Copepod nauplii	2.4	CDFW unpublished
Cladocerans	*Bosmina* sp.	6.9	CDFW unpublished
Cladocerans	*Diaphanosoma* sp.	28.3	CDFW unpublished
Cladocerans	*Ceriodaphnia* sp.	32.3	CDFW unpublished
Cladocerans	*Daphnia* sp.	50.4	CDFW unpublished
Cladocerans	Other cladocera	30.1	CDFW unpublished
Cladocerans	UnID cladocera	22.5	CDFW unpublished

Prey Category	Prey Type	Wet Weight (µg)	Source
Cumaceans	Cumaceans	330.7	CDFW unpublished
Other	Unid copepods	24.7	Mean of Unidentified calanoid and cyclopoid
Other	Ostracods	48.1	CDFW unpublished
Other	Chironomid larvae	164	CDFW unpublished
Other	Terrestrial invertebrates	236.6	CDFW unpublished
Other	Other insect larvae	490.4	CDFW unpublished
Other	Rotifer *Keratella* spp.	1.3	CDFW unpublished
Other	Rotifer *Trichocerca* spp.	2.3	CDFW unpublished
Other	Rotifer *Synchaeta* spp.	3.6	CDFW unpublished
Other	Rotifer *Polyarthra* spp.	0.5	Kimmerer 2006
Other	Other rotifer	3.6	CDFW unpublished
Other	Unid rotifer	3.6	CDFW unpublished
Other	Barnacle nauplii	13.9	CDFW unpublished
Other	Other malacostraca	494	CDFW unpublished
Other	Crab zoea	29.6	CDFW unpublished
Other	Bivalve	33.4	CDFW unpublished
Other	Annelid worm pieces	13.9	From barnacle nauplii (similar size)
Other	Other zooplankton	93.9	CDFW unpublished
Other	Fish eggs	22.3	CDFW unpublished

Note: Prey types were grouped by prey category. Prey types include all life stages, unless noted otherwise. Wet weights were generated by CDFW or from conversion of carbon weight estimates in the literature (Kimmerer 2006). Conversion of carbon weight (µg) literature values to wet weight was conducted using ratios by Beers (1966) as: dry weight = carbon weight / 0.42 and wet weight = dry weight / 0.13.

Table A2. Length-Weight Relationships for Prey Types to Calculate Mass of Prey Found in Stomachs of Delta Smelt to Determine Diet by Percent Number and Stomach Fullness.

Prey Category	Prey Type	Length-weight relationship	Source
Mysids	*Hyperacanthomysis longirostris*	*W* = 31.8 x *L* 2.533	CDFW unpublished
Mysids	*Acanthomysis aspera*	*W* = 31.8 x *L* 2.533	From H. *longirostris*
Mysids	*Neomysis mercedis*	*W* = 10.7 x *L* 3.126	CDFW unpublished
Mysids	*Neomysis kadiakensis*	*W* = 10.7 x *L* 3.126	From N. *mercedis*
Mysids	Unid Mysids	*W* = 31.8 x *L* 2.533	From H. *longirostris*
Amphipods			
Corophium spp.	*Corophium spp.*	*W* = 9.3 x *L* 3.401	CDFW unpublished
Gammarus spp.	*Gammarus spp.*	*W* = 16.5 x *L* 3.076	CDFW unpublished
Unid Amphipods	Unidentified Amphipod	*W* = 9.3 x *L* 3.401	From *Corophium*
Fish	*Tridentiger spp.*	*W* = 4.1 x *L* 3.305	CDFW unpublished
Fish	Longfin Smelt	*W* = 1.7 x *L* 3.374	CDFW unpublished
Fish	Pacific Herring	*W* = 4.1 x *L* 3.205	CDFW unpublished
Fish	Prickly Sculpin	*W* = 24.3 x *L* 2.778	CDFW unpublished
Fish	Unidentified fish	*W* = 24.3 x *L* 2.778	From Prickly Sculpin

Note: Length-weight relationships where body length (L) is in millimeters and wet weight (W) is micrograms.

Supplemental Data: Figures

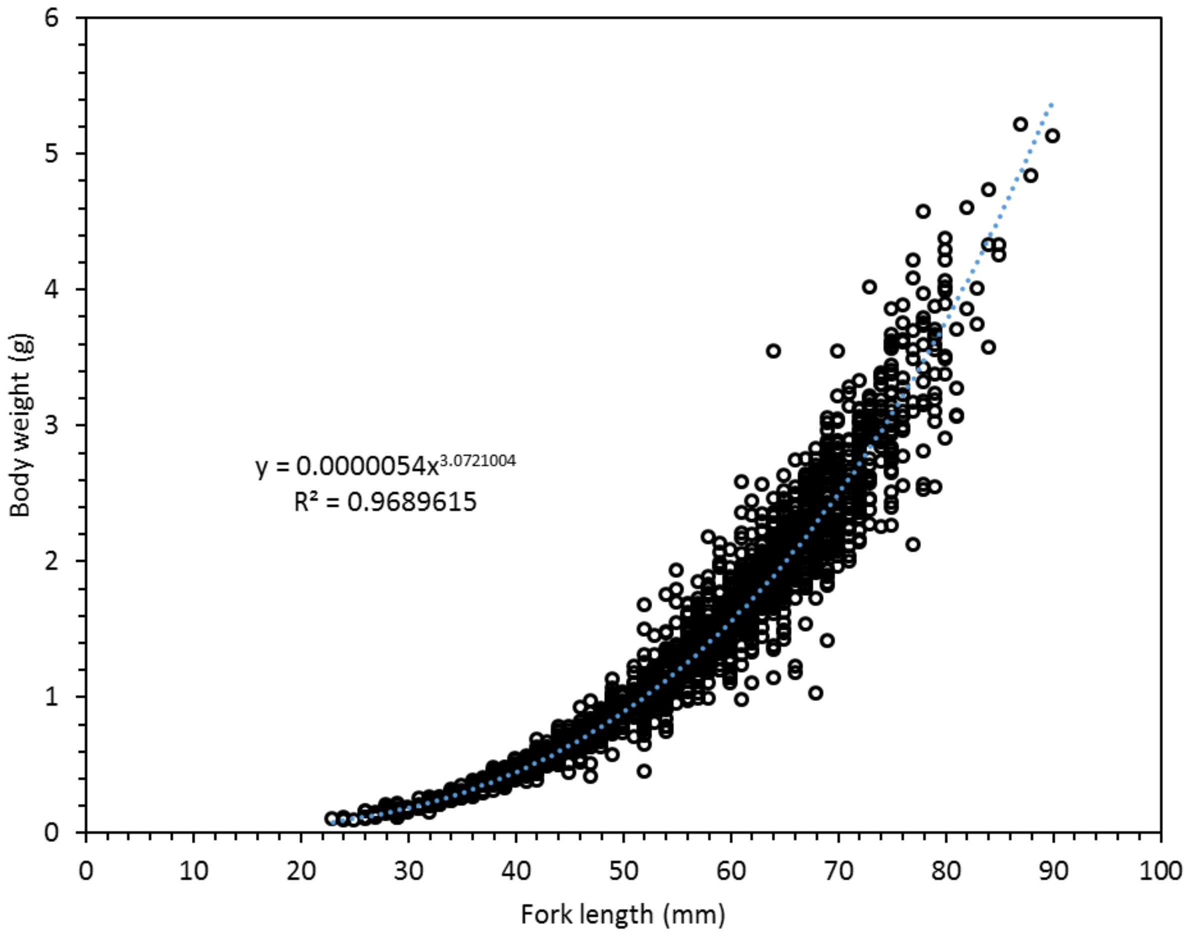
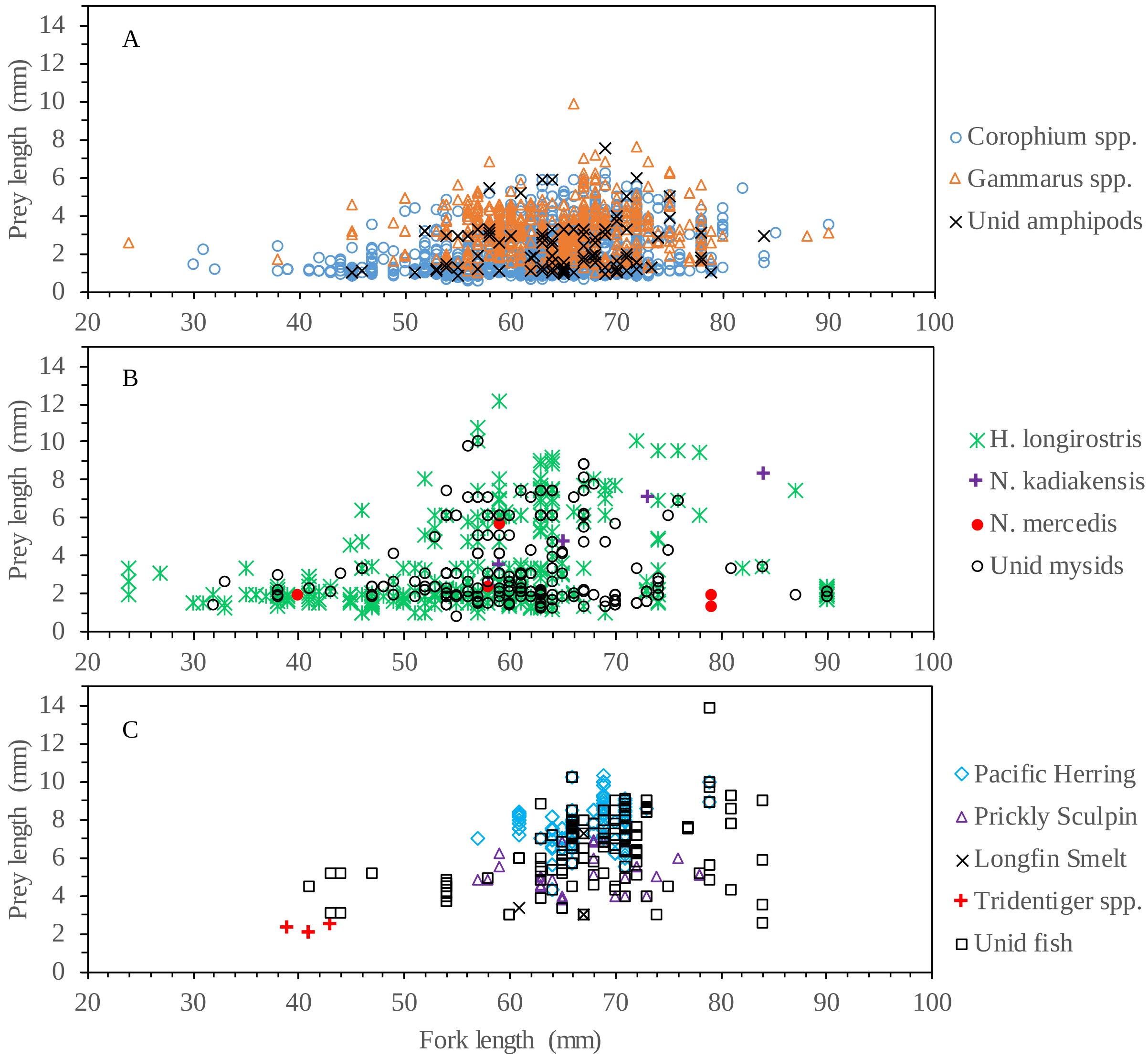
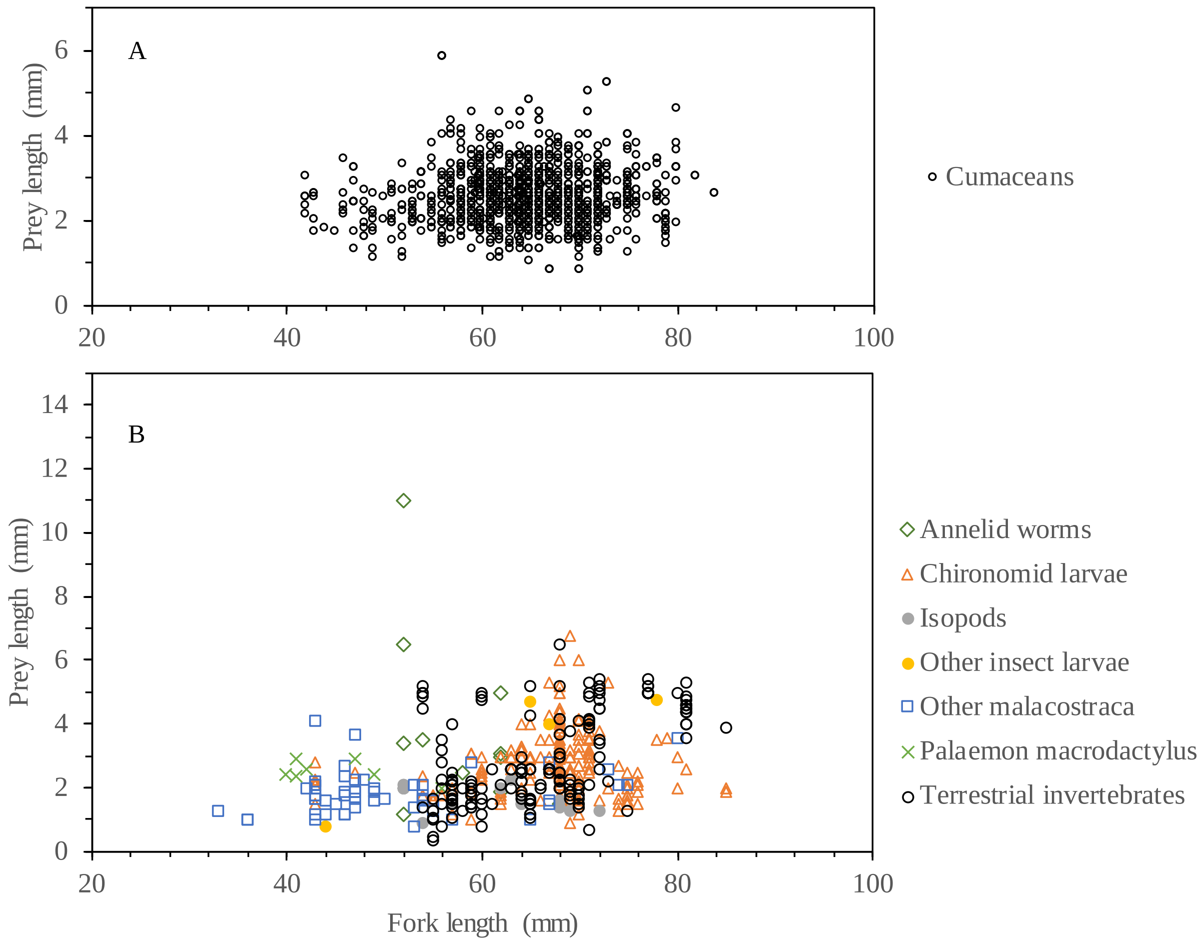


Figure B1. Scatterplot of Length-Weight Data with a Power Function for Delta Smelt (N = 1,925) Collected from 2011-2017 (CDFW and USFWS surveys)



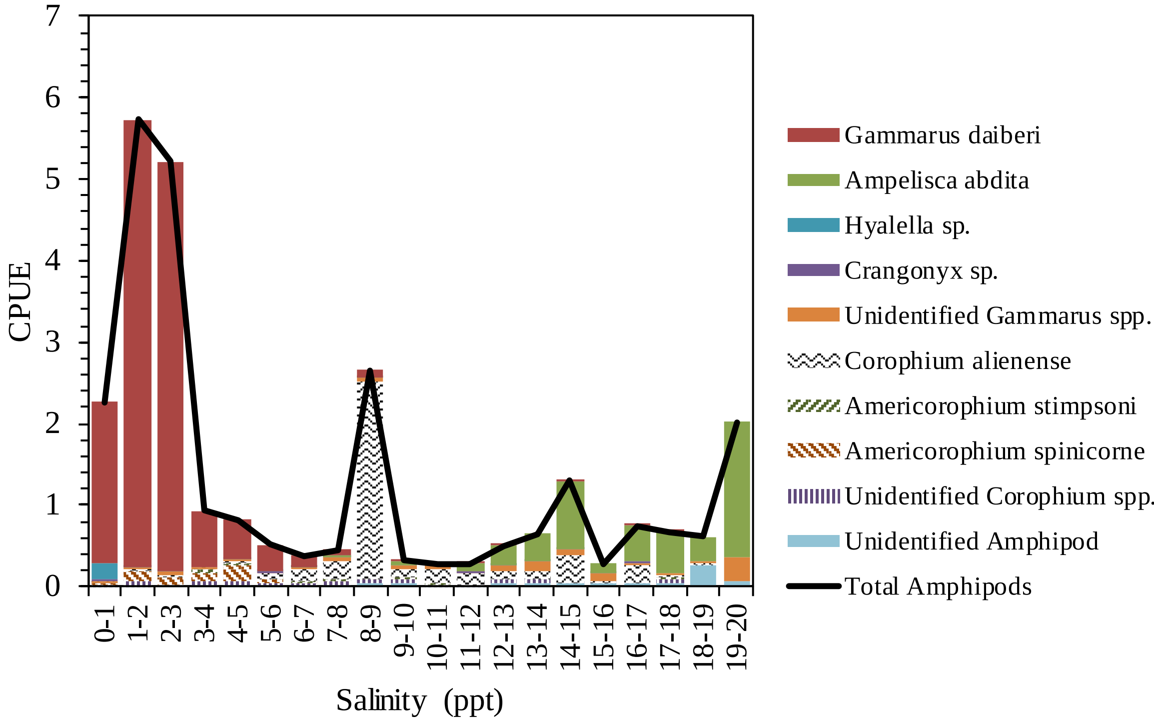
Note: Unidentified ("Unid") occurred for some prey types due to state of digestion or rare items that did not fit an existing identification category.

Figure B2. Scatterplots of Body Lengths (mm) of Large Prey Types A) Amphipods (n=5,310), B) Mysids (n=702) and C) Larval Fish (n=494) Found in Stomachs of Juvenile and Adult Delta Smelt by Fork Length (mm) Collected 2011-2017



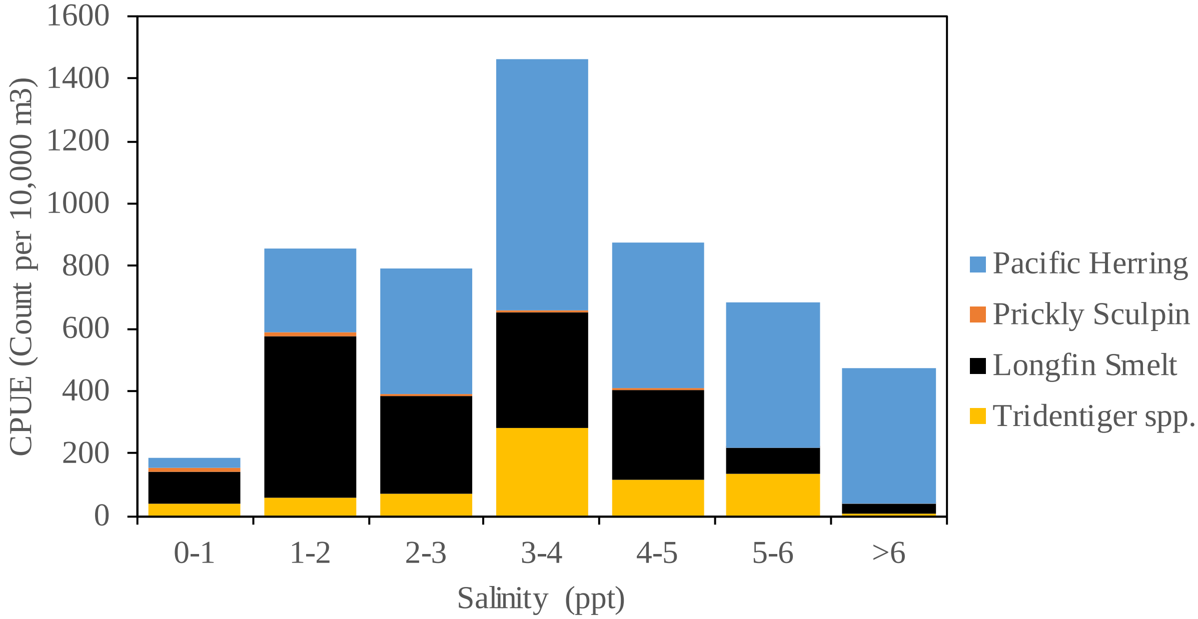
Note: Lengths were recorded for these prey types when intact that included cumaceans (n=1716 of 1765), annelid worms (n=11 of 18), chironomid larvae (n=198 of 213), other insect larvae (n=4 of 7), terrestrial invertebrates (Diptera: Chironomidae, Brachycera (flies), Homoptera (aphids), and Psocoptera (Barklice); Hymenoptera (ants), and Spiders) (n=248 of 953), shrimp *Palaemon macrodactylus* (n=7 of 7), and crab zoea and other malacostraca (n= 54 of 66) and isopods (n=20 of 20). Unidentified ("Unid") prey types occurred for some due to state of digestion or rare items that did not fit an existing category.

Figure B3. Scatterplots of Body Lengths (mm) of Prey Categories A) "Cumaceans" and B) "Other Zooplankton" Found in Stomachs of Juvenile and Adult Delta Smelt by Fork Length (mm) Collected 2011-2017



Note: The amphipod *Gammarus daiberi* was the most numerous amphipod in the salinity range common to Delta Smelt (<8 ppt), with *Corophium alienense* at salinities >6 ppt. Native *Corophium* amphipods *Americorophium stimpsoni* and *A. spinicorne* were also collected at salinity common to Delta Smelt, but at much lower CPUE than the introduced *G. daiberi*.

Figure B4. Mean CPUE (count per cubic meter) of Amphipods by Salinity (ppt) Collected by the CDFW FMWT Mysid Net During September-December Among Years 2013-2017



Note: For more information on CDFW 20-mm Survey visit: https://www.wildlife.ca.gov/Conservation/Delta/20mm-Survey.

Figure B5. Mean CPUE (count per 10,000 cubic meters) for Larval Fishes by Salinity (1 ppt) Collected by the CDFW 20-mm Survey at Core Stations During March-May Among Years 2011-2017

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