Memo

To: CSAMP Delta Smelt SDM Technical Working Group (TWG)

From: Brian Crawford and Sally Rudd, Compass Resource Management

Date: December 1, 2021

Re: Methods for merging and summarizing dynamic habitat data to use as inputs in the Dynamic Habitat Analysis/Tool

1 Short summary

To develop input datasets for the Dynamic Habitat Analysis/Tool, we leveraged existing datasets that have been compiled for water quality (water temperature, clarity/turbidity, salinity) and zooplankton that provide the largest sample sizes for capturing historical trends of dynamic habitat conditions. We summarized mean values for each of the four dynamic habitat attributes by day and subregion. The water quality data has already been linked to the 12 subregions used in the Individual-based Model in R (IBMR) programmed by Will Smith, based on the station at which data was collected. We used station IDs in the zooplankton dataset to link that data to a specific subregion as well before merging the water quality and zooplankton datasets into the final input dataset of daily mean conditions. R code and associated datasets to replicate these methods are available in a zipped folder provided to the Delta Smelt TWG.

2 Original datasets

2.1 Water quality datasets

Water quality data was taken from CSAMP's GitHub page, which synthesizes 11 data sources (listed below). It includes temperature, salinity, and clarity/turbidity data, and has already linked station-specific data to the 12 subregions used in the Individual-based Model in R (IBMR) programmed by Will Smith.

- Data sources: "EMP" (Environmental Monitoring Program); "STN" (Summer Townet Survey); "FMWT" (Fall Midwater Trawl); "EDSM" (Enhanced Delta Smelt Monitoring); "DJFMP" (Delta Juvenile Fish Monitoring Program); "20mm" (20mm Survey); "SKT" (Spring Kodiak Trawl); "Baystudy" (Bay Study); "USGS" (USGS San Francisco Bay Surveys); "USBR" (United States Bureau of Reclamation Sacramento Deepwater Ship Channel data); and "Suisun" (Suisun Marsh Fish Study)

2.2 IEP integrated zooplankton dataset

To summarize historical food density patterns within the Dynamic Habitat Analysis/Tool, we used the IEP's integrated zooplankton dataset. This dataset was accessed through the zooper package in R, available on the IEP's GitHub site. We had input from Arthur Barros (IEP) and Wim Kimmerer (SFSU) regarding 1) which taxa to include as prey in our analysis, and 2) how to convert the available zooplankton catch per unit effort (CPUE) data to biomass per unit effort (BPUE) that we can use directly as the metric of $\mu gC/m^3$ in the Tool.

2.3 Prey taxa & methods for calculating biomass

The list of taxa below are Compass's best interpretation (based on input from Arthur and Wim and delta smelt diet studies) of what should be included as delta smelt prey when calculating food density for the Dynamic Habitat Tool.

Arthur Barros sent Compass BPUE data directly for mysid/amphipod taxa, as well as the taxa-specific length-weight conversions used to calculate biomass from CPUE. We note that rows shaded light grey indicate taxa not included, for now, in calculating prey density.

Mysids/amphipods

- *Acanthomysis aspera*
- *Acanthomysis hwanhaiensis*
- *Alienacanthomysis macropsis*
- *Deltamysis holmquistae*
- *Hyperacanthomysis longirostris (Slater and Baxter 2014)*
- *Neomysis kadiakensis*
- *Neomysis mercedis (Moyle et al. 1992)*

For meso/micro zooplankton taxa, the IEP dataset includes CPUE but not biomass estimates. Arthur and Wim sent their conversion rates used to calculate biomass from CPUE for each taxon and life stage, along with any source citations for those rates. Arthur and Wim use the same conversion rates. These rates were shared with Compass, but we have not asked for explicit permission to share them further. For now, we present the table below that lists taxa, life stages, and source citations. We note that rows shaded light grey indicate taxa not included in methods calculating prey density that were used in Will Smith's IBMR, which came from Wim Kimmerer and Kenny Rose (see IBMR documentation, Appendix A).

Table 1. List of meso/micro zooplankton taxa included as Delta Smelt prey in input datasets for the Dynamic Habitat Analysis/Tool.

Taxa name	Lifestage	Source
Acanthocyclops vernalis	Adult	From J. Orsi as dry weight=8, C:DW 0.42 see BoxModel page
Acartia	Adult	Kimmerer et al. 2011 unpublished Bug Weight Report
Acartia	Juvenile	Kimmerer et al. 2011 unpublished Bug Weight Report
Acartiella sinensis	Adult	Kimmerer et al. 2011 unpublished Bug Weight Report
Acartiella sinensis	Juvenile	Kimmerer et al. 2011 unpublished Bug Weight Report
Bosmina longirostris	Adult	Dumont, H. J., I. Van de Velde, et al. (1975). "The dry weight estimate of biomass in a selection of Cladocera, Copepoda, and Rotifera from the plankton, periphyton, and benthos of continental waters." Oecologia (Berlin) 19: 75-97.
Calanoida	Adult	Kimmerer (assumed, unpublished data)
Calanoida	Juvenile	Kimmerer (assumed, unpublished data)
Cirripedia	Larva	Turner JT, Levinsen H, Nielsen TG, Hansen BW. 2001. Zooplankton feeding ecology: Grazing on phytoplankton and predation on protozoans by copepod and barnacle nauplii in Disko Bay, West Greenland. Mar Ecol Prog Ser. 221:209–219.
Cladocera	Adult	Kimmerer (assumed, use median)
Copepoda	Larva	Kimmerer (assumed, unpublished data)
Cyclopoida	Adult	Kimmerer (assumed,used A. vernalis)
Cyclopoida	Juvenile	Kimmerer (assumed,used A. vernalis)

Taxa name	Lifestage	Source
Daphnia	Adult	Dumont, H.J., van de Velde, I., Dumont S. 1975. The Dry Weight Estimate of Biomass in a Selection of Cladocera , Copepoda and Rotifera from the Plankton , Periphyton and Benthos of Continental Waters. Oecologia. 19(1):75–97.
Diaphanosoma	Adult	Dumont, H.J., van de Velde, I., Dumont S. 1975. The Dry Weight Estimate of Biomass in a Selection of Cladocera , Copepoda and Rotifera from the Plankton , Periphyton and Benthos of Continental Waters. Oecologia. 19(1):75–97.
Diaptomidae	Adult	Culver, D.A., M.M. Boucherle, D.J. Bean & J.W. Fletcher. 1985. Biomass of freshwater crustacean zooplankton from length-weight regression. Can. J. Fish. aquat. Sci., 42: 1380-1390.
Eurytemora affinis	Adult	Updated with Kimmerer data (unpublished). Ambler JW, Cloern JE, Hutchinson A. 1985. Seasonal cycles of zooplankton from San Francisco Bay. Hydrobiologia. 129(1):177–197.
Eurytemora affinis	Juvenile	Kimmerer et al. 2011 unpublished Bug Weight Report
Eurytemora affinis	Larva	Kimmerer (assumed,used Pseudodiaptomus)
Harpacticoida	Undifferent-iated	Dumont, H. J., I. Van de Velde, et al. (1975). "The dry weight estimate of biomass in a selection of Cladocera, Copepoda, and Rotifera from the plankton, periphyton, and benthos of continental waters." Oecologia (Berlin) 19: 75-97.
Keratella	Adult	Kimmerer (unpublished data)
Limnoithona	Adult	Kimmerer et al. 2011 unpublished Bug Weight Report
Limnoithona	Juvenile	Kimmerer et al. 2011 unpublished Bug Weight Report
Limnoithona sinensis	Adult	Kimmerer et al. 2011 unpublished Bug Weight Report
Limnoithona tetraspina	Adult	Kimmerer et al. 2011 unpublished Bug Weight Report
Oithona	Adult	Kimmerer et al. 2011 unpublished Bug Weight Report
Oithona	Juvenile	Uye S, Sano K. 1995. Seasonal reproductive biology of the small cyclopoid copepod Oithona. Mar Ecol Prog Ser. 118(Uchima 198513):121–128.
Oithona davisae	Adult	Kiorboe, T, and M Sabatini. 1994. “Reproductive and Life Cycle Strategies in Egg-Carrying Cyclopoid and Free-Spawning Calanoid Copepods.” Journal of Plankton Research 16 (10): 1353–66.
Oithona similis	Adult	Kiorboe, T, and M Sabatini. 1994. “Reproductive and Life Cycle Strategies in Egg-Carrying Cyclopoid and Free-Spawning Calanoid Copepods.” Journal of Plankton Research 16 (10): 1353–66.
Polyarthra	Adult	Kimmerer (unpublished data)
Pseudodiaptomus	Adult	Mean of adult Pseudodiaptomus forbesi and Pseudodiaptomus marinus
Pseudodiaptomus	Juvenile	Updated with Kimmerer data (unpublished). Kimmerer et al. 2011 unpublished Bug Weight Report
Pseudodiaptomus	Larva	Uye et al. 1983 Table 1 for 20C N3
Pseudodiaptomus forbesi	Adult	Kimmerer et al. 2011 unpublished Bug Weight Report
Pseudodiaptomus marinus	Adult	Growth and production of the inshore marine copepod Pseudodiaptomus marinus in the central part of the Inland Sea of Japan
Rotifera	Adult	Kimmerer (unpublished data)
Sinocalanus doerrii	Adult	Kimmerer et al. 2011 unpublished Bug Weight Report
Sinocalanus doerrii	Juvenile	Kimmerer et al. 2011 unpublished Bug Weight Report
Sinocalanus doerrii	Larva	Kimmerer et al. 2011 unpublished Bug Weight Report
Synchaeta	Adult	Kimmerer (unpublished data)
Synchaeta bicornis	Adult	Kimmerer (unpublished data)

Taxa name	Lifestage	Source
Tortanus	Adult	Hooff, R.C. & S.M. Bollens, 2004, Functional response and potential predatory impact of Tortanus dextrilobatus, a carnivorous copepod recently introduced to the San Francisco Estuary. Mar. Ecol. Prog. Ser. 277: 167-179.
Tortanus	Juvenile	Use cope to adult ratio of 0.5
Trichocerca	Adult	Kimmerer (unpublished data)

3 Methods

We performed the following steps to convert the raw sample data into an input dataset appropriate for the Dynamic Habitat Analysis/Tool.

Importing, subsetting, and aligning datasets

- We subsetted water quality and zooplankton original datasets to only include data between 1987 and 2020.
- We subsetted the IEP zooplankton dataset to only include taxa listed in the "Zoop_IEP_biomass_conversions.csv" file (Table 1).
- From the subsetted zooplankton dataset, we exported a table of unique station IDs with their latitude/longitude coordinates. In ArcGIS, we spatially joined each station location to its corresponding subregion (using a shapefile of the 12 subregion boundaries, available at: https://github.com/CSAMP/delta-secchi-temperature-data/tree/main/subregions). We imported this dataset (now including station IDs and subregions) back into R. Note: this was the only step conducted outside of R.
- Using the station ID/subregion table created in the previous step, we assigned each sample in the IEP zooplankton dataset and the mysid dataset provided by Arthur Barros ("Zoop_IEP_mysid_BPUE_1987-2020.csv") to a subregion.
    - We consulted Aroon Melwani (Applied Marine Sciences) who had compiled spatial location for all station IDs and found that some stations with the same ID were sometimes in different locations when used by multiple surveys (e.g., FMWT and STN). In ArcGIS, we checked Aroon's spatial layer of station IDs that changed locations and found only one station included in the IEP zooplankton dataset that moved across subregions: station 501 fell within the SE Suisun for the FMWT survey dataset and NE Suisun for all other surveys. We accounted for this change when assigning IEP data to a subregion, depending on its survey/source.

Summarizing datasets

- We created a summarized final zooplankton dataset that included a row for every date-subregion combination from the original zooplankton dataset.
    - For each date, subregion, and meso/micro zooplankton taxa, we calculated biomass per unit effort (BPUE, which we used directly as the metric of $\mu gC/m^3$ in the Tool) by 1) taking the mean catch per unit effort (CPUE) from samples for each taxa that were taken on the same date and in the same subregion and 2) multiplying taxa-specific mean CPUE by their biomass conversion rates (found in "Zoop_IEP_biomass_conversions.csv").
    - We also summed the number of samples taken on each day in each region.
    - For each date, subregion, and mysid taxon, we calculated the mean BPUE from samples for each taxon in the original mysid dataset.
    - We merged summarized BPUE data for meso/micro zooplankton and mysids into the final zooplankton dataset, aligning data by date-region combinations.

- We created a summarized final water quality dataset that included a row for every date-subregion combination from the original water quality dataset and zooplankton datasets.
    - Because the original zooplankton dataset also included temperature and clarity data, we first joined the original zooplankton dataset to the water quality dataset.
    - For each date and subregion, we calculated the mean sampled conditions for temperature, clarity, and salinity.
    - We also summed the number of samples taken on each day in each region for each water quality attribute.
- We created a summarized final input dataset for the Dynamic Habitat Analysis/Tool that included a row for every date-subregion combination from the original water quality and zooplankton datasets.
    - We joined the final zooplankton dataset with the final water quality dataset using unique date-subregion combinations.
    - We summed the total biomass across all meso/micro zooplankton and mysids for each date-subregion combination (column name: “zoop.biomass”) to use as the key metric of prey density in the Tool.
    - The output file (“water_quality_zoop_daily.csv”) contains mean conditions for water temperature, clarity/turbidity, salinity, and prey density for each date and each subregion that was sampled between 1987 and 2020. This data was used in the Dynamic Habitat Analysis/Tool.