CWPA MARKET SQUID PARALARVAL RESEARCH PROGRAM

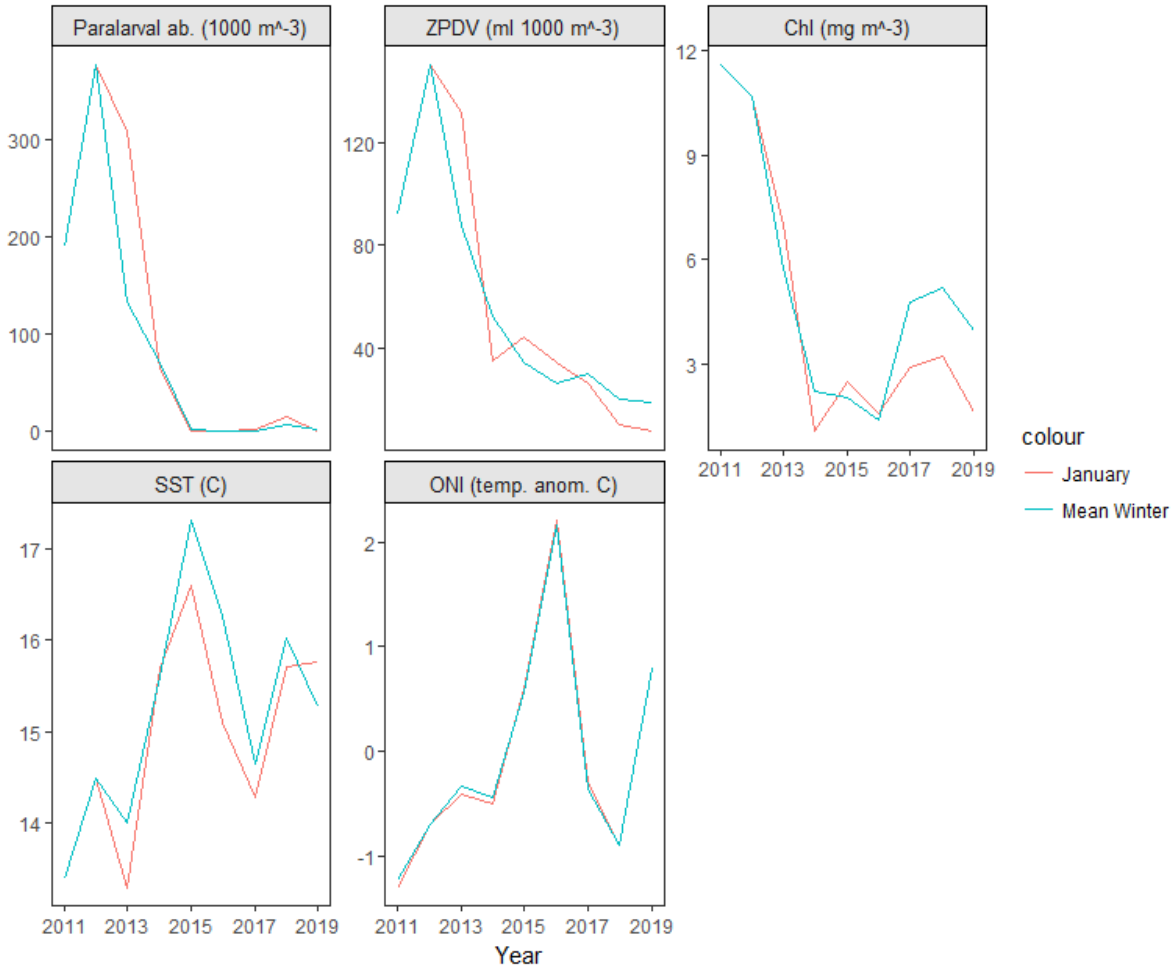
2018-19 WINTER UPDATE

Methodological Overview

The California Wetfish Producer's Association (CPWA) in collaboration with NOAA's Southwest Fisheries Science Center (SWFSC) and the California Department of Fish and Wildlife has been conducting a long-term data collection program targeting California Market Squid paralarvae in Southern California since 2011, and in Monterey since 2014. Sampling sites occur at fixed and known squid spawning and aggregation sites and were selected through a collaborative process involving the squid fishing community, government managers, and independent scientists. These sites are in shallow waters, generally between 40-100 meters, over sandy substrate and often within one km from shore. Sampling effort targets the winter hatching season in southern California, sampling occurs in December, January, and February. Summer surveys are also conducted in SC and Monterey. Depending on funding availability, additional surveys are conducted in spring and autumn. To date, over 1,000 net tows have been collected during 42 survey efforts spanning nine years. Sampling is done on chartered fishing vessels and paralarvae are captured via bongo nets with a 505-micron mesh. Zooplankton volume and preservation, paralarval sorting and identification and other lab work are conducted at the SWFSC. Paralarval ageing is conducted with SWFSC personnel in an on-going project. Paralarval condition is measured by obtaining an average weight for paralarvae at a given station location, as well as measuring lengths of all individuals at a station location, or from 10 randomized individuals if >10 individuals occur at a station.

Overview – Early Winter 2018

Market squid paralarval abundance in Southern California (SC) during the winter of 2018 remained very low compared to the long-term mean, and especially compared to paralarval densities found during previous La Niña time periods (prior to 2015), indicating lingering effects from the historic 2015-16 El Niño. The 3-month mean SC paralarval density index (PDI) for the December 2018, and January and February, 2019 winter paralarval hatching season was 3.17 paralarvae per 1,000 m^3 of filtered sea-water (± 19 SD). This is down from 7.43 (± 46.9) the previous hatching season (2017-18). The long-term SC winter mean PDI is 51.3 (± 342). Measurements of productivity, both zooplankton displacement volume (ZPDV) and surface chlorophyll (SCHL) declined from the previous year. ZPDV has steadily declined since the onset of the strong El Niño in 2014. Surface chlorophyll concentrations have recovered slightly from the El Niño, but are lower than last year, and still much lower than the previous period of high productivity (Fig. 1). Local sea surface temperature (SST) and the Ocean Niño Index (ONI) both saw cooling periods in 2017, but have warmed slightly during 2018 and 2019.



(Fig 1. Time series data for 5 indices from 2011-2019. Paralarval abundance and zooplankton displacement volumes are sampled via CWPA's market squid paralarval research program. Surface chlorophyll, temperature, and the Ocean Niño Index are derived from NOAA satellite data. Sampling effort during the winter hatching season increased to 3x during the 2012-13 season).

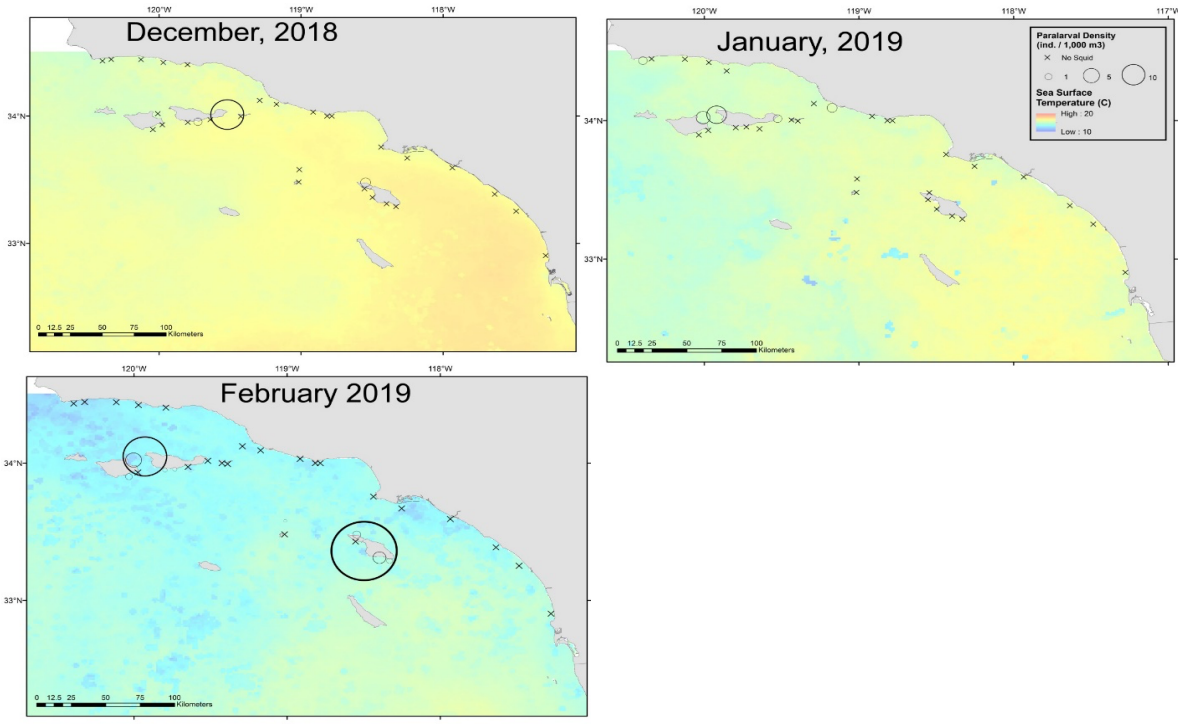
Late Winter Hatching Season, 2019

Paralarval abundance, temperature, and ocean productivity began the 2018-19 winter hatching season similarly to previous years, marked by very low abundance, warmer ocean temperatures, and reduced productivity. However, February, 2019, marked a dramatic change. A series of strong winter storms drove coastal upwelling, which cooled surface waters, increased ocean mixing, nutrient availability, zooplankton abundance, and yielded a significant increase in paralarval abundance (Table 1, Fig. 2). Zooplankton biomass and availability seems to be particularly important for market squid, likely due to the high energetic demands required by squids (O'Dor 1982). General Additive Models were used (also see Van Noord & Dorval 2017) to evaluate the importance of oceanographic variables on determining variability in paralarval density for the 2018-19 season. Sea surface temperature, ZPDV,

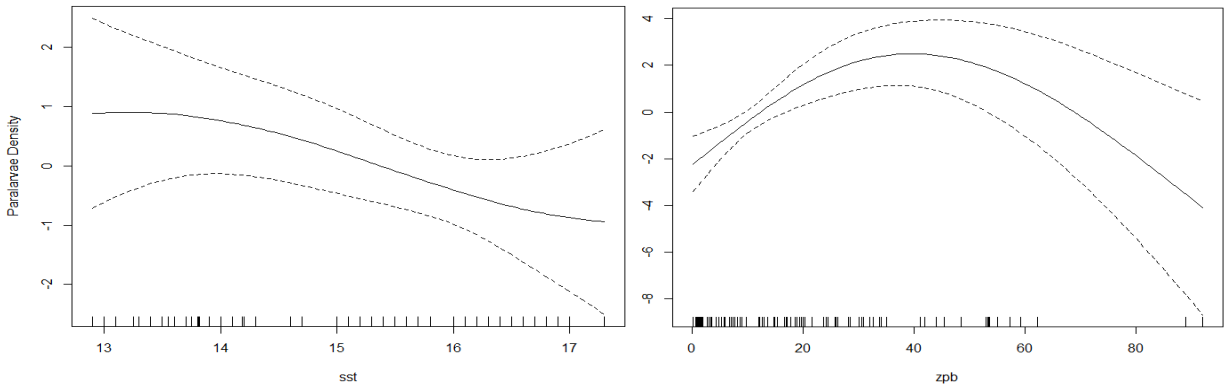
SCHL, and four geographic variables (separating the coast from the Channel Islands and north from south at Santa Monica Bay) explained 48% of the variability in paralarval abundance. Sea surface temperature and ZPDV were particularly important in the model (Fig. 3). Greater paralarval density was associated with lower SST and moderate to high ZPDV.

(Table 1. Paralarval abundance values, SST, and ZPDV from the 2018-19 winter hatching season. An * indicates at significant difference, p<0.05 using paired Mann-Whitney U tests).

2018_19	December	January	February
Paralarval ab. (ind. / 1,000m^3)	0.81 (± 0.7)	0.27 (± 0.1)	*8.32 (± 5.6)
Sea surface temperature (°F)	61.5	60.4	56.6
ZPDV (ml / 1,000m^3)	6.9 (± 5.8)	7.8 (± 7.5)	32.6 (± 22)



(Fig. 2 Chloropleth maps from the 2018-19 winter hatching season showing sea surface temperatures and paralarval sampling locations. Larger circles indicate greater paralarval densities, an “x” indicates a sampling location where no paralarvae were found. The sampling area extends form Point Conception in the north, to San Diego in the south, and includes the Channel Islands. Dramatic cooling and a significant increase in paralarval abundance was seen in February, 2019)



(Fig. 3, Generalized Additive Model outputs showing the relationship between paralarval density, with a log link function, and sea surface temperature (top) and zooplankton displacement volume (bottom).

Monterey Bay Area and Summer Sampling

The Monterey Bay Area was sampled in June, 2018 (n=15) and the paralarvae density index was 10.5 (± 7.18). This was the highest paralarvae abundance measured during the 2018-19 season. Southern California was sampled in June, 2018 and the PDI measured 0.45 (± 0.04). This was the second consecutive year that Monterey PDI values were the highest recorded in a given fishing year, indicating the population’s center of distribution may still be north following the anomalous warm water event during 2015-16, indicating that squid are seeking cooler ocean waters and greater food availability.