Methods text for mapping Washington Dungeness crab vertical lines using logbook data

For the purposes of determining risk of entanglement for whales and turtles resulting from Dungeness crab fishing activity off the coast of Washington State, we will quantify spatio-temporal patterns of fishing effort based on logbook data provided by WDFW. The relevant metric for risk in this context is the density of vertical lines connecting crab pots to surface buoys, or pot density (pots km-2). For their draft Conservation Plan, WDFW desired this information in 15-day intervals at as fine a spatial grain as possible.

The most comprehensive source of information with which to estimate pot density is logbook data, which must be reported by all permitted participants in the crab fishery. Raw logbook data include the start and end locations of each ‘string’ of crab pots, the date they were retrieved, and the total number of pots fished on each of these strings. Logbook pre-processing was done by following WDFW provided script for joining individual csv files of raw logbook data and header files, and for minor error checking and adding of some convenience fields.

We analyzed these data in three steps. First, we converted the start and end geocoordinates for each string into line features. We used the corresponding pot count for each string to simulate evenly spaced points along that string line to represent individual pots. If no pot count was provided in the logbooks for a given string line, no pots were simulated. We then overlaid these point features with a composite bathymetry grid developed by Feist et al. (2021) to assign a depth for each simulated pot. Strings that were completely or partially on land (depth>0m) or in waters greater than 200m in depth were excluded. Second, each simulated pot point feature was overlaid on a 5 x 5km regular grid in order to generate 2D maps of crab fishing effort over time.

In the third and final step, we calculated the time-averaged density of pots in each 5 x 5km grid cell during each 15-d interval. The simplest approach to estimating pot density would be to sum the total number of pots in each grid cell across all sets, vessels, and days during each interval. However, because fishery participants are not required to report the moving or removal of pots, and pots themselves are not individually-identifiable or labeled in the logbooks, this simple summation could lead to double-counting of pots (e.g., of pots that were set at the beginning of the interval, retrieved to obtain catch, and then replaced in the same or different location). To avoid double-counting, we first averaged the number of pots set in each grid cell by each vessel during each interval, and then summed these mean pot densities across all vessels to obtain our final estimate of pot density per grid cell. We recognize that this approach could either over- or under- estimate pot density. Because it assumes that each set provides an independent estimate of the number of pots in a cell during the entire interval, this approach could overestimate pot density if pots from a set early in the interval were removed for the remainder of the interval. Because there is no requirement to report sets that do not obtain catch, this approach could also underestimate pot density. However, we felt that the time-averaged pot density approach we employed was the best given the limitations inherent to the data.