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 quantified spatio-temporal patterns of fishing effort based on logbook data provided by the 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.

Second, we overlaid the point features from all strings with (i) a composite bathymetry grid to assign a depth for each simulated pot, and (ii) a 5 x 5km regular grid for subsequent mapping of fishing effort (see below and Feist et al. 2021). Simulated pots that were on land (depth >0m) or in waters greater than 200m in depth were excluded.

In the third and final step, we calculated the density of pots in each 5 x 5km grid cell during each 15-d interval, using one of two assumptions/adjustment methods.

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 labelled 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).

For method 1 (M1), to adjust for double-counting, we first averaged the number of pots set in each grid cell by each vessel during each 15-d interval, and then summed these mean pot counts across all vessels to obtain our final estimated number of pots per grid cell. We then divided this total pot count by the area of the grid cell, to get trap density per km2. 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 submit a logbook when no crab is caught for an entire trip (i.e., no fish ticket is submitted; <https://apps.leg.wa.gov/WAC/default.aspx?cite=220-340-460>), this approach could also underestimate pot density. However, we felt that the time-averaged pot density approach we employed is a reasonable approach given the limitations inherent to the data.

For method 2 (M2) after simulating pots and joining them to the 5 x 5km grid, we incorporated information on each vessel’s pot limit, as per their Washington State fishing license. There are two license categories, that allow the holder to fish either 300 pots, or 500 pots. Using the license information, we applied a weighting to each simulated pot based on that vessel’s permitted max pot number, working in 15-d intervals. The assumption is that in a 15-d interval, a fisherman will fish their allotted pot limit (WDFW, pers. comm.). We counted up simulated traps for each vessel in a 15-d interval, and divided their pot limit by this summed number of simulated traps. Using this method we up-weight traps when the number of simulated traps is less that the vessel’s pot limit, and down-weight traps when the number of simulated traps is more than the vessel’s pot limit. In effect, summing the weighted number of simulated traps for any vessel in a 15-day period will always equal their allowed maximum pot limit. We recognize that this approach could overestimate pot densities if fishermen do not have their full allotted number of pots in the water. The case of overestimating by M2 may be more pronounced at the end of the season, when the fishery footprint is reduced to a smaller area, yet the simulated pots are still being weighted by the full pot limit of the vessels that are still active in the fishery. It is possible that at the end of the season some fishermen may store some of their pots on land, some pots may remain in the water but are not being checked, or some pots may not yield any catch during fishing trips and are therefore not reported in the logbooks.

Feist, B.E., Samhouri, J.F., Forney, K.A. & Saez, L. (2021). Footprints of fixed gear fisheries in relation to rising whale entanglements on the U.S. West Coast. Fisheries Management and Ecology, 28(3), 283-294.