SUPPLEMENTARY MATERIAL 2

Dispersal and population connectivity are phenotype dependent in a marine metapopulation

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SUPPLEMENTARY MATERIAL 2: BIOLOGICAL AND BEHAVIOURAL PARAMETERS FOR DISPERSAL MODEL

We used a 3-dimensional biophysical dispersal model to simulate the movement and settlement of *Trachinops caudimaculatus* larvae throughout Port Philip Bay (PPB), with the addition of the following biological and behavioural parameters.

Mortality, growth and development, and individual behaviours are key parameters that govern the dispersal trajectories and success of individuals in the dispersal environment. Three parameters were implemented to define differences in individual growth and development among larval phenotypes: 1) pre-competency period (Prep) in which individuals are not physiologically capable of settlement; 2) development period (Dev) as a proportion of the pre-competency period within which individuals are passive dispersers before the onset of active behaviour; and 3) the initial fall velocity (iFV) describing the buoyancy of individuals during the early development period [1]. As instantaneous growth rate can be a predictor of PLD [2], the length of the Prep period was determined based on empirical data suggesting the larval duration for *T. caudimaculatus* ranges from 30 to 45 days [3], and the mean instantaneous growth rates of high-, average-, and poor-quality larval phenotypes collected from the ichthyoplankton samples. The Dev for modeling average-quality larvae was determined based on mean development times of coral reef demersal brooders [4] and adjusted to account for the longer PLD of *T. caudimaculatus* and slower growth in temperate waters. The model for poor-quality larvae used the selected Dev +25%, and −25% for modeling high-quality larvae, based on the difference in mean growth rates of poor- and high-quality larval phenotypes.

Following the development period, we incorporated parameters that allowed larvae to move horizontally and vertically through the water column. These behaviours were also varied among larval phenotypes and defined by swim speed (Sp) and target depth (TD) – the specific depth an individual will actively and constantly swim towards (at speed Sp*0.05), and homing distance (HmD). Swimming speeds in the models were proportional to SL, with average-quality larvae assigned a Sp of $0.05 ms^{-1}$, or approximately 10 body lengths (SL) per second (bls; see [5] for review of larval swimming abilities). As high-quality larval phenotypes were faster growing, at any given age, SL, and thus Sp, would be greater, and therefore Sp in the high-quality model was calculated as $0.05 ms^{-1}$ +25%. Similarly, Sp in the poor-quality model was calculated as $0.05 ms^{-1}$ −25%. TD in the models was determined from the depth distribution of larval phenotypes found in the 24-hour depth stratified ichthyoplankton samples.

There is no empirical evidence to support the HmD applied to the models. However, it is known that dispersing larvae do respond to reef cues by changing their swimming speed and direction [6], and orientation behaviour can have a significant influence on dispersal outcomes [7], thus it was decided to include HmD as a parameter. However, due to lack of empirical support for how larval phenotype will influence this parameter, HmD was held constant for all model runs. Mortality was excluded as a parameter from our model to obtain conservative estimates of dispersal outcomes, however in reality, mortality would also vary as a function of larval phenotype.

Simulated larvae were released continuously from 34 reef habitat patches around PPB (Fig. S2). The decision to release larvae daily in model simulations was based on our empirical data on the distribution of hatch dates across a lunar cycle. Data on hatch date extracted from larval otoliths collected from ichthyoplankton samples across five months were collapsed to a single lunar month by converting each hatch date to 'days since new moon'. The distribution shows that hatching is weakly semilunar, with peaks around the new and full moon, but also that hatching occurs on every single day of the lunar month (Fig. S3).

Previous model simulations using continuous release have found good correlations with empirical observations of larval settlement/recruitment of other fish species in PPB [8, 9], as the vertical stratification of currents, resulting from wind-driven flows at the surface and boundary layer flows at the benthos, do not exhibit lunar periodicity.

Table S1 Biological and behavioural model parameter values for 1) poor quality, 2) average quality, and 3) high quality *Trachinops caudimaculatus* larvae.

Parameter	Poor quality	Average Quality	High Quality
Mortality	0 %day^{-1}	0 %day^{-1}	0 %day^{-1}
Pre-competency (Prep) – the period before a fish becomes competent to settle	45 days (+ 50%)	37.5 days (+ 25%)	30 days (Ford 2014)
Initial fall velocity (iFV) – buoyance of passive hatchlings	-0.0005 ms^{-1}	-0.0005 ms^{-1}	-0.0005 ms^{-1}
Development period (Dev) – time spent as passive particles with iFV.	15 days (ave + 25%)	12 days	9 days (ave – 25%)
Swim speed (Sp) – used for horizontal, vertical = 5% of Sp	0.0375 ms^{-1} (ave – 25%)	0.05 ms^{-1} (~10bls^{-1}, 5mm SL)	0.0625 ms^{-1} (ave + 25%)
Target depth (TD) – vertical depth to swim towards (once development time is reached)	3 m	6 m	10 m
Homing distance (HmD) – distance at which the larvae can detect a reef	6 km	6 km	6 km
Maximum PLD (days)	50	50	50
Reefs to release from (see Fig. 2.1)	All	All	All
Larval release	Daily from 1 to 30 Oct 2009, releasing 500 larvae hourly from 7pm to 1am		

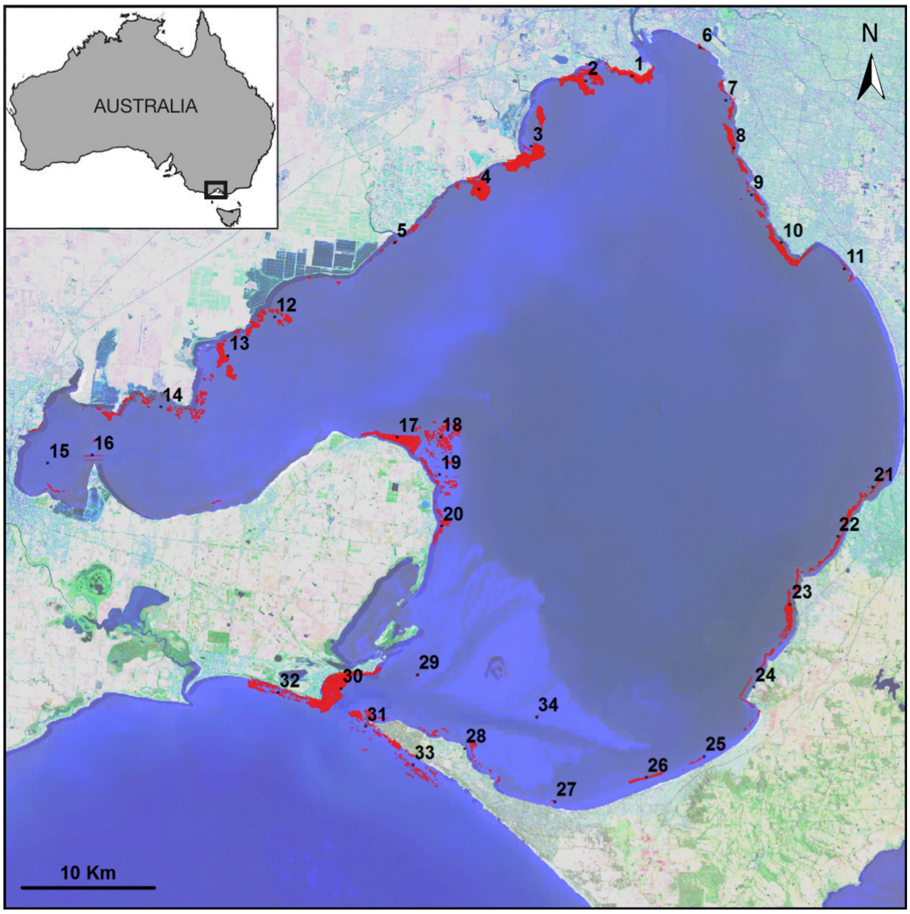

Fig. S2 Study area of Port Phillip Bay, Victoria, Australia. Rocky reefs are highlighted in red, with the 34 patches used as larval release and recruit sites in the dispersal model identified.

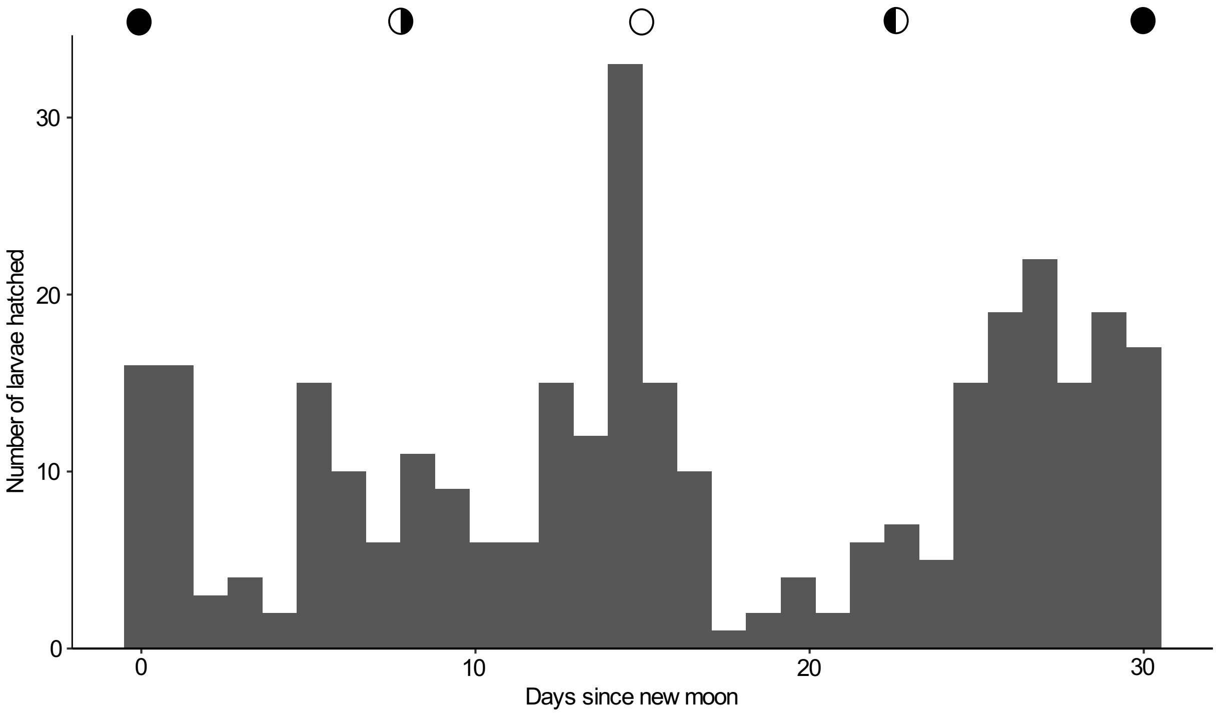

Fig. S3 Distribution of hatch dates across the lunar cycle. Data on hatch date extracted from larval otoliths collected from ichthyoplankton samples across five months were collapsed to a single lunar month by converting each hatch date to 'days since new moon'. The distribution shows peaks in hatching around the new and full moon, but also shows that hatching occurs on every single day of the lunar month. This data informed the 'Larval release' parameter in our dispersal model.

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