Supplementary Material

Supplementary Figures and Tables

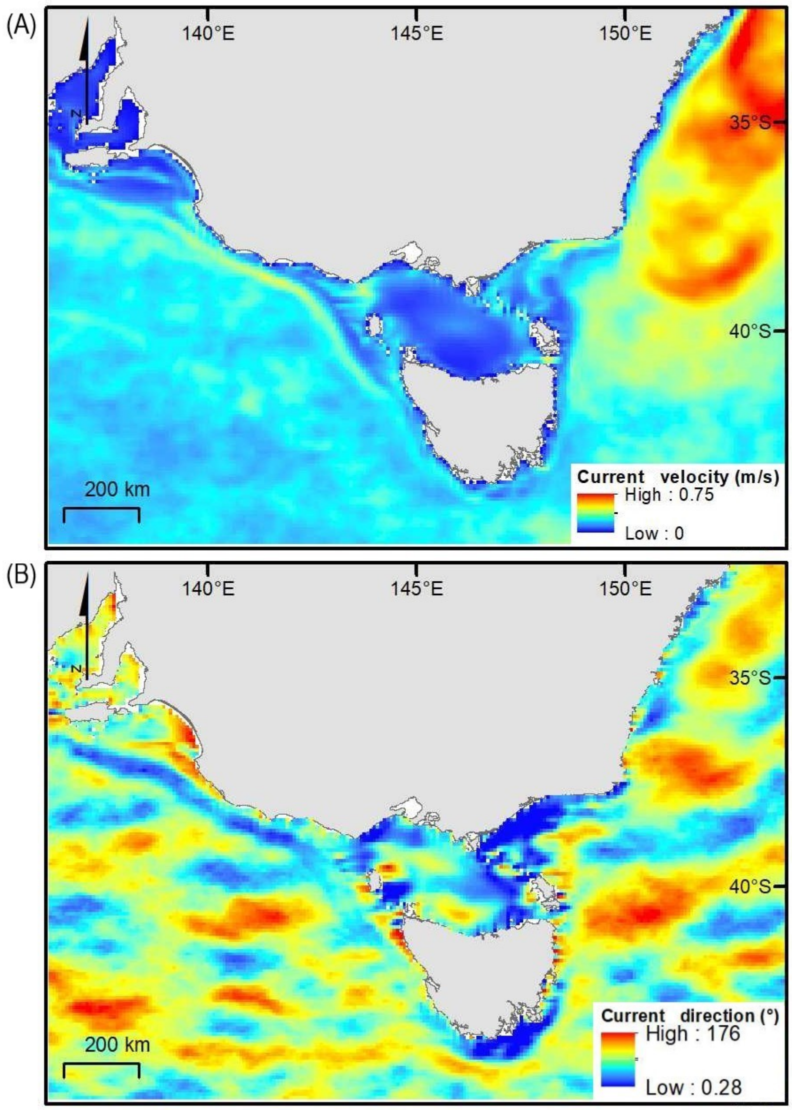

Figure S1: Absolute magnitude of water velocity, in m/s. Calculated as the square root of u squared plus v squared (A). Direction of water velocity (B), in degrees (due north is 0, due east is 90, due south is 180, due west is 270). Currents were derived from HYCOM database (HYCOM, http://hycom.org) from the surface to 50 m depth, representing the adult snapper habitat.

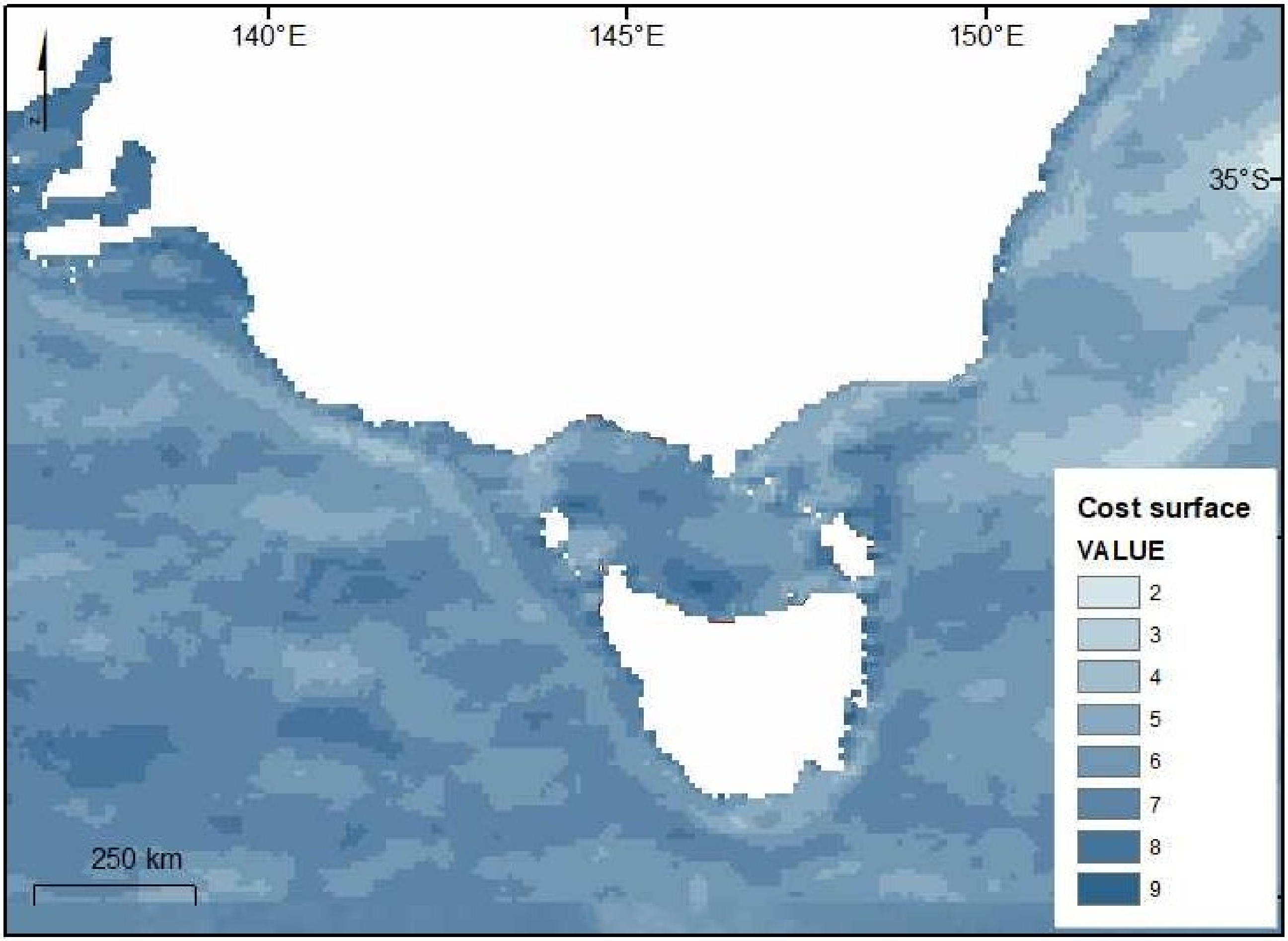

Figure S2: Cost surface raster used to identify least cost paths and quantify connectivity for adult of *C. auratus*. Cost surface was generated according to current magnitude and directions, assuming the minimum cost when moving following the ocean currents. Cost surface scores were estimated on a scale from 1 to 10, after assessing several scales and verifying that the chosen scale did not influence seascape connectivity spatial patterns and number of links.

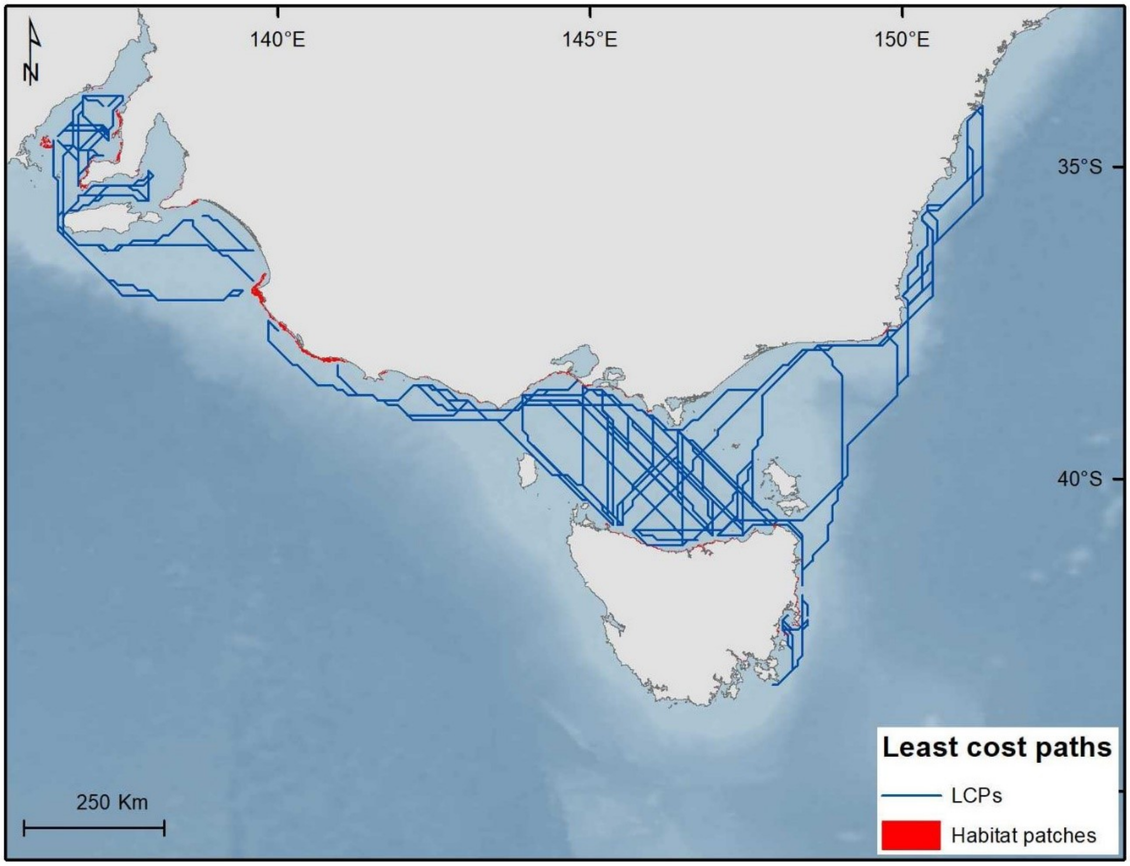

Figure S3: Snapper *C. auratus* connectivity. A cut-off of maximum link length was applied according to maximum swimming distance recorded in snapper populations across southeast Australia to eliminate all links exceeding this threshold and increasing model realism.

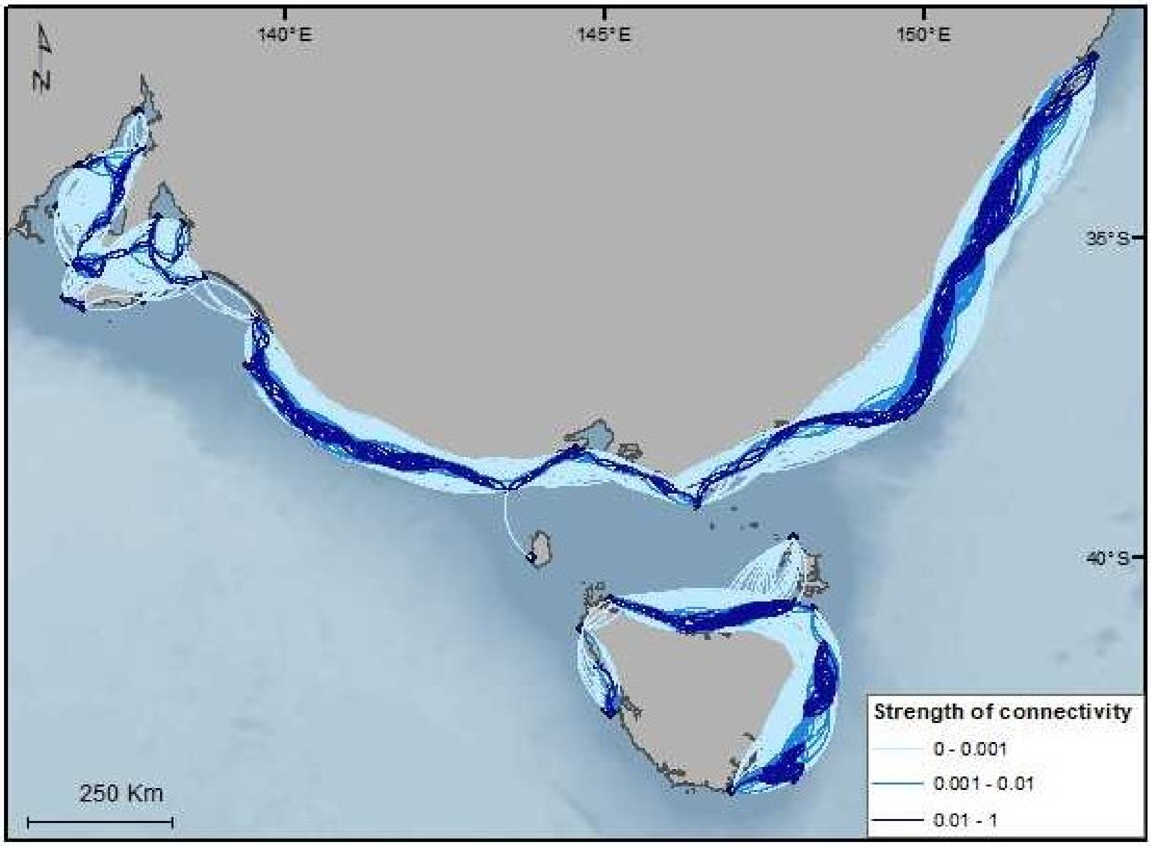

Figure S4: Purple sea urchin *H. erythrogramma* connectivity. The weight of the connections is indicative of the strength of dispersal and the directionality is implied by following the arcs in a clockwise direction.

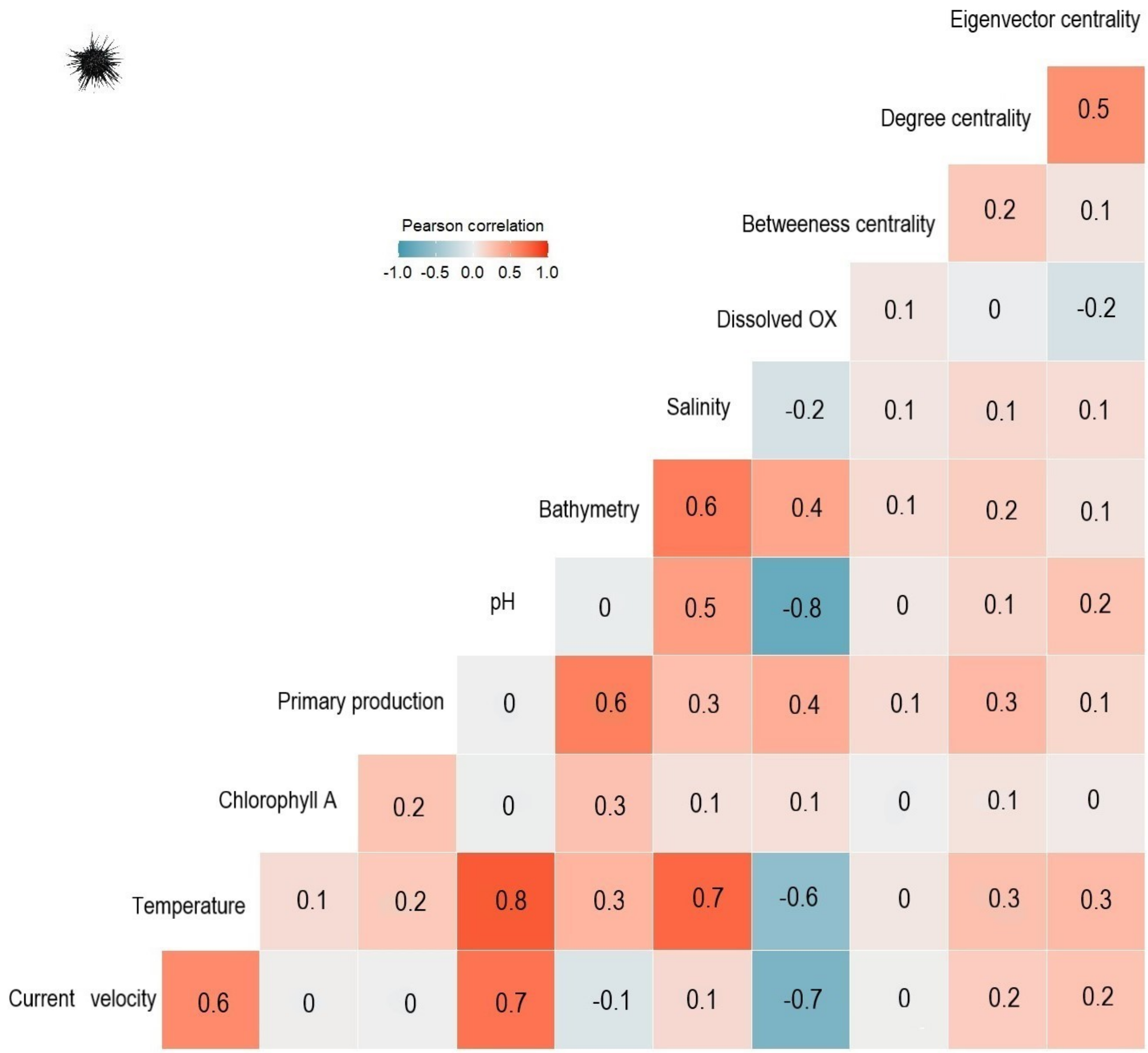

Figure S5: Pearson correlation (r) of environmental variables for *H. erythrogramma*.

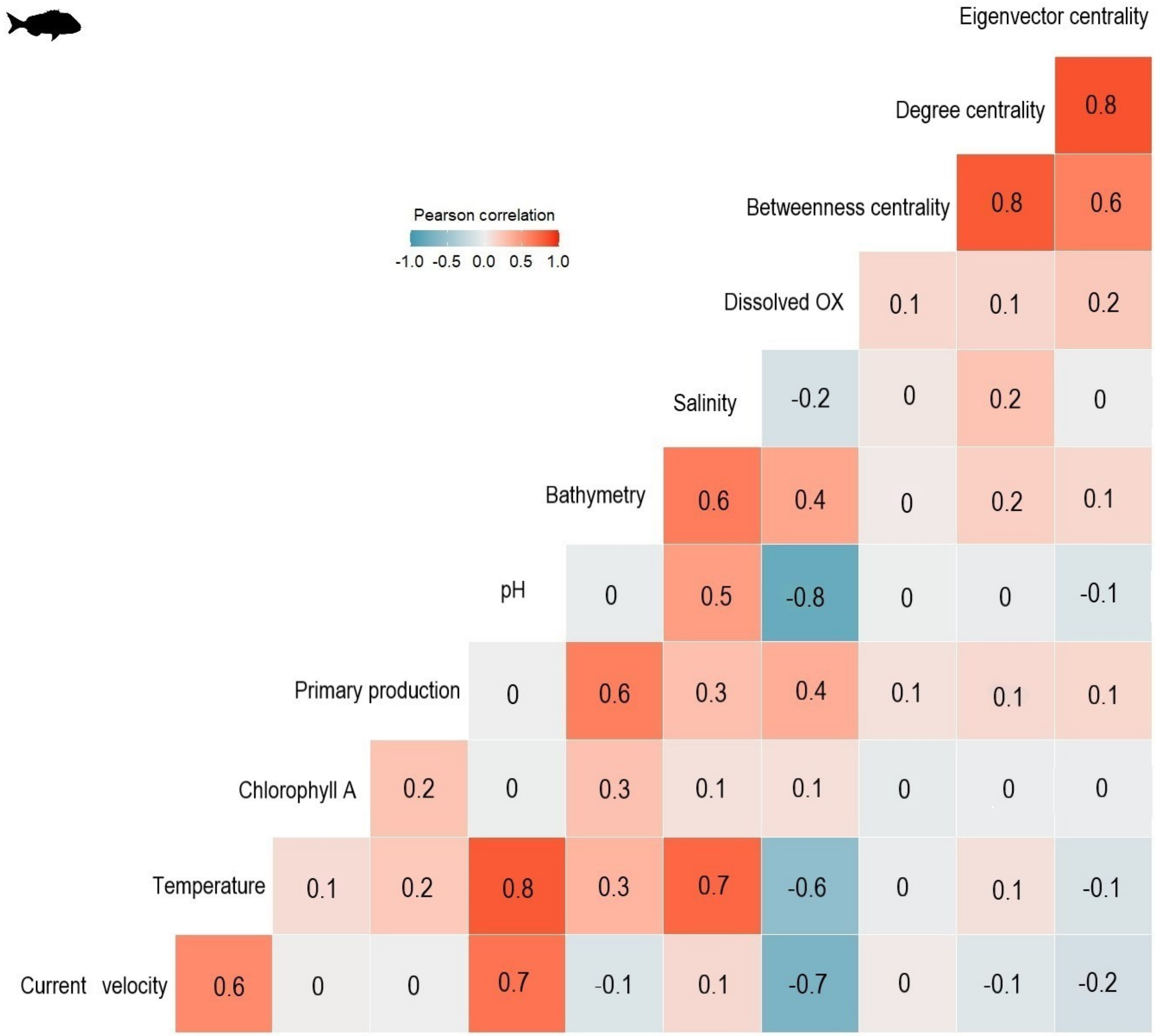

Figure S6: Pearson correlation (r) of environmental variables for *C. auratus*.

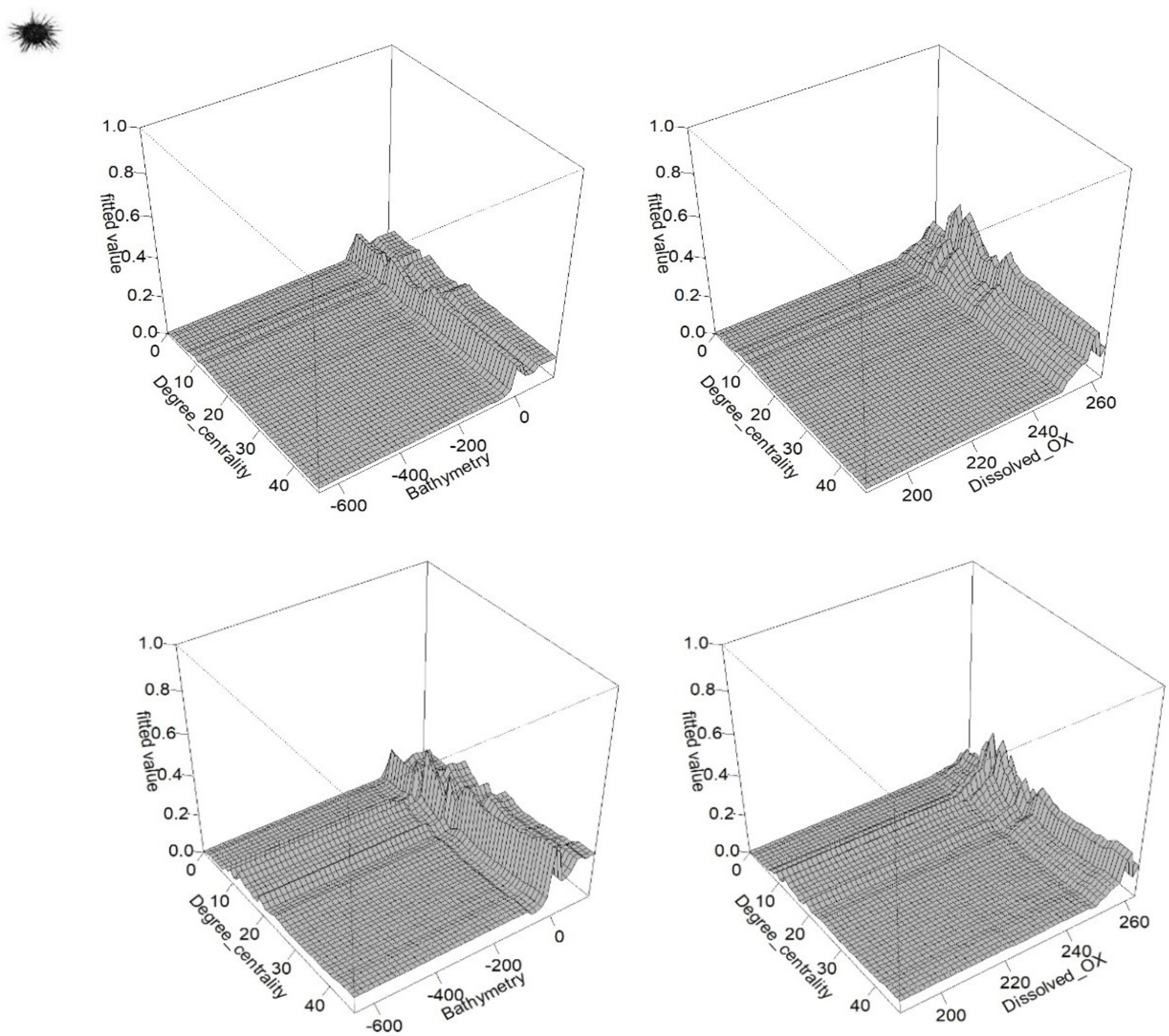

Figure S7. Plots of the interactions between degree centrality and the two most important environmental variables interacting with degree centrality. Plots showing interactions for BRT models fitted including all connectivity variables for *H. erythrogramma* with maximum fitted value 0.2 for bathymetry plot and 0.37 for dissolved oxygen (top). Plots showing fitted functions for BRT models fitted including degree centrality only for *H. erythrogramma* (top) with maximum fitted value 0.35 for bathymetry plot and 0.31 for dissolved oxygen (bottom).

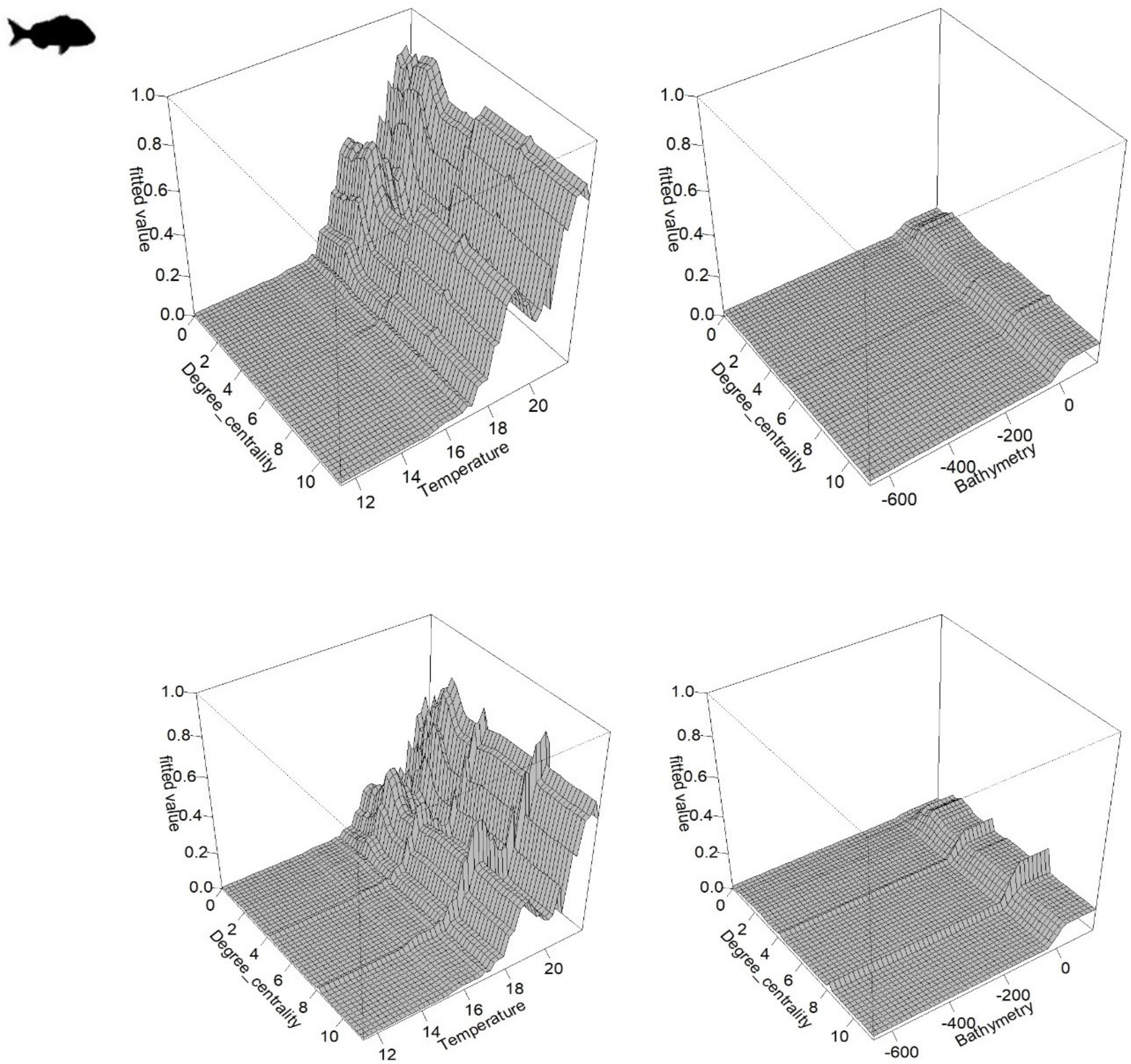

Figure S8. Plots of the interactions between degree centrality and the two most important environmental variables interacting with degree centrality. Plots showing interactions for BRT models fitted including all connectivity variables for *C. auratus* with maximum fitted value 0.88 for temperature plot and 0.12 for bathymetry (top). Plots showing fitted functions for BRT models fitted including degree centrality only for *C. auratus* with maximum fitted value 0.84 for temperature plot and 0.24 for bathymetry (bottom).

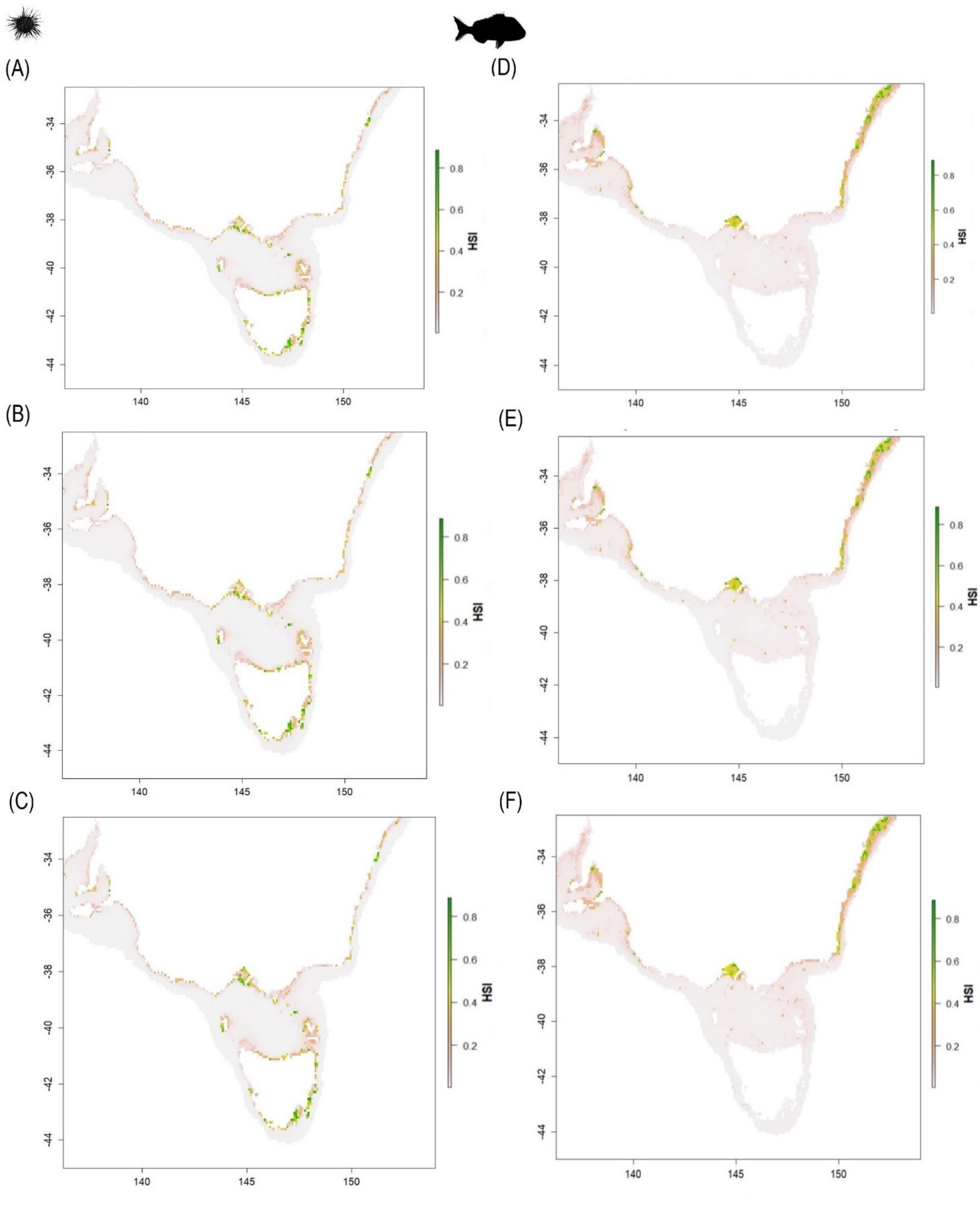

Figure S9. BRT predictions of habitat suitability index (HSI) for *H. erythrogramma* (left) for the model including all centrality metrics (A), only degree centrality (B) and without connectivity (C), and *C. auratus* (right) for the model including all centrality metrics (D), only degree centrality (E) and without connectivity (F).

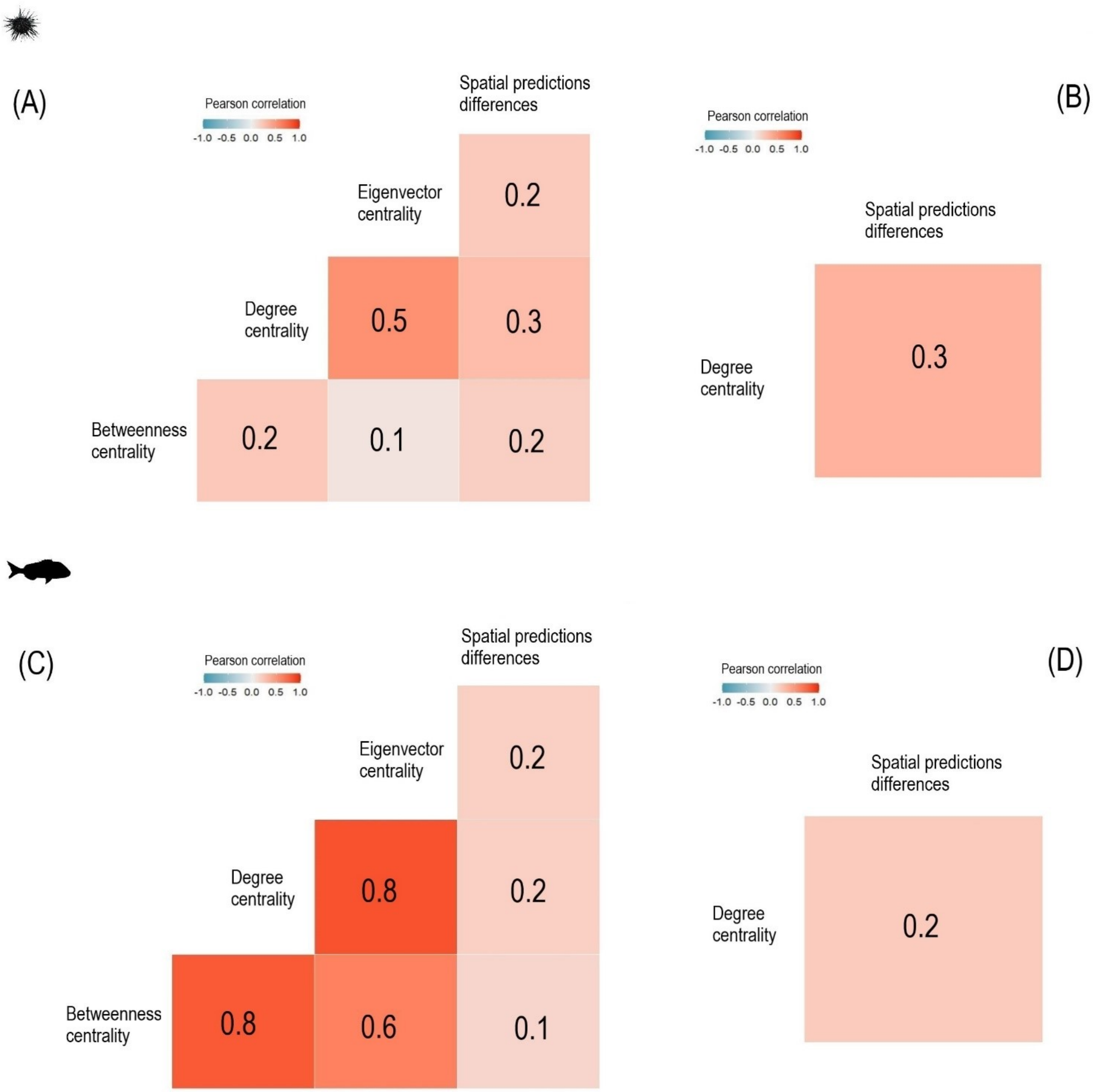

Figure S10: A) Correlation (r) of differences in spatial predictions of habitat suitability (with and without connectivity) and betweenness centrality, degree centrality, eigenvector centrality. B) Correlation (r) of differences in spatial predictions of habitat suitability (with and without connectivity) and degree centrality for *H. erythrogramma* (top). C) Correlation (r) of differences in spatial predictions of habitat suitability (with and without connectivity) and betweenness centrality, degree centrality, eigenvector centrality. D) Correlation (r) of differences in spatial predictions of habitat suitability (with and without connectivity) and degree centrality for *C.* auratus (bottom).

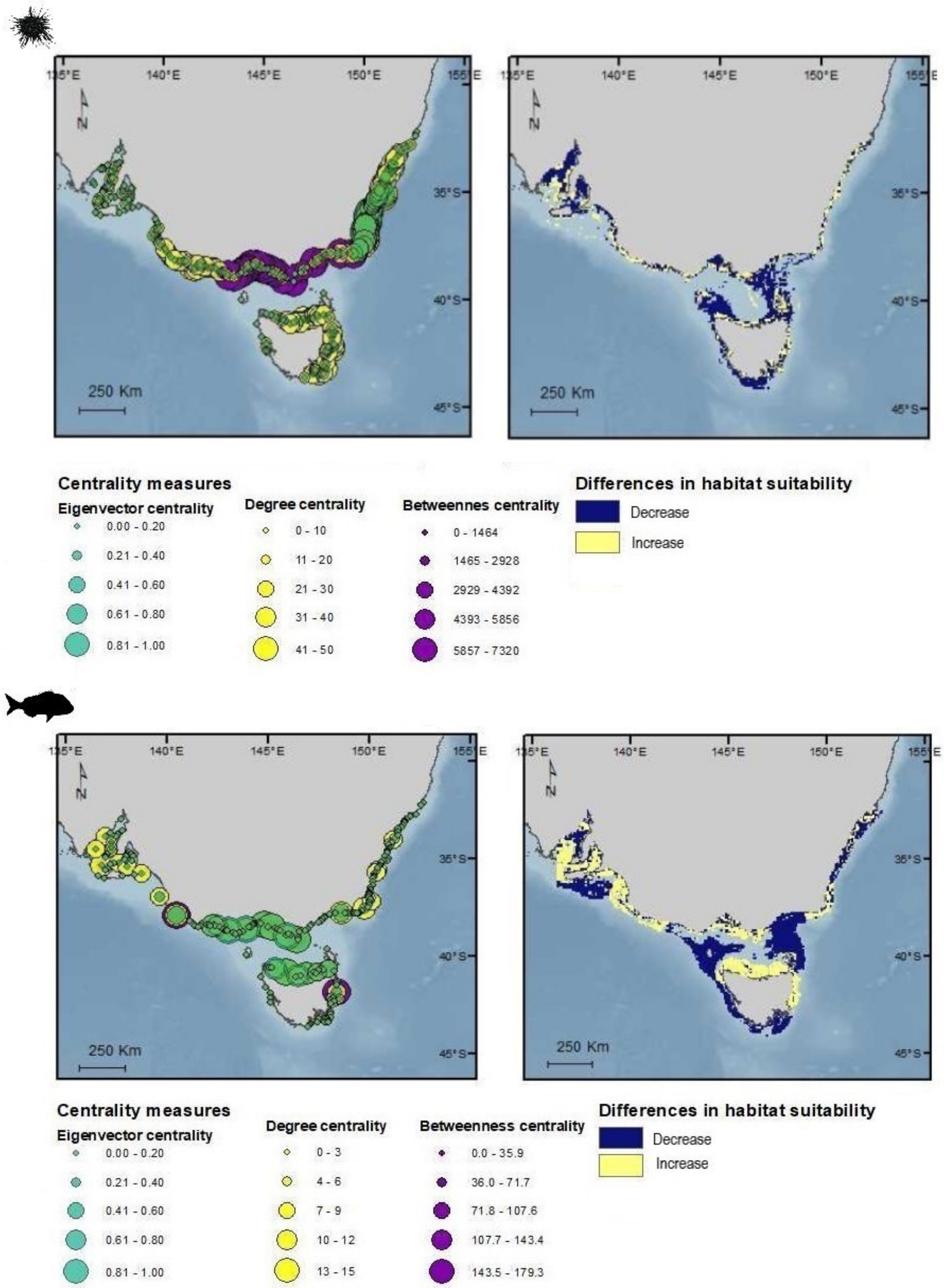

Figure S11: Maps showing the geographic distribution of centrality measures and differences in spatial predictions of habitat suitability for sea urchin *H. erythrogramma* (top) and snapper, *C. auratus* (bottom). Centrality values are shown as dots corresponding to the habitat patches centroids. Values of habitat suitability are classified as 'Increase' when predicted habitat suitability is larger for SDM incorporating connectivity compared to the SDM without connectivity. Values are classified as 'Decrease' when predicted habitat suitability is lower for SDM incorporating connectivity compared to the SDM without connectivity. Maps in WGS84.

Table S1: Species-specific demographic model parameters used as input data for *H. erythrogramma* biophysical model (Treml et al., 2012). The model simulated larval dispersal as clouds of larvae, which were released from a habitat patch and tracked as they moved through the seascape. An advection transport algorithm (Smolarkiewicz, 1983, Smolarkiewicz & Margolin, 1998, Smolarkiewicz, 2006) was used to move the dispersal kernel through current velocity fields. When larvae came in contact with suitable habitat they settled, and quantity of settled larvae were recorded. Model connectivity output is presented in Fig. S4.

Parameter	***H. erythrogramma* (purple sea urchin)**
Depth	0-35m[1]
Max PLD	5 d[2]
Competency period	3 to 5 days[3]
Spawning period	December and March [4]
Diffusivity	100 m^2s^{-1} [5]
Larval settlement likelihood	90%
Larval mortality	16% per day[6]

1. Huggett et al., 2008, 2. Williams & Anderson 1975, 3. Swanson et al., 2012, 4. Williams & Anderson, 1975, Laegdsgaard et al., 1991, 5. Okubo, 1971, 6. Rumrill, 1990, Lamare & Barker 1999.

Huggett, M.J., Crocetti, G.R., Kjelleberg, S. and Steinberg, P.D. (2008). Recruitment of the sea *urchin Heliocidaris erythrogramma* and the distribution and abundance of inducing bacteria in the field. *Aquatic Microbial Ecology*, 53, 161-171.

Laegdsgaard, P., Byrne, M., and Anderson, D. T. (1991). Reproduction of sympatric populations of *Heliocidaris erythrogramma* and *H. tuberculata* (Echinoidea) in New South Wales. *Marine Biology* 110(3): 359-374.

Lamare, M.D. and Barker, M.F. (1999) In situ estimates of larval development and mortality in the New Zealand sea urchin *Evechinus chloroticus* (Echinodermata: Echinoidea). *Marine Ecology Progress* Series, 180, 197-211.

Okubo, A. (1971). Oceanic diffusion diagrams. *Deep-Sea Research*, 18, 789-&.

Rumrill, S.S. (1990). Natural mortality of marine invertebrate larvae. *Ophelia*, 32, 163-198.

Smolarkiewicz, P. K. (1983). A simple positive definite advection scheme with small implicit diffusion. *Monthly Weather Review* 111, 479-486.

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Swanson, R.L., Byrne, M., Prowse, T.A.A., Mos, B., Dworjanyn, S.A. and Steinberg, P.D. (2012). Dissolved histamine: a potential habitat marker promoting settlement and metamorphosis in sea urchin larvae. *Marine Biology*, 159, 915-925.

Treml EA, Roberts JJ, Chao Y, Halpin PN, Possingham HP, and Riginos C (2012) Reproductive Output and Duration of the Pelagic Larval Stage Determine Seascape-Wide Connectivity of Marine Populations. *Integrative and Comparative Biology,* 52, 525-537.

Williams, D. and Anderson, D. (1975). The reproductive system, embryonic development, larval development and metamorphosis of the sea urchin *Heliocidaris erythrogramma* (Val.) (Echinoidea: Echinometridae). *Australian Journal of Zoology*, 23, 371-403.

Table S2: Details of the environmental parameters used in the SDMs.

Name	Description	Units	Source	Start year	End year
Bathymetry	Depth of the seafloor	m	Gebco/EMODnet Bathymetry	2016	2016
pH	Measure of ocean's acidity	-	In-situ measurements	1910	2007
Chlorophyll concentration	Mean mass concentration of chlorophyll in sea water	mg/m^3	Model	2000	2014
Salinity	Dissolved salt content in the ocean	PSS	In-situ measurements	1961	2009
Temperature	Mean sea water temperature	°C	Model	2000	2014
Primary production	Mean net primary productivity of carbon	mg/m3/day	Model	2000	2014
Dissolved oxygen	Mole concentration of molecular oxygen in sea water	mol/m3	Model	2000	2014
Current velocity	Sea water velocity	m/s	Model	2000	2014

Source: Bio-ORACLE (Tyberghein et al., 2012, Assis et al., 2017). All data are in long-lat coordinates (WGS84) and cell size is 0.08333 degree.*

*Tyberghein, L., Verbruggen, H., Pauly, K., Troupin, C., Mineur, F. and De Clerck, O. (2012) Bio-ORACLE: a global environmental dataset for marine species distribution modelling. *Global Ecology and Biogeography*, 21, 272-281.

Assis, J., Tyberghein, L., Bosh, S., Verbruggen, H., Serrão, E. A., and De Clerck, O. (2017). Bio-ORACLE v2.0: Extending marine data layers for bioclimatic modelling. *Global Ecology and Biogeography*.