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Appendix 1

Details of data collection and sample size for empirical results in Fig. 1–2

St. Croix, US Virgin Islands (Fig. 1)

Bluehead wrasse recruit data were taken from multiple sources. Monthly visual surveys were conducted at each site in approximately June–September of 1991, 1992, 1997, 2001, 2002 and 2003; the exact summer months sampled varied among sites and years, but full methods and sample sizes are given in Hamilton et al. (2006). Additional data were collected using similar monthly visual surveys on 30 × 1 m fixed transects at Butler Bay (BB), Northstar (NS), Cane Bay (CB), Wood Cottage (WC) and Jacks Bay (JB) in June–September 2004 and 2005, as reported in White and Warner (2007b). Values in Fig. 1A are means and standard errors taken across all of the available monthly recruitment data at each site. Sample size ranged from n = 7 (Salt River, data only available for 1991 and 1992) to n = 25 (Butler Bay and Jacks Bay, sampled in all available months from 1991 to 2005).

Coney grouper recruit data were collected during monthly visual surveys along 25 × 6 m fixed transects at BB, NS, WC, JB, Green Cay (GC), Knights Bay (KB) during June–September 2003 (White 2007). Coney grouper adult data were collected the same transects in 2003, and similar transects at the same sites in June–September 2002 and at BB, NS, CB, WC and JB in June–September 2004 (White 2007). Values in Fig. 1A are means and standard errors taken across all of the available monthly recruitment data at each site. Sample size ranged from n = 8 (GC and KB, only sampled in 2002–2003) to n = 24 (Butler Bay and Jacks Bay, sampled from 2002–2005).

Copepod data were estimated from one-week integrated tube trap collectors deployed at BB, NS, CB, WC and JB in June, July, and August 2005. Data from three collectors at each site were pooled; values in Fig. 1A represent means and standard errors taken over the three months of data from each site except for JB and WC which were not sampled in August. Methods described in more detail in White and Warner (2007a).

Lee Stocking Island, Bahamas (Fig. 2)

Bicolor damselfish densities were estimated on 16 plots at each site during two visual surveys in June and October 2003 (Samhouri 2007). These values were averaged within each sample data; values in Fig. 2A are the means and standard errors taken across the mean value for each sample data.

Densities of groupers (*Epinephelus* spp., *Cephalopholis* spp., *Serranus* spp.), lizardfish (*Synodon* spp.), and trumpetfish (*Aulostomus maculatus*) were estimated on the same 16 plots at each site during three visual surveys in June, July and August 2003 (Samhouri 2007). These values were averaged within each sample data; values in Fig. 2A are the means and standard errors taken across the mean value for each sample data.

Mean zooplankton biomass is based on diver-assisted tows of a mesh net (200 µm, 35 cm diameter mouth) 1–2 m above the bottom over 160 m permanent transects upcurrent of the reef at each site during June–August 2003 (Goby Spot: n =26 tows, Tug and Barge: n = 20 tows, Rainbow: n =20 tows; Samhouri 2007).

Appendix 2

Symbols and parameter values used in the models

Table A1. Symbols used in analytical model and, where applicable, parameter values used in Fig. 3.

Symbol	Definition	Value	Note
N	Planktivore biomass	–	–
P	Predator biomass	–	–
Z	Zooplankton biomass	–	–
S	Planktivore settler density	= ϕ	–
η	Planktivore feeding rate and efficiency	0.34	1
ξ	Predator attack rate	0.5	2
μ	Planktivore metabolic loss rate	0.002	3
σ	Per capita settler biomass	0.03	4
ϕ_Z, ϕ_P	Oceanographic process	0.75 (Fig. 3A) 0.25 (Fig. 3B)	–
ψ_Z, ψ_P	Non-oceanographic, reef-based process	0.5	–
κ_Z	Zooplankton scaling constant	5	2
κ_P	Predator scaling constant	12	2
π_Z	Planktivore–zooplankton delivery correlation	0–1	–
π_P	Planktivore–predator delivery correlation	0–1	–

Notes:
1) estimated by calculating $\eta_N I_a$ for a 10 cm planktivore given parameters in Table A2; units converted to day^{-1}
2) chosen so that $\xi\kappa_P >> \eta\kappa_Z$; see text for explanation
3) rate given in Table 2 converted to units of day^{-1}

4) mass of a settler given parameters in Table A2

Table A2. Symbols and parameter values used in numerical simulation model.

Symbol	Definition (units)	Value	Source
Planktivore population			
$N_{t,a,i}$	Numerical density of planktivores of age a in patch i at time t (planktivores m^{-2})	–	–
$\bar{N}_{\cdot}$	Mean population size in unperturbed model	–	–
$\bar{N}_j$	Mean population size in patch j, with patch i deleted	–	–
$S_{t,i}$	Number of planktivore settlers (settlers m^{-2})	–	–
V_i	Metapopulation value of patch i	–	–
$\mathbf{D}$	Dispersal matrix		
$A_{N,mat}$	Age at maturity (months)	4	Munday et al. 2006
A_N	Maximum planktivore lifespan (months)	36	Warner and Chesson 1985
I_a	Feeding rate (g $month^{-1}$)	–	–
L_a	Length at age a (cm)	–	–
L_1	Length at settlement (cm)	1.5	White and Warner 2007a
L_{gape}	Maximum size vulnerable to predation (cm)	10.0	Scharf et al. 2000
L_∞	Asymptotic maximum length (cm)	–	–
L_{max}	Maximum value of L_∞ (cm)	20	[1]
$Q_{t,i}$	Per capita zooplankton availability (g zooplankton m^{-2} s^{-1} $planktivore^{-1}$)	–	–
Q_{max}	Maximum value of $Q_{t,i}$ (g zooplankton m^{-2} s^{-1} $planktivore^{-1}$)	0.0067	Holzman and Genin 2003
α_N	Density-independent settler survival	0.33	White and Warner 2007b
β_N	Asymptotic maximum density of settlers (settlers m^{-2})	–	–
γ_ω	Cross-sectional area of reactive volume (m^{-2})	–	–
$\gamma_{\omega 0}$	Maximum cross-sectional area of reactive volume (m^{-2})	–	–
γ_{Z1}	Zooplankton flux constant (planktivore m^{-2})	–	–
γ_{Z2}	Cross-sectional area constant (planktivores)	–	–
γ	Combined flow proportionality parameter (planktivore m s^{-1})	0.033	Holzman and Genin 2003
δ_N	Background adult mortality rate ($month^{-1}$)	0.04	Warner and Chesson 1985
ε_N	Egg mass (g)	2.2×10^{-6}	Samhouri 2007
ζ_N	Feeding rate constant	1.94×10^{-5}	[2]
η_N	Assimilation efficiency	0.61	Samhouri 2007
θ_N	Reproductive allocation	0.8	[3]
κ_P	Density-dependent predation constant (predators/settlers)	46.0	White 2007
λ_N	Larval survivorship	1×10^{-5}	Cowen et al. 2006
μ_N	Metabolic loss rate ($month^{-1}$)	0.06	Feddern 1965
ξ_N	Predator attack rate ($month^{-1}$ $predator^{-1}$)	2.5	[4]
χ_N	Length-weight proportionality constant (g m^{-3})	0.01	Bohnsack and Harper 1988
ω	Flow velocity (m s^{-1})	0.1	Kiflawi and Genin 1997
Zooplankton population			
$Z_{t,i}$	Zooplankton biomass density in patch i, time t (g m^{-3})	–	–
$\mathbf{D}^Z$	Dispersal matrix	–	–
ν	Biomass export rate (s^{-1})	–	–
ρ_0	Intrinsic biomass growth rate (s^{-1})	2	[5]
ρ_1	Density-dependent competition rate (g s^{-1})	–	–
ρ_Z	Density-dependent competition coefficient (g s^{-1})	0.32	[6]

Predator population			
$P_{t,a,i}$	Numerical density of predators of age a in patch i at time t (predators m^{-2})	–	–
$A_{P,mat}$	Age at maturity (mo)	18	Heemstra and Randall 1993
A_P	Maximum predator lifespan (mo)	132	Potts and Manooch 1999
L_{P1}	Settler length (cm)	3	White unpubl.
$L_{P\infty}$	Asymptotic maximum length (cm)	31	Thompson and Munro 1983
$\mathbf{D}^P$	Dispersal matrix		
α_P	Density-independent settler survival	0.08	7
β_P	Asymptotic maximum density of settlers (settlers m^{-2})	0.02	7
δ_P	Adult mortality rate (mo^{-1})	0.046	Thompson and Munro 1978
ε_N	Egg mass (g)	2.2×10^{-6}	Samhouri 2007
θ_P	Reproductive allocation	0.85	3
λ_P	Larval survivorship	1×10^{-5}	Cowen et al. 2006
μ_P	Metabolic loss rate ($month^{-1}$)	0.0525	Thompson and Munro 1983
χ_P	Length-weight proportionality constant (g m^{-3})	0.016	Bohnsack and Harper 1988

Notes:
1) value chosen by increasing maximum reported value (obtained from a captive fish; Feddern 1965) by arbitrary 20%
2) calculated by solving Eq. 9 for ζ_N with $Q = Q_{max}$ and $L_\infty = L_{max}$
3) no literature estimates available, value chosen so that mature individuals continue to grow at reasonable rate
4) chosen so that when $\pi_P = 0$, ratio of predators to prey approximately matches that observed on St. Croix, U.S.V.I. (White 2007)
5) no data available; assume arbitrary positive growth rate. Overall consumption of zooplankton limited by feeding function and value of ρ_Z, which are better parameterized.
6) given value for ρ_0, this scales zooplankton export to value reported by Hamner et al. (2007)
7) predator settler survival assumed to be similar to adult survival rate; maximum density chosen based on observed ratio of predator to prey settlers on St. Croix, U.S.V.I. (White unpubl.).

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Appendix 3

Larval supply statistics for numerical simulation model

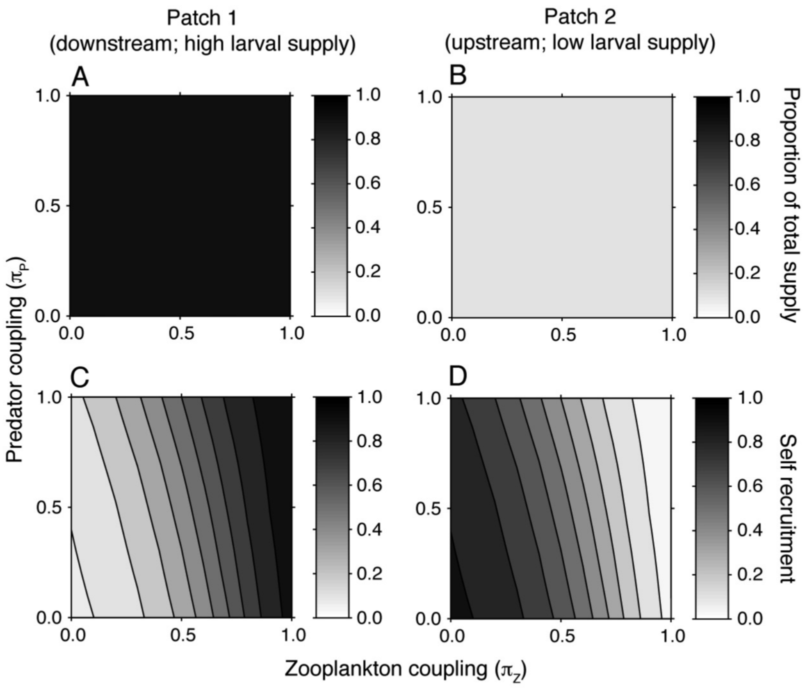
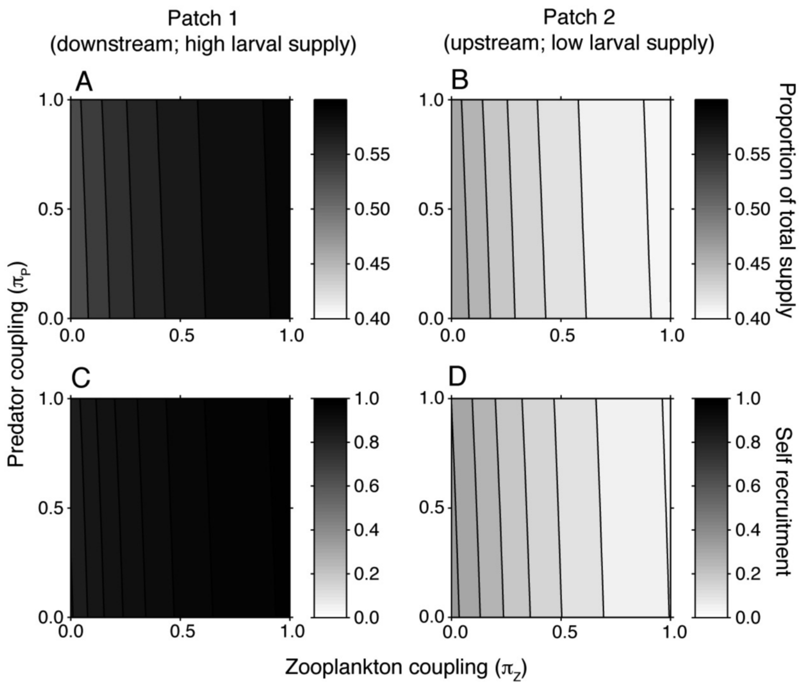


Figure A1. Results of numerical simulation model for the downstream retention scenario. Equilibrium values of (A, B) the proportion of total larvae arriving in each patch and (C, D) the proportion of locally spawned larvae returning to each patch for the planktivore population in (A, C) Patch 1 and (B, D) Patch 2 for different levels of oceanographically forced coupling with predator larval supply and zooplankton abundance. Parameter values used in these simulations given in Table A2.



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