Supplementary Information 1

Supplementary habitat information: Habitat availability at each reef system

Habitats were mapped using the Landsat Thematic Mapper (TM) satellite sensor and published methods[1].

Mangrove Scarce Systems

	Glovers Reef	Lighthouse Reef	Banco Chinchorro
Mangrove perimeter (km)	0.1	5.8	5.8
Benthic habitat area (km^2)			
Seagrass	178.3	190.6	193.8
Montastraea reef	6.7	6.1	3.3
Shallow forereef	9.6	13.6	1.3
Sand / algae	33.4	16.0	26.0

Mangrove Rich Systems

	Curlew Bank	Tobacco Cay	Turneffe Islands
Mangrove perimeter (km)	75.3	72.8	405.5
Benthic habitat area (km^2)			
Seagrass	188.0	194.2	180.2
Montastraea reef	7.1	6.0	6.7
Shallow forereef	5.5	7.2	5.4
Sand / algae	23.7	16.7	1.3

1. Green, E. P., Mumby, P. J., Edwards, A. J. & Clark, C. D. *Remote sensing handbook for tropical coastal management* (Coastal Management Sourcebooks 3, UNESCO, Paris, 2000).

Supplementary Information 2

Supplementary information on fish community structure: Full results of ANOSIM analyses.

ANOSIM is a multivariate randomisation procedure broadly analogous to ANOVA[1]. The output statistic, R, takes a value of 0 if there is no separation of community structure attributable to a factor, and 1 if perfect separation occurs (e.g. if all mangrove-rich sites were more similar to each other than to any mangrove-scarce site). Nested ANOSIM[1] necessarily assigned greater statistical power to the factor Reef than to Mangrove because of the relative degrees of freedom. This explains the difference in probability values for R statistics in Table 1.

Table 1. Scales of variation in reef fish community structure within the *Montastraea* habitat.

Response variable	Data type	ANOSIM R	
		Mangrove	Reef
68 reef species whose juveniles use lagoon habitats	D life stage^{-1} species^{-1}	0.74*	0.49**
68 reef species whose juveniles use lagoon habitats	B species^{-1}	0.65*	0.45**
68 reef species whose juveniles use lagoon habitats	B genus^{-1}	0.79*	0.63**
Reef species excl. barracuda, grouper, large snapper	B species^{-1}	0.89*	0.46**
103 reef species whose juveniles use reef habitats	B species^{-1}	0.59*	0.49**
All 164 reef species	B species^{-1}	0.52*	0.66**

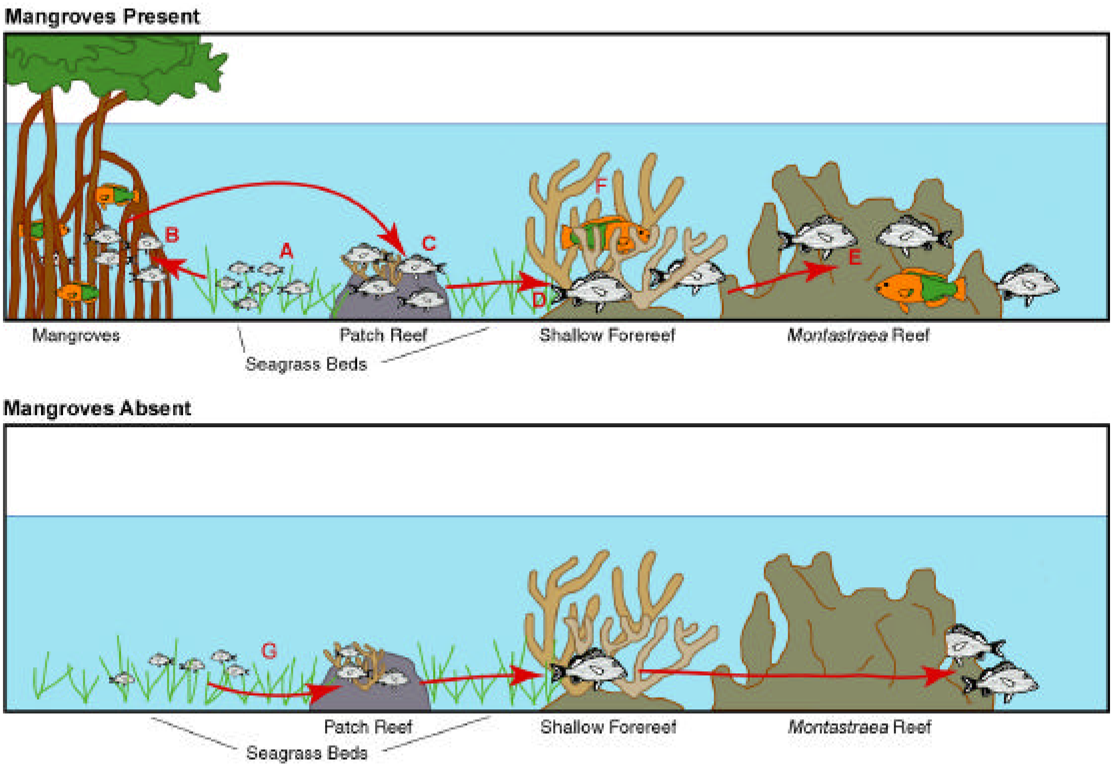
Nested ANOSIM reveals the degree to which the factors mangrove and reef explain differences in community structure between sites. Density and biomass data are denoted D and B respectively. Significant ANOSIM results are denoted * ($p<0.05$), ** ($p<0.001$).

1. Clarke, K. R. Non-parametric multivariate analyses of changes in community structure. *Australian Journal of Ecology* **18**, 117-143 (1993).

Supplementary Information 3

Supplementary information on the nursery role of mangroves: Mechanism of biomass enrichment for reef fish.

Background to size-frequency distributions: Size-frequency distributions are a widely-used method to infer ontogenetic shifts in habitat use within a population[1-3]. Although these methods do not constitute absolute proof of ontogenetic migration, they provide compelling evidence particularly when additional data on predation rates are available. We present data for *Haemulon sciurus* in Figure 2 of the published article which shows that mean size increases from seagrass to mangroves to patch reefs to forereefs. If individuals do not migrate between habitats, then the observed differences in size would most likely reflect differences in the intensity of predation among habitats. However, our data reveal that the biomass of predators on haemulids follows the same pattern as mean haemulid size, being lowest in seagrass and greatest on forereefs (ANOVA with multiple comparisons $p<0.05$). If haemulids were *not* moving between habitats as they grew larger, then an opposite trend in fish size would be expected (i.e. fish surviving to larger sizes where the biomass of predators is lowest). Further, it is difficult to conceive a situation where a high biomass of adult haemulids is supported by direct recruitment to the forereef when no sub-adult individuals were ever encountered in this habitat (Fig. 2 of published article).



We provide an illustrative schematic of the function of mangroves above. Ecosystem connectivity is stylised for *Haemulon sciurus* and *Scarus guacamaia* although other scarid, haemulid and lutjanid species also exhibited similar ontogenetic shifts in habitat use. It is not clear why some species undertake ontogenetic migrations from lagoon to forereef but various workers have hypothesized a need for different food sources[4] which are more abundant on forereefs, that larger fish outgrow the shelter offered by nursery habitats[5,6] or that greater access to ocean currents helps to disperse larvae after reproduction[7]. *H. sciurus* show a substantial shift in size frequency from seagrass (A) to mangroves at approximately 6 cm (Fig. 2 of published article). This preference for seagrass is corroborated by studies of diet in juveniles. Workers in Curaçao found that 63.5% of the stomach contents of juvenile *H. sciurus* comprised Tanaidacea, which were mainly found in the zooplankton and sediment of seagrass beds rather than mangroves[8]. On reaching a given size in seagrass beds, juvenile fish then move to mangroves (B) which serve as an intermediate nursery habitat before migrating to patch reefs (C). If mangrove is not present, *H. sciurus* move directly from seagrass to patch reefs, appearing on patch reefs (G) at a smaller size and at lower density (260 ha^{-1} compared to 3925 ha^{-1} in mangrove-rich systems). In the presence of mangroves, the biomass of *H. sciurus* is significantly enhanced on patch reefs, shallow forereefs and *Montastraea* reefs (C, D, E). *S. guacamaia* (F) has a functional dependency on mangroves and is not seen where mangroves are absent.

1. Appeldoorn, R. S. Ontogenetic changes in natural mortality rate of queen conch, *Strombus gigas* (Mollusca: Mesogastropoda). *Bulletin of Marine Science* **42**, 159-165 (1988).

2. Appeldoorn, R. S., Recksiek, C. W., Hill, R. L., Pagan, F. E. & Dennis, G. D. Marine protected areas and reef fish movements: The role of habitat in controlling ontogenetic migration. *Proceedings of the 8th International Coral Reef Symposium* **2**, 1917-1922 (1997).

3. de la Morinere, E. C., Pollux, B. J. A., Soppe, W., Nagelkerken, I. & van der Velde, G. Spatial size distribution of Caribbean coral reef fishes in the mangrove-seagrass-reef continuum: Stability and the relation with environmental conditions. *Estuaries*, (in press) (2003).

4. Parrish, J. D. & Zimmerman, R. J. Utilization of fishes of space and food resources on an offshore Puerto Rican coral reef and its surroundings. *Proc. 3rd International Coral Reef Symposium* **1**, 297-303 (1977).

5. Shulman, M. J. Recruitment of coral reef fishes: Effects of distribution of predators and shelter. *Ecology* **66**, 1056-1066 (1985).

6. Rooker, J. R. & Dennis, G. D. Diel, lunar and seasonal changes in a mangrove fish assemblage off southwestern Puerto Rico. *Bulletin of Marine Science* **49**, 684-698 (1991).

7. de la Morinere, E. C. 168 (Katholieke Universiteit Nijmegen, Amsterdam, 2002).

8. de la Morinere, E. C., Pollux, B. J. A., Nagelkerken, I. & van der Velde, G. Diet shifts of Caribbean grunts (haemulidae) and snappers (Lutjanidae) and the relation with nursery-to-coral reef migrations. *Estuarine Coastal and Shelf Science* **57**, 1079-1089 (2003).

Supplementary Information 4

Supplementary information on rates of encounter of Scarus guacamaia *juveniles and adults*

Statistical framework for *S. guacamaia*: Observations of uncommon species cannot be analysed using conventional statistical methods, so we used an alternative method, which derives its power from the number of observations, rather than fish densities. If we assume that the number of sightings occurring during an observation period (1 hour) has a Poisson distribution, analysis of the rates of observations is straightforward using Bayesian methods. Assuming a standard 'reference' or uninformative prior for each rate, then the 95% highest posterior density intervals for the rates (in sightings per observation period) are as follows: juveniles in mangrove (0.0428, 0.1858), juveniles in seagrass (0, 0.00923), juveniles on coral reefs (0, 0.00200). There are clearly large differences between rates in mangrove and in the other two habitats. Similarly, 95% highest posterior density intervals for observations of adults on reefs near rich mangrove are (0.0253, 0.0866) versus only (0, 0.00256) in areas of scarce mangrove. This can be confirmed in a classical framework by fitting a Poisson log-linear model and testing for the effect of habitat and mangrove using Analysis of Deviance (equivalent to Analysis of Variance in a normal linear model). There is overwhelming evidence that the rate of juvenile sightings is greatest in mangrove and adult sightings are greatest in mangrove-rich systems (in both cases $p<10^{-5}$, chi-squared analysis of deviance test). These conclusions are robust to assumptions made about the distribution of the number of sightings. For example, if we reduce the data to presence/absence in each observation period (discarding a little information in the process), to allow a binomial model to be fitted, then the conclusion that mangrove extent has an effect still holds in both cases.

Rates of encounter for *Scarus guacamaia*

<table>
<tr><th colspan="6">Juveniles</th></tr>
<tr><td colspan="2">Mangroves</td><td colspan="2">Seagrass</td><td colspan="2">Coral reefs</td></tr>
<tr><td colspan="2">8 in 77 h</td><td colspan="2">0 in 209 h</td><td colspan="2">0 in 962 h</td></tr>
<tr><td colspan="2">0.043 to 0.186 h^{-1}</td><td colspan="2">0.000 to 0.009 h^{-1}</td><td colspan="2">0.000 to 0.002 h^{-1}</td></tr>
<tr><th colspan="6">Adults</th></tr>
<tr><td colspan="3">Mangrove-rich system reefs</td><td colspan="3">Mangrove-scarce system reefs</td></tr>
<tr><td colspan="3">11 in 212 h</td><td colspan="3">0 in 750 h</td></tr>
<tr><td colspan="3">0.025 to 0.087 h^{-1}</td><td colspan="3">0.000 to 0.003 h^{-1}</td></tr>
</table>

More than 700 hours of surveys have been undertaken at Glovers Reef since 1998 with ca 75% of the atoll rim being represented in sampling designs. While all surveys occurred in adult *S. guacamaia* habitat, none were ever observed.

Supplementary Information 5

Supplementary information on the biomass of scarids: Proportion of total scarid biomass represented by a single individual of S. guacamaia

We have quantified the territory size of other Caribbean parrotfishes in previous work[1] and estimate the size of adult *S. guacamaia* territories to be approximately 200 m × 50 m (P.J. Mumby, pers. obs.). Maximum size of *S. guacamaia* is 120 cm, but we used a more conservative adult size of 85 cm in the estimation of biomass. Biomass of a single adult *S. guacamaia* was estimated using length-weight relationships[2], giving 12.6 kg. The total biomass of other parrotfishes was calculated as the overall mean biomass of all scarids from all study sites in the *Montastraea* habitat, and then re-scaled to the size of a *S. guacamaia* territory (ca 120 kg). Therefore, a single *S. guacamaia* constitutes *ca* 10% of the entire biomass of parrotfishes within its territory on a *Montastraea* reef in the Mesoamerican reef system.

1. Mumby, P. J. & Wabnitz, C. C. C. Spatial patterns of aggression, territory size, and harem size in five sympatric Caribbean parrotfish species. *Environmental Biology of Fishes* **63**, 265-279 (2002).
2. Bohnsack, J. A. & Harper, D. E. *Length-weight relationships of selected marine reef fishes from the southeastern United States and the Caribbean* (NOAA Technical Memorandum NMFS-SEFC-215, 1988).