# Diversification insulates fisher catch and revenue in heavily exploited tropical fisheries

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## Supplementary Figures

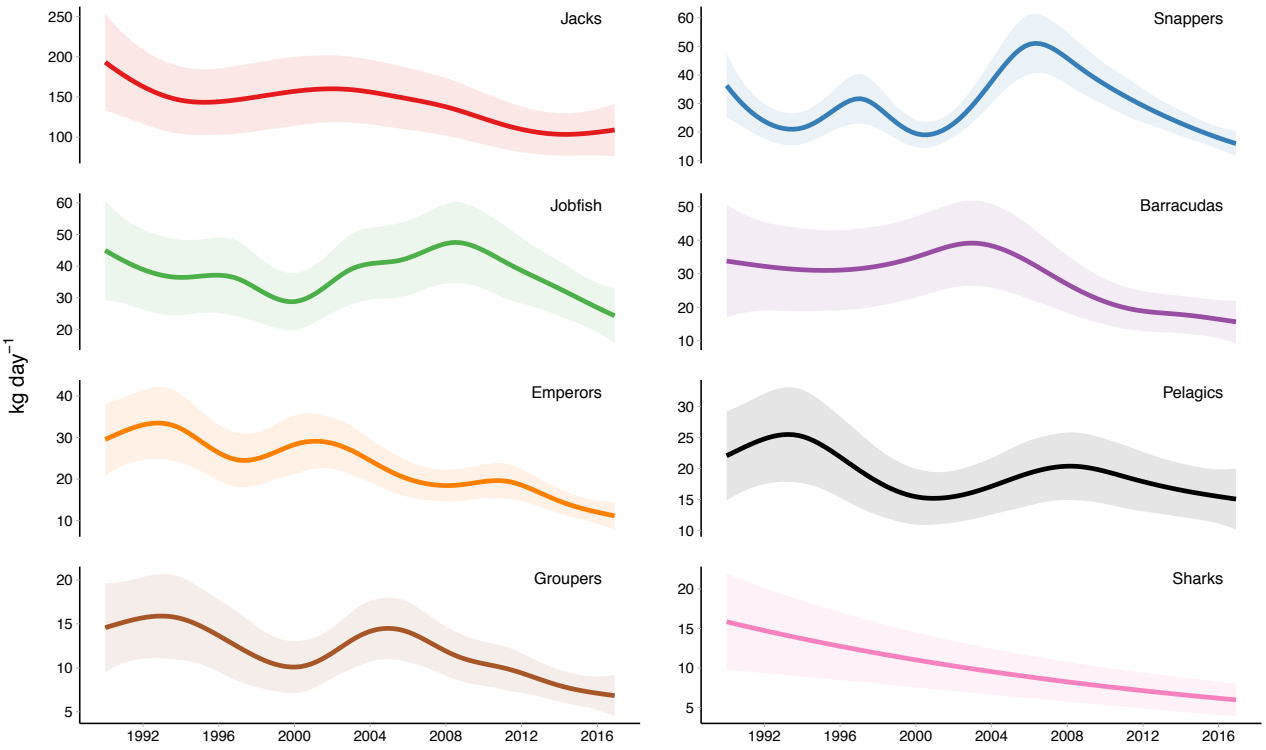


**Fig. S1 | Change in CPUE from 1990-2016 for 8 species groups.** Lines are predicted GAM temporal smooths fitted to each species group, excluding seasonal, oceanographic and vessel effects and shaded with 2 standard errors.

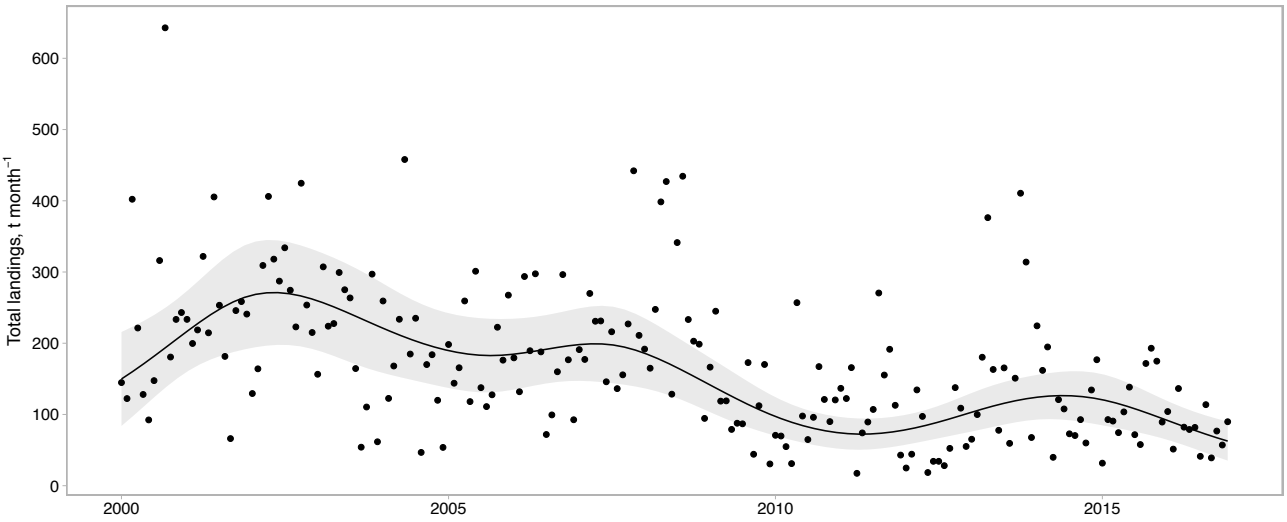


**Fig. S2 | Total landed weight from offshore fisheries over 2000-2016.** Points are monthly total landed weight (tonnes), which were fitted to the general additive model $landedweight_i = \alpha + f(monthyear_i) + f(month_i) + f(ENSO_i) + f(DMI_i)$ with Gamma-distibuted errors. Line is the predicted temporal smooth excluding seasonal, oceanographic and vessel effects, ± 2 SEM. Landings estimates were unavailable before 2000.

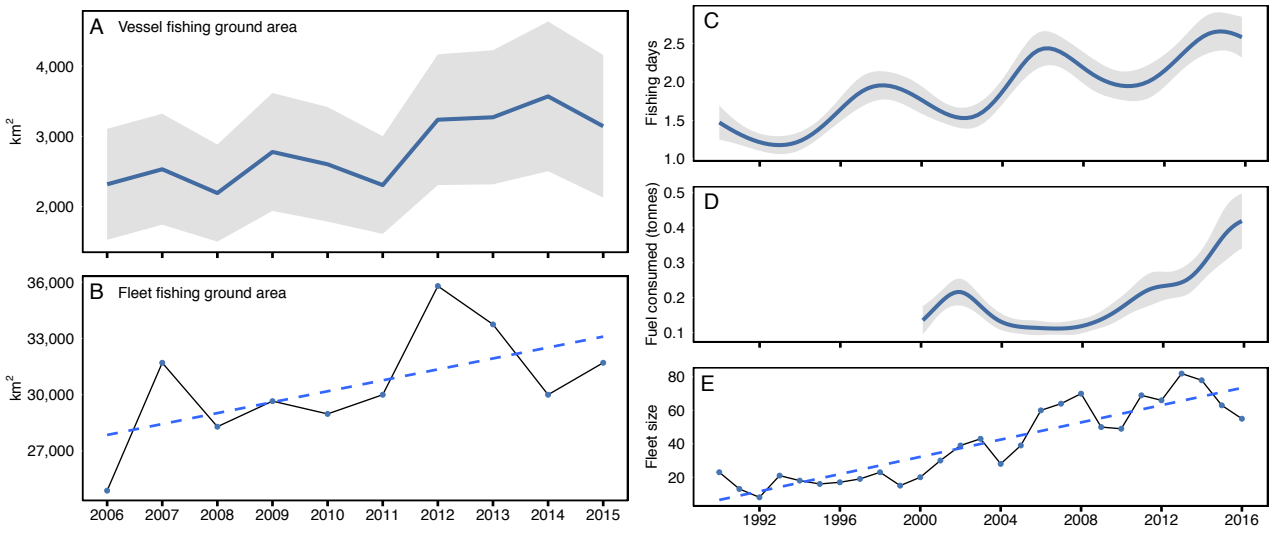


**Fig. S3 | Fishing grounds of the focal fleet (2006-2015) and effort of the full fleet (1992-2016).** Total area of fishing grounds covered by individual vessels (A) and by the entire focal fleet (B), from VMS data where fishing activity was defined as boats moving $<$ 2 knots and points within 1 km of coastlines were excluded (i.e. vessels in port or fishing shallow coastal habitats). For the full fleet, average fishing days (C) and fuel consumption (D) per fishing trip, and number of active fishing vessels in each year (E). Smoothed lines are predicted GAM temporal trends fitted to fishing trip data in A,C and D, excluding seasonal, oceanographic, and vessel effects ($\pm$ 2 SEM). Dashed lines are linear regression fits fitted to annual data in B and E. Fuel consumption data were only available from 2000.

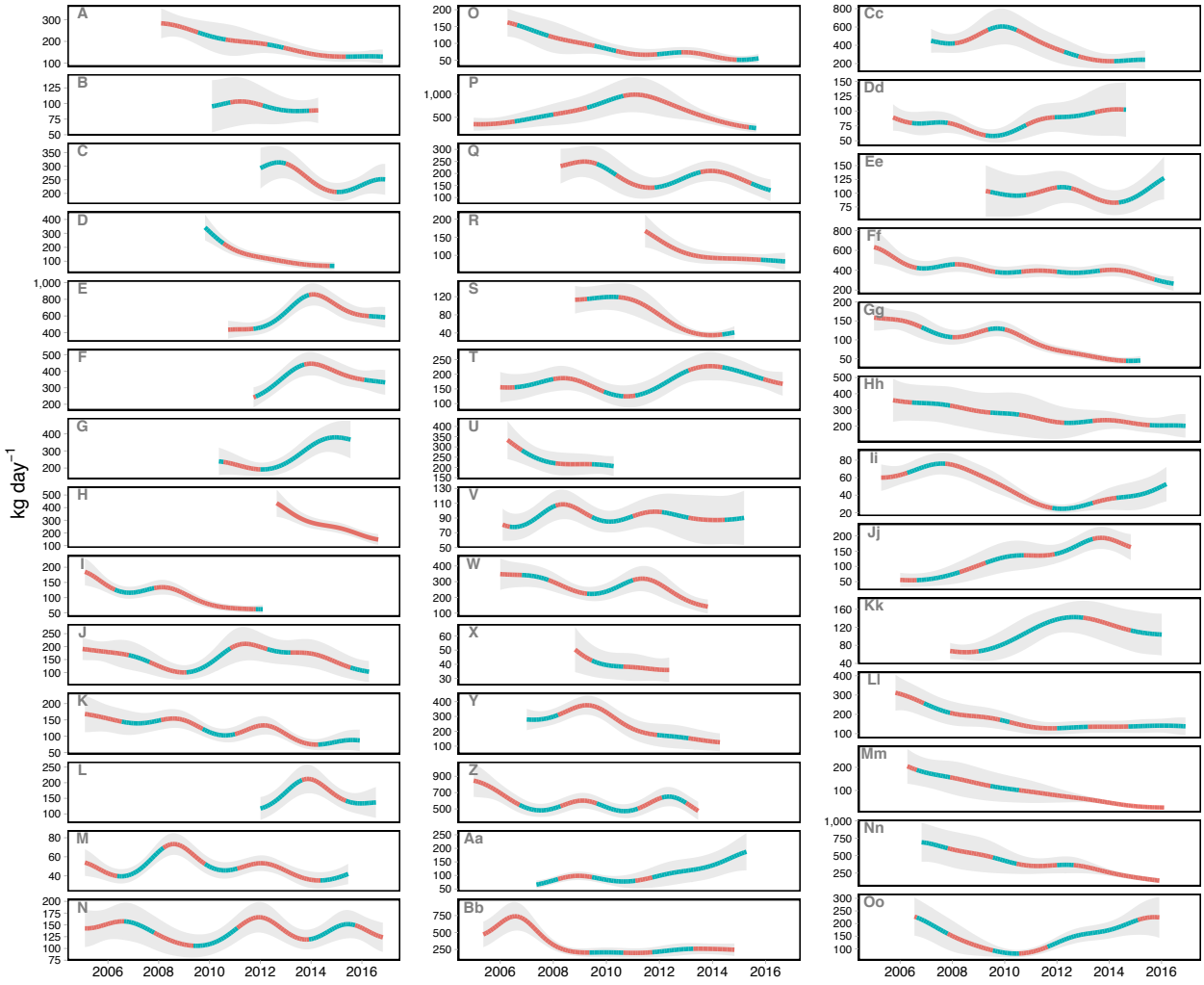


**Fig. S4 | Vessel catch trends for the 41 vessels in the focal fleet over 2005-2016.** Panels show temporal trends in CPUE for each focal vessel (± 2 SEM), coloured by trend direction (blue = increasing, red = decreasing). Lines are random-slope GAM predictions (i.e. each unique vessel), excluding seasonal and oceanographic effects. Estimates for vessels which were not surveyed at the start or end of the time series are excluded.

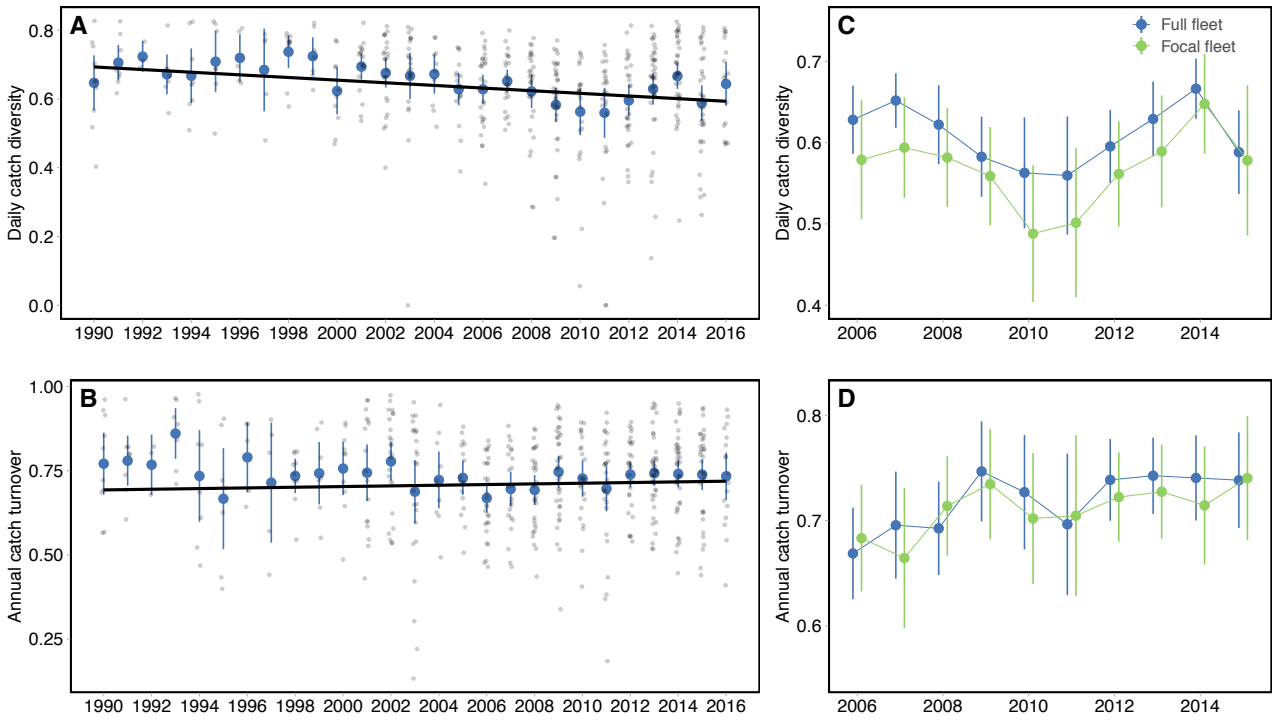


**Fig. S5 | Catch diversification from 1990-2016, for full fleet (A,B) and focal fleet (C,D).** Annual estimates of catch diversity (A,C) and catch turnover (B,D) for each vessel in each year (grey points, jittered), overlaid with mean estimates ± 2 SEM.

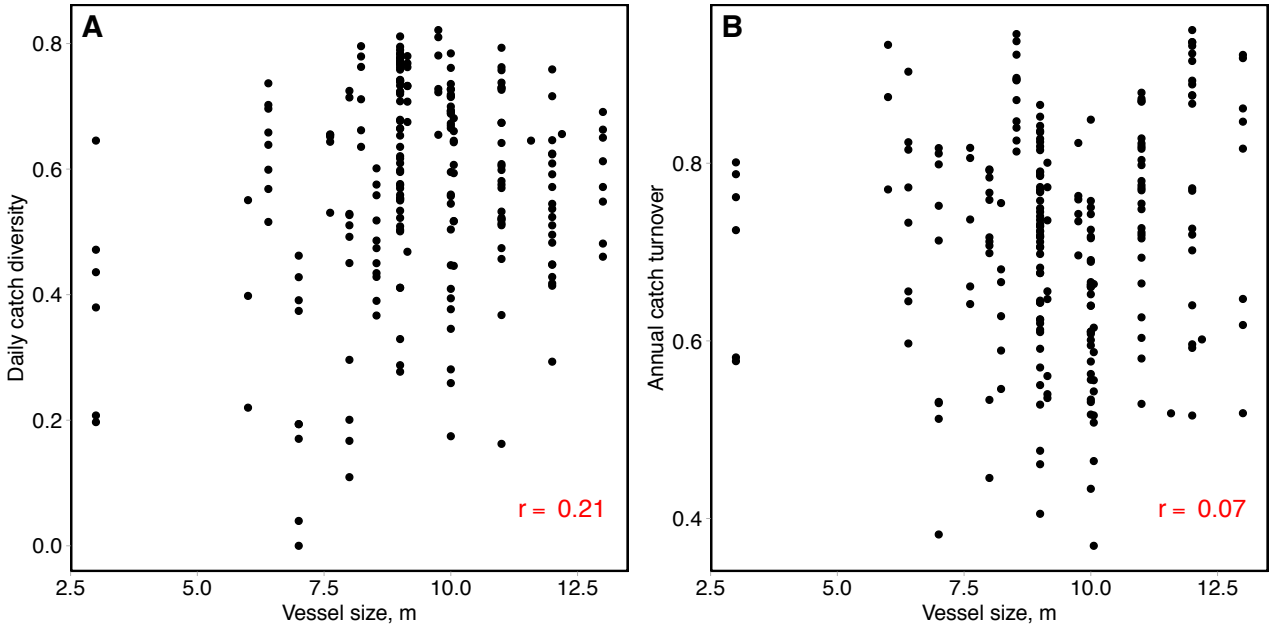


**Fig. S6 | Catch diversification according to boat length.** Points are individual vessels in the focal fleet, where each point represents average catch diversity (A) and turnover in catch composition (B) from 2006-2015. Panels annotated with Pearson correlation values.

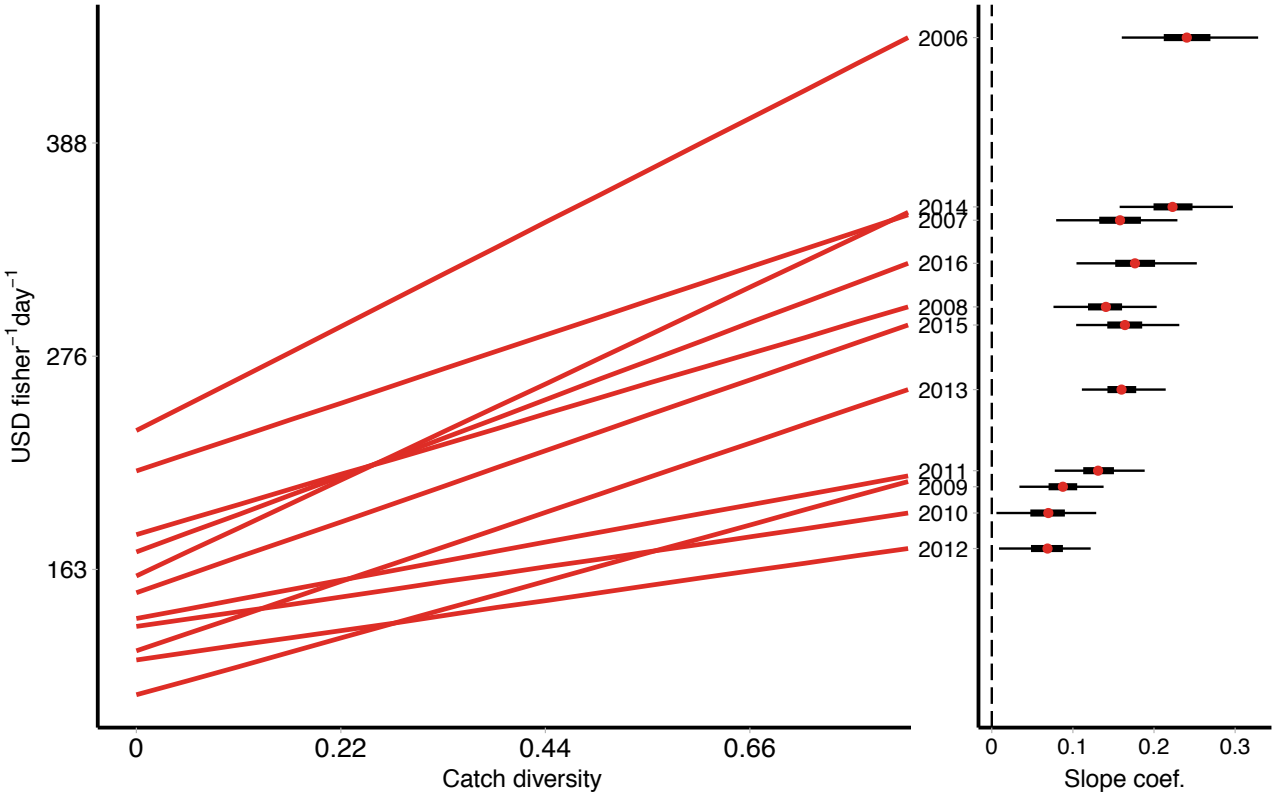


**Fig. S7 | Effect of catch diversity on daily fishing revenue (USD fisher$^{-1}$ day$^{-1}$) across years.** Lines are posterior median of revenue across the range of catch diversity, for each year in 2006-2015. Points are posterior medians (±50% and 95% CI) of 'year' slope coefficients. See main text Fig. 4A for catch diversity relationship excluding year effects, and Fig. 4C for corresponding trends in revenue corrected by catch weight (USD kg$^{-1}$ fisher$^{-1}$ day$^{-1}$).

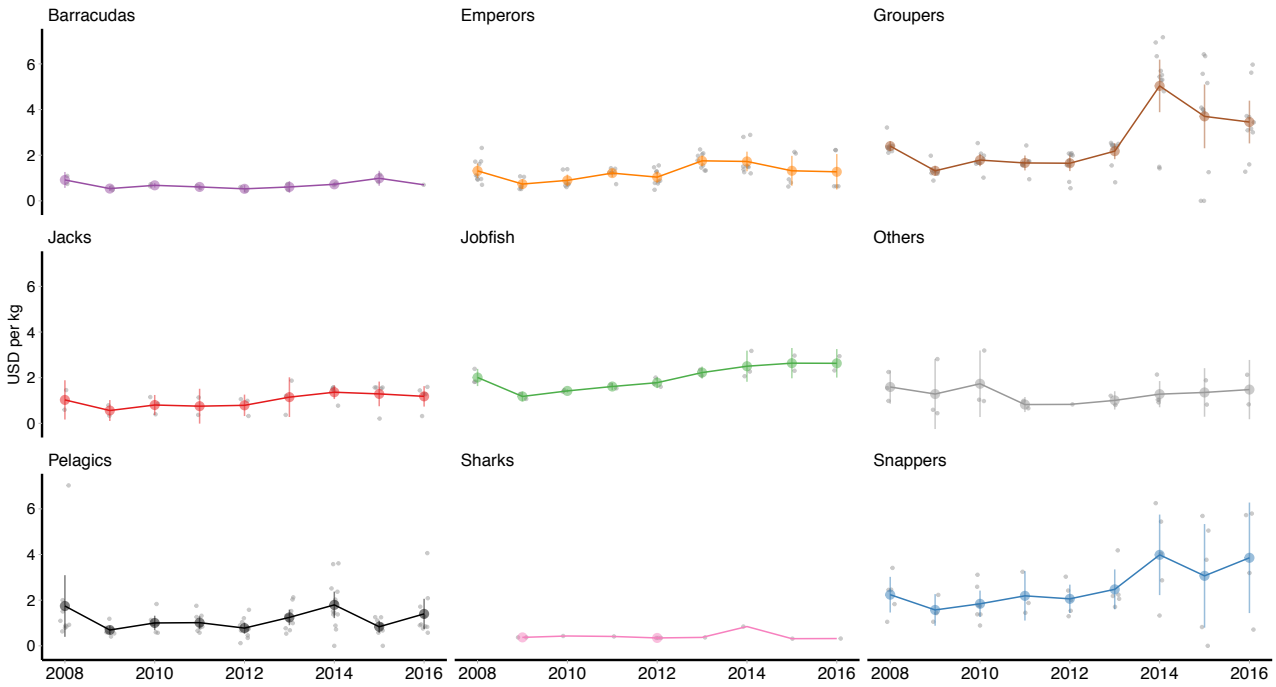


**Fig. S8 | Market value of each target group for 2008-2016 (USD per kg)** Coloured points are mean estimates ± 2 SEM, overlaid with individual fish purchases as jittered grey points.

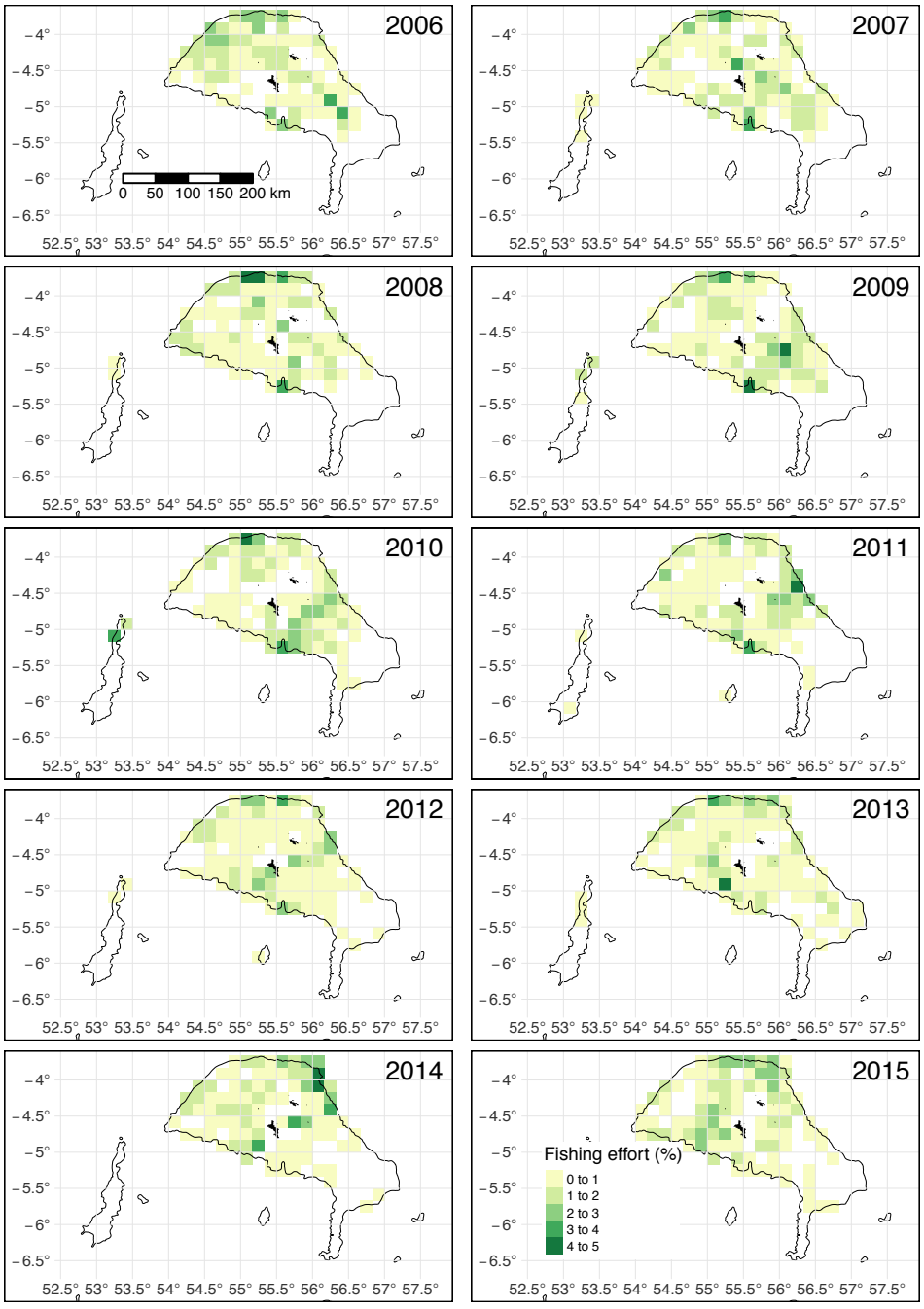


**Fig. S9 | Spatial movement and fishing grounds of focal fleet from 2006-2015.** From VMS data of the focal fleet, fishing activity was defined as boats moving $< 2$ knots and points within 1 km of coastlines were excluded (i.e. vessels in port or fishing shallow coastal habitats). Fishing effort is shaded, representing the proportional fishing activity (%) in a 10-minute grid for the core fishing grounds (90% of cumulative fishing activity).

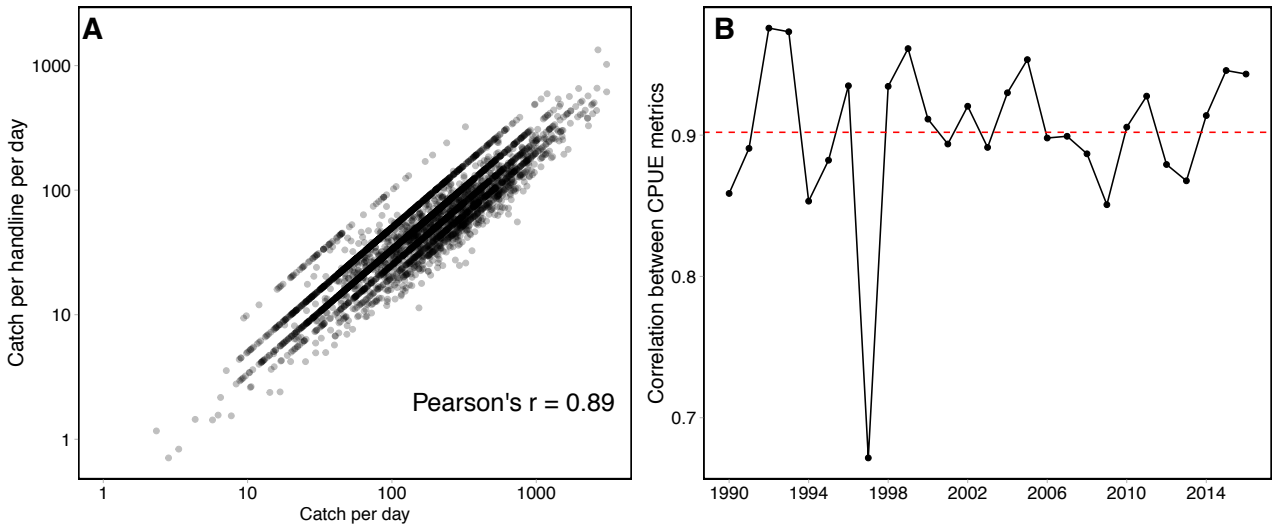


**Fig. S10 | Correlation between CPUE metrics.** Mean monthly catch rates for individual vessels for kg day$^{-1}$ and kg line$^{-1}$ day$^{-1}$, plotted on a $\log_{10}$ scale and annotated with Pearson correlation $r$ (A). From the same data, Pearson correlations between CPUE metrics are shown for each survey year, with red line indicating mean correlation across all years (B).

| Species group | Families | Species | N | MT in 2016 |
|---|---|---|---|---|
| Jacks | *Carangidae* | *Carangoides gymnostethus, Alectis indicus, Carangoides chrysophrys, Carangoides fulvoguttatus, Carangoides malabaricus, Caranx ignobilis, Caranx melampygus, Caranx sexfasciatus, Elagatis bipinnulata, Gnathanodon speciosus, Seriola rivoliana* | 11 | 434 |
| Pelagics | *Scombridae, Istiophoridae, Coryphaenidae* | *Acanthocybium solandri, Euthynnus affinis, Istiophorus platypterus, Katsuwonus pelamis, Thunnus albacares, Coryphaena hippurus, Sarda orientalis, Tetrapturus audax, Makaira indica, Makaira mazara, Gymnosarda unicolor* | 11 | 52.3 |
| Barracuda | *Sphyraenidae* | *Sphyraena bleekeri, Sphyraena forsteri, Sphyraena jello, Sphyraena obtusata* | 4 | 53 |
| Others | *Balistidae, Gerreidae, Lutjanidae, Clupeidae, Lethrinidae, Nemipteridae, Scaridae, Siganidae* | *Abalistes stellatus, Etelis carbunculus, Etelis marshi, Geres oyena, Herklotsichthys punctatus, Herklotsichthys quadrimaculatus, Lethrinus harak, Lutjanus fulviflama, Macolor niger, Sardinella melanura, Scolopsis frenatus, Siganus sp., Scarus sp.* | +14 | 7.2 |
| Snappers | *Lutjanidae* | *Lutjanus bohar Lutjanus coccineus, Lujtanus sebae* | 3 | 157 |
| Jobfish | *Lutjanidae* | *Aphareus rutilans, Aprion virescens, Pristipomoides filamentosus* | 3 | 162 |
| Groupers | *Serranidae* | *Epinephelus chlorostigma, Cephalopholis argus, Cephalopholis miniata, Cephalopholis sonnerati, Epinephelus fasciatus, Epinephelus faveatus, Epinephelus flavocaeruleus, Epinephelus macrospilos, Epinephelus morruha, Epinephelus multinotatus, Epinephelus polyphekadion, Epinephelus tukula, Plectropomus laevis, Plectropomus maculatus, Plectropomus punctatus, Variola louti, Anyperodon leucogrammicus* | 17 | 36.6 |
| Emperors | *Lethrinidae* | *Gymnocranius griseus, Gymnocranius robinsoni, Lethrinus conchyliatus, Lethrinus crocineus, Lethrinus elongatus, Lethrinus lentjan, Lethrinus mahsena, Lethrinus nebulosus, Lethrinus olivaceus, Lethrinus variegatus* | 16 | 49.3 |
| Elasmobranchs | *Carcharhinidae*, *Myliobatidae*, *Ginglymostomatidae*, *Dasyatidae*, *Lamnidae*, *Rhinobatidae*, *Sphyrnidae* | *Aetobatus narinari, Carcharhinus albimarginatus, Carcharhinus amblyrhnchos, Carcharhinus brevipinna, Carcharhinus longimanus, Carcharhinus melanopterus, Carcharhinus miliberti, Carcharhinus sorrah, Carcharhinus tjujot, Galeocerdo cuvieri, Ginglymostoma brevicaudatum, Ginglymostoma ferrugineum, Hamantura uarnak, Isurus Oxyrinchus, Loxodon macrorhinus, Manta birostris, Rhinobatos blochi, Rhynchobatus djiddensis, Sphyrna lewini, Sphyrna zygaena, Taeniura lymma, Taeniura melanospilos* | 22 | 7.25 |

**Table S1** Species caught in Seychelles' offshore small-scale fisheries, categorised into groups of closely-related species, or species that share similar habitats (i.e. the fisheries analysed). MT in 2016 from SFA annual report (33).

| Model | Response covariate(s) | Parameter | Model prior | Main text equation |
|---|---|---|---|---|
| *Focal fleet CPUE* | *kg day$^{-1}$* | $\alpha$ | *Normal*(0, 10) | *[5,6]* |
| | | $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8, \beta_9$ | *Normal*(0, 10) | |
| | | $\alpha_{vessel[i]}$ | *Normal*(0, $\sigma_{vessel}$) | |
| | | $\alpha_{year[i]}$ | *Normal*(0, $\sigma_{year}$) | |
| | | $\sigma_{vessel}$ | *Cauchy*(0, 2) | |
| | | $\sigma_{yr}$ | *Cauchy*(0, 2) | |
| | | $k$ | *Exp*(2) | |
| *Full fleet CPUE* | *kg day$^{-1}$* | $\alpha$ | *Normal*(5.1, 10) | *[6,7]* |
| | | $\beta_{10}, \beta_{11}, \beta_{12}, \beta_{13}$ | *Normal*(0, 10) | |
| | | $\alpha_{vessel[i]}$ | *Cauchy*(0, 2) | |
| | | $k$ | *Exp*(2) | |
| *Revenue* | *USD fisher$^{-1}$ day$^{-1}$* *USD kg$^{-1}$ fisher$^{-1}$ day$^{-1}$* | $\alpha$, $\beta$ | *Normal*(0, 5) | *[8,9]* |
| | | $\alpha_{vessel[i]}$ | *Normal*(0, $\sigma_{yr}$) | |
| | | $\begin{bmatrix}\alpha_{yr} \\ \beta_{yr}\end{bmatrix}$ | *Multivariate Normal*(0, S) $\boldsymbol{S_c} = \begin{bmatrix} \phi^2_{\alpha_{yr}} & \cdots & \phi_{\alpha_c}\phi_{\beta_{yr}}\rho \\ \vdots & \ddots & \vdots \\ \phi_{\alpha_c}\phi_{\beta_{yr}}\rho & \cdots & \phi^2_{\beta_{yr}} \end{bmatrix}$ | |
| | | $\phi, \sigma, \sigma_{yr}$ | *Student t* (5, 0, 3) | |
| | | $\rho$ | *LKJcorr*(2) | |
| | | $\eta$ | *Gamma*(2, 0.1) | |

**Table S2** Prior distributions for Bayesian models.