Elasmobranch diversity around the southern Caribbean island of Tobago: opportunities for conservation in a regional trade hub

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SUPPLEMENTARY MATERIAL

Table S1 Residual diagnostics returned by the R package ‘DHARMa’ (Hartig, 2020) to validate GLM model selection used to investigate the association between environmental variables and MaxN observations of 1) all sharks, 2) sharks excluding nurse sharks, 3) large sharks, 4) small sharks, 5) Caribbean reef sharks, 6) nurse sharks, 7) all rays, and 8) southern stingrays on baited remote underwater video stations in Tobago. Error family for each response variable is shown in brackets (NB = negative binomial, P = Poisson).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Response variable | KS test | Dispersion test | Outlier test | Residual vs predicted |
| All sharks (NB) | 0.97 | 0.74 | 1 | No significant problems |
| Sharks excluding nurse sharks (NB) | 0.83 | 0.9 | 1 | No significant problems |
| Large sharks (P) | 0.27 | 0.99 | 1 | No significant problems |
| Small sharks (NB) | 0.72 | 0.99 | 1 | No significant problems |
| Caribbean reef (P) | 0.69 | 0.1 | 0.44 | No significant problems |
| Nurse (NB) | 0.97 | 0.99 | 1 | No significant problems |
| All rays (NB) | 0.77 | 0.93 | 0.7 | No significant problems |
| Southern stingrays (P) | 0.12 | 0.51 | 1 | No significant problems |

Table S2 Top models (∆AIC < 2) retained for model averaging to investigate the association between environmental variables and MaxN observations of 1) all sharks, 2) sharks excluding nurse sharks, 3) large sharks, 4) small sharks, 5) Caribbean reef sharks, 6) nurse sharks, 7) all rays, and 8) southern stingrays on baited remote underwater video stations in Tobago.

|  |  |  |  |
| --- | --- | --- | --- |
|  | df | ∆AIC | weight |
| **Response = All sharks** |
| mean relief + season | 4 | 0.00 | 0.11 |
| mean relief + season + year | 4 | 0.00 | 0.11 |
| mean relief | 3 | 0.07 | 0.10 |
| mean relief + year | 3 | 0.07 | 0.10 |
| temp + mean relief | 4 | 0.51 | 0.08 |
| temp + mean relief + year | 4 | 0.51 | 0.08 |
| depth + mean relief | 4 | 1.21 | 0.06 |
| depth + mean relief + year | 4 | 1.21 | 0.06 |
| depth + mean relief + season | 5 | 1.40 | 0.05 |
| depth + mean relief + season + year | 5 | 1.40 | 0.05 |
| temp + mean relief + season | 5 | 1.48 | 0.05 |
| temp + mean relief + season + year | 5 | 1.48 | 0.05 |
| depth + temp + mean relief  | 5 | 1.61 | 0.05 |
| depth + temp + mean relief + year | 5 | 1.61 | 0.05 |
| **Response = Sharks excluding nurse sharks** |
| depth + mean relief + season | 5 | 0.00 | 0.28 |
| depth + mean relief + season + year | 5 | 0.00 | 0.28 |
| depth + temp + mean relief + season | 6 | 1.62 | 0.12 |
| depth + temp + mean relief + season + year  | 6 | 1.62 | 0.12 |
| depth + temp + mean relief | 5 | 2.00 | 0.10 |
| depth + temp + mean relief + year  | 5 | 2.00 | 0.10 |
| **Response = Large sharks**  |
| mean relief | 2 | 0.00 | 0.23 |
| mean relief + year | 2 | 0.00 | 0.23 |
| temp + mean relief | 3 | 0.83 | 0.15 |
| temp + mean relief + year | 3 | 0.83 | 0.15 |
| depth + mean relief | 3 | 1.50 | 0.11 |
| depth + mean relief + year | 3 | 1.50 | 0.11 |
| **Response = Small sharks** |
| depth + season  | 4 | 0.00 | 0.19 |
| depth + season + year  | 4 | 0.00 | 0.19 |
| depth + mean relief + season | 5 | 0.50 | 0.15 |
| depth + mean relief + season + year | 5 | 0.50 | 0.15 |
| season  | 3 | 1.51 | 0.09 |
| season + year | 3 | 1.51 | 0.09 |
| depth | 3 | 1.88 | 0.07 |
| depth + year  | 3 | 1.88 | 0.07 |
| **Response = Caribbean reef sharks** |
| mean relief + season | 3 | 0.00 | 0.19 |
| mean relief + season + year | 3 | 0.00 | 0.19 |
| mean relief | 2 | 0.53 | 0.15 |
| mean relief + year | 2 | 0.53 | 0.15 |
| (Null) | 1 | 1.52 | 0.09 |
| year | 1 | 1.52 | 0.09 |
| depth + mean relief + season | 4 | 1.80 | 0.08 |
| depth + mean relief + season + year | 4 | 1.80 | 0.08 |
| **Response = Nurse sharks** |
| depth + mean relief | 4 | 0.00 | 0.25 |
| depth + mean relief + year | 4 | 0.00 | 0.25 |
| mean relief | 3 | 0.80 | 0.16 |
| mean relief + year | 3 | 0.80 | 0.16 |
| depth + temp + mean relief | 5 | 1.99 | 0.09 |
| depth + temp + mean relief + year | 5 | 1.99 | 0.09 |
| **Response = Rays** |
| depth  | 3 | 0.00 | 0.16 |
| depth + year | 3 | 0.00 | 0.16 |
| depth + mean relief | 4 | 0.02 | 0.16 |
| depth + mean relief + year | 4 | 0.02 | 0.16 |
| depth + season  | 4 | 1.78 | 0.06 |
| depth + season + year  | 4 | 1.78 | 0.06 |
| depth + temp | 4 | 1.86 | 0.06 |
| depth + temp + year | 4 | 1.86 | 0.06 |
| depth + temp + mean relief | 5 | 1.88 | 0.06 |
| depth + temp + mean relief + year | 5 | 1.88 | 0.06 |
| **Response = Stingrays** |
| depth + mean relief | 4 | 0.00 | 0.37 |
| depth + mean relief + year | 4 | 0.00 | 0.37 |
| depth + temp + mean relief | 5 | 1.99 | 0.13 |
| depth + temp + mean relief + year | 5 | 1.99 | 0.13 |

Table S3 Model-averaged coefficients for top models (∆AIC < 2) predicting the association between environmental variables and MaxN observations of 1) all sharks, 2) sharks excluding nurse sharks, 3) large sharks, 4) small sharks, 5) Caribbean reef sharks, 6) nurse sharks, 7) all rays, and 8) southern stingrays on baited remote underwater video stations in Tobago.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | z value | Pr(>|z|) |
| **Response = All sharks MaxN** |
| Intercept  | -0.72 | 2.65 | 0.27 | 0.79 |
| Mean relief  | 0.65 | 0.18 | 3.64 | < 0.001 |
| Season  | -0.21 | 0.35 | 0.61 | 0.54 |
| Depth  | -0.05 | 0.09 | 0.5 | 0.61 |
| Temperature  | 0.01 | 0.01 | 0.43 | 0.67 |
| **Response = Sharks Excluding Nurse Sharks MaxN** |
| Intercept | -1.25 | 3.71 | 0.34 | 0.74 |
| Depth  | 0.06 | 0.03 | 2.16 | < 0.05 |
| Mean relief  | 0.57 | 0.24 | 2.40 | < 0.05 |
| Season  | -0.78 | 0.61 | 1.27 | 0.20 |
| Temperature  | -0.08 | 0.14 | 0.54 | 0.59 |
| **Response = Large Sharks MaxN** |
| Intercept | -7.4 x 10-1 | 5.8 | 0.13 | 0.90 |
| Mean relief  | -1.4 x 102 | 3.9 x 104 | < 0.01 | 1.00 |
| Temperature  | -1.06 x 10-1 | 2.2 x 10-1 | 0.49 | 0.63 |
| Depth  | 9.2 x 10-3 | 3.2 x 10-2 | 0.29 | 0.78 |
| **Response = Small Sharks MaxN** |
| Intercept | -4.2 | 1.44 | 2.89 | < 0.01 |
| Depth  | 0.06 | 0.05 | 1.32 | 0.19 |
| Season  | -1.63 | 1.21 | 1.34 | 0.18 |
| Mean relief  | 0.14 | 0.28 | 0.48 | 0.63 |
| **Response = Caribbean reef sharks MaxN** |
| Intercept | -3.26 | 0.68 | 4.78 | < 0.001 |
| Mean relief  | 0.52 | 0.39 | 1.33 | 0.18 |
| Season  | -0.61 | 0.78 | 0.78 | 0.44 |
| Depth | -0.003 | 0.02 | 0.19 | 0.85 |
| **Response = Nurse sharks MaxN** |
| Intercept | -2.88 | 2.03 | 1.41 | 0.16 |
| Depth | -0.03 | 0.04 | 0.98 | 0.33 |
| Mean relief  | 1.09 | 0.29 | 3.74 | < 0.001 |
| Temperature  | -0.01 | 0.07 | 0.15 | 0.88 |
| **Response = All rays MaxN** |
| Intercept | -0.55 | 1.86 | 0.29 | 0.77 |
| Depth  | -0.07 | 0.02 | 3.98 | < 0.001 |
| Mean relief  | -0.09 | 0.15 | 0.63 | 0.53 |
| Season | -0.02 | 0.12 | 0.18 | 0.86 |
| Temperature | 0.02 | 0.07 | 0.22 | 0.82 |
| **Response = Southern stingrays MaxN** |
| Intercept | -0.47 | 2.04 | 0.23 | 0.82 |
| Depth  | -0.07 | 0.02 | 3.84 | < 0.001 |
| Mean relief  | -0.36 | 0.18 | 1.93 | 0.05 |
| Temperature  | 0.01 | 0.07 | 0.18 | 0.86 |

Table S4 Analysis of deviance tables for the best predictive model (∆AIC = 0) for the association between environmental variables and MaxN observations of 1) all sharks, 2) sharks excluding nurse sharks, 3) large sharks, 4) small sharks, 5) Caribbean reef sharks, 6) nurse sharks, 7) all rays, and 8) southern stingrays on baited remote underwater video stations in Tobago.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | df | Deviance | Residual df | Residual Deviance | Pr(>Chi) | % deviance explained |
| **Response = all sharks MaxN** |  |
| NULL  |  |  | 170 | 116.06 |  |  |
| mean relief  | 1 | 13.84 | 169 | 102.22 | ***< 0.001*** | 11.9 |
| season  | 1 | 2.18 | 168 | 100.04 | 0.14 | 1.88 |
| Total deviance explained | 13.78 % |
| **Response = Sharks excluding nurse MaxN** |  |
| NULL  |  |  | 170 | 79.54 |  |  |
| depth  | 1 | 3.30 | 169 | 76.24 | 0.07 | 4.15 |
| mean relief  | 1 | 4.06 | 168 | 72.18 | *< 0.05* | 5.10 |
| season  | 1 | 4.20 | 167 | 67.98 | *< 0.05* | 5.28 |
| Total deviance explained | 14.53 % |
| **Response = large sharks MaxN** |  |
| NULL  |  |  | 170 | 24.26 |  |  |
| mean relief  | 1 | 4.41 | 169 | 19.85 | *< 0.05* | 18.18 |
| Total deviance explained | 18.18 % |
| **Response = small sharks MaxN** |  |
| NULL  |  |  | 170 | 48.99 |  |  |
| depth  | 1 | 5.35 | 169 | 43.64 | *< 0.05* | 10.92 |
| season  | 1 | 3.98 | 168 | 39.66 | *< 0.05* | 8.12 |
| Total deviance explained | 19.04 % |
| **Response = Caribbean reef sharks MaxN** |  |
| NULL  |  |  | 170 | 59.59 |  |  |
| mean relief | 1 | 3.04 | 169 | 56.55 | 0.08 | 5.1 |
| season  | 1 | 2.6 | 168 | 53.95 | 0.11 | 4.4 |
| Total deviance explained | 9.5 % |
| **Response = nurse sharks MaxN** |  |
| NULL  |  |  | 170 | 81.60 |  |  |
| depth | 1 | 2.82 | 169 | 78.78 | 0.09 | 3.46 |
| mean relief  | 1 | 19.47 | 168 | 59.32 | ***< 0.001*** | 23.86 |
| Total deviance explained | 27.32 % |
| **Response = all rays MaxN** |  |
| NULL  |  |  | 170 | 139.07 |  |  |
| depth  | 1 | 18.38 | 169 | 120.70 | ***< 0.001*** | 13.22 |
| Total deviance explained | 13.22 % |
| **Response = southern stingrays MaxN** |  |
| NULL  |  |  | 170 | 127.42 |  |  |
| depth  | 1 | 17.28 | 169 | 110.14 | ***< 0.001*** | 13.56 |
| mean relief  | 1 | 4.22 | 168 | 105.91 | *< 0.05* | 3.31 |
| Total deviance explained | 16.87 % |