1 Methods for standardized indices of abundance

1.1 Stock definition for CPUE analysis

Porbeagle not found in north so removed hemi Mako + blue south and north stocks (see Clarke 2011... or other refs)

1.2 Procedure for model selection

Variable name	Symbol	Explanation	% records prese
Year	β_Y	Require to estimate year effect	100
Month	β_M	Captures seasonal variability	100
Observer program	β_O	Country hosting the observer program	100
Vessel flag	β_F	Note: correlated with observer program	100
Hooks-beween-floats	β_{HBF}	Indicator of catchability for surface-dwelling species	
Shark bait			
Number of shark lines			
Lighsticks			
Shark target		Sharks explicitly defined as targets?	
SST	SST	Moon frac	

1.2.1 Note on interactions between year and observer program

1.3 Notes on the use of error distributions

Error distributions for by-catch species have been discussed at length in previous publications as these data are notoriously hard to model properly due to the high proportion of zeroes (**?**). We achieved significant improvements in model diagnostics by allowing multiple parameters in the error distribution to be fit. This is because often accounting for the large amount of zeroes in shark CPUE catch data comes at the expense of modelling large catch events, since the dispersion is assumed to be constant for all factors. This is especially a problem when the mean of the distribution is close to zero or one, as in those instances the probability of getting large events if mostly controlled by the dispersion parameter (unlike when the mean is larger and the tail is not as pronounced). However, whenever conditions are good for sharks or targeting takes place, larger catch events can happen and not modelling them properly means we are missing important drivers. Typically, this can seen as a bump in the right-hand side of qqnorm plots.

Because flag and observer programs are highly correlated, we used observer program as an explanatory categorical variable as it tended to explain a higher proportion of the data when used on its own than flag. We also explored adding an interaction between year and

observer program, as for some species of less mobile sharks we could expect to see local trends in annual abundance that are reflected in the observer program data. We checked for the relevance of including interactions early in the model selection process, and proceeded with an interaction for the remaining of the model selection if the AIC score when interactions are allowed is at least 50 lower than with additive effects only.

Hooks-between-floats on its own explains little variation, probably because it only matters when looked at within specific levels of other factors (see Fig ... – panel observers).

1.4 Model diagnostics

Used quantile residuals.

Table 1: AIC improvement over null model for mako.south from a single explanatory variable

Variable	AIC.diff	AIC.diff.sigma
program_code	1693.97	251.6
flag_id	1438.39	—
HPBCAT2	1202.23	79.45
HPBCAT	1127.42	34.67
yy	875.66	389.5
mm	733.11	178.28
sharkbait	8.37	-1.89

Table 2: AIC improvement over null model for mako.north from a single explanatory variable

Variable	AIC.diff	AIC.diff.sigma
HPBCAT2	6433.14	642.33
HPBCAT	6417.24	640.61
mm	2845.80	216.50
yy	2216.05	401.91
flag_id	115.74	61.51
program_code	114.17	44.28
sharkbait	15.46	3.29

Table 3: AIC improvement over null model for blue from a single explanatory variable

Variable	AIC.diff	AIC.diff.sigma
program_code	24382.47	16607.68
flag_id	23711.29	17163.94
HPBCAT2	20183.28	5765.59
HPBCAT	20178.74	5576.42
yy	14357.75	8612.54
mm	3725.06	2511.55
sharkbait	994.97	454.07

Table 4: AIC improvement over null model for ocs from a single explanatory variable

Variable	AIC.diff	AIC.diff.sigma
yy	3726.21	958.91
program_code	2781.62	1369.09
flag_id	1499.89	772.13
sharkbait	887.50	103.91
HPBCAT2	308.22	1656.57
HPBCAT	256.09	1658.57
mm	143.92	185.56

Table 5: AIC improvement over null model for silky from a single explanatory variable

Variable	AIC.diff	AIC.diff.sigma
program_code	10913.31	6886.75
flag_id	10144.24	5446.47
sharkbait	5382.46	1713.24
yy	4986.96	3273.31
HPBCAT2	1639.75	4527.65
HPBCAT	1628.44	4513.75
mm	957.50	358.96