Supplementary Material

Relative impacts of simultaneous stressors on a pelagic marine ecosystem

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1 Supplementary Table 1

Supplementary Table 1 Interaction matrix. Values represent the proportion of appropriately sized prey of a given species that are available to predators of a given species. The table is broken for ease of presentation.

		Prey					
		Bigeye Tuna	**Mahi Mahi**	**Blue Shark**	**Skipjack Tuna**	**Yellowfin Tuna**	**Albacore Tuna**
Predator	**Bigeye Tuna**	1	0.17	0.5102041	0.6	0.5	0.8333333
	Mahi Mahi	0.17	1	0.08673469	0.28333333	0.34	0.14166667
	Blue Shark	0.5102041	0.08673469	1	0.30612245	0.25510204	0.61224490
	Skipjack Tuna	0.6	0.28333333	0.30612245	1	0.83333333	0.5
	Yellowfin Tuna	0.5	0.34	0.25510204	0.83333333	1	0.4166667
	Albacore Tuna	0.8333333	0.14166667	0.61224490	0.5	0.4166667	1
	Striped Marlin	0.4	0.425	0.20408163	0.66666667	0.8	0.33333333
	Wahoo	0.04	0.23529412	0.02040816	0.06666667	0.08	0.03333333
	Swordfish	0.4166667	0.07083333	0.81666667	0.25	0.2083333	0.5
	Blue Marlin	0.4	0.425	0.20408163	0.66666667	0.8	0.33333333
	Lancetfish	0.4166667	0.07083333	0.81666667	0.25	0.2083333	0.5
	Opah	0.7	0.04117647	0.35714286	0.59523810	0.4571429	0.58333333

		Prey					
		Striped Marlin	**Wahoo**	**Swordfish**	**Blue Marlin**	**Lancetfish**	**Opah**
Predator	**Bigeye Tuna**	0.4	0.04	0.4166667	0.4	0.4166667	0.7
	Mahi Mahi	0.425	0.23529412	0.07083333	0.425	0.07083333	0.04117647
	Blue Shark	0.20408163	0.02040816	0.81666667	0.20408163	0.81666667	0.35714286
	Skipjack Tuna	0.66666667	0.06666667	0.25	0.66666667	0.25	0.59523810
	Yellowfin Tuna	0.8	0.08	0.2083333	0.8	0.2083333	0.4571429
	Albacore Tuna	0.33333333	0.03333333	0.5	0.33333333	0.5	0.58333333
	Striped Marlin	1	0.1	0.1666667	1	0.1666667	0.3214286
	Wahoo	0.1	1	0.01666667	0.1	0.01666667	0
	Swordfish	0.1666667	0.01666667	1	0.16666667	1	0.29166667
	Blue Marlin	1	0.1	0.16666667	1	0.1666667	0.3214286
	Lancetfish	0.1666667	0.01666667	1	0.1666667	1	0.29166667
	Opah	0.3214286	0	0.29166667	0.3214286	0.29166667	1

2 Supplementary Table 2

Supplementary Table 2 Plankton size classes. Plankton classes available from each CMIP5 model used and their size ranges, as determined from the literature. Sizes are given in equivalent spherical diameter (ESD) measured in µm. The primary reference for each CMIP5 model is noted next to the model's name. References used to determine plankton size classes are listed in the right-most column.

Earth System Model	Phytoplankton	Zooplankton	References
NOAA Geophysical Fluid Dynamics Laboratory Earth System Model Generalized ocean layer dynamics[a] (GFDL-ESM2G)	picophytoplankton: 0.2 – 2 miscellaneous phytoplankton: 2 – 5 diatoms, diazotrophs: 5 – 200	zooplankton 2 – 500	a, b, c
NOAA Geophysical Fluid Dynamics Laboratory Earth System Model Modular Ocean Model 4[a] (GFDL-ESM2M)			
NASA Goddard Institute for Space Studies ModelE2 Earth System Model with carbon cycle coupled to the Russell ocean model[d, e] (GISS-E2-R-CC)	picophytoplankton: 0.2 – 2 calcareous, miscellaneous phytoplankton: 2 – 20 diatoms, diazotrophs: 2 – 500	zooplankton 2 – 500	f, g, h, i, j
Institut Pierre-Simon Laplace Low Resolution CM5A[k] (IPSL-CM5A-LR)	miscellaneous phytoplankton: 2 – 20 diatoms: 20 – 200	microzooplankton: 2 – 20 mesozooplankton: 20 – 500	k, l, m
Institut Pierre-Simon Laplace Medium resolution CM5A[k] (IPSL-CM5A-MR)			
Max-Planck-Institute für Meteorologie Earth System Model low resolution[n] (MPI-ESM-LR)	phytoplankton 0.2 – 200	zooplankton 2 – 500	o
Max-Planck-Institute für Meteorologie Earth System Model medium resolution[n] (MPI-ESM-MR)			
Meteorological Research Institute Earth System Model Version 1[p] (MRI-ESM1)	phytoplankton 0.2 – 200	zooplankton 2 – 500	p

[a]Dunne et al., 2013
[b]Dunne et al., 2005
[c]Dunne et al., 2012
[d]Romanou et al., 2014
[e]Schmidt et al., 2014
[f]Gregg and Casey, 2007
[g]Bricaud and Morel, 1986
[h]Bricaud et al., 1983

[i]Ahn et al., 1992
[j]Sathyendranath et al., 1987
[k]Dufresne et al., 2013
[l]Aumont and Bopp, 2006
[m]Séférian et al., 2012
[n]Giorgetta et al., 2013
[o]Ilyina et al., 2013
[p]Yukimoto et al., 2011

3 Supplementary Table 3

Supplementary Table 3. Length-weight conversions. Lengths (*l*) are converted to weights following the standard exponential equation $W = aL^b$. References for both *a* and *b* values are indicated in the column for *b*. For length-weight conversion, lengths are in cm and weights in kg for all species except wahoo where lengths are in mm. Billfish lengths are eye-fork lengths. Shark lengths are precaudal lengths. All other lengths are fork lengths.

Species	l_{min}	l_{mat}	l_{max}	***a***	***b***
Albacore tuna (*Thunnus alalunga*)	-	90[d]	-	*	*
Bigeye tuna (*Thunnus obesus*)	-	107.8[e]	-	3.66×10^{-5}	2.90182[p]
Bigeye thresher shark (*Alopias superciliosus*)	68[a]	154[a]	195[a]	9.11×10^{-6}	3.0802[a]
Blue marlin (*Makaira nigricans*)	-	179.46[f]	-	-	-
Male	-	-	-	1.37×10^{-5}	2.975[f]
Female	-	-	-	1.84×10^{-5}	2.956[f]
Blue shark (*Prionace glauca*)	36[b]	-	-	-	-
Male	-	161[b]	225[b]	3.29×10^{-6}	3.225[b]
Female	-	156.6[b]	207[b]	5.39×10^{-6}	3.102[b]
Lancetfish (*Alepisaurus ferox*)	-	35[g]	168[n]	6.01×10^{-6}	2.78949[p]
Mahi mahi (*Coryphaena hippurus*)	-	-	-	-	-
Male	-	50.57[h]	-	8.09×10^{-6}	3.0157[q]
Female	-	48.38[h]	-	1.07×10^{-5}	2.9337[q]
Opah (*Lampris guttatus*)	-	80[t]	-	**	**
Shortfin mako shark (*Isurus oxyrinchus*)	60[c]	277.5[c]	321[c]	1.67×10^{-5}	2.847[c]
Skipjack tuna (*Katsuwonus pelamis*)	-	40[i]	-	7.65×10^{-6}	3.24281[p]
Striped marlin (*Kajikia audax*)	-	177[j]	-	4.68×10^{-6}	3.16[j]
Swordfish (*Xiphiaus gladius*)	-	-	-	1.37×10^{-5}	3.04[r]
Male	-	102[k]	208.9[o]	-	-
Female	-	144[k]	230.5[o]	-	-
Wahoo	-	104.6[l]	-	8.77×10^{-10}	3.28[s]

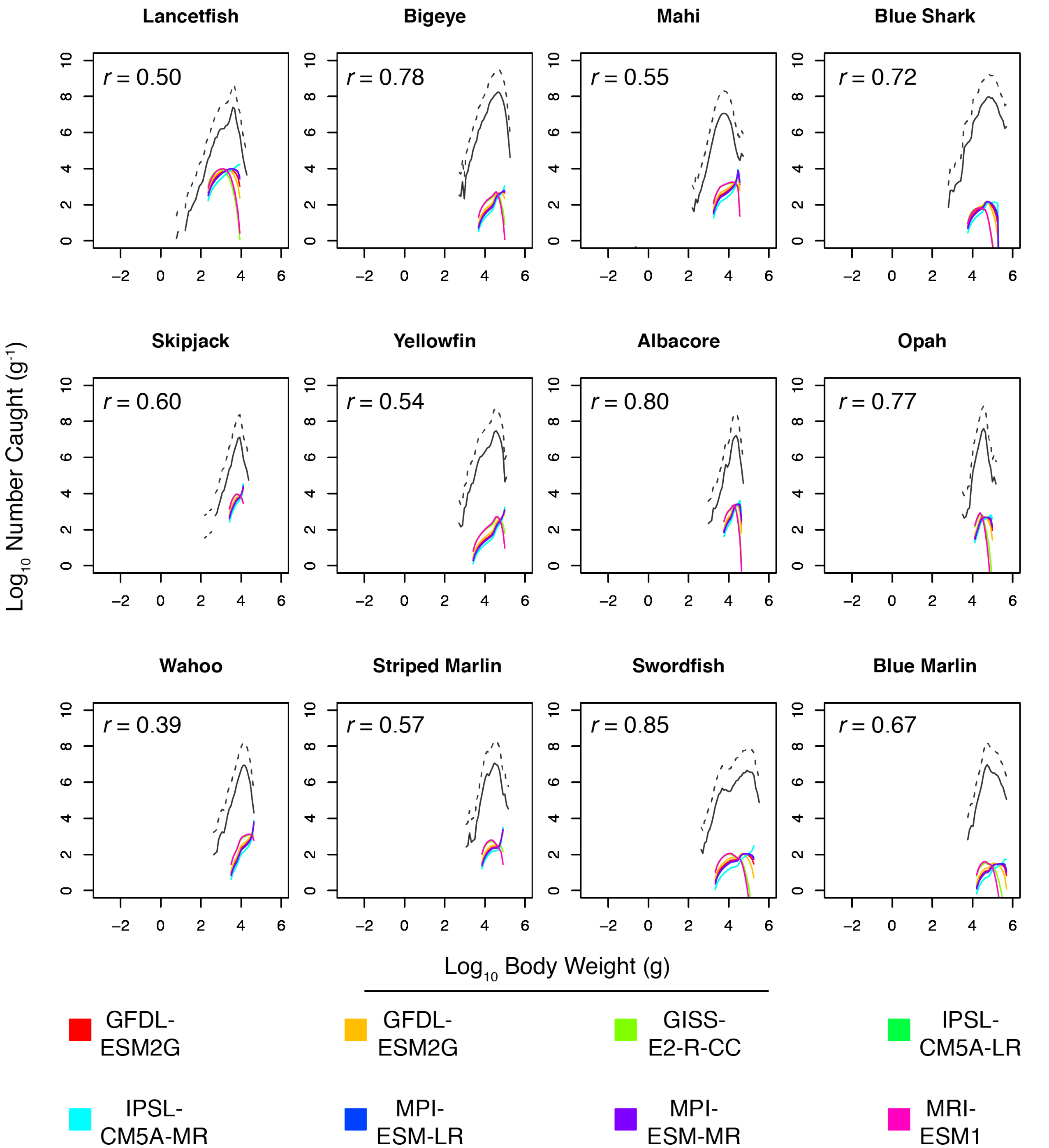
(*Acanthocybium solandri*)					
Yellowfin tuna (*Thunnus albacares*)	-	115[m]	-	3.17×10^{-5}	2.88938[p]

*Albacore lengths are converted using Uchiyama and Kazama (2003)'s equation: $W = 6.16388 - 0.323931(L) + 0.00600216(L)^{1.94647}$

** Opah lengths were converted using Sundberg and Underkoffler (2011)'s equations: $\ln(W_{female}) = 2.5815 \times \ln(L_{female}) - 8.3379$ and $\ln(W_{male}) = 2.5692 \times \ln(L_{male}) - 8.2368$

[a]Young et al., 2016
[b]Shark Working Group Report, 2017
[c]Froese and Pauly, 2017 and Boettiger et al., 2012
[d]Billfish Working Group Report, 2014a
[e]Nicol et al., 2011
[f]Billfish Working Group Report, 2016
[g]Estimated: the average size between adult and "small" lancetfish in Gibbs, 1960
[h]Alejo-Plata et al., 2011
[i]Rice et al., 2014
[j]Billfish Working Group Report, 2015
[k]DiMartini et al., 2000
[l]Zischke et al., 2013a
[m]Itano, 2000
[n]Portner et al., 2017
[o]DeMartini et al., 2007
[p]Uchiyama and Kazama, 2003
[q]Uchiyama and Boggs, 2004
[r]Billfish Working Group, 2014b
[s]Zischke et al., 2013b
[t]Francis et al., 2004

4 Supplementary Figure 1



Supplementary Figure 1 Modeled (color) and observed (black) catch size spectra. The solid line is the observed abundance. The dashed line is scaled to represent the full catch. Observed catch is scaled by dividing by 0.06 (On average, 20% of the fishery is observed and observers measure every third fish). The average Pearson correlation coefficient, *r*, across CMIP5 models is noted for each species.

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