The following supplement accompanies the article

Modeling trophic interactions to assess the effects of a marine protected area: case study in the NW Mediterranean Sea

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Supplement. Additional Data

Table S1. Detailed species names of fish groups included in the Port-Cros MPA Ecopath model, a '+' indicating the presence of secondary species. Dusky grouper were split into 3 subgroups: small, medium and large. Small juveniles feed mainly on fish; medium adults, mainly on crabs and cephalopods; and large adults, mainly on cephalopods (Harmelin & Harmelin-Vivien 1999, Linde et al. 2004). Salema were separated into small individuals (<15 cm total length) and adults, as small salema feed mainly on shallow seaweeds, while adults also feed on *Posidonia oceanica* (Verlaque 1990)

Group name	Species name
Rays	*Raja* spp.
Dusky grouper	*Epinephelus marginatus*
Amberjack+	*Seriola dumerili*, *Conger conger*, *Lophius piscatorius*, *Dicentrarchus labrax*, *Muraena helena*, *Scyliorhinus canicula*, *Dentex dentex*, *Sphyraena viridensis*
Red scorpionfish+	*Phycis phycis*, *Labrus merula*, *Labrus viridis*, *Sciaena umbra*, *Scorpaena scrofa*, *Pagrus pagrus*, *Zeus faber*
Scorpionfishes+	*Scorpaena notata*, *Scorpaena porcus*, *Serranus cabrilla*, *Serranus hepatus*, *Serranus scriba*, *Synodus saurus*
Surmullet+	*Arnoglossus laterna*, *Bothus podas*, *Gaidropsarus mediterraneus*, *Gaidropsarus vulgaris*, *Trisopterus* spp., *Mullus surmuletus*, *Ophisurus serpens*, *Ophidion rochei*, *Parophidion vassali*
Pipefishes+	*Apogon imberbis*, *Apletodon dentatus*, *Diplecogaster bimaculata*, *Lepadogaster candolei*, *Opeatogenys gracilis*, *Hippocampus* spp., *Nerophis maculatus*, *Syngnathus acus*, *Syngnathus typhle*, *Tripterygion* spp.
Wrasses	*Coris julis*, *Symphodus cinereus*, *Symphodus doderleini*, *Symphodus mediterraneus*, *Symphodus melanocercus*, *Symphodus ocellatus*, *Symphodus roissali*, *Symphodus rostratus*, *Symphodus tinca*, *Thalassoma pavo*
Gobies	*Deltentosteus colonianus*, *Deltentosteus quadrimaculatus*, *Gobius auratus*, *Gobius cruentatus*, *Gobius fallax*, *Gobius geniporus*, *Gobius paganellus*, *Gobius vittatus*, *Pomatoschistus minutus*, *Pomatoschistus quagga*, *Thorogobius ephippiatus*, *Thorogobius macrolepis*
Pagellus	*Pagellus* spp.
Diplodus+	*Diplodus puntazzo*, *Diplodus sargus*, *Diplodus vulgaris*, *Lithognathus mormyrus*, *Sparus aurata*, *Spondyliosoma cantharus*
Blennies+	*Blennius ocellaris*, *Diplodus annularis*, *Parablennius gattorugine*, *Parablennius rouxi*
Horse mackerels+	*Atherina* spp., *Trachurus* spp., *Spicara maena*, *Spicara smaris*, *Chromis chromis*, *Anthias anthias*, *Boops boops*, *Oblada melanura*
Mullets	*Mugilidae*
Salema	*Sarpa salpa*

Table S2. Input data and references by species for the fish groups in the Port-Cros MPA Ecopath model. Parameters are: landings (*Y*, t km^{-2} yr^{-1}) (from Cadiou & Bonhomme 2006), biomass in habitat area (*b*, t km^{-2} yr^{-1}), types of habitat (T: total area of the Port-Cros MPA; H: hard bottoms; S: soft bottoms; P: Posidonia beds), % of habitat—percentage of the surface of the Port-Cros MPA area occupied by the type of habitat designed [each species was assigned habitat preferences among hard bottoms (shallow rocky bottoms and deep rocky bottoms called coralligenous bottoms), soft bottoms (sandy and muddy bottoms), and seagrass meadows (mainly Posidonia beds)] (from Belsher et al. 2005), biomass in the total area of the Port-Cros MPA (*B*, t km^{-2}·yr^{-1}), with maximal biomass values in each group in **bold**. Biomasses of ontogenic groups (dusky grouper and salema) were recalculated by Ecopath, as the stages are linked in the model, and their respective *B*, *Q/B*, and growth values are calculated from a baseline estimate for adults. Detailed references by species (ref.) are given for the biomass *b* and for the diet compositions *DC* (see references list)

Group name	Species name	*Y*	*b*	*b ref.*	Habitat Type	Habitat %	*B*	*DC* ref.
Rays	*Raja spp.*	0.003	-	-	-	-	-	29
Dusky grouper	*Epinephelus marginatus*	-	4.994	17	T	100%	**4.994**	19, 25
Amberjack +	*Seriola dumerili*	0.002	2.700	18	T	100%	**2.700**	1
	Conger conger	0.010	0.116	13, 24, 31	H	7%	0.008	24
	Lophius piscatorius	0.003	0.300	10	S+H	70%	0.210	15
	Dicentrarchus labrax		0.580	11	H+P	37%	0.215	8
	Muraena helena	0.010	4.096	13, 35	H	7%	0.287	15
	Scyliorhinus canicula		0.017	24	H+P	37%	0.006	27
	Dentex dentex	0.004	5.426	13, 35	H+P	37%	**2.008**	28
	Sphyraena viridensis		0.116	10	T	100%	0.116	2
Red scorpionfish +	*Phycis phycis*	0.014	0.060	13	H	7%	0.004	39
	Labrus merula	0.012	0.237	12, 13, 24	H+P	37%	0.088	3
	Labrus viridis							24
	Sciaena umbra	0.002	0.604	18, 21	H	7%	0.042	39
	Scorpaena scrofa	0.047	4.033	13, 24, 35	H	7%	**0.282**	24
	Pagrus pagrus	0.002	0.080	13	H+P	37%	0.030	7
	Zeus faber	0.002	0.045	10	T	100%	0.045	3
Scorpionfishes +	*Scorpaena notata*	0.012	6.552	24, 35	H+P	37%	**2.424**	24
	Scorpaena porcus		0.954	13, 24	H+P	37%	0.353	24
	Serranus cabrilla		3.829	12, 13, 24, 35	H+P	37%	**1.417**	24
	Serranus hepatus	0.019	0.003	24	S	63%	0.002	3
	Serranus scriba		0.193	12, 13, 24	H+P	37%	0.072	24
	Synodus saurus		0.041	24	S	63%	0.026	24
Surmullet +	*Arnoglossus laterna*		0.001	24	S	63%	0.001	24
	Bothus podas		0.015	24	S	63%	0.010	24
	Gaidropsarus mediterraneus		0.058	24	H	7%	0.004	24
	Gaidropsarus vulgaris		0.075	24	H	7%	0.005	24
	Trisopterus spp.		0.014	13	H	7%	0.001	16, 30
	Mullus surmuletus	0.030	0.185	13, 24, 31	S	63%	**0.117**	24
	Ophisurus serpens		0.100	10	S	63%	0.063	-
	Ophidion rochei		0.002	24	S	63%	0.002	24
	Parophidion vassali		0.053	24	S	63%	0.033	24
Pipefishes +	*Apogon imberbis*		0.033	13, 35	H	7%	0.002	39
	Apletodon dentatus		0.001	24	H+P	37%	0.005	24
	Diplecogaster bimaculata		0.000	24	H+P	37%	0.000	24
	Lepadogaster candolei		0.004	24	H+P	37%	0.001	24
	Opeatogenys gracilis		0.000	24	P	30%	0.000	24
	Hippocampus spp.		0.006	24	P	30%	0.002	24
	Nerophis maculatus		0.006	24	P	30%	0.002	24
	Syngnathus acus		0.030	24	P	30%	**0.009**	24
	Syngnathus typhle		0.008	24	P	30%	0.002	24
	Tripterygion spp.		0.024	13, 24	H	7%	0.002	24
Wrasses	*Coris julis*		4.336	12, 13, 24, 35	T	100%	**4.336**	24
	Symphodus cinereus		0.044	12, 24	S	63%	0.028	24
	Symphodus doderleini		0.003	13, 24	H+P	37%	0.001	24
	Symphodus mediterraneus	0.019	0.094	12, 13, 24, 35	H+P	37%	0.035	24
	Symphodus melanocercus		0.038	12, 13, 24	H+P	37%	0.014	24
	Symphodus ocellatus		0.383	12, 13, 24	H+P	37%	0.142	24

	Symphodus roissali		0.009	12, 13, 24	H+P	37%	0.003	24
	Symphodus rostratus		0.084	12, 13, 24	H+P	37%	0.031	24
	Symphodus tinca		1.091	12, 13, 24	H+P	37%	0.404	24
	Thalassoma pavo		0.124	22	H+P	37%	0.046	9
Gobies	*Deltentosteus colonianus*		0.022	24	T	100%	0.022	24
	Deltentosteus quadrimaculatus		0.000	24	T	100%	0.000	3
	Gobius auratus		0.113	13	T	100%	**0.113**	39
	Gobius cruentatus		0.013	24	T	100%	0.013	24
	Gobius fallax		0.013	24	T	100%	0.013	24
	Gobius geniporus		0.033	24	T	100%	0.033	24
	Gobius paganellus		0.024	24	T	100%	0.024	24
	Gobius vittatus		0.146	13	T	100%	**0.146**	24
	Pomatoschistus minutus		0.002	24	T	100%	0.002	24
	Pomatoschistus quagga		0.000	24	T	100%	0.000	24
	Thorogobius ephippiatus		0.055	35	T	100%	0.055	15
	Thorogobius macrolepis		0.007	13	T	100%	0.007	-
Pagellus	*Pagellus spp.*	0.003	-	-	-	-	-	34
Diplodus +	*Diplodus puntazzo*		4.622	13, 35	H+P	37%	**1.710**	37
	Diplodus sargus	0.021	2.208	13	H+P	37%	0.817	37
	Diplodus vulgaris		0.054	13	H+P	37%	0.020	3
	Lithognathus mormyrus		0.030	10	S	63%	0.019	23
	Sparus aurata	0.001	1.602	11, 13, 35	S	63%	**1.009**	3
	Spondyliosoma cantharus	0.007	0.053	12, 13, 24	T	100%	0.053	24
Blennies +	*Blennius ocellaris*							24
	Parablennius gattorugine		0.120	13, 24, 35	H+P	37%	0.044	24
	Parablennius rouxi							39
	Diplodus annularis		0.282	12, 13, 24	H+P	37%	**0.104**	24
Horse mackerels +	*Atherina spp.*		75.000	10	H+P	37%	**27.750**	24
	Trachurus spp.		75.000	10	H+P	37%	**27.750**	38
	Spicara maena		0.565	13, 24, 35	H+P	37%	0.209	24
	Spicara smaris							24
	Chromis chromis		0.951	13, 24	H+P	37%	0.352	24
	Anthias anthias		24.988	13, 35	H	7%	1.749	15
	Boops boops	0.012	0.034	13	H+P	37%	0.012	3
	Oblada melanura		0.747	18	H+P	37%	0.276	39
Mullets	Mugilidae		4.502	10, 13	T	100%	**4.502**	4
Salema	*Sarpa salpa*	-	9.500	12	H+P	37%	**9.500**	42

Table S3. Input data and references for the other (non-fish) groups in the Port-Cros MPA Ecopath model. Parameters are biomass in habitat area (*b*, t km^{-2}yr^{-1}), dry weight (DW), wet weight (WW), dry to wet weight conversion ratio (WW/DW), types of habitat (T: total area of the Port-Cros MPA; H: hard bottoms; H deep: deep hard bottoms; S: soft bottoms; P: Posidonia beds), % of habitat—percentage of the surface of the Port-Cros MPA area occupied by the type of habitat designed [each species was assigned habitat preferences among hard bottoms (shallow rocky bottoms and deep rocky bottoms called coralligenous bottoms), soft bottoms (sandy and muddy bottoms), and seagrass meadows (mainly Posidonia beds)] (from Belsher et al. 2005), biomass in the total area of the Port-Cros MPA (*B*, t km^{-2}·yr^{-}), production/biomass (*P/B*, yr^{-1}), and consumption/biomass (*Q/B*, yr^{-1}). Detailed references (ref.) are given for the biomass *b* in DW, the *P/B* and the *Q/B* ratios (see references list)

Group name	*b* DW	*b* ref.	WW/DW	*b* WW	Habitat		*B*	Studied species for biomass data	*P/B* ref.	*Q/B* ref.
					Type	%				
Seabirds	-	5	-	-	-	-	0.290	*Calonectris diomedea, Larus michahellis, Puffinus yelkouan*	36	6[a]
Cephalopods	-	10	-	1	T	100%	1	*Octopus vulgaris*	6[a]	-
Crabs	2.5	41	3.9	9.75	H+P	37%	3.608	*Achaeus cranchii, Eurynome spinosa,* other Brachyura	32[a]	32
Decapods	-	-	-	-	-	-	-	-	32[a]	-
Bivalves	-	10	-	1	P+S	93%	0.930	*Pinna nobilis*	32[a]	32[a]
Gastropods	-	-	-	-	-	-	-	-	33	33
Sea stars	0.2	11	3.5	0.7	T	100%	0.700	*Marthasterias glacialis*	11	-
Brittle stars +	-	-	-	-	-	-	-	-	32[a]	32[a]
Sea urchins	33.3	11	3.1	103.23	H+P	37%	38.195	*Psammechinus microtuberculatus, Paracentrotus lividus*	11	-
Sea cucumbers	7.55	11	10.1	76.255	T	100%	76.255	*Holothuria tubulosa* & *Holothuria polii*	11	-
Sea worms	-	-	-	-	-	-	-	-	6[a]	6[a]
Supensivores	-	-	-	-	-	-	-	-	32[a]	32[a]
Gorgonians	257.5	20	4.5	1158.75	H deep	3.5%	40.556	*Paramuricea clavata*	32[a]	-
Small crustaceans	4.5	11	6.9	31.05	T	100%	31.050	-	11	32[a]
Amphipods	-	-	-	-	-	-	-	-	11	-
Large zooplankton	-	-	-	-	-	-	-	-	33	-
Small zooplankton	-	-	-	-	-	-	-	-	33	33
Forams	-	-	-	-	-	-	-	-	32, 33	-
Seagrass	5000	11	5.7	28500	P	30%	8550	*Posidonia oceanica*	11	-
Shallow seaweeds	774.5	14	5.2	4027.4	H sha,	3.5%	140.959	Chlorophyceae, Phaeophyceae, Rhodophyceae, other algae	26	-
Deep seaweeds	225	40	5.2	1170	H deep	3.5%	40.950	*Cystoseira balearica,* other cystoseires	33[a]	-
Phytoplankton	-	-	-	-	-	-	14[b]	-	33	-
Detritus	-	-	-	-	-	-	86.354[c]	-	-	-

[a]Synthesis of different values cited in the reference
[b]Calculated from the value of primary production in the western Mediterranean Sea: 175 g C·m^{-2}·yr^{-1} (Chassot et al. 2007)
[c]Estimated with an empirical equation (Christensen & Pauly 1993), using a value of 25 m for the euphotic zone depth in the MPA

References list for tables S2 & S3:

1: Badalamenti et al. (1995); 2: Barreiros et al. (2002); 3: Bell & Harmelin-Vivien (1983); 4: Blanco et al. (2003); 5: calculated from counts of nesting couples realized in Port-Cros islands from 2004 to 2007 and accounting on the time they spent inside the reserve (K Bourgeois, pers. comm.); 6: Coll et al. (2006); 7: Chakroun-Markouz & Kartas (1987); 8: Costa (1988); 9: Donner & Harrer (2004); 10: Francour (pers. comm.); 11: Francour (1990); 12: Francour (1997); 13: Francour (2007); 14: Frantzis et al. (1988); 15: Froese & Pauly (2009); 16: Gramitto (1999); 17: Harmelin (pers. comm.); 18: JG Harmelin (1987); 19: Harmelin & Harmelin-Vivien (1999); 20: Harmelin & Garrabou (2005); 21: Harmelin & Ruitton (2007); 22: Hereu (2004); 23: Kallianotis et al. (2005); 24: Khoury (1987); 25: Linde et al. (2004); 26: Mackinson (1999); 27: Macpherson (1981); 28: Morales-Nin & Moranta (1997); 29: Morato et al. (2003); 30: Morte et al. (2001); 31: Ody (1987); 32: Opitz (1996); 33: Pinnegar (2000); 34: Rosecchi (1993); 35: Ruitton et al. (2004); 36: Russell et al. (1999); 37: Sala & Ballesteros (1997); 38: Santic et al. (2003); 39: Stergiou & Karpouzi (2002); 40: T Thibault (pers. comm.); 41: Vadon (1981); 42: Verlaque (1990)

Table S4. Diet composition table of the Ecopath model of the Port-Cros MPA. Groups displayed in columns are considered as predator groups, feeding on the groups displayed in rows, considered as their prey. The proportion of each prey group in the predator's diet is indicated by the displayed values. Blank cells are zero values, indicating that the predator does not feed on this prey in the model. Import represent food sources coming from outside the ecosystem. Total should be one for all predator groups as it is the sum of the proportions of all prey groups in the diet of each predator group

	Group name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Seabirds																		
2	Rays																		
3	Dusky grouper—large																		
4	Dusky grouper—medium						0.010												
5	Dusky grouper—small						0.011												
6	Amberjack+			0.022	0.041		0.002												
7	Red scorpionfish+			0.022	0.041														
8	Scorpionfishes+			0.030	0.041	0.117	0.035												
9	Surmullet+		0.290	0.009	0.031	0.037	0.004												
10	Pipefishes+			0.002	0.016	0.007													
11	Wrasses			0.017	0.031	0.087	0.173												
12	Gobies			0.017	0.031	0.067	0.017			0.001									
13	Pagellus		0.290				0.018												
14	Diplodus+			0.032	0.031	0.112	0.035												
15	Blennies+			0.009	0.031	0.037													
16	Horse mackerels+	0.004		0.022	0.034	0.121	0.246	0.678	0.227										
17	Mullets					0.015	0.002												

18	Salema—adults			0.050	0.010														
19	Salema—small			0.028	0.005	0.137													
20	Cephalopods	0.004	0.011	0.637	0.323		0.120	0.005		0.238		0.030		0.220			0.008		
21	Crabs		0.024	0.053	0.314	0.242	0.017	0.061	0.038	0.006		0.013	0.037	0.071		0.469			
22	Decapods		0.156	0.050	0.020	0.021	0.065	0.170	0.508	0.216	0.523	0.132	0.216	0.142	0.009	0.098	0.031		
23	Bivalves						0.010	0.008				0.067	0.029		0.168				
24	Gastropods						0.015	0.005				0.207	0.068		0.005	0.002			
25	Sea stars							0.001							0.001				
26	Brittle stars+							0.001			0.001	0.003	0.003	0.054	0.003				
27	Sea urchins							0.012				0.064	0.013		0.120	0.040			
28	Sea cucumbers						0.020								0.040				
29	Sea worms		0.020				0.030	0.003	0.055	0.014	0.018	0.090	0.190	0.452	0.262	0.062	0.031		
30	Suspensivores											0.005	0.001	0.021	0.211	0.165			
31	Gorgonians																		
32	Small crustaceans	0.002	0.011				0.065	0.002	0.019	0.040	0.006	0.034	0.062	0.033	0.031	0.032	0.110		
33	Amphipods						0.015	0.007	0.060	0.376	0.096	0.017	0.089	0.006	0.024	0.004	0.212		
34	Large zooplankton	0.040					0.020	0.022	0.067	0.061	0.128	0.002	0.060		0.002		0.215		
35	Small zooplankton						0.040				0.113	0.033	0.200			0.009	0.011	0.244	
36	Foraminifera											0.002		0.001					
37	Posidonia														0.005				0.950
38	Shallow seaweeds							0.001				0.001	0.024		0.119	0.043		0.122	
39	Deep seaweeds																		0.050
40	Phytoplankton																		
41	Detritus							0.024	0.026	0.048	0.115	0.300	0.008			0.076	0.001	0.634	
	Import	0.950	0.198				0.030										0.380		
	Total	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table S4 (Continued).

	Group name	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1	Seabirds																		
2	Rays																		
3	Dusky grouper—large																		
4	Dusky grouper—medium																		
5	Dusky grouper—small																		
6	Amberjack+																		
7	Red scorpionfish+																		

8	Scorpionfishes+																		
9	Surmullet+																		
10	Pipefishes+																		
11	Wrasses																		
12	Gobies																		
13	Pagellus																		
14	Diplodus+		0.020																
15	Blennies+																		
16	Horse mackerels+		0.050																
17	Mullets		0.050																
18	Salema—adults																		
19	Salema—small		0.050																
20	Cephalopods		0.010																
21	Crabs		0.050	0.010															
22	Decapods		0.152	0.071	0.006		0.008												
23	Bivalves		0.032	0.004	0.001			0.100	0.001										
24	Gastropods		0.246	0.066	0.046		0.007	0.220											
25	Sea stars							0.010											
26	Brittle stars+							0.013											
27	Sea urchins			0.002	0.002			0.025											
28	Sea cucumbers			0.003	0.005		0.009												
29	Sea worms		0.070	0.012	0.022		0.104	0.050	0.001	0.004		0.015							
30	Suspensivores			0.030			0.050	0.120	0.032	0.118		0.025				0.020			
31	Gorgonians																		
32	Small crustaceans			0.073	0.248		0.005					0.059							
33	Amphipods			0.131	0.111		0.002					0.048							
34	Large zooplankton		0.240	0.015	0.015							0.020	0.011	0.050			0.011		
35	Small zooplankton		0.030	0.063	0.103							0.054	0.085	0.050	0.068	0.100	0.923		
36	Foraminifera			0.003	0.003	0.104		0.050	0.004		0.050	0.050	0.164	0.075	0.068	0.100		0.100	
37	Posidonia	0.038		0.250	0.080		0.245			0.419		0.061			0.502	0.275			
38	Shallow seaweeds	0.962		0.100	0.069		0.200	0.069	0.069	0.439		0.100			0.162	0.050			
39	Deep seaweeds			0.050			0.055			0.020					0.010	0.025			
40	Phytoplankton					0.429						0.075	0.429				0.046	0.650	0.200
41	Detritus			0.117	0.289	0.467	0.315	0.343	0.893		0.950	0.493	0.311	0.825	0.190	0.430	0.020	0.250	0.800
	Import																		
	Total	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table S5. Methods used to estimate the natural mortality rate (M, yr^{-1}) and the consumption/biomass ratio (Q/B, yr^{-1}) by fish species for the Port-Cros marine protected area Ecopath model. Parameters are maximal age (t_{max}, yr), Von Bertalanffy growth parameter (K, yr^{-1}), length at infinity (L_{inf}, cm), weight at infinity (W_{inf}, g), aspect ratio of the tail (A, dimensionless). Values of all these parameters were taken from FishBase (Froese & Pauly 2009). Empirical equations used to calculate M: $M = \exp[1.46 - 1.01 \times \mathrm{Ln}(t_{max})]$ (Hoenig 1993); $M = \exp[-0.0152 - 0.279 \times \mathrm{Ln}(L_{inf}) + 0.6543 \times \mathrm{Ln}(K) + 0.463 \times \mathrm{Ln}(T)]$ with $T = 19$°C (Pauly 1980); $M = 1.89 \times K$ (Gascuel et al. 2008). Empirical equation used to calculate Q/B: $\log10(Q/B) = 7.964 - 0.204 \times \log10(W_{inf}) - 1.965 \times T' + 0.083 \times A + 0.532 \times h + 0.398 \times d$ (Palomares & Pauly 1998) with $T' = 1000 / (T + 273.15)$ and $T = 19$°C, h and d are constants defined by the diet type

Group name	Species name	t_{max}	K	L_{inf}	Natural mortality rate M				W_{inf}	A	Q/B
					Hoenig	Pauly	Gascuel	Average			
Rays	*Raja* spp.	23	0.10	117	0.18	0.23	0.19	0.20	12520	0.00	2.52
Dusky grouper	*Epinephelus marginatus*	50	0.08	136	–	–	–	–	40161	1.48	2.64
Amberjack+	*Seriola dumerili*	15	0.19	175	0.28	0.31	0.36	0.32	62009	3.01	3.24
	Conger conger	19	0.06	265	0.22	0.13	0.12	0.16	35505	0.00	2.04
	Lophius piscatorius	24	0.11	132	0.17	0.23	0.21	0.20	28195	–	–
	Dicentrarchus labrax	15	0.19	83	0.28	0.38	0.36	0.34	6529	1.22	3.64
	Muraena helena	–	–	153	–	–	–	–	–	–	–
	Scyliorhinus canicula	12	0.12	87	0.35	0.28	0.23	0.28	2683	–	–
	Dentex dentex	–	0.08	95	–	0.21	0.15	0.18	10599	1.83	3.70
	Sphyraena viridensis	–	0.09	101	–	0.22	0.17	0.20	3971	1.48	4.23
Red scorpionfish+	*Phycis phycis*	–	–	67	–	–	–	–	4348	1.37	4.07
	Labrus merula	17	0.22	44	0.25	0.50	0.42	0.39	1462	0.82	4.58
	Labrus viridis	18	–	55	0.23	–	–	0.23	–	1.15	–
	Sciaena umbra	13	0.22	47	0.32	0.49	0.42	0.41	4369	1.76	4.38
	Scorpaena scrofa	8	–	52	–	–	–	–	2366	1.49	4.71
	Pagrus pagrus	18	0.14	65	0.23	0.33	0.26	0.28	4165	2.02	4.65
	Zeus faber	12	0.29	60	0.35	0.55	0.55	0.48	3518	1.68	4.51
Scorpionfishes+	*Scorpaena notata*	–	–		–	–	–	–	286	1.34	7.05
	Scorpaena porcus	6	0.16	29	0.70	0.45	0.30	0.49	447	1.36	6.46
	Serranus cabrilla	8	0.38	32	0.53	0.78	0.72	0.67	103	1.18	8.42
	Serranus hepatus	–	0.36	15	–	0.92	0.68	0.80	62	2.23	11.40
	Serranus scriba	12	0.19	30	0.35	0.50	0.36	0.40	349	1.28	6.69
	Synodus saurus	–	–	–	–	–	–	–	937	2.85	7.39
Surmullet+	*Arnoglossus laterna*	8	–	16	0.53	–	–	0.53	–	0.77	–
	Bothus podas	–	–	17	–	–	–	–	1357	1.23	5.02
	Gaidropsarus mediterraneus	–	0.60	27	–	1.10	1.13	1.12	81	0.90	8.38
	Gaidropsarus vulgaris	6	–	–	0.70	–	–	0.70	2787	0.99	4.14
	Trisopterus spp.	4	0.21	46	1.06	0.48	0.40	0.65	741	0.88	5.32
	Mullus surmuletus	10	0.30	28	0.42	0.69	0.57	0.56	304	1.38	7.01
	Ophisurus serpens	–	–	–	–	–	–	–	3536	0.00	3.27
	Ophidion rochei	–	–	–	–	–	–	–	132	0.00	6.38
	Parophidion vassal	–	–	–	–	–	–	–	–	0.00	–
Pipefishes+	*Apogon imberbis*	–	0.90	15	–	1.69	1.70	1.69	56	1.39	9.92

	Apletodon dentatus	–	–	–	–	–	–	–	–	–	–
	Diplecogaster bimaculata	–	–	–	–	–	–	–	–	0.40	–
	Lepadogaster candolei	–	–	–	–	–	–	–	–	–	–
	Opeatogenys gracilis	–	–	–	–	–	–	–	–	–	–
	Hippocampus spp.	–	–	–	–	–	–	–	6	–	–
	Nerophis maculatus	–	–	–	–	–	–	–	–	–	–
	Syngnathus acus	–	–	–	–	–	–	–	113	–	–
	Syngnathus typhle	–	0.56	26	–	1.06	1.06	1.06	6	–	–
	Tripterygion spp.	–	–	–	–	–	–	–	–	–	–
Wrasses	*Coris julis*	8	0.11	27	0.53	0.36	0.21	0.37	154	1.61	8.42
	Symphodus cinereus	6	–	–	–	–	–	–	–	1.53	–
	Symphodus doderleini	–	–	–	–	–	–	–	–	1.20	–
	Symphodus mediterraneus	8	–	–	–	–	–	–	–	1.19	–
	Symphodus melanocercus	–	–	–	–	–	–	–	59	1.09	9.27
	Symphodus ocellatus	5	–	–	–	–	–	–	–	1.13	–
	Symphodus roissali	8	0.35	15	0.53	0.91	0.66	0.70	62	1.05	9.10
	Symphodus rostratus	4	–	–	–	–	–	–	–	1.19	–
	Symphodus tinca	10	0.25	28	0.43	0.61	0.47	0.50	439	1.65	6.85
	Thalassoma pavo	–	–	–	–	–	–	–	–	1.05	–
Gobies	*Deltentosteus colonianus*	–	–	–	–	–	–	–	–	–	–
	Deltentosteus quadrimaculatus	–	–	–	–	–	–	–	5	0.75	14.28
	Gobius auratus	–	–	–	–	–	–	–	–	0.66	–
	Gobius cruentatus	–	–	–	–	–	–	–	84	0.69	8.00
	Gobius fallax	–	–	–	–	–	–	–	8	0.67	12.79
	Gobius geniporus	–	–	–	–	–	–	–	–	0.43	–
	Gobius paganellus	10	0.73	14	0.42	1.51	1.38	1.10	36	0.78	9.67
	Gobius vittatus	–	–	–	–	–	–	–	–	0.41	–
	Pomatoschistus minutus	3	0.93	9	1.42	1.98	1.76	1.72	11	1.07	13.00
	Pomatoschistus quagga	–	–	–	–	–	–	–	–	0.90	–
	Thorogobius ephippiatus	9	0.23	14	0.47	0.71	0.43	0.54	–	0.48	–
	Thorogobius macrolepis	–	–	–	–	–	–	–	–	1.23	–
Pagellus	*Pagellus* spp.	20	0.24	31	0.21	0.58	0.45	0.41	608	2.60	7.69
Diplodus+	*Diplodus puntazzo*	8	0.36	62	0.53	0.62	0.68	0.61	14101	3.10	4.46
	Diplodus sargus	10	0.12	47	0.42	0.33	0.23	0.33	1585	3.24	7.15
	Diplodus vulgaris	9	0.39	29	0.47	0.81	0.74	0.67	573	4.72	11.67
	Lithognathus	12	0.28	33	0.35	0.63	0.53	0.50	425	2.87	8.71

	mormyrus										
	Sparus aurata	11	0.27	58	0.38	0.53	0.51	0.47	2497	1.39	4.57
	Spondyliosoma cantharus	–	0.18	48	–	0.43	0.34	0.38	1602	1.94	5.56
Blennies+	*Blennius ocellaris*	–	–	21	–	–	–	–	120	1.19	8.18
	Parablennius gattorugine	–	–	32	–	–	–	–	600	0.92	5.59
	Parablennius rouxi	–	–	9	–	–	–	–	–	–	–
	Diplodus annularis	7	0.27	25	0.60	0.67	0.51	0.59	286	1.58	7.38
Horse mackerels+	*Atherina* spp.	4	0.26	11	1.06	0.83	0.49	0.79	15	1.20	12.60
	Trachurus spp.	12	0.23	39	0.35	0.53	0.43	0.44	552	1.69	6.59
	Spicara maena	5	0.18	18	0.85	0.56	0.34	0.58	215	3.12	10.50
	Spicara smaris	7	0.19	20	0.60	0.56	0.36	0.51	192	2.86	10.23
	Chromis chromis	–	0.25	15	–	0.74	0.47	0.60	40	1.13	10.13
	Anthias anthias	–	–	–	–	–	–	–	399	2.16	7.70
	Boops boops	6	0.18	32	0.70	0.48	0.34	0.51	217	0.97	6.95
	Oblada melanura	11	0.23	33	0.38	0.55	0.43	0.46	489	2.48	7.86
Mullets	Mugilidae	16	0.29	59	0.26	0.55	0.55	0.45	976	2.53	17.23
Salema	*Sarpa salpa*	11	0.23	45	–	–	–	–	1282	2.85	23.58

Balancing the Ecopath model

Balancing the model required the modification of some input values in 3 steps. First, we had to adjust some input consumption/biomass (*Q/B*) parameters that seemed to be unrealistically high. This was especially the case for some fish groups (wrasses, gobies, and blennies) for which no values of length at infinity (L_{inf}) were available for most species. For these groups, production/biomass (*P/Q*) was fixed and *Q/B* was estimated by the model (Table 1).

Then, although data on fish diet compositions were considered reliable, as diets were collected for every species in each group, some adjustments were necessary. For instance, stomach contents analysis of rays, carried out in the Azores Islands (Morato et al. 2003), was readjusted by removing pelagic fishes. Also, predation by the abundant amberjack+ group (fish groups were named using the most abundant species of the group, a '+' indicating the presence of secondary species) on decapods, gastropods, sea worms, and suspensivores had to be reduced. Indeed, the overly high fish consumption on these invertebrate groups led to overestimated biomass and, consequently, to insufficient primary production in the ecosystem. Data on the compositions of invertebrates' diet were less reliable. For example, the sea cucumbers' diet, from a stomach contents analysis realized in the Port-Cros MPA (Berthon 1987), initially included plants, which were replaced by detritus, based on the field knowledge that these species are detritivorous and not grazers. Cannibalism was reduced to the minimum values in diet compositions of decapod, gastropod, and sea worm groups, because the biomass estimated by the model appeared to be artificially increased by the high proportion of cannibalism in their original diets. Diets taken from other regions, and notably the Bay of Revellata on Corsica (Pinnegar 2000), did not mention salema, mullets, posidonia, or deep seaweeds, which were added to the diets of some groups. For instance, we transferred predation by crustaceans (decapods, small crustaceans, and amphipods) and by gastropods from seaweeds to *Posidonia oceanica*. Predation on some of the low biomass groups (e.g. surmullet+, blennies+, gobies, and pipefishes+) was reduced and transferred to similar groups with higher biomass.

Finally, biomass estimates were corrected for 3 groups. Biomass of cephalopods and bivalves had to be increased to sustain predation. Indeed, the biomass of these 2 groups was based on underestimated abundance values of only 1 species of each group (respectively, *Octopus vulgaris* and *Pinna nobilis*). Although these 2 species were the most abundant in the groups, we assumed that each biomass value could be tripled. Finally, biomass of horse mackerels+ was decreased 3-fold as the initial value, as biomass estimates for *Trachurus* spp. and *Atherina* spp. seemed too high (P. Francour pers. obs.). We also had to include 40% of imported prey in their diet, assuming frequent movements outside the reserve. Both steps allowed us to balance the model and to relieve pressure on lower trophic level prey (large and small zooplankton and phytoplankton).

The EcoTroph model: principles and major equations

In the EcoTroph approach, the trophic ecosystem functioning is modeled as a continuous flow of biomass surging up the food web, from lower to higher trophic levels, because of predation and ontogenic processes. Thus, according to the usual equations of fluid dynamics, the flow of the biomass present in the ecosystem at trophic level τ under steady-state conditions is equal to:

$$\Phi(\tau) = D(\tau) \times K(\tau) \quad \text{(S1)}$$

where $\Phi(\tau)$ refers to the amount of biomass that moves up the food web through trophic levels τ (expressed in t yr^{-1}), $D(\tau)$ is the density of biomass at trophic level τ (defined as the derivative of biomass with respect to trophic level τ and expressed in t TL^{-1}, t being tons and *TL* being the trophic level), and $K(\tau)$ is the speed of the flow (in *TL* yr^{-1}, i.e. the number of trophic levels crossed per year), which quantifies the velocity of biomass transfers through the food web.

The continuous distribution of the biomass across a trophic level is calculated using a discrete approximation based on small trophic classes. Conventionally, EcoTroph considers trophic classes of width $\Delta\tau$ equal to 0.1 *TL*, from Trophic Level 2 (corresponding to first-order consumers) to Trophic Level 5 (value being considered sufficient to cover all top predators likely to occur in marine ecosystems). Thus, the mean biomass $B\tau$ (in t), which is present in the (τ, $\tau + \Delta\tau$) trophic class under steady-state conditions, can be estimated as $\int D(\tau) \times d\tau$ or $D(\tau) \times \Delta\tau$ for a small interval $\Delta\tau$. Therefore:

$$B\tau = \Phi\tau \times \Delta\tau / K\tau \quad \text{(S2)}$$

where $\Phi\tau$ and $K\tau$ are the mean biomass flow and mean speed of flow within the (τ,τ+$\Delta\tau$) trophic class, respectively.

The biomass flow decreases from low to high trophic levels because of catches and natural losses occurring during trophic transfers (due to non-predation mortalities, respiration and excretion). This leads to the following equation of the biomass flow:

$$\Phi(\tau, \tau+\Delta\tau) = \Phi(\tau) \times \exp[-(\mu\tau + \varphi\tau) \times \Delta\tau] \quad \text{(S3)}$$

where $\mu\tau$ is the net natural loss rate of biomass flow and $\varphi\tau$ is the loss rate due to fishing, per trophic class.

The speed of the flow has to be determined in a state of the ecosystem defined as the reference state (see below). The mean biomass flow $\Phi\tau$ and the mean speed of flow $K\tau$ for the reference state are deduced from the Ecopath parameters using the 2 following equations (Gascuel et al. 2008):

$$P\tau = \Phi\tau \times \Delta\tau \quad \text{(S4)}$$

$$K\tau = (P/B)\tau \quad \text{(S5)}$$

The inverse $1/K\tau$ parameter is equal to the life expectancy of organisms within their trophic class, and thus $K\tau$ depends on fishing and natural mortalities, the latter being related to the abundance of predators. Then, starting with values defined for the reference state, the *K*t values are modified during simulations, according to the flow kinetic equation detailed in (Gascuel & Pauly 2009). The model also considers that only a fraction of the ecosystem biomass, called the accessible biomass B^*_τ (in t), is accessible to fisheries, due to ecological or technological reasons. Thus, starting with the reference state, EcoTroph allows users to simulate changes in the exploitation patterns, applying various effort multipliers to the accessible fishing mortality of reference F^*_τ (yr^{-1}), defined as the ratio between the catch and the accessible biomass.

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