

Estuarine-coastal gradient in food web network structure and properties

C. Vinagre*, M. J. Costa

Centro de Oceanografia, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal

*Corresponding author: cmvinagre@fc.ul.pt

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Supplement. Additional data

Table S1. List of the trophic species (groups of taxa whose members share the same set of predators and prey) used to assemble the food web networks. Mean trophic level, generality, vulnerability and connectivity for each trophic species in a food web containing all trophic species

Taxa	Group	TL	Generality	Vulnerability	Connectivity
Chlorophyta	Algae	1.0	0.0	3.2	1.6
Cyanophycota	Algae	1.0	0.0	0.5	0.2
Rhodophyta	Algae	1.0	0.0	1.7	0.8
Cryptophycophyta + Prasinophyceae	Algae	1.0	0.0	0.9	0.5
Phytoplankton	Algae	1.0	0.0	3.1	1.5
Detritus	Detritus	1.0	0.0	3.5	1.8
Echinodermata	Echinodermata	2.0	0.3	4.3	2.3
<i>Oikopleura sp.</i>	Tunicata	2.0	0.2	0.2	0.2
Amphipoda	Amphipoda	2.0	0.6	9.5	5.0
Oligochaeta	Oligochaeta	2.0	0.2	1.1	0.6
Gastropoda	Gastropoda	2.0	0.3	6.0	3.1
Ostracoda	Ostracoda	2.0	0.2	2.9	1.5
Cirripedia	Cirripedia	2.0	0.2	0.9	0.5
Lophogastrida	Lophogastrida	2.0	0.2	5.5	2.8
Cumacea	Cumacea	2.0	0.3	1.8	1.1
<i>Barbus bocagei</i>	Fish	2.0	0.2	0.9	0.5
<i>Ebalia sp.</i>	Crab	2.0	0.2	0.5	0.3
<i>Cancer decimdentatus</i>	Crab	2.0	0.2	0.5	0.3
<i>Pilumnus hirtellus</i>	Crab	2.0	0.2	0.5	0.3
<i>Pilumnus spinifer</i>	Crab	2.0	0.2	0.2	0.2
<i>Diogenes pugilator</i>	Crab	2.0	0.2	0.3	0.2
<i>Fritillaria borealis</i>	Urochordata	2.0	0.2	0.0	0.1
<i>Athanas nitescens</i> + <i>Anapagurus sp.</i>	Shrimp and Fish	2.0	0.2	0.2	0.2
<i>Chelon labrosus</i>	Fish	2.1	0.6	0.2	0.4
Bivalvia	Bivalvia	2.2	1.7	8.0	4.8
<i>Hippolyte inermis</i>	Crab	2.3	0.5	0.0	0.2
<i>Liza ramado</i>	Fish	2.4	0.6	0.3	0.5
Polychaeta	Polychaeta	2.4	2.6	8.9	5.7
<i>Cyprinus carpio</i>	Fish	2.5	1.2	0.0	0.6

Ectoprocta	Ectoprocta	2.5	0.8	0.6	0.7
Copepoda	Copepoda	2.5	0.8	6.1	3.4
Cladocera	Cladocera	2.5	0.8	1.8	1.3
<i>Processa sp.</i>	Crab	2.5	1.2	1.1	1.1
Hydrozoa	Cnidaria	2.5	1.2	2.0	1.6
<i>Liocarcinus marmoreus</i>	Crab	2.5	0.9	0.6	0.8
<i>Pagurus sp.</i>	Crab	2.5	1.5	1.2	1.4
<i>Boops boops</i>	Fish	2.5	0.9	0.2	0.5
<i>Polybius holsatus</i>	Crab	2.6	0.5	0.3	0.4
<i>Pagellus bogaraveo</i>	Fish	2.6	1.5	0.0	0.8
<i>Maja squinado</i>	Crab	2.6	0.9	0.3	0.6
<i>Echiichtys vipera</i>	Fish	2.6	1.2	0.2	0.7
Isopoda	Isopoda	2.6	0.6	5.7	3.1
<i>Diplodus bellottii</i>	Fish	2.7	1.5	0.2	0.8
Palaemonidae	Shrimp	2.7	1.2	2.3	1.8
Chaetognatha	Chaetognatha	2.7	0.5	0.0	0.2
Crangonidae	Shrimp	2.7	1.7	5.2	3.4
<i>Diplodus sargus</i>	Fish	2.7	1.5	0.2	0.8
<i>Sardina pilchardus</i>	Fish	2.7	0.9	1.8	1.4
<i>Diplodus vulgaris</i>	Fish	2.7	2.8	0.2	1.5
<i>Necora puber</i>	Crab	2.8	1.7	0.2	0.9
<i>Carcinus maenas</i>	Crab	2.9	2.1	2.9	2.5
<i>Zeus Faber + Spondyliosoma cantharus</i>	Fish	3.0	0.2	0.2	0.2
<i>Liocarcinus vernalis</i>	Crab	3.1	0.6	0.2	0.4
<i>Sparus aurata</i>	Fish	3.1	0.6	0.2	0.4
<i>Liocarcinus arcuatus</i>	Crab	3.1	0.9	0.6	0.8
<i>Barbus bocagei + Calidris canutus</i>	Fish and Bird	3.1	0.3	0.0	0.2
<i>Liocarcinus depurator</i>	Crab	3.1	0.8	0.5	0.6
<i>Larus fuscus</i>	Bird	3.1	0.8	0.3	0.5
Nemertea	Nemertea	3.2	1.1	0.3	0.7
<i>Arnoglossus imperialis</i>	Fish	3.2	1.7	0.2	0.9
<i>Liocarcinus puber</i>	Crab	3.2	1.7	0.3	1.0
<i>Anas platyrhynchos + Anas crecca + Anas clypeata</i>	Bird	3.2	0.3	0.0	0.2
<i>Eriocheir sinensis</i>	Crab	3.2	0.5	0.2	0.3
<i>Dicologlossa hexophtalma</i>	Fish	3.2	0.5	0.2	0.3
*	Bird	3.2	0.5	0.0	0.2
<i>Octopus vulgaris</i>	Cephalopoda	3.2	0.2	0.3	0.2
<i>Polybius henslowii</i>	Crab	3.2	1.1	0.6	0.8
<i>Solea lascaris</i>	Fish	3.2	1.5	0.2	0.8
<i>Syngnathus typhle</i>	Fish	3.3	0.3	0.0	0.2
<i>Scorpaena notata</i>	Fish	3.3	0.3	0.0	0.2
<i>Sepiola sp.</i>	Cephalopoda	3.3	0.6	0.8	0.7
<i>Solea solea</i>	Fish	3.3	1.4	0.8	1.1
<i>Bothus podas</i>	Fish	3.3	0.6	0.2	0.4
<i>Syngnathus acus</i>	Fish	3.3	0.6	0.2	0.4
<i>Callyonimus lyra</i>	Fish	3.3	1.4	0.5	0.9
<i>Callionymus reticulatus</i>	Fish	3.3	1.4	0.3	0.8
<i>Chelidonichthys obscurus</i>	Fish	3.3	1.4	0.0	0.7
<i>Mullus surmuletus</i>	Fish	3.3	1.2	0.3	0.8

<i>Atherina presbyter</i>	Fish	3.3	0.8	0.6	0.7
<i>Engraulis encrasicolus</i>	Fish	3.3	2.3	1.1	1.7
<i>Pomatoschistus microps</i>	Fish	3.3	2.0	1.5	1.8
<i>Recurvirostra avosetta</i>	Bird	3.3	0.3	0.0	0.2
<i>Pagrus pagrus</i>	Fish	3.3	0.6	0.3	0.5
<i>Sprattus sprattus</i>	Fish	3.3	0.5	0.9	0.7
<i>Syngnathus abaster</i>	Fish	3.4	0.8	0.5	0.6
<i>Myliobatis aquila</i>	Fish	3.4	0.8	0.0	0.4
<i>Gobius paganellus</i>	Fish	3.4	1.4	0.2	0.8
<i>Conger conger</i>	Fish	3.4	0.8	0.2	0.5
<i>Rhaphidascaaris sp. + Neoechinorhynchus sp. + Haploporus benedeni</i>	Fish parasites	3.4	0.2	0.0	0.1
<i>Larus fuscus + Larus ridibundus</i>	Birds	3.4	0.6	0.0	0.3
<i>Gobius niger</i>	Fish	3.4	1.2	0.9	1.1
<i>Pollachius pollachius</i>	Fish	3.4	1.1	0.0	0.5
<i>Belone belone</i>	Fish	3.4	1.5	0.8	1.1
<i>Solea senegalensis</i>	Fish	3.4	1.4	0.5	0.9
<i>Liza aurata</i>	Fish	3.4	0.2	0.0	0.1
<i>Buglossidium luteum</i>	Fish	3.4	1.1	0.0	0.5
<i>Pomatoschistus minutus</i>	Fish	3.4	2.6	2.6	2.6
<i>Trisopterus luscus</i>	Fish	3.5	2.1	1.1	1.6
<i>Arnoglossus laterna</i>	Fish	3.5	1.7	0.5	1.1
<i>Spicara maena</i>	Fish	3.5	0.3	0.0	0.2
<i>Raja clavata</i>	Fish	3.5	2.8	0.2	1.5
<i>Dicentrarchus labrax</i>	Fish	3.5	1.7	0.5	1.1
<i>Psetta maxima</i>	Fish	3.5	0.5	0.2	0.3
<i>Raja undulata</i>	Fish	3.5	2.6	0.2	1.4
<i>Scomber scombrus</i>	Fish	3.6	1.2	0.3	0.8
<i>Anguilla anguilla</i>	Fish	3.6	1.7	0.8	1.2
<i>Platichthys flesus</i>	Fish	3.6	2.1	0.3	1.2
<i>Halobatrachus didactylus</i>	Fish	3.6	2.1	0.3	1.2
<i>Trachurus trachurus</i>	Fish	3.6	1.2	0.2	0.7
<i>Chelidonichthys lucernus</i>	Fish	3.6	0.8	0.5	0.6
<i>Aphia minuta</i>	Fish	3.6	0.2	0.5	0.3
<i>Loligo vulgaris</i>	Cephalopoda	3.7	1.2	1.2	1.2
<i>Loligo subulata</i>	Cephalopoda	3.7	1.2	1.4	1.3
<i>Scoththalmus rhombus</i>	Fish	3.7	3.1	0.0	1.5
<i>Merluccius merluccius</i>	Fish	3.7	1.7	0.5	1.1
<i>Argyrosomus regius</i>	Fish	3.7	0.6	0.2	0.4
<i>Raja montagui</i>	Fish	3.7	3.5	0.0	1.8
<i>Sepia officinalis</i>	Cephalopoda	3.7	1.4	0.6	1.0
<i>Homo sapiens</i>	Human	3.8	7.2	0.0	3.6
<i>Phalacrocorax carbo</i>	Bird	3.8	2.9	0.0	1.5
<i>Prosorhynchus crucibulum + Gyrodactylus elegans + Prosorhynchus aculeatus + Cucullanellus minutus + Timoniella</i>	Fish parasites	4.3	0.2	0.0	0.1
Nematoda	Fish parasites	4.6	0.2	0.2	0.2
<i>Acanthocephalus clavula</i>	Fish parasites	4.6	0.2	0.0	0.1

Table S2. References used to establish feeding links

Author	Year	Title	Source
Albentosa, Perez-Camacho, Labarta, Beiras, Fernandez-Beiriz	1993	Nutritional value of algal diets to clam spat <i>Venerupis pullastra</i>	Mar Ecol Prog Ser 97:261-269
Almeida	2003	Feeding ecology of <i>Liza ramada</i> (Risso, 1810) (Pisces, Mugilidae) in a south-western estuary of Portugal	Estuar Coast Shelf Sci 57:313–323
Almeida, Moreira, Costa, Assis, Costa	1993	The feeding strategies of <i>Liza ramada</i> (Risso, 1826) in fresh and brackish water in the River Tagus, Portugal	J Fish Biol 42:95–107
Ambrose, Nelson	1983	Predation by <i>Octopus vulgaris</i> in the Mediterranean.	PSZN I: Mar Ecol 4:251-261
Angell	1986	The biology and culture of tropical oysters.	International Center for Living Aquatic Resources, Manila, 37p
Ansell	1974	Seasonal Changes in Biochemical Composition of the Bivalve <i>Abra alba</i> from the Clyde Sea Area	Mar Biol 25:13-20
Ansell, Comely, Robb	1999	Distribution, movements and diet of macrocrustaceans on a Scottish sandy beach with particular reference to predation on juvenile fishes	Mar Ecol Prog Ser 176:115-130
Arrhenius	1996	Diet composition and food selectivity of 0-group herring (<i>Clupea harengus</i> L.) and sprat (<i>Sprattus sprattus</i> (L.)) in the northern Baltic Sea	ICES J Mar Sci 53:701-712.
Atienza, Saiz, Calbet	2006	Feeding ecology of the marine cladoceran <i>Penilia avirostris</i> : natural diet, prey selectivity and daily ration	Mar Ecol Prog Ser 315:211–220
Avsar	1994	Diel diet and feeding behavior of scaldfish (<i>Arnoglossus laterna</i> , Walbaum, 1972) in the Bay of Mersin	Acta Adriat 34:89-101
Azevedo, Simas	2000	Age and growth, reproduction and diet of a sublittoral population of the rock goby <i>Gobius paganellus</i> (Teleostei, Gobiidae)	Hydrobiologia 440:129-135
Baeta, Cabral, Cabral, Marques, Pardal	2006	Feeding ecology of the green crab <i>Carcinus maenas</i> , (L., 1758) in a temperate estuary, Portugal	Crustaceana 79:1181-1193
Bainbridge 1963	1963	The food, feeding habits and distribution of the Bonga <i>Ethmalosa dorsalis</i> (Cuvier & Valenciennes).	J Cons int Explor Mer 28:270-284.
Baldoa, Drake	2002	A multivariate approach to the feeding habits of small fishes in the Guadalquivir Estuary.	J Fish Biol 61:21-32
Bauchot, M.-L. 1986	1986	Ophichthidae (including Echelidae) In P.J.P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen and E. Tortonese (eds.) Fishes of the north-eastern Atlantic and the Mediterranean.	UNESCO, Paris, p. 577-585.
Bayhan, Sever, Taskavak	2008	Age, length-weight relationships and diet composition of scaldfish, <i>Arnoglossus laterna</i> (Walbaum, 1792) (Pisces: Bothidae) in Izmir Bay (Aegean Sea)	J Anim Vet Adv 7:924-929
Bell, Harmelin-Vivien	1983	Fish fauna of French Mediterranean <i>Posidonia oceanica</i> seagrass meadows. 2. Feeding habits.	Tethys 11:1-14
Ben-Tuvia, McKay	1986	Haemulidae In P.J.P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen and E. Tortonese (eds.) Fishes of the north-eastern Atlantic and the Mediterranean.	UNESCO, Paris, p 858-864
Bernardéz, Freire, González-Gurriaran	2000	Feeding of the spider crab <i>Maja squinado</i> in rocky subtidal areas of the Ria de Arousa (North-West Spain)	J Mar Biol Assoc UK 80:95-102
Bernardon, Vall	2004	Le mullet en Mauritanie: biologie, écologie, pêche et aménagement.	FIBA UICN PRCM Arles 1-56
Cabral	2000	Comparative feeding ecology of sympatric <i>Solea solea</i> and <i>S. senegalensis</i> , within the nursery areas of the Tagus estuary, Portugal	J Fish Biol 57:1550-1562

Cabral, Costa	2001	Abundance, feeding ecology and growth of seabass, <i>Dicentrarchus labrax</i> , within the nursery areas of the Tagus estuary.	J Mar Biol Assoc UK 81:679 - 682
Cabral, Lopes, Loeper	2002	Trophic niche overlap between flatfishes in a nursery area in the Portuguese coast	Sci Mar 66:293-300
Cabral, Ohmert	2001	Diet of juvenile meagre, <i>Argyrosomus regius</i> , within the Tagus estuary.	Cah Biol Mar 42:289-293
Cardona	2001	Non-competitive coexistence between Mediterranean grey mullet: evidence from seasonal changes in food availability, niche breadth and trophic overlap	J Fish Biol 59:729-744
Carss, Ekins	2002	Further European integration: mixed sub-species colonies of great cormorants <i>Phalacrocorax carbo</i> in Britain - colony establishment, diet and implications for fisheries management.	Ardea 90:23-41
Carvalho-Varela, Cunha-Ferreira, Cruz e Silva, Monteiro, Grazina-Freitas	1981	Parasites and parasitosis in fish culture in Portugal	J World Maricult Soc 12:9-14
Casini, Cardinale, Arrhenius	2004	Feeding preferences of herring (<i>Clupea harengus</i>) and sprat (<i>Sprattus sprattus</i>) in the southern Baltic Sea	ICES J Mar Sci 61:1267-1277
Chaves, Horta, Chainho, Costa, Costa	2010	New additions to the feeding ecology of <i>Carcinus maenas</i> (L., 1758) in a South-western Europe estuary (Portugal)	Cah Biol Mar 51:229-238
Cheng, Lopez	1991	Contributions of bacteria and sedimentary organic matter to the diet of <i>Nucula proxima</i> , a deposit-feeding protobranchiate bivalve.	Ophelia 34:157-170
Chintiroglou, Koukouras	1992	The feeding habits of three Mediterranean sea anemone species, <i>Anemonia viridis</i> (Forsk), <i>Actinia equine</i> (Linnaeus) and <i>Cereuspedunculatus</i> (Pennant)	Helgol Meeresunters 46:53-68
Choy	1986	Diet and feeding habits of the crabs <i>Liocarcinus puber</i> and <i>L. holsatus</i> (Decapoda, Brachyura, Portunidae)	Mar Ecol Prog Ser 31:87-99
Clark	1962	Observations on the Food of <i>Nephtys</i>	Limnol Oceanogr 7:380-385
Coelho	2002	Alimentação de <i>Sardina pilchardus</i> (Walbaum, 1792) ao largo da costa continental Portuguesa e implicações da condição nutricional das fêmeas na qualidade dos oócitos	University of Lisbon, MSc Thesis
Coelho, Domingues, Balguerias, Fernandez, Andrade	1997	A comparative study of the diet of <i>Loligo vulgaris</i> (Lamarck, 1799) (Mollusca:Cephalopoda) from the south coast of Portugal and the Saharan Bank (Central-East Atlantic)	Fisher Res 29:245-255
Coetzee	1986	Diet composition and breeding cycle of blacktail, <i>Diplodus sargus capensis</i> (Pisces: Sparidae), caught off St. Croix Island, Algoa Bay, South Africa.	S Afr J Zool 21:237-243
Collares-Pereira, Martins, Pires, Geraldes, Coelho	1996	Feeding behaviour of <i>Barbus bocagei</i> assessed under a spatio-temporal approach	Fol Zoolog 45:65-76
Compagno, Ebert, Smale	1989	Guide to the sharks and rays of southern Africa.	New Holland (Publ.) London
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Corkett, McLaren	1978	The biology of <i>Pseudocalanus</i> .	Adv Mar Biol 15:1-231
Cornils, Schnack-Schiel, Böer, Graeve, Struck, Al-Najjar, Richter	2007	Feeding of Clausocalanids (Calanoida, Copepoda) on naturally occurring particles in the northern Gulf of Aqaba (Red Sea)	Mar Biol 151:1261-1274
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DGPA	2011	Commercial designations of fished species DGPA ANEXO I- 2011-07-15	Portuguese Fisheries and Agriculture Ministry
Dias	2007	Estudo da dieta do Corvo-marinho-de-faces-brancas (<i>Phalacrocorax carbo</i> Linnaeus, 1758) no Estuário do Rio Minho (NO-Portugal)	Degree Thesis, University of Porto
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Dorman	1991	Investigations into the biology of garfish <i>Belone belone</i> (L.), in Swedish waters	J Fish Biol 39:59-69
Durieux, Marques, Sasal, Begout, Cabral	2007	Comparison of <i>Solea solea</i> macroparasites between two nursery- continental shelf systems in the Bay of Biscay and the Portuguese coast	J Fish Biol 70:1921-1930
Farias, Figueiredo, Moura, Gordo, Neves, Serra-Pereira	2006	Diet comparison of four ray species (<i>Raja clavata</i> , <i>Raja brachyura</i> , <i>Raja montagui</i> and <i>Leucoraja naevus</i>) caught along the Portuguese continental shelf	Aquat Liv Resour 19:105-114
Fauchald, Jumars	1979	The diet of worms: a study of polychaete feeding guilds	Oceanogr Mar Biol Ann Rev 17:193-284
Fenchel, Kofoed, Lappalainen	1975	Particle Size-Selection of Two Deposit Feeders: the Amphipod <i>Corophium volutator</i> and the Prosobranch <i>Hydrobia ulvae</i>	Mar Biol 30:119-128
Figueiredo, Morato, Barreiros, Afonso, Santos	2005	Feeding ecology of the white seabream, <i>Diplodus sargus</i> , and the ballan wrasse, <i>Labrus bergylta</i> , in the Azores	Fisher Res 75:107–119
Fjøsne, Gjørseter	1996	Dietary composition and the potential of food competition between 0-group cod (<i>Gadus morhua</i> L.) and some other fish species in the littoral zone	ICES J Mar Sci 53:757-770
Fockedey, Mees	1999	Feeding of the hyperbenthic mysid <i>Neomysis integer</i> in the maximum turbidity zone of the Elbe, Westerschelde and Gironde estuaries	J Mar Syst 22 :207-228
França, Vinagre, Costa, Cabral	2004	Use of the coastal areas adjacent to the Douro estuary as a nursery area for pouting, <i>Trisopterus luscus</i> Linnaeus, 1758	J Appl Ichthyol 20:99-104
Franzoil, Maccagnani, Rossi, Ceccherelli	1993	Life cycles and feeding habits of <i>Syngnathus taenionotus</i> and <i>S. abaster</i> (Pisces, Syngnathidae) in a brackish bay of the Po River Delta (Adriatic Sea)	Mar Ecol Prog Ser 97:71-81
Fraser	1969	Experimental feeding of some medusae and chaetognatha.	J Fisher Res B Can 26:1743-1762
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Freire, Gonzalez-Gurriaran	1995	Feeding ecology of the velvet swimming crab <i>Necora puber</i> in mussel raft areas of the Ria de Arousa (Galicia, NW Spain)	Mar Ecol Prog Ser 119:139-154
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Friedman	1980	Comparative morphology and functional significance of copepod receptors and oral structures In: W.C. Kefoot (editor), Evolution and ecology of zooplankton communities	University Press of New England, Hanover, NH p. 185-197

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Gaudêncio, Cabral	2007	Trophic structure of macrobenthos in the Tagus estuary and adjacent coastal shelf	Hydrobiologia 587:241–251
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