The following appendices accompany the article

Modelling food web interactions, variation in plankton production, and fisheries in the western English Channel ecosystem

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Appendix 1. Western English Channel model structure and composition of functional groups

Group 1	Primary producers	Phytoplankton, macro-algae and micro-phytobenthos
2	Microzooplankton	
3	Mesozooplankton	
4	Macrozooplankton	
5	Deposit feeders	Worms, gastropods and small invertebrates such as amphipods
6	Suspension feeders	Cnidarians, sponges, bryozoans and acidians
7	Shrimp and prawns	Mainly *Crangon crangon*
8	Whelks	Mainly *Buccinum undatum*
9	Echinoderms	*Asterias rubens*, *Ophiura* spp., *Psammechinus miliaris*, *Astropecten irregularis*, *Luidia ciliaris*, *L. sarsi*, *Porania pulvillus*, *Anseropoda placenta*, *Marthasterias glacialis*, *Echinus acutus*, *E. esculentus* and *Spatangus purpureus*
10	Bivalves	*Nucula* spp., *Venus* spp, *Cardium* spp., *Dosinia lupinus*, *Ensis* spp., *Abra* spp., *Mytilus edulis*, *Glycymeris glycymeris*, *Cerastoderma edule*, *Ostrea edulis*, *Crassostrea gigas*
11	Scallops	*Pecten maximus*, *Aequipecten opercularis* and *Chlamys varia*
12	Small–medium crabs	*Carcinus maenas*, *Necora puber*, *Liocarcinus* spp, *Pilumnus hirtellus*, *Pagurus bernhardus*, squat lobsters and spider crabs
13	Large crab	*Cancer pagurus* and *Maja squinado*
14	Lobster	*Homarus gammarus* and *Palinurus elephas*
15	Small–medium demersals	*Agonus cataphractus*, *Callionymus lyra*, *Arnoglossus laterna*, *Buglossidium luteum* and *Microchirus variegatus*
16	Small gadoids	*Trisopterus minutus* and *T. luscus*
17	Red mullet	*Mullus surmuletus*
18, 19	Juvenile and adult sole	*Solea solea*
20, 21	Juvenile and adult plaice	*Pleuronectes platessa*
22	Dab	*Limanda limanda*
23	Lemon sole	*Microstomus kitt*
24	Large flatfish	*Scophthalmus rhombus*, *Psetta maxima* and *Lepidorhombus whiffiagonis*
25	Gurnards	*Aspitrigla cuculus*, *Trigla lucerna* and *Eutrigla gurnardus*
26, 27	Juvenile and adult whiting	*Merlangius merlangus*
28, 29	Juvenile and adult cod	*Gadus morhua*
30	Hake	*Merluccius merluccius*
31	Dogfish	*Scyliorhinus canicula*, *S. stellaris* and *Squalus acanthias*
32	Rays	*Raja clavata*, *Leucoraja naevus*, *R. montagui*, *Dipturus batis*, *R. brachyuran* and *R. microocellata*
33	Other gadoids	Mainly *Pollachius pollachius*, but also *P. virens*, *Micromesistius poutassou* and *Melanogrammus aeglefinus*
34	Anglerfish	*Lophius piscatorius* and *L. budegassa*
35	Large bottom fish	Mainly *Molva molva* and *Conger conger*, but also *Trachinus draco*, *Phycis blennioides*, *Anguilla anguilla* and *Cepola rubescens*
36	Seabreams	Mainly *Spondyliosoma cantharus*, but also *Sparus aurata* and *Pagellus bogaraveo*
37	John Dory	*Zeus faber*
38	Sandeels	*Ammodytes tobianus*
39	Herring	*Clupea harengus*
40	Sprat	*Sprattus sprattus*

Appendix 1. (continued)

Group 41	Pilchard	*Sardina pilchardus*
42	Mackerel	*Scomber scombrus*
43	Scad	*Trachurus trachurus*
44	Bass	*Dicentrarchus labrax*
45	Sharks	*Mustelus mustelus*, *M. asterias*, *Galeorhinus galeus*, *Lamna nasus* and *Prionace glauca*
46	Basking shark	*Cetorhinus maximus*
47	Cephalopods	*Sepia officinalis*, *Loligo forbesi*, *L. vulgaris* and *Illex coindetii*
48	Birds	*Fulmarus glacialis*, *Puffinus puffinus*, *Hydrobates pelagicus*, *Sula bassana*, *Phalacrocorax carbo*, *Stercorarius parasiticus* and *Larus melanocephalus*
49	Toothed cetaceans	*Phocoena phocoena*, *Delphinus delphis* and *Globiecephala melas*
50	Seals	*Haliochoerus grypus* and *Phoca vitulina*

Appendix 2. Additional comments on model adjustments and time series estimation procedure

Scallops. To account for the apparent steep decrease in abundance shown by the landings at the start of the 1970s and early 1980s, the biomass for scallops in the 1973 model described in Araújo et al. (2005) was increased and the values from 1974 to 1982 were estimated by assuming a trend similar to the landings. From 1983 onwards we used the same value as for 1982. The production-to-biomass ratio (*P*/*B*) for the 1973 model in Araújo et al. (2005) was 0.8 yr^{-1}. This value is the same used for the 1994 model, and was based on a mean *F* of 0.6 estimated by Ulrich (2000). It was decreased in this work to 0.5 yr^{-1}, to reflect a lower *F* and less productive state.

Small–medium demersal. The catch time series data were estimated assuming that they followed the same trend of the UK trawl fleet effort in the western English Channel reported in ICES (2000a).

Sole. The *P*/*B* for juvenile sole in the 1973 model described in Araújo et al. (2005) was 0.75 yr^{-1}. It was decreased to 0.65 yr^{-1} after the biomass accumulation rate was included to adjust the biomass estimate of the juvenile group, since it is estimated by Ecopath.

Plaice. The biomass time series data for plaice starts in 1976. So, we estimated the biomass for 1973 to 1975 using the average yield (landings/biomass) for 1976 to 1980 multiplied by the landings of those years. The *P*/*B* for juvenile plaice in the 1973 model described in Araújo et al. (2005) was 1.51 yr^{-1}. It was decreased to 1.35 yr^{-1} after the biomass accumulation rate was included (see comments on sole above).

Lemon sole. There was a huge increase in landings from 1973 up to 1983, but the Marine Biological Association of the UK (MBA) data does not show such an increase in catch rate. The time series of biomass was estimated both according to the MBA data and landings trend. The estimated series presents an increasing trend from 1973 to 1983, decreasing from 1983 to 1994 and increasing afterwards. This sequence resembles the landings trend. The catch data were first estimated using the same proportion of discards as in the 1994 model. However, as it resulted in very high fishing mortalities for some years of the series, the landing data (with no discards) were used to estimate the time series of fishing mortalities.

Whiting. Western English Channel whiting is treated as part of whiting in divisions VIIe–k, the Celtic Sea stock (ICES 2000a). The ICES's Virtual Population Analysis (VPA) time series data for whiting for this stock starts in 1982. The biomass data from 1973 to 1982 were estimated based on the MBA data trend, and followed the ICES data trend afterwards.

Cod. Western English Channel cod is treated as part of whiting in divisions VIIe–k. The landings per unit of effort in the western English Channel reported in ICES (2000a) show a similar trend to biomass time series for the whole stock. This trend was used to estimate the biomass series for the western English Channel. The catch series trend was estimated according the landings per unit of effort and effort data in the western English Channel as reported in ICES (2000a).

Hake. Based on ICES stock assessment data for northern hake stock (divisions IIIa, IV, VI, VII, VIIIa,b; ICES 2000a). The ICES's VPA time series data for this stock start in 1978. The biomass estimates show a declining trend. The biomasses for the years between 1973 and 1978 were estimated using a regression line of biomass against time, extrapolating the trend backwards to each year. Catch series trend was estimated according the trend of the whole stock. The *P*/*B* for the 1973 model in Araújo et al. (2005) was 0.53 yr^{-1}. This value is the same as that used for the 1994 model. It was decreased in this work to 0.44 yr^{-1}, to reflect a lower *F* and less productive state. This estimate corresponds to 1978, the first year of the ICES's VPA time series.

Anglerfish. Based on ICES stock assessment data for anglerfish in Divisions VIIb–k and VIIIa,b (ICES 2000a). The ICES's VPA time series data for anglerfish start in 1986. The landings for anglerfish in the western English Channel showed a huge increase from 1973 up to 1983. The MBA data shows a similar trend but not with the same magnitude. The biomass for 1983 to 1985 was estimated using the same catch to biomass ratio of 1986 and the catches for those years. The biomass data from 1973 to 1983 were estimated assuming that the abundance steadily increased during these years. The *P*/*B* for the 1973 model in Araújo et al. (2005) was 0.23 yr^{-1}, used to represent a low level of *F*. However, the Ecosim simulations predicted a very steep biomass decrease. So, the parameter was increased to 0.41 yr^{-1}, the same estimate as that in the 1994 model in Araújo et al. (2005).

John Dory. The MBA trawl data and ICES landings show opposite trends. It is supposed that the observed landings increase is a result of higher abundance related to higher temperatures. So we made the assumption that the biomass has increased.

Herring. It seems that there are 2 different herring stocks exploited in the English Channel. The eastern English Channel herring is managed as part of the North Sea Downs stock. The western English Channel stock is considered to be a local unit, with landings much lower than in the eastern part (Ulrich et al. 2002). There are time series of VPA biomass estimates for the North Sea and for the Celtic Sea stocks since 1960. The biomass long-term trends of these 2 stocks are very similar. As the western English Channel is between these 2 areas, it seemed quite reasonable to assume that herring abundance stock in this area followed a similar pattern to the Celtic Sea stock.

Mackerel. The mackerel caught in the western English Channel is considered part of the huge western mackerel stock that is exploited in the ICES areas II, III, IV, V, VI, VII and divisions VIIIa and VIIIb (ICES 1999). The time series catch data for the channel show a very different trend to that from the whole stock. It is, at least in part, the consequence of a different pattern

Appendix 2. (continued)

of overwintering migration during the 1970s and early 1980s, as described in the 'Introduction'. So, mackerel had to be split into the regular component and the overwintering mackerel during those years.
To estimate the biomass and landings from 1973 to the early 1980s, the following assumptions were made: (1) The catch and biomass trend for mackerel in the channel followed the same pattern of the western stock. The values for each year of the series were estimated using Eqs. (1) & (2). (2) The overwintering mackerel component was in the channel until 1984. From 1973 to 1984, the biomass and catch 'excess' was put in the overwintering group. According to Lockwood (1988), mackerel do not eat during the overwintering period, and so this group was not included in the model, as it would have little or no effect on simulations.
Scad. The scad caught in the western English Channel is considered part of the western scad stock that is exploited in the ICES divisions IIa, IVa, Vb, VIa, VIIa–c,e–k and VIIIa,b,d,e (ICES 1999). The ICES's VPA stock assessment for scad goes back only until 1982. The biomass data from 1973 up to 1982 were estimated based on the MBA data. From 1982 onwards the data were estimated according to the trend of the whole stock.
Sharks. The fishing mortalities used for 1991 to 1999 were set as the average of the estimates from 1980 to 1990. This was done because the reported landings in the last years of the series were to low, resulting in a very low level of fishing mortalities.

Appendix 3. Prey vulnerability (*v*) parameters estimates by predator

Predator	Starting *v*: 1.5	2	3	4	5	6	7	8	Average *v*	SD	Final *v*
Microzooplankton	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0
Mesozooplankton	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0
Macrozooplankton	12.1	10.7	16.7	20.2	>100	29.1	25.4	17.0	>100	>100	10
Deposit feeders	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0
Suspension feeders	1.0	1.0	1.0	>100	>100	>100	>100	>100	>100	>100	1.0
Shrimp/prawns	1.7	1.7	1.5	1.9	3.1	4.1	4.4	1.0	2.4	1.3	1.7
Whelks	1.0	1.0	1.1	1.18	1.51	1.52	1.51	1.37	1.3	0.2	1.0
Echinoderms	>100	>100	>100	>100	>100	1.0	1.0	>100	>100	>100	2
Bivalves	>100	>100	>100	1.0	2.9	1.8	1.0	1.0	>100	>100	2
Scallops	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	2
Small–medium crabs	94.9	41.3	>100	>100	2.0	3.5	3.0	1.0	>100	>100	10
Large crab	1.6	1.6	1.5	1.9	2.3	2.2	2.2	1.9	1.9	0.3	1.6
Lobster	1.4	1.5	1.6	1.5	1.6	1.5	1.4	1.4	1.5	0.1	1.5
Small–medium demersals	4.5	4.7	3.3	4.5	2.2	3.0	2.6	4.9	3.7	1.1	4.7
Small gadoids	4.8	4.6	5.4	5.2	2.6	4.2	4.1	4.5	4.4	0.9	4.6
Red mullet	>100	>100	>100	>100	4.01	5.05	4.8	5.8	>100	>100	10
Juvenile sole	2.4	2.4	2.2	2.8	2.3	2.6	2.6	3.2	2.6	0.3	2.5
Adult sole	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	10
Juvenile plaice	8.1	8.7	5.4	8.0	5.5	6.9	8.1	6.7	7.2	1.3	8.7
Adult plaice	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	10
Dab	1.0	1.0	1.0	1.0	2.19	1.86	1.99	1.0	1.4	0.5	1.0
Lemon sole	5.0	5.0	3.9	4.1	3.9	7.0	6.7	7.2	5.3	1.4	5.0
Large flatfish	4.3	4.2	3.2	3.8	3.6	3.4	2.9	5.6	3.9	0.9	4.2
Gurnards	1.0	1.0	1.3	1.3	1.2	1.2	1.0	1.2	1.1	0.1	1.0
Juvenile whiting	19.3	30.3	>100	513	1.09	1.0	1.07	24.8	>100	>100	10
Adult whiting	1.2	1.2	1.2	1.16	>100	>100	>100	1.0	>100	>100	1.2
Juvenile cod	8.0	7.3	8.7	10.7	5.6	9.2	5.8	6.1	7.7	1.8	7.3
Adult cod	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0
Hake	4.6	4.5	7.3	5.8	3.9	4.3	6.7	5.2	5.3	1.2	4.5
Dogfish	3.8	3.1	6.2	6.5	11.7	14.2	12.8	9.2	8.4	4.2	3.1
Rays	1.8	1.8	1.7	1.6	1.8	1.7	1.7	1.7	1.7	0.1	1.8
Other gadoids	11.0	8.2	19.3	9.3	>100	>100	>100	43.9	>100	>100	8.2
Anglerfish	>100	>100	>100	>100	2.19	5.14	>100	>100	>100	>100	10
Large bottom	1.2	1.2	1.2	1.2	1.2	1.0	1.0	1.0	1.1	0.1	1.2
Seabream	>100	>100	>100	>100	1.0	1.0	1.0	1.0	>100	>100	2
John Dory	>100	>100	2.1	1.2	2.5	1.7	1.0	18.5	>100	>100	5
Sandeels	3.7	4.2	2.6	2.9	2.5	1.0	1.0	2.5	2.5	1.1	4.2
Herring	1.8	1.6	2.2	1.9	5.2	3.3	3.8	2.4	2.8	1.2	1.6
Sprat	2.9	3.0	2.8	3.0	2.8	2.5	2.5	2.4	2.7	0.2	3
Pilchard	1.0	1.0	1.0	>100	>100	2.2	1.0	2.78	>100	>100	3
Mackerel	1.2	1.3	1.2	1.2	1.1	1.2	1.2	1.3	1.2	0.1	1.3
Scad	1.4	1.4	1.5	1.4	1.3	1.3	1.3	1.3	1.3	0.1	1.4
Bass	1.2	1.2	1.1	1.0	1.7	1.6	1.7	1.4	1.3	0.3	1.2
Sharks	2.0	2.0	1.7	1.7	1.5	1.4	1.4	1.5	1.7	0.2	2.0
Basking shark	>100	1.0	5.3	4	3.23	>100	3.96	13.9	>100	>100	2
Cephalopods	2.4	2.1	4.2	3.7	1.3	1.0	1.0	1.0	2.1	1.3	2.1
Birds	1.6	1.6	1.0	1.0	>100	>100	1.54	1.0	>100	>100	1.6
Toothed cetaceans	1.0	1.0	1.0	1.0	>100	>100	>100	>100	>100	>100	2
Seals	1.0	1.0	>100	>100	>100	>100	>100	>100	>100	>100	10