The following supplements accompany the article

Effects of the invasive red king crab on food web structure and ecosystem properties in an Atlantic fjord

Torstein Pedersen*, Mona M. Fuhrmann, Ulf Lindstrøm, Einar M. Nilssen, Trond Ivarjord, Virginie Ramasco, Lis L. Jørgensen, Jan H. Sundet, Knut Sivertsen, Emma Källgren, Ann Merete Hjelset, Christer Michaelsen, Geir Systad, Fredrika Norrbin, Martin-A. Svenning, Arne Bjørge, Henning Steen, Kjell T. Nilssen

*Corresponding author: torstein.pedersen@uit.no

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Supplements 1–9: Input data and structure of Ecopath models

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1 Introduction

This report gives an overview of the background data for the Ecopath models for Porsangerfjord. The fjord was divided into five subareas and one Ecopath model was estimated for each area. Much of the data needed to estimate the models were collected during a research programme (EPIGRAPH) “Ecological Processes and Impacts Governing the Resilience and Alternations in the Porsangerfjord and the Hardangerfjord”. In Porsangerfjord, the investigations were carried out in collaboration between the Institute of Marine Research (IMR), the University of Tromsø and the Finnmark University College. The report describes the background for the input data and gives all input values, modifications to dietary compositions that were needed to balance the models, and resulting balanced models.

2 Description of concepts and equations supplementing the paper

Predation mortality

The predation mortality $M2_{ij}$ on group *i* by predatory group *j* is calculated within EwE (Ecopath with Ecosim, Christensen & Walters 2004) as:

$$M2_{ij} = (B_j\,(Q/B)_j\,DC_{ji})/B_i \qquad (1)$$

where B_j is the biomass of the predator group *j*, $(Q/B)_j$ is the consumption/biomass ratio of the predatory group *j* and DC_{ji} is the proportion of prey *i* in the diet of predator *j*. B_i is the biomass of the prey group.

Feeding selection index

The feeding electivity as it is implemented in Ecopath is described by Christensen and Pauly (1992). Feeding electivies are calculated based on the standardized forage ratio (S_i) described by Chesson (1983). This measure is given by;

$$S_i = \frac{\frac{r_i}{P_i}}{\sum_{j=1}^{n} \frac{r_j}{P_j}} \qquad (2)$$

Where r_i is the relative biomass of prey *i* in a predators diet and P_i is the relative biomass of the prey in the ecosystem. The denominator is the sum for all (*n*) groups *j*. In Ecopath, the forage ratio has been transformed so that it vary between 1 and -1.

Search rates

In Ecopath, the search rates represent the "rates of effective search" of the predator per unit predator biomass (Walters et al 1997). Search rates a_{ji} are calculated for predator j consuming prey i:

$$a_{ij} = \frac{Q_{ji}}{(B_j \cdot B_i)} \tag{3}$$

where Qji is the consumption rate (g C m^{-2} year^{-1}) for predator j of prey i and is given as:

$$Q_{ji} = \frac{Q}{B}_j \cdot B_j \cdot DC_{ji} \tag{4}$$

and B_j and B_i are the biomass (g C m^{-2}) of predator j and prey i, respectively. Q/B_j (year^{-1}) is the consumption per biomass ratio of predator j. DC_{ji} is the proportion of prey i in the diet of predator j. a_{ji} has the unit: m^2/(g C year^{-1}), i.e. area per g predator biomass per year. a_{ij} can be compared for similar prey (e.g. small gadoid species) for given predators to assess if proportions of prey in the diet (DC_{ji}) are reasonable.

Omnivory and connectance

The omnivory index (OI_j) is the variance of the trophic levels of a consumer's prey groups and is estimated as (Pauly et al. 1993):

$$OI_j = \sum_{j=1}^{n} (TL_i - (TL_j - 1))^2 \, DC_{ji} \tag{5}$$

where TL_i is the trophic level of the prey and TL_j is the trophic level of the predator. OI_j is dimensionless and has the lowest possible value of zero when the predator is specialised and feeds on a single trophic level. A high value of OI_j indicates predation on several trophic levels. The square root of OI_j is the standard error of the trophic level of the predator.

The system omnivory index is defined as the average omnivory index of all consumers weighted by the logarithm of each consumer's food intake (Christensen & Walters 2004).

The connectance index (C) is computed as the number of actual links in relation to number of possible links in the food web (Christensen & Walters 2004).

Mixed trophic impact

The mixed trophic impact m_{ij} is estimated as the product of all net impacts for all possible pathways that link groups *i* and *j* (Libralato et al. 2006). Christensen and Pauly (1992) give a detailed explanation of the derivation of mixed tropics impacts. A measure of the total impact of each ecological group e_i is calculated as:

$$e_i = \sqrt{\sum_{j \neq i}^{n} m_{ij}^2} \qquad (6)$$

The 62-groups models were estimated using version 6.5.14040.0 of Ecopath with Ecosim (http://ecopath.org).

3 Description of the study area

Division into subareas

The division into subareas (Fig. S1) was based on between-area differences in density of red king crabs, biomass of benthic invertebrate and other groups and on inspection of the bathymetry and topography of the fjord and the requirement that we should have at least two bottom trawl locations within each subarea to be able to compare within-subarea variance. The total area and delimitation of the fjord are equal to the statistical area 24 of the Norwegian Directorate for Fisheries, which is used by the fishermen as a geographical location when reporting catches (http://www.fiskeridir.no/statistikk/fiskeri/kart/kart-lokasjon-og-omraade). The area and coastline length for each of the subareas were estimated by area integration and measuring distances on a digital map. The subareas have the following areas (km^2): 555.4 (1); 481.0 (2); 512.9 (3); 156.3 (4E); 171.8 (4E).

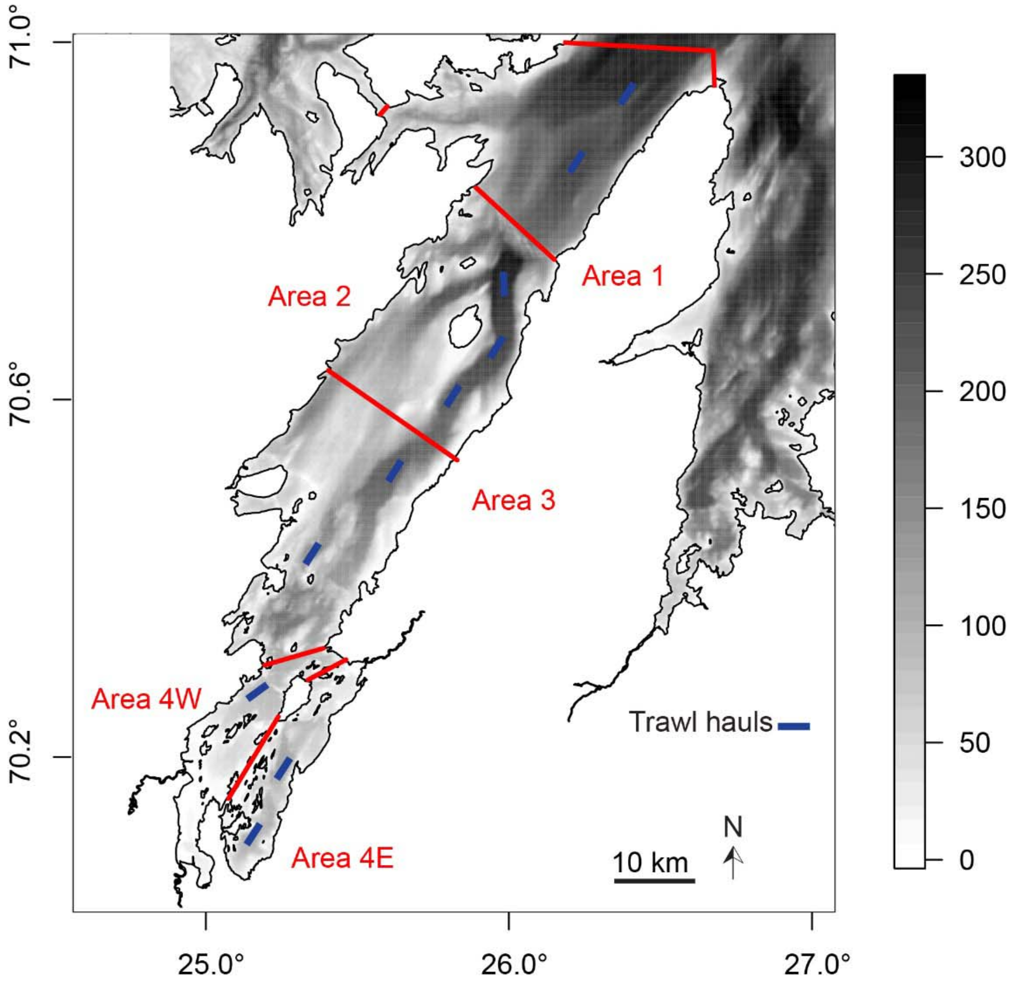

Figure S1. Overview of the five subareas in Porsangerfjorden. One Ecopath model was estimated for each subarea. Blue bars show bottom otter-trawling locations. Grey scale on the right show depth in m.

Topography and hydrography

Porsangerfjorden covers an area of approximately 1877 km^2 along 70°–71° N and 25°–26° E. The fjord is comparatively wide, measuring 15–20 km across the outer/middle fjord (Svendsen 1995). With depths of ca. 300 m at the entrance, it is open towards the outer coast and the Barents Sea. A shallow sill of ca. 60 m, together with a narrowing of the fjord ca. 30 km from the head, separates the inner part from the outer fjord. This inner area is characterized by small islands and skerries, and the area is in general shallow with two deeper basins towards the east. Cold bottom temperatures (around 0°C), and subzero temperatures in the winter and early spring, are found within these deep basins. Despite large seasonal variations in surface temperatures, downward heating occurs only slowly here (Mankettikkara 2013) and bottom temperatures throughout the year remain lower than in the rest of the fjord. Sea ice usually forms in the inner area between January and May. The influence of Atlantic water in the outer part and the isolation of the inner fjord create a temperature gradient along Porsangerfjorden. Freshwater discharge is low in Porsanger (Svendsen 1995) and occurs particularly during the melting season from three rivers in the inner part: Lakselv, Stabburselv (west) and Børselv (east). Stratification in the rest of the fjord is generally low (Svendsen 1991). Circulation and mixing are mostly wind driven, regulated by seasonal changes in magnitude and direction (Svendsen 1995, Myksvoll et al. 2012). During stratification in summer, prevailing winds can cause upwelling at the east side of the fjord (Svendsen 1991, Myksvoll et al. 2012). At the same time, surface temperatures show a marked, cross fjord trend, due to an outflow of low saline water in the east and inflow of warmer, high saline water in the west, however this trend decreases rapidly with depth (Svendsen 1991).

4 Ecological groups and model input data

Input values needed

For each group, there is a need for data on biomass (*B*), production per biomass (*P/B*), consumption per biomass (*Q/B*) and ecotrophic efficiency (*EE*). For each group, three of these four parameters need to be known while the Ecopath model may estimate the fourth parameter based on the consumption from the groups consuming the target group. Therefore, biomasses of top predators always need to be known. In addition, values for proportion of unassimilated consumption (*U/Q*), catch (*Y*, landings and discard), other mortality, emigration, immigration, biomass accumulation (*BA*, change in biomass from one year to another), discards and detritus fate of discards may be given for each group.

For carnivore groups, Ecopath default values (0.20) were used for *U/Q*. For the krill groups and for small zooplankton *U/Q* = 0.30 were applied (Slagstad et al., 1999). For benthic, predominantly detritivorous groups, *U/Q*- values were based on Valiela (1995) and T. Brey (unpubl. data, Alfred Wegener Inst. Polar and Marine Res., POB 120161, D-27576 Bremerhaven, Germany), and most most detrivore groups had higher *U/Q*-values; detrivore polychaeta (0.70), large bivalves (0.70), detrivore echinoderms and herbivore echinoids (0.70). The more omnivorous had lower *U/Q*-values; small benthic crustaceans (0.50), small molluscs (0.50), and other benthic invertebrates (0.50).

The dietary composition (weight proportions of various prey in the diet of the group), the proportion of consumed food that is not assimilated and the fishery landing data must be known for all groups. The fate of detritus, i.e. which detritus group receives the detritus from the target group, must be specified for all groups. The model uses biomass and flows in carbon units. Thus, wet (WW) or dry weight (DW) measurements must be converted to carbon (C) units. A carbon/wet weight ratio of 0.12, which is the average of the value used by Sakshaug et al. (1994) and the values for benthivorous and demersal piscivorous fish given by (Greenstreet 1996), was used to convert wet-weight (WW) measurements to carbon (C) units for mammal-, bird and fish groups. Group specific conversion factors are given for other groups.

Overview of groups with major species listed

In the models, groups were compiled so that taxa with apparently similar diet and the same or similar predators were in the same group (Table S1).

Table S1. Trophic groups used in the Ecopath models for Porsangerfjorden. Gr.: group; Ind.: individuals

Gr. no.	Group name	Main taxa
1	Grey seals	*Halichoerus grypus*
2	Harbour seals	*Phoca vitulina*
3	Whales	*Phocoena phocoena* (harbour porpoise)
4	Otters	*Lutra lutra* (Eurasian otter)
5	Piscivorous benthic feeding birds	*Gavia stellata* (red-throated loon), *Gavia arctica* (black-throated loon), *Gavia adamsii* (yellow-billed loon), *Phalacrocorax carbo* (great cormorant), *Mergus merganser* (common merganser), *Mergus serratus* (red-breasted merganser), *Cepphus grylle* (black guillemot)
6	Pelagic diving birds	*Fratercula arctica* (Atlantic puffin), *Alca torda* (razorbill)
7	Surface feeding birds	*Larus fuscus* (lesser black-backed gull), *Larus argentatus* (herring gull), *Larus marinus* (great black-backed gull), *Larus canus* (common gull), *Rissa tridactyla* (black-legged kittiwake), *Sterna paradisaea* (Arctic tern), *Stercorarius parasiticus* (Arctic skua), *Haliaeetus albicilla* (white-tailed eagle)
8	Benthic invertebrate feeding birds	*Somateria mollissima* (common eider), *Somateria spectabilis* (king eider), *Clangula hyemalis* (long-tailed duck), *Melanitta nigra* (common scoter), *Melanitta fusca* (velvet scoter)
9	Large cod (≥ 35 cm)	*Gadus morhua*
10	Small cod (< 35 cm)	*Gadus morhua*
11	Large saithe (≥ 35 cm)	*Pollachius virens*
12	Small saithe (< 35 cm)	*Pollachius virens*
13	Large haddock (≥ 35 cm)	*Melanogrammus aeglefinus*
14	Small haddock (< 35 cm)	*Melanogrammus aeglefinus*
15	Small gadoids	*Trisopterus esmarki* (Norway pout), *Gadiculus argenteus* (silvery pout), *Merlangius merlangius* (whiting), *Micromesistius poutassou* (blue whiting)
16	Halibut	*Hippoglossus hippoglossus* (Atlantic halibut)
17	Other large flatfish	*Hippoglossoides platessoides* (long rough dab), *Pleuronectes platessa* (plaice), *Microstomus kitt* (lemon sole), *Glyptocephalus cynoglossus* (witch flounder), *Platichthys flesus* (European flounder)
18	Other small flatfish	Same species as in group 17, but length < 35 cm
19	Other large demersal fish	*Anarhichas lupus* (Atlantic wolff ish), *Anarhichas mino*r (spotted wolffish), *Brosme brosme* (tusk), *Molva molva* (ling), *Sebastes* spp. (redfish), *Lophius piscatorius* (anglerfish), skates , *Cyclopterus lumpus* (Lumpfish)
20	Other small demersal fish	*Lumpenus* spp., small skates , Stichaidae, small *Sebastes* spp., Zoarcidae, Liparidae
21	Cottids	*Myoxocephalus scorpius* (Atlantic shorthorn sculpin), *Artedillus atlanticus* (hookear sculpin)
22	Small pelagic fish	*Mallotus villosus* (capelin), Ammodytidae (sandeel), *Benthosema glaciale* (glacier lanternfish), *Maurolicus muelleri* (Müllers pearlside), *Argentina silus* (greater argentine)
23	Herring	*Clupea harengus*

Gr. no.	Group name	Main taxa
24	Salmon	*Salmo salar*
25	Sea trout	*Salmo trutta*
26	Arctic charr	*Salvelinus alpinus*
27	Small krill	*Thyssanoessa inermis*, *Thyssanoessa raschii*
28	Large krill	*Meganyctiphanes norvegica*
29	Small zooplankton	*Calanus finmarchicus*, *Acartia longiremis*, *Pseudocalanus* spp., *Metridia* spp., *Oithona* spp.
30	Microzooplankton	Heterotrophic dinoflagellates, ciliates, tintinnids
31	Heterotrophic nanoflagellates	
32	Schyphomedusa	*Cyanea capillata*, *Aurelia aurita*
33	Chaetognaths	*Sagitta elegans*
34	Other large zooplankton	Pelagic amphipods, pelagic polychaetes, appendicularians
35	Pandalid shrimps	*Pandalus borealis* (deep-water shrimp), *Pandalus montagui*, *Eualus gaimardii*, *Eualus pusiolus*
36	Large red king crab	*Paralithodes camtschaticus*, ind. ≥ 130 mm carapace length (CL)
37	Medium red king crab	≥70 mm CL and < 130 mm CL
38	Small red king crab	Bottom settled juveniles < 70 mm CL
39	Crangonid shrimps	*Sclerocgrangon boreas*, *Sabinea septemcarinata*, *Lebbeus* spp., *Pontophilus norvegicus*, *Spirontocaris* spp.
40	Other large crustaceans	*Hyas araneus*, *Hyas coarctatus*, Paguridae, *Lithodes maja*, Munididae
41	Predatory asteroids	*Asterias rubens*, *Crossaster* spp., *Leptasterias* spp., *Henricia* spp., *Pseudarchaster* spp.
42	Predatory gastropods	*Buccinum undatum*, *Neptunea* spp., *Colus* spp., Naticidae, limpets, Nudibranchia (except *Aplysia* spp.), *Epitonium* , Nudibranchia (except *Aplysia sp*p.). Smaller infaunal families, all Philinoidea (*Cylichna* spp., *Retusa* spp., Scaphandridae, Philinidae)
43	Predatory polychates	Nephtyidae, Lumbrineridae, Syllidae, Polynoidae, Amphinomidae, Phyllodocidae, Glyceridae, Hesionidae, Pholoidae
44	Other predatory benthic invertebrates	*Ophiura* spp., Nemertea, Plathyelminthes, *Pycnogonum* spp. and *Nymphon* spp. (Pycnogonida), *Rossia* spp. (Cephalopoda), Edwardsiidae, other Actinaria
45	Detritivorous polychaetes	Maldanidae, Owenidae, Chaetopteridae
46	Small benthic crustaceans	Benthic Amphipoda, Mysida, Cumacea, Leptostraca, Isopoda, Cirripedia
47	Small molluscs	Small gastropods (except predatory), *Lepeta caeca*, *Rissoella* spp., small bivalves (*Yoldiella* spp., *Parvicardium minimum*, *Nuculana* , *Musculus niger*, *Bathyarca glacialis*, *Hiatella arctica*), Caudofoveata, Polyplacophora, littoral snails (mainly Margharitidae), Nudibranchia (except *Aplysia*), *Hiatella arctica* (not found in grabs), Anomiidae
48	Large bivalves	*Mytilus edulis*, *Yoldia hyperborea*, *Mya* spp., *Arctica islandica*, *Mya truncata*, *Cardiidae*, *Chlamys islandica*, *Modiolus modiolus*
49	Detritivorous echinoderms	Ophiuroidea, Holothuroidea (mainly *Cucumaria frondosa*), *Ophiopholis aculeata*

Gr. no.	Group name	Main taxa
50	*Ctenodiscus crispatus*	Mud star
51	Large epibenthic suspension feeders	Actinaria, Alcyonacea, *Gorgonocephalus* spp., Brachiopoda, Porifera, Hydroidea, Ascidiacea
52	Other benthic invertebrates	Sipuncula, Echiura, Hemichordata, *Aplysia* sp.
53	Herbivorous echinoids	*Strongylocentrotus droebachiensis*
54	Bacteria	
55	Kelp	*Laminaria hyperborea*, *Saccharina latissima*, *Alaria pylaii*, *Laminaria digitata*
56	Annual macroalgae	*Chorda filum*, *Halosiphon tomentosum*, *Dictyosiphon foeniculaceus*
57	Littoral macroalgae	*Ascophyllum nodosum*, *Fucus serratus*, *Fucus vesicolosus*, *Fucus disticus*, *Fucus spiralis*, *Devalera ramentacea*, *Palmaria palmata*
58	Benthic microalgae and recruiting microalgae	Benthic diatoms
59	Phytoplankton	
60	Discards and offal	Discard from the fishery, mainly offal from the fishery of gadoids
61	Detritus from macroalgae	From macroalgae
62	Detritus from all other sources	From all groups except macroalgae groups

5 Data input for the groups

Mammals

There are four mammal groups in the model and an overview of input values is given in Table S2.

Table S2. Overview of input values for the mammal groups (Gr. 1–4) to the Ecopath models for the subareas. Gr.; group

				Biomass in subareas (g C m^{-2})				
Gr. no.	Group name	*P*/*B* ($year^{-1}$)	*Q*/*B* ($year^{-1}$)	1	2	3	4E	4W
1	Grey seals	0.12	16.0	$4.5*10^{-4}$	$5.2*10^{-4}$	$4.9*10^{-4}$	$0.3*10^{-4}$	$0.5*10^{-4}$
2	Harbour seals	0.09	15.0	$0.5*10^{-4}$	$0.5*10^{-4}$	$5.1*10^{-4}$	$49*10^{-4}$	$31*10^{-4}$
3	Whales	0.133	12.8	$2.8*10^{-5}$	$2.8*10^{-5}$	$2.8*10^{-5}$	$2.8*10^{-5}$	$2.8*10^{-5}$
4	Otters	0.250	68.4	$1.1*10^{-4}$	$0.9*10^{-4}$	$1.2*10^{-4}$	$3.2*10^{-4}$	$3.4*10^{-4}$

1. Grey seals

The grey seals were mainly distributed in the outer part of the fjord around Tamsøya and used Tamsøya as a haul-out site. There were 20–40 animals present in Porsangerfjorden at Tamsøya during the period November–December 2009–2010. During the period February–April there may be 100–200 animals present. Based on counting, it was assumed that in the outer part of the fjord (subareas 1, 2 and 3) 30 animals were present during the whole year, and in addition that 100 more animals were present in these areas during March and April (K. T. Nilssen, IMR, pers. comm.). This gives an average annual abundance of 47 individuals for the outer area (1, 2 and 3). In addition, 1–4 animals were often observed in the inner area (4E and 4W) in August–October, and it was assumed that during August–October, two individuals were present in subarea 4W and one individual was present in 4E. Individual body weight was 134 kg WW (Dommasnes et al. 2002). This gives a total biomass in the fjord of 6.3 tonnes WW, and when converted to carbon (C/WW = 0.12) this gives subarea biomasses (g C m^{-2}) of 0.000449 (subarea 1), 0.000518 (2), 0.000486 (3), 0.000026 (4E) and 0.000047 (4W). The value of *P/B* was set to 0.12 $year^{-1}$ calculated from the natural mortality rate of 0.05 $year^{-1}$ and population size and annual catches in 2009 and 2010 in Finnmark (Øigård et al. 2012).

The harvesting mortality rate (F) was calculated to 0.067 year^{-1} from the catches and the natural mortality rate.

The value of *Q/B* was set to 16.0 year^{-1} (K. T. Nilssen, IMR, pers. comm.), which is similar to 15.0 year^{-1} used by (Dommasnes et al. 2002).

Diet was estimated by reconstruction based on otoliths and hard remains from stomach sampling by Institute of Marine Research (IMR) from March 2005 (n = 12) and February and March 2007 (n = 37). Dietary composition was: large cod (32.8%), small cod (20.0%), other large demersal fish (12.1%), large haddock (8.5%), small saithe (6.3%), small haddock (5.0%), small gadoids (4.6%), other small demersal fish (3.7%), other large flatfish (3.4%), cottids (2%), herring (1.6%) and small pelagic fish (0.2%).

2. Harbour seals

The harbour seals were mostly distributed in the inner part of Porsangerfjorden. Average annual abundance for 2009–2010 was in the range 220–250, and average abundance for Porsangerfjorden in the models was assumed to be 235 animals based on counting (Kjell Nilssen, IMR, pers. comm.). A new counting in 2013 gave 194 individuals (K. Nilssen, IMR, pers. comm). Individual body weight was 58 kg WW (Dommasnes et al. 2002). This gives a total biomass in the fjord of 13.6 tonnes WW. Using a C/WW factor of 0.12, total carbon biomass for the fjord was calculated as 1.63 t C.

Data on positions and behaviour were retrieved for 15 individual harbour seals in Porsangerfjorden from the period autumn 2009 to winter 2013 (Ramasco et al. 2015). The proportion of time spent foraging was calculated for each time interval between two successive positions (45 min) for each tagged harbour seal (n = 15) following Ramasco et al. (2015a). Each position, and associated foraging time budget, was assigned to one of the five subareas in Porsangerfjorden (1, 2, 3, 4W or 4E) and the total amount of time spent foraging per subarea was therefore calculated and divided by the total time spent foraging. In this way a proportion of time spent foraging per area, animal and season (autumn, September–November; winter, December–February; spring, March–May) was computed. The values were averaged across individuals and multiplied by population estimates to calculate the total predation effort per area. Carbon biomasses in the model subareas in fjord were calculated by multiplying proportions of predation effort times total carbon biomasses for the fjord.

The value of *P/B* was set to 0.09 year^{-1} (Härkonen & Heide-Jørgensen 1990). The harvesting mortality rate (F) was calculated as 0.03 year^{-1} from the total stock size in Finnmark of 900 individuals and the average harvest of 26.5 individuals in Finnmark for 2009 and 2010 (Nilssen & Bjørge 2015). The value of *Q/B* was set to 15.0 year^{-1} (Dommasnes et al. 2002).

The diet of harbour seals was investigated from scats collected in 2009, 2010 and 2011 (n = 48) from the inner part of Porsangerfjorden (N 70.152°, E 25.151°) (Ramasco 2015). Diet proportions were estimated from length of otoliths that were converted to fish length and fish weight (*op cit.*). Cottids and gadoids were the major prey groups in terms of weight. The great majority of fish were less than 35 cm in length. Dietary composition was calculated taking into account different recovery rates for the different species due to species-specific otolith sizes and hence species-specific recovery rates. Dietary composition was: cottids (68.7%), small cod (11.2%), other small flatfish (3.0%, witch flounder, long rough dab, plaice), other small demersal fishes (5.8%, redfish, eelpouts, liparids), small pelagic fishes (4.3%, sandeel, daubed shanny, snakeblenny, capelin), herring (3.8%), small saithe (1.8%) and small haddock (1.4%).

3. Whales

In Porsangerfjorden, white-beaked dolphins, harbour porpoises and killer whales may be present, but there are no estimates of abundance based on sighting and counting in Porsangerfjorden. Based on visual observations from Porsangerfjorden, we assumed that harbour porpoise was the most abundant whale species in terms of biomass. Abundance values from sighting surveys from the coast of Finnmark from 1988 and 1989 gave an average density of harbour porpoises of 0.00594 individuals km^{-2}. This correspond to a total of 11 individuals in Porsangerfjorden and with a body weight of 39 kg WW this gives a wet biomass of 0.00023 t WW km^{-1}. Using a C/WW of 0.12 this gives a C biomass of 0.000028 g C m^{-2}. It was assumed that the whales were evenly distributed in all subareas.

The value of *P*/*B* was set to 0.133 year^{-1} (Lockyer 2003), and *Q*/*B* was set to 12.8 year^{-1} based on a daily food intake of 3.5% of the body mass (Santos & Pierce 2003).

Stable isotope data (Fontaine et al. 2007) show that harbour porpoises on the coast of Finnmark had a pelagic food chain signature and were likely to feed on pelagic planktivore feeding fishes. Stomach data from the coast of Finnmark from 1988 show that capelin, herring, saithe and haddock were important prey (Bjørge 2003) and the dietary composition in the models was; small pelagic fishes (40%), herring (30%), small saithe (15%) and small haddock (15%).

4. Otters

Otters were frequently observed along the shores in Porsangerfjorden (H. K. Strand, IMR, pers. comm.). The density of otters can differ between mainland and island shoreline, with Heggberget (1995) giving values for average densities for northern Norway during 1990–93 of 4.75 animals per 10 km for island shoreline and 1.75 animals per 10 km for mainland shoreline. In an investigation in Finnmark carried out during 1999, however, the densities of otters had increased since the period 1991–92 and no difference in density was found between island and mainland shoreline (Bjørn 2000). Thus, it was assumed that the density of otters in Porsangerfjorden was equal to 4.75 otters per 10 km shoreline at mainland and islands. The distances of mainland and island shorelines were measured on digital maps, giving a total of 494 km mainland and 179 km island shoreline. This equated to a total of 321 individuals in Porsangerfjorden with the highest area density in inner areas which had the longest relative distances of shoreline. Biomasses in C within subareas were estimated according to the distance of shoreline, assuming a body weight of 7.2 kg WW and using a C/WW of 0.12.

A *P/B* of 0.25 year^{-1} was used (Kruuk & Conroy 1991), and a *Q/B* of 68.4 year^{-1} was calculated from a daily consumption of 1.35 kg WW per individual and a body mass of 7.2 kg WW (Heggberget 1995).

In northern Norway, otters mainly feed on gadoids, such as cod and saithe (*Pollachius virens*), various flatfishes and cottidae (Heggberget 1995), ranging from 4 to 60 cm in length. The dietary composition was: small cod (20%), other small flatfish (15%), other small demersal fish (15%), small saithe (13%), cottids (10%), other large flatfish (10%), small haddock (7%), small gadoids (5%) and other large demersal fish (5%).

Bycatch of otters in in the fishery in Finnmark is uncommon since traps are seldomly used at shallow waters (Bjørn 2000).

Bird groups

The abundance of birds was estimated from sighting surveys during June 2005 and March 2006, 2010 and 2012 (G. H. Systad, Norwegian Institute for Nature Research (NINA), unpubl. material). Earlier data were from the breeding season during 1988–90 (Strann 1992) and from air-plane sighting surveys during the winter period 1998–99 (Systad & Bustnes 1999). The average annual abundance of each species in each subarea was calculated from the total numbers counted during surveys in the fjord, by firstly multiplying total numbers with the number of months they were present and secondly dividing by 12 months. For some species that were present during the whole year, the number counted from the summer and the winter season were weighted according to the number of months the surveys were considered to represent.

The average annual biomass of each species was calculated from the average annual abundance and the body mass, and these biomasses were summed to give the average annual biomass of the group in each subarea. Biomass in wet weight was converted to carbon using a C/WW-ratio of 0.12. Table S3 gives an overview of input values for the bird groups.

Table S3. Overview of input values for the bird groups (Gr. 5–8) to the Ecopath models for the subareas. Gr.: group

				Biomass in subareas (g C m^{-2})				
Gr. no.	Group name	*P/B* ($year^{-1}$)	*Q/B* ($year^{-1}$)	1	2	3	4E	4W
5	Piscivorous benthic feeding birds	0.210	103.0	$0.8*10^{-4}$	$0.4*10^{-4}$	$3.9*10^{-4}$	$1.3*10^{-4}$	$9.2*10^{-4}$
6	Pelagic diving birds	0.078	135.6	$1.4*10^{-6}$	$1*10^{-9}$	$1*10^{-9}$	$1*10^{-9}$	$1*10^{-9}$
7	Surface feeding birds	0.128	118.9	$2.9*10^{-4}$	$6.5*10^{-4}$	$1.4*10^{-4}$	$3.4*10^{-4}$	$6.1*10^{-4}$
8	Benthic invertebrate feeding birds	0.163	57.6	$3.8*10^{-4}$	$5.5*10^{-4}$	$4.3*10^{-4}$	$33*10^{-4}$	$47*10^{-4}$

5. Piscivorous benthic feeding birds

This group comprises great cormorants (*Phalacrocorax carbo*), common merganser or goosander (*Mergus merganser*), red-breasted merganser (*Mergus serrator*), black guillemot (*Cepphys grylle*), red-throated diver (*Gavia stellata*), black-throated diver (*Gavia arctica*) and yellow-billed diver (*Gavia adamsii*) (Table S1).

In addition to the numbers breeding in the area, about 1000 male goosanders (*Mergus merganser*) use the area during summer from May to September, giving an annual average number of 500 individuals (G. H. Systad, NINA, pers. comm.). Great cormorants and goosanders contribute most to the biomass of this group (Table S4). The number of birds during winter in this group is relatively low compared to the numbers breeding in the fjord during summer (Systad & Bustnes 1999). The average annual wet biomass of the group in Porsangerfjorden was 3.57 tonnes WW. The annual average biomass for the group for the whole fjord was calculated as 0.000229 g C m^{-2}. The spatial counting data for cormorants, red-breasted merganser, goosander and black guillemot were used to estimate the proportions of the biomass in the subareas.

Table S4. Overview of numbers of birds in the "Piscivorous benthic feeding birds" group, estimated in Porsangerfjorden. Average annual abundances are based on countings in 2005. Biomasses were calculated for the whole fjord. Annual av. no. ind.: annual average number of individuals

Species	No. counted	Present	Annual av. no ind.	Body mass (kg WW)	Biomass (t WW)	*Q/B* ($year^{-1}$)
Red-throated diver	10	May–Sep	5	1.30[a]	0.007	101.1[d]
Black-throated diver	20	May–Sep	10	3.00[h]	0.030	101.1[d]
Yellow-billed loon	5	Jan–Dec	5	5.30[e]	0.027	101.1[d]
Great cormorant	1265	Apr–Sept	736	3.25[b]	2.393	101.1[b]
Red-breasted merganser	50	Jan–Dec	50	1.30[c]	0.065	107.3[f]
Goosander	1000	May–Sep	500	1.62[g]	0.810	99.8[g]
Black guillemot	625	Jan–Dec	625	0.39[b]	0.244	154.7[b]

[a]Platteeuw and van Eerden (1997) average for female and male, [b]Barrett et al. (2002), [c]Platteeuw and van Eerden (1997), [d]set to same value as for great cormorant, [e]Dunning Jr (1992), [f]Buijse et al. (1993), [g]Feltham (1995), [h]Grandgeorge et al. (2008)

A *P/B* value of 0.21 $year^{-1}$ was estimated from the annual survival rate of 80.4% for adult Norwegian cormorants (Fiske & Røv 1997), and this value was applied in the model.

Values for *Q/B* were taken from the literature (Table S4). Consumption values were calculated for each group and an overall *Q/B* for the group was calculated as 103.0 $year^{-1}$ based on the total consumption by the group divided by the average annual biomass.

The diet was calculated by using information from Barrett et al. (2002) for great cormorant and black guillemot. For red-throated diver, black-throated diver and yellow-billed loon, which are not mentioned in Barrett et al. (2002), it was assumed that they had the same diet as great cormorant. For goosanders, dietary information was taken from Svenning et al. (2005b) who investigated the diet of male goosanders in the Tanafjord, Finnmark. The dietary proportions of each species were weighted by their consumption values, and the dietary proportions of the total group which were input to the Ecopath models were calculated, taking the energy content of the prey into account. The dietary composition in the model was: small pelagic fish (40.2%), cottidae (2.0%), other small demersal fish (2.0%), small cod

(18.0%), small saithe (18.0%), predatory polychaetes (4.6%), small haddock (9.0%), other large crustaceans (4.6%), small benthic crustaceans (0.9%), small molluscs (0.5%).

6. Pelagic diving birds

This group consists of Atlantic puffin and razorbill which breed in small numbers at the breeding colony at Sværholtklubben (N 70° 58’ 30”, E 26° 41’ 0”) at the eastern border of subarea 1. The available literature and survey information indicate that, except for the outer subarea 1, the group had very low abundance in Porsangerfjorden. For pelagic diving birds, the biomasses were set to the low value of $1*10^{-9}$ g C m^{-2} for the subareas other than 1. Common guillemot and Brünnich guillemot do not breed near Porsangerfjorden. It was assumed that the average annual abundance in subarea 1 was 22 puffins and 18 razorbills, and with body masses of 0.46 kg WW for puffins and 0.71 kg WW for razorbills (Barrett et al. 2002), this gives a biomass of $1.4*10^{-6}$ g C m^{-2} in subarea 1.

The value for *P/B* used in the model (0.078 $year^{-1}$) was estimated as the average of the survival rates given by Sandvik et al. (2005) for razorbill (*P/B* = 0.084 $year^{-1}$) from Hornøya (N 70° 23’, E 31° 09’), northern Norway and two estimates for puffins from Hornøya (*P/B* = 0.056 $year^{-1}$) and Røst (N 67° 31’, E 12° 05’) (*P/B* = 0.110 $year^{-1}$), northern Norway. Consumption per bird was taken from Barrett et al. (2002) and converted to consumption per biomass for each species. The *Q/B*-values were calculated from Anker-Nilssen and Barrett (1991), and were 186.9 $year^{-1}$ for puffins and 94.0 $year^{-1}$ for razorbills. This gave a *Q/B* of 135.6 $year^{-1}$ for this group.

The dietary values for the group were based on the diet for Atlantic puffin from the Barents Sea, given by Barrett et al. (2002): 30% capelin, 30% sandeels, 10% herring (“fatty” fish) and 30% “lean” fish. The dietary composition in the model was: small pelagic fishes (60%), herring (10%), small saithe (10%), small haddock (10%), small cod (5%) and small gadoids (5%).

7. Surface feeding birds

This group consists of great and lesser black-backed gull (*Larus marinus* and *Larus fuscus*), herring gull (*Larus argentatus*), common gull (*Larus canus*), black-legged kittiwake (*Rissa tridactyla*), Arctic tern (*Sterna paradisaea*), Arctic skua (*Stercorarius parasitticus*), and white-tailed eagle (*Haliaeetus albicilla*) (Table S1). Some few northern gannets have been observed to forage in the outer part of Porsangerfjorden (Pettex et al. 2012), but numbers of average abundance are not available and this species was not included in the group.

Table S5. Overview of annual average numbers of individuals in the "Surface feeding" group, based on sightings in June 2005 in Porsangerfjorden (G. H. Systad, NINA, unpubl. matr.). Annual av. no. ind.: annual average number of individuals

Species	No. counted	Present	Annual av. no. ind.	Body mass (kg WW)	Bio-mass (t WW)	*Q/B* (year^{-1})
Arctic skua	70	May–Aug	23	0.35[b]	0.008	97.8[b]
Lesser black-backed gull	90	Jun–Aug	23	0.80[b]	0.018	134.6[e]
Herring gull	3000	Jan–Dec	3000	1.00[b]	3.000	134.6[b]
Great black-backed gull	1812	Mar–Nov	1359	1.68[b]	2.283	90.5[b]
Common gull	413	Apr–Oct	275	0.38[b]	0.105	123.5[b]
Black-legged kittiwake	40326[a]	Mar–Sep	1000	0.41[b]	0.273	187.8[b]
Arctic tern	784	Jun–Aug	196	0.11[b]	0.022	276.4[b]
White-tailed eagle	20	Jan–Dec	20	4.50[c]	0.090	58.8[d]

[a]Numbers counted in the breeding colony at Sværholtklubben, assuming that 1000 ind. feed in subarea 1 during March-September, [b]Barrett et al. (2002), [c]Ferguson-Lee and Christie (2001), [d]Wille and Kampp (1983), [e]same as for great black-backed gull

Herring gull and great black-backed gull made up most of the biomass of the group (Table S5). The total average biomass for the group was 0.000371 g C m^{-2}.

The *P/B* value used in the model (0.128 year^{-1}) was based on estimates for black-legged kittiwake from 1990–2002 from Hornøya, northern Norway (Sandvik et al. 2005). Individual values for annual *Q/B* for all species were calculated from values in the literature (Table S5). For white-tailed eagle, the daily food consumption was set to 15% of their body weight, assuming that most of their diet was fish (Wille & Kampp 1983). Consumption was calculated for each species and an overall *Q/B* for the group was calculated as 118.9 year^{-1} based on the total consumption by the group divided by the biomass. The total consumption for this group was calculated as 689 ton WW for the whole fjord.

The diet for the group was calculated from the diet of the various species weighted by their consumption. The herring gull (*L. argentatus*) was the most abundant species within the group and the species with the highest consumption. According to Barrett et al. (2002), herring gulls in the Barents Sea eat mostly fish (30%), invertebrates (40%) and offal (30%), and this was assumed to be true also for the gulls in Porsangerfjorden. Greater black-backed gull was assumed to eat mostly (90%) fish (herring, cod, capelin, sandeels). Common gull was assumed to eat fish and invertebrates (crustaceans). The black-legged kittiwake consumed 80% fish and 20% invertebrates according to Barrett et al. (2002). Arctic tern at the coast of the Norwegian Sea feeds mostly on lean fish including 0-group herring and sandeels.

The dietary composition in the models was: small pelagic fish (21.8%), herring (21.5%), discard and offal (21.4%), herbivorous echinoids (11.8%), other large crustaceans (8.8%), other small demersal fish (5.9%), large krill (5.3%), small cod (1.8%) and small saithe (1.7%).

8. Benthic invertebrate feeding birds

This group is dominated by common eider (*Somateria molissima*) which is present all year in Porsangerfjorden and breeds within the fjord. During June 2005, 9650 individuals of common eider were counted (Table S6). Other species that were present all year long were long-tailed duck (*Clangula hyemalis*) with 210 individuals, velvet scoter (*Melanitta fusca*) with 190 individuals and common scoter (*Melanitta nigra*) with 125 individuals. During winter 2010, 490 individuals of king eiders (*Somateria spectabilis*) was counted and they are assumed to be present from December to March, giving an annual average of 163 individuals. Biomasses of the species were calculated from annual average numbers and body mass (Table S6). This resulted in a biomass for the group of 16.7 tonnes WW and 0.000107 g C m^{-2}, assuming a C/WW ratio of 0.12.

Table S6. Overview of annual average numbers of individuals in the “Benthic invertebrate feeding birds” group, based on sightings in the period 2005–2012 in Porsangerfjorden (G.H. Systad, NINA, unpubl. mat.). Annual av. no. ind.: annual average nunber of individuals

Species	No. coun -ted	Present	Annual av. no. ind.	Body mass (kg WW)	Biomass (t WW)	*Q/B* ($year^{-1}$)
Common eider	9650	Jan–Dec	9650	1.63[a]	15.73	57.6[c]
Spectacled eider	490	Dec–Mar	163	1.79[e]	0.29	57.6[d]
Long-tailed duck	210	Jan–Dec	210	0.95[b]	0.20	57.6[d]
Common scoter	125	Jan–Dec	125	1.30[b]	0.16	57.6[d]
Velvet scoter	190	Jan–Dec	190	1.84[b]	0.35	57.6[d]

[a]Barrett et al. (2002), [b]Pilarczyk et al. (2012), [c]Blicher et al. (2011), [d]same as for common eiders, [e]Zeffer et al. (2003)

The value for *P/B* used in the models (*P/B* = 0.163 year^{-1}) was estimated for common eiders from Grindøya (N 69° 38’, E 18° 51’), northern Norway during 1985–2002 (Yoccoz et al. 2002). A value for *Q/B* (carbon units) of 57.6 year^{-1} was estimated from Blicher et al. (2011) and used in the models.

Barrett et al. (2002) report a diet of 100% invertebrates (molluscs and crustaceans) for common eider. According to Bustnes (1998), blue mussel is the most important prey species for common eider. Bustnes and Erikstad (1988) investigated the diet of eiders at Sommarøy (northern Norway) and found a diet with much blue mussel and also lumpfish eggs. Bustnes and Lønne (1994) give data for non-empty stomachs of common eiders in Kvalsundet (northern Norway): large bivalves (blue mussels) 12%, other large crustaceans (crabs) 6%, herbivorous echinoids (sea urchins) 67% and others 15% (suggested to be composed of other benthic invertebrates 3%, small mollusca 3%, fish 3%, detritivorous echinoderms 3%, predatory benthos 3%.). The diet in the model was calculated as the average of the values (lumpfish eggs excluded due to short seasonal appearance) from the two investigations reported – Bustnes and Erikstad (1988) and Bustnes and Lønne (1994). In Porsangerfjorden, common eiders have been observed to feed on blue mussels, green sea urchins and spider crabs (*Hyas* spp.) (Mikko Vihtakari, UiT The Arctic University of Tromsø, pers. comm). It is also likely that eiders may feed on red king crab juveniles, but this has not been reported. The diet used in the models was: large bivalves (46.0%), herbivorous echinoids (38.1%), other large crustaceans (4.6%), small molluscs (4.3%), small benthic crustaceans (2.8%), predatory polychaetes (1.7%), predatory gastropods (1.0%), predatory asteroids (1.0%), detritivorous echinoderms (0.4%) and detritivorous polychaetes (0.1%).

Fish groups

Each of the models contain 17 fish groups, and fish were sampled using several gears and methods (Table S7). The biomasses of most small fish groups (< 35 cm in length), except for herring, and cottids in some subareas, were calculated from the consumption of the other groups. Biomasses of herring and capelin were calculated from hydroacoustic integration during the research surveys in 2009 and 2010. Values of *P/B* and *Q/B* were taken from the Sørfjord model of Pedersen et al. (2008).

Table S7. Overview of sampling gears and methods used for sampling and estimating abundance of fish from Porsangerfjorden. N: number of samples or trawl hauls taken

Gear	Period	N	Target groups	Reference
Otter bottom trawl	2009–2010	53	Demersal fish, deep-sea shrimp	
Pelagic trawl	2009–2010	22	Pelagic fishes	
Acoustical abundance estimation	2009–2010		Capelin, herring	
Beach seine	2008–2014	114	Cod and saithe 0-group, intertidal fish, Cottidae, 0–4 m depth	Heggland (2013)
Fishing rod sampling	2010–2011	28	Cod, saithe haddock, 5–50 m depth	Michaelsen (2012)
Underwater video	2011		Fish at shallow water (< 35 m depth)	Michaelsen (2012)
Epibenthic trawl	2007–2011		Epibenthic species	

For the large fish groups (“Large cod”, “Large saithe”, “Large haddock”, “Other large flatfishes” that were ≥ 35 cm in length), except for the “Other large demersal fish” group, biomass values were calculated from catch in kg WW per 20 min haul time, using the same catchability coefficient (adjusted for trawl haul time) as for Sørfjord (N 69° 35’, E 19° 45’) , northern Norway (Pedersen et al. 2008). The resulting biomasses in WW units were then converted to C using a C/WW factor of 0.12. For subareas 1, 2 and 3, the values for *B*, *P/B* and *Q/B* of the small cod, small saithe and small haddock were calculated by the multi-stanza procedure (Table S8), using the large cod, large saithe and large haddock respectively as the leading groups. From the values of biomass and *Q/B* for the large leading group and *P/B* values for the small groups, the multi-stanza procedure calculates the biomasses and *Q/B* values of the small group. For cod, saithe and haddock in subareas 4E and 4W, the biomass of large fishes were so low compared to small cod, saithe and haddock, that the small and large groups were kept un-linked, not applying the multi-stanza procedure.

Table S8. Overview of parameter values for the multi-stanza groups for cod, saithe and haddock in models for subarea 1, 2 and 3. Age for start of stanza in months is given and in column marked “L” the crosses denotes the leading group within the stanza. Gr.: group; Z: the instantaneous mortality rate; K: growth coefficient in the von Bertalanffy growth equation

Gr. No.	Group name Stanza group	Age, start (mn)	L	*Z* (yr^{-1})	*Q/B* (yr^{-1})	Biomass in subareas ($g\ C\ m^{-2}$)		
						1	2	3
9	Large cod	36	X	0.53	3.00	0.1870	0.0828	0.0755
10	Small cod	0		1.20	8.53	0.0560	0.0248	0.0226
11	Large saithe	36	X	0.53	3.00	0.0234	0.0117	0.0117
12	Small saithe	0		1.20	6.27	0.0171	0.0086	0.0086
13	Large haddock	36	X	0.53	3.00	0.1110	0.0450	0.0183
14	Small haddock	0		1.20	6.27	0.0813	0.0330	0.0134

Cod; K = 0.1 $year^{-1}$, recruitment power 1.0, Wmaturity/Winfinity 0.0900
Saithe; K = 0.3 $year^{-1}$, recruitment power 1.0, Wmaturity/Winfinity 0.0900
Haddock; K = 0.3 $year^{-1}$, recruitment power 1.0, Wmaturity/Winfinity 0.0900

The large gadoids (large cod, haddock and saithe) have traditionally been the main targets in the fishery, and large cod have been the most important group. There are no precise landing or catch statistics for Porsangerfjorden. Values for landings which are needed in the Ecopath models were thus based on an estimate of the total mortality rate of large cod, which was estimated from the age composition. By assuming a natural mortality rate of 0.2 $year^{-1}$ (ICES 2014), the fishing mortality rate (F) was calculated as the difference between the total and the natural mortality rate. It was then assumed that the other large fish groups that were exploited in the fishery had the same fishing mortality as large cod. This seems reasonable since the gears used (gill nets, baited long-line, hand line and recreation fishery using rods and lures) are not very species selective. The landings were calculated from the relationship: catch = $F*B$, where B is the biomass. It was assumed that 67.5% of the catch became landings and 33.3% was discarded as offal after the fish was gutted.

9. Large cod (≥ 35 cm in length) and 10. Small cod (< 35 cm in length)

Cod were distributed along the fjord, but large cod were very scarce in the inner colder subareas (4E and 4W) during 2009–2010. This is in contrast to the situation in 1992, when the largest catches of cod in September were caught in the inner subarea 4E (Larsen 2010). Earlier, there were a number of spawning areas and fishery on spawning cod in the bays and fjords (Smørfjord, Olderfjord, Billefjord) on the western side of the fjord (Maurstad & Sundet

1998), but during the sampling period 2009–2010 there was only spawning from Smørfjord and further out in Porsangerfjorden. During summer and early autumn, pelagic cod juveniles were found in most of the fjord and were caught by pelagic trawl. In the middle of August, cod juveniles with lengths from 3 to 10 cm settled in the shallow subtidal zones and were caught by beach seine throughout the fjord. Genetic analysis show that most of these settled juveniles have similar genetic profiles to the coastal cod group, while there were still a mixture of offspring of northeast Arctic cod and coastal cod juveniles in the pelagic mid-fjord (Fevolden et al. 2012).

The value for annual mortality (*Z*) of small cod were set equal to the *P/B* of 1.2 year^{-1} used in the Sørfjord model (Pedersen et al. 2008), based on estimation of mortality rates in coastal cod (Pedersen and Pope, 2003a, b).

The annual mortality (*Z* value) for large cod used in the multi-stanza calculations was estimated using the Chapman-Robson catch-curve estimator on the age frequency distribution of coastal cod in Porsangerfjorden from 2009 (Chapman & Robson 1960, Larsen 2010). The *Z* value was estimated as 0.53 year^{-1} (95% ci; 0.44, 0.63). Assuming a natural mortality rate of 0.2 year^{-1}, this gives a fishing mortality rate (*F*) of 0.33 year^{-1}, and this value was used in the models. This is very similar to the average fishing mortality rate for the whole Norwegian coastal cod stock (north of 62°N), where estimates of average fishing mortality rate for 2009 and 2010 of ca. 0.30 year^{-1} were given for 4–7 year old fish by several assessment methods (ICES 2014).

The *Q/B* value of large cod was set equal to the value (3.0 year^{-1}) used in the Sørfjord model (Pedersen et al. 2008), and *Q/B* was calculated as 8.53 year^{-1} for small cod by the multi-stanza procedure (Table S8).

Dietary values for large cod were based on stomachs (n = 560) sampled by bottom-trawl and pelagic trawl hauls (n = 52) during 2009 and 2010, and there were separate dietary compositions for each subarea (Table S9). The diets of the cod groups were dominated by deep-water shrimp.

The dietary composition for small cod was based on samples from trawl at deep water and fishing rods at shallow water. Small cod had a shallower distribution than large cod and the environmental conditions in the various subareas were more similar at shallow than at deeper water. Since most of the small cod is distributed in shallow water and it is not possible to sample water shallower than 50 m with a bottom trawl, small cod and stomachs at shallow water were sampled using fishing rods (Michaelsen 2012). The rod had a jig with five fly-fishing hooks of size 10 with rubber baits and a 100 g brass sinker. The distance between the rubber baits was 10 cm. The rod sampling was performed along transects from ca. 2 m to 50 m depth, fishing for 5 min at each depth interval: 2–5 m, 5–10 m, 10–20 m, 20–30 m and 30–50 m. Stomachs were sampled from a total of 28 rod-fishing transects. A total of 97 stomachs was sampled by rod fishing at 10 locations during 2010 and 2011. The dietary composition of small cod used in the models (see Table S9), was calculated as the average of the composition from stomach samples from bottom and pelagic trawl hauls (n = 28 hauls, n = 142 stomachs) in the given subarea and the composition from all stomachs (n = 97) sampled in the fjord by rod-sampling at shallow water (Michaelsen 2012). The dietary compositions estimated for subarea 3 were also used in the models for subarea 4E and 4W, where very few cod were sampled. Digested legs from medium sized red king crabs were observed in some large cod stomachs. We did not find any red king crab in the stomach samples of small cod, but it has been observed that small cod had fed on red king crabs in Porsangerfjorden (H. K. Strand, IMR, pers. comm.). To reflect this, a small proportion (0.3%) of the diet of small cod was allocated to small red king crab.

Table S9. Overview of dietary composition of large and small cod, used in the models for Porsangerfjorden. Gr.: group; bent. inv.: benthic invertebrates

		Propotion of diet					
	Subarea	1	1	2	2	3 & 4	3 & 4
	Cod group	Large	Small	Large	Small	Large	Small
Gr. no.	Gr. Name						
10	Small cod	0.0002	0.0583	0.0275	0.0583	0.0069	0.0583
12	Small saithe	0.0000	0.0541	0.0049	0.0541	0.0000	0.0541
14	Small haddock	0.1549	0.0000	0.0049	0.0000	0.0140	0.0000
15	Small gadoids	0.3006	0.3497	0.0179	0.0000	0.0000	0.1370
18	Other small flatfish	0.0098	0.0008	0.0001	0.0008	0.0156	0.0010
20	Other small demersal fish	0.0065	0.0760	0.0290	0.0752	0.0104	0.1170
21	Cottids	0.0000	0.0374	0.0000	0.0374	0.0000	0.0370
22	Small pelagic fish	0.0578	0.0622	0.2036	0.1017	0.1348	0.0990
23	Herring	0.1892	0.0030	0.0064	0.0000	0.0044	0.0000
27	Small krill	0.0110	0.0051	0.0073	0.0088	0.0000	0.0015
28	Large krill	0.0110	0.0000	0.0036	0.0043	0.0000	0.0000
34	Other large zooplankton	0.0000	0.0000	0.0001	0.0005	0.0000	0.0000
35	Pandalid shrimps	0.2542	0.1850	0.6791	0.4624	0.7751	0.3144
37	Medium king crab	0.0000	0.0000	0.0000	0.0000	0.0076	0.0000
38	Small king krab (< 70 mm)	0.0000	0.0000	0.0000	0.0000	0.0003	0.0100
39	Crangonid shrimps	0.0002	0.0013	0.0002	0.0000	0.0000	0.0000
40	Other large crustaceans	0.0031	0.0775	0.0048	0.1119	0.0155	0.0840
43	Predatory polychaetes	0.0006	0.0380	0.0002	0.0383	0.0005	0.0400
44	Other predatory bent. inv.	0.0009	0.0000	0.0102	0.0000	0.0031	0.0000
45	Detritivorous polychaetes	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
46	Small benthic crustaceans	0.0000	0.0298	0.0000	0.0243	0.0066	0.0290
47	Small molluscs	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
49	Detritivorous echinoderms	0.0001	0.0219	0.0000	0.0219	0.0000	0.0219

11. Large saithe (≥ 35 cm in length) and 12. Small saithe (< 35 cm in length)

Saithe in Porsangerfjorden belong to the northeast Arctic stock of saithe. This stock spawns along the coastal banks of Norway and the small juveniles enter the coastal zone and the fjords during the spring (Bergstad et al. 1987). Small 0-group saithe settle in shallow water during June and 0-group saithe have a shallower distribution than 0-group cod. In Porsangerfjorden, 1-group and older saithe occur frequently in schools around skerries and shallows and are likely to be under-estimated by bottom-trawl surveys. The saithe move towards the outer coast and coastal banks with increasing length and age (Bergstad et al. 1987).

Values of *P/B* and *Q/B* for large saithe were set equal to the values for large cod, 0.53 year^{-1} and 3.00 year^{-1}, respectively. For small saithe, *P/B* was equal to the value for small cod (1.2 year^{-1}), while *Q/B* was calculated as 6.72 year^{-1} by the multi-stanza procedure.

Dietary composition of large saithe was calculated from 29 stomachs sampled from bottom-trawl hauls in Porsangerfjorden, and this diet was used for all subareas. Dietary composition was: small other demersal fish (38.3%, mainly snakeblennies (*Lumpenus* spp.)), small pelagic fishes (25.9%), pandalid shrimp (18.9%), small krill (4.4%), large krill (4.4%), small gadoids (3.0%), other large zooplankton (2.6%), herring (1.8%) and kelp (0.8%). Few stomachs were available from Porsangerfjorden for small saithe, so the dietary composition was taken from a study in Ullsfjord, northern Norway (Pedersen et al. 2016). The dietary composition used in the models for all subareas was: small krill (48.90%), large krill (34.59%), small gadoids (10.29%), small zooplankton (2.04%), small other demersal fishes (1.96%), other large zooplankton (1.16%), small pelagic fishes (0.49%), predatory polychaetes (0.39%) and small molluscs (0.19%).

Catches, landings and discards were calculated using the same fishing mortality rate as for large cod.

13. Large haddock (≥ 35 cm in length) and 14. Small haddock (< 35 cm in length)

Haddock had the highest abundance in the outer subarea 1. Values of *P/B* and *Q/B* for large haddock were set equal to the values for large cod, 0.53 year^{-1} and 3.00 year^{-1}, respectively. For small haddock, *P/B* was equal to the value for small cod (1.2 year^{-1}), while *Q/B* was calculated as 6.724 year^{-1} by the multi-stanza procedure.

Stomachs were sampled in 2009 and 2010 in Porsangerfjorden and a separate diet was calculated for subarea 1, while common diets were used for subarea 2 and 3 since there were few stomachs sampled from these subareas. In subarea 1, diets were based on 26 stomachs from small and 37 stomachs from large haddock, while in subarea 2 and 3 there were 34 and 33 stomachs from small and large haddock, respectively.

Table S10. Overview of dietary composition of large and small haddock, used in the models for Porsangerfjorden. Gr.: group

		Proportion of diet			
	Subarea	1	1	2, 3, 4	2, 3, 4
	Haddock group	Large	Small	Large	Small
Gr. no.	Gr. name				
10	Small cod	0.0075	0.0000	0.0000	0.0000
15	Small gadoids	0.1598	0.0172	0.0000	0.0000
20	Other small demersal fish	0.0000	0.0137	0.0000	0.0000
22	Small pelagic fish	0.0226	0.2744	0.0060	0.0000
23	Herring	0.0132	0.0961	0.0000	0.0000
27	Small krill	0.0492	0.0141	0.2654	0.4738
29	Small zooplankton	0.0002	0.0000	0.0000	0.0000
34	Other large zooplankton	0.0508	0.0034	0.0004	0.0713
35	Pandalid shrimps	0.1945	0.0137	0.1915	0.0183
40	Other large crustaceans	0.0150	0.0192	0.0086	0.0092
41	Predatory asteroids	0.0489	0.0000	0.0000	0.0000
42	Predatory gastropods	0.0094	0.0000	0.0009	0.0000
43	Predatory polychaetes	0.0000	0.0000	0.0000	0.0020
45	Detritivorous polychaetes	0.2914	0.3122	0.5146	0.3361
46	Small benthic crustaceans	0.0041	0.0007	0.0008	0.0010
47	Small molluscs	0.0368	0.0847	0.0040	0.0513
49	Detritivorous echinoderms	0.0966	0.1506	0.0078	0.0369

Catches, landings and discards were calculated using the same fishing mortality rate as for large cod.

Overview of input parameters for groups other than cod, saithe and haddock

Input parameters for fish groups other than the cod, saithe and haddock groups are given in Table S11.

Table S11. Overview of input values for the fish-groups (Gr. 15–26) to the Ecopath models for the subareas. In areas where no fish of a given group was sampled, the biomass of the group was set to a very low value ($1*10^{-9}$). M: biomass value is estimated by the Ecopath model; Gr.: group

				Biomass in subareas (g C m^{-2})				
Gr. no.	Group name	*P/B* ($year^{-1}$)	*Q/B* ($year^{-1}$)	1	2	3	4E	4W
15	Small gadoids	1.20	6.0	M	M	M	M	M
16	Halibut	0.53	3.0	0.00301	0.02025	0.00753	$1*10^{-9}$	$1*10^{-9}$
17	Other large flatfish	0.53	3.0	0.01172	0.04152	0.06033	0.00200	0.00082
18	Other small flatfish	1.20	6.0	0.00001	0.00572	0.00565	0.01732	0.00530
19	Other large demersal fish	0.53	3.0	0.1485	0.00372	M	$1*10^{-9}$	$3.5*10^{-6}$
20	Other small demersal fish	1.20	6.0	M	M	M	M	M
21	Cottidae	1.29	3.93	M	M	M	0.111	M
22	Small pelagic fish	1.00	6.0	M	M	M	M	M
23	Herring	1.00	4.0	0.0523	0.0333	0.0785	0.668	0.334
24	Atlantic salmon	0.28	3.1	$9*10^{-5}$	$9*10^{-5}$	$9*10^{-5}$	$9*10^{-5}$	$9*10^{-5}$
25	Sea trout	0.48	3.1	$8*10^{-6}$	$8*10^{-6}$	$8*10^{-6}$	$8*10^{-6}$	$8*10^{-6}$
26	Arctic charr	1.27	6.34	$3*10^{-6}$	$3*10^{-6}$	$3*10^{-6}$	$3*10^{-6}$	$3*10^{-6}$

15. Small gadoids

This group comprises whiting, Norway pout, silvery pout and blue whiting. The group had its highest bottom trawl CPUE (catch per unit effort) in the outer subarea 1. Biomasses of the group were estimated by the Ecopath models since these fishes were likely to be under-estimated by the research bottom-trawl due to their small sizes.

The value of *P/B* was set equal to that for small cod (1.2 $year^{-1}$). The value of *Q/B* was set to 6.0 $year^{-1}$ and is equal to that used for small cod in the Sørfjord model (Pedersen et al. 2008).

Dietary composition was equal in models for all subareas, and was taken from dietary composition for small gadoids based on stomach sampling during 2009–2010 in Ullsfjord, northern Norway (Kolsum 2011, Pedersen et al. 2016): small krill (54.52%), large krill (24.98%), small zooplankton (7.52%), small gadoids (5.87%), other large zooplankton (3.16%), herring (1.53%), small pelagic fishes (1.51%), detritivorous polychaetes (0.50%) and pandalid shrimp (0.40%). The proportion allocated to pandalid shrimp equalled the proportions that “Other shrimps” (0.21%) and pelagic shrimps (0.19%) had in the Ullsfjord model.

16. Halibut

Halibut was relative abundant at the bottom-trawl grounds around Tamsøya (subarea 2) during surveys in winter 2009 and 2010 (Fig. S2). Biomasses in the subareas were calculated from average catch in kg WW per 20 min haul time, using the same catchability coefficient adjusted for trawl time as given in Pedersen et al. (2008). In the inner two subareas 4E and 4W, no halibut was caught.

Values of *P/B* and *Q/B* were set to the same as for large cod, 0.53 year^{-1} and 3.0 year^{-1}, respectively.

A total of 30 stomachs was sampled from halibut in Porsangerfjorden and the great majority (n = 28) were sampled in subarea 2. The diet was equal in models for all subareas and was dominated by fish. The dietary composition in the models was: small other demersal fish (44.0%), small gadoids (24.4%), small haddock (12.2%), small cod (12.2%), pandalid shrimps (5.0%) and small pelagic fishes (2.2%).

Catches, landings and discards were calculated using the same fishing mortality rate as for large cod.

17. Other large flatfish (≥ 35 cm in length) and 18. Other small flatfish (< 35 cm in length)

These groups consisted of (in order of decreasing CPUE in research bottom-trawl catches): *Hippoglossoides platessoides* (long rough dab), *Pleuronectes platessa* (plaice), *Microstomus kitt* (lemon sole), *Glyptocephalus cynoglossus* (witch flounder) and *Platichthys flesus* (European flounder). These groups had their highest abundance in subarea 3. For other large flatfish, biomass was estimated from CPUE from bottom-trawl hauls, while biomass for small flatfish was derived by swept-area estimate of the epibenthic trawl.

For “Other large flatfish”, *P/B* and *Q/B* were set to the same values as for large cod, 0.53 year^{-1} and 3.0 year^{-1}, respectively. For “Other small flatfish”, *P/B* was set equal to the value for small cod (1.2 year^{-1}), while *Q/B* was set to 6.0 year^{-1} and was equal to the value used for small cod in the Sørfjord model (Pedersen et al. 2008).

The diet of “Other small flatfish” was based on analysis of stomachs from long-rough dab sampled in February and March 2011 in subarea 3 in Porsangerfjorden (E. Källgren, UiT, unpubl. material). A total of 52 stomachs from small long-rough dab (< 35 cm in length) and 4 stomachs from large long-rough dab (≥ 35 cm in length) was analysed. The dietary proportions for small flatfish derived from these were: detritivorous polychaetes (46%), predatory polychaetes (32%), small benthic crustaceans (5%), pandalid shrimps (8%), small molluscs (3%), small krill (2%), other large crustaceans (2.0%), other benthic invertebrates (1.8%) and detritivorous echinoderms (0.2%).

Plaice made up a large proportion of the "Other large flatfish" group in Porsangerfjorden, but there were no plaice stomachs with content available from Porsangerfjorden. Stable isotope data from plaice in Porsangerfjorden show similar values as for long-rough dab (T. Pedersen, UiT, unpubl. results). The plaice stomachs sampled during winter when plaice was present at deep water and were caught by bottom trawl, were empty. Long-rough dab is one of the few predators that have been identified as predators on sea urchins in a fjord in northern Norway (Klemetsen 1993), and a small proportion (0.5%) of the diet was allocated to herbivorous echinoids. The dietary composition for "Other large flatfish" was based on the long-rough dab diet described above: detritivorous polychaetes (41%), predatory polychaetes (30%), pandalid shrimps (8%), small molluscs (9.8%), small benthic crustaceans (5%), small krill (2%), other large crustaceans (2%), other benthic invertebrates (1.3%), herbivorous echinoderms (0.5%) and detritivorous echinoderms (0.2%).

Catches, landings and discards were calculated using the same fishing mortality rate as for large cod.

19. Other large demersal fish (≥ 35 cm in length)

This group comprises anglerfish (*Lophius piscatorius*), skates, Atlantic (*Anarhichas lupus*) and spotted (*A. minor*) wolfish, redfish (*Sebastes* spp.) and lumpfish (*Cyclopterus lumpus*). Biomass was estimated using CPUE data from the research trawl hauls, with redfish and anglerfish contributing most to the biomass in the group. The group had its highest biomass in the outer subarea 1 (Table S11). In subarea 3, the biomass was estimated by the model.

For "Other large demersal fish", *P/B* and *Q/B* were set to the same values as for large cod, 0.53 year^{-1} and 3.0 year^{-1}, respectively.

There were few stomach samples from this group from Porsangerfjorden. Stomach data from one spotted wolffish caught in Porsangerfjorden showed that it had three small red king crabs in the stomach. Anglerfish are fish predators (Ofstad 2013) while skates and wolffish prey more on larger benthic invertebrates (Falk-Petersen et al. 2010). Diet data from redfish from

Sørfjord, northern Norway, during 1993–96 show a diet dominated by krill (T. Pedersen, UiT, unpubl. data). The dietary composition for this group was based on the sources mentioned above and was weighted by the average research bottom-trawl CPUE (WW) of each species in subareas 1, 2 and 3 and the resulting diet was used in all models for the subareas. Dietary composition was: small krill (26.7%), large krill (26.0%), other large crustaceans (6.3%), schypomedusae (4.1%), small haddock (3.7%), small pelagic fish (3.5%), predatory polychaetes (2.8%), other small flatfish (2.5%), large bivalves (2.4%), herbivorous echinoids (2.4%), large haddock (1.8%), small gadoids (1.8%), other large flatfish (1.8%), small other demersal fish (1.8%), small cod (1.8%), other benthic invertebrates (1.8%), small zooplankton (1.4%), other predatory benthic invertebrates (1.4%), small molluscs (1.2%), small red king crab (1.2%), predatory asteroids (1.2%), large cod (0.9%), small saithe (0.9%) and cottids (0.9%).

Catches, landings and discards were calculated using the same fishing mortality rate as for large cod. Grey seals and otters were predators on this group.

20. Other small demersal fish

This group comprises snakeblennies (*Leptoclinus maculatus* and *Lumpenus lampretaeformis*, Stichaeidae), and small specimens of skates, Liparidae, redfish (*Sebastes* spp.), rocklings (*Gaidropsarus vulgaris*, *Enchelyopus cimbrius*), eelpouts, butterfish (*Pholis gunellus*) and Atlantic poacher (*Leptagonus decagonus*). Butterfish inhabit shallow water while Atlantic poacher were found mainly at deeper water in the cold inner subarea 4E. All fish in this group were less than 35 cm in maximum body length. These fishes were frequently found in stomachs of large predatory fish (cod, saithe, halibut). Biomass was estimated by the model.

The value of *P/B* was set equal to that for small cod (1.20 year^{-1}), while *Q/B* was set to 6.0 year^{-1} and was equal to the value used for small cod in the Sørfjord model (Pedersen et al. 2008).

No dietary data were available for Porsangerfjorden for this group. Snakeblennies feed on zooplankton, small crustaceans, molluscs, brittle stars and worms (http://www.fishbase.org/search.php), and the other species also feed on either zooplankton or small benthic invertebrates. The following dietary composition was assumed: small zooplankton (40%), detritivorous polychaetes (35%), small krill (15%), predatory polychaetes (5%) and small benthic crustaceans (5%).

21. Cottids

The most common species in this group in Porsangerfjorden were shorthorn sculpin (*Myoxocephalus scorpius*) and Atlantic hookear sculpin *(Artedillus atlanticus)* (Källgren et al. 2015). Shorthorn sculpin were distributed in the upper subtidal in all areas of the fjord and were also common at deeper water in the inner two subareas (4E and 4W). Hookear sculpins were mostly distributed in the inner two subareas.

Shorthorn sculpin were caught by beach seine, and both species were caught by epibenthic trawl and the research otter-bottom trawl. They were also the most frequently observed fish group at shallow water (4–30 m depth) in video surveys in subarea 4E (T. Pedersen, UiT, unpubl. data). Biomass of the group was estimated by the model in subareas 1, 2, 3 and 4W where shorthorn sculpin was mainly distributed at shallow water. In these subareas, the epibenthic trawl was likely to underestimate biomass since trawl haul was not taken at depths < 30 m. In subarea 4E, where cottids were also caught at deep water (> 30 m depth), the swept-area biomass estimate from the epibenthic trawl model (0.111 g C m^{-2}), was used in the model.

Cottidae were important prey in the diet for harbour seal in Porsangerfjorden (see group 2 description above), and cannibalism occurs in the area (H. K. Strand, IMR, Norway, pers. comm.). A value of *P/B* was set equal to the annual mortality rate *Z* (*Z* = 1.29 $year^{-1}$, 95% ci; 0.79, 1.80) estimated from the average age distribution of females and males of short-horn sculpin caught during 2009–2011 (Källgren 2012), using the Chapman-Robson catch-curve method (Chapman & Robson 1960). The value of *Q/B* was set to 3.93 $year^{-1}$ which is equal to an estimated value for longhorn sculpin (*Myoxocephalus octodecimspinosus*) (Araújo & Bundy 2011), which has a similar life span as shorthorn sculpin.

Dietary composition was based on data from shorthorn sculpin and Atlantic hookear sculpin sampled during 2009–2011 (Källgren 2012, Källgren et al. 2015). The dietary composition in all subarea models was: predatory polychaetes (20%), detritivorous polychaetes (20%), pandalid shrimps (18%), small benthic crustaceans (8%), small molluscs (7%), crangonid shrimps (5%), small pelagic fish (5%), small cod (4%), cottids (4%), herring (3%), small saithe (3%), small haddock (1%), small other demersal fish (1%) and small krill (1%).

22. Small pelagic fish

This group consists of capelin (*Mallotus villosus*), sandeel (Ammodytidae), greater argentine (*Argentina silus*) and the small mesopelagic fishes glacier lanternfish (*Benthosema glaciale* and Müllers pearlside (*Maurolicus muelleri*). Capelin and sandeel were the two most important taxa in the group. Capelin occurring in the outer part of Porsangerfjorden is likely to belong to the large Barents Sea capelin stock that has spawning areas along the coast of Norway. Two of the historical spawning areas for this stock – Porsangnes (N 70° 53’, E 25° 53’) and Nordvågen (N 70° 58’, E 25° 03’) – are located in Porsangerfjorden, but spawning does not occur here every year (Sætre & Gjøsæter 1975). This capelin stock spawns on gravel or cobble substrate mainly during March and April and attracts top predators feeding on pre-spawning, spawning and post-spawning dying capelin (Sætre & Gjøsæter 1975). The Barents Sea capelin dies after spawning. The eggs are also predated by haddock and diving birds (Gjøsæter & Sætre 1974). It is also likely that there is a local capelin stock in Porsangerfjorden that is mainly distributed in the inner part of the fjord. Capelin were caught in bottom and pelagic trawl hauls in area 4E and 4W, and mature capelin ready to spawn were caught in the inner part of area 4W in May 2009.

Sandeel have been caught during summer by pelagic trawl. Sandeel lack a swim bladder and are not suited for acoustical abundance estimation. Biomass estimates for capelin in the subareas were calculated from acoustical data, but these are likely to be underestimates for the biomass of the whole group. Thus, in the models the biomasses for the group were estimated from the consumption by the predators on this group.

The value of *P/B* was set to 1.0 year^{-1} which is equal to both that used for herring in the model that used for herring in the Sørfjord-model (Pedersen et al. 2008). The value of *Q/B* was set to 6.0 year^{-1}, which is equal to that used for herring in the Sørfjord-model (*op cit*.).

No dietary data were available for capelin from Porsangerfjorden, and the dietary compositions were based on dietary from 41 capelin stomachs sampled in Ullsfjord during 2009–2010 (Torstein Pedersen, UiT, unpubl. material). The dietary composition used in the models was: small krill (80.8%), small zooplankton (11.9%), other large zooplankton (7.3%).

Small pelagic fishes were frequent in the stomach contents of cod, salmonids, grey- and harbour seals and are known to be preyed on by several sea bird species. Sandeels were also frequent in predator stomachs of cod, saithe, halibut and harbour seals in Porsangerfjorden, and were predated on by sea birds like gulls, terns, mergansers and goosanders (Barrett et al. 2002, Svenning et al. 2005a, 2005b). There was no catch of this group in Porsangerfjorden.

23. Herring

Juvenile herring from the Norwegian spring spawning herring stock has been observed frequently in Porsangerfjorden. In a number of publications from the first part of the 1960s, it was described how the 0-group juvenile herring enter Porsangerfjorden during autumn (October–November), migrate to the inner cold part of the fjord and stay in water with sub-zero temperature during the winter (subarea 4E) (Dragesund & Hognestad 1961, 1963, 1964). November was the month of the year with the warmest water (ca. 1.5°C) at the bottom in Austerbotn (subarea 4E) in 1962 and 1963 (Hognestad 1963). In Austerbotn, the small herring occupied the ice-covered cold water close to the bottom during the winter until the ice disappeared in May (Dragesund & Hognestad 1963, 1964). From May to June, the herring migrated outwards along the eastern side of the fjord (*op cit.*). Data from the field campaign during 2008–2010 indicated that the distribution and migration patterns of herring in Porsangerfjorden in this period were similar to those observed in the 1960s.

Average annual biomass values for the period 2009–2010 estimated acoustically showed that area 4E had the highest value (B = 0.668 g C m^{-2}) compared to the other areas (B < 0.08 g C m^{-2}) (Table S11). In the inner western subarea 4W, no acoustical estimates were available and it was assumed that the biomass was half the value of subarea 4E since 4W is much shallower than 4E.

The value of P/B was assumed to be equal to that of herring in the Sørfjord model (P/B = 1.0 year^{-1}) (Pedersen et al. 2008). Since the juvenile herring fed very little during the winter period from December to April (Hognestad 1992), the Q/B was set to a lower value (Q/B = 4.0 year^{-1}) than used for herring in the Sørfjord model (Q/B = 6.0 year^{-1}) (Pedersen et al. 2008).

According to Hognestad (1992), the 0 and 1-groups which dominated the herring group in Porsangerfjorden predominantly fed on the copepod *Calanus finmarchicus*, and in addition the diet contained some small copepods, Ostracoda, *Balanus* nauplii and krill. Based on this, the dietary composition for herring in all subareas was assumed to be: small zooplankton (80%), small krill (10%) and other large zooplankton (10%).

Herring were found in stomachs of cod, salmonids, harbour seals, grey seals and whales, and are known to be preyed on by saithe and several bird species. There was no catch of herring in the fjord during 2009—2010.

24. Atlantic salmon

Salmon use the coastal waters as feeding grounds prior to returning to the rivers for spawning, and adult returning salmon are present in the fjord in the period June–August. Based on the number of smolts produced per year in the rivers in Porsangerfjorden (72000 individuals, M. Svenning, NINA, unpubl. res.), an expected biomass of returning adult salmon of 27 t WW was calculated. By assuming that each adult salmon was present in the fjord for three weeks and that 72000 smolts were present in the fjord for three weeks, an average annual *B* was calculated as $9.3*10^{-5}$ g C m^{-2}. It was reported that, on average, 6.88 t WW of adult salmon was caught by the sea fishery in the Porsanger County during 2009 and 2010. Data on sea catch were taken from official statistics: (https://www.ssb.no/statistikkbanken/SelectVarVal/Define.asp?MainTable=Sjofiske4&KortNavnWeb=sjofiske&PLanguage=0&checked=true).

Assuming that natural mortality of adult returning salmon was neglible within Porsangerfjorden, *P/B* was calculated as (sea catch)/biomass, resulting in a *P/B* of 0.28 $year^{-1}$. In the models, *Q/B* was set to the same value as for sea trout, *Q/B* = 3.1 $year^{-1}$.

Diet was estimated from 440 stomachs of adult returning salmon sampled during May, June and July in 2008 from Porsangerfjorden and Laksefjord, the eastern neighbour fjord to Porsangerfjorden, and one location just north of Porsangerfjorden (Rasmussen 2012). Dietary proportions were calculated from the average stomach content (WW). Dietary composition was: herring (52%), small pelagic fishes (28%, capelin and sandeel), haddock (13.0%) and large krill (7%).

Salmon were caught in the sea by set net, gill nets and by trolling, and to a lesser extent by sport fishermen using rods and lures. A total annual average of 6.88 t WW was caught during 2009 and 2010 (see internet reference above).

25. Sea trout

Sea trout (*Salmo trutta*) use fjord areas as feeding grounds during summer and enter rivers and freshwater lakes to reproduce. In the sea, sea trout mainly use the near shore area, but may also forage some distance from the shore (Rikardsen & Amundsen 2005). Time of sea residence for sea trout is variable and some sea trout may be present in sea-water all year round in some fjords (Rikardsen et al. 2006). Biomass for sea trout was calculated as 2.1 t WW (Martin Svenning, NINA, unpubl. data.). Assuming a C/WW of 0.12, carbon biomass was calculated as $8*10^{-6}$ g C m^{-2}.

The value of *P/B* for sea trout was calculated as 0.48 $year^{-1}$, based on data of tag–recapture derived survival rate during the sea residence from Vardnes river, northern Norway (Berg & Jonsson 1990). Based on estimates of monthly feed intake for sea trout in Balsfjord (N 69° 22', E 19° 03'), northern Norway, from Rikardsen et al. (2006), *Q/B* was calculated as 3.1 $year^{-1}$.

Stomachs from sea trout (n = 24) were sampled from Porsangerfjorden during summer 2010. These data were combined with the data given by Rikardsen et al. (2006) from Balsfjord for the rest of the year and the dietary composition used in the models was: herring (22.0%), small pelagic fishes (29.7%), small benthic crustaceans (11.0%), pandalid shrimp (8.0%), small other demersal fishes (8.0%), small krill (4.0%), large krill (4.0%), small cod (5.0%), small saithe (5.1%) and predatory polychaetes (3.2%).

Landings of sea catch of sea trout (Cs) was calculated assuming the same fishing mortality as for salmon (F = 0.28 $year^{-1}$) and calculating Cs = $B*F$.

26. Arctic charr

Arctic charr (*Salvelinus alpinus*) use fjord areas as feeding grounds during summer and enter rivers and freshwater lakes to reproduce. In the sea, they mainly use the near shore area. Arctic charr, on average, spend only about one month in sea-water, while time of sea residence for sea trout is variable and some sea trout may be present in sea-water all year round in some fjords (Rikardsen et al. 2006). Biomass of Arctic charr was calculated as ca. 1.3 t WW (M. Svenning, NINA, unpubl. data.). Assuming a C/WW of 0.12, carbon biomass was calculated as $3*10^{-6}$ g C m^{-2}.

The *P/B* value for Arctic charr in the sea was calculated as 1.27 $year^{-1}$, based on a survival during the marine period of 28.2% (Rikardsen 2000). A value for *Q/B* of 6.34 $year^{-1}$ for Arctic charr was calculated, assuming that *P/Q* was 0.2 and *P/B* = 1.27 $year^{-1}$.

Stomachs from Arctic charr (n = 8) were sampled from Porsangerfjorden during summer 2010. The diet for Arctic charr was derived from these stomachs and used in the models for all subareas: herring (31.5%), small krill (25.3%), large krill (25.0%), small cod (8.5%), small saithe (6.4%) and small demersal fishes (3.3%). This dietary composition is supported by an investigation by (Grønvik & Klemetsen 1987), showing that Arctic charr have more plankton in their diet than sea trout and salmon.

Sea landings of Arctic charr (Cs) was calculated assuming the same fishing mortality in the sea as for salmon (F = 0.28 $year^{-1}$), and calculating $Cs = B*F$.

Zooplankton and pelagic nekton groups

Much of the input data to the Ecopath models for these groups (gr. no. 27–35) were taken from similar fjord systems in northern Norway, particularly Balsfjord, Ullsfjord and Sørfjord (Hopkins et al. 1989, Pedersen et al. 2008). These data were supplemented with zooplankton investigations in Porsangerfjorden during 2010–2014 (F. Norrbin, UiT, unpubl. material). An overview of the input values for the zooplankton and nekton groups are shown in Table S12.

For the groups where the biomasses were estimated by the Ecopath models (small krill, large krill and other large zooplankton) (Table S11), the estimated biomasses depend on the consumption by their predators. For their main predators, there were local data (i.e. from Porsangerfjorden) available on the diets.

Small krill, large krill, small zooplankton and microzooplankton are predominantly herbivores feeding on phytoplankton, but these groups are also important predators on zooplankton and detritus groups. Microzooplankton are part of the microbial food-web and link the microbial food-web with the grazer food-web. They feed on small phytoplankton and heterotrophic nanoflagellates. Heterotrophic nanoflagellates are major bacteriovores and they also feed on small phytoplankton. Schypomedusae, chaetognaths and other large zooplankton are important predators on small zooplankton and it was assumed that the values taken in studies from coastal and fjord areas in northern Norway are representative for Porsangerfjorden.

Table S12. Overview of sources of input data for the zooplankton and nekton groups. Where values are given for a parameter, they are equal in the models for all subareas. When values were estimated by the model (M), the resulting value may differ between the subarea models. Gr.: group; M: estimated by the Ecopath model

Gr. no.	Group name	*B* (g C m^{-2})	*P/B* (yr^{-1})	*Q/B* (yr^{-1})	*EE*
27	Small krill	M	2.50[a]	16.7[a]	0.9[a]
28	Large krill	M	2.35[b]	16.7[c]	0.9[c]
29	Small zooplankton	2.00[a]	6.5[a]	26.0[a]	M
30	Microzooplankton	0.42[a]	36.5[a]	121.7[a]	M
31	Heterotrophic nanoflagellates	0.26[a]	36.5[a]	121.7[a]	M
32	Schypomedusae	0.011[a]	6.5[a]	23.5[a]	M
33	Chaetognaths	0.020[d]	3.8[a]	19.0[a]	M
34	Other large zooplankton	M	2.0[a]	13.3[a]	0.9[a]
35	Pandalid shrimps	M[g]	1.20[e]	10.0[f]	0.9[a]

[a]Same as in the Sørfjord-model (Pedersen et al. 2008), [b]from Lindley (1982), [c]same as for small krill, [d]from Zhou et al. (2005), [e]length–frequency analysis (E. M. Nilssen, UiT, unpubl. results), [f]calculated from an assumed *P/Q* of 0.15 which is the same value as used in the Sørfjord model, [g]estimated by model in subareas 1, 2, and 3, while there was a separate assessment for subarea 4E (see text below).

27. Small krill

This group comprises *Thysanoessa raschii* and *Thyssanoessa inermis*. For Porsangerfjorden, biomasses were estimated by the model. Christensen (1995) estimated a *P/B* of 2.43 for *T. inermis* and *T. raschii* from the North Sea and Skagerrak, based on data from Lindley (1980).

The Porsangerfjorden models use a *P/B* of 2.5 year^{-1} and a *Q/B* of 16.7 year^{-1}, based on a *P/Q* of 0.15 adopted from the North Sea Ecopath model (Christensen 1995).

These species are predominantly herbivores, although *T. raschii* may consume detritus during the winter (Hopkins et al. 1989) and this is supported by stable isotope data from Porsangerfjorden (Torstein Pedersen, UiT, unpubl. material). The dietary composition in the model was equal to that of the Sørfjord model: phytoplankton (71%), detritus from pelagic groups (15%), microzooplankton (10%) and small zooplankton (4%).

Small krill are important prey for herring and small pelagic fishes and a number of other fish groups also feed on small krill.

28. Large krill

This group consists of *Meganyctiphanes norvegica*. Biomasses were estimated by the models. The *P/B* value was set to 2.35 $year^{-1}$, which is the average value of the estimated *P/B* values from two years from the Norwegian Sea (Lindley 1982). The *Q/B* value was set to the same (16.70 $year^{-1}$) as for small krill.

Large krill may feed on both phytoplankton and zooplankton (Kaartvedt et al. 2002), and have a higher proportion of small zooplankton in their diet than have small krill. Large krill have a very versatile feeding strategy and may switch between feeding mainly on phytoplankton and zooplankton (mainly copepods). Stable isotope data from Porsangerfjorden show a higher trophic level for *M. norvegica* than for *Thyssanoessa* spp. (Torstein Pedersen, UiT, unpubl. material). Thus, stable isotope data indicate that large krill has a trophic level between 2 and 3, with a significant proportion of small zooplankton in their diet. The dietary composition in the models was: phytoplankton (70%) and small zooplankton (30%).

29. Small zooplankton

This group comprises zooplankton smaller than 8 mm in length, the main groups being herbivorous copepods, cladocerans and appendicularians. It is dominated by copepods with *Calanus finmarchicus* as the most productive species, and the smaller copepods *Oithona* spp., *Microcalanus* spp., *Microsetella* spp. and *Acartia longiremis* also abundant (F. Norrbin, UiT, unpubl. material).

There are some investigations of zooplankton from Porsangerfjorden. During zooplankton investigations using vertically hauled zooplankton nets (180 µm) for the period 1962–65 (Hognestad 1992) and during 2012–2014 Norrbin (UiT, unpubl. material), displaced volume of zooplankton was measured for stations along Porsangerfjorden. These investigations indicate that small zooplankton in Porsangerfjorden follow the general seasonal pattern described for other fjords in northern Norway, where biomass has a seasonal minimum in March–April before the spring phytoplankton bloom and zooplankton reproduction, followed by a biomass increase and a maximum during August–October (Tande 1991). Neither during 1962–65 nor during 2012 and 2014, were any clear differences between subareas in zooplankton volume evident.

Based on counts for March, April, May and November 2014, and visual inspection of VPR (Video Plankton Recorder) data from August 2012/2013, *Pseudocalanus* spp. and

A. longiremis were markedly more common in Austerbotn (area 4E) than in all other areas during winter and spring. In November, all small groups (i.e. also *Oithona*, *Microsetella* and *Microcalanus*) were more abundant in Østerbotn, while the larger species (*Calanus* and *Metridia*) were more common outside. In general, the smaller copepod species are also more common in shallow bays of the other areas.

The biomass in the models was set at 2.0 g C m^{-2}, which is the same as used in the Sørfjord-model. This value was assumed to be representative for fjord and coastal waters in northern Norway around 70^{o}N (Pedersen et al. 2008).

The *P/B* value was set as 6.5 $year^{-1}$, which is equal to the *P/B* used for copepods in Balsfjord (Hopkins et al. 1989). A *Q/B*-value of 26 $year^{-1}$ was used, based on a *P/Q* of 0.25, which is slightly lower than the *P/Q* of 0.30 used for copepods in the North Sea (Christensen 1995).

The dietary composition was equal to the Sørfjord model (Pedersen et al. 2008): phytoplankton (65%), microzooplankton (16%), detritus from pelagic groups (9%), small zooplankton (5%) and heterotrophic nanoflagellates (5%).

30. Microzooplankton

This group comprises heterotrophic dinoflagellates, ciliates and tintinnids. In the microbial food web, heterotrophic nanoflagellates consume bacteria and are in turn consumed by ciliates and heterotrophic dinoflagellates. Ciliates and dinoflagellates are consumed by copepods and krill (Azam et al. 1983, Nielsen & Hansen 1995). To obtain input biomass values, the approach from the Sørfjord model (Pedersen et al. 2008) was followed where the values for biomass, *P/B* and *Q/B* were derived from Archer et al. (2000). They investigated the fjords Malangen, Balsfjord and Ullsfjord in northern Norway in 1997. Heterotrophic nanoflagellates, heterotrophic dinoflagellates and ciliates had similar biomasses. The production of microzooplankton that was available for higher trophic levels, averaged over the three fjords, corresponded to 11% of the total phytoplankton primary production (Archer et al. 2000). On an annual basis, this corresponds to consumption of microzooplankton by small zooplankton and krill amounting to 14.3 g C m^{-2} $year^{-1}$. Based on this, the average annual biomass of microzooplankon was calculated as 0.40 g C m^{-2} in the Sørfjord model (Pedersen et al. 2008), and this value was used in the Porsangerfjorden models.

The value of *P/B* was calculated as 36.5 $year^{-1}$, based on a growth rate of 0.1 day^{-1} (Archer et al. 2000) and assuming that stocks were stable and that mortality rate was equal to growth rate. The *Q/B* value for microzooplankton was calculated as 121.7 $year^{-1}$ from a *P/Q* value assumed to be 0.3 and the *P/B* of 36.5 $year^{-1}$ (Archer et al. 2000).

The diet for the group in the models was equal to the Sørfjord model (Pedersen et al. 2008): phytoplankton (83%), heterotrophic nanoflagellates (12%) and bacteria (5%).

31. Heterotrophic nanoflagellates

Annual average biomass of heterotrophic nanoflagellates was set as 0.26 g C m^{-2}, based on an investigation in fjords in northern Norway (Archer et al. 2000). Based on the same investigation, the values for *P/B* (36.5 $year^{-1}$) and *Q/B* (121.7 $year^{-1}$) were calculated and these values were the same as for microzooplankton. The common taxa of heterotrophic nanoflagellates observed were bacterivorous (Archer et al. 2000), and the diet was based on Verity et al. (1999), Archer et al. (2000), and was equal to that of the Sørfjord model (Pedersen et al. 2008): bacteria (95%) and phytoplankton (5%).

32. Schypomedusae

The schypomedusae *Cyanea capillata* and *Aurelia aurita* were common in Porsangerfjorden. Pelagic trawling in Porsangerfjorden (T. Pedersen, UiT, unpubl. results.) suggested a similar abundance as in Sørfjord and the same values as for the Sørfjord model were used: *B* = 0.011 g C m^{-2}, *P/B* = 6.5 $year^{-1}$ and *Q/B* = 23.5 $year^{-1}$ (Pedersen et al. 2008). The dietary composition used was also the same as in the Sørfjord model (Pedersen et al. 2008): small zooplankton (80%), small krill (7%), schypomedusae (5%), detritus from pelagic groups (4%), chaetognaths (3%) and other large zooplankton (1%).

33. Chaetognaths

Data for chaetognaths were based on investigations in the Sørfjord-Ullsfjord system in northern Norway during 1995–96 (Zhou et al. 2005). Using abundances from that study, length–frequency distributions from sampling in Sørfjord, and dry weight–total length relations and a C/DW-ratio of 0.46 from Parsons and Takahashi (1973), the biomass of chaetognaths (*Parasagitta elegans*) was calculated as 0.02 g C m^{-2} in Ullsfjord and this value was used for biomass in the Porsangerfjorden models. From data in Falkenhaug (1991), which found an average abundance of *Parasagitta* of about 45 m^{-2} in the northern Barents Sea, a biomass value of ca. 0.06 g C m^{-2} was used.

The value for *P/B* (3.8 $year^{-1}$) was based on data from Sørfjord and is the same as in the Sørfjord-model (Pedersen et al. 2008). The *Q/B*-value used in the models (19.0 $year^{-1}$) was calculated from the *P/B* value assuming a *P/Q* of 0.20. This value is similar to a *Q/B* value based on feeding rates of ca. 22 $year^{-1}$ from (Falkenhaug 1991).

Chaetognaths are carnivores and the dietary composition was based on investigations from the Barents Sea (Falkenhaug 1991): small zooplankton (90%) and microzooplankton (10%).

34. Other large zooplankton

This is zooplankton larger than 8 mm size and the group comprises pelagic amphipods, pelagic polychaetes, pteropods, and the appendicularians *Oikopleura dioica* and *Fritillaria borealis*. Biomass was estimated by the model and the values for *P/B* and *Q/B* were the same as for pandalid shrimps, 1.20 and 8.00 $year^{-1}$, respectively. The dietary composition was assumed to be: small zooplankton (50%), detritus from pelagic groups (30%) and phytoplankton (20%). This group is mainly predated by pelagic fishes, gadoid fishes and pandalid shrimps.

35. Pandalid shrimps

The deep-water shrimp *Pandalus borealis* is the main species in this group. Other species in the group are *Pandalus montagui*, and *Eualus gaimardii*, *Eualus pusiolus*. Deep-water shrimp dominates with regard to abundance and biomass and is abundant in all subareas with a very high abundance in the inner subarea 4E.

The biomasses of shrimp in the subareas were estimated by the models except for subarea 4E. There were few predators in subarea 4E in which deep-water shrimp could be identified in the stomachs, and there were generally very low levels of large fishes in the area. Thus, we attempted to assess the level of biomass of deep-water shrimp in subarea 4E by comparing the CPUE data from the otter sampling bottom trawl from subarea 4E relative to CPUE of the outer three subareas. In subarea 4E, the average CPUE (biomass per haul in otter bottom trawl) of deep-water shrimp was 9.1 times the average CPUE for the three outer subareas. Correspondingly, average CPUE of deep-water shrimp caught by epibenthic trawl in 4E was 8.5 times higher than the average CPUE for the three outer subareas. This shows that the biomass in subarea 4E was much higher than in the areas further out. The input value for biomass in the model for area 4E was assumed to be 9 times the average of the model-estimated biomass of pandalid shrimps in the three outer subareas. During balancing, this value had to be reduced since there was too little food available in the model.

A value of *P/B* of 1.20 year^{-1} (E. M. Nilssen, UiT, unpubl. material) was assumed for all subareas. This value is based on length–frequency analysis from samples collected in Porsangerfjorden during 2008–2011. The *Q/B* value for the outer three subareas was set at 8.0 year^{-1}, based on an assumed *P/Q* of 0.15, which is the same *P/Q*-value assumed in the Sørfjord-model (Pedersen et al. 2008). In subareas 1, 2 and 3, the average bottom temperatures during 2006–2010 were ca. 5.1°C, 3.9°C and 3.8°C, respectively. In subareas 4E and 4W, the average annual bottom temperatures were 0.28 and 0.08°C, and the *Q/B* for these areas was adjusted downwards according to an expected Q_{10} of 2.5. Daoud et al. (2007) found a Q_{10} for respiration of deep-water shrimp (average of juveniles, females and males) of ca. 2.8 between 2°C and 8°C. The resulting adjusted *Q/B*-values were 5.3 and 5.2 year^{-1} for subareas 4E and 4W, respectively.

The diet of deep-water shrimp is composed of phytoplankton for the small stages, copepods and krill (Hopkins et al. 1993), as well as benthic invertebrates (polychaetes, amphipods and echinoderms) and detritus (Wienberg 1981, Pedersen et al. 2016). The diet in the models was: small zooplankton (40%), detritus from pelagic groups (17%), phytoplankton (15.5%), detritivorous polychaetes (11.3%), small krill (10%), other large zooplankton (3%), large krill (2%), small benthic crustaceans (1%) and small molluscs (0.2%).

Deep-water shrimp is a very important prey for cod in Porsangerfjorden and is also consumed by other fish groups. There was no commercial catch of shrimp since shrimp-trawling has not allowed in Porsangerfjorden.

Benthic invertebrates

Red king crab (gr. 36–38)

The first single catches of the red king crab (RKC) in Porsangerfjorden were made in 2000 (Jørgensen & Nilssen 2011) and in 2006, the RKC was present in the fjord in relatively high abundances (Hvingel et al. 2012). An underwater-video survey showed that RKC was most abundant at deeper water stations (> 10 m deep), mainly where the substrate was soft bottom with gravel and/or sand (H. Steen, IMR, unpublished material). They may also use shallow water and littoral habitats. The mature crabs migrate to shallow water during autumn and early winter in order to hatch their eggs and mate (E. M. Nilssen, UiT, unpub. material).

Fertilized eggs are carried beneath the abdomen by females and hatch the next March–April (H. Michelsen, UiT, pers. comm.). After the eggs have hatched, the female crabs moult and produce another clutch of eggs which become fertilized by males; they then extrude the fertilized eggs, which are carried beneath the abdomen until the next spring. The pelagic larval period lasts for about two to three months before they settle in shallow water in early summer (Epelbaum et al. 2006).

Red king crab was split into three size-stanzas: large crabs with a carapace length (CL) above the lowest legal size for commercial catch (130 mm) (gr. 36), medium sized crabs with CL between 70 and 130 mm (gr. 37), and small crabs < 70 mm CL (gr. 38).

The abundance of RKC in Porsangerfjorden was estimated by the IMR using a beam-trawl with an opening of 6 m (Hjelset et al. 2009). Towing time was standardised to 30 min at 1.5 knots. This trawl caught king crabs > 70 mm CL, i.e. large and medium sized crabs. The average abundances of king crab > 70 mm CL for the period 2009–2011 were 429 km^{-2} for subarea 1, 1757 km^{-2} for subarea 2, 2083 km^{-2} for subarea 3. For subarea 4E, only one trawl haul from the outer part of subarea 4E (local density was 2160 km^{-2}) had nonzero catch of red king crab. Another study estimated low abundance of RKC in 4E and 4W (Fuhrmann et al. 2015), and it was assumed that the area with high density was representative only of the outer 15% of the inner area while the rest of the subarea had no large crabs and an average of the subarea was calculated. It was assumed that abundances (and resulting biomasses, see below) were equal in subarea 4E and 4W (Table S13).

To calculate abundances of the smaller RKC groups with CL < 70 mm, not caught representatively by the crab-trawl, a calculation procedure (mimicking the multi-stanza procedure in Ecopath) was performed in Excel, using published values for individual growth functions and mortality rates. An initial number of larvae was set to 1000 individuals, and numbers at age in the following age-classes were then calculated assuming that the population was in balance with constant numbers in each age and size group. Red king crabs have relatively large sex-differences with regard to individual growth and mortality rates and males grow to a much larger size than females, being also the main target in the commercial fishery. Values for size-at-age were based on Windsland et al. (2013) who estimated von Bertalanffy's growth functions (VBF) for length at age t: $L_t = L_\infty * (1-\exp(-K*t))$, for male and female RKC from Finnmark during the period 1994–2007. Their estimates for L_∞ were 192.5 mm for males and 158.6 for females. K, the growth coefficient in the VBF function, was estimated to be 0.0213 $month^{-1}$ (0.256 $year^{-1}$) for males and 0.0196 $month^{-1}$ (0.235 $year^{-1}$) for females. In the calculation procedure, carapace length-at-age was calculated with the VBF-function using the average values of K for females and males of 0.2454 year^{-1} and L_∞ of 175.6 mm.

Body weights (WW) at age were calculated using the body weight–length relationship (E. M. Nilssen, UiT, unpublished data): body weight (g WW) = exp(-7.9168 + 3.175*ln(CL)), where CL is carapace length in mm. Biomass values measured in WW were converted to biomass in carbon using a factor for C/WW of 0.0494, calculated from data for RKC based on measurements of energy content of body components (Paul & Paul 1996).

To calculate the biomasses in each size-stanza of RKC in given subareas, the initial number of larvae in the back-calculation procedure was adjusted so that the number of individuals of medium and large RKC (> 70 mm CL) in the calculation-procedure was equal to the abundance estimated by beam-trawling (ind. m^{-2}) in the subareas. The resulting biomass values (g C m^{-2}) for the large RKC group for each subarea were used as input values to the multi-stanza procedure in Ecopath, with large RKC as the leading group. This means that the biomasses of the other RKC-groups were “back-calculated” based on the biomass value of large RKC, the mortality rates and the VBF-growth function similar to the Excel calculation-procedure described above. Numbers at age were calculated assuming that the population was in balance (constant numbers in age and size groups) and published mortality rates for RKC from Finnmark for the period 1994–2012 from Windsland (2015) were applied (Table S13).

Table S13. Overview of parameters applied for the calculation of biomass in the various groups of red king crab by the multi-stanza procedure. The stanzas were divided into: large (CL > 130 mm), medium (70 < CL < 130 mm), small (< 70 mm CL) and pelagic larvae younger than 3 months. CL: carapace length; Gr.: group; mn: months

Gr. no.	Stanza group	Age, start (mn)	*Z* (yr^{-1})	*Q/B* (yr^{-1})	Biomass in subareas (g C m^{-2})				
					1	2	3	*4E*	4W
36	Large	65	1.00[a]	3.34[d]	0.00694	0.0284	0.0368	0.0050	0.0050
37	Medium	25	0.35[b]	4.49	0.0162	0.0664	0.0860	0.0117	0.0117
38	Small	0	0.50[c]	9.17	0.00206	0.00842	0.0109	0.0015	0.0015

K = 0.245 year^{-1}, recruitment power = 1.0, Wmaturity/Winf = 0.09
[a]Total mortality rate for red king crab during 2008–2012 (Windsland 2015), [b]natural mortality rate for red king crab for the period 1995–2012 (Windsland 2015), [c]set equal to the value for large crustaceans in Sørfjord model (Pedersen et al. 2008), [d]Lower value of 2.90 year^{-1} used in subarea 4E and 4W

There were few data suitable to serve as a basis to calculate *Q/B*. In decapods, the body energy content changes during the moult cycle (Anger 1984), and often laboratory experiments report feeding rates when animals were fed to satiation. The *Q/B* values used in the models were calculated from data obtained in an experiment by Siikavuopio and James (2013), where red king crabs with an average body mass of 2200 g WW were fed formulated food with an energy density of 20.8 kJ g^{-1} WW, at different temperatures of 3.9°C, 8.2°C and 12.1°C, lasting for 100 days. A *Q/B* value calculated as 3.34 $year^{-1}$, based on the experiment at 3.9°C, was used for large RKC in our models for subarea 1, 2 and 3, this being the leading group in the multi-stanza procedure. From the values of biomass and *Q/B* for the large RKC group and the *P/B* values for the other RKC groups, the multi-stanza procedure allowed calculation of the biomasses and *Q/B* values of the medium and small groups. For subarea 4E and 4W, a *Q/B* value of 2.9 $year^{-1}$ was used for the leading large RKC since temperature was lower than in the outer subareas.

Large crustaceans are considered to be “messy feeders” that do not consume all the prey they kill (Dall 1981, Mikkelsen & Pedersen 2012). To take this into account, the proportion of unassimilated food (*U/Q*) was set to 0.3, which is higher than the value of 0.2 commonly used for fish groups.

Diet was estimated from stomach analysis sampled in Porsangerfjorden during 2011. In total, 138 stomachs from 22 stations were sampled in May and October, from a depth range of 22 to 232 m. Specimens were sampled either by crab trawl at the deeper stations or by SCUBA-diving at the shallower stations (< 20 m depth), followed by immediate dissection and freezing of stomachs at -20°C. Stomach analysis was performed at UiT and stomach contents were identified to the lowest possible taxon under a stereo microscope. Six empty stomachs were excluded from further analysis (total analysed, n = 132). Since stomach contents were extremely fragmented, dietary composition was estimated as frequency of occurrence (FO). Prey items were grouped into the Ecopath groups (*i*) and FO*i* was calculated for each group. Importance of a specific Ecopath group *i* in the crabs’ diet was then calculated by dividing FO_i by the sum of FO for all groups. All unidentified material or material that could not be assigned to one Ecopath group (e.g. unidentified Gastropoda, foraminiferans, plastic, wood/plants, sediment and bird feathers) was excluded from the calculation.

In Porsangerfjorden, 14 of the Ecopath groups were identified in RKC stomachs, showing that RKC feed on a wide range of prey. The stomach analysis from Porsangerfjorden indicates some size differences in the diet. Algae were present in 50–60% of the crabs, but in small quantities in each crab. Red king crab in Finnmark have also been shown to be cannibalistic (Haugan 2004) but we found no occurrences of cannibalism in our material.

Dietary proportions in the models were initially set to the FO values in Table S14 for all subareas, but during balancing the dietary proportions were adjusted if the ecotrophic efficiency of a group (EE) was > 1, meaning that the production of a prey group was too low to balance the consumption by the predators and other mortality. Dietary proportions were modified so that similar prey had similar preference values.

Table S14. Overview of the original input for the dietary compositions of red king crab in all subarea models before balancing. Dietary proportions were calculated by dividing FO_i by the sum of FO for all groups in the diet of a red king crab size-stanza. N: number of stomachs analysed

Prey group no.	Red king crab group / Prey group	Proportion of diet: Small CL < 70 N = 47	Medium 70 < CL <130 N = 68	Large CL > 130 N = 14
40	Other large crustaceans	0.019	0.026	0.043
41	Predatory asteroids*			
42	Predatory gastropods	0.032	0.058	0.043
43	Predatory polychaetes	0.019	0.006	0.000
44	Other predatory invert.	0.000	0.006	0.000
45	Detritivorous polychaetes	0.038	0.103	0.064
46	Small benthic crustaceans	0.139	0.167	0.085
47	Small molluscs	0.133	0.058	0.128
48	Large bivalves	0.006	0.051	0.021
49	Detritivorous echinoderms	0.120	0.058	0.085
50	*Ctenodiscus crispatus*	0.000	0.045	0.064
51	Large epibenthic suspension feeders	0.171	0.083	0.106
53	Herbivorous echinoids	0.108	0.077	0.128
55–58	Macroalgae groups	0.184	0.231	0.191
62	Detritus from all other sources	0.032	0.032	0.043
	Sum	1.000	1.000	1.000

*Proportions of predatory asteroids were determined during balancing, so that preference values were similar to those of similar prey.

36. Large red king crab

This group consists of crabs that were ≥ 130 mm CL and were thereby larger than the minimum legal size for commercial catch. Since there were no precise catch statistics for RKC in Porsangerfjorden, the landings (*Cs*) were calculated as $Cs = F*B$. Windsland (2015) states a total mortality rate Z of 1.00 year^{-1} and a natural mortality rate of 0.35 year^{-1} for the period 2008–2012. A fishing mortality of 0.65 year^{-1} was then calculated as the difference between the total and the natural mortality rate.

37. Medium red king crab

This group consists of crabs with CL between 70 mm and 130 mm and is the RKC group with the highest biomass and consumption. Crabs of about 70 mm CL have been found in guts of spotted wolffish (*Anarhichas minor*) in Porsangerfjorden. Legs of red king crabs have been found in stomachs of large cod during winter, and these legs had probably been predated from soft newly-moulted red king crabs.

38. Small red king crab

This group consists of crabs with CL < 70 mm. Small RKC may occur aggregated in relatively shallow water of 5–30 m depth and the abundance of this size group is difficult to assess by field studies. Under-water video from the inner eastern part of Porsangerfjorden (subarea 4E) in 2012 showed a large aggregation of small red king crabs with CL of 4–7 cm (T. Pedersen, UiT, unpubl. material). Small RKC has been found in cod stomachs in Porsangerfjorden (H. K. Strand, IMR, Norway, pers. comm.).

Benthic invertebrates groups 39–52

Data for other benthic invertebrate groups (gr. 40–52), except for herbivorous echinoids (gr. 53), were estimated from van Veen grabs (0.1 m^{-2}) and epibenthic trawl hawls (ET). For benthic invertebrate species that could be sampled by grab and epibenthic trawl, separate values for biomass and *P/B* could be estimated from samples taken in the various subareas. The ET is a small beam trawl of 2 m width and has a mesh size of 5 mm. The ET is considered as a semi-quantitative technique, and the hauls had standardized towing time. It obtains better estimates for larger, motile and/or clumped species than single grab samples, which is why data from these two sampling methods were combined. In general, epibenthic species were considered from ET and infaunal species were estimated from grabs.

A total of 40 grab samples (year 2010, Fig. S2, see also Fuhrmann et al. 2015) and 77 epibenthic trawl hawls (years 2007–2010, Fig. S2) were analysed. Sampling depths ranged from 30 to 289 m. Material from grab samples was fixed in formalin, and transferred to ethanol before identification. Epifauna were directly processed on board the ship.

Identification of organisms was performed to the lowest possible taxon. All unidentified material was excluded from the analysis.

Total production (P) and *P/B* ratios were estimated from raw data in the following stepwise approach: biomass records (in g wet weight m^{-2}) for species at each station were converted to energy values (J m^{-2}) by mean established conversion factors compiled in *Brey T., 2001. Population dynamics in benthic invertebrates. A virtual handbook. Version 01.2. http://www.thomas-brey.de/science/*. Polychaete tubes were, in general, removed before weighing: for the genus *Spiochaetopterus*, a conversion factor from WW including tubes to WW excluding tubes was established (Fuhrmann et al. 2015). Other tubes and hard shells were excluded during conversion. Data were mostly aggregated to family level because conversion factors were available at this level.

Annual somatic *P/B* ratios were then estimated using empirical artificial neural networks (ANN) available as an Excel data-entry worksheet (Brey 2012) (version 01-2012). Artificial neural networks have been shown to improve prediction of community production over multiple linear regressions (Brey 2012). The mean individual body mass (J) served as input for the ANN. For epifaunal colonial organisms like Porifera, Hydroida and Bryozoa, the weight of the colony was considered as the biomass per individual. Other biotic factors were set as dummy variables and comprised *motility* (infauna, sessile, crawler, facultative swimmer), *feeding* (herbivore, omnivore, carnivore), *habitat* (lake, river, marine, subtidal, exploited) and *taxon* (Mollusca, Annelida, Crustacea, Echinodermata, Insecta). For other recorded taxa (e.g. Echiura), *taxon* was set to the most similar category (i.e. Annelida in the case of Echiura).

Mean annual bottom temperatures (ranging from ca. 0°C to 4°C) were based on data from long- term measuring stations between 2008 and 2010 (Fig. S2), provided by UiT The Arctic University of Norway, Tromsø. Values for the sampling stations were taken from similar depths of the nearest environmental station.

Values for *P/B* were computed for each species at each station, and total production was obtained by multiplying the *P/B* by the biomass at that station. Community *P/B* per Ecopath group in each subarea was then calculated by dividing the sum of production (kJ $year^{-1}$) by the sum of biomass (kJ). Biomass values were converted from energy to carbon according to Salonen et al. (1976).

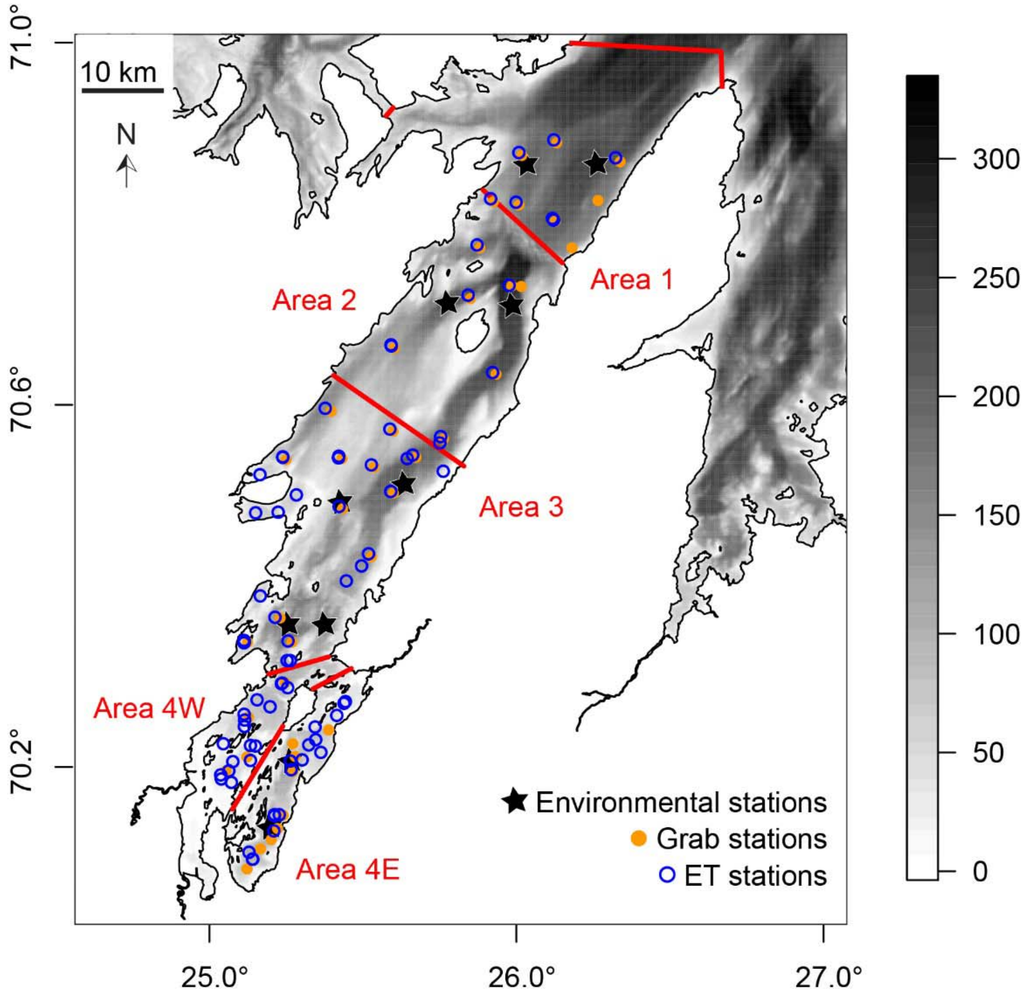

Figure S2. Benthic stations in Porsangerfjorden. Orange circles represent locations for van Veen grab sampling (0.1 m^{-2}) taken in 2010, and blue open circles show locations for epibenthic trawl (ET) hawls taken in 2007–2010. Stars show environmental stations. Grey scale on the right show depth in m.

Table S15. Overview of input values for the benthic invertebrates estimated by grab and epibenthic trawl (Gr. 39–53) to the Ecopath models for the subareas. Values for biomass (g C m^{-2}), *P/B* ($year^{-1}$) and *Q/B* ($year^{-1}$) are given. ET: epibenthic trawl; G: grab, ET/G: combination of epibenthic trawl and grab data; Bmod: *P/B* values estimated by the Brey-model; PQ: *Q/B* was calculated as *Q/B* = (*P/B*)/(*P/Q*); M: biomass estimated by the model; Li: values were taken from other studies; Gr.: group

				Subarea				
Gr. no.	Group name	Para-	Method	1	2	3	4E	4W
39	Crangonid shrimps	*B*	ET	0.0024	0.0152	0.0194	0.1194	0.031
		P/B	Bmod	0.7	0.333	0.388	0.172	0.295
		Q/B	PQ 0.15	4.67	2.22	2.59	1.15	1.97
40	Other large crustaceans	*B*	Model	M	M	M	M	M
		P/B	Li	0.5	0.5	0.5	0.5	0.5
		Q/B	Li	3.33	3.33	3.33	3.33	3.33
41	Predatory asteroids	*B*	ET	0.0134	0.0096	0.00092	0.0172	0.131
		P/B	Bmod	0.121	0.111	0.19	0.067	0.064
		Q/B	PQ 0.25	0.48	0.44	0.76	0.27	0.26
42	Predatory gastropods	*B*	ET/G	0.0245	0.0084	0.01159	0.017	0.03
		P/B	Bmod	0.91	0.63	0.518	0.178	0.259
		Q/B	PQ 0.15	6.07	4.2	3.45	1.19	1.73
43	Predatory polychaetes	*B*	ET/G	0.3078	0.4486	0.43	0.2531	0.127
		P/B	Bmod	0.944	0.855	0.902	0.842	0.841
		Q/B	PQ 0.15	6.29	5.7	6.01	5.61	5.61
44	Other predatory benthic invertebrates	*B*	ET/G	0.1823	0.119	0.0355	0.0726	0.295
		P/B	Bmod	0.885	0.814	0.798	0.582	0.413
		Q/B	PQ 0.20	4.44	4.07	4.02	3.87	3.46
45	Detritivorous polychaetes	*B*	G	0.762	1.491	1.398	8.89	3.237
		P/B	Bmod	1.655	1.622	1.51	1.135	1.12
		Q/B	PQ 0.20	8.28	8.11	7.55	5.68	5.6
46	Small benthic crustaceans	*B*	Model	M	M	M	M	M
		P/B	Bmod	2.182	1.082	1.506	1.43	2.166
		Q/B	PQ 0.15	14.55	7.21	10.04	9.53	14.44
47	Small molluscs	*B*	ET/G	0.1724	0.0831	0.1188	0.4184	0.217
		P/B	Bmod	0.808	1.081	1.065	0.421	0.85
		Q/B	PQ 0.15	5.39	7.21	7.1	2.81	5.67
48	Large bivalves	*B*	Model	M	M	M	M	3.297
		P/B	Bmod	0.55	0.801	0.19	0.121	0.117
		Q/B	PQ 0.08	6.88	10.01	2.38	1.51	1.46
49	Detritivorous echinoderms	*B*	ET/G	0.0196	0.0125	0.00079	0.0371	0.143
		P/B	Bmod	0.761	0.64	0.399	0.161	0.18
		Q/B	PQ 0.08	9.51	8	4.99	2.01	2.25
50	*Ctenodiscus crispatus*	*B*	ET	0	0.0665	0.026	1.2389	0.042
		P/B	Bmod	0.145[1)]	0.145	0.151	0.137	0.108
		Q/B	PQ 0.08	1.81	1.81	1.89	1.71	1.35
51	Large epibenthic suspension feeders	*B*	M	M	M	M	M	M
		P/B	Bmod	0.102	0.096	0.16	0.123	0.067
		Q/B	PQ 0.08	1.28	1.2	2	1.54	0.84
52	Other benthic invertebrates	*B*	ET/G	0.0861	0.004	0.0016	0.0027	M
		P/B	Bmod	1.028	1.263	0.638	1.225	0.78
		Q/B	PQ 0.15	6.85	8.42	4.25	8.17	5.2
53	Herbivorous echinoids	*B*	Survey	0.072	0.167	0.183	0.228	0.592
		P/B	Litt.	0.42	0.42	0.42	0.42	0.42
		Q/B	PQ 0.10	4.2	4.2	4.2	4.2	4.2

39. Crangonid shrimps

This group comprises *Sclerocrangon boreas* (sculptured shrimp), *Sabinea septemcarinata*, *Lebbeus polaris*, *Pontophilus norvegicus* and *Spirontocaris* spp. The most abundant species, *S. boreas* and *S. septemcarinata*, were mainly distributed in the inner cold subareas A4E and 4W, but some *S. septemcarinata* were also present in the outer subareas. Biomasses were estimated by epibenthic trawl and were highest in the inner subarea A4E (Table S15). In the inner two subareas A4E and A4W, *S. boreas* had more than twice the biomass of *S. septemcarinata*.

Values for *P/B* of *S. boreas* males and females sampled at Svalbard were estimated by length–frequency analysis as 0.19 and 0.41 year^{-1} for females and males respectively (Birkely & Gulliksen 2003a). The *P/B* values used for crangonid shrimps in the Ecopath models were estimated by the Brey model based on average body weights from Porsangerfjorden (Table S15). The relatively high value for *P/B* (0.7 year^{-1}, see table S15) in the outer subarea 1 for crangonid shrimps was due to lower body masses and higher temperatures here than in the inner subareas. Values of *P/B* ranged from 0.172 to 0.388 year^{-1} in the inner subareas (Table S15). Values of *Q/B* were calculated from *P/B* values, assuming a *P/Q* of 0.15.

Birkely and Gulliksen (2003b) investigated the contents of 197 stomachs and found that the sculptured shrimp at Svalbard was a carnivore that fed on both epi- and infauna. The mean percentage (by number) composition was: polychaetes (33.8%), amphipods (21.8), molluscs (26.1%), hydrozoans (0.9%), sediment and unidentified (8.4%), and other content (9.0%). The dietary composition in the Porsangerfjorden models was set as: detritivorous polychaetes (33%), small benthic crustaceans (26%), small molluscs (20%), predatory polychaetes (20%) and other benthic invertebrates (1%).

40. Other large crustaceans

This group comprises *Hyas araneus* and *H. coarctatus*, *Pagurus* spp., *Lithodes maja* and *Munida sarsi*. Biomass was estimated by the Ecopath model, since it was likely that the epibenthic trawl gave underestimates of the biomass. Values of *P/B* calculated by the Brey model (0.1–0.3 year^{-1}) also seemed very low in comparison to data from the literature. Therefore, *P/B* and *Q/B* were set to the same values, 0.50 and 3.33 year^{-1} respectively, as in the Sørfjord model (Pedersen et al. 2008).

No dietary data exist for this group in Porsangerfjorden. The diet used in the models was derived from the fact that biomasses of small molluscs and detritivorous echinoderms were low in Porsangerfjorden. Thus, the diet in the Porsangerfjorden models contains relatively more detritivorous polychaetes and less detritivorous echinoderms and small molluscs than in the Sørfjord model. Stable isotope signatures of *Hyas* spp., *Pagurus* spp. and *L. maja* were close to the range of red king crabs, and indicate a similar diet (M. Fuhrmann, UiT, unpubl. data). The dietary composition used in the Porsangerfjorden models was: detritivorous polychaetes (53.8%), pelagic detritus (33.7%), detritus from macroalgae (3.8%), large bivalves (2.7%), small molluscs (2.0%), small benthic crustaceans (2.0%) and large epibenthic suspension feeders (2.0%).

41. Predatory asteroids

This group comprises, among others, *Asterias rubens*, *Crossaster papposus*, *Henricia* spp., *Hippasterias phygian*, *Pseudarchaster parelii*, *Pteraster* spp. and *Solaster endeca*. Biomass was estimated from epibenthos trawl (ET) hauls.

Values of *P/B* for the Porsangerfjorden models were estimated by the Brey model and *Q/B* was calculated assuming a *P/Q* of 0.25 (Shirley & Stickle 1982).

There are no dietary data from Porsangerfjorden for this group and the diet in the models was based on information from the literature. *Asterias rubens* preys on large bivalves such as *Chlamys islandica*, *Mytilus edulis* and *Mya arenaria* but may also prey on the ascidian *Ciona intestinalis* (Bruun 1968, Gulliksen & Skjæveland 1973, Saier 2001), small mollusca (small bivalves and small gastropods), small benthic crustaceans and predatory polychaetes, and can also be cannibalistic (Anger et al. 1977). *Crossaster* and *Solaster* to a large degree feed on echinoderms, with *Crossaste*r preferring echinoids such as *Strongylocentrotus droebachiensis* while *Solaster* feed more on holothurians (Himmelman & Dutil 1991). *Crossaster* also feed on other asteroids (Gaymer et al. 2004). Trophic levels estimated from stable isotopes range from 2.7 to 3.3 for *A. rubens* and *Henricia* spp. (M. Fuhrmann, UiT, unpubl. data). The diet used in the models was: large bivalves (64%), detritus from pelagic groups (carrion) (23%), small molluscs (10%), predatory asteroids (1%), detritivorous echinoderms (1%), herbivorous echinoids (1%).

42. Predatory gastropods

Abundance of the relatively large species of the group were estimated from epibenthic trawl data. The main taxa were *Buccinum undatum*, *Neptunea* spp., Naticidae (*Lacuna* spp., *Euspira* spp., *Cryptonautica* spp.), *Colus* spp. and Nudibranchia (except *Aplysia* spp., which is a grazer). The group also contains the smaller infaunal families estimated from grab data, e.g. Philinoidea (*Cylichna*, *Retusa*, Scaphandridae, Philinidae) and scaphopods. Biomass values were estimated by combining data from epibenthos trawl hauls for the larger epibenthic groups and data from grab samples for the smaller infaunal groups.

The value for *P/B* was estimated by the Brey model and *Q/B* was calculated assuming a *P/Q* of 0.15. Values of *P/Q* reported for various gastropod species ranges from ca. 0.35 to 0.05 (Kideys 1998), and an intermediate value was chosen.

The large gastropods *B. undatum* and *Neptunea* spp. feed to a large degree on large bivalves (Nielsen 1974), but also on polychaetes (Taylor 1978) and carrion (Evans et al. 1996). The boring gastropods (Naticidae) feed on both small molluscs and large bivalves (Kitchell et al. 1981). Results from stable isotope analysis revealed a trophic level of 2.8–3.6 for these two molluscs (similar for *Lunatia* spp.). The diet used in the models was: large bivalves (58%), small molluscs (22%), detritivorous polychaetes (10%), detritus from pelagic groups (10%).

43. Predatory polychaetes

This group comprises exclusively predatory polychaetes from which biomass was estimated from grab samples. The main families were Nepthtyidae, Lumbrinidae, Syllidae, Polynoidae, Amphinomidae, Phyllodocidae, Glyceridae, Hesionidae and Pholoidae. This is a group with a relatively high biomass and food consumption.

Values of *P/B* were estimated by the Brey model and *Q/B* values were calculated assuming a *P/Q* of 0.15.

According to Jumars et al. (2015), predatory polychaetes feed on other small polychaetes, small amphipods, molluscs, foraminiferans, nematodes, benthic ostracods and copepods. Cannibalism is also likely and there is evidence of detritus feeding. Stable isotopes from Porsangerfjorden were available for Nephtyidae and support carnivory as a major feeding mode. Some algae and detritus may be consumed by Amphinomidae and bacteria by Hesionidae. Dietary composition used in the models was: detritivorous polychaetes (42%), bacteria (10%), detritus from pelagic groups (carrion) (10%), small benthic crustaceans (10%), detritus from macroalgae (10%), predatory polychaetes (10%) and small molluscs (8%). Several fish groups and invertebrates feed on predatory polychaetes.

44. Other predatory benthic invertebrates

This is a diverse group comprising Edwardsiidae (burrowing sea anemone), Nemertea, plathyelminthes and predatory ophiurids (mainly *Ophiura sarsi* with size < 5 mm and body mass < 0.033 g WW), where biomass was assessed from grab samples. For pycnogonids, *Rossia* spp. (Cephalopoda), Actinaria and *Ophiura* spp. with a body mass > 0.033 g WW, biomass was assessed from epibenthic trawl hauls (ET). Values of *P/B* were estimated by the Brey model. Values of *Q/B* were calculated assuming a *P/Q* of 0.20.

Edwardsiidae are predators that mainly feed on invertebrates (Hand & Uhlinger 1994). Nemerteans feed mainly on polychaetes and crustaceans (Thiel & Kruse 2001). Pycnogonidae feed mainly on porifera and hydroids (Arnaud & Bamber 1988). Actinarians also feed on zooplankton and *Rossia* probably feeds on mysids, small shrimp, krill and amphipods. The dietary composition for the group was: detritivorous polychaetes (44%), small zooplankton (20%), small benthic crustaceans (10%), large epibentic suspension feeders (10%), small krill (10%) and small molluscs (6%).

45. Detritivorous polychaetes

This group comprises detritivorous polychaetes but also omnivore polychaetes that in addition might graze or filter-feed. Main families and species were Maldanidae, Owenidae and *Spiochaetopterus typicus*, which were abundant in the subarea A4E; other families included Trichobranchidae, Ampharetidae and Pectinariidae. This was a very abundant and productive group in Porsangerfjorden and biomass values were estimated from grab samples.

The *P/B* values were estimated using the Brey model. Values of *Q/B* were estimated from the *P/B* values and a *P/Q* of 0.2, which is the same value as used in the Sørfjord-model (Pedersen et al. 2008).

The diet of these polychaetes consists mainly of detritus, bacteria and phytoplankton (Jumars et al. 2015). Stable isotope signatures from Porsangerfjorden (M. Fuhrmann, UiT, unpubl. material) reveal higher δ15N for Maldanidae and S. typicus than Owenidae (Owenia fusiformis), indicating that the latter is able to pick more fresh material or filter feed (see also Jumars et al, 2015). The dietary composition in the models was very similar to the diet for the group in the Sørfjord-model (Pedersen et al. 2008): detritus from pelagic groups (65%), bacteria (30%) and some phytoplankton (5%).

46. Small benthic crustaceans

This group comprises benthic crustaceans sampled by grab and by epibenthic trawl. Data were taken from grab samples for all Cumacea, Isopoda, Tanaidacea, Amphipoda with body size < 5 mm and unidentified Arthropoda. Data were taken from epibenthic trawls for *Balanus* sp., Mysida, and other amphipods with body size > 5 mm. Biomasses were estimated by the model since several of the species were likely to be underestimated by grab sampling, due to their high mobility and epi- and hyperbenthic life style, and many were too small to be well sampled by the epibenthic trawl.

Values of *P/B* were estimated by the Brey model using body size data from samples. Values of *Q/B* were calculated assuming a *P/Q* of 0.15 (Christensen 1995).

The dietary composition in the models was similar to that of the Sørfjord-model (Pedersen et al. 2008): detritus from pelagic groups (78%), detritus from macroalgae (11%), phytoplankton (6%), other large zooplankton (5%).

47. Small molluscs

This diverse group includes mainly small nonpredatory gastropods (e.g. *Lepeta caeca*, *Rissoella* spp.*)* and small bivalves (*Yoldiella* spp., *Nucula* spp., *Bathyarca glacialis*, *Parvicardium minimum*, Thyasiridae, *Nuculana* spp., *Musculus niger*), Caudofoveata and Polyplacophora (body mass < 0.1 g WW) that were sampled by grab. Data for larger Polyplacophora, littoral snails and *Hiatella arctica* (mostly stuck to larger shells) were taken from epibenthic trawl hauls. Biomass values were estimated from the combined grab and epibenthic trawl data.

Values of *P/B* were estimated by the Brey model. Values of *Q/B* were estimated assuming that *P/Q* was 0.15 (Christensen 1995).

This group comprises mainly detritivores and some grazers. Stable isotope signatures (M. Fuhrmann, UiT, unpubl. material) indicate deposit feeding for *B. glacialis* and *Yoldiella* spp., while *H. arctica* probably feeds more on fresh material/phytoplankton. The dietary composition in the models was: detritus from pelagic groups (65%), kelp (10%), detritus from macroalgae (10%), phytoplankton (10%) and benthic microalgae (5%).

48. Large bivalves

This group consists of *Yoldia hyperborea*, *Mya truncata*, *Arctica islandica*, *Mytilus edulis*, *Modiolus modiolus*, *Chlamys islandica* and larger Cardiidae, sampled by grab and epibenthic trawl (ET). Biomasses were estimated by the models for most various subareas, since the shallow areas with rough bottom with much *C. islandica* and *M. edulis* were not covered by grab or epibenthic trawl samples.

Values of *P/B* were estimated by the Brey model from samples. Values of *Q/B* were calculated assuming that *P/Q* was 0.08 (Pedersen et al. 2008).

Large bivalves feed on detritus, phytoplankton and bacteria (Ward & Shumway 2004, Kach & Ward 2008). The dietary composition used in the models was: detritus from pelagic groups (60%), phytoplankton (20%) and bacteria (20%).

49. Detritivorous echinoderms

This group consists mainly of ophiurids and the holothurian *Cucumaria frondosa*. For Ophiuridea with body mass ≥ 0.1 g WW, *Ophiopholis aculeata* and large Holothuroidea, data were taken from epibenthic trawl samples. Data for Ophiurida with body mass < 0.1 g WW, the holothurian *Labidoplax buski* and *Psolidium* spp., were taken from grab samples. Biomasses for this group were very low in subareas 2 and 3.

Values of *P/B* were estimated from the Brey model. Values of *Q/B* were calculated by assuming that *P/Q* was 0.08 (calculated from a data set supplied by T. Brey).

Cucumaria frondosa may feed on phytoplankton and zooplankton (Hamel & Mercier 1998). Stable isotope signatures for *O. aculeata* from Porsangerfjorden indicate a trophic level of ca. 2 and mainly suspension feeding, suggesting some phytoplankton in the diet (M. Fuhrmann, UiT, unpubl. material) (Graeve et al. 1997). Dietary composition in the models was: detritus from pelagic groups (50 %), bacteria (30%), phytoplankton (10%) and detritus from macroalgae (10%).

50. *Ctenodiscus crispatus*

This detritivorous asteroid forms one group since it is eaten by few predators except red king crab. *Ctenodiscus* was very abundant in the inner cold subarea (4E, Austerbotn) with high abundance and biomass. Biomass values were estimated from grab data.

Values of *P/B* were estimated by the Brey model. Values of *Q/B* were calculated assuming that *P/Q* was 0.08.

Ctenodiscus is a deposit feeder and obtains its food from the surface layer of the sediments (Shick et al. 1981, Hopkins et al. 1989). Its fatty acid composition indicates microbial input (*ibid.*). Stable isotope signatures with high δ15N from Porsangerfjorden suggest that it mainly has a bacterial diet (M. Fuhrmann, UiT, unpubl. mat.). The diet in the models was: bacteria (80%), detritus from pelagic groups (20%).

Red king crab feed on *Ctenodiscus* in Porsangerfjorden (Table S14).

51. Large epibenthic suspension feeders

This group comprises Actinaria, Alcyonacea, *Gorgonocephalus* spp. (a large ophiurid), Porifera, Bryozoa, Brachiopoda and, Ascidiacea collected by epibenthic trawl samples. Since many species in the group were large colonial animals with clumped distribution and present in rocky areas, it is likely that the biomass estimated by the sampling devices was underestimated and thus the biomass was estimated by the model. The value of *P/B* was estimated by the Brey model. The value of *Q/B* was calculated assuming that *P/Q* was 0.08.

The dietary composition used in the model was: detritus from pelagic groups (60%), small zooplankton (30%) and microzooplankton (10%). Sea anemones (Actinaria) were preyed on by cod in Porsangerfjorden, and pycnogonids are known to feed on Porifera.

52. Other benthic invertebrates

This group comprises Sipuncula, Echiura, Hemichordata and the gastropod *Aplysia*. Biomasses were estimated from the grab samples. Values of *P/B* were estimated by the Brey-model. Values of *Q/B* were calculated assuming that *P/Q* was 0.15 (Christensen 1995).The species in this group were considered mainly to be detritivores (Macdonald 2010), while *Aplysia* is a grazer on macroalgae (Fredriksen 2003). Dietary composition in the models was: detritus from pelagic groups (80%), detritus from macroalgae (10%) and kelp (10%).

53. Herbivorous echinoids

This group consists of the sea urchins, mainly *Strongylocentrotus droebachiensis*. Data on this group from the upper sublittoral were collected simultanously to the data on macroalgae (see description for macroalgae group 56–58) at a total of 776 stations. Abundance of sea urchins (individuals m^{-2}, herbivorous echinoids), was visually assessed using an aquascope and the mean individual size was catergorised into one of six size-categories. Individual weight was calculated from weight samples for each size category and total biomass was assessed by multiplying mean individual weight by abundance. The width of the zone with *S. droebachiensis* and the biomass (kg WW m^{-2}) was visually assessed. The shoreline distances were measured along the zero-water level using maps in GIS (Garmin: Map Sources, version

6.10.2). Each station was allocated to a distance of shore line (varying from 200 to 2000 m) with relatively homogenous topography and vegetation, for which it was assumed that the station was representative. The biomass in the sublittoral was calculated by multiplying the assessed biomass (kg WW m^{-2}) by the zone width (m) and shoreline distance (m) that the station represented.

Under-water video was used to assess the abundance below ca. 4 m depth and, using a drop-camera, a total of 95 transects from ca. 2–25 m depth in Porsangerfjorden were investigated. Based on these investigations and expert judgement, it was assumed that the biomass of sea urchins below 4 m depth was equal to that assessed by the surface survey above 4 m depth. The biomasses (in WW) for the subareas were converted from wet weight to carbon using a factor for C/WW of 0.018. This factor was derived from an ash free dry weight (AFDW)/WW ratio of 0.035 for echinoids (Ricciardi & Bourget 1998), a J per mg AFDW ratio of 23.66 (Rumohr et al. 1987) and a factor of 46 kJ g^{-1} C (Salonen et al. 1976). Biomass estimates for the sublittoral of the various subareas were: 0.072 (subarea 1), 0.167 (2), 0.184 (3), 0.188 (4E) and 0.456 g C m^{-2} (4W). Biomasses for the areas below 30 m depth were estimated from sampling by epibenthic trawl (ET) and were very low (< 0.0001 g C m^{-2}) for the three outer subareas (1, 2 & 3), but were higher for subarea 4E (0.040 g C m^{-2}) and 4W (0.136 g C m^{-2}). These values were added to the biomass values from the sublittoral to give the total biomasses: 0.072 (1), 0.167 (2), 0.184 (3), 0.228 (4E) and 0.592 g C m^{-2} (4W).

An average Z = 0.42 $year^{-1}$, based on samples from northern Norway, was estimated by Sivertsen and Hopkins (1995). Assuming that $P/B = Z$, this value is intermediate between the P/B of 0.29 $year^{-1}$ estimated in Greenland fjords (Blicher et al. 2007) and the P/B of 0.80 $year^{-1}$ estimated at Nova Scotia (Miller & Mann 1973). A P/B value of 0.42 $year^{-1}$ was used in the models. The value of Q/B was calculated as 4.2 $year^{-1}$, based on a P/Q value of 0.10 (Miller & Mann 1973).

Strongylocentrotus droebachiensis is mainly a herbivorous grazer feeding on macroalgae, but may also feed on other echinoderms, small blue mussels and carrion (Himmelman & Steele 1971, Briscoe & Sebens 1988, Sivertsen et al. 2008). In barren areas where sea urchins have grazed down macroalgae, benthic microalgae form a major part of the diet of sea urchins (Chapman 1981). Barren areas over-grazed by sea urchins in Porsangerfjorden were observed in 2001 (Sivertsen 2002) and have thereafter been common in Porsangerfjorden (K. Sivertsen, UiT, pers. comm.). The dietary composition in the models was set to: benthic microalgae and recruiting macroalgae (58%), kelp (20%), detritus from macroalgae (10%), annual macroalgae (5%), littoral macroalgae (5%) and large bivalves (2%).

Predators on green sea-urchins are red king crab, gulls, eiders, long rough dab and Atlantic wolffish (Himmelman & Steele 1971, Sivertsen 1997).

54. Bacteria

Large ranges of values for biomass, *P/B*, *Q/B* and *P/Q* values have been reported for marine bacteria. Bacterial production seems to change seasonally according to the amount of bioavailable dissolved organic carbon (BDOC), which is produced mainly by phytoplankton (Middelboe et al. 2012). For the North Atlantic, Ducklow (2000) gives an average value for the ratio of bacterial production to primary production (Bact-P/PP) of 0.25. For Arctic coastal areas and fjords in the Atlantic, the average values for the ratio of bacterial to primary production were in the range 0.07–0.50 (Middelboe et al. 2012). In the Sørfjord model (Pedersen et al. 2008), bacterial production made up 42 g C m^{-2} compared to a total primary production of 139.1 g C m^{-2}, corresponding to an average annual Bact-P/PP of 0.30. Based on the data from Kongsfjorden, Svalbard reported by Iversen and Seuthe (2011), an annual average Bact-P/PP of 0.39 was estimated by seasonal interpolation of their data. Since no specific data for bacterial production exist for Porsangerfjorden and recent literature values are similar to those used in the Sørfjord model, we used the same values for bacteria for the Porsangerfjorden models as in the Sørfjord model: *P/B* = 143 $year^{-1}$ and *Q/B* = 340.5 $year^{-1}$. We attempted to estimate bacterial biomasses using the models for the subareas. Since bacterial *P/B* is lower at low temperatures (Kirchman et al. 2009), it is likely that the values for *P/B* and *Q/B* for the inner colder area are lower than in the outer warmer area, but no attempt was made to adjust these rates due to different to ambient temperature.

Bacteria consume dissolved organic carbon (DOC) and the dietary composition in the models was detritus from pelagic groups (98%) and detritus from macroalgae (2%). Bacteria are consumed by heterotrophic nanoflagellates, ciliates (microzooplankton) and by benthic invertebrates that are predominantly detritivores. Some of the bacterial production is lost due to virus induced mortality, and in a fjord in Greenland, virus induced mortality was estimated to range from 4%–36% of bacterial production (Middelboe et al. 2012). This suggests that some of the production of bacteria is not consumed by the groups in the model and EE was set to 0.90.

Benthic algae

Assessment methodology

The distribution and biomass of macroalgae groups (and herbivorous echinoids, see gr. 54) were assessed using surface surveys for depths down to 4 m and underwater-video for depths from ca. 2–25 m. The surface surveys were conducted at low tide using a rubber boat, and a total of 776 stations were surveyed during 2010, 2011 and 2012. At each station, the following data were recorded: GPS position, the slope, visually assessed proportional coverage of bottom substrate type, macroalgal species composition and biomass in the littoral zone.

The slope was estimated by measuring distance from the shore–water interface and the depth at a point about 12–16 m away from the shore, using a marked rope. The macroalgae in the intertidal littoral zone were allocated to four categories: *Ascophyllum nodusum*, *Fucus* spp. (*F. serratus*, *F. disticus*, *F. vesiculosus*), Rhodophyta (*Devalera ramentacea*, *Palmaria palmata*) and one category for other algae. The width and wet weight biomass (kg WW m^{-2}) of the zone representing each category was assessed visually. Visual assessment and actual measurements of biomasses at 20 stations in the inter-tidal littoral zone and 5 sub-littoral stations were compared, and the two methods showed very good agreement (K. Sivertsen, UiT, unpubl. material).

In the sublittoral zone down to 4 m depth, macroalgal species composition and biomass (kg WW m^{-2}) were visually assessed using an aquascope. The macroalgae were classified into four categories of kelp (*Alaria esculenta*, *Laminaria digitata*, *Laminaria hyperborea* and *Saccharina latissima*) and two categories of annual brown algae – *Chorda filum* and filamentous brown algae (e.g. *Ectocarpus*, *Pylaiella* and *Dictyosiphon foeniculaceus*). The width of the zone representing each category and biomasses were visually assessed.

The shoreline distance was measured as described for herbivorous echinoids (see gr. 54). Each station was allocated a distance of shoreline (varying from 200 to 2000 m) with relatively homogenous topography and vegetation, and it was assumed that the station was representative for this distance. For each category of macroalgae, values for the category's biomass in the littoral and the sublittoral zone was calculated by multiplying the assessed biomass (kg WW m^{-2}) by the zone width (m) and the shoreline distance (m) measured at the station.

Under-water video was used to assess the composition of sub-tidal macroalgae from ca. 2 m depth down to 25 m depth, and a total of 95 video-stations were investigated throughout Porsangerfjorden (Fig. S3). The number of stations in the subareas were as follows: 25 (subarea 1), 44 (2), 25 (3), 4 (4E) and 7 (4W). The observations at each station were made by a cable

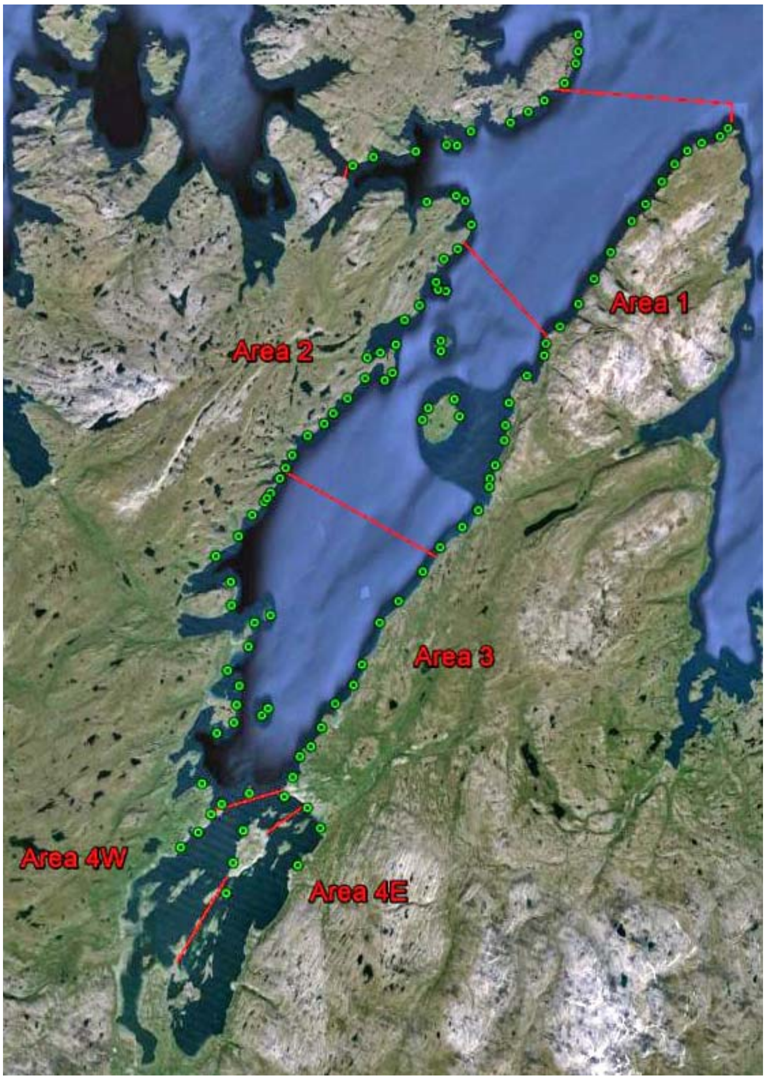

Figure S3. Videostations (green circles) for observation of sub-littoral macroalgae in Porsangerfjorden surveyed in 2008–2010.

connected underwater camera vehicle (UVS 5080), with an inbuilt depth sensor. The video camera was towed from a boat, along more or less straight-lined transects directed at an angle of approximately 90 degrees away from the shoreline with an average speed of approximately 1 knot. Each transect wase started from a nearshore point and ended at the point where 25 m depth was reached. The observed macroalgae were classified into four categories of kelp (*Laminaria*, *Alaria*, *Saccharina*, *Saccorhiza*) and one category for all other macroalgae, mainly consisting of filamentous brown alga, with *Desmarestia* and *Chorda* being the most prominent genera. Each videotransect was split into shorter segments for every three metres in depth (2–5 m, 5–8 m, 8–11 m, etc). For each depth segment, the average coverage for each of the macroalgal categories and the total macroalgal biomass density (kg WW m^{-2}) was visually assessed. To calculate integrated biomass estimates (kg m^{-2}) for an entire video transect, the biomass estimates for each depth segment multiplied by the length of the same depth segment divided by the total transect length, were summed.

To calculate total average biomass (g C m^{-2}) within each subarea, firstly total biomass in each algal category was calculated for each depth range using the data from the suface survey (0–4 m) and underwater-video survey (4–25 m). For each survey, the total average biomass of the various groups, per m shoreline within each subarea, was calculated. The underwater-video values (average values per m for the 2–5 m depth interval) were used for the range 4–5 m depth. For the depth range 5–25 m, underwater-video values were used. The values for average biomasses per m shoreline (g WW m^{-1}) were multiplied by the shoreline distances of each subarea to calculate the total biomass (t WW and t C)within the subarea, and the biomasses from the two depth-ranges were summed (Table S16).

To convert biomass values from wet to dry weight, 207 samples of algae in 20 categories were weighed wet and after drying for 21–24 hours at 95°C, and DW/WW-factors for each macroalgal category were estimated. The biomass (t C) for each subarea was divided by the the total area (km^2) of the subarea to give the average biomass of the subarea, which is the input to the Ecopath model (Table S16). An overview of the input values for benthic algal groups is given in Table S16.

The *P/B* values were calculated by: i) calculating production separately for the depth range covered by the surface survey (0–4 m depth) and the under-water survey (4–25 m depth), ii) summing the production (total production) from the two depth ranges, and iii) dividing total production by total biomass to yield *P/B* values (Table S16).

Table S16. Overview of Ecopath input-values for the benthic algal groups. Mo refers to biomass estimated by the model, Li refers to values taken from other studies (literature refererences) and weighted by the species-composition in the survey data. S-survey is surface survey for the depth interval 0–4 m depth and U-survey is underwater survey for the depth interval 4–25 m depth. Areas (km^2) of subareas used to calculate average biomass per subarea: 555.4 (subarea 1), 481.0 (2), 512.9 (3), 156.3 (4E), 171.8 (4W). Gr.: group

Gr. no.	Group name	Parameter	Method	Subarea 1	2	3	4E	4W
55	Kelp	*B* (t C)	S-Survey	1951	1902	1528	417	6837
		B (t C)	U-survey	1920	1567	780	11	5
		B (t C)	Total	3871	3469	2308	428	6842
		B (t C km^{-2})	Total	6.97	7.21	4.50	2.74	39.83
		P (t C $year^{-1}$)	S-Survey	1248	1263	1139	459	7071
		P (t C $year^{-1}$)	U-survey	1389	1168	622	9	5
		P (t C $year^{-1}$)	Total	2637	2431	1761	467	7076
		P (t C km^{-2} $year^{-1}$)	Total	4.75	5.05	3.43	2.99	41.20
		P/B ($year^{-1}$)	Li	0.681	0.701	0.763	1.092	1.034
56	Annual & other macroalgae	*B* (t C)	S-Survey	14	14	71	2	126
		B (t C)	U-survey	88	52	19	5	14
		B (t C)	Total	102	66	89	7	140
		B (t C km^{-2})	Total	0.183	0.137	0.174	0.045	0.817
		P/B ($year^{-1}$)	Li	1.5	1.5	1.5	1.5	1.5
57	Littoral algae	*B* (t C km^{-2})	S-Survey	1.13	1.72	5.09	7.14	19.62
		P/B ($year^{-1}$)	Li	0.49	0.49	0.49	0.49	0.49
58	Benthic microalge and recruiting macroalgae	*B* (t C km^{-2})	Mo					
		P/B ($year^{-1}$)	Li	6.8	6.8	6.8	6.8	6.8

55. Kelp

This group contains *Alaria esculenta*, *Laminaria digitata*, *Laminaria hyperborea*, *Saccharina latissima* and *Saccorhiza dermatodea*. These algae are dependent on hard bottom substrate, but *S. latissima* was often found attached to small stones. Under-water video showed that there was scarce hard bottom substrate below ca. 17 m depth. *Laminaria hyperborea* had the highest abundance in the outer exposed subareas, while *S. latissima* was more abundant in the inner sheltered areas. In the inner western subarea 4W, there were areas with unusual intertidal kelp associations (Sivertsen & Bjørge 2014). The kelps *S. latissima* and *L. digitata*, which are typically sub-littoral species, here form large inter-tidal kelp beds. Nine intertidal kelp beds were found, ranging from 0.01 to 3 km^2 and covering a total area of 8.3 km^2 (*op cit.)*.

Values for biomass in g WW m^{-2} were converted to carbon units (g C m^{-2}) using factors for DW/WW measured on material from Porsangerfjorden for each kelp-group (K. Sivertsen, UiT, unpubl. material): 0.275 for *L. digitata*, *L. hyperborea* and *A. esculenta*, and 0.234 for *S. latissima*. A C/DW ratio of 0.35 (Dunton & Dayton 1995) was assumed. The calculated biomasses (g C m^{-2}) in the subareas were: 6.97 (subarea 1), 7.21 (2), 4.50 (3), 2.74 (4E) and 39.83 (4W).

The value of *P/B* for kelp was calculated from values in the literature. Based on a value for biomass of *L. hyperborea* in Finnmark of 8.5 kg WW m^{-2} and a production of 0.8 kg DW m^{-2} $year^{-1}$ (Sjøtun et al. 1995), and using a DW/WW ratio of 0.192 (Sivertsen, UiT, unpubl. material) and a C/DW ratio of 0.35 (Dunton & Dayton 1995), a *P/B* of 0.63 $year^{-1}$ was calculated. Similar *P/B* values for *L. hyperborea* from two locations in Scotland and one at Helgoland ranged from 0.64 to 0.95 $year^{-1}$ with an average of 0.73 $year^{-1}$ (Jupp & Drew 1974). A *P/B* of 0.63 $year^{-1}$ was used to calculate production for all kelp species except *S. latissima* and *Saccorhiza dermatodea*. For *S. dermatodea*, an annual species, and *S. latissima*, a fast growing species with a relatively small perennial stipe, a *P/B* value of 1.1 $year^{-1}$, given by Nielsen et al. (2014), was used to calculate production. *Saccharina latissima*, *L. hyperborea* and other kelp-species also release significant amounts of DOC increasing the *P/B*-values (Johnston et al. 1977, Abdullah & Fredriksen 2004).

Values of *P/B* ($year^{-1}$) for the kelp group, specific for subareas, were calculated from the overall production divided by the total biomass of the group in the subareas in Porsangerfjorden (Table S16). Since *S. latissima*, with the highest *P/B*, was relatively more abundant in the inner subareas, the *P/B* values for the group were highest in the inner areas.

56. Annual and other macroalgae

This group comprises *Chorda filum*, which is a long threadlike brown alga, *Dictyosiphon foeniculaceus*, *Pilayella* and *Ectocarpus* spp., assessed by the surface survey, and other annual macroalgae assessed by the under-water video (mainly *Desmarestia* and *Chorda*). The annual algae were abundant during summer at shallow water in sheltered areas in Porsangerfjorden. *Chorda* grows as long threads which may be several metres long. These algae die during autumn. For *Chorda filum*, a DW/WW factor of 0.086 was measured, and for other annual macroalgae (*Pilayella* and *Ectocarpus* spp.), a DW/WW factor of 0.122 was measured (K. Sivertsen, UiT, unpubl. data). A C/DW of 0.35 (Dunton & Dayton 1995) was assumed. The calculated biomasses (g C m^{-2}) in the subareas were: 0.183 (subarea 1), 0.137 (2), 0.174 (3), 0.045(4E) and 0.815(4W) (Table S16).

Chorda filum may lose tissue during the growth process and hence the production of tissue is greater than the standing biomass measured during summer (South & Burrows 1967). No published value for *P/B* was found and the *P/B* value for the group was set to 1.5 $year^{-1}$.

57. Littoral macroalgae

This group comprises the brown algae *Ascophyllum nodusum*, *Fucus serratus*, *Fucus vesicolosus*, *Fucus disticus*, *Fucus spiralis*, and the red algae *Devalera ramentacea* and *Palmaria palmata*. The brown algae dominated with regard to biomass. The group is not considered to be heavily grazed, and most of the production enters the detritus (Vadas et al. 2004). Biomass values were converted from WW to DW using the following DW/WW factors: 0.265 for *Ascophyllum*, 0.237 for *Fucus*, and 0.178 for *Devalera* and *Palmaria* (K. Sivertsen, UiT, unpubl. data). Carbon biomasses were calculated using a C/DW ratio of 0.38 (Hardwickwitman & Mathieson 1986). The calculated biomasses (g C m^{-2}) in the subareas were: 1.13 (subarea 1), 1.72 (2), 5.09 (3), 7.14 (4E) and 19.62 (4W).

For *A. nodusum*, a *P/B* value of 0.44 $year^{-1}$ could be calculated from Cousens (1984), and Vadas et al. (2004) gave a *P/B* value of 0.54 $year^{-1}$. An average of these values (*P/B* = 0.49 $year^{-1}$) was used for littoral macroalgae in the models.

58. Benthic microalgae and recruiting macroalgae

This group comprises benthic diatoms and small recruiting specimens of macroalgae in areas overgrazed by sea urchins. In barren areas where sea urchins have grazed down macroalgae, benthic microalgae form a major part of the diet of sea urchins (Chapman 1981). Microalgae also grow on sandy and muddy substrates (Woelfel et al. 2010). Biomasses were estimated by the Ecopath models.

A biomass of 2.2 g C m^{-2} and a production of 15 g C m^{-2} year were measured at 8 m depth in a location at Nova Scotia, Canada. In this area, sea urchins feeding on microalgae had biomass ranging from 247 to 1116 g WW m^{-2} (Chapman 1981). This correspond to a *P/B* of 6.8 $year^{-1}$ and this value was used in the models. Herbivorous echinoids were the main grazer on this group.

59. Phytoplankton

Porsangerfjorden is a wide fjord with little runoff and the water masses in Porsangerfjorden are only stratified due to freshwater supply and heating from May to October (Svendsen 1995). Depending on the wind direction, there may be either upwelling on the eastern side of the fjord and downwelling on the western side during periods with up-fjord wind, or upwelling on the western side and downwelling on the eastern side during periods with down-fjord wind (*op. cit.*).

Investigations in Porsangerfjorden during 1990–93 showed that nutrients in spring were always high until April, with values for nitrate of 8–11 µmol l^{-1}, phosphate 0.7–1.3 µmol l^{-1} and silicate 4–6.5 µmol l^{-1} (Hegseth 1995). During winter, the phytoplankton biomass was very low. Porsangerfjorden had relatively large variations in bloom timing, from the middle of April to the last part of May. In May there was a minimum of nutrients, while in June the levels were higher and then varied throughout the summer due to occasional blooms occurring. Depending on the wind conditions, the water in the fjord may either be closed off from the coastal water, or there may be some exchange with coastal water in the spring with warmer coastal water entering the fjord on the western side and colder fjord water leaving the fjord on the eastern side (*op. cit.*).

The phytoplankton was investigated during a three year period 2002–2004 at three stations, in subareas 4E, 3 and 2 in Porsangerfjorden (Eilertsen & Frantzen 2007). Phytoplankton biomass, measured as chlorophyll a, had the highest values in April at the two outer stations, while the inner stations had more even values in the period from April to September. Except for the onset of the bloom in April, the values were quite similar between the stations (*op cit.*).

A value of phytoplankton biomass of 2.0 g C m^{-2} given for the Barents Sea (Sakshaug et al. 1994) was used in the models. An average value of 115 g C m^{-2} $year^{-1}$ for particulate primary production by phytoplankton for Balsfjord, based on three years of measurement (Eilertsen & Taasen 1984), was used in the models. By adding a production of 15 g C m^{-2} $year^{-1}$ of DOC (Sakshaug et al. 1994), this gave a total primary production by phytoplankton of 130 g C m^{-2} $year^{-1}$, and this value was used in the models. The *P/B* value was calculated from biomass and production and was 65 $year^{-1}$.

60. Discarded catch

Detritus as defined in the model is dead organic material. For all groups in the model, the fate of detritus from the group is specified as input data. The main component of this group was assumed to be offal and this was specified as 30% of the catches of fish. All discard enters the "Discarded and offal" detritus group.

61. Detritus from macroalgae

A large part of the production of kelp, about 82% of the kelp production on a global scale, is not grazed directly (Miller & Mann 1973), but is detached and enters the pool of detritus derived from macroalgae (Krumhansl & Scheibling 2012). With the exception of recruiting macroalgae, neither of the other groups of macroalgae in the model are grazed heavily, and the majority of the macroalgal production enters the macroalgal detritus group. Macroalgal-derived detritus may be degraded by bacteria which increase the content of nitrogen, and hence increase the nutritional value for the detritivores (Norderhaug et al. 2003). Macroalgae also release a considerable proportion of the production as DOC (Abdullah & Fredriksen 2004). The biomass of macroalgal detritus has not been measured, but was set to 2 g C m^{-2} in the models, based on the consideration that the biomass is considerably lower than that of living macroalgae.

62. Detritus from pelagic and all other groups

This detritus group consists mainly of dead and dying phytoplankton cells, and zooplankton faecal pellets. Zooplankton pellets constitute an important part of the particulate matter that sinks out of the euphotic zone in north Norwegian fjords (Reigstad 2000). The sedimented detritus is food for detritivorous benthic organisms. Dissolved organic carbon (DOC) is included in the detritus pool and is the source of carbon for bacteria (Azam et al. 1983). The amount of DOC has been measured as about 67 g C m^{-2} in fjords in mid- and northern Norway (Børsheim et al. 1999, Gašparović et al. 2005). Much of the DOC is refractory material that is unavailable for microbioal breakdown (*op. cit.*). The bioavailable dissolved organic carbon (BDOC) changes markedly through the seasons due to seasonal changes in phytoplankton production (Middelboe et al. 2012). If was difficult to specify a separate group for dead bodies of organisms (carrion) from all the other groups. The biomass of this detritus group was set to 67 g C m^{-2}.

6 Dietary input matrices

Table S17. Overview of dietary input values for consumer groups before balancing of models for subareas. Diet for groups 1–8. Gr.: group; inv.: invertebrates; nanoflag: nanoflagellates; epibent susp.: epibenthic suspension

	Subarea	All	All	All	All	All	All	All	All
	Gr. no. predator	1	2	3	4	5	6	7	8
Gr.	Prey	Grey seals	Harbour seals	Whales	Otters	Piscivorous benthic feeding birds	Pelagic diving birds	Surface feeding birds	Benthic invertebrate feeding birds
9	Large cod	0.328							
10	Small cod	0.200	0.112		0.200	0.180	0.050	0.018	
11	Large saithe								
12	Small saithe	0.063	0.018	0.150	0.130	0.180	0.100	0.017	
13	Large haddock	0.085							
14	Small haddock	0.050	0.014	0.150	0.070	0.090	0.100		
15	Small gadoids	0.046			0.050		0.050		
17	Other large flatfish	0.034			0.100				
18	Other small flatfish		0.030		0.150				
19	Other large demersal fish	0.121			0.050				
20	Other small demersal fish	0.037	0.058		0.150	0.020		0.059	
21	Cottids	0.020	0.687		0.100	0.020			
22	Small pelagic fish	0.002	0.043	0.400		0.402	0.600	0.218	
23	Herring	0.016	0.038	0.300			0.100	0.215	
28	Large krill							0.053	
38	Small RKC								
40	Other large crustaceans					0.046		0.088	0.046
41	Predatory asteroids								0.010
42	Predatory gastropods								0.010
43	Predatory polychaetes					0.046			0.017
45	Detritivorous polychaetes								0.001
46	Small benthic crustaceans					0.009			0.028
47	Small molluscs					0.005			0.043
48	Large bivalves								0.460
49	Detritivorous echinoderms								0.004
52	Herbivorous echinoderms							0.118	0.381
60	Discarded catch							0.214	
	Sum	1.000	1.000	1.000	1.000	0.998	1.000	1.000	1.000

Table S17, continuation, groups 9–14

	Subarea	1	1	2	2	3 & 4	3 & 4	All	All	1	1
	Gr. no. predator	9	10	9	10	9	10	11	12	13	14
Gr.	Prey	Large cod	Small cod	Large cod	Small cod	Large cod	Small cod	Large saithe	Small saithe	Large haddock	Small haddock
10	Small cod	0.0002	0.058	0.028	0.058	0.007	0.058			0.008	
12	Small saithe		0.054	0.005	0.054		0.054				
14	Small haddock	0.155		0.005		0.014					
15	Small gadoids	0.301	0.350	0.018			0.137	0.030	0.103	0.160	0.017
18	Other small flatfish	0.010	0.001		0.001	0.016	0.001				
19	Other large demersal fish										
20	Other small demersal fish	0.007	0.076	0.029	0.075	0.010	0.117	0.383	0.020		0.014
21	Cottids		0.037		0.037		0.037				
22	Small pelagic fish	0.058	0.062	0.204	0.102	0.135	0.099	0.259	0.005	0.023	0.274
23	Herring	0.189	0.003	0.006		0.004		0.018		0.013	0.096
27	Small krill	0.011	0.005	0.007	0.009		0.002	0.044	0.489	0.049	0.014
28	Large krill	0.011		0.004	0.004			0.044	0.346		
29	Small zooplankton								0.020		
34	Other large zooplankton				0.001			0.026	0.012	0.051	0.003
35	Pandalid shrimps	0.254	0.185	0.679	0.462	0.778	0.314	0.189		0.195	0.014
36	Large RKC										
37	Medium RKC					0.0076					
38	Small RKC					0.0030	0.010				
39	Crangonid shrimps		0.001								
40	Other large crustaceans	0.003	0.078	0.005	0.112	0.016	0.084			0.015	0.019
41	Predatory asteroids									0.049	
42	Predatory gastropods									0.009	
43	Predatory polychaetes	0.001	0.038		0.038	0.001	0.040		0.004		
44	Other predatory benthic inv.	0.001		0.010		0.003					
45	Detritivorous polychaetes									0.291	0.312
46	Small benthic crustaceans		0.030		0.024	0.007	0.029			0.004	0.001
47	Small molluscs								0.002	0.037	0.085
49	Detritivorous echinoderms		0.022		0.022		0.022			0.097	0.151
55	Kelp							0.007			
	Sum	1.000	1.000	0.999	1.000	1.000	1.004	1.000	1.000	1.000	1.000

Table S17, continuation, group 13–22

	Subarea	2, 3 & 4	2, 3 & 4	All	All	All	All	All	All	All	All
	Gr. no. predator	13	14	15	16	17	18	19	20	21	22
Gr.	Prey	Large haddock	Small haddock	Small gadoids	Halibut	Other large flatfish	Other small flatfish	Other large demersal fish	Other small demersal fish	Cottids	Small pelagic fish
9	Large cod							0.009			
10	Small cod				0.122			0.018		0.040	
11	Large saithe										
12	Small saithe							0.009		0.030	
13	Large haddock							0.018			
14	Small haddock				0.122			0.037		0.010	
15	Small gadoids			0.059	0.244			0.018			
17	Other large flatfish							0.018			
18	Other small flatfish							0.025			
20	Other small demersal fish				0.440			0.018		0.010	
21	Cottids							0.009		0.040	
22	Small pelagic fish	0.006		0.015	0.022			0.035		0.050	
23	Herring			0.015						0.030	
27	Small krill	0.265	0.474	0.545		0.020	0.020	0.267	0.150	0.010	0.808
28	Large krill			0.250				0.260			
29	Small zooplankton			0.075				0.014	0.400		0.119
32	Schypomedusae							0.041			
33	Chaetognaths										
34	Other large zooplankton		0.071	0.032							0.073
35	Pandalid shrimps	0.192	0.018	0.004	0.050	0.080	0.080			0.180	
38	Small RKC							0.012			
39	Crangonid shrimps									0.050	
40	Other large crustaceans	0.009	0.009			0.020	0.020	0.063			
41	Predatory asteroids							0.012			
43	Predatory polychaetes		0.002			0.302	0.320	0.028	0.050	0.200	
44	Other predatory benthic inv.							0.014			
45	Detritivorous polychaetes	0.515	0.336	0.005		0.410	0.460		0.350	0.200	
46	Small benthic crustaceans	0.001	0.001			0.050	0.050		0.050	0.080	
47	Small molluscs	0.004	0.051			0.098	0.030	0.012		0.070	
48	Large bivalves							0.024			
49	Detritivorous echinoderms	0.008	0.037			0.002	0.002				
52	Other benthic invertebrates					0.013	0.018	0.018			
53	Herbivorous echinoids					0.005		0.024			
	Sum	0.999	1.000	1.000	1.000	1.000	1.000	1.003	1.000	1.000	1.000

Table S17, continuation, groups 23–31

	Subarea	All	All	All	All	All	All	All	All	All
	Gr. no. predator	23	24	25	26	27	28	29	30	31
Gr.	Prey	Herring	Salmon	Sea trout	Arctic charr	Small krill	Large krill	Small zooplankton	Microzooplankton	Heterotrophic nanoflagellates
10	Small cod			0.050	0.086					
11	Large saithe			0.051						
12	Small saithe				0.064					
14	Small haddock		0.130							
20	Other small demersal fish			0.080	0.033					
21	Cottids									
22	Small pelagic fish		0.280	0.297						
23	Herring		0.520	0.220	0.315					
27	Small krill	0.100		0.040	0.253					
28	Large krill		0.070	0.040	0.250					
29	Small zooplankton	0.800				0.040	0.300	0.050		
30	Microzooplankton					0.100		0.160		
31	Heterotrophic nanoflag.							0.050	0.120	
34	Other large zooplankton	0.100								
35	Pandalid shrimps			0.080						
43	Predatory polychaetes			0.032						
46	Small benthic crustaceans			0.110						
54	Bacteria								0.050	0.950
59	Phytoplankton					0.710	0.700	0.650	0.830	0.050
62	Detritus from all other sources					0.150		0.090		
	Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table S17, continuation, groups 32–40

	Subarea	All	All	All	All	All	All	All	All	All
	Gr. no. predator	32	33	34	35	36	37	38	39	40
Gr.	Prey	Schypomedusae	Chaetognaths	Other large zooplankton	Pandalid shrimps	Large RKC	Medium RKC	Small RKC	Crangonid shrimps	Other large crustaceans
27	Small krill	0.070			0.100					
28	Large krill				0.020					
29	Small zooplankton	0.800	0.900	0.500	0.400					
30	Microzooplankton		0.100							
32	Schypomedusae	0.050								
33	Chaetognaths	0.030								
34	Other large zooplankton	0.010			0.030					
40	Other large crustaceans					0.019	0.026	0.043		
41	Predatory asteroids					*	*	*		
42	Predatory gastropods					0.032	0.058	0.043		
43	Predatory polychaetes					0.019	0.006		0.200	
44	Other predatory benthic inv.						0.006		0.010	
45	Detritivorous polychaetes				0.113	0.038	0.103	0.064	0.330	0.538
46	Small benthic crustaceans				0.010	0.139	0.167	0.085	0.260	0.020
47	Small molluscs				0.002	0.133	0.058	0.128	0.200	0.020
48	Large bivalves					0.006	0.051	0.021		0.027
49	Detritivorous echinoderms					0.120	0.058	0.085		
50	*Ctenodiscus crispatus*						0.045	0.064		
51	Large epibent susp. feeders					0.171	0.083	0.106		0.020
52	Other benthic invertebrates									
53	Herbivorous echinoids					0.108	0.077	0.128		
55	Kelp					0.184	0.231	0.191		
59	Phytoplankton			0.200	0.155					
61	Detritus from macroalgae									0.038
62	Detritus from all other sources	0.040		0.300	0.170	0.032	0.032	0.043		0.337
	Sum	1.000	1.000	1.000	1.000	1.001	1.001	1.001	1.000	1.000

Table S17, continuation, groups 41–50

	Subarea	All	All	All	All	All	All	All	All	All	All
	Gr. no. predator	41	42	43	44	45	46	47	48	49	50
Gr.	Prey	Predatory asteroids	Predatory gastropods	Predatory polychaetes	Other predatory benthic invertebrates	Detritivorous polychaetes	Small benthic crustaceans	Small molluscs	Large bivalves	Detritivorous echinoderms	*Ctenodiscus crispatus*
27	Small krill				0.100						
28	Large krill										
29	Small zooplankton				0.200						
34	Other large zooplankton						0.050				
41	Predatory asteroids	0.010									
43	Predatory polychaetes			0.100							
45	Detritivorous polychaetes		0.100	0.420	0.440						
46	Small benthic crustaceans			0.100	0.100						
47	Small molluscs	0.100	0.220	0.080	0.060						
48	Large bivalves	0.640	0.580								
49	Detritivorous echinoderms	0.010									
51	Large epibenthic susp. feeders				0.100						
53	Herbivorous echinoids	0.010									
54	Bacteria			0.100		0.300			0.200	0.300	0.800
55	Kelp							0.100			
56	Annual macroalgae							0.050			
59	Phytoplankton					0.050	0.060	0.100	0.200	0.100	
61	Detritus from macroalgae			0.100			0.110	0.100		0.100	
62	Detritus from all other sources	0.230	0.100	0.100		0.650	0.780	0.650	0.600	0.500	0.200
	Sum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table S17, continuation, groups 52–55

	Subarea	All	All	All	All
	Gr. No. Predator	51	52	53	54
Gr.	Prey	Large epibenthic suspension feeders	Other benthic invertebrates	Herbivorous echinoids	Bacteria
29	Small zooplankton	0.300			
30	Microzooplankton	0.100			
48	Large bivalves			0.020	
55	Kelp		0.100	0.200	
56	Annual macroalgae			0.050	
57	Littoral macroalgae			0.050	
58	Benthic microalgae & recruiting macroalgae			0.580	
61	Detritus from macroalgae		0.100	0.100	0.020
62	Detritus from all other sources	0.600	0.800		0.980
	Sum	1.000	1.000	1.000	1.000

7 PREBAL and balancing of the models

The input data to the model for each subarea are described above with a summary of the dietary input (Table S17). Before balancing, the PREBAL –approch was used to diagnose if input values for groups were reasonable according to the guidelines presented in Link (2010). In fig. S4, S5 and S6 the values for biomass, P/B and Q/B in the baseline model for subarea 3 are shown. There are a number of logical constraints used when balancing an Ecopath model (Heymans et al. 2016). The ecotrophic efficiency (EE) can not exceed 1.0. Values close to 0.0 can be expected for top-predators that are not efficiently predated by other groups or exploited by fishery. EE-values close to 1.0 can be expected for when most of the production is predated by other groups or fished. The gross efficiency (GE) is usually between 0.1 and 0.3. However, lower values for GE can be found for benthic detritivores which have low food assimilation and for top-predators with low production per biomass (Pedersen et al. 2016). The net efficiency should be lower than gross efficiency (Heymans et al. 2016). The proportion of biomass respired (R) should be lower than the assimilation (A), thus, the ratio R/A < 1.0. Respiration/biomass ratios are expected to range between 1-10 $year^{-1}$ for fish and may range from 50-100 year^{-1} for groups with high turnover. Production should typically be less than respiration.

The first balancing attempt resulted in some groups having an ecotrophic efficiency (EE) > 1, i.e. there was too little food to satisfy the consumption need by the group. To balance the model, the dietary compositions were modified by reducing the dietary proportions for prey groups that had EE > 1 and increasing the dietary proportions for groups that had “unused” production. During this process, values for niche selectivities and search rates for predators were inspected to see if values differed much for prey groups that were expected to be similar. It was also considered to be unlikely if a predator had a very high search rate for a prey with EE > 1 that was rare in the diet and in such cases proportions of rare prey in the diet were reduced so that search rates of similar prey became similar.

For the red king crab groups, the original proportion in the diets (see table S17) of “Detritus from all other sources” were increased during balancing to satisfy the consumption needs of red king crab. In subarea 3, the proportions of “Detritus from all other sources” were increased to 0.138, 0.212 and 0.080 for large, medium and small RKC. This was based on the observed attraction of medium and large RKC to bait and carrion. Detritus groups has by definition trophic level 1 in Ecopath models.

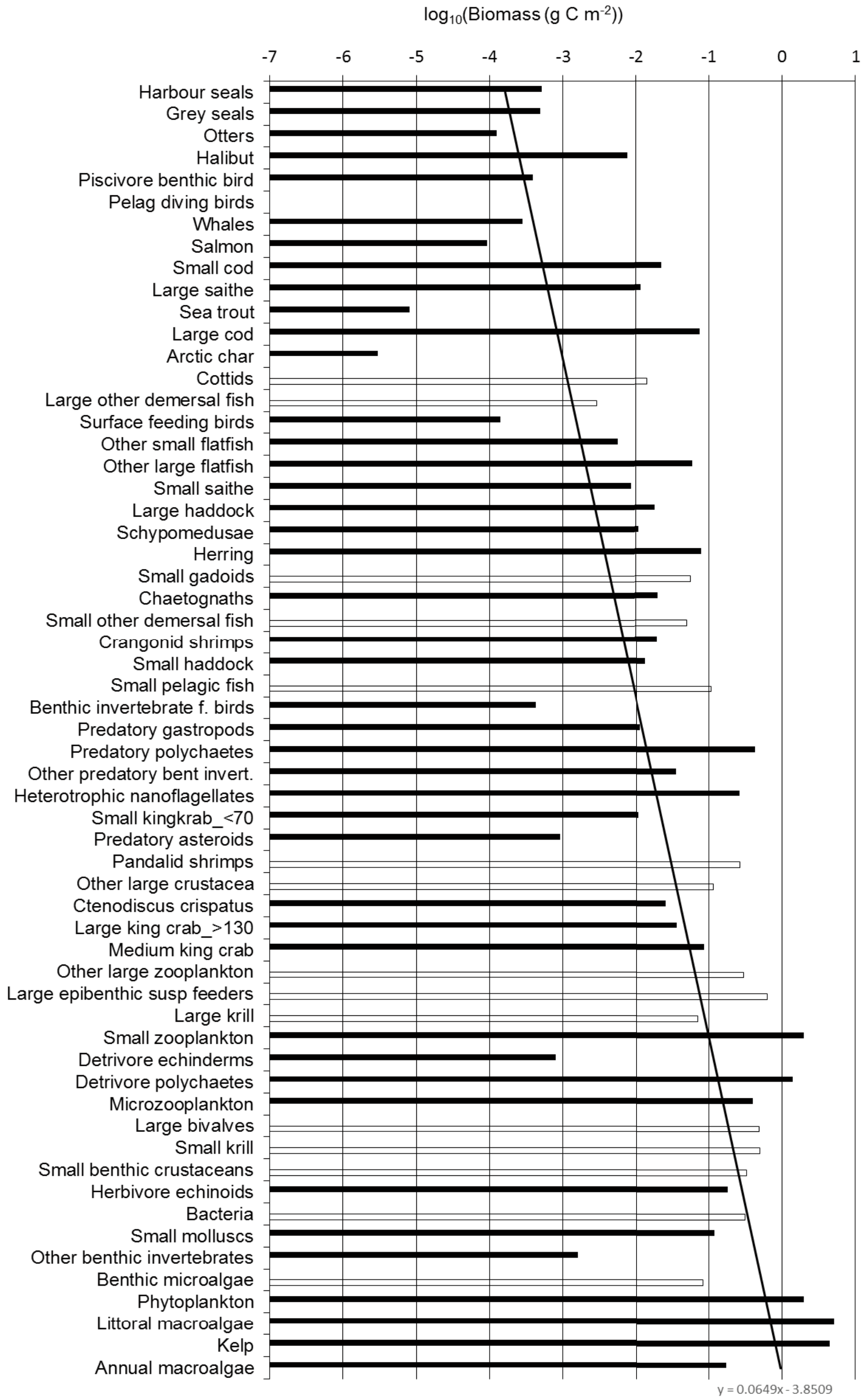

Fig. S4. Plot of $\log_{10}$-transformed biomass values for groups ranked from the highest trophic (top) to the lowest trophic level (bottom). Regression line indicate trend. Filled bars shows groups with biomass values given as input values and open bars shows groups where biomass are estimated by the model.

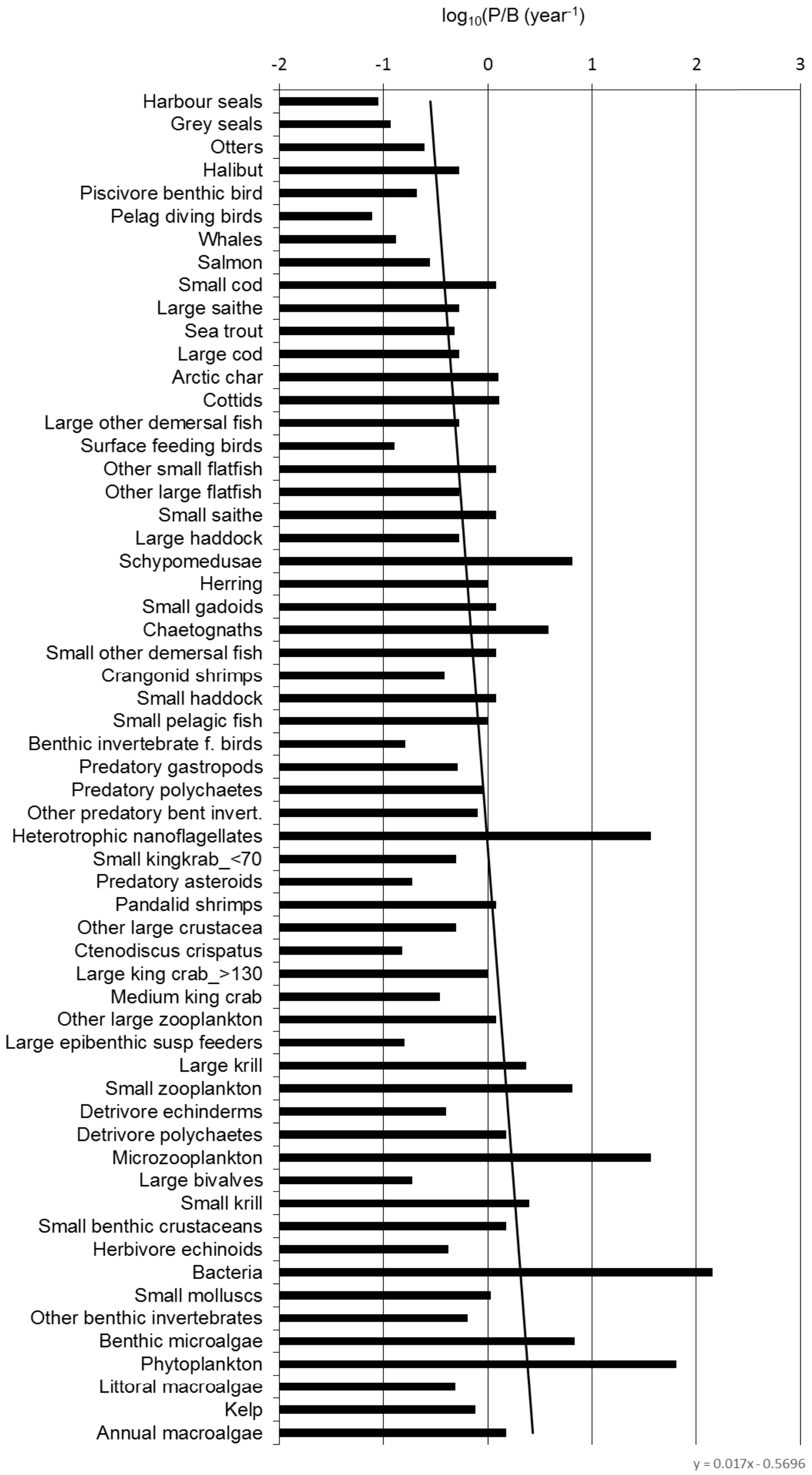

Fig. S5. Plot $\log_{10}$-transformed P/B values for groups ranked from the highest trophic (top) to the lowest trophic level (bottom). Regression line indicate trend.

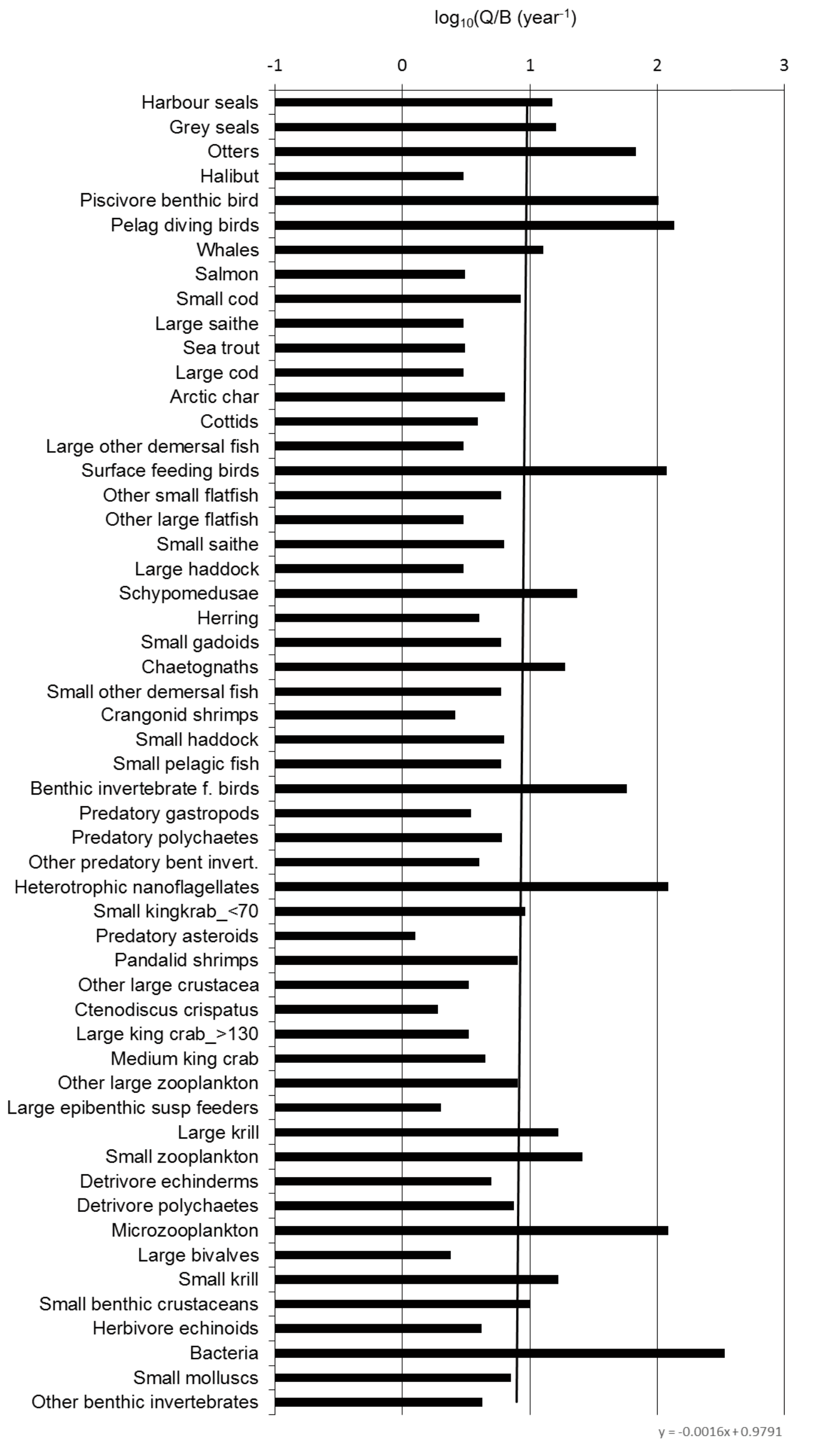

Fig. S6. Plot $\log_{10}$-transformed Q/B values for groups ranked from the highest trophic (top) to the lowest trophic level (bottom). Regression line indicate trend.

8 Model output, pedigree and uncertainty assessment

A pedigree assessment of the input for subarea 3 model was performed (Table S18a, S18b).

Table S18a. Overview of pedigree assessment for input to Ecopath model for subarea 3

Gr. no.	Group name	Biomass	*P/B*	*Q/B*	Diet	Catch
1	Grey seals	5	7	7	5	5
2	Harbour seals	5	7	7	5	5
3	Whales	4	7	7	5	
4	Otters	4	7	7	4	
5	Piscivorous benthic feeding birds	6	7	7	4	2
6	Pelagic diving birds	5	7	7	4	
7	Surface feeding birds	6	7	7	4	
8	Benthic invertebrate feeding birds	6	7	7	4	
9	Large cod	5	8	3	5	4
10	Small cod	5	4	3	5	
11	Large saithe	5	6	3	2	4
12	Small saithe	5	4	3	4	
13	Large haddock	5	6	3	5	4
14	Small haddock	5	4	4	5	
15	Small gadoids	-1	6	3	3	
16	Halibut	5	6	3	5	
17	Other large flatfish	5	6	3	5	
18	Other small flatfish	5	6	3	5	
19	Other large demersal fish	5	5	5	4	
20	Other small demersal fish	-1	6	3	3	
21	Cottids	-1	8	5	5	
22	Small pelagic fish	-1	5	3	4	
23	Herring	5	5	2	4	
24	Salmon	4	4	5	5	5
25	Sea trout	4	7	7	5	2
26	Arctic charr	4	7	4	4	2
27	Small krill	-1	3	3	3	
28	Large krill	-1	7	3	3	
29	Small zooplankton	2	7	4	3	
30	Microzooplankton	2	7	5	3	
31	Heterotroph nanoflagellates	2	7	4	3	
32	Schypomedusae	4	3	3	2	
33	Chaetognaths	2	3	7	3	
34	Other large zooplankton	-1	6	5	3	
35	Pandalid shrimps	-1	8	4	3	

Table S18a, continuation

Gr. no.	Group name	Biomass	*P/B*	*Q/B*	Diet	Catch
36	Large red king crab	5	7	8	4	5
37	Medium red king crab	5	7	8	4	5
38	Small red king crab	5	7	8	4	5
39	Crangonid shrimps	5	8	4	3	
40	Other large crustaceans	-1	6	3	3	
41	Predatory asteroids	5	6	3	3	
42	Predatory gastropods	5	6	3	3	
43	Predatory polychaetes	5	6	3	3	
44	Other predatory benthic invertebrates	5	6	3	3	
45	Detritivorous polychaetes	5	6	3	3	
46	Small benthic crustaceans	-1	6	3	3	
47	Small molluscs	5	6	3	3	
48	Large bivalves	-1	6	3	3	
49	Detritivorous echinoderms	5	6	3	3	
50	*C. crispatus*	6	6	3	3	
51	Large epibenthic suspension feeders	5	6	3	3	
52	Other benthic invertebrates	5	6	3	3	
53	Herbivorous echinoderms	5	6	3	3	
54	Bacteria	-1	3	3	3	
55	Kelp	5	7			
56	Annual macroalgae	5	7			
57	Litt macroalgae	5	7			
58	Benthic microalgae & recruiting macroalgae	-1	5			
59	Phytoplankton	2	7			

Table S18b. Judgement of pedigree index values and uncertainty. Indices judged are shown in Table S18a. Assumed 95% confidence intervals (CI) for input values are shown for each index value

Input variable	Judgement of input	Index	CI(+/-)
Biomass	Estimated by Ecopath	-1	80
	From other model	2	80
	Guesstimates	3	80
	Approximate or indirect method	4	50
	Sampling based, low precision	5	30
	Sampling based, high precision	6	10
P/B and *Q/B*	Estimated by Ecopath	1	80
	Guesstimates	2	70
	From other model	3	60
	Empirical relationships	4	50
	Similar group/species, similar system	5	40
	Similar group/species, same system	6	30
	Similar group/species, similar system	7	20
	Similar group/species, similar system	8	10
Diet	General knowledge of related group/species	1	80
	From other model	2	80
	General knowledge of same group/species	3	60
	Qualtitative dietary composition study	4	50
	Quantitative but limited dietary composition study	5	30
	Quantitative, detailed dietary composition study	6	10
Catch	Guesstimate	1	70
	From other model	2	70
	FAO (Food and Agriculture Organization) statistics	3	80
	National statistics	4	50
	Local study, low precision/incomplete	5	30
	Local study/ high precision/complete	6	10

Results from the Monte Carlo uncertainly analysis are given in figure S7.

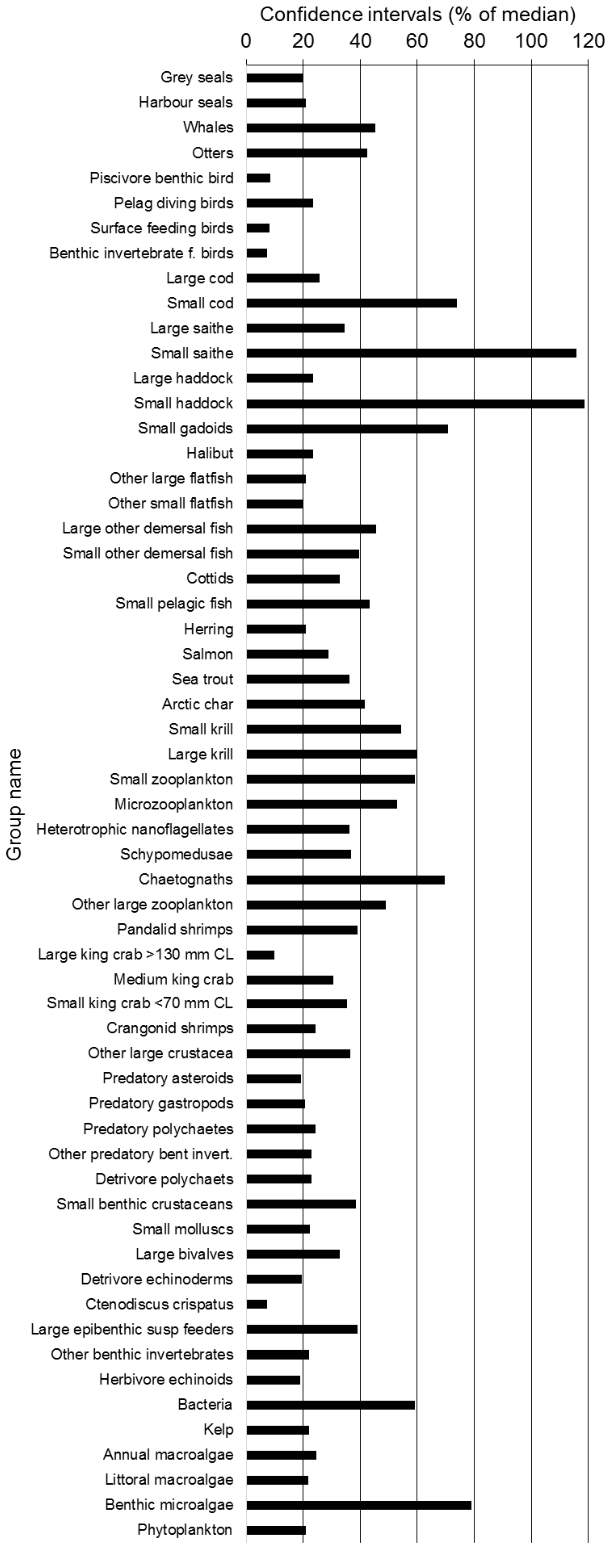

Figure S7. Calculated 95 % confidence intervals (CI) given as % of median for biomass values based on Monte Carlo uncertainty analysis of baseline model for subarea 3. Assessed uncertainty based on pedigree was input to Monte Carlo analysis. Average of lower and upper confidence intervals is given. Due to asymmetry of CI (upper CI may be > lower CI), average CI values may exceeed 100 %

Table S19. Approximate 95 % confidence intervals (2.5 and 97.5 percentiles) for summary statistics and ecosystem properties calculated from 100 Monte Carlo trials for baseline Ecopath models for the subarea 3. CI ((97.5 per. – 2.5 per.)*100/2) is also given in % of the median. P/B: production per biomass, *) RKC is not included

	Median	2.5 p.	97.5 p.	CI (% of median)
Primary Production (g C m^{-2} $year^{-1}$)	145.2	103.4	180.4	26.5
Export (g C m^{-2} $year^{-1}$)	36.0	3.8	89.0	118.4
Sum of all consumption (g C m^{-2} $year^{-1}$)	254.2	193.7	347.0	30.2
Sum of all flows into detritus (g C m^{-2} $year^{-1}$)	162.1	113.9	220.3	32.8
Biomass residence time (days)	51.2	40.8	70.5	29.0
Sum of all production (g C m^{-2} $year^{-1}$)	236.9	182.7	293.1	23.3
Total biomass (excl. detritus) (g C m^{-2})	20.1	18.1	22.1	10.0
P/B (excl. detritus) ($year^{-1}$)	11.8	9.4	14.5	21.5
Connectance index	0.111	0.111	0.111	0
System omnivory index	0.200	0.196	0.205	2.4
Production by macroalgae (g C m^{-2} $year^{-1}$)	6.09	4.91	7.46	20.9
Production by fish (g C m^{-2} $year^{-1}$)	0.47	0.38	0.58	21.5
Production of pred. benthic inv. (g C m^{-2} $year^{-1}$)*	0.44	0.34	0.61	30.5
Production of detritiv. benthic inv.(g C m^{-2} $year^{-1}$)*	2.90	2.41	3.69	22.0
Biomass of benthic invertebrates (g C m^{-2})*	3.56	3.11	4.00	12.5
Total P/B ($year^{-1}$) for benthic invertebrates*	0.96	0.79	1.12	17.2
Consumption by red king crab (g C m^{-2} $year^{-1}$)	0.61	0.44	0.87	35.1
Ascendency (%)	29.6	27.7	33.2	9.2
Overhead (%)	70.4	66.6	72.3	4.0

Omnivory indexes and niche overlap were calculated from the Ecopath model for subarea 3 (Fig. S8 and Fig. S9).

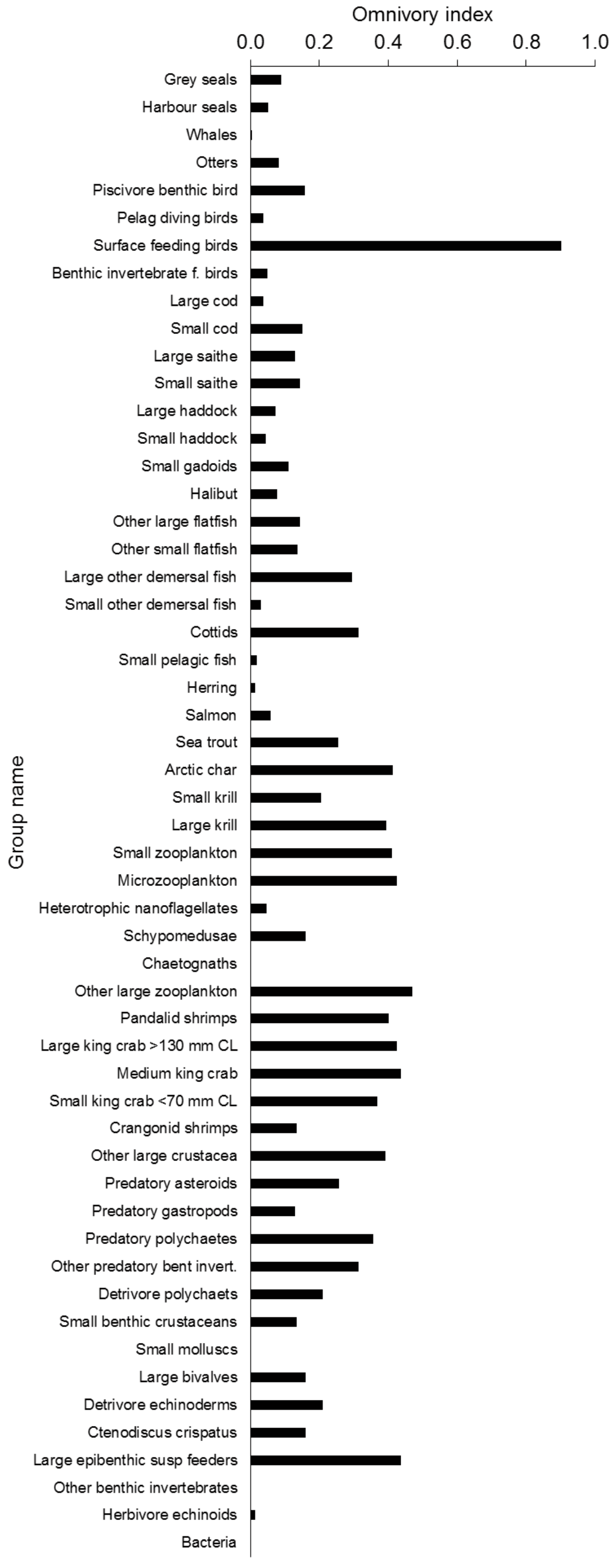

Figure S8. Omnivory index for the various groups in baseline model for subarea 3

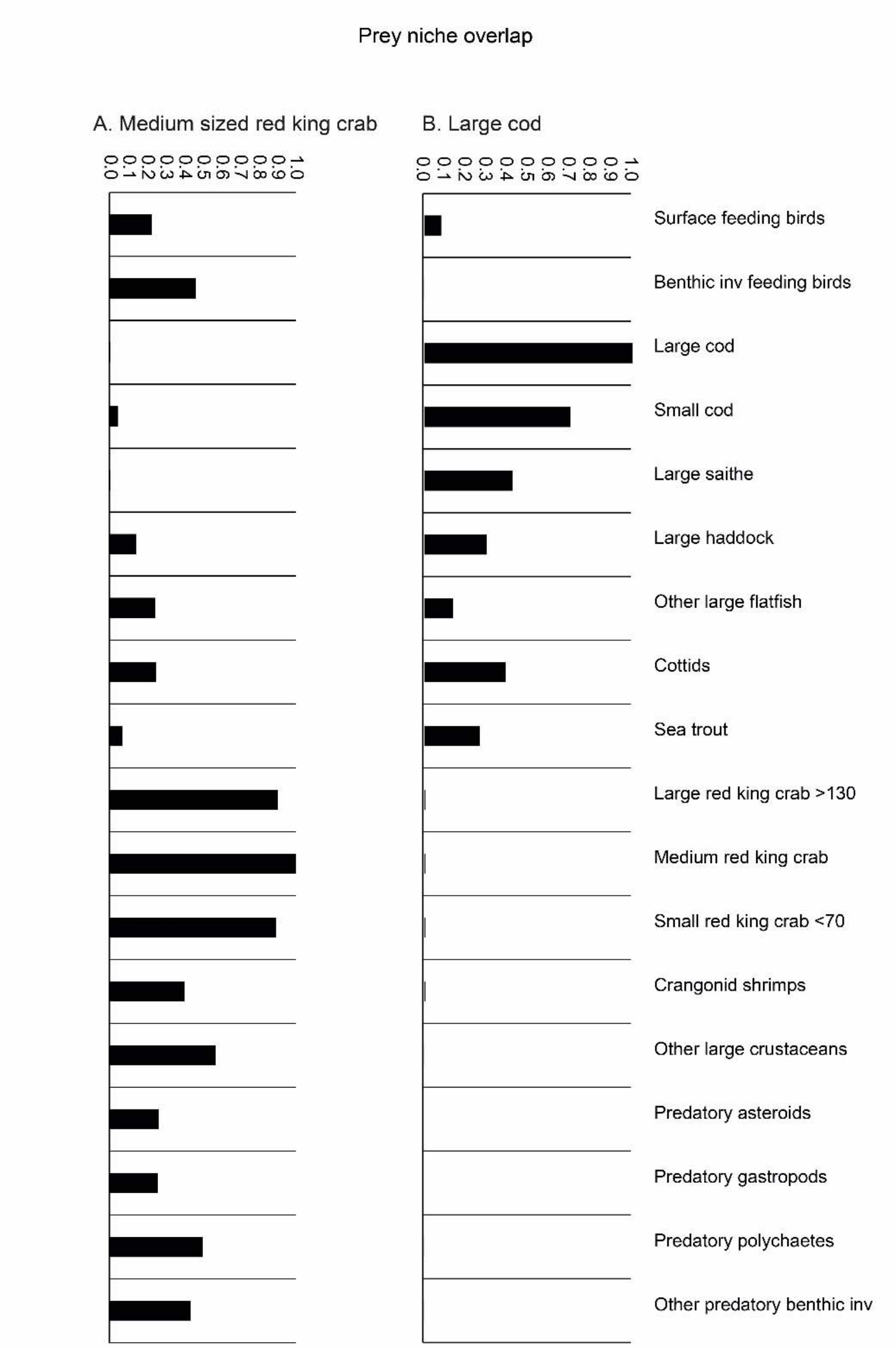

Figure S9. Prey niche overlap in baseline model for subarea 3 between (A) medium sized red king crab (RKC) and other groups, and (B) large cod and other groups. Only prey groups with niche overlap larger than 0.2 with either medium RKC or large cod are shown

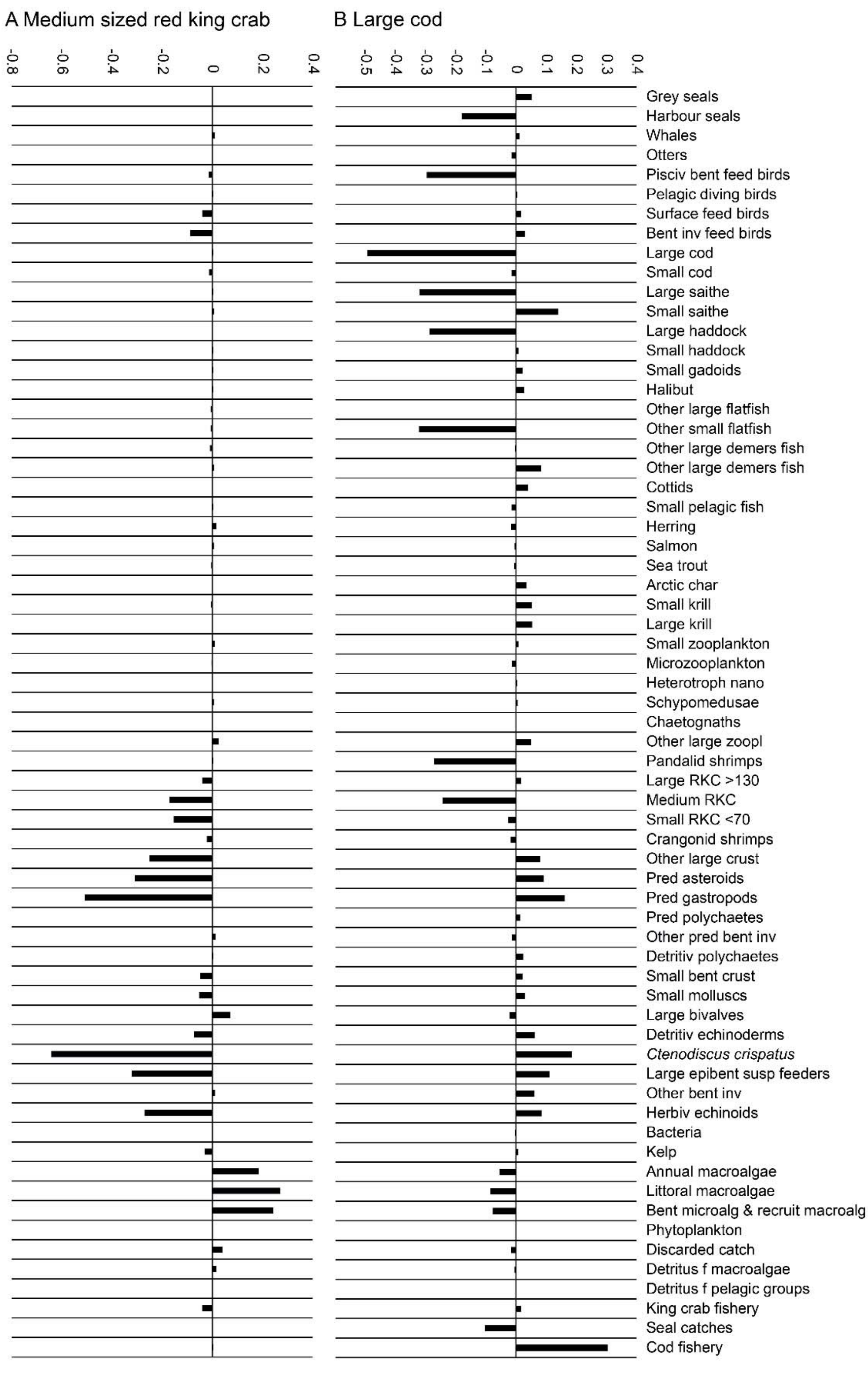

Figure S10. Mixed trophic impact (vertical y-axes) in baseline model in subarea 3 by (A) medium sized red king crab and (B) large cod, on various groups and fisheries (three lower “groups”: King crab, Seals, Cod)

9 Scenario analysis

Ecosim requires the setting of a number of parameters in addition to those estimated by Ecopath. These other settings include: maximum relative *P*/*B* (production:biomass ratio, for primary producers only): 2; maximum relative feeding times: 2; feeding time adjustment rate: 0.5; fraction of other mortality sensitivity to changes in feeding time: 1; predator effect on feeding time: 1; density dependent catchability (qmax/qo) where qmax is the maximum relative catchability and qo is the baseline: 1; the maximum consumption per biomass (QBmax) relative to the baseline consumption per biomass (Q/Bo), QBmax/QBo for handling time: 1000; switching power parameter: 0

Table S20. Overview of input and settings for scenario simulations on the models of the various subareas.

Time period (years)	Red king crab fishing mortality (yr^{-1})	Scenario phase	Ecopath model sampled at year
1–29	Original baseline	1	25
30–68	High	2	65

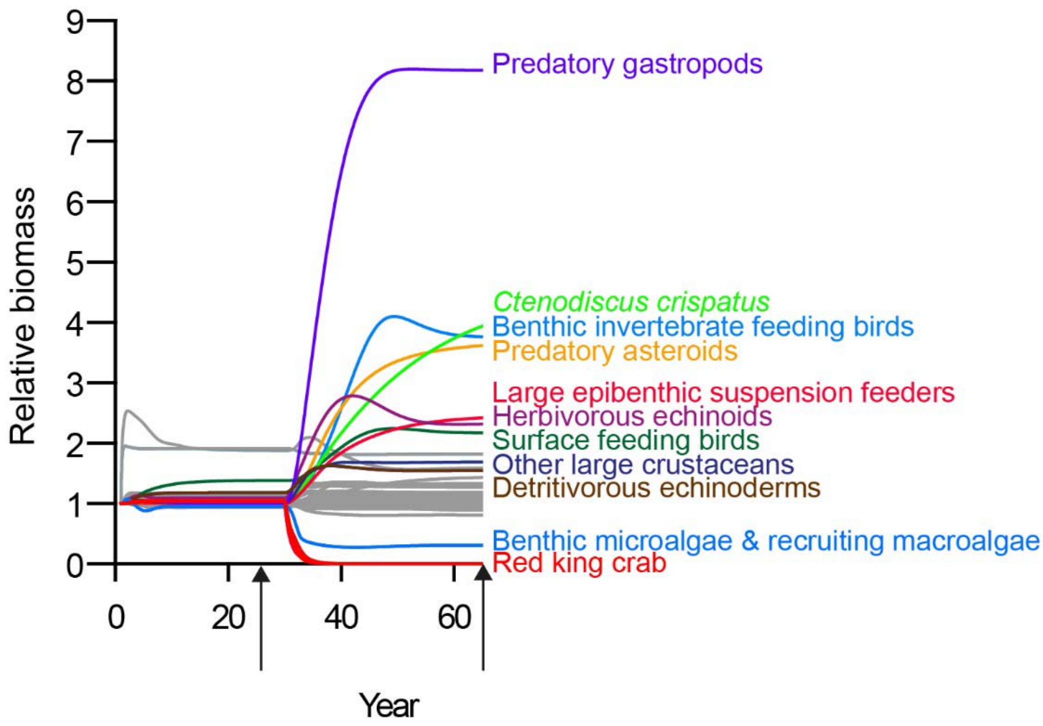

Figure S11. Changes in relative biomass (biomass at time divided by biomass at start, time = 0) of various groups in a crab-removal Ecosim scenario for subarea 3, where red king crab biomass was removed by an intensive fishery during years 30–68. Arrows show when models were “sampled” at years 25 and 65 for comparing Ecopath outputs.

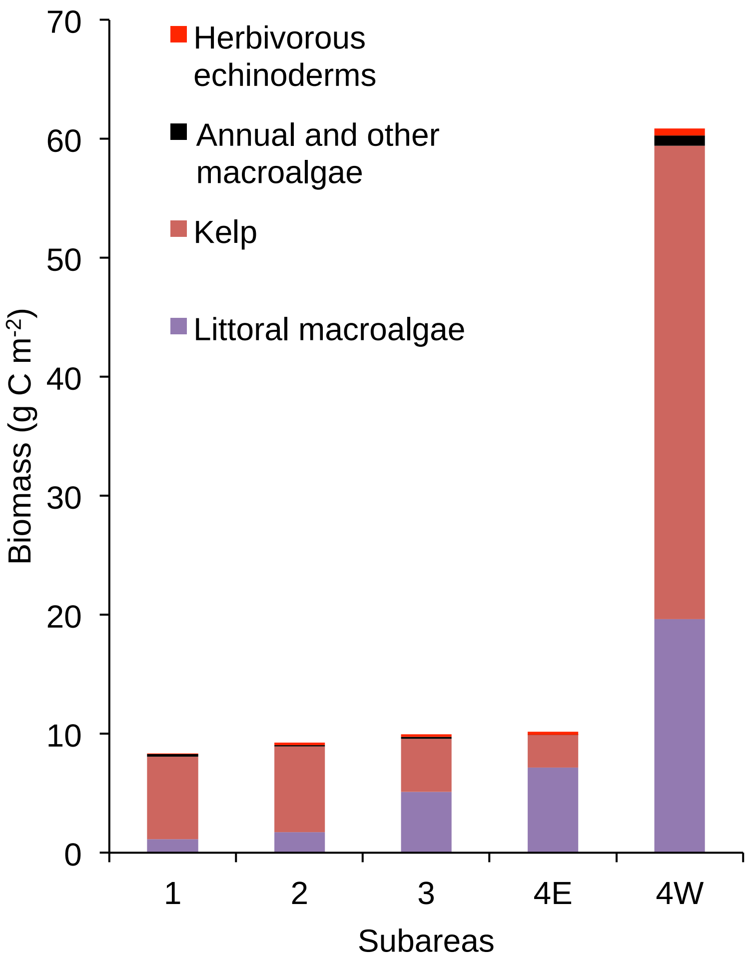

Figure S12. Biomass of the groups of macroalgae and herbivore echinoids in the various subareas based on data in table S15 and S16.

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