The following supplement accompanies the article

Novel approach for testing the food limitation hypothesis in estuarine and coastal fish nurseries

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Supplement S1: Statistical distribution of the uncertain parameters

The variance (V) and the mean (E) of literature data are used to define a beta distribution for ratio parameters (comprised between 0 and 1), and a gamma distribution for the strictly positive parameters. The relationships between the variance (V) and the mean (E) of data to the shape parameters of the beta distribution (α and β), and to the shape (α) and rate (β) parameters of the gamma distribution are:

beta distribution coefficients: $$\alpha = \frac{\mathrm{E}\left(\mathrm{E}-\mathrm{E}^2-V\right)}{\mathrm{V}} \quad \text{(S1.1)}$$

$$\beta = \frac{(1-\mathrm{E})(\mathrm{E}-\mathrm{E}^2-\mathrm{V})}{V} \quad \text{(S1.2)}$$

gamma distribution coefficients: $$\alpha = \frac{\mathrm{E}^2}{\mathrm{V}} \quad \text{(S2.1)}$$

$$\beta = \frac{\mathrm{E}}{\mathrm{V}} \quad \text{(S2.2)}$$

A parameter defined as a variable X whose logarithm is normally distributed (with a known mean: E and a known variance: V) follows a log-normal distribution, which is directly defined by E and V. The mean (E') of X can be expressed in function of the mean (E) and variance (V) of log(X):

mean of lognormal distribution: $$\mathrm{E}' = \mathrm{e}^{\left(\mathrm{E}+\frac{\mathrm{V}}{2}\right)} \quad \text{(S3)}$$

An exception is applied to the parameter K, which is in the denominator of the consumption equation. Indeed, if K follows a beta distribution, the distribution of 1/K is unknown and has an unstable mean. K is thus defined with a gamma distribution. Therefore, 1/K is defined as an inverse gamma distribution, which is defined by the shape (α) and rate (β) parameters of the K distribution. The mean (E') of 1/K can be expressed in function of the mean (E) and variance (V) of K:

mean of inverse gamma distribution: $$\mathrm{E}' = \frac{\mathrm{E}}{(\mathrm{E}^2-\mathrm{V})} \quad \text{with the constraint: } \mathrm{V} < \mathrm{E}^2 \quad \text{(S4)}$$

Supplement S2: data collection for the Bay of Vilaine

Survey data

Macrobenthic invertebrate biomass and fish abundance

Given the mismatch in the locations of the sampling stations between the two surveys (fish and invertebrates) and the uneven spatial distribution of the sampling effort, we stratified the bay of Vilaine in three zones (Figure 1, which is a simplification of the 5 habitats defined by Kopp et al. 2013). Splitting is necessary because the sampling efforts of fish and benthic invertebrates decrease from zone 1 to zone 2, and zone 3 (respectively 3.4 stations.km^{-2}, 2.0 stations.km^{-2}, and 1.5 stations.km^{-2} for fish sampling; and respectively 0.42 stations.km^{-2}, 0.17 stations.km^{-2}, and 0.17 stations.km^{-2} for benthic invertebrate sampling). Therefore, for each cohort/species, the average abundance/biomass is computed in each zone and raised to the surface area to provide a total abundance/biomass. Bootstrap method is used to estimate the uncertainty on total abundance/biomass of each cohort/species.

Fish weight-length relationships

For each haul of the survey, fish are weighed by species all together, and they are all individually measured (a subsample is measured if the number exceeds 30 individuals). An observation is described as follows:

$$W_h = \sum_{n \in 1:N} a.L_n{}^b \qquad \text{(S5)}$$

W_h is the weight in g. of all individuals of a single species in the haul h; L_n in mm is the length of the n^{th} fish individual; a and b, the parameters of the relationship. These parameters are then estimated using all observations with an optimization algorithm in the software R (R Core Team 2012).

Table S1: weight-length parameters (weight in g and length in mm)

Species	**a**	**b**
Dicologlossa cuneata	3.028e-5	2.723
Pleuronectes platessa	1.369e-5	2.953
Solea solea	9.237e-6	2.994
Mullus surmuletus	7.636e-6	3.121
Merlangius merlangus	9.749e-6	2.972
Merluccius merluccius	5.454e-6	3.055
Trisopterus luscus	9.705e-6	3.054

Literature data

Macrobenthic invertebrates

Table S2: Summary of macrobenthic invertebrate parameters.

Parameter	**Value or range of values**	**Uncertainty details**	**Source**
Conversion ratio (CR)	0.672	sd=0.0111	survey
Production-to-biomass ratio (P:B)	0.222-9.723 year^{-1}	sd range: 0.0356-1.988	(Brey 2012)
Regeneration (R)	0-0.5	Conservative approach	various sources
Energy conversion (E)	0.851-6.694 kJ.g^{-1}	Negligible uncertainty	(Brey et al. 2010)
Accessibility (A)	Easily accessible : 1 Hardly accessible : 0.117	sd=0.0485	survey

Additional details on these parameters are provided in Tableau et al 2015 for the 94 taxa.

Fish juveniles

Table S3: Fish data compiled from the literature. * As *Merluccius merluccius* shifts to an exclusive fish diet after 150 mm, this proportion becomes 0 for larger fish.

fish	*Dicologlossa cuneata*	*Pleuronectes platessa*	*Solea solea*	*Solea solea*	*Mullus surmuletus*	*Merlangius merlangus*	*Merluccius merluccius*	*Trisopterus luscus*
age group	G1	G0	G0	G1	G0	G0	G0	G0
shape	flatfish	flatfish	flatfish	flatfish	roundfish	roundfish	roundfish	roundfish
diet	exclusive benthivore	exclusive benthivore	exclusive benthivore	exclusive benthivore	exclusive benthivore	partial benthivore	partial benthivore	partial benthivore
Ld_0 (mm)	110	70	70	110	70	70	70	70
d0	April 11	August 7	July 31	May 21	August 11	July 12	April 9	July 9
G (mm.day^{-1})	0.38	0.51	0.60	0.60	0.77	0.79	0.67	0.83
Z (day^{-1})	0.0179	0.0171	0.0179	0.0179	0.0103	0.00760	0.00765	0.00770
q	0.257	0.380	0.257	0.257	0.500	0.500	0.500	0.500
DC	1	1	1	1	1	0.5	0.27*	0.75
E (kJ.g^{-1})	5.78	5.66	5.78	5.78	6.88	6.24	6.24	6.24
E sd	0.618	0.802	0.618	0.618	1.69	0.805	0.805	0805
K	0.197	0.316	0.197	0.197	0.312	0.385	0.385	0.385
K sd	0.0675	0.0792	0.0675	0.0675	0.0969	0.0720	0.0720	0.0720

Growth period and growth rate

The main growth period of fish juveniles in temperate ecosystems is ranging from spring to fall and is very consistent over many fish species (Forest 1975, Gordon 1977, Desaunay et al. 1981, Van Der Veer et al. 1990, Hamerlynck & Hostens 1993, Shi et al. 1997, Amara 2004, Otxotorena et al. 2010). This is explained by lower food intake during winter (Zanuy & Carrillo 1985). By conservative approach, we focus only on the food intake during the main growth period in summer. As a growth decrease is generally observed during fall, we set the end of the growth period in our model on October 1 (early fall). For G0 fish, the beginning of the growth period is deduced from the growth rate and the fish size from which they eat on macrobenthic invertebrates (set at 70 mm, see Tableau et al. 2016). For G1 *Solea solea*, the length at the beginning of the growth period is associated to the length of G0 at the end of the growth period (11 cm), this is supported by the observations in Desaunay et al. (1981). As no G0 *Dicologlossa cuneata* are observed, we use the same length for G1 *Dicologlossa cuneata*. This assumption is supported by the observations in Forest (Forest 1975).

The growth rates can vary over time and among the nursery habitats (Ciotti et al. 2014). The general strategy was to use data corresponding to the closest habitats of the bay of Vilaine when no local data were available. When length time series were available, the match with the fish length observed in the survey was checked (Forest 1975, Gordon 1977, Desaunay et al. 1981, Van Der Veer et al. 1990, Hamerlynck & Hostens 1993, Shi et al. 1997, Amara 2004, Otxotorena et al. 2010). The conservative approach for the growth period limits the potential overestimation of the exploitation efficiency.

Table S4: growth data collection (G0 for young of the year and G1 for one year old)

Species	Age group	Growth rate ($mm.day^{-1}$)	Source	Comment
Dicologlossa cuneata	G1	0.38	Forest 1975	graphic analysis on local data
Pleuronectes platessa	G0	0.51	Amara 2004	local data
Solea solea	G0	0.60	Marchand 1991	local data
Solea solea	G1	0.60	Desaunay et al. 1981, Marchand 1991	local data & graphic analysis on local data
Mullus surmuletus	G0	0.77	N'Da and Deniel 2005	data analysis on local data
Merlangius merlangus	G0	0.79	Hamerlynck and Hostens 1993	graphic analysis on external data - good match between lengths at the same period
Merluccius merluccius	G0	0.67	Kacher and Amara 2005, Otxotorena et al. 2010	average on two local data
Trisopterus luscus	G0	0.83	Hamerlynck and Hostens 1993	graphic analysis on external data - good match between lengths at the same period

Mortality rate

The mortality rates vary among nursery habitats and over time (Iles & Beverton 1991). In the exploitation efficiency analysis, emigration and natural mortality can be confounded as it results in a decrease of food consumption anyway. Mortality rates are available only for two flatfish species and are used for the others. A single data is available for three roundfish species, the average of the two Gadiformes species (*Merlangius merlangus* and *Trisopterus luscus*) is used for *Merluccius merluccius*:

Pleuronectes platessa (51 data): mean = 0.0171 $nb.day^{-1}$ & sd = 0.0088 (Iles & Beverton 1991, Modin & Pihl 1994, Nash & Geffen 2012)

Limanda limanda (9 data): mean = 0.0187 $nb.day^{-1}$ & sd = 0.0103 (Iles & Beverton 1991)

Mullus surmuletus (1 data): mean = 0.0103 (N'Da & Deniel 2005)

Merlangius merlangus (1 data): mean = 0.0076 (Hamerlynck & Hostens 1993)

Trisopterus luscus (1 data): mean = 0.0077 (Hamerlynck & Hostens 1993)

As the survey is done around the middle of the growth period (August 22), errors in mortality rates have small consequences: an overestimated mortality would result in a higher consumption estimate on the time period before the survey, but a lower one on the period after the survey. As we want to estimate the exploitation on the full time period, the lack of accuracy of this parameter is acceptable.

Catch efficiency

Catch efficiency data have been estimated in several studies on various flatfish species including *Pleuronectes platessa* and *Solea solea*. The catch efficiencies are most likely overestimated in these studies given the experimental protocols (e.g Kuipers 1975). Consequently, fish abundances are probably underestimated, which fits with the conservative approach. First, available data have been compiled per study and then averaged over the different studies. *Solea solea* value has been attributed to *Dicologlossa cuneata* given their close phylogeny (*Soleidae* family). Data on roundfish species are scarcer but conservative data are suggested for *Merlangus merlangius* and *Trisopterus luscus*. This data has been associated to the roundfish *Mullus surmulutus* and *Merluccius merluccius*.

Table S5: catch efficiency data

Species	q	Trawl	Source
Pleuronectes platessa	50.6 %	2 m beam trawl	(Rogers & Lockwood 1989)
Pleuronectes platessa	28.4 %	2 m beam trawl	(Kuipers 1975)
Pleuronectes platessa	39.5 %	2 m beam trawl	(Kuipers 1975)
Pleuronectes platessa	33.5 %	2 m beam trawl	(Edwards & Steele 1968)
Solea solea	25.7 %	2 m beam trawl	(Rogers & Lockwood 1989)
Merlangius merlangus	50.0 %	3 m beam trawl	(Hamerlynck & Hostens 1993)
Trisopterus luscus	50.0 %	3 m beam trawl	(Hamerlynck & Hostens 1993)

Diet

The first age groups of the three flatfish species are exclusive benthivorous species (Amara et al. 2001, Le Loc'h 2004). *Mullus surmulletus* is also an exclusive benthivore (N'da 1992). Based on the gravimetric proportion of benthic invertebrate prey observed in gut contents of G0 *Merlangius merlangus* and *Trisopterus luscus* (Hamerlynck & Hostens 1993), the estimated proportions are 50 % and 75 % respectively. Based on Mahe et al. (2007), the proportions in the *Merluccius merluccius* diet of benthic invertebrates are averaged over three regions (27 %). As G0 *Merluccius merluccius* diet shifts from a mix of fish and benthic invertebrates to only fish around 15mm, the proportion is set to 0 after 150 mm (Le Loc'h 2004, Mahe et al. 2007).

Energy density

An investigation has been done on all articles of the journals "Aquaculture", "Aquaculture nutrition" and "Aquaculture research". A complementary research in all journals has been done with the keywords "Body composition" "energy density". The body composition is often described as a proportion of proteins, lipids, glycogen, and water. Energy conversion coefficients have been compiled from different studies (Brett & Groves 1979, Brafield 1985, Cho & Kaushik 1990, Jobling 1993).

Proteins: 23.7kJ.g^{-1}

Lipids: 36.3kJ.g^{-1}

Glycogen: 17.2kJ.g^{-1}

Water: 0kJ.g^{-1}

As adult body composition varies with the reproduction season, only juvenile data are used. Pelagic fish data are rejected as this kind of fish has a higher fat concentration. Data corresponding to fish fed with high fat food are rejected. All data referring only to the flesh or the liver were also rejected. Among the 186 data collected, 62 referring to the fish taxa *Gadidae*, *Perciformes*, *Pleuronectidae*, and *Soleidae* were used. The average and the standard deviation of the corresponding taxa are attributed to each species. 25 references are used (Pandian 1970, Holdway & Beamish 1984, Smith et al. 1986, Hidalgo et al. 1987, Costopoulos & Fonds 1989, Marais 1990, Imsland et al. 2000, Lee et al. 2003, Person-Le Ruyet et al. 2004, Dias et al. 2004, Rosenlund et al. 2004, Tibbetts et al. 2005, Rema et al. 2008, Borges et al. 2009, Silva et al. 2010, Ding et al. 2010, Gatta et al. 2011, Li et al. 2012, Marinho et al. 2014, Guerreiro et al. 2015, Bonvini et al. 2015, López et al. 2016, Zhang et al. 2016, Li et al. 2017, Salas-Leiton et al. 2017).

Gross conversion efficiency (growth-to-food intake ratio)

An investigation has been done on all articles of the journals "Aquaculture", "Aquaculture nutrition" and "Aquaculture research". A complementary research has been done in all journals with the keywords "growth efficiency energy", "gross growth efficiency energy", "gross conversion efficiency energy", "food conversion efficiency energy", "feed conversion efficiency energy". Data collected in winter are rejected as lower temperature gives lower conversion efficiency (e.g.Zanuy & Carrillo 1985). When conversion efficiency data are estimated on a temperature gradient, we take only values around the optimal temperature. When data refer to weight conversion efficiency, we convert the production and the consumption in energy when possible. Gross conversion efficiencies are higher for young fish as no energy is allocated to reproduction. Thus, we use only gross conversion efficiencies referring to fish juveniles (Mateo 2007). We used 189 data referring to the fish taxa *Gadidae*, *Perciformes*, *Pleuronectidae*, and *Soleidae*. As these data mostly come from aquaculture studies, they are expected to be a bit higher than the gross conversion efficiency occurring in natural environment. The exploitation efficiencies are consequently likely underestimated. The average and the standard deviation of the corresponding taxa are attributed to each species. 31 references are used (Pandian 1970, Edwards et al. 1972, Marais & Kissil 1979, Hidalgo et al. 1987, Fonds et al. 1992, Hamerlynck & Hostens 1993, Lankford & Targett 1994, Buckel et al. 1995, Björnsson & Tryggvadóttir 1996, Deacon & Hecht 1999, Imsland et al. 2000, Kim & Lall 2001, Kim et al. 2001, Peck et al. 2003, Person-Le Ruyet et al. 2004, Dias et al. 2004, Rosenlund et al. 2004, Tibbetts et al. 2005, Mateo 2007, Rema et al. 2008, Borges et al. 2009, Silva et al. 2010, Ding et al. 2010, Gatta et al. 2011, Guerreiro et al. 2012, Li et al. 2012, Bonvini et al. 2015, López et al. 2016, Zhang et al. 2016, Li et al. 2017, Salas-Leiton et al. 2017).

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