Supporting Information

Material and Methods

From capture to maintenance in experimental tanks

Fishing procedures were optimized following Peleteiro et al. (2004) and preliminary tests. Briefly, sardines were concentrated by tightening the net, coaxed gently into buckets so that they were always immersed in water then transferred immediately into 1 m^3 tanks of oxygenated seawater on board. After boat and lorry transport to the IFREMER experimental station at Palavas-les-Flots (Hérault, France), fish were held in outdoor tanks (4.5m^3) supplied with a flow of aerated local seawater at prevailing temperature and photoperiod. The whole operation, from capture to outdoor tanks, took less than 4 hours. The first 2-3 days following capture constituted the most critical period of acclimation, but this varied quite a lot from one fishing event to another, probably due to the sea temperature when the fishing was carried out (the higher the sea temperature, the higher the mortality in the few days after fishing). During the first 5 days, daily prophylactic baths of oxytetracycline (100 ppm) were administered to prevent bacterial infections from fishing injury and scale loss. Over the first week, sardines were fed both *Artemia nauplii* and aquaculture pellets (mix of pellet sizes: 0.1mm, 0.3mm and 0.8mm), with increasing proportions of pellets and decreasing proportions of *Artemia* throughout the week, concluding with meals exclusively of pellets. Pellets were distributed by automatic feeders throughout the day whereas *Artemia* meals were provided once, in the morning. To maximize survival, food rates were high (between 2% and 6% of biomass), such that body condition increased from a mean (± SD) of 1.0 (± 0.1) at fishing to 1.2 (± 0.1) at the start of experiments. Natural swimming and schooling behavior occurred within a few days of capture. After 2 to 3 weeks acclimation (depending on fishing dates) and upon confirmation of the absence of NODA virus, sardines were moved into indoor tanks for experiments.

Feeding conditions

As in most experimental studies, we tried to be as close as possible to the natural environment (i.e. tanks were supplied with water pumped from the sea, followed natural photo- and thermo-period) to have natural behavior of sardines. The number and density of fish per tank allowed for the formation of schools (Fig. S2 and Movie S1). To control accurately the quality, quantity and size of the food along the 7-month of the experiment, the use of living prey would not have been appropriate and we therefore chose to feed sardines with

standardized aquaculture pellets having the same quality in terms of lipid and protein contents. Both pellet sizes shared similar lipid class contents except for the phospholipid class (see Table S1). Moreover, the two pellet sizes corresponded to main prey sizes found in the wild during those two periods (Le Bourg et al., 2015). Although we are aware of the limitation of inert food versus live prey, normal feeding behavior on aquaculture pellets was ensured before the start of the study (Movie S1). Finally, based on the mean age at the beginning of the experimentation (i.e. 1.2 years) and on the von Bertalanffy curves adjusted by Van Beveren et al. (2014), monthly growth rates in captivity were similar to the ones in the wild (around 1.5 mm month^{-1} and between 0.5 and 2.5 mm month^{-1}, in Van Beveren et al. (2014) and this study, respectively).

Estimation of food loss

To quantify loss of non-ingested food, we performed an additional 2-week experiment in a single tank, with a similar density of sardines to the previous experiment, where we estimated the quantity of food that (i) deposited on the bottom of the tank and (ii) left the tank through a bottom grid. To do so, 5 glass Petri dishes were placed on the bottom of the tank before each meal (total tank area = 76.6 x 10^{-2} m^2, bottom grid area = 15.6 x 10^{-2} m^2, dish area = 1.45 x 10^{-2} m^2) and a 70-µm-mesh sieve used to filter outflowing water (Fig. S3). The experiment comprised 16 meals (4 meals per day) distributed over 10 days. Fish were fed 1.2mm pellet in large quantity on days 1 and 3, fasted on days 2 and 4. Fish were acclimated to 0.1mm pellet on days 5 and 6, then days 7 and 8 repeated days 1 and 2 but using the smaller pellet in large quantity, with days 9 and 10 repeating days 7 and 8. Petri dishes and sieve were removed for analysis 90 minutes after each meal.

Samples from Petri dishes and the sieve were then filtered through a 0.7-µm dry filter (dried beforehand at 60°C in the autoclave for 24 hours and weighed to the nearest 0.0001g), then filters were rinsed with distilled water to remove salt. After manually removing faeces and scales, filters were dried at 60°C in the autoclave for 24 hours and then weighed, so that mass of matter could be estimated as the difference in filter dry weights. The total mass of collected matter was the sum of matter collected by the sieve and matter collected by the 5 dishes weighted by the ratio of tank surface to dish surface (without the bottom grid area):

$$\text{collected } matter = \sum \text{collected matter}_{\text{dish}} \times \frac{S_{\text{tank}} - S_{\text{bottom grid}}}{\sum S_{\text{dish}}} + \text{collected matter}_{\text{sieve}} \quad [1]$$

Finally, the non-ingested food was estimated as the quantity of collected matter during a meal corrected by the mean quantity of collected matter while fish were fasting and expressed as a fraction of the meal size:

$$\text{non-}ingested\ \text{food} = \frac{\text{collected matter}_{\text{meal}} - \text{collected matter}_{\text{fasting}}}{\text{meal size}} \times 100 \quad [2]$$

Results

Body condition and total length over time: mixed-effect models

The impact of the different treatments on body condition and total length were tested using linear mixed-effect models with both random slopes and intercepts for both individuals and tanks (to study tank effect among treatments). The model selection process was following recommendations provided by Burnham and Anderson (2002) and Zuur et al. (2009). The selected model is presented here using REML estimation. Selected models and violin plots of body condition and total length distributions are presented in Fig. S4. For the body condition index, the validation graphs are presented in Fig. S5. Homogeneity, normality and independence were checked through plots of Fig. S5 and only 3 individuals are considered as outliers (i.e. <1% of all individuals) (Fig. S5B). The results of the selected model are presented in Table S2. Simultaneously, the same process was used for the total length parameter. The validation graphs are presented in Fig. S6. Homogeneity, normality and independence were checked through plots of Fig. S6. The results of this selected model are presented in Table S3.

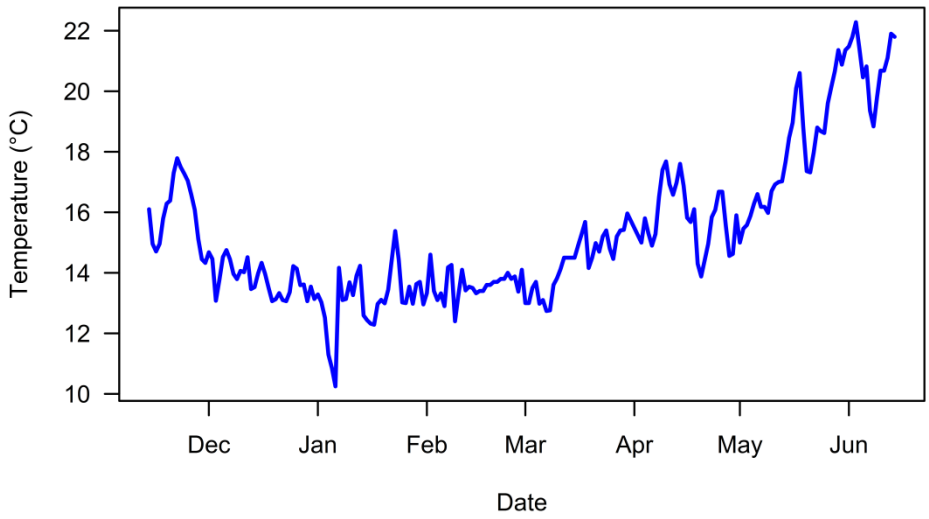

Fig. S1: Evolution of the water temperature in tanks throughout the 7-month experiment

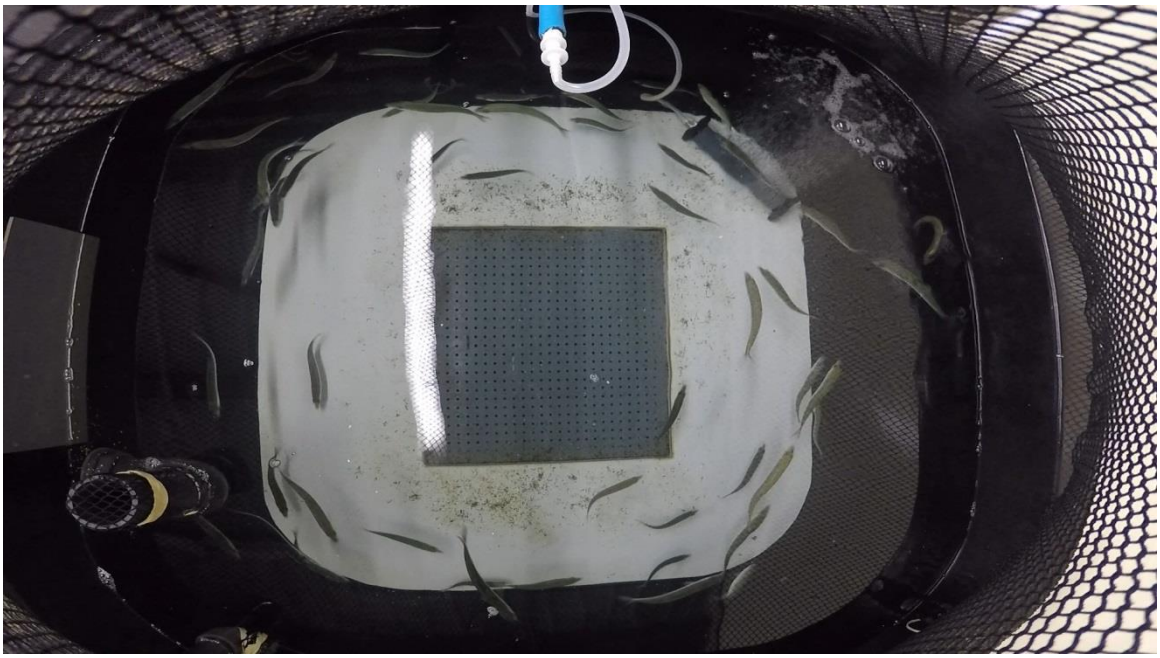

Fig. S2: Picture of the swimming and schooling behavior of sardines in the 300 L experimental tank

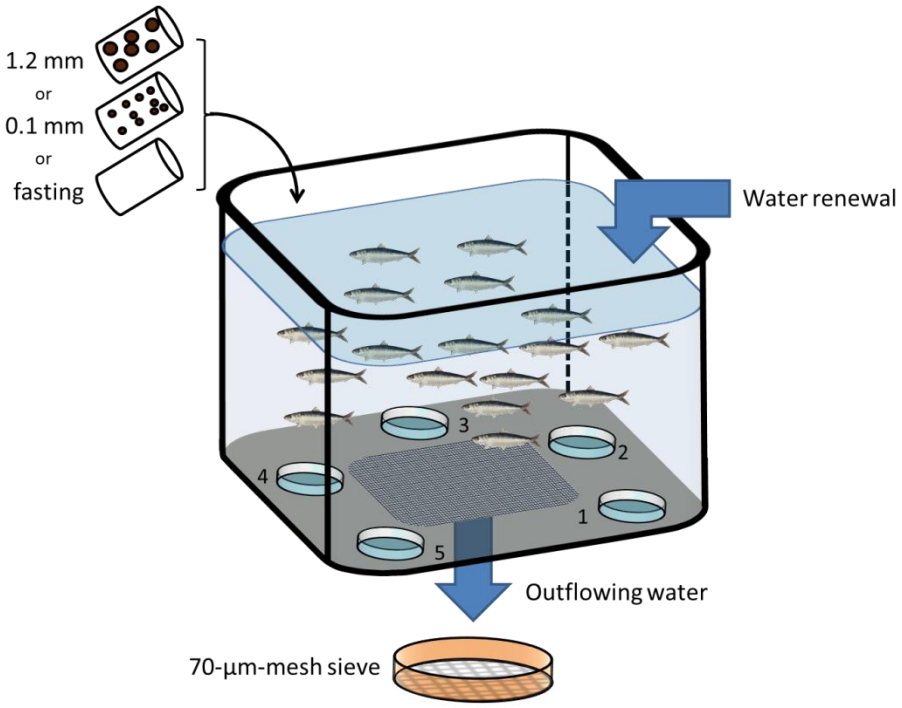

Fig. S3: Experimental design to estimate the non-ingested food

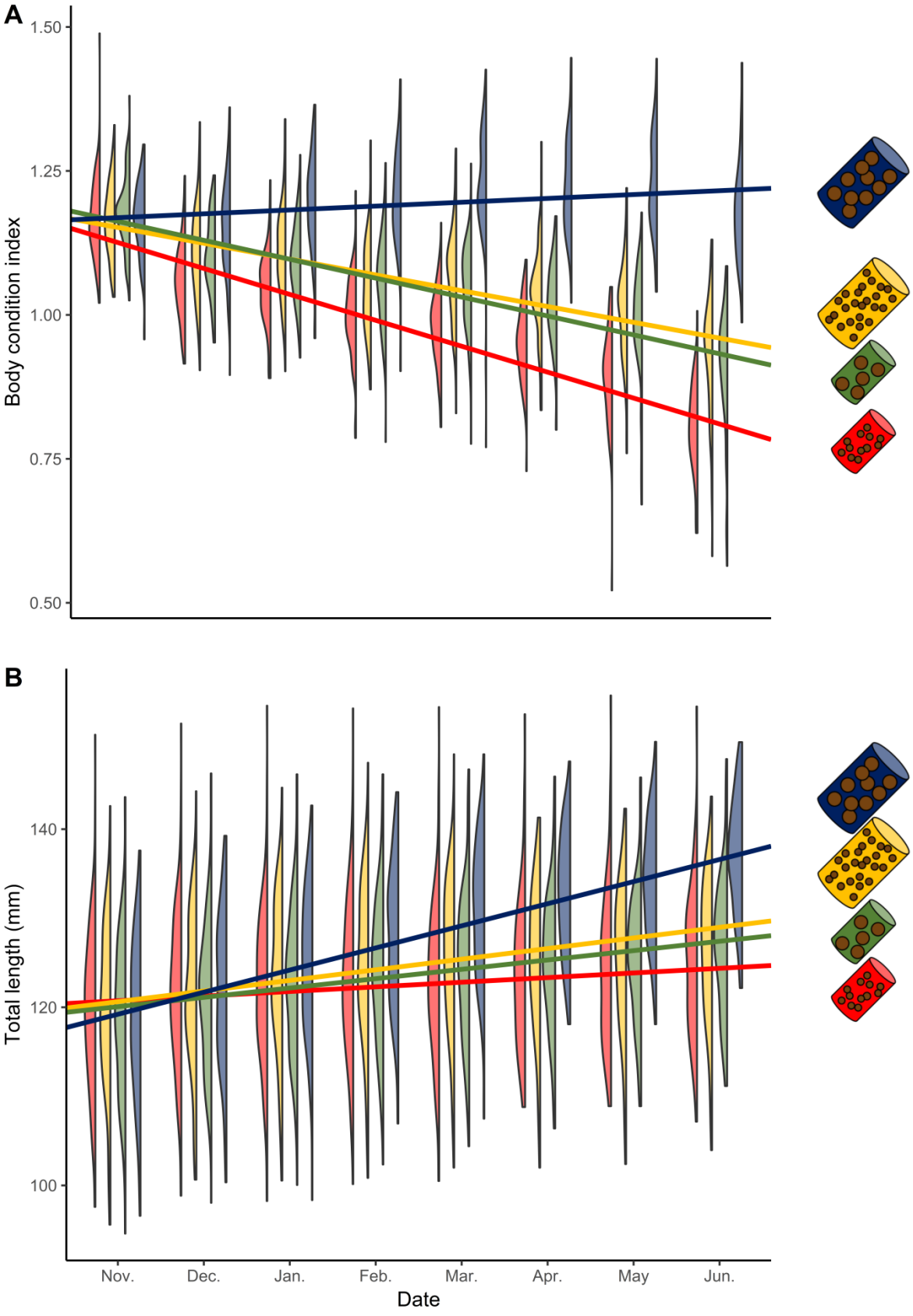

Fig. S4: Violin plots of body condition index (A) and total length (B) distributions over time. Selected linear mixed-effect models were added (lines).

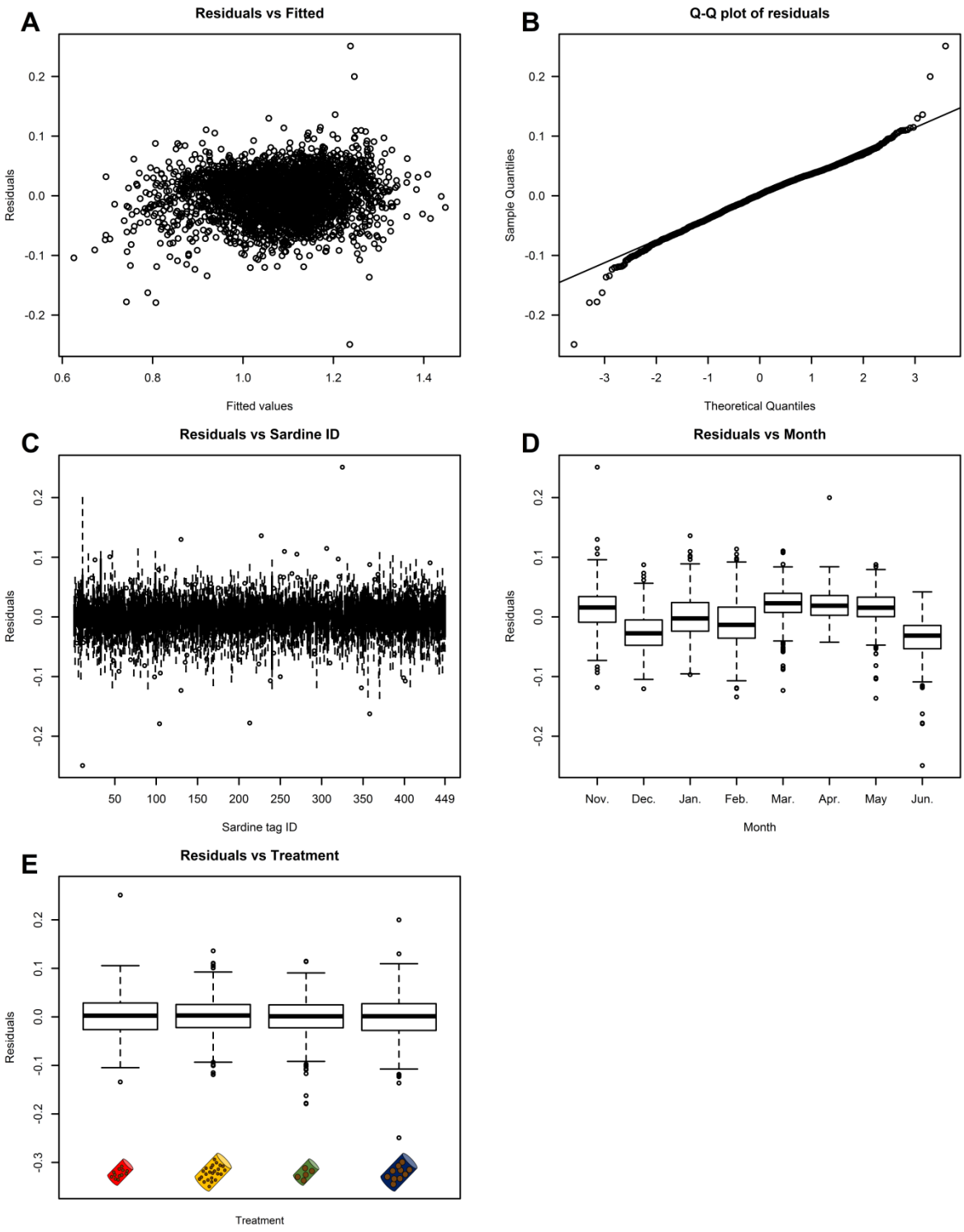

Fig. S5: Validation graphs of the selected body condition model. A: Fitted values versus residuals. B: Q-Q plot of the residuals. C: Residuals versus sardine ID. D: Residuals versus time (month). E: Residuals versus treatments

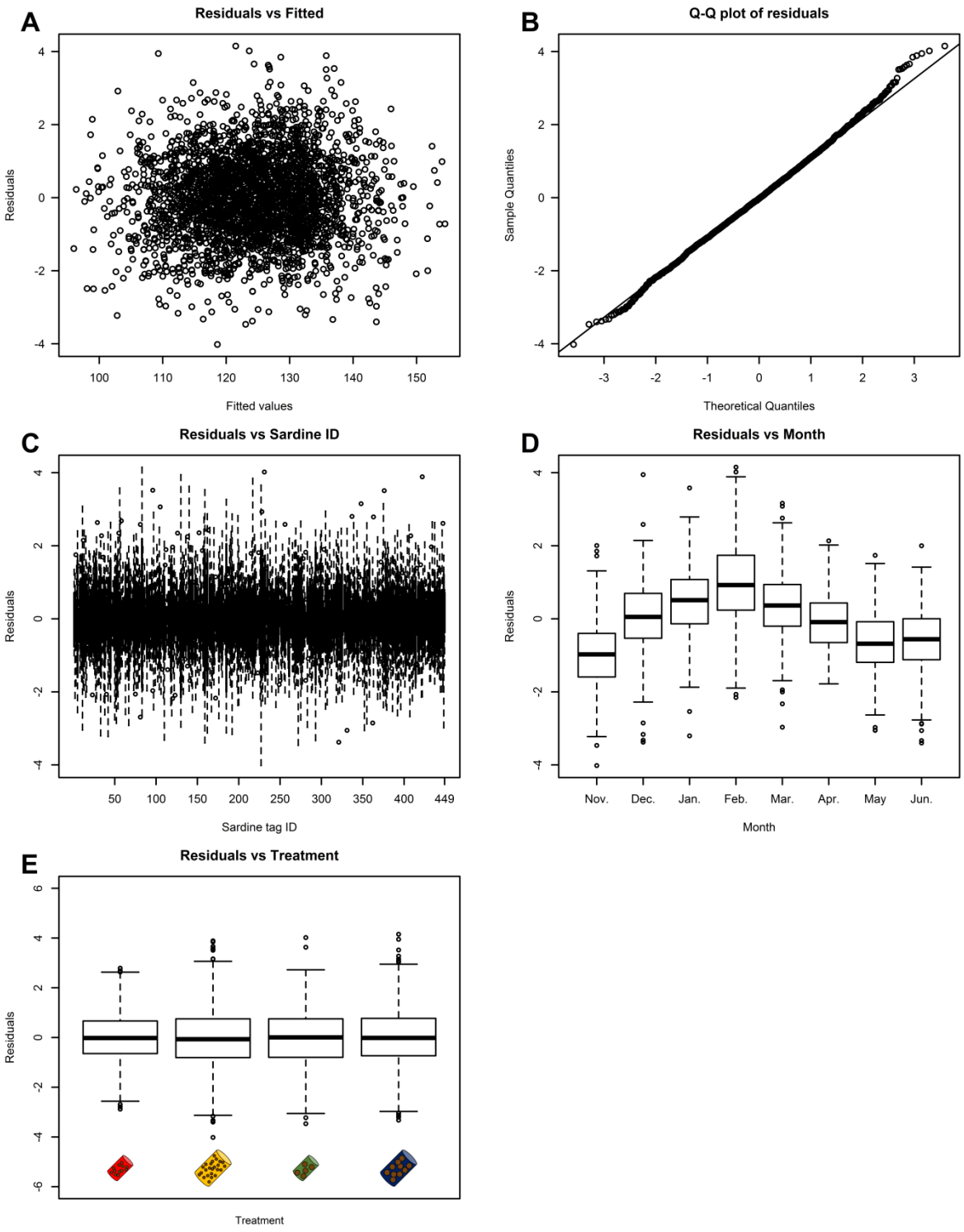

Fig. S6: Validation graphs of the selected total length model. A: Fitted values versus residuals. B: Q-Q plot of the residuals. C: Residuals versus sardine ID. D: Residuals versus time (month). E: Residuals versus treatments

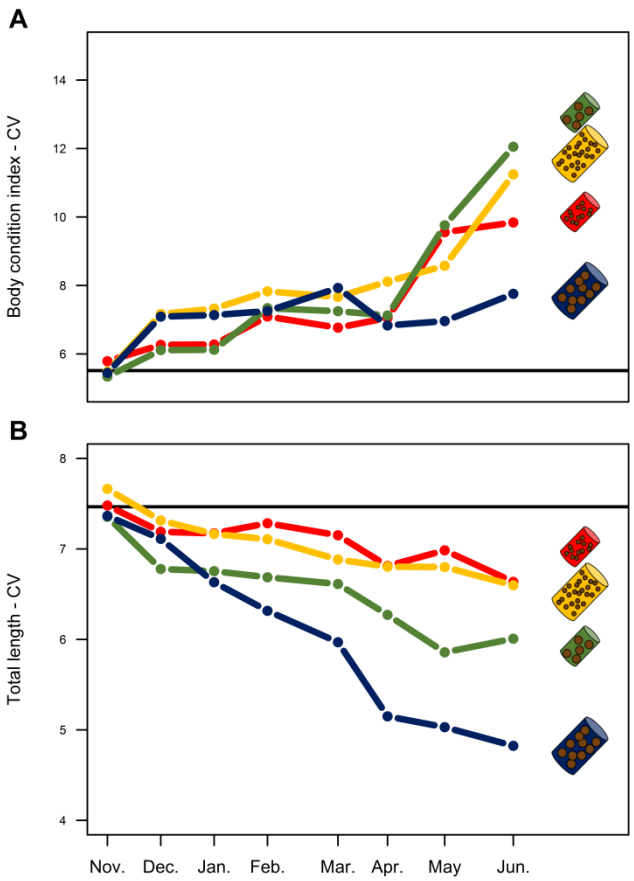

Fig. S7: Time series of the CV of the body condition (A) and total length (B) of all sardines in each feeding treatment: red: pellet size of 0.1mm and pellet quantity of 0.3%; green: 0.1mm and 0.6%; yellow: 1.2mm and 0.1% and blue: 1.2mm and 0.6%. Dark line is the mean body condition and total length at the beginning of the experiments.

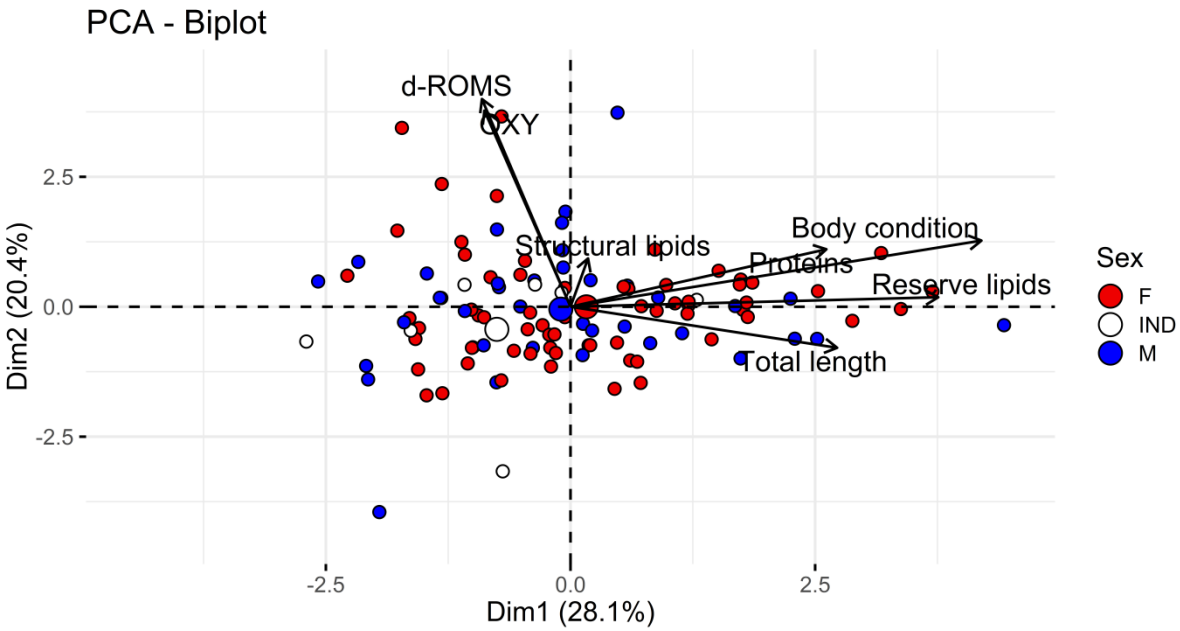

Fig. S8: Biplot of the PCA built using body condition, total length, reserve and structural lipids and proteins contents, d-ROMS and OXY as explanatory variables, with grouping by sex. The large circles represent the barycenter of the individuals for a given sex.

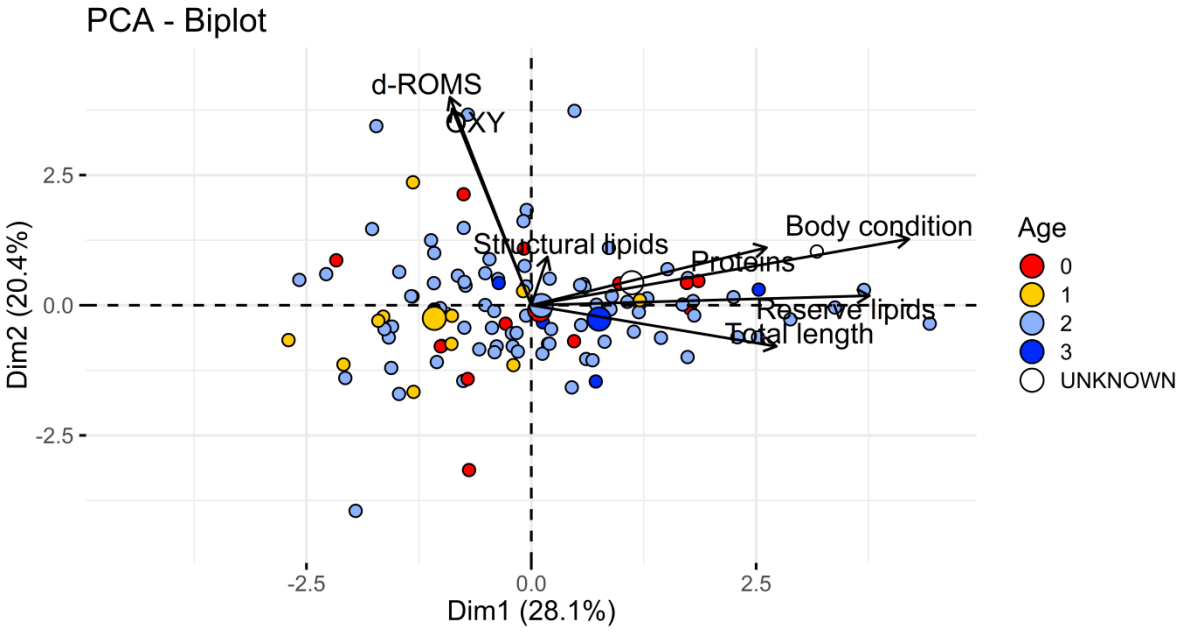

Fig. S9: Biplot of the PCA built using body condition, total length, reserve and structural lipids and proteins contents, d-ROMS and OXY as explanatory variables, with grouping by age. The large circles represent the barycenter of the individuals for a given age.

158 **Table S1. Mean ± sd of lipid class contents (µg/mg) of 0.1 and 1.2 mm pellets used in this**
159 **study: triacylglycerols TAG), free fatty acids (FFA), alcohols (ALC), sterols (ST),**
160 **acetone-mobile polar lipids (AMPL), diacylglycerols (DAG) and phospholipids (PL).**
161

Pellet size (mm)	TAG	FFA	ALC	ST	AMPL	DAG	PL
0.1	67.1 ± 13.5	4.6 ± 4.3	3.5 ± 2.7	7.0 ± 5.0	12.0 ± 6.6	2.7 ± 2.5	55.7 ± 13.7
1.2	69.0 ± 24.6	3.6 ± 4.1	2.9 ± 2.6	5.7 ± 4.9	10.4 ± 11.3	2.1 ± 2.4	24.6 ± 14.3

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Table S2. Results of the selected mixed effect model of body condition over time. Estimations of the predictors of all other fixed effects were based on the estimations of treatment 1. For instance, the intercept of treatment 4 (BLUE) was +1.18 (i.e. 1.14+0.04) and the slope was +0.01 (i.e. -0.04+0.05).

Random effects:

	Standard deviation	*Correlation*
(Intercept)	0.06	(Intercept)
Date	0.01	-0.17

Fixed effects:

Predictors	*Estimates*	*95% CI*	*df*	*p-value*
(Intercept)	1.14	1.12 – 1.15	2565	**<0.001**
Date	-0.04	-0.05 – -0.04	2565	**<0.001**
Treatment 2 (YELLOW)	0.02	-0.00 – 0.04	445	0.050
Treatment 3 (GREEN)	0.02	0.01 – 0.04	445	**0.012**
Treatment 4 (BLUE)	0.04	0.02 – 0.05	445	**<0.001**
Date:Treatment 2 (YELLOW)	0.02	0.01 – 0.02	2565	**<0.001**
Date:Treatment 3 (GREEN)	0.01	0.01 – 0.02	2565	**<0.001**
Date:Treatment 4 (BLUE)	0.05	0.05 – 0.06	2565	**<0.001**
Observations	3018			

Table S3. Results of the selected mixed effect model of total length over time. Estimations of the predictors of all other fixed effects were based on the estimations of treatment 1. For instance, the intercept of treatment 4 (BLUE) was 119.87 mm (i.e. 120.59-0.72) and the slope was +2.48 (i.e. 0.52+1.96).

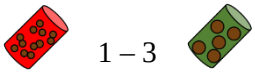
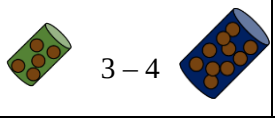
Random effects:

	Standard deviation	*Correlation*
(Intercept)	8.84	(Intercept)
Date	0.61	-0.35

Fixed effects:

Predictors	*Estimates*	*95% CI*	*df*	*p-value*
(Intercept)	120.59	118.95 – 122.24	2565	**<0.001**
Date	0.52	0.39 – 0.65	2565	**<0.001**
Treatment 2 (YELLOW)	-0.06	-2.39 – 2.27	445	0.959
Treatment 3 (GREEN)	-0.44	-2.77 – 1.90	445	0.713
Treatment 4 (BLUE)	-0.72	-3.05 – 1.61	445	0.543
Date:Treatment 2 (YELLOW)	0.67	0.49 – 0.85	2565	**<0.001**
Date:Treatment 3 (GREEN)	0.53	0.35 – 0.71	2565	**<0.001**
Date:Treatment 4 (BLUE)	1.96	1.78 – 2.14	2565	**<0.001**
Observations	3018			

Table S4. p-values of multiple pairwise comparisons between the four treatments for reserve and structural lipids, proteins, d-ROMS and OXY in March and June.

Treatments	Reserve lipids		Structural lipids		Proteins		d-ROMS		OXY	
	March	June	March	June	March	June	March	June	March	June
 1 – 2	0.462	0.741	0.702	0.979	0.684	0.481	1.000	0.150	1.000	0.219
 1 – 3	0.471	0.545	0.068	0.374	0.782	0.768	1.000	0.137	1.000	0.550
 2 – 3	0.808	0.964	0.513	0.710	0.945	0.545	1.000	0.773	1.000	0.837
 1 – 4	**<0.001**	**<0.001**	0.051	0.642	0.129	0.053	1.000	**0.001**	1.000	0.061
 2 – 4	**<0.001**	**<0.001**	0.567	0.825	0.290	0.513	1.000	0.093	0.867	0.546
 3 – 4	**<0.001**	**<0.001**	0.850	0.085	0.946	0.067	0.868	0.180	1.000	0.596

Movies

Movie S1: Feeding behavior of sardines fed with aquaculture pellets after acclimation

References

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