Appendix A

Acoustic disturbance

Based on a meta-analysis of sound exposure experiments [1], we summarize known effects of anthropogenic noise for fish in Table S1. Subsequently, we identify, based on documented responses of fish to changes in physiology or behaviour, potential direct consequences for individual-level processes in the model (energy expenditure, food intake, mortality and reproductive output; Table S1). It should be noted that, while many acoustic disturbances are of an impulsive nature (seismic surveys, pile driving), our choice of ‘potential effects’ relate to regular exposure to such pulses, not the effects of individual pulses. We give a broad overview of how acoustic disturbances may affect individual-level processes (Table S1) to motivate the link between acoustic disturbances and changes in individual level processes.

Across different fish species, anthropogenic noise has been shown to increase stress and affect foraging behaviour, movement behaviour and the auditory system [1]. Stress has been linked to increased energy expenditure, decreased food intake, increased mortality and decreased reproductive output (Table S1). Changes in foraging behaviour may result in increased energy expenditure or lower food intake, while short-term consequences for mortality or reproductive output seem unlikely (Table S1). Changes in movement behaviour may lead to increased energy expenditure (Table S1) but have not been documented to affect food intake or reproductive output. Changes in the auditory system of fish may lead to decreased food intake, increased mortality and decreased reproduction (for example, through the negative consequences of elevated hearing thresholds; Table S1). Although it has often been argued that displacement from foraging areas and spawning grounds affects fish [2], these effects play on a larger scale than the experiments reviewed by Cox et al. [1] and we did not include this link in our table. Yet, we do analyse the effect of reduced reproductive output on the population growth rate based on another link in the table. In summary, anthropogenic noise could eventually lead to increased energy expenditure, reduced food intake, increased mortality and reduced reproductive output for individual cod (Table S1).
Model formulation

The body mass of an individual is assumed to consist of structural mass $x$ (muscles and bones), reserves $y_r$ (lipids and fat) and gonads $y_g$. Total individual body mass $w$ is hence given by:

$$w = x + y_r + y_g.$$ 

The mass-length relationship equals:

$$x = \frac{\gamma l^\delta}{(1 + q_j)}$$

which relates the structural mass $x$ to the condition parameter $q_j$ and the length $l$ with scaling parameters $\gamma$ and $\delta$.

Food ingestion follows a Holling type-II functional response. Unlike van Leeuwen et al. [3], we do not explicitly consider multiple food resources. Instead, the food ingestion rate $I(l)$ is defined as the ratio between the feeding level $F(l)$ and the time the individual needs to digest a unit mass of food $G(l)$ (the inverse $1/G(l)$ equals an individual’s maximum feeding rate):

$$I(l) = \frac{1}{G(l)} (1 - \psi_I) F(l).$$

The feeding level $F(l)$ is assumed constant in time, but body size-dependent (figure S1B). Food ingestion decreases proportionally with acoustic foraging disturbance multiplier $\psi_I$. Digestion time scales with length as:

$$G(l) = \varepsilon l^\theta,$$

with scaling constant $\varepsilon$ and exponent $\theta$.

The net-energy $N(l, w)$ equals:

$$N(l, w) = \sigma I(l) - (1 + \psi_T) T(w).$$
Ingested food is assimilated to energy with efficiency $\sigma$. The energy is then first used to cover the energy expenditure for metabolic maintenance. The standard metabolic maintenance requirements are represented by term $T(w)$. The energy expenditure increases proportionally with the acoustic disturbance energy expenditure multiplier $\psi_T$ relative to the standard metabolic maintenance requirements. The standard metabolic requirements depend on the total body weight, including both structural and reversible mass:

$$T(w) = \alpha w^\beta,$$

with scaling constant $\alpha$ and exponent $\beta$.

To assess the population growth rate, we consider a situation with ample food availability. The net-energy is always taken to be positive and we do not consider starvation conditions. A proportion $k$ of the net-energy is invested in growth in structural mass; the remaining proportion $1 - k$ of the net-energy is invested in reversible and gonad mass (see below). The proportion $k$ is defined as:

$$k(l, x, y_r, y_g) = \begin{cases} 
\frac{1}{q(l) + 1}, & \frac{y_r + y_g}{x} > q(l) \\
\frac{1}{q(l) + 1} \left( \frac{y_r + y_g}{q(l) x} \right)^2, & \text{otherwise.}
\end{cases}$$

$$q(l) = \begin{cases} 
q_j, & l < l_m; \\
q_a, & \text{otherwise.}
\end{cases}$$

The proportion $k$ depends on the ratio between the reversible $(y_r + y_g)$ and structural $(x)$ mass. The proportion $k$ targets for a constant ratio $q(l)$ between reversible and structural mass (note that $k = 1/(q(l) + 1)$ when $y_r + y_g = q(l) x$). When the actual ratio between reversible and structural mass drops below the target condition level $q(l)$, $k(l, x, y_r, y_g)$ decreases with a decrease in the ratio between the reversible and structural mass. This slows down growth in structural mass and favours restoring reserve mass to reach the target condition. The value of $q(l)$ depends on the size of the individual, it is equal to $q_j$ before, and equal to $q_a$ after they have
become sexually mature. Sexual maturity is reached when an individual reaches the size at maturation $l_m$. Since $q_j < q_a$, adults accumulate more reserves than juveniles, a surplus they allocate to reproduction.

For each individual, mortality is a sum of background mortality $\mu_0$, size-dependent background mortality $D_s$, and, fisheries $D_v$ mortality, resulting in the following equation for the per capita mortality rate:

$$D(l) = (1 + \psi_D)\mu_0 + D_s(l) + D_v(l).$$

The term $\psi_D \mu_0$, background mortality multiplied by acoustic disturbance mortality multiplier $\psi_D$, represents the increase in mortality due to acoustic disturbance. The size-dependent background mortality $D_s(l)$ decreases exponentially with body size:

$$D_s(l) = \mu_s e^{-\frac{l}{l_s^\delta}},$$

with mortality constant $\mu_s$ and characteristic size $l_s$. Fisheries mortality $D_v(l)$ depends on body size following a double sigmoid function (see Figure S1C):

$$D_v(l) = \mu_v \left( X(l, l_v, l_vh) - (1 - \rho)X(l, l_vd, l_vdh) \right),$$

in which $X(l, l_1, l_2)$ is defined as:

$$X(l, l_1, l_2) = \begin{cases} 
0.0, & n x \leq 0.0 \\
\frac{1}{6} n x^3, & 0.0 < n x \leq 1.0 \\
\left(-\frac{3}{2} n x + \frac{3}{2} n x^2 - \frac{1}{3} n x^3 + 0.5, \right) & 1.0 < n x \leq 2.0 \text{ with } n x = 1.5 \left( \frac{l - l_1}{l_2 - l_1} \right) \\
\left(\frac{9}{2} n x - \frac{3}{2} n x^2 + \frac{1}{6} n x^3 - 3.5, \right) & 2.0 < n x \leq 3.0 \\
1.0, & \text{otherwise} 
\end{cases}$$

The fisheries mortality depends on mortality constant $\mu_v$, the average fisheries retention in the largest size classes' $\rho$ and sigmoid function $X(l, l_1, l_2)$. The sigmoid function depends on the body length $l$, the length at the start $l_1$ and at $50\%$ $l_2$ of the s-shaped part of the function. For the increasing part of $D_v (l)$, the sigmoid is defined by the length at the start $(l_v)$ and at $50\%$ $(l_vh)$ of
fisheries retention. For the decreasing part of $D_\nu(l)$, the sigmoid depends on the length at the start ($l_{vd}$) and at 50% ($l_{vdn}$) of the fisheries mortality decline (Figure S1C).

The individual life history is a mix of continuous and discrete time processes that operate within each year. The individual-level functions for feeding, energy allocation and mortality lead to a set of ODEs that describe the continuous-time changes of the individual throughout its life. The age $a$, structural mass $x$, length $l$ and survival probability $s$ change continuously with time $\tau$ as:

$$\frac{da}{d\tau} = 1.0,$$

$$\frac{dx}{d\tau} = \kappa N,$$

$$\frac{dl}{d\tau} = \frac{dx}{d\tau} \frac{dx}{dl} = kN \frac{l}{\delta x},$$

$$\frac{ds}{d\tau} = -D(l)s.$$

The dynamics of the reversible mass of reserves $y_r$ and gonads $y_g$ depend on the time of the year and the sexual maturity of the individual. During the first period, with length $\tau_r$, of each year, the energy invested in reversible and gonad mass is stored in the reserves only and the gonads remain empty. Within each year $n$ with length $Y$, these dynamics during the intervals $(nY) \leq \tau < (nY + \tau_r)$ are hence described by:

$$\frac{dy_r}{d\tau} = (1 - k) \eta$$

$$\frac{dy_g}{d\tau} = 0.0.$$

At day $\tau_r$ within each year (that is, at all time-points $\tau_n = (nY + \tau_r)$), the individual decides whether it will spawn at the end of the year. This decision depends on the reserve mass in relation to the target body condition:

$$y_g(\tau_n^+) = \begin{cases} 0.0, & y_r(\tau_n^-) \leq q_j x(\tau_n^-) \\ y_r(\tau_n^-) - q_j x(\tau_n^-), & y_r(\tau_n^-) > q_j x(\tau_n^-) \end{cases}$$
If the ratio of reserves over structural mass is smaller than or equal to $q_j$, the individual will not spawn because any investment in reproduction would lower the body condition below the target condition $q_j$. In this case, all variables stay the same. On the other hand, if the ratio of reserves over structural mass is larger than $q_j$, the individual will spawn. In this case, the surplus of reserve mass, in excess of the target body condition $q_j$, is transferred to the gonads. All other variables stay the same.

Depending on the decisions about spawning at time points $\varphi_n$, the dynamics that occur subsequently until the end of the year, during intervals $(nY + \tau_r) \leq \tau < (nY + \tau)$, are:

For years without spawning:

\[
\frac{dy_r}{d\tau} = (1 - k)N,
\]
\[
\frac{dy_g}{d\tau} = 0.0,
\]

For years with spawning:

\[
\frac{dy_r}{d\tau} = \begin{cases} 
(1 - k)N & l < l_m, \\
0.0 & l \geq l_m,
\end{cases}
\]
\[
\frac{dy_g}{d\tau} = \begin{cases} 
0.0 & l < l_m, \\
(1 - k)N & l \geq l_m.
\end{cases}
\]

If no spawning occurs, energy invested in reversible mass is stored in reserves by all individuals. In years with spawning, energy invested in reversible mass is stored in the gonads by individuals with a length larger than $l_m$, while energy invested in reversible mass is stored in the reserves by immature individuals, with length smaller than $l_m$.

Spawning occurs at the end of each year at day $\varphi$, at the time points $\zeta_n = (nY + \varphi)$:

\[
B = (1 - \psi_y) \frac{\sigma_y y_g(\zeta_n)}{m(l_b)}.
\]
\[ R_0(\zeta^+_n) = R_0(\zeta^-_n) + B \, s(\zeta^-_n), \]
\[ y_g(\zeta^+_n) = 0.0. \]

The number of offspring \( B \) that an individual produces depends on the mass of the gonads, the mass \( m(l_b) \) at the size of birth \( l_b \) and the gonad-to-offspring conversion efficiency \( \alpha_r \). The number of offspring produced decreases proportionally with the reproductive failure multiplier \( \psi_B \) due to acoustic disturbance. To calculate the lifetime reproductive output \( R_0 \), the number of offspring \( B \) is multiplied by the survival probability of the individual and added to the offspring the individual has produced so far. The gonadal mass is set to zero. All other variables do not change.

The initial state of an individual in the model is defined at the moment at which the individual starts feeding actively. At this moment, the individual age is \( a_b \) and body size is \( l_b \). Its survival probability up to that moment depends on the mortality in the egg and larval phase \( \mu_e \). The individuals reserves contain a portion of the total mass such that, while the gonads are empty, the ratio between reversible and structural mass is equal to the target ratio \( q_j \). This results in the following state of the model variables for newborns:

\[ a(0) = a_b, \]
\[ x(0) = \frac{1}{(1 + q_j)} m(l_b), \]
\[ l(0) = l_b, \]
\[ s(0) = e^{-\mu_e \, a_b}, \]
\[ h(0) = 0.0, \]
\[ y_r(0) = \frac{q_j}{(1 + q_j)} m(l_b), \]
\[ y_g(0) = 0.0. \]

**Feeding level functions**

For the intermediate and low feeding-levels, we assume sigmoid function:
\[ F = f_1 + f_2 X(l, l_1, l_2). \]

The feeding-level starts at level \( f_1 \) and gradually shifts following function \( X \) with length to \( f_1 + f_2 \). The shift starts at \( l_1 \) and at length \( l_2 \) the shift is halfway. With \( l_1 = 0.39 \) cm and \( l_2 = 30 \) cm, we define the intermediate feeding level function as \( F_{\text{int}} = 0.7 + 0.25 X(l, 0.39, 30) \) and the low feeding level function as \( F_{\text{low}} = 0.55 + 0.35 X(l, 0.39, 30) \) (Figure S1B).

**Model parameters**

Parameters and their values are listed in Table S2. The parameter values used by van Leeuwen et al. [3] are based on Baltic Sea cod. To represent Atlantic cod in the North Sea, we adjust the length at maturation \((l_m)\), adult target condition \((q_a)\) and the size-dependent functions for fisheries retention, energy expenditure for metabolic maintenance, and digestion time (Figure S1A-C). The derivation of these parameter values is described below. Otherwise, we use the parameter values as given in van Leeuwen et al. [3].

The metabolic rate and the digestion time are temperature dependent. The average annual North Sea SST is \( {\sim}10 \) °C [4]. Assuming the sea bottom is about 2 degrees colder, we use 8 °C for the derivation of the size-dependent metabolic rate and the digestion time. The metabolic rate is derived from oxygen consumption of cod reared in light at 8 °C [5]. We convert dry-to-wet body-mass with conversion factor 5 [see data in 5], oxygen to grams energy using an oxy-calorific coefficient of 13.6 kJ⋅g\(^{-1}\) O\(_2\) [6] and energy-to-wet-weight ratio of 7 kJ/g [7]. To compress annual activity into \( Y = 250 \) days (Table S2), we rescale the metabolic rate parameters to \( \beta = 0.9124 \) and \( \alpha = 0.022 \) (Figure S1A). The digestion time \( G \) is derived from data of maximum growth in body mass in Atlantic cod, fed ad lib in captivity [8]. For a situation with maximum feeding, the growth in body mass equals the weight increase \((N)\) in the model; \( N = \sigma \frac{1}{G} - T \). We derive digestion time scaling parameters \( \epsilon = 270.651 \) and \( \theta = -2.389 \) from the growth rate between \( l = 0.39 - 150 \) cm at 8 °C, using a year with length \( Y = 250 \) days, \( \sigma = 0.6 \) (Table S2) and the metabolic rate above (Table S2, Figure 1B).
Fisheries retention is defined as the ratio between the age-specific annual fisheries mortality rate and the maximum fisheries mortality rate in the same year. We use data from the ICES fisheries assessments between 2000-2016 [9]. Each age class is converted to a mean annual size-at-age based on the mean size per age class in the years 2000-2016 of the cod IBTS-survey data [10]. We use a double s-shaped function for the relationship between fisheries retention and body size and fitted the curve to the data points manually (Figure S1C). Fisheries retention starts at $l_v = 10$ cm and reaches 50% of its maximum at $l_{vh} = 34$ cm. From $l_{vd} = 58$ cm, fisheries retention gradually decreases to the average retention in the last age class (6+ years old) $\rho = 0.55$ and reaches 50% of this level at $l_{vdh} = 78$ cm. Over the last ten years, the maximum fisheries mortality for North Sea cod ranged between 0.35 (2016) and 0.75 (2006; [9]). We use a daily mortality rate of $\frac{0.31}{\gamma} = 0.00124 \text{ d}^{-1}$, which is the currently advised maximum cod fisheries mortality [11].

The typical size at maturation of Atlantic cod varies across regions; we use $l_m = 62$ cm, which is the length where 50% of Atlantic cod in the North Sea are reported mature by Thorsen et al. [12]. The adult target body condition is taken as $q_a = 1.2$ based on a mean 24% somatic weight loss after spawning in Atlantic cod from the Gulf of St. Lawrence [13].
Figure S1 (A) Maintenance costs (black solid line) and maximum ingestion rate $\frac{1}{G}$ (red dashed line), (B) feeding level in case of high (green), intermediate (blue) and low (red) food availability, (C) fisheries retention data (black dots; 2000-2016, 65), the length at the start of the increase $l_v$ (blue solid line), at 50% of the increase $l_{vh}$ (green solid line), at the start of the decline $l_{vd}$ (blue dashed line) and 50% of the decline $l_{vdh}$ (green dashed line) of fisheries retention and fisheries retention implemented in the model (black line) and (D) mortality rate as a function of body size implemented in the model.
Table 5.1 Potential consequences of anthropogenic noise for individual level processes. The observed effects of anthropogenic noise on fish (row names on the left) were chosen based on a meta-analysis of anthropogenic noise experiments with fish by Cox et al. [1]. We show an overview of potential consequences of the observed effects of anthropogenic noise for individual level processes (column names on top) that have been documented for fish. Colours of the cells indicate the quality of evidence (orange – documented consequences for individual level process; yellow – logical consequence but no consequences have been documented, or, only anecdotal studies of consequences for individual level process; blue – no short-term consequences for individual level process have been documented).

<table>
<thead>
<tr>
<th>Observations</th>
<th>Consequences</th>
<th>Energy expenditure</th>
<th>Food intake</th>
<th>Mortality</th>
<th>Reproductive output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress (Higher levels of cortisol)</td>
<td>✓ Elevated cortisol increases the metabolic rate [14].</td>
<td>✓ Elevated cortisol reduces food intake [15,16].</td>
<td>? Stress may lead to mortality [17].</td>
<td>✓ Elevated cortisol decreases fertilization rate [18], and, leads to deformities in fish larvae [19].</td>
<td></td>
</tr>
<tr>
<td>Foraging behaviour (Decrease of foraging behavior, such as: food consumption, foraging efficiency, and discrimination error of prey items.)</td>
<td>✓ More energy spent to come to the same food intake [20,21].</td>
<td>✓ Lower food intake due to less successful foraging or less time spent foraging [22].</td>
<td>× No direct consequences documented.</td>
<td>× No direct consequences documented.</td>
<td></td>
</tr>
<tr>
<td>Movement behaviour (Increase of movement related behaviour, such as: adjusted swimming depth, directional changes, schooling adjustments, swimming speed.)</td>
<td>✓ Schooling reduces the energetic costs of movement [23] and faster swimming costs more energy [24].</td>
<td>× No direct consequences documented.</td>
<td>× No direct consequences documented.</td>
<td>× No direct consequences documented.</td>
<td></td>
</tr>
<tr>
<td>Auditory system (Changes in the auditory system, such as the hearing threshold.)</td>
<td>× No direct consequences documented.</td>
<td>? Lower prey detection.</td>
<td>? Lower predator detection.</td>
<td>? Cod uses sounds for mate finding [25].</td>
<td></td>
</tr>
</tbody>
</table>
Table S2 Model variables and default parameter values based on van Leeuwen et al. (2013).

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Unit</th>
<th>Description</th>
<th>Value</th>
<th>Source</th>
<th>Derivation</th>
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<tr>
<td>Model variables</td>
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<td></td>
</tr>
<tr>
<td>$a$</td>
<td>[d]</td>
<td>Age</td>
<td></td>
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<td></td>
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<tr>
<td>$x$</td>
<td>[g]</td>
<td>Structural mass</td>
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<tr>
<td>$y_r$</td>
<td>[g]</td>
<td>Reserves</td>
<td></td>
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</tr>
<tr>
<td>$y_g$</td>
<td>[g]</td>
<td>Gonads</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$s$</td>
<td>-</td>
<td>Survival probability</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$R_o$</td>
<td>-</td>
<td>Reproductive output</td>
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<td></td>
</tr>
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<td>Derived model variables</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$l$</td>
<td>[cm]</td>
<td>Length</td>
<td>$m = \gamma \ l^6$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$w$</td>
<td>[g]</td>
<td>Total body mass</td>
<td>$w = x + y_r + y_g$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$m$</td>
<td>[g]</td>
<td>Length-based mass</td>
<td>$m = x(1 + q_j)$</td>
<td>Structural mass and liver weight</td>
<td></td>
</tr>
<tr>
<td>Parameters</td>
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<td></td>
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<td>$\Upsilon$</td>
<td>[d]</td>
<td>Length of growing season</td>
<td>250</td>
<td>[3]</td>
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<td>$\tau_r$</td>
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<td>Day of spawning decision</td>
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<td>[3]</td>
<td></td>
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<tr>
<td>$\alpha_b$</td>
<td>[d]</td>
<td>Age of first feeding</td>
<td>22</td>
<td>[3]</td>
<td>Atlantic cod, Norway</td>
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<td>$l_b$</td>
<td>[cm]</td>
<td>Length at birth</td>
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<td>[3]</td>
<td>Atlantic cod, Norway</td>
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<td>$l_s$</td>
<td>[cm]</td>
<td>Characteristic length mortality</td>
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<td>[3]</td>
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<tr>
<td>$l_m$</td>
<td>[cm]</td>
<td>Maturation length</td>
<td>62</td>
<td>[12]</td>
<td>Length 50% mature (North Sea cod)</td>
</tr>
<tr>
<td>$l_v$</td>
<td>[cm]</td>
<td>Size of start fishing vulnerability</td>
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<td>[9]</td>
<td>North Sea cod</td>
</tr>
<tr>
<td>$l_{vh}$</td>
<td>[cm]</td>
<td>Size of 50% fishing vulnerability</td>
<td>34</td>
<td>[9]</td>
<td>North Sea cod</td>
</tr>
<tr>
<td>$l_{vd}$</td>
<td>[cm]</td>
<td>Size of start decrease fisheries vulnerability</td>
<td>58</td>
<td>[9]</td>
<td>North Sea cod</td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
<td>Value</td>
<td>Source</td>
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<td></td>
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<tr>
<td>$l_{\text{redh}}$</td>
<td>cm</td>
<td>Size of %50 decrease fisheries vulnerability</td>
<td>78</td>
<td>[9] North Sea cod</td>
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<tr>
<td>$\rho$</td>
<td>-</td>
<td></td>
<td>0.55</td>
<td>[9] North Sea cod</td>
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<td>$q_j$</td>
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<td>Juvenile condition target</td>
<td>0.7</td>
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<td>$q_a$</td>
<td>-</td>
<td>Adult condition target</td>
<td>1.2</td>
<td>[13] Atlantic cod, NW</td>
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<td>$\gamma$</td>
<td>$[(g \text{ cm}^{-1})\delta]$</td>
<td>Length-weight scaling constant</td>
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<td>[3] Atlantic cod, NE</td>
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<tr>
<td>$\delta$</td>
<td>-</td>
<td>Length-weight scaling exponent</td>
<td>3.0</td>
<td>[3] Atlantic cod, NE</td>
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<tr>
<td>$\varepsilon$</td>
<td>$[d \text{ cm}^{-\theta} g^{-1}]$</td>
<td>Digestion time scaling constant</td>
<td>270.651</td>
<td>[5,8] Derived from maximum growth rate, metabolic rate and $I(l)$</td>
<td></td>
</tr>
<tr>
<td>$\theta$</td>
<td>-</td>
<td>Digestion time scaling exponent</td>
<td>-2.389</td>
<td>[5,8] Derived from maximum growth rate, metabolic rate and $I(l)$</td>
<td></td>
</tr>
<tr>
<td>$\alpha$</td>
<td>$[g^{1-\beta} d^{-1} g^{-1}]$</td>
<td>Metabolic rate scaling constant</td>
<td>0.022</td>
<td>[5] Derived from oxygen consumption of Atlantic cod at 8 C</td>
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<tr>
<td>$\beta$</td>
<td>-</td>
<td>Metabolic rate scaling exponent</td>
<td>0.9124</td>
<td>[5] Derived from oxygen consumption of Atlantic cod at 8 C</td>
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<tr>
<td>$\sigma_0$</td>
<td>-</td>
<td>Conversion efficiency</td>
<td>0.6</td>
<td>[3] Across fish species</td>
<td></td>
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<tr>
<td>$\sigma_r$</td>
<td>-</td>
<td>Gonad-offspring conversion efficiency</td>
<td>0.5</td>
<td>[3] Female offspring only</td>
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<tr>
<td>$\mu_e$</td>
<td>$[d^{-1}]$</td>
<td>Egg mortality</td>
<td>0.03</td>
<td>[3]</td>
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<tr>
<td>$\mu_s$</td>
<td>$[d^{-1}]$</td>
<td>Size-dependent mortality constant</td>
<td>0.03</td>
<td>[3]</td>
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<tr>
<td>$\mu_0$</td>
<td>$[d^{-1}]$</td>
<td>Size-independent background mortality</td>
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<td>[3]</td>
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<tr>
<td>Parameter</td>
<td>Description</td>
<td>Formula</td>
<td>Value</td>
<td>Reference</td>
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<td>-------------</td>
<td>---------</td>
<td>-------</td>
<td>-----------</td>
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</tr>
<tr>
<td>( \mu_v )</td>
<td>[d(^{-1})]</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>( F_{\text{high}} )</td>
<td>Fishing mortality</td>
<td></td>
<td>0.00124</td>
<td>[11]</td>
<td></td>
</tr>
<tr>
<td>( F_{\text{int}} )</td>
<td>Length dependent</td>
<td>( 0.7 + 0.25 X(l, 0.39, 30) )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( F_{\text{low}} )</td>
<td>Length dependent</td>
<td>( 0.55 + 0.35 X(l, 0.39, 30) )</td>
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</tr>
<tr>
<td>( \psi_D )</td>
<td>Acoustic mortality multiplier</td>
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<tr>
<td>( \psi_B )</td>
<td>Acoustic reproductive failure multiplier</td>
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<tr>
<td>( \psi_T )</td>
<td>Acoustic energy expenditure multiplier</td>
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<tr>
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<td>Acoustic feeding failure multiplier</td>
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<td>0 - 1</td>
<td></td>
<td></td>
</tr>
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References used in Appendix A

10. ICES. 2018 ICES Database of Trawl Surveys (DATRAS).


