# Appendix A. Method and data transformation

Table A.1: Parameter values for von Bertalanffy growth model from literature. Temperature corresponds to average temperature in natural environment of the species. The last parameter for von Bertalanffy growth curve, time at which shell height is null ($t_0$) was estimated because not given in literature.

| Species | $K$ ($y^{-1}$) | $L_{inf}$ (mm) | Time period (y) | Shell height range (mm) | Region | Temperature (°C) | Estimated $t_0$ (y) |
|---|---|---|---|---|---|---|---|
| *A. purpuratus*[a] | 0.84 | 124.6 | 1-3 | 30-120 | Tongoy Bay | 15 | 0.75 |
| *M. varia*[b] | 0.57 | 50.93 | 1-6 | 10-50 | Bay of Brest | 13 | -0.2 |
| *N. subnodosus*[c] | 0.61 | 116.0 | 0.3-3 | 20-95 | Bahia Juncalito | 25 | -0.75 |
| *P. maximus*[d] | 0.66 | 106.8 | 1-8 | 20-110 | Bay of Brest | 12 | 0.5 |
| *P. magellanicus*[e] | 0.26 | 131.7 | 2-15 | 10-150 | Bay of Fundy | 8.5 | 1.4 |

[a] Stotz and González (1997) [b] Conan and Shafee (1978) [c] Villalejo-Fuerte et al. (2004)
[d] Buestel and Laurec (1975) [e] Roddick et al. (1994)

Table A.2: Linear regression model coefficients of relations between tissue dry weight and shell heights. For *N. subnodosus*, data comes from an allometric relations, explaining perfect fit.

| Species | Intercept | Slope | $R^2$ adjusted | p-value | Reference |
|---|---|---|---|---|---|
| *A. purpuratus* | 0.0038 | 2.31 | 0.91 | $< 2\ 10^{-16}$ | Aguirre-Velarde et al. (2019b) |
| *M. varia* | 0.0028 | 3.93 | 0.94 | $< 2\ 10^{-16}$ | Régnier-Brisson (2024) |
| *N. subnodosus* | 0.0135 | 2.68 | 1 | $< 2\ 10^{-16}$ | Villalejo-Fuerte et al. (2004) |
| *P. maximus* | 0.0087 | 2.99 | 0.72 | $5.29\ 10^{-6}$ | Pazos et al. (1997) |
| *P. magellanicus* | 0.0006 | 4.52 | 0.92 | $< 2\ 10^{-16}$ | Claereboudt et al. (1994) |

Table A.3: Equations of the DEB model: links to environmental conditions (forcing variables $T$ temperature, and $X$ food), energy fluxes and state variable differential equations. Definition of parameters estimated and their values used in this study can be found in Table 4. For all species, reference temperature, $T_{ref}$ was set at 20 °C, Arrhenius temperature $T_A$ at $8000K$, and maturity maintenance rate coefficient $\dot{k}_J$ at 0.002 $d^{-1}$

| Equation | Unit | Definition |
|---|---|---|
| Link to environmental conditions | | |
| $c_T = \exp(\frac{T_A}{T_{ref}} - \frac{T_A}{T})$ | - | Correction factor to temperature |
| $f = \frac{X}{(X+X_K)}$ | - | Scaled functional response |
| Energy fluxes | | |
| $\dot{p}_A = \begin{cases} 0 & \text{if } E_H < E_H^b \\ c_T \dot{p}_{Am} f V^{2/3} & \text{otherwise} \end{cases}$ | $J\ d^{-1}$ | Assimilation rate |
| $\dot{p}_C = [E]\frac{[E_G] c_T \dot{v} V^{2/3} + \dot{p}_S}{\kappa [E] + [E_G]}$ | $J\ d^{-1}$ | Mobilisation rate |
| $\dot{p}_S = c_T [\dot{p}_M] V$ | $J\ d^{-1}$ | Somatic maintenance rate |
| $\dot{p}_G = \kappa \dot{p}_C - \dot{p}_S$ | $J\ d^{-1}$ | Growth rate |
| $\dot{p}_J = c_T \dot{k}_J E_H$ | $J\ d^{-1}$ | Maturity maintenance rate |
| $\dot{p}_R = (1-\kappa)\dot{p}_C - \dot{p}_J$ | $J\ d^{-1}$ | Maturation or reproduction |
| $\dot{p}_D = \dot{p}_S + \dot{p}_J + (1-\kappa_R)\dot{p}_R$ | $J\ d^{-1}$ | Dissipation rate |
| State variable differential equations | | |
| $\frac{dE}{dt} = \dot{p}_A - \dot{p}_C$ | $J\ d^{-1}$ | Dynamics of reserve |
| $\frac{dV}{dt} = \dot{p}_G / [E_G]$ | $J\ d^{-1}$ | Dynamics of structure |
| $\frac{dE_H}{dt} = \begin{cases} \dot{p}_R & \text{if } E_H < E_H^p \\ 0 & \text{otherwise} \end{cases}$ | $J\ d^{-1}$ | Dynamics of maturity level |
| $\frac{dE_R}{dt} = \begin{cases} 0 & \text{if } E_H < E_H^p \\ \dot{p}_R & \text{otherwise} \end{cases}$ | $J\ d^{-1}$ | Dynamics of reproduction buffer |

Table A.4: Results based on hypothesis of multiplying by two the fecundity for simultaneous hermaphrodites. All values needed are presented in previous table 2 in section 2.1.2. Calculation of fecundity (number of eggs time number of spawning events), reproduction rate (fecundity divided by 365 days), egg volume ($\frac{4}{3}\pi(\frac{D}{2})^3$), egg dry weight (considering 1 $\mu m^3$ of an egg has the same dry weight for species, and cross calculation from value given for *P. magellanicus* in Carnegie (1994)), reproductive effort (fecundity times egg dry weight), egg energy (dry weight of an egg times energetic value of 26 $kJ\ g_{dw}^{-1}$ given by MacDonald and Thompson (1985) for *P. magellanicus*) and reproductive energy (fecundity times energy of one egg) for each species.

| Species | Fecundity (# $year^{-1}$) | Reproduction rate (# $year^{-1}$) | Egg volume ($\mu m^3$) | Egg dry weight ($g\ dw$) | Reproductive effort ($g\ year^{-1}$) | Egg energy ($J$) | Reproductive energy ($J\ year^{-1}$) |
|---|---|---|---|---|---|---|---|
| *A. purpuratus* | 48,000,000 | 131,507 | 123,585 | $1.33\ 10^{-7}$ | 6.39 | 0.00346 | 166,020 |
| *M. varia* | 8,000,000 | 21,918 | 113,097 | $1.22\ 10^{-7}$ | 0.97 | 0.00317 | 25,322 |
| *P. maximus* | 22,560,000 | 61,808 | 143,793 | $1.55\ 10^{-7}$ | 3.49 | 0.00402 | 90,789 |
| *N. subnodosus* | 61,500,000 | 168,493 | 75,766 | $8.16\ 10^{-8}$ | 5.02 | 0.00212 | 130,409 |
| *P. magellanicus* | 67,000,000 | 183,562 | 156,073 | $1.68\ 10^{-7}$ | 11.26 | 0.00437 | 292,656 |

Table A.5: Values of functional responses used for each method, for each species, for individual estimations ("Ind."), simulations with *Placopecten magellanicus* parameters and physical co-variation rules ("Simu. Pl"), common multi-species parameter estimation with all parameters equals except the ones implied in physical co-variation rules ("Comm.") and multi-species parameter estimation with differences on $\dot{v}$ and $[\dot{p}_M]$ ("Multi.", degree of similarity of 6).

| Species | Functional response | Ind. | Simu. Pl | Comm. | Multi. |
|---|---|---|---|---|---|
| *A. purpuratus* | f_Paracas | 1.06 | 1 | 1.06 | 1.16 |
| *M. varia* | f_tL19SA | 0.81 | 1 | 1 | 1.19 |
| *N. subnodosus* | f_AM | 1.2 | 1 | 1 | 0.75 |
| | f_CL | 0.76 | 1 | 1 | 1.16 |
| | f_RA | 0.98 | 1 | 1.05 | 0.85 |
| | f_RC | 0.75 | 1 | 1.03 | 0.99 |
| | f_MA | 1.2 | 1 | 1 | 1.06 |
| *P. maximus* | f_EV | 0.98 | 1 | 1.14 | 1.01 |
| | f_B | 1.3 | 1 | 0.99 | 0.98 |
| | f_CB | 0.24 | 1 | 1.08 | 1.01 |
| *P. magellanicus* | f_MD10 | 1.2 | 1 | 0.99 | 0.87 |
| | f_MD31 | 1.2 | 1 | 0.99 | 0.92 |
| | f_RO | 0.86 | 1 | 1.08 | 1.01 |

# Appendix B. Joint multi-species parameter estimation

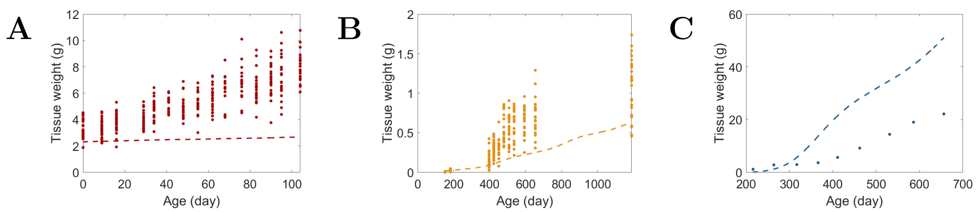


Figure B.1: Tissue weight at age, data (points) and predictions (dashed lines) with *P. magellanicus* parameter values and physical co-variation rules on maturity threshold at puberty and maximum assimilation rate, after estimation with same parameter values for all species. A) dry weight of *A. purpuratus*, B) dry weight of *M. varia* and C) wet weight of *N. subnodosus*.

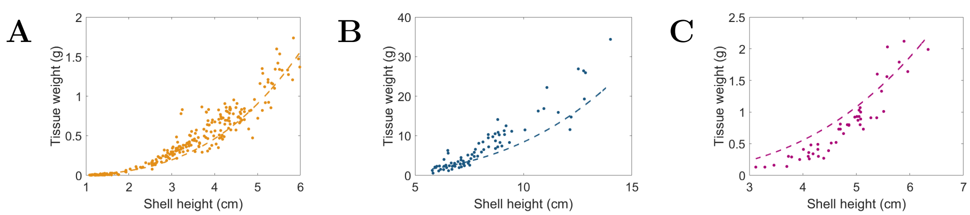


Figure B.2: Relationship between tissue weight and shell height, data (points) and predictions (dashed lines) with *P. magellanicus* parameter values and physical co-variation rules on maturity threshold at puberty and maximum assimilation rate, after estimation with same parameter values for all species. A) *M. varia*, B) *N. subnodosus* and C) *P. magellanicus*.

# Appendix C. Multi-species parameter estimation with different parameters

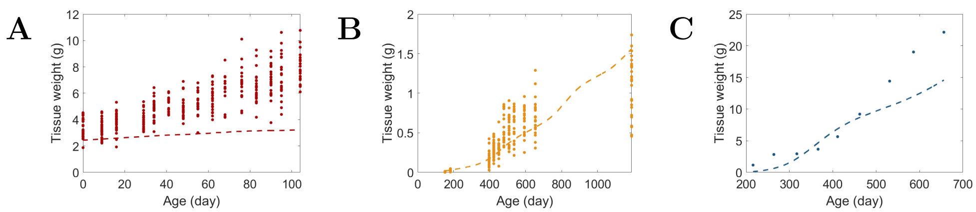


Figure C.1: Tissue weight at age, data (points) and predictions (dashed lines) with *P. magellanicus* parameter values and physical co-variation rules on maturity threshold at puberty and maximum assimilation rate, for A) dry weight of *A. purpuratus*, B) dry weight of *M. varia* and C) wet weight of *N. subnodosus*. Estimation of energy conductance ($\dot{v}$) and somatic maintenance ($[\dot{p}_M]$) free and with a degree of similarity of 6.

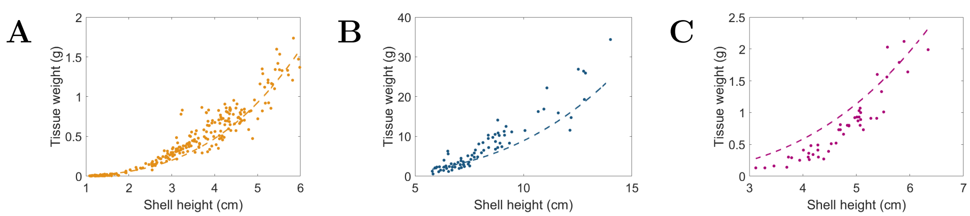


Figure C.2: Relationship between tissue weight and shell height, data (points) and predictions (dashed lines) with *P. magellanicus* parameter values and physical co-variation rules on maturity threshold at puberty and maximum assimilation rate, for A) *M. varia*, B) *N. subnodosus* and C) *P. magellanicus*. Estimation of energy conductance ($\dot{v}$) and somatic maintenance ($[\dot{p}_M]$) free and with a degree of similarity of 6.