S1: Supplementary material and methods:

a) data compilation and selection:

Cited data points have been taken from available peer-reviewed journals, searched via 'Web of Science' from the associated databases. We tried to exclusively chose sub tidal species from temperate seas. As data from physiological studies regularly stems from very specific experimental approaches, frequently working with non-model organisms, selection criteria could not be confined to one experimental protocol in all analyzed animal groups. In addition, many publications give only scarce information about the general handling of animals or water quality criteria within the experimental set up. However, where enough published information was available, the following minimal selection criteria were applied (e.g. within the fish, crustacean, cephalopod groups):

Metabolic rate measurements:

- animals should have been fasted before the measurements for some time to prevent elevated respiration rates due to digestive processes, i.e. specific dynamic action of food (SDA).
- acclimation time within the respiration chamber should have been sufficiently long to allow for recovery from handling stress especially for determination of routine metabolic rates, e.g. over night or when a decline of oxygen consumption is observed until control levels are reached again.
- methods regarded as appropriate for the determination of dissolved oxygen were measurements using (i) polarographic or Clark-type electrodes, (ii) fiber optical oxygen sensors or (iii) the Winkler titration method

Measurements of carbonate system parameters in body fluids:

- at least two carbonate system parameters had to be accurately quantified, preferably pH and dissolved inorganic carbon (DIC / C_T)
- methods regarded as appropriate for pH determination were measurements using (i) glass electrodes / microelectrodes or (ii) combination glass electrodes from various manufacturers or (iii) fiber optical pH sensors, all calibrated with precision NBS buffers.
- methods regarded as appropriate for determination of DIC were those based on the deliberation of CO_2 from aqueous solutions by acidification and subequent (i) conductometric or infrared (e.g. using a Capnicon or Corning instrument) or (ii) gas chromatographic measurement.

Table S1: Data sources for metabolic rates and acid base parameters displayed in Fig. 2:

	Routine metabolic rates	*Active metabolic rates*	*Control acid-base parameters*	*Acid-base parameters exercise*
teleost fish	Scarabello et al. 1991, Steffensen et al. 1987, Thomas1983, Lee et al. 2003, Bernier et al. 2004, Garry and Duthie 1982, Yamamoto 1991, Chatelier et al. 2005, Dickson et al. 2002	Steffensen et al. 1987, Van den Thillart et al. 1983, Lee et al. 2003, Bernier et al. 2004, Garry and Duthie 1982, Yamamoto 1991, Chatelier et al. 2005, Dickson et al. 2002	Larsen et al. 1997, Lee et al. 2003, McKenzie et al., 2002, Michaelidis et al. 2007, Thomas et al. 1987, Milligan and Wood 1987, Holeton et al. 1983, van den Thillart et al. 1983, Thomas et al. 1983, Bernier et al. 2004	Milligan and Wood 1987, Holeton et al. 1983, Van den Thillart et al. 1983, Bernier et al. 2004, Korsmeyer et al. 1997
crustacea	Hill et al. 1991, Legeay and Massabuau 2000, Hamilton and Houlihan 1992, Watt et al. 1999, Booth et al. 1982, Batterton and Cameron 1978, Brown and Terwilliger 1999, McMahon et al. 1979, McGaw 2007	Booth et al. 1982, McMahon et al. 1979, Hamilton and Houlihan 1992, McGaw 2007	Henry and Cameron 1983, Booth et al. 1984b, Hill et al. 1991, Hamilton and Houlihan 1992, Pane and Barry 2007, McDonald et al. 1979, Spicer et al. 2007, Watt et al. 1999	McDonald et al. 1979, Booth et al. 1984b, Hamilton and Houlihan 1992
echino-dermata	Webster 1975, Johansen et al. 1982, Otero-Villanueva et al. 2004, Spicer et al. 1988, Vahl 1984		Spicer 1995, Miles et al. 2007, Spicer et al. 1988, Johansen and Petersen 1971	
cephalopoda	Seibel and Childress 2000, Houlihan et al. 1982, Houlihan et al. 1986, Wells et al. 1983, Seibel et al. 1997, Melzner et al. 2007, Odor and Webber 1991, Shadwick et al. 1990, Hunt and Seibel 2000	Webber and Odor 1986, O`Dor and Webber 1991, Shadwick et al. 1990, Houlihan et al. 1986, Wells et al. 1983	Houlihan et al. 1982, Houlihan et al. 1986, Johansen et al. 1982, Pörtner et al. 1991	Pörtner et al. 1991, Houlihan et al. 1986
bivalvia	Camacho et al. 2000, Michaelidis et al. 2005, Gold-Bouchot et al. 1995, Sukhotin et al. 2002, Booth et al. 1984a, Baldwin and Lee 1979, Kraffe et al. 2008, Yang et al. 1998	Baldwin and Lee 1979 Kraffe et al. 2008	Michaelidis et al. 2005, Booth et al. 1984a, Lindinger et al. 1984, Thomsen 2009	

b) standardization of metabolic rates

Standard / routine as well as active metabolic rates have been scaled to an average animal mass and a common temperature to enable a comparison of results from various marine taxa. 15°C and a body mass of 20 g have been chosen as mean values. In all cases, specific respiration rates refer to body mass and where necessary, additional data have been used to transform the rates from soft tissue weight to total body mass (especially for bivalves, references are given in tables). In some cases, original publications give only ranges for temperature and masses; these data have been averaged to obtain suitable initial values for scaling.

Mass scaling was performed according to the following equation:

$$MO_{2\,st.} = \left(\frac{20}{m\ ex.}\right)^{0.75} \times MO_{2\,ex.}$$

st. = standardized, ex. = experimental, MO_2 = metabolic rate [µmol / kg min]

According to Hemmingsen (1960) a mass exponent of 0.75 is valid for a wide variety of ectothermic invertebrates and vertebrates.

Temperature scaling was performed according to the following equation using a Q_{10} value of 2.5:

$$Q_{10} \times MO_{2\,ex.}{}^{\frac{10}{15-Tex.}} = MO_{2\,st.}{}^{\frac{10}{15-Tex.}}$$

st. = standardized, ex. = experimental, MO_2 = metabolic rate [µmol / kg min], T = temperature [°C].

c) calculation of extracellular PCO_2 and bicarbonate concentrations

In most publications PCO_2 and apparent bicarbonate concentrations in extracellular fluids have been calculated from measured pH and dissolved inorganic carbon values according to the Henderson–Hasselbalch equation.

$$PCO_2 = \frac{C_{CO_2}}{10^{(pH-pK1')} \times \alpha_{CO_2} + \alpha_{CO_2}}$$

C_{CO2}= dissolved inorganic carbon [mM], pK_1'= apparent first dissociation constant of carbonic acid, α_{CO2} = CO_2 solubility coefficient of the respective body fluid [mM /Pa]

However, sometimes authors only stated measured values of pH and DIC in their results section. In these cases, we used the given data to calculate extracellular PCO_2 and bicarbonate concentrations. Respective constants for CO_2 solubility and apparent carbonic acid dissociation were taken from the following literature sources:

- for fish data: constants according to Boutilier et al. (1985)
- for crustacean data: constants according to Truchot (1976)
- for cephalopod data: constants according to Truchot (1976)

- for echinoderm data: values were computed using the CO2SYS program (Lewis & Wallace 1998) with seawater constants (K_1, K_2) of Mehrbach et al. (1973) as refitted by Dickson & Millero (1987)

d) determination of gill Na^+/K^+-ATPase activity:

Na^+/K^+-ATPase activity was measured in gill crude extracts of *Sepia officinalis*, *Mytilus edulis, Carcinus maenas* and *Zoarces viviparus* in a coupled enzyme assay with pyruvate kinase (PK) and lactate dehydrogenase (LDH) using the method of Allen & Schwarz (1969) as described in Deigweiher et al. (2008) and Melzner et al. (2009). Frozen gill tissue samples were quickly homogenized with 257 a conical glass tissue grinder in 10 volumes of ice-cold buffer 258 (50mM imidazole, pH 7.4 (for *Z. viviparus* and *C. maenas*) or pH 7.7 (for *S. officinalis* and *M. edulis*), 250mM sucrose, 1mM EDTA, 5 mM ß-mercaptoethanol, 0.1% (w/v) deoxycholate, protease inhibitor cocktail from Sigma–Aldrich (Taufkirchen, Germany, Cat. No. P 8340) followed by Ultra Turrax treatment (2×10 s) on ice. Cell debris was removed by centrifugation for 10min at 1000 g and 0°C. The supernatant was used as a crude extract for Na^+/K^+-ATPase activity measurements. The reaction was started by adding the sample homogenate to the reaction buffer containing 100 mM imidazole, pH 7.4, 80 mM NaCl, 20 mM KCl, 5 mM $MgCl_2$, 5 mM ATP, 0.24 mM Na-(NADH + H^+), 2 mM phosphoenolpyruvate, about 12 U ml^{-1} PK and 17 U ml^{-1} LDH using a PK/LDH enzyme mix (Sigma-Aldrich, Taufkirchen, Germany). Due to different acclimation temperatures, oxidation of NADH coupled to the hydrolysis of ATP was followed photometrically at 14-15°C (*S. officinalis, M. edulis, C. maenas*) or 10°C (*Z. viviparus*) in a DU7400i spectrophotometer (Beckman Coulter, Krefeld, Germany) over a period of 10 min measuring the decrease of extinction at λ = 339 nm. Enzyme activity was calculated using an extinction coefficient for NADH of ε = 6.31 mM^{-1} cm^{-1} and given as ATP [µmol] consumed per g gill fresh mass per hour. All samples were run in triplicate.