Supplement 1: Implications of lipid correction for the $\delta^{13}C$ values reported in this study

Introduction

According to Post et al. (2007) the levels of C:N ratios of the medusae sampled in this study were sufficient to warrant a lipid correction of $\delta^{13}C$ values. However, lipid correction equations are potentially different in the context of jellyfish (D'Ambra et al. 2014) and are unknown in the context of zooxanthellate jellyfish. Moreover, in the context of zooxanthellate jellyfishes, $\delta^{13}C$ values and C:N ratios are expected to be correlated (main text, Djeghri et al. 2020). This makes unlikely that lipid correction, based on C:N ratios, would significantly change the conclusions of the present work. Nonetheless, we explore the potential effect of these correction on our $\delta^{13}C$ data below.

Method

The lipid corrections, specific to scyphozoan (D'Ambra et al. 2014) and general for aquatic animals (Post et al. 2007) were applied to the corrected $\delta^{13}C$ obtain from *Mastigias papua* medusae in this study. The lipid corrected $\delta^{13}C$ values were treated following the same statistical procedure as described in the main text.

Results and Discussion

The corrected $\delta^{13}C$ without lipid correction, and lipid-corrected following D'Ambra et al. (2014) and Post et al. (2007) are presented in Fig. S1. Although both lipid-corrections yielded changes in the absolute values of corrected $\delta^{13}C$, the relative position of the different populations of *M. papua*, on which rest our conclusions from the main text, is mostly unchanged.

Literature Cited

D'Ambra I, Carmichael RH, Graham WM (2014) Determination of $\delta^{13}C$ and $\delta^{15}N$ and trophic fractionation in jellyfish: implications for food web ecology. Mar Biol 161:473–480

Djeghri N, Stibor H, Lebeau O, Pondaven P (2020) $\delta^{13}C$, $\delta^{15}N$, and C:N ratios as nutrition indicators of zooxanthellate jellyfishes: insights from an experimental approach. J Exp Mar Biol Ecol 522:151257

Post DM, Layman CA, Arrington DA, Takimoto G, Quattrochi J, Montaña CG (2007) Getting to the fat of the matter: models, methods and assumptions for dealing with lipids in stable isotopes analyses. Oecologia 152:179–189

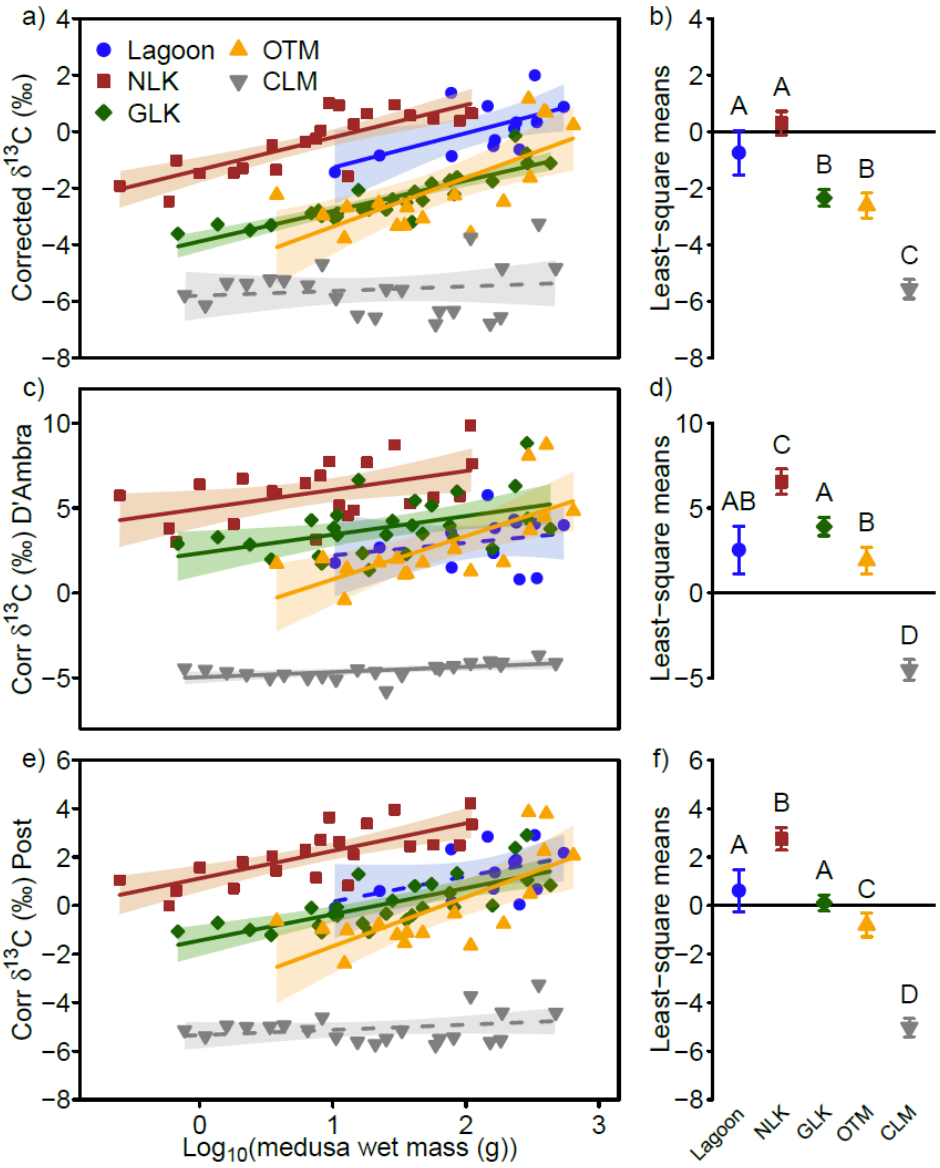

Fig. S1. Effect of lipid correction on *Mastigias papua* corrected $\delta^{13}C$. Top panel: uncorrected data. Middle panel: data lipid-corrected according to D'Ambra et al. (2014). Bottom panel: data lipid-corrected according to Post et al. (2007). Left panels show the relation between corrected $\delta^{13}C$ and medusa wet mass. Solid lines indicate a significant slope (p-value < 0.05). Shaded areas are 95 % C. I. around regression lines. Right panels compare the least-square means (i.e. means corrected for the effect of medusa wet mass) in the different sampling sites. Error bars are 95 % C. I. around the least-square means. Statistically significant differences are indicated by different capital letters (A, B, C and D; Tukey post-hoc, p-value < 0.05)

Supplement 2: Detail of fatty acids compositions

Table S2. Relative composition (%; mean ± s.d.) of fatty acids in *Mastigias papua* medusae from the different sampling sites. NLFA = neutral lipid fatty acids, PLFA = polar lipid fatty acids, TLFA = total lipid fatty acids. SFA = saturated fatty acids, MUFA = mono-unsaturated fatty acids, PUFA = poly-unsaturated fatty acids, DMA = dimethyl acetals. The sums do not equal 100 % as unidentified fatty acids have not been included in this table and as only fatty acids accounting for > 2 % in at least one sample are represented

Table S2. Lagoon

	Lagoon NLFA n = 13	 PLFA n = 13	 TLFA n = 13
14:0	2.19 (± 0.84)	1.04 (± 0.17)	1.64 (± 0.51)
16:0	37.32 (± 5.12)	23.86 (± 2.05)	30.81 (± 3.57)
17:0	0.87 (± 0.41)	0.96 (± 0.39)	0.91 (± 0.39)
18:0	7.94 (± 1.73)	13.74 (± 2.86)	10.7 (± 2.08)
Σ SFA	**49.93 (± 3.9)**	**40.38 (± 3.13)**	**45.23 (± 2.2)**
16:1n-5	–	–	–
16:1n-7	3.59 (± 0.72)	1.18 (± 0.24)	2.43 (± 0.53)
16:1n-9	0.39 (± 0.22)	–	0.19 (± 0.1)
18:1n-7	1.15 (± 0.47)	1.33 (± 0.35)	1.24 (± 0.38)
18:1n-9	9.99 (± 2.65)	4.24 (± 1.31)	7.24 (± 2.13)
20:1n-11	0.13 (± 0.06)	–	0.07 (± 0.04)
20:1n-9	0.31 (± 0.52)	0.13 (± 0.18)	0.22 (± 0.34)
22:1n-9	0.25 (± 0.19)	0.03 (± 0.02)	0.14 (± 0.1)
Σ MUFA	**16.55 (± 2.01)**	**7.21 (± 1.2)**	**12.05 (± 1.79)**
16:2n-4	0.09 (± 0.04)	0.02 (± 0.01)	0.06 (± 0.02)
16:4n-3	0.34 (± 0.24)	–	0.17 (± 0.13)
18:2n-6	1.21 (± 0.32)	1.22 (± 0.29)	1.21 (± 0.27)
18:2n-9	1.96 (± 0.92)	0.6 (± 0.3)	1.32 (± 0.65)
18:3n-3	0.62 (± 0.51)	0.65 (± 0.23)	0.63 (± 0.36)
18:3n-6	1.82 (± 0.71)	1.91 (± 0.88)	1.84 (± 0.72)
18:4n-3	2.35 (± 0.58)	7.08 (± 1.67)	4.59 (± 0.76)
18:5n-3	0.32 (± 0.22)	0.03 (± 0.02)	0.18 (± 0.13)
20:3n-3	0.08 (± 0.07)	0.05 (± 0.03)	0.06 (± 0.05)
20:4n-6	3.47 (± 1.15)	8.44 (± 1.94)	5.94 (± 1.39)
20:5n-3 (EPA)	3.96 (± 0.74)	10.71 (± 1.79)	7.3 (± 1.37)
21:5n-3	0.17 (± 0.14)	0.13 (± 0.02)	0.15 (± 0.07)
22:4n-6	0.65 (± 0.19)	0.94 (± 0.18)	0.79 (± 0.16)
22:5n-3	1.86 (± 0.83)	1.92 (± 0.41)	1.86 (± 0.56)
22:5n-6	0.4 (± 0.17)	0.59 (± 0.19)	0.49 (± 0.14)
22:6n-3 (DHA)	7.32 (± 1.33)	9.37 (± 1.46)	8.35 (± 1.04)
Σ PUFA	**27.47 (± 3.26)**	**44.38 (± 2.67)**	**35.75 (± 2.49)**
Σ n-3	*17.22 (± 2.85)*	*30.11 (± 2.62)*	*23.49 (± 2.5)*
Σ n-6	*8.18 (± 1.39)*	*13.64 (± 1.73)*	*10.87 (± 1.34)*
16:0DMA	0.63 (± 0.27)	0.83 (± 0.28)	0.73 (± 0.24)
16:1n-7DMA	1.26 (± 0.51)	1.72 (± 0.39)	1.47 (± 0.3)
18:0DMA	1.3 (± 0.38)	1.65 (± 0.36)	1.47 (± 0.26)
20:1n-7DMA	–	1.88 (± 0.58)	0.89 (± 0.25)
Σ DMA	**3.19 (± 1.06)**	**6.09 (± 0.68)**	**4.55 (± 0.53)**

Table S2. Continued: Uet era Ngermeuangel (NLK)

	NLK NLFA n = 22	PLFA n = 22	TLFA n = 22
14:0	1.65 (± 0.47)	1.23 (± 0.17)	1.45 (± 0.27)
16:0	47.71 (± 2.87)	19.41 (± 1.37)	35.33 (± 3.71)
17:0	0.27 (± 0.07)	0.18 (± 0.04)	0.23 (± 0.05)
18:0	5.49 (± 0.66)	7.78 (± 1.25)	6.54 (± 0.92)
Σ SFA	**55.53 (± 2.62)**	**29.4 (± 2.22)**	**44.14 (± 3.24)**
16:1n-5	–	–	–
16:1n-7	2.02 (± 0.33)	0.71 (± 0.05)	1.42 (± 0.14)
16:1n-9	0.19 (± 0.06)	0.08 (± 0.02)	0.14 (± 0.04)
18:1n-7	0.35 (± 0.11)	0.42 (± 0.1)	0.38 (± 0.1)
18:1n-9	12.07 (± 1.12)	4.43 (± 0.5)	8.65 (± 0.95)
20:1n-11	–	–	–
20:1n-9	0.1 (± 0.02)	–	0.06 (± 0.02)
22:1n-9	–	–	–
Σ MUFA	**15 (± 1.32)**	**6.04 (± 0.45)**	**10.97 (± 0.94)**
16:2n-4	0.18 (± 0.05)	0.08 (± 0.01)	0.14 (± 0.04)
16:4n-3	0.03 (± 0.02)	–	0.01 (± 0.01)
18:2n-6	0.86 (± 0.1)	0.81 (± 0.06)	0.84 (± 0.07)
18:2n-9	1.83 (± 0.28)	0.83 (± 0.31)	1.37 (± 0.2)
18:3n-3	0.13 (± 0.04)	0.15 (± 0.02)	0.14 (± 0.03)
18:3n-6	1.62 (± 0.24)	2.56 (± 0.32)	2.02 (± 0.24)
18:4n-3	1.52 (± 0.29)	13.17 (± 1.92)	6.69 (± 1.65)
18:5n-3	1.22 (± 0.32)	0.06 (± 0.02)	0.7 (± 0.2)
20:3n-3	0.1 (± 0.03)	0.06 (± 0.02)	0.08 (± 0.02)
20:4n-6	2.01 (± 0.68)	8.26 (± 1.2)	4.74 (± 1.02)
20:5n-3 (EPA)	3.8 (± 0.56)	11.65 (± 1.2)	7.23 (± 0.73)
21:5n-3	0.05 (± 0.02)	0.03 (± 0.01)	0.04 (± 0.01)
22:4n-6	0.38 (± 0.15)	0.82 (± 0.18)	0.57 (± 0.16)
22:5n-3	1.36 (± 0.34)	1.79 (± 0.23)	1.55 (± 0.24)
22:5n-6	0.11 (± 0.04)	0.11 (± 0.04)	0.11 (± 0.04)
22:6n-3 (DHA)	8.5 (± 0.69)	10.85 (± 0.95)	9.57 (± 0.53)
Σ PUFA	**24.1 (± 1.67)**	**51.82 (± 2.1)**	**36.3 (± 2.42)**
Σ n-3	*16.75 (± 1.04)*	*37.79 (± 2.32)*	*26.05 (± 1.89)*
Σ n-6	*5.29 (± 0.86)*	*12.92 (± 1.26)*	*8.62 (± 1.24)*
16:0DMA	0.17 (± 0.04)	1.19 (± 0.31)	0.62 (± 0.17)
16:1n-7DMA	0.29 (± 0.11)	2.57 (± 0.34)	1.3 (± 0.33)
18:0DMA	0.42 (± 0.16)	3.24 (± 1.05)	1.66 (± 0.63)
20:1n-7DMA	–	1.76 (± 0.29)	0.78 (± 0.22)
Σ DMA	**1 (± 0.3)**	**8.82 (± 1.13)**	**4.45 (± 1.05)**

Table S2. Continued: Goby Lake (GLK)

	GLK NLFA n = 24	PLFA n = 24	TLFA n = 23
14:0	1.78 (± 0.61)	1.54 (± 0.58)	1.62 (± 0.52)
16:0	41.67 (± 3.27)	27 (± 7.54)	34.79 (± 4.43)
17:0	0.2 (± 0.06)	0.31 (± 0.08)	0.24 (± 0.04)
18:0	4.77 (± 1.14)	15.36 (± 4.62)	9.04 (± 2.01)
Σ SFA	**48.75 (± 2.81)**	**45.17 (± 12.59)**	**46.26 (± 5.53)**
16:1n-5	0.2 (± 0.16)	0.45 (± 0.11)	0.3 (± 0.09)
16:1n-7	2.77 (± 1.25)	0.84 (± 0.23)	1.93 (± 0.73)
16:1n-9	0.15 (± 0.09)	0.02 (± 0.03)	0.09 (± 0.04)
18:1n-7	0.31 (± 0.1)	0.43 (± 0.14)	0.36 (± 0.1)
18:1n-9	14.52 (± 1.68)	3.67 (± 0.97)	9.81 (± 1.44)
20:1n-11	0.11 (± 0.05)	1.71 (± 0.45)	0.82 (± 0.27)
20:1n-9	0.28 (± 0.09)	0.01 (± 0.01)	0.16 (± 0.06)
22:1n-9	0.31 (± 0.3)	–	0.18 (± 0.18)
Σ MUFA	**19.3 (± 2.42)**	**7.56 (± 1.65)**	**14.21 (± 1.83)**
16:2n-4	0.12 (± 0.05)	0.2 (± 0.09)	0.15 (± 0.04)
16:4n-3	3.62 (± 1.46)	–	2.1 (± 0.99)
18:2n-6	1.08 (± 0.11)	0.84 (± 0.23)	0.98 (± 0.13)
18:2n-9	1.62 (± 0.24)	–	0.91 (± 0.19)
18:3n-3	0.1 (± 0.01)	0.17 (± 0.03)	0.14 (± 0.02)
18:3n-6	1.61 (± 0.17)	4.64 (± 1.42)	3.03 (± 0.85)
18:4n-3	0.58 (± 0.29)	8.19 (± 3.46)	4.14 (± 2.16)
18:5n-3	2 (± 0.75)	0.05 (± 0.04)	1.19 (± 0.51)
20:3n-3	0.05 (± 0.03)	0.05 (± 0.05)	0.05 (± 0.04)
20:4n-6	1.98 (± 1.06)	7.85 (± 3.31)	4.77 (± 2.48)
20:5n-3 (EPA)	2.42 (± 0.45)	5.66 (± 2.45)	3.99 (± 1.42)
21:5n-3	0.3 (± 1.43)	2.35 (± 0.9)	1.17 (± 0.98)
22:4n-6	1.07 (± 1.48)	1.42 (± 0.59)	1.27 (± 1)
22:5n-3	1.56 (± 0.62)	1.55 (± 0.6)	1.56 (± 0.44)
22:5n-6	0.39 (± 0.37)	0.54 (± 0.79)	0.44 (± 0.47)
22:6n-3 (DHA)	7.85 (± 1.66)	5.7 (± 2.27)	7.08 (± 1.21)
Σ PUFA	**26.81 (± 3.69)**	**40.36 (± 11.97)**	**33.71 (± 6.89)**
Σ n-3	*18.49 (± 2.96)*	*24.05 (± 7.39)*	*21.55 (± 3.88)*
Σ n-6	*6.55 (± 1.85)*	*15.63 (± 4.97)*	*10.87 (± 3.61)*
16:0DMA	0.54 (± 0.39)	1.29 (± 0.35)	0.86 (± 0.2)
16:1n-7DMA	–	0.72 (± 0.18)	0.31 (± 0.08)
18:0DMA	1.78 (± 1.2)	4.4 (± 1.19)	2.88 (± 0.6)
20:1n-7DMA	–	–	–
Σ DMA	**2.32 (± 1.59)**	**6.41 (± 1.55)**	**4.05 (± 0.77)**

Table S2. Continued: Ongeim'l Tketau (OTM)

	OTM NLFA n = 18	PLFA n = 18	TLFA n = 18
14:0	2.26 (± 0.35)	0.68 (± 0.15)	1.3 (± 0.26)
16:0	41.42 (± 3.15)	22.99 (± 4.11)	30.09 (± 3.92)
17:0	0.41 (± 0.24)	0.43 (± 0.25)	0.42 (± 0.24)
18:0	7.28 (± 2.69)	11.25 (± 3.88)	9.53 (± 2.81)
Σ SFA	**51.96 (± 3.46)**	**36.08 (± 8.01)**	**42.02 (± 6.29)**
16:1n-5	–	–	–
16:1n-7	3.28 (± 0.86)	0.89 (± 0.29)	1.82 (± 0.46)
16:1n-9	0.28 (± 0.13)	0.11 (± 0.09)	0.18 (± 0.11)
18:1n-7	1.09 (± 0.46)	1.2 (± 0.42)	1.14 (± 0.4)
18:1n-9	9.22 (± 1.4)	3.34 (± 0.43)	5.67 (± 1.02)
20:1n-11	–	–	–
20:1n-9	0.09 (± 0.05)	–	0.03 (± 0.02)
22:1n-9	0.41 (± 0.42)	0.02 (± 0.02)	0.18 (± 0.15)
Σ MUFA	**15.12 (± 1.61)**	**5.97 (± 0.6)**	**9.57 (± 1.19)**
16:2n-4	0.07 (± 0.05)	0.02 (± 0.02)	0.04 (± 0.02)
16:4n-3	0.21 (± 0.07)	0.05 (± 0.06)	0.11 (± 0.05)
18:2n-6	0.67 (± 0.3)	0.79 (± 0.32)	0.74 (± 0.3)
18:2n-9	4.62 (± 0.85)	1.47 (± 0.31)	2.72 (± 0.59)
18:3n-3	0.27 (± 0.18)	0.54 (± 0.18)	0.43 (± 0.17)
18:3n-6	1.52 (± 0.37)	2.24 (± 0.75)	1.98 (± 0.62)
18:4n-3	2.3 (± 0.57)	7.95 (± 3.69)	5.89 (± 2.83)
18:5n-3	0.68 (± 0.3)	0.1 (± 0.02)	0.34 (± 0.18)
20:3n-3	–	0.04 (± 0.04)	0.03 (± 0.02)
20:4n-6	2.72 (± 0.81)	8.78 (± 2.12)	6.47 (± 2)
20:5n-3 (EPA)	3.77 (± 1.3)	11.74 (± 3.56)	8.54 (± 2.56)
21:5n-3	0.08 (± 0.01)	0.11 (± 0.03)	0.1 (± 0.02)
22:4n-6	0.65 (± 0.23)	0.99 (± 0.35)	0.87 (± 0.33)
22:5n-3	1.63 (± 0.51)	2.13 (± 0.72)	1.92 (± 0.57)
22:5n-6	0.29 (± 0.1)	0.58 (± 0.31)	0.45 (± 0.17)
22:6n-3 (DHA)	6.28 (± 0.93)	8.51 (± 1.77)	7.66 (± 1.33)
Σ PUFA	**26.07 (± 2.55)**	**46.99 (± 7.42)**	**38.98 (± 6.2)**
Σ n-3	*15.32 (± 2.31)*	*31.27 (± 5.72)*	*25.12 (± 4.36)*
Σ n-6	*6.03 (± 1.07)*	*14.22 (± 2.51)*	*11.08 (± 2.54)*
16:0DMA	0.24 (± 0.06)	0.69 (± 0.12)	0.52 (± 0.13)
16:1n-7DMA	0.72 (± 0.26)	1.8 (± 0.58)	1.35 (± 0.39)
18:0DMA	1.15 (± 0.28)	2.9 (± 0.5)	2.21 (± 0.44)
20:1n-7DMA	–	1.89 (± 0.96)	1.18 (± 0.76)
Σ DMA	**2.12 (± 0.54)**	**7.57 (± 0.9)**	**5.43 (± 1.06)**

Table S2. Continued and end: Clear Lake (CLM)

	CLM NLFA n = 21	PLFA n = 21	TLFA n = 21
14:0	1.39 (± 0.43)	0.42 (± 0.13)	0.75 (± 0.22)
16:0	19.59 (± 6.08)	14.15 (± 1.86)	16.01 (± 2.99)
17:0	–	1.63 (± 0.3)	1.08 (± 0.21)
18:0	19.77 (± 3.43)	17.03 (± 1.47)	17.92 (± 1.72)
Σ SFA	**42.29 (± 9.22)**	**34.98 (± 2.79)**	**37.45 (± 4.34)**
16:1n-5	2.41 (± 0.79)	–	0.8 (± 0.28)
16:1n-7	1.76 (± 0.55)	1.25 (± 0.25)	1.42 (± 0.25)
16:1n-9	1.36 (± 0.82)	0.39 (± 0.38)	0.72 (± 0.37)
18:1n-7	1.64 (± 0.45)	2.39 (± 0.36)	2.14 (± 0.34)
18:1n-9	2.39 (± 0.63)	2.06 (± 0.23)	2.17 (± 0.26)
20:1n-11	0.1 (± 0.11)	–	0.04 (± 0.04)
20:1n-9	0.15 (± 0.17)	0.1 (± 0.06)	0.12 (± 0.06)
22:1n-9	1.85 (± 1.35)	–	0.62 (± 0.41)
Σ MUFA	**12.48 (± 1.99)**	**6.49 (± 0.71)**	**8.51 (± 0.84)**
16:2n-4	–	2.22 (± 1.1)	1.44 (± 0.61)
16:4n-3	–	0.15 (± 0.05)	0.1 (± 0.03)
18:2n-6	1.58 (± 0.52)	3.77 (± 0.39)	3.04 (± 0.37)
18:2n-9	–	–	–
18:3n-3	0.69 (± 0.28)	1.17 (± 0.18)	1.02 (± 0.18)
18:3n-6	–	–	–
18:4n-3	3.95 (± 1.2)	1 (± 0.4)	1.99 (± 0.7)
18:5n-3	0.08 (± 0.15)	–	0.03 (± 0.06)
20:3n-3	3.42 (± 3.28)	–	1.15 (± 1.14)
20:4n-6	5.42 (± 2.45)	19.74 (± 2.42)	14.91 (± 2.22)
20:5n-3 (EPA)	2.29 (± 1.05)	11.33 (± 1.26)	8.3 (± 1.28)
21:5n-3	–	0.05 (± 0.04)	0.04 (± 0.02)
22:4n-6	2.06 (± 0.88)	2.13 (± 0.32)	2.11 (± 0.4)
22:5n-3	2.14 (± 1)	2.14 (± 0.59)	2.16 (± 0.5)
22:5n-6	0.47 (± 0.45)	0.67 (± 0.13)	0.61 (± 0.19)
22:6n-3 (DHA)	2.08 (± 0.97)	4.3 (± 0.7)	3.57 (± 0.73)
Σ PUFA	**25.38 (± 6.06)**	**50.04 (± 2.85)**	**41.76 (± 3.6)**
Σ n-3	*14.66 (± 3.16)*	*20.39 (± 1.89)*	*18.52 (± 1.59)*
Σ n-6	*10.72 (± 3.84)*	*27.42 (± 2.69)*	*21.8 (± 2.73)*
16:0DMA	2.82 (± 1)	1.47 (± 0.49)	1.91 (± 0.46)
16:1n-7DMA	4.23 (± 1.33)	1.97 (± 0.41)	2.71 (± 0.33)
18:0DMA	8.65 (± 2.49)	3.61 (± 0.65)	5.26 (± 0.71)
20:1n-7DMA	–	–	–
Σ DMA	**15.7 (± 4.51)**	**7.05 (± 1.42)**	**9.88 (± 1.22)**

Supplement 3: Potential stress in *Mastigias papua* from Palau and its impact on n-3:n-6 ratio of polar lipids as a trophic marker

Introduction

n-3:n-6 ratios are used in this study primarily as trophic markers of mixotrophy (see main text). However, the position of medusae from Goby Lake (GLK) relative to medusae from other sites is substantially lower in n-3:n-6 of polar lipid fatty acids (PLFA) than what is seen in other trophic markers (Fig. 6c and d in the main text). This suggests that n-3:n-6 ratios in PLFA can be affected by factors other than nutrition. The proportion of n-3 polyunsaturated fatty acids (PUFA) in photosymbiotic cnidarians can be negatively affected by stress (e.g. heat, nutrient limitation, Tolosa et al. 2011). A reduction in n-3 PUFA concentrations would then lead to a reduced n-3:n-6 ratio making stress a potential explanation for the discrepancy seen in this indicator.

To investigate this further, we compute here another indicator of stress: unsaturation. Unsaturation of membrane fatty acids (FA) control membrane fluidity (e.g. Cossins & Prosser 1978). In cnidarian-zooxanthellae symbioses, good membrane fluidity is central to the symbiosis health (Tchernov et al. 2004). However, stress (e.g. heat, nutrient limitation) can increase the proportion of saturated fatty acids (SFA) and reduce the proportion of polyunsaturated fatty acids (PUFA) and most particularly n-3 PUFA (Al-Moghrabi et al. 1995, Tolosa et al. 2011, Tagliafico et al. 2017) therefore reducing unsaturation. Thus, a reduced unsaturation, particularly in PLFA—which comprise membrane FA—could be interpreted as a sign of stress. This could be confused by temperature (Cossins & Prosser 1978), but it is unlikely in the context of this study where the temperatures of the different sampling sites did not differ much (measured at 5 m deep; hottest: Clear Lake 33 °C, coldest: Lagoon 30 °C).

In addition, we investigate here the relationship between average unsaturation and the second principal component for the principal component analysis as the latter is supported by numerous n-3 PUFA (e.g. 18:4n-3, 20:5n-3, 22:6n-3, Fig. 5b in the main text).

Method

Average unsaturation was computed from the fatty acids composition of *Mastigias papua* medusae obtain as detailed in the main text (section 2.3.) as:

$$U = \frac{\sum P_{FAn} \times n}{\sum P_{FAn}}$$

With P_{FAn} the proportion of a given fatty acid of unsaturation n. Note that this was computed for both neutral lipid's fatty acids (NLFA) and polar lipid's fatty acids (PLFA).

The influence of medusa wet mass and sampling site on average unsaturation was tested using the same protocol as described in section 2.4. of the main text: ANCOVAs with permutation followed by model simplification in case of a lack of effect of wet mass (either alone or through its interaction with sampling site). In addition, the Pearson's correlation coefficient (r_P) between average unsaturation and PC2 of the ACPs described in the main text was computed.

Results

The average unsaturation was unaffected by medusa wet mass in both NLFA and PLFA (ANCOVAs with permutation, p-value > 0.05 for medusa mass and interaction between medusa mass and sampling site). The model was thus simplified to take in account sampling site only. Sampling site was found to have a significant effect on both NLFA (Kruskal-Wallis test, χ^2 = 15.5, p-value < 0.001) and PLFA (Kruskal-Wallis test, χ^2 = 62.8, p-value < 0.001) average unsaturation. In NLFA, the average unsaturation was relatively similar from one site to another (generally between 1 and 1.5, Fig. S3a). By comparison, in PLFA, larger differences were observed (Fig. S3b). The average unsaturation of PLFA was rather constant and high in medusae from the lagoon, NLK and CLM (between 2 and 3 as a function of the site with a range size within a site never exceeding 0.5, Fig. S3b). By opposition, medusae from GLK and, in a lesser extent, OTM, had much more variable average unsaturation of their PLFA (range respectively ca. 0.75-2.75 and 1.25-2.75, Fig. S3b). Medusae from GLK were essentially separated in two groups (Fig. S3b) which is similar to their distribution across the PC2 of the PCA performed on PLFA (Fig. 5b in the main text). The similarity between PC2 and unsaturation is further supported by the good correlation between PC2 and unsaturation in PLFA (r_P = 0.93 in, p-value < 0.05) and in NLFA (r_P = -0.74, p-value < 0.05) although the latter is harder to interpret as PC2 of NLFA only represents a small (6.92 %) proportion of the variation in NLFA composition. Two groups can therefore be delineated in the population of medusae from GLK, one with low average unsaturation characterized by numerous n-3 PUFA, the other with high average unsaturation characterized by SFA (Fig. S3b and Fig. 5b in the main text).

Discussion

Medusae from GLK of the group with high SFA, low n-3 PUFA and low average unsaturation can be interpreted as presenting signs of stress (Tolosa et al. 2011, Tagliafico et al. 2017). It is interesting to note that some other medusae from GLK did not presented these signs suggesting that the stress is specific to individuals. Why some individuals experience more stress than other remains unclear, but this does not appear to be linked to their size as no significant relationship between medusa wet mass and either the PC2 or unsaturation of their PLFA have been found (result not shown). This stress, through a decrease in n-3 PUFA (Tolosa et al. 2011, Tagliafico et al. 2017) might also explain why the n-3:n-6 ratios of the PLFA from medusae from GLK is relatively low (Fig. 6d in the main text). Although to a lesser extent, these signs of stress are also found in some medusae from OTM.

Potential stress-inducing environmental factors are numerous. Some of the most studied are heat stress and food limitation which can act synergistically (e.g. Tagliafico et al. 2017). *Mastigias papua* from Palau are known to be susceptible to heat stress and to react through bleaching (Dawson et al. 2001) a process which is known in scleractinian corals, to affect FA

compositions (e.g. Bachok et al. 2006). However, medusae from GLK did not presented any signs of bleaching which make the hypothesis of a heat-stress unlikely. Another possibility is food limitation. Although no abundances data are available, we noticed that zooplankton densities in GLK appeared particularly low as compared to other lakes. This food limitation may have resulted in a nutritive stress for the medusae as zooplankton predation can be important for access to nitrogen and phosphorus (e.g. Kremer 2005) or organic compounds such as lipids (Tagliafico et al. 2017).

Literature Cited

Al-Moghrabi S, Allemand D, Couret JM, Jaubert J (1995) Fatty acids of the scleractinian coral *Galaxea fascicularis*: effect of light and feeding. J Comp Physiol B 165:183–192

Bachok Z, Mfilinge P, Tsuchiya M (2006) Characterization of fatty acid composition in healthy and bleached corals from Okinawa, Japan. Coral Reefs 25:545–554

Cossins AR, Prosser CL (1978) Evolutionary adaptation of membranes to temperature. Proc Nat Acad Sci USA 75:2040–2043

Dawson MN, Martin LE, Penland LK (2001) Jellyfish swarms, tourists, and the Christ child. Hydrobiologia 451:131–144

Kremer P (2005) Ingestion and elemental budgets for *Linuche unguiculata*, a scyphomedusa with zooxanthellae. J Mar Biol Assoc UK 85:613–625

Tagliafico A, Rudd D, Rangel MS, Kelaher BP, Christidis L, Cowden K, Scheffers SR, Benkendorff K (2017) Lipid-enriched diets reduce the impact of thermal stress in corals. Mar Ecol Prog Ser 573:129–141

Tchernov D, Gorbunov MY, de Vargas C, Yadav SN, Milligan AJ, Häggblom M, Falkowski PG (2004) Membrane lipids of symbiotic algae are diagnostic of sensitivity to thermal bleaching in corals. Proc Natl Acad Sci USA 101:13531–13535

Tolosa I, Treignier C, Grover R, Ferrier-Pagès C (2011) Impact of feeding and short-term temperature stress on the content and isotopic signature of fatty acids, sterols, and alcohols in the scleractinian coral *Turbinaria reniformis*. Coral Reefs 30:763–774

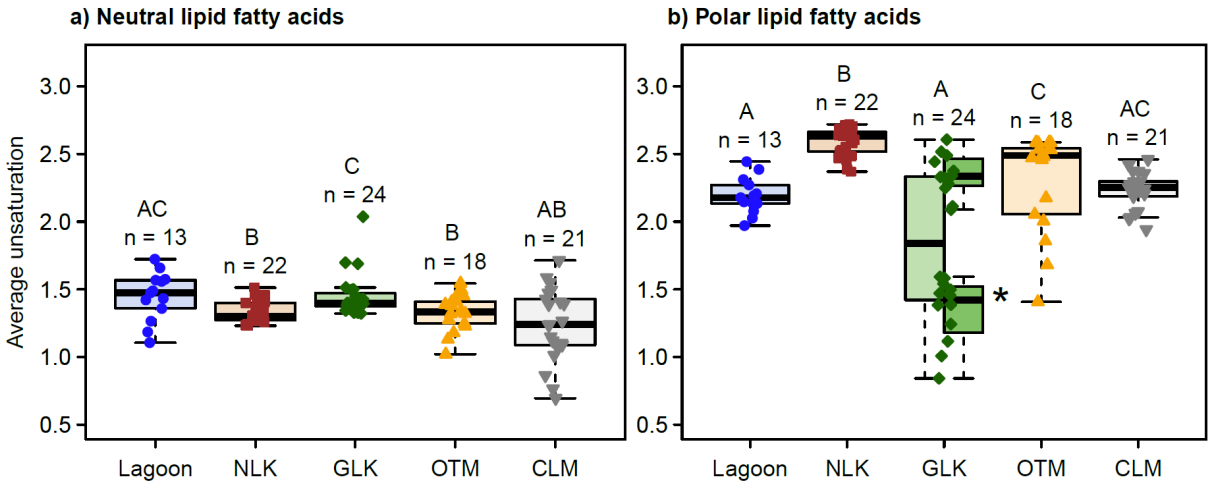

Fig. S3. Effect of sampling sites of *Mastigias papua* on their average unsaturation in (a) neutral lipid fatty acids (NLFA) and in (b) polar lipid fatty acids (PLFA). Boxplots represent the median, 1st and 3rd quartiles and minimum and maximum, excluding outliers. Statistically significant differences are indicated by different capital letters (A, B and C; Dunn post-hoc tests, p-value < 0.05). No significant effect of medusa wet mass has been found (see table 4). *In PLFA, the medusae from GLK were clearly split in two groups (highlighted by the darker green boxplots). The group with the lowest unsaturation was significantly different from all other groups (Dunn post-hoc test, p-value < 0.05)

Supplement 4: Organ-specific patterns and their importance for the interpretation of $\delta^{13}C$ signatures

Introduction

Isotopic and elemental composition of oral arms (as opposed to umbrella) were also obtained for the *Mastigias papua* medusae sampled. Here, we discuss organ-specific patterns and the important consequence they have for the interpretation of the $\delta^{13}C$ signatures.

Method

The isotopic and elemental data was obtained following the same protocol as detailed in the main text (see section 2.2. in main text). They were however not corrected by the isotopic baseline as we do not compare between the different sites here.

ANCOVAs with permutations (10 000 permutations) were performed to assess the effect of medusa wet mass and organ. These were performed separately on each sampling site and used the organ (umbrella versus oral arms) as the categorical factor and Log_{10} transformed medusa wet mass as the covariate. It was checked; 1) if the slopes for the different organs were significantly different (i.e. p-value of the interaction organ-medusa mass < 0.05); 2) if not, it was checked if the slopes were significant (i.e. p-value of the effect of the medusa mass < 0.05); and 3) if the intercept for the different organs were different (i.e. p-value of the effect of the organ < 0.05).

Results

The $\delta^{13}C$ signature of *Mastigias papua* varied according to organ and the medusa wet mass. In medusae from Uet era Ngermeuangel (NLK), Goby Lake (GLK) and Ongeim'l Tketau (OTM) the patterns are similar: With medusa size, the $\delta^{13}C$ in oral arms tend to stay constant whereas it increases in the umbrella (Fig. S4A). In the medusae from the lagoon, the $\delta^{13}C$ tend to increase with size. Oral arms have a lower $\delta^{13}C$ than umbrella but have no different slopes in relation to medusa size (Fig. S4A). In medusae from Clear Lake (CLM) size have no significant effect, and oral arms have a lower $\delta^{13}C$ signature than umbrella (Fig. S4A).

The $\delta^{15}N$ signature of *Mastigias papua* also varied according to organ and the medusa wet mass. Medusae from GLM and OTM presented similar patterns; $\delta^{15}N$ signatures tended to decrease with medusa size. This decrease was faster in oral arms than in umbrella (Fig. S4A). Medusae from NLK and CLM presented an opposed pattern with their $\delta^{15}N$ increasing with medusa size (albeit without significant differences in slopes between oral arms and umbrella, Fig. S4A). The $\delta^{15}N$ of medusae from the lagoon was not significantly influenced by medusa size (Fig. S4A). Lastly, in medusae from most sites (Lagoon, GLK, OTM, and CLM) the $\delta^{15}N$ of oral arms was lower than the $\delta^{15}N$ of umbrella. This pattern was however reversed in medusae from NLK (Fig. S4A).

Finally, the C:N ratios of medusae were neither influenced by their size nor the organ sampled in most sites (Lagoon, NLK, GLK, and CLM, Fig. S4A). The only exception was

medusae from OTM which had increasing C:N ratios with size, and oral arms of lower C:N ratios than umbrella (Fig. S4A).

Discussion

A strong pattern of $\delta^{13}C$ data in this study is an increase of the values with medusa size in umbrella of medusae of all sites except in medusae from Clear Lake (CLM, Fig. S4A). This increase is thus seen only in medusae with Symbiodiniaceae but is generally not mirrored in their oral arms (Fig. S4A). This is odd, as an increase in $\delta^{13}C$ due to increased autotrophy (see main text) would be expected to be stronger in oral arms which contain more Symbiodiniaceae (Muscatine et al. 1986, Freeman et al. 2016). Moreover, this pattern is supported by neither $\delta^{15}N$ or C:N ratios (which would be expected to be, respectively, negatively and positively correlated to $\delta^{13}C$, see main text). Hence we hypothesize that the increases seen in the $\delta^{13}C$ signatures of the umbrella, but not in oral arms, are explained by other mechanisms linked to the shapes of these organs.

One hypothetical mechanism can be based on the "depletion-diffusion hypothesis" (see Muscatine et al. 1989, reviewed in Ferrier-Pagès & Leal 2019). *In-hospite* pools of dissolved inorganic carbon have two sources: (1) respiration (of both symbionts and host) and (2) diffusion from the surrounding sea-water; and one sink: photosynthesis performed by the symbionts. When photosynthesis is high, the carbon pool gets depleted resulting in less fractionation during inorganic carbon uptake by the algae and thus an increase in $\delta^{13}C$ values (Muscatine et al. 1989, Swart et al. 2005, Ferrier-Pagès & Leal 2019 see also Fry 1996). In this context the different shapes of the oral arms and of the umbrella may be of importance: The umbrella, with medusa growth, gets thicker whether oral arms become more and more complex (Uchida 1926). The complex shape of oral arms would favor diffusion of dissolved inorganic carbon from surrounding water whether this would get more and more limited in the umbrella as it gets thicker (Fig. S4B). This limitation of the diffusion in the umbrella would then increase fractionation even without increase of photosynthesis.

An alternative mechanism can be hypothesized based on Freeman et al. (2016, 2017). They observed that umbrella tissues are isotopically enriched relative to oral arms in *Cassiopea xamachana* which is in agreement with what is found here (with the exception of $\delta^{15}N$ in medusae from NLK, Fig. S4A). Freeman et al. (2016, 2017) attributed this to a trophic transfer from the oral arms to the umbrella. To explain the size-related pattern seen here, it may be hypothesized that this transfer of matter from the oral arms to the umbrella increases with medusa size, compensating its reduced access to dissolved nutrients.

These two mechanism remain hypothetical but could, in conjunction or not, explain the size-related patterns documented here. Therefore, the different shapes of the umbrella and of the oral arms would explain their differences in the evolution of their $\delta^{13}C$ signatures along medusa sizes. Importantly, this implies that the strong size-specific patterns seen in $\delta^{13}C$ data cannot be interpreted as variation in nutrition.

LITERATURE CITED

Ferrier-Pagès C, Leal MC (2019) Stable isotopes as tracers of trophic interactions in marine mutualistic symbioses. Ecol Evol 9:723–740

Freeman CJ, Stoner EW, Easson CG, Matterson KO, Baker DM (2016) Symbiont carbon and nitrogen assimilation in the *Cassiopea-Symbiodinium* mutualism. Mar Ecol Prog Ser 544:281–286

Freeman CJ, Stoner EW, Easson CG, Matterson KO, Baker DM (2017) Variation in $\delta^{13}C$ and $\delta^{15}N$ values suggests coupling of host and symbiont metabolism in the *Symbiodinium-Cassiopea* mutualism. Mar Ecol Prog Ser 571:245–251

Fry B (1996) $^{13}C/^{12}C$ fractionation by marine diatoms. Mar Ecol Prog Ser 134:283–294

Muscatine L, Wilkerson FP, McCloskey LR (1986) Regulation of population density of symbiotic algae in a tropical marine jellyfish (*Mastigias* sp.). Mar Ecol Prog Ser 32:279–290

Muscatine L, Porter JW, Kaplan IR (1989) Resource partitioning by reef corals as determined from stable isotope composition I. $\delta^{13}C$ of zooxanthellae and animal tissue versus depth. Mar Biol 100:185–193

Swart PK, Saied A, Lamb K (2005) Temporal and spatial variation in the $\delta^{15}N$ and $\delta^{13}C$ of coral tissue and zooxanthellae in *Montastraea faveolata* collected from the Florida reef tract. Limnol Oceanogr 50:1049–1058

Uchida T (1926) The anatomy and development of a rhizostome medusa, *Mastigias papua* L. Agassiz, with observations on the phylogeny of Rhizostomae. J Fac Sci Imp Univ Tokyo (IV: Zool) 1:45–95

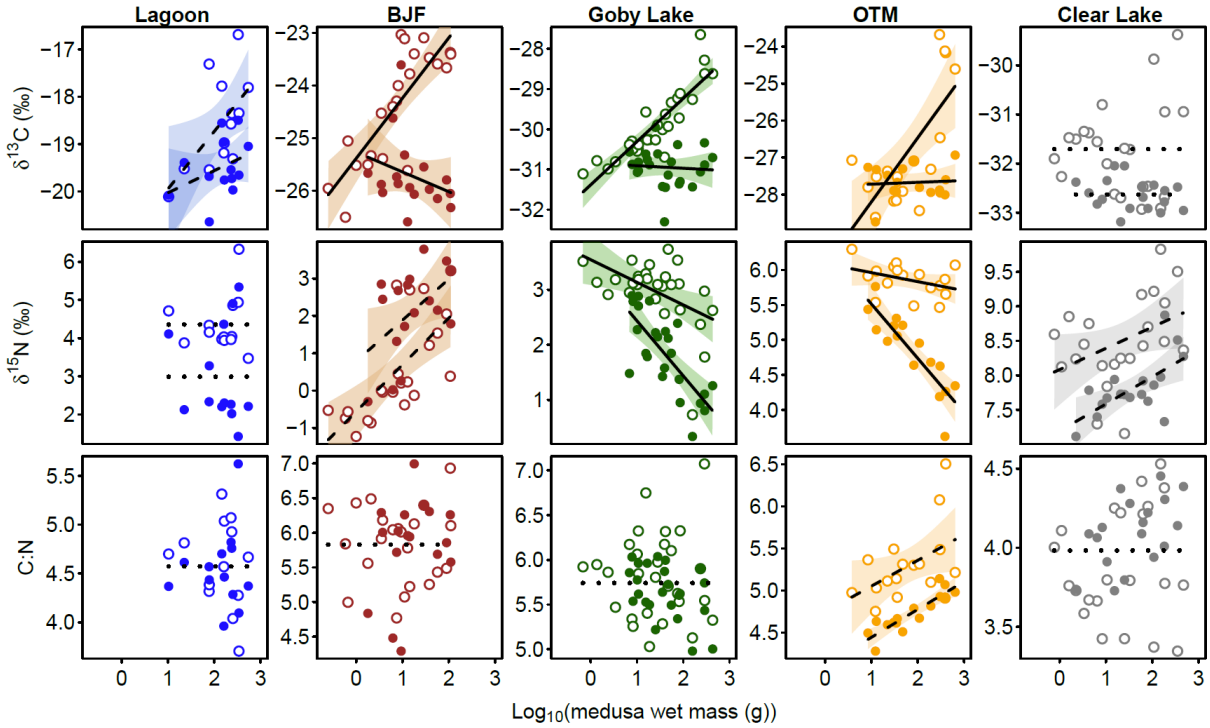

Fig. S4A. Effect of medusa size (wet mass) and organ (umbrella (full symbols) versus oral arms (empty symbols)) on $\delta^{13}C$ (top panels), $\delta^{15}N$ (middle panels) and mass C:N ratios (bottom panels) in *Mastigias papua* in the different sites sampled. Horizontal dotted lines without shaded areas indicate no significant effect of medusa wet mass. If there is no effect of the organ only one line is drawn. Dashed lines indicate significant effect of size with no significant difference of slopes between umbrella and oral arms. Solid lines indicate significant effect of the interaction wet mass-organ (i.e. significantly different slopes between umbrella and oral arms). Shaded areas are 95 % C. I. around regression lines. Statistics are based on ANCOVAs with permutations. The threshold for statistical significance was set at $\alpha = 0.05$. Note the different scales on the y-axes

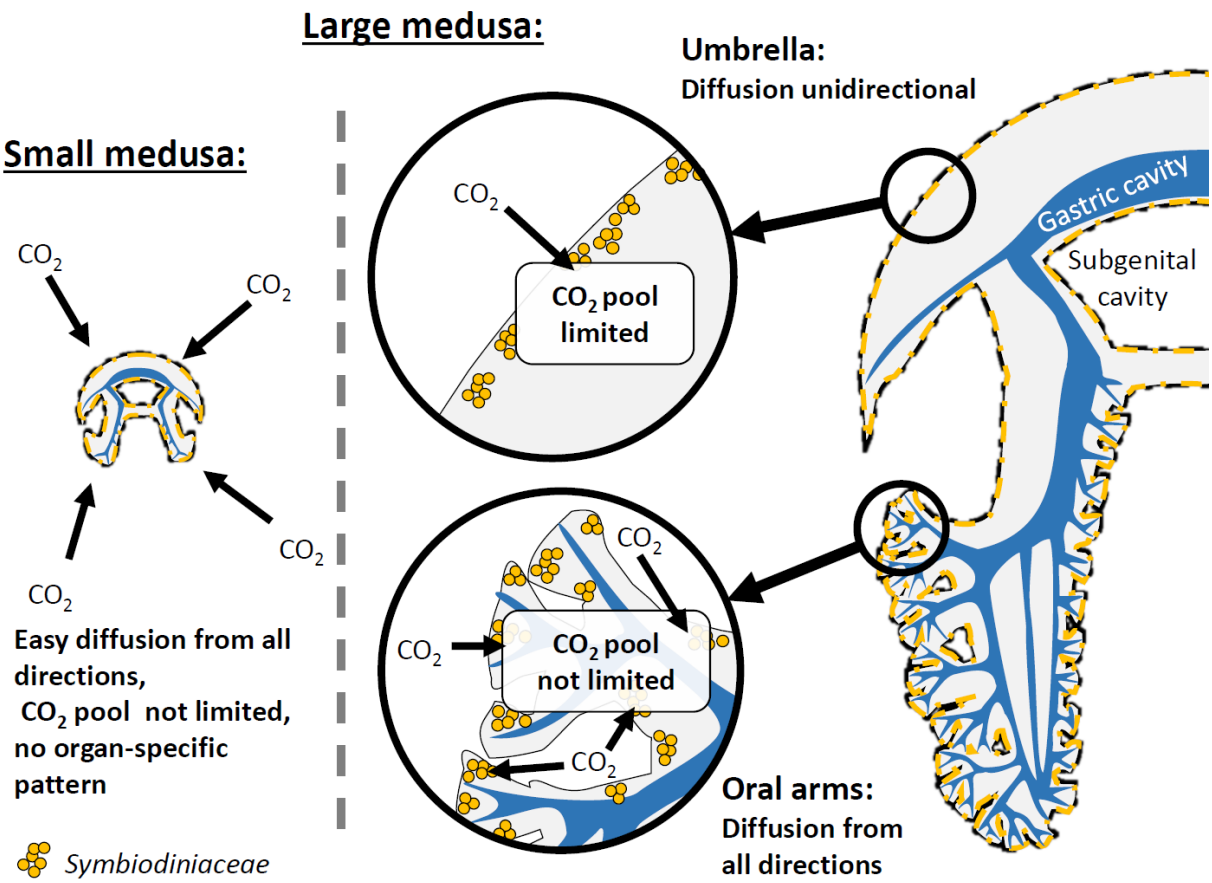

Fig. S4B. Hypothesized effects of medusa size and organ shapes on the diffusion of dissolved CO_2 from the sea-water to the Symbiodiniaceae through the host tissues. Due to their complex shape, the oral arms would favor diffusion unlike the umbrella. Blue = digestive system, orange = Symbiodiniaceae cells. See Uchida (1926) for details on *Mastigias* anatomy and development