Carbon injection potential of the mesopelagic-migrant pump in the Southern Ocean during summer

Authors

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Supplementary Material

1 Acoustics

The RV Investigator's Simrad EK80 echosounders continuously recorded calibrated acoustic data within a vertical range of 1500 m. Pulses lasting 2.048 ms were emitted every 2-3 s from split-beam transducers operating at 18, 38, 70, 120, and 200 kHz, mounted on the vessel's retractable keel. The acoustic data, visualized as echograms (refer to **Figure 5**), were processed using Echoview V.11.1.49 software in accordance with IMOS open ocean standards. Any instances of poor data quality, such as when equipment obstructed the acoustic beam, were identified visually and removed manually. Backscattering strengths (Sv; dB re 1 m^2 m^{-3}) were calculated from the 'cleaned' echograms, averaging over 50 pings horizontally and 5 m vertically. Data from 30 m to 200 m depth, beyond the influence of bubble interference and the near-field for all transducers, were selected using a threshold of -

80 dB re 1 m^2 m^{-3}. Daytime and nighttime periods were defined as 10:00–14:00 hours and 00:00–03:00 hours, respectively.

2 Tables and Figures

Table 1 | Length to weight equations used to determine the carbon weight (CW; in mg) and dry weight (DW; in mg) of micronekton sampled with the RMT'16 net and mesozooplankton with the Neuston net. Lengths are given in total length (TL; mm) or standard length (SL; mm).

Taxonomic group	Length to CW	CW to DW *
Prawn[1,2,3] (Decapod)	$CW = 10^\wedge(3.787 * log\_10\ (TL) - 3.972) * 0.435$	$DW = CW/0.42$ (10)
Crustacean[1,2,4] (amphipod)	$CW = 10^\wedge(2.717 * log\_10\ (TL) - 1.911) * 0.345$	$DW = CW/0.37$ (11)
Krill[1,2]	$CW = 10^\wedge(3.23 * log\_10\ (TL) - 3.261) * 0.419$	$DW = CW/0.39$ (10)
Chaetognath[1,2]	$CW = 0.0001352 * TL^\wedge 3.1545 * 0.367$	$DW = CW/0.39$ (10)
Fish[1,5,6] (Myctophidae)	$CW = 10^\wedge(2.902 * log\_10\ (SL) - 1.797) * 0.092$	$DW = CW/0.44$ (10)
Gelatinous[1,7,8] (jellyfish)	CW = 10^ (2.767*log_10 (TL)-3.643)	$DW = CW/0.11$ (12)
Pyrosome[1,9]	$CW = (0.0013 * TL^\wedge 2 + 0.0151 * TL) * 39.2$	$DW = CW/0.35$ (9)
Salp(this study)	$CW = -0.0069TL2 + 0.7618TL - 14.446$	$DW = CW/0.20$ (this study)
Copepod[4] (*R. gigas*)	$DW = 0.0822 * e^{(0.4079*TL)}$	NA
Copepod[4] (*Oithona* spp.)	L = 0.75 mm DW= 0. 0094 mg	NA
Copepod[18] (*N. tonsus*)	$DW = 469.64 * TL - 1123.06$	NA

*Superscripts denote references

Table 2 | Regressions used to calculate respiratory oxygen uptake (RO; µL O_2 ind. h^{-1}); RQ = respiratory quotient; DW = dry weight of an individual in milligrams; D = depth in meters; T = temperature in Celsius.

Taxonomic group	Weight to RO	RQ
Prawn[1,11, 13] (Decapod)	$RO = e\text{^}(-0.2512 + 0.7886 * ln(DW) + 0.0490 * T)$	0.97
Crustacean[1, 14] (amphipod)	$RO = e\text{^}(19.191 + 0.766\, ln(DW) - 5.256 * (1000/(T + 273.15)) - 0.113 ln(D))$	1.45
Krill[1,15]	$RO = e\text{^}(0.392 + 0.753\, ln(DW) + 0.046 * (1000/(T + 273.15)) - 0.107 ln(D))$	1.7
Chaetognath[1,14]	$RO = e\text{^}(18.327 + 0.766\, ln(DW) - 5.256 * (1000/(T + 273.15)) - 0.113 ln(D - 0.448))$	1.67
Fish[1,16] (Myctophidae)	$RO = e\text{^}(26.083 + 0.885\, ln(DW) - 7.374 * (1000/(T + 273.15)) - 0.124 ln(D))$	2.5
Gelatinous[1,11] (jellyfish)	$RO = e\text{^}(-0.2512 + 0.7886 * ln(DW) + 0.0490 * T)$	0.97
Pyrosome[1,9]	$RO = e\text{^}(21.917 + 0.762\, ln(DW) - 5.739 * (1000/(T + 273.15)) - 0.269 ln(D))$	2.8
Salp[1,17]	$RO = e\text{^}(21.917 + 0.762\, ln(DW) - 5.739 * (1000/(T + 273.15)) - 0.269 ln(D))$	1.6
Copepod[1,12]	$RO = e\text{^}(18.775 + 0.766 * \log(DW) + \left(-5.256 * \left(\frac{1000}{T + 273.15}\right)\right) - 0.113 * \log(D)$	1.58

Table 3 | Gut flux (gut carbon; GC) parameters; ISF = index of stomach fullness in % of total body weight; DW = dry weight in milligrams; CW = carbon weight in milligrams; GPT = gut passage time in hours; T = temperature in degrees Celsius.

Taxonomic group	ISF	GPT (h)
Prawn[1] (Decapod)	0.0104 *DW	1.5
Crustacean[1] (amphipod)	5.3	4.8
Krill[1]	1.2	2.3
Chaetognath[1]	36.6	10.96*e^0.086(T)
Fish[1] (Myctophidae)	3.3	2.6
Gelatinous[1] (jellyfish)	0.03 *CW	1.43
Cephalopod[1]	0.042	2
Pyrosome[1*]	NA	1.43
Salp[1*]	NA	1.43
Copepod[1]	1.2	1.04

*tunicates – fecal pellet production = 0.25 *CW; gut flux -> GF = (FP/24)*(GPT-DM)

Table 4 | Biomass (mg C m^{-3}) and percentage contribution of micronekton taxa per site, depth, and time of day. E = epipelagic (0 – 200 m depth); UM = upper mesopelagic (200 – 400 m depth); LM = lower mesopelagic (400 – 1000 m depth).

Site	Taxon	Depth Stratum	Day (mg C m^{-3})	Night (mg C m^{-3})
SOTS	Crustacean (other)	E	0.003	0.056
SOTS	Fish	E	0.032	0.293
SOTS	Gelatinous (other)	E	0.357	0.391
SOTS	Krill	E	0.006	0.166
SOTS	*P. atlanticum*	E	0.276	2.053
SOTS	*S. thompsoni*	E	0.000	0.000
SOTS	Crustacean (other)	UM	0.012	0.057
SOTS	Fish	UM	0.020	0.320
SOTS	Gelatinous (other)	UM	0.040	0.047

SOTS	Krill	UM	0.006	0.038
SOTS	*P. atlanticum*	UM	2.789	0.036
SOTS	*S. thompsoni*	UM	0.000	0.000
SOTS	Crustacean (other)	LM	0.102	0.033
SOTS	Fish	LM	0.442	0.031
SOTS	Gelatinous (other)	LM	0.059	0.019
SOTS	Krill	LM	0.011	0.005
SOTS	*P. atlanticum*	LM	0.021	0.097
SOTS	*S. thompsoni*	LM	0.000	0.000
P1	Crustacean (other)	E	0.006	0.011
P1	Fish	E	0.007	0.187
P1	Gelatinous (other)	E	0.031	0.185
P1	Krill	E	0.002	0.107
P1	*P. atlanticum*	E	0.000	0.000
P1	*S. thompsoni*	E	0.461	5.297
P1	Crustacean (other)	UM	0.012	0.014
P1	Fish	UM	0.001	0.084
P1	Gelatinous (other)	UM	0.396	0.165
P1	Krill	UM	0.003	0.075
P1	*P. atlanticum*	UM	0.000	0.000
P1	*S. thompsoni*	UM	2.624	0.883
P1	Crustacean (other)	LM	0.267	0.144
P1	Fish	LM	0.680	0.284
P1	Gelatinous (other)	LM	0.207	0.141
P1	Krill	LM	0.060	0.034
P1	*P. atlanticum*	LM	0.000	0.000
P1	*S. thompsoni*	LM	0.083	0.511
P2	Crustacean (other)	E	0.098	0.121
P2	Fish	E	0.003	0.239
P2	Gelatinous (other)	E	0.061	0.058
P2	Krill	E	0.000	0.767
P2	*P. atlanticum*	E	0.000	0.000
P2	*S. thompsoni*	E	4.872	1.666
P2	Crustacean (other)	UM	0.006	0.051
P2	Fish	UM	0.060	0.324

P2	Gelatinous (other)	UM	0.112	0.092
P2	Krill	UM	0.091	0.067
P2	*P. atlanticum*	UM	0.000	0.000
P2	*S. thompsoni*	UM	1.353	0.903
P2	Crustacean (other)	LM	0.087	0.088
P2	Fish	LM	0.316	0.246
P2	Gelatinous (other)	LM	0.398	0.106
P2	Krill	LM	0.038	0.030
P2	*P. atlanticum*	LM	0.000	0.000
P2	*S. thompsoni*	LM	0.080	0.179

Table 5 | Mean (± SD) downward carbon export (mg C m^{-2} d^{-1}) where BGP = Biological Gravitational Pump measured using sediment traps deployed at the base of the epipelagic (between 179 – 200 m depth); Micro = micronekton component of the Mesopelagic Migrant Pump (MMP); Meso = mesozooplankton component of the MMP.

Site	Pump	mg C m^{-2} d^{-1}	sd mg C m^{-2} d^{-1}
SOTS	BGP	106.53 (± 29.33)	29.33
SOTS	Micro	4.98 (± 1.47)	1.47
SOTS	Meso	1.26	NA
P1	BGP	111.93 (± 14.95)	14.95
P1	Micro	9.03 (± 6.29)	6.29
P1	Meso	63.13	NA
P2	BGP	79.8 (± 7.55)	7.55
P2	Micro	7.87 (± 1.63)	1.63
P2	Meso	67.48	NA

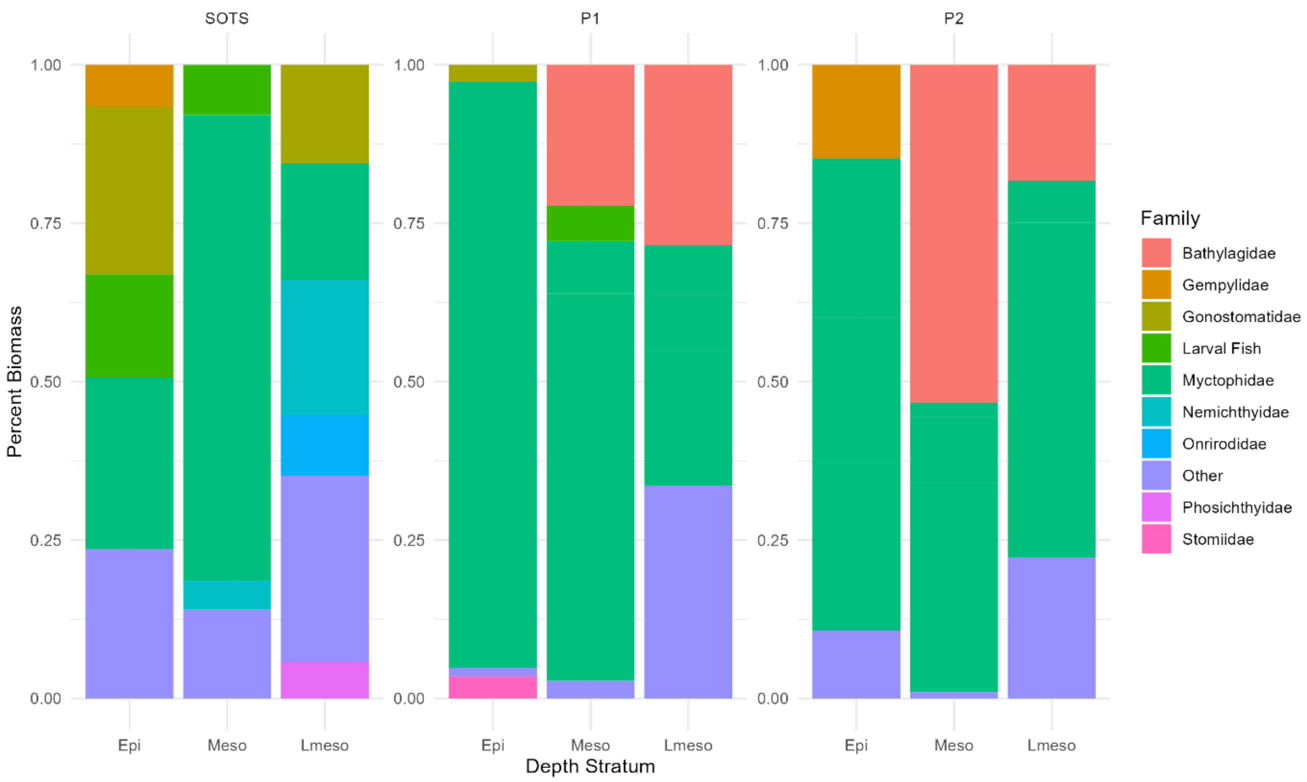

Figure 1. Dominant fish families in percentage of total biomass observed per site and depth stratum. Epi = epipelagic (0 – 200 m depth); Meso = upper mesopelagic (200 – 400 m depth); Lmeso = lower mesopelagic (400 – 1000 m depth).

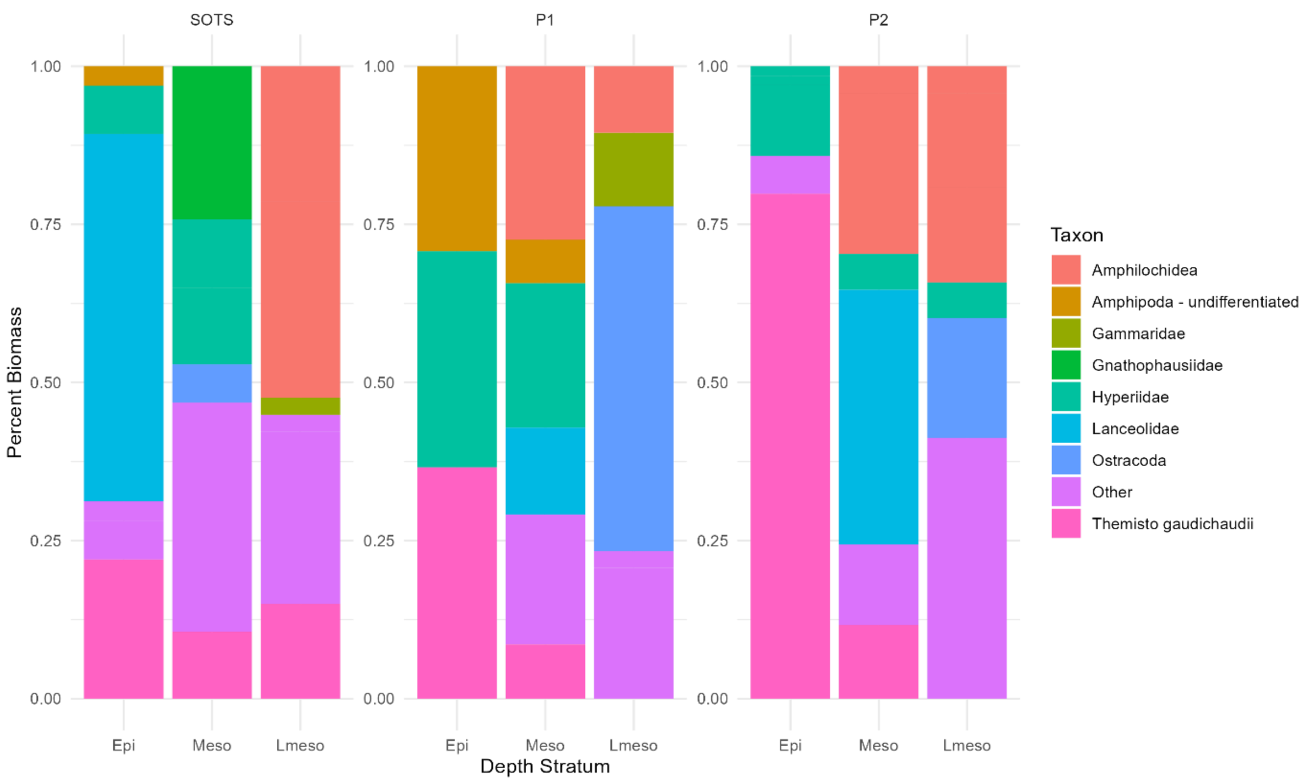

Figure 2. Dominant crustacean taxa in percentage of total biomass observed per site and depth stratum. Epi = epipelagic (0 – 200 m depth); Meso = upper mesopelagic (200 – 400 m depth); Lmeso = lower mesopelagic (400 – 1000 m depth).

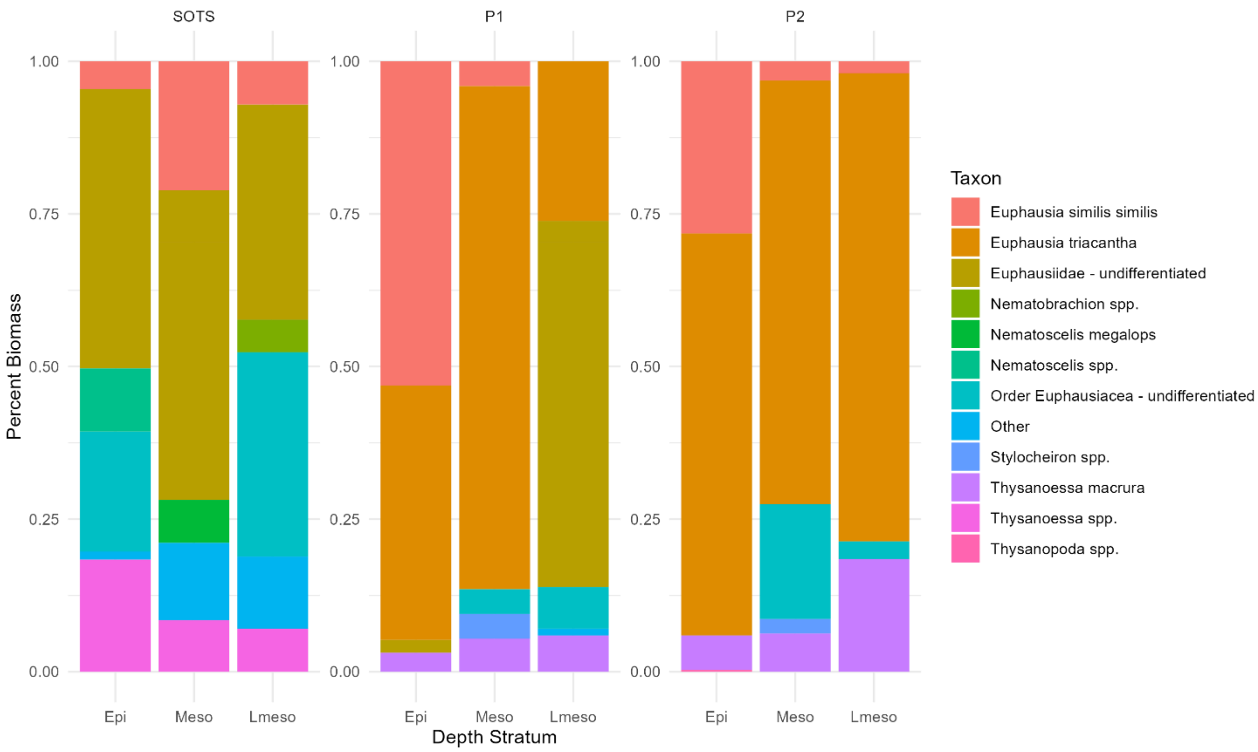

Figure 3. Dominant krill species in percentage of total biomass observed per site and depth stratum. Epi = epipelagic (0 – 200 m depth); Meso = upper mesopelagic (200 – 400 m depth); Lmeso = lower mesopelagic (400 – 1000 m depth).

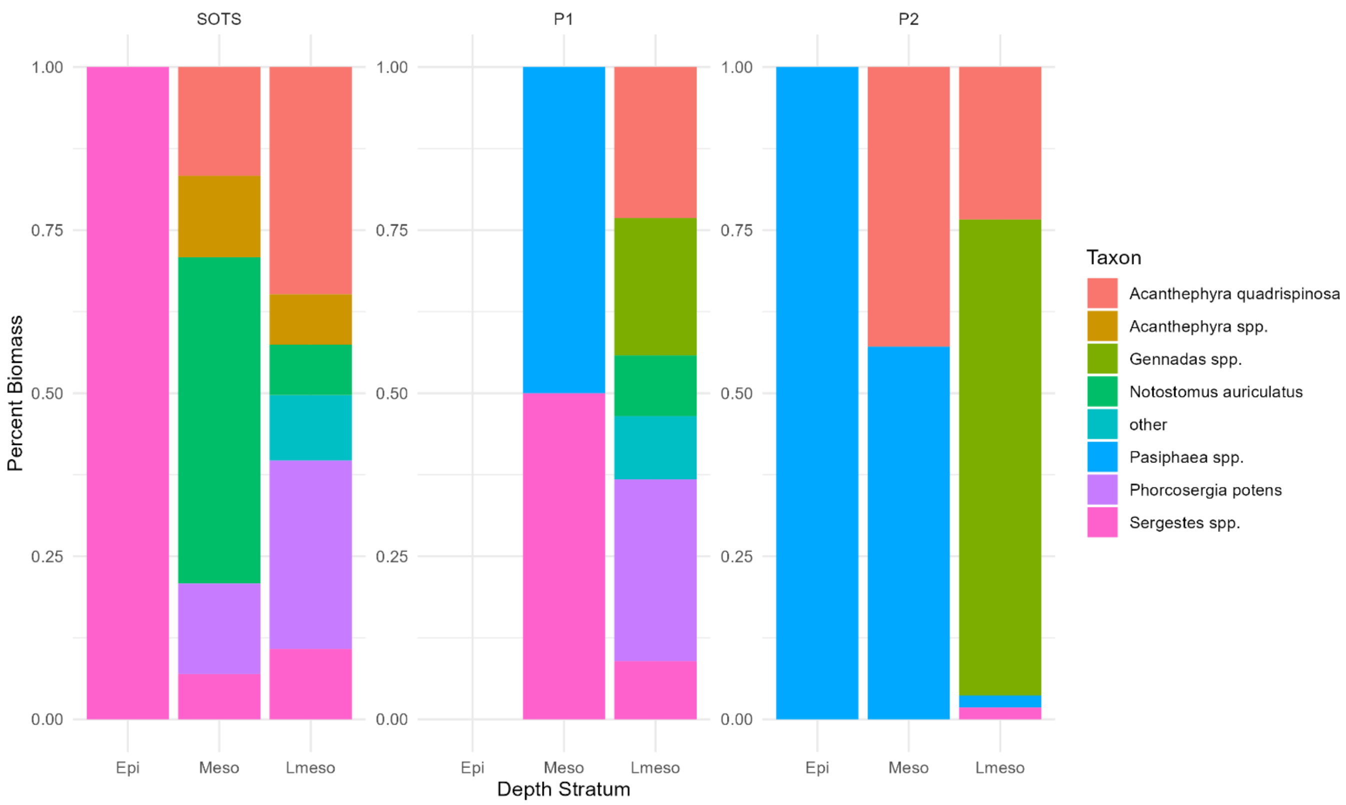

Figure 4. Dominant prawn species in percentage of total biomass observed per site and depth stratum. Epi = epipelagic (0 – 200 m depth); Meso = upper mesopelagic (200 – 400 m depth); Lmeso = lower mesopelagic (400 – 1000 m depth).

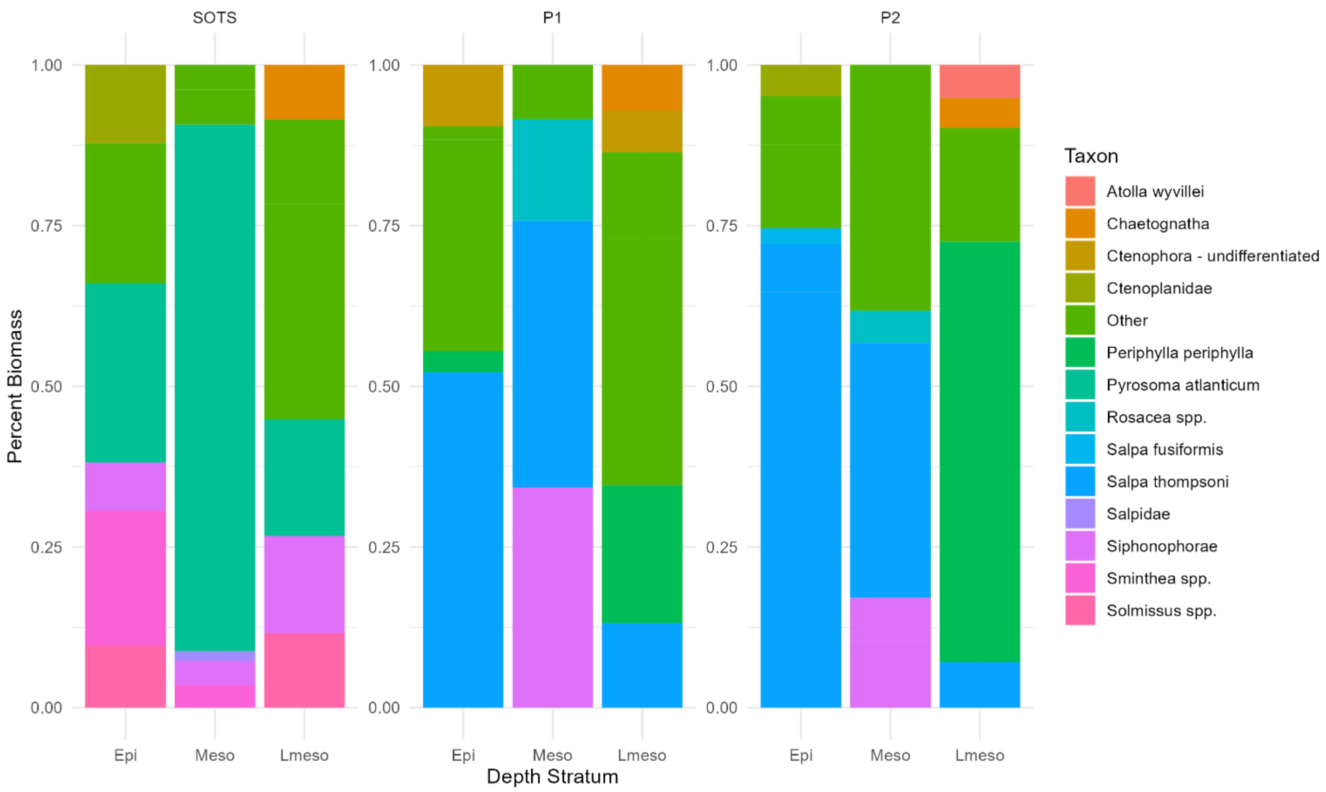

Figure 5. Dominant gelatinous taxa in percentage of total biomass observed per site and depth stratum. Epi = epipelagic (0 – 200 m depth); Meso = upper mesopelagic (200 – 400 m depth); Lmeso = lower mesopelagic (400 – 1000 m depth).

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