**Supplementary Materials**

**Foraging strategies under extreme events: Contrasting adaptations by benthic macrofauna to drastic biogeochemical disturbance**

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**Supplementary Text I: Background of the study region**

Kueishantao Island (KST, 24.843°N, 121.951°E), also known as Turtle Island, is situated at a tectonic junction off the coast of northeastern Taiwan and the southern end of the Okinawa Trough. KST is a Holocene stratovolcano and volcanic activity beneath the KST area is still vigorous, even though the last eruption occurred ~7000 years ago (Chen *et al.* 2005). In the last two decades, KST shallow vents are among the most intensively studied shallow vent systems in the world due to their extreme geochemical properties and their easy accessibility. The active YV vents are typically within the temperature range of >70 °C and fluid fluxes are up to 150 m3/h, whereas the temperature range of the semi-inactive WV fluctuates between 30–65 °C, with frequent degassing activity (Chen *et al.* 2005; Chen *et al.* 2018). The low pHvalues (down to 1.75 at certain locations) were recorded as the lowest in the world two decades ago (Chen *et al.* 2005). Before May 2016, more than 30 hydrothermal vents located at a water depth between 6 to 30 m were still active (Chen *et al.* 2005; Chen *et al.* 2018), making them easily accessible for scientists to study the geochemical and biological processes of these vent systems. However, in 2016, KST was hit by a M5.8 earthquake and a subsequent C5 typhoon within a few weeks (12th May and 2nd-10th July, respectively), disrupting normal conditions, and providing a unique opportunity to study food web changes induced by the extreme events.

**Supplementary Text II: Extreme impact of Earthquake and Typhoon in 2016.**

To demonstrate how M5.8 earthquake (12th May, 2016) and a subsequent C5 typhoon Nepartak (2nd-10th July, 2016) could have impacted our study area, we present three videos online (links below):

**Video S1. Turtle Island live earthquake video recorded and reported by the Taiwan National TV channel**. The Earthquake caused a tremor and subsequently triggered landslides on the cliff face in the KST vent region. Watch here: <https://www.youtube.com/watch?v=DI-1-t7peBI>.

**Video S2. KST ocean conditions during and after typhoon Nepartak in 2016.**

Using snapshot footages captured by NTU2 buoy camera during and after typhoon at the KST, we show the real-time offshore rough ocean conditions during the typhoon condition in July, 2016. In comparison, we show the calm ocean conditions side by side after the typhoon in August, 2016. These images are courtesy of the Institute of Oceanography at the National Taiwan University (https://po.oc.ntu.edu.tw/buoy/buoy2017/index.php). Watch here: <https://www.youtube.com/watch?v=bBKEqbTMPcA>

**Video S3. Turtle Island shallow vents changes from 2001 to 2017.** We made a video documenting a time-series of the KST vent activity change. These footages include helicopter and drone aerial video/photo from 2001 to 2017 as well as underwater filming around Turtle Island shallow vents from 1960 to 2017. In these images, we use arrows to demonstrate changes in the landscape and vent activities through time. Our video shows that although there were already gradual decreases in vent activities from 2001, the 2016 M5.8 earthquake and C5 typhoon have changed venting activity drastically. The major changes after the extreme events include: 1) a significant decrease in the intensity of conspicuous white color produced by the dominant chemoautotrophic sulfur bacteria (e.g. epsilonproteobacteria and gammaproteobacteria) in the WV seawater after the extreme events; 2) disappearance of abundant native sulfur accretions near the active Yellow Vent. Watch here: <https://www.youtube.com/watch?v=us6hIY5MqGU>

**Supplementary Text III.** **Will Oven-drying and freeze-drying method affect the stable isotope values for different batch of samples?**

We do not believe that there would be a significant difference of the freeze-drying vs oven-drying preparation method on the stable isotope values of our benthic macroinvertebrates. Both methods are commonly used. Oven-drying can cause isotopic fractionation due to the loss of lighter isotopes relative to the heavier isotopes during evaporation, potentially leading to slightly higher **13C and **15N values (de Lecea, Smit & Fennessy 2011). However, this effect is more pronounced in samples with high lipid content, such as fatty fish (e.g. salmon, sardines, tuna, and mackerel) with up to 20% lipid content and is not expected to significantly impact our results. A comparative study of freeze-drying and oven-drying preparation methods shows that these methods do not affect the isotope values of freshly caught benthic macroinvertebrates samples (Akamatsu et al. 2016). Even if had the oven-drying procedure caused lipid loss and led to 13C and 15N enrichment in our sampels, the **13C and **15N values of consumers in 2015 are actually lower than those in 2018. Therefore, our interpretation based on these data are not be affected. In addition, for organisms with C:N > 3.5, we applied lipid correction to *δ*13C values for muscle tissue samples (*n*=49) following Logan et al. (2008). This will allow us to account for effect of the lipid content on isotope values. We did not perform lipid extraction prior to stable isotope analyses of muscle tissues, because lipid extraction is known to affect *δ*15N values (Svensson *et al.* 2016).

**Supplementary Table S1.** Individual *δ*13C, *δ*15N and *δ*34S values of individual organisms and the shell width from the Kueishantao (KST) shallow hydrothermal vent.

| **Species** | **Body size(mm)** | **Year** | **13C** | **15N** | **34S** |
| --- | --- | --- | --- | --- | --- |
| *Bostrycapulus gravispinosus* | 14.24 | 2015 | -20.2 | 6.9 | 10.3 |
| *Bostrycapulus gravispinosus* | 13.92 | 2015 | -20.4 | 6.8 | 8.2 |
| *Bostrycapulus gravispinosus* | 13.77 | 2015 | -20.4 | 6.4 | 8.7 |
| *Ergalatax contracta* | 24.12 | 2015 | -19.2 | 8.2 | 7.3 |
| *Ergalatax contracta* | 22.62 | 2015 | -19.7 | 8.6 | 6.4 |
| *Ergalatax contracta* | 20.20 | 2015 | -20.3 | 7.8 | 6.7 |
| *Thylacodes adamsii* | N.D | 2015 | -21.4 | 7.4 | 4.8 |
| *Thylacodes adamsii* | N.D | 2015 | -21.6 | 7.1 | 7.5 |
| *Thylacodes adamsii* | N.D | 2015 | -21.1 | 6.6 | 9.4 |
| *Xenograpsus testudinatus* | 23.58 | 2015 | -13.1 | 5.0 | 4.3 |
| *Xenograpsus testudinatus* | 22.89 | 2015 | -11.1 | 5.2 | 6.9 |
| *Xenograpsus testudinatus* | 21.12 | 2015 | -13.6 | 5.3 | 6.3 |
| *Xenograpsus testudinatus* | 18.36 | 2015 | -16.8 | 6.1 | 10.0 |
| *Xenograpsus testudinatus* | 21.91 | 2015 | -16.9 | 6.7 | 10.3 |
| *Xenograpsus testudinatus* | 22.99 | 2015 | -15.6 | 5.2 | 9.4 |
| *Xenograpsus testudinatus* | 23.18 | 2015 | -15.5 | 4.0 | 7.7 |
| *Xenograpsus testudinatus* | 19.46 | 2015 | -15.7 | 5.7 | 10.3 |
| *Xenograpsus testudinatus* | 26.86 | 2015 | -18.1 | 5.3 | 9.1 |
| *Xenograpsus testudinatus* | 19.54 | 2015 | -18.0 | 6.7 | 7.9 |
| *Xenograpsus testudinatus* | 20.89 | 2015 | -16.1 | 4.3 | 3.9 |
| *Xenograpsus testudinatus* | 16.36 | 2015 | -13.2 | 5.2 | 7.6 |
| *Xenograpsus testudinatus* (male) | 22.83 | 2018 | -15.7 | 8.6 | 5.8 |
| *Xenograpsus testudinatus* (female) | 18.84 | 2018 | -16.9 | 7.8 | 6.7 |
| *Xenograpsus testudinatus* (male) | 23.84 | 2018 | -18.2 | 8.6 | 5.8 |
| *Xenograpsus testudinatus* (male) | 22.46 | 2018 | -15.3 | 8.2 | 5.3 |
| *Xenograpsus testudinatus* (female) | 18.69 | 2018 | -17.6 | 7.5 | 4.7 |
| *Xenograpsus testudinatus* (female) | 15.96 | 2018 | -16.3 | 6.0 | 1.2 |
| *Xenograpsus testudinatus* (male) | 24.31 | 2018 | -17.2 | 8.2 | 4.0 |
| *Xenograpsus testudinatus* (female) | 18.09 | 2018 | -16.5 | 7.8 | 8.0 |
| *Xenograpsus testudinatus* (male) | 22.18 | 2018 | -15.6 | 6.4 | 4.8 |
| *Xenograpsus testudinatus* (female) | 18.17 | 2018 | -17.8 | 8.1 | 5.7 |
| *Xenograpsus testudinatus* (male) | 27.14 | 2018 | -13.8 | 6.7 | 5.3 |
| *Xenograpsus testudinatus* (male) | 18.73 | 2018 | -15.7 | 7.1 | 5.9 |
| *Xenograpsus testudinatus* (male) | 19.16 | 2018 | -15.2 | 7.1 | 7.0 |
| *Xenograpsus testudinatus* (female) | 17.32 | 2018 | -15.5 | 6.9 | 5.7 |
| *Xenograpsus testudinatus* (female) | 19.53 | 2018 | -15.9 | 7.4 | 5.4 |
| *Xenograpsus testudinatus* (female) | 18.85 | 2018 | -15.5 | 7.4 | 5.8 |
| *Ergalatax contracta* | 20.85 | 2018 | -15.3 | 9.1 | 7.9 |
| *Ergalatax contracta* | 22.8 | 2018 | -15.2 | 10.5 | 9.5 |
| *Ergalatax contracta* | 18.0 | 2018 | -15.5 | 9.6 | 9.0 |
| *Ergalatax contracta* | 21.47 | 2018 | -16.2 | 10.2 | 12.6 |
| *Ergalatax contracta* | 20.44 | 2018 | -16.0 | 9.8 |  |
| *Ergalatax contracta* | 20.0 | 2018 | -15.2 | 10.2 | 10.7 |
| *Thylacodes adamsii* | N.D | 2018 | -18.7 | 5.9 | 11.0 |
| *Thylacodes adamsii* | N.D | 2018 | -18.2 | 0.7 | 13.8 |
| *Thylacodes adamsii* | N.D | 2018 | -18.6 | 5.7 | 13.8 |
| *Bostrycapulus gravispinosus* | 12.98 | 2018 | -18.2 | 4.6 | 11.7 |
| *Bostrycapulus gravispinosus* | 13.34 | 2018 | -16.6 | 0.3 | 12.4 |
| *Bostrycapulus gravispinosus* | 13.35 | 2018 | -17.6 | 1.2 | 11.5 |

**Supplementary Table S2.** Individual *δ*13C, *δ*15N and *δ*34S values of potential food sources the from the Kueishantao (KST) shallow hydrothermal vent collected in 2018.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **Sample description** | **Nitrogen Content** (%) | **15NAIR** (‰) | **Carbon Content** (%) | **13CV-PDB** (‰) | **Sulphur Content** (%) | **34SV-CDT** (‰) | |
| 2018 | green algae | 1.34 | 6.47 | 6.56 | -21.92 | 2.58 | 16.89 |
| 2018 | green algae | 1.98 | 7.19 | 13.74 | -17.99 | 2.54 | 16.33 |
| 2018 | green algae | 2.44 | 5.28 | 19.02 | -17.08 | 2.37 | 11.92 |
| 2018 | green algae | 3.94 | 5.07 | 30.47 | -20.37 | 2.30 | 11.79 |
| 2018 | green algae | 3.36 | 5.22 | 26.33 | -20.60 | 3.41 | 18.99 |
| 2018 | bacteria | 0.23 | 5.24 | 1.07 | -19.86 | 3.74 | 5.48 |
| 2018 | bacteria | 0.41 | 5.37 | 1.83 | -20.16 | 4.36 | 4.12 |
| 2018 | zooplankton | 0.59 | 4.24 | 3.85 | -21.89 | 1.68 | 19.86 |
| 2018 | zooplankton | 2.14 | 8.01 | 9.48 | -19.75 | 1.64 | 19.92 |
| 2018 | zooplankton | 1.93 | 7.94 | 8.88 | -19.78 | 2.02 | 20.11 |
| 2018 | zooplankton | 1.34 | 5.32 | 6.33 | -20.12 | 1.93 | 20.16 |
| 2018 | zooplankton | 5.72 | 8.95 | 22.68 | -19.48 | 1.63 | 19.22 |
| 2018 | zooplankton | 2.20 | 6.19 | 11.53 | -21.59 | 2.42 | 16.19 |
| 2018 | zooplankton | 4.64 | 8.82 | 17.92 | -19.59 | 1.84 | 17.58 |
| 2018 | zooplankton | 4.61 | 8.85 | 18.47 | -19.51 | 2.00 | 19.29 |
| 2018 | zooplankton | 0.92 | 5.17 | 4.61 | -20.40 | 2.00 | 19.25 |
| 2018 | zooplankton | 3.05 | 7.74 | 13.08 | -19.11 | 1.75 | 18.54 |
| 2018 | zooplankton | 2.00 | 6.05 | 10.91 | -20.94 | 2.17 | 16.70 |
| 2018 | zooplankton | 5.23 | 7.94 | 23.72 | -20.15 | 1.74 | 17.12 |
| 2018 | zooplankton | 1.22 | 5.20 | 5.67 | -20.11 | 1.63 | 20.94 |
| 2018 | zooplankton | 4.27 | 8.40 | 17.48 | -19.70 | 1.60 | 20.64 |
| 2018 | zooplankton | 4.05 | 8.22 | 16.31 | -19.73 | 1.67 | 18.77 |
| 2018 | zooplankton | 0.89 | 5.08 | 4.77 | -20.77 | 2.38 | 15.14 |
| 2018 | zooplankton | 3.70 | 7.05 | 17.39 | -20.15 | 1.83 | 13.60 |
| 2018 | zooplankton | 2.29 | 5.36 | 11.62 | -20.48 | 3.18 | 11.44 |
| 2018 | zooplankton | 3.36 | 7.90 | 13.74 | -19.44 | 3.15 | 11.72 |
| 2018 | zooplankton | 1.69 | 4.90 | 8.83 | -20.53 | 1.96 | 14.49 |
| 2018 | zooplankton | 1.75 | 5.09 | 9.27 | -20.43 | 3.31 | 11.69 |
| 2018 | zooplankton | 2.16 | 8.10 | 9.75 | -20.52 | 2.53 | 14.02 |
| 2018 | Vent POM | 0.26 | 3.79 | 1.59 | -22.21 | 19.53 | 3.49 |
| 2018 | Vent POM | 0.44 | 6.06 | 2.23 | -21.48 | 9.56 | 6.02 |
| 2018 | Vent POM | 0.56 | 5.83 | 2.78 | -21.57 |  |  |
| 2018 | Vent POM | 0.39 | 4.22 | 1.99 | -21.51 | 10.91 | 6.50 |
| 2018 | Vent POM | 0.26 | 4.64 | 1.66 | -22.45 | 36.02 | 3.26 |
| 2018 | Vent POM | 0.21 | 3.37 | 1.67 | -23.28 | 1.21 | 11.37 |
| 2018 | Vent POM | 0.20 | 3.84 | 1.68 | -23.43 | 28.71 | 2.34 |
| 2018 | Vent POM | 0.29 | 4.02 | 2.48 | -23.54 | 17.05 | 2.51 |
| 2018 | Vent POM | 0.26 | 2.71 | 1.23 | -21.13 | 24.49 | 3.00 |
| 2018 | Vent POM | 0.30 | 4.32 | 1.45 | -21.58 | 26.43 | 5.12 |
| 2018 | Vent POM | 0.23 | 3.29 | 1.15 | -21.68 | 12.70 | 6.02 |
| 2018 | POM\_Seawater | 0.70 | 5.47 | 3.51 | -20.71 | 0.77 | 14.70 |
| 2018 | POM\_Seawater | 0.41 | 2.85 | 2.27 | -21.05 | 0.64 | 17.02 |
| 2018 | POM\_Seawater | 0.42 | 3.32 | 2.34 | -20.60 | 0.75 | 16.36 |

**Supplementary Table S3.** MANOVA and ANOVA results comparing *δ*13C, *δ*15N, and *δ*34S values between the *Xenograpsus testudinatus* collected in the Yellow and White Vents in 2018 (N=16). This result shows that there are no significant differences in *δ*13C, *δ*15N, and *δ*34S for vent crabs in different habitats.

Manova summary

**Df Pillai approx F num Df den Df P-adj**

Regression 1 0.48737 3.803 3 12 0.0796

Residuals 14

ANOVA summary

**Response **34S:**

**Df Sum Sq Mean Sq F value P-adj**

Location 1 1.5844 1.584 0.7208 0.4102

Residuals 14 30.775 2.198

**Response **13C:**

**Df Sum Sq Mean Sq F value P-adj**

Location 1 7.812 7.812 9.282 0.0348

Residuals 14 11.782 0.8416

**Response **15N:**

**Df Sum Sq Mean Sq F value P-adj**

Location 1 1.442 1.442 2.766 0.1580

Residuals 14 7.296 0.521

**Supplementary Table S4.** MANOVA and ANOVA results comparing *δ*13C, *δ*15N, and *δ*34S values between the male and female *Xenograpsus testudinatus* in 2018 (N=16). The results show that there is no significant difference in *δ*13C, *δ*15N, and *δ*34S values between sexes.

Manova summary

**Df Pillai approx F num Df den Df P-adj**

Regression 1 0.2716 1.4915 3 12 0.2667

Residuals 14

ANOVA summary

**Response **34S:**

**Df Sum Sq Mean Sq F value P-adj**

Sex 1 0.031 0.0306 0.0133 0.91

Residuals 14 32.329 2.3092

**Response **13C:**

**Df Sum Sq Mean Sq F value P-adj**

Sex 1 1.756 1.756 1.378 0.2601

Residuals 14 17.839 1.274

**Response **15N:**

**Df Sum Sq Mean Sq F value P-adj**

Sex 1 0.250 0.250 0.412 0.5311

Residuals 14 8.488 0.606

**Supplementary Table S5.** MANOVA and ANOVA results comparing *δ*13C, *δ*15N, *δ*34S values between 2015 and 2018 for vent crab (*Xenograpsus testudinatus*) pooled from both yellow and white vent.

Manova summary

**Df Pillai approx. F num Df den Df P-adj**

Regression 1 0.889 50.8 3 19 6.397e-09 \*\*\*

Residuals 21

ANOVA summary

**Response **34S:**

**Df Sum Sq Mean Sq F value P-adj**

Sampling\_year 1 70.283 70.283 37.464 0.003 \*\*

Residuals 21 39.397 1.876

**Response **13C:**

**Df Sum Sq Mean Sq F value P-adj**

Sampling\_year 1 1.1615 1.1615 0.906 0.1822

Residuals 21 26.9315 1.2825

**Response **15N:**

**Df Sum Sq Mean Sq F value P-adj**

Sampling\_year 1 16.060 16.0604 23.765 6.51e-07 \*\*\*

Residuals 21 14.192 0.6758

**Supplementary Table S6.** Summary of Welch Two Sample t-test comparing *δ*13C, *δ*15N, and *δ*34S values for *Ergalatax contracta* before and after disturbance. Lower and upper limits of 95% Confidence Intervals (CI) are also presented. The isotope value unit is per mil (‰).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Mean of 2018** | **Mean of 2015** | **CI.lower** | **CI.upper** | **p-adj value** |
| ****34S** | 9.94 | 6.8 | 0.94 | 5.34 | 0.015 |
| ****13C** | -19.73 | -15.57 | 3.07 | 5.27 | 0.003 |
| **15N** | 9.90 | 8.20 | 0.91 | 2.49 | 0.004 |

**Supplementary Table S7.** MANOVA andANOVA results comparing *δ*13C, *δ*15N, *δ*34S values between the pooled vent crab (*Xenograpsus testudinatus*) from the yellow and white vent and pooled Gastropod group (*Ergalatax contracta, Thylacodes adamsii, Bostrycapulus gravispinosus*) in 2015.

Manova summary

**Df Pillai approx F num Df den Df P-adj**

Regression 1 0.84509 21.822 3 12 3.77e-05 \*\*\*

Residuals 14

ANOVA summary

**Response **34S:**

**Df Sum Sq Mean Sq F-value P-adj**

Regression 1 9.3729 9.3729 4.4881 0.9025

Residuals 14 29.2371 2.0884

**Response **13C:**

**Df Sum Sq Mean Sq F-value P-adj**

Regression 1 57.477 57.477 65.996 4.563e-06\*\*\*

Residuals 14 12.193 0.871

**Response 15N:**

**Df Sum Sq Mean Sq F-value P-adj**

Regression 1 10.5862 10.5862 14.876 4.028e-05\*\*\*

Residuals 14 9.9632 0.7117

**Supplementary Table S8.** MANOVA andANOVA results comparing *δ*13C, *δ*34S values between the pooled vent crab (*Xenograpsus testudinatus*) from the yellow and white vent and pooled Gastropod group (*Ergalatax contracta, Thylacodes adamsii, Bostrycapulus gravispinosus*) in 2018.

Manova summary

**Df Pillai approx F num Df den Df P-adj**

Regression 1 0.76966 40.096 2 24 2.231e-08 \*\*\*

Residuals 25

ANOVA summary

**Response **34S:**

**Df Sum Sq Mean Sq F-value P-adj**

Regression 1 220.789 220.789 80.598 5.396e-09\*\*\*

Residuals 25 68.485 2.739

**Response **13C:**

**Df Sum Sq Mean Sq F-value P-adj**

Regression 1 2.985 2.9850 1.8453 0.1865

Residuals 25 40.442 1.6177

**Supplementary Table S9**.The *δ*13C, *δ*15N, and *δ*34S niche space for all organisms calculated from R package SIBER (Jackson *et al.* 2011). TA stands for the total community area, SEA stands for the Standard Ellipse Area, and SEAc stands for Standard Ellipse Area corrected for small sample size (n<50). Although we reported the niche space for filter feeder *B. gravispinousus and T. adamsii*, we did not discuss these values. This is because a minimum of data points of five for each group is required to calculate the covariance matrix and ensure sufficient degrees of freedom (Jackson *et al.* 2011). Our sample sizes for these two organisms were small (n=3) to draw any meaningful inference. The SEAc of *E. contracta* and pooled *X. testudinatus* were denoted in bold.

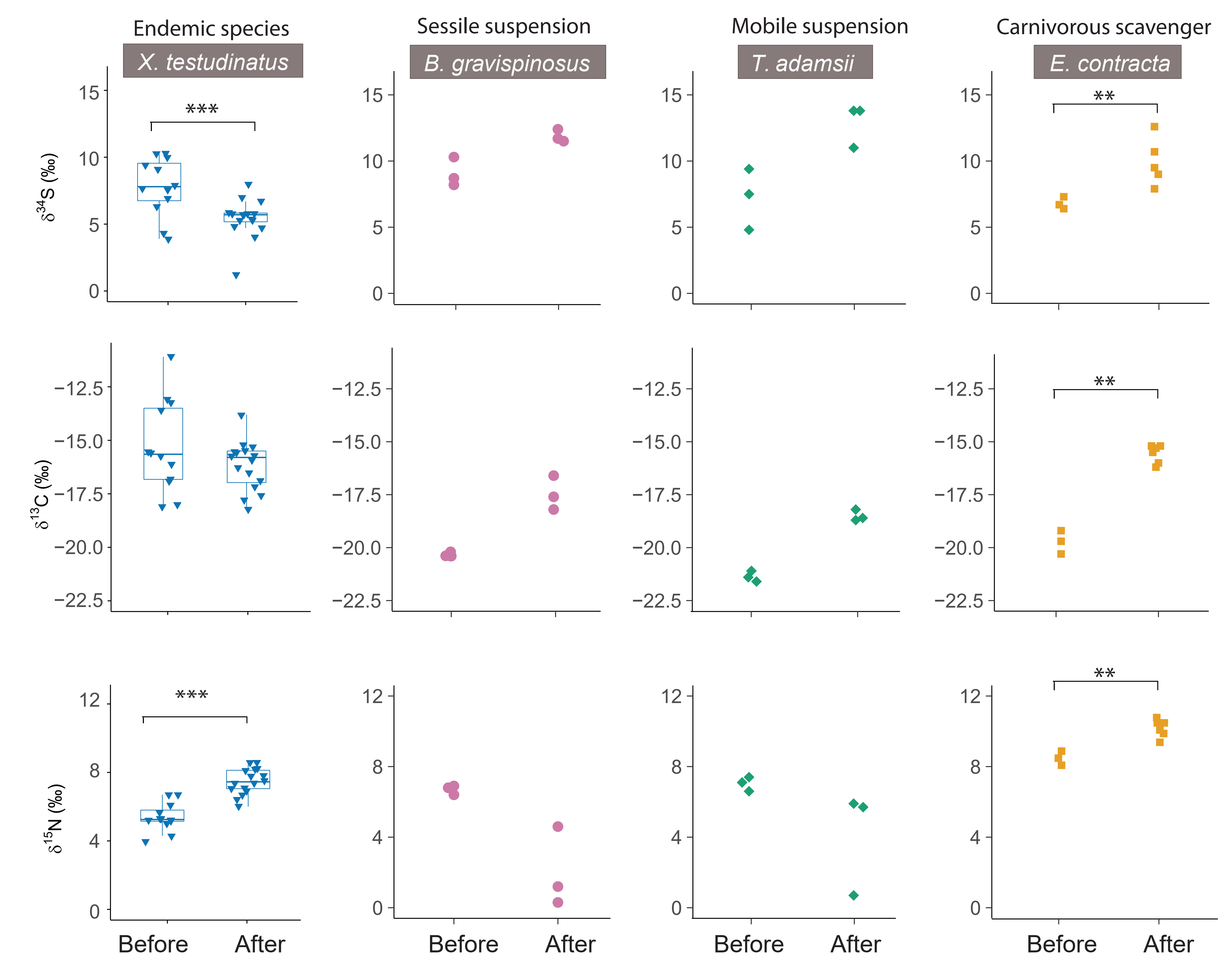
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *δ*13C & *δ*15N |  | ***B. gravispinosus*** | | | | | | | | | ***T. adamsii*** | | | | | | | ***E. contractaa*** | | | | ***X. testudinatus*** | | | | | | | |
|  | | | | **2015** | | **2018** | | | **2015** | | | **2018** | | | **2015** | | | | **2018** | | | | **2015** | | | | **2018** | |
| TA | | | 0.04 | | 1.43 | | | 0.125 | | | 0.21 | | | 0.32 | | | | 0.77 | | | | 10.15 | | | | 6.56 | |
| SEA | | | 0.07 | | 2.59 | | | 0.226 | | | 0.38 | | | 0.58 | | | | 0.68 | | | | 5.10 | | | | 2.38 | |
| SEAc | | | 0.15 | | 5.19 | | | 0.45 | | | 0.76 | | | **1.16** | | | | **0.86** | | | | **5.61** | | | | **2.55** | |
|  |  | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *δ*13C & *δ*34S |  | | **2015** | | | | | **2018** | | | **2015** | | | **2018** | | | **2015** | | | | **2018** | | | | **2015** | **2018** | | |
| TA | | | 0.05 | | 0.37 | | | 0.87 | | | 1.56 | | | 0.35 | | | | 1.555 | | | | 28.00 | | | | 15.32 | |
| SEA | | | 0.09 | | 0.67 | | | 1.57 | | | 1.65 | | | 0.63 | | | | 1.65 | | | | 12.98 | | | | 5.26 | |
| SEAc | | | 0.18 | | 1.34 | | | 3.14 | | | 2.20 | | | **1.25** | | | | **2.20** | | | | **14.28** | | | | **5.64** | |
|  | | |  | |  | | |  | | |  | | |  | | | |  | | | |  | | | |  | |

**Supplementary Fig. S1.** Underwater image next to the new Yellow Vent mouths (121.962°E, 24.834° N) to monitor the vent crab (*Xenograpsus testudinatus*) population change in

2018.

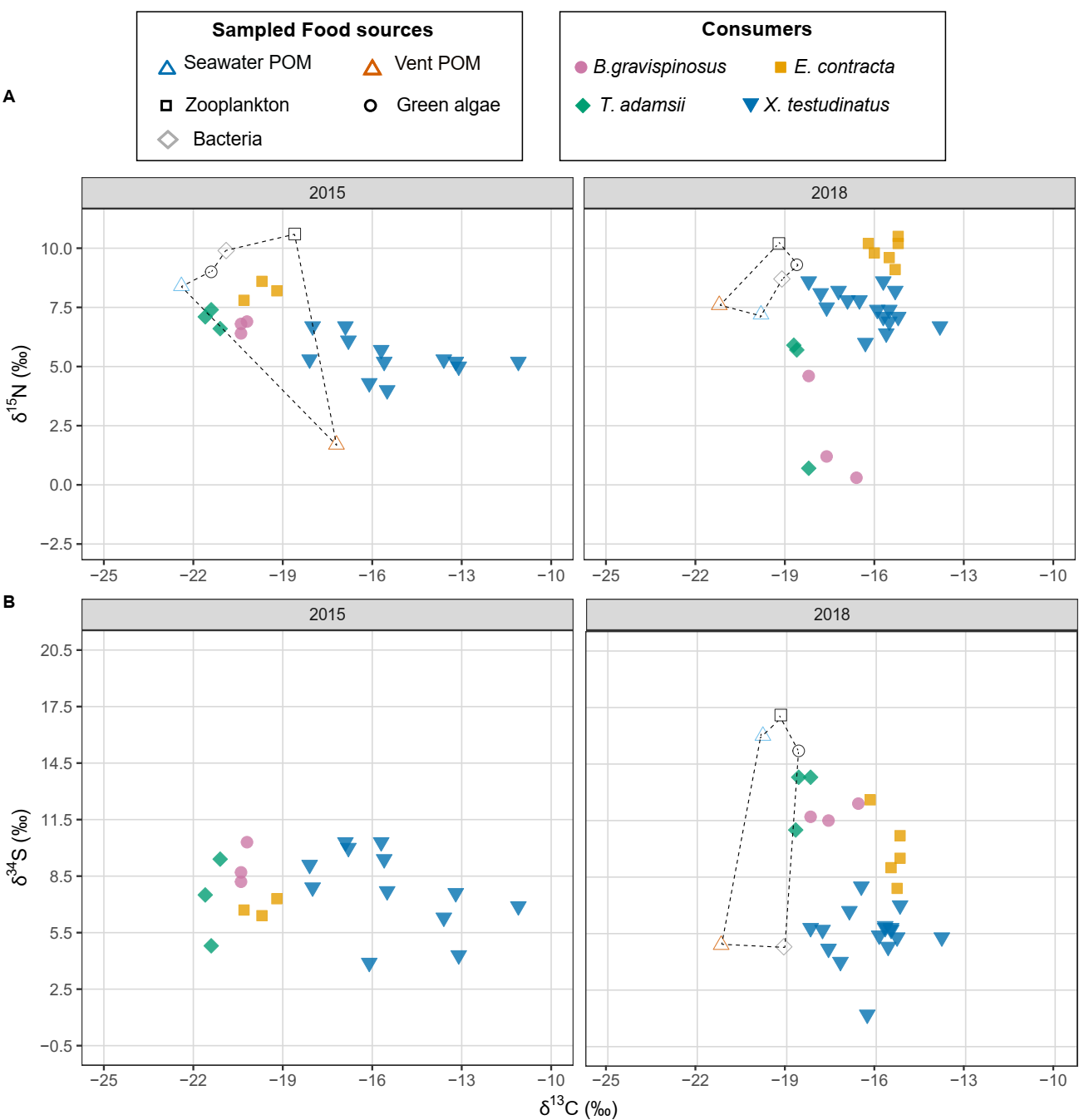


**Supplementary Fig. S2**. Inter-annual *δ*34S, *δ*13C and *δ*15N variability of benthic organism tissues in the Kuishantao Island in 2015 and 2018: vent crabs (*Xenograpsus testudinatus*); a sessile suspension feeder limpet (*Bostrycapulus gravispinosus*); a mobile suspension feeder snail (*Thylacodes adamsii*); and carnivorous scavenger snail (*Ergalatax contracta*) before and after the 2016 catastrophic events (Richter M5.8 earthquake and C5 Typhoon). \*\*\* denotes for *P*-adj <0.001 and \*\* denotes for *P*-adj <0.05. The boxplot was not plotted for the gastropods due to their small sample sizes (n<6) for each year.



**Supplementary Discussion I: Why Bayesian mixing model is an inappropriate approach**

To visualize the isotope mixing space defined by the sampled food sources, we added dietary fractionation factors of 3.4‰, 1‰ and 0‰ for **15N, **13C, **34S, respectively, to the potential food sources based on values from Fig. 3 and Table 1. The boundaries of these mixing spaces are shown as the convex hulls in Supplementary Fig. S3.



Supplementary Fig.S3. The isotope mixing space defined by the sampled food sources. We added dietary fractionation factors of 3.4‰, 1‰ and 0‰ for 15N, 13C, 34S, respectively, to the potential food sources based on values from Fig. 3 and Table 1. The boundaries of these mixing spaces are shown as dotted convex hulls.

In subplot A2015, *X. testudinatus* specimens except one lay outside the source mixing space, suggesting an incomplete sampling of potential source endmembers. To properly apply a Bayesian mixing model, all potential dietary resources that can contribute to isotope values in consumer should be characterized, otherwise information regarding the endmembers that constitute the mixture is incomplete. Therefore, any attempt to reconstruct dietary contribution to vent crab would be misleading and overestimate the dietary contributions from the sampled endmembers (Weltje 1997). There has been a report of one algae film sample, which could be an additional potential dietary source for vent crabs. However, this is only based on one measurement (Wang et al., 2022), which makes it anecdotal until confirmed with more measurements. Although the gastropods lay inside the endmember mixing space (the convex hull region), we cannot exclude that they fed on the missing source endmembers in the vent area. Hence, the mixing model would lead to overestimate the dietary contribution from the isotopically characterized sources.

In subplot A-2018, all consumers also lay outside the 13C and 15N mixing space (the dotted convex hull area). The two filter feeders’ **15N values are lower than the sampled food sources, suggesting we do not have all dietary nitrogen source endmembers, which could be the nitrogen fixing cyanobacteria (see Discussion). Therefore, if we apply the mixing model for 2018 for carbon and nitrogen sources, our interpretation would be erroneous. Future studies should aim to characterize the **15N and **13C compositions of cyanobacteria in the KST region.

As we argued in the main text, S is not a good tracer for dietary change for the KST region before the disturbance because the vent **34S signature masks the entire KST region. After the disturbance, two processes affect basal sulfur dietary sources: 1) the vent flux decreases and seawater sulfate’s influence became stronger and moved towards to the vent areas (Fig. 2); 2) the shifts in sulfur speciation and the overall sulfur species in the KST region became more**34S depleted. For the 13C and 34S space (subplot B-2018), the **13C values of all consumers lay outside the sampled endmember mixing space in 2018, suggesting we do not have all potential carbon sources to apply a Bayesian mixing model. Future isotope study should aim to expand sampling of potential dietary sources, including biofilm, isolated sulfur bacteria as well as nanobacteria from the KST region.

**Reference:**

Chen, C.-T.A., Zeng, Z., Kuo, F.-W., Yang, T.F., Wang, B.-J. & Tu, Y.-Y. (2005) Tide-influenced acidic hydrothermal system offshore NE Taiwan. *Chemical Geology,* **224,** 69-81.

Chen, X.-G., Lyu, S.-S., Zhang, P.-P., Yu, M.-Z., Chen, C.-T.A., Chen, Y.-J., Li, X., Jin, A., Zhang, H.-Y., Duan, W. & Ye, Y. (2018) Gas discharges from the Kueishantao hydrothermal vents, offshore northeast Taiwan: Implications for drastic variations of magmatic/hydrothermal activities. *Journal of Volcanology and Geothermal Research,* **353,** 1-10.

de Lecea, A.M., Smit, A.J. & Fennessy, S.T. (2011) The effects of freeze/thaw periods and drying methods on isotopic and elemental carbon and nitrogen in marine organisms, raising questions on sample preparation. *Rapid Communications in Mass Spectrometry,* **25,** 3640-3649.

Jackson, A.L., Inger, R., Parnell, A.C. & Bearhop, S. (2011) Comparing isotopic niche widths among and within communities: SIBER – Stable Isotope Bayesian Ellipses in R. *Journal of Animal Ecology,* **80,** 595-602.

Svensson, E., Schouten, S., Hopmans, E.C., Middelburg, J.J. & Damste, J.S.S. (2016) Factors controlling the stable nitrogen isotopic composition (*d*15N) of lipids in marine animals. *PLoS ONE,* **11**.

Weltje, G.J. (1997) End-member modeling of compositional data: Numerical-statistical algorithms for solving the explicit mixing problem. *Mathematical Geology,* **29,** 503-549.