*Supplementary Material*

Geographic Variation in Population Structure and Grazing Features of *Calanus glacialis/marshallae* in the Pacific Arctic Ocean

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Materials and Methods

Back calculation of reproduction timing

Firstly, development time from hatching to C4 was calculated by an equation D =16380\*(T +13.04)^(-2.05) in each region using mean temperature (Corkett et al. 1986). Then, the relative time to reach a particular stage compared to the time from hatching to C4 for *C. finmarchicus* (Corkett et al. 1986) multiplied by the development time. The embryonic duration was also estimated by an equation D = 975\*(T +13.04)^(-2.05) (Corkett et al. 1986). Finally, reproduction timing was made by sampling date minus the development time and embryonic duration (Supplementary Table 3).

ダイアグラム

自動的に生成された説明

Supplementary Figure 1. Geographical distribution of *Calanus glacialis/marshallae* on the abundance in the Pacific sector of the Arctic Ocean during October 2019.

黒い背景と白い文字

中程度の精度で自動的に生成された説明

Supplementary Figure 2. Regional comparison of Calanus glacialis/marshallae C5 lipid accumulation category in the Pacific sector of the Arctic Ocean during autumn 2019. The labels in X-axis mean the groups identified by cluster analysis (cf. Fig. 2).



Supplementary Figure 3. Relationship between temperature and development time for each stage of *Calanus glacialis/marshallae* (Corkett et al. 1986). Color backgrounds mean the water masses observed in this study (cf. Fig. 3). wCW, warm coastal water; wSW, warm shelf water; cSW, cool shelf water; AnW, Anadyr water; MWW, modified winter water (cf. Danielson et al., 2020).

Supplementary Table 1. Information on field sampling and sample analyses of *Calanus glacialis/marshallae* in the Pacific sector of the Arctic Ocean during October 2019.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
| Station | Latitude (N) | Longitude (W) | Date | Microscopy | Gut pigment | Lipid accumulation | Fatty acid |
| 13 | 66.50 | 168.75 | Oct. 08, 2019 | ○ |  | ○ | 〇 |
| 18 | 69.01 | 168.76 | Oct. 08, 2019 | ○ |  | ○ | 〇 |
| 25 | 72.50 | 161.75 | Oct. 10, 2019 | ○ |  | ○ | 〇 |
| 26 | 73.00 | 160.01 | Oct. 10, 2019 | ○ |  | ○ | 〇 |
| 30 | 72.33 | 155.01 | Oct. 11, 2019 | ○ |  | ○ | 〇 |
| 31 | 72.16 | 153.76 | Oct. 11, 2019 | ○ |  | ○ | 〇 |
| 34 | 72.00 | 147.50 | Oct. 11, 2019 | ○ |  | ○ |  |
| 35 | 72.00 | 145.00 | Oct. 12, 2019 | ○ |  | ○ |  |
| FP2 | 74.77 | 150.51 | Oct. 14, 2019 | ○ |  | ○ |  |
| FP3 | 76.47 | 161.63 | Oct. 15, 2019 | ○ |  | ○ |  |
| 39-01 | 77.00 | 165.00 | Oct. 15, 2019 | ○ |  | ○ | 〇 |
| MIZ-01 | 78.10 | 164.89 | Oct. 16, 2019 |  |  |  | ○ |
| 40-02 | 77.25 | 165.00 | Oct. 16, 2019 | ○ |  | ○ | ○ |
| 42-01 | 77.75 | 165.00 | Oct. 17, 2019 |  |  |  |  |
| MIZ-02 | 78.00 | 164.99 | Oct. 17, 2019 |  |  |  | ○ |
| 40-03 | 77.25 | 165.00 | Oct. 17, 2019 |  |  |  | ○ |
| MIZ-03 | 78.04 | 164.96 | Oct. 18, 2019 | ○ |  | ○ | ○ |
| 39-02 | 77.00 | 165.00 | Oct. 18, 2019 |  |  |  |  |
| 41-03 | 77.50 | 165.00 | Oct. 19, 2019 |  |  |  |  |
| MIZ-04 | 78.10 | 164.96 | Oct. 19, 2019 |  |  |  | ○ |
| 39-03 | 77.00 | 165.00 | Oct. 19, 2019 |  |  |  |  |
| 41-04 | 77.50 | 165.00 | Oct. 20, 2019 |  |  |  |  |
| MIZ-05 | 78.01 | 164.99 | Oct. 20, 2019 |  |  |  |  |
| 43 | 77.25 | 166.00 | Oct. 20, 2019 | ○ |  | ○ |  |
| 39-04 | 77.00 | 165.00 | Oct. 21, 2019 |  |  |  |  |
| MIZ-06 | 78.02 | 164.98 | Oct. 21, 2019 |  | ○ |  | ○ |
| 44 | 77.00 | 166.00 | Oct. 21, 2019 |  | ○ |  |  |
| 39-05 | 77.00 | 165.00 | Oct. 22, 2019 |  | ○ |  |  |
| MIZ-07 | 77.78 | 164.07 | Oct. 22, 2026 |  | ○ |  |  |
| 45 | 77.00 | 164.00 | Oct. 22, 2019 |  | ○ |  |  |
| 39-06 | 77.00 | 165.00 | Oct. 22, 2019 |  | ○ |  |  |
| MIZ-08 | 77.78 | 163.59 | Oct. 23, 2019 |  | ○ |  |  |
| 46 | 77.25 | 163.99 | Oct. 23, 2019 | ○ | ○ | ○ |  |
| 39-07 | 77.78 | 163.59 | Oct. 24, 2019 |  | ○ |  |  |
| MIZ-09 | 77.83 | 163.00 | Oct. 24, 2019 |  | ○ |  |  |
| 49 | 77.00 | 168.76 | Oct. 24, 2019 |  | ○ |  |  |
| 52 | 74.00 | 168.74 | Oct. 25, 2019 | ○ |  | ○ | ○ |
| 54 | 73.00 | 168.75 | Oct. 26, 2019 | ○ |  | ○ |  |
| 61 | 69.50 | 168.75 | Oct. 27, 2019 | ○ |  | ○ | ○ |
| 70 | 67.78 | 168.60 | Oct. 27, 2019 | ○ |  | ○ |  |
|  |  |  |  |  |  |  |  |

Supplementary Table 2. Mean water-column values in environmental parameters in the Pacific sector of the Arctic Ocean during October 2019.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |
| Station |  |  | Temperature |  | Salinity |  | Dissolved Oxygen |  | Turbidity |
| 13 |  |  | 3.745 |  | 32.496 |  | 2.407 |  | 3.287 |
| 18 |  |  | 5.601 |  | 32.118 |  | 2.432 |  | 1.849 |
| 25 |  |  | 3.612 |  | 31.457 |  | 2.474 |  | 0.583 |
| 26 |  |  | 0.908 |  | 32.812 |  | 2.250 |  | 0.461 |
| 30 |  |  | -0.207 |  | 30.580 |  | 2.488 |  | 0.052 |
| 31 |  |  | 2.686 |  | 31.742 |  | 2.336 |  | 0.361 |
| 34 |  |  | 0.642 |  | 31.228 |  | 2.448 |  | 0.096 |
| 35 |  |  | -0.069 |  | 30.524 |  | 2.532 |  | 0.053 |
| FP2 |  |  | -0.337 |  | 30.885 |  | 2.460 |  | 0.035 |
| FP3 |  |  | -0.376 |  | 31.168 |  | 2.434 |  | 0.049 |
| 39-01 |  |  | -0.825 |  | 31.489 |  | 2.399 |  | 0.058 |
| 40-02 |  |  | -0.810 |  | 31.385 |  | 2.389 |  | 0.061 |
| MIZ-03 |  |  | -1.351 |  | 31.380 |  | 2.351 |  | 0.053 |
| 43 |  |  | -0.897 |  | 31.475 |  | 2.395 |  | 0.057 |
| 46 |  |  | -0.770 |  | 31.318 |  | 2.389 |  | 0.050 |
| 52 |  |  | -0.269 |  | 32.495 |  | 2.269 |  | 0.142 |
| 54 |  |  | 0.591 |  | 32.301 |  | 2.461 |  | 0.947 |
| 61 |  |  | 2.953 |  | 32.250 |  | 2.275 |  | 2.291 |
| 70 |  |  | 3.008 |  | 32.513 |  | 2.334 |  | 1.223 |
|  |  |  |  |  |  |  |  |  |  |

Supplementary Table 3.

Estimated date of hatching and reproduction of *Calanus glacialis**/marshallae* in each region (cf. Fig. 2) in the Pacific sector of the Arctic Ocean in 2019.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Southern shelf | Northern shelf | Slope | Slope | Basin | Basin | Basin | Basin | Basin |
| Dominant stages | C5 | C4 | C4 | C3 | C5 | C4 | C3 | C2 | C1 |
| Mean temperature (ºC) a | 3.83 | 2.30 | 0.27 | 0.27 | -0.51 | -0.51 | -0.51 | -0.51 | -0.51 |
| Development timeb | 49.95 | 60.75 | 81.22 | 81.22 | 91.97 | 91.97 | 91.97 | 91.97 | 91.97 |
| Factorc | 1.17 | 1 | 1 | 0.85 | 1.17 | 1 | 0.85 | 0.69 | 0.55 |
| Development time to the dominant stage (Days) | 58.23 | 60.75 | 81.22 | 68.65 | 107.21 | 91.97 | 77.74 | 63.51 | 50.81 |
| Sampling date | 10/8-27 | 10/10-26 | 10/10-25 | 10/10-25 | 10/11-23 | 10/11-23 | 10/11-23 | 10/11-23 | 10/11-23 |
| Hatching date | 8/10-29 | 8/10-26 | 7/20-8/4 | 8/2-17 | 6/25-7/7 | 7/11-23 | 7/25-8/6 | 8/8-20 | 8/21-9/2 |
| Embryonic duration (Days) d | 2.97 | 3.62 | 4.83 | 4.83 | 5.47 | 5.47 | 5.47 | 5.47 | 5.47 |
| Reproduction date | 8/7-26 | 8/6-22 | 7/15-30 | 7/28-8/12 | 6/20-7/2 | 7/6-18 | 7/20-8/1 | 8/3-15 | 8/16-28 |

a: The water column means the temperature at all stations, including each group (cf. Fig. 2).

b: D=16380\*(T+13.04)^(-2.05), (Corkett et al. 1986)

c: Relative time to reach the stage compared to the time from hatching to C4 for *C. finmarchicus* (Corkett et al. 1986).

d: D=975(T+13.04)^(-2.05), (Corkett et al. 1986)