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Assemblages of Mollusks (Gastropoda and Bivalvia) on the Intertidal Platform around Kattoshi, Hakodate Bay, Hokkaido

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Abstract

This study described quantitative data on the current molluscan assemblage on the intertidal platform around Kattoshi, Hakodate Bay, southern Hokkaido, Japan. A total of 25 gastropod species and ten bivalve species were recorded from four-season sampling. Cluster analysis and subsequent indicator value (IndVal) calculation showed that the platform has three groups of sites with different assemblages. Group-1 accounted for 78-88% of the sites and was characterized by two gastropods *Barleeia angustata* and *Reticunassa fratercula*, which were also the top two species in the annual abundance. The indicator species of Group-2 (6-13% of the sites) included three gastropods, *Cantharidus japonicus*, *Lirularia iridescens* and *Homalopoma sangarense*. Group-3 was the least abundant (3-8% of the sites) and *Batillaria cumingii* and *Ruditapes philippinarum* were significant indicators. Overall, the current molluscan assemblage of the platform was characterized by two extremely dominant gastropod species, *B. angustata* and *R. fratercula*, while a previous study found *H. sangarense* to be dominant from December 1996 to August 1997. These results indicate the molluscan assemblage has changed over the past quarter-century.

Key words : Mollusk, Assemblage, Intertidal zone, Hakodate Bay

Introduction

The coast around Cape Kattoshi, located on the western coast of Hakodate Bay, southwestern Hokkaido, Japan (41°44'N, 140°36'E, Fig. 1), forms a characteristic rocky platform that is widely exposed at low tide from the seawall to 150-200 m offshore. There are a variety of marine benthic organisms on the platform, where many ecological studies of various species, including crustaceans (e.g. Wada et al., 1995 ; Goshima et al., 1995, 1996 ; Yoshino et al., 2001 ; Takahashi and Goshima, 2012) and mollusks (e.g. Ito et al., 1996, 1998 ; Yamakami and Wada, 2021), have been conducted. Some of these studies have emphasized the importance of gastropods as food for the whelk *Neptunea arthritica* (Yamakami and Wada, 2021) and as a source of shells for *Pagurus* hermit crabs (Ohmori et al., 1995 ; Wada et al., 1999 ; Yoshino et al., 1999 ; Mima et al., 2003 ; Oba and Goshima, 2004). However, there are no current data on the molluscan assemblages on the platform around Kattoshi, although Yoshino et al. (2001) described the species composition of gastropods in the investigation from December 1996 to August 1997. Here, we investigate the current molluscan assemblages in Kattoshi.

Materials and Methods

Quadrat sampling of the mollusks was conducted at low tide of December 2019, March 2020, June 2020, and October 2020 on the intertidal rock platform at Kattoshi (Fig. 1). Four transects perpendicular to the shoreline were run at 30 m intervals, and fifteen quadrats (15 × 15 cm) were placed on each transects at point 10 m intervals from 10 to 150 m from the shoreline. We collected all gastropods and bivalves within each quadrat, except those that were burrowed in the inner part of the sediment, with tweezers and a brush. The brush was used to scrape up small animals such as *Barleeia angustata* from the sediment surface. All samples were brought back to the laboratory. We identified the species of all living specimens (> 2 mm) and counted the number of individuals for each species in the quadrats. After finishing the procedure, all specimens were returned to the study site.

Compositionally-similar groups of quadrats (60 quadrats × 4 months) were identified by applying cluster analysis to understand the overall spatial pattern of the molluscan assemblage on the platform. The assemblages were clustered into several groups by K-medoids method and distance matrix for K-medoids was converted from the Morisita-Horn similarity index (Wolda, 1981). The number of clusters with maximum overall average silhouette width, a measure for the clustering quality, was taken as the optimal number of the clusters

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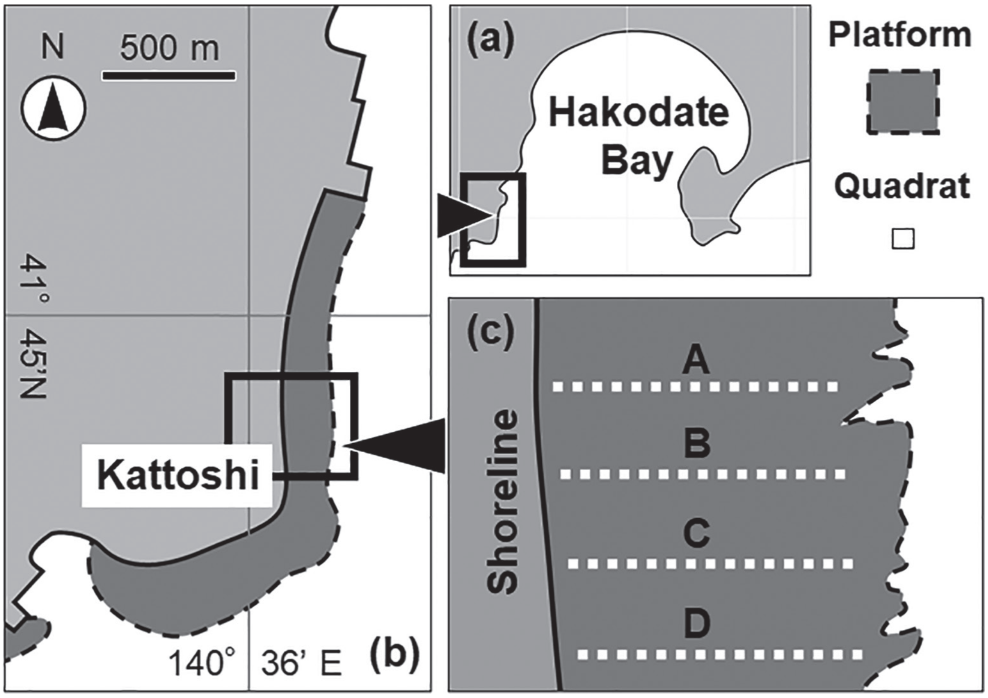

Fig. 1. Map of the study area showing (a) Hakodate Bay, southwestern Hokkaido, Japan, (b) the coast around Kattoshi, and (c) the position of the sampling sites on the platform. A, B, C and D indicate four transect lines extending perpendicular to the shoreline.

(Rousseeuw, 1987). Subsequently, characteristic species of the clustered site groups were identified using the Indicator Value (IndVal) method (Dufrêne and Legendre, 1997). IndVal is an index that takes into account the number of both individuals and occurrence sites and is at a maximum (=100%) when the individuals of a species occurred in all sites, of only one group. The significance of each species as an indicator was assessed by a permutation test with 5,000 iterations for IndVal, and significant species with IndVal > 25 were only considered.

All statistical analyses were carried out using R version 4.0.2 (R Core Team, 2020). Specifically, we used R package vegan (Oksanen et al., 2019) for the generation of dissimilarity matrix, cluster (Maechler et al., 2019) for K-medoids clustering, and labdsv (Roberts, 2019) for indicator species analysis. The raw data are available in the Appendix.

Results and Discussion

During the study period, 72,514 individuals of 25 gastropod species and 108 individuals of ten bivalve species were recorded (Table 1). The small gastropod *Barleeia angustata* was the most abundant species throughout the year, which accounted for 95% of the specimens collected. Although far less than *B. angustata, Reticunassa fratercula* and *Cantharidus japonicus* were the second (1.4%) and third (0.8%) most abundant species, respectively.

K-medoids clustering grouped the 240 quadrats into three clusters with the highest (0.81) overall average silhouette width (Fig. 2). A total of 201 quadrats were in Group-1, accounting for 78-88% of sampling sites. A total of 24 and 15 quadrats were in Group-2 (6-13%) and Group-3 (3-8%), respectively. The following species were identified as significant indicators from each group by IndVal method; Group-1, *B. angustata* and *R. fratercula*; Group-2, *C. japonicus*, *Lirularia iridescens* and *Homalopoma sangarense*; Group-3, *Batillaria cumingii* and *Ruditapes philippinarum* (Table 1).

Yoshino et al. (2001), who examined 3,660 live specimens of gastropods collected on the platform of Kattoshi from December 1996 to August 1997, reported that *H. sangarense* was the most abundant species (59%) and *R. fratercula* was the second most abundant (18%). They also included *C. japonicus* into "others". The paper did not focus on *B. angustata*, although it occurred at that time on the platform (K. Yoshino and K. Ito, personal communication). However, in the present study *H. sangarense* was less abundant than *R. fratercula* and *C. japonicus*. The present molluscan assemblage of Kattoshi is characterized by two dominant gastropods *B. angustata* and *R. fratercula* suggesting that the assemblage has changed over the past quarter century.

Marine animal communities and the ecosystem functions, are constantly changing. This is due, in part, to global environmental changes, local habitat modification, fisheries and species invasions. In this situation, ecosystem predictions and managements based on long-term data are essential for

Table 1. Number of individuals for each sampling month and IndVal values for each group for each species. Bold font indicate $p < 0.05$ and highlighted figures indicate IndVal (%) > 25.

	No. of individuals					IndVal (%)			
	Dec.	Mar.	June	Oct.	Total	G-1	G-2	G-3	*P*
Gastropoda									
Cellana toreuma	7	5	7	4	23	2.19	0.00	7.48	0.168
Nipponacmea sp.	2	2	2	0	6	0.10	0.00	12.41	**0.013**
Nipponacmea habei	0	3	0	0	3	0.50	0.00	0.00	1.000
Lottia emydia	2	5	1	0	8	1.13	2.27	0.00	1.000
Lottia tenuisculpta	1	0	6	3	10	4.48	0.00	0.00	0.477
Cantharidus japonicus	199	130	187	80	596	4.13	86.66	0.26	**< 0.001**
Cantharidus jessoensis	7	2	0	1	10	0.03	12.14	0.00	**0.014**
Lirularia iridescens	13	13	31	23	80	1.59	39.17	0.00	**< 0.001**
Monodonta confusa	4	10	1	12	27	0.47	2.77	7.10	0.165
Chlorostoma lischkei	26	21	27	45	119	10.96	1.31	5.95	0.666
Omphalius rusticus	8	3	6	7	24	1.18	1.39	13.30	0.058
Homalopoma sangarense	41	37	41	64	183	3.55	28.28	8.10	**0.017**
Hiloa tristis	36	56	10	39	141	2.63	22.15	0.19	0.020
Batillaria cumingii	7	13	11	15	46	0.21	0.00	31.02	**< 0.001**
Lacuna turrita	1	0	3	2	6	0.38	6.73	0.00	0.134
Alvania concinna	77	137	30	174	418	14.13	13.10	2.98	0.704
Barleeia angustata	24,761	18,987	5,760	20,177	69,685	96.84	2.37	0.04	**< 0.001**
Reticunassa fratercula	242	256	305	227	1,030	48.32	12.02	18.74	**0.011**
Reticunassa multigranosa	4	2	6	3	15	0.07	10.04	2.41	0.066
Ocinebrellus inornatus	11	14	13	24	62	7.81	12.35	2.58	0.395
Reishia bronni	1	0	0	0	1	0.50	0.00	0.00	1.000
Lirabuccinum fuscolabiatum	1	0	1	0	2	0.00	8.33	0.00	**0.013**
Neptunea arthritica	2	1	1	1	5	0.01	7.95	2.26	**0.041**
Retusa insignis	0	0	13	0	13	2.49	0.00	0.00	0.892
Haminoea japonica	0	0	1	0	1	0.50	0.00	0.00	1.000
Bivalvia									
Nucula paulula	5	11	10	5	31	3.38	0.46	10.64	0.179
Septifer keenae	3	0	0	5	8	2.49	0.00	0.00	0.806
Modiolus nipponicus	1	1	1	1	4	1.99	0.00	0.00	1.000
Cardita leana	1	0	0	0	1	0.50	0.00	0.00	1.000
Turtonia minuta	0	1	8	0	9	1.99	0.00	0.00	1.000
Ruditapes philippinarum	9	3	25	1	38	0.54	1.74	31.12	**< 0.001**
Protothaca euglypta	5	1	6	0	12	1.67	5.22	0.00	0.476
Irus mitis	2	0	1	0	3	1.49	0.00	0.00	1.000
Heteromacoma irus	0	0	1	0	1	0.50	0.00	0.00	1.000
Anisocorbula venusta	0	1	0	0	1	0.50	0.00	0.00	1.000

the sustainable use of ecosystem services. It is therefore important to continue monitoring animal communities in Kattoshi, including molluscan assemblages.

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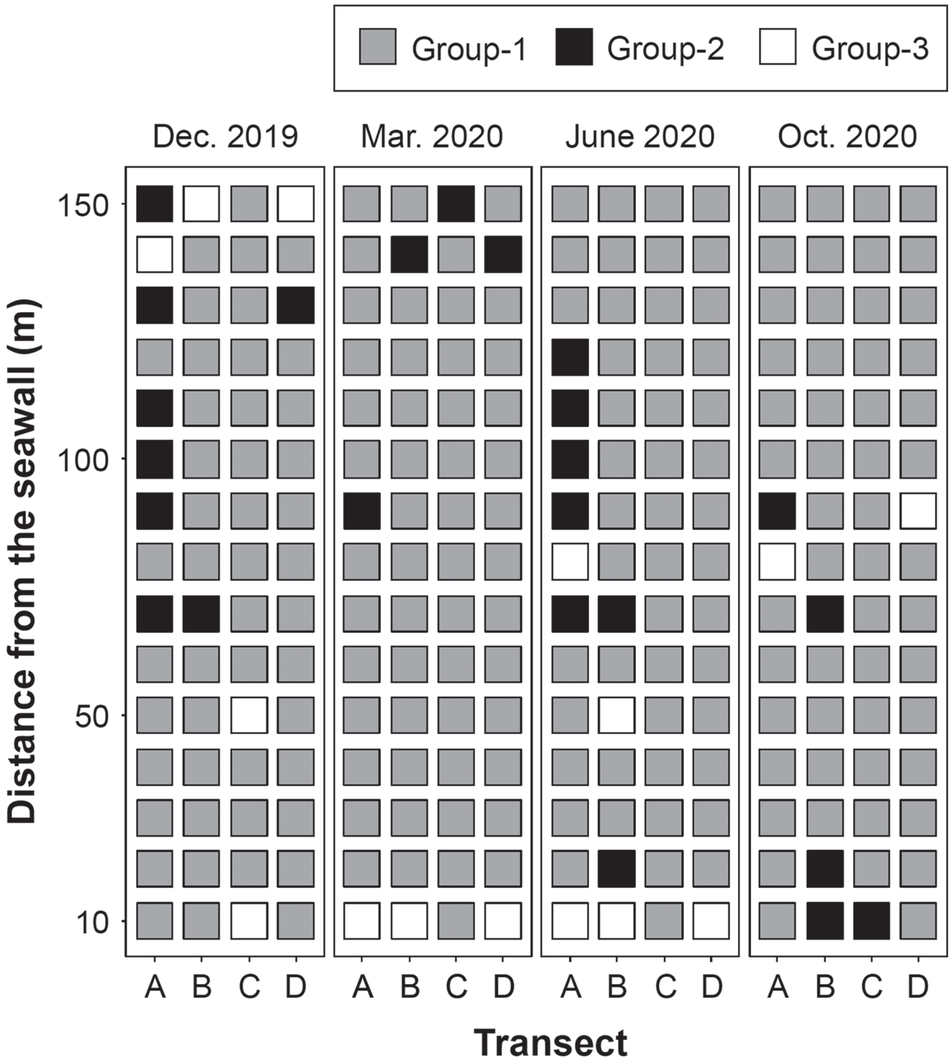

Fig. 2. The spatial distribution of three site groups generated by K-medoids clustering on the basis of assemblage composition over all sampling seasons.

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Appendix

Species	12A10	12A20	12A30	12A40	12A50	12A60	12A70	12A80	12A90	12A100	12A110	12A120	12A130	12A140	12A150	12B10	12B20	12B30	12B40	12B50	12B60	12B70
Cellana toreuma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nipponacmea sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Nipponacmea habei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lottia emydia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lottia tenuisculpta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Cantharidus japonicus	9	0	0	0	0	1	7	0	10	7	3	1	4	0	50	0	7	1	9	4	1	21
Cantharidus jessoensis	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
Lirularia iridescens	0	0	0	0	0	0	0	0	0	0	0	0	2	0	4	0	0	0	0	0	0	0
Monodonta confusa	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
Chlorostoma lischkei	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	2	0	0
Omphalius rusticus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
Homalopoma sangarense	0	0	0	0	0	0	3	0	0	0	6	0	1	6	0	0	6	0	0	2	0	0
Hiloa tristis	0	0	0	0	0	0	0	0	0	0	0	0	2	1	10	0	0	0	0	0	0	0
Batillaria cumingii	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lacuna turrita	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Alvania concinna	0	0	0	0	0	0	0	0	0	3	0	0	2	1	1	0	0	0	0	0	0	0
Barleeia angustata	25	207	104	117	524	821	0	14	8	1	0	18	2	1	45	5	176	918	440	22	125	9
Reticunassa fratercula	4	1	4	2	1	6	0	1	1	1	1	1	0	4	2	2	4	1	2	0	1	4
Reticunassa multigranosa	0	0	0	0	0	0	0	0	2	1	0	0	1	0	0	0	0	0	0	0	0	0
Ocinebrellus inornatus	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	2	1	0
Reishia bronni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lirabuccinum fuscolabiatum	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Neptunea arthritica	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Retusa insignis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haminoea japonica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nucula paulula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
Septifer keenae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modiolus nipponicus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cardita leana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turtonia minuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ruditapes philippinarum	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Protothaca euglypta	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Irus mitis	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heteromacoma irus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anisocorbula venusta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

12B80	12B90	12B100	12B110	12B120	12B130	12B140	12B150	12C10	12C20	12C30	12C40	12C50	12C60	12C70	12C80	12C90	12C100	12C110	12C120	12C130	12C140	12C150	12D10	12D20
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	5	2	7	2	0	2	2	0	4	0	0	0	0	0	0	1	1	0	0	0	0	2	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	1	1	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0
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0	0	0	0	1	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	17	3	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	1	4	0	0	0	0	0	0	2	0	1	0	4	0	0	0	1	0	1	0	0
413	260	281	318	1413	987	57	2	0	148	391	1477	2	421	1216	917	245	252	1076	1097	332	153	193	20	442
18	5	5	2	10	17	0	11	0	0	1	4	3	0	13	13	4	6	2	8	5	1	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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12D30	12D40	12D50	12D60	12D70	12D80	12D90	12D100	12D110	12D120	12D130	12D140	12D150	3A10	3A20	3A30	3A40	3A50	3A60	3A70	3A80	3A90	3A100	3A110	3A120	3A130	3A140
0	2	0	0	0	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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3	4	19	26	2	9	1	2	0	0	0	2	2	1	4	9	1	1	6	1	11	3	2	3	1	9	8
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3A150	3B10	3B20	3B30	3B40	3B50	3B60	3B70	3B80	3B90	3B100	3B110	3B120	3B130	3B140	3B150	3C10	3C20	3C30	3C40	3C50	3C60	3C70	3C80	3C90	3C100	3C110	3C120	3C130	3C140
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3C150	3D10	3D20	3D30	3D40	3D50	3D60	3D70	3D80	3D90	3D100	3D110	3D120	3D130	3D140	3D150	6A10	6A20	6A30	6A40	6A50	6A60	6A70	6A80	6A90	6A100	6A110	6A120	6A130
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16	0	0	0	0	0	1	0	0	0	0	0	1	0	6	0	0	0	0	0	0	0	0	0	1	0	0	1	0
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6A140	6A150	6B10	6B20	6B30	6B40	6B50	6B60	6B70	6B80	6B90	6B100	6B110	6B120	6B130	6B140	6B150	6C10	6C20	6C30	6C40	6C50	6C60	6C70	6C80	6C90	6C100	6C110	6C120	6C130
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6C140	6C150	6D10	6D20	6D30	6D40	6D50	6D60	6D70	6D80	6D90	6D100	6D110	6D120	6D130	6D140	6D150	10A10	10A20	10A30	10A40	10A50	10A60	10A70	10A80	10A90	10A100
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10A110	10A120	10A130	10A140	10A150	10B10	10B20	10B30	10B40	10B50	10B60	10B70	10B80	10B90	10B100	10B110	10B120	10B130	10B140	10B150	10C10	10C20	10C30	10C40	10C50
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10C60	10C70	10C80	10C90	10C100	10C110	10C120	10C130	10C140	10C150	10D10	10D20	10D30	10D40	10D50	10D60	10D70	10D80	10D90	10D100	10D110	10D120	10D130	10D140	10D150
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