

Community dynamics over a decadal scale at Logatchev, 14°45'N, Mid-Atlantic Ridge

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Abstract: Hydrothermal vent community dynamics over a ten year span was studied in the Logatchev area, 14°45'N on the Mid-Atlantic Ridge. On the SERPENTINE cruise in March 2007 with the R/V *Pourquoi pas?* and the ROV *Victor 6000* (IFREMER), composition, abundance and distribution of dominant megafauna at Logatchev were examined and compared to published data from 1997. Our results revealed notable changes in several community characteristics. The most significant changes evident in March 2007 compared to July 1997 were the increase up to by order of magnitude in the population density of predatory gastropods *Phymorhynchus* spp. at the site Irina-2 and disappearance of a live population of vesicomysids at the site Anya's Garden. Other notable differences between the two periods of observation were the overall increase in the abundance in 2007 of the mussel *Bathymodiolus puteoserpentis* and a high abundance of gravid females of the shrimp *Rimicaris exoculata* at Irina-2. It is suggested that the extinction of vesicomysids occurred owing to either a sediment slide at a steep slope of the Anya's Garden locality or instability of a biotope required for vesicomysids. Live vesicomysids were not found over a large area explored at Logatchev in 2007. Other changes observed in 2007 apparently were related to seasonal fluctuations in the community at Logatchev or fluctuations in the hydrothermal activity. Any successional stages over a decadal scale at Logatchev were not observed.

Keywords: Hydrothermal vent • Community dynamics • Succession • *Phymorhynchus* • *Bathymodiolus puteoserpentis* • Vesicomysids • Logatchev • Mid-Atlantic Ridge

Introduction

Temporal changes and fluctuations are important ecological characteristics of animal communities. Understanding of temporal changes in hydrothermal vent communities is

especially important because of the ephemeral nature of the habitat and extremely dynamic environment at hot vents. However, data on temporal variations at hydrothermal vents remain limited and most of research on community dynamics and succession has been conducted at the East Pacific Rise (Juniper & Tunnicliffe, 1997; Sarazzin et al., 1997). In the present study we examined changes on a ten year scale in the hydrothermal community at Logatchev in the Atlantic Ocean.

The Logatchev hydrothermal region is located between 14°N and 15°N on the Mid-Atlantic Ridge. The region includes two active vent areas known as Logatchev-1 and -2 and three relict hydrothermal fields, Logatchev-3, -4 and -5 (Cherkashov et al., 2000; Fouquet et al., 2008). The Logatchev-1, depth 2900-3050 m, formerly known as “14-45” (Bogdanov et al., 1995), is the largest and the most active in the region. It was discovered in 1993-1994 during the 7th Cruise of the RV *Professor Logatchev* (St.-Petersburg, Russia). According to recent data and maps, the Logatchev-1 area extends over approximately 500 m in the north-west south-east direction and comprises at least nine hydrothermal sites of various size and type (Borowski et al., 2008; Fouquet et al., 2008). Logatchev-2 lies 5.5 km south-east of Logatchev-1 at the depth of 2640-2760 m. This area was also discovered in 1993-1994 concurrent with Logatchev-1. A relict field known as Logatchev-3 was discovered in 2000; it is located 3.5 km south of Logatchev-1 at the depth 3000-3100 m (Cherkashov et al., 2000). Another relict field, Logatchev-4, lies 1 km north-east of Logatchev-1, at approximately 3000 m depth (Cherkashov et al., 2000), and a new relict field, Logatchev-5 was discovered in 2007 at the summit of the Logatchev ridge, 1 km east of Logatchev-1 (Fouquet et al., 2008).

The major geological peculiarities of the Logatchev hydrothermal system include its association with gabbro-peridotites, location close to the top of the rift wall and development of “smoking craters” (Bogdanov et al., 1995). The main biological peculiarity of this area is the population of thysirids *Thyasira* (*Parathyasira*) sp. at the site Anya’s Garden (Gebruk et al., 2000) co-occurring with mussels *Bathymodiulus puteoserpentis* (von Cosel, Métivier & Hashimoto, 1994) and vesicomid clams. This is the only known live population of vesicomids north of the equator on the Mid-Atlantic Ridge. The clams were referred to *Ectenagena* aff. *kaikoi* in Gebruk et al. (2000), but appeared to belong to the new genus and species *Abyssogena southwardae* (Krylova et al., 2010).

On the SERPENTINE cruise (March 2007) with the R/V *Pourquoi pas?* and the ROV *Victor 6000* (IFREMER), three hydrothermal vent areas in the Logatchev region were examined: Logatchev-1, 2 and -3. One of the main goals at Logatchev-1 was the study of hydrothermal community dynamics over a ten year span: the composition, abundance and distribution of dominant megafauna were compared with the data from 1997 presented by Gebruk et al. (2000). At Logatchev-2 and -3 scientific goals were exploratory: there were no ROV or submersible dives at these sites before.

Material and Methods

Data from the *Victor 6000* Dives 315-06 (20/21 March

2007) and 316-07 (22/23 March 2007) were used for this study. At Irina-2 (Fig. 1) estimations of the abundance of gastropods *Phymorhynchus* spp. were made from images captured from the video footage and still photographs taken at the periphery of the mussel bed and the base of the central chimney complex (following the map and study points in Gebruk et al., 2000) and on solitary black smoker. The abundance of the ophiuroid, *Ophioctenella acies* (Tyler et al., 1995) was estimated for the following three attributes: ophiuroids on exposed surfaces of sulphides (i), one layer of ophiuroids on the mussel bed (ii) and a multi-layer carpet of ophiuroids on the mussel bed (iii). The distribution and abundance of selected macrofauna at Irina-2 and Anya’s Garden based on ROV dives in 2007 was compared to data from *Alvin* dives at Irina-2 in 1997 (Gebruk et al., 2000). Frames captured from video footage and still photographs from *Alvin* dives in 1997 at Anya’s Garden were in part re-examined for comparative studies. Still photographs and frames captured from the *Victor 6000* dive footage (using the Ifremer Vemo+ software) were used in the analysis. Images of the best quality covering an area of 1.5-2 m² were selected. Individuals were enumerated; abundances were standardized to 1 m². Laser scale was used for spatial calibration. In total 137 images taken on dives in 2007 were analysed. Calculations were carried out with SYSTAT 11 (2006). All the data and metadata from the *Victor 6000* dives are stored in the Biocean database (Fabri et al., 2006) and metadata are available on the web site <http://www.ifremer.fr/biocean>.

Results and Discussion

Population density of Phymorhynchus spp. at Irina-2

Gastropods of the genus *Phymorhynchus* are an important component in the hydrothermal community at Irina-2. The following three species are previously known from this site: *P. moskalevi* (Sysoev & Kantor, 1995), *P. ovatus* (Warén & Bouchet, 2001) and *P. carinatus* (Warén & Bouchet, 2001). These species cannot be distinguished based on images, therefore the analysis was made for the genus. *Phymorhynchus* occurred in high density on the mussel bed at Irina-2 in July 1997 and March 2007. In July 1997, the highest density of *Phymorhynchus* was evident at the periphery of the mussel bed exhibiting a mean density of 29.8 ind.m⁻² (SD 4.8) (Table 1). In March 2007, the density had increased dramatically at the periphery of the mussel bed, where the mean density was 121.4 ind.m⁻² (SD 10.6). At the base of the central chimney complex only single specimens were present in 1997. During March 2007, the population density was 40.2 (SD 13.5). In the vicinity of a solitary ‘small black smoker’ in July 1997 only single

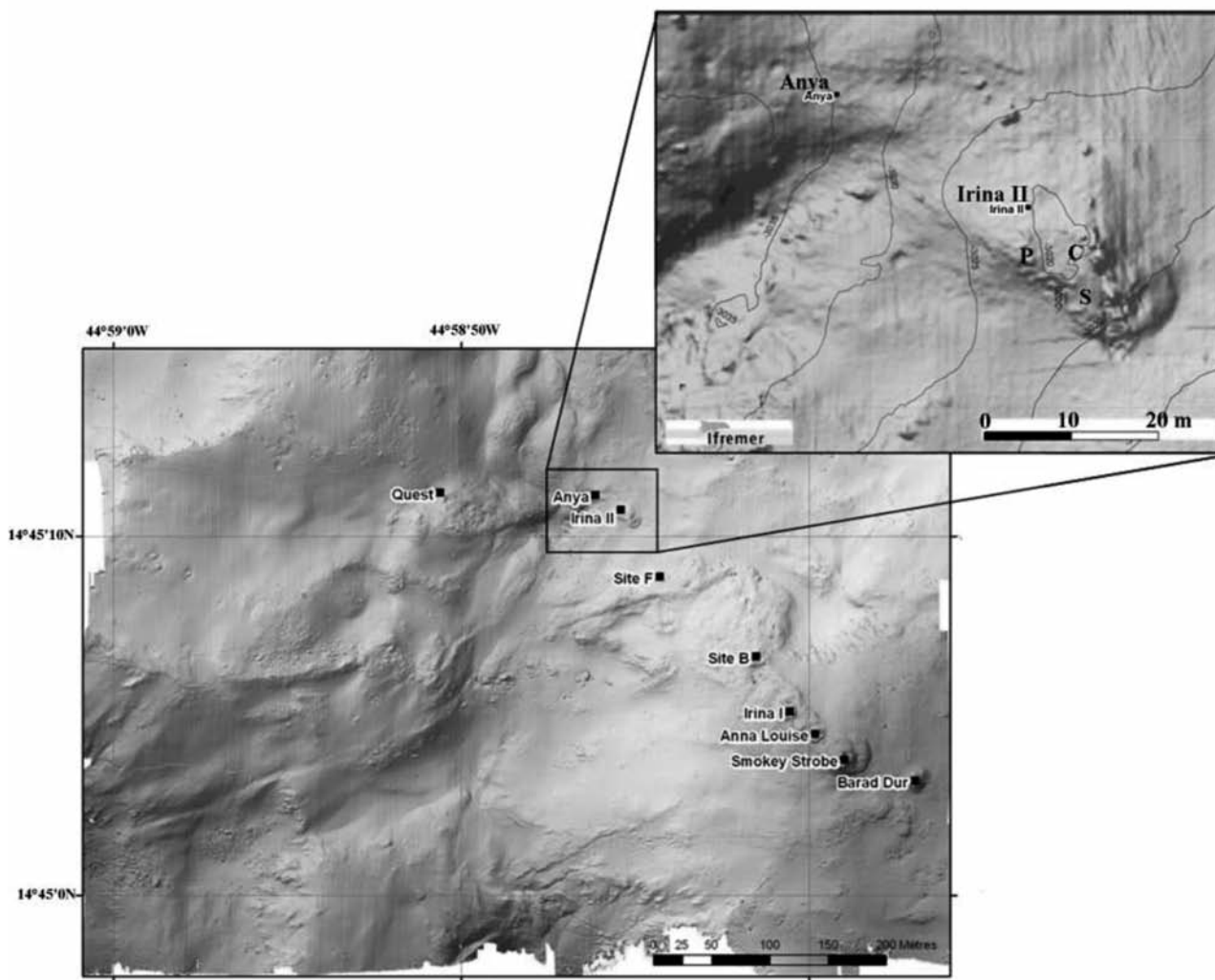


Figure 1. Sites of hydrothermal activity at Logatchev-1. In box: Irina-2 and Anya's Garden (marked "Anya") enlarged. P- Periphery of mussel bed, C - Central chimney, S - Solitary black smoker (Labels correspond to sites on Figure 2).

Figure 1. Sites d'activité hydrothermale à Logatchev-1. Dans le cadre - Irina-2 et Anya's Garden (indiqué "Anya") agrandis. P - Périphérie de la moulière, C - Cheminée centrale, S - Fumeur noir solitaire (les lettres correspondent aux sites de la Figure 2).

specimens were observed. In March 2007, the density was 62.2 ind.m^{-2} (SD 3.1) (Table 1).

Population density of Ophioctenella acies at Irina-2

Another dominant species on the mussel bed at Irina-2 was the ophiuroid, *Ophioctenella acies*. In July 1997, the population density of *O. acies*, close to the base of the central chimney complex, was estimated as 80 ind.m^{-2} (Table 1). In March 2007, we calculated the density of *O. acies* at the same point on the mussel bed. On sulphides, the mean density was 10 ind.m^{-2} (SD 3.2), in areas with a single layer of ophiuroids on the mussel bed, the density was 56.2 ind.m^{-2} (SD 7.5) and where multi-layers occurred the value was 103.8 ind.m^{-2} (SD 5.3). Although the quality

of video footage from 1997 did not allow more detailed density estimations, some increase in population density of *O. acies* between July 1997 and March 2007 was evident.

Hydrothermal community changes at Anya's Garden

Dramatic changes in the density of dominant species occurred over the ten year span at Anya's Garden. The most significant change was in the total absence of live vesicomysids in 2007. Live vesicomysids were also not found at other sites in the Logatchev area during approximately 21 hours of ROV survey time. Bivalves sampled at Anya's Garden in 1997 that were also sampled in 2007 included *Thyasira (Parathyasira) sp.* and *Bathymodiolus puteoserpentis*. Single empty valves of thyasirids were

Table 1. Population density (ind.m⁻²) of *Phymorhynchus* spp. and *Ophioctenella acies*. Mean values are given, SD - standard deviation, N - number of enumerations.

Tableau 1. Densité de population (ind.m⁻²) de *Phymorhynchus* spp. et *Ophioctenella acies*. Les valeurs moyennes sont données, SD – écart-type, N – nombre de comptages.

	July 1997	March 2007
Irina-2		
Population density of <i>Phymorhynchus</i> spp.		
Periphery of mussel bed	29.8 (SD 4.8) (N = 17)	121.4 (SD 10.6) (N = 15)
Clusters	10.3 (SD 1.6) (N = 3)	85.6 (SD 6.3) (N = 12)
Base of chimney complex	Single specimens	40.2 (SD 13.5) (N = 17)
Solitary black smoker	Single specimens	62.2 (SD 3.1) (N = 16)
Population density of <i>Ophioctenella acies</i>		
Base of chimney complex		10 (SD 3.2) (N = 12)
Exposed sulphides		56.2 (SD 7.5) (N = 11)
Mussel bed, one layer of ophiuroids		103.8 (SD 5.3) (N = 9)
Mussel bed, multi-layer carpet	Max. 80 ind. m ⁻²	
Anya's Garden		
Exposed sulphides		7.7 (SD 1.5) (N = 14)
Mussel bed/clumps, one layer of ophiuroids		80 (SD 4.4) (N = 16)
Mussel bed/clumps, multi-layer carpet	Max. 20 ind. m ⁻²	157.7 (SD 8.6) (N = 15)

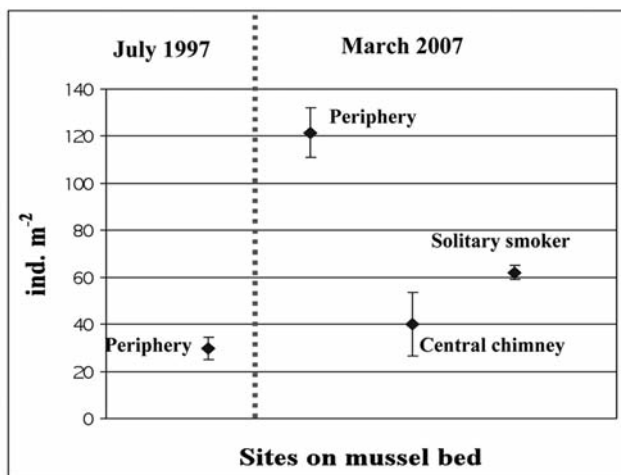


Figure 2. Population density of *Phymorhynchus* spp. at Irina-2.

Figure 2. Densités de la population de *Phymorhynchus* spp. à Irina-2.

observed on the sediment surface in 2007, whereas in 1997 the density of dead shells reached 20 ind.m⁻². The density of mussels, *B. puteoserpentis*, at this site had increased; in July 1997 from 4-60 to 80-100 ind.m⁻² in March 2007. The population density of brittle stars, *O. acies*, also increased significantly from 1997 to 2007 (Table 1). In July 1997, a maximum of 20 ind.m⁻² were registered, where as in March

2007 the values were 7.7 ind.m⁻² (SD 1.5) on sulphides; 80 ind.m⁻² (SD 4.4) in areas with a single layer of ophiuroids and 157.7 ind.m⁻² (SD 8.6) in multi-layer areas.

Other observations in the Logatchev region.

Mussels. The abundance of mussels *Bathymodiolus puteoserpentis* in the vicinity of the Logatchev-1 area in March 2007 increased relative to July 1997. However, this information is based on a single visual observation, which highlighted two significant pieces of evidence: 1) in 2007 we observed clumps of mussels (several tens of individuals per clump) on sulphide chimneys at Anna-Louise, but in 1997 only few single mussels occurred at this site; and 2) in March 2007 numerous juveniles 3-5 mm long were present (observed and sampled at Irina-2), but there were no juveniles < 15 mm in length in July 1997.

Shrimps. Population of shrimps at Irina-2 remained stable during the two sample periods. The main swarm in 2007 had clear red patches of juveniles. *Chorocaris* occurred solitarily or in small groups. *Mirocaris* was numerous at the base of the swarm and on the mussel bed. Numerous juveniles of different species were present on the mussel bed. *Alvinocaris* was common at the base of chimney complex and especially around the periphery of the mussel bed. New observation was made in 2007: numerous adults of *Rimicaris* were observed within mussel layers on chimney walls at Irina-2.

In March 2007 many females of *Rimicaris exoculata* (Williams & Rona, 1986) were ovigerous. Females with eggs (reddish or orange mass underlying the abdomen) were clearly evident among swarming shrimps during ROV dives, they were recorded on video and several tens of gravid females were sampled using slurp-gun. Despite no histological studies on the eggs, under microscopy it was noticed that eggs in the same females were of different size and at different stages: small orange eggs, eggs with a white patch (the eye) and eggs with larvae. These observations support the hypothesis of asynchronous gametogenesis proposed for *R. exoculata* based on histological studies of oocytes (Ramirez Llodra et al., 2000; Copley et al., 2007).

In earlier studies, gravid females were found to be very rare. Single individuals were reported among thousands of specimen caught during months from July to October and February (Gebruk et al., 1997). The scarcity of ovigerous females was also noted in summer samples by Ramirez Llodra et al. (2000). Samples taken in different years in November and September contained 20 females each (Copley et al., 2007). This information and our new observations indicate that the reproduction in *R. exoculata* is most likely synchronous and without clear seasonality. However, this remains to be tested, as with variations in reproduction related to depth and geographic area. The case for synchronous reproduction is supported by the population size structure with several pronounced size peaks both for males and females (Gebruk et al., 1997; Vereshchaka, 1997).

Earlier it was suggested that ovigerous *R. exoculata* leave main aggregations around high temperature zones (Gebruk et al., 1997; Ramirez Llodra et al., 2000; Copley et al., 2007). Our new data demonstrate that ovigerous females do occur among swarming shrimps. However, these data suggest that the reproduction period in this species is relatively short.

Concluding remarks

Overall, the most significant change in the hydrothermal community at Irina-2 evident in March 2007 compared to July 1997 was the dramatic increase in the population density of predatory gastropods *Phymorhynchus* spp. This increase (in addition to the relative increase in the abundance of *O. acies*) could be a seasonal fluctuation if it followed the increase in the abundance of mussels that possibly was a result of a reproductive event. Alternatively, a fluctuation in the hydrothermal activity at this site could occur, that resulted in extinguishing of a part of the population of mussels (before the reproduction event that we recorded) and as a result increase in the abundance of predators/scavengers and deposit feeders.

Disappearance of a population of vesicomyids at Anya's Garden is another important change in the hydrothermal

community at Logatchev. We suggest that the extinction of vesicomyids occurred owing to either a sediment slide at a steep slope of the Anya's Garden locality or instability of a biotope required for vesicomyids. Anya's Garden is a relatively small field, about 12 m in diameter (Gebruk et al., 2000). It is a soft sediment habitat lying on a steep slope of ca. 40–45°, thus with a high probability of sediment sliding. The weight of the marker "Anya" in 2007 was covered with the sediment indicating a possible sediment slide at this site. There is also a possibility of changes in hydrothermal regime that altered a habitat required for vesicomyids.

Changes in the hydrothermal regime were observed on the SERPENTINE cruise in the area Logatchev-2. An extensive field (several tens of m across) of dead mussel shells was found on the slope of the mound that had a weakly active chimney on top expelling shimmering water. The mussel shells still had their periostracum, indicating a recent catastrophic collapse of a large population, apparently as a result of a rapid slowing down of the hydrothermal activity. Only a few live mussels, as well as shrimps *Chorocaris chacei* (Williams & Rona, 1986) and *Mirocaris fortunata* (Martin & Christiansen, 1995) were recorded on the single active chimney.

Apparently there are no conditions for a stable population of vesicomyids at Logatchev: in 2007 no signs of any other population were observed. Several spots of dead vesicomyid shells in the area north-west of Irina-2 were reported by Gebruk et al. (2000). Mussels in similar habitats are more successful, apparently owing to dual symbionts in their gills (sulphur-oxidizing and methane-oxidizing bacteria). Clumps of mussels were numerous at Anya's Garden in March 2007.

In this study, shifts in the ecological makeup of the Mid-Atlantic hydrothermal communities were evident over a decadal scale. These changes were observed in the composition and abundance of dominant species. This is the first case where such changes have been documented for the MAR hydrothermal vents. However, long-term observations on the MAR still remain unclear. In the detailed assessment of decadal-scale ecological changes at the hydrothermal community at TAG Copley et al. (2007) found consistency in the identity, distribution and abundance of dominant species between 1994 and 2004. Reported ecological changes in the Atlantic hydrothermal communities were related to changes in the pattern of hydrothermal activity and occurred on a small scale at annual or interannual cycles (Copley et al., 1997 & 1999).

Long-term ecological changes in hydrothermal communities in the Atlantic contrast with vent sites in the East-Pacific where up to 6 successional stages may occur over a time frame of 5–8 years (Juniper & Tunnicliffe, 1997; Sarazzin et al., 1997). The Atlantic hydrothermal fauna is considerably more depauperate relative to the East

Pacific (Desbruyères et al., 2006). The dominant species in the MAR hydrothermal communities (bathymodiolin mussels and alvinocaridid shrimps) occupy different habitats reducing competition pressure. Therefore biological interactions are more complicated in the Pacific hydrothermal communities resulting in the more pronounced community dynamics and change of dominants.

Acknowledgements

The authors thank the Captain and the crew of the R/V *Pourquoi pas?*, the pilots and the crew of the ROV *Victor 6000* and the SERPENTINE shipboard scientific party. We are also grateful to Paul Dando and two anonymous referees for helpful comments and editing the English style. AG in part was funded by grant from the Presidium of the Russian Academy of Sciences, Program 17, and theme 11.3.

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