Benthic diversity in fjords after a decade of mariculture

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Abstract:

Aquaculture of salmonids in open sea cages is a growing sector in Iceland but this activity is known to have a negative impact on benthic marine biodiversity. To assess the impact of mariculture activities this study re-sampled 6 sites located in the regional zone, previously sampled in 2009 and 2010 after a decade of mariculture, in Dýrafjörður and Arnarfjörður. Changes in benthic community were analyzed by looking at the variation in diversity, evenness, similarity and species composition between sites and location. Despite the disappearance of certain species, the number of taxa found was similar among years. The relative abundance of individuals increased in Dýrafjörður but decreased in Arnarfjörður. Diversity increased in most cases and the distribution of species became more even as well. Results from the biotic index (AMBI and NQI1) showed rather sign of improvement. Simple matching test showed level of similarity around 70% while Bray-Curtis similarity test showed mixed results with 3 sites around 70% similarity and 3 around 45% similarity. When comparing the benthic community species composition between the base-line sampling and the “10 years after” sampling, this study found around 70% of taxa present and around 35% of the most abundant species present between samplings in 4 of the 6 sites. Species such as *Chaetozone setosa*, *Levinsenia gracilis*, *Maldane sarsi, Mediomastus sp., Pherusa sp.*, *Sternaspis sp*., *Abra sp., Arctica islandica, Ennucula tenuis, Parvicardium pinnulatum* and *Macoma calcarea* increased their densities while species as *Prionospio steenstrupi, Polydora sp., Ophelina acuminata, Crenella sp., Kellia sp.* and *Mya sp.* decreased their densities. Increases in the number of species and their population density could be the consequence of the organic input coming from the mariculture and should therefore be monitored in the long term.

Key words: Benthic community composition, mariculture, diversity index, evenness index, biotic index, feeding guild, ecological group.

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Introduction

Aquaculture of salmonids in open sea cages is a growing sector in Iceland. Salmonid production in the Westfjords region grew from 1.808 tons in 2012 to 27.340 tons in 2021 (Mælaborð fiskeldis, mast.is). Farming sites in the Westfjords region include Arnarfjörður, Dýrafjörður, Patreksfjörður,Tálknafjörður, Ísafjardardjúp and Önundarfjörður. This study looks at data from two fjords, Arnarfjörður and Dýrafjörður, where farmed biomass have been highest during past 10 years.

Large scale aquaculture in open sea cages (mariculture) is known to have a negative impact on benthic marine biodiversity. Organic enrichment can lead to loss of diversity and reduced species evenness by creating habitats that favour certain tolerant species. This may eventually lead to the removal of suspension and deposit feeders, thus affecting sediment characteristics, and exacerbating changes in community composition (Pearson and Rosenberg, 1978; Gowen et al., 1987, Karakassis et al., 1998).

Studies show that the impact of mariculture activities on the seabed are usually confined to the farm site location, with the highest accumulation of organic waste material being found within a 50 meter radius from the cages and decreasing as one moves further from them. This area is referred to as the “local impact zone”. Behind this zone is an area termed the “Intermediate impact zone”, the zone where the main source of impact is still the farming activity but where other factors could also contribute. Outside this zone is the “Regional impact zone”, the zone where the impact from finfish farming could be one of several sources of impact but not the main one (ISO 12787). The size of each zone is subject to factors such as sea current, depth and inclination of the seabed, thus the size of each zone cannot be fixed. The same standard suggests a reference station (which can be considered, by definition, free from any impact of mariculture) located somewhere between 500 -2000 meters beyond the local impact zone (ISO 12878).

Environmental impact is regularly monitored by contractors of the farming companies to ensure sediment quality and benthic community function. This monitoring usually occurs in condition of peak biomass (or > 70%) on local, intermediate, and regional zones or within 250 meters from the cages array. However, a long-term release of organic waste material could lead to impacts and environmental changes in the water column and seabed at a larger scale (regional zone and beyond). This could be especially true, and could be exacerbated, by the relatively closed conditions of a narrow fjord system and related issues connected to water exchange and sediment accumulation (BuhlMortensen et al., 2009, Husa et al., 2014, Kutti et al., 2007a,b).

Since 2003 the Natural Science Institute of the Westfjords (NAVE) has conducted sampling and research on benthic marine biodiversity in the Westfjords region. Base line sampling was carried out in order to acquire information on seabed characteristics at the beginning of mariculture enterprises.

To assess the impact of mariculture activities over a long timescale this study re-sampled 3 sites previously sampled in 2009 and 2010 after a decade of mariculture activities in Dýrafjörður and Arnarfjörður. By investigating the changes in the benthic marine community species composition and related diversity, this project aims to gain better insight into the effects of mariculture on fjord ecosystems.

Mariculture in Arnarfjörður and Dýrafjörður

Arnarfjörður and Dýrafjörður are located in the Westfjords region (northwest Iceland). Communities in these fjörds are relatively small, with only one village in Arnarfjörður, Bíldudalur (206 inhabitants in 2016) which hosts 2 industrial operators, the Arnarlax fish farming company, which operates an active fish processing facility and the Kalkþörungafélagið ehf., a mærl processing company. Therefore, in Arnarfjörður, the only significant source of environmental impact, beside mariculture, is the mining of mærl, a practice which eventually affects the benthic community outside of the mining area, mainly due to the settling of fine material coming from the dredge. In Dýrafjörður the main living centre is Þingeyri (326 inhabitants in 2020). Apart from mariculture there is no other significant industrial activity in the area. It is therefore rational to assume that mariculture in these two fjords is the main anthropogenic input of organic waste material into this fjord ecosystem.

Salmonid aquaculture began in Dýrafjörður in 2009 and in Arnarfjörður in 2011 (Karl Steinar Óskarsson Matvælastofnun, pers. comment). The number of slaughtered farmed salmonid from 2010-2022 in Dýrafjörður and Arnarfjörður can be seen in table 1. In Dýrafjörður rainbow trout (*Oncorhynchus mykiss*) was farmed from 2010 until 2017 and was later replace by Atlantic salmon (*Salmo salar*). In Arnarfjörður only Atlantic salmon have been farmed.

Year	Dýrafjörður	Arnarfjörður
2010	250.000	0
2011	0	0
2012	326.212	660.000
2013	850.000	320.000
2014	376.357	0
2015	300.049	0
2016	535.069	395.591
2017	1.706.477	4.718.489
2018	0	4.950.971
2019	3.956.000	11.672.800
2020	6.813.934	8.315.601
2021	2.132.678	4.704.892

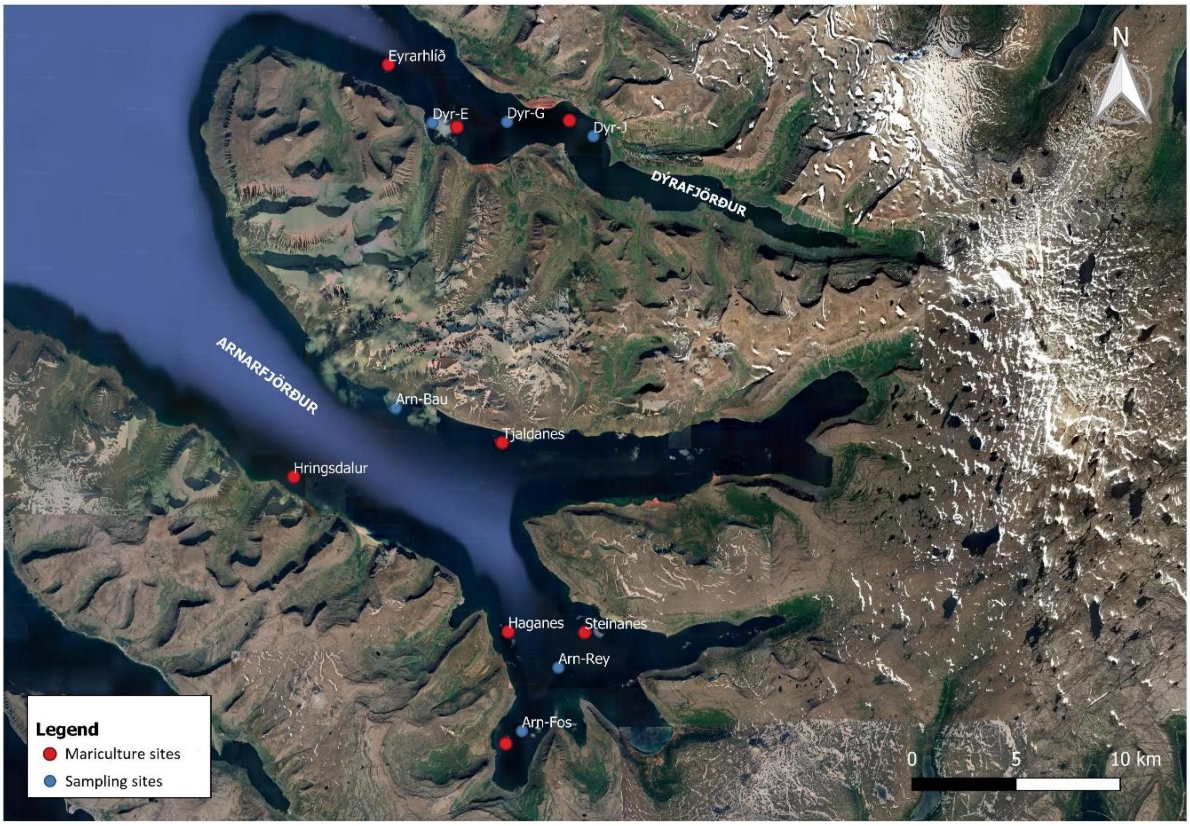
Table 1. Salmonids production in Kg from mariculture in Dýarfjörður and Arnarfjörður for year between 2010 and 2021. Karl Steinar Óskarsson, Matvælastofnun, pers. Comment.

Methodology

Sampling

Sampling sites were chosen between the sites sampled during the base line monitoring that was conducted 2009-2010 (Þórisson et al. 2010 a,b, Eiríksson et al. 2010). Three sites were re-sampled in 2020 and 2021 in each fjord (Arnarfjörður and Dýrafjörður) with all stations located 900 meters or more from mariculture cages (Map 1, table 2).

Map.1 Sampling sites (blue dots) and mariculture site (red dots) in Dýrafjörður and Arnarfjörður.



Sites	Dyr_E	Dyr_G	Dyr_J	Arn_B	Arn_F	Arn_R
Gps coordinates	N65.89038°	N65.89075°	N65.88465°	N65.76878°	N65.63030°	N65.65760°
	W23.62723°	W23.54947°	W23.45965°	W23.66528°	W23.53399°	W23.49608°
Deapth (m)	21	39	22	93	76	98
Distance from mariculture site (m)	900	2400	1300	>5000	1000	2000
Number of samples 2009 -10	5	5	5	3	3	3
Size Van Veen greip 2009-10 (cm^2)	200	200	200	200	200	200
Number of samples 2020-21	5	5	5	2	2	2
Size Van Veen greip 2020-21 (cm^2)	200	200	200	1000	1000	1000

Table 2: Sampling site location (gps coordinates), seabed depth, distance from the closest mariculture sites, number of samples and greip size for base-line sampling 2009-2010 and "10 years after" sampling 2020-2021.

Sampling was schedule for summer 2020 even though one of the selected sites in Arnarfjörður (Reykjafjörður, Arn_Rey) was sampled in January 2010. Due to covid concerns the sampling was delayed and took place in Arnarfjörður the 25th of Oktober 2020 and in Dýrafjörður the 23rd of April 2021. This delay allowed for the sampling in Dýrafjörður to take place at same time of year as the base line sampling (April 15th 2009).

Sampling was designed to use the same Van Veen grab used in the base-line sampling (200 cm^2 sampling area). This grab worked well in the 2021 sampling of Dýrafjörður but it did not work in the 2020 sampling of Arnarfjörður, therefore a 1000 cm^2 grab was used here instead. Sampling was also designed for 3 samples at each location. The number of replicates at each site was reduce to 2 in Arnarfjörður due to logistical reasons (sampling 2 x 1000 cm^2 grabs equal 10 x 200cm^2 grapes) but increased to 5 samples in Dýrafjörður. Five samples are equivalent to the number of samples that were taken in 2009 in Dýrafjörður. Available samples from 2010 were 3 replicates for each site at Arnarfjörður (Baul A and Foss C, sampled the 10th of July 2010) here named Arn-F and Arn- B together with Station E (Reykjafjordur- Control, sampled 18th of January 2010) here named Arn-R. Sampling effort was consistent between the two years in Dýrafjörður but not in Arnarfjörður. Thus, the density of individuals is always presented as relative abundance or density per meter square.

Samples collected on the seabed were sieved immediately after sampling with seawater with a 500 µm sieve as ten years prior. Samples were then treated with formaldehyde solution (8%) for 5 days and then formaldehyde was replaced with isopropanol. Samples were then sorted, and animal taxa analysed with a stereoscope (Leica mz12). Species identification was carried out by the author using available benthic marine species identification keys (Holte 1977, Ingimarsson Ó. 1982, Hartmann- Schröder 1996, Enckell P.H. 1998). To avoid misidentification, samples taken from 2009-2010 were either worked at present time or reviewed in case they had been already worked. Species names used are according to the World Register of Marine Species. In order to obtain a comparable species list between years species names were synchronized (for example species were sometimes join to families).

Redox potential was not measured during this study due to technical issues.

Data analyses

Base line monitoring is performed at a site where future changes are foreseeable. This allows for the comparison of baseline parameters or “natural conditions” to future conditions after mariculture. Here we assume that data gathered during the baseline monitoring are representative of “natural conditions”.

Benthic community composition was interpretated by using commonly used indices such as Margalef species richness, Pielou´s evenness index, Shannon-Wiener diversity index and Simpson diversity index (Primer 6). ATZI´s Marine Biotic index AMBI (Borja A. et al., 2012) and

NQI 1 biotic index (Vannportalen 2018, Van Hoey et al., 2019, Woods P., 2021) were also calculated (fig. 1).

	Formula	Range
S	Number of species (taxa)	0 and up.
N	Number of individuals in each sample	0 and up.
Species richness (Margalef)	d = (S-1)/Log(N)	0 and up.
Pielou's evenness	J´= H´/Log (S)	1.1. 1 = all species are even
Shannon-Wiener diversity index	H´= Σ (pi)* (ln pi) p_i = The proportion of the entire community made up of species *i*.	0 and up. Higher the number higher the diversity.
Simpson diversity index	1-ʎ´=Σ (Ni*(Ni-1)/N*(N-1)	0-1. 1 = high diversityþ
ENS (Shannon-Wiener index)	ENS= $e^{H´}$	0 and up. Higher the number higher the number of effective species.
AMBI index	AMBI = {(0 x % GI) + (1,5 x % GII) + (3 x % GIII) + (4,5 x GIV) + (6 x GV)} / 100	0-6. 0 = unpolluted, 6 very polluted.
NQI 1 index	0,5* (1-AMBI/7)+ 0,5*(SN/2,7)*(N/(N+5)) SN= ln S/ ln(ln N)	0-1. 1 = very good.

Figure 1.Used Indexes formulas and ranges.

To get a better understanding of the difference in diversity between the two sampling years we calculated the “True diversity” or the “Effective number of species” from the Shannon-Wiener diversity index values found for each site. Effective number of species (ENS) is defined as: “*The number of equally-common species required to give a particular value of an index*" (Lou Jost, 2006). For the Shannon-Weiner index (H´) this is calculated as the exponent of the index or exp(H´).

Similarities between benthic communities were then analyse with Simple Matching Coefficent and Bray-Curtis similarity tests (Clarke and Warwick, 2001).

Presence- absence, number of most abundant species present between years at sites, number of taxa which decrease, increases, number of new recruits and taxa non longer present in later sampling were looked at, together with possible changes due to trophic characteristics of species found.

Results

All samples were classified as soft bottom, site depth was not found different in 2020-2021 when compared to the sampling done in 2009 and 2010. Benthic community composition and density can be seen in appendix 1 and appendix 2 as the average of the samples adapted to m^2.

Species richness, abundance, evenness, diversity and biotic indexes

Number of taxa (S), relative abundance of individuals (N), Margalef species richness (d), Pielou´s evenness index (J´), Shannon- Wiener diversity index (H´) and Simpson (1-Lambda) , AMBI biotic index and NQI 1 biotic index are in table 3. Nematodes were not excluded from these calculations as their presence is often associated with organic enrichment even though their abundance could be affected by sieve size used.

In Dýrafjörður, when comparing between sampling years, with reference to our assumption that base-line sampling represents "natural conditions", then the number of taxa (species richness, S) remains stable at site E (S = 42), decreased at sites G (from 30 to 26) and J (from 38 to 37) (table 3). The relative abundance (number of individuals per m^2) increased in all Dýrafjörður sites. Margalef´s index of species richness, d, decreased in all sites between years but the decrease was more pronounce at site G (from 3,55 to 2,67) due to a decrease in taxa and a subsequent increase in abundance of animals. Pielou´s evenness index, J', increased at sites E and G between years, and decreased at site J. The diversity of the benthic community increased at sites E and G between years and decreased at site J. The biotic index AMBI decreased at all sites between years and all sites were categorized as "Slightly disturbed". The NQI1 biotic index increased at site E between years and decreased at site G and J. According to the NQI1 index the ecological status of sites E and G was "Moderate" (between good and bad) and "Good" at site J (Gundersen et al. 2011).

From 2010-2020 in Arnarfjörður the number of taxa (S) decreased at site B (from 18 to 16 taxa), increased at site F (from 13 to 22) and R (from 14 to 20). The relative abundance decreased in all sites. Margalef´s index of species richness, d, increased in all sites. Pielou´s evenness index, J', increased at sites B and R, and decreased at site F. The diversity of the benthic community increased at all sites, even though Simpson index decreased slightly at site F. The Biotic index "AMBI" decreased at sites B and R, and increased at site F. All sites were categorized as "Moderately disturbed". The "NQI1" index increased at all sites. According to the NQI1 index the ecological status of all the sites in Arnarfjörður is "Moderate" (between good and bad) with some sites ecological condition showing improvement between the two sampling years (Gundersen et al. 2011). When interpreting these results it should be kept in mind that the grab used did not have same sampling area between years in Arnarfjörður (3x200 cm^2 in 2010 vs 2x1000 cm^2 in 2020), however, as mentioned above, all values were converted to number of individuals per m^2 (table 3).

Location	Sites	S	N	d	J'	H'(loge)	1-Lambda'	AMBI	NQI
Dýrafjörður	E09	42	7690	4,58	0,68	2,53	0,86	2,80	0,62
Dýrafjörður	E21	42	12320	4,35	0,78	2,91	0,91	2,58	0,62
Dýrafjörður	G09	30	3490	3,56	0,67	2,27	0,82	2,41	0,63
Dýrafjörður	G21	26	11770	2,67	0,75	2,43	0,88	2,19	0,61
Dýrafjörður	J09	38	2720	4,68	0,84	3,05	0,93	2,51	0,65
Dýrafjörður	J21	37	7090	4,06	0,74	2,68	0,89	2,33	0,64
Arnarfjörður	B10	18	2483	2,18	0,54	1,56	0,58	3,74	0,49
Arnarfjörður	B20	16	830	2,23	0,62	1,72	0,69	3,30	0,53
Arnarfjörður	F10	13	1417	1,65	0,57	1,46	0,57	3,56	0,48
Arnarfjörður	F20	22	1210	2,96	0,48	1,49	0,54	3,82	0,52
Arnarfjörður	R10	14	1617	1,76	0,39	1,02	0,37	4,04	0,45
Arnarfjörður	R20	20	1535	2,59	0,55	1,66	0,64	3,80	0,51

Table 3. Results for Number of taxa (S), relative abundance of individuals per m2 (N), Margalef species richness (d), Pielou´s evenness index (J´), Shannon-Wiener diversity index (H´) and Simpson (1-Lambda), AMBI and NQI 1 biotic indexs for 6 sites in 2 different sampling years (E09= site E year 2009).

Species Diversity and effective number of species

In Dýrafjörður the Shannon-Weiner species diversity index, H’, was found to increase significantly between years at site E (t (14826) = -20.5, *P* < .005) and site G (t (4820) = -6.7, *P* < .005), and decrease significantly at site J (t (5857) = 16.1, *P* < .005). In Arnarfjörður the Shannon-Weiner species diversity index, H’, was found to increase significantly between years at site B (t (1662) = -3.2, *P* < .005), and site R (t (3145) = -12.1, *P* < .005). H´ decreased at site F in Arnarfjörður (t (2436) = 0.56, *P* = .57), however this decrease was not statistically significant (table 4).

The ENS for each location follows the same pattern as above for H´. This is to be expected since the ENS is derived from the H´. In Dýrafjörður, at site E ENS increased by ~31% between years (~12,5 species in 2009 to ~18,3 species in 2021), at site G ENS increased by ~15% between years (~9,6 species in 2009 to ~11,3 species in 2021) and at site J ENS decreased by ~31% between years (~21,0 species in 2009 to ~14,6 species in 2021). In Arnarfjörður, at site B ENS increased by ~15% between years (~4,8 species in 2010 to ~5,6 species in 2020), at site F ENS decreased by ~4% between years (~4.6 species in 2010 to ~4.5 species in 2020) and at site R ENS increased by ~48% between years (~2,7 species in 2010 to ~5,3 species in 2020) (table 4).

Location	Sites	H´	ENS	ENS diff. %	Significance
Dýrafjörður	E09	2,53	12,56	31	*P* < 2.2e-16
Dýrafjörður	E21	2,91	18,32		
Dýrafjörður	G09	2,27	9,64	15	*P* = 1.681e-11
Dýrafjörður	G21	2,43	11,36		
Dýrafjörður	J09	3,05	21,04	-31	*P* < 2.2e-16
Dýrafjörður	J21	2,68	14,58		
Arnarfjörður	B10	1,56	4,76	15	*P* = 0.001574
Arnarfjörður	B20	1,72	5,60		
Arnarfjörður	F10	1,53	4,64	-4	*P* = 0.5729
Arnarfjörður	F20	1,49	4,45		
Arnarfjörður	R10	1,01	2,74	48	*P* < 2.2e-16
Arnarfjörður	R20	1,66	5,27		

Table 4. Shannon- Wiener diversity index (H´), ENS, % difference in ENS and results from t test on the Shannon-Wiener index for 6 sites in 2 different sampling years.

Similarity

In Dýrafjörður the simple matching coefficient shows a 76%, 73% and 74% similarity between the 2009 and 2021 community composition for sites E, G and J respectively (fig. 2). The Bray-Curtis similarity between the 2009 and 2021 community composition was 68%, 43% and 47% for sites E, G and J respectively (fig. 3).

In Arnarfjörður the simple matching coefficent shows a 74%, 75% and 63% similarity between the 2010 and 2020 community composition for sites F,R and B respectively (fig. 4). The Bray-Curtis similarity between the 2010 and 2020 community composition was 79%, 70% and 42% for sites F, R and B respectively (fig. 5).

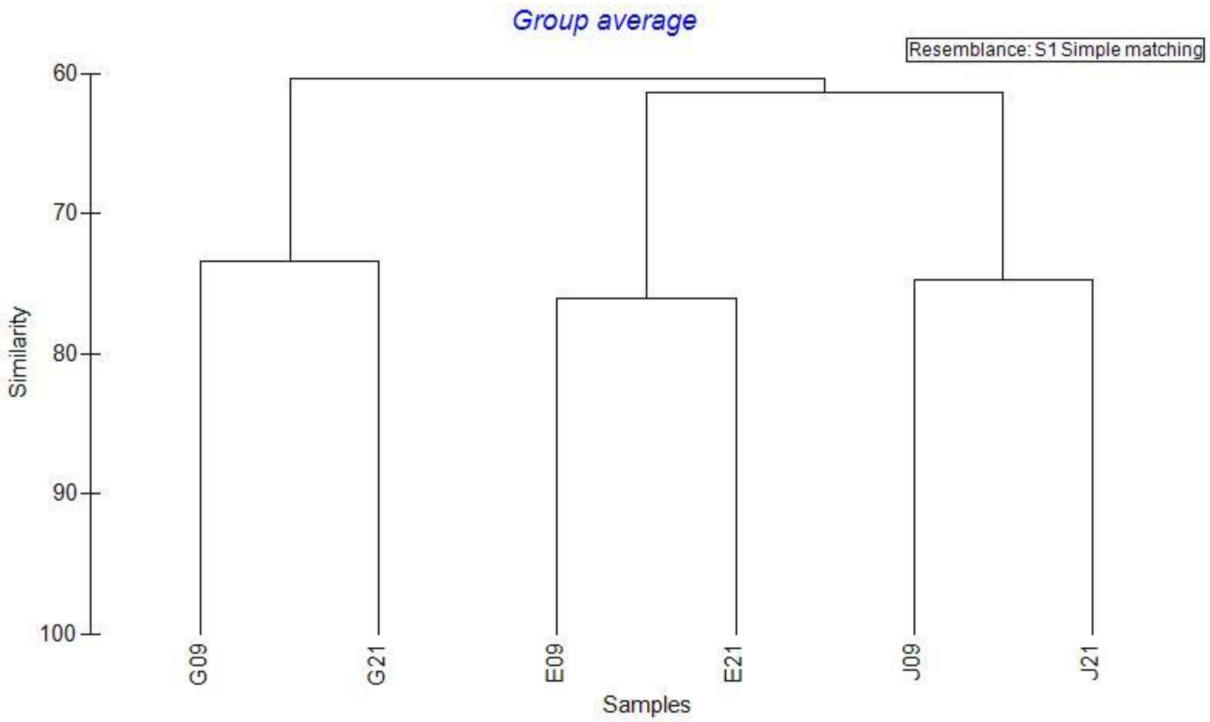


Figure 2. Result of Simple matching resemblance test for the 3 sites in Dýrafjörður.

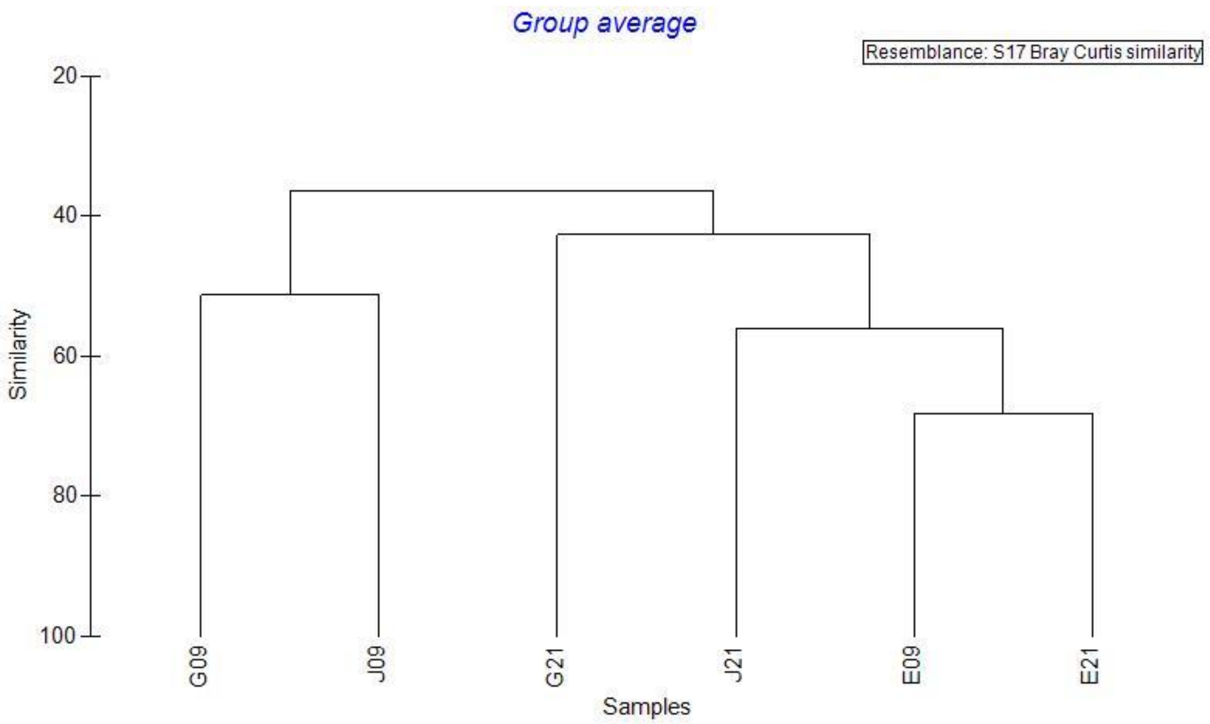


Figure 3. Result of Bray-Curtis similarity test for the 3 sites in Dýrafjörður.

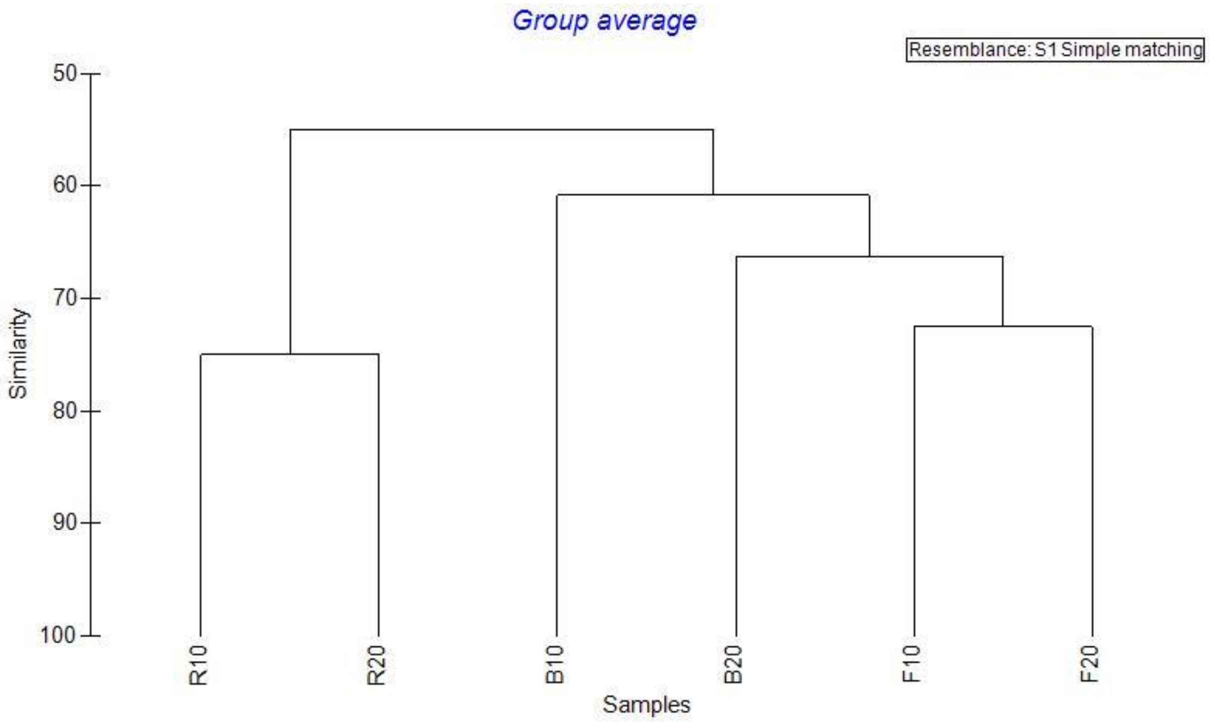


Figure 4. Result of Simple matching resemblance test for the 3 sites in Arnarfjörður.

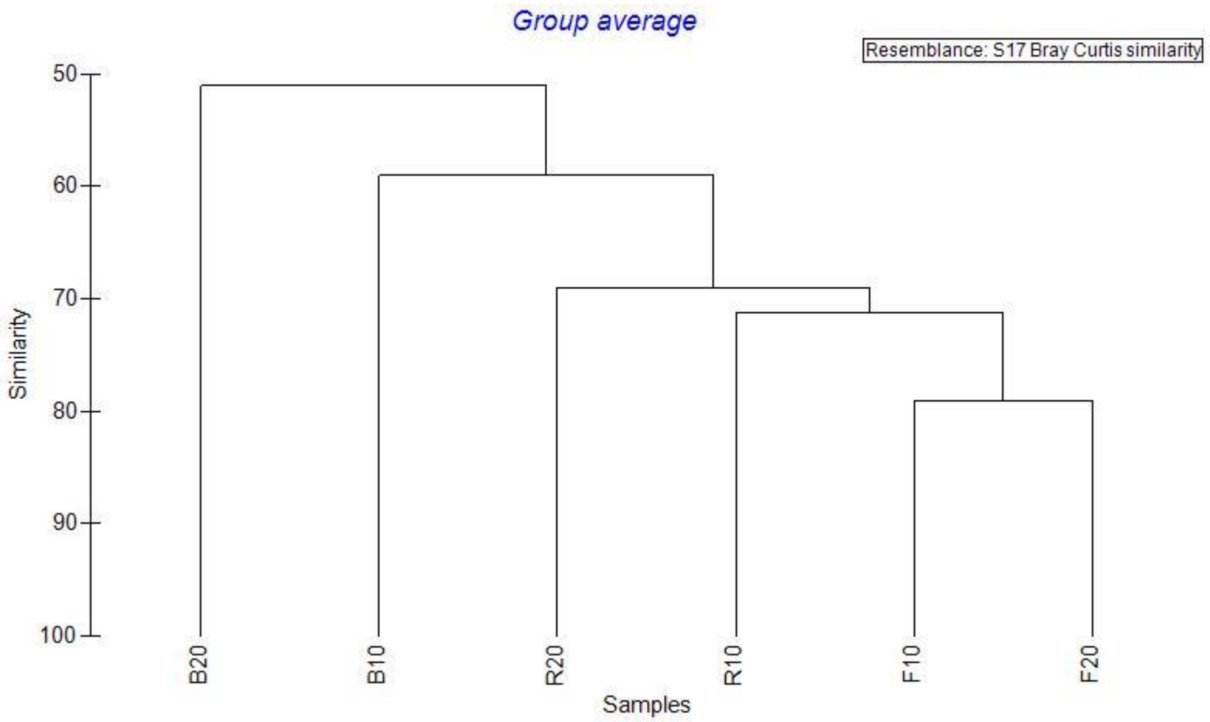


Figure 5. Result of Bray-Curtis similarity test for the 3 sites in Arnarfjörður.

Changes in benthic community composition by site

Changes in the benthic community composition at site E in Dýrafjörður can be visualized in figure 6. Of the 42 taxa found at this site in 2009, 33 taxa or 78% were also found in 2021, there were 9 new recruits (NR) while 9 taxa were no longer present in 2021 (NLP). The 18 most abundant taxa in 2009 were also found in 2021. Of the 33 taxa found also in 2021, 26 increased, 6 decreased and 1 was found with same relative abundance between years (table 5).

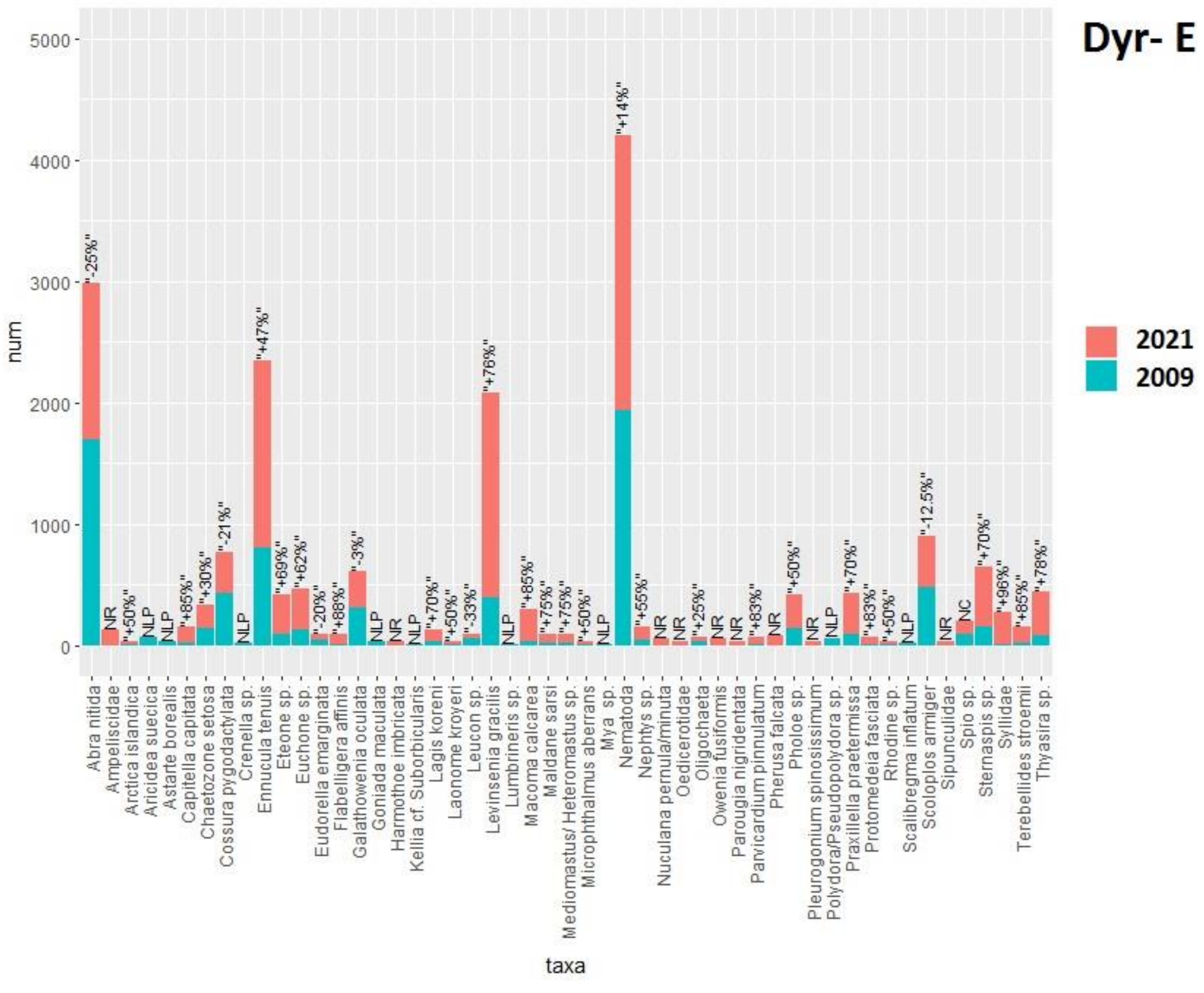


Figure 6. Benthic community composition, relative abundances per m² and % increase (+) or % decrease (-) for the 2 years (2009 and 2021) at site E in Dýrafjörður.

Changes in benthic community composition at site G in Dýrafjörður can be visualized in figure 7. Of the 30 taxa found at this site in 2009, 18 taxa or 60%, were also found in 2021, there were 9 new recruits (NR) while 12 taxa were no longer present in 2021 (NLP). The 9 most abundant taxa in 2009 were also found in 2021. Of the 18 taxa found also in 2021, 17 increased and 1 (*Eteone sp.*) decreased (table 5).

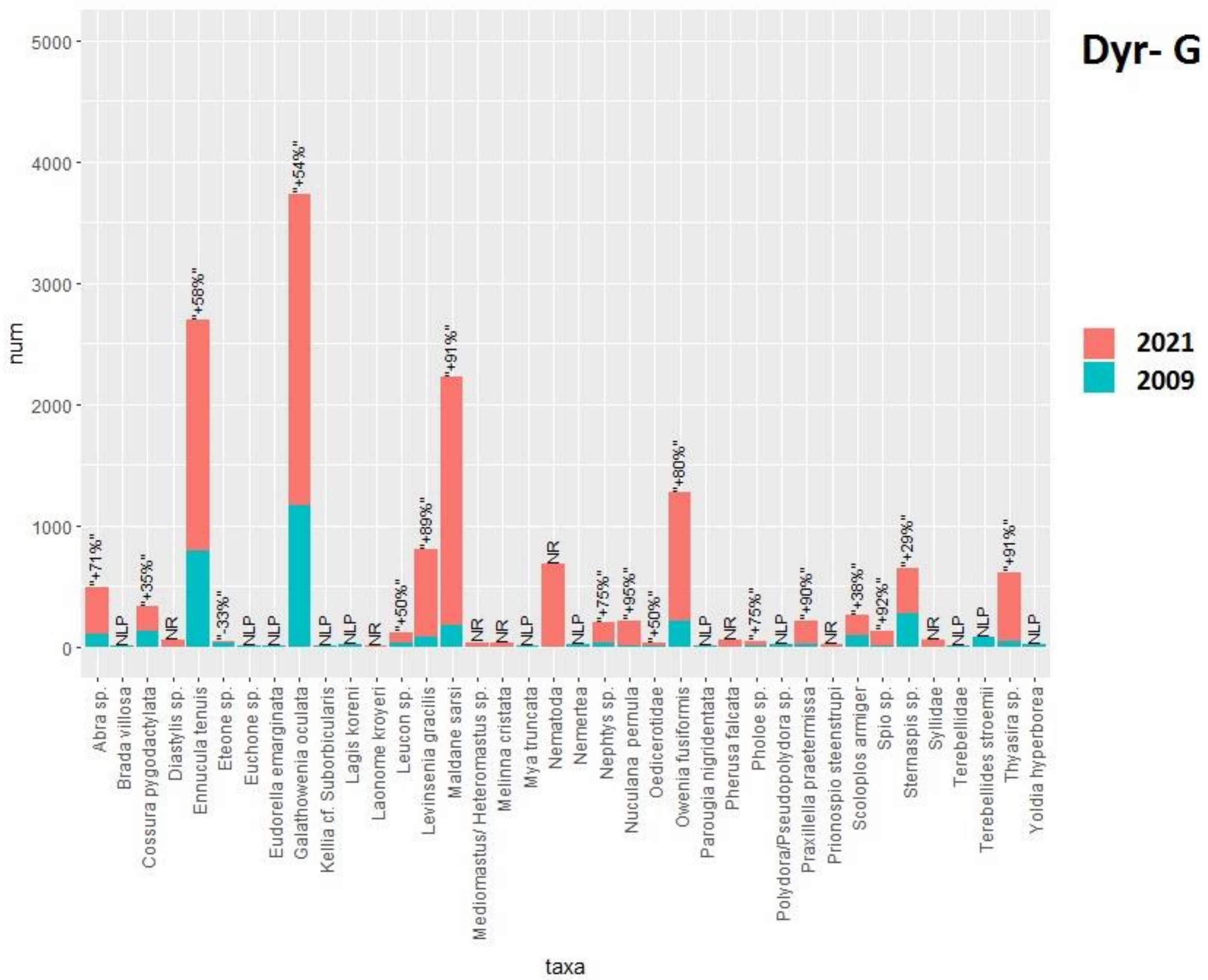


Figure 7. Benthic community composition, relative abundances per m²and % increase (+) or % decrease (-) for the 2 years (2009 and 2021) at site G in Dýrafjörður.

Changes in benthic community composition at site J in Dýrafjörður can be visualized in figure 8. Of the 38 taxa found at this site in 2009, 28 taxa or 74% were also found in 2021, there were 9 new recruits (NR) while 10 taxa were no longer present in 2021 (NLP). The 17 most abundant taxa in 2009 were also found in 2021. Of the 28 taxa found also in 2021, 18 increased, 8 decreased and 2 had the same abundance among years (table 5).

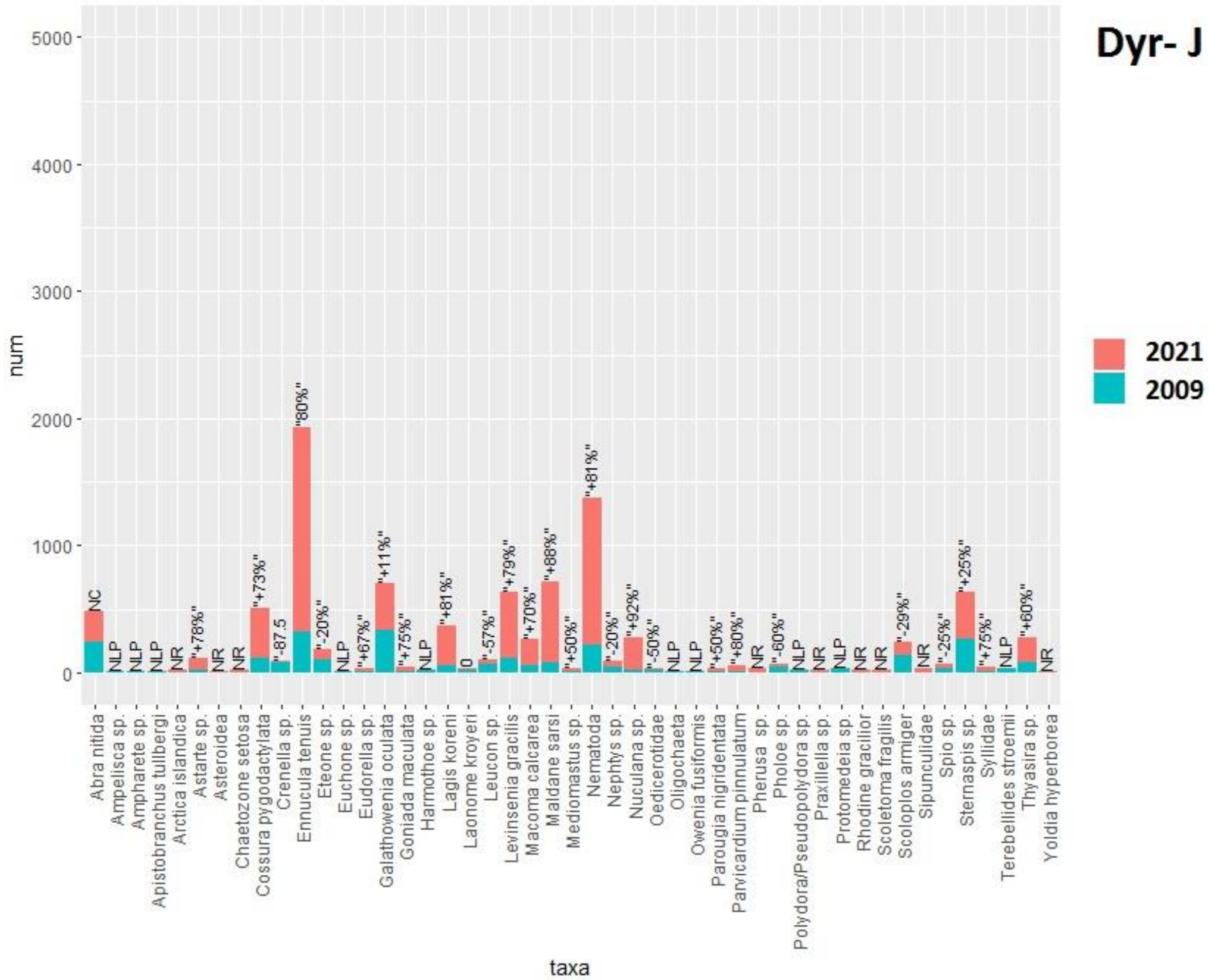


Figure 8. Benthic community composition, relative abundances per m²and % increase (+) or % decrease (-) for the 2 years (2009 and 2021) at site J in Dýrafjörður.

Changes in benthic community composition at site B in Arnarfjörður can be visualized in figure 9. Of the 18 taxa found at this site in 2010, 9 taxa or 50 % were also found in 2020, there were 7 new recruits (NR) while 9 taxa were no longer present in 2020 (NLP). The 3 most abundant taxa found in 2010 were also found in 2021 with the 4th most common species, the polychaete *Parougia nigridentata*, not found again in 2020. Of the 9 taxa found also in 2021, 2 increased and 7 decreased (table 5).

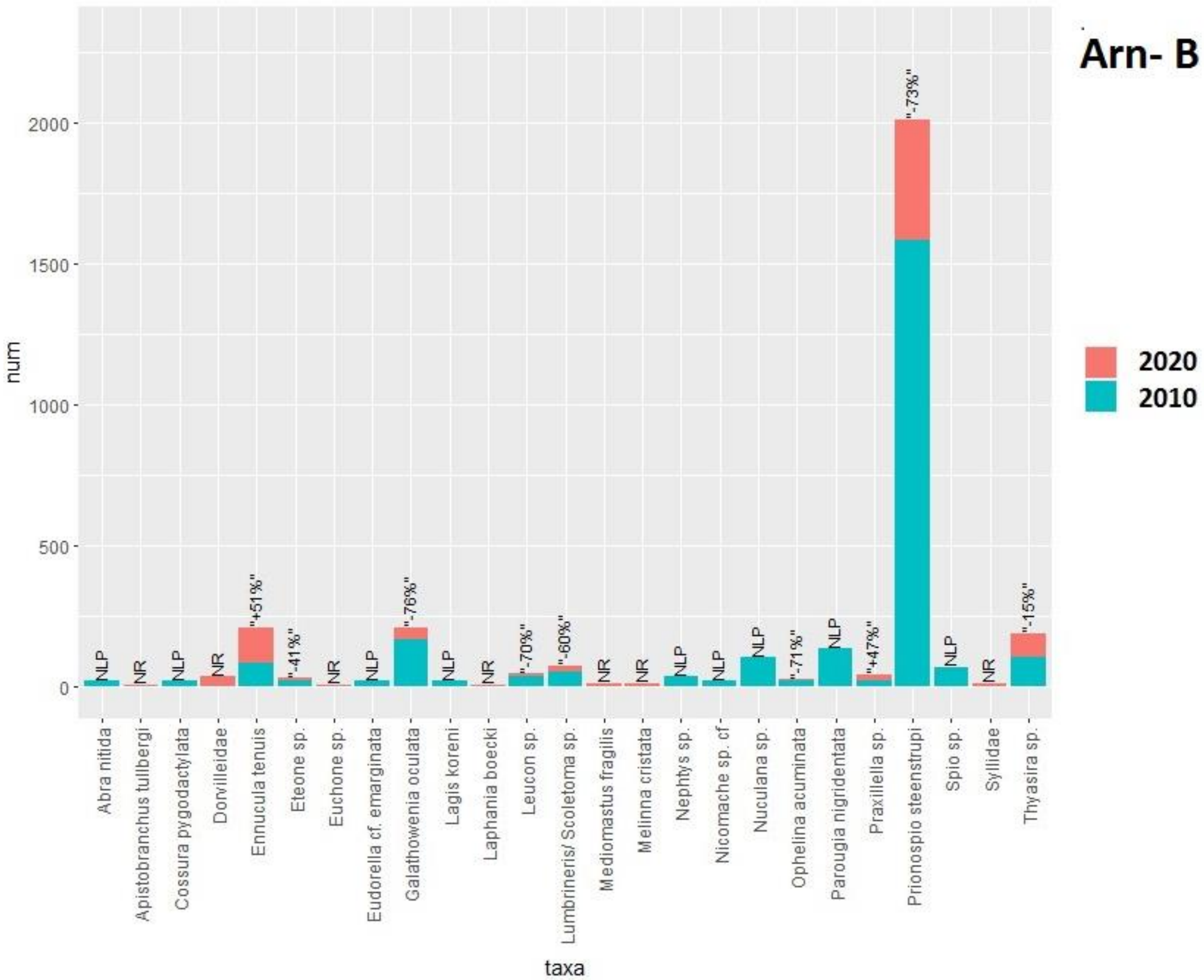


Figure 9. Benthic community composition, relative abundances per m^2 and % increase (+) or % decrease (-) for the 2 years (2010 and 2020) at site B in Arnarfjörður.

Changes in benthic community composition at site F in Arnarfjörður can be visualized in figure 10. Of the 13 taxa found at this site in 2010, 12 taxa or 92 % were also found in 2020, there were 10 new recruits (NR) while 1 species were no longer present in 2020 (NLP), this was the polychaete *Microphthalmus aberrans*. The 3 (but maybe up to7) most abundant taxa found in 2010 were also found in 2021. Of the 12 taxa found also in 2021, 1 increased and 11 decreased (table 5).

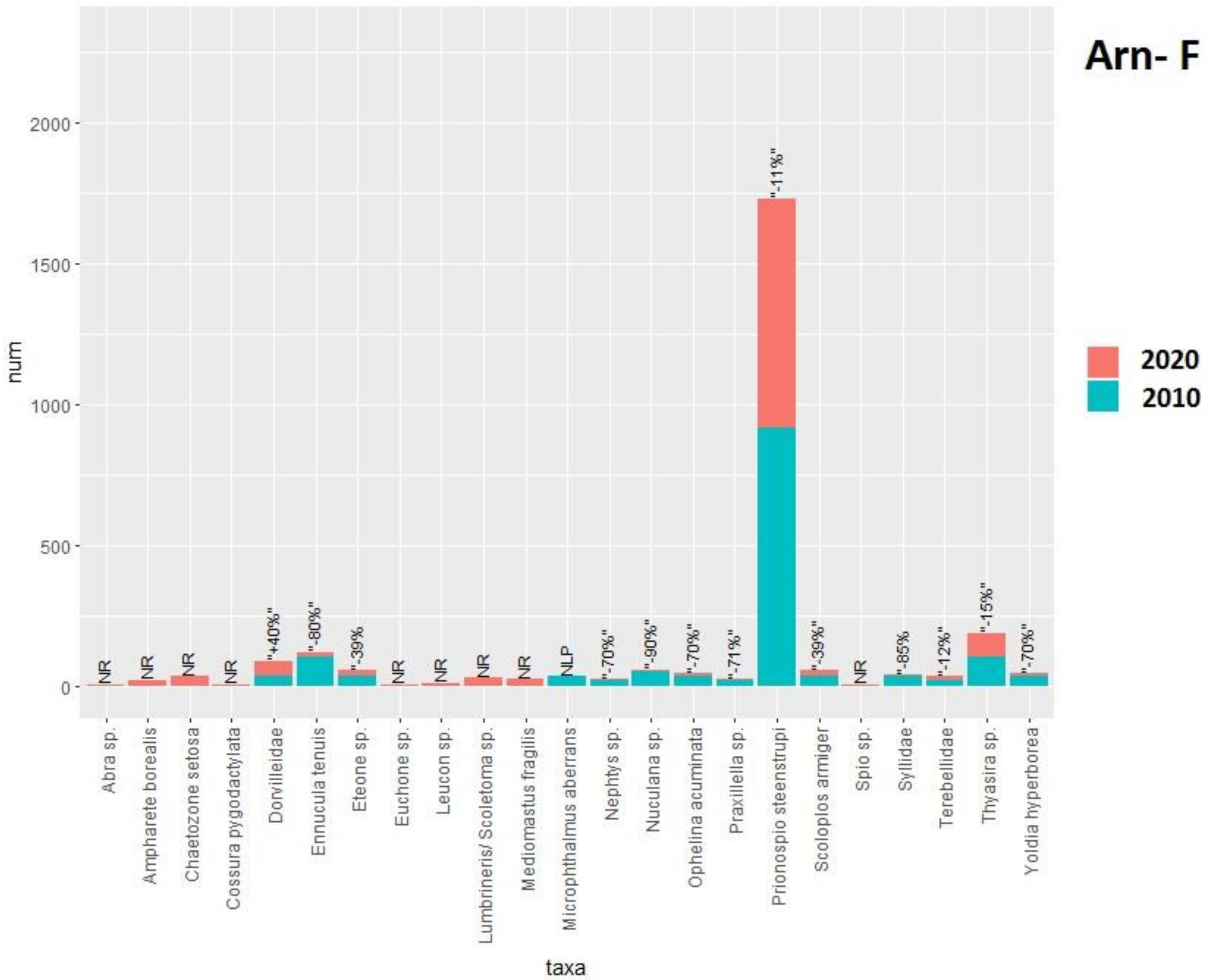


Figure 10. Benthic community composition, relative abundances per m^{2}and % increase (+) or % decrease (-) for the 2 years (2010 and 2020) at site F in Arnarfjörður.

Changes in benthic community composition at site R in Arnarfjörður can be visualized in figure 11. Of the 14 taxa found at this site in 2010, 12 taxa or 86% were also found in 2020, there were 8 new recruits (NR) while 2 taxa were no longer present in 2020 (NLP). The 7 most abundant taxa found in 2010 were also found in 2021. Of the 12 taxa found also in 2021, 3 increased and 9 decreased (table 5).

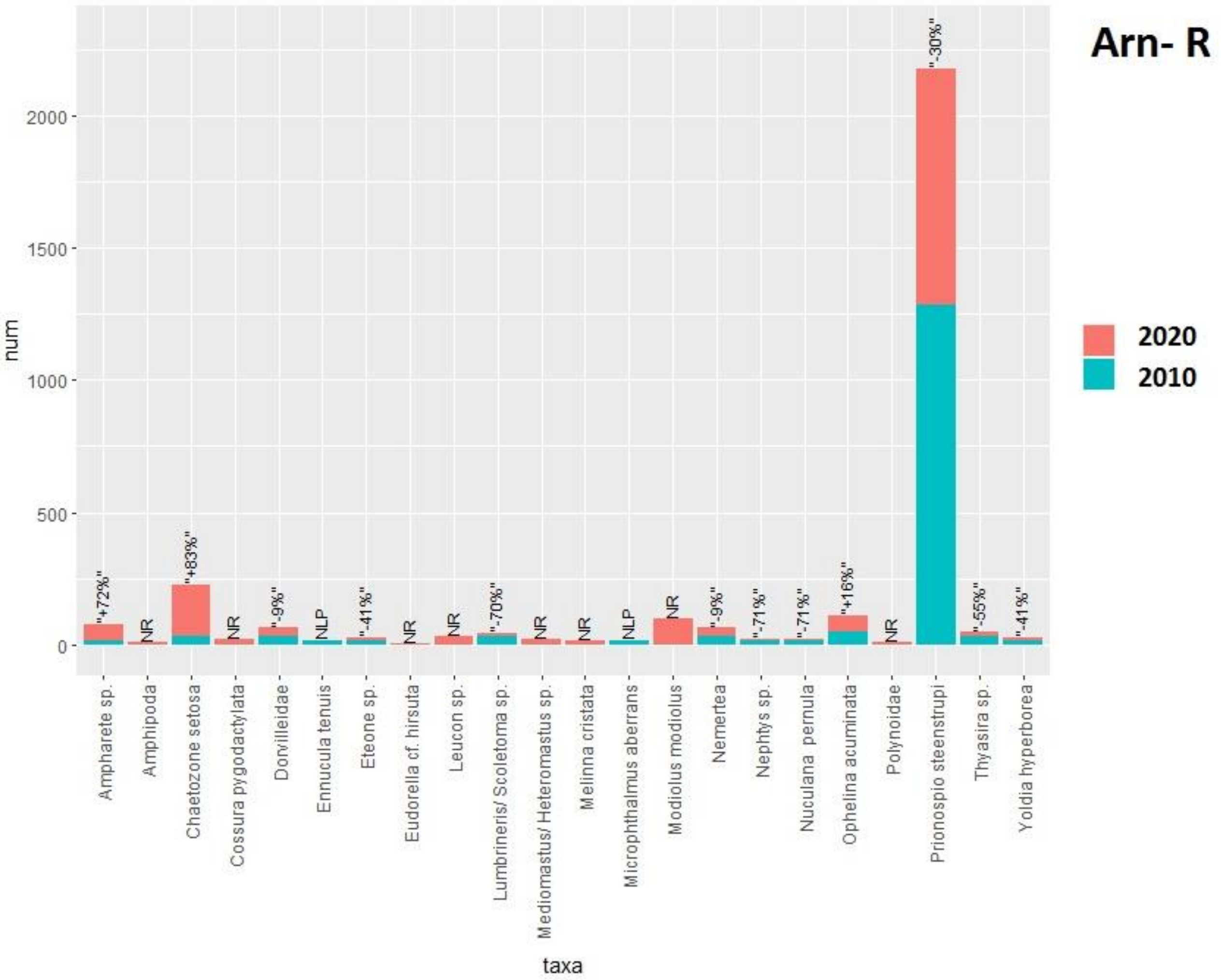


Figure 11. Benthic community composition, relative abundances per m^2 and % increase (+) or % decrease (-) for the 2 years (2010 and 2020) at site R in Arnarfjörður.

	Dýrafjörður					
Sites	**E09**	**E21**	**G09**	**G21**	**J09**	**J21**
Number of Taxa	42	42	30	26	38	37
Effective species, % increase-decrease	31%		15%		-31%	
Simple matching similarity %	76%		73%		75%	
Bray Curtis similarity %	68%		43%		47%	
Number of taxa found in 2009 also found in 2021 (%)	33 of 42	78%	18 of 30	60%	28 of 38	74%
Number of most abundant taxa from 2009 found in 2021 (% of 2021)	18	43%	9	35%	17	46%
Of those found btw years, how many increased	26		17		18	
Of those found btw years, how many decreased	6		1		8	
New recruits taxa	9		9		9	
Taxa no longer present	9		12		10	
	Arnarfjörður					
Sites	**B10**	**B20**	**F10**	**F20**	**R10**	**R20**
Number of Taxa	18	16	13	22	14	20
Effective species, % increase-decrease	15%		-4%		48%	
Simple matching similarity %	60%		72%		75%	
Bray Curtis similarity %	42%		79%		70%	
Number of taxa found in 2010 also found in 2020 (%)	9 of 18	50%	12 of 13	92%	12 of 14	86%
Number of most abundant taxa from 2010 found in 2020 (% of 2020)	3-7	20%*	3	14%	7	35%
Of those found btw years, how many increased	8		1		3	
Of those found btw years, how many decreased	1		11		9	
New recruits taxa	7		10		8	
Taxa no longer present	9		1		2	

Table 5. Summary of results. % of species calculated considering 3 as number of species.*

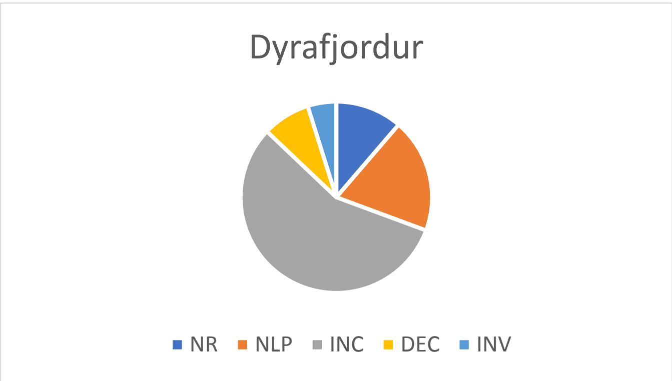
Changes in benthic community composition by location

The benthic community in Dýrafjörður was characterized by polychaetes, bivalves and nematodes. The number of polychaetes taxa decreased from 34 in 2009 to 30 in 2021. The number of bivalve species decreased from 12 to 10. Of the 55 taxa found in 2009, 42 were also found in 2021 (76%), of those, the 21 most abundant taxa (38%) in 2009 were also found in 2021. Of those there were 16 polychaetes species, 3 bivalve species, 1 cumacea and nematodes. Of those 21 taxa, 19 increased and 2 decreased (Appendix 4). The most common species were the bivalve *Ennucula tenuis* followed by nematodes (not analyzed down to species level) and the polychaetes *Galatowenia oculata*, *Levinsenia gracilis* and *Maldane sarsi*.

The benthic community in Arnarfjörður was characterized by polychaeta and bivalvia. Of the 27 taxa found in 2010, 22 were found in 2020 or 81 %. Polychaeta went from 19 taxa in 2010 to 21 in 2020, the 5 species of bivalvia that were found in 2010 were also found in 2020. The 4 most abundant taxa found in 2010 were also found in 2020 but this number could increase up to 9 taxa due to specimen from polychaeta family Dorvilleidae found in 2020 which could be matching the *Parougia nigridentata* found in 2010. These 4 taxa include the polychaeta *Prionospio steenstrupi* (the most abundant species at all 3 sites in Arnarfjörður), *Galatowenia oculata* and 2 bivalve species *Ennucula tenuis* and *Thyasira sp.* (Appendix 4).

Both polychaetes and bivalves species showed variable changes in density independently from sites "New recruits" in the "after 10 years" sampling were all found in low density. The polychaete *Melinna cristata* (a surface deposit feeder, ecological group (ecog.) 3 according to AMBI index) were found as new recruits in both fjords. Taxa no longer present in the "after 10 years"sampling were mostly found in low density in the base-line sampling (i.e. *Brada villosa* and *Aricidea suecica*) with polychaetes of genus *Polydora* in Dýrafjörður and *Parougia nigridentata* in Arnarfjörður having a more noticeable decrease. Some taxa were found to disappear in one site and appeared in another site of the same fjord (i.e. the bivalve *Abra sp.* and the polychaete *Cossura pygodactylata*). Polychaetes of the genus *Nepthys* and *Praxillella* along with bivalves of genus *Thyasira* and *Nuculana* were found to increase in Dýrafjörður but disappeared or heavily decreased in Arnarfjörður (Appendix 3).

Clear differences can be noticed between the two fjords. In Dýrafjörður more than 56% of taxa were found to increase (INC) in density, 19% were no longer present (NPL), 11% were new recruits (NR), 8% decreased (DEC) and 5% were found invariant (INV). In Arnarfjörður 49% of taxa were found to decrease in density, 23% were new recruits, 17% increased and 11% were no longer present (fig. 12). Differences between two locations were already clear by looking at number of taxa found in the sample and at the population density per m^2 (table 3).



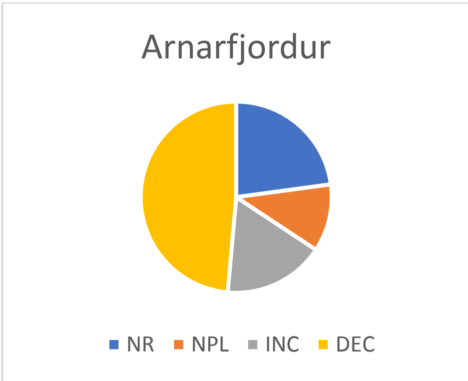


Fig. 12. Proportions of new recruits (NR), taxa no longer present (NPL), taxa which increased (INC), taxa that decreased (DEC) and taxa which abundance remain the same (INV) for the two locations of this study.

In Dýrafjörður the density of the 11 most abundant species (including nematodes) can be seen in figure 13. *Abra nitida,* a suspension feeder, and *Scoloplos armiger,* a subsurface deposit feeder (Jumars et al. 2015), both classified in ecological group 3 according to the AMBI index, were the only two species which slightly decreased. *Galatowenia oculata* (subsurface deposit feeder, ecog. 3), *Levinsenia gracilis* (surface/subsurface deposit feeder, ecog. 3) and *Maldane sarsi* (subsurface deposit feeder, ecog. 2) showed the most positive increases. The rest of the community can be seen in figure 14. Almost all most abundant taxa increased in the later sampling. The bivalve *Crenella sp.* (ambi ecogroup 2), and the polychaetes *Aricidea suecica* (deposit feeder, ecog. 1) and *Polydora/Pseudopolydora* (suspension and deposit feeders, ecog. 3-4) were no longer found in the later sampling along with a few other species which were found in little abundance during base-line sampling.

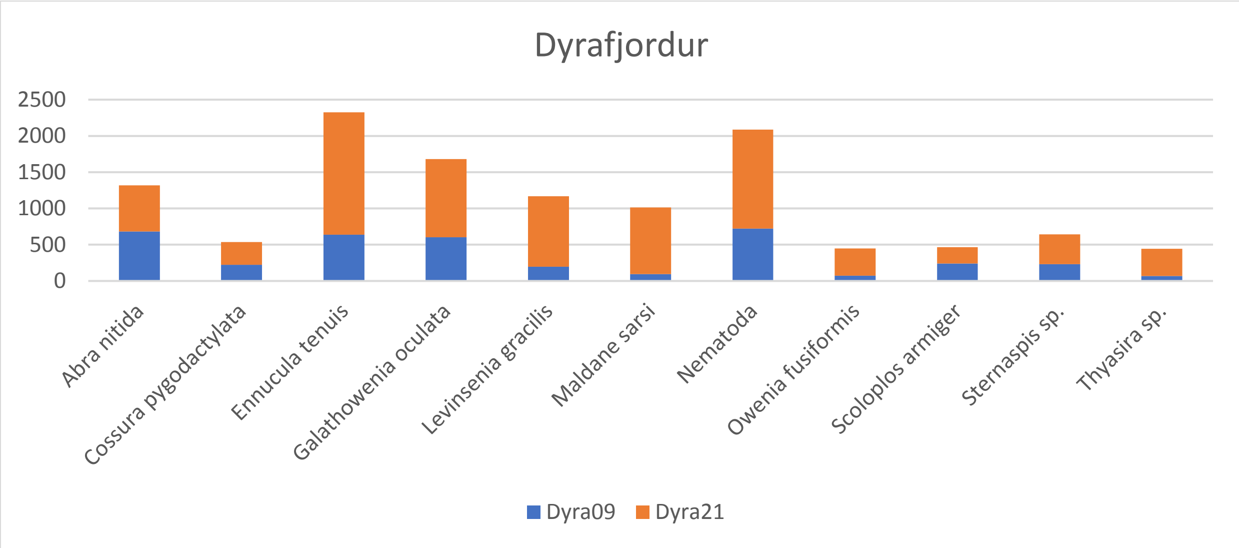


Fig. 13. Relative abundances per m² between years of the 11 most common taxa found in Dýrafjörður (sites joined).

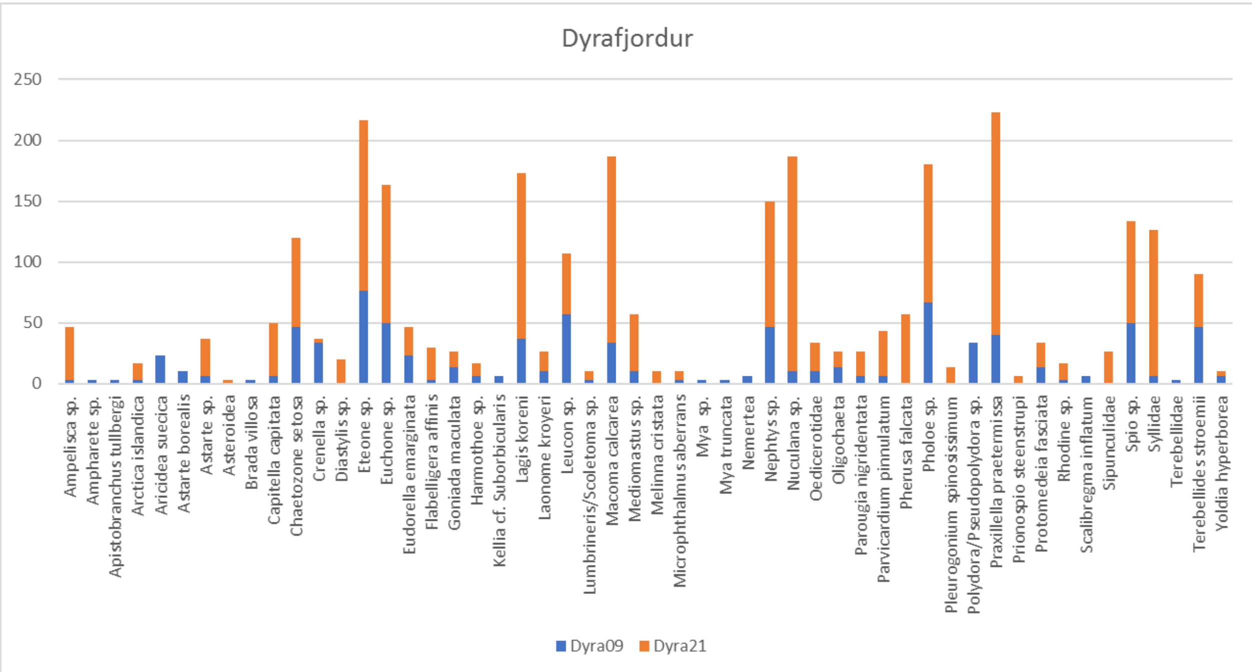


Fig. 14. Relative abundances per m² of the benthic community in Dýrafjörður (sites joined), except for the 11 most common taxa (fig.13).

In Arnarfjordur the polychaete *Prionospio steenstrupi* (suspension and deposit feeder, ecog. 4) was extrapolated from the main chart due to its high density. The polychaete *Parougia negridentata* (carnivor/scavenger, ecog. of similar species set as 4 by AMBI) was no longer present in the “after 10 years” sampling. This disappearance is though not definite as the population density of the polychaete family to which *Parougia* belongs increased. Unfortunately these individuals could not be identify down to species level due to their small sizes. Three species of the Dorvilleidae family had been found in Arnarfjörður during the last decade, the mentioned *Parougia negridentata*, *Ophryotrocha cosmetandra* and *Ophryotrocha lobifera* (Cristian Gallo og Margrét Thorsteinsson 2017, Roger Velvin and Snorri Gunnarson 2017, Hans-Petter Mannvik and Snorri Gunnarsson 2019) with the first two very similar and difficult to distinguish. *Spio. sp* (suspensionand surface deposit feeder, ecog. 3), *Nephtys sp.* (carnivor/predator, ecog. 2) and *Galatowenia oculata* (subsurface deposit feeder, ecog. 3) decresed in density along with bivalves of genus *Nuculana* (ecog. 1), (fig.15).

The Polychaete *Mediomastus fragilis* (subsurface deposit feeder, ecog. 3) together with the bivalve *Modiolus modiolus* (ecog. 2) were the noticeable new recruits. *Ampharete* (surface deposit feeder, ecog. 1-2) and *Chaetozone setosa* (surface deposit feeder, ecog. 4) together with bivalve *Ennucula tenuis* (ecog. 2) and *Thyasira sp.* (ecog. 2) seems to have been affected positively (fig. 15).

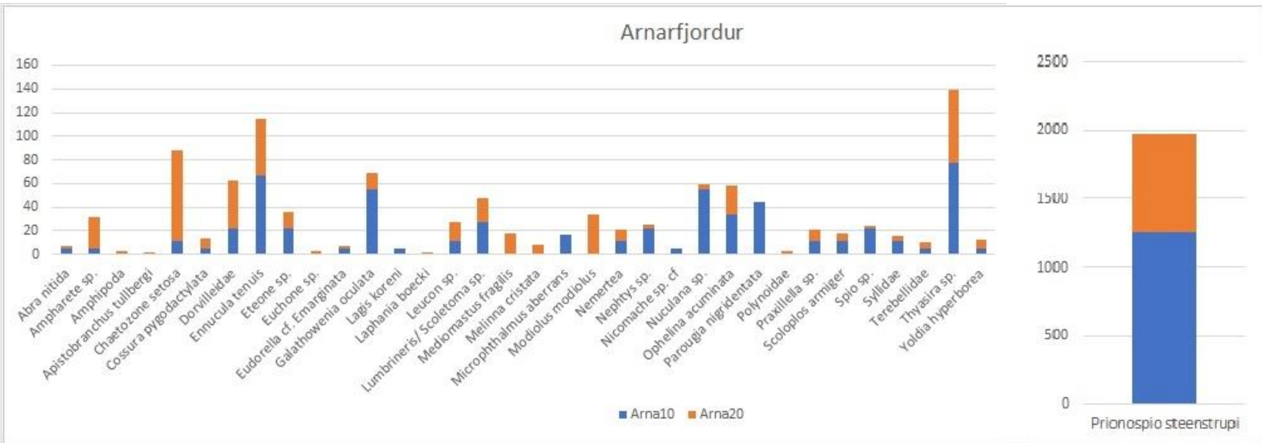


Fig. 15. Relative abundances per m² of the benthic community in Arnarfjörður (sites joined).

Discussion

Changes in benthic community between 2 sampling times (10 years between) were analyzed by looking at the variation in diversity, evenness, similarity and species composition between sites and location. Sampled sites were all located in the regional zone where impact from the mariculture activities should be negligible.

Despite the disappearance of certain species, the number of taxa found was similar among years. The number of individuals increased in Dýrafjörður but decreased in Arnarfjörður. The two fjords are very different with Dýrafjörður being smaller and shallower than Arnarfjörður. Moreover, Arnarfjörður also has a threshold at the mouth of the fjord which affects water circulation and oxygen levels in the fjord (Ólafsdóttir S. et al. 2017) and because of this presents naturally low animal diversity (Vaquer and Duarte, 2008, Woods et al., 2021). The increase in population density in Dýrafjörður could possibly be due to the presence of mariculture in the fjord but was not possible to address this issue on this study.

Diversity increased in most cases and the distribution of species became more even as well. The Shannon-Wiener diversity index increased significantly in 5 of the 6 sites. Evenness between relative abundance of individuals of different taxa inside the community increased in 4 of the 6 sites. True diversity (ENS) also increased in 4 of 6 sites. Diversity was though rather low in both fjords but especially in Arnarfjörður and as said here above this seems to be part of a “natural” state.

Results from the biotic index (AMBI and NQI1) showed rather sign of improvement especially in Arnarfjörður still the ecological status which is derived from them can be affected by the low natural diversities.

Simple matching test showed level of similarity, between benthic community of the two sampling years, around 70% for 5 sites out of 6. The Bray-Curtis similarity test, by taking in consideration not only the taxa but also the density of them, which increased, showed mixed results with 3 sites around 70% similarity and 3 around 45% similarity. No level of similarity are set to assess if this similarities were satisfactory.

When comparing the benthic community species composition between the base-line sampling and the “10 years after” sampling, this study found around 70% of taxa present and around 35% of the most abundant species present between samplings in 4 of the 6 sites. As said above, the number of species, for the most part increased in density in Dýrafjörður and decreased in Arnarfjörður. In Dýrafjörður there were more species that were not found again than new recruits species. In Arnarfjörður there were more new species than species which were not found again after ten years.

Of polychaetes, species such as *Chaetozone setosa*, *Levinsenia gracilis*, *Maldane sarsi, Mediomastus sp., Pherusa sp.* and *Sternaspis sp*. increased their densities in the “after 10 years” sampling. The population density of *Praxillella sp*., Syllidae and *Nepthys sp*. show mixed results (increased or decreased) while species as *Prionospio steenstrupi, Polydora sp.* and *Ophelina acuminata* decreased their densities. Between bivalves, *Abra sp., Arctica islandica, Ennucula tenuis, Parvicardium pinnulatum* and *Macoma calcarea* increased in density while *Crenella sp., Kellia sp.* and *Mya sp.* decreased or were no longer present in the "after 10 years" sampling.

These results do not seem to be justified by the feeding guild of species, with suspension feeders and deposit feeders both increasing and decreasing in relative abundances with no discernable pattern. No clear answers were found by looking at the species' sensitivity to anthropogenic disturbances. If on one hand the tolerant species *Capitella capitata* increased in abundance at site E in Dýrafjörður and sensitive species such as *Crenella sp., Mya sp., Prionospio steenstrupi* and *Ophelina acuminata* were no longer found or decreased. On the other hand, other sensitive species of polychaeta as *Pherusa falcata* and *Maldane sarsi* together with the bivalve *Parvicardium pinnulatum* were not so negatively affected. Even more intriguing was the disappearance of polychaetes of the genus *Polydora* (or *Pseudopolydora*) in all sites in Dýrafjörður since this genus is supposed to tolerate a certain degree of organic enrichment and it is classified in the ecological group 3-4 according to AMBI list (ambi.atzi.es).

This study found changes in benthic community diversity, evenness and composition after the fjords have been used for 10 years by mariculture activity but these changes were not severe. Natural variability influence the benthic community and distinguishing between natural variability and induced human changes (in this case mariculture) can be difficult, especially in the regional zone and beyond. Nevertheless, the increase in the number of species and their population density could be the consequence of the organic input coming from the mariculture (Pearson and Rosenberg, 1978) and should therefore be monitored in the long term.

Thanks

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Appendix 1

Benthic community composition (density/m^2) between two sampling, 2009 and 2021 in Dýafjörður.

Taxa Dýrafjörður	**E09**	**E21**	**G09**	**G21**	**J09**	**J21**	**Taxa Dýrafjörður**	**E09**	**E21**	**G09**	**G21**	**J09**	**J21**
Annellida Polychaeta							**Annellida Polychaeta**						
Ampharete sp.					10		Syllidae	10	260		60	10	40
Apistobranchus tullbergi					10		Terebellidae			10			
Aricidea suecica	70						*Terebellides stroemii*	20	130	80		40	
Brada villosa			10				**Annellida Oligochaeta**	30	40			10	
Capitella capitata	20	130					**Nematoda**	1940	2260		680	220	1160
Chaetozone setosa	140	200				20	**Nemertea**			20			
Cossura pygodactylata	430	340	130	200	110	400	**Mollusca Bivalvia**						
Eteone sp.	100	320	30	20	100	80	*Abra nitida*	1700	1280			240	240
Euchone sp.	130	340	10		10		*Abra sp.*			110	380		
Flabelligera affinis	10	80					*Arctica islandica*	10	20				20
Galathowenia oculata	310	300	1170	2560	330	370	*Astarte borealis*	30					
Goniada maculata	30				10	40	*Astarte sp.*					20	90
Harmothoe imbricata		30					*Crenella sp.*	20				80	10
Harmothoe sp.					20		*Ennucula tenuis*	810	1540	790	1900	320	1610
Lagis koreni	30	100	20		60	310	*Kellia cf. Suborbicularis*	10		10			
Laonome kroyeri	10	20	0	10	20	20	*Macoma calcarea*	40	260			60	200
Levinsenia gracilis	400	1680	80	720	110	520	Mya sp.	10					
Lumbrineris sp.	10						Mya truncata			10			
Maldane sarsi	20	80	180	2040	80	640	*Nuculana pernula*			10	210		
Mediomastus sp.	20	80		40	10	20	*Nuculana pernula/minuta*		60				
Melinna cristata				30			*Nuculana sp.*					20	260
Microphthalmus aberrans	10	20					*Parvicardium pinnulatum*	10	60			10	50
Nephtys sp.	50	110	40	160	50	40	*Thyasira sp.*	80	360	50	560	80	200
Owenia fusiformis		60	210	1060	10		*Yoldia hyperborea*			20			10
Parougia nigridentata		40	10		10	20	**Arthropoda Amphipoda**						
Pherusa sp.						30	*Ampelisca sp.*					10	
Pherusa falcata		80		60			*Ampeliscidae*		130				
Pholoe sp.	140	280	10	40	50	20	Oedicerotidae		40	10	20	20	10
Polydora/Pseudopolydora sp.	60		20		20		*Protomedeia fasciata*	10	60				
Praxillella praetermissa	100	330	20	200			*Protomedeia sp.*					30	
Praxillella sp.						20	**Arthropoda Cumacea**						
Prionospio steenstrupi				20			*Diastylis sp.*				60		
Rhodine gracilior						20	*Eudorella emarginata*	50	40	10			
Rhodine sp.	10	20					*Eudorella sp.*					10	30
Scoletoma fragilis						20	*Leucon sp.*	60	40	40	80	70	30
Scalibregma inflatum	20						**Arthropoda Isopoda**						
Scoloplos armiger	480	420	100	160	140	100	*Pleurogonium spinosissimum*		40				
Spio sp.	100	100	10	120	40	30	**Sipunculidae**		40				40
Sternaspis sp.	150	500	270	380	270	360	**Asteroidea**						10

Appendix 2

Benthic community composition (density/m^2) between two sampling, 2010 and 2020 in Arnarfjörður.

Taxa Arnarfjordur	B10	B20	F10	F20	R10	R20
Annellida Polychaeta						
Ampharete borealis	0	0	0	20	0	0
Ampharete sp.	0	0	0	0	17	60
Apistobranchus tullbergi	0	5	0	0	0	0
Chaetozone setosa	0	0	0	35	33	195
Cossura pygodactylata	17	0	0	5	0	20
Dorvilleidae	0	35	33	55	33	30
Eteone sp.	17	10	33	20	17	10
Euchone sp.	0	5	0	5	0	0
Galathowenia oculata	167	40	0	0	0	0
Lagis koreni	17	0	0	0	0	0
Laphania boecki	0	5	0	0	0	0
Lumbrineris/ Scoletoma sp.	50	20	0	30	33	10
Mediomastus fragilis	0	10	0	25	0	0
Mediomastus/ Heteromastus sp.	0	0	0	0	0	20
Melinna cristata	0	10	0	0	0	15
Microphthalmus aberrans	0	0	33	0	17	0
Nephtys sp.	33	0	17	5	17	5
Nicomache sp. cf	17	0	0	0	0	0
Ophelina acuminata	17	5	33	10	50	60
Parougia nigridentata	133	0	0	0	0	0
Polynoidae	0	0	0	0	0	10
Praxillella sp.	17	25	17	5	0	0
Prionospio steenstrupi	1583	430	917	815	1283	895
Scoloplos armiger	0	0	33	20	0	0
Spio sp.	67	0	0	5	0	0
Syllidae	0	10	33	5	0	0
Terebellidae	0	0	17	15	0	0
Nemertea	0	0	0	0	33	30
Mollusca Bivalvia						
Abra nitida	17	0	0	0	0	0
Abra sp.	0	0	0	5	0	0
Ennucula tenuis	83	125	100	20	17	0
Modiolus modiolus	0	0	0	0	0	100
Nuculana pernula	0	0	0	0	17	5
Nuculana sp.	100	0	50	5	0	0
Thyasira sp.	100	85	100	85	33	15
Yoldia hyperborea	0	0	0	10	17	10
Arthropoda Amphipoda	0	0	0	0	0	10
Arthropoda Cumacea						
Eudorella cf. emarginata	17	0	0	0	0	0
Eudorella cf. hirsuta	0	0	0	0	0	5
Leucon sp.	33	10	0	10	0	30

Appendix 3

Comparison of the benthic community composition between two sampling, 2009 and 2021 in Dýafjörður and 2010 and 2020 in Arnarfjörður. NR (new recruits), NPL (no longer present), NC (no change) and % increase or % decrease (-).

Locations	**Dýrafjörður**			**Arnarfjörður**			**Locations**	**Dýrafjörður**			**Arnarfjörður**		
Sites	**E**	**G**	**J**	**B**	**F**	**R**	**Sites**	**E**	**G**	**J**	**B**	**F**	**R**
Abra nitida	-25%		NC	NLP			*Microphthalmus aberrans*	50%				NLP	NLP
Abra sp.		71%			NR		*Modiolus modiolus*						NR
Ampelisca sp.			NLP				*Mya sp.*	NLP	NLP				
Ampeliscidae	NR						*Mya truncata*	NLP	NLP				
Ampharete sp.			NLP		NR	72%	Nematoda	14%	NR	81%			
Amphipoda						NR	Nemertea		NLP				-9%
Apistobranchus tullbergi			NLP	NR			*Nephtys sp.*	55%	75%	20%	NLP	-70%	-71%
Arctica islandica	50%		NR				*Nicomache sp. cf*				NLP		
Aricidea suecica	NLP						*Nuculana pernula*		95%		NLP		-71%
Astarte borealis	NLP						*Nuculana pernula/minuta*	NR					
Astarte sp.			78%				*Nuculana sp.*			92%	NLP	-90%	
Asteroidea			NR				Oedicerotidae	NR	50%	-50%			
Brada villosa		NLP					Oligochaeta	25%		NLP			
Capitella capitata	85%						*Ophelina acuminata*				-71%	-70%	16%
Chaetozone setosa	30%		NR		NR	83%	*Owenia fusiformis*	NR	80%	NLP			
Cossura pygodactylata	-21%	35%	73%	NLP	NR	NR	*Parougia nigridentata*	NR	NLP	50%	NLP		
Crenella sp.	NLP		-88%				*Parvicardium pinnulatum*	83%		80%			
Diastylis sp.		NR					*Pherusa sp.*			NR			
Dorvilleidae				NR	40%	-9%	*Pherusa falcata*	NR					
Ennucula tenuis	47%	58%	80%	51%	-80%	NLP	*Pholoe sp.*	50%	75%	-60%			
Eteone sp.	69%	-33%	-20%	-41%	-39%	-41%	*Pleurogonium spinosissimum*	NR					
Euchone sp.	62%	NLP	NLP	NR	NR		*Polydora/Pseudopolydora sp.*	NLP	NLP	NLP			
Eudorella emarginata	-20%	NLP		NLP			Polynoidae						NR
Eudorella sp.			67%			NR	*Praxillella praetermissa*	70%	90%				
Flabelligera affinis	88%						*Praxillella sp.*			NR	NLP	-71%	
Galathowenia oculata	-3%	54%	11%	-76%			*Prionospio steenstrupi*		NR		-73%	-11%	-30%
Goniada maculata	NLP		75%				*Protomedeia fasciata*	83%					
Harmothoe imbricata	NR						*Protomedeia sp.*			NLP			
Harmothoe sp.			NLP				*Rhodine gracilior*			NR			
Kellia cf. Suborbicularis	NLP	NLP					*Rhodine sp.*	50%					
Lagis koreni	70%	NLP	81%	NLP			*Scalibregma inflatum*	NLP					
Laonome kroyeri	50%	NR	NC				*Scoletoma fragilis*			NR			
Laphania boecki				NR			*Scoloplos armiger*	-13%	38%	-29%		-39%	
Leucon sp.	-33%	50%	-57%	-70%	NR	NR	Sipunculidae	NR		NR			
Levinsenia gracilis	76%	89%	79%				*Spio sp.*	NC	92%	-25%	NLP	NR	
Lumbrineris sp.	NLP			-60%	NR	-70%	*Sternaspis sp.*	70%	29%	25%			
Macoma calcarea	85%		70%				Syllidae	96%	NR	75%	NR	-85%	
Maldane sarsi	75%	91%	88%				Terebellidae		NLP			-12%	
Mediomastus sp.	75%		50%	NR	NR		*Terebellides stroemii*	85%		NLP			
Mediomastus/ Heteromastus sp.		NR				NR	*Thyasira sp.*	78%	91%	60%	-15%	-15%	-55%
Melinna cristata		NR		NR		NR	*Yoldia hyperborea*		NLP	NR		-70%	-41%

Appendix 4

Benthic community composition (density/m^2) with sites joined by location, between two sampling, 2009 and 2021 in Dýafjörður and 2010 and 2020 in Arnarfjörður .

Location	**Dýrafjörður**		**Location**	**Dýrafjörður**		**Location**	**Arnarfjörður**	
Taxa	**2009**	**2021**	**Taxa**	**2009**	**2021**	**Taxa**	**2010**	**2020**
Abra nitida	647	507	*Mya truncata*	3	0	*Abra nitida*	6	0
Abra sp.	37	127	Nematoda	720	1367	*Abra sp.*	0	2
Ampelisca sp.	3	0	Nemertea	7	0	*Ampharete borealis*	0	7
Ampeliscidae	0	43	*Nephtys sp.*	47	103	*Ampharete sp.*	6	20
Ampharete sp.	3	0	*Nuculana pernula*	3	70	Amphipoda	0	3
Apistobranchus tullbergi	3	0	*Nuculana pernula/minuta*	0	20	*Apistobranchus tullbergi*	0	2
Arctica islandica	3	13	*Nuculana sp.*	7	87	*Chaetozone setosa*	11	77
Aricidea suecica	23	0	Oedicerotidae	10	23	*Cossura pygodactylata*	6	8
Astarte borealis	10	0	Oligochaeta	13	13	Dorvilleidae	22	40
Astarte sp.	7	30	*Owenia fusiformis*	73	373	*Ennucula tenuis*	67	48
Asteroidea	0	3	*Parougia nigridentata*	7	20	*Eteone sp.*	22	13
Brada villosa	3	0	*Parvicardium pinnulatum*	7	37	*Euchone sp.*	0	3
Capitella capitata	7	43	*Pherusa sp.*	0	10	*Eudorella cf. emarginata*	6	0
Chaetozone setosa	47	73	*Pherusa falcata*	0	47	*Eudorella cf. hirsuta*	0	2
Cossura pygodactylata	223	313	*Pholoe sp.*	67	113	*Galathowenia oculata*	56	13
Crenella sp.	33	3	*Pleurogonium spinosissimum*	0	13	*Lagis koreni*	6	0
Diastylis sp.	0	20	*Polydora/Pseudopolydora sp.*	33	0	*Laphania boecki*	0	2
Ennucula tenuis	640	1683	*Praxillella praetermissa*	40	177	*Leucon sp.*	11	17
Eteone sp.	77	140	*Praxillella sp.*	0	7	*Lumbrineris/ Scoletoma sp.*	28	20
Euchone sp.	50	113	*Prionospio steenstrupi*	0	7	*Mediomastus fragilis*	0	12
Eudorella emarginata	20	13	*Protomedeia fasciata*	3	20	*Mediomastus/ Heteromastus sp.*	0	7
Eudorella sp.	3	10	*Protomedeia sp.*	10	0	*Melinna cristata*	0	8
Flabelligera affinis	3	27	*Rhodine gracilior*	0	7	*Microphthalmus aberrans*	17	0
Galathowenia oculata	603	1077	*Rhodine sp.*	3	7	*Modiolus modiolus*	0	33
Goniada maculata	13	13	*Scalibregma inflatum*	7	0	Nemertea	11	10
Harmothoe imbricata	0	10	*Scoletoma fragilis*	0	7	*Nephtys sp.*	22	3
Harmothoe sp.	7	0	*Scoloplos armiger*	240	227	*Nicomache sp. cf*	6	0
Kellia cf. Suborbicularis	7	0	Sipunculidae	0	27	*Nuculana pernula*	6	2
Lagis koreni	37	137	*Spio sp.*	50	83	*Nuculana sp.*	50	2
Laonome kroyeri	10	17	*Sternaspis sp.*	230	413	*Ophelina acuminata*	33	25
Leucon sp.	57	50	Syllidae	7	120	*Parougia nigridentata*	44	0
Levinsenia gracilis	197	973	Terebellidae	3	0	Polynoidae	0	3
Lumbrineris sp.	3	0	*Terebellides stroemii*	47	43	*Praxillella sp.*	11	10
Macoma calcarea	33	153	*Thyasira sp.*	70	373	*Prionospio steenstrupi*	1261	713
Maldane sarsi	93	920	*Yoldia hyperborea*	7	3	*Scoloplos armiger*	11	7
Mediomastus sp.	3	7				*Spio sp.*	22	2
Mediomastus/ Heteromastus sp.	7	40				Syllidae	11	5
Melinna cristata	0	10				Terebellidae	6	5
Microphthalmus aberrans	3	7				*Thyasira sp.*	78	62
Mya sp.	3	0				*Yoldia hyperborea*	6	7