# Ecology of Eyjafjörður Project

## Chemical and biological parameters measured in Eyjafjörður in the period April 1992 - August 1993

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## Ágrip (Iclandic summary)

Umfangsmikil rannsókn á umhverfi og lífríki Eyjafjarðar var unnin í samvinnu Hafrannsóknastofnunarinnar, Háskólans á Akureyri og Rannsóknastofnunar fiskiðnaðarins á tímabilinu apríl 1992 til ágúst 1993. Rannsóknirnar spönnuðu vítt svið og í hverjum leiðangri var skráður hiti, selta og flúrljómun á dýptarsniði með sondumælum og tekin sjósýni til greininga á næringarefnum, súrefni og *a*-blaðgrænu á fyrirfram ákveðnu stöðvaneti. Staðsetning stöðvanna, gefin upp í lengdar- og breiddargráðum, er að finna í töflu 1.1. Jafnframt söfnun sjósýna og mælinga með sondu voru tekin sýni til rannsókna á örverum, svifþörungum, dýrasvifi, fiskasvifi og botndýrum. Dreifing stöðva um fjörðinn kemur fram á mynd 1.1 og þar er sýnt hvað var gert á hverri stöð. Eins og fram kemur í gagnaskýrslu um niðurstöður rannsókna á hafeðlisfræði (Steingrímur Jónsson 1996) voru farnir alls 15 leiðangrar á fyrrgreindu tímabili. Dagsetningar hverrar yfirferðar eru gefnar upp í töflu 1.2. Auk framangreindra mælinga og söfnunar sýna í leiðöngrum, var settur upp vindmælir í Hrísey og aflað vindgagna frá Akureyri og Grímsey (Steingrímur Jónsson 1996). Orkustofnun lét í té mælingar á ferskvatnsrennsli til fjarðarins. Straummælingar voru gerðar við Dagverðareyri og í mynni fjarðarins. Í tengslum við hvern leiðangur sem farinn var á sjó voru sýni til greininga á næringarefnastyrk í árvatni tekin í Svarfaðardalsá, Hörgá, Eyjafjarðará og Fnjóská (sjá 2. kafla). Birtumælingar, skráðar með sírita, voru gerðar á Hjalteyri (sjá 3. kafla). Á sama tíma og framangreind gagnasöfnun átti sér stað, voru tekin sýni með fötu úr yfirborði og plöntusvifsháf frá Grímseyjarferjunni Sæfara á ferð hennar yfir Hörgárgrunn, í námund við 10. stöð og rétt sunnan við Grímsey. Þessi sýni voru tekin vikulega frá vori og fram á haust árin 1992 og 1993. Mælt var hitastig, selta, næringarefnastyrkur, *a*-blaðgræna og tekin sýni til talninga og greininga á tegundum svifþörunga (Kristinn Guðmundsson og Agnes Eydal 1998).

Í áðurnefndri gagnaskýrslu (Steingrímur Jónsson 1996) var einkum gerð grein fyrir hafeðlisfræðilegum og veðurfarslegum gögnum sem safnað var í Eyjafirði á umræddu tímabili, þ.e. ferskvatnsrennsli til fjarðarins, upplýsingum um vinda og strauma í firðinum og yfirlit yfir dreifingu hita, seltu og eðlisþyngdar sjávar. Hér verða hins vegar gerð skil á niðurstöðum mælinga á næringarefnastyrk í firðinum og í fjórum ám sem renna í innanverðan fjörðinn (2. kafli; Jón og Sólveig), birtuskilyrðum, magni og tegundasamsetningu svifþörunga (3. kafli; Kristinn), rannsóknum á dýrasvifi (4. kafli; Ástþór og Öivind), fiskaasvifi (5. kafli; Konráð) og tegundasamsetningu botndýra (6. kafli; Sigmar) og greiningu örvera frá árunum 1995 og 1996 (7. kafli, Rannveig). Sumt sem hér birtist hefur áður verið kynnt á haustfundi Alþjóðahafrannsóknaráðsins 1994 (Steingrímur Jónsson and Kristinn Guðmundsson 1994, Öivind Kaasa and Kristinn Guðmundsson 1994). Gögn og sýni frá yfirborðssýnatöku um borð í ferjunni Sæfara árið 1992 hafa áður verið birt í úttekt á útbreiðslu svifþörunga sem geta valdið skelfiskeitrun (Kristinn Guðmundsson and Agnes Eydal 1998).

Yfirlit myndatexta á íslensku er að finna á blaðsíðu 12 og listi yfir töfluheitin, með skýringartextum á íslensku, er á blaðsíðu 14.

## 1. INTRODUCTION

Eyjafjörður, a fjord located on the central north coast of Iceland (Figure 1.1), is the second longest fjord in Iceland, 60 km long and 15 km wide at the mouth with a surface area of about 440 km², north to 66° 10'. The fjord, like most Icelandic fjords, has quite steep sides down to about 40 m and then gradually flattens out. The depth of Eyjafjordur increases gradually from the shallow inner basin at Akureyri, a town at the head of the fjord, to 200 m depth at the mouth. The bottom of the fjord is covered with thick layers of sediments (Hafliðason 1983).

An interdisciplinary study of the fjord was initiated in 1992 as a collaboration of the Marine Research Institute, the University of Akureyri and the Icelandic Fisheries Laboratories. The main purpose of the project was to obtain an understanding of, and to describe, the ecology of the fjord. A total of 36 stations (Figure 1.2), distributed in the fjord and one station outside of the fjord, were sampled during each cruise. The station grid is shown in Figure 1 and the positions are listed in Table 1.1. Data were collected on 15 cruises from April 29th 1992 to 18th of August 1993. The dates of each cruise are given in Table 1.2. During spring the interval between cruises was three weeks, during summer four weeks and during the winter six weeks. Profiles of CTD and fluorescence were made at each of the 36 stations. Oxygen and nutrients were sampled at ten stations. Phytoplankton, zooplankton and samples of eggs, larvae and juvenile fish (ichthyoplankton) were collected at up to seven stations. During spring and summer, measurements of the primary productivity were made at 6 stations. Benthic and bacterial samples were only taken at Station 10 in the inner part of the fjord. Current measurements were performed during the summer of 1992 at four locations in the fjord. Wind observations were made at Hrísey, an island in the middle of the fjord. Meteorological data were also collected by the Icelandic Meteorological Office at Akureyri and Grímsey, an island about 40 km north of the mouth of Eyjafjörður. Data on the freshwater inflow to the fjord was obtained from the Icelandic National Energy Authority. In connection with the cruises, nutrients were measured close to the river mouth in the four major rivers, Fnjóská, Eyjafjarðará, Hörgá and Svarfaðardalsá. Measurements of the surface irradiance together with measurements of sea surface temperature were made at Hjalteyri, close to Station 10. Data on surface irradiance and sea surface temperature are also available from Grímsey. In order to increase the sampling frequency during the phytoplankton growth season, bucket samples and phytoplankton net samples were taken weekly from a ferry, m/s Sæfari, as it passed Station 10 and at a station near the south coast of Grímsey. The data obtained from samples taken by the crew of the ferry were sea surface temperature, salinity, nutrients and chlorphyll-*a*. An investigation on bacteria (chapter 7) was undertaken in 1995 and 1996.

In a datareport, Steingrímur Jónsson (1996) dealt with the physical parameters measured during this project, *i.e.* the runoff, wind, currents and CTD, whereas the following report is on the chemical and biological data. Some of the results, given here, were presented at ICES Statutory Meeting in 1994 (Steingrímur Jónsson and Kristinn Guðmundsson 1994, Öivind Kaasa and Kristinn Guðmundsson 1994) and some of the data sampled from the ferry, m/s Sæfari in 1992, were used in a report on the occurrence of phytoplankton in the context of possible shellfish toxity in the fjord (Kristinn Guðmundsson and Agnes Eydal 1998).

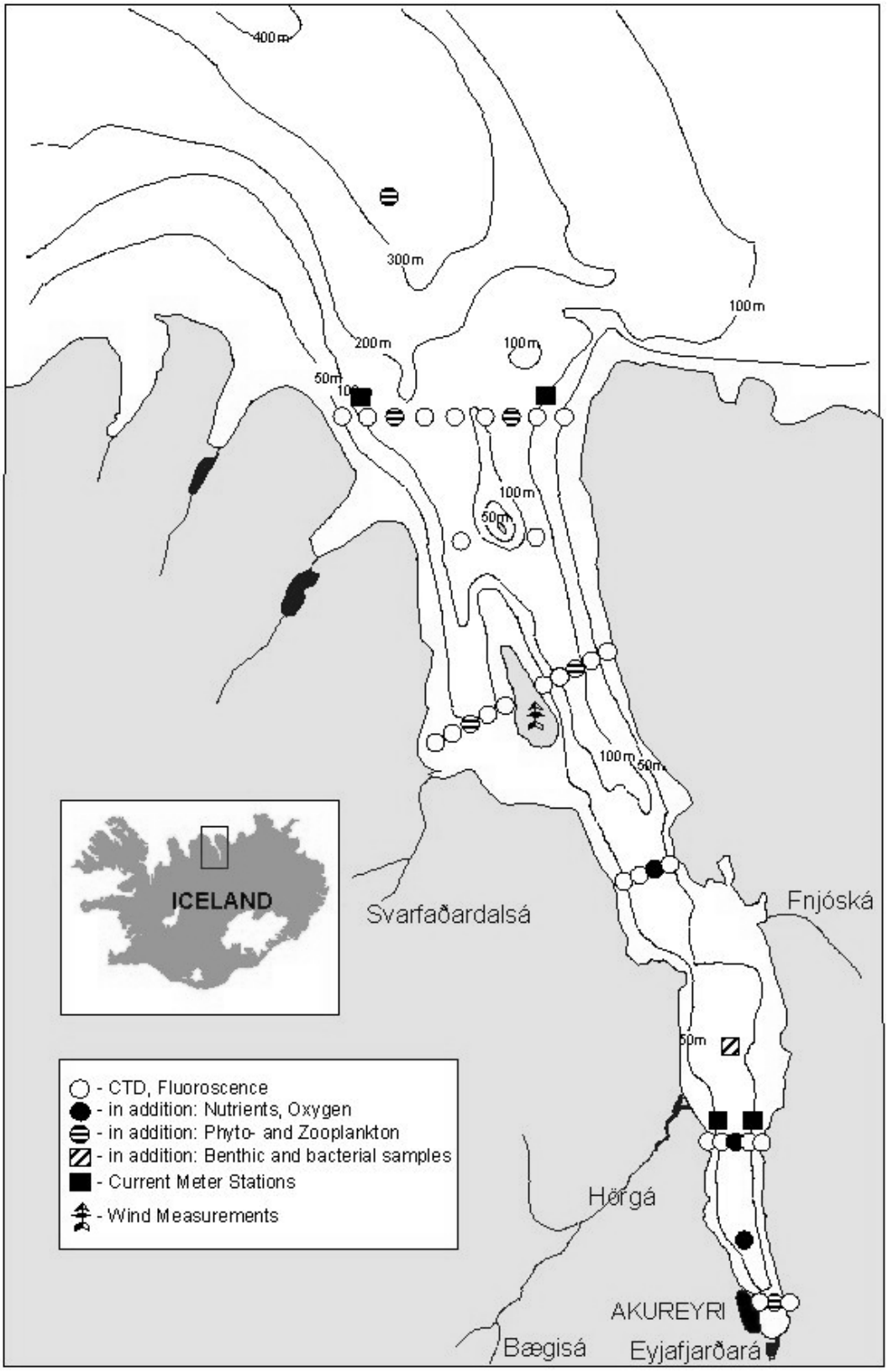


Figure 1.1. A station map, showing the study area, the main rivers entering the fjord, location of all stations as well as the parameters sampled at each station (Steingrímur Jónsson 1996).

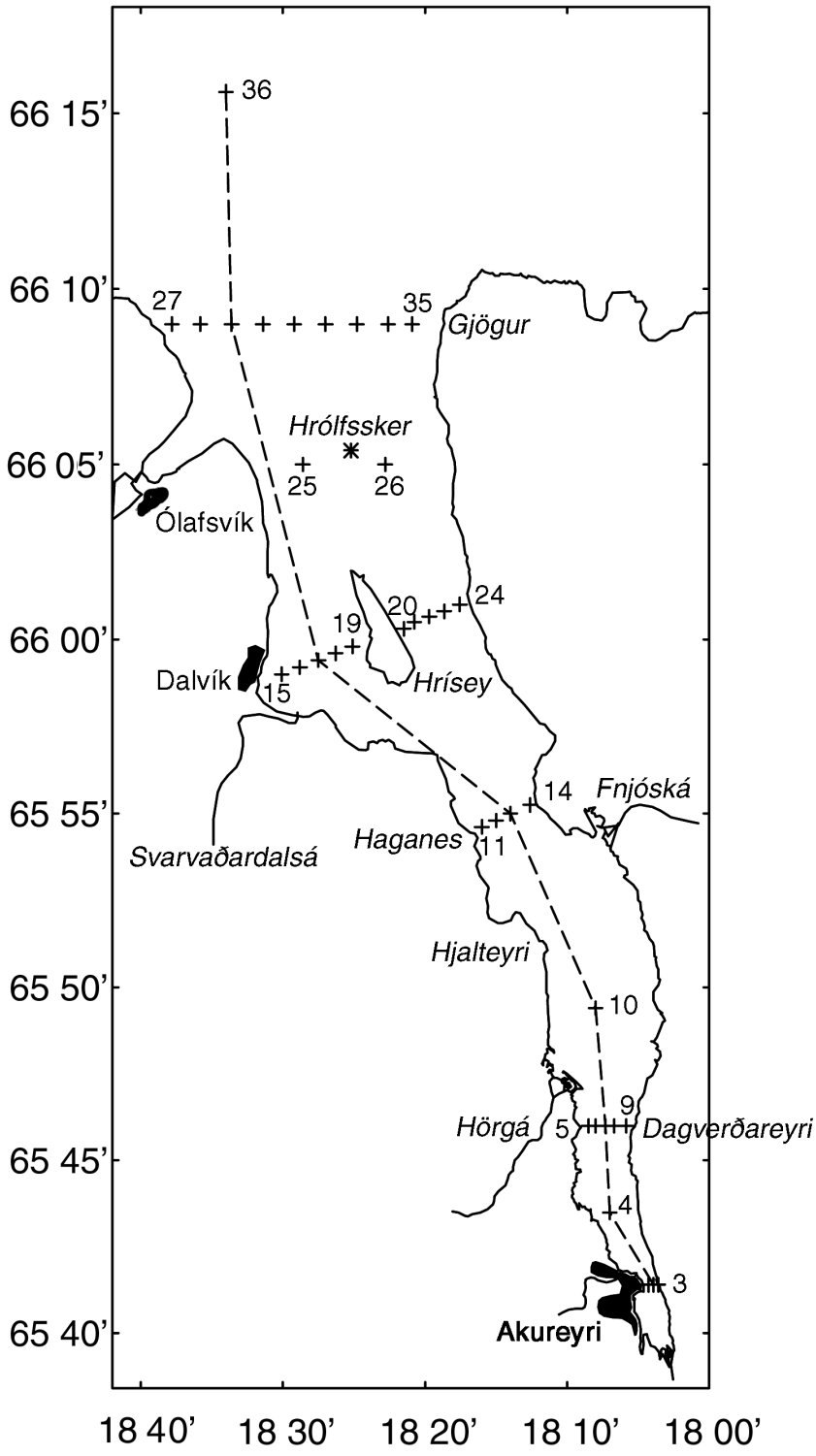


Figure 1.2. A station map showing the position and the enumberation of stations in the Eyjafjördur project 1992 - 1993. The position of a vertical profile along the western side of the fjord, used in chapters 2 and 3, is shown (broken line) and the names of the vertical transects in chapter 3 are given.

Table 1.1. List of stations, with geographical positions, bottom depths and names of transects.

| Section or station name | Station no. | Latitude (°N) | Longitude (°W) | Bottom depth (m) |
|---|---|---|---|---|
| Oddeyri | 1 | 65°41.40´ | 18°04.29´ | 36 |
| | 2 | 65°41.40´ | 18°03.95´ | 46 |
| | 3 | 65°41.40´ | 18°03.60´ | 35 |
| Nunnuhólmi | 4 | 65°43.50´ | 18°07.00´ | 62 |
| Dagverðareyri | 5 | 65°46.00´ | 18°08.50´ | 50 |
| | 6 | 65°46.00´ | 18°08.00´ | 70 |
| | 7 | 65°46.00´ | 18°07.30´ | 71 |
| | 8 | 65°46.00´ | 18°06.70´ | 68 |
| | 9 | 65°46.00´ | 18°05.85´ | 44 |
| Hjalteyri | 10 | 65°49.40´ | 18°08.00´ | 90 |
| Haganes | 11 | 65°54.62´ | 18°16.00´ | 34 |
| | 12 | 65°54.80´ | 18°15.00´ | 98 |
| | 13 | 65°55.00´ | 18°14.00´ | 96 |
| | 14 | 65°55.25´ | 18°12.60´ | 76 |
| Dalvík | 15 | 65°59.00´ | 18°30.08´ | 25 |
| | 16 | 65°59.20´ | 18°28.80´ | 45 |
| | 17 | 65°59.40´ | 18°27.50´ | 54 |
| | 18 | 65°59.60´ | 18°26.30´ | 59 |
| | 19 | 65°59.80´ | 18°25.10´ | 49 |
| Hrísey | 20 | 66°00.30´ | 18°21.50´ | 35 |
| | 21 | 66°00.50´ | 18°20.75´ | 115 |
| | 22 | 66°00.65´ | 18°19.70´ | 116 |
| | 23 | 66°00.80´ | 18°18.65´ | 109 |
| | 24 | 66°01.00´ | 18°17.55´ | 36 |
| Hrólfssker | 25 | 66°05.00´ | 18°28.60´ | 131 |
| | 26 | 66°05.00´ | 18°22.80´ | 130 |
| Gjögur | 27 | 66°09.00´ | 18°37.80´ | 34 |
| | 28 | 66°09.00´ | 18°35.80´ | 127 |
| | 29 | 66°09.00´ | 18°33.60´ | 181 |
| | 30 | 66°09.00´ | 18°31.40´ | 205 |
| | 31 | 66°09.00´ | 18°29.20´ | 186 |
| | 32 | 66°09.00´ | 18°27.00´ | 89 |
| | 33 | 66°09.00´ | 18°24.80´ | 137 |
| | 34 | 66°09.00´ | 18°22.60´ | 105 |
| | 35 | 66°09.00´ | 18°20.90´ | 44 |
| Eyjafjarðaráll | 36 | 66°15.60´ | 18°34.00´ | 343 |

Table 1.2. Dates of the cruises.

| Cruise no. | Dates |
|---|---|
| 1 | 29 April 1992 - 1 May 1992 . |
| 2 | 19 May 1992 - 21 May 1992 |
| 3 | 9 June 1992 - 11 June 1992 |
| 4 | 13 July 1992 - 15 July 1992 |
| 5 | 24 August 1992 - 26 August 1992 |
| 6 | 29 September 1992 - 1 October 1992 . |
| 7 | 16 November 1992 - 18 November 1992 |
| 8 | 5 January 1993 - 6 January 1993 |
| 9 | 15 February 1993 - 16 February 1993 |
| 10 | 29 March 1993 - 31 March 1993 |
| 11 | 19 April 1993 - 21 April 1993 |
| 12 | 10 May 1993 - 12 May 1993 |
| 13 | 7 June 1993 - 9 June 1993 |
| 14 | 14 July 1993 - 16 July 1993 |
| 15 | 16 August 1993 - 18 August 1993 |

**Acknowledgements**

We would like to thank all the people who were involved or assisted in various ways towards the accomplisment of the project. Mentioning the persons and the role each one played would easily become quite an extensive list. Here we will, therefore, only specify our thanks to the crew on Gunnar Níelsson EA 555 and the following technicians at Hafrannsóknastofnunin and the University of Akureyri, Örn Guðnason, Birgir Ásgeir Kristjánsson and Stefanía Sæmundsdóttir, who helped with the work in the field.

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## Listi yfir töflur (list of tables in Icelandic)

## 2. CHEMISTRY

Seawater samples for nutrients analyses were sampled on every cruise at 10 stations distributed along the fjord (Figure 1). At each station a waterbottle sample was taken at 0, 5, 10, 20, 30, 50, 75, 100, 150, 200 and 300 meter depth or as the bottom depth allowed. In connection with the sampling at sea, samples for nutrients and chloride analyses were also collected downstream in each of the four major rivers discharging into the fjord, i.e. Eyjafjarðará, Fnjóská, Hörgá and Svarfaðardalsá.

### Methods

Nutrient samples were taken in a plastic bottle, and samples for the determination of oxygen were taken according to the standard Winkler method. All samples for nutrients were filtered and deep frozen for transport and storage until analyses. Nitrate and silicate were analysed in a Chemlab autoanalyzer with methods described by Grasshoff (1970), phosphate was analysed with a Varian spectrophotometer according to the method of Strickland and Parson (1968) and chloride was analysed in a Technicon autoanalyzer according to the method of O´Brien (1962). Samples for the determination of oxygen were titrated ashore as soon as possible after each cruise. Oxygen saturation was then calculated according to UNESCO (1986).

### Results

Seasonal and depth variations in nutrient concetrations ($PO_4$-P, $NO_3$-N and $SiO_2$, µmole $l^{-1}$) and oxygen saturation (%) for each station is given in figures 2.9.1-2.9.10. Vertical sections of nutrient concentrations ($PO_4$-P, $NO_3$-N and $SiO_2$, µmole $l^{-1}$) and oxygen saturation (%) through a transect along the west side of the fjord (stations 2, 4, 7, 10, 13, 17, 33, 36) for each cruise is given in figures 2.10.1-2.10.15.

The property-property relations involving nutrients, oxygen and salinity (Figures 2.1-2.4) exhibit variations which are related to both biogeochemical processes and coastal runoff influences (Figures 2.5-2.8). The relationship between phosphate and nitrate is shown in figure 2.1. The relationship is described by the equation: $NO_3 = (15.08 \pm 0.18) * PO_4 - (1.66 \pm 0.10)$, $R^2 = 0.88$.

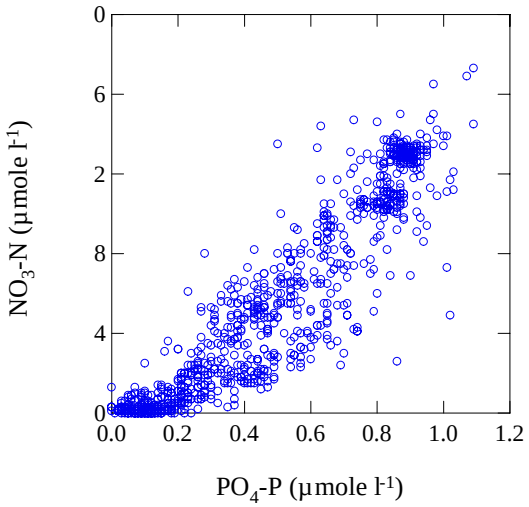


Figure 2.1. The relationship between phosphate and nitrate.

The relationship between silicate and nitrate is shown in figure 2.2.

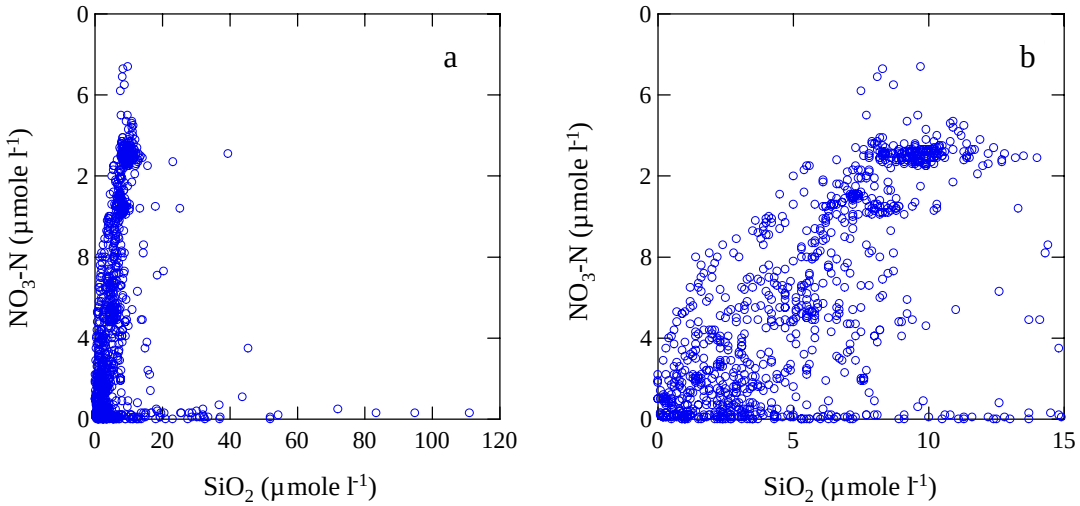


Figure 2.2. The relationship between silicate and nitrate a) all samples b) samples where the silicate concentration was < 15 µmole $l^{-1}$.

The relationship between salinity and silicate is shown in figure 2.3.

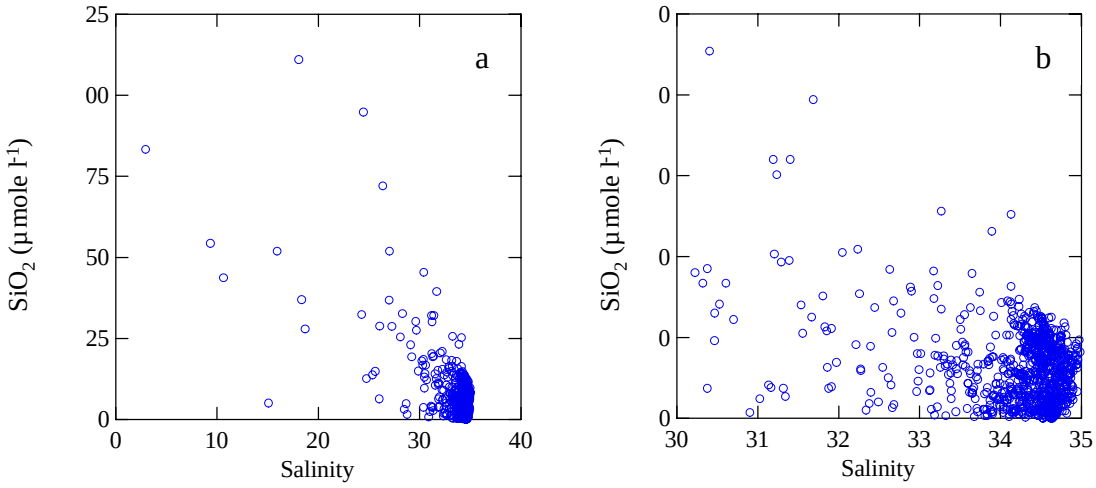


Figure 2.3. The relationship between salinity and silicate a) all samples b) samples where salinity was > 30.

The relationship between oxygen saturation and salinity is shown in figure 2.4.

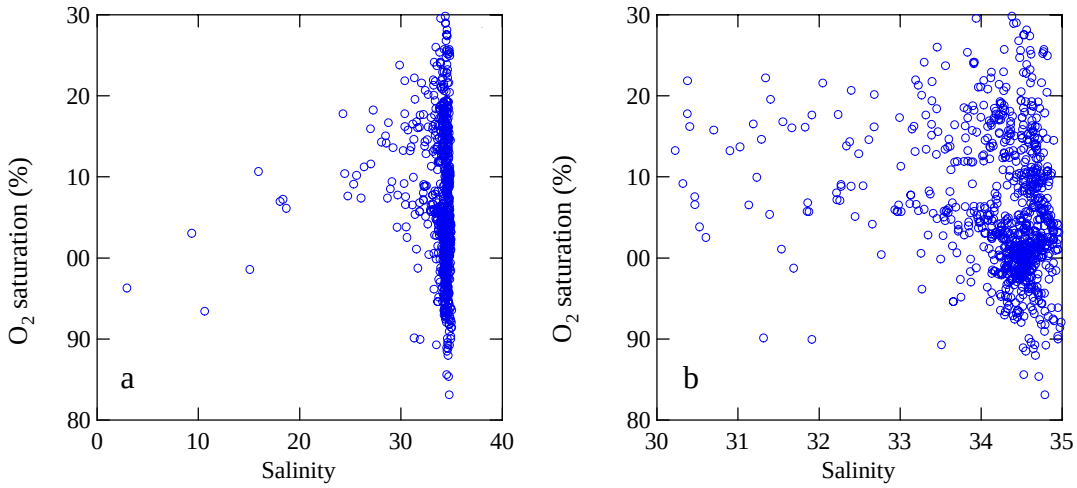


Figure 2.4. The relationship between oxygen saturation and salinity a) all samples b) samples where salinity was > 30.

Seasonal variations in nutrient concentrations in the four rivers is shown in figures 2.5-2.7 and time variations in chloride concentration is shown in figure 2.8.

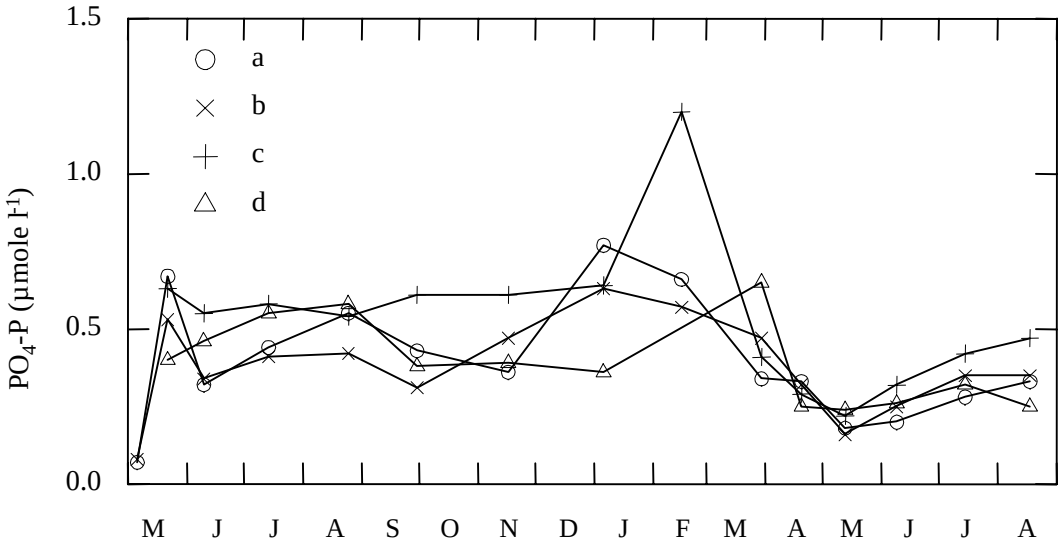


Figure 2.5. Seasonal variations in phosphate concentration in the four major rivers disharging into the fjord, a) Eyjafjarðará, b) Fnjóská, c) Hörgá and d) Svarfaðardalsá.

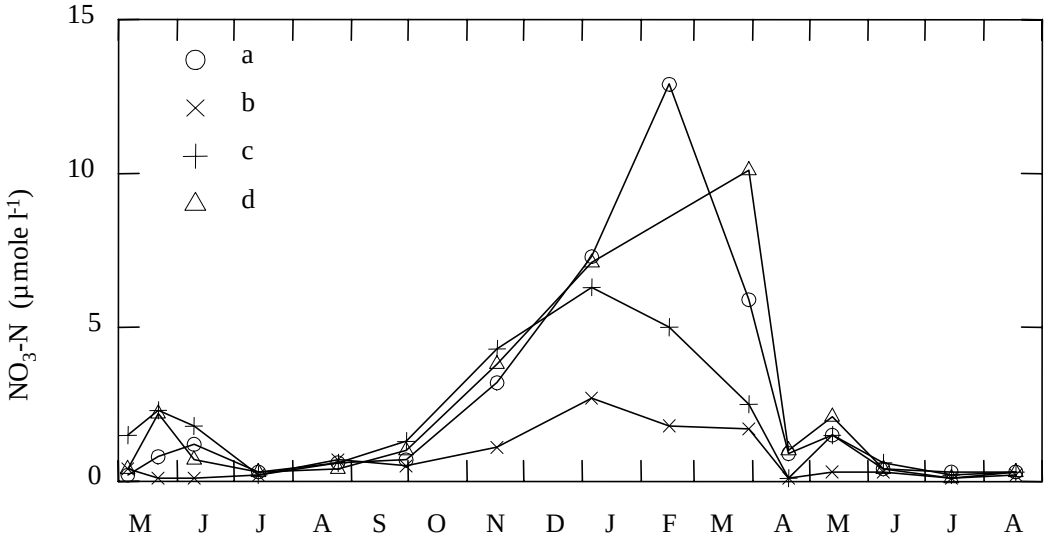


Figure 2.6. Seasonal variations in nitrate concentration in the four major rivers disharging into the fjord, a) Eyjafjarðará, b) Fnjóská, c) Hörgá and d) Svarfaðardalsá.

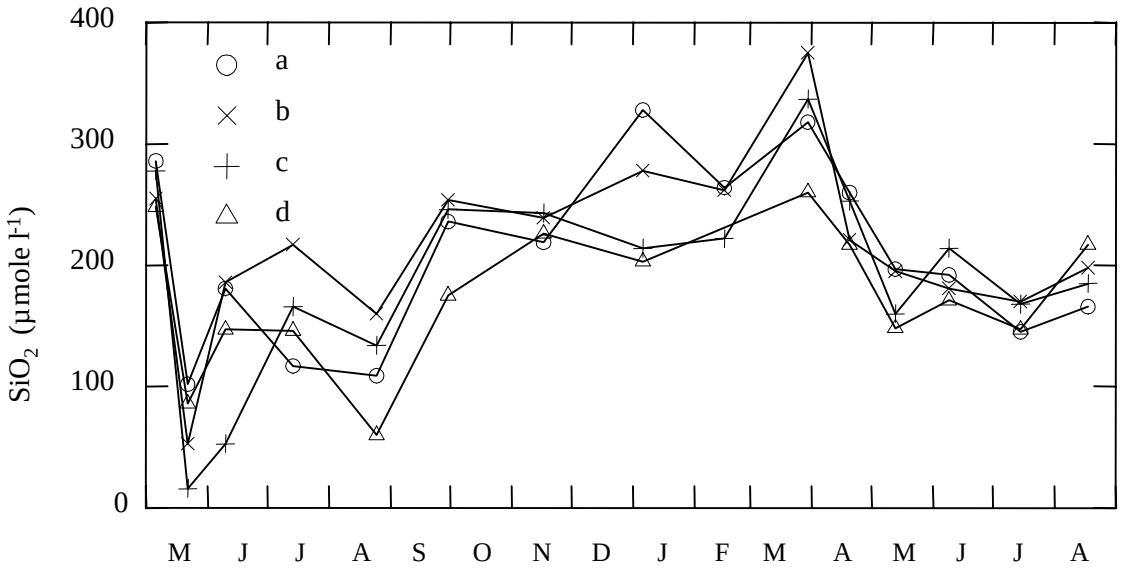


Figure 2.7. Seasonal variations in silicate concentration in the four major rivers disharging into the fjord, a) Eyjafjarðará, b) Fnjóská, c) Hörgá and d) Svarfaðardalsá.

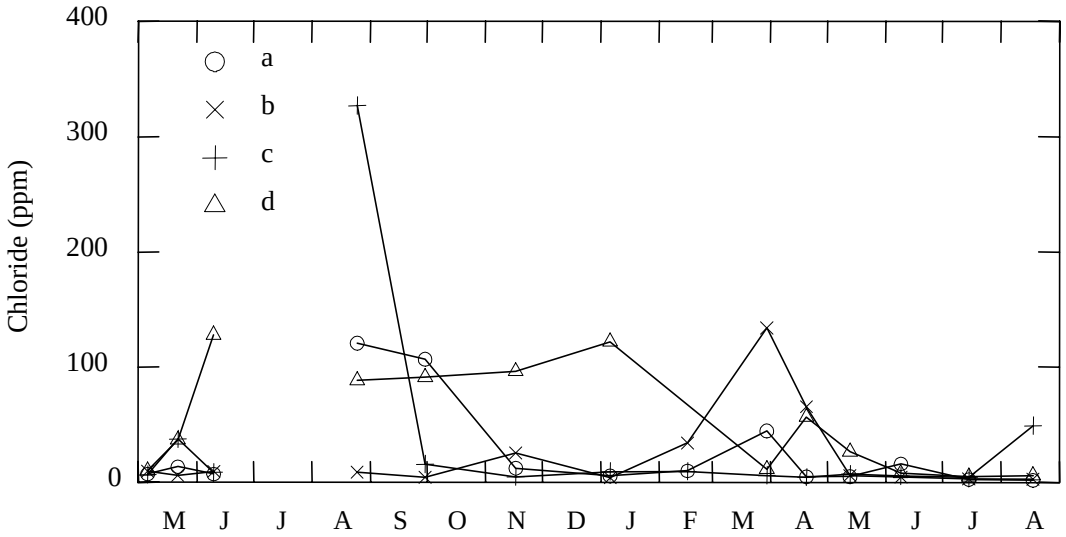


Figure 2.8. Seasonal variations in chloride concentration in the four major rivers disharging into the fjord, a) Eyjafjarðará, b) Fnjóská, c) Hörgá and d) Svarfaðardalsá.

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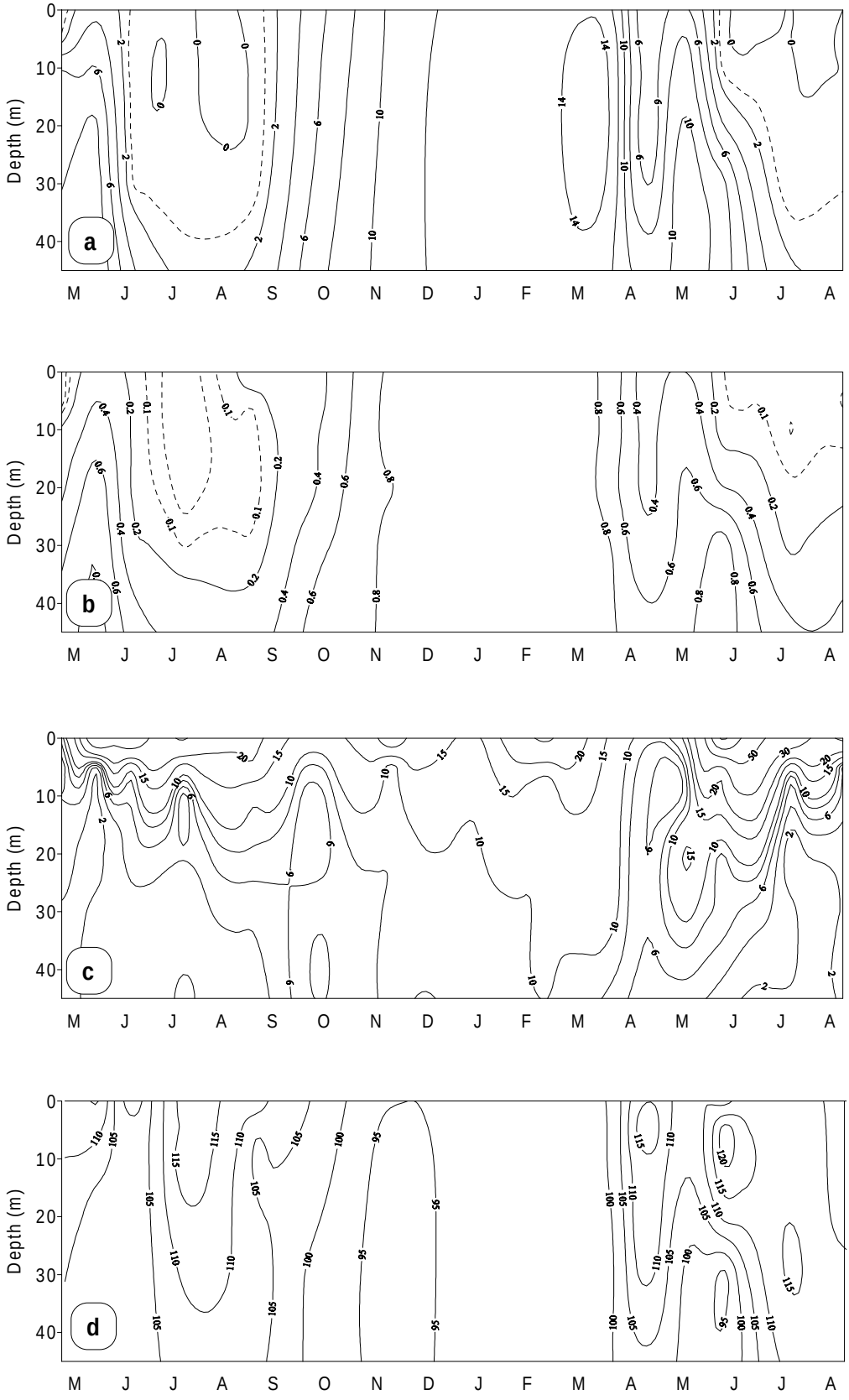


Figure 2.9.1. Seasonal variations in nutrients concentration and oxygen saturation at station 2, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

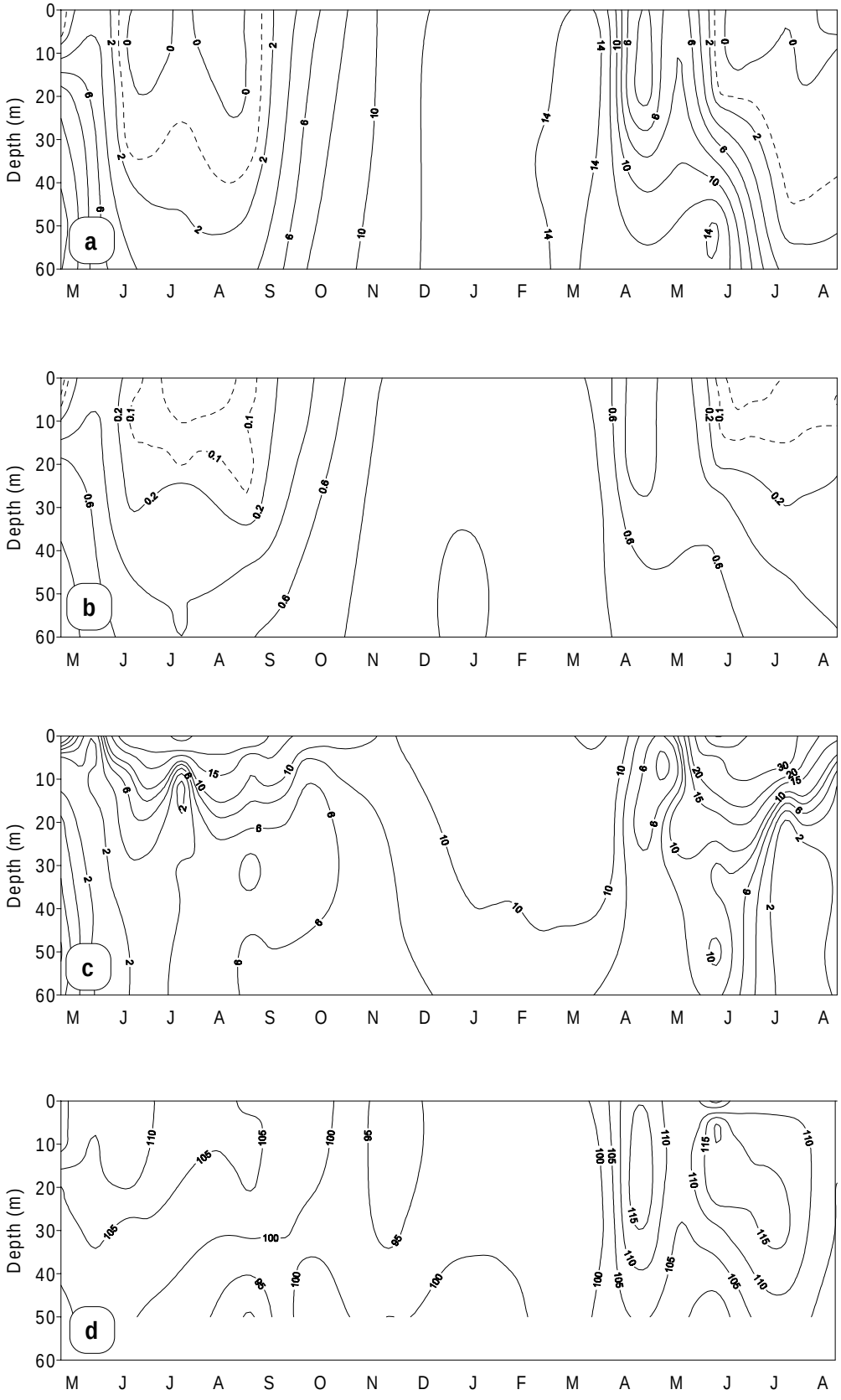


Figure 2.9.2. Seasonal variations in nutrients concentration and oxygen saturation at station 4, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

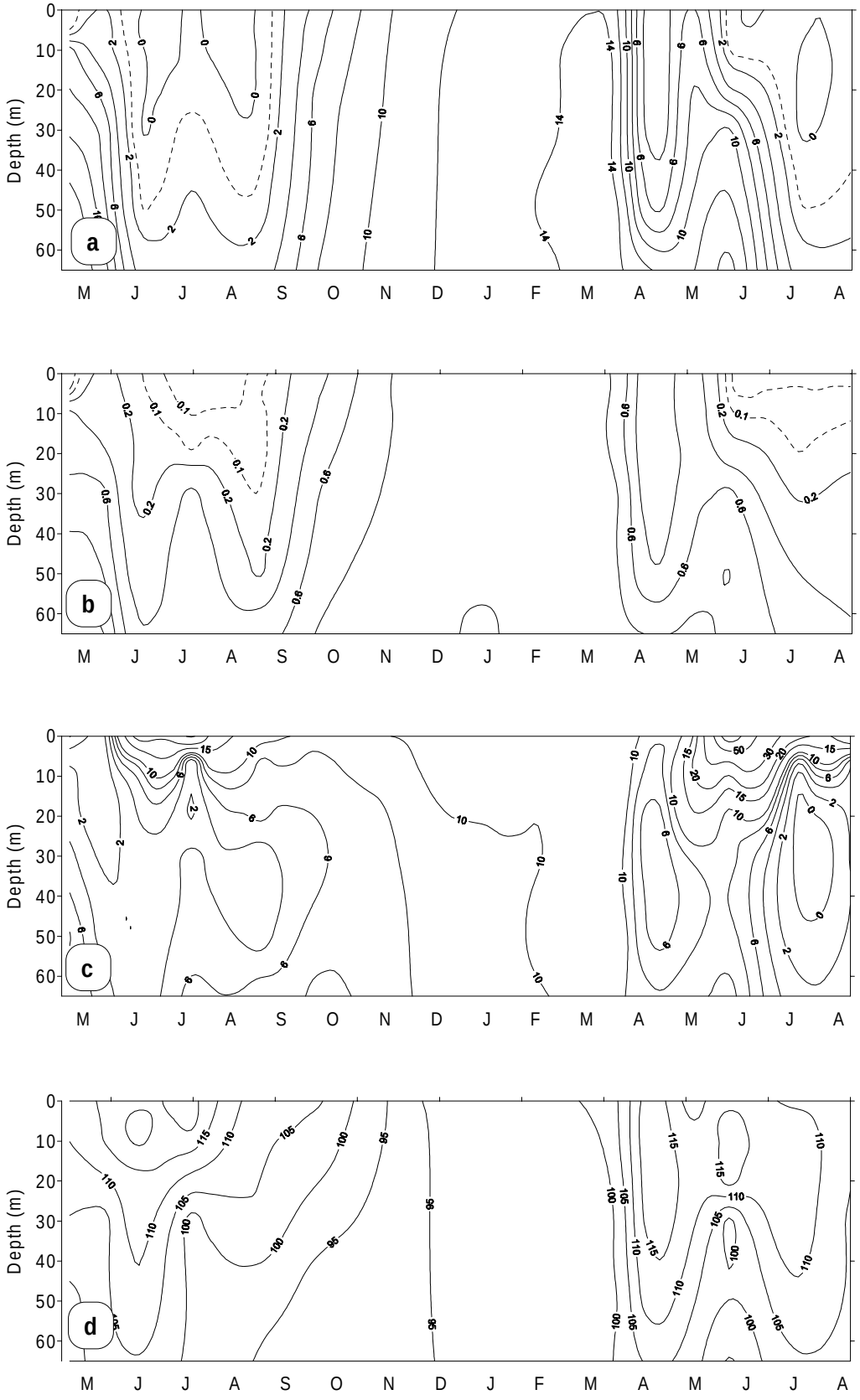


Figure 2.9.3. Seasonal variations in nutrients concentration and oxygen saturation at station 7, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

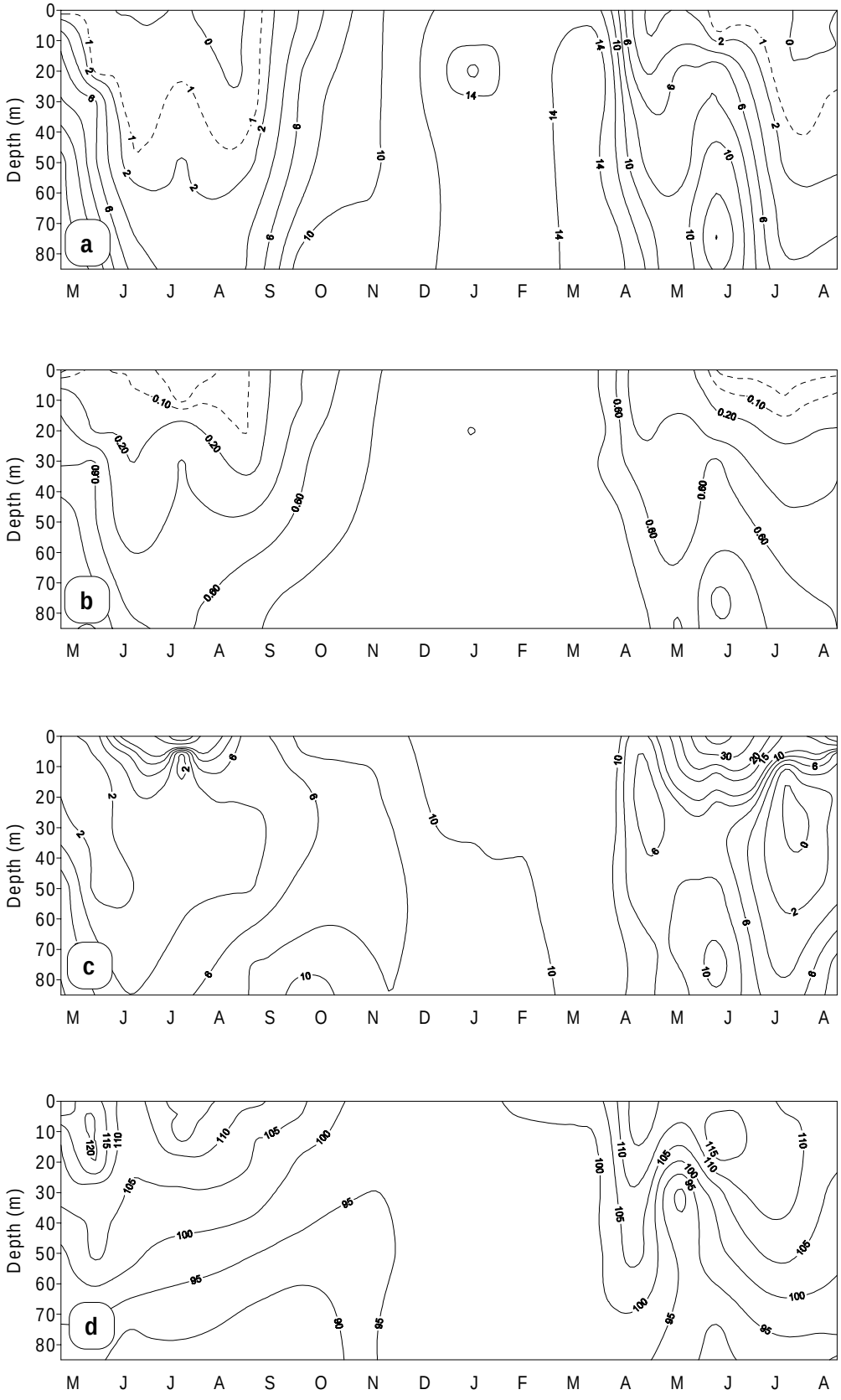


Figure 2.9.4. Seasonal variations in nutrients concentration and oxygen saturation at station 10, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

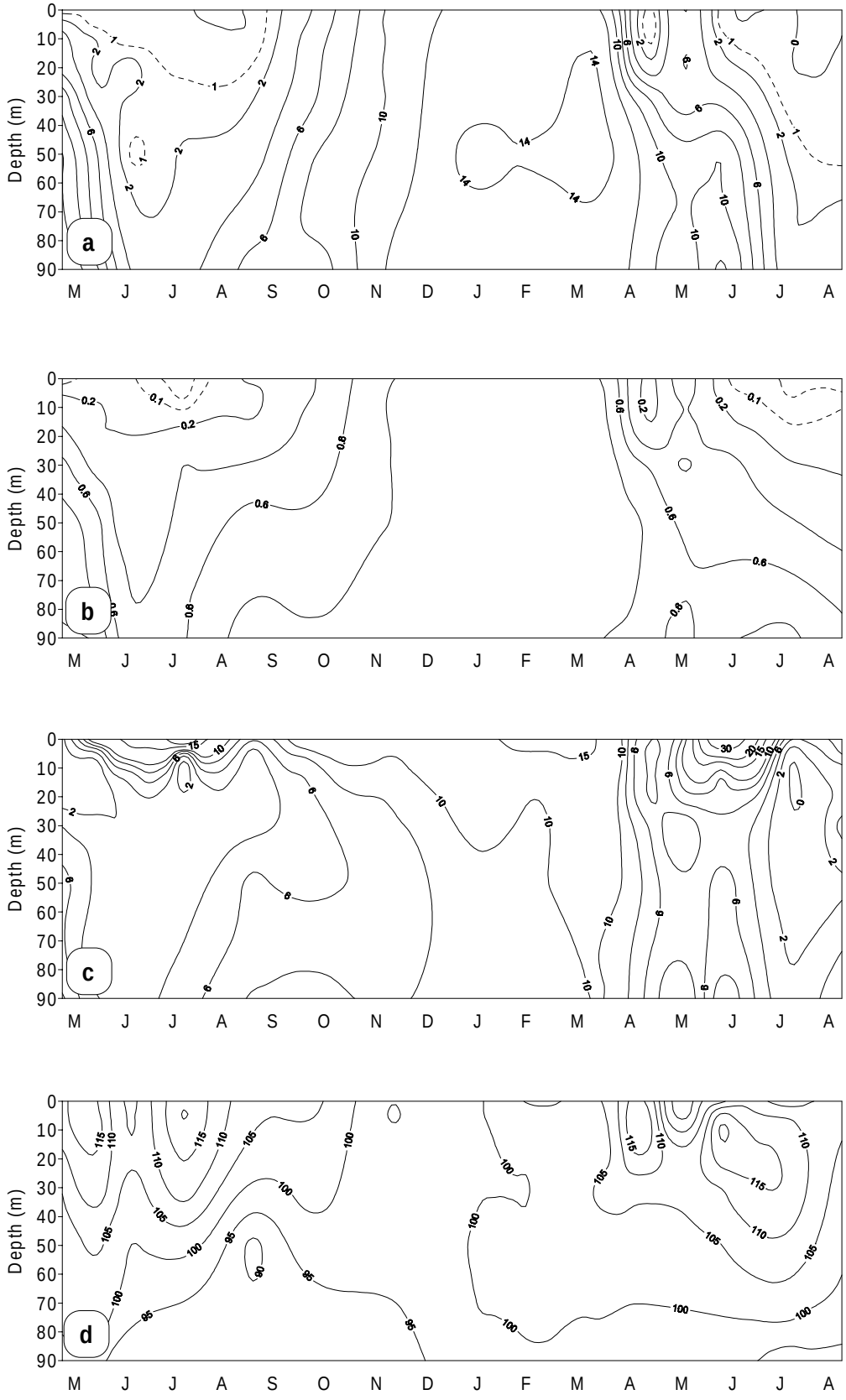


Figure 2.9.5. Seasonal variations in nutrients concentration and oxygen saturation at station 13, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

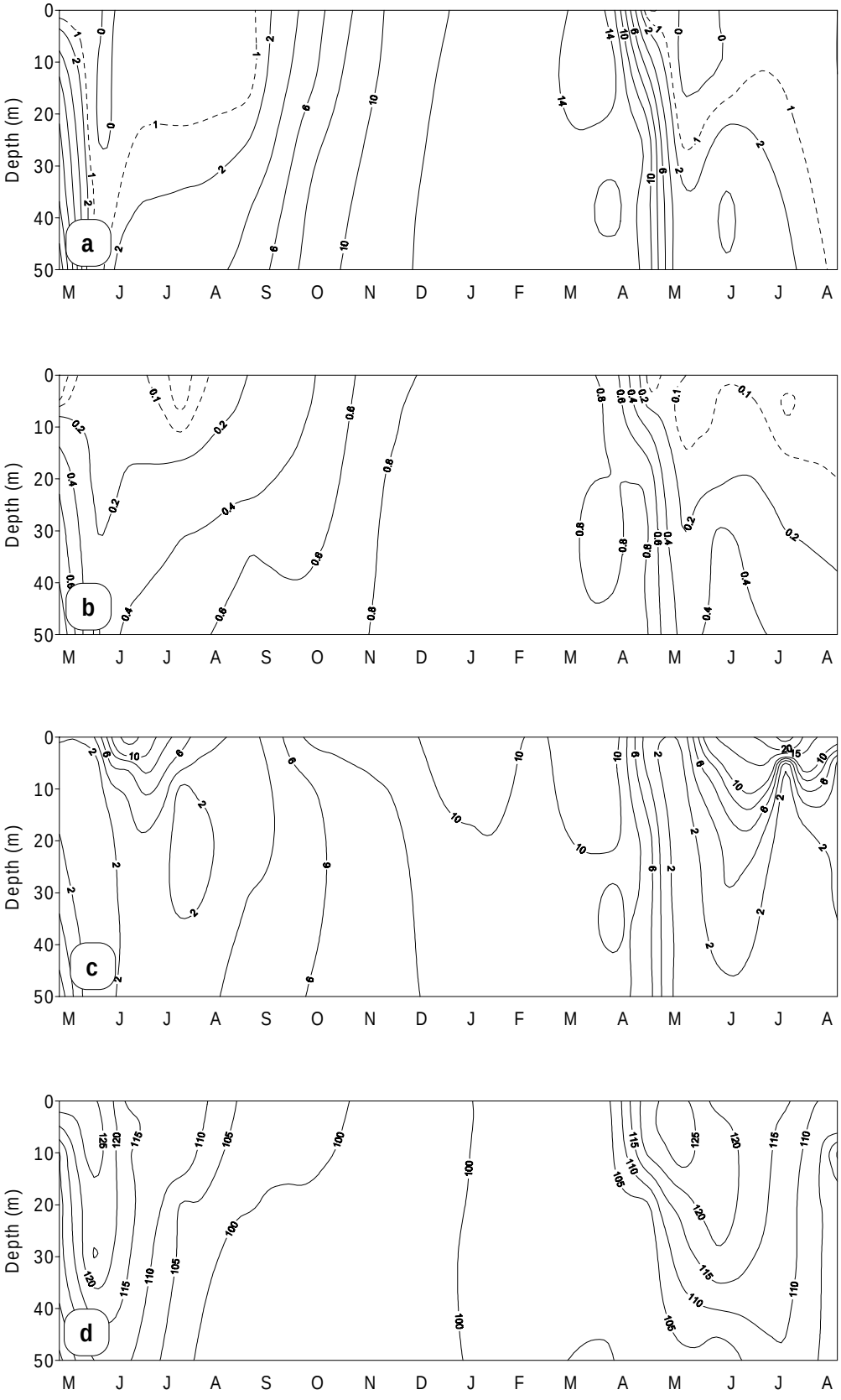


Figure 2.9.6. Seasonal variations in nutrients concentration and oxygen saturation at station 17, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

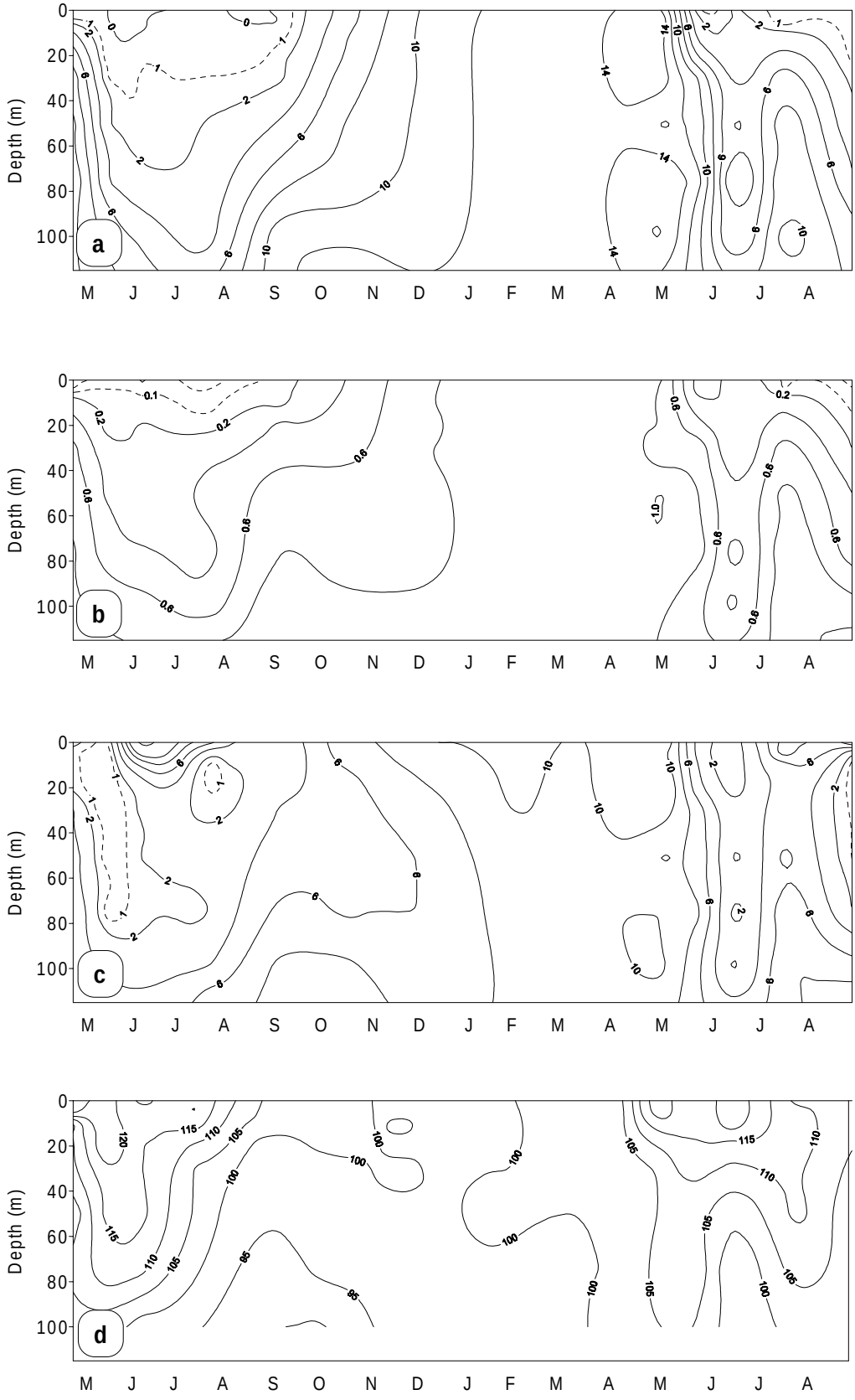


Figure 2.9.7. Seasonal variations in nutrients concentration and oxygen saturation at station 22, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

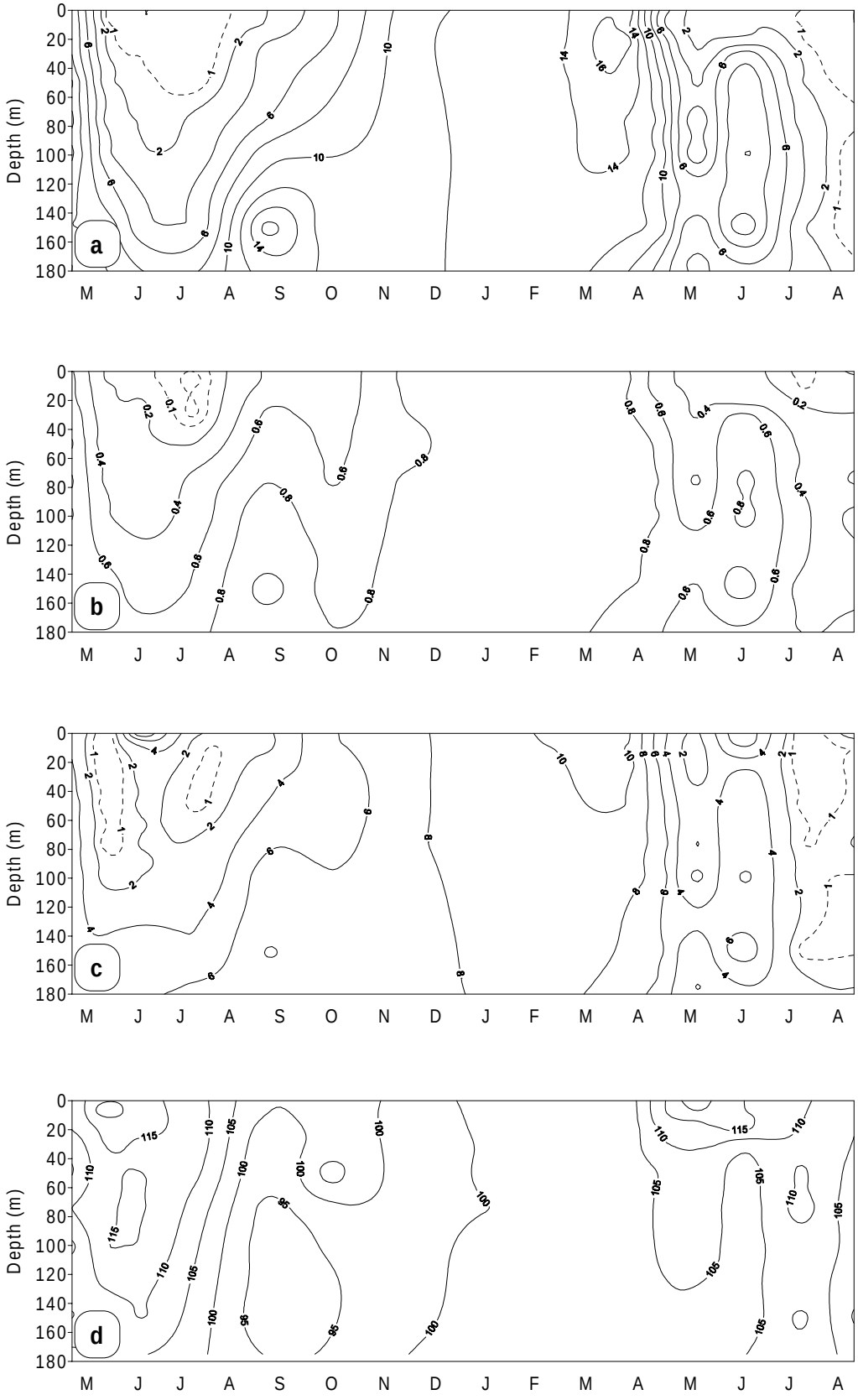


Figure 2.9.8. Seasonal variations in nutrients concentration and oxygen saturation at station 29, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

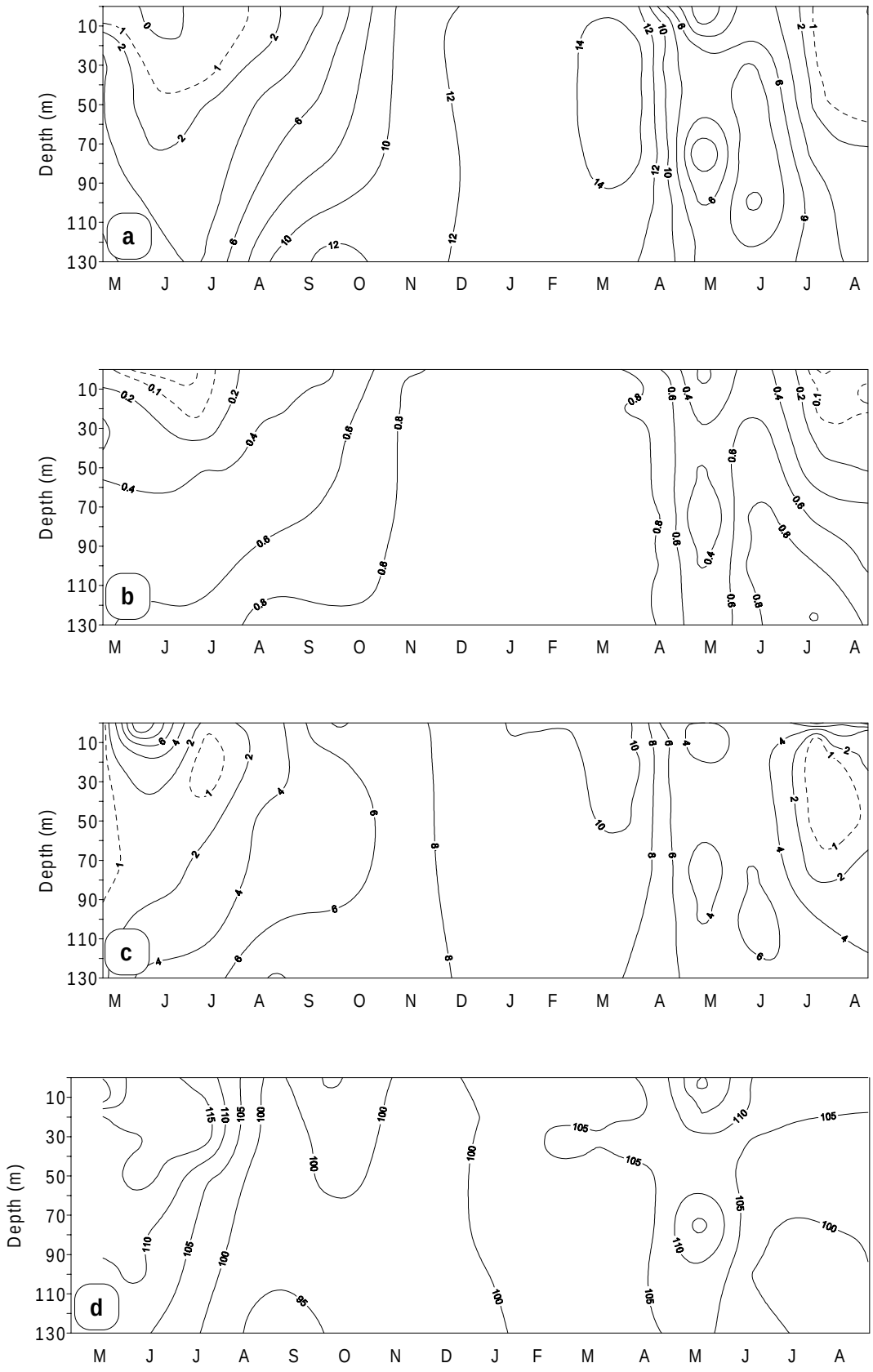


Figure 2.9.9. Seasonal variations in nutrients concentration and oxygen saturation at station 33, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

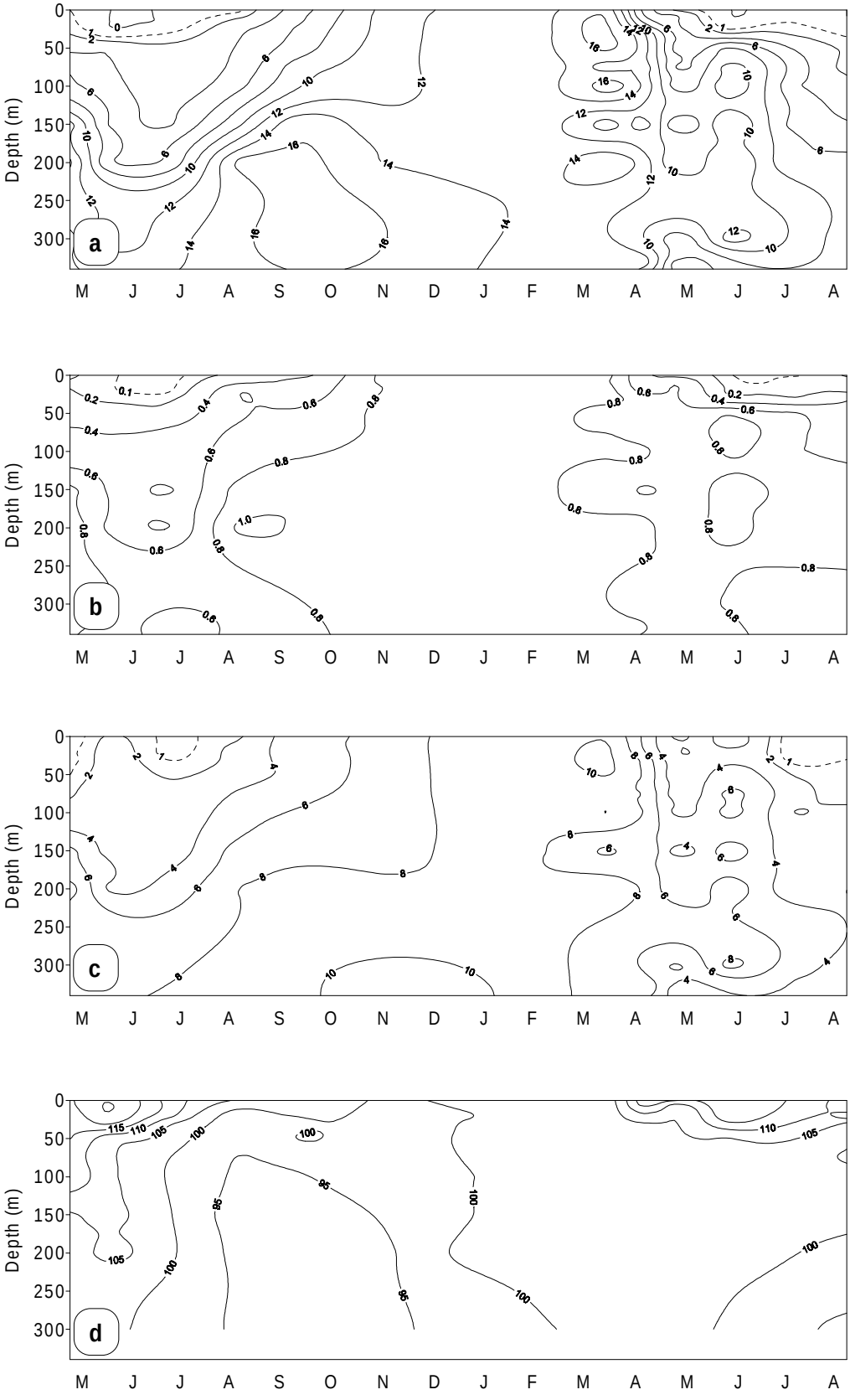


Figure 2.9.10. Seasonal variations in nutrients concentration and oxygen saturation at station 36, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

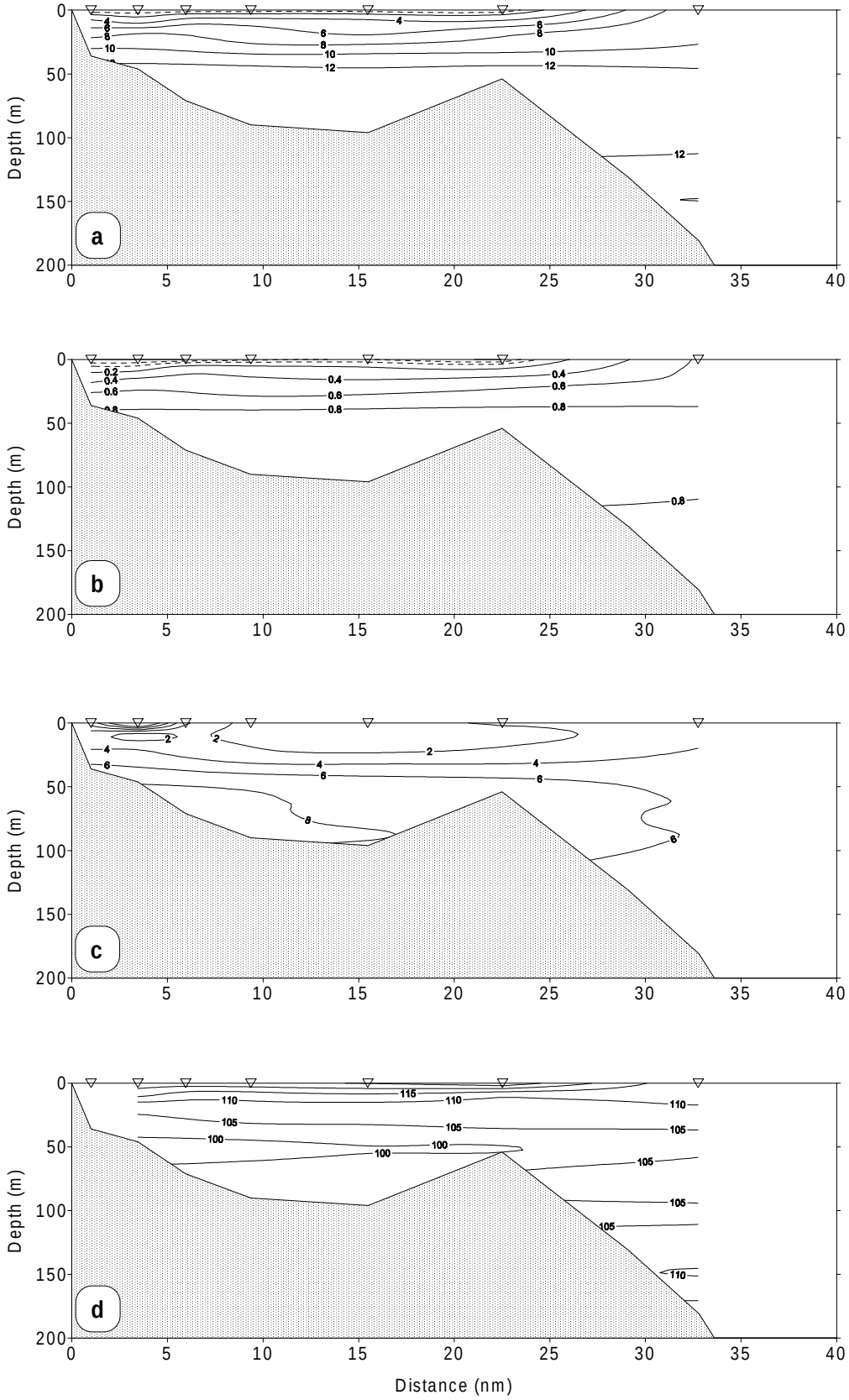


Figure 2.10.1. Vertical profiles along the west side of the fjord on cruise 1, 29/4-1/5 1992, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

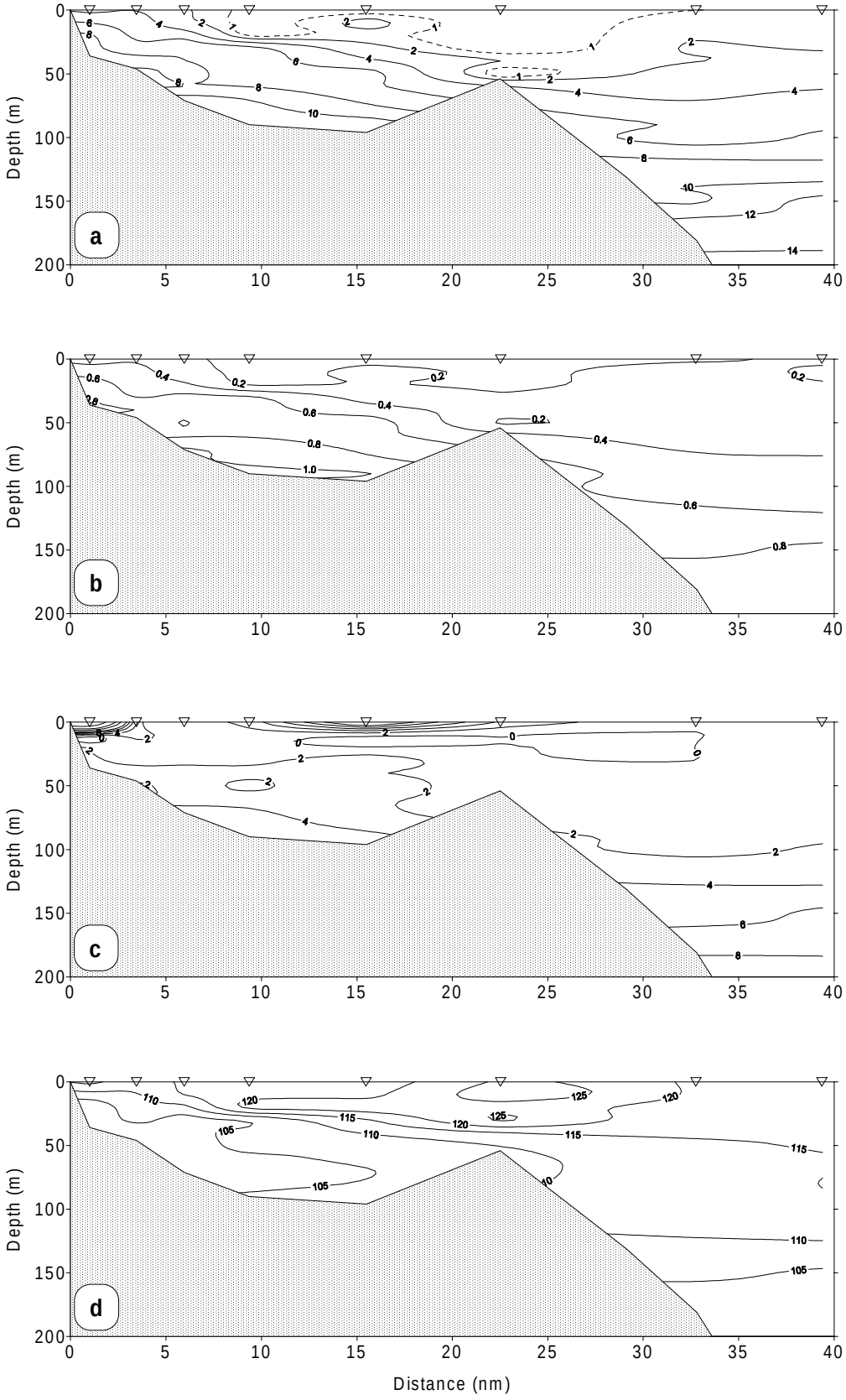


Figure 2.10.2. Vertical profiles along the west side of the fjord on cruise 2, 19-21/5 1992, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

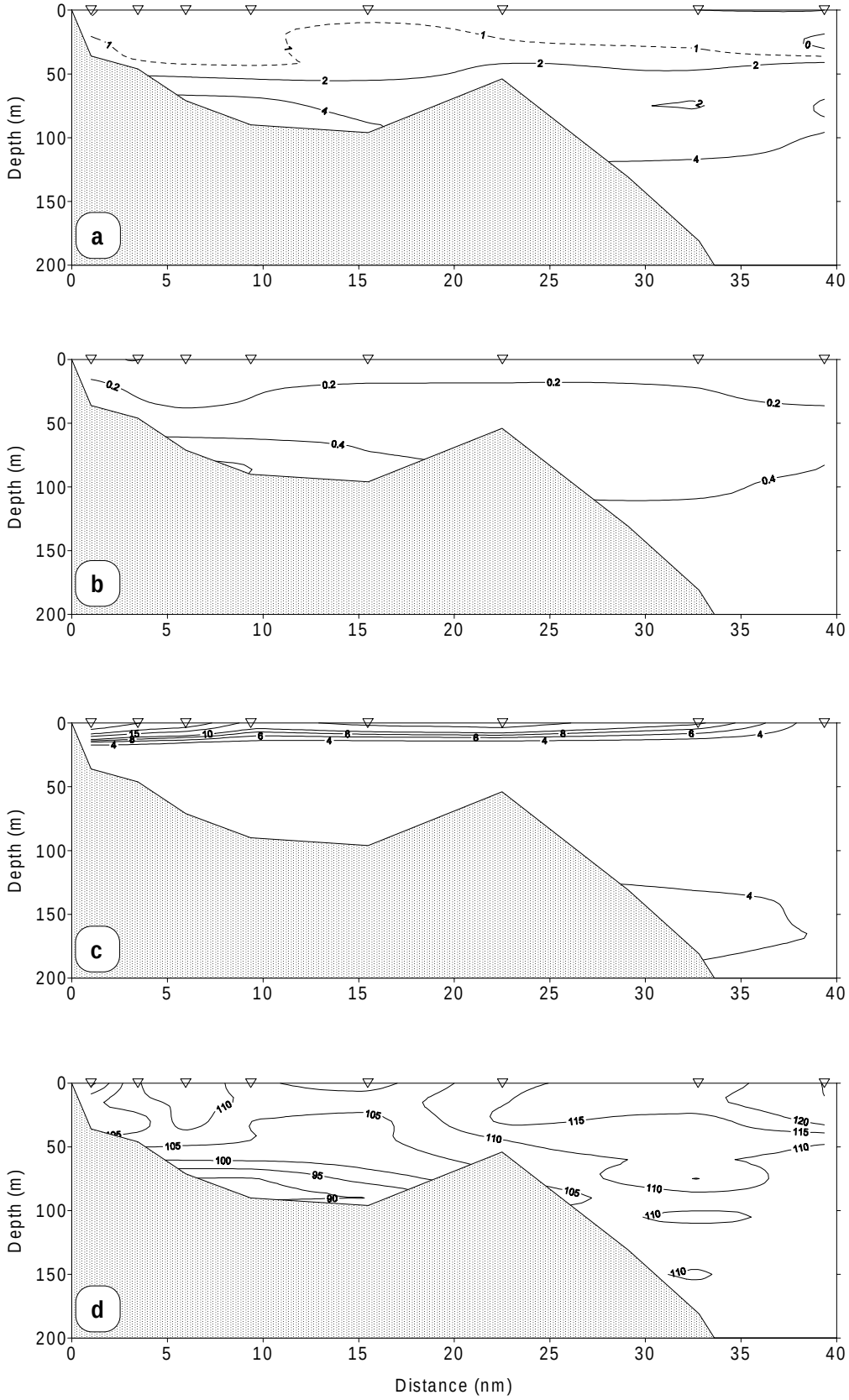


Figure 2.10.3. Vertical profiles along the west side of the fjord on cruise 3, 9-11/6 1992, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

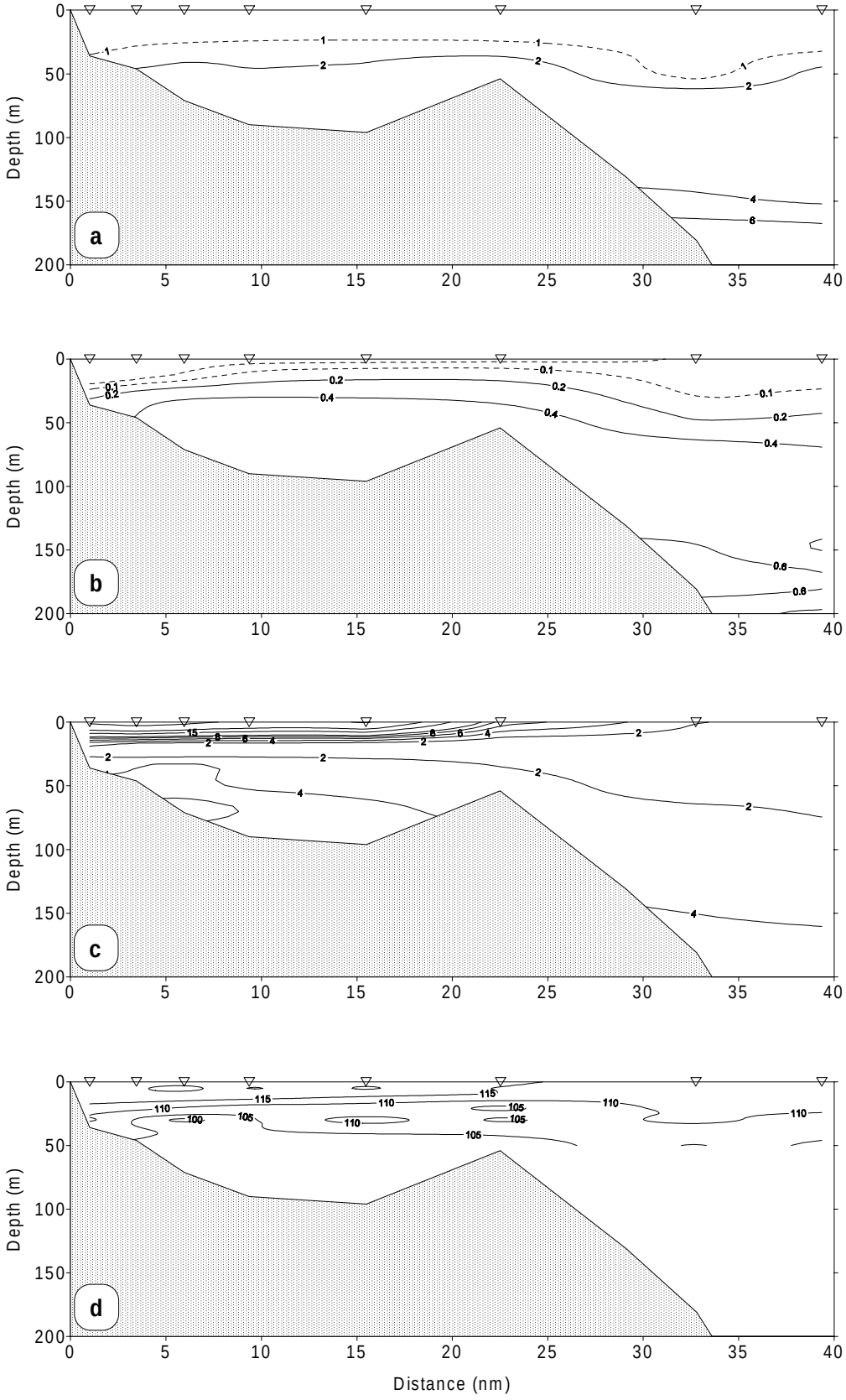


Figure 2.10.4. Vertical profiles along the west side of the fjord on cruise 4, 13-15/7 1992, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

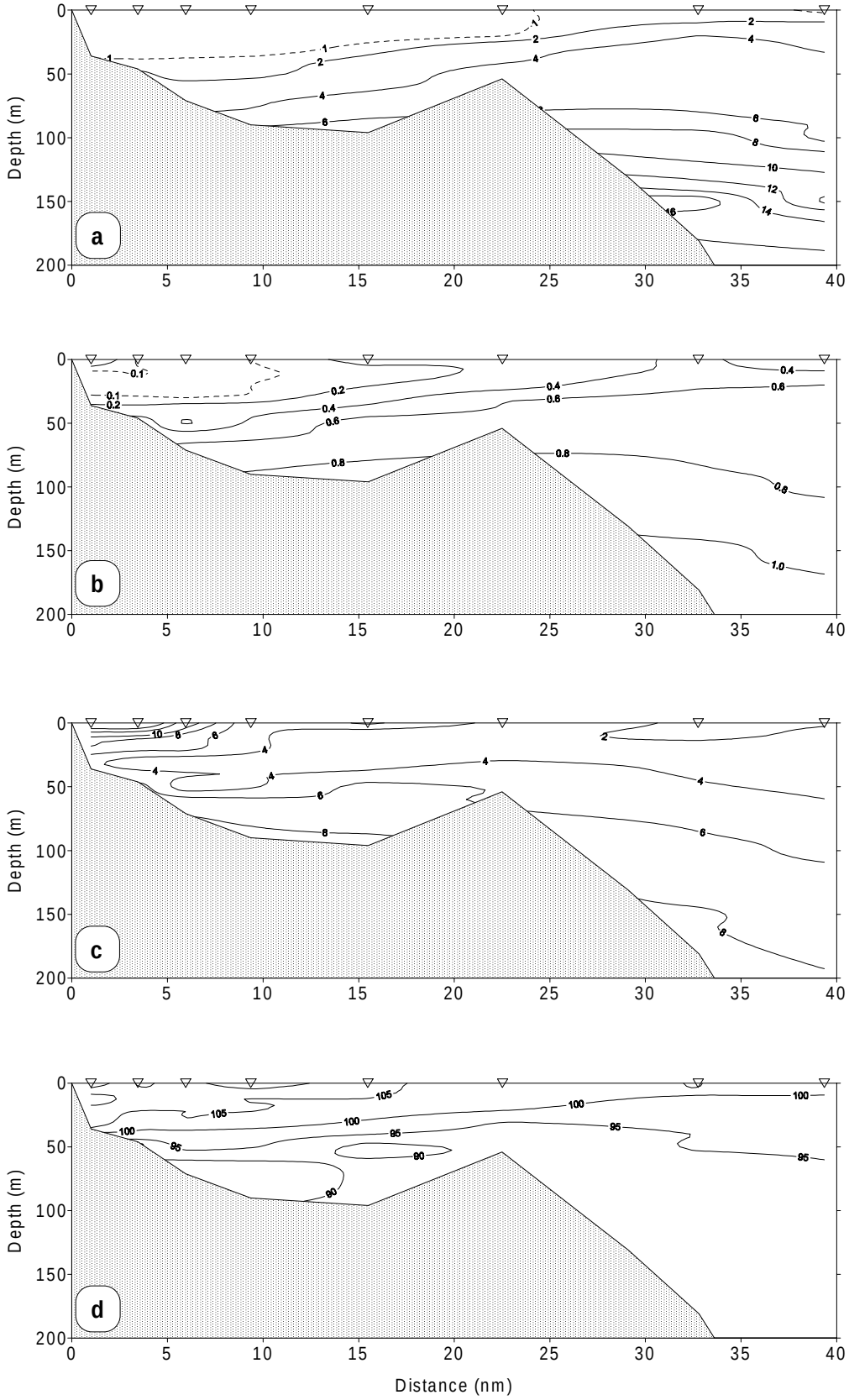


Figure 2.10.5. Vertical profiles along the west side of the fjord on cruise 5, 24-26/8 1992, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

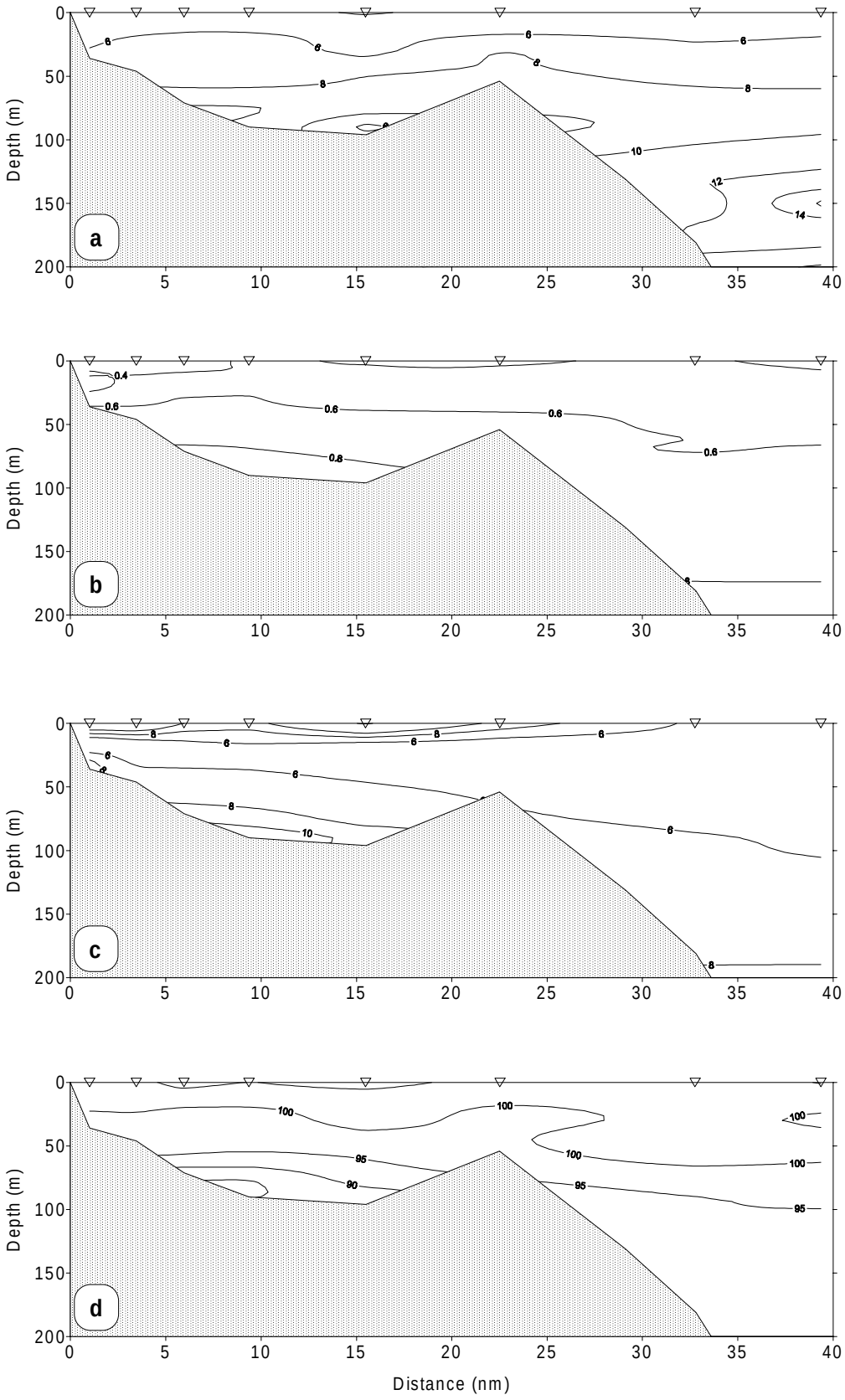


Figure 2.10.6. Vertical profiles along the west side of the fjord on cruise 6, 29/9-1/10 1992, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

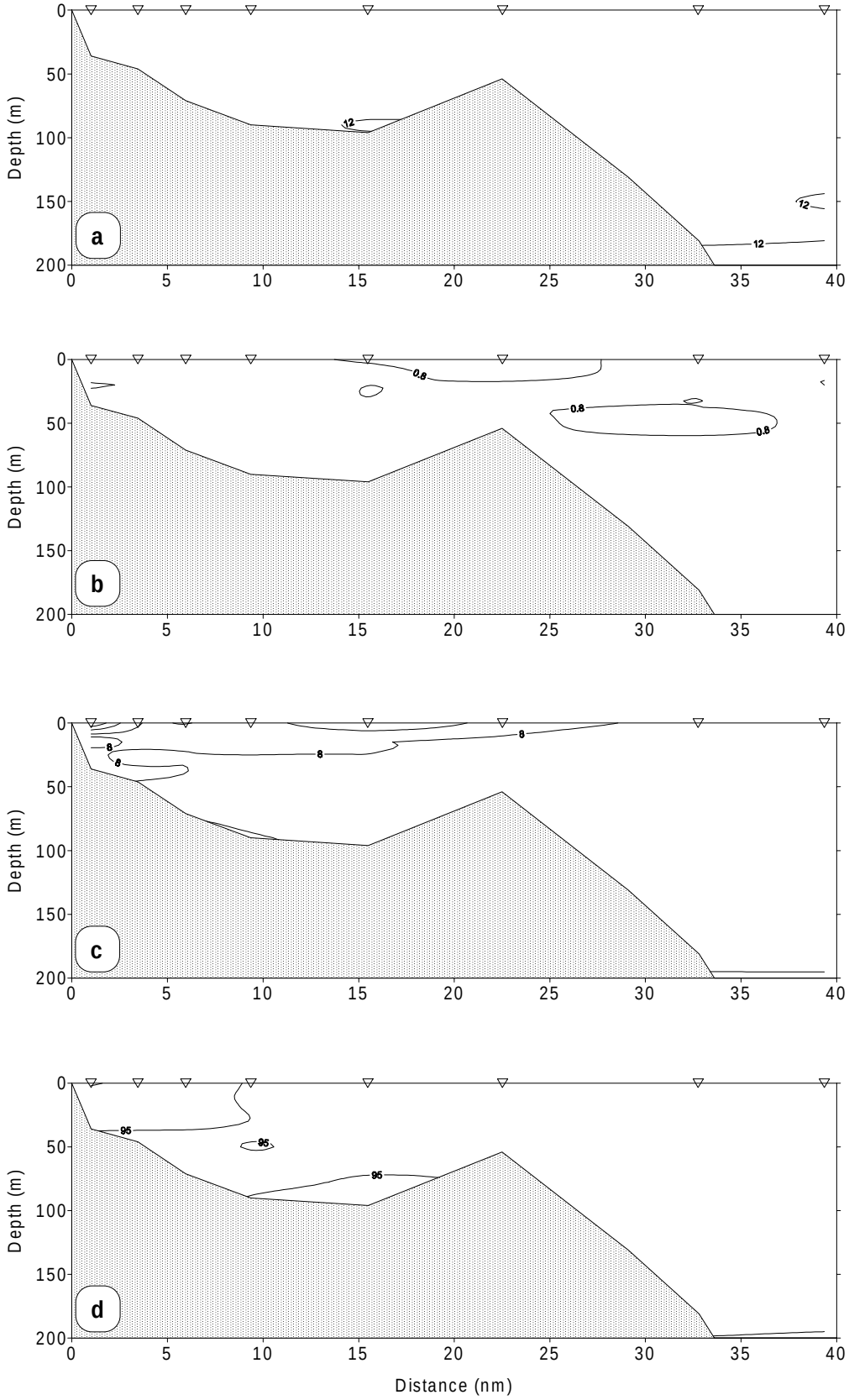


Figure 2.10.7. Vertical profiles along the west side of the fjord on cruise 7, 16-18/11 1992, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

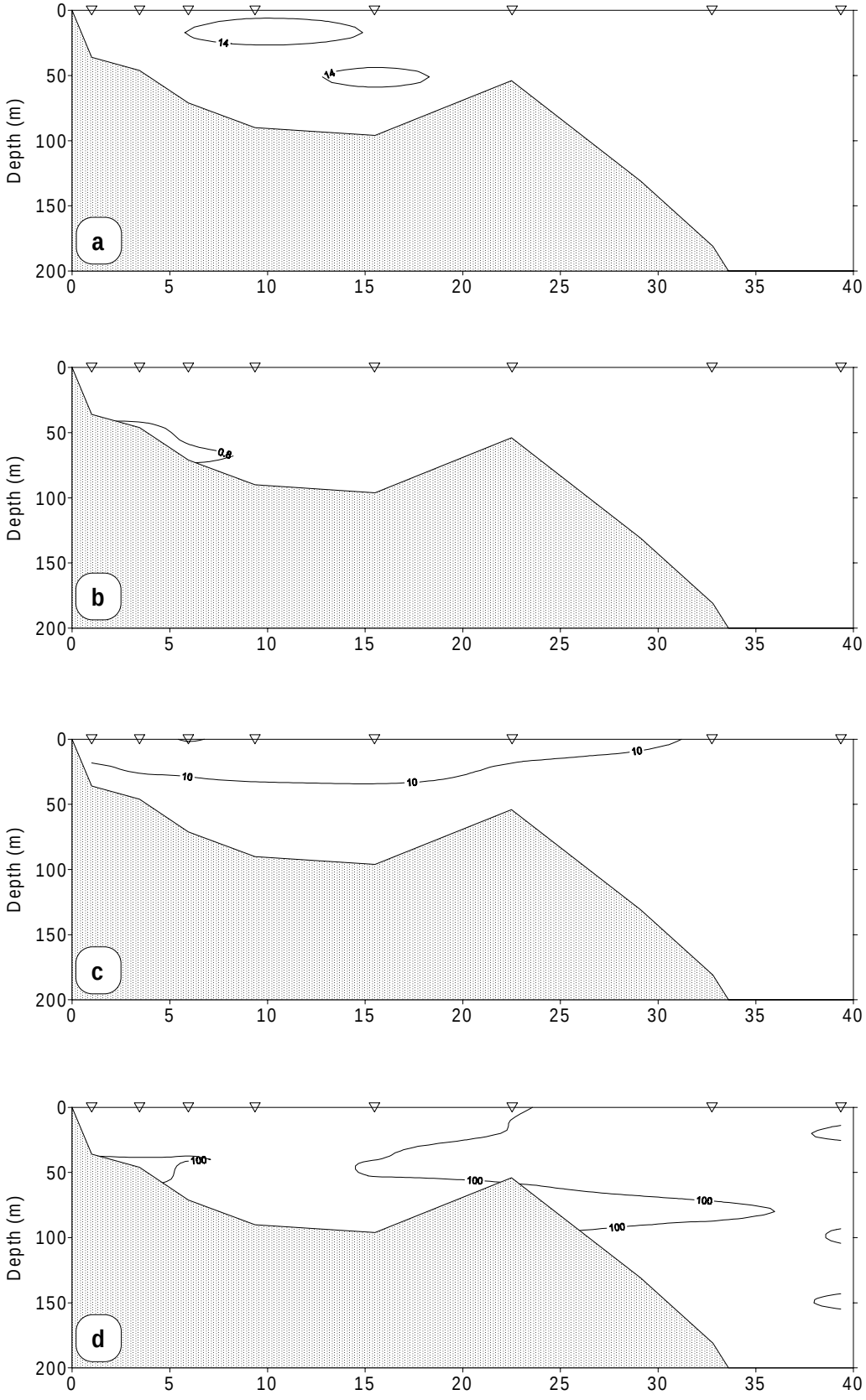


Figure 2.10.8. Vertical profiles along the west side of the fjord on cruise 8, 5-6/1 1993, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

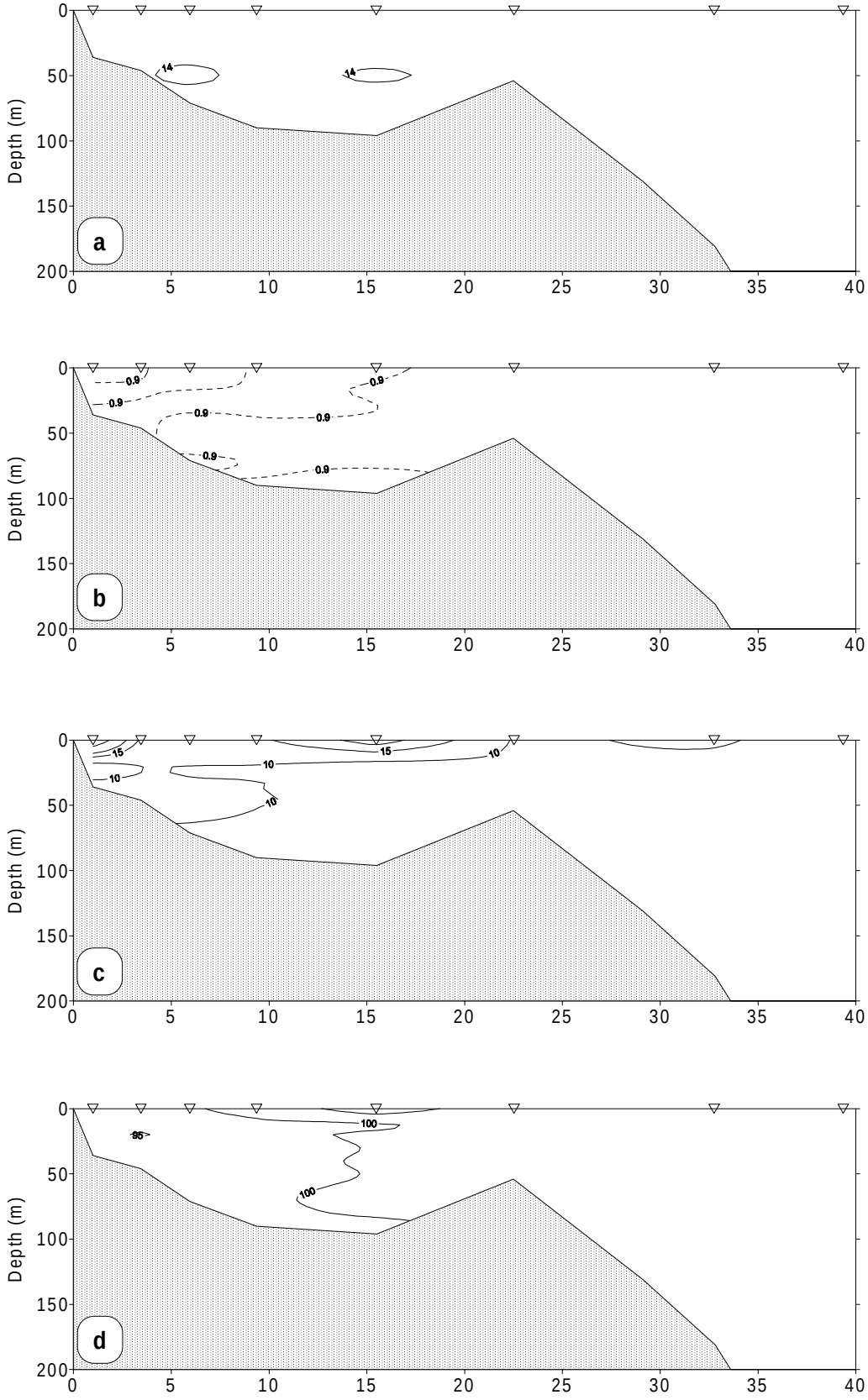


Figure 2.10.9. Vertical profiles along the west side of the fjord on cruise 9, 16-16/2 1993, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

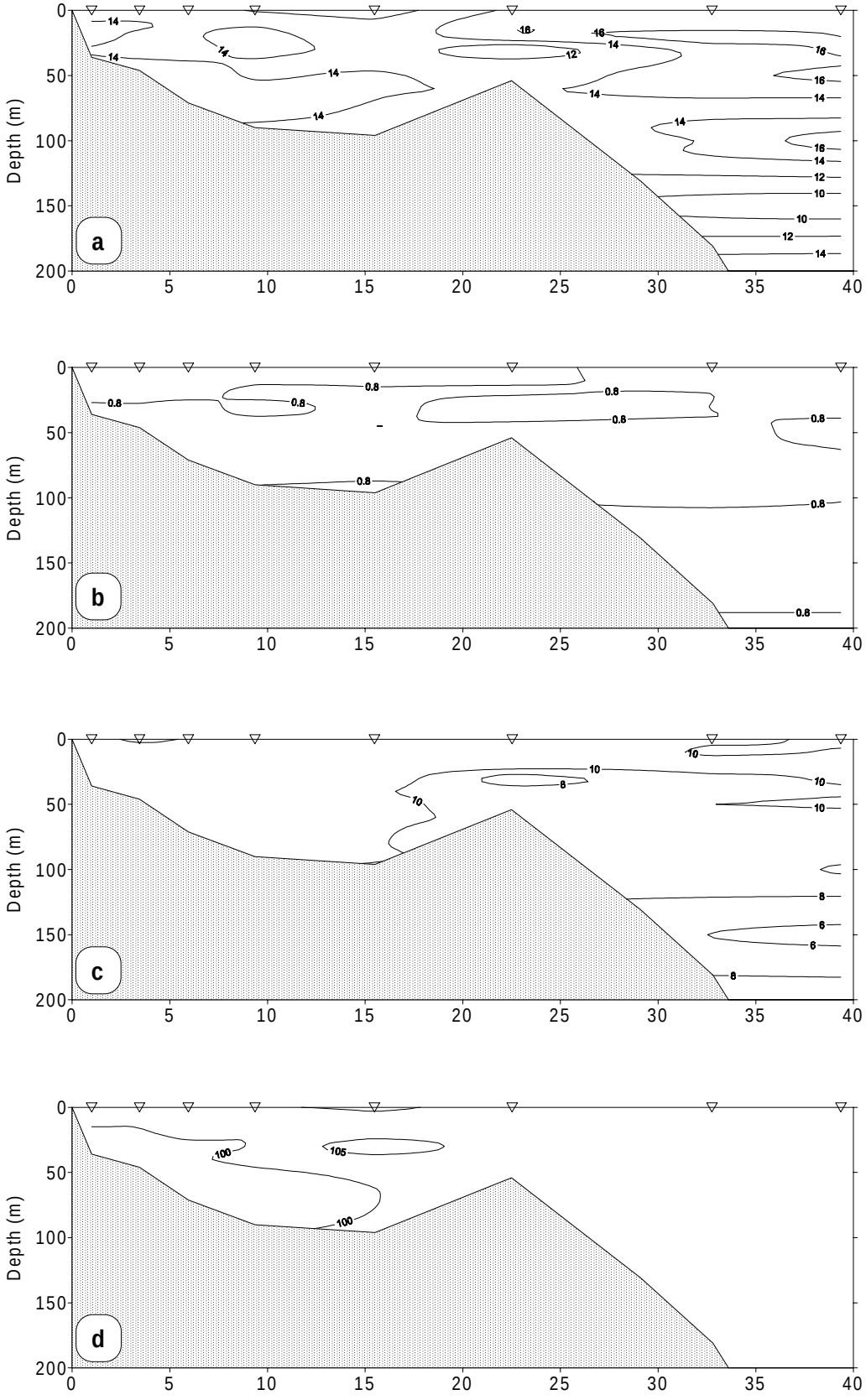


Figure 2.10.10. Vertical profiles along the west side of the fjord on cruise 10, 29-31/3 1993, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

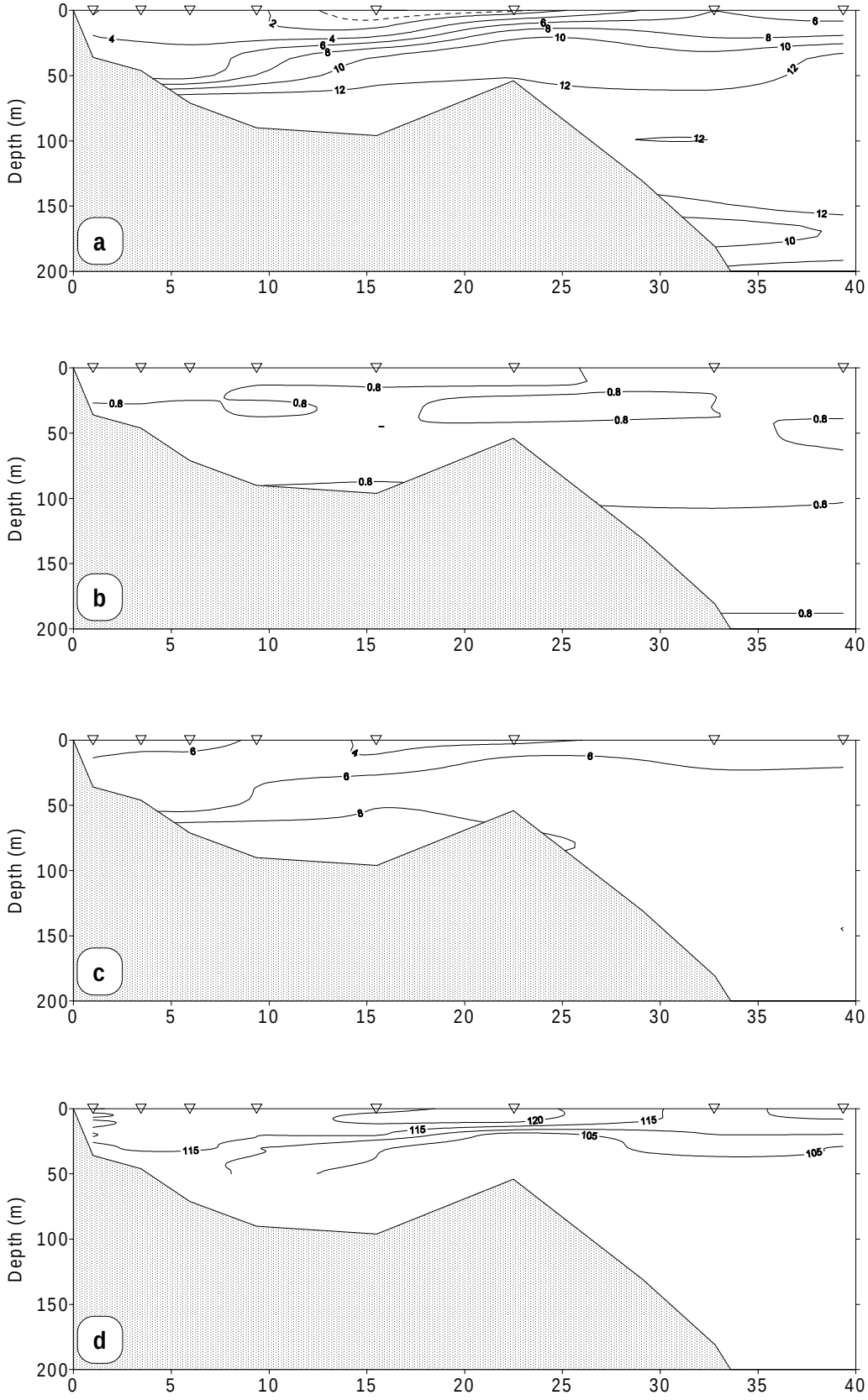


Figure 2.10.11. Vertical profiles along the west side of the fjord on cruise 11, 19-21/4 1992, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

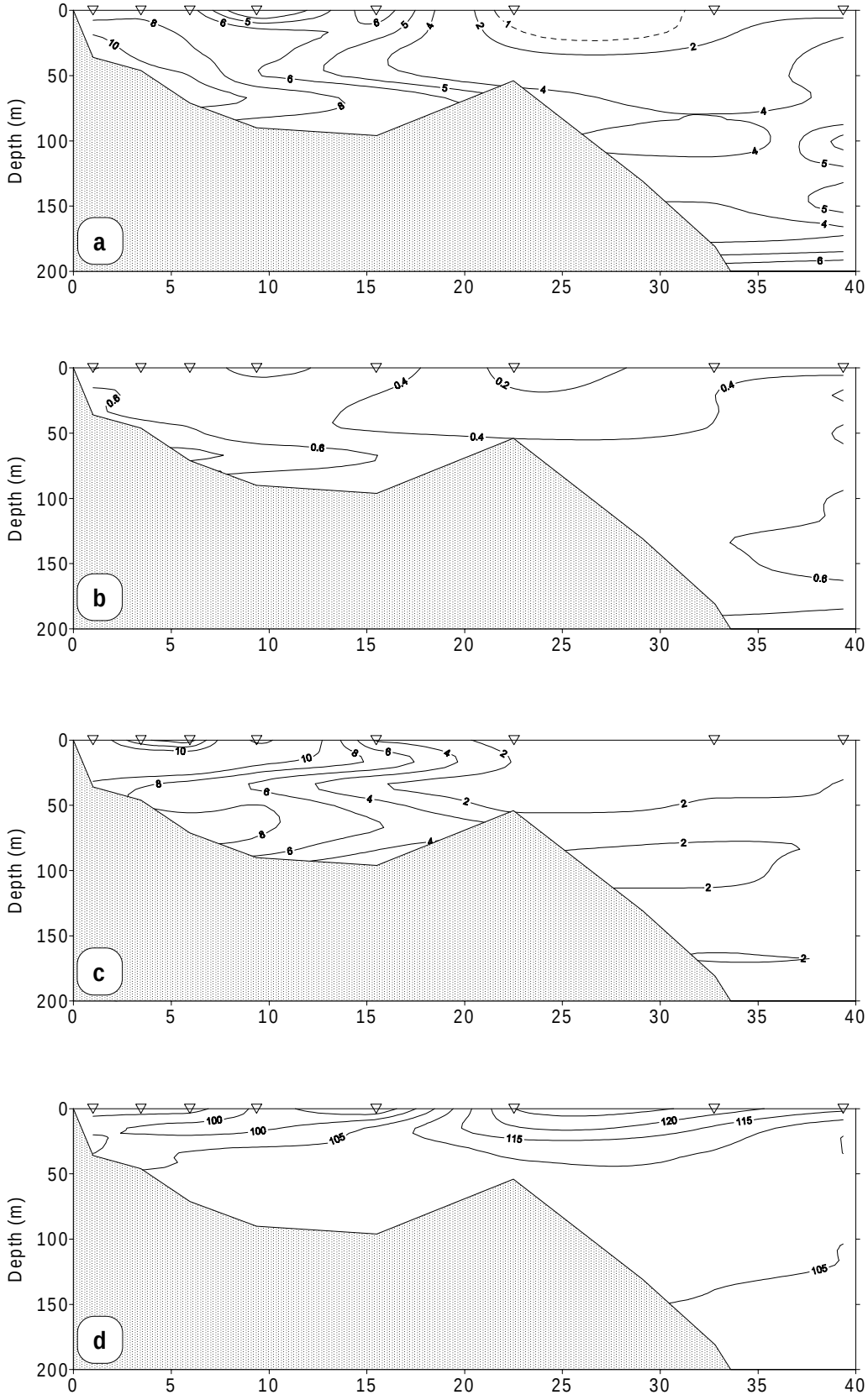


Figure 2.10.12. Vertical profiles along the west side of the fjord on cruise 12, 10-12/5 1993, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

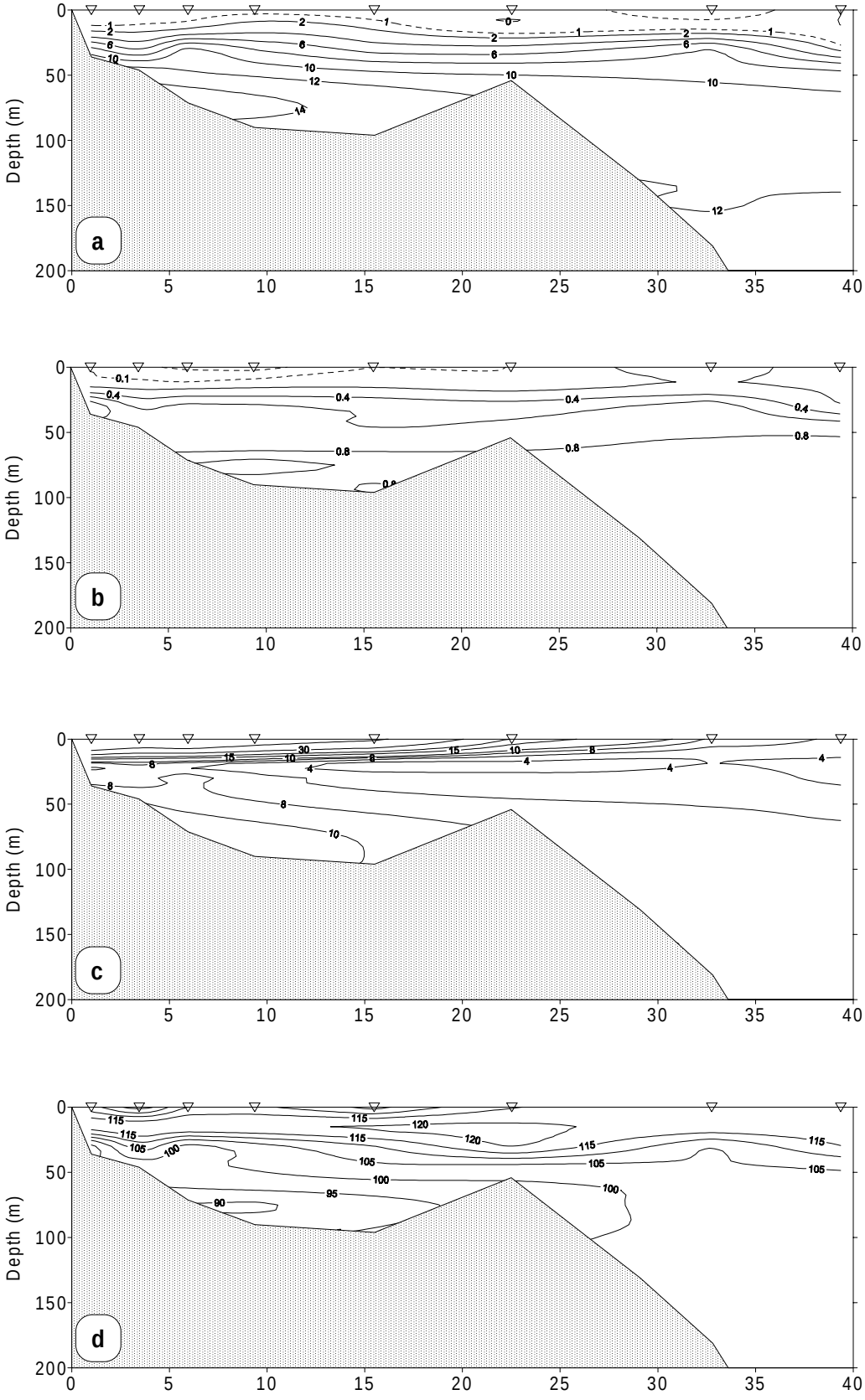


Figure 2.10.13. Vertical profiles along the west side of the fjord on cruise 13, 7-9/6 1993, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

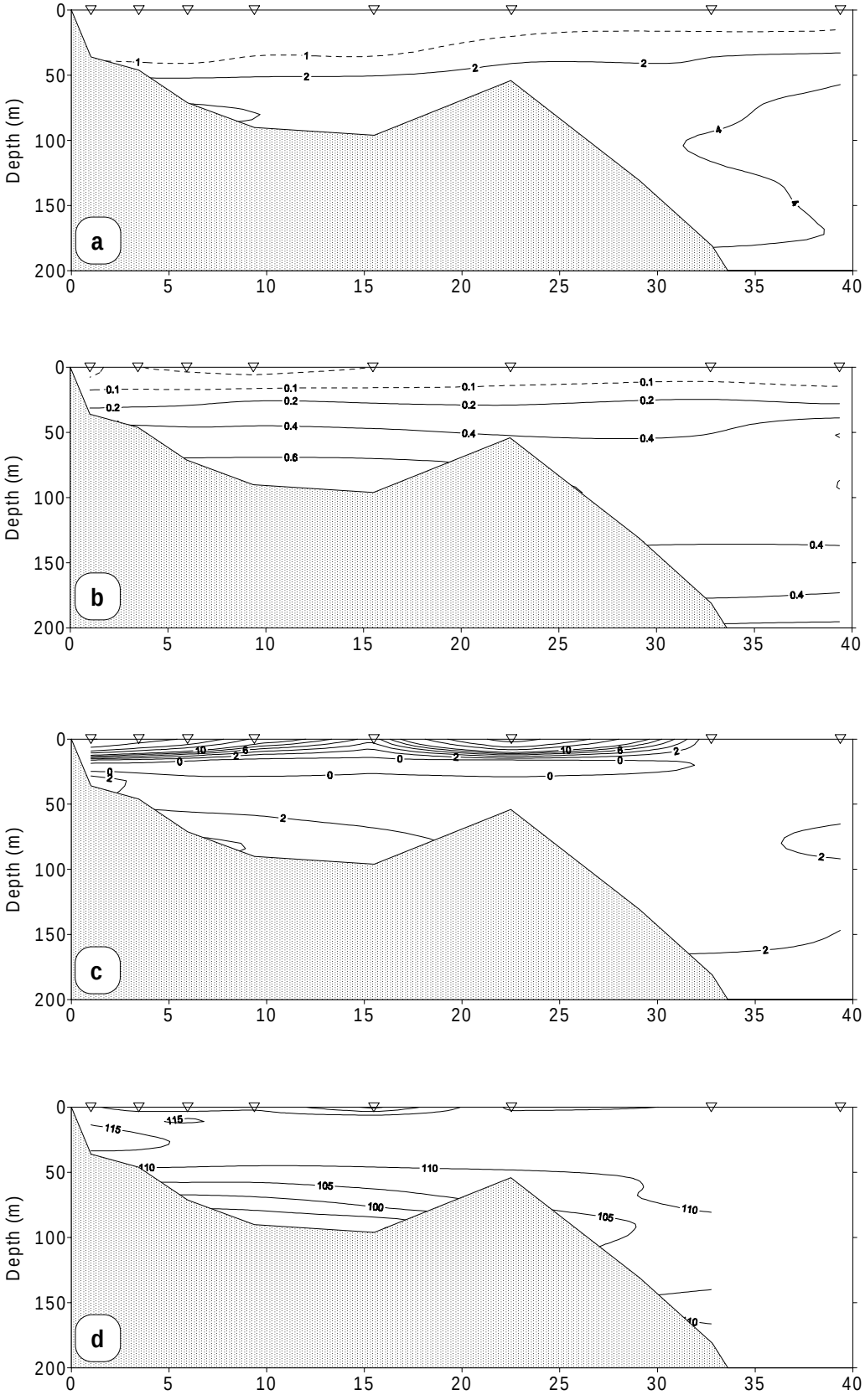


Figure 2.10.14. Vertical profiles along the west side of the fjord on cruise 14, 14-16/7 1993, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

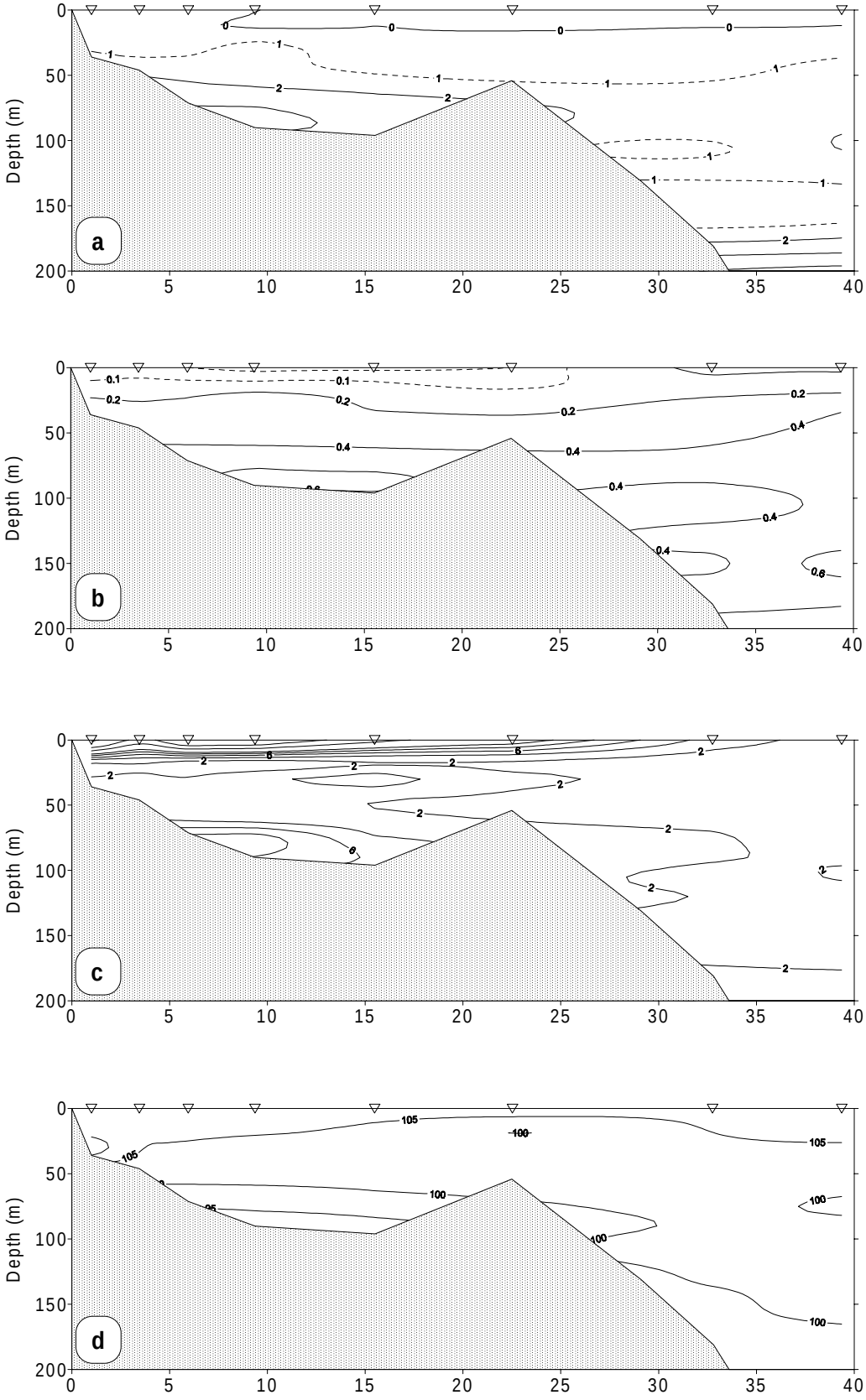


Figure 2.10.15. Vertical profiles along the west side of the fjord on cruise 15, 16-18/8 1993, a) $NO_3$-N (µmole $l^{-1}$), b) $PO_4$-P (µmole $l^{-1}$), c) $SiO_2$ (µmole $l^{-1}$) and d) oxygen saturation (%).

# 3. PHYTOPLANKTON

The objective for the sampling of data on phytoplankton was to obtain information on the seasonal and spatial changes in distribution of phytoplankton biomass (chlorophyll *a*) and to obtain data for calculation of the primary production. The station grid is shown in figure 1.2 and the sampling dates in table 1.2. The observations on the surface irradiance, the *in situ* attenuation of light, the chlorophyll *a* distribution and the results of experiments on productivity as a function of light intensity (P*vs.*I) are presented, along with information on the methods used. The distribution of phytoplankton biomass is illustrated and the horizontal distribution of the calculated primary production per square meter and day given for each cruise during the growth season. Identified species from netsamples are listed in table 3.3.

## *Irradiation at the surface*

The available irradiance for the phytoplankton photosynthesis (PAR) is an important parameter for calculations of the primary production. The surface irradiance was measured at Hjalteyri, using a LI-COR (LI-190SA) cosines corrected, 2π quantum sensor. The sensor was situated on an old pier and coupled to a datalogger. The datalogger was set for sampling the hourly mean of the photon flux and the maximum and minimum values for each hour. Recording started in late February 1992 and continued through 1994. The data (Figure 3.1) were plotted as the sum of photons per square meter for each day during 1992 and 1993.

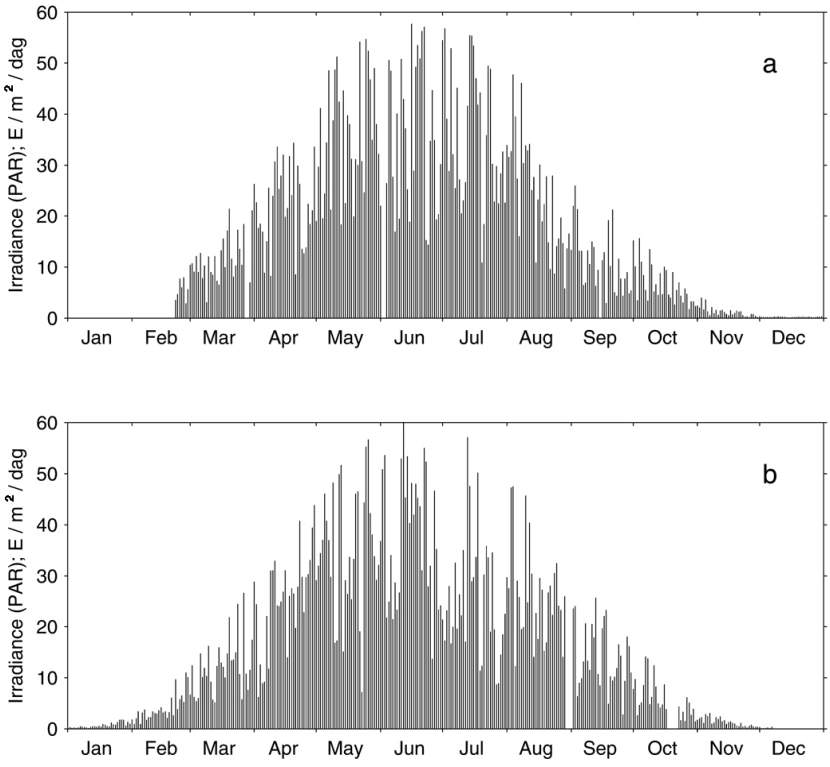


Figure 3.1. Daily surface irradiation at Hjalteyri in a) 1992, b) 1993.

*Attenuation of light*

The light attenuation was measured as the Secchi depth on each cruise (Table 3.1) whenever possible, at the 7 stations selected for water sampling (Figure 1.1). Calculated constants for the best fit of a simple linear model of log-log transformed data of the measured Secchi depths (Ds) and the corresponding chlorophyll-*a* values (Figure 3.2, F-statistics: 76.6 for 1 and 124 degrees of freedom) are given in equation (3.1).

$$Ds = 10.4 \times (\text{chlorophyll-a})^{-0.25} \qquad (3.1)$$

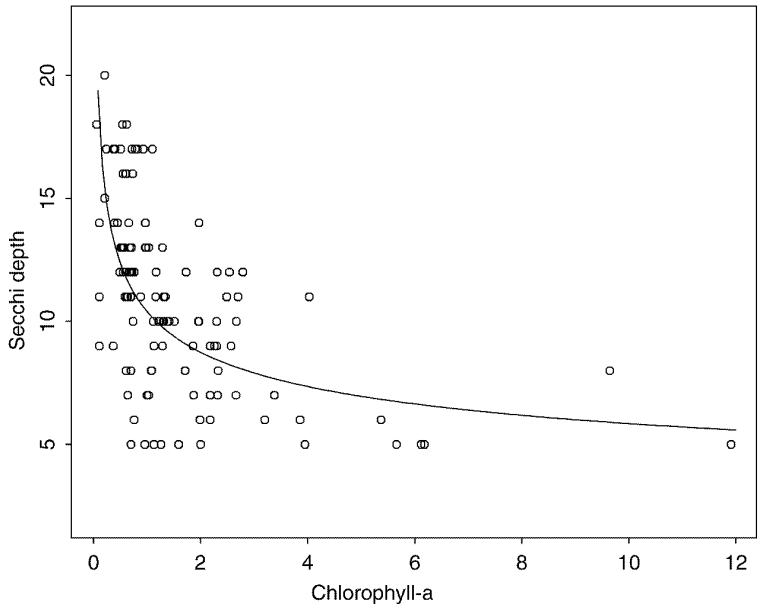


Figure 3.2. Secchi depth *vs.* chlorophyll *a*, a chlorophyll dependant attenuation model.

Combining equation (3.1) with equation (3.2) of Pool and Atkins (1929),

$$k' = 1.7 / Ds \qquad (3.2)$$

leads to the following equation (3.3) for the attenuation coefficient (k'), as a function of the chlorophyll concentrations in the water:

$$k' = 0.163 / (\text{chlorophyll } a)^{-0.25} \qquad (3.3)$$

All data from stations with lower number than four, belonging to the innermost transect, were excluded in order to avoid severe influence of sediment-rich river water. Only chlorophyll concentrations measured at shallower water depths than the corresponding Secchi depth were used. Thus *in situ* light conditions may be calculated from the measured surface irradiation ($I_o$; Figure 3.1) according to

$$I_z = I_o \, e^{-k'z} \qquad (3.4)$$

where k' is according to Secchi readings and equation 3.2 or equation 3.3 and measured chlorophyll *a*.

*Calibration of the fluorometer*

The distribution of phytoplankton (chlorophyll *a*) was measured by use of a fluorometer (Sea Tech Flash Lamp Fluorometer) connected to the CTD unit. For calibration, watersamples for chlorophyll *a* analysis were taken at 7 stations on each cruise. Subsamples from waterbottles taken at 0, 5, 10, 15, 20, 30 and 50 m, where the bottom depth allowed, were filtered on Whatman GF/C and stored in freezer for later analysis. The samples were measured in 90% acetone extracts, in accordance to the standard trichromatic method of SCOR/UNESCO (Anon. 1966). The fluorescence readings (FSU) were calibrated against the respective results of the chlorophyll *a* measurements, figure 3.3, using simple linear regression.

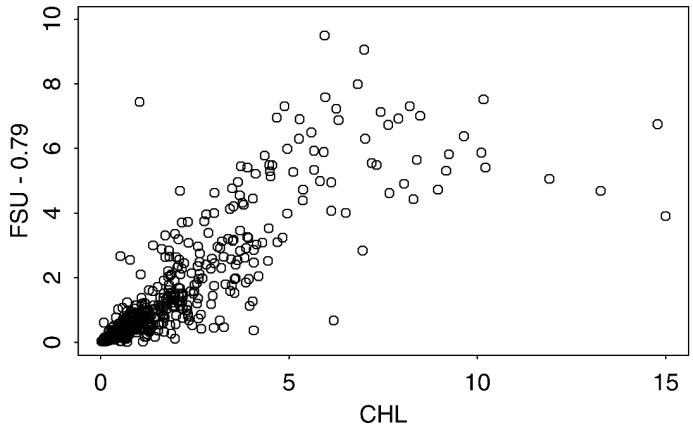


Figure 3.3. Measured fluorescence (FSU) *vs.* chlorophyll *a* (CHL). The fluorescence readings are in relative units and the chlorophyll in mg $m^{-3}$.

The analysis revealed significant correlation to a straight linear model (F-statistic: 1436 for 1 and 607 degrees of freedom, $R^2$: 0.7) were CHL(FSU) = FSU - 0.4. A simple linear regression model assumes all the variability to be due to the dependant variable Y, which in this case would be the measured chlorophyll-a. Obviously that is not the case here and therefore, recalculation of the above results in accordance with the geometric mean regression (Ricker 1984) was appropriate, leading to:

$$CHL(FSU) = 1.2 \times FSU - 0.835 \qquad (3.4).$$

First, all values lower than 0.69 (68 out of 44078) were ruled out as noise. Then a baseline value of 0.79 was subtracted from the rest of the fluorescence readings, as readings in clear deep water during the winter cruises rarely fell below 0.8. Furthermore, as the baseline value is insignificantly different from the intercept (Equation 3.4), a simple multiplication, 1.2 x (FSU - 0.79) = CHL(FSU), was used to convert fluorescence readings to the corresponding chlorophyll-a values. Negative numbers, due to subtraction of the baseline, were made equal to zero. An examination of the residuals ((CHL - CHL(FSU))/CHL) support the adaptation of the above given conversion constants (Figure 3.4).

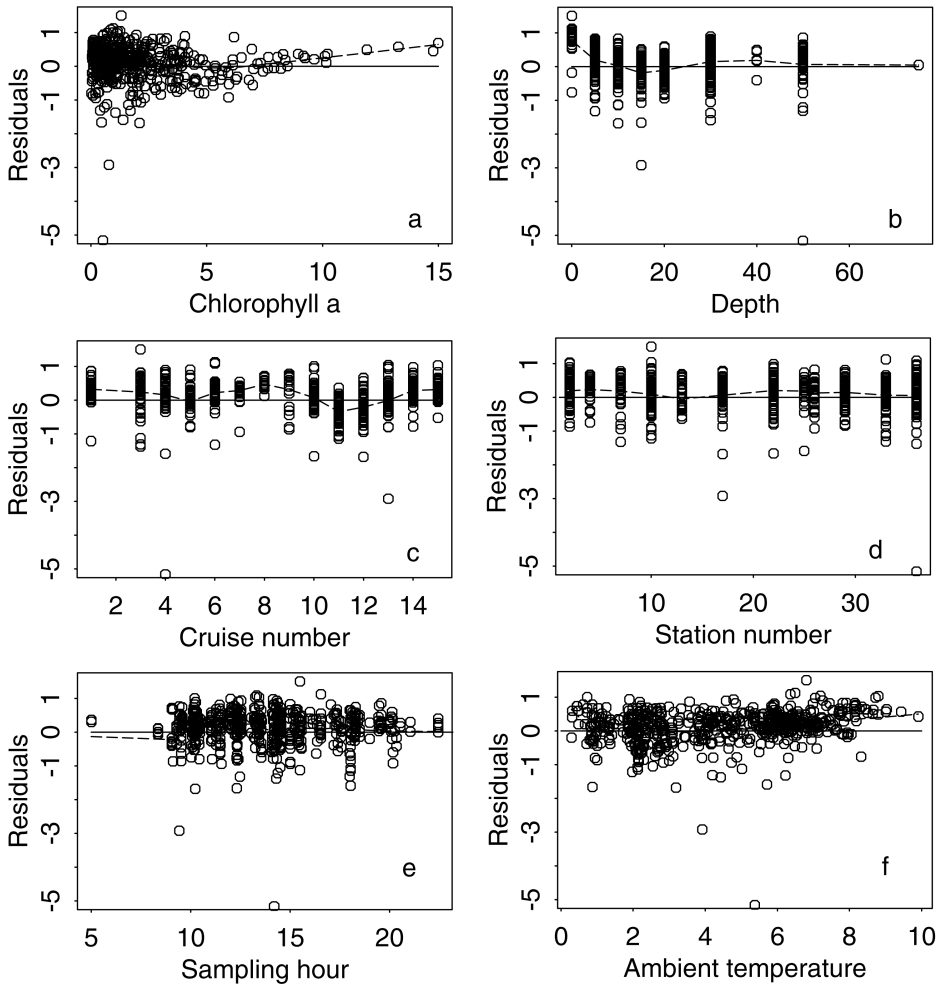


Figure 3.4. Scatter plots of the residuals of measured chlorophyll-a and converted fluorescence ((CHL - CHL(FSU)) / CHL) illustrate the correlation relative to a) the concentration of the measured chlorophyll-a, b) the sampling depth, c) the time of year (cruise numbers), d) the horizontal distribution (station numbers), e) the time of day (sampling hours) and f) the ambient temperature.

*Distribution of phytoplankton*

The seasonal changes in distribution of phytoplankton is presented in figures 3.6, using the measured chlorophyll *a* concentrations (mg $m^{-3}$) from vertical transects at the selected stations for watersampling (*i.e.* stations 2, 10, 17, 22, 29, 33 and 36). Furthermore, the vertical profiles of CHL(FSU) illustrated for each cruise during the growth seasons (Figures 3.7 and 3.8) reveals the distribution of phytoplankton biomass in the fjord, in longitudinal and transverse vertical sections, respectively. An exception is the second cruise, in May 1992, as no fluorometer was available. That leaves the results of water sample analysis as the only available information for the corresponding period, and is dealt with accordingly in figure 3.7b.

The horizontal distribution of chlorophyll *a*, integrated for a water column below a square meter from the surface to 50 m depth, is illustrated (Figure 3.9) for each cruise during the growth seasons in 1992 and 1993.

*Photosynthesis vs. irradiance experiments*

In order to facilitate the calculation of primary production, experiments revealing the response in photosynthesis to a range of light intensities (P*vs.*I-experiments) were undertaken. Except for the two first cruises, April and May 1992, P*vs.*I-experiments were performed for 6 selected stations on each cruise during the growth seasons. The samples were illuminated for four hours in a temperature regulated incubator with white fluorescent light tubes (Philips TLF 20W/33). The productivity values, as a ratio of the corresponding chlorophyll *a* concentrations ($P^B$), were analyzed according to Platt *et al.* (1980). The derived constants, *i.e.* the productivity indices, of each fitted set of data is listed in table 3.2. Visual inspection of properties of the productivity indeces, the maximum productivity ($P^B_{max}$) at saturating light and the slope of the light dependant productivity (alfa) are illustrated in figure 3.5. The temporal (cruise numbers) variability is apparently much greater than the spatial (station numbers) variability of the $P^B_{max}$.

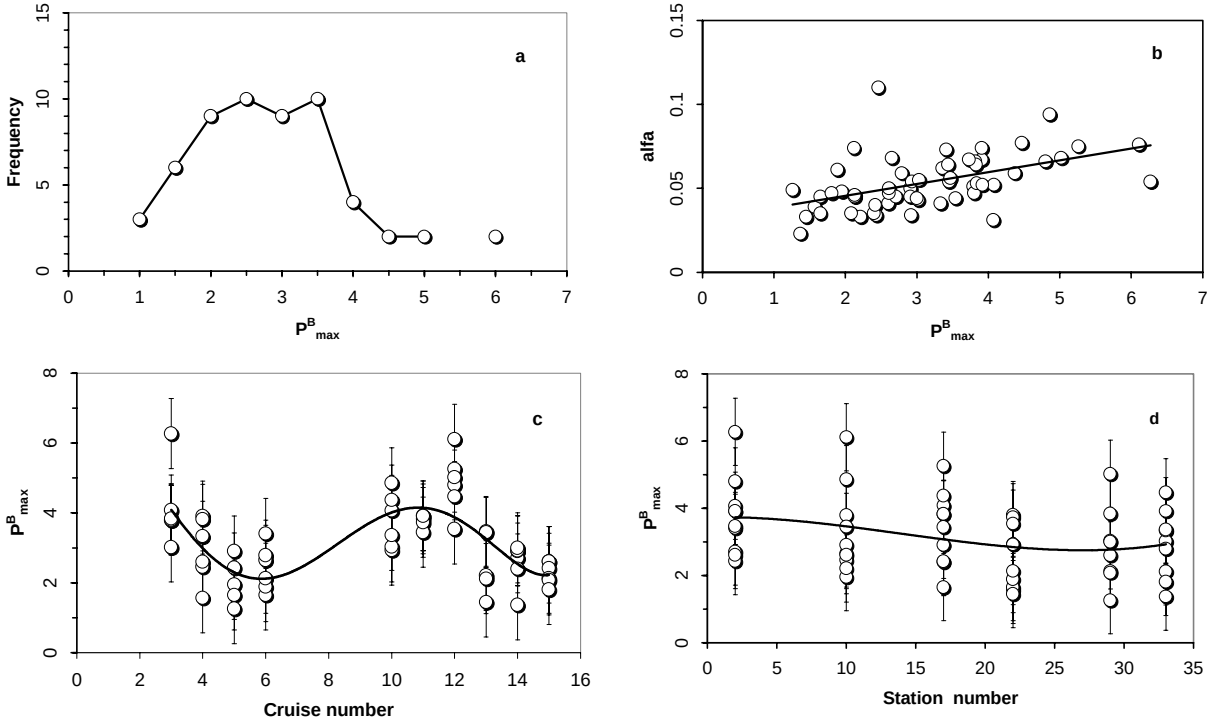


Figure 3.5. Analysis of the chlorophyll-a related productivity indexes derived from P*vs.*I-experiments; a) the frequency distribution of the productivity maximum ($P^B_{max}$), b) correlation of the slope of the light dependant productivity (alfa) and $P^B_{max}$, c) the temporal variability of $P^B_{max}$ (cruise numbers) and d) the spatial variability of $P^B_{max}$ (station numbers).

*Primary production*

The measurements of surface irradiance (Figure 3.1), the equation (3.3) for calculation of chlorophyll *a* dependant attenuation, the phytoplankton distribution (CHL(FSU)) in the fjord (Figure 3.6 - 3.9) and the above mentioned constants derived from analysis of P*vs.*I experiments (Table 3.2) were used in calculation of the daily primary production at each station.

The light intensity at the respective depth intervals and day was calculated for each meter of the euphotic zone. The euphotic zone has been defined as the 1% light

depth, *i.e.* 2.7 * Ds. All light measured at the surface was initially reduced by 6%, for reflection at the surface. Further attenuation of light in the watercolumn was calculated according to equation 3.4, using k' from respective Secchi readings (Table 3.1) and equation 3.2 or the relevant chlorophyll-a values and equation 3.3.

Table 3.1. The observed Secchi depths (m), during 1992 and 1993

| Cruise/Station | 2 | 10 | 17 | 22 | 29 | 33 |
|---|---|---|---|---|---|---|
| 1 | 3 | 5 | 7 | 8 | 10 | 3 |
| 2 | 6 | 9 | 12 | 13 | 9 | 10 |
| 3 | 1.5 | 11 | 5.5 | 6.5 | 13 | 9 |
| 4 | 5 | 7 | | | 13 | 12 |
| 5 | 6.5 | 11 | 12 | 13 | 17 | 17 |
| 6 | 7 | 14 | 17 | 17 | 17 | 13 |
| 10 | 12 | 11 | 12 | | 14 | 14 |
| 11 | 6 | 4.5 | 4.5 | 3 | 6 | 8 |
| 12 | 0.5 | 4.5 | 6 | 5 | 6.5 | 6 |
| 13 | 3 | 5 | 8 | 8 | 10 | 9 |
| 14 | 4.5 | 5 | 9.5 | 10 | 7.5 | 8.5 |
| 15 | 6 | 6 | 7 | 7 | 10.5 | 9 |

The productivity relative to the chlorophyll *a* ($P^B$) was calculated for each meter (z) of the euphotic zone according to the equation of Jassby and Platt (1976),

$$P^B_z = P^B_{max} * \tanh(\text{alfa } I_z/P^B_{max}) \qquad (3.5)$$

The applied constants, $P^B_{max,}$ alfa, are derived from the respective P*vs*.I-experiments (Table 3.2) and the variable $I_z$, calculated for each depth interval, using the hourly records of irradiance at the surface (Figure 3.1). The chosen equation (Jassby and Platt 1976) does not include inhibition of photosynthesis due to high light intensities. That may suite the area as the relevance of photoinhibition *in-situ* is debatable for a well mixed surface layer (Gallegos and Platt 1985), which frequently is the case in Icelandic waters. The $P^B_z$ was finally multiplied by the chlorophyll *a* for the relevant depth and integrated for each meter of the euphotic zone and each hour of the day. The results, *i.e.* the daily productions below a square meter, are presented in figure 3.10 and illustrate the distribution of the primary production, mg C $m^{-2}$ $d^{-1}$, for each cruise during the growth seasons in 1992 and 1993.

Table 3.2. The constants derived from curve fitting data from P *vs.* I-experiments in Eyjafjörður 1992 - 1993.

$P_{max}$: chlorophyll-a related carbon assimilation rate [C $h^{-1}$ / Chl-a] at light saturation, Iopt: the light intensity [µE $m^{-2}$ $s^{-1}$] at maximal rate of carbon assimilation, Ik: the light intensity at the crossing point of straight lines representing the light dependant assimilation and light saturating assimilation rates of carbon and alfa: the slope of the light dependant assimilation rate Pmax / Ik.

| Cruise | Station | Depth | Pmax | alfa | Ik | Iopt |
|---|---|---|---|---|---|---|
| 3 | 2 | 5 | 6.27 | 0.054 | 116 | 315 |
| 3 | 10 | 10 | 3.79 | 0.051 | 74 | 201 |
| 3 | 17 | 10 | 4.08 | 0.052 | 78 | 253 |
| 3 | 22 | 10 | 3.80 | 0.047 | 81 | 220 |
| 3 | 29 | 10 | 3.84 | 0.053 | 73 | 199 |
| 3 | 33 | 10 | 3.02 | 0.043 | 70 | 194 |
| 4 | 2 | 5 | 3.91 | 0.067 | 58 | 197 |
| 4 | 10 | 10 | 2.46 | 0.110 | 22 | 116 |
| 4 | 17 | 10 | 3.82 | 0.066 | 58 | 185 |
| 4 | 22 | 10 | 1.57 | 0.039 | 40 | 133 |
| 4 | 29 | 10 | 2.60 | 0.041 | 63 | 213 |
| 4 | 33 | 10 | 3.33 | 0.041 | 82 | 222 |
| 5 | 2 | 5 | 2.43 | 0.034 | 72 | 191 |
| 5 | 10 | 10 | 1.95 | 0.048 | 41 | 124 |
| 5 | 17 | 10 | 2.91 | 0.050 | 58 | 159 |
| 5 | 22 | 10 | 1.65 | 0.045 | 37 | 118 |
| 5 | 29 | 10 | 1.26 | 0.049 | 26 | 100 |
| 6 | 2 | 10 | 3.41 | 0.073 | 47 | 121 |
| 6 | 10 | 10 | 2.65 | 0.068 | 39 | 104 |
| 6 | 17 | 10 | 1.65 | 0.035 | 47 | 149 |
| 6 | 22 | 10 | 1.89 | 0.061 | 31 | 98 |
| 6 | 29 | 10 | 2.13 | 0.045 | 47 | 136 |
| 6 | 33 | 10 | 2.79 | 0.059 | 48 | 106 |
| 10 | 2 | 10 | 4.07 | 0.031 | 131 | 195 |
| 10 | 10 | 10 | 4.86 | 0.094 | 52 | 170 |
| 10 | 17 | 10 | 4.37 | 0.059 | 74 | 202 |
| 10 | 22 | 10 | 2.93 | 0.054 | 54 | 152 |
| 10 | 29 | 10 | 3.03 | 0.055 | 55 | 186 |
| 10 | 33 | 10 | 3.36 | 0.062 | 54 | 147 |
| 11 | 2 | 10 | 3.92 | 0.052 | 76 | 206 |
| 11 | 10 | 10 | 3.45 | 0.054 | 64 | 276 |
| 11 | 17 | 10 | 3.83 | 0.064 | 60 | 162 |
| 11 | 22 | 10 | 3.73 | 0.067 | 56 | 191 |
| 11 | 33 | 10 | 3.91 | 0.074 | 53 | 155 |

Table 3.2. (continues)

| Cruise | Station | Depth | Pmax | alfa | Ik | Iopt |
|---|---|---|---|---|---|---|
| 12 | 2 | 10 | 4.80 | 0.066 | 73 | 198 |
| 12 | 10 | 10 | 6.11 | 0.076 | 80 | 218 |
| 12 | 17 | 10 | 5.26 | 0.075 | 70 | 189 |
| 12 | 22 | 10 | 3.54 | 0.044 | 81 | 177 |
| 12 | 29 | 10 | 5.02 | 0.068 | 74 | 201 |
| 12 | 33 | 10 | 4.47 | 0.077 | 58 | 158 |
| 13 | 2 | 10 | 3.47 | 0.056 | 62 | 169 |
| 13 | 10 | 10 | 2.21 | 0.033 | 68 | 184 |
| 13 | 17 | 10 | 3.44 | 0.064 | 54 | 147 |
| 13 | 22 | 10 | 1.45 | 0.033 | 45 | 160 |
| 13 | 33 | 10 | 2.12 | 0.074 | 29 | 112 |
| 14 | 2 | 10 | 2.71 | 0.045 | 60 | 192 |
| 14 | 10 | 10 | 2.91 | 0.045 | 65 | 234 |
| 14 | 17 | 10 | 2.40 | 0.035 | 68 | 185 |
| 14 | 22 | 10 | 2.92 | 0.034 | 86 | 234 |
| 14 | 29 | 10 | 3.00 | 0.044 | 68 | 189 |
| 14 | 33 | 10 | 1.37 | 0.023 | 61 | 193 |
| 15 | 2 | 10 | 2.61 | 0.047 | 55 | 164 |
| 15 | 10 | 10 | 2.61 | 0.050 | 52 | 174 |
| 15 | 17 | 10 | 2.42 | 0.040 | 60 | 167 |
| 15 | 22 | 10 | 2.13 | 0.046 | 46 | 165 |
| 15 | 29 | 10 | 2.08 | 0.035 | 59 | 167 |
| 15 | 33 | 10 | 1.81 | 0.047 | 39 | 134 |

*Phytoplankton identification*

Samples for species identification and counting were stored in 100 ml dark bottles, fixed in 4% neutralized formaldehyde solution. Netsamples were preserved in formaldehyde as well. The net samples from Station 10 have been analyzed, revealing an impression of the seasonal changes in the composition of the phytoplankton species. A total of 69 species and genera were recorded. The most prominent species observed in May 1992 were colonies of *Phaeocystis pouchetii*. A small pennate diatom *Pseudnitzschia granii,* which frequently coexists with *P. pouchetii,* was also present in samples otherwise full of diverse diatoms. Blooms of *Skeletonema costata* were observed in early spring 1993 and in August of both years. The diatoms generally dominated the phytoplankton from March to October. In early spring *Cheatoceros spp.* and *Thalassiosira spp.* were the most prominent, but during the summer *Pseudonitzschia* species of several different genera were numerous. Dinoflagellates were most diverse and had the highest abundance in the summer and autumn samples, along with the diatoms. During the winter there were only a small number of dinoflagellates observed. The succession of species, on a seasonal scale, showed a high degree of resemblance during the periods overlapping. The list of species, identified at Station 10 (Öivind Kaasa and Kristinn Guðmundsson 1994, Kristinn Guðmundsson and Agnes Eydal 1998), is given as table 3.3.

Table 3.3. List of species/groups of phytoplankton and ciliates identified from netsamples, Eyjafjörður 1992 and 1993. - **Diatoms**.

| Names: Sampling date at station no 10: | 1.5.1992 | 21.5.1992 | 9.6.1992 | 13.7.1992 | 24.8.1992 | 29.9.1992 | 16.11.1992 | 5.1.1993 | 15.2.1993 | 29.3.1993 | 19.4.1993 | 12.5.1993 | 7.6.1993 | 14.7.1993 | 18.8.1993 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Diatoms (Bacillariophyceae)** | | | | | | | | | | | | | | | |
| *Attheya septentrionalis* (Östrup) Crawford | | | | | | | | | | | | | | x | |
| *Cerataulina pelagica* (Cleve) Hendey | x | | | | | | | | | | | | | | |
| *Chaetoceros concavicornis* Mangin *f. volans* (Schütt) Hustedt | x | | | | | | | | | | | | | | x |
| *Chaetoceros constrictus* Gran | | x | x | | | | | | | | | | | x | x |
| *Chaetoceros constrictus* Gran, resting cells | | | | | | | | | | | | | | x | |
| *Chaetoceros convolutus* Castracane | | x | | | | x | | | | | | | | x | |
| *Chaetoceros cf. crinitum* Schütt | | | | | | | | | | x | | | | | |
| *Chaetoceros debilis* Cleve | | x | | | | | | | | | | x | | x | |
| *Chaetoceros debilis* Cleve, resting cells | x | | | | | | | | | | x | | | | |
| *Chaetoceros decipience* Cleve | | | | | | | | | | | | | | x | |
| *Chaetoceros diadema* (Ehrenberg) Gran | x | x | x | | | | | | | | | x | x | x | |
| *Chaetoceros diadema* (Ehrenberg) Gran, resting cells | | | | | | | | | | | | | x | x | |
| *Chaetoceros furcellatus* Bailey | x | x | | | x | | | | | | | | | | |
| *Chaetoceros furcellatus* Bailey, resting cells | x | | | | | | | | | | | x | | | |
| *Chaetoceros laciniosus* Schütt | x | x | | | | | | | | | | | x | x | |
| *Chaetoceros simplex* Ostenfeld | | | | x | x | | | | | | | | | | |
| *Chaetoceros socialis* Lauder | | | | | | | | | | x | x | x | | | |
| *Chaetoceros tenuissimus* Meurier | | | | x | | | | | | | | | | | |
| *Chaetoceros* sp. unspecified resting cells | | | | x | x | | | | | | | | | | |
| *Chaetoceros* sp. small cells (3-5µm) | | | | | | | | | | | x | | | | |
| *Cylindrotheca closterium* (Ehrenberg) Reimann & Lewin | x | x | x | x | x | x | x | | x | | | | | x | x |
| *Dactylosolen fragilissimus* (Bergon) Hasle | x | | | | | | | | | | | | | | |
| *Fragilariopsis cf. oceanica* (Cleve) Hasle | | x | | | | | | | | x | x | | | | |
| *Leptocylindrus danicus* Cleve | | x | | x | | | | | | | | | x | x | |
| *Leptocylindrus minimus* Gran | | x | x | | x | | | | | | x | x | | | |
| *Navicula* sp. | x | | | | | | | | x | | x | | x | | |
| *Nitzschia cf. lognissima* (Brébisson) Ralfs | | | | | | | | | x | | | | | | |
| *Odontella aurita* (Lyngbye) Agardh | | | | | | | | | x | x | x | | | | |
| *Pleurosigma* spp. | | | | | | | | | x | x | | | | | |
| *Porosira glacialis* (Grunow) Jörgensen | | | | | | | | | | x | x | | | | |
| *Pseudo-nitzschia delicatissima* (Hasle) Hasle | | | | x | | x | | | | | x | | | | |
| *Pseudo-nitzschia granii* (Hasle) Hasle | | x | | | | | | | | | | | | | |
| *Pseudo-nitzschia pseudodelicatissima* (Hasle) Hasle | x | | | | | x | | | | | | | x | x | |
| *Pseudo-nitzschia seriata* (Cleve) Peragallo | x | x | x | x | | | x | | | | | | x | x | |
| *Pseudo-nitzschia turgidula* (Hustedt) Hasle | x | | | | | | | | | | | | x | | |
| *Proboscia alata* (Brightwell) Sundström | | x | | | | | | | | | | | | x | |
| *Rhizosolenia hebetata* Bailey f. *semispina* (Hensen) Gran | | | x | | | | | | | | | | x | x | x |
| *Skeletonema costatum* (Greville) Cleve | x | | | | x | x | x | | x | x | x | x | | x | x |
| *Thalassionema nitzschioides* (Grunow) Grunow | | | | x | | | | | | | | x | | | |
| *Thalassiosira anguste lineatum* (Schmidt) Fryxell & Hasle | x | x | | | | x | | | | | | x | | | |
| *Thalassiosira bioculata* (Grunow) Ostenfeld | x | x | | | | | | | | | | | | | |
| *Thalassiosira gravida* Cleve | x | x | | | | x | | | x | | x | x | x | | |
| *Thalassiosira nordenskioeldii* Cleve | x | x | | | | | | | | x | x | x | | | |

Table 3.3. List of species/groups of phytoplankton and ciliates identified from netsamples, Eyjafjörður 1992 and 1993. - **Flagellates**.

| Names: Sampling date at station no 10: | 1.5.1992 | 21.5.1992 | 9.6.1992 | 13.7.1992 | 24.8.1992 | 29.9.1992 | 16.11.1992 | 5.1.1993 | 15.2.1993 | 29.3.1993 | 19.4.1993 | 12.5.1993 | 7.6.1993 | 14.7.1993 | 18.8.1993 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dinoflagellates (Dinophyceae)** | | | | | | | | | | | | | | | |
| *Alexandrium cf. ostenfeldii* (Paulsen) Balech & Tangen | x | x | | | | | | | | | | x | | | |
| *Alexandrium cf. tamarense* (Lebour) Balech | | | x | x | x | | | | | | | | x | | x |
| *Amylax triacantha* (Jörgensen) Sournia | | | x | | | | | | | | | | | | x |
| *Ceratium longipes* (Bailey) Gran | | | | | x | | x | | | | | | | | x |
| *Dinophysis acuminata* Claparéde & Lachmann | | | x | | x | x | x | x | x | | | x | | | |
| *Dinophysis acuta* Ehrenberg | | x | | | | | x | | | | | | | | |
| *Dinophysis norvegica* Claparéde & Lachmann | | | | | x | x | x | x | x | | | | | | |
| *Ensiculifera/Scrippsiella* | | x | x | x | x | x | | | x | | | x | x | | x |
| *Ensiculifera/Scrippsiella*, cysts | | | | | x | x | | | | | | | | | x |
| *Gonyaulax polygramma* Stein | | | x | | | | | | | | | | | | |
| *Gonyaulax spinifera* (Claparéde & Lachmann) Diesing | | | x | | | | | | | | | | | | x |
| *Gymnodinium* spp. | | x | x | x | | x | | | | | | | x | | x |
| *Heterocapsa triquetra* (Ehrenberg) Stein | | | | | | | | | | | | | x | x | x |
| *Lebouraia minuta* Abé | | | x | | | | | | | | | | | | |
| *Phalacroma cf. rotundata* (Clap. & Lachm.) Kofoid & Michener | | | | | | | x | x | x | | | | | x | x |
| *Phalacroma cf. ruudi* Braarud | | | | | | | | | x | | | | | | |
| *Preperidinium meunieri* (Pavillard) Elbrächter | | x | x | | | | x | | x | | | | x | | |
| *Protoperidinium bipes* (Paulsen) Balech, see P&D | | | | | | | | | | | | | x | | |
| *Protoperidinium brevipes* (Paulsen) Balech | | x | x | | x | | | | | | | x | x | x | x |
| *Protoperidinium cf. conicoides* (Paulsen) Balech | | | | | | | | | | | | | x | | |
| *Protoperidinium depressum* (Bailey) Balech | | | | | | | x | | x | | | | | | x |
| *Protoperidinium divergens* (Ehrenberg) Balech | x | x | | | x | | | | | | | | | | |
| *Protoperidinium granii* (Ostenfeld) Balech, see P&D | | | x | | | | | | | | | x | x | x | x |
| *Protoperidinium ovatum* Pouchet, see P&D | | x | x | x | x | | x | x | x | | | | x | | x |
| *Protoperidinium pellucidum* Bergh | x | x | | | x | | x | | x | | | x | x | x | x |
| *Protoperidinium cf. pyriforme* (Paulsen) Balech, see P&D | | | x | | | | | | | | | | | | |
| *Protoperidinium roseum* (Paulsen) Balech, see P&D | | x | x | x | | | | x | | | | | x | x | x |
| **Chrysophyceae** | | | | | | | | | | | | | | | |
| *Dictyocha speculum* Ehrenberg | | x | | | | | x | | x | | | | x | | |
| *Dinobryon* spp. | | | x | x | x | x | | | | | | | x | | |
| **Haptophyceae** | | | | | | | | | | | | | | | |
| *Phaeocystis pouchetii* (Hariot) Lagerheim | x | x | x | | | | | | | | x | x | x | x | |
| **Euglenaphyceae** | | | | | | | | | | | | | | | |
| *Eutreptia/Eutreptiella sp.* | | | x | | | | | | | | | | | | |
| *Euglena spp.* | | | | | | | | | | | | | x | | |
| **Ciliata** | | | | | | | | | | | | | | | |
| *Laboea spp.* | | | | | x | | | | | | | | x | | x |
| *Parafavella* spp. | | | x | | | | | | | | | | x | | x |

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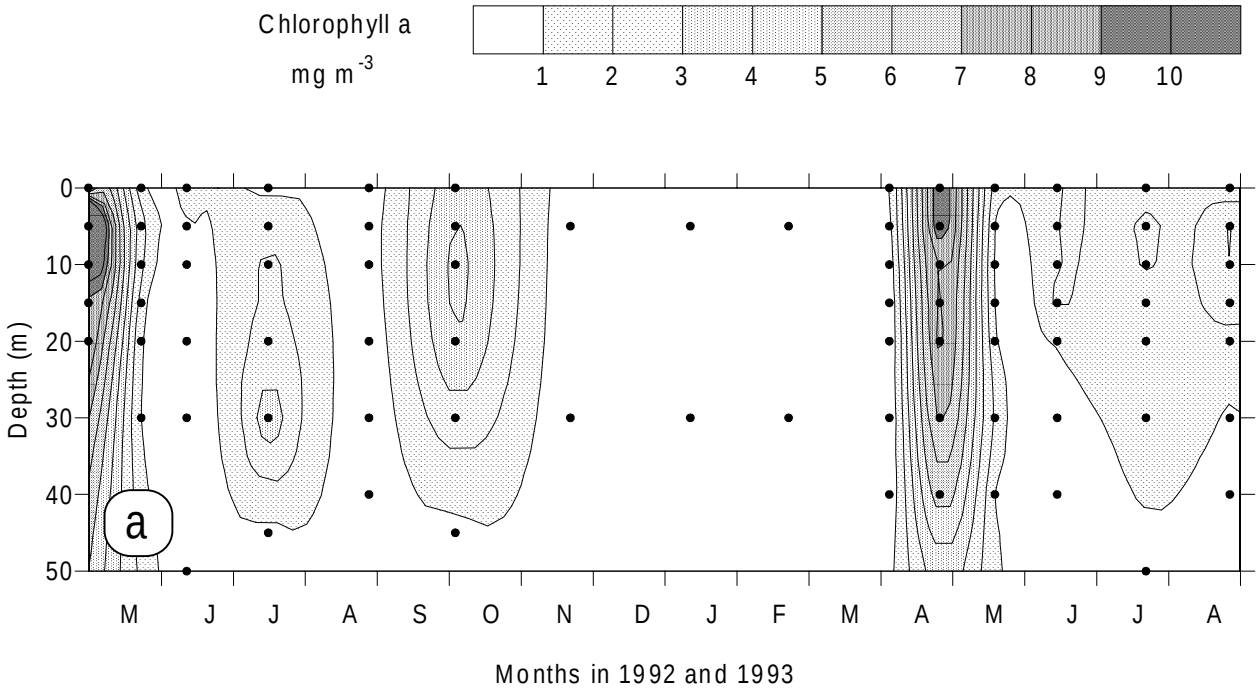



Figure 3.6. The seasonal changes in chlorophyll *a* at a) station 2.

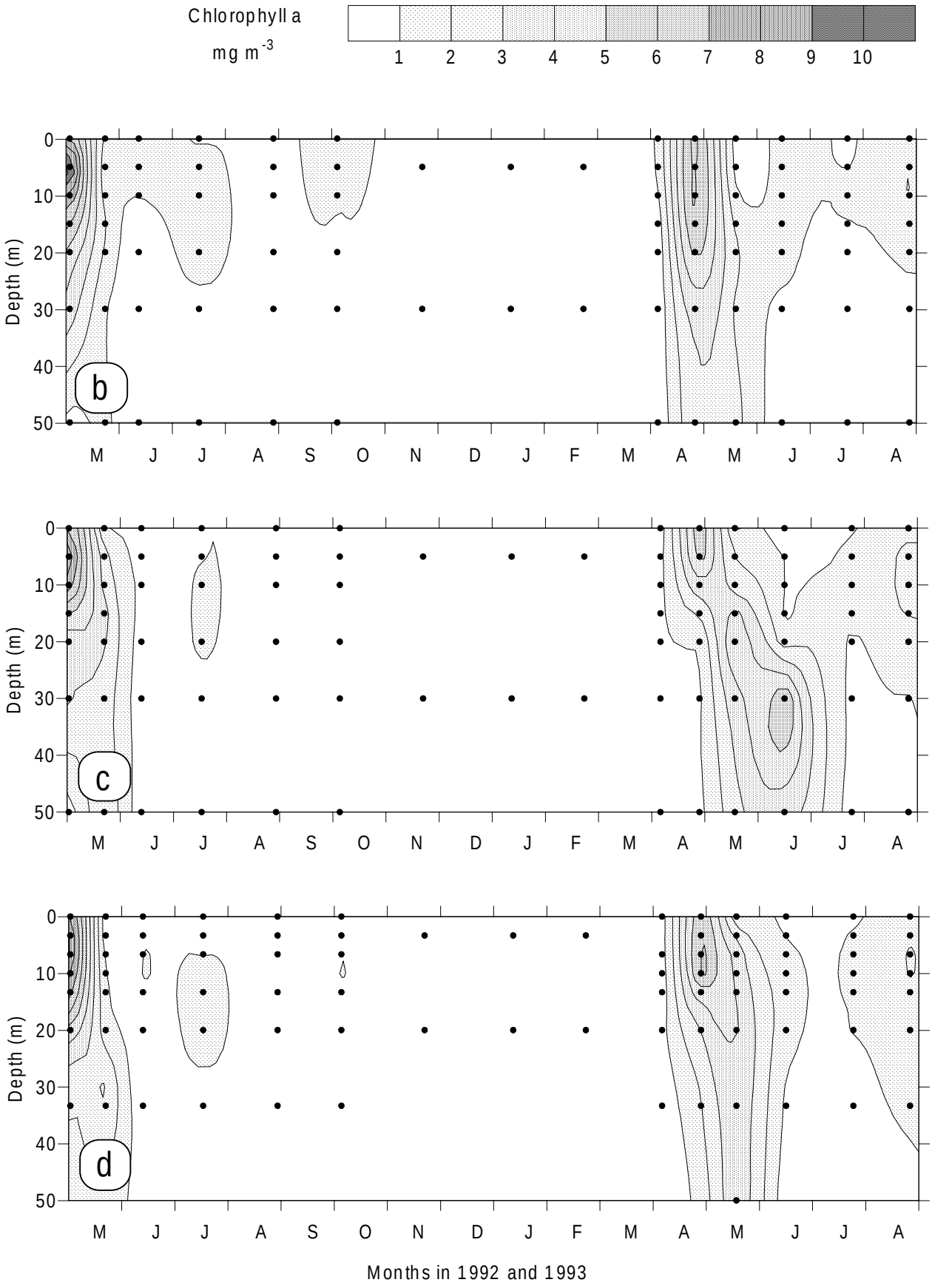



Figure 3.6. The seasonal changes in chlorophyll *a* at b) station 10, c) station 17 and d) station 22.

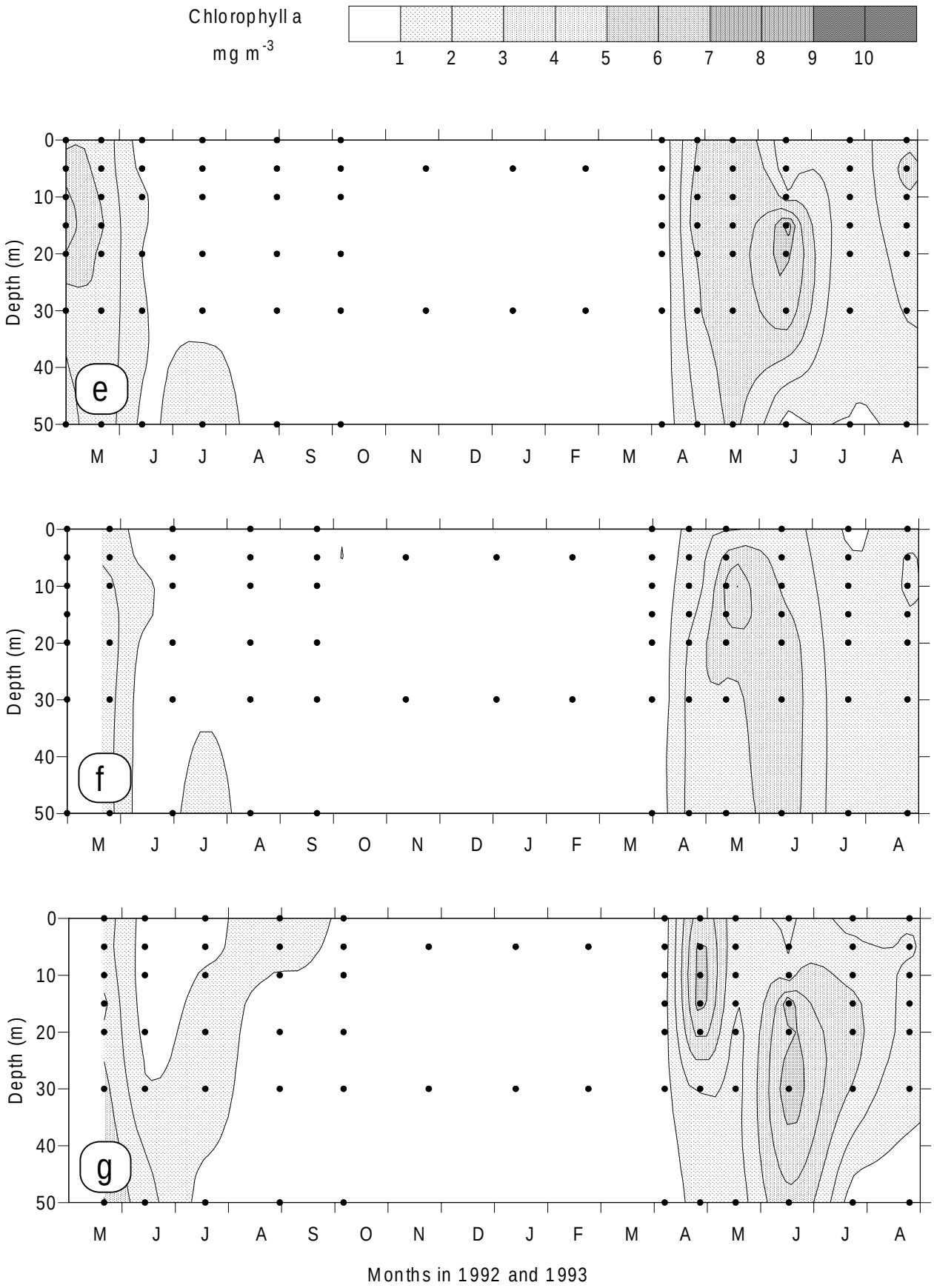



Figure 3.6. The seasonal changes in chlorophyll *a* at e) station 29, f) station 33 and g) station 36.

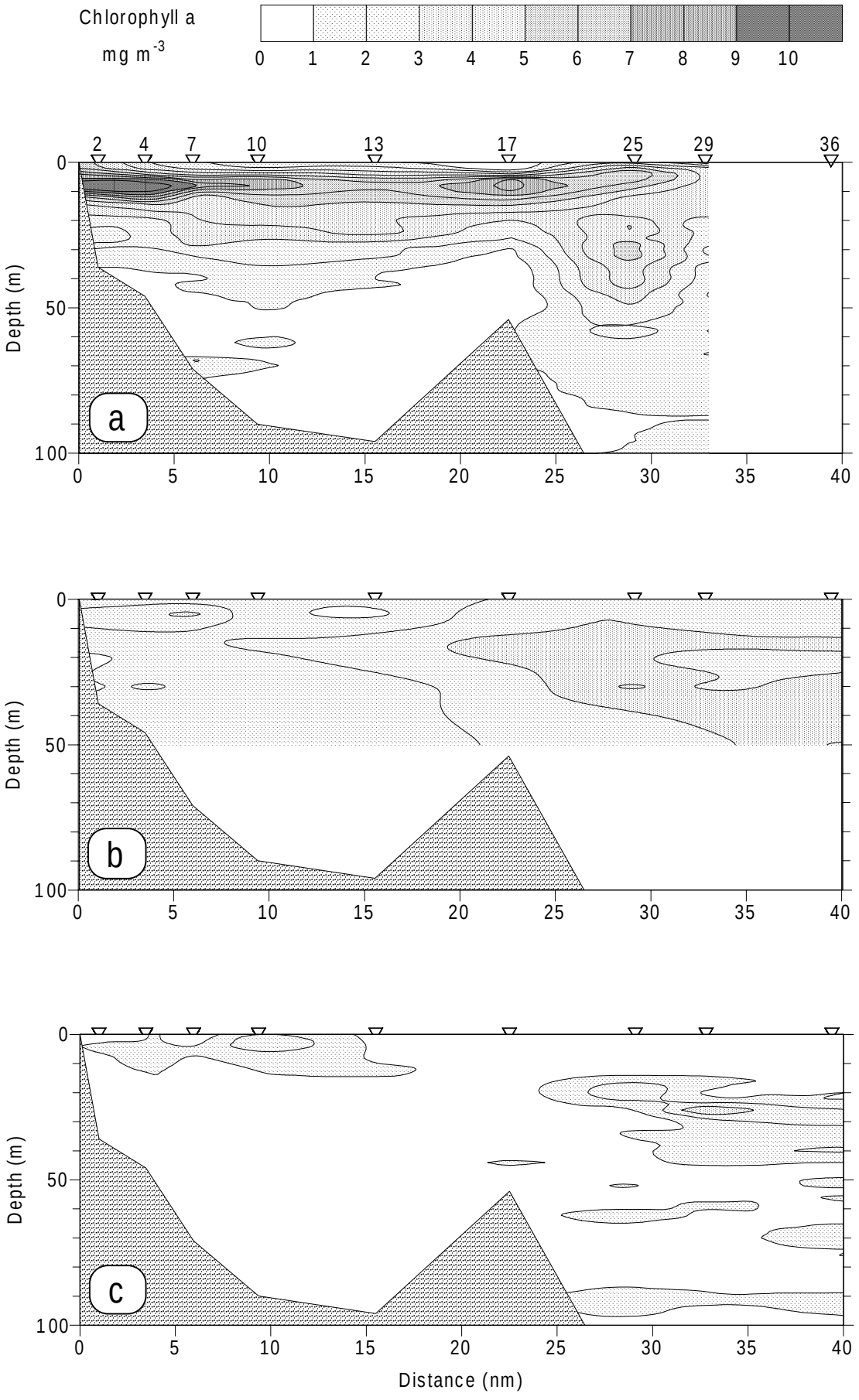



Figure 3.7. The chlorophyll *a* distribution along the west side of the fjord in 1992 on a) cruise 1, 29/4 - 1/5, b) cruise 2, 19 - 21/5, and c) cruise 3, 9 -11/6.

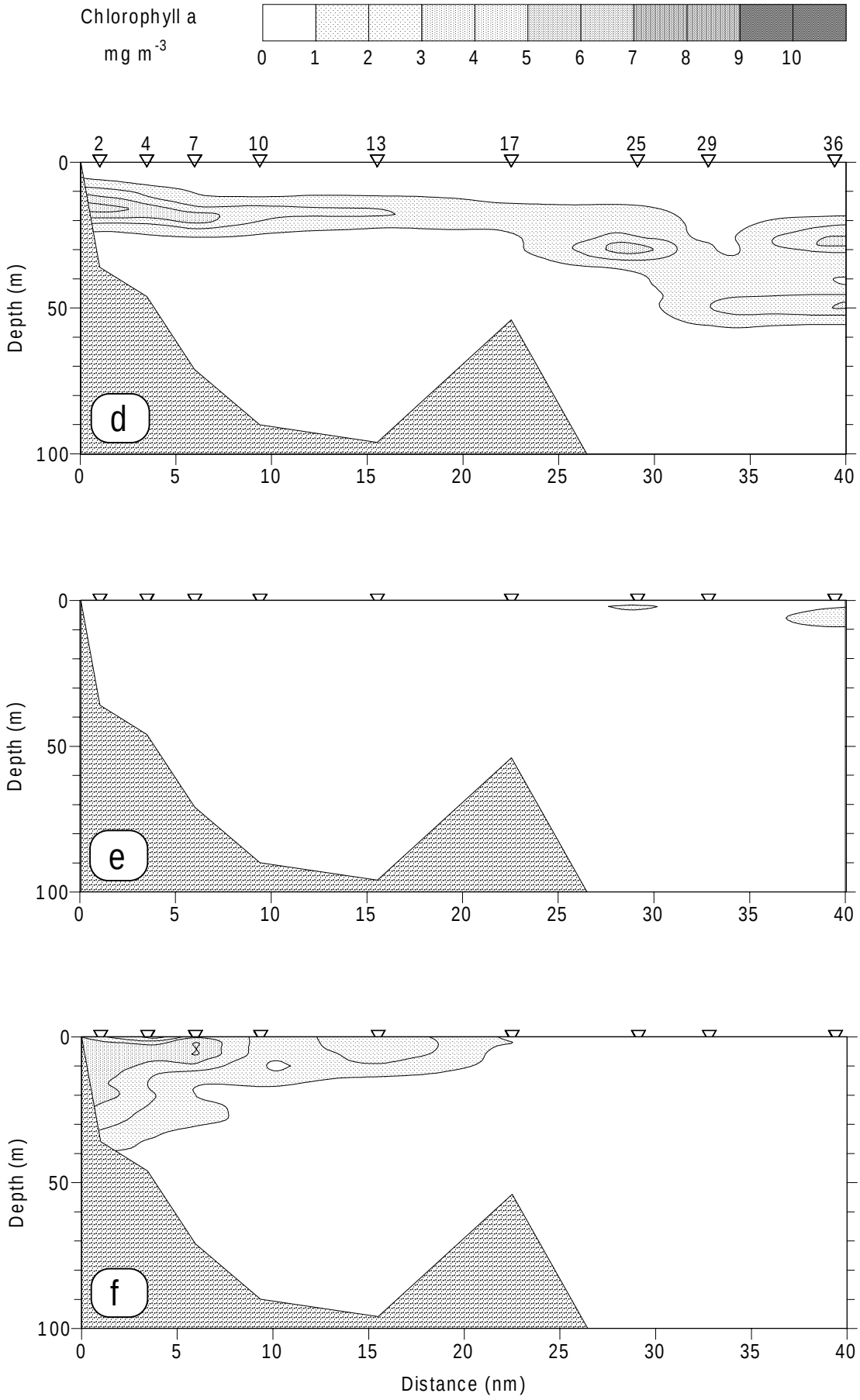



Figure 3.7. The chlorophyll *a* distribution along the west side of the fjord in 1992 on d) cruise 4, 13 - 15/7, e) cruise 5, 24 - 26/8, and f) cruise 6, 29/9 - 1/10..

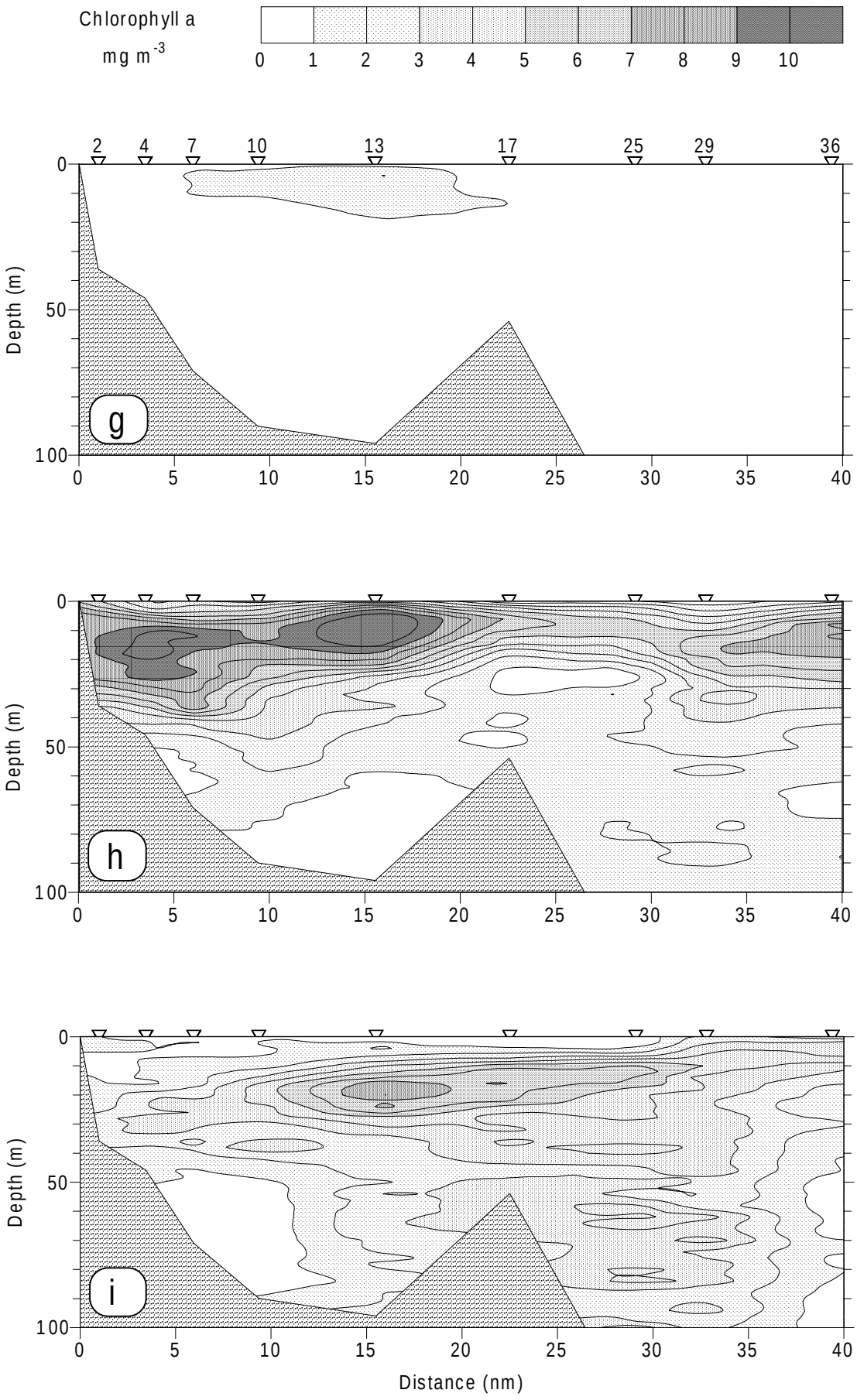



Figure 3.7. The chlorophyll *a* distribution along the west side of the fjord in 1993 on g) cruise 10, 29 31/3, h) cruise 11, 19 - 21/4, and i) cruise 12, 10 - 12/5.

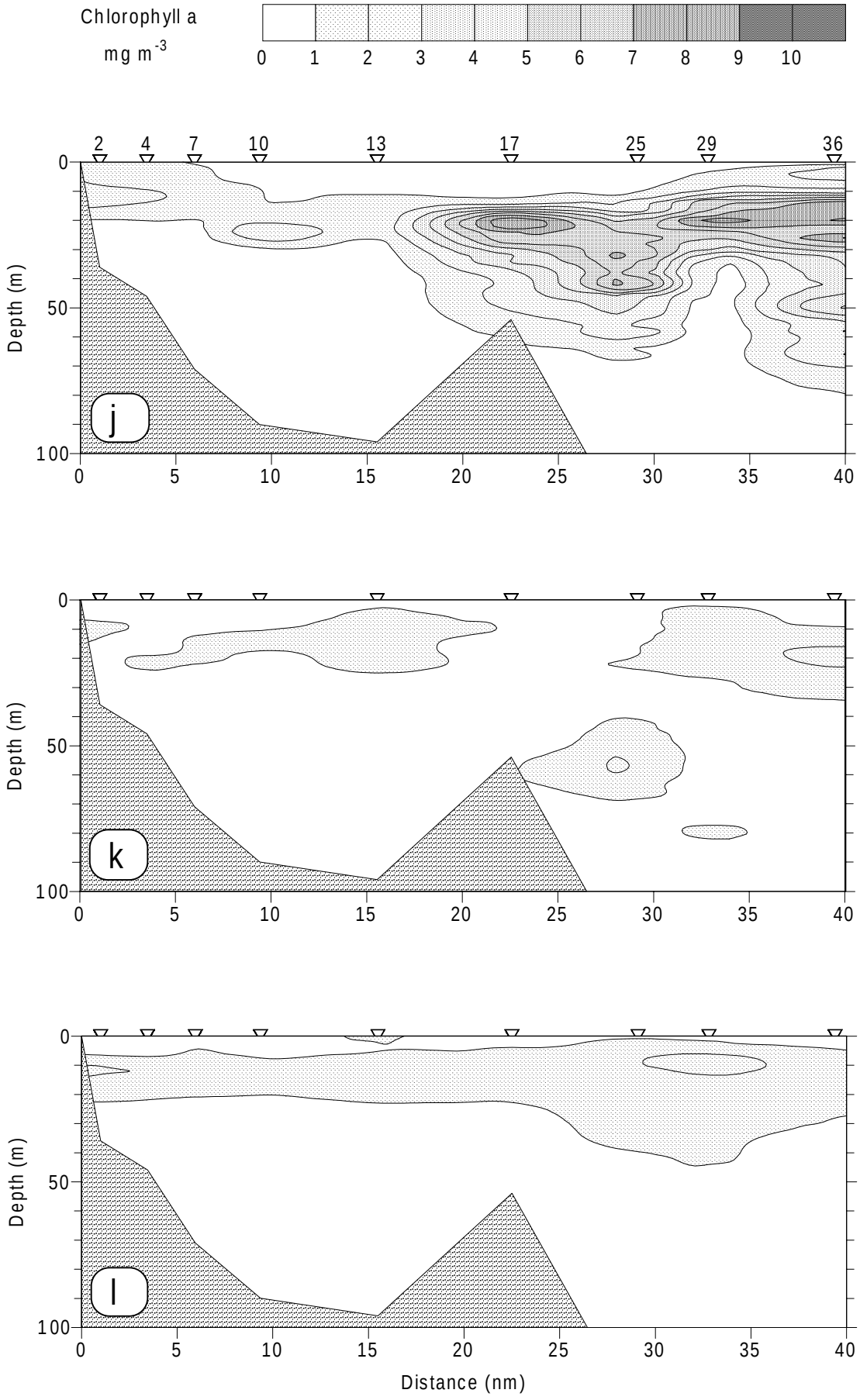



Figure 3.7. The chlorophyll *a* distribution along the west side of the fjord in 1993 on j) cruise 13, 7 - 9/6, k) cruise 14, 14 - 16/7, and l) cruise 15, 16 - 18/8.

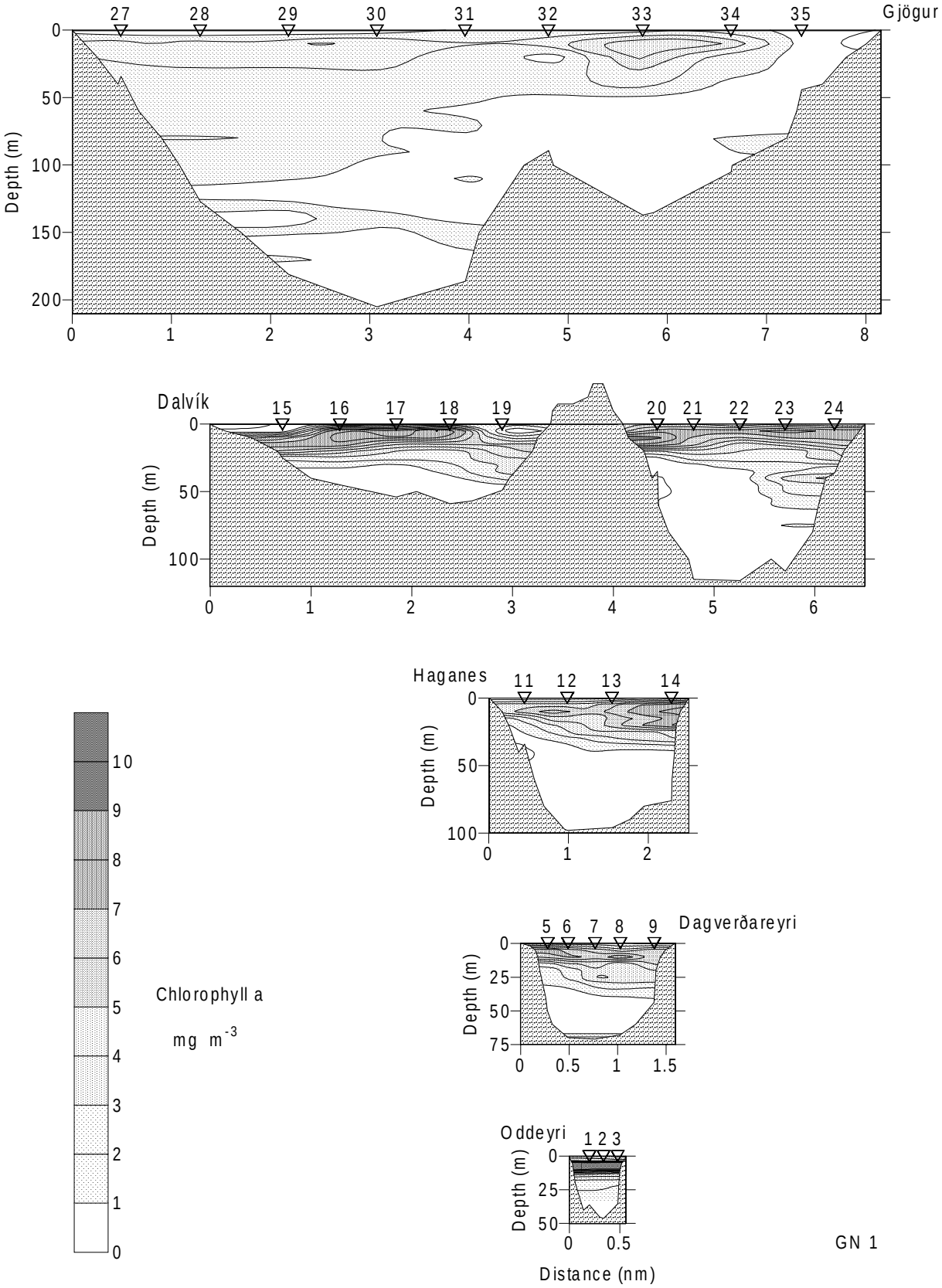



Figure 3.8. The vertical distribution of chlorophyll *a* at five transects in the fjord on cruise 1 (GN 1), 29/4 - 1/5 1992. For locations of stations see Figure 1.2.

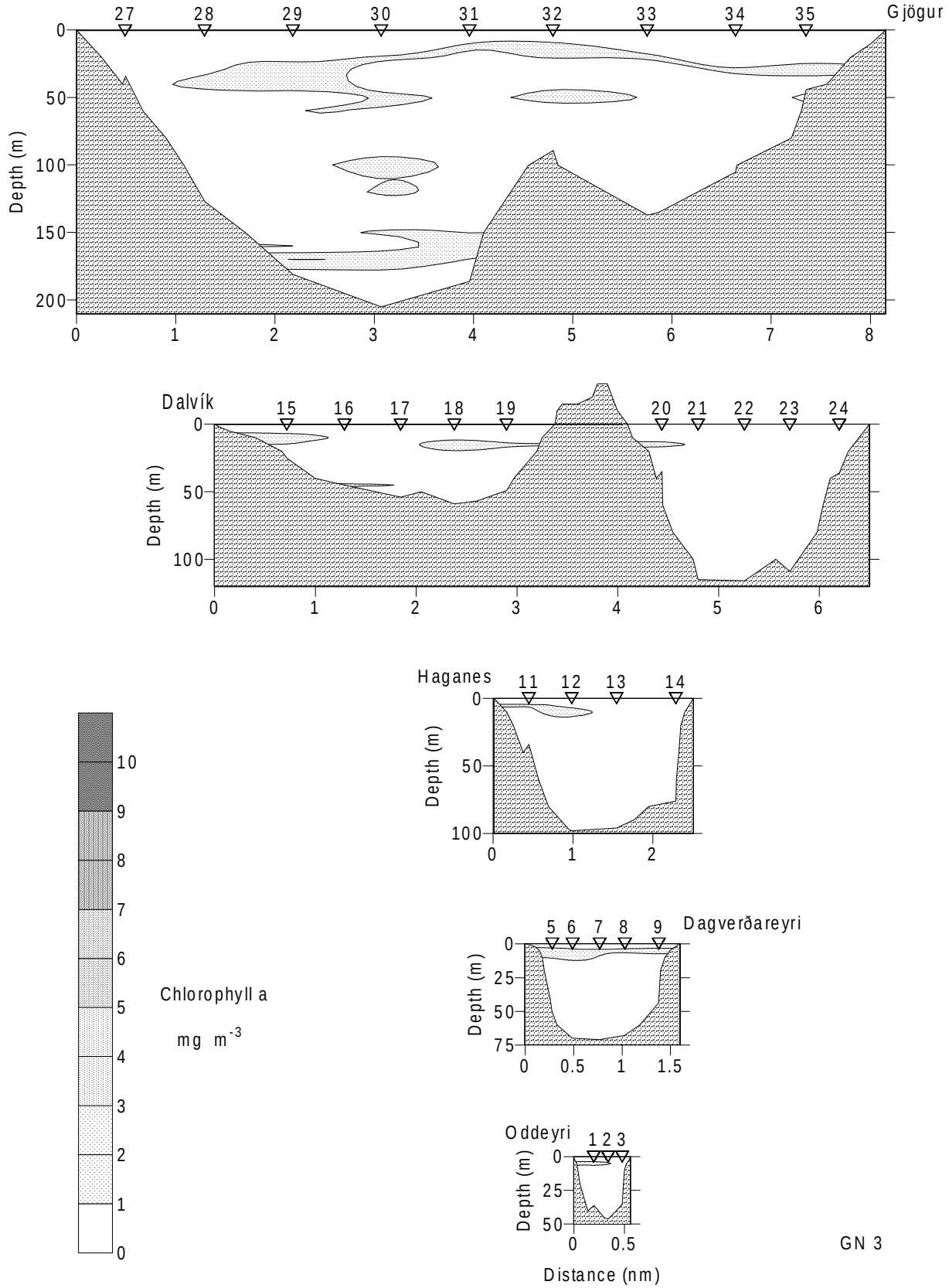



Figure 3.8. The vertical distribution of chlorophyll *a* at five transects in the fjord on cruise 3 (GN 3), 9 - 11/6 1992. For locations of stations see Figure 1.2.

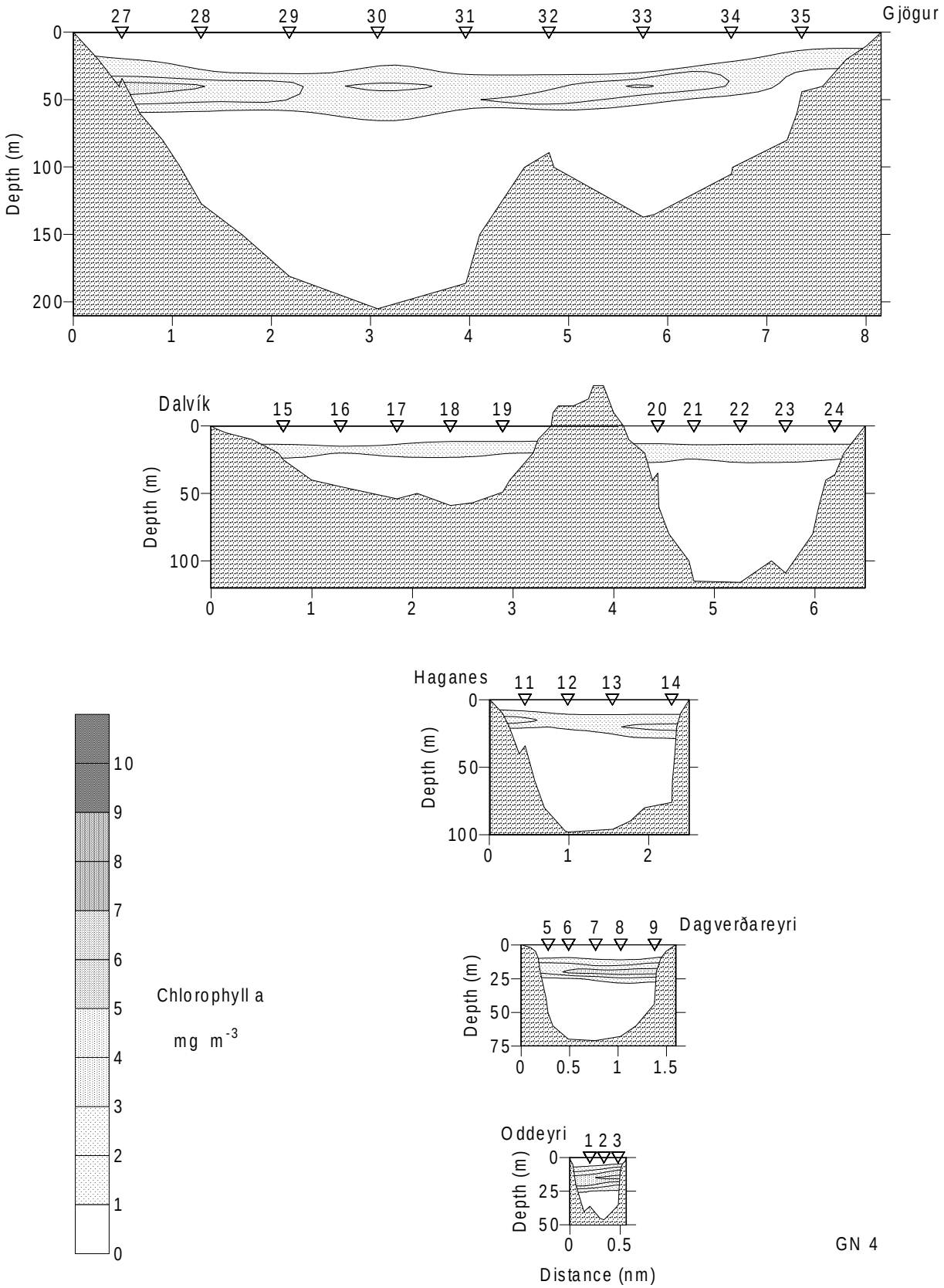



Figure 3.8. The vertical distribution of chlorophyll *a* at five transects in the fjord on cruise 4 (GN 4), 13 - 15/7 1992. For locations of stations see Figure 1.2.

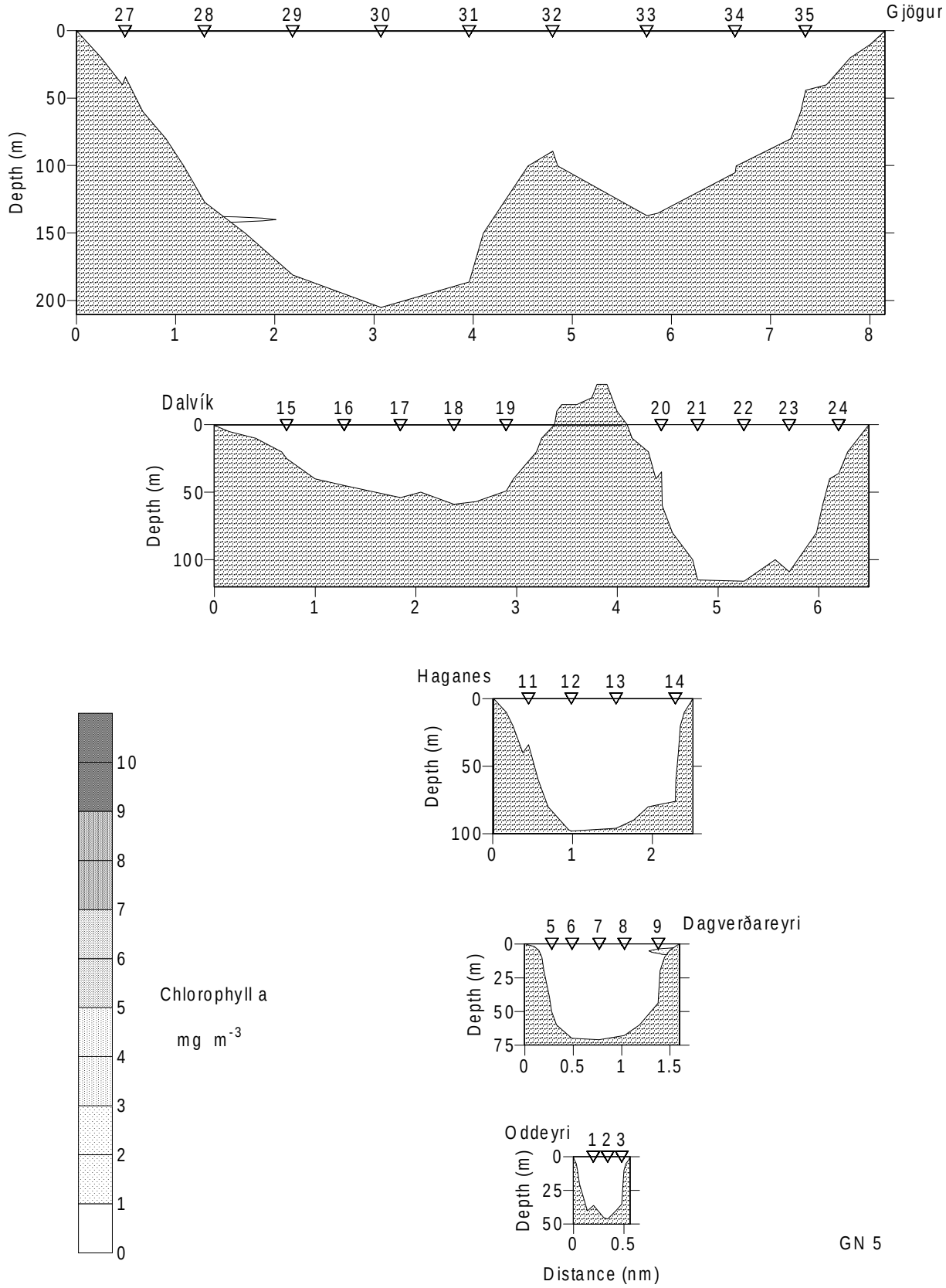



Figure 3.8. The vertical distribution of chlorophyll *a* at five transects in the fjord on cruise 5 (GN 5), 24 - 26/8 1992. For locations of stations see Figure 1.2.

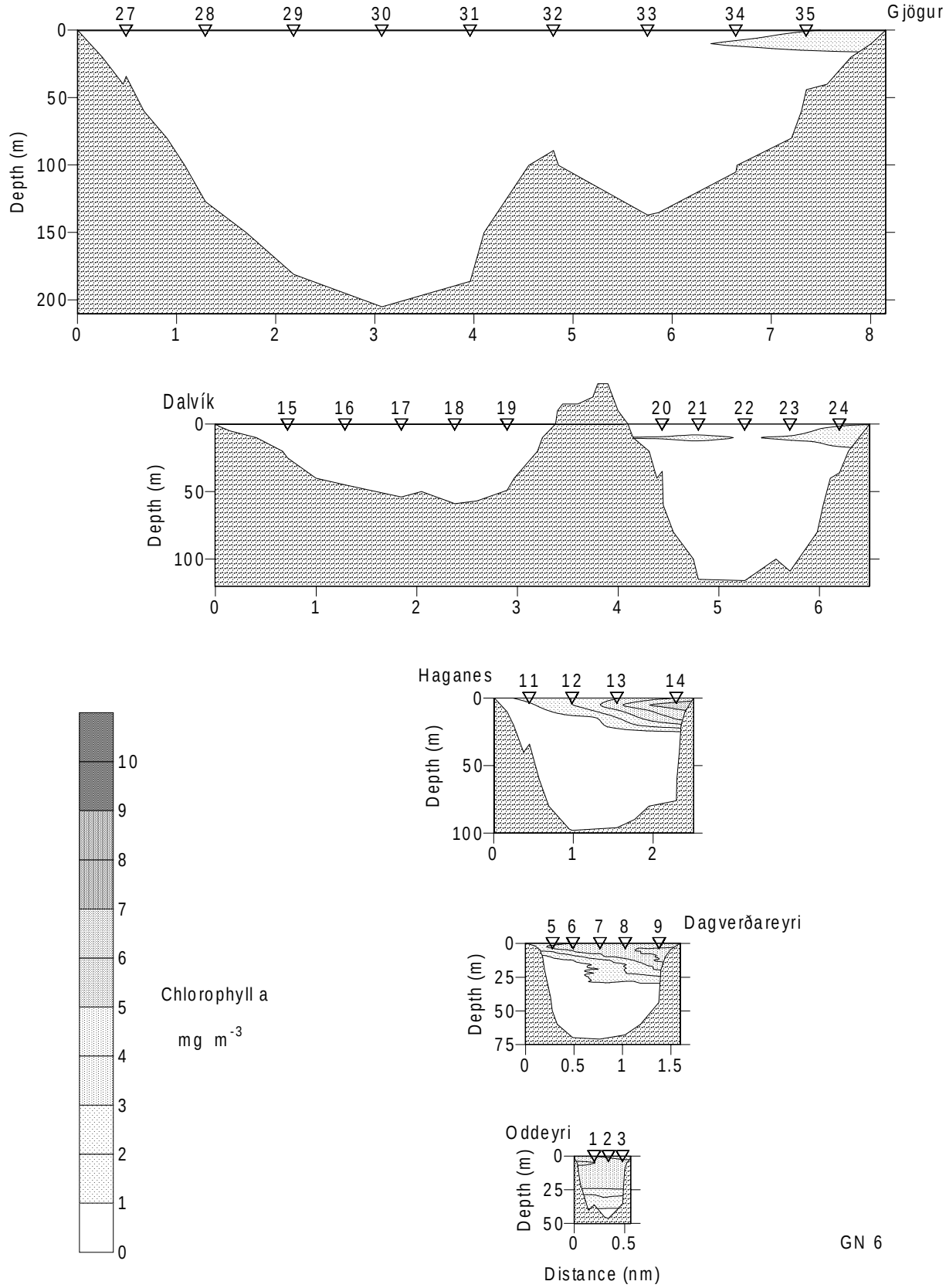



Figure 3.8. The vertical distribution of chlorophyll *a* at five transects in the fjord on cruise 6 (GN 6), 29/9 - 1/10 1992. For locations of stations see Figure 1.2.

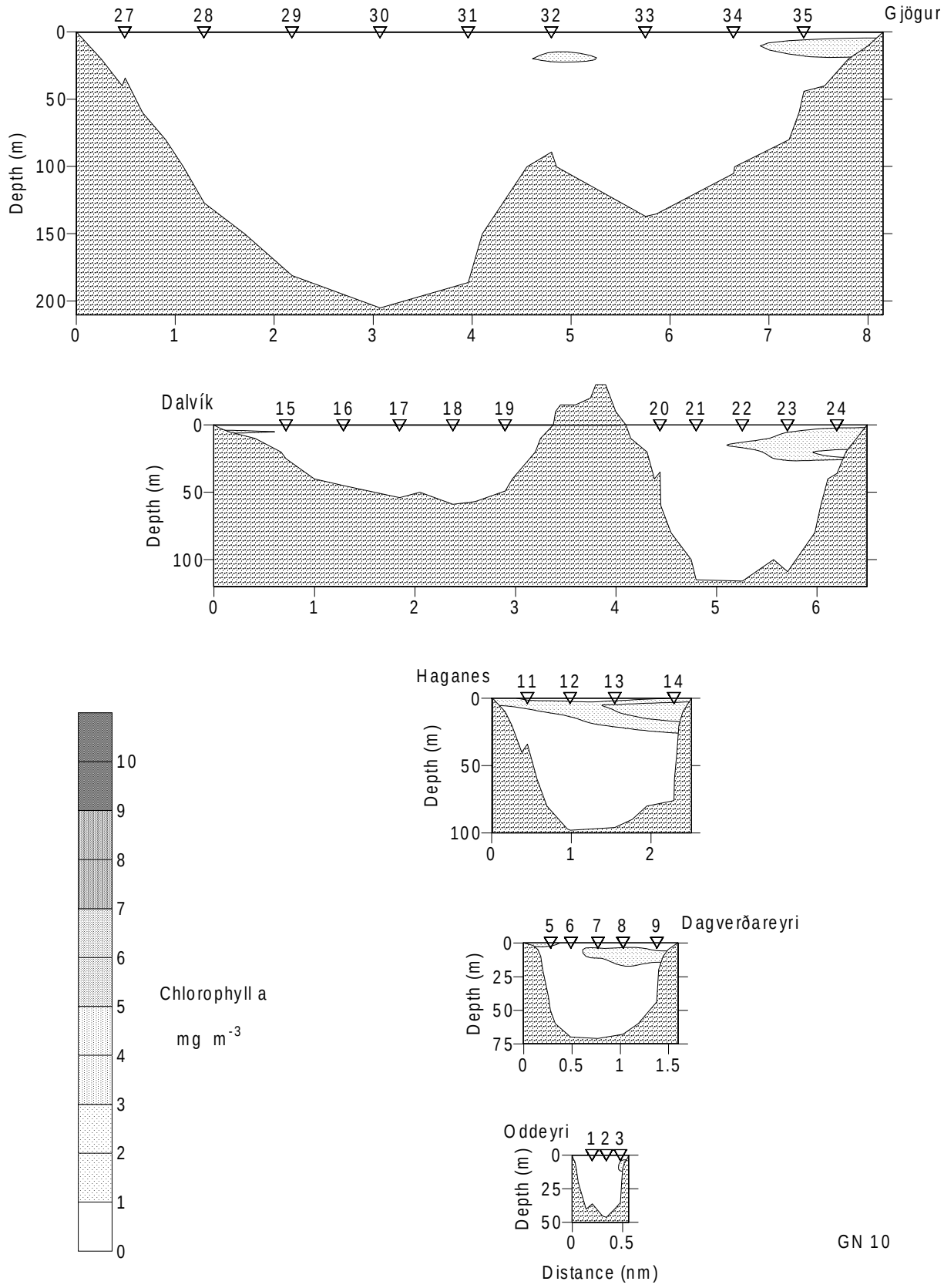



Figure 3.8. The vertical distribution of chlorophyll *a* at five transects in the fjord on cruise 10 (GN 10), 29 - 31/3 1993. For locations of stations see Figure 1.2.

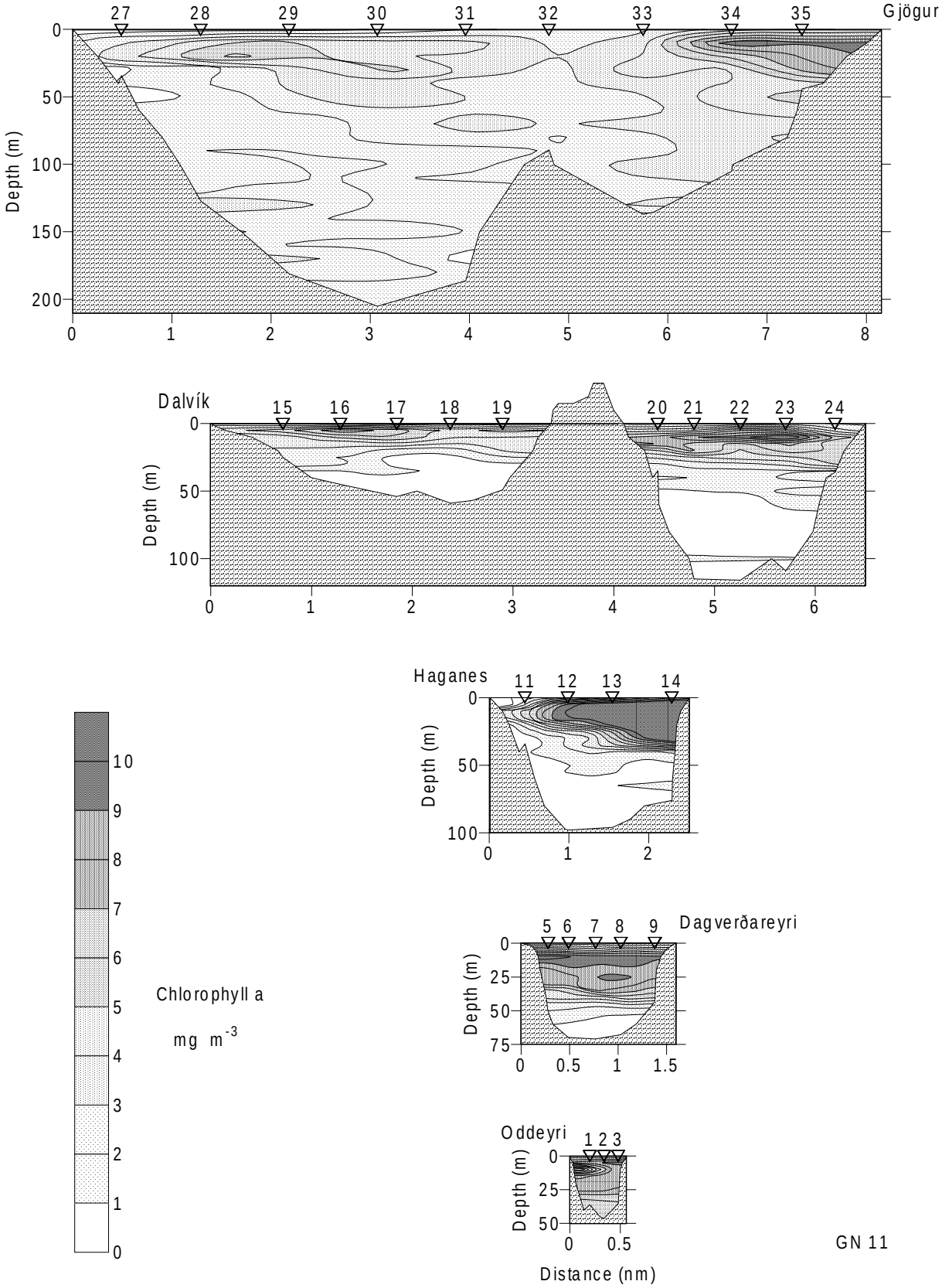



Figure 3.8. The vertical distribution of chlorophyll *a* at five transects in the fjord on cruise 11 (GN 11), 19 - 21/4 1993. For locations of stations see Figure 1.2.

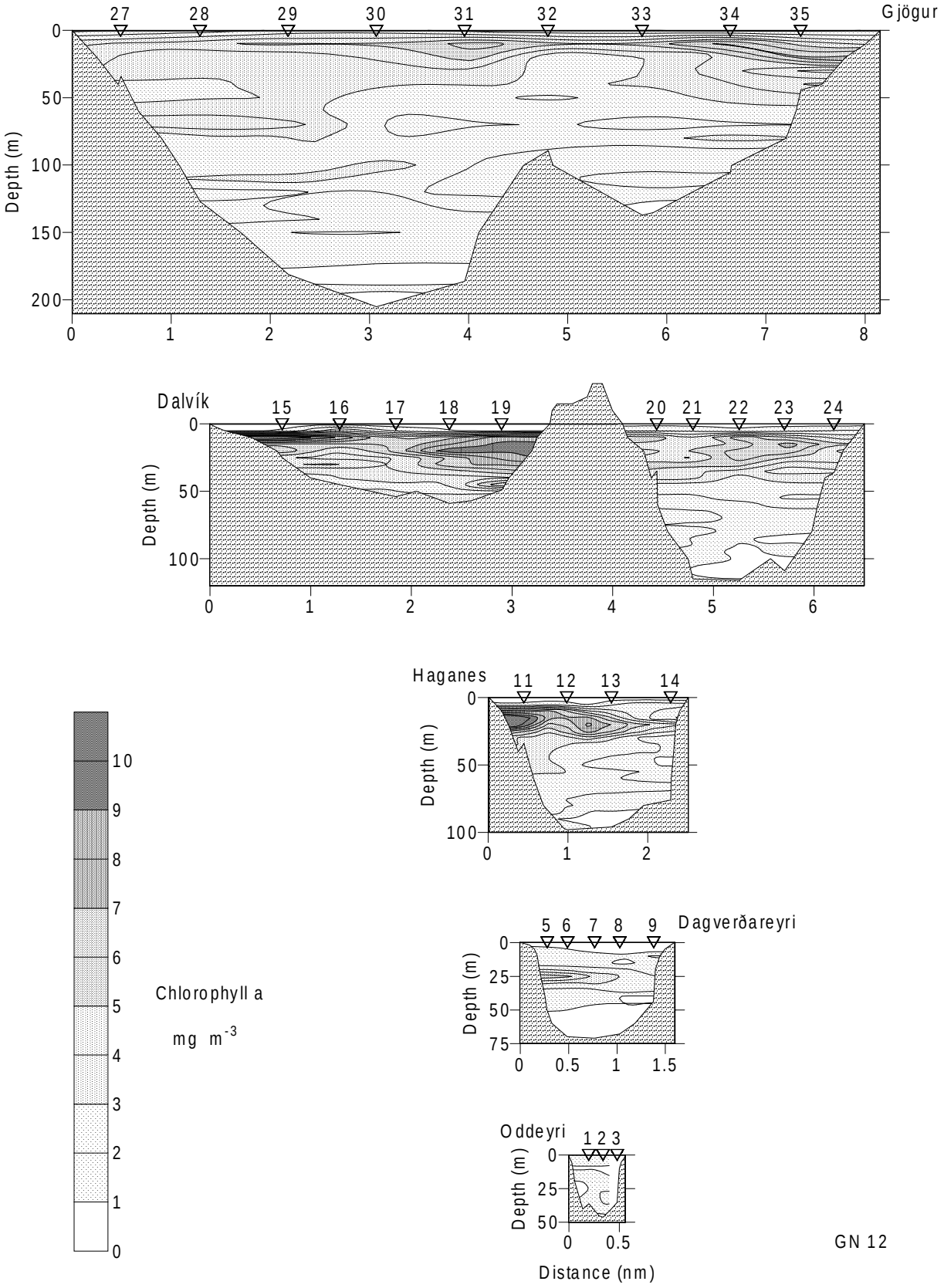



Figure 3.8. The vertical distribution of chlorophyll *a* at five transects in the fjord on cruise 12 (GN 12), 10 - 12/5 1993. For locations of stations see Figure 1.2.

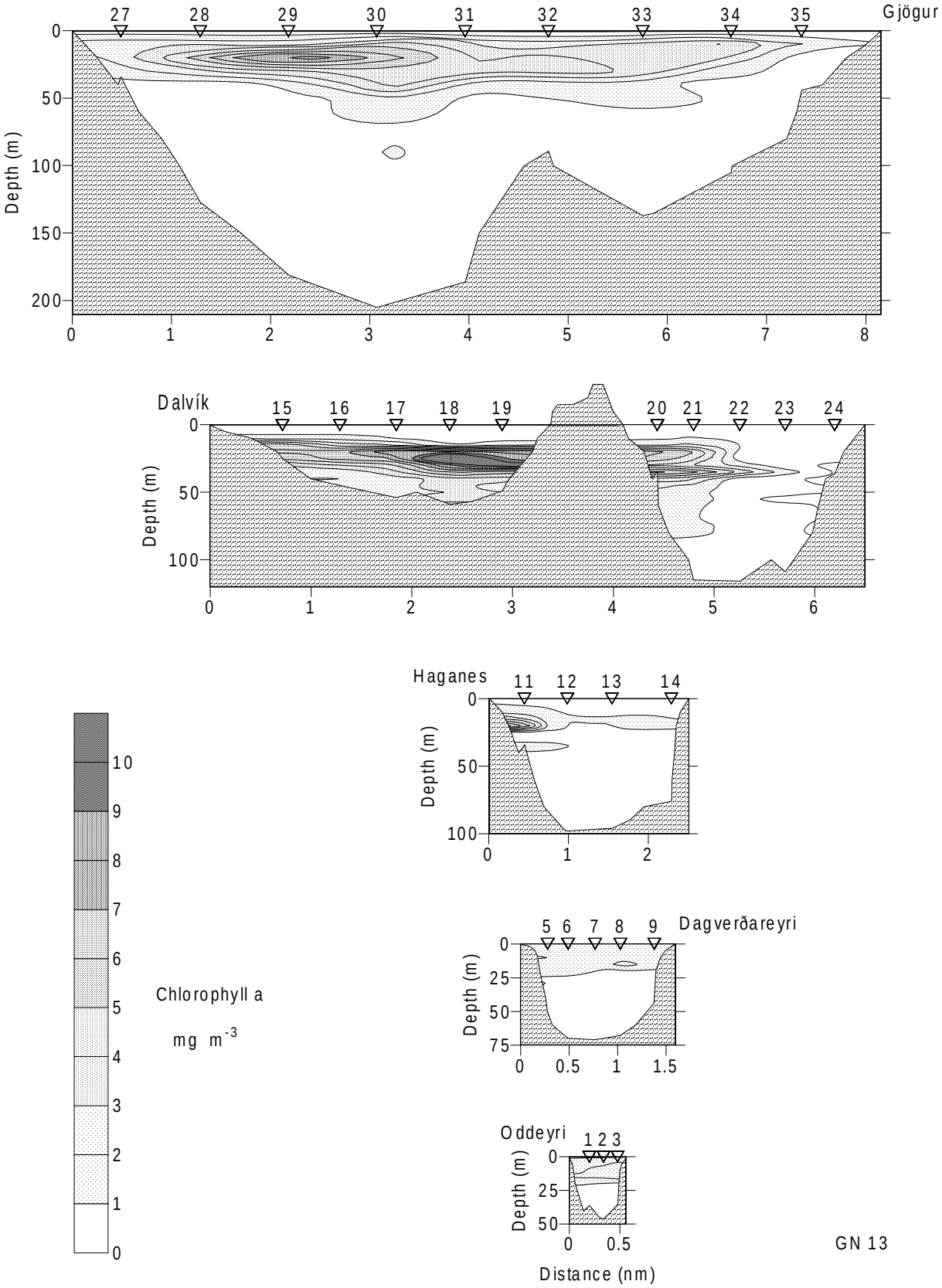



Figure 3.8. The vertical distribution of chlorophyll *a* at five transects in the fjord on cruise 13 (GN 13), 7 - 9/6 1993. For locations of stations see Figure 1.2.

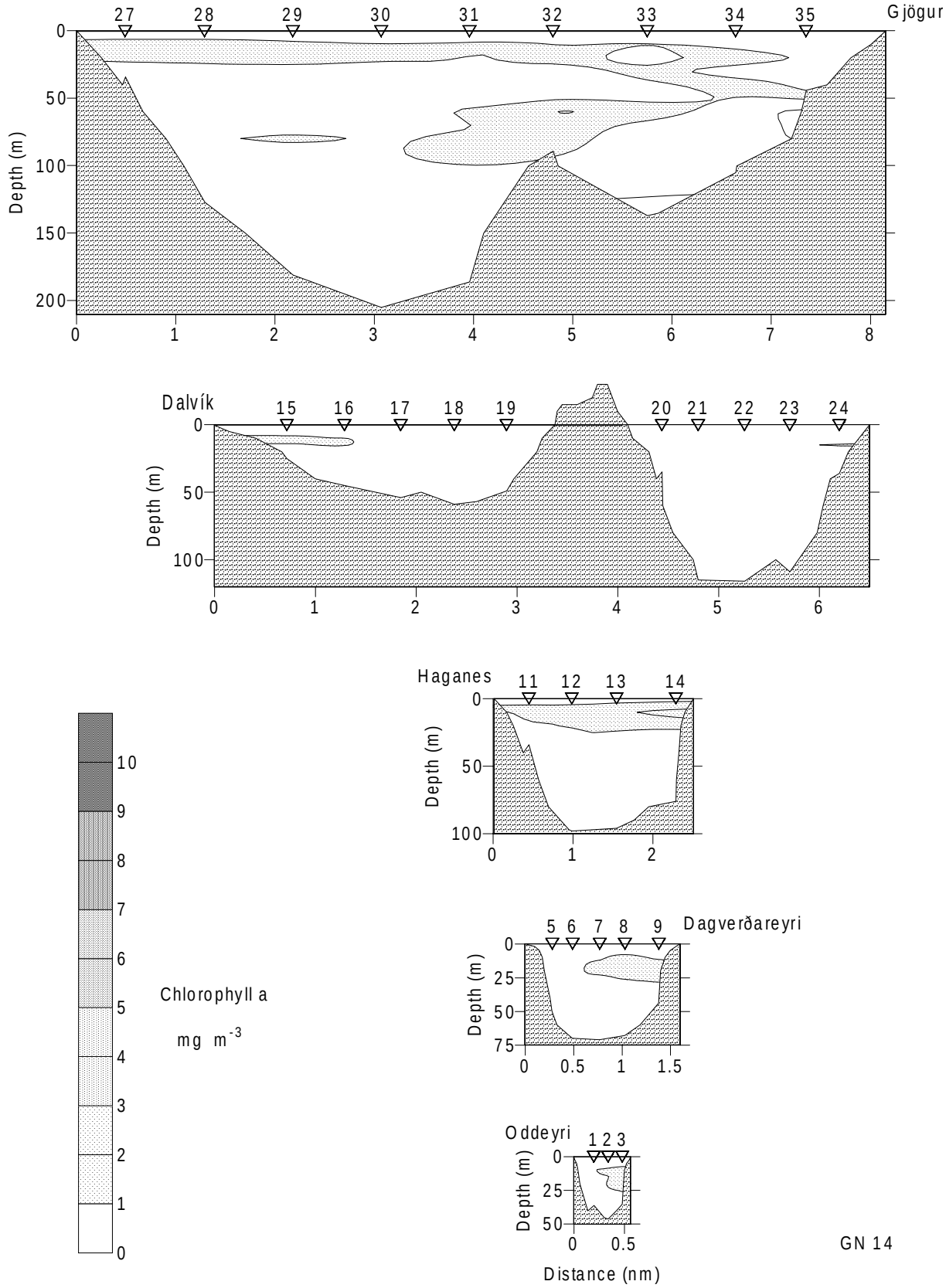



Figure 3.8. The vertical distribution of chlorophyll *a* at five transects in the fjord on cruise 14 (GN 14), 14 - 16/7 1993. For locations of stations see Figure 1.2.

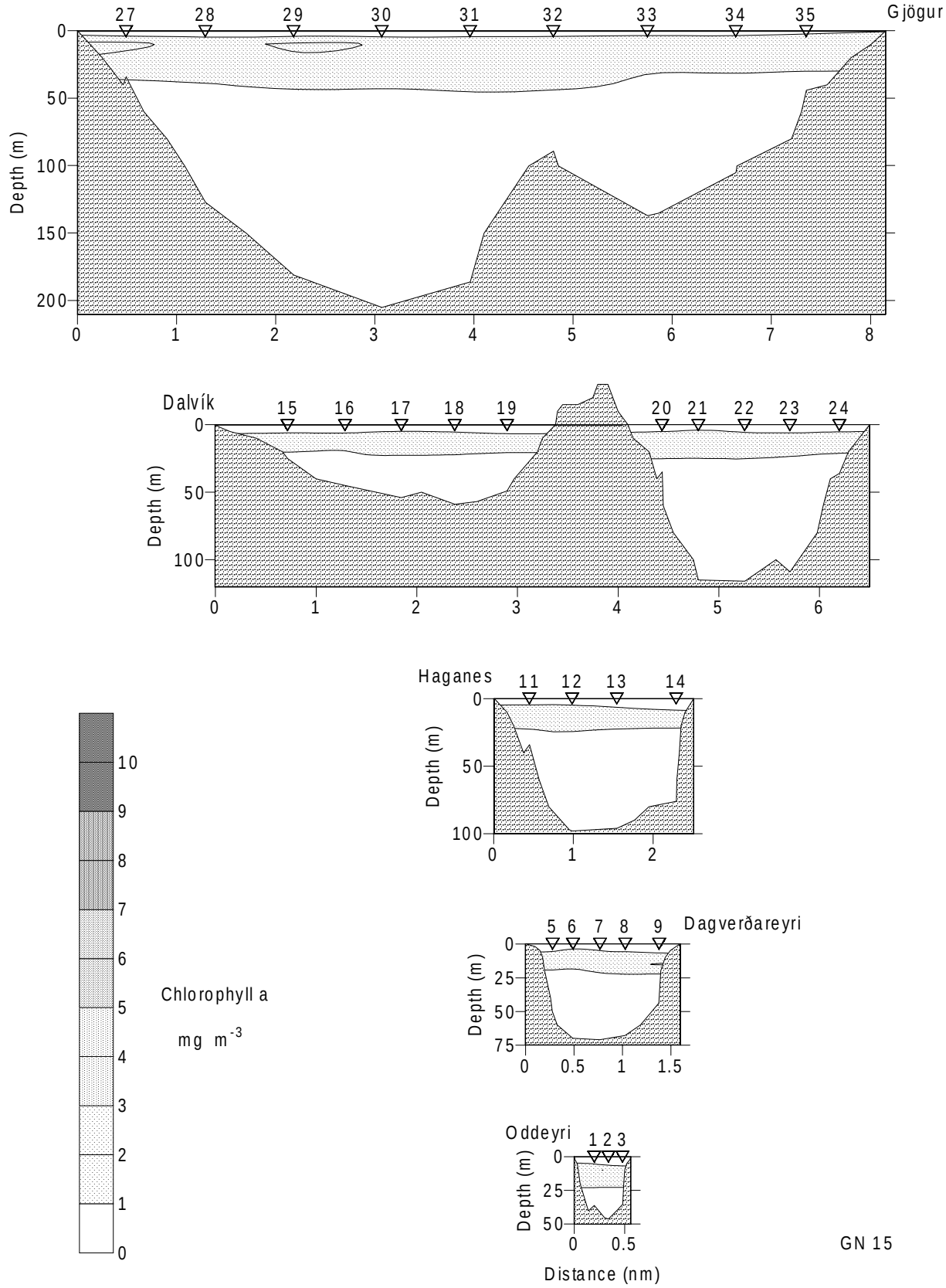



Figure 3.8. The vertical distribution of chlorophyll *a* at five transects in the fjord on cruise 15 (GN 15), 16 - 18/8 1993. For locations of stations see Figure 1.2.

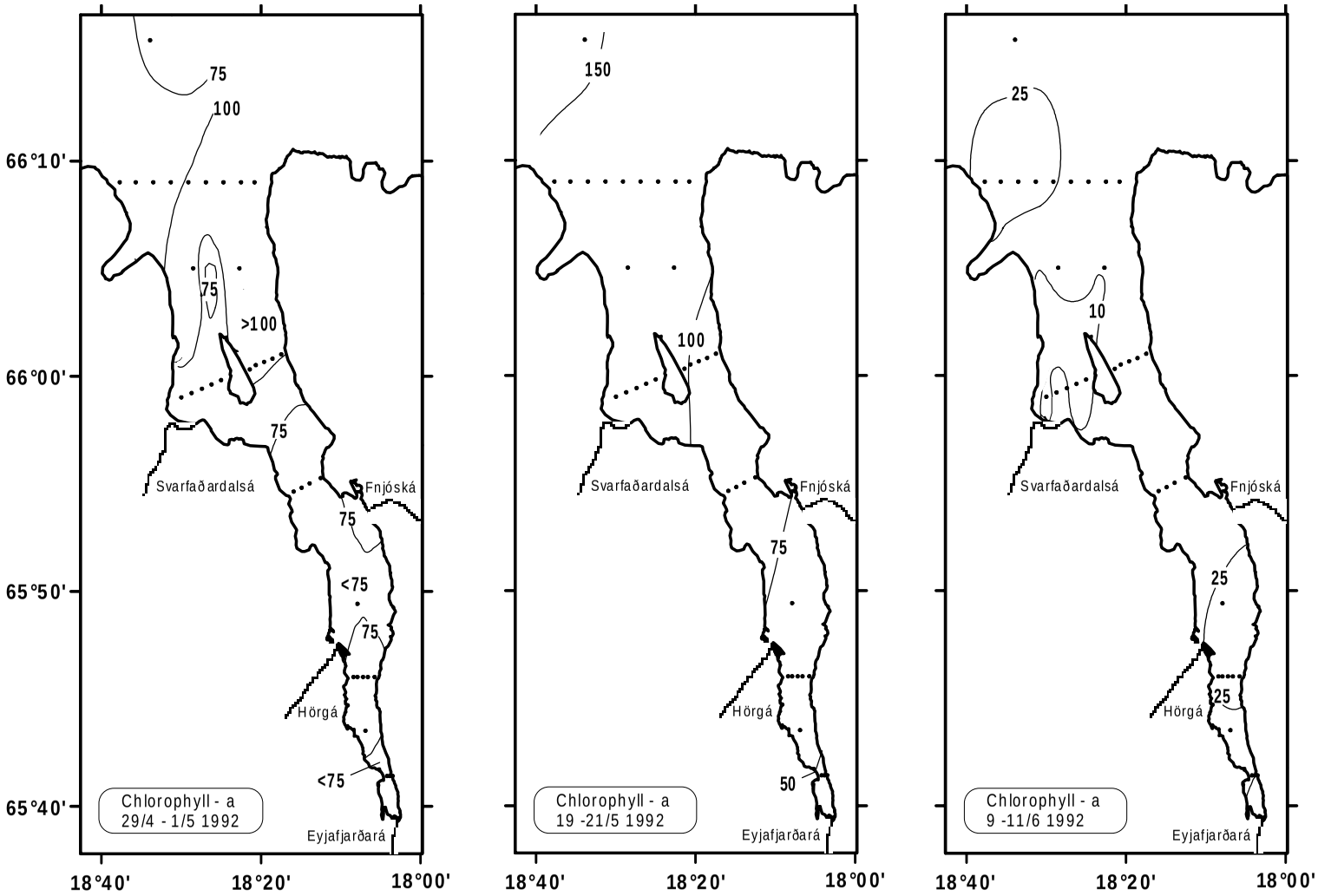



Figure 3.9. The horizontal distributation of depth integrated chlorophyll *a* (mg $m^2$).

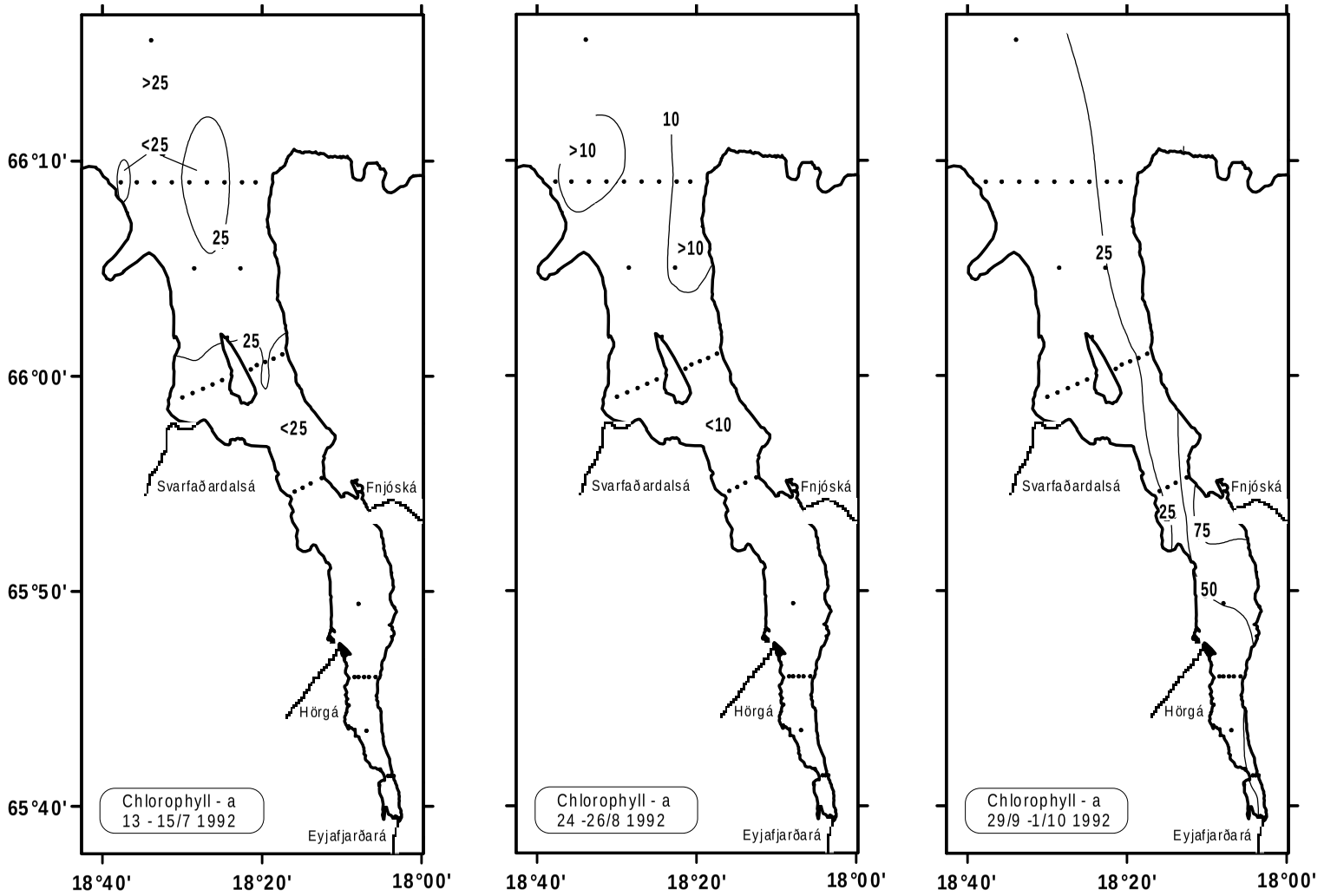



Figure 3.9. The horizontal distributation of depth integrated chlorophyll *a* (mg $m^2$, continued).

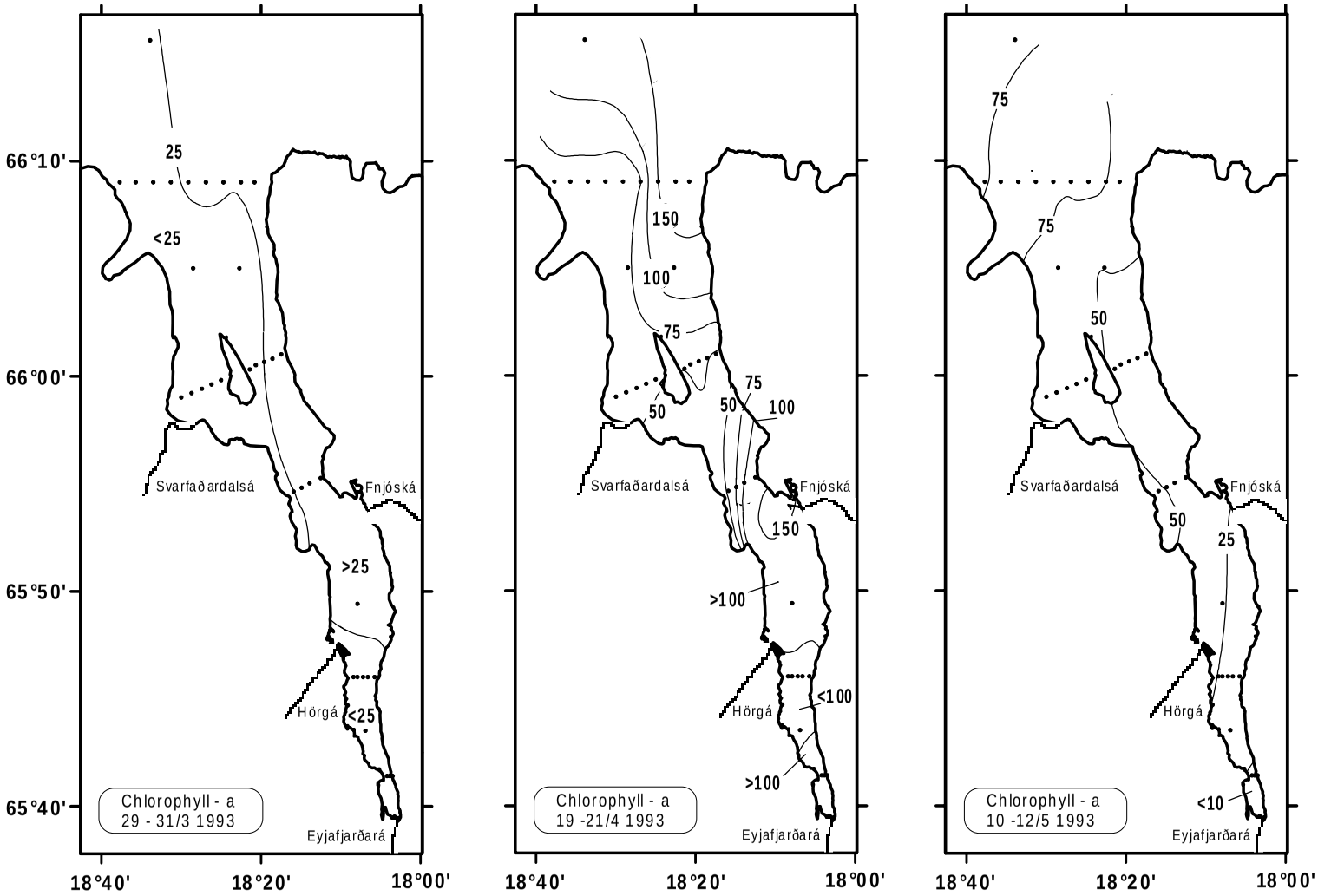





Figure 3.9. The horizontal distributation of depth integrated chlorophyll *a* (mg $m^2$, continued).

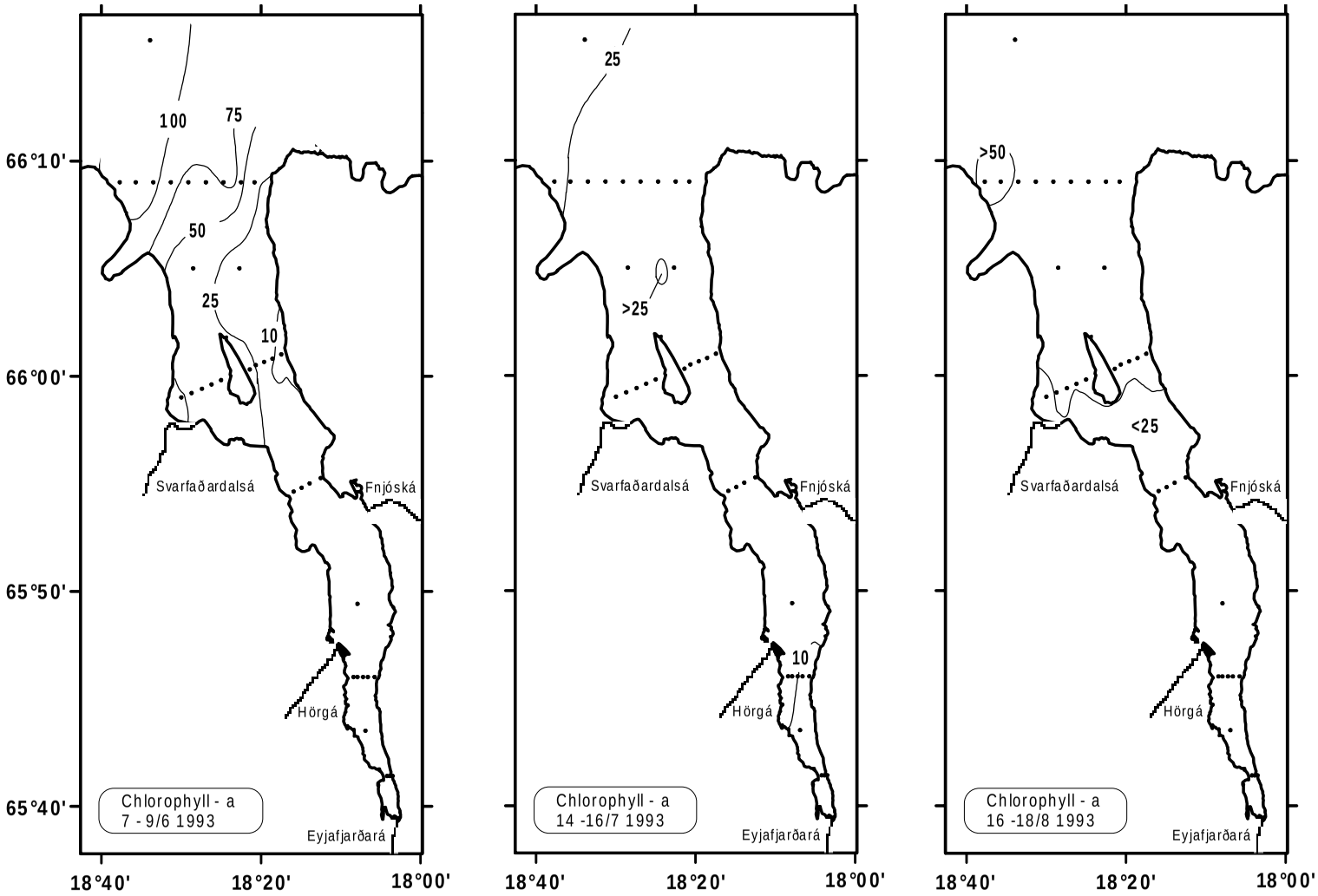



Figure 3.9. The horizontal distributation of depth integrated chlorophyll *a* (mg $m^2$, continued).

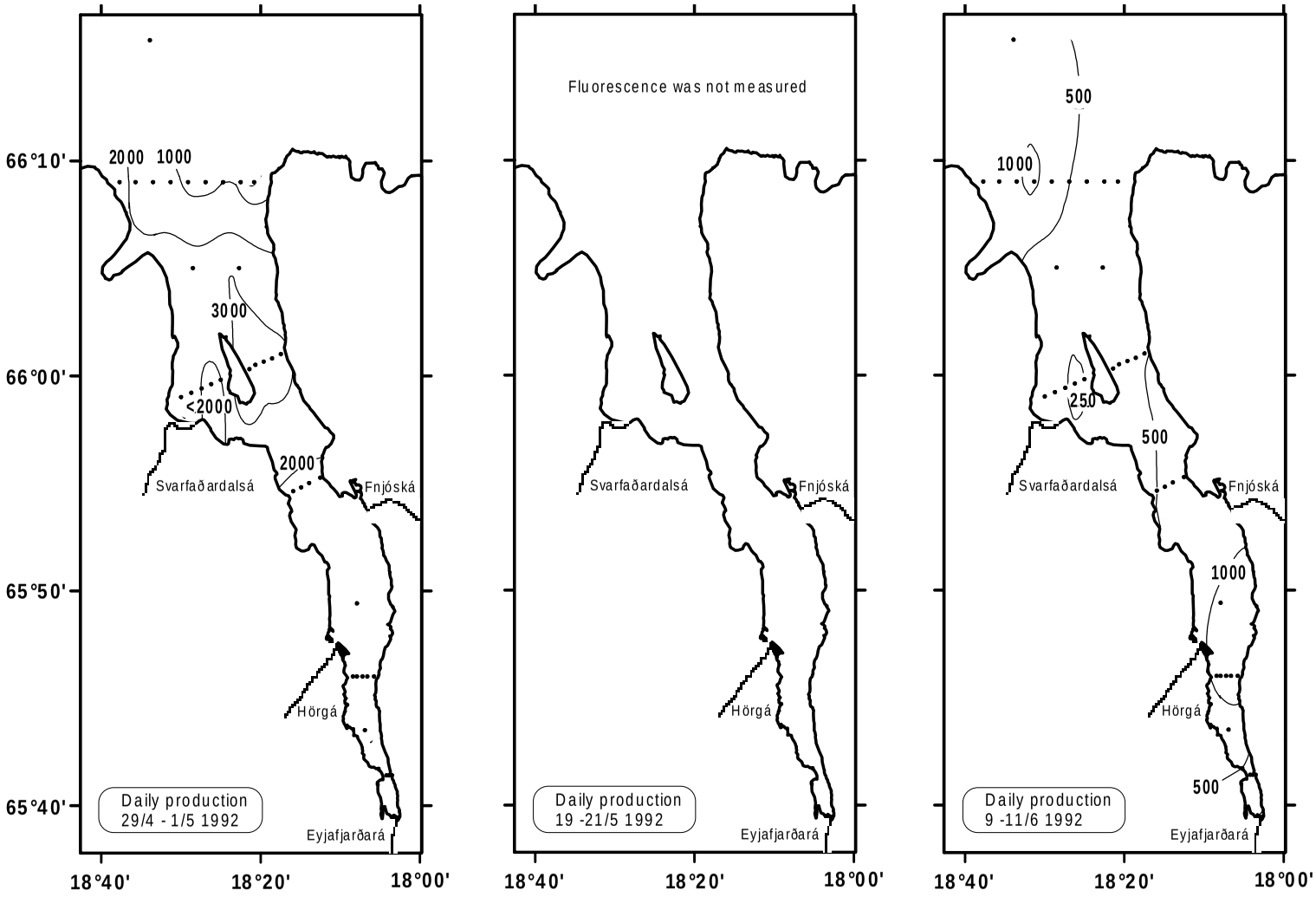



Figure 3.10. The horizontal distributation of depth integrated daily primary production (mg $m^{-2}$ $d^{-1}$).

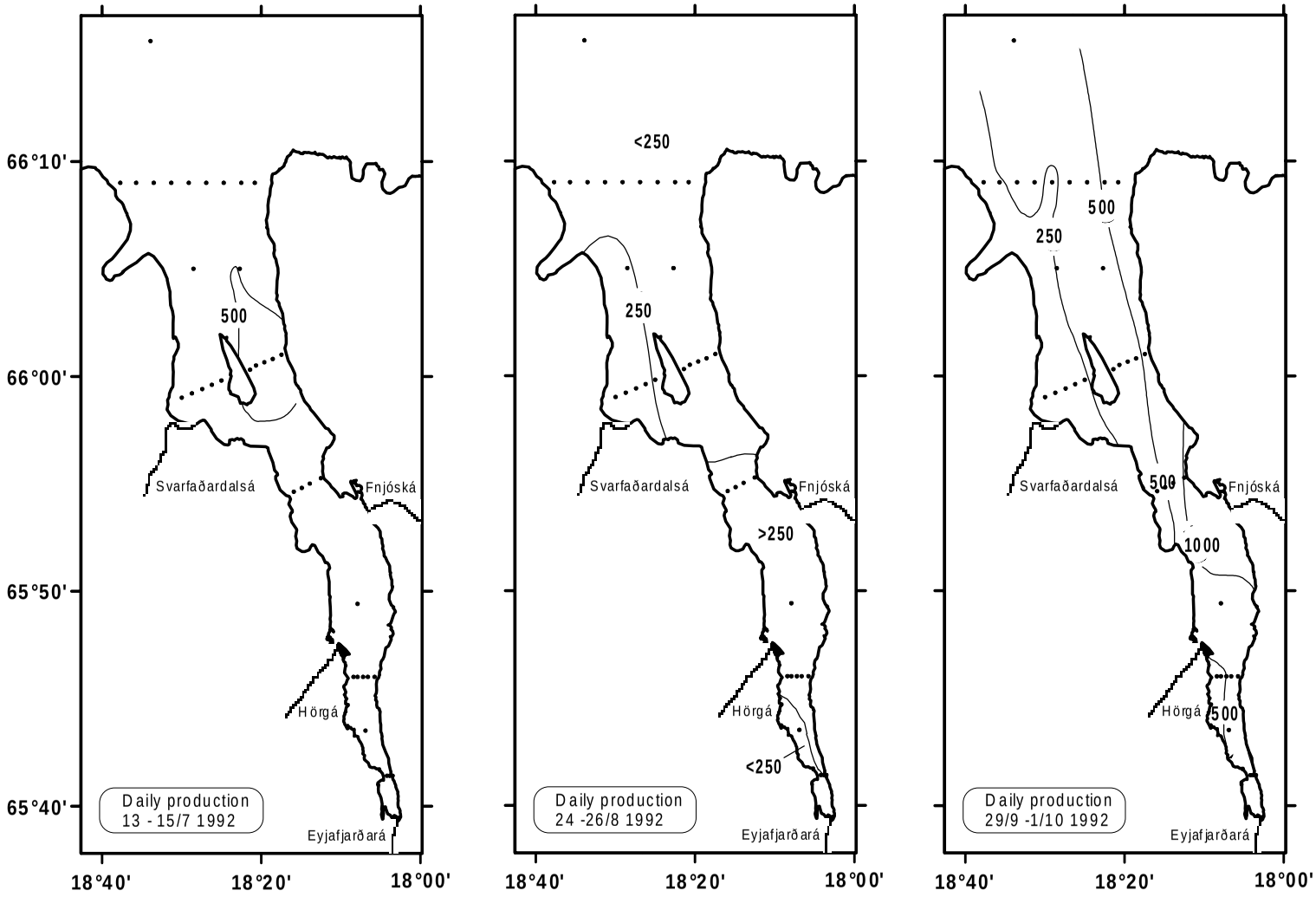



Figure 3.10. The horizontal distributation of depth integrated daily primary production (mg $m^{-2}$ $d^{-1}$, continued).

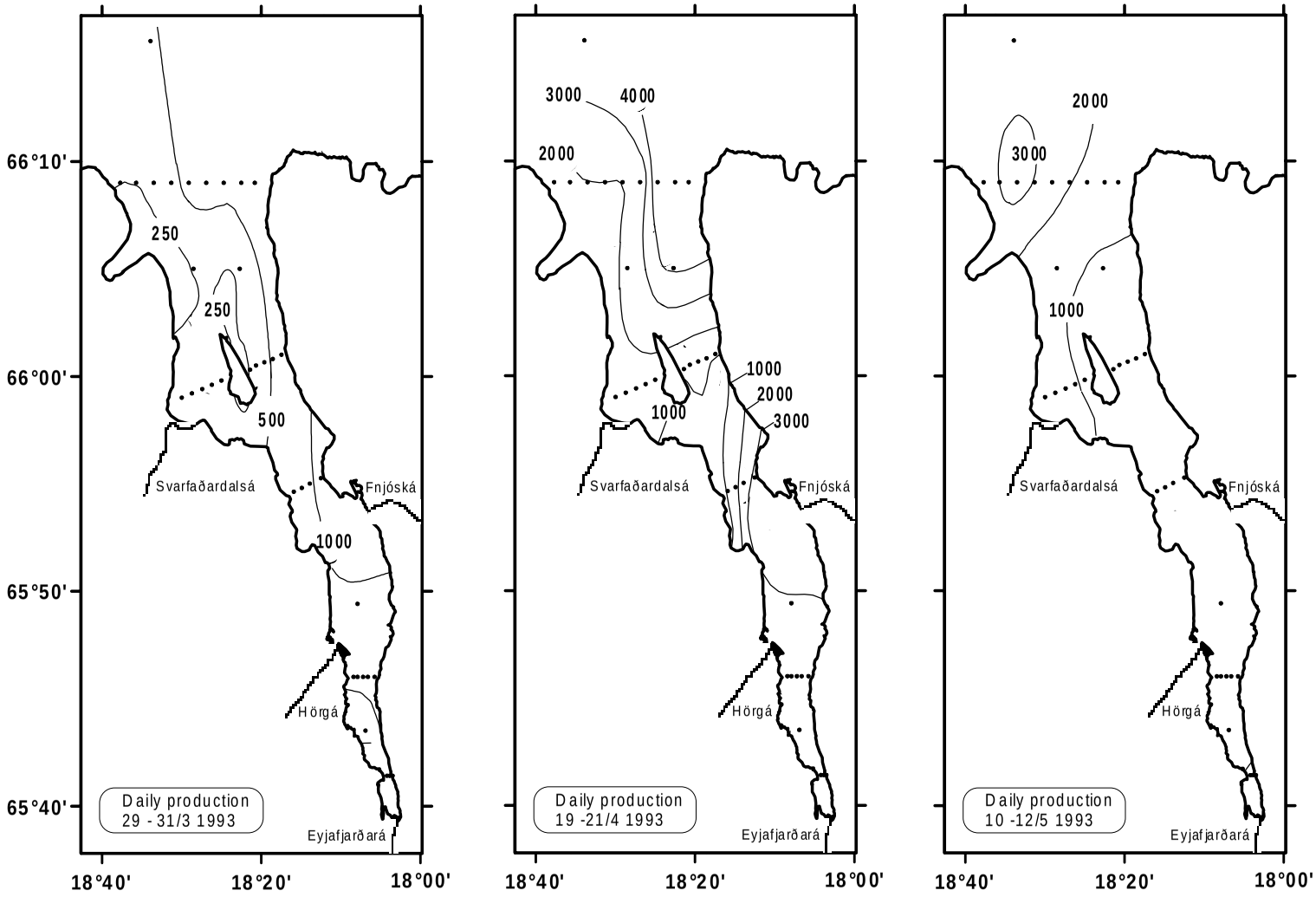





Figure 3.10. The horizontal distributation of depth integrated daily primary production (mg $m^{-2}$ $d^{-1}$, continued).

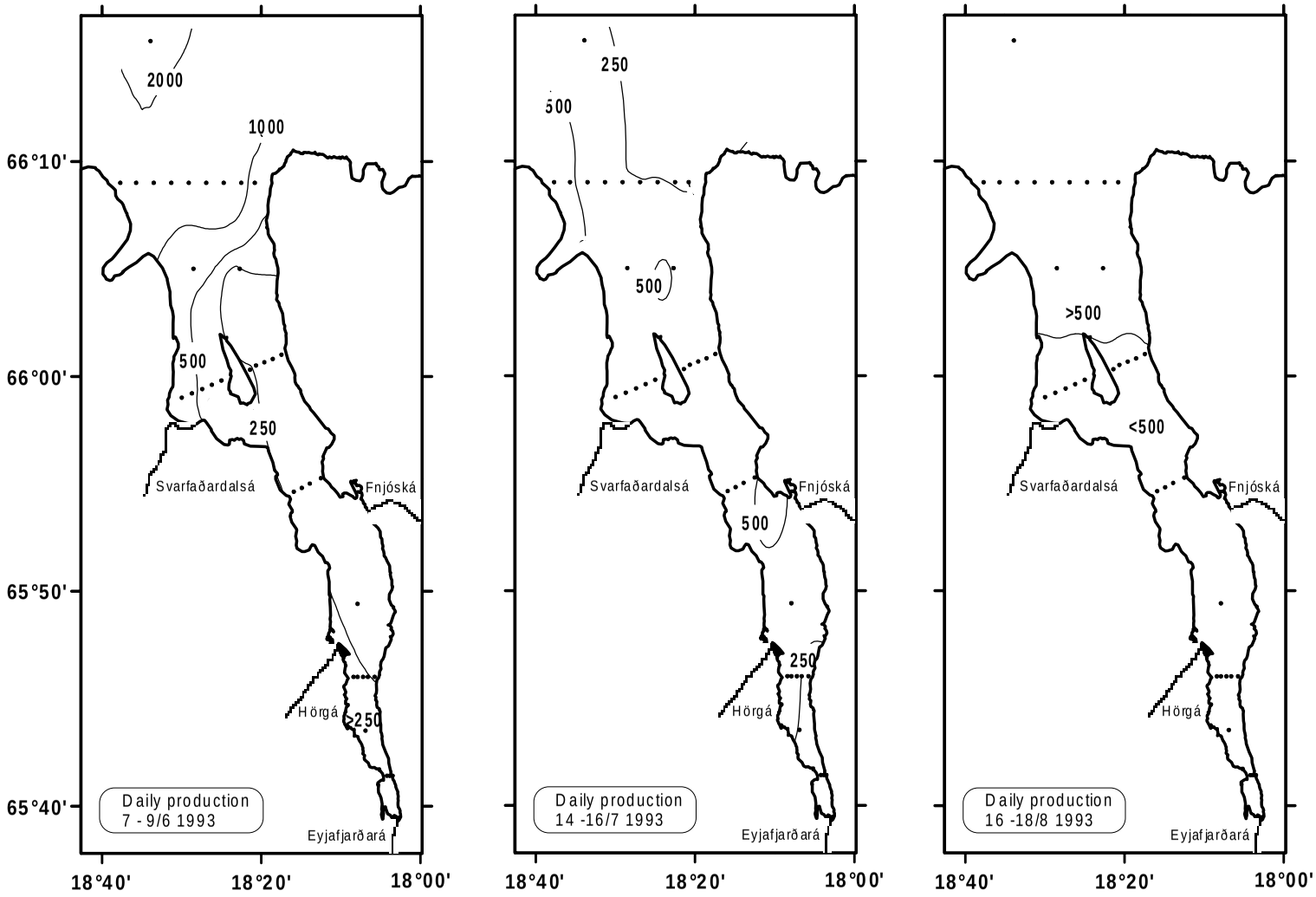



Figure 3.10. The horizontal distributation of depth integrated daily primary production (mg $m^{-2}$ $d^{-1}$, continued).

# 4. ZOOPLANKTON

The purpose of the studies on zooplankton was to give an overview of species composition, abundance and seasonal changes of the most important species. The results are mostly based on data from a single station in the inner part of the fjord (station 10 in Figure 1.2).

## Method

The zooplankton was collected on every cruise at 7 stations, using 200 µm mesh WP-2 net of 0.25 m² opening. The net was hauled vertically at 1 $ms^{-1}$, usually from 3 m above the bottom and to the surface. The zooplankton samples were preserved in a 4% neutralized formaldehyde seawater solution after collection. In the laboratory the samples were sub-sampled with Lea's whirling vessel (Wiborg 1951) and analyzed for species composition. All samples from station 10 have been worked up, 3 samples from station 2, and 2 samples from station 36 (Figure 1.2).

## Results

A total of 38 species and taxonomic groups were identified in the samples (Table 4.1). More species and taxonomic groups were found at station 10 near the middle of the fjord (31) than at station 2 in the innermost part and at station 36 in the mouth of the fjord (22 and 18, respectively).

In the innermost part of the fjord (station 2) the total zooplankton numbers appeared to be of the same order of magnitude as near the middle (station 10), whereas at the mouth (station 36) the numbers were a magnitude lower (Figures 4.1a, 4.2a, 4.3).

Copepods dominated the zooplankton at all three stations, usually comprising >60-80% of the total zooplankton at most sampling dates (Figures 4.1b, 4.2b, 4.4a). In April and May, however, euphausiids made up a significant fraction of the catch (~20-80%), and in July 1992, and in April and August 1993 cirripedes were relatively abundant (~10-20%).

At all three stations, the copepods *Oithona* spp. and *Acartia* spp. were most abundant among the copepods (>60%). The relative abundance of *Calanus finmarchicus* was lowest at Stn 2 (<2%) and highest at station 36 (~10-20%) (Figures 4.1c, 4.2c, 4.4b).

The seasonal changes in the plankton community were monitored at station 10 near the middle of the fjord (Kaasa and Gudmundsson 1994). The seasonal changes of total abundance were characterized by one main annual peak during autumn (August-October (~9000 individuals 1 $m^{-3}$) (Figure 4.3).

The most abundant copepods, *Oithona* spp. and *Acartia* spp., showed similar seasonal changes through the year, with peaks in September-October (Figure 4.5). Cirripede larvae occurred in highest numbers in mid to late summer (July-August) (Figure 4.5).

The abundance of *Calanus finmarchicus* peaked in spring both in 1992 and 1993 (Figure 4.5). However, the spring increase occurred somewhat later in 1992 (May-June) than in 1993 (April-May). The peak was also much higher during 1992 (~400 individuals 1 $m^{-3}$) than 1993 (~100 individuals 1 $m^{-3}$). Kaasa and Gudmundsson (1994) identified two main spawning periods of *C. finmarchicus* during spring and summer in the fjord. In 1992 these occurred in March-April and July, whereas in 1993 both spawnings appeared to take place a month later (Kaasa and Gudmudsson 1994).

## References:

Kaasa, Ø, Gudmundsson, K. 1994. Seasonal variations in the plankton community in Eyjafjörður, North Iceland. International Council for the Exploration of the Sea, Council Meeting 1994/L:24

Wiborg, K. F. 1951. The whirling wessel, an apparatus for fractioning of plankton samples. Fikeridirektorates Skrifter, 9: 1-16.

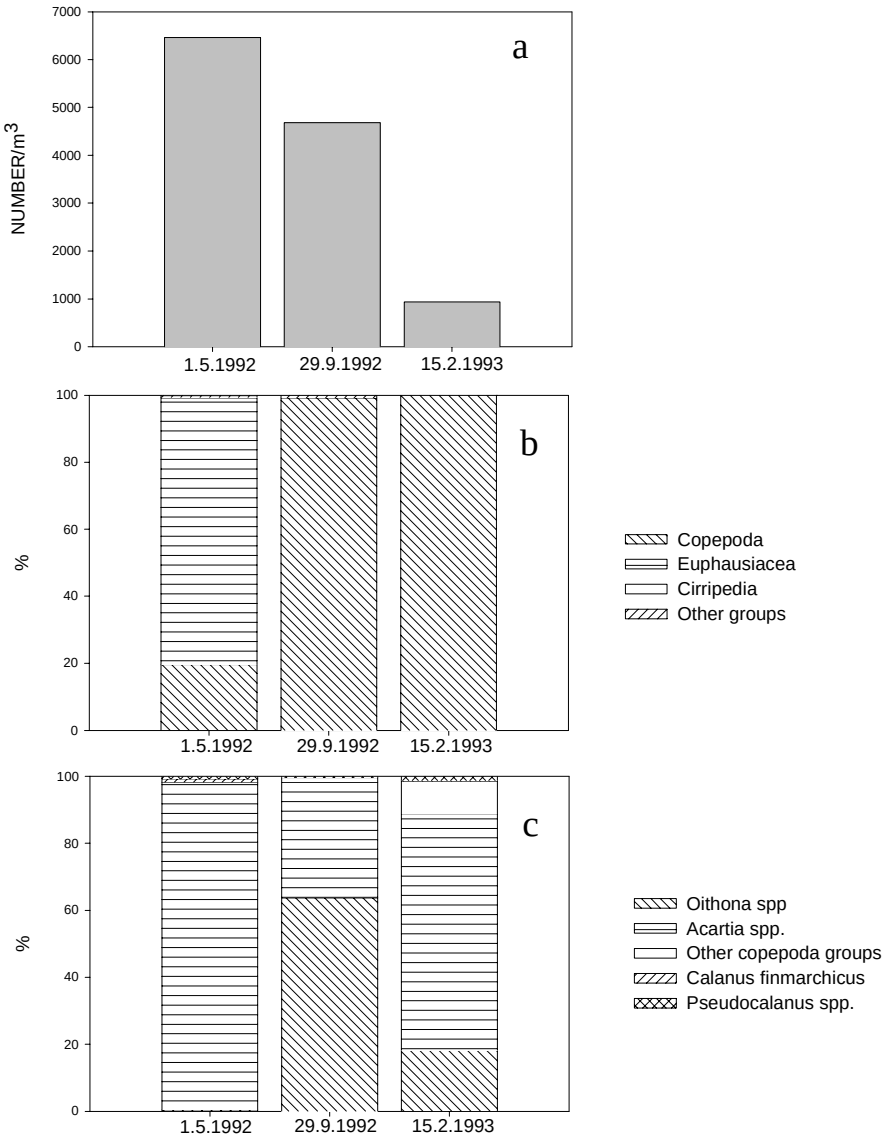



Figure 4.1. Abundance of total zooplankton (a), relative abundance of the most numerous zooplankton taxa (b) and relative abundance of the most abundant copepods (c) at station 2. For location of station refer to Figure 1.2.

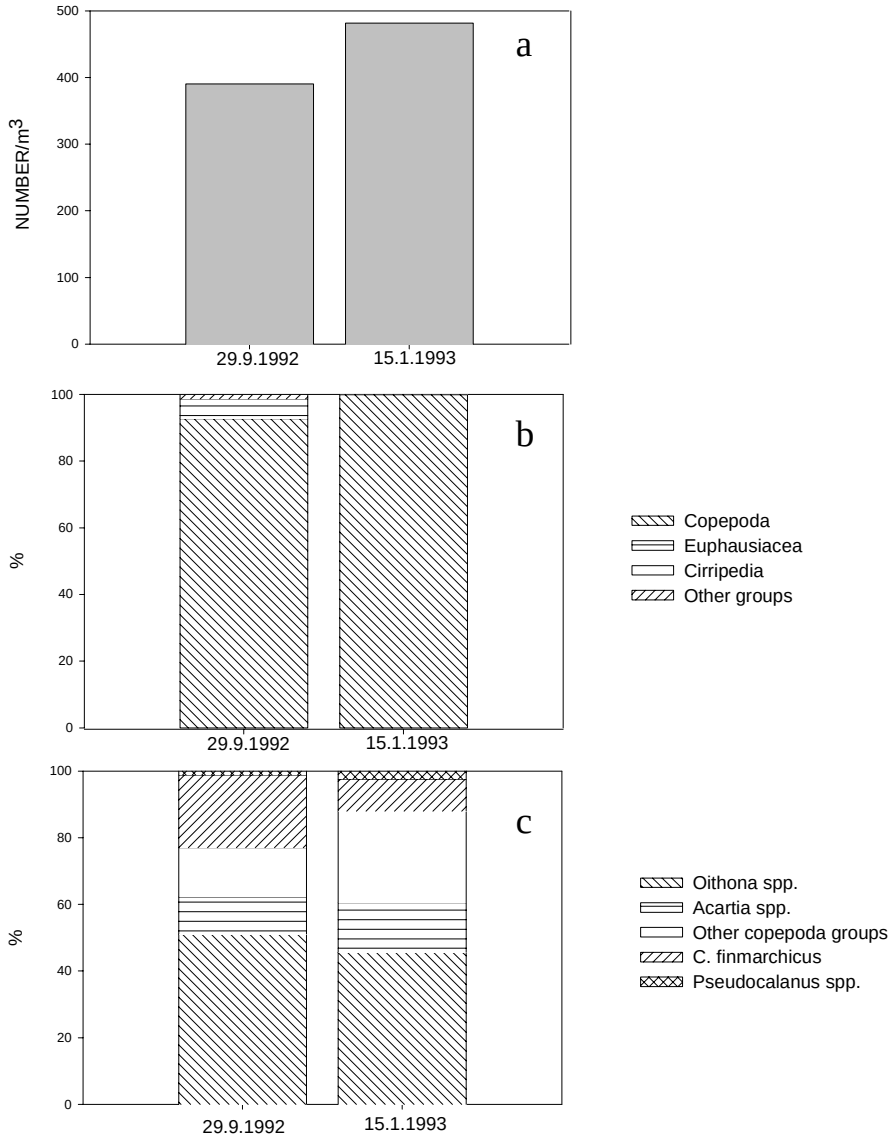



Figure 4.2. Abundance of total zooplankton (a), relative abundance of the most numerous zooplankton taxa (b) and relative abundance of the most abundant copepods (c) at station 36. For location of station refer to Figure 1.2.

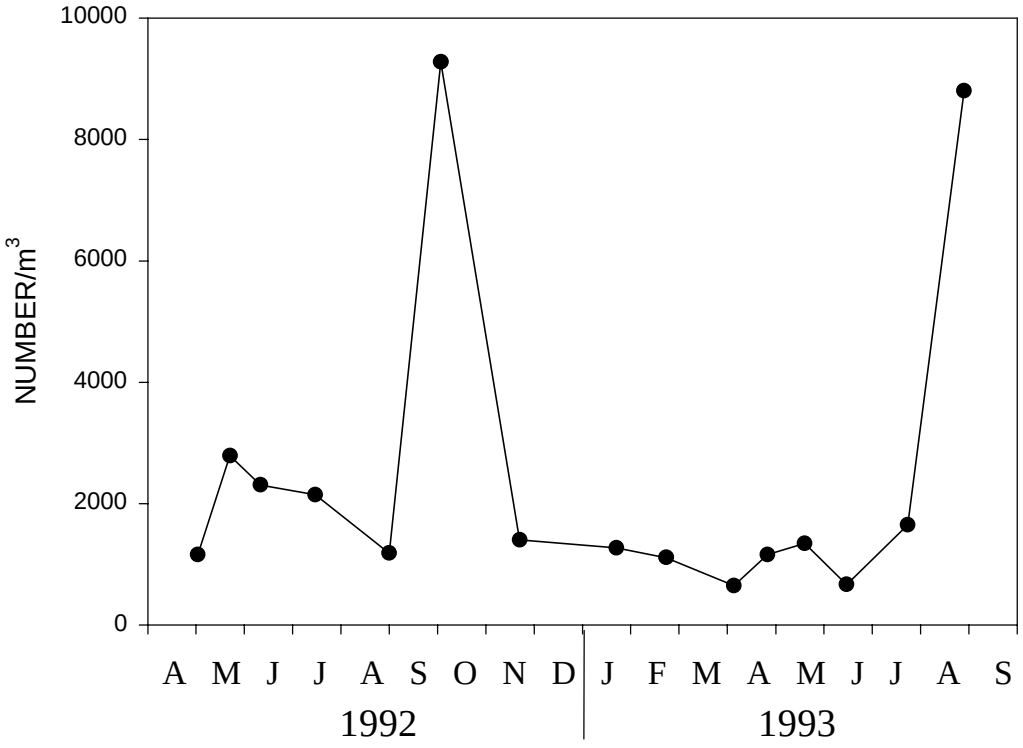



Figure 4.3. Abundance of total zooplankton at station 10 from May 1992 to August 1993. For location of station refer to Figure 1.2.

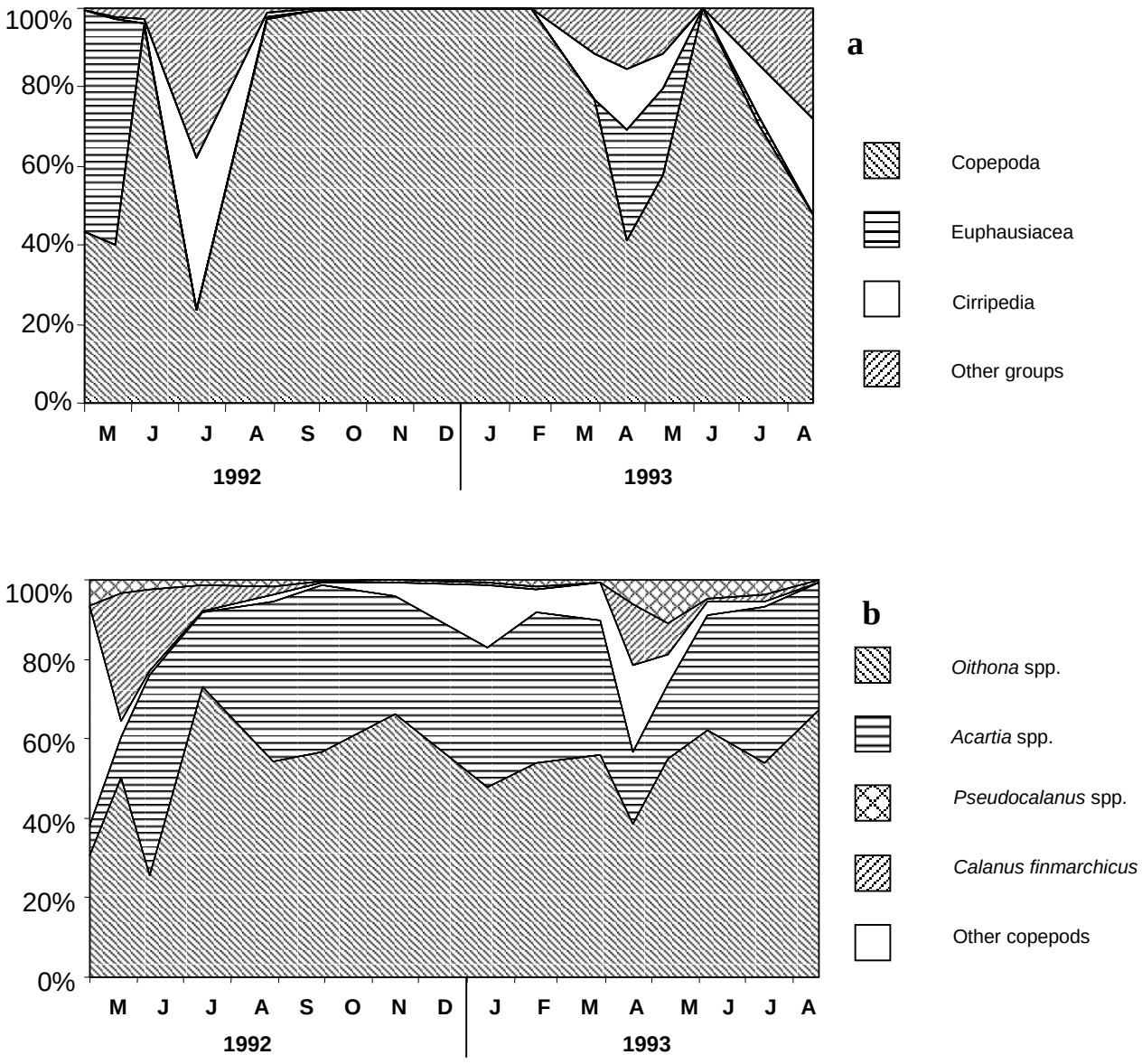



Figure 4.4. Relative abundance of the most numerous zooplankton taxa (a) and relative abundance of the most abundant copepods (b) at station 10 from May 1992 to August 1993. For location of station refer to Figure 1.2.

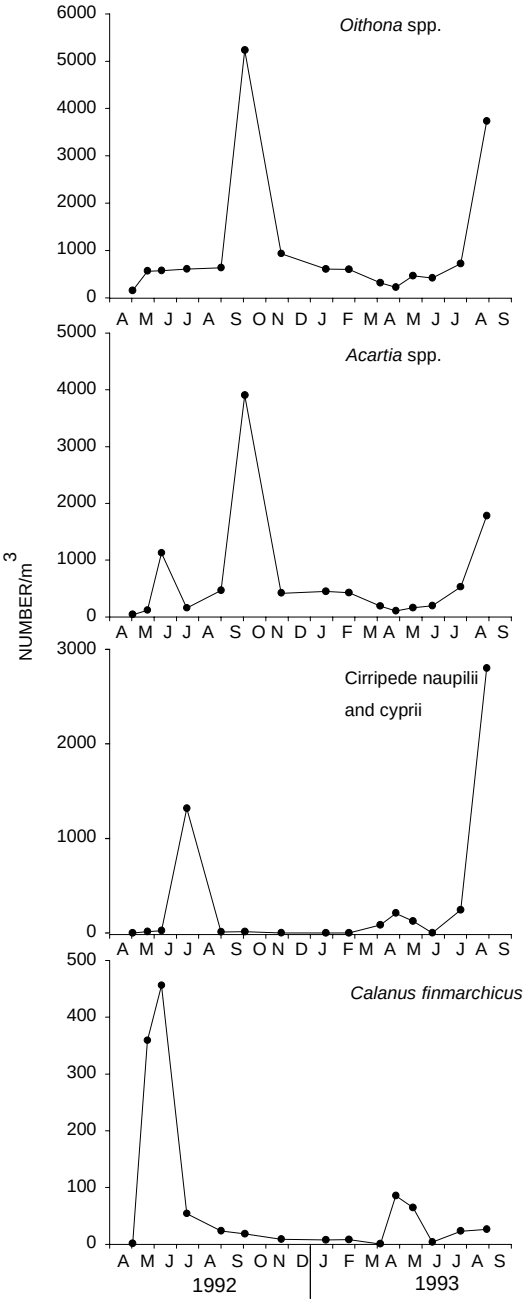



Figure 4.5. Abundance of the most abundant zooplankters at station 10 from May 1992 to August 1993. For location of station refer to Figure 1.2.

Table 4.1. Species or taxa identified at stations 2, 10 and 36. For location of stations refer to Figure 1.2.

| TAXON | Stn 2 | Stn 10 | Stn 36 |
|---|---|---|---|
| Coelenterata | | | |
| *Cyanea capillata* | | x | |
| *Aglantha digitale* | x | | x |
| Unidentified | x | x | x |
| Polychaeta | | | |
| Unidentified | x | | |
| Gastropoda | | | |
| Unidentified | x | x | x |
| Bivalvia | | | |
| Unidentified | | x | |
| Cladocera | | | |
| *Podon leuckarti* | x | x | |
| *Evadne nordmanni* | | x | |
| Copepoda | | | |
| *Calanus finmarchicus* | x | x | x |
| *Calanus hyperboreus* | | | x |
| *Calanus glacialis* | x | x | x |
| *Pseudocalanus* spp. | x | x | x |
| *Centrophagus hamatus* | | | x |
| *Microcalanus* spp. | x | x | x |
| *Euchaeta norvegica* | | x | x |
| *Scolecithricella minor* | | x | |
| *Temora longicornis* | x | x | |
| *Metridia longa* | x | x | x |
| *Acartia longiremis* | | x | |
| *Acartia* spp. | | | x |
| Unidentified Calanoida | x | | |
| *Oithona spinirostris* | x | x | x |
| Unidentified Cyclopoida | x | | |
| Cirripedia | | | |
| Unidentified | x | x | |
| Amphipoda | | | |
| *Themisto abyssorum* | | x | x |
| *Themisto* spp. | | x | |
| Euphausiacea | | | |
| Euphausiid eggs | x | x | |
| Euphausiid larvae | x | x | x |
| *Thysanoessa raschi* | | x | |
| Decapoda | | | |
| Bracyura | | x | |
| Natantia | | x | |
| Anomura | | x | |
| Chaetognata | | | |
| *Sagitta elegans* | x | x | x |
| *Eukrohnia hamata* | x | x | x |
| Ctenophora | | | |
| Unidentified | | x | |
| Larvacea | | | |
| Unidentified | x | x | x |
| Fish eggs | | | |
| Unidentified | x | x | |
| Fish larvae | | | |
| Undentified | x | x | |

# 5. ICHTHYOPLANKTON

In this chapter, the results from the ichthyoplankton part of the project is presented. The aim of the ichthyoplankton part of the study was to find out:

1) which fish species spawn in Eyjafjordur
2) the spawning time and spawning area of each species
3) the hatching time for each species
4) the spatio-temporal distribution of eggs, larvae and juveniles
5) the growth rate of the larvae and juveniles

As the ichthyoplankton data was more extesive in 1992 than in 1993, more emphasis will be laid on the 1992 results in the following. The results from 1993 will be used mainly for comparison.

## Material and methods

Ichthyoplankton sampling covered April to August in 1992 but only June to August data were available in 1993. During the sampling periods, samples were collected monthly at 5-6 stations inside the fjord but in some months, an extra station outside the fjord was added (Figure 5.1). In August available data from the annual 0-group surveys was analysed. The 0-group surveys, however, only provided samples from three stations (Figure 5.1, roman numerals).

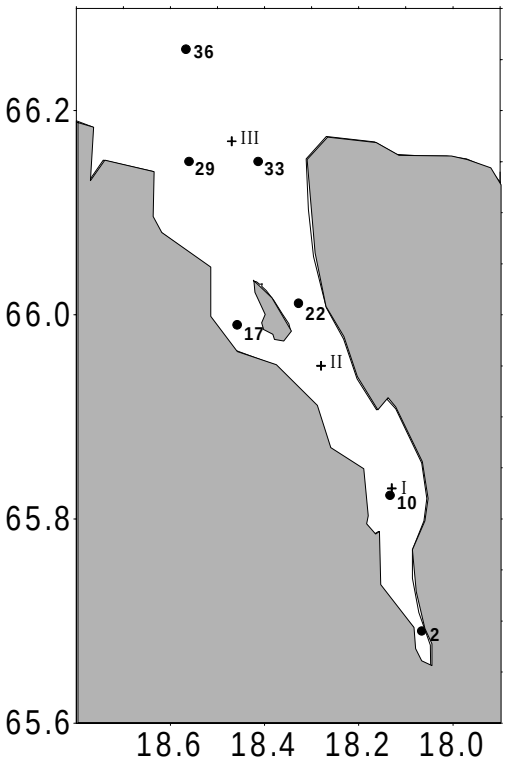



Figure 5.1. Sampling stations in Eyjafjordur 1992 and 1993. Filled circles and bold numerals: routinely sampled Bongo stations, crosses and Roman numerals: stations sampled with a pelagic juvenile trawl in August. Please note that degrees are shown with decimals in stead of minutes on all maps in this chapter.

During April to July the fish eggs and fish larvae were sampled using a 60 cm diameter Bongo net with a mesh size of 200 μm. At each station, a four depths, stepwise tow was taken. The Bongo net was towed for 5 minutes at each of the depths: 0, 10, 20 and 30 m at a speed of 2.5 miles per hour.

In August the juveniles were sampled with a large pelagic trawl with an 16x16 m opening and 5 mm mesh size in the cod end. The trawl was towed at 2.0 miles per hour for 15 minutes at a fixed depth. The depth was determined by registrations of small fish by an echo sounder, if no registrations were detected the sampling depth was 20 m to the headline. Due to the large difference in overall size and mesh size of the collecting gear in August (pelagic trawl) as compared to the Bongo net used in the other months, the results from these two groups of samples are not entirely comparable.

The samples were preserved in 4 % neutralised formalin/seawater solution. In the laboratory the samples were subsampled, if necessary, with a Motoda plankton splitter and the ichthyoplankton separated from the zooplankton. The fish eggs, larvae and juveniles were then separated down to species or groups and individuals counted and the diameter of eggs and the length of larvae and juveniles measured.

## Results

*Overall trends in the distribution*

During the sampling periods in 1992 and 1993 a total of 4.641 eggs, 10.625 larvae and 1.592 juveniles were caught and identified (Table 5.1). An order of magnitude more ichthyoplankton was found in Eyjafjordur in 1992 than in 1993 (Tables 5.1 - 5.6). If only the two comparable months June and July are compared, the abundance of fish eggs and larvae in 1992 (total number: 7694) is still about tenfold the abundance in these months in 1993 (total number: 854).

In April and May 1992, the highest concentrations of ichthyoplankton (mostly eggs) was in the middle part of the fjord (Figures 5.2 and 5.3). In June high concentrations of dab eggs and larvae of cod, sand eels and rough dab were recorded at the innermost station (station 2). One month later dab eggs were still concentrated at the head of the fjord but the distribution of other species was more varied. The number of fish larvae and juveniles were relatively low in August (Table 5.6), and the ichthyoplankton was rather evenly distributed.

The distribution of the ichthyoplankton in 1993 had a tendency towards the inner and middle parts of the fjord in June but the middle and outer parts of the fjord in July and August (Tables 5.4 and 5.5). In spite of relatively low numbers of cod and no haddock in July 1993, rather high densities of these two species were found in August 1993.

In 1992, the overall tendency of fish eggs sizes was from larger eggs of a species in spring towards smaller eggs of the same species in summer. The size reduction in 1992 was significant for all species, shown in Figure 5.4.a, except for cod. In July 1992 the eggs of lemon sole and rockling were significantly smaller than the eggs of the same species in July 1993.

The larvae of capelin and snake blenny were on the average longer in June 1992 than in June 1993, but those of the sand eel were shorter in June 1992. In July 1992 the larvae of both capelin and sand eel were shorter than those of the same species in July 1993 (Figure 5.4 b-d). The above differences are all significant ($P \leq 0,05$). On the average, the larvae of capelin and sand eel added 3.5 mm and 7.8 mm to their length respectively, between June and July 1992 compared to 11.9 mm and 12.3 mm respectively, for the same time interval 1993.

Table 5.1. Total number of eggs, larvae and juveniles of fishes caught in Eyjafjordur in each month. a) 1992 and b) 1993. *In July, number of cod larvae and cod juveniles are combined.

**a**

| species/month | Apr(eggs) | Apr(larvae) | May(eggs) | May(larvae) | June(eggs) | June(larvae) | July(eggs) | July(larvae) | Aug(larvae) | Aug(juven.) |
|---|---|---|---|---|---|---|---|---|---|---|
| cod | 193 | | 304 | 2 | 29 | 528 | 3 | 8* | | 31 |
| haddock | | | | | | | | | | |
| plaice | 20 | | 100 | 1 | 18 | | | | | |
| rough dab | 115 | | 347 | 17 | 6 | 388 | | 1 | | 8 |
| dab | | | | 6 | 544 | 22 | 1826 | 4 | | |
| lemon sole | | | | | | | 404 | | | |
| capelin | | | | 11 | 8 | 624 | | 756 | 3320 | |
| herring | | | | 3 | | | | | | |
| sand eel | | 107 | | 1542 | | 2172 | | 57 | | |
| snake blenny | | 27 | | 20 | | 42 | | | | 207 |
| Yarrels blenny | | | | 42 | | | | | | |
| butterfish | | | | 5 | | 42 | | 2 | | |
| sea snail | | | | 21 | | 14 | | | | |
| sea scorpion | | | | 5 | | 2 | | | | |
| rockling | 5 | | 24 | | 94 | | 88 | 1 | | |
| pogge | | | | | | 6 | | 1 | | |
| wolffish | | | | | | | | | | 1 |
| lumpsucker | | | | | | | | | | 1 |
| unidentified | | | | | | | 2 | 2 | | |
| Total | 333 | 134 | 775 | 1675 | 699 | 3840 | 2323 | 832 | 3320 | 248 |

**b**

| species/month | June(eggs) | June(larvae) | July(eggs) | July(larvae) | Aug(larvae) | Aug(juven.) |
|---|---|---|---|---|---|---|
| cod | 2 | | | 4* | | 916 |
| haddock | | | | | | 49 |
| plaice | 2 | | 8 | 1 | | |
| rough dab | 11 | 2 | 3 | 7 | | |
| dab | 2 | | 10 | 1 | | |
| lemon sole | | | 248 | 1 | | |
| capelin | | 16 | | 230 | | |
| herring | | | | 1 | | |
| sand eel | | 22 | | 25 | | |
| snake blenny | | 13 | | 2 | | |
| butterfish | | 3 | | 2 | | |
| sea snail | | 2 | | 9 | | |
| rockling | 141 | | 74 | | | |
| pogge | | | | 1 | | |
| lumpsucker | | | | | | 2 |
| unidentified | | | 4 | | | |
| Total | 158 | 58 | 347 | 284 | 0 | 967 |

*The more abundant fish species*

**Cod** *(Gadus morhua)*

Cod and haddock eggs can not be separated visually until the embryo has developed its caracteristic pigment pattern shortly before the egg hatches (Fridgeirsson 1978). All embryos examined in both years at this stage were cod embryos. Furthermore, no haddock larvae were found in the samples among the more than 500 identified cod larvae. It is thus here assumed, that all eggs of the typical appearance and size range of cod/haddock eggs were cod eggs.

The spawning of cod in 1992 took place in the mid part of the fjord in April and May (Figure 5.5). The larvae hatched during late May and early June as 99 % of the cod caught in May were eggs, but 98 % were larvae in the June samples. In June, most of the cod larvae were found at the innermost station. The June-patch at the head of the fjord had disappeared by July and the concentration of cod juveniles was low in the entire fjord. In August the cod juveniles were again relatively evenly distributed and the abundance was very low (0.04 / 1000 $m^3$, see Table 5.6).

Conspicuously few eggs and larvae were found in 1993. No larvae were caught in June and only few eggs were present at station 17 (Tables 5.4 and 5.5). In July, cod larvae and juveniles were only present at the opening of the fjord and in low numbers. In August, however, the average abundance of cod juveniles was rather high (1.3 / 1000 $m^3$).

**Capelin** *(Mallotus villosus)*

In 1992, no capelin larvae were caught in April and only a few in May (Figure 5.6). In June, most of the fjord had a concentration between 200-400 capelin larvae / 1000 $m^3$. A patch of capelin was observed at the opening of the fjord in July. The patch of larvae disappeared during the following weeks and only few capelin larvae were caught in August (Table 5.6). The few capelin eggs in June (Table 5.1) were caught when the net accidentally touched bottom at station 2.

In June and July 1993 the distribution of capelin larvae was somewhat similar to that in 1992 except that the concentration was about one degree of magnitude lower in 1993. No capelin larvae were found in the fjord in August 1993.

**Rough dab** *(Hippoglossoides platessoides limandoides)*

During 1992, rough dab spawned in April and May. As with cod, the main spawning seems to have taken place in the mid part of the fjord (Figure 5.7). In May, 95 % of the rough dab caught were eggs. In June, 99 % of the caught rough dab were larvae, most of them concentrated in the southernmost part of the fjord. In July, only few rough dab larvae were found and rough dab larvae were also few in August.

In June and July 1993 very few rough dab larvae were caught and then only in the northern part of the fjord. No rough dab was caught in August.

**Sand eel species**

Ammodytes spp. larvae were not separated to the species level but the majority of the larvae were probably *Ammodytes marinus*. According to the distribution and abundance of larvae in 1992 the larvae seem to hatch in April and May (Figure 5.8). The spawning was restricted to a rather small area west of the

island Hrisey. As was seen with cod and rough dab, the sand eel larvae formed a dense patch at the souternmost part of Eyjafjordur in June but in July the patch had disappeared again. A few sand eel larvae were caught in the mid part of the fjord in August 1992.

The abundance of sand eel larvae was low in June and July 1993 and no sand eel larvae were caught in August 1993.

**Plaice** *(Pleuronectes platessa)*

Plaice spawned during April and May 1992 in the mid part of the fjord (Figure 5.9, upper row). In June, the highest abundance of the remaining eggs was at the southern end of the fjord (Figure 5.2). No plaice was caught in July or August. Only a few plaice eggs were caught in June and July 1993 but none in August.

**Dab** *(Limanda limanda)*

The main spawning of dab took place at the head of the fjord during June and July but spawning had already started at a slow pace west of the island Hrisey in May (Figure 5.9, lower row). High concentrations of dab eggs were recorded at the head of the fjord in June, similar to that with some other ichthyoplankton species. The concentration of dab eggs at the south end of the fjord still increased until July. In 1993, only few dab eggs and just one dab larva were found.

*Other fish species*

No **haddock** *(Melanogrammus aeglefinus)* eggs, larvae or juveniles were found in any month 1992 (Table 5.1), but some haddock juveniles were caught at all three stations in August 1993 (Table 5.6).

Three **herring** *(Clupea harengus)* larvae were found in May 1992, but only one herring larva was caught in 1993, in July (Table 5.1).

**Lemon sole** *(Microstomus kitt)* eggs were only found in July during both years, mainly in the northern half of the fjord (Tables 5.2 and 5.4). In 1992, up to 1400 lemon sole eggs per 1000 $m^3$ were caught. Egg concentrations were an order of magnitude lower in July 1993.

**Snake blenny** *(Lumpenus lampretaeformis lampretaeformis)* larvae were rather common in the southern part of the fjord during April to June 1992 but no larvae were caught in July (Table 5.3). Some larvae of snake blenny were again caught in August 1992. In 1993 some snake blenny larvae were caught in June and July (Table 5.5).

Some eggs of **rockling species** were found in April and May in 1992 and rockling species eggs were found at most stations in June and July in both 1992 and 1993 (Tables 5.2 and 5.4).

**Butterfish** *(Pholis gunnellus)* larvae were found in May through July 1992 (Table 5.3). Only a few butterfish larvae were found in 1993 (Table 5.5).

## References:

Fridgeirsson, E. 1978. Embryonic development of five species of gadoid fishes in Icelandic waters. Rit Fiskideildar V (V). 68 pp.

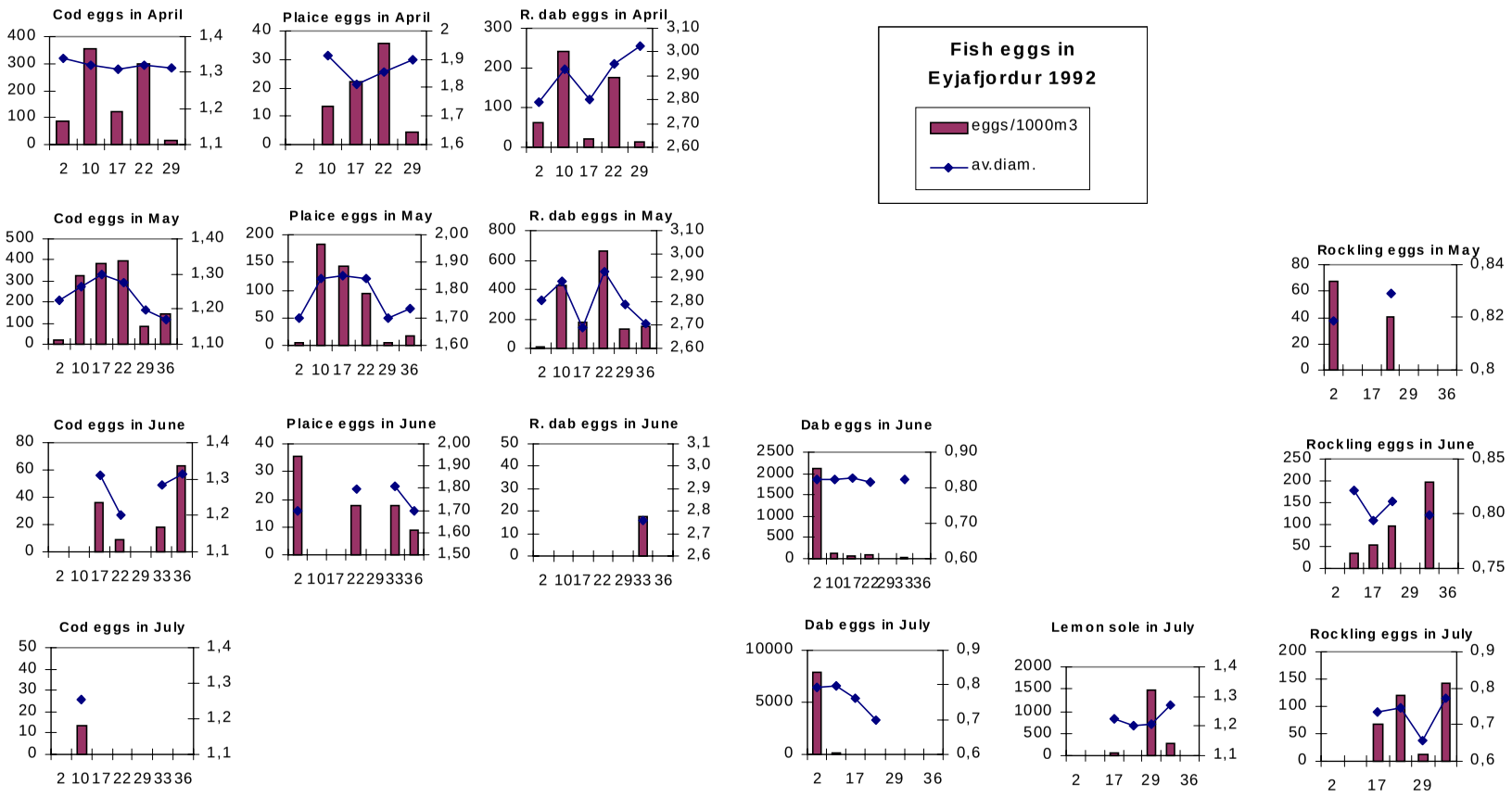



Figure 5.2. Number (columns) and average diameter (lines) of eggs of the more common fish species in Eyjafjordur 1992. The x-axis: station number, left y-axis: No/1000 $m^3$, right y-axis: average diameter (mm) of eggs.

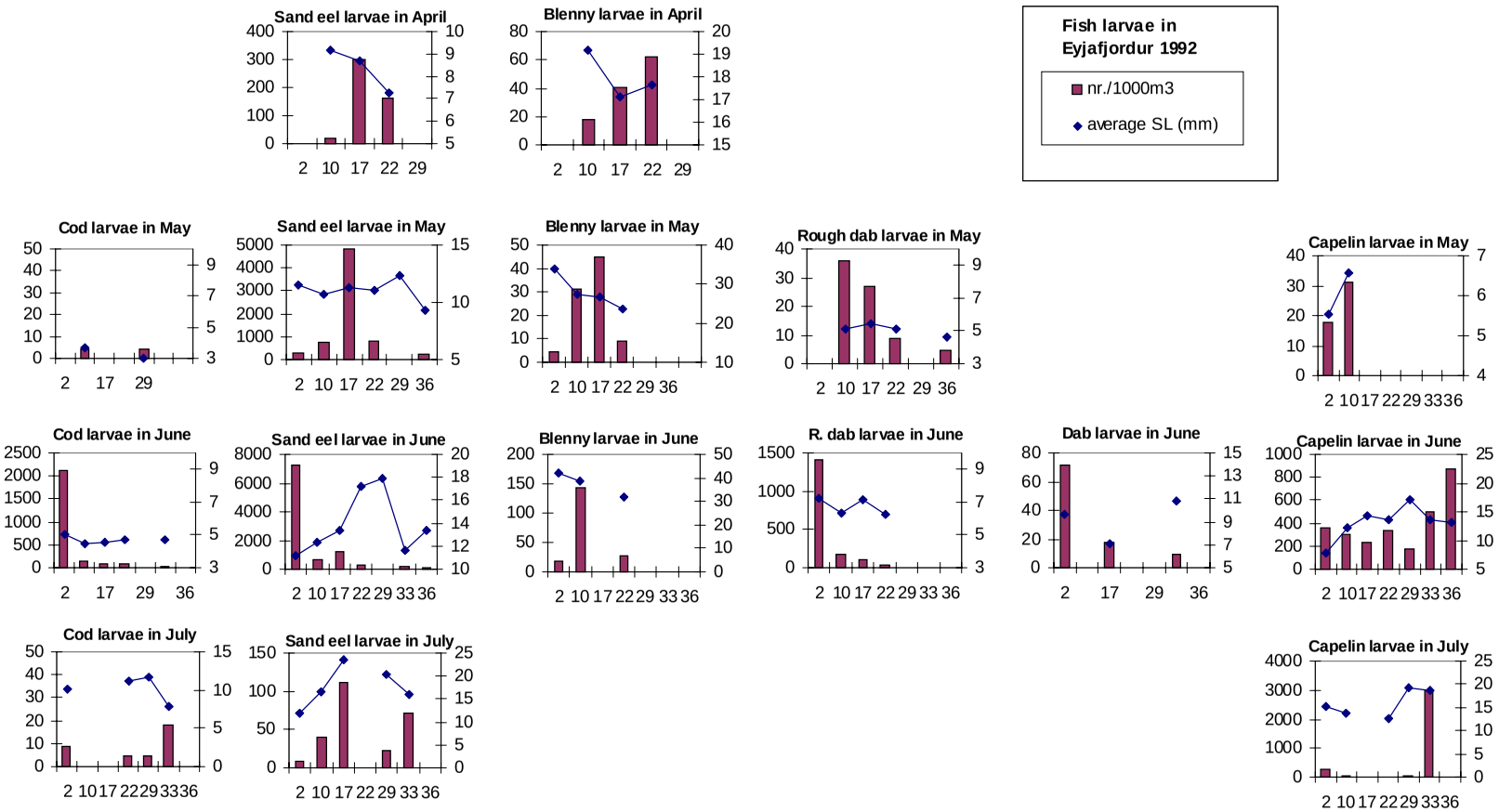



Figure 5.3. Number (columns) and average standard length (lines) of larvae of the more common fish species in Eyjafjordur in 1992. The x-axis: station number, left y-axis: No/1000 $m^3$, right y-axis: average standard length (mm) of larvae.

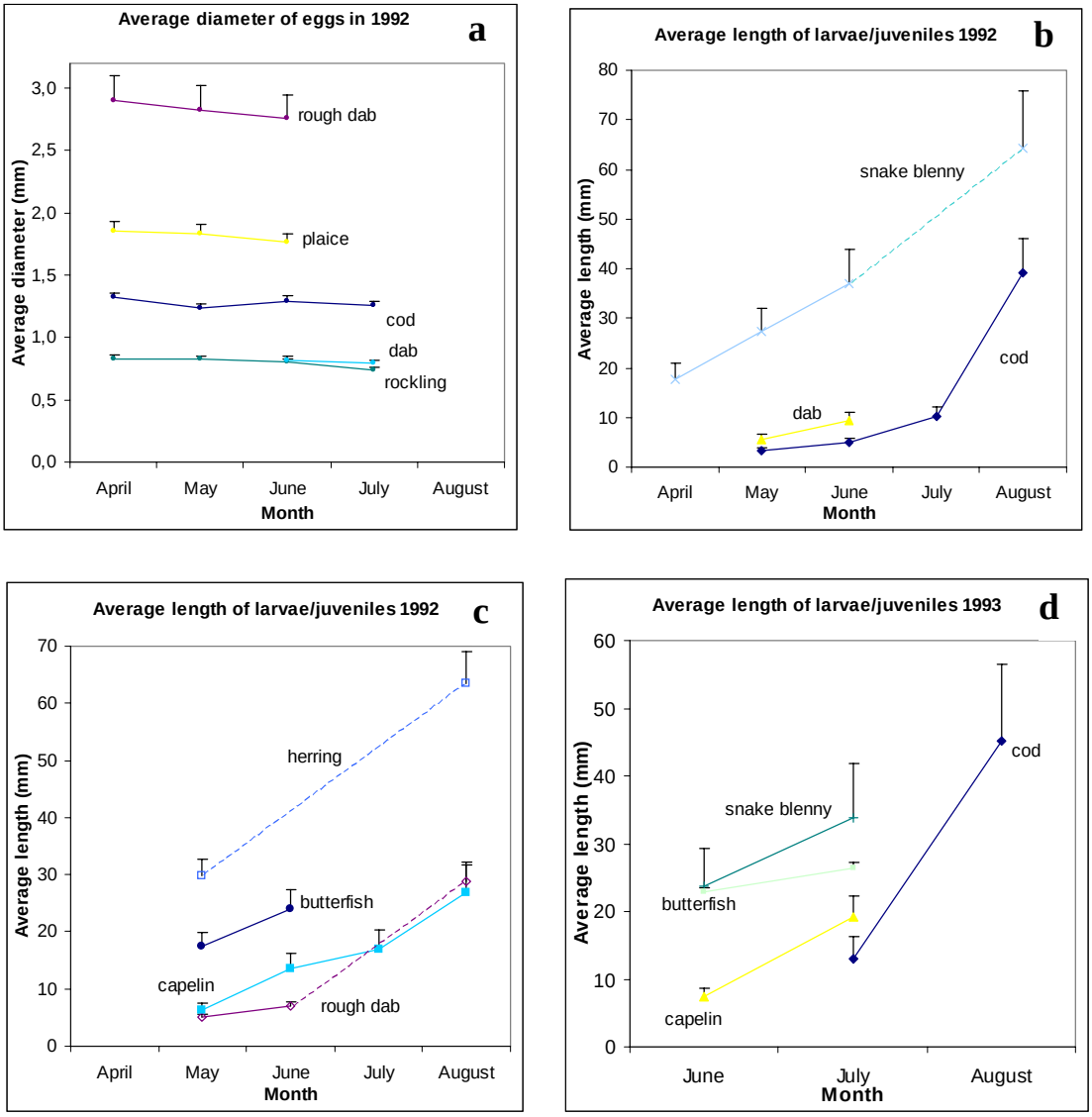



Figure 5.4. Monthly averages of a) diameters of eggs 1992, b) and c) standard lengths of fish larvae and overall lengths of juveniles 1992, d) standard lengths of fish larvae and overall lengths of juveniles 1993. Vertical bars denote one standard deviation

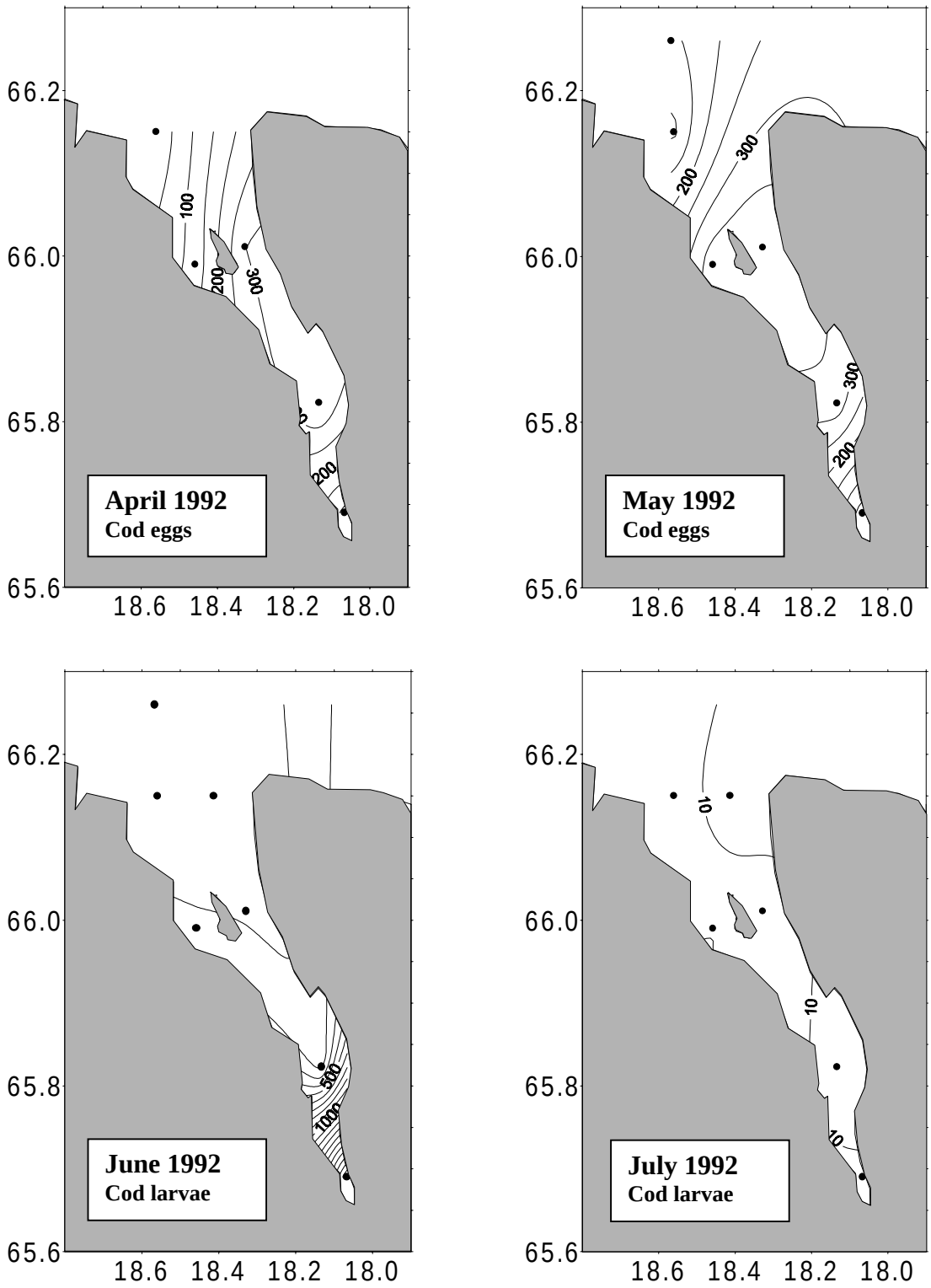



Figure 5.5. The distribution of cod eggs (April/May) and cod larvae (June/July) in Eyjafjordur 1992 (No/1000 $m^3$). Juveniles caught in August were < 0.05/1000 $m^3$.

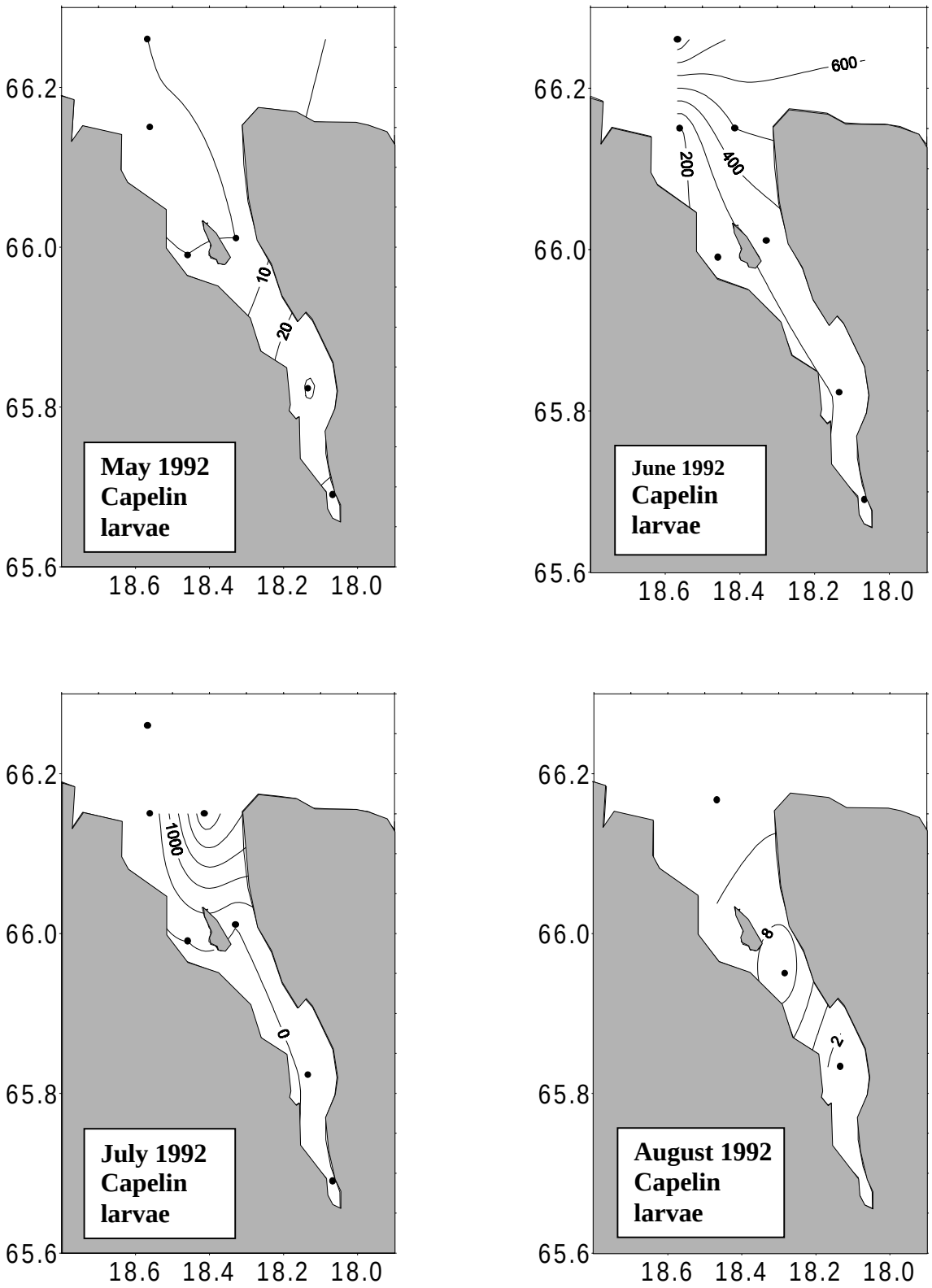



Figure 5.6. The distribution of capelin larvae (No/1000 $m^3$) in Eyjafjordur 1992.

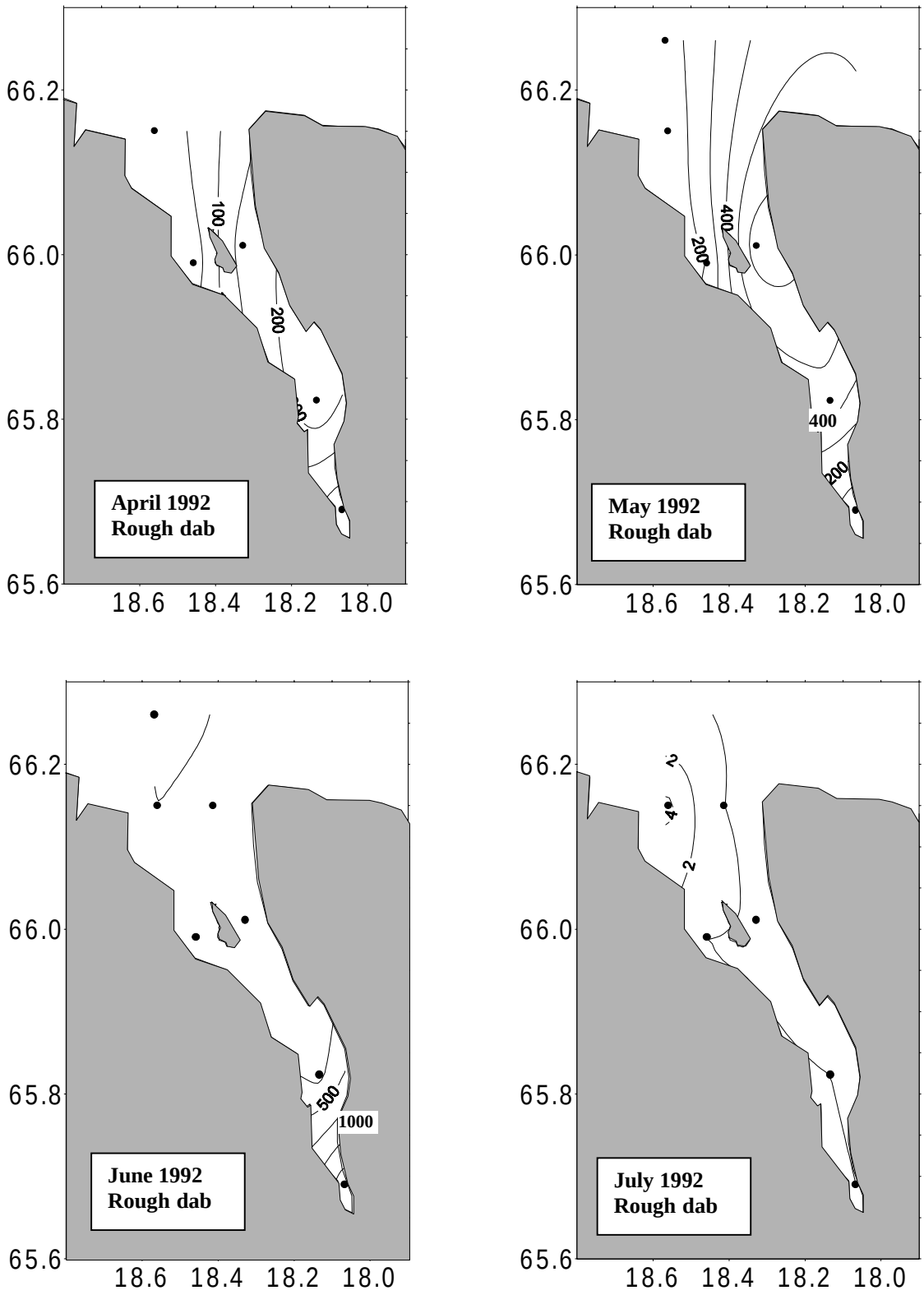



Figure 5.7. The distribution of rough dab eggs (April/May) and rough dab larvae (June/July) in Eyjafjordur 1992 (No/1000 $m^3$). Less than 0.05 larvae/1000 $m^3$ were caught in August.

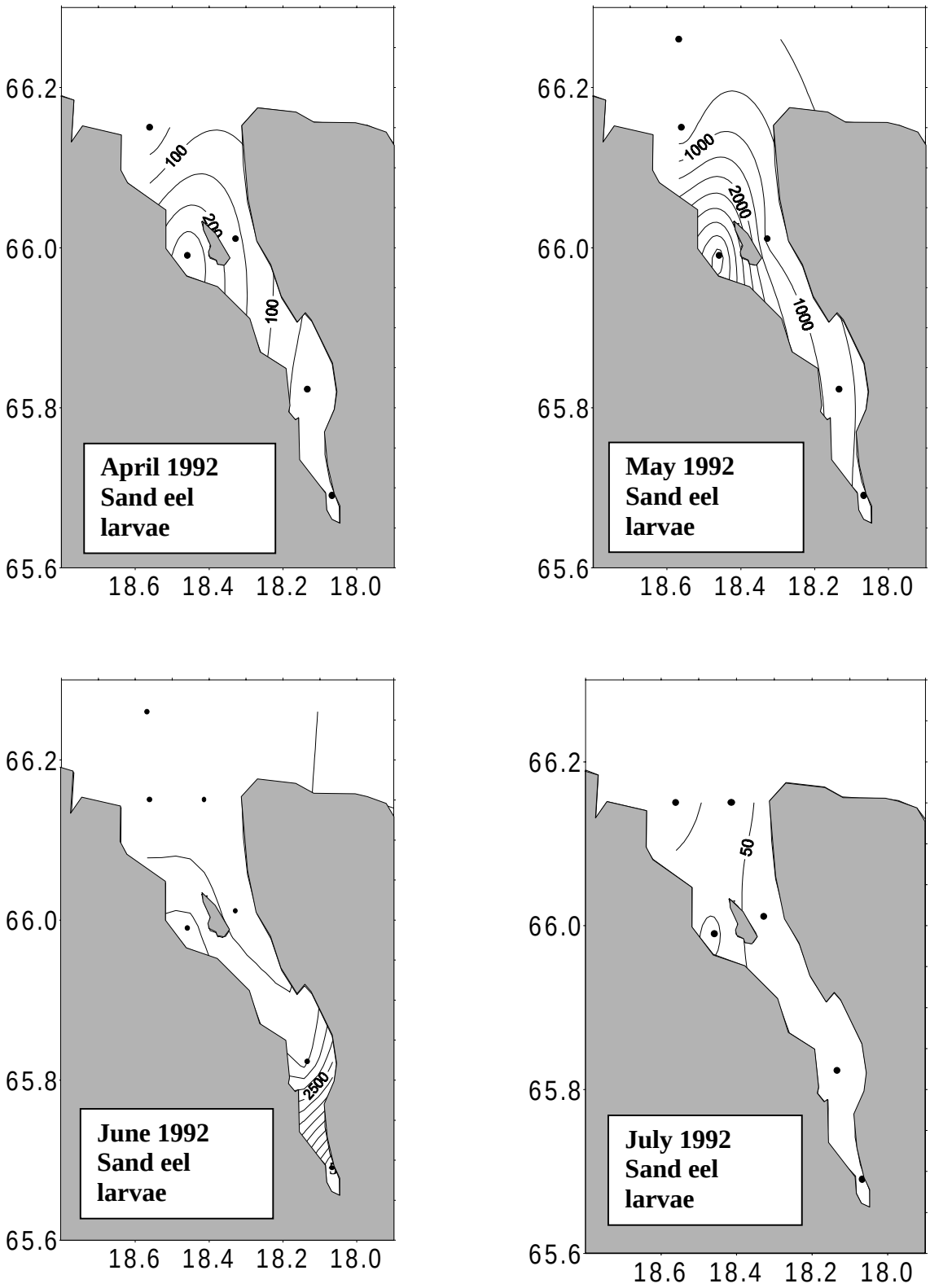



Figure 5.8. The distribution of Ammodytidae larvae (No/1000 $m^3$) in Eyjafjordur 1992. No Ammodytidae larvae were caught in August.

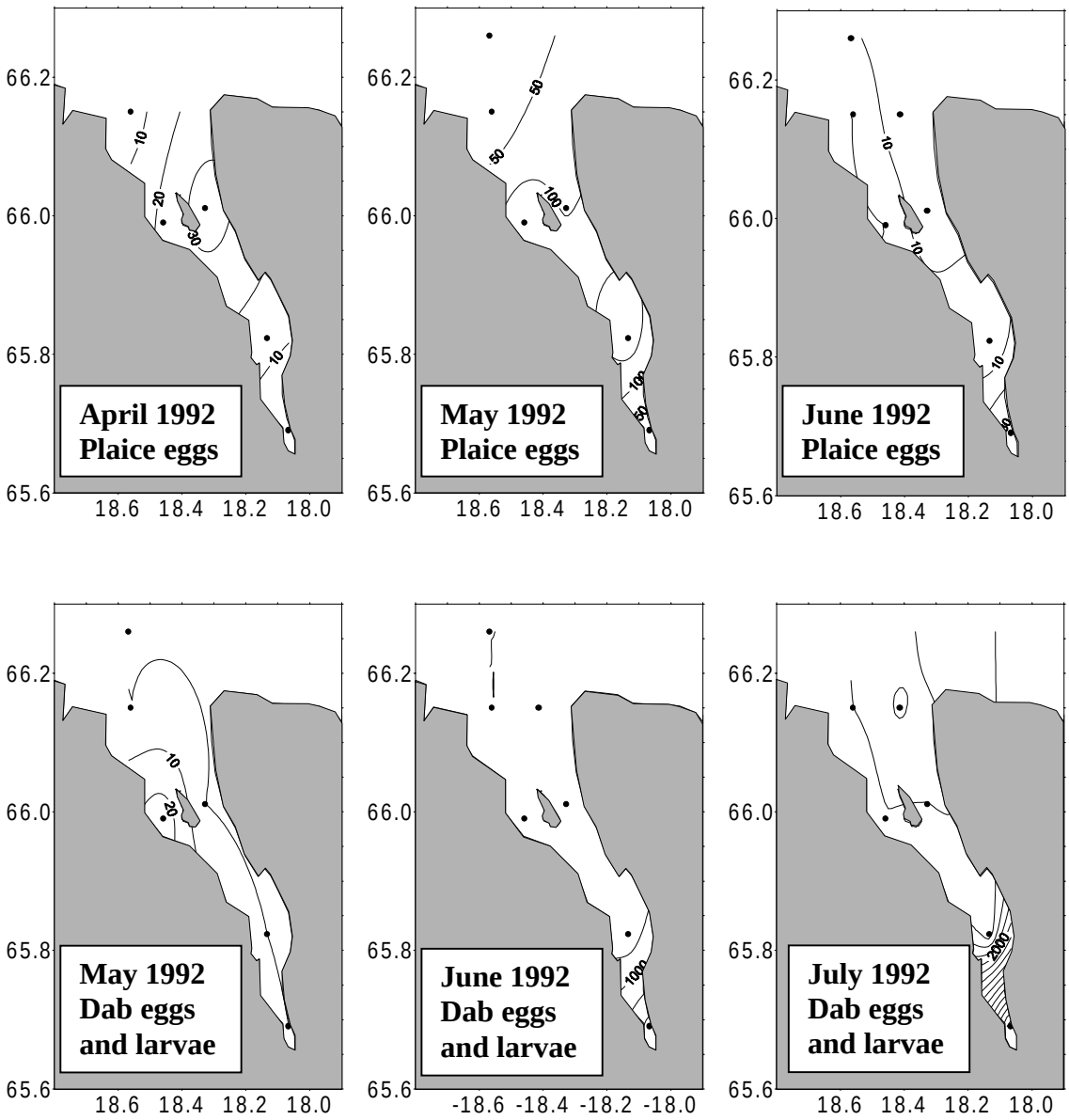



Figure 5.9. The distribution of plaice eggs (upper row), and dab eggs and larvae (lower row) in Eyjafjordur 1992 (No/1000 $m^3$). Eggs or larvae of these species were not caught during months not shown.

Table 5.2. Number/1000 $m^3$ and average diameter (mm) of eggs at individual stations and months in 1992.

| Aprí 29-30, 1992 | | | | May 19-21, 1992 | | | | June 9-11, 1992 | | | | July 13-15, 1992 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Eggs** | | | | **Eggs** | | | | **Eggs** | | | | **Eggs** | | | |
| station | nr/1000m3 | av.diam.(m | species | station | nr/1000m3 | av.diam.(m | species | station | nr/1000m3 | av.diam.(m | species | station | nr/1000m3 | av.diam.(m | species |
| 2 | 84,9 | 1,34 | cod | 2 | 22,4 | 1,23 | cod | 2 | 0 " | | cod | 2 | 0 | | cod |
| 10 | 353,1 | 1,32 | | 10 | 326,3 | 1,26 | | 10 | 0 " | | | 10 | 13,4 | 1,25 | |
| 17 | 120,7 | 1,31 | | 17 | 384,4 | 1,30 | | 17 | 35,8 | 1,31 | | 17 | 0 | | |
| 22 | 299,5 | 1,32 | | 22 | 397,8 | 1,27 | | 22 | 8,9 | 1,2 | | 22 | 0 | | |
| 29 | 13,4 | 1,31 | | 29 | 84,9 | 1,20 | | 29 | 0 " | | | 29 | 0 | | |
| 33 | | | | 33 | | | | 33 | 17,9 | 1,29 | | 33 | 0 | | |
| 36 | | | | 36 | 143 | 1,17 | | 36 | 62,6 | 1,31 | | 36 | | | |
| 2 | 0 " | | plaice | 2 | 4,5 | 1,70 | plaice | 2 | 35,8 | 1,7 | plaice | | | | |
| 10 | 13,4 | 1,91 | | 10 | 183,3 | 1,84 | | 10 | 0 " | | | | | | |
| 17 | 22,4 | 1,81 | | 17 | 143 | 1,85 | | 17 | 0 " | | | | | | |
| 22 | 35,8 | 1,86 | | 22 | 93,9 | 1,84 | | 22 | 17,9 | 1,8 | | | | | |
| 29 | 4,5 | 1,90 | | 29 | 4,5 | 1,7 | | 29 | 0 " | | | | | | |
| 33 | | | | 33 | | | | 33 | 17,9 | 1,81 | | | | | |
| 36 | | | | 36 | 17,9 | 1,73 | | 36 | 8,9 | 1,7 | | | | | |
| 2 | 62,6 | 2,79 | Rough dab | 2 | 8,9 | 2,81 | Rough dab | 2 | 0 " | | Rough dab | | | | |
| 10 | 241,4 | 2,93 | | 10 | 429,1 | 2,89 | | 10 | 0 " | | | | | | |
| 17 | 22,4 | 2,80 | | 17 | 178,8 | 2,69 | | 17 | 0 " | | | | | | |
| 22 | 174,3 | 2,95 | | 22 | 657,1 | 2,93 | | 22 | 0 " | | | | | | |
| 29 | 13,4 | 3,03 | | 29 | 129,6 | 2,79 | | 29 | 0 " | | | | | | |
| 33 | | | | 33 | | | | 33 | 17,9 | 2,76 | | | | | |
| 36 | | | | 36 | 147,5 | 2,7 | | 36 | 0 " | | | | | | |
| | | | | | | | | 2 | 2127,7 | 0,82 | Dab | 2 | 7938,7 | 0,79 | Dab |
| | | | | | | | | 10 | 125,2 | 0,82 | | 10 | 196,7 | 0,80 | |
| | | | | | | | | 17 | 53,6 | 0,83 | | 17 | 22,4 | 0,76 | |
| | | | | | | | | 22 | 80,5 | 0,81 | | 22 | 4,5 | 0,70 | |
| | | | | | | | | 29 | 0 " | | | 29 | 0 | | |
| | | | | | | | | 33 | 44,7 | 0,82 | | 33 | 0 | | |
| | | | | | | | | 36 | 0 " | | | 36 | | | |
| | | | | | | | | | | | | 2 | 0 | | lemon sole |
| | | | | | | | | | | | | 10 | 0 | | |
| | | | | | | | | | | | | 17 | 53,6 | 1,22 | |
| | | | | | | | | | | | | 22 | 4,5 | 1,20 | |
| | | | | | | | | | | | | 29 | 1461,7 | 1,20 | |
| | | | | | | | | | | | | 33 | 286,1 | 1,27 | |
| | | | | | | | | | | | | 36 | | | |
| 2 | 0 " | | Rockling | 2 | 67,1 | 0,82 | Rockling | 2 | 0 " | | Rockling | 2 | 0 | | Rockling |
| 10 | 0 " | | | 10 | 0 " | | | 10 | 35,8 | 0,82 | | 10 | 0 | | |
| 17 | 0 " | | | 17 | 0 " | | | 17 | 53,6 | 0,79 | | 17 | 67,1 | 0,73 | |
| 22 | 22,4 | 0,83 | | 22 | 40,2 | 0,83 | | 22 | 98,3 | 0,81 | | 22 | 120,7 | 0,75 | |
| 29 | 0 " | | | 29 | 0 " | | | 29 | 0 " | | | 29 | 13,4 | 0,65 | |
| 33 | | | | 33 | | | | 33 | 196,7 | 0,8 | | 33 | 143,0 | 0,77 | |
| 36 | | | | 36 | 0 " | | | 36 | 0 " | | | 36 | | | |

Table 5.3 (next page). Number/1000 $m^3$ and average standard length (mm) of larvae at individual stations and months in 1992.

→

| Aprîl 29-30, 1992 | | | | May 19-21, 1992 | | | | June 9-11, 1992 | | | | July 13-15, 1992 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Larvae** | | | | **Larvae** | | | | **Larvae** | | | | **Larvae** | | | |
| station | nr/1000m3 | av. SL (mm | species | station | nr/1000m3 | av. SL (mm | species | station | nr/1000m3 | av. SL (mm | species | station | nr/1000m3 | av. SL (mm | species |
| | | | | 2 | 0 " | | cod | 2 | 2109,8 | 5,1 | cod | 2 | 8,94 | 10,1 | cod |
| | | | | 10 | 4,5 | 3,7 | | 10 | 143 | 4,5 | | 10 | 0 " | | |
| | | | | 17 | 0 " | | | 17 | 89,4 | 4,5 | | 17 | 0 " | | |
| | | | | 22 | 0 " | | | 22 | 80,5 | 4,8 | | 22 | 4,47 | 11,2 | |
| | | | | 29 | 4,5 | 3 | | 29 | 0 " | | | 29 | 4,47 | 11,7 | |
| | | | | 33 | | | | 33 | 26,8 | 4,7 | | 33 | 17,88 | 7,9 | |
| | | | | 36 | 0 " | | | 36 | 0 " | | | 36 | | | |
| | | | | 2 | 0 " | | plaice | | | | | | | | |
| | | | | 10 | 0 " | | | | | | | | | | |
| | | | | 17 | 0 " | | | | | | | | | | |
| | | | | 22 | 4,5 | 5,8 | | | | | | | | | |
| | | | | 29 | 0 " | | | | | | | | | | |
| | | | | 33 | | | | | | | | | | | |
| | | | | 36 | 0 " | | | | | | | | | | |
| | | | | 2 | 0 " | | rough dab | 2 | 1412,5 | 7,2 | rough dab | 2 | 0 " | | rough dab |
| | | | | 10 | 35,8 | 5,1 | | 10 | 178,8 | 6,4 | | 10 | 0 " | | |
| | | | | 17 | 26,8 | 5,4 | | 17 | 107,3 | 7,1 | | 17 | 0 " | | |
| | | | | 22 | 8,9 | 5,1 | | 22 | 35,8 | 6,3 | | 22 | 0 " | | |
| | | | | 29 | 0 " | | | 29 | 0 " | | | 29 | 4,47 | 4,2 | |
| | | | | 33 | | | | 33 | 0 " | | | 33 | 0 " | | |
| | | | | 36 | 4,5 | 4,6 | | 36 | 0 " | | | 36 | | | |
| | | | | 2 | 0 " | | dab | 2 | 71,5 | 9,6 | dab | 2 | 0 " | | dab |
| | | | | 10 | 0 " | | | 10 | 0 " | | | 10 | 0 " | | |
| | | | | 17 | 26,8 | 5,6 | | 17 | 17,9 | 7,1 | | 17 | 0 " | | |
| | | | | 22 | 0 " | | | 22 | 0 " | | | 22 | 0 " | | |
| | | | | 29 | 0 " | | | 29 | 0 " | | | 29 | 0 " | | |
| | | | | 33 | | | | 33 | 8,9 | 10,8 | | 33 | 17,9 | 10,5 | |
| | | | | 36 | 0 " | | | 36 | 0 " | | | 36 | | | |
| | | | | 2 | 17,9 | 5,5 | capelin | 2 | 357,6 | 7,8 | capelin | 2 | 295,0 | 15,2 | capelin |
| | | | | 10 | 31,3 | 6,6 | | 10 | 304 | 12,2 | | 10 | 49,2 | 13,9 | |
| | | | | 17 | 0 " | | | 17 | 232,4 | 14,4 | | 17 | 0,0 " | | |
| | | | | 22 | 0 " | | | 22 | 339,7 | 13,6 | | 22 | 8,9 | 12,6 | |
| | | | | 29 | 0 " | | | 29 | 178,8 | 17,1 | | 29 | 58,1 | 19,2 | |
| | | | | 33 | | | | 33 | 500,6 | 13,5 | | 33 | 2968,1 | 18,5 | |
| | | | | 36 | 0 " | | | 36 | 876,1 | 13,2 | | 36 | | | |
| 2 | 0 " | | sand eel | 2 | 286,1 | 11,5 | sand eel | 2 | 7259,3 | 11,2 | sand eel | 2 | 8,9 | 11,9 | sand eel |
| 10 | 17,9 | 9,2 | | 10 | 737,6 | 10,7 | | 10 | 697,3 | 12,3 | | 10 | 40,2 | 16,7 | |
| 17 | 299,5 | 8,7 | | 17 | 4809,7 | 11,3 | | 17 | 1198 | 13,4 | | 17 | 111,8 | 23,5 | |
| 22 | 160,9 | 7,3 | | 22 | 831,4 | 11 | | 22 | 250,3 | 17,2 | | 22 | 0,0 " | | |
| 29 | 0 " | | | 29 | 8,9 | 12,3 | | 29 | 8,9 | 17,9 | | 29 | 22,4 | 20,3 | |
| 33 | | | | 33 | | | | 33 | 178,8 | 11,6 | | 33 | 71,5 | 15,9 | |
| 36 | | | | 36 | 219 | 9,2 | | 36 | 116,2 | 13,4 | | 36 | | | |
| | | | | 2 | 4,5 | 27,7 | herring | | | | | | | | |
| | | | | 10 | 0 " | | | | | | | | | | |
| | | | | 17 | 0 " | | | | | | | | | | |
| | | | | 22 | 0 " | | | | | | | | | | |
| | | | | 29 | 8,9 | 31 | | | | | | | | | |
| | | | | 33 | | | | | | | | | | | |
| | | | | 36 | 0 " | | | | | | | | | | |
| 2 | 0 " | | snake blenn | 2 | 4,5 | 34 | snake blenn | 2 | 17,9 | 42 | snake blenny | | | | |
| 10 | 17,9 | 19,2 | | 10 | 31,3 | 27,5 | | 10 | 143 | 38,5 | | | | | |
| 17 | 40,2 | 17,1 | | 17 | 232,4 | 26,7 | (13.1) | 17 | 0 " | | | | | | |
| 22 | 62,6 | 17,6 | | 22 | 8,9 | 23,8 | | 22 | 26,8 | 31,7 | | | | | |
| 29 | 0 " | | | 29 | 0 " | | | 29 | 0 " | | | | | | |
| 33 | | | | 33 | | | | 33 | 0 " | | | | | | |
| 36 | | | | 36 | 0 " | | | 36 | 0 " | | | | | | |
| | | | | 2 | 13,4 | 17,5 | butterfish | 2 | 71,5 | 25 | butterfish | 2 | 8,94 | 24,8 | butterfish |
| | | | | 10 | 0 " | | | 10 | 89,4 | 22,8 | | 10 | 0 " | | |
| | | | | 17 | 8,9 | 17 | | 17 | 0 " | | | 17 | 0 " | | |
| | | | | 22 | 0 " | | | 22 | 8,9 | 22,6 | | 22 | 0 " | | |
| | | | | 29 | 0 " | | | 29 | 0 " | | | 29 | 0 " | | |
| | | | | 33 | | | | 33 | 17,9 | 25,5 | | 33 | 0 " | | |
| | | | | 36 | 0 " | | | 36 | 0 " | | | 36 | | | |
| | | | | 2 | 0 " | | seasnail | 2 | 53,6 | 6,2 | seasnail | | | | |
| | | | | 10 | 0 " | | | 10 | 0 " | | | | | | |
| | | | | 17 | 80,5 | 7,3 | | 17 | 0 " | | | | | | |
| | | | | 22 | 8,9 | 9,9 | | 22 | 8,9 | 8 | | | | | |
| | | | | 29 | 4,5 | 8,3 | | 29 | 0 " | | | | | | |
| | | | | 33 | | | | 33 | 0 " | | | | | | |
| | | | | 36 | 0 " | | | 36 | 0 " | | | | | | |
| | | | | 2 | 0 " | | sea scorpio | 2 | 0 " | | sea scorpion | | | | |
| | | | | 10 | 0 " | | | 10 | 0 " | | | | | | |
| | | | | 17 | 17,9 | 10,5 | | 17 | 0 " | | | | | | |
| | | | | 22 | 0 " | | | 22 | 0 " | | | | | | |
| | | | | 29 | 0 " | | | 29 | 0 " | | | | | | |
| | | | | 33 | | | | 33 | 8,9 | 13,7 | | | | | |
| | | | | 36 | 4,5 | 7,5 | | 36 | 0 " | | | | | | |
| | | | | | | | | 2 | 35,8 | 33,5 | rockling ssp | 2 | 0 " | | rockling ssp |
| | | | | | | | | 10 | 0 " | | | 10 | 0 " | | |
| | | | | | | | | 17 | 0 " | | | 17 | 4,47 | 25 | |
| | | | | | | | | 22 | 0 " | | | 22 | 0 " | | |
| | | | | | | | | 29 | 0 " | | | 29 | 4,47 | 2,9 | |
| | | | | | | | | 33 | 0 " | | | 33 | 0 " | | |
| | | | | | | | | 36 | 0 " | | | 36 | | | |
| | | | | | | | | 2 | 17,9 | 9,7 | pogge | | | | |
| | | | | | | | | 10 | 0 " | | | | | | |
| | | | | | | | | 17 | 0 " | | | | | | |
| | | | | | | | | 22 | 8,9 | 15,4 | | | | | |
| | | | | | | | | 29 | 0 " | | | | | | |
| | | | | | | | | 33 | 0 " | | | | | | |
| | | | | | | | | 36 | 0 " | | | | | | |

Table 5.4. Number/1000 $m^3$ and average diameter (mm) of eggs at individual stations and months in 1993.

**June 7-9, 1993**

**Eggs**

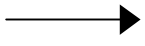
| station | nr/1000m3 | av.diam.(mm | species |
|---|---|---|---|
| 2 | 0 | | cod |
| 10 | 0 | | |
| 17 | 4,3 | 1,32 | |
| 22 | 0 | | |
| 29 | 0 | | |
| 33 | 0 | | |
| 36 | | | |
| | | | |
| 2 | | | plaice |
| 10 | 4,3 | 1,8 | |
| 17 | | | |
| 22 | | | |
| 29 | | | |
| 33 | | | |
| 36 | | | |
| | | | |
| 2 | | | rough dab |
| 10 | | | |
| 17 | 6,5 | 2,85 | |
| 22 | 13 | 2,78 | |
| 29 | | | |
| 33 | | | |
| 36 | | | |
| | | | |
| 2 | | | dab |
| 10 | | | |
| 17 | 2,2 | 0,9 | |
| 22 | | | |
| 29 | | | |
| 33 | | | |
| 36 | | | |
| | | | |
| 2 | 112,3 | 0,82 | rockling |
| 10 | 0 | | |
| 17 | 10,8 | 0,82 | |
| 22 | 138,2 | 0,8 | |
| 29 | 17,3 | 0,83 | |
| 33 | 25,9 | 0,83 | |
| 36 | | | |

**July 14-16, 1993**

**Eggs**

| station | nr/1000m3 | av.diam.(mm | species | |
|---|---|---|---|---|
| 2 | | | | |
| 10 | | | | |
| 17 | | | | |
| 22 | | | | |
| 29 | | | | |
| 33 | | | | |
| 36 | | | | |
| | | | | |
| 2 | | | plaice | |
| 10 | | | | |
| 17 | | | | |
| 22 | | | | |
| 29 | 17,3 | 1,28 | | |
| 33 | | | | |
| 36 | | | | |
| | | | | |
| 2 | | | rough dab | |
| 10 | | | | |
| 17 | | | | |
| 22 | 4,3 | 2,6 | | |
| 29 | 2,2 | | | |
| 33 | | | | |
| 36 | | | | |
| | | | | |
| 2 | 0,0 | | dab | |
| 10 | 0,0 | | | |
| 17 | 4,3 | 0,8 | | |
| 22 | 2,2 | 0,8 | | |
| 29 | 0,0 | | | |
| 33 | 8,6 | 0,76 | | |
| 36 | 4,3 | 0,8 | | |
| | | | | |
| 2 | 0,0 | | lemon sole | |
| 10 | 0,0 | | | |
| 17 | 69,1 | 1,25 | | |
| 22 | 125,3 | 1,26 | | |
| 29 | 71,3 | 1,28 | | |
| 33 | 114,5 | 1,25 | | |
| 36 | 23,8 | 1,27 | | |
| | | | | |
| 2 | 0,0 | | rockling | |
| 10 | 4,3 | 0,81 | | |
| 17 | 6,5 | 0,79 | | |
| 22 | 84,2 | 0,78 | | -1,3 |
| 29 | 38,9 | 0,8 | | |
| 33 | 23,8 | 0,78 | | |
| 36 | 6,5 | 0,81 | | |

Table 5.5 (next page). Number/1000 $m^3$ and average standard length (mm) of larvae at individual stations and months in 1993.



**June 7-9, 1993**

**Larvae**

| station | nr/1000m3 | av. SL (mm) | species |
|---|---|---|---|
| 2 | 0 | " | cod |
| 10 | 0 | " | |
| 17 | 0 | " | |
| 22 | 0 | " | |
| 29 | 2,2 | 19 | |
| 33 | 6,5 | 11,0 | |
| 36 | 0,0 | " | |
| 2 | 0,0 | " | plaice |
| 10 | 0,0 | " | |
| 17 | 0,0 | " | |
| 22 | 0,0 | " | |
| 29 | 2,2 | 12,6 | |
| 33 | 0,0 | " | |
| 36 | 0,0 | " | |
| 2 | 0 | " | rough dab |
| 10 | 0 | " | |
| 17 | 0 | " | |
| 22 | 4,3 | 6,1 | |
| 29 | 0 | " | |
| 33 | 0 | " | |
| 36 | | | |
| 2 | 0,0 | " | dab |
| 10 | 0,0 | " | |
| 17 | 0,0 | " | |
| 22 | 2,2 | 9,9 | |
| 29 | 0,0 | " | |
| 33 | 0,0 | " | |
| 36 | 0,0 | " | |
| 2 | 0,0 | " | lemon sole |
| 10 | 0,0 | " | |
| 17 | 0,0 | " | |
| 22 | 0,0 | " | |
| 29 | 2,2 | 4,9 | |
| 33 | 0,0 | " | |
| 36 | 0,0 | " | |
| 2 | 4,3 | 7,1 | capelin |
| 10 | 25,9 | 7,1 | |
| 17 | 4,3 | 8,2 | |
| 22 | 0 | " | |
| 29 | 0 | " | |
| 33 | 0 | " | |
| 36 | | | |
| 2 | 6,5 | 16,7 | sand eel |
| 10 | 4,3 | 16,3 | |
| 17 | 19,4 | 16,6 | |
| 22 | 17,3 | 13,1 | |
| 29 | 0 | " | |
| 33 | 0 | " | |
| 36 | | | |
| 2 | 2,2 | " | herring |
| 10 | 0,0 | " | |
| 17 | 0,0 | " | |
| 22 | 0,0 | " | |
| 29 | 0,0 | " | |
| 33 | 0,0 | " | |
| 36 | 0,0 | " | |
| 2 | 2,2 | 35,5 | snake blenny |
| 10 | 0 | " | |
| 17 | 17,3 | 22,5 | |
| 22 | 0 | " | |
| 29 | 0 | " | |
| 33 | 8,6 | 20,6 | |
| 36 | | | |
| 2 | 6,5 | 22,9 | butterfish |
| 10 | 0 | " | |
| 17 | 0 | " | |
| 22 | 0 | " | |
| 29 | 0 | " | |
| 33 | 0 | " | |
| 36 | | | |
| 2 | 0 | " | sea snail |
| 10 | 0 | " | |
| 17 | 4,3 | 9,3 | |
| 22 | 0 | " | |
| 29 | 0 | " | |
| 33 | 0 | " | |
| 36 | | | |

**July 14-16, 1993**

**Larvae**

| station | nr/1000m3 | av. SL (mm) | species |
|---|---|---|---|
| 2 | 0 | " | cod |
| 10 | 0 | " | |
| 17 | 0 | " | |
| 22 | 0 | " | |
| 29 | 2,2 | 19 | |
| 33 | 6,5 | 11,0 | |
| 36 | 0,0 | " | |
| 2 | 0,0 | " | plaice |
| 10 | 0,0 | " | |
| 17 | 0,0 | " | |
| 22 | 0,0 | " | |
| 29 | 2,2 | 12,6 | |
| 33 | 0,0 | " | |
| 36 | 0,0 | " | |
| 2 | 0,0 | " | rough dab |
| 10 | 0,0 | " | |
| 17 | 0,0 | " | |
| 22 | 6,5 | 14,2 | |
| 29 | 6,5 | 14,9 | |
| 33 | 2,2 | 12,7 | |
| 36 | 0,0 | " | |
| 2 | 0,0 | " | dab |
| 10 | 0,0 | " | |
| 17 | 0,0 | " | |
| 22 | 2,2 | 9,9 | |
| 29 | 0,0 | " | |
| 33 | 0,0 | " | |
| 36 | 0,0 | " | |
| 2 | 0,0 | " | lemon sole |
| 10 | 0,0 | " | |
| 17 | 0,0 | " | |
| 22 | 0,0 | " | |
| 29 | 2,2 | 4,9 | |
| 33 | 0,0 | " | |
| 36 | 0,0 | " | |
| 2 | 4,3 | 18,1 | capelin |
| 10 | 13,0 | 16,8 | |
| 17 | 4,3 | 10,1 | |
| 22 | 136,1 | 21,1 | |
| 29 | 179,3 | 19,8 | |
| 33 | 99,4 | 18,3 | |
| 36 | 60,5 | 17,7 | |
| 2 | 6,5 | 17,3 | sand eel |
| 10 | 0,0 | " | |
| 17 | 0,0 | " | |
| 22 | 2,2 | 8,8 | |
| 29 | 4,3 | 26,0 | |
| 33 | 41,0 | 30,5 | |
| 36 | 0,0 | " | |
| 2 | 2,2 | " | herring |
| 10 | 0,0 | " | |
| 17 | 0,0 | " | |
| 22 | 0,0 | " | |
| 29 | 0,0 | " | |
| 33 | 0,0 | " | |
| 36 | 0,0 | " | |
| 2 | 0,0 | " | snake blenny |
| 10 | 0,0 | " | |
| 17 | 0,0 | " | |
| 22 | 0,0 | " | |
| 29 | 2,2 | 29,4 | |
| 33 | 0,0 | " | |
| 36 | 2,2 | 38,2 | |
| 2 | 2,2 | 26,2 | butterfish |
| 10 | 0,0 | " | |
| 17 | 0,0 | " | |
| 22 | 0,0 | " | |
| 29 | 0,0 | " | |
| 33 | 0,0 | " | |
| 36 | 2,2 | 26,7 | |
| 2 | 0,0 | " | sea snail |
| 10 | 0,0 | " | |
| 17 | 0,0 | " | |
| 22 | 0,0 | " | |
| 29 | 13,0 | 9,8 | |
| 33 | 4,3 | 8,6 | |
| 36 | 2,2 | 7,1 | |
| 2 | 0,0 | " | pogge |
| 10 | 0,0 | " | |
| 17 | 0,0 | " | |
| 22 | 0,0 | " | |
| 29 | 2,2 | 22 | |
| 33 | 0 | " | |
| 36 | 0 | " | |

Table 5.6. Number of juveniles/1000 $m^3$ caught at each of three 0-group stations sampled in August. a) 1992, b) 1993.

**August 18, 1992**

Juveniles/1000$m^3$

| station/ species | cod | rough dab | capelin | herring | sand eel | snake blenny | wolffish | lumpsucker |
|---|---|---|---|---|---|---|---|---|
| 66°10 (III) | 0,08 | 0,01 | 4,1 | 0,1 | 0,01 | (+) | (+) | (+) |
| 65°57 (II) | 0,03 | 0,02 | 9,3 | 1,4 | 0,7 | 0,7 | 0 | 0 |
| 65°50 (I) | 0,02 | (+) | 0,6 | 0,9 | 0 | 0,2 | 0 | 0 |
| Average | 0,04 | 0,01 | 4,67 | 0,81 | 0,24 | 0,29 | 0 | 0 |

**August 19, 1993**

Juveniles/1000$m^3$

| station/ species | cod | haddock | lumpsucker |
|---|---|---|---|
| 66°10 (III) | 2,8 | 0,1 | 0,01 |
| 65°57 (II) | 1 | 0,07 | 0 |
| 65°50 (I) | 0,08 | 0,02 | 0 |
| Average | 1,29 | 0,06 | 0 |

## 6. BENTHIC MACROFAUNA

Study on benthic macrofauna was carried out at a single location (station 10 in Figure 1.2). The aim of the investigation was to obtain information on species composition and temporal changes in abundance and biomass of the most important species.

### Methods

During the period April 1992 to August 1993 sampling of macrofauna was undertaken at one station in 15 cruises (station 10, Table 1.1, Figure 1.2). The sediments were mud to muddy sand (Hafliðason 1984). At each sampling date three replicate samples were taken, using van Veen grab (0.1 $m^2$). The sediment was sieved through a series of sieves (4.0, 1.0 and 0.5 mm) and the material preserved in 4% neutralised formaldehyde seawater solution. In the laboratory fauna were sorted from the sediments, identified to lowest possible taxon, counted and weighed (wet weight, ± 0,001 g).

For each sampling date pooled data from three replicate grab samples were used to estimate changes in species richness. In order to examine the temporal changes in species richness samples were standardized by estimating the 'expected' number of species from *n* individuals (rarefaction, $ES_n$), using number of individuals in the smallest sample (August 1993, *n* = 217) as the standard sample size (Magurran 1988).

### Results

A total of 17,016 specimens of macrofauna were identified to 53 taxa. The abundance and biomass of each taxon at given sampling date is given in Table 6.1 and 6.2, respectively.

*Total abundance and biomass*

Foraminifera and Polychaeta were the most common components of the macrofauna in Eyjafjörður with total abundance of 12,646 (74.68 %) and 3,585 individuals (21.17 %), respectively (Table 6.3). Surely the numbers of Foraminifera were overestimated because the specimens were easily broken and no morphological attribute ("head", "tail") could facilitate accurate counting. In terms of total biomass three phylum were dominating; Mollusca (119,366.5 mg, 37.69 %), Polychaeta (107,240.5 mg, 33.86 %) and Echinodermata (7,2471.0 mg, 22.88 %, Table 6.3).

No effort was made to identify the Foraminifera material to species level. It was, however, believed to consist of a single species with total abundance of 12,646 individuals (Table 6.4). Five polychaeta species also dominated the macrofauna at station 10 in Eyjafjörður, where *Cossura longocirrata* was the most common one (1,202 individuals in total) followed by *Paraonis fulgens*, *Chaetozone setosa*, *Maldane sarsi* and *Nephtys* sp. (502, 382, 329 and 220 individuals in total, respectively). *Nuculoma tenuis* was the only Molluscan among the ten most dominant species (176 individuals in total).

In terms of total biomass *Yoldia hyperborea* was the most dominant species (102,365 mg, Table 6.5) but another bivalve, *Nuculoma tenuis*, was also

common (15,696 mg). The second most dominant taxon was the Asteroid *Ctenodiscus crispatus*, 72,471 mg. Several Polychaeta species contributed significantly to the total biomass; *Nephtys* sp. (56,418 mg), *Scalibregma inflatum* (32,756 mg), *Maldane sarsi* (9,768 mg) and *Sternaspis scutata* (1,994 mg). The large amphipod, *Ceradocus torelli*, was also of a considerable biomass, 11,896 mg.

*Temporal changes, total macrofauna*

When the study commenced (April 1992) the macrofauna abundance was high (average abundance 7,273.3 individuals/$m^2$, Figure 6.1a). The macrofauna density declined through spring and summer and reached a low in August (3,323.3 individuals/$m^2$) followed by an increased density in September (7,443.3 individuals/$m^2$). Between 30 September 1992 and 5 January 1993 only one sampling trip was made, 16 – 18 November, indicating reduced total abundance (3,780.0 individuals/$m^2$). The total abundance was, however, highest in January (7,556.7 individuals/$m^2$) followed by a sharp decline the following month. During the period March to May the macrofauna abundance increased again reaching maximum of 3.683.3 individuals/$m^2$ before a rather rapid decline occurred at the end of the study period, reaching lowest values of 726.7 individuals/$m^2$.

In general the mean total macrofauna biomass increased steadily from a low value at the onset of study (23.7 g/$m^2$, Figure 6.1b) reaching maximum values during the period March – June 1993 (85.5 to 140.1 g/$m^2$). During the last two months of the study the biomass dropped to low values again (37.4 g/$m^2$, in August).

*Diversity*

Total number of species varied between 12 (August 1993) and 24 (July 1992, Figure 6.2a). Diversity measured by expected numbers of species (ES(n)) suggested low diversity during the winter months (Figure 6.2b). Peak diversity occurred in July and August 1992 and in spring 1993 (March – May) followed by a decreasing diversity at the end of study period (August 1993).

*Temporal changes in the abundance of dominant species*

The Foraminiferans abundance ranged between 586.7 and 7076.7 individuals/$m^2$, Figure 6.3a). They increased in numbers during spring, both years, but their densities declined during summer (1993) or late summer (1992). Maximum densities occurred in September and January.

The polychaetes *Cossura longocirrata* (range: 3.3 – 2,943.3 individuals/$m^2$), *Paraonis fulgens* (range: 13.3 – 1,353.3 individuals/$m^2$) and *Chaetozone setosa* (range: 3.3 – 440.0 individuals/$m^2$) were in high numbers when the study commenced. However, the densities were negligible in the following autumn (Figure 6.3a-d) and they barely existed for the rest of the study period. Other dominant polychaetes, *Maldane sarsi* (range: 30.0 – 180.0 individuals/$m^2$), and *Nephtys* sp. (range: 23.3 – 96.7 individuals/$m^2$), had higher average densities during summer 1992 than in summer 1993 (Figure 6.3e-f).

The average density of the bivalve *Nuculoma tenuis* (range: 20.0 – 66.7 individuals/$m^2$) peaked through spring and summer, in both years (Figure 6.3g), but were low in abundance during most part of the winter.

*Temporal changes in the biomass of dominant species*

92% of the total biomass of the macrofauna community in Eyjafjörður was contributed by seven species (Figure 6.4). Although most of the species occurred in the majority of the sampling months some, however, occurred infrequently during the study period (*Ctenodiscus crispatus*, *Scalibregma inflatum* and to some degree *Ceradocus torelli*, Figure 6.5b, d and f).

The biomass of *Yoldia hyperborea* (range: 6.6 – 43.0 g /$m^2$) increased during summer 1992 and peaked in the autumn (Figure 6.5a). In 1993 the peak occurred in the spring (May). During winter the biomass was relatively low. *Nephtys* sp. (range: 0.2 – 53.9 g /$m^2$) peaked in biomass during summer (June or July, Figure 6.5c) and in November (SD very high, however) but had low values during late winter and spring (1993). *Nuculoma tenuis* (range: 0.01 – 7.3 g /$m^2$) increased in biomass from April to August (1992, Figure 6.5e) and it showed, in general, a progressively less biomass numbers through the winter months. Rising biomass occurred in March to July (1993), when it was at the maximum before dropping again in August. The biomass of *Maldane sarsi* (range: 0.1 – 10.4 g /$m^2$) peaked sharply in July 1992 but stayed relatively low most of the study period (Figure 6.5g).

**References:**

Hafliðason, H. 1984: The marine geology of Eyjafjördur, North Iceland: Sedimentological, petrographical and stratigraphical studies. M.Phil. thesis, 281 ps.

Magurran, A.E. 1988. Ecological Diversity and Its Measurement, University Press, Cambridge, 179 ps.

Table 6.1. Benthic macrofauna in Eyjafjörður (station 10). Total number of benthic taxon in each grab sample (a - c, van Veen grab (0.01 $m^2$)) at each sampling date (months) during the period April 1992 to August 1993. For colonial animals the number of individuals is not given but their occurrance indicated with x. Number of species and total number of individuals per grab is given at the bottom of the table.

| | | | 1992 | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | April | | | May | | | June | | | July | | | August | | | September | | | November | | |
| Phylum | | Species | a | b | c | a | b | c | a | b | c | a | b | c | a | b | c | a | b | c | a | b | c |
| Foraminifera | | | | | 400 | 608 | 409 | 28 | 452 | 286 | 220 | 376 | 262 | 630 | 77 | 194 | 387 | 547 | 602 | 931 | 121 | 483 | 390 |
| Porifera | | | | | | | | | | | x | | | | | | | | | | | | |
| Hydrozoa | | | | | | | | | x | | | | x | | | | | | | | | | |
| Nemertinea | | | | | | | | | | | | | | | | | | | | | | | |
| Nematoda | | | | | 36 | 83 | 70 | | 7 | 23 | 30 | 2 | 7 | 7 | 10 | | | 4 | | 10 | 5 | 8 | 5 |
| Polychaeta | | Polychaeta spp. | 81 | 55 | 50 | 1 | 3 | | 20 | 9 | 31 | 15 | 27 | 17 | 47 | 54 | 8 | 10 | | 1 | | 19 | |
| | Aphroditidae | Aphroditidae sp. | | | | | 1 | | | | | | | | | 1 | | | 2 | | | | 6 |
| | | *Harmothoe nodosa* | | | 1 | 1 | 1 | | | | | | | | | | | | | | | | |
| | | *Harmothoe* sp. | | | | | | | | | | | | | | | | | | | | | |
| | Phyllodocidae | *Eteone longa* | 19 | 11 | 13 | 2 | 3 | 1 | 2 | 2 | | 7 | 1 | 1 | 2 | | | | | | | 6 | |
| | Nephtyidae | *Nephtys* sp. | 8 | 6 | 15 | 4 | 7 | 7 | 5 | 6 | 6 | 9 | 6 | 5 | 3 | 4 | 4 | 5 | 18 | 1 | 2 | 4 | 7 |
| | Lumbrineridae | Lumbrineridae sp. | | | | | | | | | | | | | | | | | 3 | | | | |
| | | *Lumbrineris fragilis* | 4 | 1 | 6 | 1 | 2 | 1 | 1 | | | 2 | | 1 | | 2 | 1 | | 3 | 1 | | 3 | |
| | Spionidae | Spionidae sp. | | | | | | | | | | | | | | | | | | | | | |
| | Paraonidae | Paraonidae sp. | | | | | | | | | | | | | | | | | | | | | |
| | | *Paraonis fulgens* | 192 | 122 | 92 | | 5 | | 11 | 4 | | 26 | 6 | | 3 | 6 | 7 | | 8 | | | | |
| | Cirratulidae | Cirratulidae sp. | | | | | | | | | | | | | 1 | | | | | | | | |
| | | *Chaetozone setosa* | 60 | 32 | 40 | 13 | 23 | 19 | 23 | 32 | 16 | 25 | 4 | 3 | 14 | 11 | 12 | | 1 | | 1 | 10 | |
| | Cossuridae | *Cossura longocirrata* | 458 | 276 | 149 | 39 | 79 | 7 | 34 | 30 | 4 | 4 | 9 | 6 | 68 | | | | | | | 3 | |
| | Opheliidae | Opheliidae sp. | | | | | | | | | | | | | | | 2 | | | | | | |
| | Scalibregmatidae | *Scalibregma inflatum* | | | | 1 | | 1 | | 1 | 2 | | | | | | | | | | | | |
| | Capitellidae | Capitellidae sp. | | | 7 | | | | 17 | 10 | 18 | 6 | 9 | 7 | 2 | | | | | | | | |
| | Maldanidae | Maldanidae sp. | | | | | | | 11 | | | | | | | | | | | | | | |
| | | *Maldane sarsi* | 7 | 8 | 14 | 7 | 9 | 3 | | 7 | 7 | 15 | 21 | 18 | 12 | 9 | 13 | 1 | 9 | 11 | | 4 | 5 |
| | Sternaspidae | *Sternaspis scutata* | | | 1 | | | | | | | | | | | | | | 1 | | | | |
| | Pectinariidae | *Pectinaria koreni* | | | | | | | | | | | | | | | | | | 1 | | | 2 |

Table 6.1 continued

1992

| Phylum | | Species | April a | April b | April c | May a | May b | May c | June a | June b | June c | July a | July b | July c | August a | August b | August c | September a | September b | September c | November a | November b | November c |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ampharetidae | Ampharetidae sp. | | | 1 | | | | | | | | | | | | | | | | | | |
| | | *Amage auricula* cf. | 1 | | | | | | | | | | | | | | | | | | | | |
| | | *Melinna cristata* | | | | | | | | | | | | | | | 1 | | | | | | |
| | Terebellidae | *Terebellides stroemi* | | | | | | | | | | | | | | 1 | | | 1 | | | 1 | 1 |
| | Oweniidae | Oweniidae sp. | | | | | | | | | | 6 | | | 7 | 2 | | | 10 | 4 | 8 | | |
| Crustacea | Copepoda | | | | | | | | | | | | | | | | | | | | | | |
| | Harpacticoida | | | | 2 | 2 | | | | | | | 4 | | | | | | | | | | |
| | Cumacea | Cumacea sp. | | | | | | | 1 | | | 1 | | | | | | | | | | | 2 |
| | | *Leucon nasica* | | | 2 | | 1 | 2 | | 5 | | 1 | 1 | 2 | | | | 1 | 1 | | 1 | 2 | 2 |
| | Tanaidacea | | | | 6 | 7 | 3 | | | 7 | 1 | 13 | 1 | 4 | 3 | 1 | | | 1 | 1 | | 4 | |
| | Amphipoda | Amphipoda sp. | | | | | | | | | | 2 | | | 1 | | | | 1 | 1 | | | 1 |
| | | *Ceradocus torelli* | | | | | | 1 | | | 1 | | 3 | 1 | | | | | | | | | 2 |
| | Brachyura | *Hyas araneus* | | | | | | | | | | | | | | | | | 1 | | | | |
| Mollusca | Bivalvia | Bivalvia sp. | | | | 3 | | | | 1 | | 1 | | | | | | | | | | | |
| | | *Nuculoma tenuis* | 3 | | 3 | | 4 | 3 | | | | 3 | 5 | 2 | 6 | 5 | 7 | 3 | 4 | 3 | 6 | 5 | 1 |
| | | *Nuculana* sp. | | | | | | | | | | | | | | | | | | 1 | | | |
| | | *Yoldia hyperborea* | | | | 1 | | 3 | | 3 | 1 | 1 | 1 | 1 | 3 | | 1 | 1 | 2 | 1 | 2 | 3 | 2 |
| | | *Modiolus modiolus* | | | | | | | | | | | | | | | | | | | | | |
| | | *Thyasira flexuosa* | | | | | | | | | | | | | | | | | | | | | |
| | | *Abra prismatica* | | | | | | | | | | | | | | | | | 2 | | | | |
| | | *Macoma calcarea* | | | | | 1 | | | | | | | | | | | | | | | | |
| | | *Mya truncata* | | | | | | 1 | | | | | | | | | | | | | | | |
| | Gasropoda | Prosobranchia sp. | | | | | | | | | | | 1 | | | | | | | | | | |
| | | *Lunatia pallida* | | | | | | | | | | | | | | | | | | | | | |
| | | *Oenopoda* sp. | | | | | | | | | | | | | | | | | | | | | |
| Bryozoa | | | | | | | | | | | | | x | x | x | x | | x | x | x | x | | x |
| Echinodermata | Asteroidea | *Ctenodiscus crispatus* | | | | | | | | | | | | | | | | | | | | | |
| | | Number of species | 10 | 8 | 18 | 15 | 16 | 13 | 13 | 15 | 13 | 19 | 19 | 16 | 17 | 13 | 11 | 9 | 19 | 14 | 9 | 14 | 14 |
| | | Total number of individuals | 2825 | 511 | 838 | 773 | 621 | 77 | 584 | 426 | 337 | 515 | 368 | 705 | 259 | 290 | 443 | 572 | 670 | 967 | 146 | 555 | 426 |

Table 6.1 continued

| Phylum | | Species | 1993 January a | b | c | February a | b | c | March a | b | c | April a | b | c | May a | b | c | June a | b | c | July a | b | c | August a | b | c |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Foraminifera | | | 709 | 953 | 461 | 73 | 120 | 60 | 230 | 245 | 196 | 180 | 241 | 150 | 215 | 300 | 403 | 140 | 95 | 100 | 64 | 115 | 17 | 53 | 47 | 76 |
| Porifera | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Hydrozoa | | | | | | | | | | | | | | | | | | x | | | | | | | | |
| Nemertinea | | | | | | | | | | | | | | | | | | | | | | | 2 | | | |
| Nematoda | | | | 1 | | | | | | | | | 1 | | | | 4 | | | | | | | | | |
| Polychaeta | | Polychaeta spp. | 12 | 31 | 19 | 5 | 7 | 5 | 2 | 3 | 17 | | | | | 4 | 4 | 4 | 4 | 8 | 6 | | | 4 | | |
| | Aphroditidae | Aphroditidae sp. | | | | | | | | | | | | | | | | | | | | | | | | |
| | | *Harmothoe nodosa* | 1 | | | | | | | | | | | | | | | | | | | | 1 | | | |
| | | *Harmothoe* sp. | | | | | | | 2 | 1 | | | | | | | | | | | | | 1 | | | |
| | Phyllodocidae | *Eteone longa* | 1 | 2 | 1 | | | | | | 1 | | 1 | | | 1 | 3 | | | | | | | | | |
| | Nephtyidae | *Nephtys* sp. | 6 | 3 | 1 | | 1 | 7 | 4 | 4 | 7 | 5 | 5 | 1 | 9 | 5 | 3 | 5 | 4 | 3 | 1 | 3 | 4 | 2 | 3 | 2 |
| | Lumbrineridae | Lumbrineridae sp. | | | | | | | | | | | | | | | | | | | | | | | | |
| | | *Lumbrineris fragilis* | 2 | 2 | 1 | 1 | 1 | | 4 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 1 | | | | | 1 | | | 1 | 1 |
| | Spionidae | Spionidae sp. | | | | | | | | | 3 | | | | | | | | | | | | | | | |
| | Paraonidae | Paraonidae sp. | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| | | *Paraonis fulgens* | | | | | | | | | | | 4 | | 9 | 2 | 5 | | | | | | | | | |
| | Cirratulidae | Cirratulidae sp. | | | | | | | | | | | | | | | | 1 | | | | | | | | |
| | | *Chaetozone setosa* | 10 | 6 | 1 | | | 1 | | | 3 | | 2 | 3 | 3 | 5 | 8 | | | 1 | | | | | | |
| | Cossuridae | *Cossura longocirrata* | 1 | | 3 | | | | | | | | | | 1 | 1 | 29 | | | | | | | | | 1 |
| | Opheliidae | Opheliidae sp. | | | | | 1 | | | | | | 1 | | | | | | | | | | | | | |
| | Scalibregmatidae | *Scalibregma inflatum* | 1 | | | 1 | | | 2 | 1 | | | | | 1 | | | 1 | 1 | | | 1 | 1 | | | |
| | Capitellidae | Capitellidae sp. | 1 | | | | | | | | 2 | | | | | | | | | 2 | | | | | | |
| | Maldanidae | Maldanidae sp. | | | | | | | | | | | | | | | | | 2 | | | | | | | |
| | | *Maldane sarsi* | 6 | 3 | 8 | 15 | 3 | 1 | 6 | 12 | 8 | 5 | 7 | 2 | 9 | 7 | 16 | 13 | 3 | 6 | 6 | 1 | 3 | 4 | 3 | 2 |
| | Sternaspidae | *Sternaspis scutata* | | | 1 | | 1 | 1 | | | | | | | 1 | 3 | | | | | 1 | | | | | |
| | Pectinariidae | *Pectinaria koreni* | | | | | | | | | 2 | | | | | | | | | | | | | | | |
| | Ampharetidae | Ampharetidae sp. | | | | | | | | | 2 | | | | | | 2 | | | | | | | | | |
| | | *Amage auricula* cf. | | | | | | | | | | | | | | | | | | | | | | | | |
| | | *Melinna cristata* | | | | | | | | | | | | 1 | | | | | | | 1 | | | | | |
| | Terebellidae | *Terebellides stroemi* | | | | | | | | | | | 1 | 2 | | | | | | | | | | | | |
| | Oweniidae | Oweniidae sp. | | | | | 1 | | | | 2 | | | 1 | | | | 1 | 4 | 7 | | | | | | |

Table 6.1 continued

| Phylum | | Species | 1993 January a | b | c | February a | b | c | March a | b | c | April a | b | c | May a | b | c | June a | b | c | July a | b | c | August a | b | c |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crustacea | Copepoda | | | 1 | | | | | | | | | | | | | | | | | | | | | | |
| | Harpacticoida | | | | | | | | 2 | | | | | | | | | | | | | | | | | |
| | Cumacea | Cumacea sp. | | | | | | | | 1 | | | | 1 | | | | 1 | | | | | | | | |
| | | *Leucon nasica* | | | 1 | | | | 2 | | | | | | | | 1 | | | 1 | | | | | | |
| | Tanaidacea | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Amphipoda | Amphipoda sp. | | | | | | | | | | | | | 1 | | | | | | | | | | | 1 |
| | | *Ceradocus torelli* | | 1 | | | | 1 | 1 | | | | 1 | | | | | | | | | | | 1 | | |
| | Brachyura | *Hyas araneus* | | | | | | | | | | | | | | | | | | | | | | | | |
| Mollusca | Bivalvia | Bivalvia sp. | | | | | | | | | | | | | | | | | | | | | | | | |
| | | *Nuculoma tenuis* | 5 | 2 | | 3 | 2 | 4 | 10 | 3 | 5 | 5 | 2 | 8 | 6 | 4 | 10 | 8 | 3 | 7 | 4 | 7 | 4 | 5 | 2 | 4 |
| | | *Nuculana* sp. | | | | | | | | | | | | | | | | | | | | | | | | |
| | | *Yoldia hyperborea* | 3 | | 4 | 2 | | 1 | 2 | 1 | 1 | 3 | 3 | 2 | 1 | 5 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | | | 4 |
| | | *Modiolus modiolus* | | | | | | | | | | | | | 1 | | | | | | | | | | | |
| | | *Thyasira flexuosa* | | | | | | | | | | | | | | | | | | 1 | | | | | | |
| | | *Abra prismatica* | | | | | | | | | | | | | | | | | 1 | | | | | | | |
| | | *Macoma calcarea* | | | | | | | | | | | | | | | | | | | | | | | | |
| | | *Mya truncata* | | | | | | | | | | | | | | | | | | | | | | | | |
| | Gasropoda | Prosobranchia sp. | | | | | | | | | | | | | | | | | | | | | | | | |
| | | *Lunatia pallida* | | | | | | | | | | | | | | | | | | 3 | | | | | | 1 |
| | | *Oenopoda* sp. | | | | | | | | | | | | | 1 | | | | | | | | | | | |
| Bryozoa | | | x | | x | | | x | x | | x | x | x | | x | x | x | | | | | | | | x | |
| Echinodermata | Asteroidea | *Ctenodiscus crispatus* | | | | | | 1 | | | 1 | 1 | | | 1 | | 1 | | 1 | | | | | | | |
| | | Number of species | 14 | 11 | 12 | 7 | 9 | 11 | 13 | 10 | 16 | 8 | 15 | 11 | 16 | 13 | 16 | 11 | 12 | 11 | 8 | 7 | 9 | 6 | 8 | 7 |
| | | Total number of individuals | 2751 | 1005 | 501 | 100 | 137 | 82 | 267 | 273 | 253 | 202 | 272 | 174 | 261 | 340 | 492 | 175 | 120 | 140 | 85 | 129 | 35 | 69 | 58 | 90 |

Table 6.2. Benthic macrofauna in Eyjafjörður (station 10). Total biomass (mg) of benthic taxon in each grab sample (a - c. van Veen grab (0.01 $m^2$)) at each sampling date (months) during the period April 1992 to August 1993. Number of species and total biomass (g) per grab is given at the bottom of the table.

| | | | 1992 | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | April | | | May | | | June | | | July | | | August | | | September | | | November | | |
| Phylum | | Species | a | b | c | a | b | c | a | b | c | a | b | c | a | b | c | a | b | c | a | b | c |
| Foraminifera | | | | | 544 | 11 | 13 | 31 | 229 | 116 | 227 | 217 | 119.5 | 286 | 44 | 91.5 | 123.5 | 195 | 180 | 228.5 | 57.5 | 180 | 125 |
| Porifera | | | | | | | | | | | 1 | | | | | | | | | | | | |
| Hydrozoa | | | | | | | | | 1 | | | | 0.5 | | 0.5 | | | | | | | | |
| Nemertinea | | | | | | | | | | | | | | | | | | | | | | | |
| Nematoda | | | | | 1 | 0.5 | 2 | | 1 | 6 | 1 | 1 | 0.5 | 0.5 | 0.5 | | | 0.5 | | 1 | 1 | 1 | 0.5 |
| Polychaeta | | Polychaeta spp. | 51 | 80 | 84 | 125 | 45.5 | 45 | 3 | 4 | 12 | 13 | 4 | 10 | 24 | 40 | 4 | 19 | | 0.5 | | 17 | |
| | Aphroditidae | Aphroditidae sp. | | | | | 25 | | | | | | | | | 0.5 | | | 0.5 | | | | 36 |
| | | *Harmothoe nodosa* | | | 48 | 197 | 52 | | | | | | | | | | | | | | | | |
| | | *Harmothoe* sp. | | | | | | | | | | | | | | | | | | | | | |
| | Phyllodocidae | *Eteone longa* | 4.5 | 4 | 13 | 0.5 | 0.5 | 2 | 1 | 2 | | 1 | 0.5 | 0.5 | 1.5 | | | | | | | 1 | |
| | Nephtyidae | *Nephtys* sp. | 965 | 1254 | 1820 | 975 | 897 | 867 | 196 | 778 | 449 | 2710 | 611 | 2416 | 1845 | 1698 | 468 | 2547 | 471 | 97 | 138 | 186 | 15849 |
| | Lumbrineridae | Lumbrineridae sp. | | | | | | | | | | | | | | | | | 0.5 | | | | |
| | | *Lumbrineris fragilis* | 4.5 | 2 | 29.5 | 0.5 | 4.5 | 0.5 | 1 | | | 4 | | 0.5 | | 1 | 0.5 | | 4 | 0.5 | | 3 | |
| | Spionidae | Spionidae sp. | | | | | | | | | | | | | | | | | | | | | |
| | Paraonidae | Paraonidae sp. | | | | | | | | | | | | | | | | | | | | | |
| | | *Paraonis fulgens* | 140 | 91 | 113 | | 17 | | 9 | 5 | | 20.5 | 2 | | 3 | 6 | 9 | | 6 | | | | |
| | Cirratulidae | Cirratulidae sp. | | | | | | | | | | | | | 0.5 | | | | | | | | |
| | | *Chaetozone setosa* | 93 | 59 | 81 | 10 | 18.5 | 20 | 36 | 35 | 11 | 16 | 3 | 3 | 15 | 3 | 15 | | 1 | | 1 | 2 | |
| | Cossuridae | *Cossura longocirrata* | 21.5 | 17 | 9 | 0.5 | 3.5 | 1 | 0.5 | 3 | 1 | 0.5 | 1 | 1 | 5.5 | | | | | | | 1 | |
| | Opheliidae | Opheliidae sp. | | | | | | | | | | | | | | | 1 | | | | | | |
| | Scalibregmatidae | *Scalibregma inflatum* | | | | 1475 | | 323 | | 813 | 1261 | | | | | | | | | | | | |
| | Capitellidae | Capitellidae sp. | | | 26 | | | | 46 | 5 | 30 | 20 | 18 | 24 | 0.5 | | | | | | | | |
| | Maldanidae | Maldanidae sp. | | | | | | | 6 | | | | | | | | | | | | | | |
| | | *Maldane sarsi* | 187 | 621 | 747 | 236 | 352 | 106 | | 189 | 106 | 1415 | 1117 | 575 | 229 | 314 | 566 | 118 | 270 | 315 | | 38 | 73 |
| | Sternaspidae | *Sternaspis scutata* | | | 2 | | | | | | | | | | | | | | 216 | | | | |
| | Pectinariidae | *Pectinaria koreni* | | | | | | | | | | | | | | | | | | 270 | | | 443 |

Table 6.2 continued

1992

| Phylum | | Species | April a | April b | April c | May a | May b | May c | June a | June b | June c | July a | July b | July c | August a | August b | August c | September a | September b | September c | November a | November b | November c |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ampharetidae | Ampharetidae sp. | | | 1 | | | | | | | | | | | | | | | | | | |
| | | *Amage auricula* cf. | 4 | | | | | | | | | | | | | | | | | | | | |
| | | *Melinna cristata* | | | | | | | | | | | | | | | 305 | | | | | | |
| | Terebellidae | *Terebellides stroemi* | | | | | | | | | | | | | | 17 | | | 0.5 | | | 0.5 | 0.5 |
| | Oweniidae | Oweniidae sp. | | | | | | | | | | 1 | | | 2 | 0.5 | | | 5 | 3 | 7 | | |
| Crustacea | Copepoda | | | | | | | | | | | | | | | | | | | | | | |
| | Harpacticoida | | | | 0.5 | 0.5 | | | | | | | 0.5 | | | | | | | | | | |
| | Cumacea | Cumacea sp. | | | | | | | 0.5 | | | 1 | | | | | | | | | | | 1 |
| | | *Leucon nasica* | | | 0.5 | | 2 | 4 | | 15 | | 1 | 5 | 0.5 | | | | 0.5 | 1 | | 1 | 3 | 6 |
| | Tanaidacea | | | | 1 | 0.5 | 0.5 | | | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 0.5 | | | 0.5 | 0.5 | | 2 | |
| | Amphipoda | Amphipoda sp. | | | | | | | | | | 1 | | | 44 | | | | | 8 | | | 4 |
| | | *Ceradocus torelli* | | | | | | 877 | | | 1400 | | 2886 | 1401 | | | | | | | | | 1592 |
| | Brachyura | *Hyas araneus* | | | | | | | | | | | | | | | | | 8 | | | | |
| Mollusca | Bivalvia | Bivalvia sp. | | | | 1 | | | | 1 | | 1 | | | | | | | | | | | |
| | | *Nuculoma tenuis* | 2 | | 2 | | 163.5 | 269.5 | | | | 466 | 567 | 275 | 643 | 595 | 909.5 | 169 | 227 | 625 | 454 | 849 | 158 |
| | | *Nuculana* sp. | | | | | | | | | | | | | | | | | | 98 | | | |
| | | *Yoldia hyperborea* | | | | 298 | | 4186 | | 4867 | 465 | 25 | 1919 | 22 | 6213 | | 3687 | 2120 | 5270 | 1615 | 3170 | 5394 | 3440 |
| | | *Modiolus modiolus* | | | | | | | | | | | | | | | | | | | | | |
| | | *Thyasira flexuosa* | | | | | | | | | | | | | | | | | | | | | |
| | | *Abra prismatica* | | | | | | | | | | | | | | | | | 1 | | | | |
| | | *Macoma calcarea* | | | | | 0.5 | | | | | | | | | | | | | | | | |
| | | *Mya truncata* | | | | | | 0.5 | | | | | | | | | | | | | | | |
| | Gasropoda | Prosobranchia sp. | | | | | | | | | | | 1 | | | | | | | | | | |
| | | *Lunatia pallida* | | | | | | | | | | | | | | | | | | | | | |
| | | *Oenopoda* sp. | | | | | | | | | | | | | | | | | | | | | |
| Bryozoa | | | | | | | | | | | | | 47 | 19 | 1 | 1.5 | | 1 | 2 | 641 | 11 | | 0.5 |
| Echinodermata | Asteroidea | *Ctenodiscus crispatus* | | | | | | | | | | | | | | | | | | | | | |
| | | Number of species | 10 | 8 | 18 | 15 | 16 | 13 | 13 | 15 | 13 | 19 | 19 | 16 | 17 | 13 | 11 | 9 | 19 | 14 | 9 | 14 | 14 |
| | | Total biomass (g) | 3.46 | 2.13 | 3.52 | 3.33 | 1.60 | 6.73 | 0.53 | 6.84 | 3.97 | 4.92 | 7.30 | 5.03 | 9.07 | 2.77 | 6.09 | 5.17 | 6.66 | 3.90 | 3.84 | 6.68 | 21.73 |

Table 6.2 continued

1993

| Phylum | | Species | January a | January b | January c | February a | February b | February c | March a | March b | March c | April a | April b | April c | May a | May b | May c | June a | June b | June c | July a | July b | July c | August a | August b | August c |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Foraminifera | | | 298 | 364 | 153 | 11 | 16 | 15 | 19 | 81 | 17.5 | 62 | 77.5 | 56 | 65 | 107 | 148 | 58 | 40 | 53 | 26 | 38 | 10 | 19 | 18 | 26 |
| Porifera | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Hydrozoa | | | | | | | | | | | | | | | | | | 19 | | | | | | | | |
| Nemertinea | | | | | | | | | | | | | | | | | | | | | | | 18 | | | |
| Nematoda | | | | 0.5 | | | | | | | | | 0.5 | | | | 0.5 | | | | | | | | | |
| Polychaeta | | Polychaeta spp. | 8 | 31 | 15 | 27 | 68 | 18 | 77 | 1 | 77 | | | | | 8 | 8 | 33 | 69 | 396 | 139 | | | 25 | | |
| | Aphroditidae | Aphroditidae sp. | | | | | | | | | | | | | | | | | | | | | | | | |
| | | *Harmothoe nodosa* | 103 | | | | | | | | | | | | | | | | | | | | 165 | | | |
| | | *Harmothoe* sp. | | | | | | | 343 | 1220 | | | | | | | | | | | | | 14 | | | |
| | Phyllodocidae | *Eteone longa* | 0.5 | 1 | 0.5 | | | | | | 0.5 | | 0.5 | | | 0.5 | 1 | | | | | | | | | |
| | Nephtyidae | *Nephtys* sp. | 2125 | 403 | 953 | | 28 | 27 | 838 | 89 | 11 | 688 | 401 | 34 | 65 | 2172 | 497 | 2039 | 3371 | 2277 | 1 | 963 | 269 | 350 | 548 | 1032 |
| | Lumbrineridae | Lumbrineridae sp. | | | | | | | | | | | | | | | | | | | | | | | | |
| | | *Lumbrineris fragilis* | 5 | 3 | 1 | 0.5 | 0.5 | | 4 | 2 | 1 | 4 | 5 | 5 | 1 | 16 | 2 | | | | | 0.5 | | | 1 | 3 |
| | Spionidae | Spionidae sp. | | | | | | | | | 1 | | | | | | | | | | | | | | | |
| | Paraonidae | Paraonidae sp. | | | | | | | | | | | 0.5 | | | | | | | | | | | | | |
| | | *Paraonis fulgens* | | | | | | | | | | | 2 | | 4 | 3.5 | 2 | | | | | | | | | |
| | Cirratulidae | Cirratulidae sp. | | | | | | | | | | | | | | | | 0.5 | | | | | | | | |
| | | *Chaetozone setosa* | 7 | 3 | 1 | | | 2 | | | 1 | | 1 | 1 | 1 | 7 | 3.5 | | | 0.5 | | | | | | |
| | Cossuridae | *Cossura longocirrata* | 0.5 | | 1 | | | | | | | | | | 0.5 | 0.5 | 3 | | | | | | | | | 0.5 |
| | Opheliidae | Opheliidae sp. | | | | | 0.5 | | | | | | 0.5 | | | | | | | | | | | | | |
| | Scalibregmatidae | *Scalibregma inflatum* | 2262 | | | 2040 | | | 8428 | 4172 | | | | | 1005 | | | 1887 | 3092 | | | 2322 | 3676 | | | |
| | Capitellidae | Capitellidae sp. | 0.5 | | | | | | | | 8 | | | | | | | | | 0.5 | | | | | | |
| | Maldanidae | Maldanidae sp. | | | | | | | | | | | | | | | | | 7 | | | | | | | |
| | | *Maldane sarsi* | 99 | 27 | 519 | 24 | 2.5 | 8 | 110 | 67 | 250 | 137 | 179 | 3 | 110 | 27 | 126 | 51 | 40 | 135 | 133 | 9 | 20 | 7 | 103 | 7 |
| | Sternaspidae | *Sternaspis scutata* | | | 7 | | 340 | 103 | | | | | | | 32 | 1015 | | | | | 279 | | | | | |
| | Pectinariidae | *Pectinaria koreni* | | | | | | | | | 32 | | | | | | | | | | | | | | | |

Table 6.2 continued

1993

| Phylum | | Species | January | | | February | | | March | | | April | | | May | | | June | | | July | | | August | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | a | b | c | a | b | c | a | b | c | a | b | c | a | b | c | a | b | c | a | b | c | a | b | c |
| | Ampharetidae | Ampharetidae sp. | | | | | | | | | 1 | | | | | | 1 | | | | | | | | | |
| | | *Amage auricula* cf. | | | | | | | | | | | | | | | | | | | | | | | | |
| | | *Melinna cristata* | | | | | | | | | | | | 53 | | | | | | | 55 | | | | | |
| | Terebellidae | *Terebellides stroemi* | | | | | | | | | | | 0.5 | 2 | | | | | | | | | | | | |
| | Oweniidae | Oweniidae sp. | | | | | 0.5 | | | | 0.5 | | | 1 | | | | 0.5 | 7 | 7 | | | | | | |
| Crustacea | Copepoda | | | 0.5 | | | | | | | | | | | | | | | | | | | | | | |
| | Harpacticoida | | | | | | | | 1 | | | | | | | | | | | | | | | | | |
| | Cumacea | Cumacea sp. | | | | | | | | 1 | | | | 0.5 | | | | 1 | | | | | | | | |
| | | *Leucon nasica* | | | 2 | | | | 3 | | | | | | | | 3 | | 2 | | | | | | | |
| | Tanaidacea | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Amphipoda | Amphipoda sp. | | | | | | | | | | | | | 4 | | | | | | | | | | 11 | |
| | | *Ceradocus torelli* | | 972 | | | | 881 | 441 | | | | 448 | | | | | | | | | | | 998 | | |
| | Brachyura | *Hyas araneus* | | | | | | | | | | | | | | | | | | | | | | | | |
| Mollusca | Bivalvia | Bivalvia sp. | | | | | | | | | | | | | | | | | | | | | | | | |
| | | *Nuculoma tenuis* | 301 | 345 | | 17 | 163 | 328 | 318 | 647 | 241 | 354 | 337 | 784 | 1168 | 73 | 48 | 1009 | 9.5 | 287 | 195 | 1483 | 496 | 285 | 289 | 146 |
| | | *Nuculana* sp. | | | | | | | | | | | | | | | | | | | | | | | | |
| | | *Yoldia hyperborea* | 1500 | | 4841 | 2639 | | 1825 | 2051 | 1 | 2330 | 1893 | 3735 | 6539 | 49 | 6542 | 6320 | 2095 | 2114 | 1880 | 4008 | 5 | 3043 | | | 6264 |
| | | *Modiolus modiolus* | | | | | | | | | | | | | 1 | | | | | | | | | | | |
| | | *Thyasira flexuosa* | | | | | | | | | | | | | | | | | | 116 | | | | | | |
| | | *Abra prismatica* | | | | | | | | | | | | | | | | | 1 | | | | | | | |
| | | *Macoma calcarea* | | | | | | | | | | | | | | | | | | | | | | | | |
| | | *Mya truncata* | | | | | | | | | | | | | | | | | | | | | | | | |
| | Gasropoda | Prosobranchia sp. | | | | | | | | | | | | | | | | | | | | | | | | |
| | | *Lunatia pallida* | | | | | | | | | | | | | | | | | | 1 | | | | | 1079 | |
| | | *Oenopoda* sp. | | | | | | | | | | | | | 4 | | | | | | | | | | | |
| Bryozoa | | | 5 | | 1 | | | 4.5 | 2 | | 3.5 | 7 | 0.5 | | 5 | 1 | 1 | | | | | | | | 2 | |
| Echinodermata | Asteroidea | *Ctenodiscus crispatus* | | | | | | 10112 | | | 12367 | 9850 | | | 11388 | | 10999 | | 17755 | | | | | | | |
| | | Number of species | 14 | 11 | 12 | 7 | 9 | 11 | 13 | 10 | 16 | 8 | 15 | 11 | 16 | 13 | 16 | 11 | 12 | 11 | 8 | 7 | 9 | 6 | 8 | 7 |
| | | Total biomass (g) | 8.71 | 2.15 | 6.49 | 4.76 | 0.62 | 13.32 | 12.64 | 6.28 | 15.34 | 12.99 | 5.19 | 7.48 | 13.90 | 9.97 | 18.16 | 7.19 | 26.51 | 5.15 | 4.84 | 4.82 | 7.71 | 1.68 | 2.05 | 7.48 |

Table 6.3. Benthic macrofauna taxa observed in Eyjafjörður (station 10). Total abundance and biomass (mg) of each taxon is shown, including proportion (%) of total macrofauna abundance and biomass. Taxa are ranked by abundance dominance (%).

| Taxon | Abundance | % | Biomass (mg) | % |
|---|---|---|---|---|
| Foraminifera | 12,646 | 74.78 | 4,796 | 1.51 |
| Polychaeta | 3,585 | 21.17 | 107,240.5 | 33.86 |
| Nematoda | 313 | 1.85 | 19.5 | 0.01 |
| Mollusca | 264 | 1.56 | 119,366.5 | 37.69 |
| Crustacea | 118 | 0.70 | 12,043.5 | 3.80 |
| Echinodermata | 6 | 0.04 | 7,2471 | 22.88 |
| Nemertinea | 2 | 0.01 | 18 | 0.01 |
| Bryozoa | - | - | 756.5 | 0.24 |
| Hydrozoa | - | - | 21 | 0.01 |
| Porifera | - | - | 1 | 0.00 |
| Total | 16,934 | | 316,733.5 | |

Table 6.4. Ten most dominant benthic macrofauna species in Eyjafjörður (station 10), ranked by total number of individuals

| Taxon | Species | Abundance |
|---|---|---|
| Foraminifera | Foraminifera sp. | 12,646 |
| Polychaeta | *Cossura longocirrata* | 1,202 |
| Polychaeta | Polychaeta spp. | 583 |
| Polychaeta | *Paraonis fulgens* | 502 |
| Polychaeta | *Chaetozone setosa* | 382 |
| Polychaeta | *Maldane sarsi* | 329 |
| Nematoda | Nematoda | 313 |
| Polychaeta | *Nephtys* sp. | 220 |
| Bivalvia | *Nuculoma tenuis* | 176 |
| Polychaeta | Capitellidae | 81 |

Table 6.5. Ten most dominant benthic macrofauna species in Eyjafjörður (station 10), ranked by total biomass (mg)

| Taxon | Species | Biomass (mg) |
|---|---|---|
| Bivalvia | *Yoldia hyperborea* | 102,365 |
| Asteroidea | *Ctenodiscus crispatus* | 72,471 |
| Polychaeta | *Nephtys* sp. | 56,418 |
| Polychaeta | *Scalibregma inflatum* | 32,756 |
| Bivalvia | *Nuculoma tenuis* | 15,696 |
| Amphipoda | *Ceradocus torelli* | 11,896 |
| Polychaeta | *Maldane sarsi* | 9,768 |
| Foraminifera | Foraminifera sp. | 4,796 |
| Polychaeta | *Sternaspis scutata* | 1,994 |
| Polychaeta | Polychaeta spp. | 1,581 |

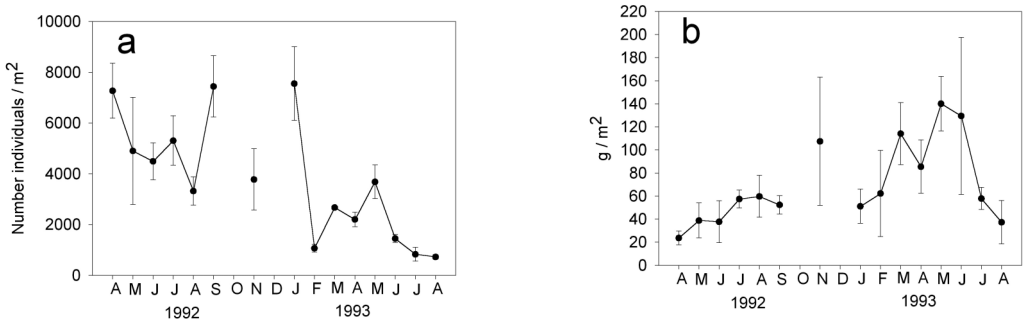



Figure 6.1. Total benthic macrofauna in Eyjafjörður (station 10) showing a) temporal changes in average abundance (number of individuals/$m^2$) and b) temporal changes in average biomass (wet weight, g /$m^2$). Shown at each sampling date is the mean ± the standard deviation.

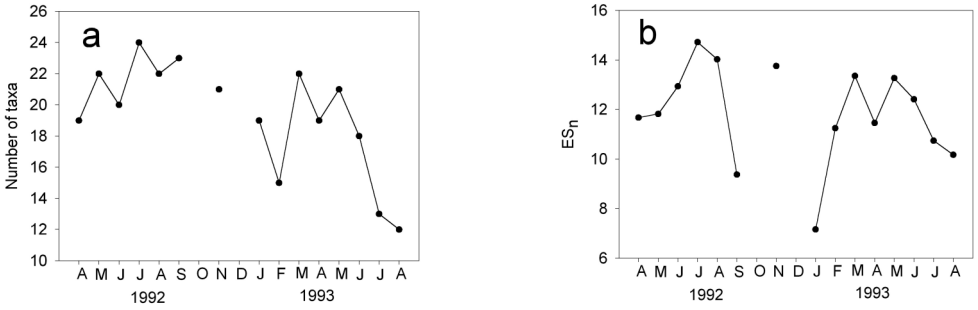



Figure 6.2. Temporal changes in species richness as a) number of species and b) expected number of species ($ES_n$).

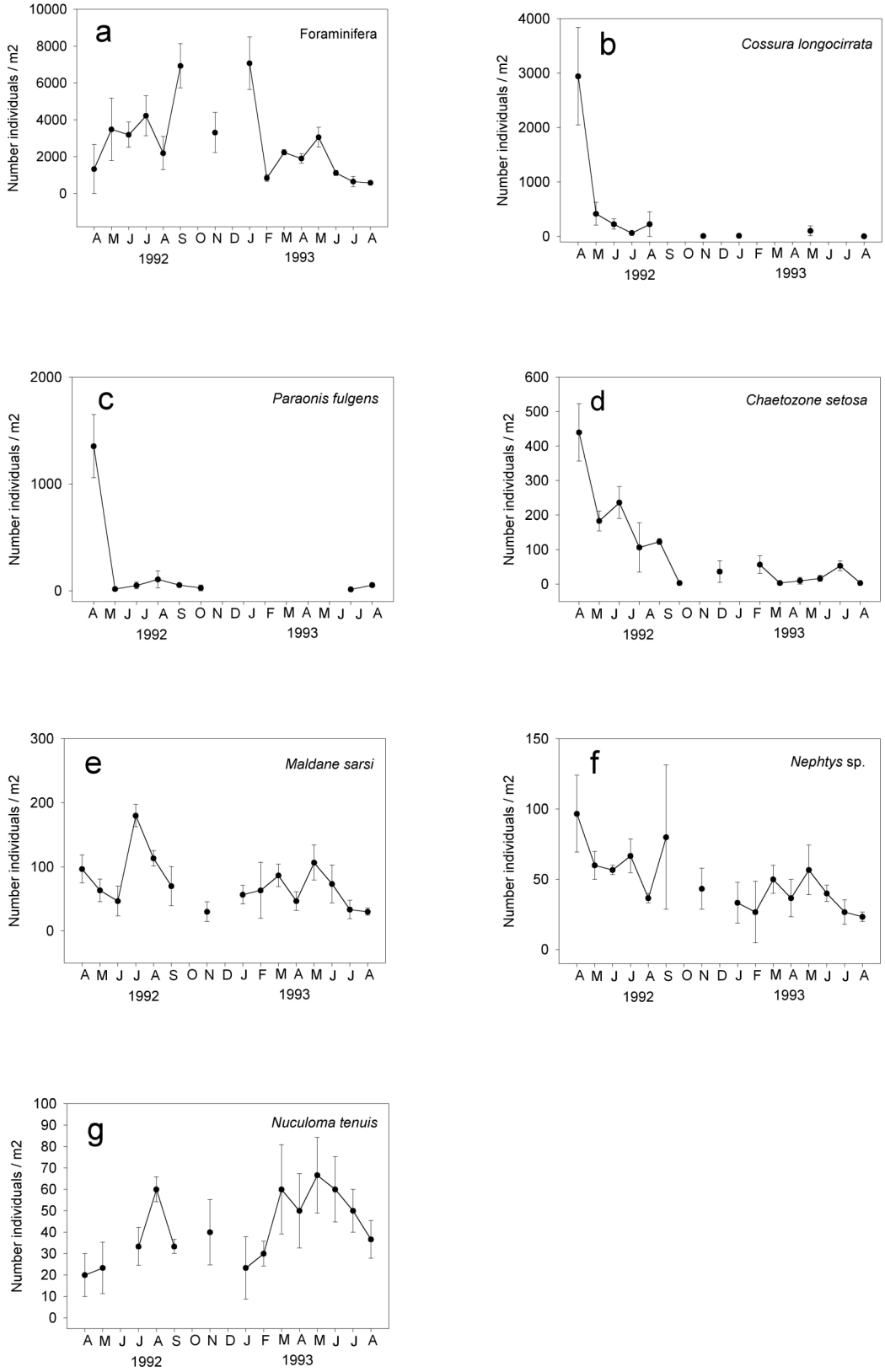



Figure 6.3. Temporal changes in average abundance (number of individuals/$m^2$) of dominant benthic macrofauna species. Shown at each sampling date is the mean ± the standard deviation.

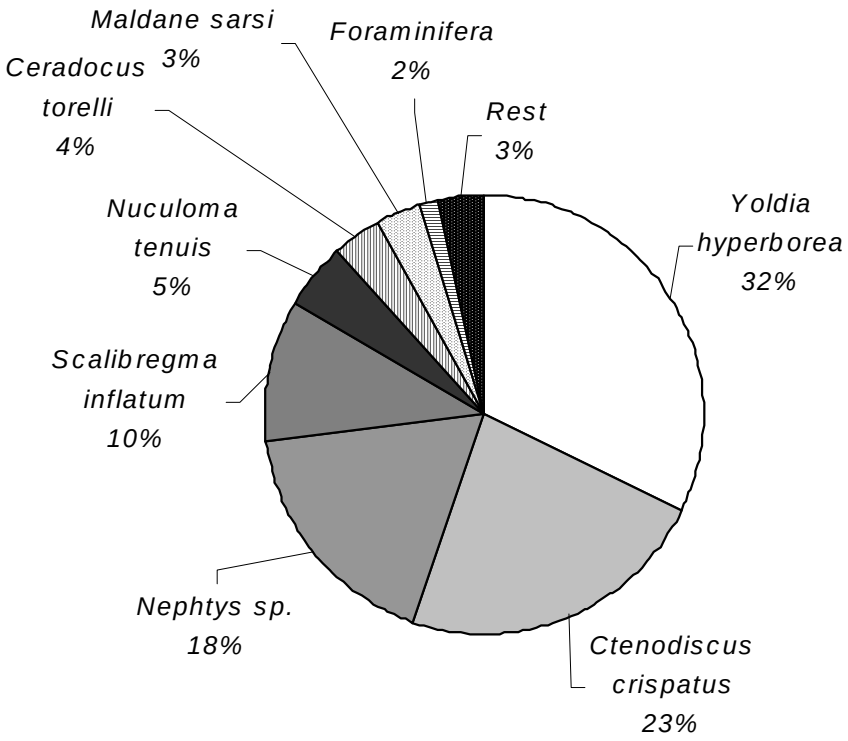



Figure 6.4. Contribution (%) of species to the total benthic macrofauna biomass (wet weight, g /m$^2$). All samples pooled.

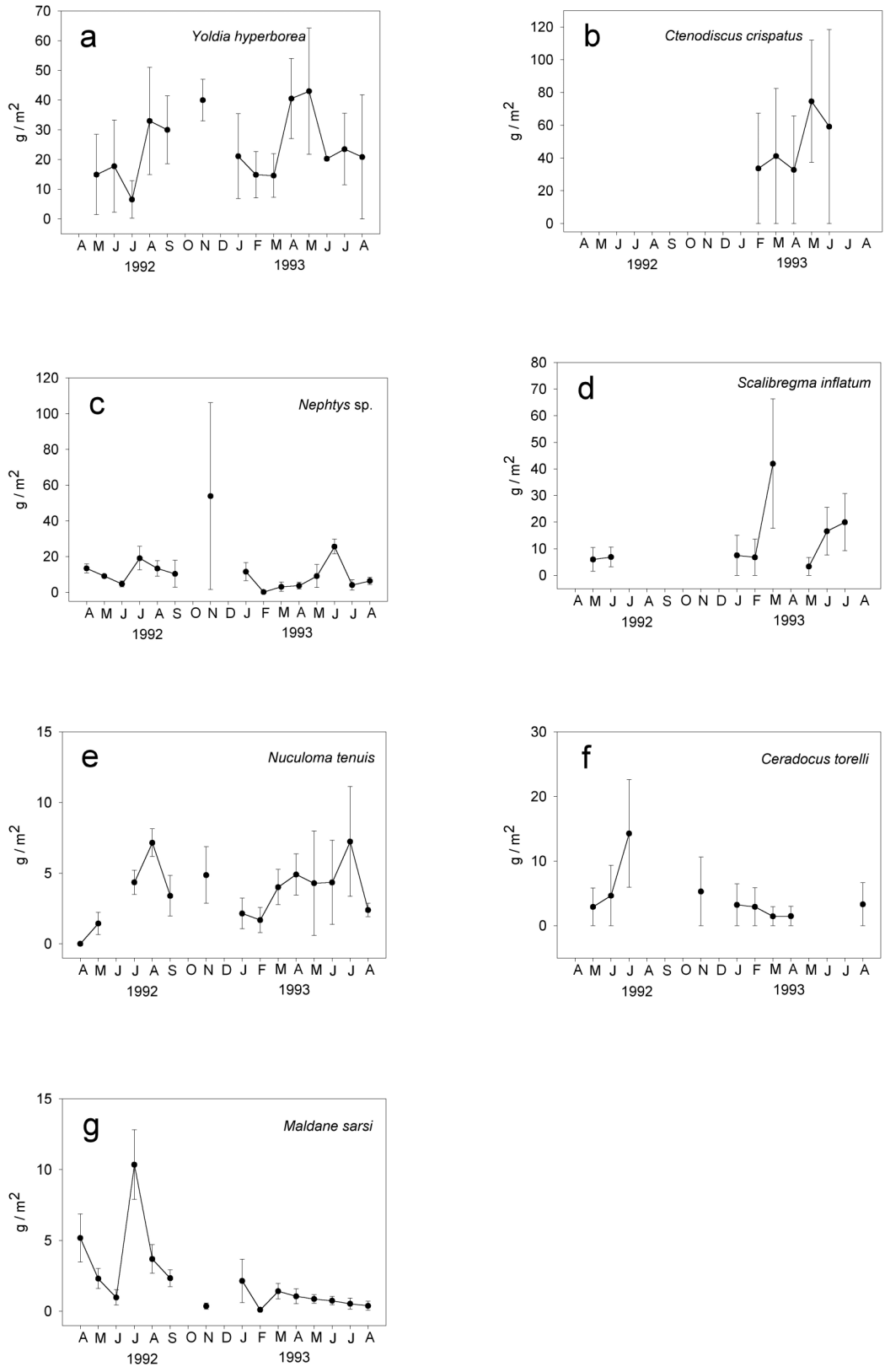



Figure 6.5. Temporal changes in average biomass (wet weight, g /$m^2$) of dominant benthic macrofauna species. Shown at each sampling date is the mean ± the standard deviation.

# 7. BACTERIA

All samples were collected from a single location in Eyjafjörður (station 10 in Figure 1.2) from May 1995 to November 1996, *i.e.* samples of seawater, phytoplankton, zooplankton and kelp (*Laminaria*). Total counts of viable aerobic bacteria and the number of *Vibrio* bacteria were evaluated. The results show variations in total bacterial counts throughout the sampling period. No clear correlation was observed between water temperature or salinity and the bacterial counts in the water column.

## Methods

Bacterial samples were collected from the sea water column, zooplankton, phytoplankton and kelp (*Laminaria*) during May 1995 to November 1996. The sea water samples were collected with NISKIN samplers at 10-15 m below the surface, and aseptically transferred to sterile glass bottles. Zooplankton was collected with a WP-2 net (0.25 $m^2$, 200 µm mesh net) and transferred to sterile glass containers. Kelp (*Laminaria*) samples were collected at the shore east of station 10 (Figure 1.2), *i.e.* the middle section of three stems were cutted each time and transferred to sterile Stomacher bags.

All samples were kept on ice until they were subjected to bacteriological analysis on return to the laboratory and plated out within 3-5 hr after collection. Samples were homogenized at 400 rpm for 120 sec. with 20-sec. bursts at 5-sec. intervals in an ULTRA TURRAX T25 (IKA) and serial dilutions made in 0.1% peptone in aged seawater. The total counts of viable aerobic bacteria were evaluated on a non selective tryptic soy agar medium containing 70% aged seawater (TSA-sw, 2,4 % NaCl final concentration).

Alkaline peptone water (APW, pH 8.6, 1% NaCl final concentration) was used for selective enrichment and enumeration of *Vibrio* bacteria according to the method of O´Neill *et al.* (1992). Agar plates were incubated for 10 days at 15°C before enumeration and isolation of colonies. Twelve colonies were randomly picked from plates containing a total of 25-250 colonies and streaked onto plates of MA for biochemical characterization of *Vibrio* bacteria by series of tests, including motility, Gram reaction, catalase and cytochrome oxidase reactions, utilization of glucose and sensitivity to the vibriostatic compound, O/129 (2,4-diamino-6,7-diisopropyl pteridine phosphate).

## Results

*Sea water*

A total of 300 bacterial strains were isolated from the sea water samples, and submitted to taxonomic studies. The majority of these strains were found to be Gram-negative rods representating a diverse array of taxa.

The variation in total counts of viable, aerobic bacteria was registered throughout the sampling period (Figure 7.1.). The maximum counts were recorded during early summer (May), followed by a reduction during the summer months and a second peak seemed to occur in late summer.

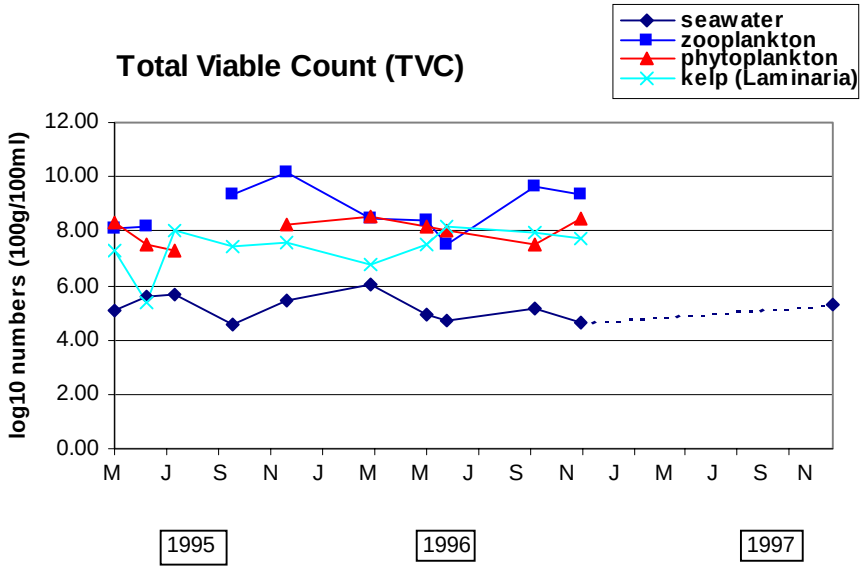



Figure 7.1. Total bacterial counts (100ml/100 g) in Eyjafjörður (station 10) during the period of May 1995 to November 1996 (and in August 1997).

The maximum bacterial counts do not seem to correlate with the water temperature which gradually increases throughout the summer and reaches a maximum in July-August. An increase in temperature does not seem to affect the total counts of aerobic bacteria. Bacterial growth rate is expected to be depressed by low water temperatures, and growth may directly or indirectly be related to seasonal changes in freshwater flow, temperature and salinity, but water temperature does not seem to be the dominant factor to control bacterial growth.

The lack of correlation of bacterial densities with water temperature may indicate that the sharp decrease in the bacterial concentration from March to June and in July could be due to antimicrobial substances obtained from the phytoplankton community. The results are in accordance with the results obtained by Chan and McManus (1968), who observed highest bacterial counts in the sea water in late spring and a reduction in bacterial densities during mid-summer. According to Lignell *et al.* (1992), and Marrasé *et al.* (1992), the bacterioplankton use the dissolved and dead particulate organic matter lost directly from the phytoplankton community, and bacterial productivity was shown to be controlled by the availability of both carbon and those nutrients that limit phytoplankton growth. These authors point out that a part of the bacterial population is only able to resist lower concentrations of the antibiotic produced by some phytoplankton species, and are inhibited by the higher concentrations produced during mid-summer. These observations may explain the observed reduction in bacterial densities during the summer months, and following the phytoplankton bloom in April.

Other studies have revealed a positive correlation between temperature and bacterial densities, but the ratio between total and viable or culturable microflora has been shown to flucutuate without showing a clear seasonal pattern (Corre and Prieur 1990).

*Vibrio* were one of many colony types that developed from sea water samples following incubation at 15°C (Figure 7.2.). The number of *Vibrio* bacteria seem to correlate with the total viable count, and a gradual increase in concentration of this grouph was recovered during the spring and summer months, with a maximum occurring in March and November. The maximum number of *Vibrio* recorded in March is followed by a relatively sharp decrease in concentration and relatively low summer values. *Vibrio* spp. are belived to be the dominant bacterial group in brackish, estuarine, coastal and offshore waters, and the association of *Vibrio* spp. with phytoplankton and zooplankton has been reported by a number of authors (Colwell and Kaper 1977, Murphy and Oliver 1992).

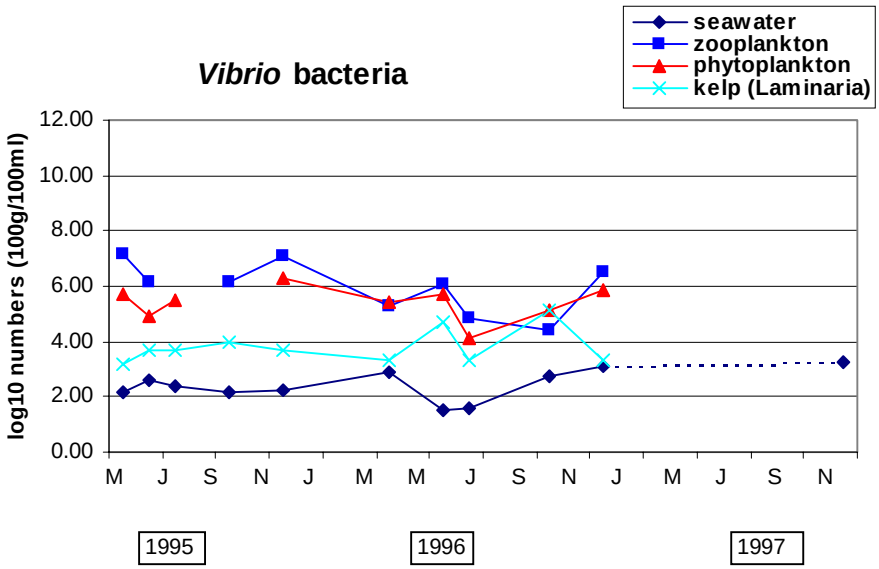



Figure. 7.2. Total counts of *Vibrio* bacteria in Eyjafjörður (station 10) during the period of May 1995 to November 1996 (and August 1997).

Studies on the ecology of a number of *Vibrio* species have revealed a close relationship between the presence of *Vibrio* bacteria (halophilic bacteria) and water temperature and salinity but other unidentified factors also appear to influence the presence of these bacteria in certain areas (Bockemühl *et al.* 1986, Kaper *et al.* 1979, Kelly 1982, O´Neill *et al.* 1992, Zaccone *et al.* 1992).

Low temperatures (<10°C) have been shown to be a major inducer of the viable, but nonculturable forms of *Vibrio* and other psychrophilic bacteria, and the bacteria have been shown to be able to persist as "dwarfs" under conditions of varying salinity and temperature, even when they are no longer recoverable by conventional methods of selective enrichment and plating (Xu *et al.* 1982).

Traditionally the numbers of surviving cells are measured by their ability to reproduce in culture media, but the dwarf cells are incapable of growth in conventional media, and are said to be viable but non-culturable. Non-culturable cells continue all the same to harbor the potential for virulence because such bacteria are likely to persist in the dormant phase until suitable conditions for (out)growth return (Colwell *et al.* 1985, Xu *et al.* 1982).

In higher latitudes where the sea water temperatures do not exceed 10°C, it has been pointed out that the bacteria may enter the nonrecoverable state at lower

temperatures than previously thought. Recovery of the bacteria in these environments may also be more dependant on the presence of phytoplankton or zooplankton densities in the surrounding water (Chan and McManus 1968, Palumbo *et al.* 1984, Marrasé *et al.* 1992, Pomeroy and Deibel 1986, Lingnell *et al.* 1992). Low water temperatures and stable salinity values may therefore partly account for the abscence of positive correlation between water temperature and salinity and *Vibrio* counts in the water column.

*Other samples*

A total of 700 isolates were characterized from zooplankton, phytoplankton and kelp samples collected during the period. The variations in viable counts were found to be considerable throughout the sampling period (Figure 7.1.).

Maximum bacterial numbers in zooplankton samples were found in late autumn followed by a slow reduction in abundance during the winter months. In phytoplankton maximum numbers were found in November and minimum numbers were recorded during the summer months.

The lowest water temperatures were recorded in late winter (around 1°C), and minimum values of bacterial numbers were recorded during the same period (log total counts = 2). Bacterial densities in zooplankton are at the same time at the highest value. These results can possibly be explained by a peak following the zooplankton peak in the autumn time (September-October).

The vibrios that are associated with zooplankton have been shown to demonstrate rhythmic cycles of occurrence in the water column in parallel with apperance of plankton blooms, and the association of vibrios with shellfish, crustaceans and zooplankton is supposed to play an important ecological role in these systems because of their ability to mineralize organic matte and digest chitin, a major structural component of many aquatic invertebrates (Murphy and Oliver 1992, Colwell and Kaper 1977, Kaneko and Colwell 1973, Kaneko and Colwell 1975, Colwell *et al.* 1973).

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