

ENVIRONMENTAL ANOMALIES, OBSERVED IN THE WATERS OF THE NORTH ATLANTIC IN THE REYKJANES RIDGE AND NORWEGIAN SEA AREAS IN 1997, AND THEIR IMPACT ON LARVAL REDFISH CHARACTERISTICS

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Year 1997 was atypical in many respects in the wide area of the North Atlantic. From the Reykjanes Ridge to the Norwegian Sea there was considerable increase of salinity and a lack of Arctic Intermediate Water. Cause of this was the activity of North Atlantic Current (NAC), which contributed to the general warming of the large region south of the research area, increased salinity and introduced profound changes in the water masses. In the present study large-scale character of the observed phenomena was confirmed. These conditions influenced spawning activity of redfish, and possibly growth of the larvae, which were small throughout the research period from April to July 1997.

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Introduction

In the general paper, reporting results of the Polish investigations on the Reykjanes Ridge in 1985, 1986 and 1997, Janusz et al. (subm.) argued that environmental conditions were responsible for the relative dispersal of the concentrations of redfish (*Sebastes mentella*). They further hypothesized, that two distinct groups, observed in the area (Johansen et al. 2000) originated as a result of gross environmental anomalies, to which deep-water redfish is less subjected.

In the present note, this argument is further strengthened by additional environmental data from the Reykjanes Ridge area and from Norwegian Sea, supplemented by the gross biological characteristics of the redfish larvae collected in the Reykjanes region.

Materials and Methods

All research, reported here, was conducted by, and on, the commercial trawler M/T "Regulus", adapted for oceanographic and biological research. This vessel is a 90m stern trawler of 2600 BRT, 2650 hp, using large rope trawl with the vertical opening of 110 m and horizontal opening 200 m, towed at 3.5 kn. The sonar Wesmar 680 E-14 and a netsonde Elac LAZ 2500 were used. The oceanographic sonde SensorData Mini CTD SD-202 was used to the depth of 500m (on some stations to 950 m). The signal was registered every 2 seconds. Altogether 17 oceanographic stations were done in the Reykjanes Ridge area in April (14 stations) and in July (3 stations) (Fig. 1). Also, 6 stations were done eastwards of Iceland, in the Norwegian Sea (Fig. 2). The

latter were done (10-14 July) to the depth of 950 m. In the present paper only horizontal distributions of oceanographic parameters were shown (profiles were published by Janusz et al.), but both horizontal distributions and profiles were given for the Norwegian Sea.

Plankton collection was made using standard Bongo net (61 cm) with the mesh 0.505 mm in both nets. Procedure of collection was close to standard (double oblique tow, ship's speed 2.5-3.0 kn, net speed when lowering 50m/min, and hauling back 20 m/min). Maximum depth was 150 m. Water flow was measured by one flowmeter (HydroBios, Germany) and depth by the bathythermograph unit. Redfish larvae were sorted out immediately, measured to 1 mm, and preserved in 95% ethyl alcohol, for the age and growth analysis, which was performed on land later. The detailed list of the larval material was given in the Appendix.

Results

Oceanographic observations – Reykjanes Ridge

The water temperature on the surface ranged from 5.17 to 7.06 °C in April and 9.50 to 10.42 °C in July. On the depth of 500 m, it ranged from 3.74 to 6.57 °C (Fig. 3). For comparison, results of horizontal surface temperature distributions, obtained on R/V "Professor Siedlecki" in 1985 and 1986 (see Janusz et al., *subm.*), were given on Fig. 4. As it can be seen, temperature ranges were similar, but isotherm patterns were different. Salinity was exceptionally high during the research period (see Dietrich 1965, Lee 1968) and ranged 35.53-35.74 PSU at the surface and 35.33-35.53 at

500 m (Fig. 5). Salinity was 0.7 PSU higher than the "typical" one for the region. Salinity in the area during R/V "Professor Siedlecki" cruises in 1985 and 1986 ("typical" years) were given on Fig. 6-7 for comparison.

Oceanographic observations – Norwegian Sea

The vertical profiles (0-950 m) of temperature changed considerably along transect (Fig. 8-9). Temperature range was $-0.58-10.91^{\circ}\text{C}$. The temperature in the north-east part of the region was $4-7^{\circ}\text{C}$, and $0-6^{\circ}\text{C}$ in the south-west part in the region (in the layer 100-500 m). On the other hand, in the north-eastern part 0°C isotherm was at 800m, whereas in the south-western part the same isotherm was at 500 m. The seasonal thermocline was at about 50-80 m. The difference between surface temperature and a temperature at lower thermocline border was 4°C .

Salinity in the investigated area was rather diverse (Fig. 10), with range from 35.06 to 35.44 PSU. There was no apparent halocline.

Relative density σ_t was distributed similarly to temperature (Fig. 11), with range 27.04 to 28.49. Relative density was highest on south-western stations. The gradient of the relative density in the upper layer of water (up to 80 m) was $0.7 \text{ kg/m}^3/\text{m}$.

Larval redfish characteristics

The abundance of redfish larvae was 0.05 to 46.15 individuals/100 m^3 . Mean abundance for all plankton tows was for April $8.61/100\text{m}^3$ and for May $11.96/100\text{m}^3$. The greatest abundance was observed along the border of exclusive economic zone of Iceland (Janusz et al., *subm.*) The dominance of the smallest larvae was apparent (larvae 5-7 mm long are in post-spawning

stage; Fig. 12), especially in mid-April (mean length 6.89 mm). This was further elucidated by the ageing exercise (Fig. 13), which proved that majority of read otoliths were few days old. There is a distinct phase in larval growth, reflected in the growth of the otolith (Fig. 14). In larvae up to 7 days old, increment (=1 day) width does not change and equals approximately 1 μm . Then it starts to increase and in oldest otoliths investigated reaches 3.5 μm .

Discussion

Presented results further strengthen and compliment conclusions reached by Janusz et al. (subm.). The year of research presented (1997) was exceptional in the extent of warm-water influence south to the areas investigated. The main reason for this was an activity of North Atlantic Current (NAC), pushing of polar waters to the far north and a lack of oceanographic front/gradient between polar waters and NAC. The conclusion about the large-scale of observed events is confirmed by the situation in the Norwegian Sea. In the surface layer there was Central Water with salinity greater than "typical" (about 0.3 PSU difference). Also, the Arctic Intermediate Water was lacking. Predictably, in the east (Norwegian Sea) the influence of NAC was weaker, and strongest over the Reykjanes Ridge, where redfish abundance, density and availability were affected (Janusz et al., subm.).

Biological investigations of redfish larvae suggested the increasing spawning activity between April and May, and relative concentration of the spawning stock in the north north-east part of the investigated region, but otherwise a

relative dispersal of the spawning stock. Larvae were small, which may suggest active transport to outside of the investigated area, but also slower growth related to impoverished waters due to the lack of oceanographic fronts in the area in 1997. The otolith-based study highlights the frequently observed but not well-understood phenomenon of decoupling of otolith growth and body growth. Otolith growth proceeds in units (increments), whereas body growth is continuous. Change (most frequently increase) in the increment width with age during first weeks of life, and then gradual decrease, results in the complicated (exponential, asymptotic or logistic) curve of otolith growth, whereas body growth (length or weight) may be simple, e.g. linear.

Literature Cited

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Lee AJ. 1968. Environmental surveys – NORWESTLANT 1-1, 1963. ICNAF 7: 38-160.

Figure Explanations

Fig. 1. Positions of the oceanographic stations executed in the Reykjanes Ridge area.

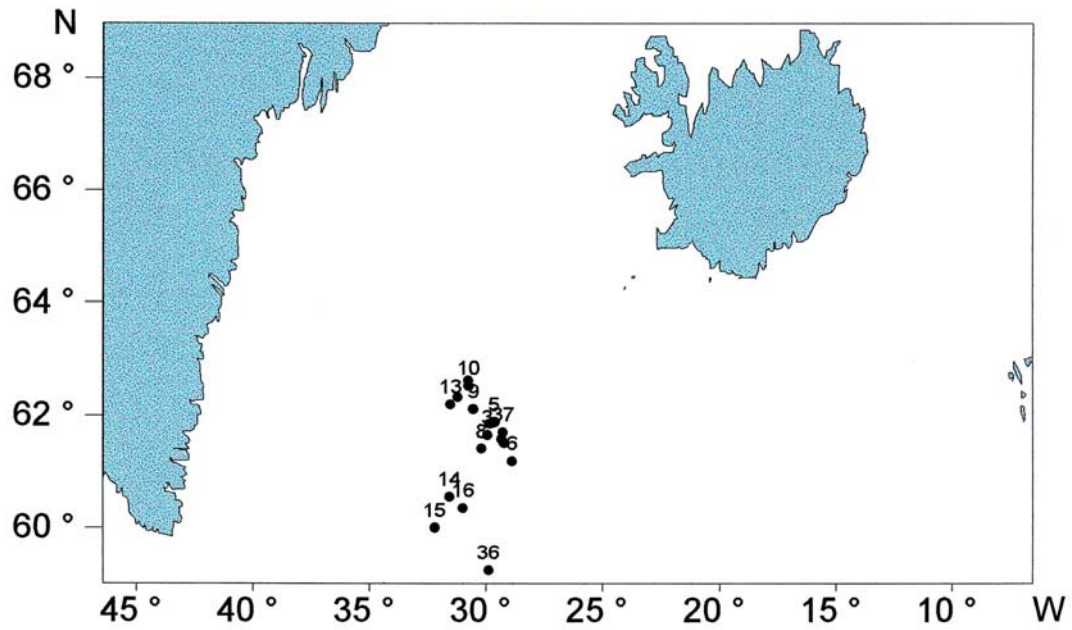


Fig. 2. Positions of the oceanographic stations executed in the Norwegian Sea.

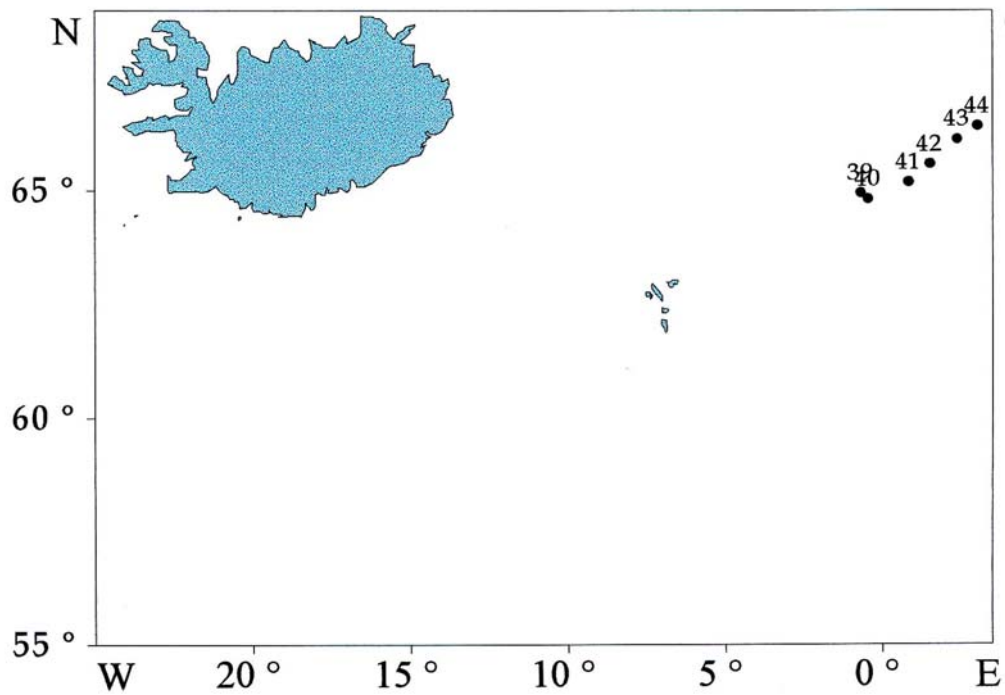


Fig. 3. Horizontal distribution of temperatures at the surface and on 500 m (4 -18 April 1997).

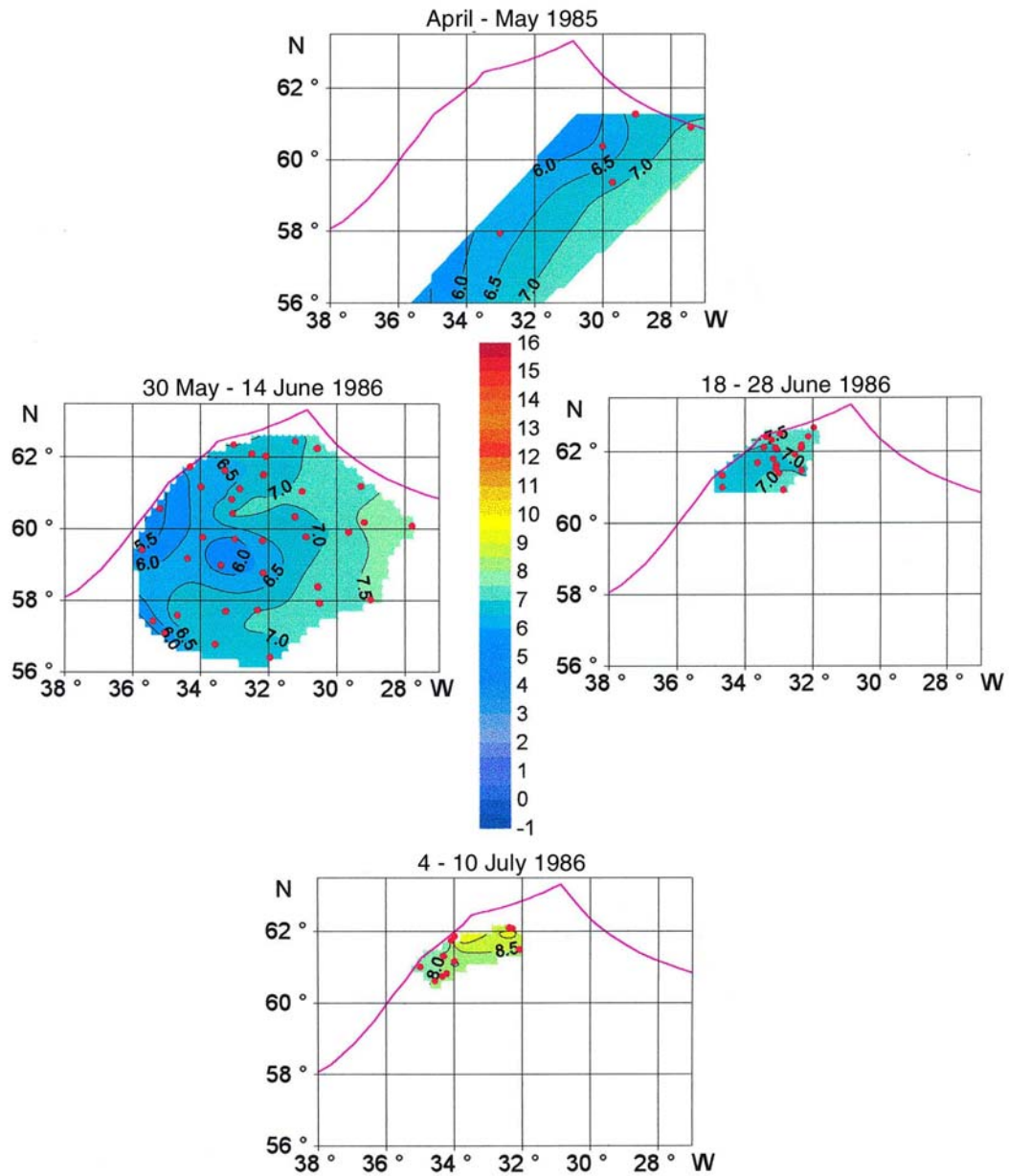


Fig. 4. Horizontal distribution of surface temperatures during two cruises of R/V "Professor Siedlecki" in 1985 and 1986.

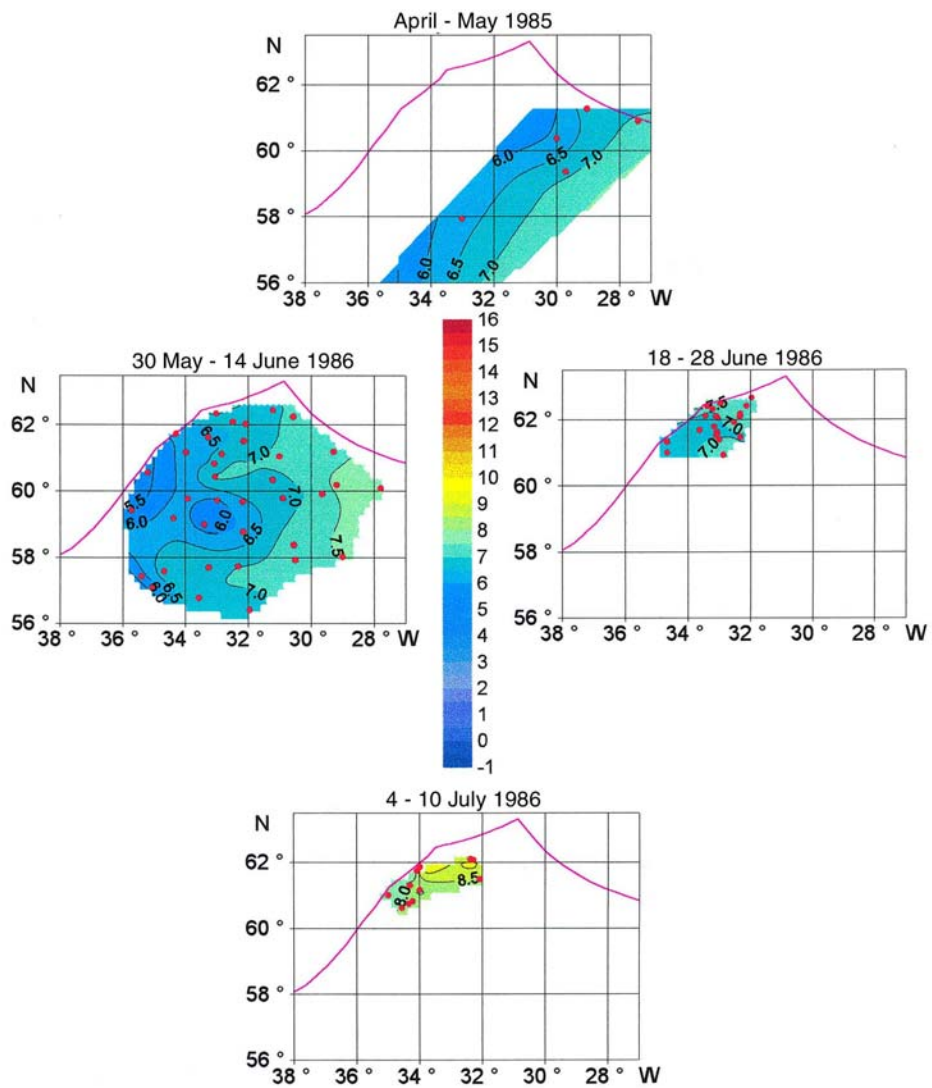


Fig. 5. Horizontal distribution of salinity at the surface and on 500 m (4-18 April 1997).

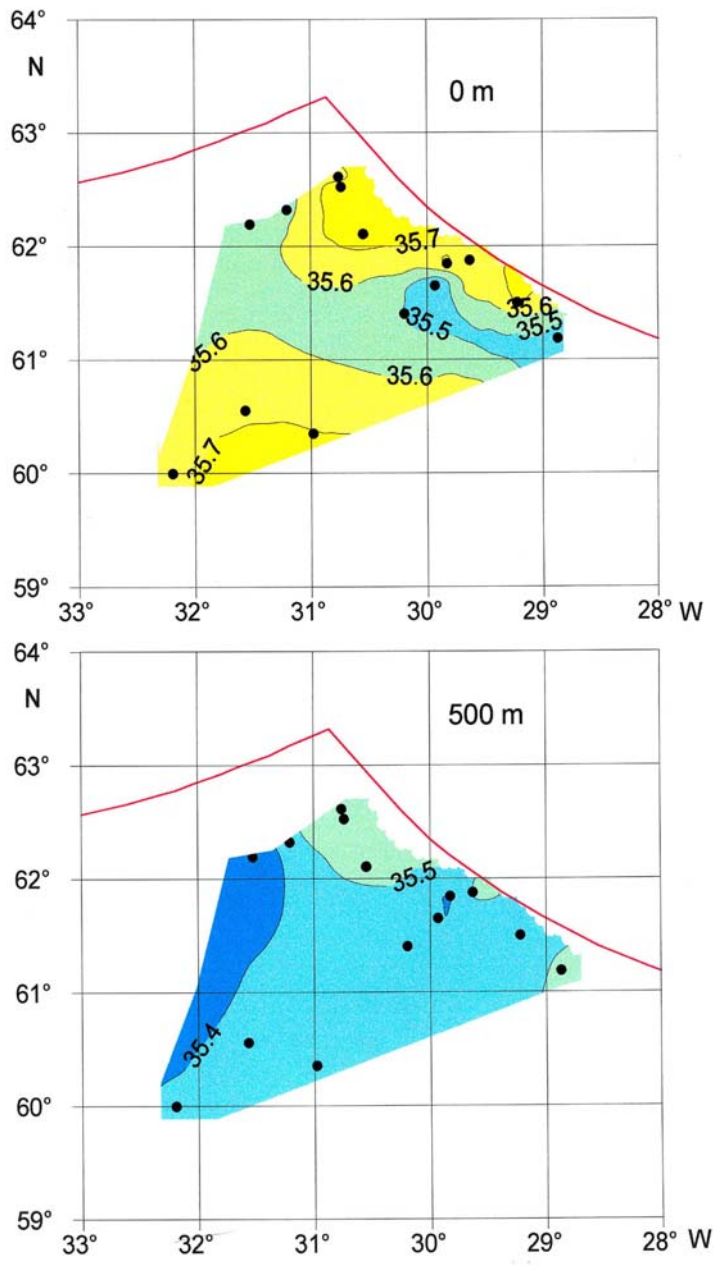


Fig. 6. Horizontal distribution of salinity at the surface during two cruises of R/V "Professor Siedlecki" in 1985 and 1986.

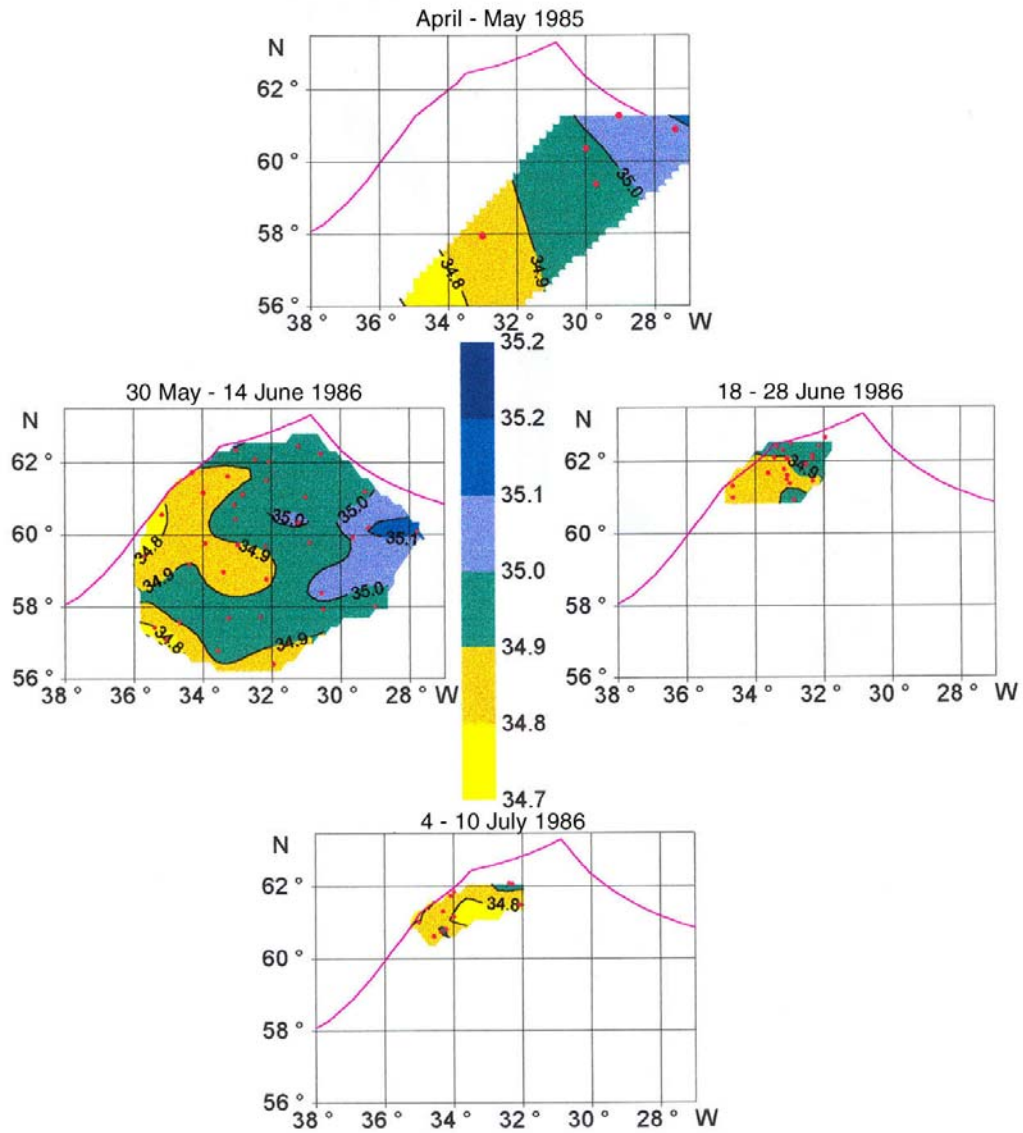


Fig. 7. Horizontal distribution of salinity on 500 m during two cruises of R/V "Professor Siedlecki" in 1985 and 1986.

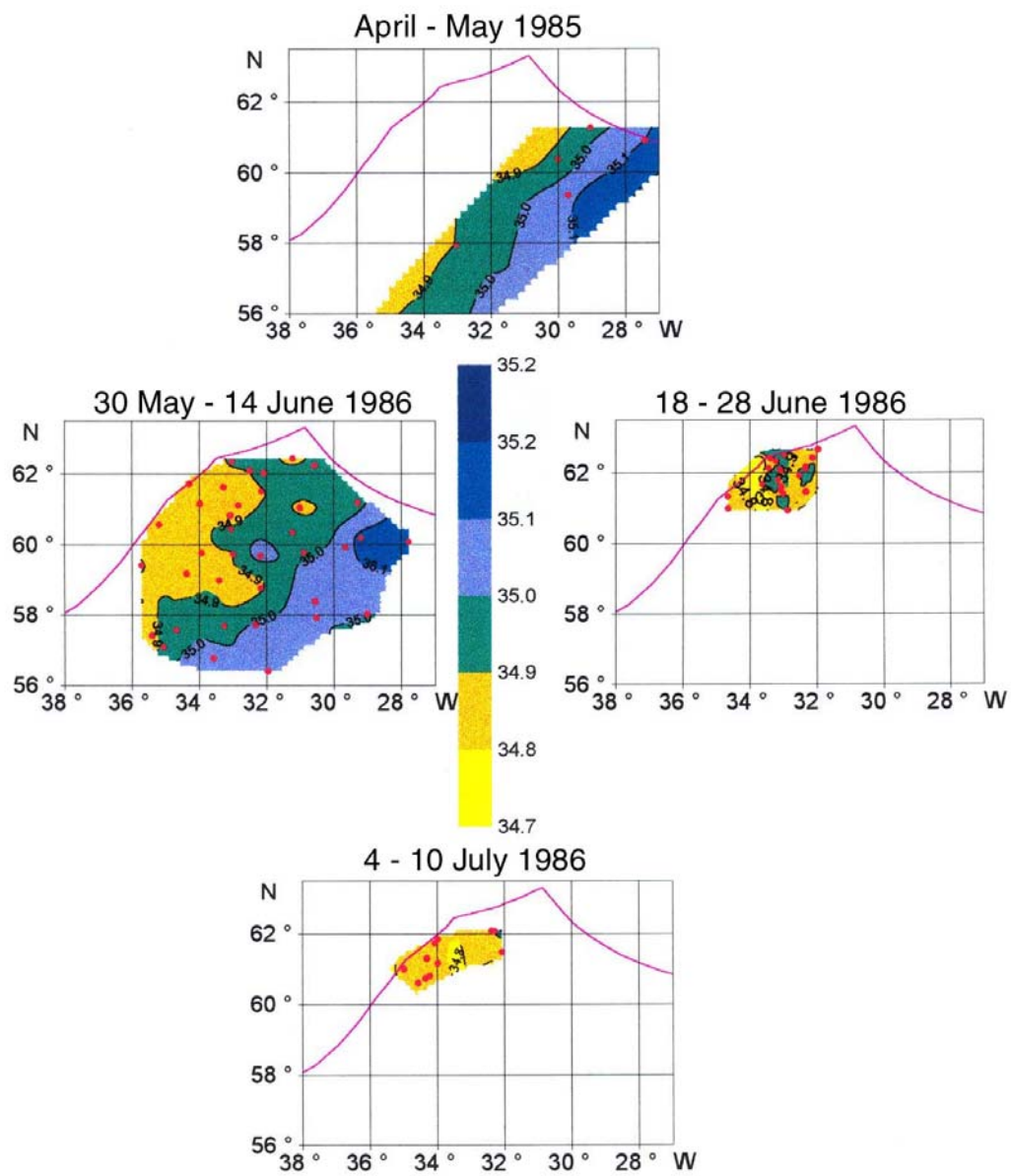


Fig. 8. Temperature profile along transect in the Norwegian Sea in July 1997.

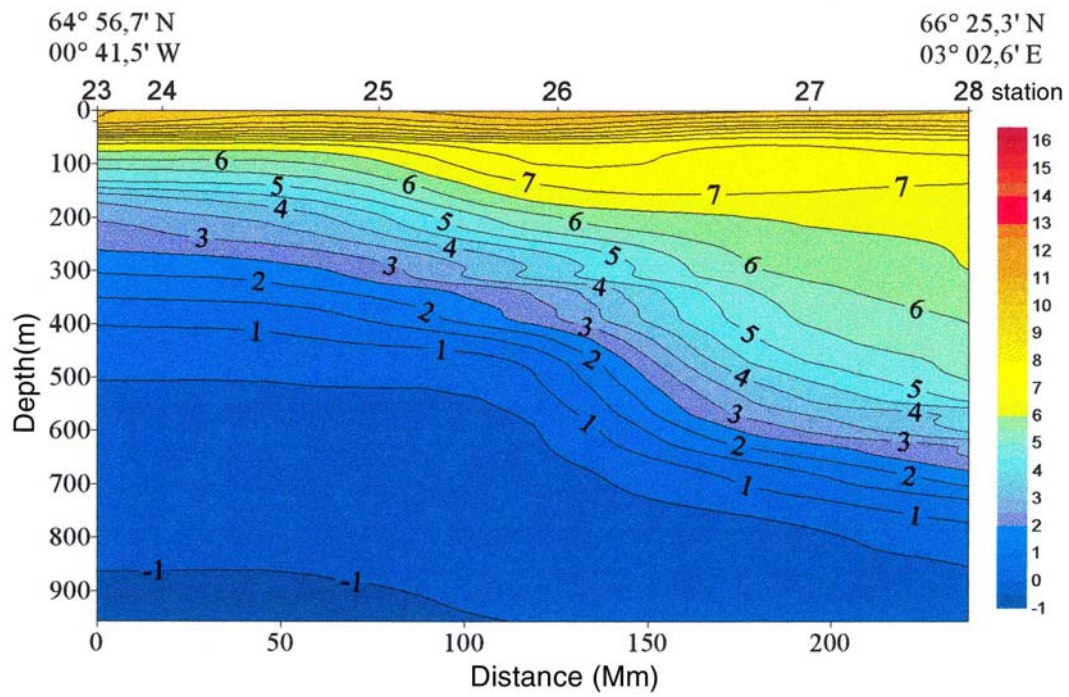


Fig. 9. Vertical temperature plots for two marginal stations (no. 39 and 44) in the Norwegian Sea in July 1997.

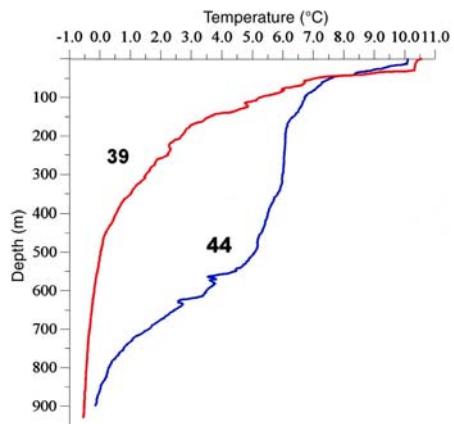


Fig. 10. Salinity profile along transect in the Norwegian Sea in July 1997.

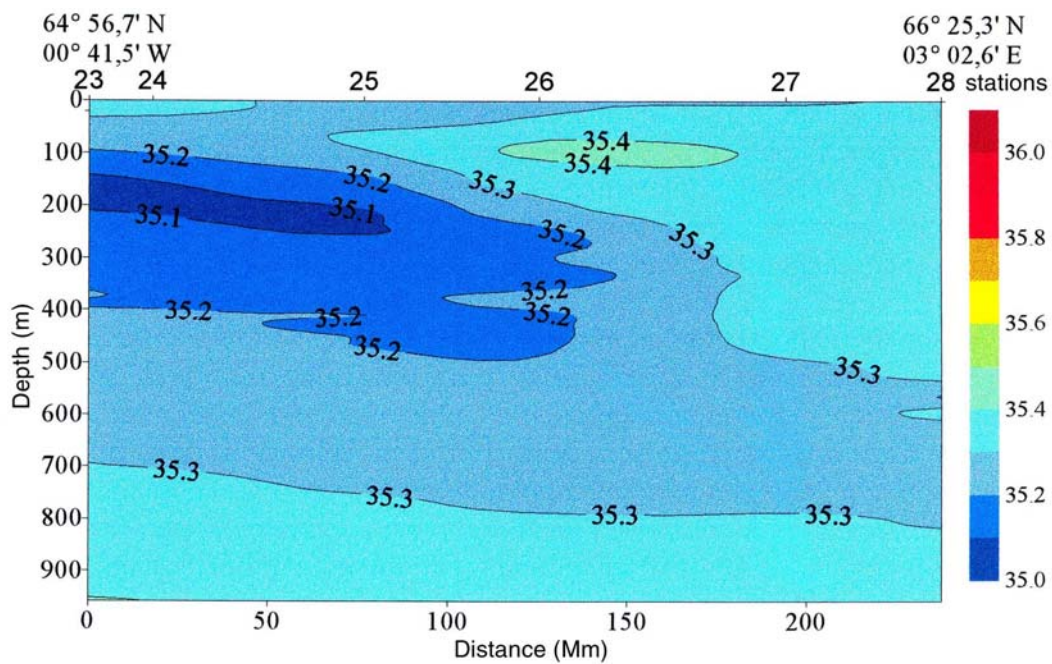


Fig. 11. Relative density profile (σ_T) along transect in the Norwegian Sea in July 1997.

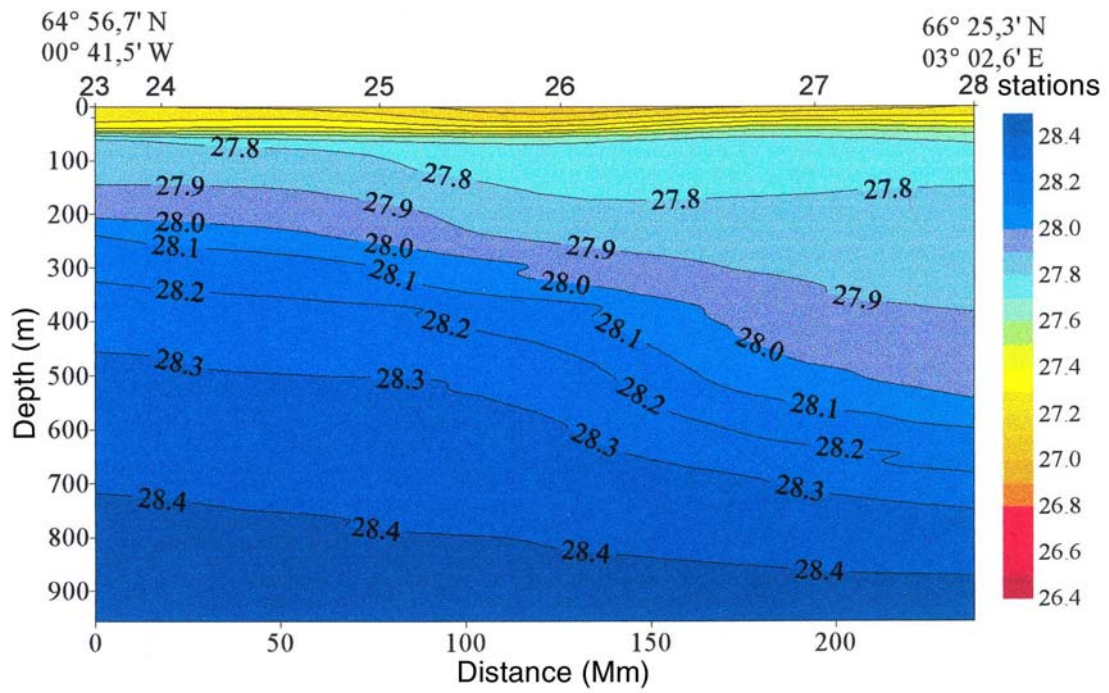


Fig. 12. Length frequency (SL = standard length) of redfish larvae in time sequence from April to July 1997 on the Reykjanes Ridge.

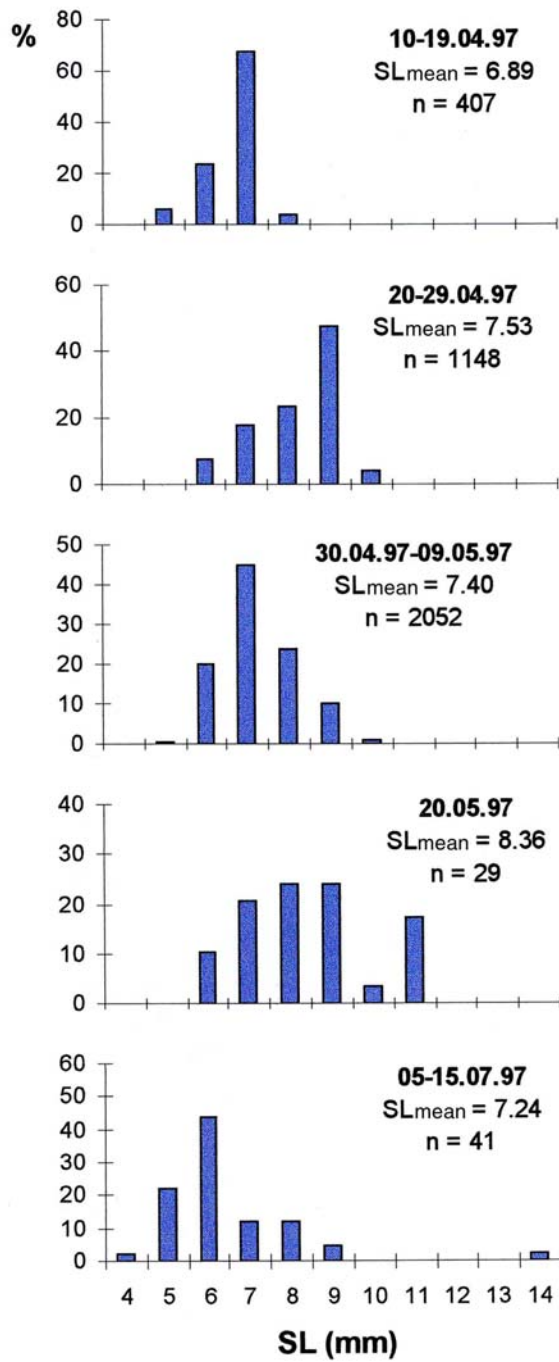


Fig. 13. Results of the otolith-based age structure analysis of redfish larvae; a) relation between length and age; b) relation between otolith size and standard length; c) otolith size and age.

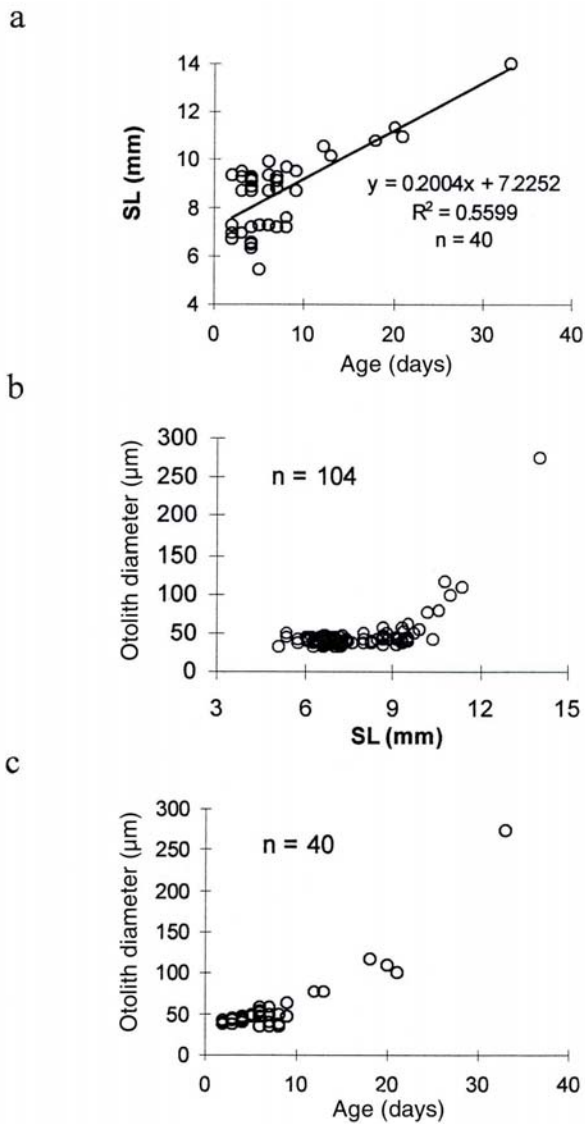
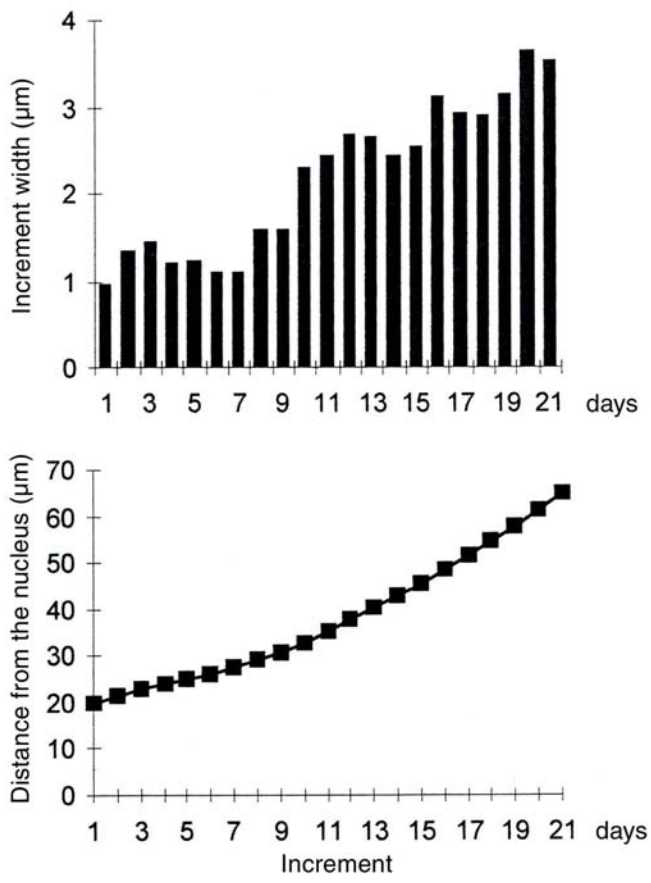


Fig. 14. Growth of the redfish otoliths in the first 21 days of their life.



Appendix

The list of Bongo stations, where larvae of redfish (*Sebastes mentella*) were caught (April – July 1997).

Station	Date	Time GMT	Position		Number of larvae total no./100 m ³	
2 B	97-04-10	21:27 - 21:47	61° 11' N	28° 52' W	3	0.30
3 B	97-04-11	17:10 - 17:40	61° 29' N	29° 13' W	19	0.70
5 B	97-04-14	3:44 - 4:13	62° 31' N	30° 44' W	82	3.91
6 B	97-04-15	15:15 - 15:40	62° 11' N	31° 31' W	4	0.22
8 B	97-04-17	21:17 - 21:35	59° 60' N	32° 12' W	96	4.63
9 B	97-04-18	22:05 - 22:30	60° 46' N	29° 27' W	104	5.83
10 B	97-04-19	22:35 - 23:00	61° 25' N	28° 46' W	99	5.64
11 B	97-04-20	22:05 - 22:25	61° 28' N	28° 54' W	92	5.30
12 B	97-04-21	21:35 - 22:00	60° 57' N	28° 23' W	50	6.46
13 B	97-04-24	22:33 - 22:59	61° 13' N	28° 30' W	114	6.81
14 B	97-04-26	22:30 - 23:00	61° 42' N	29° 14' W	786	39.17
15 B	97-04-27	22:15 - 22:40	61° 8' N	28° 17' W	43	7.60
16 B	97-04-30	03:22 - 03:50	61° 37' N	29° 8' W	322	14.91
17 B	97-05-01	15:35 - 16:00	62° 9' N	30° 0' W	1330	46.15
18 B	97-05-02	23:10 - 23:30	61° 9' N	28° 34' W	77	3.93
19 B	97-05-04	02:10 - 02:40	58° 45' N	33° 20' W	182	9.22
20 B	97-05-04	17:55 - 18:35	57° 59' N	33° 24' W	68	5.20
21 B	97-05-05	12:40 - 13:40	57° 22' N	33° 18' W	43	3.68
22 B	97-05-20	02:00 - 02:30	55° 25' N	34° 1' W	16	2.06
23 B	97-05-20	13:30 - 14:05	55° 23' N	34° 3' W	13	0.49
36 B	97-07-06	11:30 - 12:00	61° 35' N	29° 19' W	1	0.05