

Cod larval patches in Icelandic waters in 1998

by

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Abstract:

A cod larvae/juvenile patch south of Reykjanes peninsula SW-Iceland was sampled three times during June 1998. The patch was retained in the same area during the whole three weeks of sampling. At the start of the experiment the estimated number of cod larvae in the patch was $5.0 \cdot 10^9$ larvae, with an average length of 7.0 mm. At the end of the experiment, 22 days later, the estimated number of larvae/juveniles in the patch had been reduced to $1.9 \cdot 10^8$ and the average length had increased to 10.6 mm. The growth was thus slow during the period (0.16 mm d^{-1}) and the mortality high ($14.8 \% \text{ d}^{-1}$) on the average. Larvae, 6-9 days old during the second coverage, experienced average mortalities of 3-9 % per day during the next 18.5 days but most 12-27 days old larvae had average mortalities of 13-19 % per day during the experiment. The elevated and stable average mortality indicated for the period 30-45 days posthatching, points to a short high mortality period at metamorphosis.

Key words: cod, larvae, juveniles, patch, mortality, survival, growth, Iceland

Introduction

Reliable assessments of the year-class strength of commercial fish stocks at the earliest possible stage benefits both fishery management and the fishing industry. For cod and several other spring spawning species the earliest attempts to assess the year-class size are often made during late summer when the juveniles are 3-4 months old. The results are merely indicative indexes of limited use however, and the first reliable estimates are not made until the juveniles are 1, sometimes even 2 years old. The trade-off between less reliable early and more reliable late estimates of the year-class may thus seem unavoidable.

Due to the enormous (but variable) mortality rates during the egg and larval stages the number of eggs and larvae of many fish species do not correlate with the year-class size at recruitment (Peterman et al. 1988, Bailey and Spring 1992, Thorisson 1994). For cod however, correlations have been found between the number of 2-3 months old cod juveniles and the year-class size at recruitment (Sundby et al. 1989). It has still to be determined if this age (2-3 months) is the earliest possible stage to make usable estimates of the year-class. It is not self evident though that such early estimates are less reliable than estimates made at 3-4 months of age. Provided that mortality rates are already down to relatively low and predictable levels (Campana 1996), abundance

estimates on 2 months old cod juveniles might even be more reliable as no juveniles have left the pelagic yet and the smaller distribution area is more manageable.

Finding the earliest possible stage for usable year-class estimates requires hard-to-get information to establish mortality curves for the first 3-4 months in the life of cod. Year to year variations must also be taken into account. Some mortality calculations based on enclosure studies exist (Kvenseth 1983, Pedersen et al. 1989) but successful studies based on repeatedly surveyed larval/juvenile patches of cod were not found (Campana et al. 1989, Thorisson and Asgeirsson 1999).

The following study is a part of a multi-disciplinary project on the early life history of cod which started in 1997. The aim of the project is to compare environmental conditions with biological parameters and construct a predictive model of the growth and survival during the first 3-4 months in the life of each cohort of cod. The present study is an effort towards constructing a mortality curve for this “dramatic” time-period in the early life history of cod.

Material and methods

The material was collected during two cruises in early and late June 1998 in the waters southwest and west of Iceland (Fig. 1). During the first cruise, a coarse grid of stations revealed two patches of cod larvae/juveniles, one around Snaefellsnes peninsula and the other south of Reykjanes peninsula (Figure 1). To increase the resolution, a grid of in-between stations were taken at the end of the cruise. The patch area south of Reykjanes was thus covered independently two times, with 3.5 days interval, during the first cruise. During the first cruise 50 stations were sampled on 2-9 June 1998. On the second cruise 48 stations were sampled during 24-28 June.

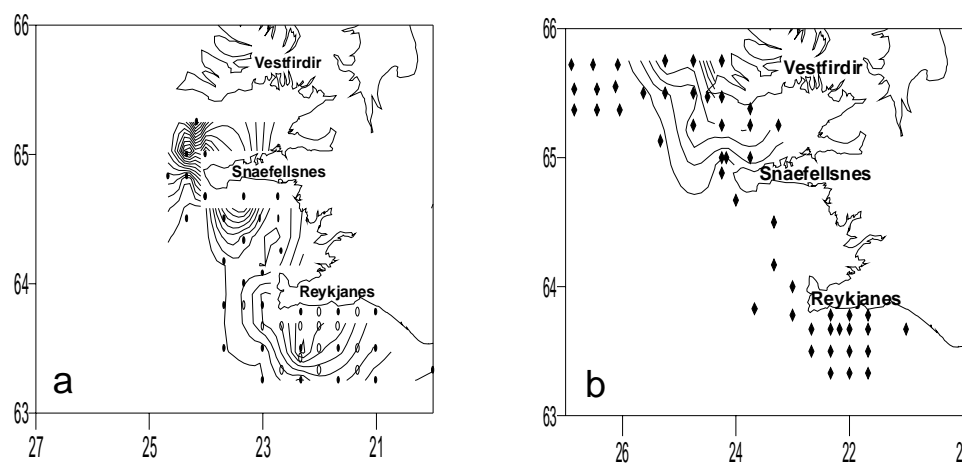


Figure 1. The positions of sampling stations on the first cruise are shown in **a**. Dots: first coverage, open circles: second coverage. Stations on the second cruise are shown in **b**. High concentrations of cod larvae/juveniles are shown with contour lines.

On each station temperature and salinity were profiled with a CTD Sonde. Larvae/juvenile and zooplankton samples were also taken at every station with Tucker trawl and WP2-net respectively. The Tucker trawl had an opening of 4 m², a mesh size of 1 mm and was equipped with a flow meter. The trawl was lowered from the surface at 1 m/s to 40 m depth (or within 10 m from the bottom) and retrieved at <0.5 m/s while cruising at 1 m/s. The WP2 zooplankton-net with a mesh size of 200 µm was towed vertically from 50 m to the surface. The samples of cod larvae/juveniles for daily rings readings were put into small capped vials and deep-frozen in liquid

nitrogen. Samples of cod larvae/juveniles not intended for age reading and all zooplankton samples were fixed in 4 % neutralized formaldehyde in seawater.

As there was incidentally some tendency towards sampling high density areas more often during the night than during the day, the observed diurnal variation in catchability was not corrected for.

The minimum total number of cod larvae/juveniles in the patch was estimated using a isoline graph made with the help of the Surfer® software package. The areas between isolines were multiplied with the average density in the area. Thereafter all areas were added together for the total number in the patch. Cod densities below 10/1000 m³ in the first cruise and below 1/1000 m³ in the second, were assumed to lie outside the patch and were ignored.

Random samples of cod larvae/juveniles from the total catch of each cruise were taken for daily rings readings. From the second coverage 112 cod larvae/juveniles were age read and 33 larvae/juveniles from the third coverage. Daily rings were counted at least three times on each polished lapillus using 1000 x magnification and random samples rechecked by a different reader. The length distribution of each age sample was adjusted to the total length distribution of the whole cruise and also to the total number of larvae caught in each cruise.

A satellite monitored surface drifter, drogued at 15 m depth was placed at the center of the Snaefellsnes patch during the first cruise. A similar drifter, entered the area of the cod larval/juvenile patch south of Reykjanes on the 20 May and stayed in the area during the whole experiment.

Results

During the whole sampling period 2-28 June a satellite monitored surface drifter kept circulating close to the center of the cod larval/juvenile patch, with an overall average movement of 0.7 nm/day to the NW (Figure 2).

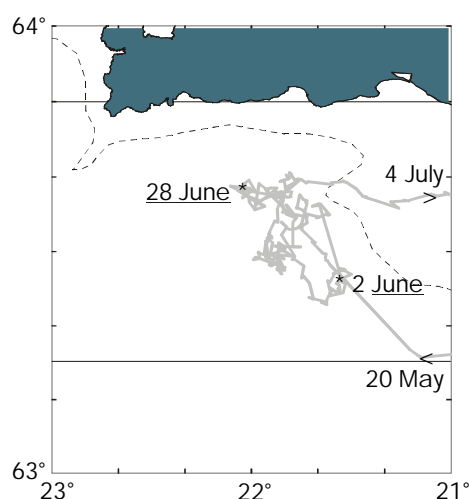


Figure 2. The drift route (grey line) of a surface drifter, drogued at 15 m depth, that stayed close to the center of the cod larval/juvenile patch during the experiment. The borders of the area selected for the patch study are shown with thin lines. Also shown is the 100 m depth contour (broken line).

Temperature and salinity distribution were relatively stable in the patch area in June and will not be discussed further. Zooplankton results will be presented later, when stomach analyses are ready for publication.

During the interval between cruises the Snaefellsnes patch moved almost 50 nautical miles to the north, up to the Vestfirðir peninsula (the surface drifter travelled even farther and more westward). As the available ship time did not allow for sufficient coverage of this patch during the second cruise it was unusable for comparisons between cruises and will not be discussed further.

The distribution of the cod larvae/juveniles caught in the patch area during the first coverage is shown in Figure 3a. The average length of the 308 measured larvae/juveniles was 6.98 mm and their length distribution is shown in Figure 4. The calculated total number in the patch was 5.0×10^9 individuals.

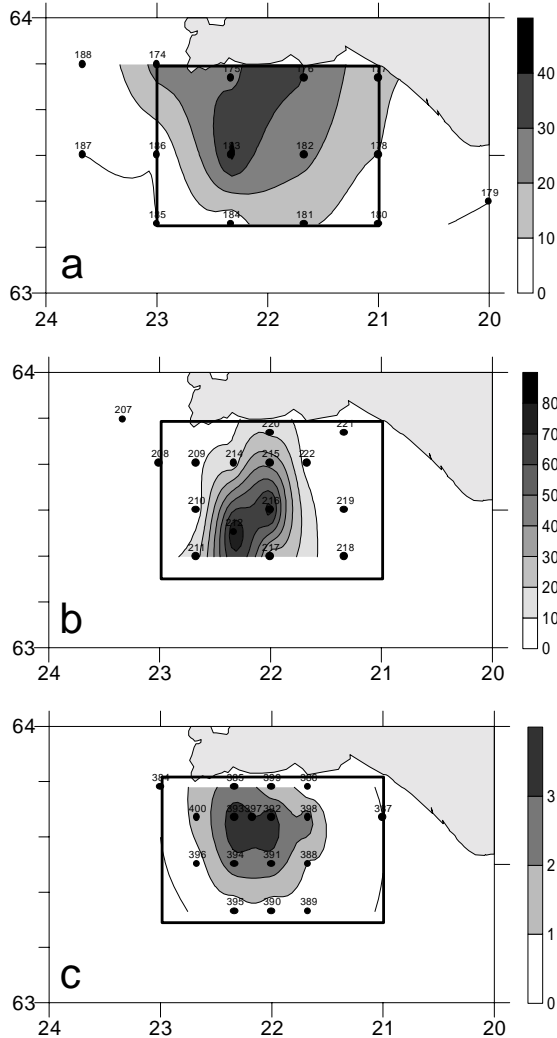


Figure 3. The distribution of the cod larvae/juveniles (number/1000m³) in the patch south of Reykjanes. First coverage: a, second coverage: b and third coverage: c. The inner frame shows the area used for calculations. Note different scales.

The distribution during the second coverage, 3.5 days later, is shown in Figure 3b and the length distribution (n=839) in Figure 4. Calculated total number was down to 3.34×10^9 and average length was 7.15 mm. Only 62 larvae/juveniles were caught in the patch area during the third coverage. The distribution is shown in Figure 3c and the length distribution in figure 4. The calculated total number in the patch had reduced to 1.94×10^8 individuals and the average length had increased to 10.6 mm.

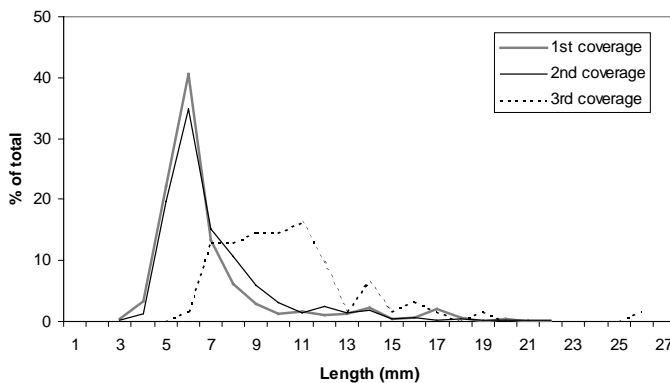


Figure 4. Length distributions of the cod larvae and juveniles caught in the three coverages of the patch south of Reykjanes. Between the 1st and 2nd coverages 3.5 days elapsed and

18.5 days between the 2nd and 3rd coverages.

Figure 5 shows the reduction in numbers of cod larve/juveniles in the Reykjanes patch in June 1998. Between the first and second coverages the total number of cod larvae/juveniles in the patch decreased by 11.5 % per day on the average (Figure 5). Between the second and the third coverages the mortality was higher or 15.4 % per day on the average.

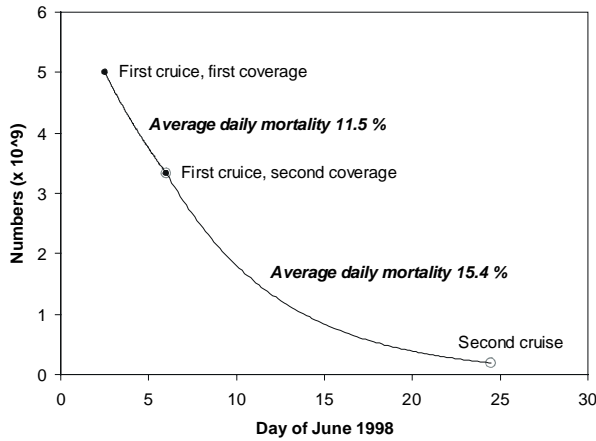


Figure 5. The average daily mortality of cod larvae/juveniles in the Reykjanes patch during the experiment.

The average length of larvae increased only by about 0.2 mm between the first and second coverages. The slow apparent growth is probably caused by the addition of newly hatched larvae to the patch as is hinted at in Figure 6 (thin line). The highest mortality between the 1st and 2nd coverages appears to be among 6-8 mm larvae and 13-20 mm larvae/juveniles (lengths at start of experiment). Because the length of the cod larvae/juveniles increases by about 3 mm between the 2nd and 3rd coverages, mortality rates tend to level out between neighbouring length groups (grey line).

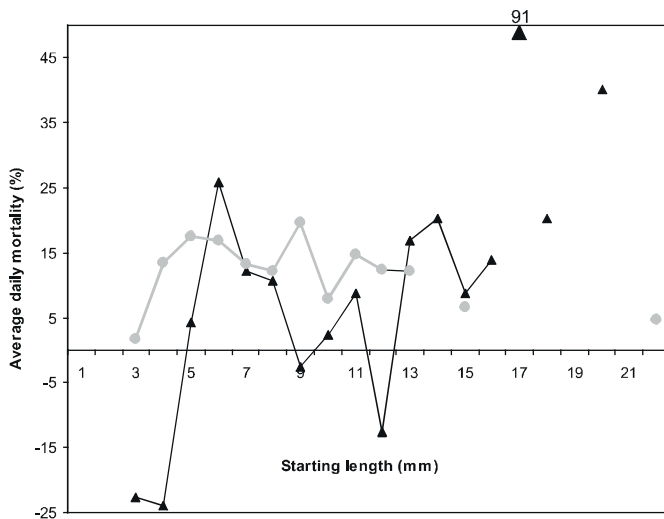


Figure 6. Average daily mortality per length group. Thin black line and filled triangles: 1st vs. 2nd coverages. Thick grey line and filled circles: 2nd vs. 3rd coverages. Each length group (mm) is assumed to increase in length by 1 mm between coverages 1-2 and by 3 mm between coverages 2-3.

By adjusting the daily ring readings from both cruises to age at 5 June the average daily mortality for different age groups have been calculated. As shown in Figure 7, the average mortalities of 6-9 days old larvae (4.6-6.1 mm) were 3-9 % per day, but no information is available for the youngest larvae (1-5 days old). The average mortality of 12-27 days old larvae (5.3-21.2 mm) was between 13-19 % per day except for the 23 days old larvae (9 %).

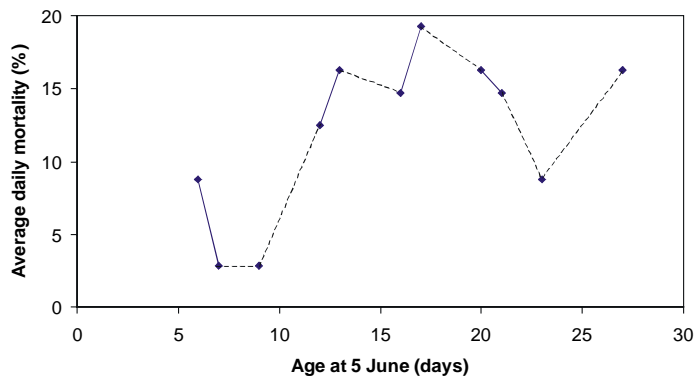


Figure 7. Average mortality per day for age groups, between second and third coverages. Age shown is initial age and the mortality is an average for the following 18.5 days.

Discussion

The restricted overall movement of the surface drifter located in the Reykjanes patch strongly indicates a retention of the patch and that the same intact patch was sampled in all three cases. Furthermore, the distribution of the larvae indicate that the coverage of the patch was acceptable (Figure 3). The calculated total numbers of cod larvae/juveniles in the patch are minimum numbers however, for two reasons. In each instance, a small but variable part of the distribution area reached outside the frame used for calculations and a small part of the depth distribution of the larvae/juveniles may have reached below the maximum depth of the Tucker net. Available data indicate that each of these variable fractions were probably within 10 % of the total. The main shortcoming of the present study was the low number of larvae/juveniles caught during the last coverage.

Similar studies have been reported for other species of fish larvae (Fortier and Legget 1985, Munk 1986, Incze et al. 1989, Davis et al. 1991, Gallego et al. 1996) and attempts have also been made to study cod larvae and juveniles in this way (Aro et al 1992, Thorisson and Asgeirsson 1999). The present paper may however, be the first report of a successful mortality study of this kind on a cod larval patch.

The larvae/juveniles caught in this study were about the same size as those caught west of Iceland in late June 1997, which were 10.9 mm (Thorisson and Asgeirsson 1999), but were considerably smaller than the 15.9 mm average reported for the same area in mid-June 1985 (Thorisson 1991). Both studies report faster growth at this time of year (0.3 mm/d and 0.43 respectively), compared to the 0.16 mm/d measured in the present study. The above studies did not assess the mortality rate, but reports from rearing experiments in Norway give 2-10 % average daily mortality during the first 40 days (Solemdal 1989). By indirect calculations, however, the average *in situ* mortalities of eggs and early larvae of cod have been estimated to be about 12 % per day (Fossum 1988). The average mortality in the Reykjanes patch in 1998 is even higher but the slow growth suggests bad feeding conditions which may be a part of the explanation. When finished, the zooplankton and stomach analysis will provide additional insight into the life history of this cod larvae/juvenile patch.

The mortalities of 1-5 days old larvae are probably very high (Fossum 1988, Pedersen et al. 1989, Sundby et al. 1989), but this could not be confirmed as no larvae from this youngest age group were caught during the first cruise. The samples in question contained much phytoplankton however, and the possibility that the smallest larvae may have been caught but overlooked, can not be overruled. The high disappearance rate of larger larvae can not be explained by low catchability for the larger larvae

however, as these age- and length groups were easily caught with the same gear during the first cruise.

The number of larvae/juveniles caught in the second cruise are too few to give reliable information on each and every age group, but certain trends extending through several age groups are statistically significant. The mortality of cod larvae/juveniles with starting age 6-9 days was low or moderate. The high mortality of most older age groups (12-27 d) indicate a high mortality period between 30 and 45 days of age. The sudden rise in mortality and the similarity between age groups above 12 days suggests a short duration of this high mortality period. This period, at 30-45 days posthatching, coincides with metamorphosis (Bergstad 1984, Pedersen and Petersen 1992). The present results thus suggest a short high-mortality period during metamorphosis.

Acknowledgements

We wish to thank Aðalbjorg Jonsdottir for doing some of the age readings, Hedinn Valdimarsson for the supplied data on the surface drifter and crews of the research vessels and colleagues at the MRI for their help during sampling and working up of the samples.

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