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Sturlaugsson, J. 1995. Migration Studies on Homing of Atlantic Salmon (Salmo salar L.) in Coastal Waters W-Iceland - Depth movements and sea temperatures recorded at migration routes by data storage tags. International Council for the Exploration of the Sea. C.M. 1995/M:17. 13 p.

International Council for the Exploration of the Sea
C.M.1995/M:17
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MIGRATION STUDY ON HOMING OF ATLANTIC SALMON (Salmo salar L.) IN COASTAL WATERS W- ICELAND
- Depth movements and sea temperatures recorded at migration routes by data storage tags

by

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Abstract

In 1994 migration study on homing of Atlantic salmon (Salmo salar L.) in coastal waters was carried out in W- Iceland using Icelandic data storage tags. Schools of homing salmon were captured in seawater when entering their home water in a ocean ranching station in Hraunsfjord. In August a total of 60 salmon were tagged and transferred (25-95 km) in sea water to 4 releasing sites, at shore and at sea over depth of 180 m. Salmon from all release sites were recaptured in Hraunsfjord (50% mean recapture), mostly during a period of 10 days from release. The mean travelling speed ranged from 70 -1044 m/hour. The tags measured both pressure (depth 0 -123 m) and temperatures with 15 minutes intervals during a period of 10 days. The majority of the salmon spent most of their time in the uppermost 3 meters. Common behaviour was occasional deep dives (10-123 m) and then usually few hours of migration through deeper layers. During that time two patterns of vertical movements were observed, series of rapid dives down from the surface or continuous movements in those layers. The deepest dive taken in a 15 min period was 98 meters (0.1 m/sec). The records of sea temperature showed a decline with increased depth (up to 5 °C/hour), also showing that salmon were swimming down through the thermocline at 20 - 40 meters depth. One example of a large variation in water temperature (5.4°C) in the 0-1 meter layer, suggested that the salmon entered a river.

Key words: Atlantic salmon, homing, coastal waters, data storage tags

Introduction

Data storage tag (DST-100) was developed in Iceland by the engineers at Star Oddi Ltd in cooperation with fish biologists at the Institute of Fisheries and Aquaculture Research and the Marine Research Institute in Iceland (Fig. 1a). The smallness (17 x 56 mm),low weight (12 g), and cylindral shape of this data storage tag makes it possible to use the tag on relatively small fish. The tag is used either internally or externally (Fig. 1a & 1b). It records series of measurements from the environment of the fish, both of pressure (depth) and temperature. The present use of the data storage tags on salmon, was the first instance of data storage recording of the vertical movements and the corresponding changes in temperatures from Atlantic salmon (Salmo salar L.) migrating in the sea.

Fig. 1a. The data storage tag (DST 100) used in the study, externally attached to a salmon.

Fig. 1b. Tagged salmon in tagging chute, ready for transport to the release site.

The present results are preliminary and are just intended to give some examples of swimming behaviour of salmon in the study and to present some of the possibilities opened by the use of the data storage tags. This study is part of a larger tagging project, to be continued into 1996, with transplantation of data storage tagged salmon in sea water up to 420 km from the recapture site. To detect possible influence of environmental factors on the vertical svimming behaviour, the depth distribution will be compared to available data from areas involved, such as recordings of sea temperatures, photoperiod and tidal cycles.

Material and methods

In 1994 a migration study on homing of Atlantic salmon in coastal waters was carried out in W- Iceland using DST-100 (Fig. 2). This study was a continuation of earlier research that was carried out in 1993 using prototype of the tag that only measured temperature.

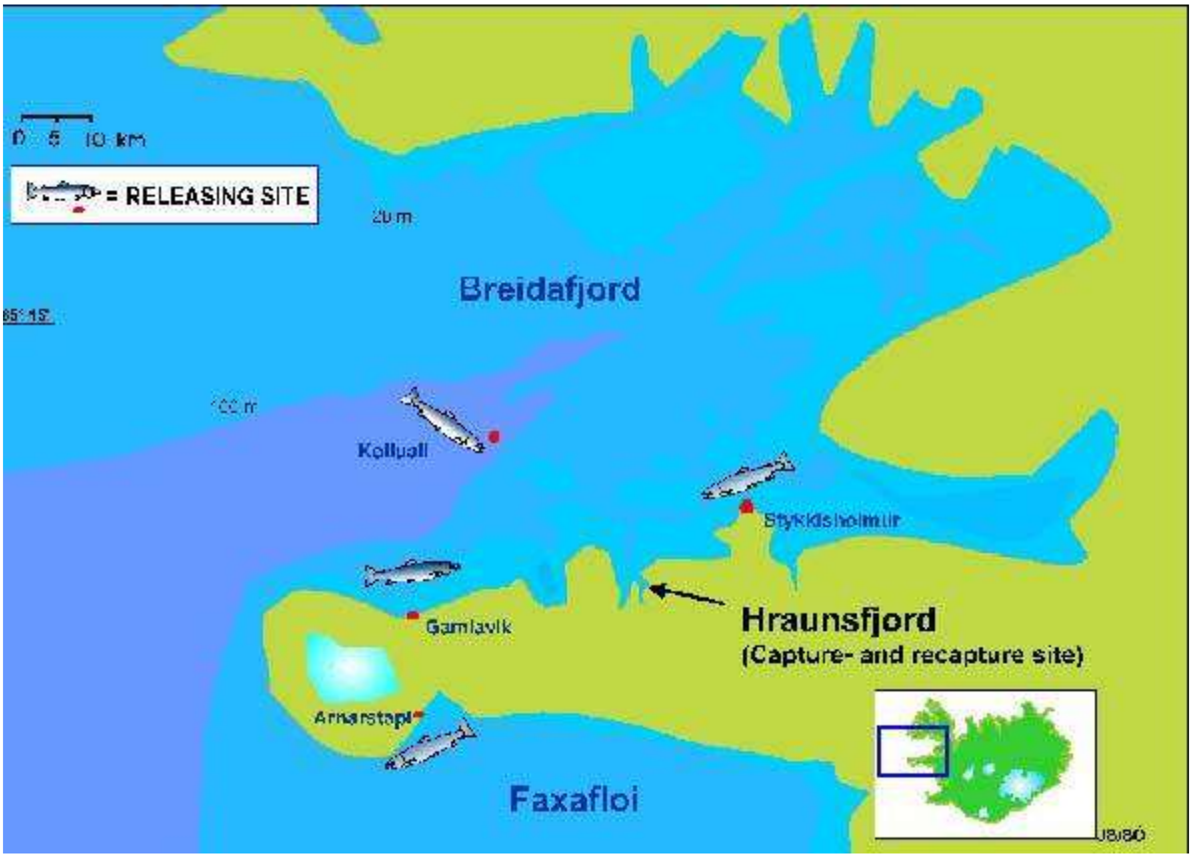

Fig. 2. The study area involved in the migration study on homing of salmon. Location of releasing sites and of capture and recapture site are shown. Water depth intervals are shown (0-20m, 20-100m, >100m).

Schools of homing salmon were captured in seawater when entering their home water in Hraunsfjord at the Silfurlax ocean ranching station and transferred in sea water to tanks with running seawater (33.5 ‰). The salmon were tagged with DST-100 (Fig. 1a) and length and weight measured. Tags were fastened externally adjacent to the dorsal fin by metal threading. In this study we used pressure sensors that ranged from 0-123 bars (0 - 123 m), with one meter resolution. The tags recorded in one meter intervals as follows: 0-1m = 1m, 1-2m = 2m etc. The tags measured temperature in the range 0-20°C in steps of 0.1 °C (tolerance 0.2 °C). In the second generation tags used here, the non-volatile memory could store 1980 recordings. The 3rd generation tags can now store about 8000 records. The tags were programmed for measurements at 15 minutes intervals for a period of 10 days and 7 hours.

Four groups of 15 salmon were transported in seawater on car or boat to different release sites (Fig. 2 & Table 1). A total of 60 salmon were tagged and released over the period from17th to 20th of August. The tagged salmon were released along the shore in 25, 41 and 95 km distance from Hraunsfjord (shortest seaway) and one release site was 14 km offshore 29 km away from Hraunsfjord over a bottom depth of 180 meters.

Results and discussion

Recaptures and migration speed

Thirty of the tagged salmon (50%) were recaptured in Hraunsfjord (Table 1 & Fig. 2.).

	Releasing sites Number of salmons released and recaptured			
Categories of salmon	Stykkisholmur	Kolluall	Gamlavik	Arnarstapi
Tagged & released:	15	15	15	15
Recaptured:	9 (60%)	9 (60%)	6 (40%)	6 (40%)

Table 1. Number of salmon released and recapture rates in relation to releasing sites.

Releasing sites

Number of salmons released and recaptured

Most of the salmon (25) from all release sites were recaptured during a period of 10 days from release, but the last recapture day was the 13 September, 24 days after the fish was released. The mean migration speed ranged from 70 - 1044 m/hour (shortest seaway). In most of instances the salmon released at the shorter distances from capture site were soon recaptured in Hraunsfjord. An exception was salmon released at Kolluall, that after 6 days were still over depts as shown by about 80 m deep dive taken that day (Fig. 3), but that depth is only found in narrow part of the study, and equals approximately the area > 100 m shown in Fig. 2.

The salmon did lose weight during their migration, one extreme case were salmon that lost 10% of its body weight during 10 days period of migration.

The recordings from the recaptured salmon were approximately 15 thousands of each, depth of fish and sea temperature, a total of over 30 thousands recordings.

Vertical movements

The majority of the salmon spent most of their time in the uppermost 3 meters of the seawater and most often in the depth interval 0 -1 meter (Fig. 3-7). The salmon postsmolts migrating oceanward trough the Breidafjord Bay (see Fig. 2), also migrated mostly in the uppermost 3 meters (Sturlaugsson and Thorisson 1995). Common behaviour was occasional deep dives (10-123 m) often followed with rapid shallower dives (Fig. 3-7). The swimming of homing salmon into deeper layers when homing are phenomenon that have been explained as excursions to scan the different environmental parameters as cues for orientation (Westerberg, 1982; McKeown, 1984).

When the salmon swam down to 10 meters or more they usually migrated through deeper layers for few hours and even up to 12 hours (Fig. 4 & 6). During that time two patterns of vertical movements were observed. Series of rapid dives down from the surface were observed (Fig. 5) or continious movements in the deeper layers (Fig. 4). One fish dived just once below 10 meters but migrated the rest of the way in the uppermost 3 meters. Some salmon that were released at the shore, dived down to 30- 60 m depths (Fig. 6 & 7). In some instances, considering the bottom topgraphy this indicated a migration some km off shore (Fig. 6 & 2).

The dives recorded often started in the beginning of outgoing tide, suggesting that one possible reason for this behaviour was that the salmon were swimming down below the strongest outward current in order of selective tidal transport. Selective tidal transport has been recorded among cod (Gadus morhua L.) by means of transponding acoustic tags (Arnold et al. 1994).

The dives observed ranged from few meters up to more than 123 meters. The deepest dive taken in a 15 min period was 98 meters, indicating a vertical velocity of at least 0.1 m/s. The deep dives reported here is in contrast to earlier research on homing salmon in coastal waters (Westerberg 1982), but salmon swimming down to considerable depths have been reported in the feeding grounds in the open Atlantic (Jakupsstovu et al. 1985).

Temperature recordings

The records showed a decline in the sea temperature with increased depth, showing that salmon were swimming down trough the thermocline at depth of 20 - 40 meters (Fig. 3 & 7). Large variations in water temperature in a short time intervals was observed paralell to swimming to deeper layers, when temperature changes up to 5 centigrades per hour were recorded.

The increased temperature variation recorded in the 0-1 meter layer at end of August suggests that the salmons did brake the surface layer and were possibly contacting air, but the tags were placed beside their dorsal fin (Fig.1a).

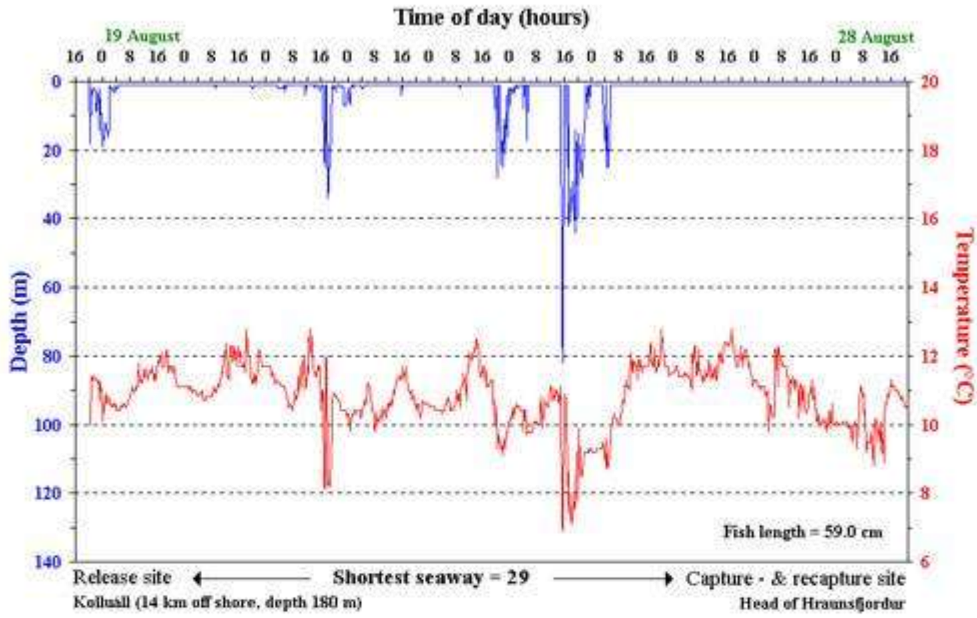

Fig. 3. Depth distribution of homing salmon 1 and corresponding sea temperature in relation to time.

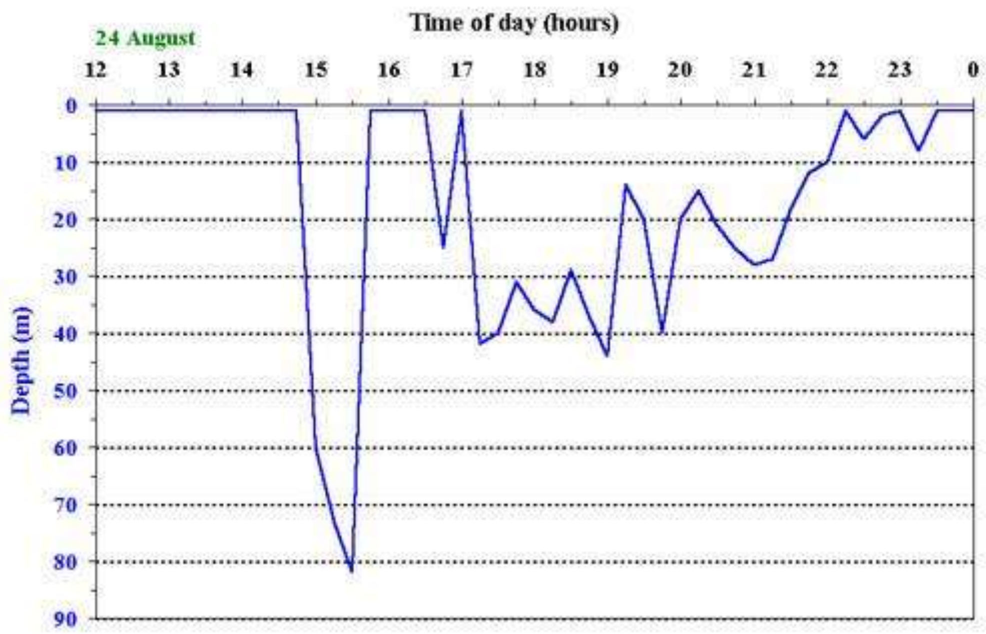

Fig. 4. Depth distribution of homing salmon 1 for selected time interval (the deepest dives in fig. 3).

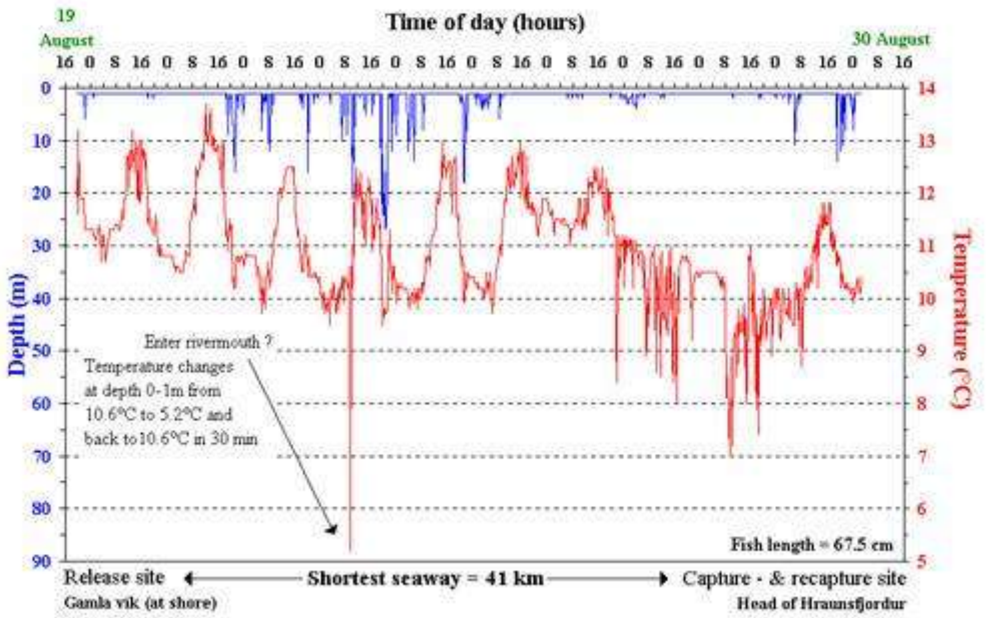

Fig. 5. Depth distribution of homing salmon 2 and corresponding sea temperature in relation to time.

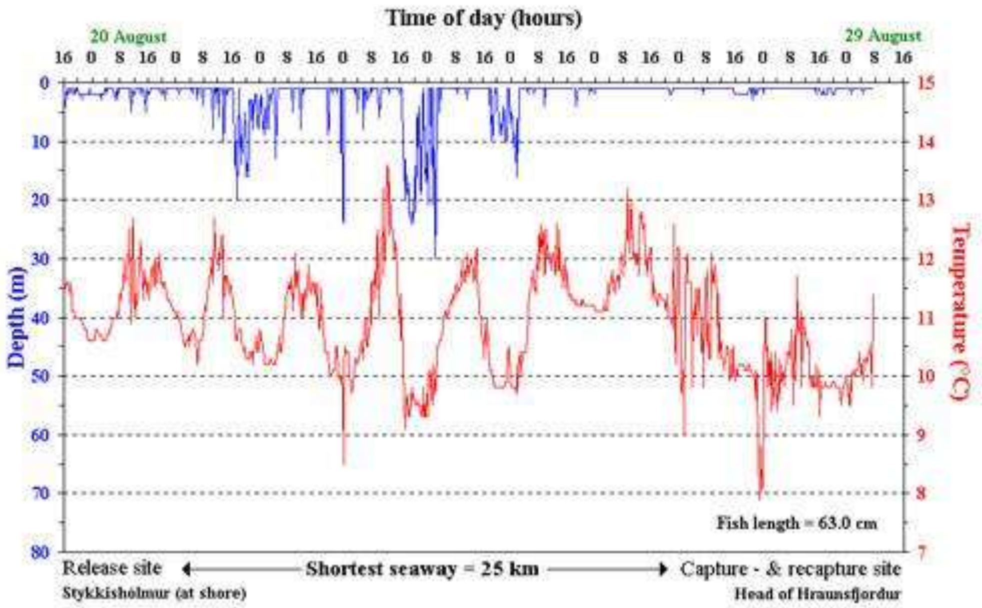

Fig. 6. Depth distribution of homing salmon 3 and corresponding sea temperature in relation to time.

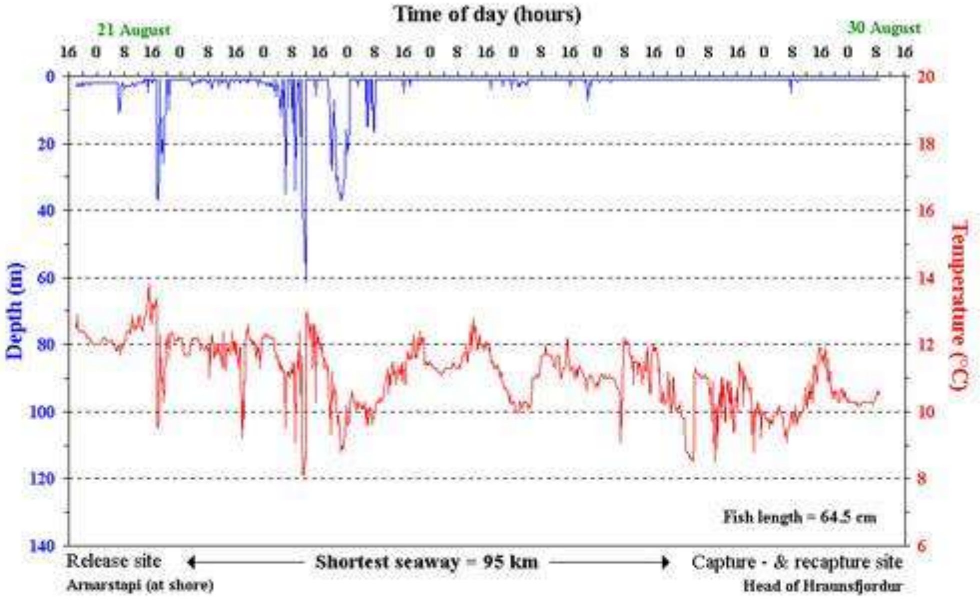

Fig. 7. Depth distribution of homing salmon 4 and corresponding sea temperature in relation to time.

One example of a rapid temperature change indicated that the salmon entered a river, or were possibly swimming at the surface, contacting air (Fig. 5). A large deviation (5.4°C) in the morning between two normal recordings for that area (10.6°C) in the 0-1 meter layer suggested that the only possible explanation was migration into freshwater, because the lowest air temperature recorded in the area was 6.1 °C during the previous night (data from the Meterological Institute).

Daily rythm in sea temperature was common in the 0-1 meter layer (Fig. 5) with amplitudes up to 4 °C between day and night.

Concluding remarks

The use of data storage tags made it possible to detect the vertical distribution of homing salmon for long periods and distances. Additionally we were able to observe the remarkable homing abilities of the salmon, that enabled them to return back to their water of origin after being transplanted to different areas e.g. with regard to direction of currents in the migration route.

While migrating the salmon spent most of the time close to the surface, as has been reported from fishing experiments and a number of acoustic telemetry trackings. The deep dives taken by the salmon trough the thermocline is on the other hand contrasting to earlier research on homing salmon in coastal waters (Westerberg 1982). The first dives subsequent to release are probably related to the handling of the salmon, but many instances of deep dives after considerable time from release shows that the homing salmon are swimming through deeper layers, and even some of the salmon released at the shore. The purpose of this migration behaviour may be to detect some environmental cues or it may be a responce to tidal currents (selective tidal transport). Tides have been shown to influence migration of homing salmon (Hawkins et al. 1979).

The approximate horizontal location of salmon tagged with data storage tags is possible due to the fact that the salmon spent most of their migrating time close to the surface. It is possible to compare the sea temperature data from the tags, to sea surface data from satellite measurements. In the N-Atlantic area satellites measures sea surface temperature at 4 times each 24 hours and the maximum area solution is 1 km2. This opens up a new way to track salmons over long periods and large areas.

Recordings over long periods (weeks or months) will make it possibile to use the temperatures recordings for comparison with the growth of the fish, and the growth patterns of scales/otholiths.

The results discussed here together with the possibilities mentioned shows how important data storage tags can be in the near future migration studies of salmon and other fishes in sea waters. This is especially true regarding long term studies on the widely travelling Atlantic salmon, were data storage tags have large advantage over traditional telemetry measurings (Sturlaugsson 1995). The first step to sample series of data from both feeding and spawning migration have been taken in Iceland by tagging recovered kelts with DST-100, but other possibilities are being discussed such as using data storage tags on salmons caught on long line in the feeding areas.

Acknowlegdments

Thanks are due to director Sigmar Gudbjornsson at the Star Oddi Ltd for his support throughout the project. Thanks are due to Mr. Konrad Thorisson at the Marine Research Institute for his cooperation during this study. I also acknowledge the help of the staff at Silfurlax Ltd ranching station and the help of Mr. Sumarlidi Oskarsson at the Institute of Fisheries and Aquaculture Research. This work was sponsored by the Research Council of Iceland and by the Icelandic Ministry of Fisheries.

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