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MIGRATORY PATTERN OF WILD SEA TROUT (*Salmo trutta* L.) IN SE-ICELAND RECORDED BY DATA STORAGE TAGS

by

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Abstract
Sea trout (*Salmo trutta* L.) were tagged with data storage tags and conventional tags in the river Grenlaekur, SE- Iceland in early May 1995. The data storage tags measured both pressure (depth) and temperature with 4 hours interval during periods up to 5 months. Sea trout were caught by fly fishing anglers about 6 km above the estuary and tagged. Fish were tagged with data storage tags either externally or implanted surgically into the body cavity of the fish. Tagged sea trout were recaptured by anglers troughout the summer in Grenlaekur, thereof 21% after they had migrated to sea. Data storage tagged sea trout showed strong negative relationship between length at tagging (39-65 cm) and the cumulative temperature experienced in freshwater until sea migration, as the biggest fish started their sea migration late in May and the smallest in mid June. The recordings showed that fish migrated into sea water predominantly nocturnally. The growth of sea trout in the sea was negatively related to their length at tagging. During sea migration the sea trout spent most of their time in the uppermost 5 meters, but deeper dives were taken down to a 26 meter depth. Occasional high temperature recordings from sea trout while feeding at sea are likely to be related to brief migrations into an estuary or river. After a period of 33 to 97 days in sea, the sea trout entered fresh water for spawning and/or overwintering. In freshwater, the fish showed diurnal rhythm in depth, staying deeper at day.

Key words: Sea trout, behaviour, migration, growth, telemetry, stock assessment

Introduction

The project is based on tagging of anadromous brown trout (*Salmo trutta* L.) with Icelandic data storage tags (DST), manufactured by Star-Oddi Ltd. These tags record series of measurements from the environment of the fish and have been used in pioneer research in this field of telemetry (Sturlaugsson 1995;Thorsteinsson 1995). The tag used in this study (DST 100), measured both pressure (depth) and temperature. The small size, low weight and cylindrical shape of these data storage tags enabled us to use them on relatively small migrants. This study was the first instance of DSTs used in research on this species.

River Grenlaekur SE-Iceland was choosen as a study area because its sea trout stock varies in life history parameters (size, age, migration pattern etc.) and is harvested by angling, that also ensures recovery of DSTs. This sea trout stock is the largest in number in Iceland, with a mean annual rod catch for the last couple of years around 3500 sea trout or 5 tonnes (Gudbergsson 1996).

Anadromous brown trout are found in all parts of Iceland and are the most common salmonid species in SE-Iceland. Studies on sea trout are few in Iceland, majority of them being juvenile studies (see Jóhannsson & Einarsson 1993 for review).

The main aim of the research was to improve the knowledge of brown trout biology in Iceland. The research work focused on the feeding migration of the sea trout in the sea. The new DST telemetry enables sampling series of data directly from the fish´s environment, and over longer periods of time in the sea than previously possible. This method provides unique information about the timing of the anadromous migration and the spatial and temporal distribution of these migrants in the sea.

Material and methods

Study area

In 1995 a migration study on sea trout was carried out in Grenlaekur SE-Iceland (Fig. 1), as a part of an ongoing research project. River Grenlaekur is mainly springfed and the discharge in the upper part of the river system is about 1.9 m^3/sec. River Grenlaekur has a joint estuary with large glacial river (River Skafta) with a mean discharge of about 120 m^3/sec (Rist 1990). The air temperature data referred to was received from a weather station 20 km landward from the estuary of Grenlaekur.

Tagging

In May 6-7 1995, we tagged a total of 170 sea trout about 6 km above the estuary. All of them were tagged with conventional tags (Floy), but thereof 44 were also tagged with DSTs. The trout tagged were caught by fly fishermans and released the same day following tagging. The sea trout were both tagged externally (26 fish) and internally (18 fish) and half of each group were injected with antibiotics. Fish were anaesthetized using MS 222 (Tricane Methane Sulfonate) while tagged and measured (length and weight). Sex was determined if possible and for determination of age few scales were taken and later that summer also from untagged fish captured by anglers. Internal tagging was done by surgical implantation (Fig 2.a). After placement of the tag in the body cavity the incision was closed by a suture that disappears in few weeks. The incision was closed having the indentification plastic tube of the DST hanging out trough the body wall (Fig 2.b).

Externally the DST were fastened adjacent to the dorsal fin by steel threading (0.5 mm) (Fig. 3). The DSTs used measured both depth and temperature at an interval of 4 hours, enabling data logging for roughly 5 months. The DSTs (56x17 mm) weigthed less than 1 gram in water. The temperature and pressure range were -3 to 17 °C and 0 to 70 m respectively. The nominal accuracy for the temperature was +/- 0.2 °C and for pressure +/- 0.5 m

Recaptures
Recaptures were based on sea trout recaptured by anglers troughout the fishing season, from early May to late October. Return of tags were rewarded.

Results and discussion

Size, maturation and age composition
The length distribution of tagged sea trout are shown in relation to their number of sea migration Fig. 4. Thereof the DST-tagged trout were at tagging 36.6-66.0 cm in length and weighed between 0.40 -3.10 kg. Fish that had matured the previous autumn were 21% of the total number observed. Most of them had spawned once but instances of individuals participating 4 times in spawning were seen. The age of tagged fish was 4-8 years. These fish had spent 3-4 years continuously in the river before first sea migration. After that they were migrating every year the next 1-3 years into the sea. Back calculations of length from scales indicated that the sea trout averaged 26 cm in length when starting their first sea migration.

Recaptures
Recapture rates of DST tagged sea trout in 1995 were 21% in the fall after sea migration, and additionally 29% were caught in the river before out migration. This high total recapture rate of 50% in 1995 was much higher than recorded for conventionally tagged sea trout (13%). This difference of recorded recapture rates between the two types of tags is likely to be related to many reasons, one of them being a biased attitude of anglers towards the DSTs. No differerence in recapture rate was found between internally and externally tagged fish. Also there were no differences in recapture rates between those that were injected with antibiotics and the untreated ones. The sea trout recaptured after sea migration were 38.5- 65.0 cm in length at tagging.

Tag attachment
The incisions of internally tagged fish healed perfectly within the 1st month after tagging and more than a year after tagging we had two recoveries of internally tagged fish without any erosion around the identification tube. The double tagging showed that sea trout showed no loss of DSTs in the angling season following the tagging. Despite that we had some examples late in that season showing that the steel thread were getting out of the fish, with one example of no posterior fastening, but even in that case no wounds were observed. Recaptures of conventional tags in 1996 included one fish tagged in 1995 that had lost externally fastened DST. As a large majority of the sea trout in River Grenlaekur are recaptured in the year of tagging, convenient external tagging are ensuring results, but the more arduous internal tagging also include some additional recaptures in later years.

Body Growth

The body growth of the sea trout in the sea was negatively related to their length at tagging. The weight increase of DST tagged sea trouts at recapture after sea migration were 160-650 g, with the day-growth in weight of 0.39-0.89 %. The sea trout increased their length during this time of 1-5.8 cm and had the day-growth in length of 0.39-0.89 %. Further data analysis on the growth of sea trout will be done in relation to water temperature after receiving additional data from the tagging in 1996. The size difference will be used, but in addition we will also check wether there is a possibility of linking difference in monitored temperatures to the scales/otholiths growth pattern as has been suggested (Sturlaugsson 1995).

Measurements from migrating sea trout

We received series of vertical movements and corresponding water temperature for time periods up to 5 months (Fig. 5). These data series are the first instances of such measurements that include the sea phase and the freshwater phase before and after sea migration.

Sea migration - timing and duration in relation to environmental parameters

The results give a good picture of the timing of the run both into and out of the sea. The DST tagged sea trout started their sea migration in the period from May 27 to June 17. The timing of their migration was significantly negatively related to their size, also reflecting the different cumulative temperature experienced before entering the sea. Such size related behaviour can be used for management purposes, e.g. by specifying the start of the angling period each year in relation to the status of the stock (composition) the previous winter. The migrants entered the sea predominantly nocturnally. This is likely to reflect avoidance of predating pressure in the lowest areas of the river. In that area the great skua (*Stercorarius skua*) is preying on sea trout when migrating trough the extremely shallow sandy areas and seals (*Phoca vitulina*) are predating on them in the estuary and in the sea. Nocturnal out migration trough estuary have also been observed among sea trout smolts (Moore et al. 1994). The duration of the sea trout sea migration were 33 to 97 days.

Vertical distribution in the sea

The measuring intervals of DSTs used in 1995 did not allow detailed analysis of depth pattern. But due to long periods of recording, we gained good overview of the depth preferred on the average during different time intervals of the migration, that is likely to reflect the feeding behaviour. In general the depth recordings showed that the sea trout spent most of their time in the uppermost 5 meters (Fig. 5 and 6). But the recordings were also showing that they were swimming trough deeper layers, with examples of fish entering depths of 26 meters. Diurnal pattern were observed by some fish, that were staying closer to sea surface at night (Fig. 7). The salinity distribution from measurements August 10 1995 in area very close to the Grenlaekur estuary shows distribution that indicate that the sea trout from Grenlaekur might manly beiing utilizing depth levels with the very lowest salinity and highest temperature (Fig 8).

Behaviour in the river

Comparison of water temperatures measured by the DSTs within the river enabled approximate location of the sea trout in the river, based on detectable differences in temperature between areas. Such difference was for example detected between the lower area of the river and the upper area of the river. This difference was also reflected by the different relationship between the water temperatures in these areas and the air temperature (Fig. 9). The dicharge in river were compared to the vertical distribution of the sea trout for some periods, but no continuous relationship were found between these parameters for those periods (Fig. 10)

Horizontal location - possibilities

The sea trout while in the sea experienced variable temperatures, where the largest changes in a short time are likely to indicate excursions into estuaries or rivers. Although considerable work has been done in analysing data from the DSTs, many things are undone and will be analysed along with the data derived from the 1996 tagging. Example of this is the use of sea temperature data to specify the horizontal location of sea trout while migrating in the sea. Most of the time the sea trout is migrating close to the surface. It is thus possible to track the horizontal location (Karlsson et al. 1996). The objective will be to get some indication regarding the location in relation to estuaries and the distance from shore. By comparing temperature data from a DST to sea surface temperature data from satellite measurements, it is possible to locate the approximate area (temperature zone) where the fish are migrating.

General conclusions

The DSTs largely increase our understanding of the factors involved in the migration and distribution of anadromous brown trout stocks. Some of these factors are surely affecting the observed fluctation in the size of sea trout stocks. Some of the new information, such as timing of the sea run will right away have practical importance regarding stock assessment and conservation in the area, espesially if they are linked to data derived from traditional measurements/estimates of the stock and its size. This will lead to more reliable assessment of the rod fishery of the of anadromous brown trout stocks. In addition we can use some tips from spatial and temporal distribution to control and even improve traditional data sampling methods.

In order to look more closely into estuarine migrations of sea trouts it would be interesting to do tagging experiments, using the new smaller DSTs that additionally to pressure and temperature sensors have a salinity sensor. Such DSTs were tested for the first time in the summer 1996 on salmon migrating in coastal waters giving very interesting results (Sturlaugsson et al. unpublished data).

The data storage tags will be a very important research tool in fisheries research in the future. They will open new methods of studying the behaviour and environment of fish, not the least of anadromous fish. This is due to the fact that the DSTs enable unique possibilities regarding sampling continuous series of behavioural and environmental information from areas and over time periods where other sampling methods fail. This new dimension in research of fish will therefore add valuable information to our understanding of fish behaviour and their reactions to their environment.

Acknowlegdments

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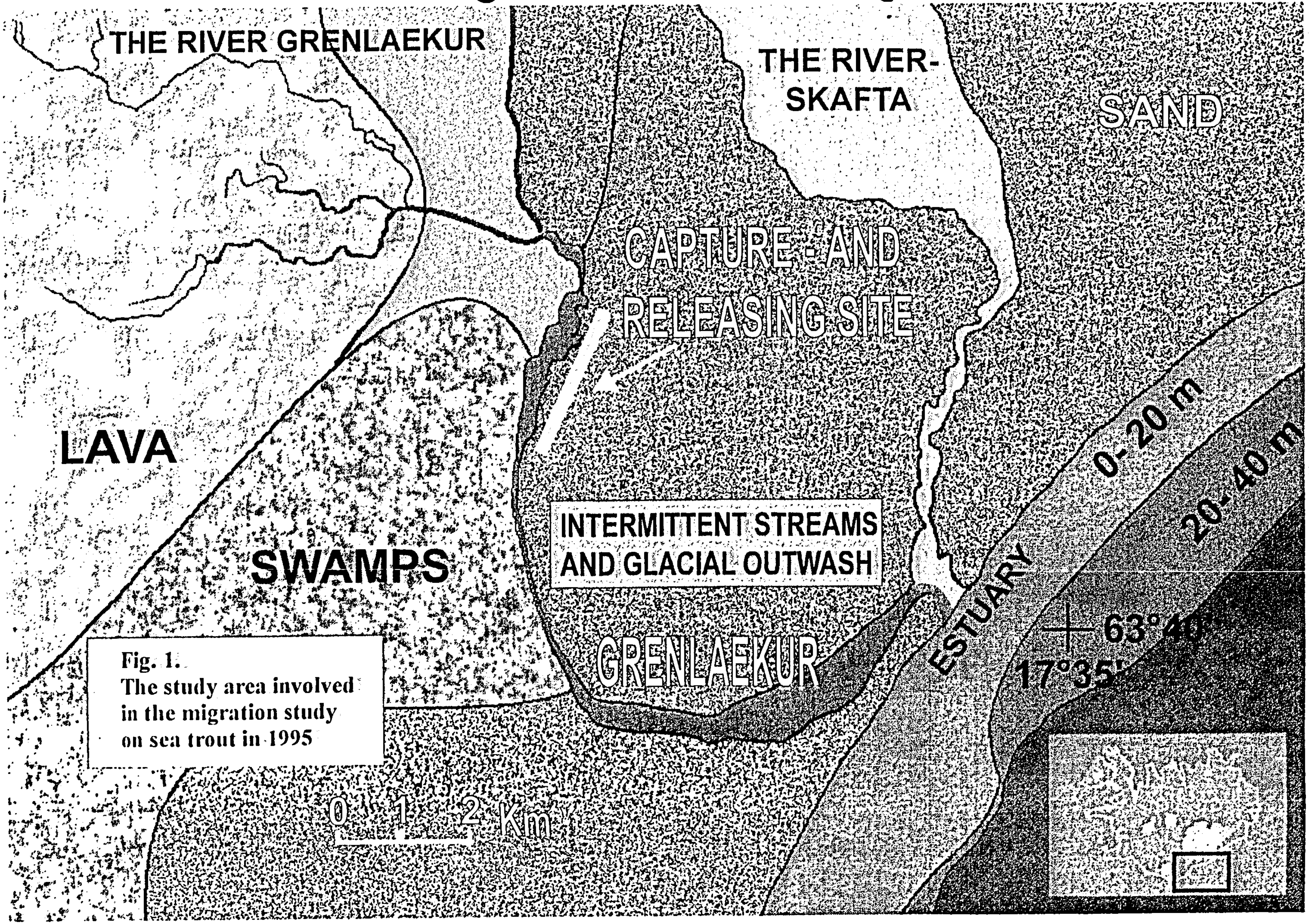

Fig. 1.
The study area involved in the migration study on sea trout in 1995

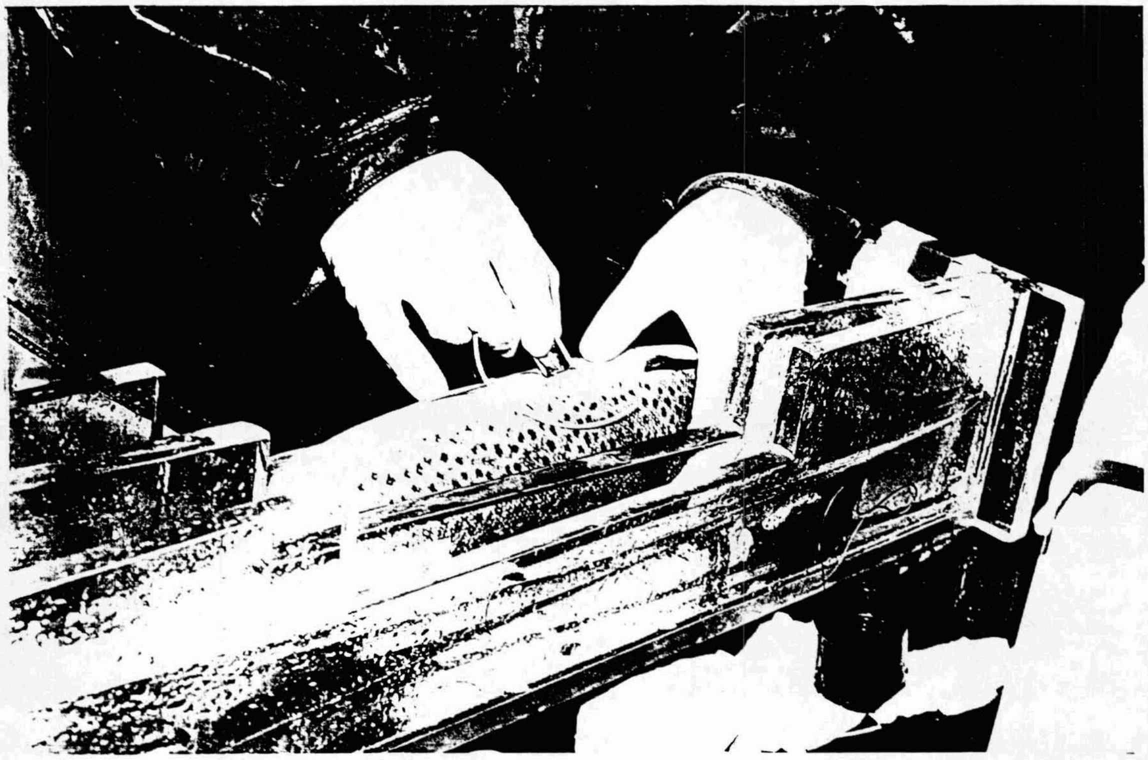

Fig. 2a. Implanting of DST into the body cavity of a sea trout.

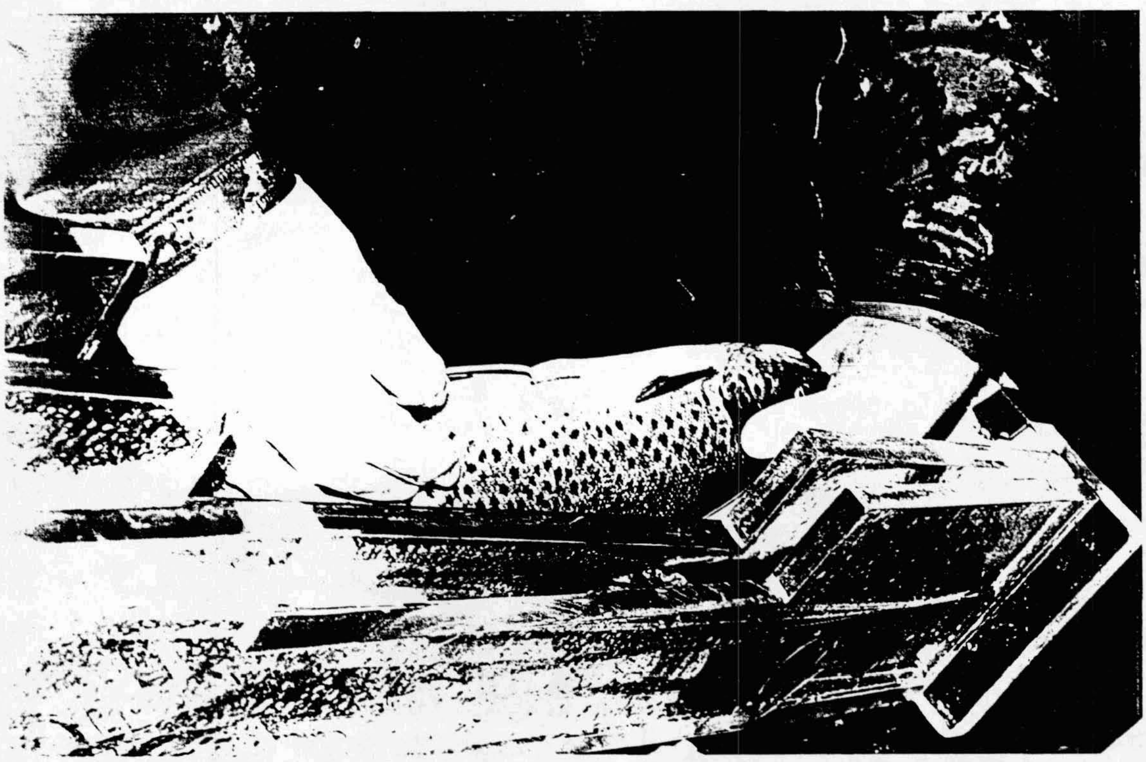

Fig. 2b. Internally tagged sea trout.
Placement of the DST indentification tube are shown.

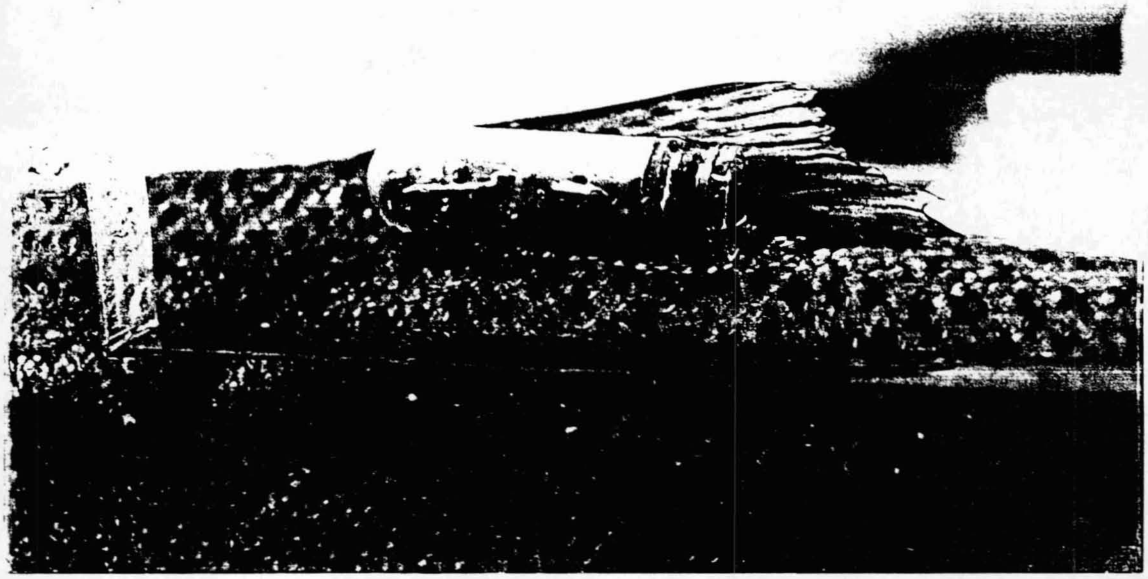

Fig. 3a. The data storage tag (DST 100) used in the study, externally attached to a sea trout

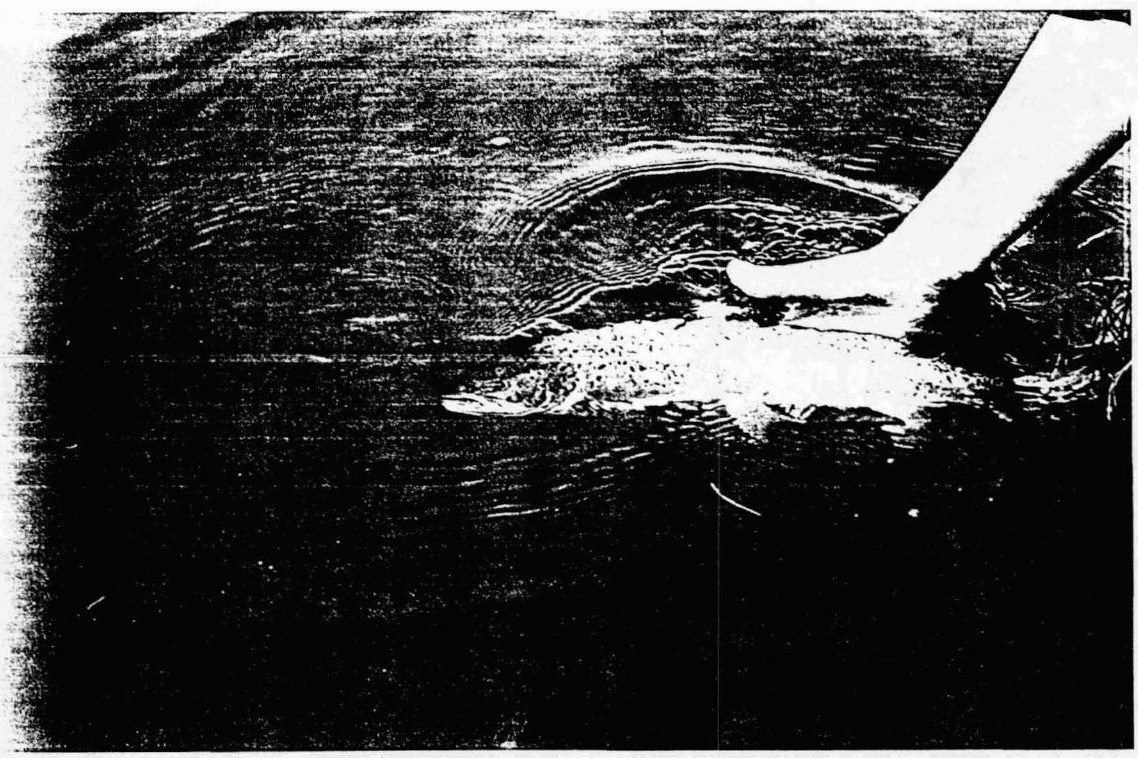

Fig.3b. Externally tagged sea trout at release.

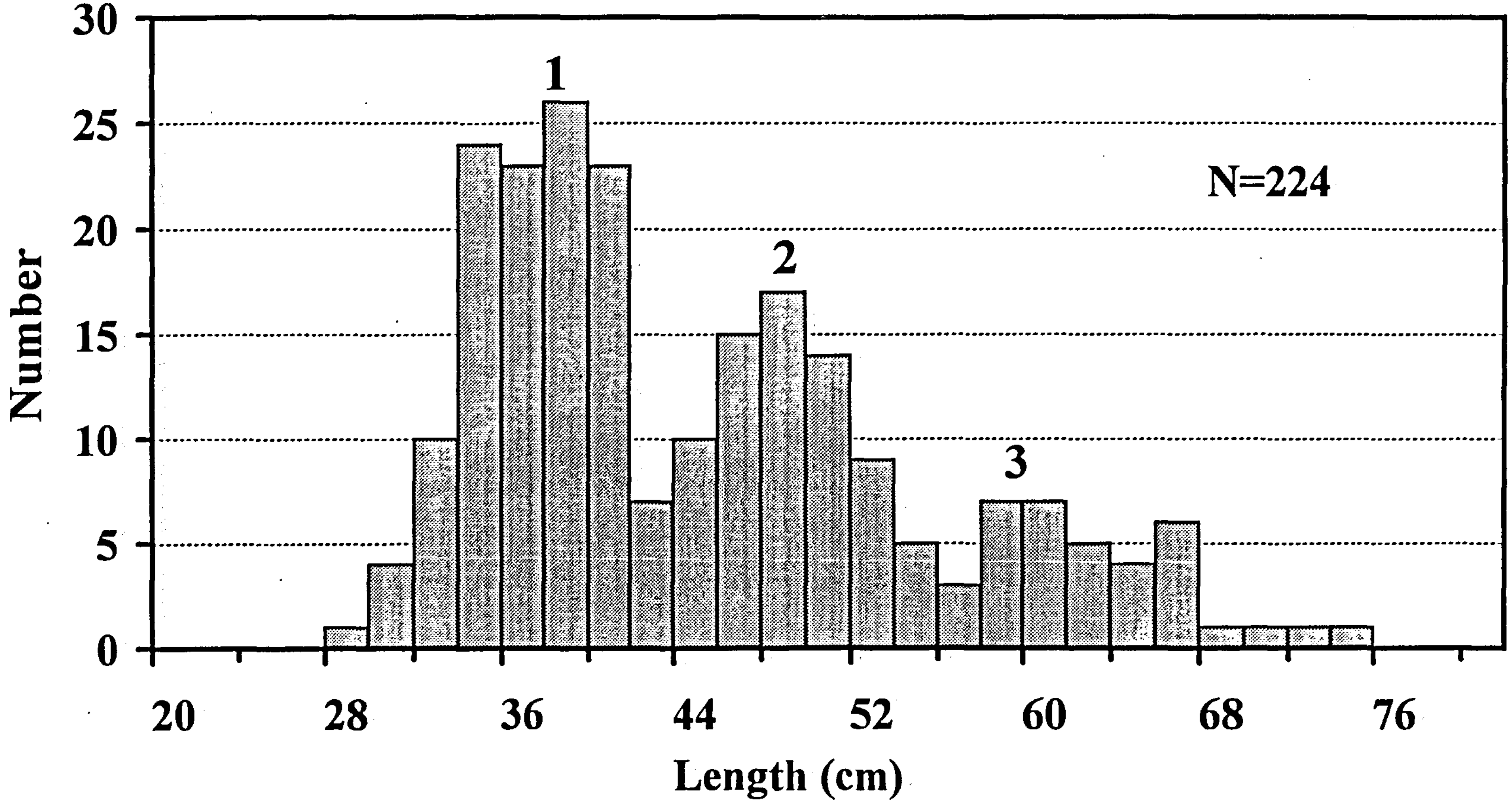

Fig. 4. Length distribution of sea trout in River Grenlaekur in relation to their number of sea migration (1-3). Total number of analysed fish is given (N)

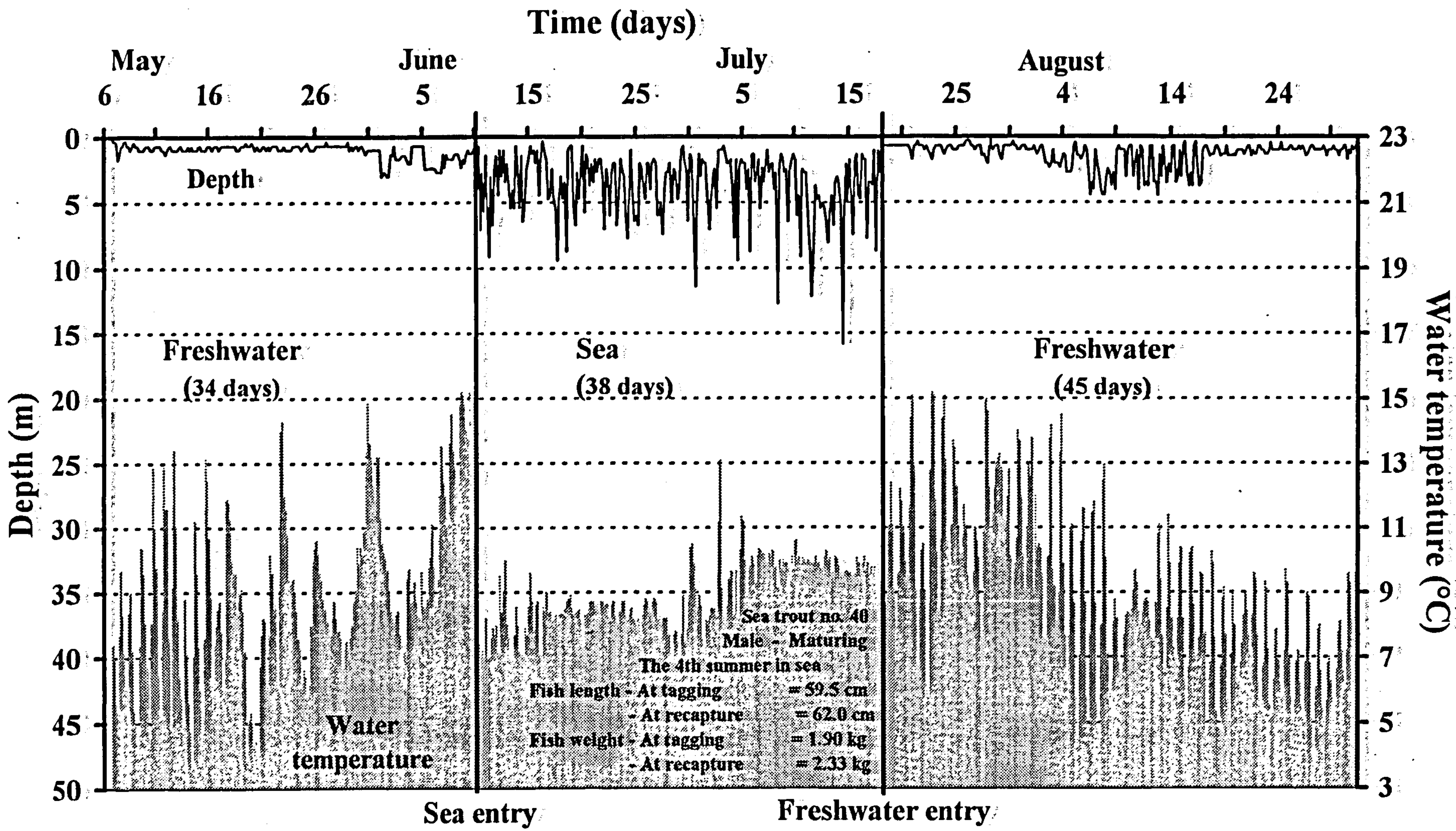

Fig. 5. Depth distribution of wild sea trout from River Grenlaekur SE - Iceland and corresponding water temperature in relation to time. The water temperature profile are fill out.

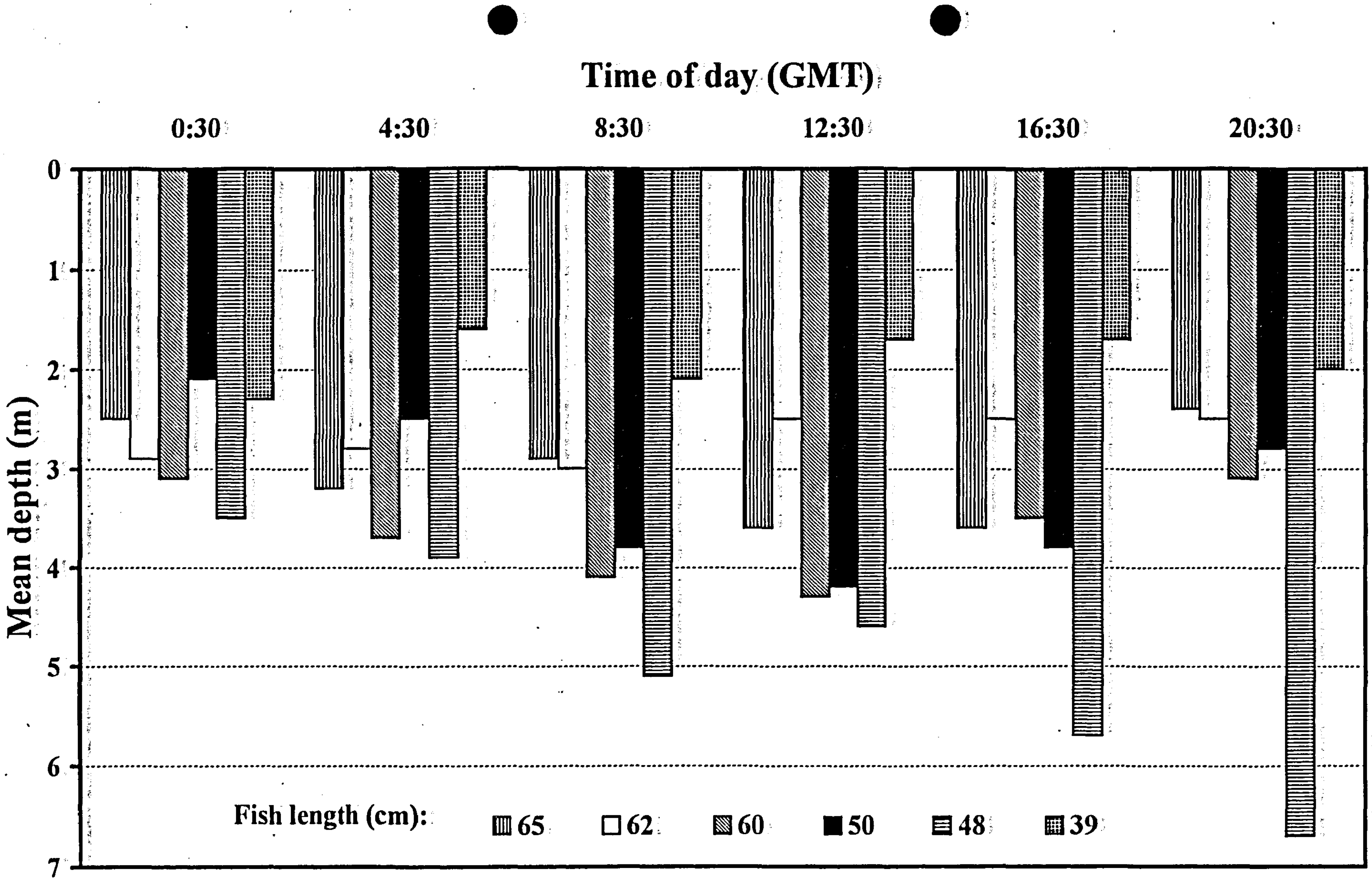

Fig. 6. Mean depth of DST tagged sea trout from River Grenlaekur SE - Iceland in sea, in relation to their length and time of day

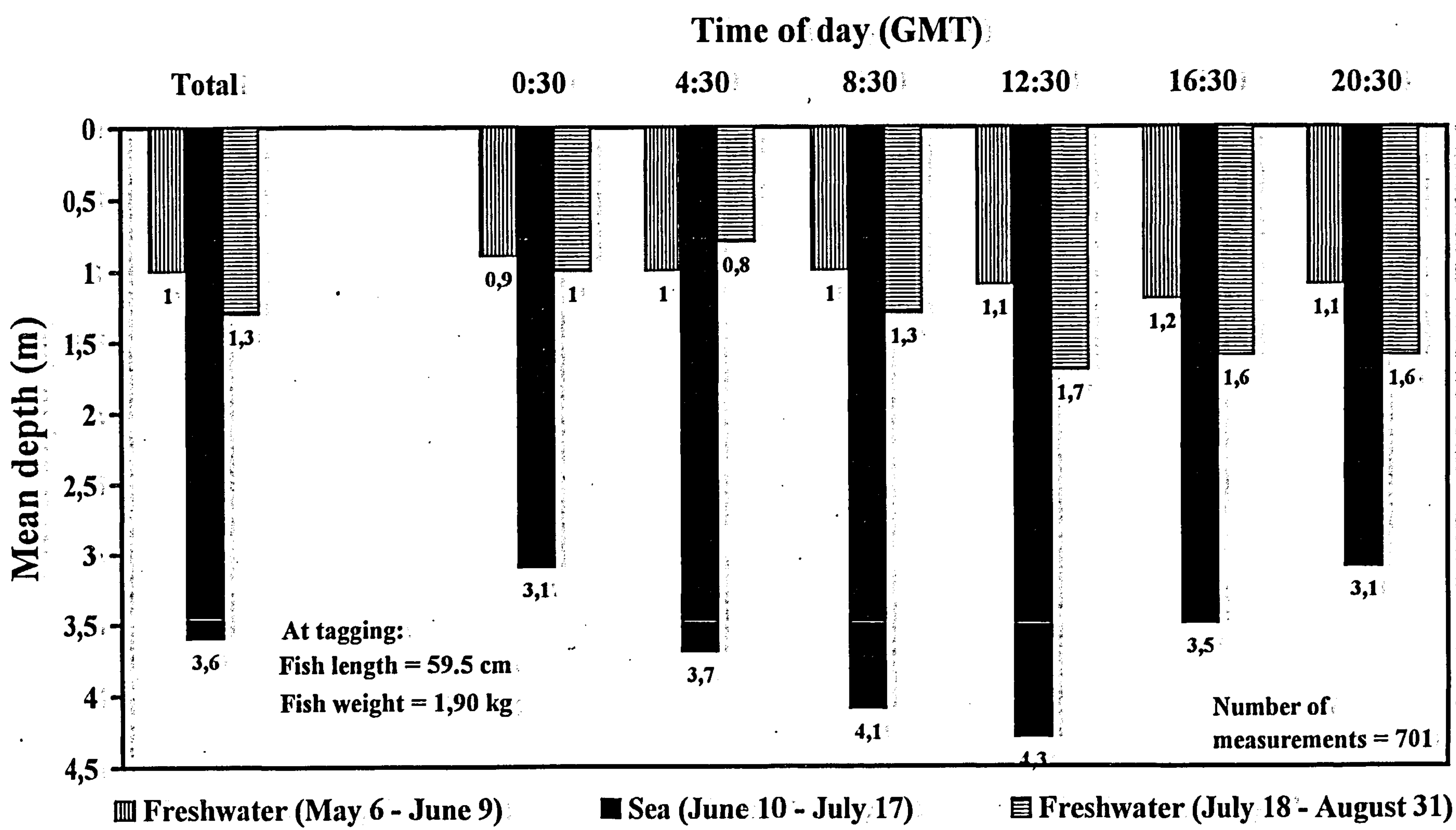

Fig. 7. Mean depth of DST tagged sea trout from River Grenlaekur SE-Iceland in both the river and the sea in relation to time of day.

Fig. 8. Salinity in relation to depth at location 63°45' 97" and 16°36' 26" in August 10 1995

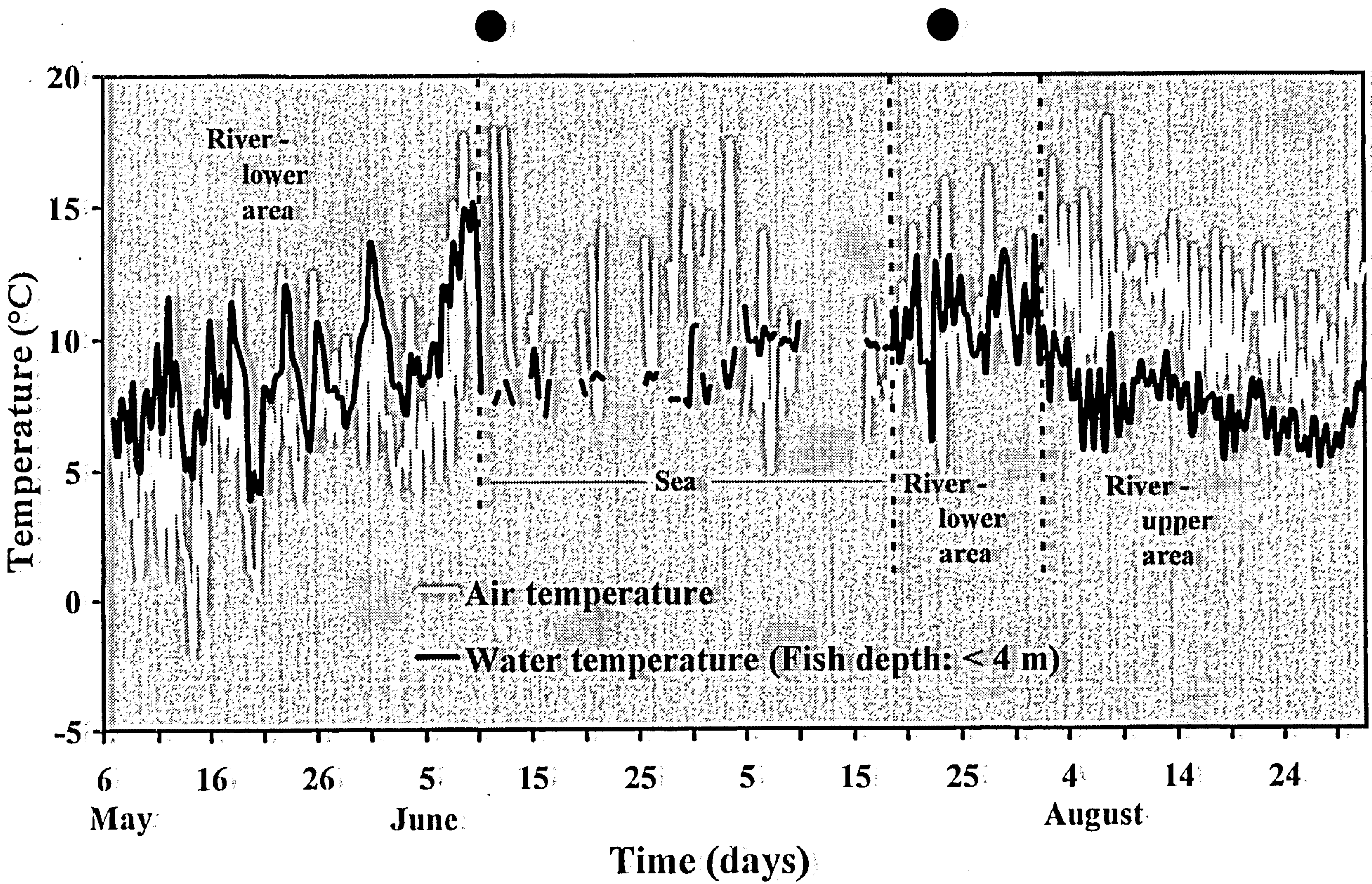

Fig. 9. Comparision of water temperature experienced by DST tagged sea trout from River Grenlaekur SE-Iceland in the depth interval 0 - 4 m and corresponding air temperature recorded near River Grenlaekur

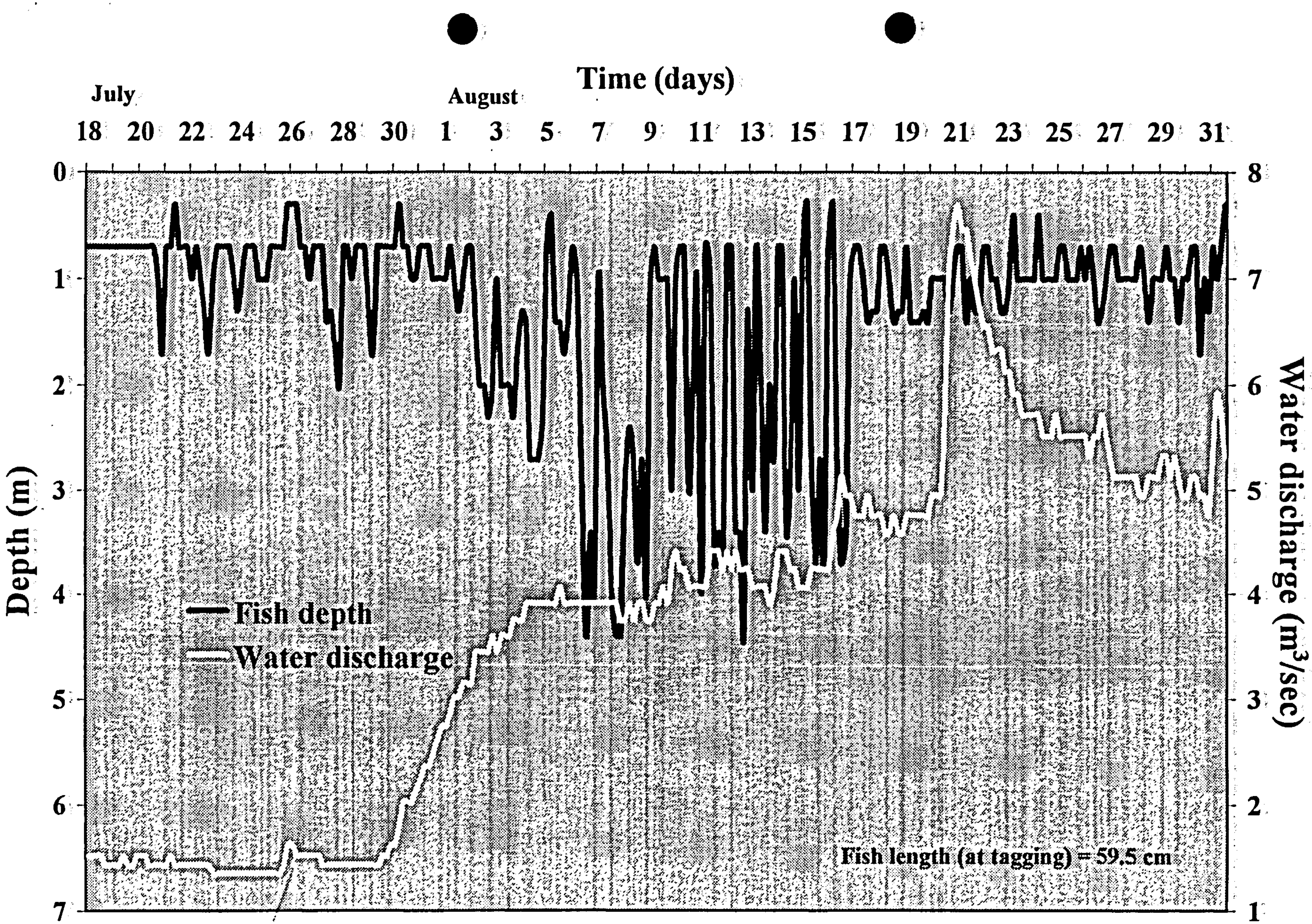

Fig. 10. Depth of DST tagged sea trout in River Grenlaekur in relation to the water discharge