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Mortality and growth of wild and introduced cultured eels (*Anguilla anguilla* (L)) in a Danish stream, with special reference to a new tagging technique

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Abstract

A total of 563 stream dwelling wild eels and 798 introduced cultured eels were tagged with visible implant tags. One year after tagging, recapture was 33.6 and 8.0%, respectively, for the two groups and tag loss was estimated to be almost 30%. Survival rate of wild tagged eels was twice as high as for cultured tagged eels. Estimated coefficients of natural mortality in wild and cultured eels below 30 cm were affected by migration and, possibly, some density dependent effect. The instantaneous coefficient of natural mortality in wild eels above 30 cm could be described by the formula $M = W^{-1/3}$ (Ursin, 1967).

Growth depression due to tagging and marking was not evident. The mean annual increment of tagged cultured eels was 35.8 mm. This was in accordance with the mean annual increment of wild tagged eels in the same size range. Contrary to wild tagged eels, the cultured tagged eels showed increasing increment with increasing length at tagging, probably due to artificial selection for growth at the eel farm.

Annual increments back-calculated from a series of 38 burned and cracked otoliths showed close agreement with annual increments measured in tagged and recaptured wild eels.

Keywords: *Anguilla*, tagging technique, mortalities, growth, age determination.

Introduction

The elver recruitment to the Danish coast has decreased over the last decades (Moriarty, 1989) with an associated reduction in the Danish eel fishery. To offset this tendency, a national stocking programme for eels is under development. Approximately 3.5 mill. cultured eels were stocked into Danish marine and fresh waters in 1990.

Mortality and growth of wild eel stocks in Danish streams have been studied by Rasmussen & Therkildsen, 1979; Rasmussen, 1983 and Bisgaard & Pedersen, 1990. Few data are available on mortality and growth of introduced cultured eels (Berg, 1988; Nielsen, pers. comm. 1990), although these are important parameters in the economy of stocking. Age determination of the European eel is well known as being problematic, due to widely differing methods for the preparation of the otolith, as well as differences in the interpretation of the otolith by the reader (Moriarty & Steinmetz, 1979). A major problem in the age determination of eels is the formation of supernumary zones in some otoliths as a consequence of interrupted summer growth, which can lead to faulty age determination (Deelder, 1981).

Tagging or marking of eels is often associated with reduced growth and mortality or tag loss. The main reason for this is the digging behaviour of the eel. Known tagging methods affect the eel negatively (Nielsen, 1988).

This paper describes growth and mortality of wild and introduced cultured eels. Basic research on a new tagging technique has been carried out and age determination using the burning and cracking method is tested.

Study area

The investigation took place in the stream Giber Å (Fig. 1), situated about 10 km south of Århus. The stream starts at an altitude of 53 m above sea level. During its course into the Århus Bay, the stream goes through the small hyper-eutrophic lake, Wilhelmsborg Slotssø. The total length of the stream is about 15 km. The catchment area is 49 km^2. In 1989, the daily mean, maximum and minimum water discharge were 141, 1686 and 13 $dm^3 \cdot s^{-1}$, respectively (Nordemann, pers. comm. 1990).

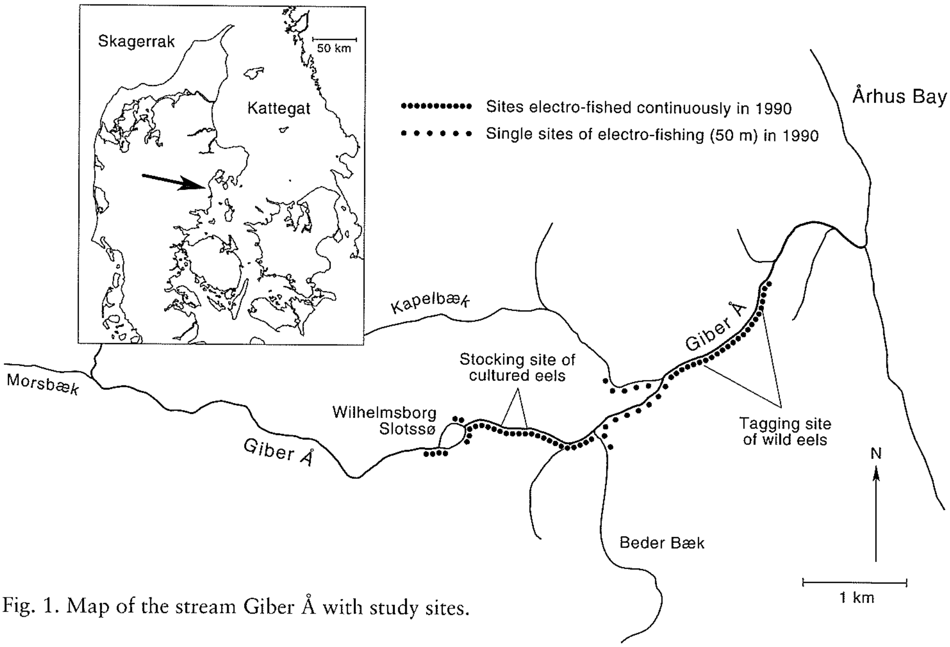

Fig. 1. Map of the stream Giber Å with study sites.

Measurement of water temperatures (8 a.m.) by local authorities showed a maximum of 14.9 °C in June and a minimum of 2.1°C in December with a mean of 11.8 °C from mid-April to mid-November. From the brook Morsbæk to Wilhelmsborg Slotssø, the stream is strongly regulated and surrounded by agricultural land. At the study sites (10°10'-10°12'E, 56°03'N), the stream substratum consists of stones and gravel. Macrophytic vegetation in the stream is particularly scarce due to shading from surrounding deciduous forest. The stream width is 3-5 m and the depth 10-50 cm. Three weirs are present in the stream but eel-migration is facilitated by eel-ladders. In addition to eel, pike (*Esox lucius* L.), perch (*Perca fluviatilis* L.), nine-spined stickleback (*Pungitius pungitius* L)), brown trout (*Salmo trutta* L)) and tench (*Tinca tinca* L)) are present.

Materials and methods

Visible Implant tags (V.I. tags) measure 2.5 mm in length, 1 mm in width and 0.1 mm in thickness and were imprinted with an alphanumeric code. The tag was implanted subcutaneously using a special hypodermic syringe, approximately 3 cm posterior to the anus, adjacent to the anal fin. After implantation, the tags were visible but, generally, illegible.

In August 1989 (time t_0), a stretch of 900 m in Giber Å was electro-fished (220 V, D.C.) by wading (Fig. 1) to sample wild eels. Captured eels were anaesthetized in Chlorbutanol and measured to the nearest mm. Eels longer than 13 cm were tagged with V.I. tags and marked by clipping one of the pectoral fins. A total of 563 wild eels were tagged and marked, mean length 34.03 cm, SD 11.37.

Cultured eels were bought in October 1989 from an eel farm in mid-Jutland. The eels were imported from England and France as glass eels in 1988 and 1989. The cultured eels were measured and tagged as described for wild eels. The total number of tagged and marked cultured eels was 798, mean length 20.02 cm, SD 3.01. When released (October 1989, time t_0), the cultured eels were scattered evenly over a stretch of 400 m in Giber Å, downstream from Wilhelmsborg Slotssø (Fig. 1). The stocking density was approximately 1 eel $\cdot$ 3 m^{-2}. There were wild eels at the stocking locality, with a density of approximately 1 eel $\cdot$ 25 m^{-2}, at the end of September 1990.

During August, September and October 1990 (time t_1) Giber Å was electro-fished to sample tagged eels. For sites of electro-fishing, see Fig. 1. For every 100 m fished, captured eels were anaesthetized in Chlorbutanol and checked for fin-excisions. Eels with fin-excisions were examined for V.I. tags. If the tag was recognizable, it was removed, the code recorded and the eel length measured to nearest mm and the eel released again. If there were no signs of a tag, the eel was brought to the laboratory for control of tag loss by dissection. Eels without any sign of fin-excision were measured to nearest half centimeter (rounded down) and released.

The tag loss in per cent was estimated as $N_{ex}/N_{rec} \cdot 100$, where N_{rec} was the total number of eels recaptured. N_{ex} was the number of eels recaptured with fin-excisions but without tags. Wild and cultured eels were treated separately.

To see if the tag loss was size specific, the length-frequency distributions of recaptured eels with V.I. tags and eels recaptured with fin-excisions but without V.I. tags were compared.

For every 500 m electro-fished, a stretch of 50 m was fished two or three times in succession. To investigate the size selectivity of the electro-fishing, the size specific probability of capture (p_i) was estimated as: $(\hat{p}_i) = 1 - (T - C_1)/(T - C_k)$ where $T = (C_1 + C_2 + \ldots + C_k)$ and C_k was the number of eels in size group i (size groups at 5 cm intervals) captured in the k'th fishing.

The total number of tagged eels ($\hat{N}$) in the stream at the time of recapture (t_1) was estimated by use of the removal method (Bohlin *et al.*, 1989; Seber & Le Cren, 1967). The estimate was separated into 5-cm size groups ($\hat{N}_i$) as $n_i(t_1)/\sum n_i(t_1) \cdot \hat{N}$, where $\sum n_i(t_1)$ was the total number of eels recaptured with V.I. tags at time t_1 and $n_i(t_1)$ was the number of eels recaptured with V.I. tags at time t_1, belonging to size group i at time t_0.

To investigate immigration into Wilhelmsborg Slotssø, 2-300 m were electrofished along the banks and upstream the lake.

The instantaneous coefficient of total mortality (Z) is defined as $Z = M + B + F$, where M is the instantaneous coefficient of natural mortality, B the instantaneous coefficient of silver eel migration and F the instantaneous coefficient of fishing mortality. Z was calculated for size group i as $Z = \ln(\hat{N}_i(t_1) - N_i(t_0)) / (t_1 - t_0)$, where $N_i(t_0)$ was the number of eels in size group i at time t_0, ($\hat{N}_i(t_1)$ was the estimated number of eels at time t_1 belonging to size group i at time t_0. $t_1 - t_0$ was approximately one year. The fishing mortality was assumed to be of no importance.

Growth and age determination

Length increment of wild tagged eels and cultured tagged eels are compared within the size range of cultured eels. A Wallford plot of length at recapture against length at release is given for both types of tagged eels.

The otoliths from 46 wild, untagged specimens sampled in May 1989 and stored frozen, were prepared by the burning and cracking method (Christensen, 1964; Moriarty, 1973). The best broken surface from 38 sets of otoliths were photographed. The length distributions of these 38 eels were: mean 40.2 cm, SD 6.23, range 24.5-55.0 cm (measured to nearest mm). The photographs were enlarged to give an otolith length of approximately 15-20 cm, a magnification in the order of $\times 80$. The distinct black annuli were taken to represent annual growth checks, contrary to less pronounced checks (Moriarty, 1983; Poulovits & Biro, 1986), which are attributed supernumary zone formation. Measurements were taken from the first clearly marked annulus outside the nucleus. The distance from this annulus to the n'th annulus was measured with a dial calliper with an accuracy of 0.1 mm. Assuming that the first clearly marked annulus represents the beginning of freshwater growth, equivalent to a total length of 70 mm (Bisgaard & Pedersen, 1990) and assuming that for each eel there is a linear relationship between the radius of the otolith and the length of the eel (Bisgaard & Pedersen, 1990) the back-calculated length was derived by the following formula:

$$L_n = a + r_n / R \cdot (L - a);$$ (Bagenal & Tesch, 1978).

r_n = distance from the first annulus to the n'th annulus measured on the photograph.
R = distance from the first annulus to the otolith margin measured on the photograph.
L = total length. a = 70 mm. L_n = the length of the eel at n'th annuli.

$I_n = L_{n+1} - L_n$ = the back-calculated annual length increment in the n'th year.

The mean annual length increment as a function of the length of back-calculated eels is calculated and compared with the mean annual increment of wild tagged eels.

The growth parameters of back-calculated eels L_∞, k and t_0 in the von Bertalanffy growth equation, $L_{(t)} = L_\infty (1 - e^{(-k(t - t_0))})$, were estimated by approximating length by age data to linearity by Taylor series. The parameters were then estimated by an iterated least-square method.

Results

Length/weight relationship and condition factor

From 110 wild eels, collected in May 1989, the length/weight relationship was $W = L^{3.88} \cdot 1.0 \cdot 10^{-4}$ (r = 0.97). W = weight in gram, L = length in cm. Fultons condition factor (K) = mean 0.11, SD 0.03 in the size range 13-31 cm.

Prior to release (October 1990), the length/weight relationship was determined from 47 cultured eels: $W = L^{3.22} \cdot 7.8 \cdot 10^{-4}$ (r = 0.99). Fultons condition factor (K) = mean 0.15, SD 0.02 in the size range 13-31 cm.

Tagging with V.I. tags

V.I. tags placed subcutaneously were still recognizable after one year when the eels were examined externally. In only a few eels of small body size were the tags externally readable. Percent tag loss seemed to be higher for cultured eels than for wild eels (Table 1), but the tag loss was found to be independent of eel type, $p > 0.2$ ($\chi^2 = 1.59$). As a mean for both groups, tag loss was almost 30%.

No difference (t-test) was found between the length frequency distribution of eels recaptured with tags and eels recaptured without tags but with fin excisions (wild eels, $p > 0.7$; cultured eels, $p > 0.4$). Thus, tag loss was not size specific.

Table 1. Results from tagging of wild and cultured eels with V.I. tags.

	Total no. of tagged eels	Total no. of recaptures	No. of eels with tags	Total % recapture	% tag loss
Cultured eels	798	64	42	8.0	34.4
Wild eels	563	189	142	33.6	24.9

Survival

It was estimated that 302±102 (±95% confidence limits) tagged wild eels (size range 13-60 cm) were still in the stream at time t_1, corresponding to a survival of 53.5%±18.1% after one year. The estimate for tagged cultured eels was 130±51 or a survival of 16.3%±6.4% (size range 13-32 cm). The number of surviving wild eels in the size range ≤32 cm (equalling the size range for the cultured eels) was 97±33 corresponding to a survival of 40.1%±13.6%.

The survival of wild and cultured eels was found to be significantly different (t-test; $p < 0.05$).

Mortality

The capture probability did not vary with size, $p \geq 0.20$ ($\chi^2 = 2.474$). Therefore, percent recapture reflects the mortality (Z) (Table 2) of the size groups. In the size range 15-42.5 cm, percent recapture was positively correlated with length (r = 0.95; $p < 0.001$), indicating that mortality is size dependent. Decreasing percentage recapture in wild eels above 42.5 cm (Fig. 2) is probably caused by emigration of silver eels.

Table 2. Mean length (cm), number of eels tagged (N_{tag}), number of eels recaptured (N_{rec}), estimated number in stream (N_i) and instantaneous coefficient of mortality (Z_i) of each size group. Wild and cultured eels are treated separately. Expected recaptures from regression (Fig. 2), expected numbers in stream (N_{exp}) and instantaneous coefficients of natural mortality (M_i) are given for each size group of wild eels.

Wild eels

Mean length, cm	N_{tag}	N_{rec}	N_i	$Z_i \cdot yr^{-1}$	Expected recaptures	N_{exp}	$M_i \cdot yr^{-1}$
<15	24	2	4	1.79	–	–	1.79
17.5	47	5	11	1.45	–	–	1.45
22.5	57	7	17	1.21	–	–	1.21
27.5	81	19	40	1.19	–	–	1.19
32.5	88	27	59	0.40	–	–	0.40
37.5	88	24	50	0.56	–	–	0.56
42.5	71	25	55	0.26	–	–	0.26
47.5	57	20	42	0.31	23	48	0.17
52.5	32	10	21	0.42	15	31	0.13
57.5	12	3	6	0.69	6	12	0
>60	8	0	0	>2.08	4	8	0

Cultured eels

Mean length, cm	N_{tag}	N_{rec}	N_i	$Z_i \cdot yr^{-1}$
<15	11	0	0	2.40
17.5	372	13	40	2.23
22.5	324	21	65	0.61
27.5	60	8	25	0.88
>30	6	0	0	>1.79

By linear least-square regression, a function for percent recapture at length, in the size range 15-42.5 cm was established: percent recapture $= -7.72 + 1.04 \cdot L$, L = length in cm. By extrapolation, expected percent recapture and expected number of eels above 42.5 cm are estimated, ignoring the apparent silver eel emigration. This estimate allows the calculation of the natural mortality (M) (Table 2).

In cultured eels, the sudden decrease in per cent recapture in the largest size group is believed to be caused by the emigration of cultured small male silver eels; in the size range 15-27.5 cm per cent recapture was positively correlated with length ($r = 0.98$; $p < 0.02$). There was a significant difference between wild and cultured eels with regard to recapture percentage, $p < 0.001$ (ANCOVA test).

Migration

The migratory behaviour of wild and cultured eels was found to be different (Fig. 3). Nearly all of the wild eels were recaptured within the tagging site and the percentage of recaptures drops rapidly both up and downstream from this site. Cultured eels actively migrated away from the stocking site. Percentage recapture decreased downstream with only one eel recaptured approximately 2.6 km downstream from the stocking site. Upstream from this site percentage recapture increases and was highest just downstream from the weir at Wilhelmsborg Slotssø. No tagged eels were recaptured in Wilhelmsborg Slotssø, but eels in the same size range as the tagged were captured in the lake.

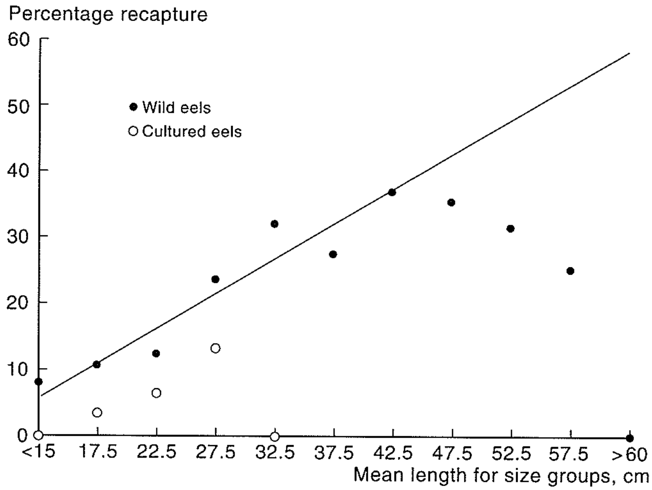

Fig. 2. Percent recapture of tagged eels at time t_1 from size groups at time t_0. Regression is estimated from the size range 15-42.5 cm (wild eels) and extrapolated to a length of 60 cm. See text for function of regression.

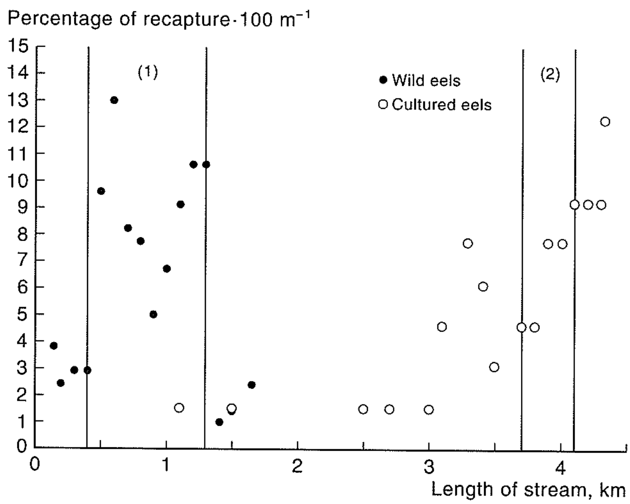

Fig. 3. Percentage of recapture pr. 100 m. Vertical lines shows the tagging site of wild eels (1) and stocking site of cultured eels (2). The left side of the graph is the downstream limit of study area; the right side shows the upstream limit at the weir at the lake Wilhelmsborg Slotssø.

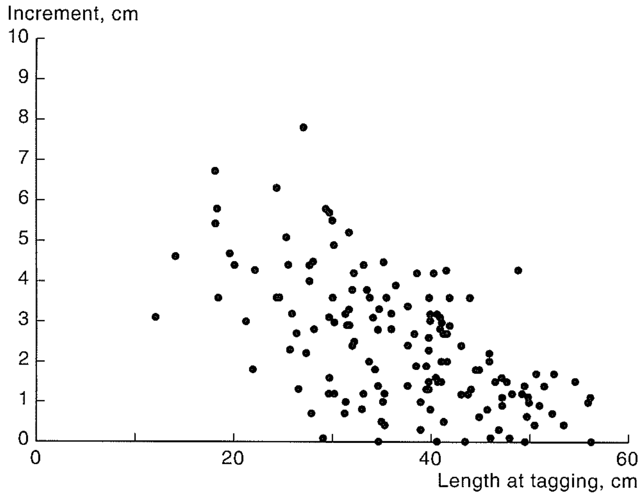

Fig. 4. Increment vs. length at tagging of 142 wild eels. Tagged July-August 1989 and recaptured in August 1990.

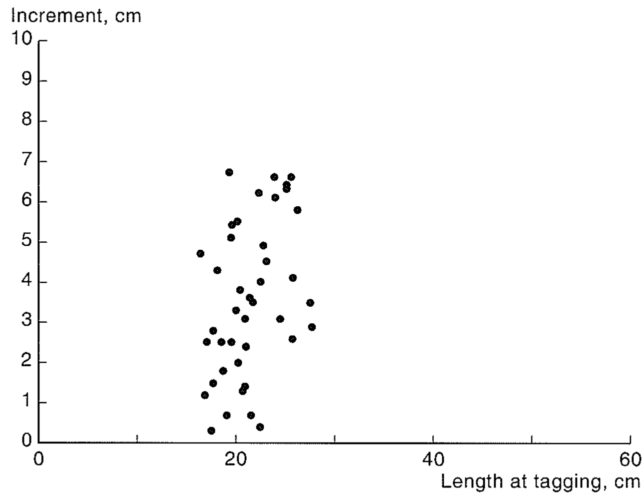

Fig. 5. Increment vs. length at tagging of 42 cultured eels. Tagged October 1989 and recaptured in September-October 1990.

Length increment

Fig. 4 presents data of increment vs. length at tagging from wild tagged eels. The maximum recorded growth during release was 78 mm from an eel with a body length of 272 mm when tagged. Five specimens showed no increase at all (range 347-562 mm). The average growth of the sample was 24.5 mm, SE 1.3. Annual increment is negatively correlated with length at tagging ($r = -0.57$; $p < 0.001$) indicating that smaller eels grow faster than larger eels.

Growth of the cultured tagged eels (Fig. 5) varied from 3 to 66 mm with an average of 35.8 mm, SE 2.9. The annual increment is positively correlated with length at tagging ($r = 0.39$; $p < 0.02$) indicating that the larger cultured eels grow faster than smaller cultured eels. The mean growth of wild tagged eels in the same size range as cultured tagged eels is 39.6 mm, SE 3.3. No significant difference (*t*-test; $p > 0.05$) in mean growth of wild tagged and cultured tagged eels was found.

Table 3. Back-calculated annual increments (mm) from 38 otoliths of untagged wild eels. Year 1 is the first post-immigration year.

Year	Mean	SE	n	Min-max
1	44.2	2.1	38	22.1-86.8
2	35.9	2.4	38	9.8-73.4
3	36.8	2.3	38	14.1-70.4
4	37.5	2.7	38	4.5-89.0
5	35.5	2.4	38	9.9-74.5
6	34.5	1.9	38	10.6-64.7
7	32.1	1.9	37	14.0-64.1
8	34.9	2.0	35	13.3-73.6
9	28.9	1.6	27	12.7-48.1
10	23.5	1.3	19	11.2-33.6
11	25.8	4.8	11	14.0-72.6
12	16.5	2.8	5	11.3-28.8
13	26.2	6.5	3	17.1-42.1

Age determination

As a measure of readability of the otoliths used for back-calculation, the two authors independently made age determination from a set of 30 random otoliths. The discrepancy between the readings of the two authors were: Identical (20), difference of one year (9), difference of three years (1). The readings of author A resulted in a mean age of 9.1 years and author B in a mean age of 8.9 years.

Annual back-calculated increments are shown in Table 3. The mean annual increment measured in the first year of growth differed significantly from year 2-12 (*t*-test; $p \leq 0.05$). From year 2, the measured mean growth is rather constant until year 8 but decreases for the last years measured. The annual increment is negatively correlated with age ($r = -0.33$; $p < 0.001$).

Comparison of annual incremental growth as a function of body length of wild back-calculated and wild tagged eels is shown in Table 4. The mean values given in the table are slightly larger for wild tagged eels below 30 cm but smaller than for

Table 4. Annual mean increment (mm) of back-calculated wild (BCW) eels and tagged wild (TW) eels related to body length (cm) and grouped in intervals of 5 cm. * denotes significant difference.

	TW			BCW			
Length, cm	Mean	SE	n	Mean	SE	n	*t*-test $p \leq 0.05$
10-14	38.5	5.3	2	35.1	2.0	59	
15-19	52.4	4.7	5	36.4	2.2	52	*
20-24	38.5	4.9	7	34.6	1.8	55	
25-29	33.1	4.4	19	32.5	1.6	53	
30-34	28.1	2.6	27	33.3	1.6	48	*
40-44	22.5	2.3	25	31.7	3.5	16	*
45-49	12.2	2.1	20	23.0	1.6	2	
50-54	11.0	1.6	10	16.0	0.8	2	
55-59	7.0	2.9	3	–	–	–	

wild back-calculated eels above 30 cm. The mean annual increment is significantly different for the three size groups (Table 4).

Growth calculation

A Wallford plot of length at recapture against length at release of wild tagged and cultured tagged eels is shown in Table 5. Calculating asymptotic growth ($Lt_{+1} = Lt$) from the parameters of the Wallford line shows that cultured tagged eels, as expected, has no upper limit of growth, whereas wild tagged eels has an upper limit of 615.6 mm.

Von Bertalanffy's theoretical growth parameters estimated from length at age data of wild back-calculated eels was L_∞ 903.4 mm, $t_0 = -1.44$ and $k = 0.053$ ($r = 0.91$; $p < 0.001$).

Table 5. Linear least-square regression of L_{t+1} on L_t (Wallford plot) of wild tagged and cultured tagged eels.

Sample	Const.	Coeff.	*n*	r
Cultured	−1.595	1.241	42	0.90*
Wild	6.131	0.900	142	0.99*

* significant ($p < 0.001$).

Discussion

The main advantage of V.I. tags is that they do not interfere with the digging behaviour of the eel (Nielsen, 1988). The small size of V.I. tags makes it possible to tag eels down to a length of 13 cm.

The growth of both wild tagged and cultured tagged eels in this study seemed to be unaffected by marking and tagging. Especially external tags seems to result in depressed growth during the first year (Berg, 1985; Nielsen, 1988).

V.I. tags are still recognizable but not externally readable one year after tagging. It is therefore necessary to use a type of external marking to indicate the presence of a subcutaneous tag, for example fin-clipping which can be detected after more than one year (Nielsen, 1988).

The shedding of V.I. tags (30% in one year) is about the same as that found with other internal tags (Nielsen, 1988). In a laboratory study (Bisgaard & Pedersen, unpublished data) approximately 30% of the eels lost the tags after three months, indicating that tag loss occurs primarily during the first three months. The eels did not suffer from tagging or handling mortality in this experiment, even though the eels were anaesthetized and measured monthly over a 4-month period.

Any discussion of estimated mortality should be considered in light of the statistical uncertainties in the estimation of the number of eels in the stream at time t_1. Ursin (1967) states that the natural mortality is a function of weight, that is $M = W^{-1/3}$. Rasmussen & Therkildsen, (1979) and Bisgaard & Pedersen (1990) found that the Ursin relationship is a fair approximation when estimating the natural mortality of wild eels for all body sizes. When comparing the estimated natural mortality (Table 2) with Ursin (Fig. 6), there is good agreement where the eel length is over

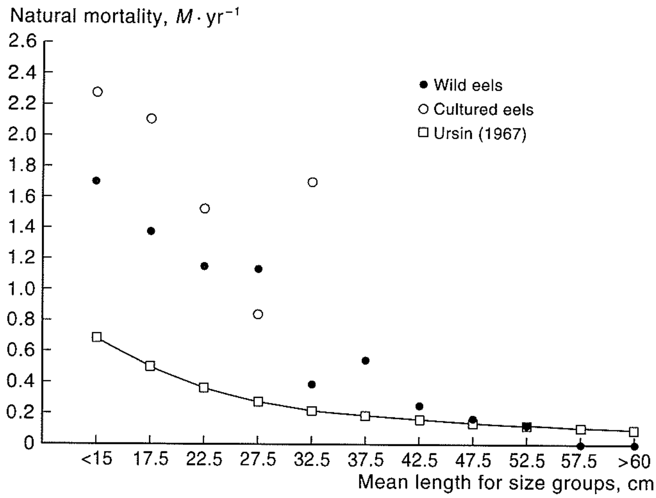

Fig. 6. Instantaneous coefficients of natural mortality (M) in size groups from time t_0 to time t_1. 'Ursin 1967' is the instantaneous coefficient of natural mortality estimated from the formula $M = W^{-1/3}$.

32.5 cm. Below this length, there is a marked difference between the estimated natural mortality of wild and cultured eels and the Ursin relationship.

The sudden increase in natural mortality of wild eels below 32.5 cm (Table 2) is assumed to be caused primarily by migration out of the study area. Tesch (1977) mentions 25-30 cm as the length where eels change from a migratory phase to a more stationary phase. The wild tagged eels seemed to be more stationary and this is probably a result of the fact that about 60% of the wild tagged eels are over 30 cm in length.

The high values of mortality of cultured eels are believed to be caused by migration out of the study area, as with wild eels. Nielsen (pers. comm. 1990) found that there was a massive downstream migration of cultured eels during the first days after release in a little stream. The downstream limit of migration has presumably been determined in this study (Fig. 3). However, it cannot be ruled out that there has been a considerable upstream migration into Wilhelmsborg Slotssø, although none of the tagged eels were recaptured there. The estimated natural mortality of cultured eels was about 4 times higher than the values estimated by Ursin (1967) (Fig. 6). This is nearly the same as found by Berg (1988), who estimated values of natural mortality in cultured pigmented elvers that were 4-8 times higher than Ursin (1967). The estimated mortality for both wild and cultured eels could be influenced by other factors, for example, cannibalism by bigger eels which were well represented at site 1, or some density dependent factor, especially in cultured eels. The cultured eels were stocked at a much higher density (1 eel · 3 m^{-2}) than that estimated for native eels, whose actual density may represent the upper limit of the carrying capacity at the stocking locality. Moriarty (1986) suggests that the eels are affected by population pressure, resulting in a higher rate of upstream migration and Vøllestad & Jonsson (1988) estimated instantaneous coefficients of total mortality in the range of 0.088-0.225 in eels from River Imsa and found that the mortality was density dependent above a certain threshold. The estimates are hardly comparable with the estimates from Giber Å, because Vøllestad & Jonsson (1988) make the estimates under the assumption that the mortality is independent of size. Handling could be another factor that increases the mortality in eels (Berg, 1988) but we have found no evidence of this.

As the wild eels having grown least are correlated with the largest body length (Fig. 5) it seems possible, that the largest eels not yet emigrated, are the slowest growing eels, or these eels have been preparing the journey to the spawning grounds. In other words, that food intake during the summer has been used for storage of fat and not increase in length (Deelder, 1957). Contrary to wild tagged and wild back-calculated eels, no asymptotic limit of growth was found in cultured tagged eels. The cultured tagged eels are represented in a limited range of body length and are possibly not genetically neutral concerning growth potential due to artificial selection for growth at the eel farm. The increasing growth with increasing length of cultured tagged eels is similar to length-at-age data from Vester Vedsted Brook (Rasmussen, 1983). It also fits the predicted physiological determined growth calculated by Rasmussen & Therkildsen (1979) who suggest that population growth data, fit to be described by the von Bertalanffy growth equation, are affected by the emigration of silver eels.

Difficulties in reading burned and cracked otoliths have been described by Moriarty (1983) and it is demonstrated that the otoliths used in the present study were, in some cases, open to different interpretation.

Size and growth selectivity due to emigration of silver eels are most probably influential on growth data of wild tagged eels. This would explain the significant difference between back-calculated increments and increments from wild tagged eels in the size ranges from 35-39 and 40-44 cm (Table 4).

These results resemble those of Moriarty (1983) who also demonstrated good accuracy when comparing back-calculated growth rates with tagged and recaptured eels. With eels of known age, the burning and cracking method has also been proven to be satisfactory in the studies of Moriarty & Steinmetz (1979) and Vøllestad & Næsje (1988). In a review on age determination of eels, Vøllestad *et al.* (1988) conclude that the burning and cracking method seems to be the best method available.

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