GREAT LAKES FISHERY COMMISSION

2002 Project Completion Report[1]

Lake Trout Trofic Ecology in Little Moose Lake, NY

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December 2002

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LAKE TROUT TROFIC ECOLOGY IN LITTLE MOOSE LAKE, NY

Summary

We found significant seasonal and ontogenic variation of lake trout diet in Little Moose Lake. The proportion of stomachs with zooplankton prey was significantly lower during April and May than in other months while the opposite seasonal trend is shown for other invertebrates with higher levels from April to June. Proportion of stomachs with fish prey was higher in winter. Similar seasonal patterns are observed for prey abundance in the diet. The proportion of stomachs with zooplankton prey increased with lake trout length up to around 450 mm and decreased sharply among larger fish. Proportions with other invertebrates did not vary significantly although they were also fewer among larger fish. The lake trout proportions feeding on fish prey increased with size. Numbers of prey by stomach increased with lake trout length in the range for which prey were consumed but numbers of zooplankton reached there maximum at 450 mm and of other invertebrates at 550 mm. Lake trout in Little Moose lake is stunt and fish are smaller at age than any other population reported in the literature. A vonBertalanffy grow model with parameters L_8 =543.6, L_o=-126.7, and k= 0.179 describes the lake trout length at age relationship from the Little Moose Lake samples but large positive residuals are generated for individuals with no zooplankton and mostly with fish prey in their stomach contents. Smaller *b* coefficient for weight at length allometric equation for fish larger than 400 mm indicate they are in worse condition than smaller fish. From the 20 species present in zooplankton samples, relatively large *Daphnia pulicaria* was the most abundant and was present in all stations and months. Accordingly, this species was the most commonly found in the stomachs making up on average 80% of the zooplankton prey. For all species size of zooplankton prey in fish stomachs was always higher than size in the plankton samples indicating prey size selection by lake trout.

Introduction

Little Moose Lake is an oligotrophic system with a lake trout population characterized by slow growing individuals that supports a stable sport fishery. However, some anglers have expressed a desire to improve the mean size of lake trout and have suggested stocking fish prey. This study investigates the feeding ecology of lake trout in Little Moose Lake in terms of major taxa consumed, prey size selection on zooplankton prey and effect of feeding in growth rates. The ultimate goal of this work is to better understand the trophic ecology of lake trout, its influence in growth and help guiding management efforts in systems with variable food webs.

Little Moose Lake is a small, private lake located in the Adirondack Mountains of New York and is part of the Black and Oswegatchre watershed. It has an elevation of 550 m, an area of 271 hectares, a mean depth of 15 m and a maximum of 39 m. The lake is oligotrophic with Secchi depths from 5.5 to 8.25 m. The lake stratifies in the summer and winter with a thermocline from 4 to 7.5 m (Weidel 1996). The bottom is largely sand, with some gravel and rocky areas in the littoral zone (Warner 1952).

The native fish species in the lake include lake trout (*Salvelinus namaycush*), lake whitefish (*Coregonus clupeaformis*), round whitefish (*Prosopium cylinacracium*), brook trout (*Salvelinus fontinalis*), white sucker (*Catostomus commersoni*), and brown bullhead (*Ictalurus nebulosos*). Other native fish include sculpins (*Cottus sp*.), longnose suckers (*Catostomus catostomus*), and common shiners (*Notropis cornutus*). Introduced species include Atlantic salmon (*Salmo salar*), smallmouth bass (*Micropterus dolomieui*) and rainbow smelt (*Osmerus mordax*) (Warner 1952).

Little Moose Lake is owned by members of the Adirondack League Club, which have kept catch records for many years. Sharp declines in lake trout catch rates occurred from the early 1900's to the 1950's. Smallmouth bass were first reported in 1951, and although rare then (Warner 1952) they have become one of the most abundant fish species in the lake, especially in the littoral zone (Weidel 1996). Atlantic salmon were introduced in 1894 and have been stocked on and off since then and although some limited natural reproduction occurs the population is mostly supported by stocking. These introductions may have had a negative effect on the lake trout population. Some evidence exists to show that the diet of lake trout has shifted from a heavy reliance on fish to one dominated by zooplankton and aquatic invertebrates. Based on 19 samples taken in 1950 and 1951, Warner (1952) found that most stomachs had fish or fish remains, mostly of finescale suckers and sculpins, and claimed that fish were the most important item in the lake trout diet.

Over the past three decades the lake trout fishery in Little Moose Lake has produced a large number of small to medium size (30-55 cm) fish each season. In addition, every year a small number of trophy fish (> 60 cm) are caught. These characteristics are common for lake trout populations that are heavily dependent upon zooplankton (Martin 1952, Konkle *et al*. 1986).

Materials and Methods

Data

Lake trout samples were collected from late spring 1996 to fall 1997, mainly during May and June (Table 1). The 306 fish in the sample were caught by sport fishermen with hook and line along the lakeshore and the numbers in Table 1 reflect mostly seasonal fluctuation in catchability of lake trout to the fishing gear. Fish in the sample represent about 75% of the sport fishery during the study period. Most samples with known location were caught at St Louis Point in the east shore of the lake (Fig. 1).

Length was measured for 299 fish and ranged from 209.0 to 813.0 mm. Weight was recorded for 286 fish and ranged from 50 to 6808.9 g. Otoliths were taken from 266 fish for ageing. Sex determination was performed for 204 fish, 134 of which were females.

<u>Stomach content analysis</u>: The stomachs from 306 fish were removed, preserved and taken to the laboratory for examination of their contents. Items in the stomach contents were counted and zooplankton were identified to the species level while other

invertebrates, mostly insects, were assigned to order. Length frequencies were obtained for zooplankton prey.

Plankton samples: Zooplankton samples were collected using horizontal tows with a 250-μm mesh standard zooplankton net at six stations in 1996 and in 2 stations in 1997 (Table 4). Three of the stations were relatively deep and four were in shallow waters (Fig. 1). During 1996, tows in the deep stations were made at 15 m depth and in 1997 bottom tows were added. Samples were taken during daytime.

Organisms were identified to the species level, counted and measured. Samples were analyzed using a digital imaging system. An estimate of density in number per liter was calculated.

Analysis

We investigated the variation of lake trout diet with fish size and season in terms of presence of prey groups found in the stomachs (zooplankton, other invertebrates, and fish), and of counts of these prey groups. For the analysis we used generalized linear (GLMs) (McCullagh and Nelder 1989) and additive models (GAMs) (Hastie and Tibshirani 1986, 1989). GLMs allow for heterogeneous variances and GAMs allow also for the incorporation of non-linear terms using scatterplot smoothers. Their application for the analysis of stomach content data was proposed by Stefánsson and Pálsson (1997) and applied to feeding analysis by Waiwood *et al.* (1991), Adlerstein and Welleman (2000) and Adlerstein *et al*. (2002).

We modeled the proportion of stomachs with each prey type and the prey counts as a function of fish length and the month fish were captured. The month was incorporated in the models as a factor with 12 levels and fish length as a continuous smooth covariate. An interaction term was not included in these models since data were scarce for months other than May. To describe the relationship between the proportion of stomachs with each prey group and the linear predictor, GAMs with the binomial variance function V(?)

= ?(1-?) and the logit-link function log(?/(1-?)) (McCullagh and Nelder 1989) were used. Grouped binary data in the form of proportions are often analysed using the binomial distribution (Collet 1994). The length of the fish was introduced as a nonparametric spline of the form described in Chambers and Hastie (1992). For this analysis we excluded the 26 stomachs where no food contents were found. For the analysis of prey numbers in the stomachs GLMs with the negative binomial variance V(?) =? + ?²/*v*, and a logarithmic-link log(?) functions were used to relate the expected numbers to the predictors. The negative binomial distribution accommodates highly skewed to symmetric frequencies for positive random variables and was used since the dependent variable are counts, the frequency distribution was skewed and the variance related to the square of its mean (McCullagh and Nelder 1989). Length of the fish was introduced as a natural spline of the form described in Ripley and Venables (2000). For this analysis we included data from stomachs where the corresponding prey group was present.

Explanatory variables were assessed according to whether they explained a significant portion of the corresponding model deviance. Appropriate degrees of freedom of the smooth length terms were investigated within the analysis of deviance. All tests were performed at a 95% confidence level.

To analyze lake trout growth we fitted a vonBertalanffy growth model of the form:

$$L_t \; ? \; L_? (1 ? e^{? k(t ? t_0)})$$

where L_t is the fish length in (mm) at age t (years), L_8 is the asymptotic length, k is the growth coefficient and to is the hypothetical age when fish would have been zero length. To investigate fish condition we fitted weight at length allometric relationships.

We investigated prey size selection of zooplankton organisms by comparing the size distribution of zooplankton prey in fish stomach contents with length of zooplankton in samples.

Analyses were done using routines contained in the S-Plus programming environment (Becker *et al*. 1988). For the analysis incorporating a negative binomial distribution we used S-Plus functions developed by Ripley and Venables (2000) that allow for estimation of the negative binomial parameter.

Results

The length composition of lake trout in Little Moose Lake samples was dominated by individuals between 400 and 500 mm (Fig. 2). Only 4 fish were larger than 600 mm. Age ranged from 3 to 32 years and most fish were between 8 to 11 year old (Fig.2). The sample length structure is determined by fish catchability to the hook and line gear. Among individuals for which sex was determined there were about double the number of females than males throughout the range of ages.

Ontogenic and seasonal variation of Lake trout diet

<u>Proportion of stomachs with prey groups</u>

Only 26 out of the 306 fish had no food in their stomachs. Zooplankton prey were found in 46% of the stomachs of fish in the full range of sizes available in the sample (Fig. 3). The most abundant species was *Daphnia pulicaria*. Other invertebrates were present in 76% of the stomachs of fish over 350 mm and consisted mainly of insect larvae from the following taxa in order of numerical importance: Diptera, Ephemeroptera (*Hexagenia)*, Hemiptera, Trichoptera and Megaloptera. The occurrence of some of these taxa and of crayfish gave evidence of benthic feeding. Some stomachs contained rotifers. Fish prey were found in 10% of the stomachs in almost the full range of fish in the sample and consisted mostly of sculpins and smelts. Also a 400 mm lake trout was reported in the stomach contents of a 32 years old specimen. Zooplankton and other invertebrates were found together in 40% of the stomachs and when both were present the numbers were negatively correlated (Fig. 4). Only in 9 of the 306 stomachs analyzed the 3 prey groups were present.

Results from the analysis of deviance for binomial GAMs for the presence of prey groups zooplankton, other invertebrates and fish, are shown in Table 2. Seasonal variation and ontogenic variation were significant for each prey group except for invertebrate variation with length. Figure 4 represents for each prey group the fitted effect from the binomial GAMs of fish length and month accounting for the effect of each other.

Zooplankton: Lower proportions of stomachs with zooplankton prey were found in April and May (10 to 30%) than in other times of the year (>50%). Proportions in fish of lengths from 200 up to around 450 mm (˜ 50%) sharply declined among larger fish.

Invertebrates: The opposite seasonal trend is shown for presence of other invertebrates with significantly higher levels from April to June (over 80%) than during other months (as low as 25% in December). Proportions did not vary significantly with the size of the fish although levels were lower among larger fish (Table 2, Figure 4).

Fish: The proportion of lake trout feeding on fish prey increased with size (<10% to 30%) among the larger individuals and was significantly higher from January to March (˜ 30%) than in other months.

To investigate is there were differences in the proportions by prey groups between years, which could affect the previous analysis, GAMs similar to those above by including year as a factor instead as month were run with data collected during May. No significant differences between years were found (Probability of Chi = 0.99 (fish prey), 0.88 (zooplankton), 0.56 (invertebrates)

Prey abundance by group

Abundance of prey in lake trout stomachs is skewed with most stomachs with very few organisms per category (Fig 5). Fish and zooplankton counts increased in the stomachs with predator length up to around 500 mm (Fig. 3). Number of invertebrate prey also increased with length but they are found among fish larger than 400 mm. Stomachs of fish larger than 550 cm were mostly empty, contained no zooplankton prey and few other invertebrates and fish.

Results of the analysis of deviance in Table 3 indicate that seasonal and ontogenic variation of the number of zooplankton and other invertebrate prey in lake trout stomachs (when these groups were present) was significant. Numbers of fish prey did not vary by months and only marginally with length, but the number of lake trout with fish prey was very low. Figure 6 represents for each prey group the fitted effect from the negative binomial GLMs for fish length and month accounting for the effect of each other. Seasonal patterns shown indicate that prey numbers varied accordingly with the proportion of stomachs containing corresponding prey groups. In terms of the increase of prey counts with predator length the trends are more pronounced than for the proportions and are significant for each group.

Growth

The rate of increase in length at age of lake trout in the study declines from over 30 mm per year to less than 20 mm per year when fish reach around 420 mm and 9 years of age (Table 5, Fig. 8a). The increase in weight at age also decreases but after age 10 (Table 5). No differences were observed in length at age between male and female fish. A vonBertalanffy grow model with parameters L_8 =543.6 (se=13.76), L_o=-126.7 (se=80.52), and k= 0.179 (se=0.022) describes the length at age relationship from Lake trout in Little Moose Lake based on the available samples (Fig. 8a). Nevertheless the fit results in mostly negative residuals for ages under 9 and over 14 years (Fig 8b), ages for which the number of samples is low. Also, some very high residuals are spread through the range of ages in the sample. These large positive residuals correspond to lake trout that had no zooplankton and mostly with fish prey in their stomach contents.

The weight at age data is shown in Fig. 9. Given the relationship observed no growth model was fitted. The weight of fish in the sample ranges from 50 to 6808 grams for length between 209 and 813 mm and only 4 fish exceeded 2000 grams and 600 mm. No differences are observed in the length and weight relationship between males and female lake trout (Fig. 10). Also no differences are observed between the overall relationship and that of lake trout where fish prey were present in the stomachs.

Weight increases linearly between about 400 to 600 mm (Fig. 9b) and fitting a weight at length relationship of the form *Weight=a Length* ^{b} with data from the 200 to 600 mm range (Table 6) results in mostly negative residuals for fish between 200 and 400 mm in length (Figure 10). When analysis is performed separately for fish smaller and larger than 400, the residuals are symmetric (Fig. 11) and the *b* coefficient for smaller fish is significantly larger than that for larger fish (Table 4).

Zooplankton in plankton samples and in the stomachs

Twenty taxa were found in the plankton samples of which *E. lacustris, D. minutus, C. bicuspidatus, and Nauplii* were the most abundant and found at all stations (Table 7). Among these 20 taxa only *D. schodleri* was found exclusively in deep stations. Except for *M. edax,* zooplankton species were most abundant in June and July (Fig. 12). The size of the organisms in 1996 and 1997 samples during these months ranged from 0.25 to 2.5 mm (Fig.13). Organisms with largest average size were *L. kindtii and S. crystalline* but they were found in low numbers (Table 7). From the species of relatively large size *D. pulicaria* was the most abundant and was present in all stations and at all months. Accordingly, this species was the most commonly found in the stomachs making up on average 80% of the zooplankton prey. The other species in order of importance were the large *S. crystalline,* relatively abundant in samples in shallow waters and the small and very abundant *E. lacustris*. The smallest prey size corresponded to copepod nauplii and rotifers.

The size of zooplankton prey in the stomachs was always higher than the size in the plankton samples (Table 7). As an example we present the size distribution of *D. pulicaria,* the most abundant zooplankton prey, in the stomachs and in the plankton samples (Fig. 14). Organisms in the plankton samples from June 1996 ranged from 1.1 to 2.3 mm while sizes in the stomachs ranged from 2.1 to 2.3 mm and in 1997 organisms in the plankton ranged from 0.9 to 1.4 mm and in the stomachs from 1.9 to 2.4 mm. Size of zooplankton prey did not vary with size of the predator (Fig. 15).

Discussion and Conclusions

The diet of lake trout population in Little Moose Lake consists mostly of zooplankton and other invertebrates, while very few individuals were found to feed on fish. Results from this study show an ontogenetic shift in the diet of lake trout from a mix of zooplankton, invertebrate and fish prey dominated by zooplankton in small fish to exclusively other invertebrates and fish in predators over 500 mm. Also, the diet varies seasonally with a shift of the dominance of zooplankton during April and May when other invertebrates are predominant.

The lake trout population in Little Moose Lake is growth limited. The increase in size of fish seam stagnated when they reach about 12 years of age and their size ranges between 400 and 500 mm. Only 3 out of 306 lake trout in the sample were over 600 mm. Although there is a wide diversity of growth rates throughout the geographic range of the species (Martin 1952), levels in Little Moose are lower than in other reported studies in cold, oligotrophic lakes. Length at age of fish sampled for this study are also much smaller than in fish collected in Little Moose Lake during 1950 and 1952 (Warner 1952) where for example the mean length of age 6 fish was about double. These characteristics of the population are most likely due to a combination of the dominance of zooplankton and absence of fish in the diet and food limitation due to competition with other species. The stomach contents in the earlier samples contained always fish. Growth efficiency model for fishes (Kerr 1971a, 1971b, 1971c), suggests lake trout must have access to increasingly larger prey to achieve large body size. Further, it has been reported that absence of suitable forage fish might cause the population to be dominated by small, slow growing individuals (Konkle and Sprules 1986). Given that growth of lake trout seem to be food limited one option to achieve an improvement in the size and condition of lake trout in Little Moose Lake is to reduce the abundance of competitors. Increasing abundance of forage fish in the Lake will probably result in unexpected and undesirable outcomes.

There are some few lake trout older than age 7 that are much larger at age than the rest of the fish in the sample. These larger individuals were found with fish and or invertebrates other than zooplankton in their stomachs and thus it is possible that they have grown bigger because the diet of these fish is less dependent on zooplankton. Trophic differences among individuals of a population have been thought responsible for within lake trout population variation in growth (Martin 1966, Vander Zander et al. 2000). Also, Martin 1966 showed that planktivourus lake trout grow more slowly and reach smaller terminal sizes than piscivorous fish.

Our findings on the presence of larger zooplankton size in the zooplankton tows than in the stomach samples indicates lake trout size selection for larger zooplankton. Also the numerical dominance in the stomach contents of the most abundant but not the largest prey available *Daphnia pulicaria* in Little Moose Lake and the relatively scarce but large littoral species *Sida crystallina* reflects a compromise between size and abundance when selecting prey.

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Table 1. Number of fish collected in Little Moose Lake by year and month available for the study.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1996	0	0	1	0	60	10	5	5	16	3	8	6
1997	3	15	25	22	71	28	10	2	12	1	0	2

Table 2. Analysis of deviance table for binomial GAMs for the effect of fish length and month on proportion of stomachs with zooplankton, other invertebrates and fish prey groups

Terms	Resid Df	Resid Dev	Test	Df	Dev.	Pr(Chi)
Zooplankton						
s(Length,3)+month	256	261.58				
month	259	288.83	-s(Length, 3)	3	-27.25	<0.0001
s(Length, 3)	267	355.57	-month	11	-93.99	<0.0001
Other Invertebrates						
s(Length,2)+month	260	156.19				
month	262	157.42	-s(Length, 2)	2	-1.22	0.528
s(Length, 2)	271	225.80	-month	11	-69.61	<0.0001
Fish						
s(Length,3)+month	259	177.16				
month	262	184.38	- s(Length, 3)	3	-7.21	0.062
s(Length, 3)	270	207.13	- month	11	-29.97	0.001

Table 3. Analysis of deviance table for negative binomial GLMs for the effect of fish length and month on zooplankton counts in stomach contents, other invertebrates and fish prey groups.

Terms	Resid. Df	Resid. Dev	Test	Df	Deviance	Pr(Chi)
Zooplankton						
ns(length,3)+month	127	171				
month	130	193	-ns(length,3)	3	22.2	<0.0001
ns(length, 3)	138	224	-month	11	53.2	0.0000
Invertebrates						
ns(length,4)+month	214	287				
month	218	310	-ns(length,4)	4	46	0.0001
ns(length)	225	442	-month	11	155	0.0000
Fish						
length+month	25	22.3				
month	31	25.8	-length	1	3.5	0.06
length	32	32.4	-month	7	10.1	0.18

Table 4. Number of zooplankton tow samples taken at each site in Little Moose Lake. Sites D1 to D3 correspond to deep stations and L1 to L4 are littoral sites. In deep stations tows were performed at 15 m and in 1997 about half correspond to bottom tows.

Year		4	5	6	7	8	9	10	11
1996	D1	-	-	19	21	18	8	10	0
	D2	-	-	20	21	16	7	8	9
	L1	-	-	17	21	16	8	10	7
	L2	-	-	19	14	18	12	10	9
	L3	-	-	13	22	17	9	8	8
	L4	-	-	16	20	20	9	8	7
1997	D1	13	22	25	9	40	39	20	18
	D3	19	49	68	42	76	89	37	41

Table. 5. Lake trout mean weight (Wght in kg) and length (Lgth in cm) at age and variance in Little Moose samples for ages with more than one fish.

Age	4	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Lgth	21.7	27.1	35.0	38.1	42.2	44.0	45.4	46.6	47.4	49.2	48.7	49.1	49.4	50.1	58.7
Var	1.28	18.71	46.25	40.77	25.91	21.84	10.77	7.48	29.85	15.2	6.58	6.59	11.23	11.66	270.8
Wght	0.07	0.15	0.35	0.46	0.56	0.66	0.72	0.78	0.86	0.88	0.87	0.9	0.94	1.02	1.95
Var	<0.01	<0.01	0.05	0.07	0.04	0.04	0.02	0.02	0.15	0.03	0.03	0.02	0.03	0.07	3.62

Table 6. Coefficients for a length weight relationship of the form *Weight=a Length* ^{b} for lake trout in Little Moose Lake samples within length ranges.

Fish length (mm)	a	Confidence Intervals (95%)	b	Confidence intervals (95%)
200-600	0.0000166	0.0000074-0.0000372	2.87035	2.586868-2.977346
200-400	0.0000013	0.0000004-0.0000088	3.28949	2.966861- 3.631577
400-600	0.0000396	0.0000138-0.0001175	2.73011	2.554254- 2.905471

Table 7. Average number of zooplankton organisms per liter by species and plankton sampling station, average length in plankton samples (Site Plk) and in the stomachs (Size Stm), and percentage of the fish samples with the species in the stomachs (%Stm).

Taxa	D1	D2	D3	L1	L2	L3	L4	Size Plk	Size Stm	% Stm
Bosmina longirostris	0.69	2.53	0.70	1.22	0.61	1.30	2.73	0.56	0.6	0.01
Cyclops bicuspidatus	3.76	4.37	3.03	1.40	1.73	1.96	2.69	0.77	1.7	0.18
Cyclops vernalis	-	-	0.04	0.64	-	0.32	-	0.98	-	-
Daphnia dubia	0.25	0.45	0.08	1.06	0.69	0.99	1.62	1.38	-	-
Daphnia galeata mendotae	0.21	0.30	0.36	0.62	0.24	0.51	0.41	1.64	2.4	0.28
Daphnia longiremis	0.35	0.68	0.21	0.57	0.17	0.21	0.72	1.24	-	-
Daphnia pulicaria	0.87	1.28	0.49	0.72	0.21	0.34	1.11	1.43	2.18	79.0
Daphnia retrocurva	0.06	-	0.05	0.26	0.64	0.16	-	1.43	-	-
Daphnia schødleri	1.02	0.11	-	-	-	-	-	1.51	2.7	0.03
Diaptomus minutus	2.14	6.95	1.87	3.28	3.94	5.05	10.40	0.84	0.5	0.02
Diaptomus oregonensis	-	-	-	-	0.01	-	-	1.1	-	-
Epischura lacustris	1.70	2.55	0.31	4.14	3.99	3.78	9.41	1.04	-	1.78
Holopedium gibberum	0.21	0.19	0.23	0.27	0.19	0.11	0.26	1.66	-	-
Leptodora kindtii	0.19	0.34	0.08	-	0.02	-	-	2.4	7.8	0.91
Mesocyclops edax	1.23	2.47	1.39	0.59	0.56	0.48	0.95	0.87	2.2	0.08
Polyphemus pediculus	-	-	0.20	0.08	0.32	-	-	0.84	1.03	0.14
Sida crystallina	0.17	0.37	0.22	0.22	2.46	1.11	1.86	2.00	2.69	4.28
Nauplii	2.33	1.65	2.50	3.82	2.12	4.16	3.55	0.35	-	-
Asplanchna	-	0.34	-	-	-	-	0.06	1.15	-	
Other Rotifers	-	0.11	-	-	0.21	-	-	0.3	-	-

List of Figures

1. Contour map of Little Moose Lake and location of plankton stations.
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8. a) Length at age data and Bertalanffy growth curve, with parameters L_8 =543.6 (se=13.76), L_o=-126.7 (se=80.52), and k= 0.179 (0.022), for lake trout from Little Moose Lake samples with 95% confidence intervals.
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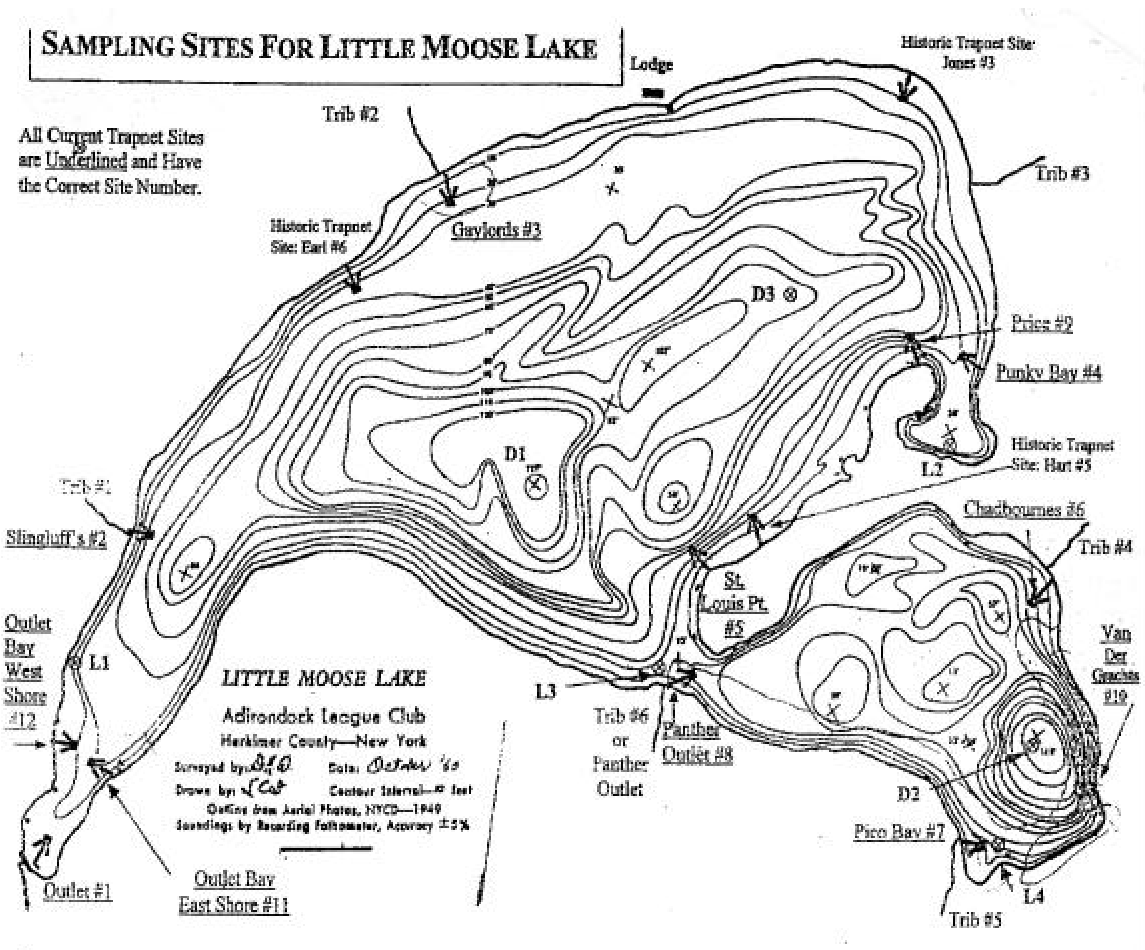
13. Number of zooplankton organisms per liter in plankton samples by species and month.

14. Size of zooplankton organisms (in mm) in Little Lake plankton samples in June 1996 and in May and June 1997.

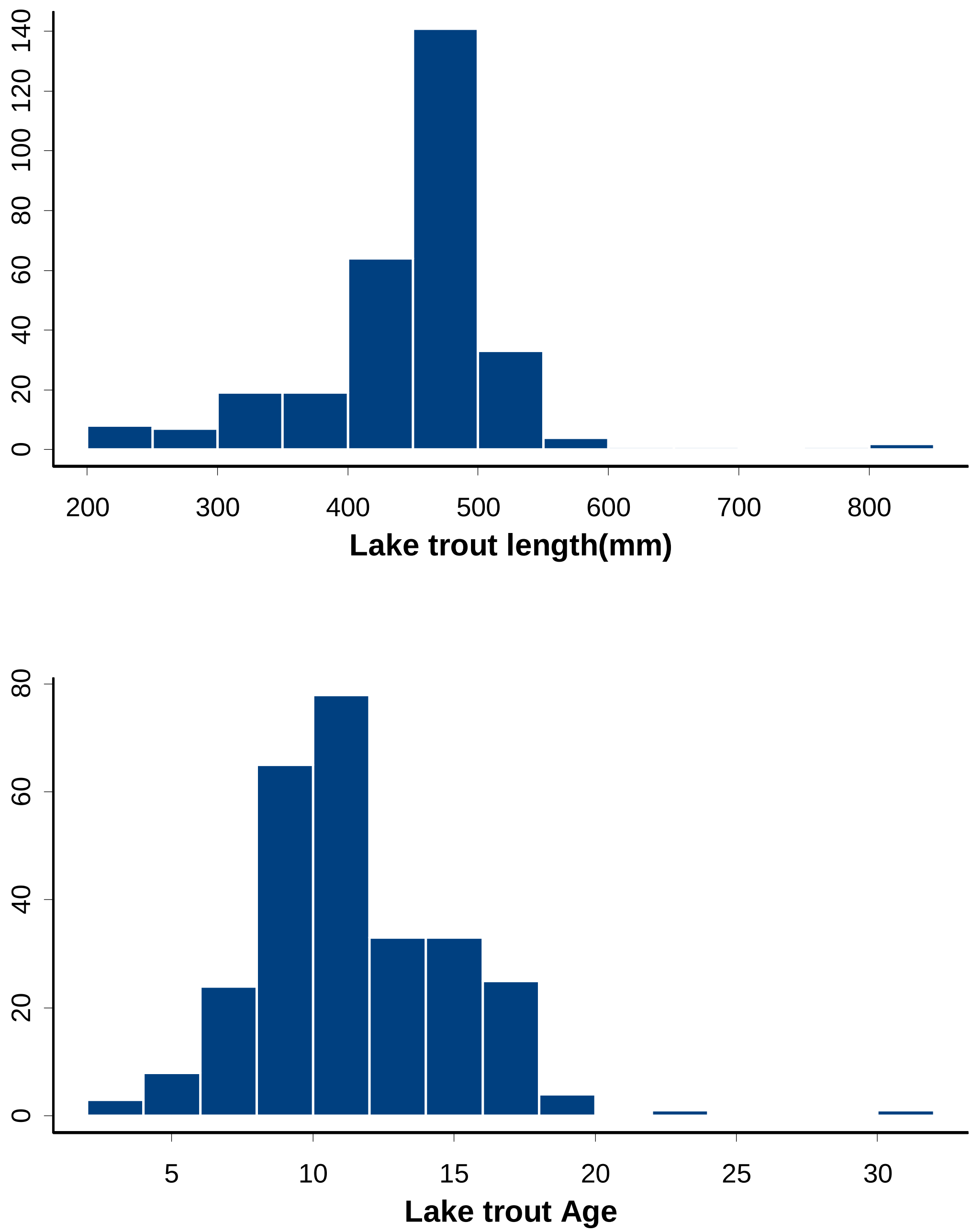
15. Frequency distribution of *D. pulicaria* sizes in plankton and in the stomachs in June samples in 1996 and 1997.

16. Length of zooplankton prey and Lake trout length in 1996 samples.



SAMPLING SITES FOR LITTLE MOOSE LAKE
All Current Trapnet Sites are Underlined and Have the Correct Site Number.
Lodge
Historic Trapnet Site: Jones #3
Trib #2
Trib #3
Historic Trapnet Site: Earl #6
Gaylords #3
D3
Price #9
Punky Bay #4
D1
L2
Historic Trapnet Site: Hart #5
Chadbournes #6
Slingluff's #2
Trib #4
St. Louis Pt. #5
Van Der Grachts #10
Outlet Bay West Shore #12
L1
LITTLE MOOSE LAKE
Adirondack League Club
Herkimer County—New York
L3
Trib #6 or Panther Outlet
Panther Outlet #8
D2
Pico Bay #7
L4
Outlet #1
Outlet Bay East Shore #11
Trib #5

Fig.1.



0
20
40
60
80
100
120
140
200
300
400
500
600
700
800
Lake trout length(mm)
0
20
40
60
80
5
10
15
20
25
30
Lake trout Age

Fig.2

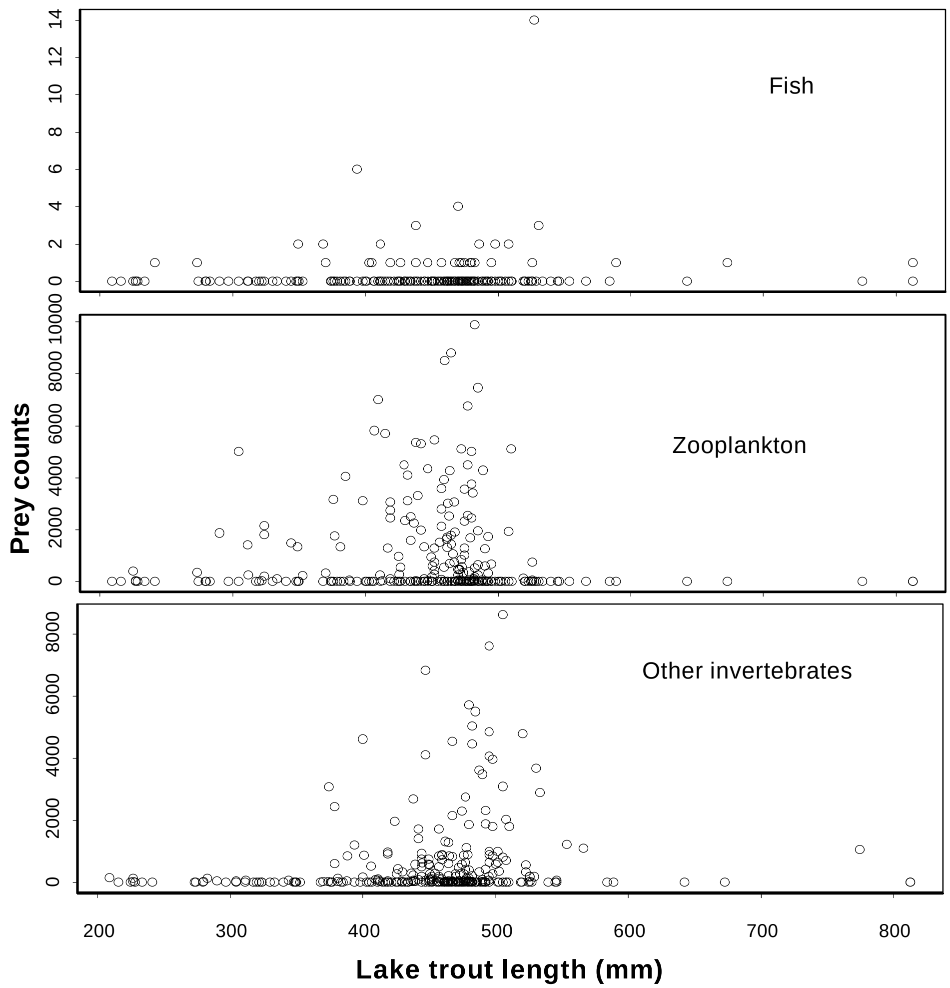

Fish
Zooplankton
Other invertebrates
Prey counts
Lake trout length (mm)
0
2
4
6
8
10
12
14
0
2000
4000
6000
8000
10000
0
2000
4000
6000
8000
200
300
400
500
600
700
800

Fig 3.

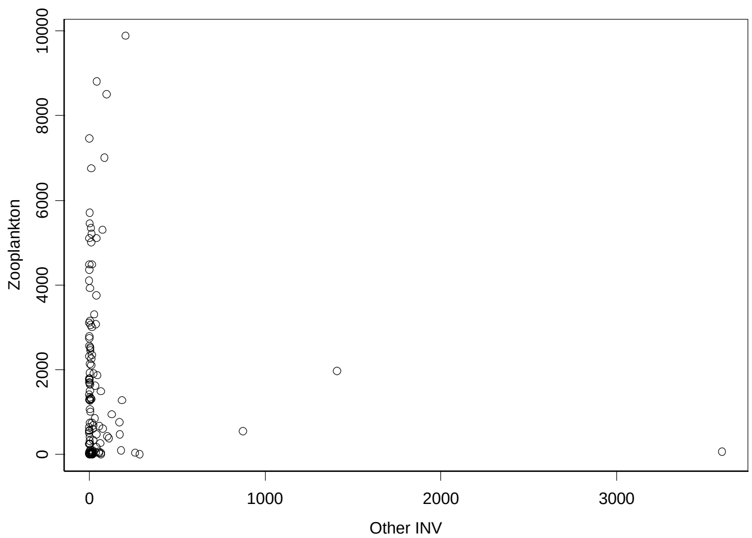
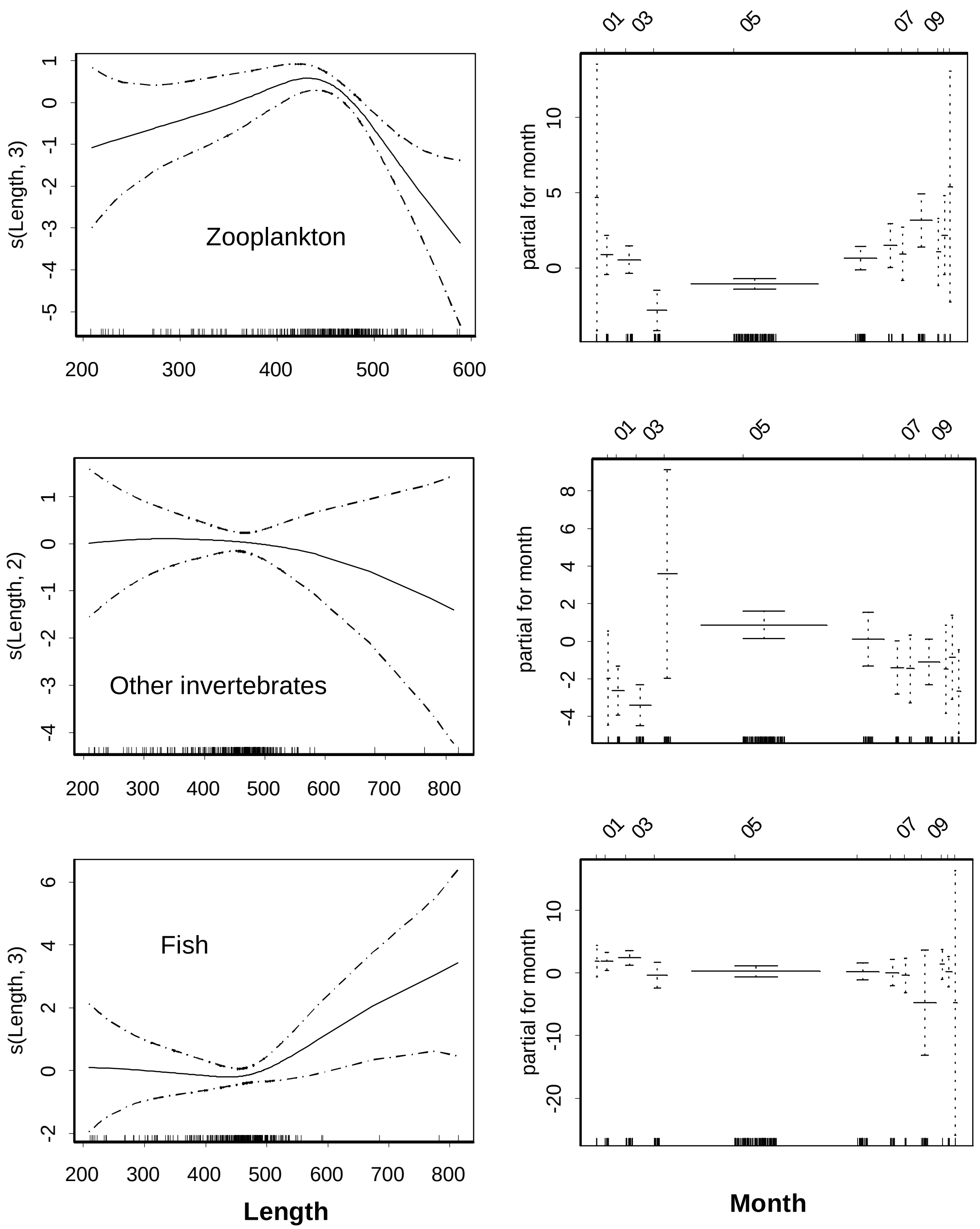

Zooplankton
0
2000
4000
6000
8000
10000
0
1000
2000
3000
Other INV

Fig. 4



Zooplankton
s(Length, 3)
partial for month
Other invertebrates
s(Length, 2)
partial for month
Fish
s(Length, 3)
partial for month
Length
Month
01
03
05
07
09

Fig.5

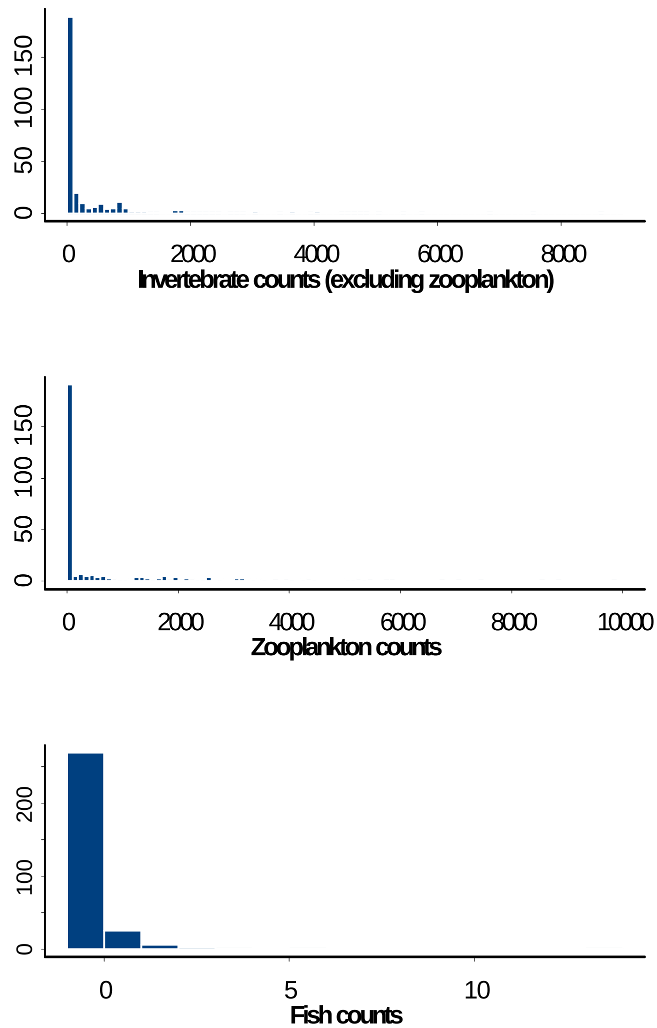

0
50
100
150
0
2000
4000
6000
8000
Invertebrate counts (excluding zooplankton)
0
50
100
150
0
2000
4000
6000
8000
10000
Zooplankton counts
0
100
200
0
5
10
Fish counts

Fig 6

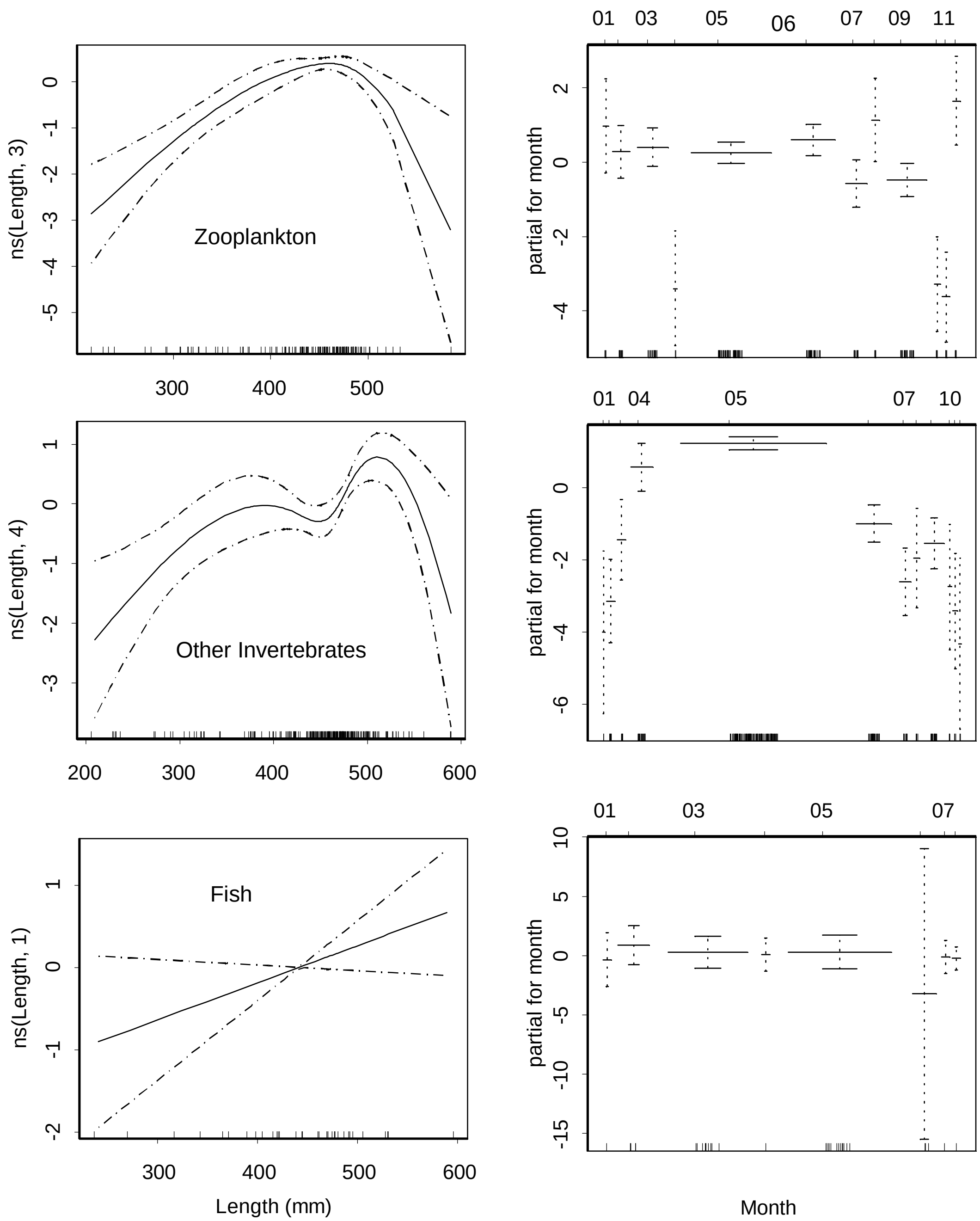

Zooplankton
Other Invertebrates
Fish
ns(Length, 3)
ns(Length, 4)
ns(Length, 1)
partial for month
Length (mm)
Month

Fig.7

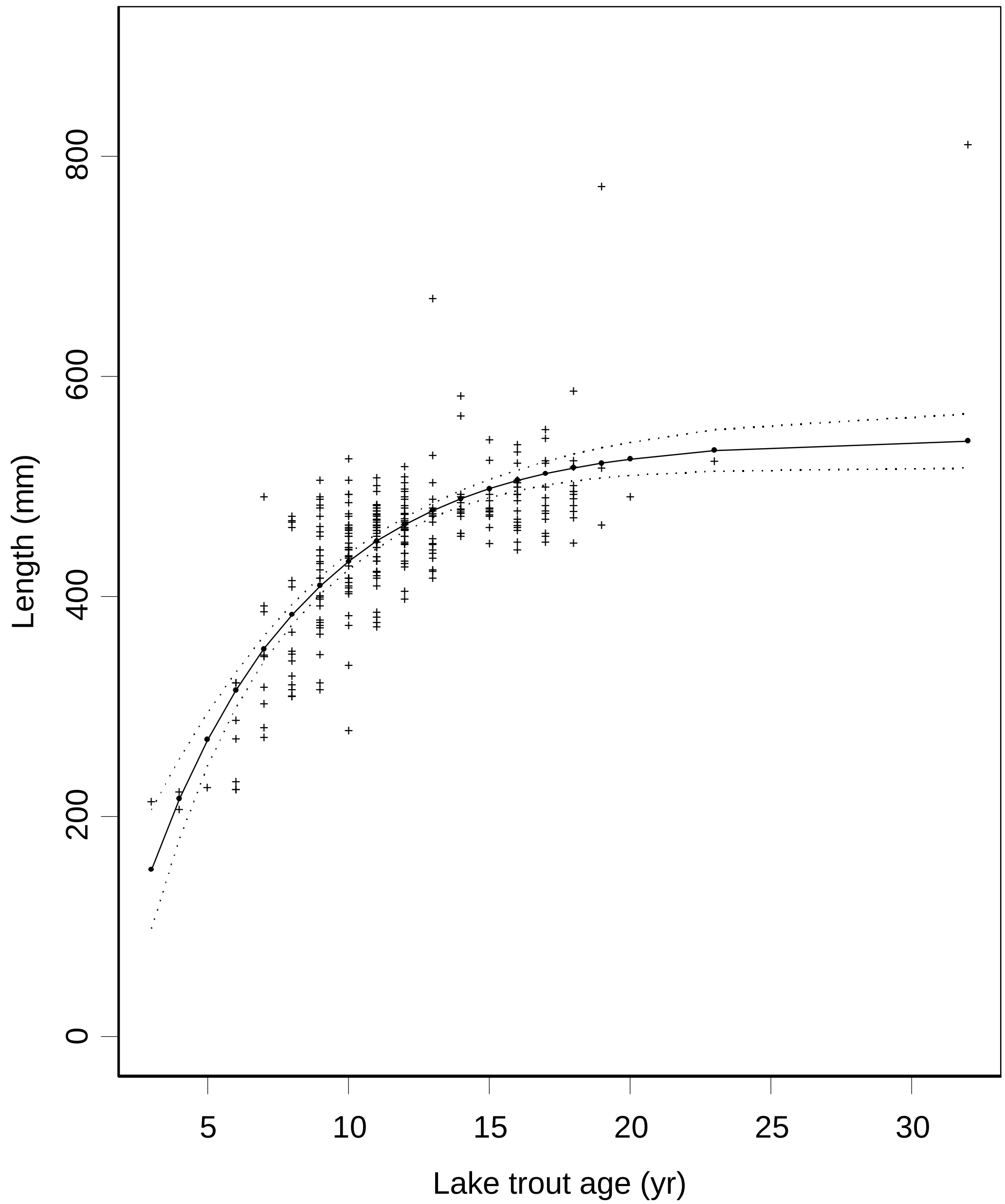


Fig. 8a.

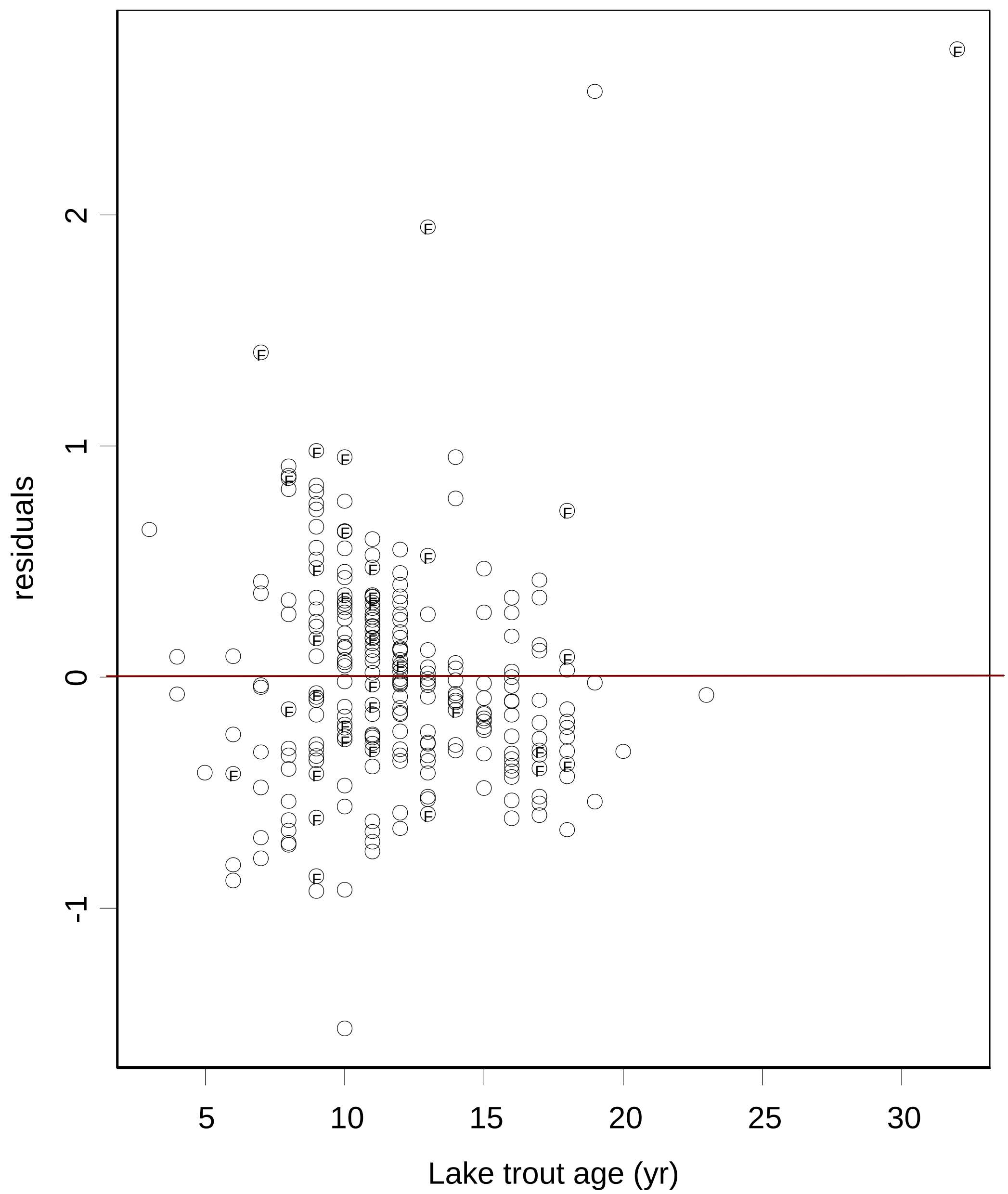


Fig.8b.

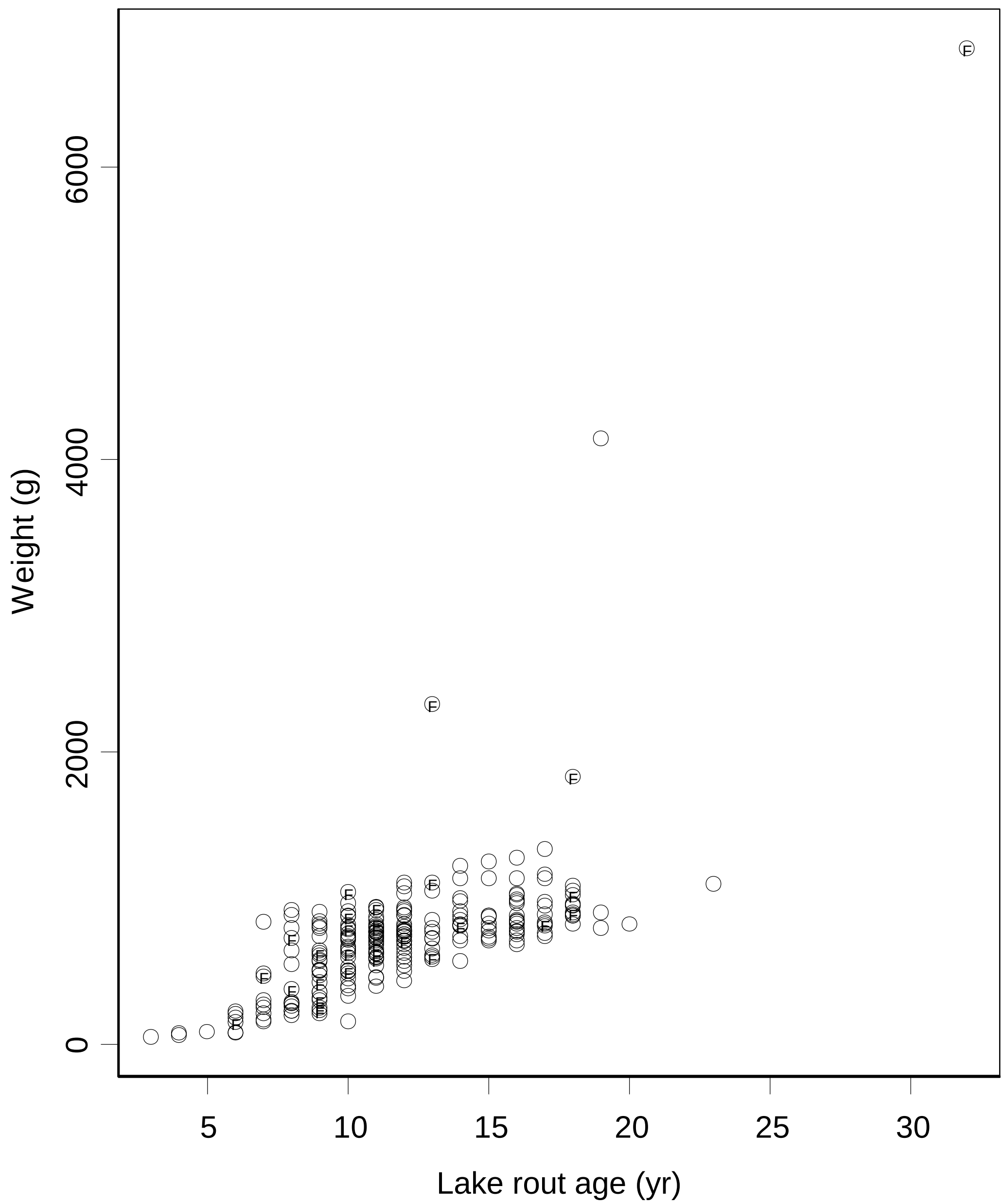
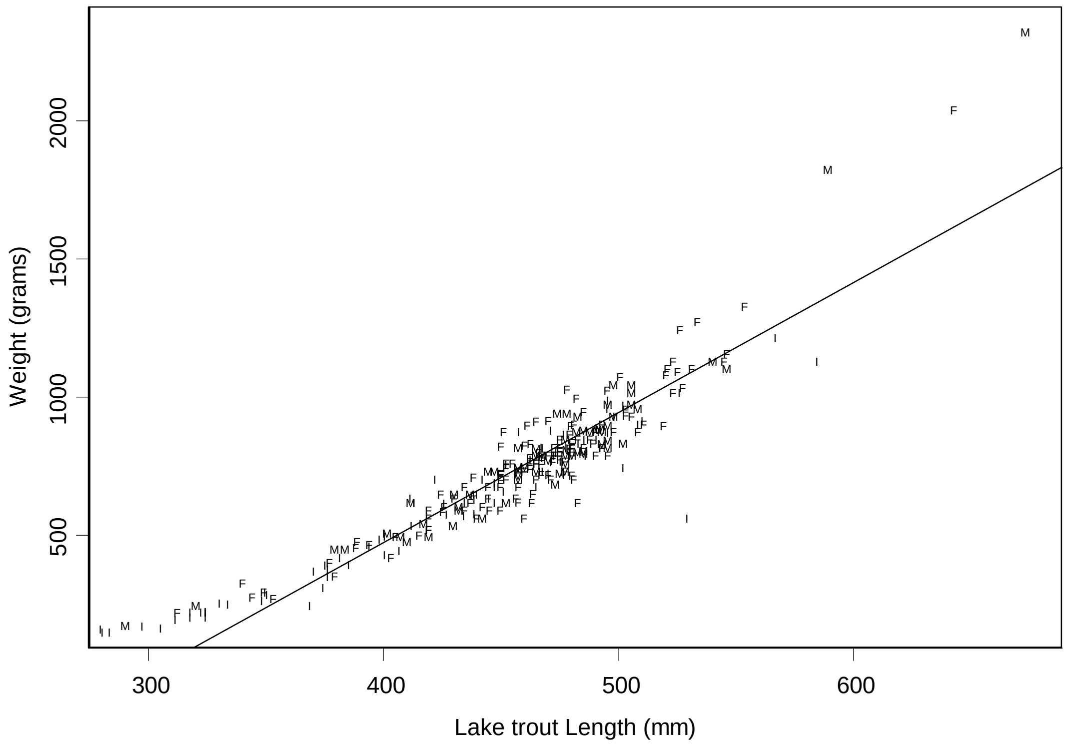


Fig.9



Weight (grams)
500
1000
1500
2000
300
400
500
600
Lake trout Length (mm)

Fig. 10.

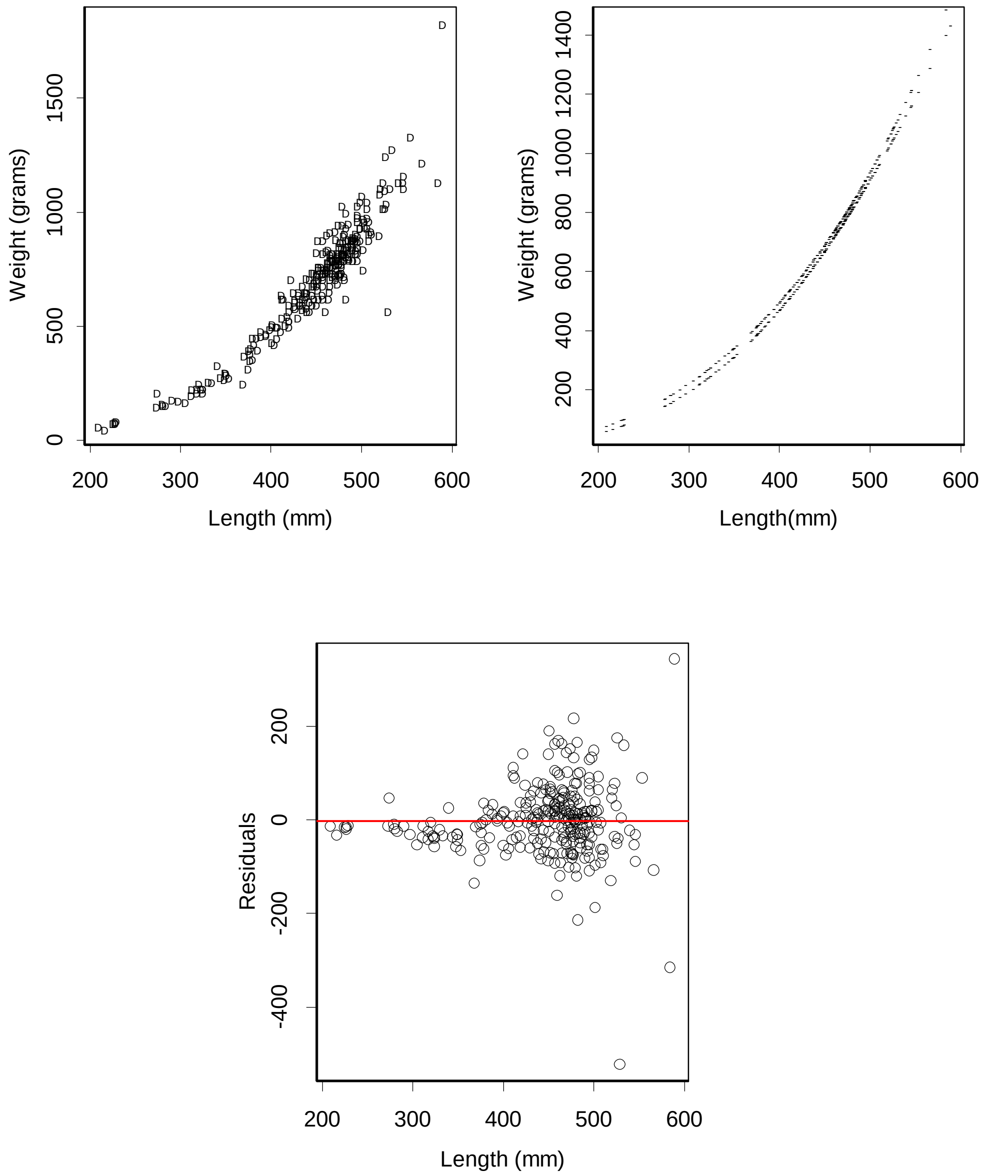


Fig. 11.

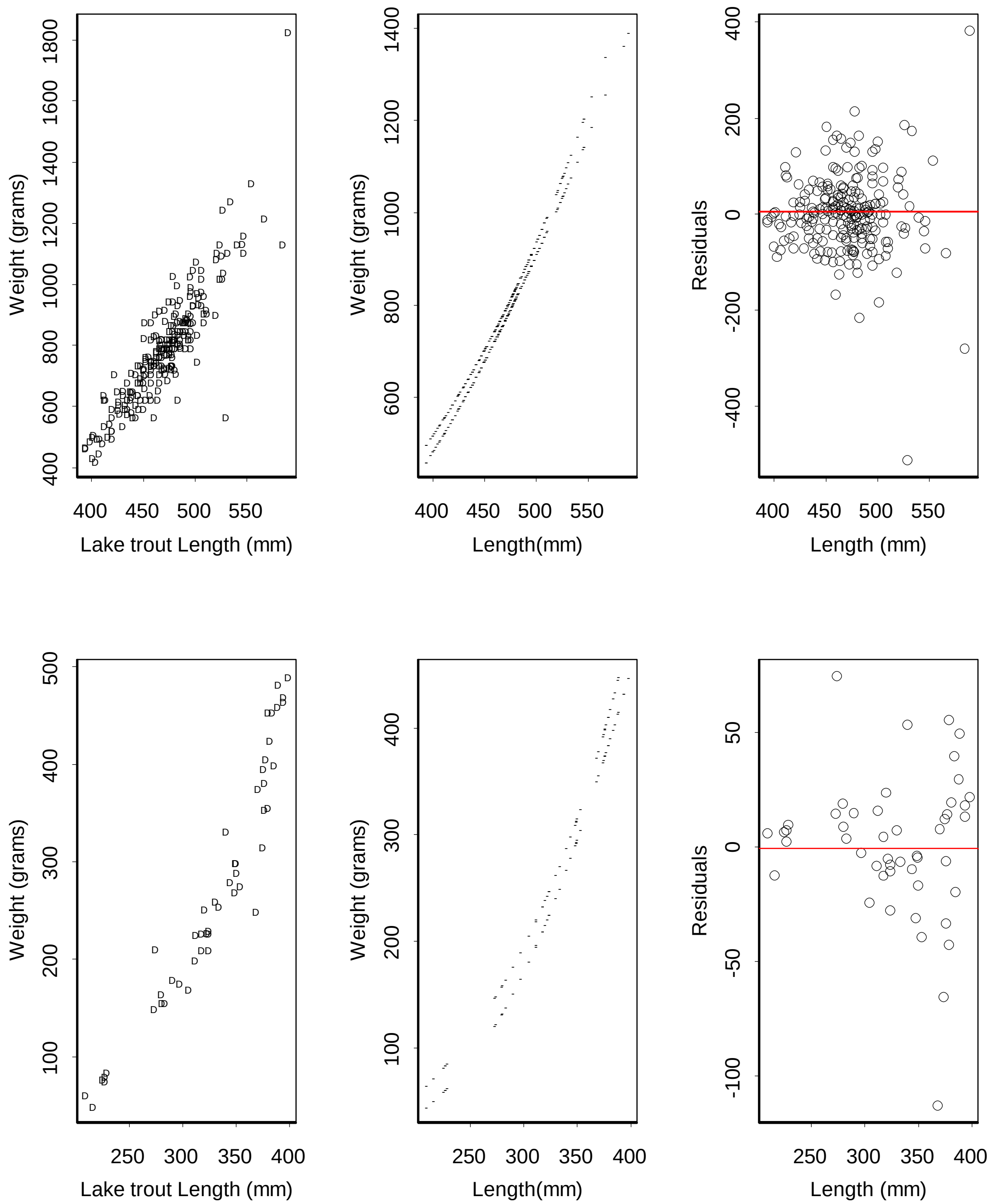

Weight (grams)
Lake trout Length (mm)
Weight (grams)
Length(mm)
Residuals
Length (mm)
Weight (grams)
Lake trout Length (mm)
Weight (grams)
Length(mm)
Residuals
Length (mm)

Fig. 12.

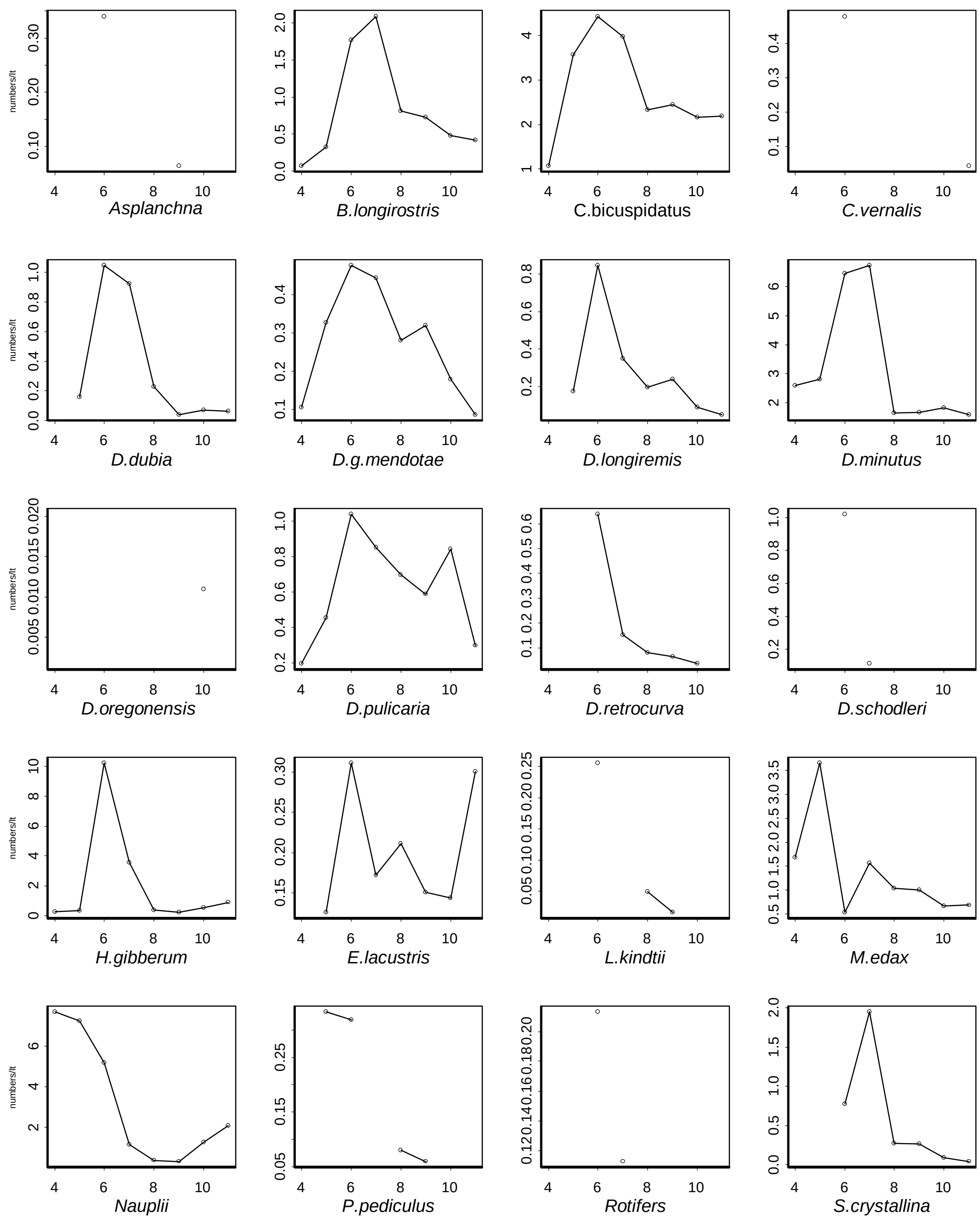


Fig. 13. Numbers per liter in tows

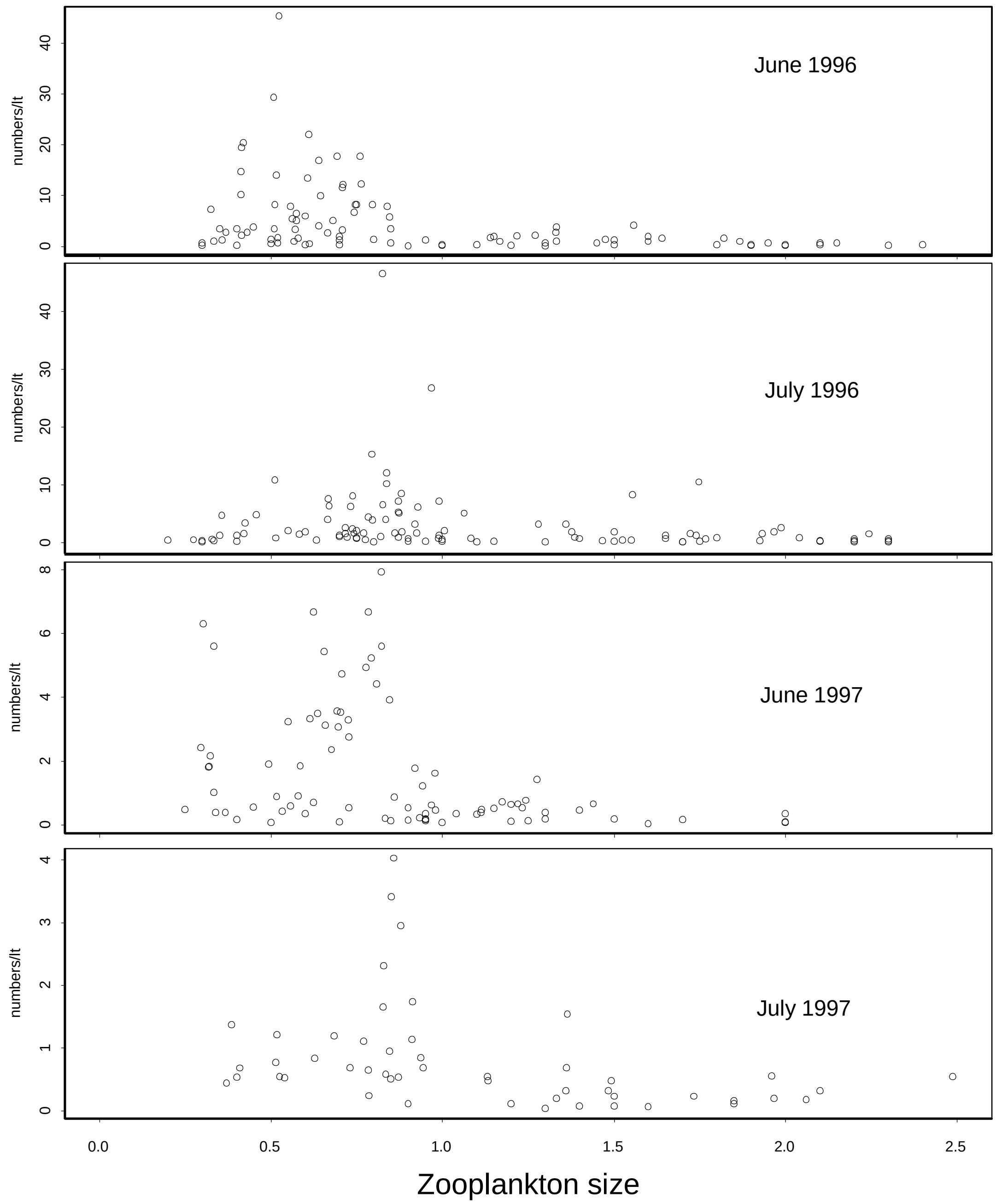

June 1996
July 1996
June 1997
July 1997
numbers/lt
numbers/lt
numbers/lt
numbers/lt
0
10
20
30
40
0
2
4
6
8
0
1
2
3
4
0.0
0.5
1.0
1.5
2.0
2.5
Zooplankton size

Fig 14.

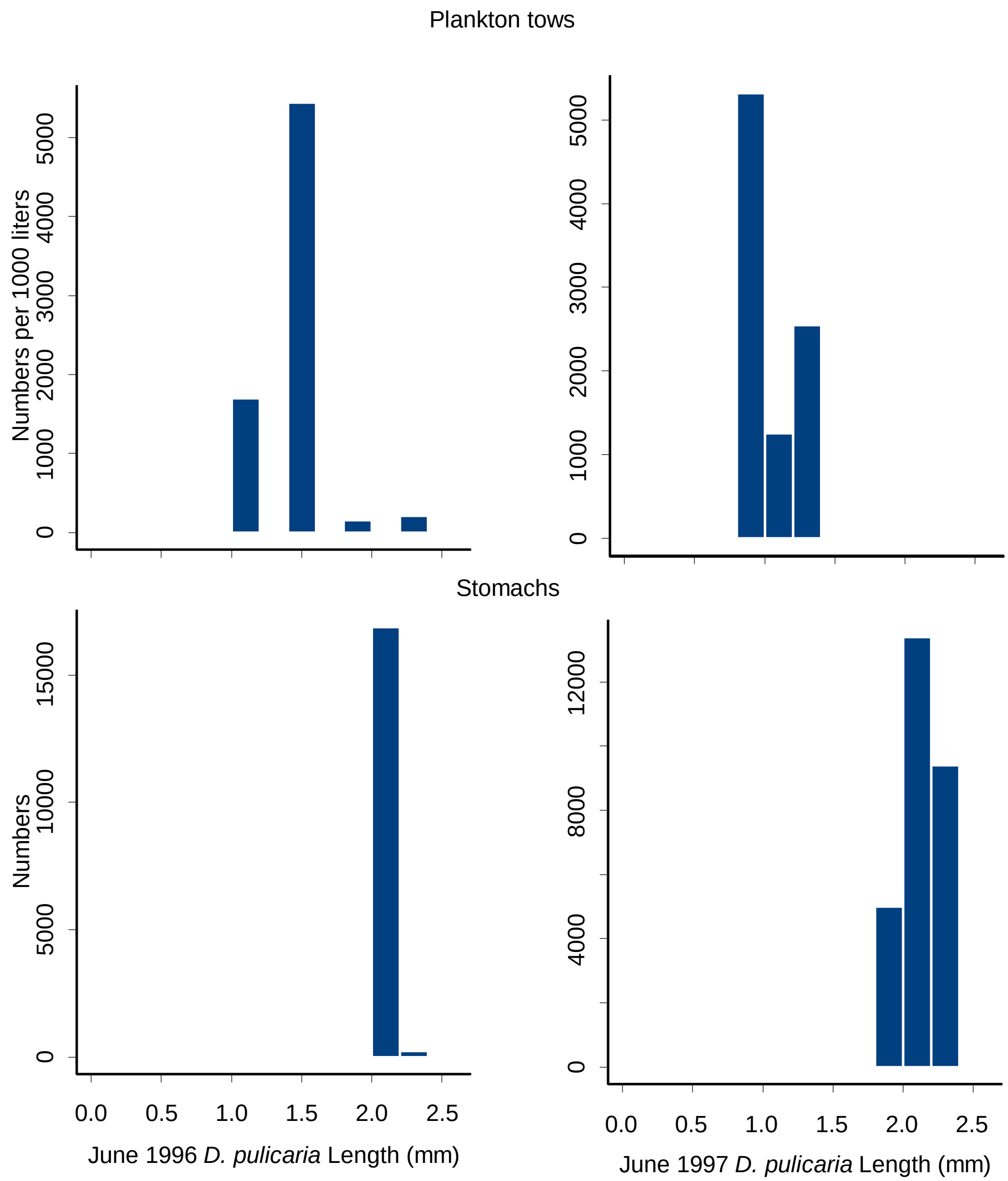

Plankton tows
Numbers per 1000 liters
0
1000
2000
3000
4000
5000
Stomachs
Numbers
0
5000
10000
15000
0
4000
8000
12000
0.0
0.5
1.0
1.5
2.0
2.5
June 1996 D. pulicaria Length (mm)
June 1997 D. pulicaria Length (mm)

Fig. 15.

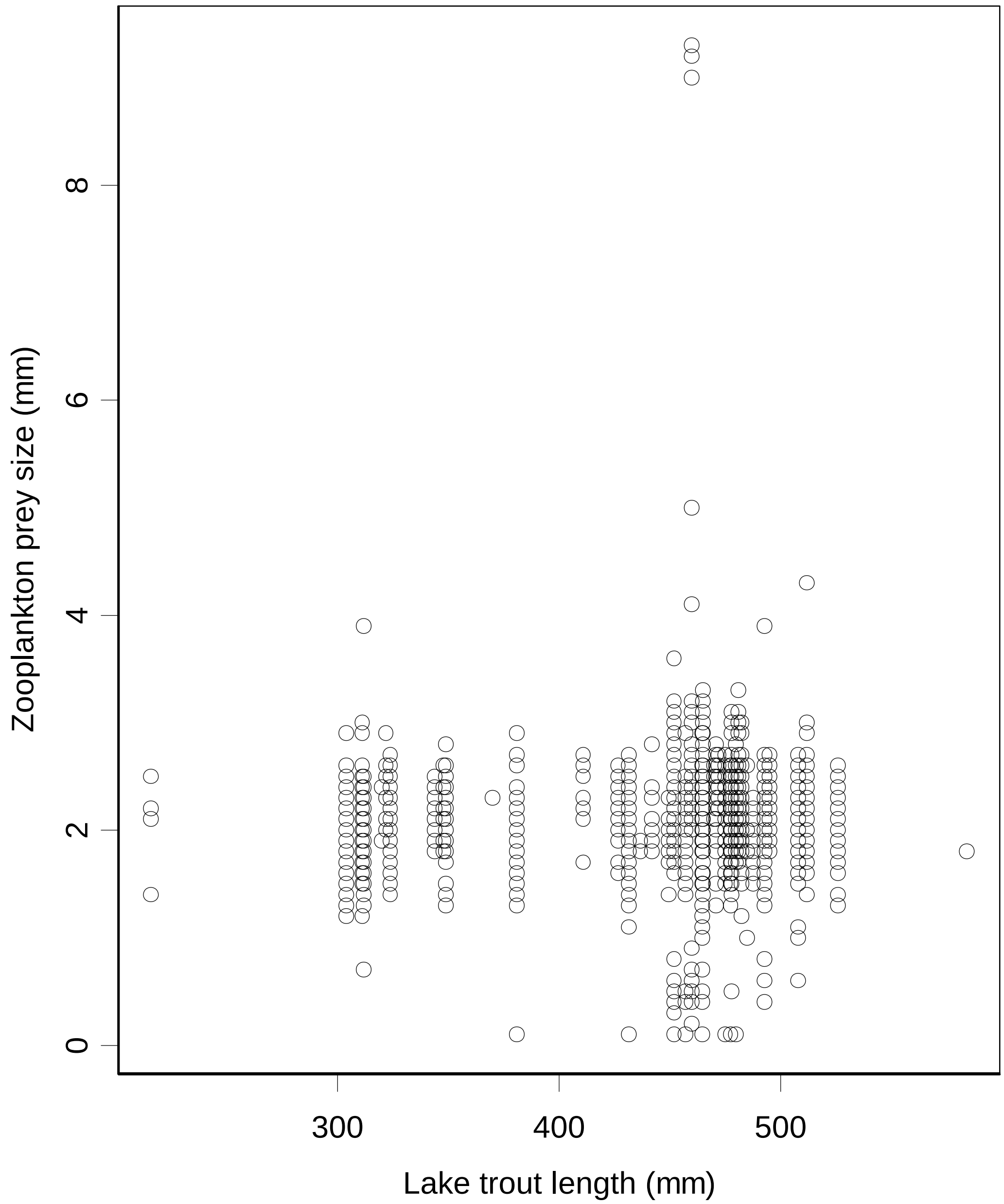

Zooplankton prey size (mm)
0
2
4
6
8
300
400
500
Lake trout length (mm)

Fig 16.