

Zooplankton - Algal Interactions in
Brown and Crampton Lakes
University of Notre Dame
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Brown and Crampton are two lakes with similar characteristics yet overwhelming biological differences. In particular the drastic difference in midsummer algal growth between these two Michigan lakes prompted this research. The zooplankton communities were studied throughout a ten week period. As the phytoplankton developed, the changes that occurred to the microorganisms were noted in each lake independently and in comparison to each other. Observations made of the zooplankton's reaction to their environment were validated by patterns seen in two different population counts taken at one meter increments. Based on pH, chlorophyll, light and dissolved oxygen readings, conclusions were made. Crampton Lake increased in species diversity from June to July. Brown Lake, having a great overflow of phytoplankton decreased in species diversity between the two test periods. Brown Lake showed more total species diversity than the clearer Crampton. In all the population counts, Rotifera outnumbered the other two main categories of species, Crustacea and Cladocera. Any environmental characteristics which affected this group of zooplankton, had a great bearing on the total zooplankton community. Influential characteristics included: physical conditions, (ie: changes in climate, food supply and predation pressure). The data collected from this research was compiled with two other projects dealing with algal and benthic communities in an effort to uncover a feasible reason for the difference in phytoplankton production between Brown and Crampton Lakes. Research proved that Blue-green algae, which made up the massive phytoplankton crop, thrived in the bicarbonate rich hard-waters of Brown whereas it did not flourish in Crampton.

Introduction

Zooplankton consist primarily of small members of the species Crustacea and Rotifera, as well as the larger Cladocera. These plankton feed on suspended organic detritus, each other (those which are carnivorous) and in some cases upon phytoplankton. Zooplankton graze the phytoplankton by two methods: filtration and the raptorial method of actively grasping prey and chewing it. The method of filtering water to remove particulate organic matter is the dominant mode of food collection and ingestion. This filtration rate is measured in volume of water containing food particles filtered per unit time. Filtering rates are found to increase as body lengths and temperatures increase. Conversely, as oxygen levels drop, these rates fall as well. Because of these factors, zooplankton have abilities to select food for consumption. This selectivity leads to many zooplankton - algal interactions.

Previous studies have shown that zooplankton and the phytoplankton upon which they feed in lakes directly affect each other. Berquest (1985) concluded that changes in the zooplankton community structure can dictate distinct changes in the algal community and its primary producers. Respiration and excretion by the zooplankton releases substances back into the dissolved substance pools of the lake. In these areas, the substances are available for uptake again by the phytoplankton. The excretion of ammonia, urea and phosphates is crucial to maintaining substance cycles in the phytoplankton. As Moss states, "It is only by rapid recycling of nitrogen and phosphorous through the zooplankton that dense blooms of blue-green algae can be maintained. The nitrogen and phosphorous compounds would otherwise be lost to the sediments." Berquest further theorizes that the two characteristics which determine an algal's response to zooplankton grazing are size and species composition of the zooplankton. Some alga taxa are unmanageable in size and shape for the zooplankton. For example, filaments can get caught in zooplankton's feeding appendages. These unmanageable taxa increase the cost of zooplankton foraging and reproduction. Other phytoplankton, such as cyanobacteria, produce toxins which reduce zooplankton filtering and reproduction rates. Thus toxin-producing and oversized algae would be less likely to be grazed upon.

A study done by Dini (1989) involved the dominant zooplankton *Daphnia* and explored the organism's genomic potential for diel migratory behavior. Many other zooplankton as well as *Daphnia* display this behavioral characteristic of migrating. During daylight the zooplankton migrate down to darker, safer waters in response to visual predation by fish. At night they ascend when the light intensity is low to feed on the phytoplankton which are

abundant in the upper waters. Dini's theory, called the predation avoidance hypothesis, is a prime example of nocturnal migration. Normally the larger species of the Crustacea and the Cladocera evidence this migratory pattern. Crustacea and Cladocera are further developed and thus able to sense light as the cue of this vertical migration. Two other patterns which are often present are: 1. twilight migration, with two peaks at dawn and dusk, and 2. reverse migration, showing one peak during daylight. In order to test if these patterns are present, 24-hour sampling is necessary. When these migrating zooplankton exist in the waters, influencing both selectivity and rates of grazing, algal size classes are effected differently.

Zooplankton/algal grazing interactions, nutrient status of algae, and vertical migration patterns lead to seasonal patterns in the zooplankton community. This seasonal periodicity of different species may be reflected week to week or month to month. The focus of this research was to identify some of the patterns of zooplankton communities in two Michigan lakes, Brown and Crampton. The lakes are in close proximity to each other and are similar in size. One main difference between the two lakes is that mid-way through the summer Brown becomes glutted with phytoplankton while Crampton remains relatively clear. This striking difference inspired a second focus of this research: to combine evidence of zooplankton patterns with that of other projects dealing with the phytoplankton and the benthic zone in an attempt to discover a plausible solution to the mystery of differential algal growth in two similar lakes.

Materials and Methods

Brown Lake showed a growth in algae from June 7th to June 29th, at which time the lake was totally green. The beginning of this growth was monitored in the first 24-hour test period which occurred on June 9th -10th. Simultaneous observations were made at Crampton and Brown lakes over the 24-hour period. Samples were taken every two hours at the deepest point in each lake: at Brown, over a 4 meter depth and at Crampton, over a 10 meter depth. After anchoring at these deep spots, milk carton buoys were set out so sample location would be consistent. Samples were then taken at every two meters in Crampton and every one meter at Brown. The instrument used to retrieve these samples was a Schindler Trap.

In its first year of use at U.N.D.E.R.C., the Schindler Trap proved to be more accurate than the VanDorn sampler used in previous years. With its

larger size and clear plexiglass, the Schindler reduced shading effects and was less detected by zooplankton. The only modifications on the device were lead weights taped to the bottom trap door opposite the hose and collecting bucket. The lead's purpose was to offset the weight of the hose and bucket which was causing the trap to tilt sideways when lowered. This modification allowed effective performance of the Schindler Trap. Unlike the VanDorn, the trap could be lowered vertically and take much more accurate readings at specific samples since the top and bottom doors slowly closed off a trapful of the specified lake water. Once samples were retrieved, they were placed in marked containers. 10 mL of sugared formalyn was added to preserve the specimen.

During the sampling period, weather conditions and air temperature were also noted. Water temperature and dissolved oxygen was measured at every sample level using an oxygen/temperature probe. Light levels were determined using a light probe and secci dish. pH readings were recorded using a Hach portable pH meter.

Samples were analyzed in the lab using a compound microscope and Sedgewick-Rafter cells which held 1 mL of lake water. Zooplankton were identified and counted. Each sample was measured and the result multiplied by the amount of zooplankton in 1 mL. This was to give a rough idea of the quantity of zooplankton in each test layer. The second sample period occurred one month later on July 11th-12th, soon after the phytoplankton had reached its peak. The same procedures were used. However, one of the collecting buckets' screen had been punctured and the repair caused clogged filtering.

Twice during the algal bloom season, on June 13th and 22nd, water samples were taken from both bottom and surface waters. General chemistry tests for phosphorous, nitrogen and bicarbonate were made using the Hach Water Chemistry Analysis Kit. The specific procedures presented in the instruction booklet were followed.

Using a compass, sonar, trolling motor with battery, and the procedure outlined by Hellenthal's Mapping Procedure (Hellenthal 1991), Brown Lake was scanned. The resulting map was used to compare with that of Crampton's. In addition to Brown, two nearby lakes, Gilbert and an unnamed lake, were mapped to test if accelerated phytoplankton growth was a regional entity. Identical procedures as stated above were used in both cases.

Results

The patterns noted in this experiment were based primarily on species diversity rather than number. Great fluctuations which normally occur in zooplankton population numbers due to short lifespan and rapid turnover would have confused data. In Crampton Lake, the rotifers Keratella cochlearis, Kellicottia longispina and Polyorthra vulgaris were the predominant species in both June and July test periods (fig.1,2). Crustacean species of the calanoids and cyclopods were predominant in June (fig.1) while the rotifer Tricochocerca longiseta and the cladocera Holopedium gibberum dominated in July (fig.2). The remaining zooplankton in the middle range of occurrence showed tremendous difference. While in the first 24-hour test period only two rotifers and one cladocera occurred frequently, in the second period ten species were present: four rotifers, three crustaceans and three cladocera. Thus, in Crampton Lake, all the main groups of zooplankton (Rotifera, Crustacea and Cladocera) increased in diversity. The diversity increased from 12 species in June to 18 species in July.

The primary zooplankton in Brown Lake during both test periods were once again the rotifers K.cochlearis and P.vulgaris as well as young crustacean nauplii (fig.3). Brown's July sample also includes as its dominants the Calanoids, the rotifers Tricochocerca longiseta and Epiphanes brachionus, as well as the cladocera Ceriodaphnia laticaudata. (fig.4). There were many species which fell into the middle-range during both time periods: six rotifers and three crustacea in June, and three rotifers, two crustacea and two cladocera in July. Thus there were more species in the June sample. This was reflected in the more than twofold decrease of rotifers from the first test period (27 species in June) to the second (17 species in July).

Patterns of migration were also evident from the population counts. The number of zooplankton species in Crampton which exhibited a diel nocturnal migration more than tripled from June to the July sampling. Half of these diel migrations were rotifers, including the very dominant K. cochlearis, K. longispina and P. vulgaris (refer to figs 1-4). Evidence of reverse migration was uncommon (found only in two species) and the twilight pattern equally as uncommon (found only in three species). In Brown, the number of species exhibiting any sort of diel migration pattern was nearly the same for both June and July. However the rotifers K.cochlearis, P. vulgaris and the Calanoids which were predominantly nocturnal in June switched to the reversal pattern by July.

Similarities and differences in zooplankton population between the two lakes were also examined. In June, Brown had twice as many species (27) as

Crampton (12). Rotifers were predominant over crustaceans and cladocera in both lakes. Brown had more species of rotifers and Crampton had more species of Crustacea and Cladocera. In July, the number of species in Brown had dwindled down to such an extent that species diversity was about equal (Brown - 17, Crampton - 18) in both lakes. Once again rotifers were predominant in Brown and Crampton over other zooplankton divisions. The types of species present were also nearly identical during the second test period.

Diel migration patterns were investigated in a comparison study between the two lakes. In June, Brown had twice as many species exhibiting nocturnal migration as Crampton. In July, Crampton had more species displaying this pattern. Although actual numbers of populations were not evaluated in the large scale comparison of these two lakes, it was possible to make some conclusions. In June, Brown had three times as many total zooplankton as Crampton and four times as many total zooplankton in July. Thus, the more heavily algae-inhabited lake boasted larger numbers of zooplankton than the clearer lake.

The weather conditions for both 24-hour sampling periods were very similar. Both occurred during a full moon, exhibited sunny days, clear nights and cloudy rainy mornings. The air temperatures ranged from 14 C° to 25 C°, and varied at most from each other by a degree or two. The July sampling occurred during a Chaoboris (midge) emergence. Dissolved oxygen readings were consistent in Brown during both samplings, but increased by 10 units in Crampton's second sample period (fig.5). Brown and Crampton experienced similar dissolved oxygen readings, except for Crampton's increase in July. Secchi dish results indicated a decrease in visibility in Brown by one meter (~2M - ~4M) between June and July(fig.6). Crampton remained consistent at 4M visibility. Most noticeable in the light readings was the great difference in clarity between Crampton's average of 4M and Brown's average of 1.5M.

In the general chemistry tests performed on surface and bottom waters, phosphorous and nitrate levels were identical for both lakes and changed little over the ten weeks. Major differences did occur in the bicarbonate tests: in June Brown had 66mg/L in Comparison to Crampton's 1.6 mg/L. In July Brown had 54.8 mg/L while Crampton had 1.2 mg/L. These results proved Brown to be a hard-water lake.

In the mapping of Crampton (fig.7), we discovered that the deepest part of the lake was 25 feet. A water inlet previously unknown was also spotted. Gilbert Lake (fig. 8), a very phytoplanktonous bog-lake was indicated to be as deep as Crampton. This finding helped disprove any theory that Brown's overflow of algal blooms was simply a result of shallow waters.

Discussion

The zooplankton communities observed in Brown and Crampton Lakes did react in some ways to fluctuations in phytoplankton growth. However, because of movement in swarms, vertical migrations and possibility of food selectivity, zooplankton can coexist abundantly with minimal competition and thus are not directly 'at the mercy' of algal population. Predation contributed to the noted pattern of zooplankton existence. Rotifers dominated over crustaceans and cladocera in both lakes the entire ten week period. Rotifers are preyed upon by larger carnivorous plankters and insect larvae (such as the phantom midge), but are able to reproduce rapidly by parthenogenesis. Through high production, a large quantity of these species can be maintained. Larger zooplankton, such as the Crustacea and Cladocera, are invulnerable to invertebrate predation but readily taken by fish. Their reproduction is not as rapid as the rotifers, and thus they depend on vertical migration to maintain a population. In comparison to Brown, Crampton's surge of these larger species in June indicates that its deeper waters provide more areas for zooplankton to migrate from their fish predators.

One predominant zooplankton-algal interaction which resulted in low numbers of crustaceans and cladocerans in Brown involved the affluence of blue-green algae. This type of algae is known to negatively affect the zooplankton which feed upon it, namely the larger species.

As Moss states, "The blue-green algae have a reputation for being poorly assimilated foods [for Cladocera]... indefinite maintenance of Daphnia populations is not possible on certain blue-green algal species". (Moss 1980). Wetzel further addresses this point in saying, "Circumstantial evidence also suggests that algae releasing toxic organic compounds are selected against by zooplankton, regardless of food size and shape..." This algal toxicity in Brown would not only account for the lack of larger zooplankton compared to Crampton, but would also result in the difference in lake clarity (fig. 7). Since none of this algae could be processed by zooplankton, the phytoplankton population built up, further magnifying the already large number of algae.

Another zooplankton-algal reaction involved the shape of the phytoplankton. Cellular forms of algae are ingested more easily than filamentous forms. In addition, zooplankton filtration rates, growth and survivorship are greater when feeding on these cellular forms. In Brown, where filamentous algae such as Aphantizominon predominated, there was a significant decrease in zooplankton species diversity.

A final interaction evidenced by patterns in the zooplankton population was algal concentration. Regardless of whether algal toxicity had any direct

effect on high concentrations of algal blooms on Brown, the zooplankton were negatively affected. Studies indicate that the rate of zooplankton feeding stabilizes or decreases as food particles (in this case phytoplankton) increase. This was demonstrated in Brown from June to July. As algae concentration increased, species diversity decreased.

On the large scale of this project, the difference in bicarbonate in Brown Lake had significant consequences. It was this bicarbonate which the blue-green algae thrived upon. Thus, this appeared to be the main cause for the differential algal growth between Brown and Crampton Lakes. The maps of Gilbert and the unnamed lake further supported this theory by proving that Gilbert was phytoplankton rich in addition to being as deep as Crampton. Therefore the difference was not merely the result of greater visibility of algae through shallow waters, but a difference in the water itself.

The primary reason for the massive difference in algal growth between Brown and Crampton Lakes was the bicarbonate-rich waters of the former which allowed blue-green algae to thrive.

Since these fragile organisms support the food chain, future research must be done on zooplankton interactions. Observation of a lake's microorganisms and their reaction to environmental stress, both natural and man-made, is an essential way of monitoring our precious resources. In an age where pollution has become a real threat, it is vital that these precious resources be maintained.

Acknowledgement

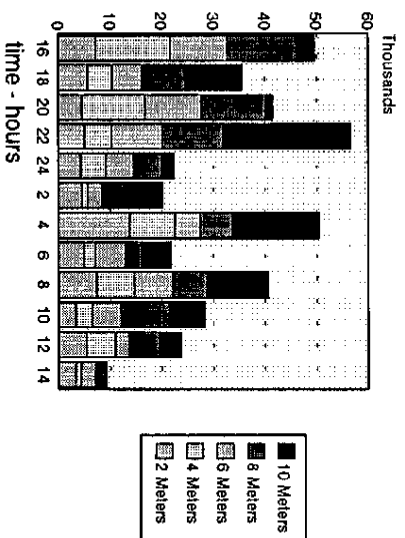
Special thanks to The Bernard J. Hank Family Endowment for their generous funding of this course. Without the Hank Family, this wonderful opportunity would not have been possible. This paper is also dedicated to my advisor, Dr. Ronald Hellenthal for his great help and understanding in my achieving the goals of this project. Much gratitude goes to Dr. Martin Berg for his leadership and constant help over the summer. Thanks also to all the U.N.D.E.R.C. instructors who gave so much of themselves in the effort to enrich our minds with new ideas. To Jean Keaveny and Rich Huftalen, the T.A.'s who helped run the whole program and my fellow U.N.D.E.R.C. classmates who shared this summer (and even a few 24-hour test periods out on a lake) with me, thank you for all of the memories.

References Cited

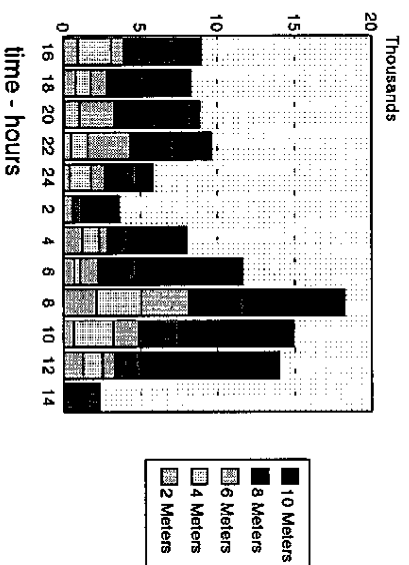
- Berg, M. & A. St. Amad. 1991. Guide to U.N.D.E.R.C.
- Bergquest, A.M. 1985. Effects of herbivory on phytoplankton community composition, size structure, and primary production. Ph.D. Dissertation, Notre Dame.
- Dini, M.L. 1989. The adaptive significance of diel vertical migration in Daphnia. Ph. D. Dissertation, Notre Dame.
- Hellenthal, R.A. 1991. Bios 420: Aquatic Ecology - class project guide.
- Moss, B. 1980. Ecology of Fresh Waters. John Wiley, New York.
- St. Amand, A.L. 1990. Mechanisms controlling metalimnetic communities and the importance of metalimnetic phytoplankton to whole lake primary productivity. Ph. D. Dissertation, Notre Dame.
- Ward, H.B. and G.C. Whipple. 1959. Fresh-water Biology. John Wiley, New York.
- Wetzel, R.G. 1983. Limnology. Saunders, Chicago.

Fig. 1 Dominant Species - Crampton - June

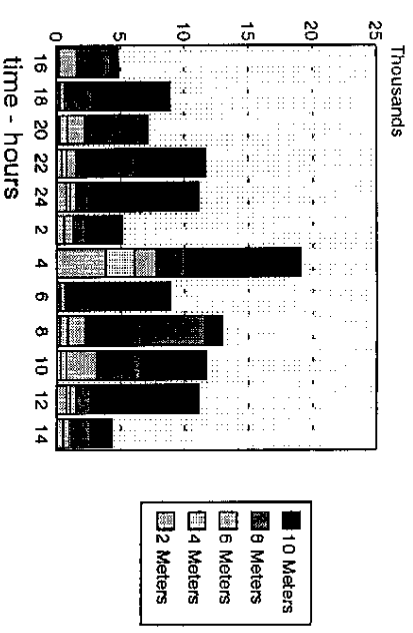
K. cochlearis



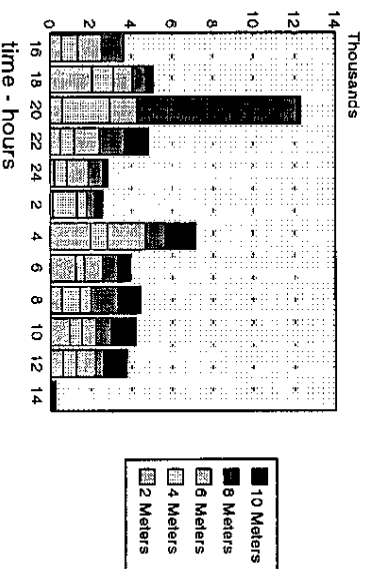
P. vulgaris



K. longispina



Cyclopod



Calanoid

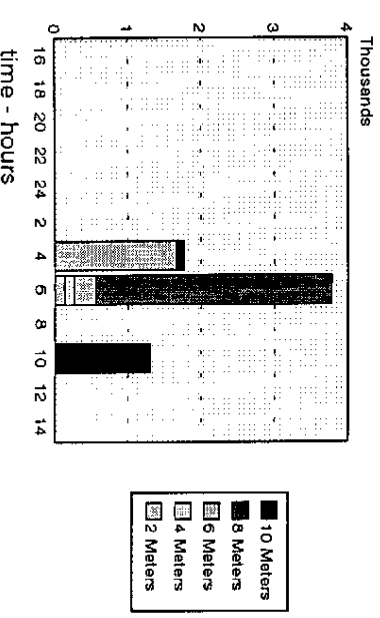
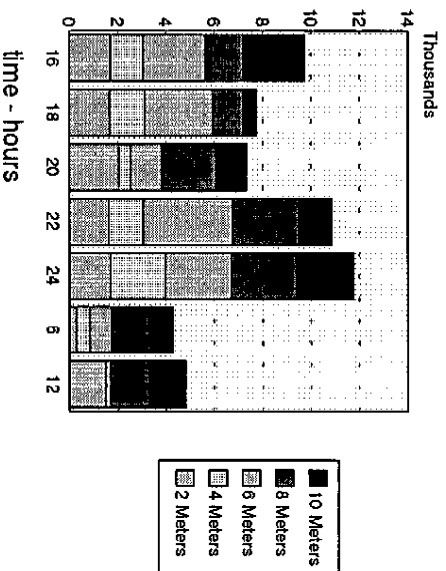
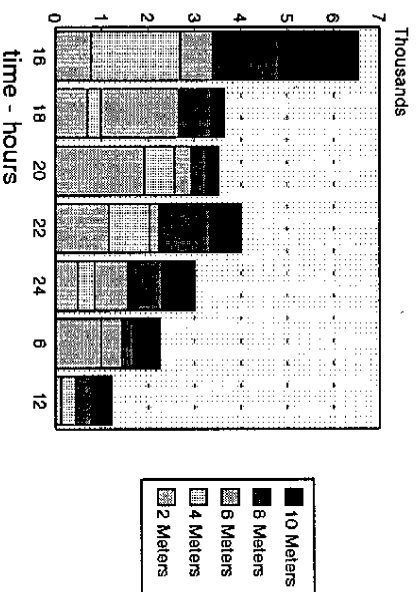


Fig. 2 Dominant Species - Crampton - July

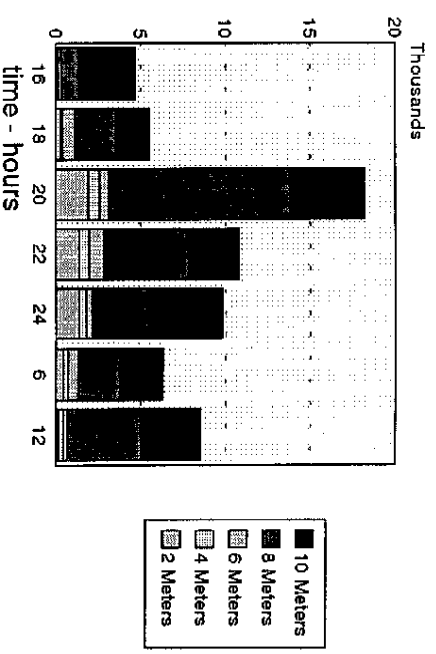
K. cochlearis



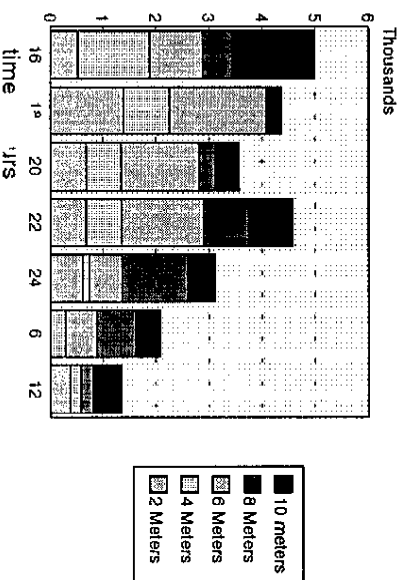
P. vulgaris



K. longispina



T. longiseta



H. gibberium

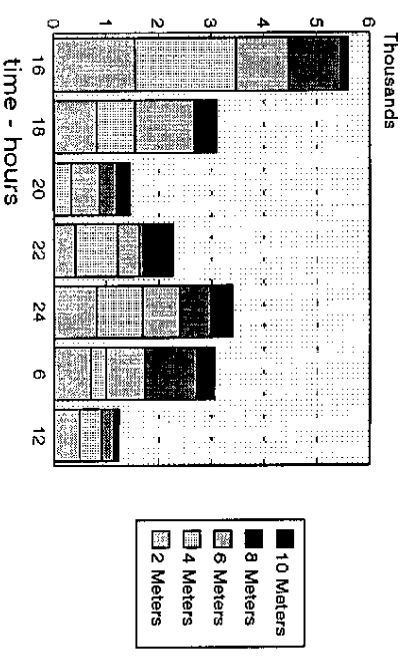
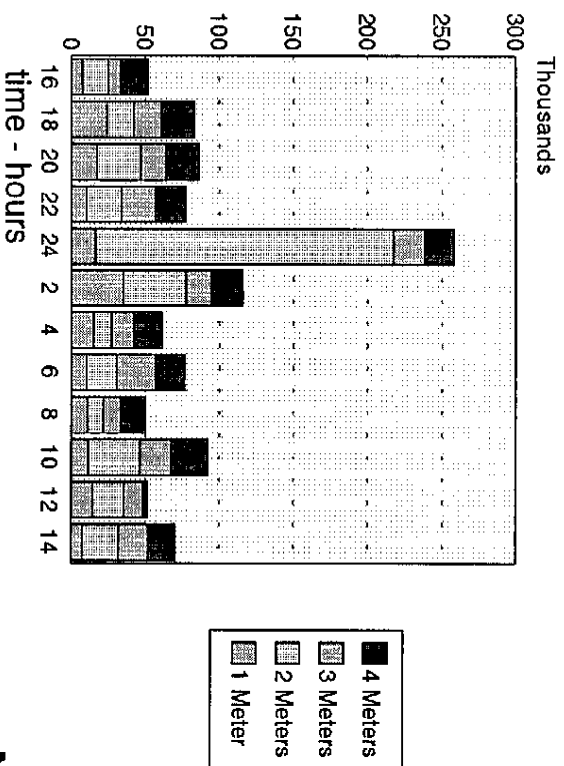
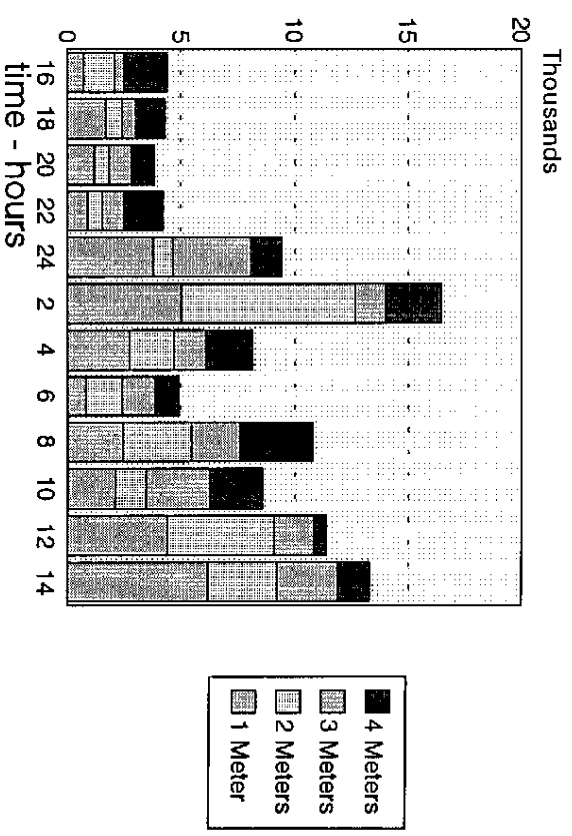


Fig. 3 Dominant Species - Brown - June

K. cochlearis



P. vulgaris



Nauplii

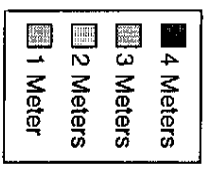
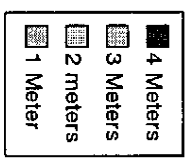
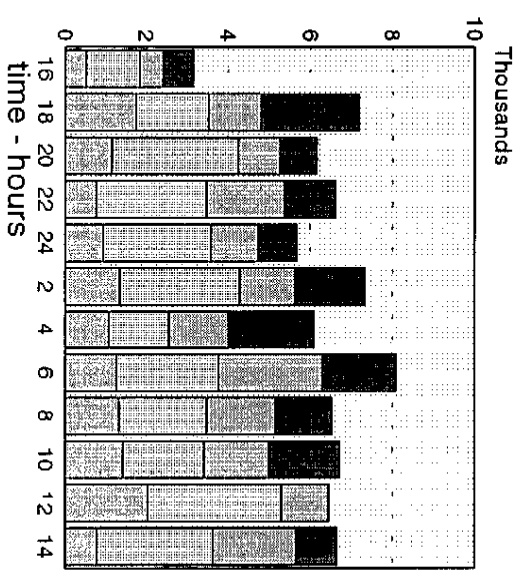
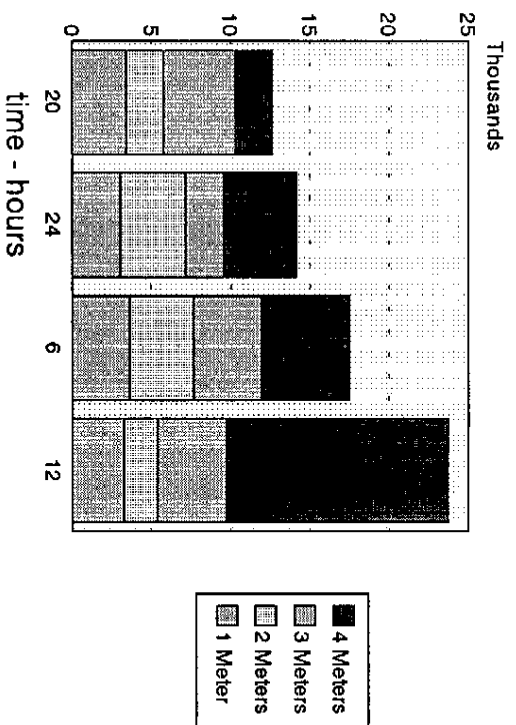
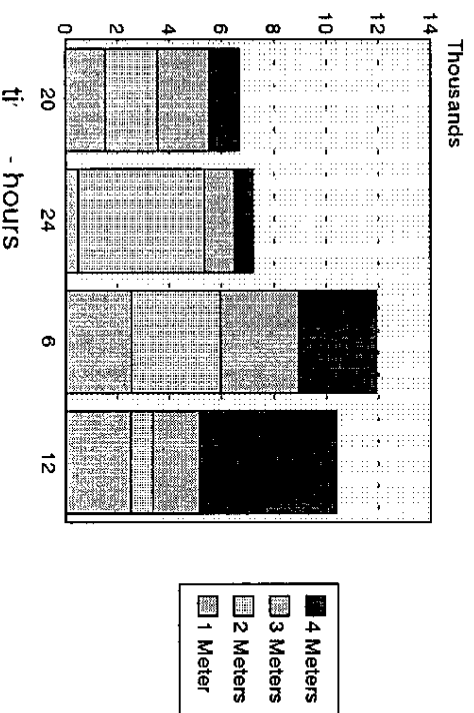


Fig. 4 Dominant Species - Brown - July

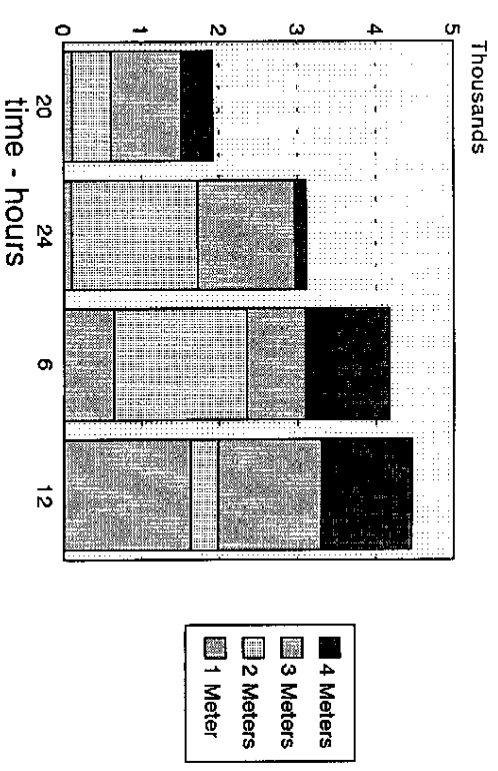
K. cochlearis



Nauplii



P. vulgaris



Calanoid

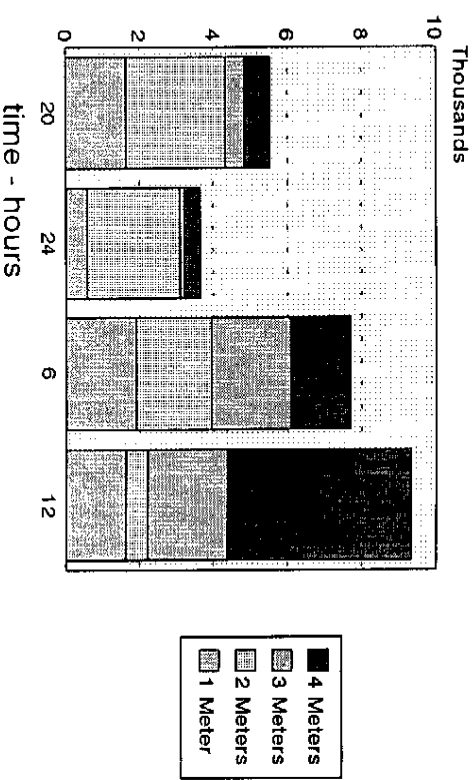
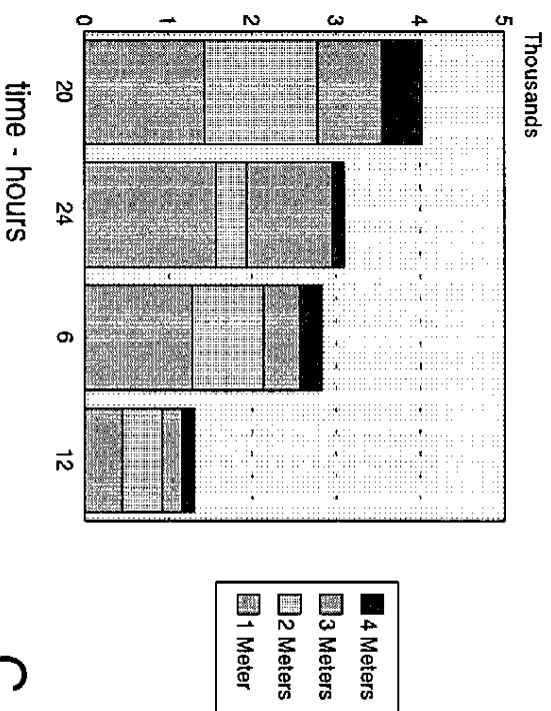
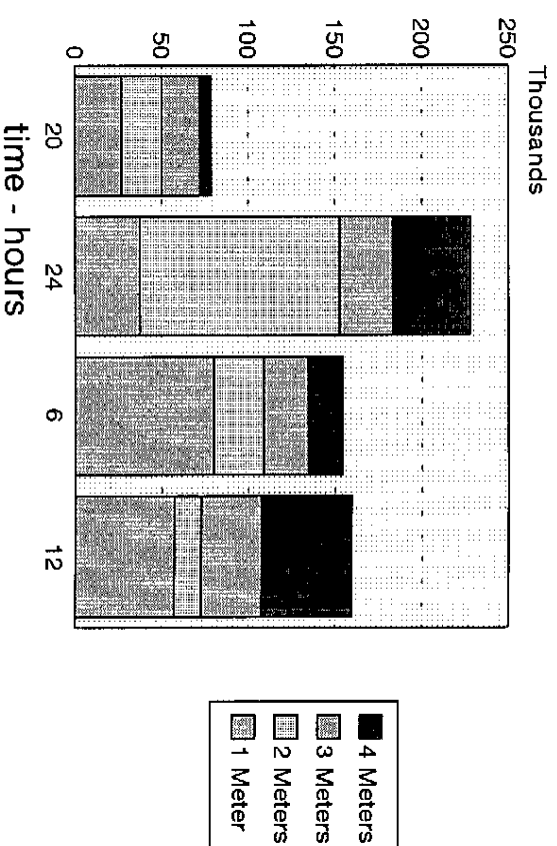


Fig. 4 (cont.)

T. longisetata



E. brachionus



C. laticaudata

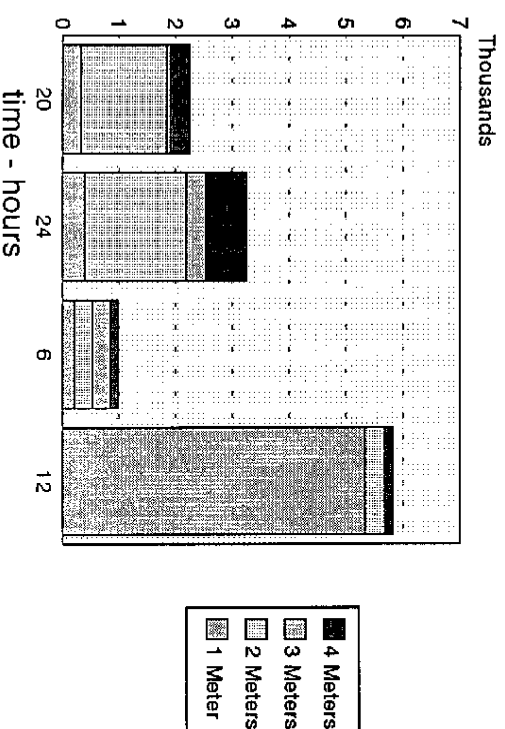
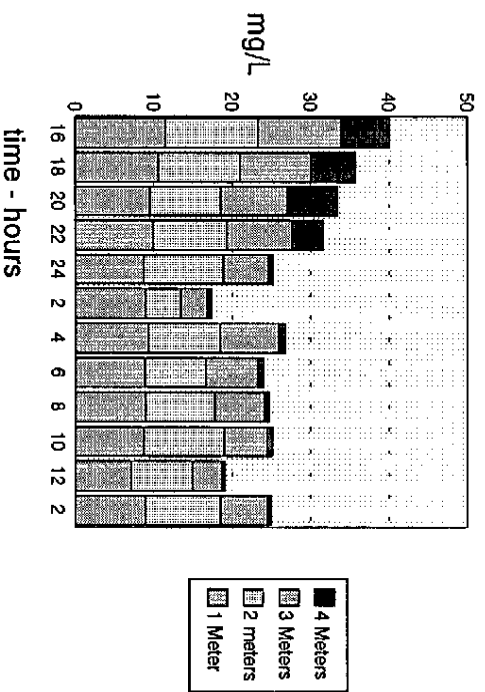
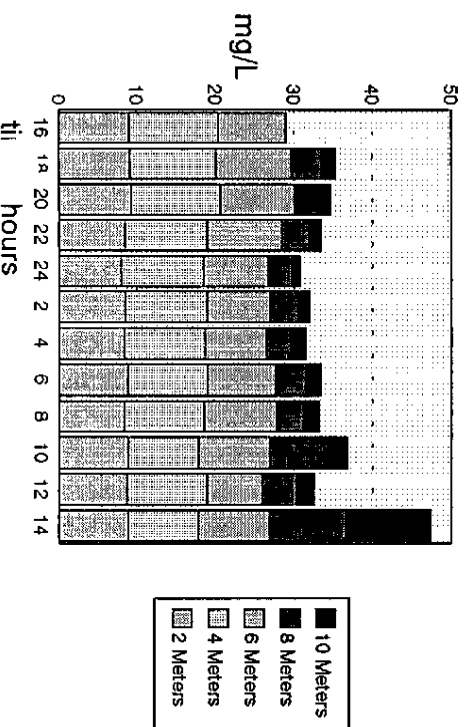


Fig. 5 Dissolved Oxygen Readings

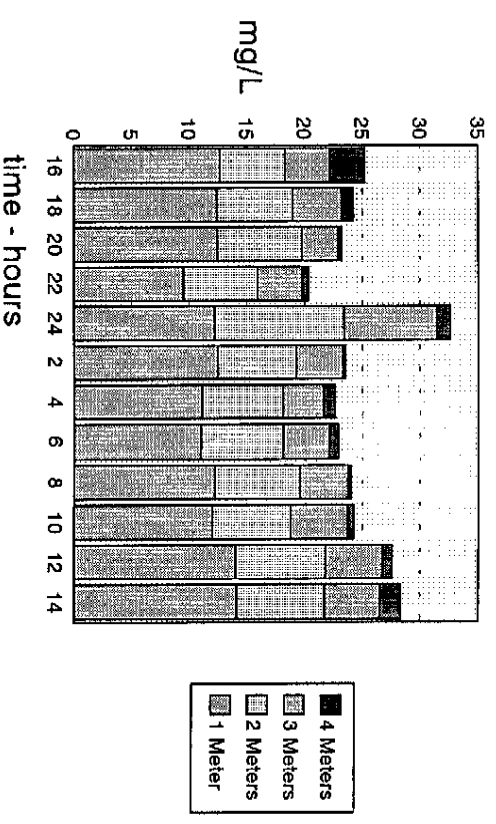
Brown - June



Crampton - June



Brown - July



Crampton - July

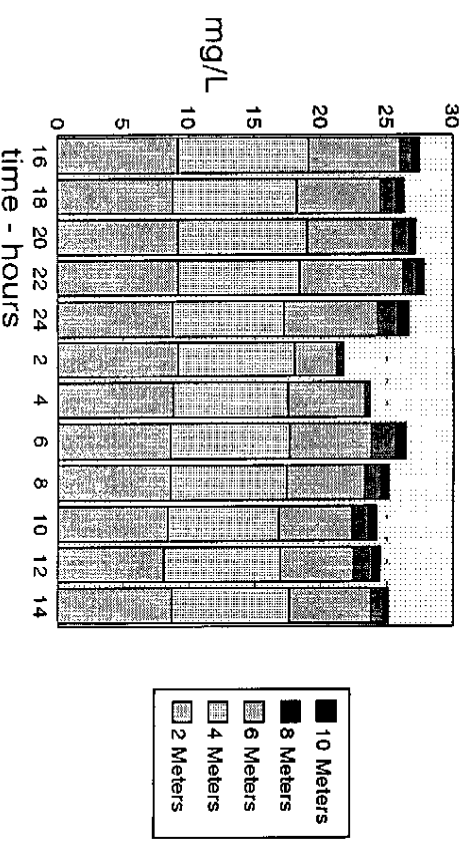
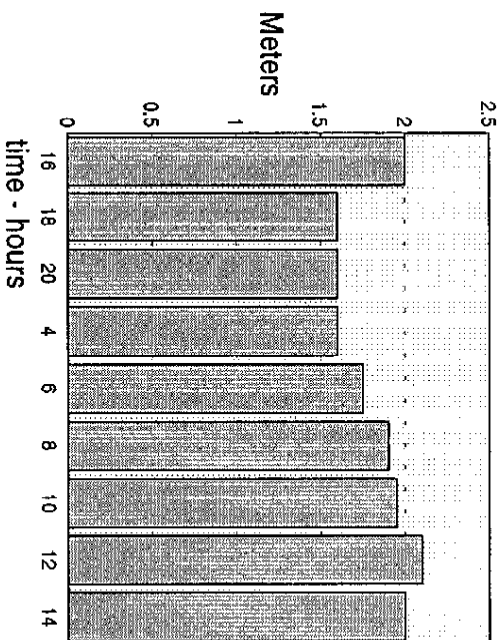
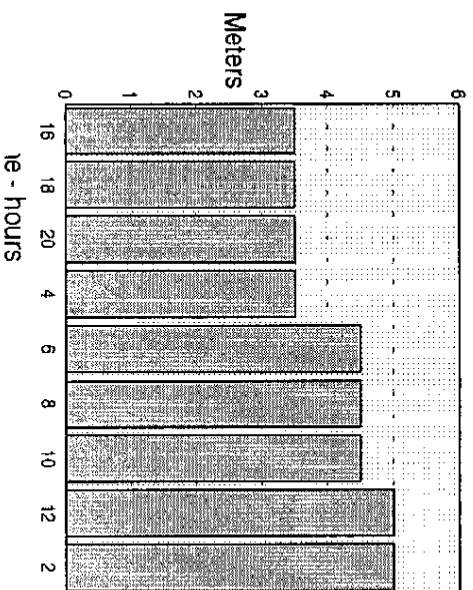


Fig. 6 Seccchi Light Readings

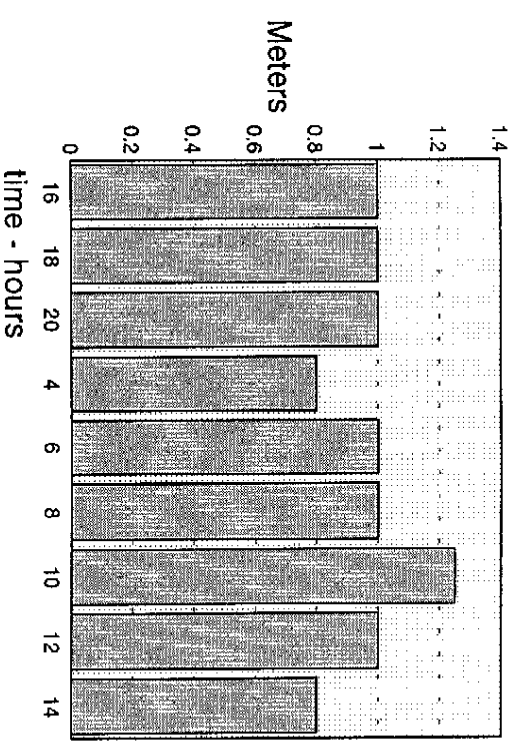
Brown - June



Crampton - June



Brown - July



Crampton - July

