# Progress Report: Lake Chautauqua Fish Production Study, 1997

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## ABSTRACT

In 1997, Wasenza Pool of Lake Chautauqua provided excellent habitat for forage fish production with clupeids being the numerically dominant taxa produced and released into the river. The high production of clupeids did not seem to cause a food-limitation bottleneck for the YOY of later-spawning game fish (centrarchids, white bass), and probably provided valuable food resources for those game fish that grew large enough to switch from zooplanktivory to piscivory. However the size-structure of the zooplankton community likely favored clupeid production over game fish production.

Over 280,000 centrarchids and white bass, and 38,000,000 clupeids were estimated to have been produced and released from Wasenza Pool in 1997. Growth and survival of released centrarchids and white bass may have been limited by their small size as most of them were likely to have still been zooplanktivorous when flushed out of the lake. Clupeids, on the other hand, were not likely to be food limited after being flushed into the Illinois River as most were large enough to switch to omnivory when Wasenza Pool was drained. Two invasive fish species (grass carp, bighead carp) and one invasive cladoceran species (*Daphnia lumholtzi*) were also collected from Wasenza Pool in 1997.

Probably the most important management recommendation from this year's study is to delay drainage of Wasenza Pool until a greater proportion of centrarchids and white bass have grown large enough to switch to piscivory and thus take advantage of the high forage fish production. Emergent willow stands in Wasenza Pool seemed neither beneficial nor detrimental to larval fish production, and the results of this study alone do not justify the time and expense necessary to eradicate the willow stands for fisheries management. Suggestions for future studies include development of management strategies to suppress production of exotic species in managed floodplain lakes, and examination of effects of a wide range in flood regimes on fish and zooplankton production.

## INTRODUCTION

Moist soil management units usually are manipulated to maximize benefits for migratory waterfowl. However, if prudently managed, it appears some of these same units may be used for production of larval fish (Irons et al. 1997). Lake Chautauqua (a floodplain lake of the Illinois River) is currently divided into two pools: Kikunessa and Wasenza. Wasenza Pool is managed primarily as a moist soil unit for the benefit of waterfowl and shorebirds. This pool is typically flooded from fall to early summer and the sediments are compacted by annual dewatering in summer and fall. In 1996, up to 27 million fish, represented by 34 taxa, were produced and escaped from Wasenza Pool (Irons et al 1997), demonstrating it may provide valuable spawning and nursery habitat for fishes.

In assessing the suitability of moist soil units for fish production, it is important to examine factors such as food availability and competition among species, as well as documenting taxonomic diversity and numbers of fish produced and released in a given year. Because larval stages of most freshwater fish species are zooplanktivorous, year-class strength of many species can be strongly dependent on the availability of edible zooplankton. Previous studies from systems (mainly Midwestern reservoirs) into which gizzard shad have been stocked as forage for piscivores have shown that high densities of young-of-year (YOY) gizzard shad can severely deplete zooplankton resources to the point where YOY of later-spawning taxa such as centrarchids are severely limited by food availability (Dettmers and Stein 1992, Dettmers and Stein 1996, Stein et al. 1995). The strength of this interspecific competition in the larval and juvenile stages may vary greatly among aquatic systems (Welker et al. 1994). In the Illinois River and associated floodplain lakes, gizzard shad are an indigenous member of the fish community. Many floodplain lakes such as Lake Chautauqua are now leveed off from the mainstem river and water levels are managed artificially, although periodic flooding events cause the lake to temporarily revert back to a more "natural" system. In assessing the role of semi-natural floodplain lakes as fish nurseries, it is important to determine whether interactions similar to those described in reservoirs occur between fish species in the larval/juvenile stage and to what extent these interactions are affected by seasonal flooding and/or various management strategies (water level management, timing of draining, etc).

The 1997 Wasenza Pool fish production study was designed to continue and expand upon the work begun by Irons et al.(1997). Study goals were as follows:

1) Document the various fish taxa utilizing Wasenza Pool as spawning habitat, and the approximate timing of spawning for dominant taxa.

2) Estimate number of young-of-year (YOY) fish produced and released from Wasenza Pool in 1997.

3) Assess the food resources available to zooplanktivorous YOY fish by examining zooplankton abundance and community structure.

4) Determine whether zooplanktivory by YOY clupeids resulted in a food-limitation bottleneck for YOY centrarchids.

5) Determine the effect of various management strategies involving the filling and draining of Wasenza Pool, water level management, and vegetation control (i.e. emergent willow stands) on YOY fish production.

## METHODS

### Adult Fish Sampling

In order to assess taxonomic diversity of potential brood stock, adult fish were collected using multiple gears from mid April to late May in 1997. Adult fish sampling consisted of 9 electrofishing runs (15 min each), 16 fyke net sets (24 hours each) at shoreline sites, and 4 tandem fyke net sets (24 hours each) at offshore sites. The pulsed-DC electrofishing rig, fyke nets, and tandem fyke nets we used were the same gears and methods used during Long Term Resource Monitoring Program (LTRMP) sampling and are described in detail by Gutreuter et al. (1995). All fish collected during adult fish sampling were identified to species, enumerated, and measured. Naming conventions, both common and scientific, for fish follow the American Fisheries Society (1991) and are listed in Table 1.

## Random Site Sampling

Sampling of water quality, zooplankton, and YOY fish was conducted at sites selected at random from a geographic information system (GIS) coverage of the pool. Sites were stratified by nearshore (within 50 m of shore) and offshore (greater than 50 m from shore) habitats. Random site sampling was conducted from April 17 - July 3, 1997.

Water Quality: We monitored temperature ($^oC$), dissolved oxygen (mg/L), and nephelometric turbidity (NTU) twice a week, at five nearshore and five offshore random sites throughout the study. Temperature and DO (dissolved oxygen) were measured 0.25 m below the surface using either a YSI model 57 or 55 oxygen meter. Turbidity of water samples collected just below the surface was measured by means of a Hach turbidometer.

Larval Fish Sampling: We collected larval fish twice per week from Wasenza Pool using light traps and ichthyoplankton nets. Light traps followed the design of Kilgore and Morgan (1993) and were the same traps used in the previous year's study (Irons et al 1997). Light traps were deployed for approximately 12 hours each, beginning at sunset, at five nearshore and five offshore random sites twice per week. In addition, we towed paired ichthyoplankton nets (500 $\mu$m mesh) just under the surface for 10 min at three nearshore and three offshore random sites twice per week. Initially, we used the same nets as Irons et al (1997) (0.5 m diameter, 2.0 m long). However, due to lower water levels in 1997 than in 1996 we began using smaller, rectangular nets (12"X18" frame, 1.0 m long) to avoid digging the nets into the sediments. Upon collection, larval fish were anesthetized with alka-seltzer to prevent regurgitation of gut contents and immediately preserved using either alcohol or 10% buffered sugar formalin. To estimate the volume of water sampled we used General Oceanics digital flowmeters (Model 2030, General Oceanics, Inc., Miami, FL) mounted in the center of each net. The volume of water sampled by each net was calculated using the following formula:

$$\text{Volume } (m^3) = A*(2.687*r*0.01)$$

Where A = area of net opening in $m^2$
2.687 = constant from flowmeter

r = number of revolutions from flowmeter
0.01 = conversion factor to $m^3$

The total number of fish caught in both nets (left and right) was divided by the total volume of water sampled by both nets to yield an estimate of the number of fish / $m^3$ sampled. In the laboratory, larval fish were viewed under 1x to 4x magnification and identified to family, genus, and species as practical using keys by Auer (1982), Hogue et al. (1976), and May and Gasaway (1967). Cross polarized lighting was used to count myomeres. Fish lengths (total length) were measured using a video imaging system and Optimas image analysis software.

Standing stock estimates were calculated from plankton tow samples. Total catch/volume sampled (fish/$m^3$) of larval fish for both shoreline and offshore habitats was multiplied by the estimated volume of the respective habitat type (shoreline and offshore). At a water surface elevation of 435 ft, volume of nearshore and offshore habitat were estimated to be 542,000 and 7,600,000 $m^3$ respectively (pers. comm., Jim Rogala, NBS-EMTC, data from GIS coverage). On each sampling date, volume of shoreline and offshore habitat was calculated by multiplying the depth of the water column above elevation 435 by the area of each habitat type (shoreline=$8.6 \times 10^5$ $m^2$, offshore=$8.684 \times 10^6$ $m^2$), and adding this volume to the baseline volume at elevation 435.

Zooplankton Sampling: Zooplankton were collected by means of a hand-operated diaphragm pump. The suction hose was attached 0.25 m from the bottom of a wooden pole which was constantly raised and lowered during collection to sample the entire water column. One 30- L sample was collected during each 10 minute ichthyoplankton tow (10 L / 3 min). Thus, approximately the same area sampled for larval fish was simultaneously sampled for zooplankton. Water was pumped through 55-$\mu$m mesh to retain zooplankton. Zooplankton were rinsed into a collection vial, anesthetized with alka-seltzer to reduce egg loss, and preserved with 10% buffered sugar formalin. Zooplankton were identified and enumerated using an imaging and analysis system and Optimus software. Copepods were identified as either Cyclopoid or Calanoid, but both taxa were lumped together for this report. Nauplius larvae were not divided into Cyclopoid or Calanoid taxa and are reported simply as nauplius larvae. Cladocerans were identified to genus and species where possible using Hebert (1995) and Pennak (1978). *Leptodora*, *Daphnia lumholtzi*, *D. retrocurva*, *Ceriodaphnia*, *Chydorus*, *Moina*, and various male *Daphnia* were present only sporadically, in low numbers, and not included in data analysis. Cladoceran species included in data analysis were *Daphnia galeata*, *D. parvula*, *D. pulex*, *D. ambigua*, and *Bosmina longirostris*. Rotifers were not enumerated or identified in this study as the smallest body dimension of many taxa was less than the mesh size employed in the zooplankton concentrators. For each sample, 5-ml subsamples were examined until at least 100 individuals of the most common taxa had been enumerated or organisms in 60% of the sample had been counted. For cladocerans, total lengths and egg counts were obtained for at least 50 individuals of common taxa and at least 25 individuals of rarer taxa per sample. Biomass was estimated using the regressions of Culver et al (1985) and Dumont et al (1975) and Rosen (1981). Biomass of nauplius larvae was estimated using the regressions of Culver et al (1985).

## Fixed-Site Intensive Sampling

In addition to the random site collections, we collected YOY fish and zooplankton from two fixed sites during four 24-hr periods to examine diel patterns in abundance. Samples were collected every 3 hrs and preserved in the same manner as the random site samples except that zooplankton samples were collected from 60-L (rather than 30-L) of lake water. Fixed site A (enclosed site) was surrounded by dense beds of emergent willow trees. Fixed site B (open site) was an offshore site with no emergent vegetation.

## Escapement Sampling

The control structure at Wasenza Pool consists of four gates approximately 1.5 m wide. We began collecting fish escaping from the Wasenza Pool via the south control structure on June 6. However, escapement sampling was halted as water levels began to rise and water began to flow back into Wasenza Pool. We resumed escapement sampling on June 23 as water levels receded below levee height and water left the pool only through the south control structure. We sampled fish exiting the control structure on 10 of the 13 days from June 23 - July 5 using a small mesh hoop net (standard LTRMP hoop net [1.2 m diameter] lined with 3-mm "Ace"-type nylon netting) and an ichthyoplankton net (500-µm mesh, described in Irons et al 1997). Nets were set in the effluent for 1 to 15 minutes; 1 minute when flows and fish catches were high and up to 15 minutes when flows and catches were low. Generally we conducted 4-5 hoop net and ichthyoplankton net collections on each sampling date.

All fish collected by the ichthyoplankton net were identified and measured in the same manner as those collected at the random sites. Hoop net catches often contained larval fish that had been retained by the net but could obviously fit through the mesh. These numbers were documented, but not used in hoop net escapement summaries because we did not know how many fish in these small size-classes had gone through the hoop nets. Only those fish which were too large to easily fit through the 3 mm mesh were used for hoop net escapement estimates.

Flow meters were used to determine the amount of water sampled by each net. Estimates of the total numbers of fish escaping from Wasenza Pool were calculated separately for small-mesh hoop nets and plankton nets. Using the difference in gauge heights between successive sampling dates, we calculated the volume of water drained from Wasenza Pool using volume data obtained from Jim Rogala (NBS-EMTC, data from GIS coverage; described in previous section). Fish collections (#/$m^3$) on two consecutive dates were averaged and multiplied by the volume of water drained between the dates to obtain an estimate of fish escapement. Fish escapement data from June 23 was not used as no discernable difference in gauge height was detected between June 23 and June 24. Escapement data from the June 6 date was also not used because this collection represented only one date and was much earlier than subsequent escapement collections. Fish escapement data presented in this paper was collected from June 24-July 5 during which time gauge height readings declined steadily. During this period we estimated 42% of the volume of Wasenza pool drained through the control structure.

## RESULTS

### Habitat

Vegetation: Aquatic macrophytes were extremely rare or absent in Wasenza Pool in 1997. However, some sections of the pool were characterized by stands of emergent vegetation, primarily willows. Sites with emergent vegetation are referred to as vegetated sites in this report, while sites without emergent vegetation are referred to as open.

Depth: Water levels were much lower in 1997 as compared with 1996, reaching flood stage only for a short time in June (Fig. 1). During this time, most of the levees surrounding Wasenza pool remained above water although some portions of the south levee were submerged. Average depth of shoreline and offshore sites remained fairly steady from the end of April to mid-June and then increased slightly before falling again in July (Fig. 2). Significant differences in depth were found between shoreline and offshore sites during the duration of the study (paired T-test, $p<0.05$). However, this difference was small (0.22 m). Mean depth of shoreline sites was 1.3 m whereas mean depth of offshore sites was 1.5 m.

Water Quality: Water temperature increased from 10° C in mid April to 30° C in late June and subsequently decreased to 25°C at the end of the study in early July. Fluctuations within a 24 hour period increased over time with fluctuations of less than 1 ° C / 24 hr recorded in late May, but fluctuations of nearly 5° C / 24 hr recorded by late June (Fig. 3).

Dissolved oxygen (DO) measurements taken in the afternoon (random site samples) fluctuated between 7 and 16 mg/L during the study. Fluctuations within a 24 hr period increased over time with DO ranging from approximately 6 mg/L to 10 mg/L in late May; and ranging from approximately 6 mg/L to nearly 20 mg/L by late June (Fig. 4).

Nephelometric turbidity ranged from approximately 25 to 200 ntu during the course of the study. Turbidities were highest in early May, but subsequently declined by late May to below 100 ntu for the remainder of the study (Fig. 5).

## Adult Fish

We collected 2,036 adult fish, represented by 42 total taxa (3 hybrids), using electrofishing gear and fyke nets. White bass (21%), river carpsucker (16.7%), shortnose gar (14.8%), common carp (9.3%), gizzard shad (7.5%), and freshwater drum (5.3%) accounted for 74.6% of the catch. Less abundant game fish species collected during adult fish sampling included black crappie, white crappie, bluegill, green sunfish, orangespotted sunfish, sauger, largemouth bass, yellow bass, walleye, channel catfish, and northern pike (Table 1).

## Random Site Collections

Taxonomic diversity and habitat preference: In 1997, light traps and plankton nets combined collected YOY fish from eight families. Within these families, we were able to identify eight genera, and six species. We set 115 light traps (63 nearshore, 52 offshore) and collected a total of 437 fish. Clupeids were most abundant (48%), followed by cyprinids (21%). Twenty-nine percent (126 fish) of the catch could not be identified to family due to sample decomposition, but this group was represented primarily by the catch of one light trap (100 fish) (Table 1). Overall, more larval fish were captured by nearshore than offshore light traps (Kruskal Wallis, $p<0.05$), but no difference was found between clear and vegetated sites (Kruskal Wallis, $p>0.05$). Clupeid capture rates did not vary significantly between nearshore and offshore sites (Kruskal Wallis, $p>0.05$) or between clear and vegetated sites (Kruskal Wallis, $p>0.05$). Cyprinids were more common at nearshore than offshore sites (Kruskal Wallis, $p<0.05$), but no difference was found between clear and vegetated sites (Kruskal Wallis, $p>0.05$).

Ichthyoplankton tows indicated the larval fish community of Wasenza Pool was dominated by Clupeidae (91%) followed by Cyprinidae (3.4%), Catostomidae (0.9%) and Centrarchidae (0.7%) (Table 1). Overall, larval fish were more abundant (#/$m^3$) at clear vs vegetated sites (Kruskal Wallis, $p<0.05$), but abundances were not significantly different between shoreline and offshore sites (Kruskal Wallis, $p>0.05$). Within the dominant taxa, clupeids were more abundant at clear vs vegetated sites (Kruskal Wallis, $p<0.05$). No significant difference in abundance between clear and vegetated sites were found for cyprinids, catostomids or centrarchids (Kruskal Wallis, $p>0.05$). No significant difference in abundance between shoreline and offshore sites was found for any of the dominant taxa (Kruskal Wallis, $p>0.05$) (Figs. 6,7).

Spawning and Growth: Abundance and size-distribution data from random site collections (ichthyoplankton tows) suggest clupeids spawned in mid-May and again in mid-June with peak abundances occurring in June (Fig. 8). Mean length of clupeid larvae increased from approximately 5 mm at time of first collection to approximately 20 mm when Wasenza Pool was drained (Fig. 8, Table 2). Cyprinids likely spawned most heavily in May, with larvae exhibiting no detectable growth patterns during the study (Fig. 8, Table 2). The lack of a strong growth pattern amongst the cyprinids may have been due to different spawning or growth rates among the multiple species (Table 1) found within the family. Catostomids likely spawned in mid May but subsequently were found only in low numbers, making assessment of growth patterns difficult (Fig. 8, Tables 1,2). Centrarchids probably did not begin spawning until early to mid-June. Mean length of centrarchids collected from random sites increased from approximately 5 mm to approximately 10 mm by the end of the study (Fig. 8, Table 2).

## Zooplankton production

*Daphnia spp.* abundance and biomass in offshore, open sites followed nearly the same pattern as clupeid abundance with a major peak in mid-June followed by precipitous decline (Fig. 9). Conversely, abundance and biomass of *Bosmina longirostris* began to increase dramatically during the period of peak clupeid abundance and continued to climb as clupeid and daphnid abundances declined (Fig. 10). The high abundance of *Bosmina longirostris* buffered the decline in *Daphnia* biomass resulting in a leveling off of overall cladoceran biomass in late June (Fig. 11).

Unlike the cladocerans, copepods (and to a lesser extent their nauplius larvae) exhibited abundance patterns which tended to mirror that of the clupeids (Figs. 12, 13). As clupeid numbers rose, copepod numbers fell, and as clupeid numbers decreased, copepod numbers increased or at least stopped declining.

## Fixed-Site Intensive Sampling

Ichthyoplankton tows during 24-hr sampling collected YOY fish from nine families. Within these families, we were able to identify ten genera and seven species. Clupeidae were the most abundant (97.4%) followed by Cyprinidae (2.1%). The remaining seven families represented <1% of the catch.

In order examine diel patterns in abundance, we divided each abundance estimate by the maximum abundance within it's respective diel sample. For example, during the June 11-12 diel sampling (enclosed site), the clupeid abundance at 14:00 hrs (June 11) was 1.2/L. The maximum clupeid abundance during that same sampling set was 6.5/L at 5:05 on June 12. Dividing 1.2 by 6.5 yields an abundance ratio of 0.18 for 14:00 hrs. The abundance ratio at 5:05 would, of course, be 1. Clupeid abundances were slightly higher near dusk and dawn at the open site (Fig. 14). No diel pattern in abundance was evident at the enclosed site. Cyprinids were more abundant during the nighttime hours at both the open and enclosed sites (Fig. 14).

## Escapement Sampling

Seventeen species from 10 families were identified during escapement sampling

(Table 1). Size-distributions of fish captured by ichthyoplankton nets as opposed to hoop nets showed little overlap for all taxa except for the cyprinids. Ichthyoplankton nets primarily captured larval and early juvenile stages whereas hoop net data were primarily from juvenile YOY (Figs. 15, 16). Clupeids were the dominant (71.0 - 78.2%) larval and juvenile fish taxa flushed from the pool, followed by cyprinids (27 - 20.7%) (Table 1). Among the cyprinids, we found two recently established exotic species; grass carp and bighead carp (note: bighead carp identification is provisional). Based on outflow volumes and the number of YOY grass carp (48) and bighead carp (2) captured, we estimated over 60,000 YOY grass carp and 955 bighead carp were produced and released from Wasenza Pool (Table 1). Commercially important species such as buffalo and common carp represented <1.0% of YOY fish released with and estimated >15,000 buffalo and >6,000 common carp produced and released in 1997. Production of buffalo may have been much higher, but most of the YOY catostomids captured by ichthyoplankton net could not be identified beyond the family level (Table 1). Game fish species represented approximately 1% of YOY fish released from Wasenza Pool in 1997 with over 80,000 white bass, and 170,000 centrarchids (largemouth bass and other sunfish) estimated to have been produced and released in 1997 (Table 1). It is difficult to estimate the total number of fish escaping from Wasenza pool because different species may be attracted or repelled by moving water and escapement may not be uniform over time (Figs. 17,18). This paper estimates escapement only during the draining of the first 42% of Wasenza pool from June 24 through July 5. Total escapement may be more than double the numbers presented in this section.

## DISCUSSION

Larval Fish Habitat Preferences: Previous studies of habitat preference have shown that catch rates of larval and juvenile fish vary strongly between vegetated and open (non-vegetated) sites. Larval centrarchids tend to be more abundant at vegetated sites whereas clupeids and cyprinids tend to dominate catches at open sites (Dewey and Jennings 1992). Vegetation richness (number of plant taxa present) seems to affect fish community structure more strongly than vegetation biomass (Dewey and Jennings 1992, Eadie and Keast 1984). In this study, ichthyoplankton tow data indicated that clupeids preferred open sites to vegetated sites, but no difference was detected in light trap catches. No habitat preference (with regard to vegetation) was found for centrarchids, cyprinids, or catostomids in either light trap or plankton tow catches. The lack of habitat preference by most of the dominant Wasenza pool taxa in 1997 may have been due to the lack of plant diversity. Vegetated sites were dominated by emergent stands of willows with a few sites also containing beds of *Polygynum.* No beds of submersed aquatic macrophytes were observed in this study. The large stands of emergent willows in Wasenza Pool in 1997 seemed to have little effect on most larval fish abundance patterns. However, although light traps could be placed within thick willow beds, ichthyoplankton tows could only be conducted near the edges of these willow beds where the willows were more sparse. It is possible that results would have been different if we could have conducted ichthyoplankton tows through the thicker patches of willow.

In 1996, Irons et al. (1997) found that catches (light trap and plankton tow) of larval fish were much higher in shoreline as opposed to offshore habitats, but suggested that this difference may be reduced in low water years. In 1997, light traps placed in shoreline sites caught more cyprinids than those placed in offshore sites, but no difference was found for the other dominant taxa. Plankton tow data did not indicate a preference for shoreline or offshore habitat for any of the taxa collected. The strong differences between shoreline and offshore catches in 1996, and the lack of differences (except for cyprinid light trap catches) in 1997 was likely due to differences in water regime (Fig. 1). In 1997, water levels in Wasenza pool were lower (1-2 m) than in 1996 (3-4 m) with little difference in depth found between nearshore and offshore sites in 1997. Differences in larval fish abundance between nearshore and offshore sites may be regulated primarily by depth and negligible in years such as 1997 when low water levels result in relatively uniform depths between the two habitat types.

Larval Fish Production: In 1997, the family Clupeidae (represented by gizzard shad, threadfin shad, and skipjack herring) overwhelmingly dominated both random site and escapement catches. In 1996, despite a much different water regime, clupeids also dominated the larval fish catch from random site catches (87% ) and, too a lesser extent, escapement (55%) (Irons et al. 1997). In terms of numeric dominance, Wasenza Pool produced more forage fish than "desirable" sport fish such as centrarchids and white bass, or commercially harvested species such as buffalo and common carp (Table 1).

High production of forage fishes can be both detrimental and favorable to sport fish growth and survivorship. Initially, high numbers of early spawning forage fish (such as clupeids) may reduce the availability of food resources (zooplankton) for later spawning game fish species such as centrarchids (Stein et al. 1995). However, once this bottleneck is passed, and YOY game fish switch from zooplanktivory to piscivory, a large forage base is highly beneficial to game fish growth and survival. In 1997, over 170,00 centrarchids and 80,000 YOY white bass were produced and released into the Illinois River along with over 49 million forage fish (clupeids and small cyprinids).

Zooplankton/Clupeid Interactions: It is unlikely that zooplanktivory by clupeids strongly limited cladoceran production in 1997. Overall cladoceran biomass increased until mid June and then leveled off. Bosmina abundance and biomass actually increased during and after peak clupeid abundance. If predation was the primary force controlling *Daphnia*, one might have expected to see the decline occurring during peak clupeid abundance rather than during the period of rapid clupeid decline. It may be *Daphnia* were themselves food limited since egg production by the dominant species had declined by late June (Fig. 19). However, *Bosmina* egg production also declined without a concurrent decrease in *Bosmina* abundance (Figs. 19, 10).

Copepods may have been more strongly affected by clupeid predation than were cladocerans. Previous studies have shown small gizzard shad larvae (5-17 mm TL) prefer copepods over cladocerans (Dettmers and Stein 1992). Most gizzard shad collected in the random site samples of this study fell within a 5-17 mm size range until the end of the study. During this time, copepod numbers fell as clupeid numbers increased, and as clupeid numbers decreased, copepod numbers increased or at least stopped declining.

Previous studies in Midwestern reservoirs have shown that predation by gizzard shad larvae and early juveniles can result in depletion of zooplankton numbers (Stein et al 1995, DeVries et al. 1991, DeVries and Stein 1992) with strongest effects occurring in reservoirs with low zooplankton biomass and dominated by copepods rather than by cladocerans (Dettmers and Stein 1992). In Wasenza Pool, zooplankton biomass was high. Cladoceran biomass alone was higher than total crustacean zooplankton biomass in the high biomass reservoir of Dettmers and Stein (1992). The zooplankton community was initially dominated (numerically) by copepods in the beginning of the study, but cladocerans were co-dominant with copepods by the end of the study (Fig. 20). Although clupeids may have exerted an effect on the copepod community in 1997, predation by YOY clupeids did not result in an overall crash in zooplankton resources.

While clupeid zooplanktivory did not seem to cause a significant bottleneck for the larval centrarchids, zooplankton availability did seem to favor clupeid rather than centrarchid growth and survival. Whereas centrarchid larvae feed on progressively larger zooplankters as they grow larger (Welker et al 1994, Bremigan and Stein 1994), clupeid larvae may do so to a lesser extent or continue to feed on smaller zooplankton size classes (Bremigan and Stein, 1994), often showing a high selectivity for *Bosmina* (Cramer and Marzolf 1970, Welker et al 1994, Bremigan and Stein 1994). Although cladoceran abundance continued to increase during the study, the cladoceran community was dominated by the smaller size classes from mid-June to July (Fig. 21). Also during this period, copepod abundance decreased, whereas nauplius larvae remained abundant (Figs. 12, 13). Thus, as the centrarchid larvae began to grow and required larger zooplankton prey, the size structure of the zooplankton community was shifting towards dominance by the smaller size classes, with *Bosmina* becoming the dominant taxa in terms of abundance and biomass. This change in size-structure may have had a detrimental effect on centrarchid growth and survival.

<u>Diel Abundance Patterns</u>: Strong diel patterns in vertical distribution or habitat preference (e.g. vegetated vs clear) could bias abundance and species diversity estimates obtained from sampling surface waters during only one part of the day. In 1997, random site ichthyoplankton tows were conducted during daylight hours only, (generally between 15:00 and 20:00 hrs) and sampled surface waters representing less than a third of the water column. However, this random site sampling regime probably did not strongly bias estimates of clupeid abundances. Clupeid abundances from 15:00 - 20:00 hrs exhibited nearly the entire range in abundance exhibited over the

entire 24 hr sampling period (Fig. 14). Cyprinid abundances, were probably underestimated since maximum abundances occurred during the nighttime hours (21:00 - 5:00 hrs) (Fig. 14). However the maximum cyprinid abundance during the diel sampling (0.89/L) does not fall outside the range of abundances found during random site sampling (Fig. 7). Diel abundance patterns for the other families were not examined due to low numbers of fish collected ($\leq$23 fish/family).

In addition to the taxa identified during random site sampling (Table 1), diel sampling of larval/juvenile fish indicated reproduction occurred in one additional family (Lepisostidae:gar), two additional genera (*Poxomis*:crappie, *Labidesthes*:silversides), and one additional species (*Labidesthes sicculus*: brooks silverside). Of these taxa, only the Lepisostidae was likely new. The other taxa were probably present in random samples but could not be identified to the genus and/or species level. All of these taxa were represented by only a few individuals. These results do not indicate that our random site protocol significantly underestimated species abundance or reproduction in Wasenza Pool.

Escapement: In 1997, drainage of Wasenza Pool began near June 24. Water drained from Wasenza Pool flows into Quiver Lake which is a small, creek-fed, backwater lake that drains into the Illinois River. Because zooplankton productivity is typically much lower in rivers than in lakes, fish produced in Wasenza Pool may exhibit low survivorship if they are flushed into the creek/river system while they are still dependent on zooplankton. In 1997, many of the clupeid YOY captured in the ichthyoplankton and hoop nets were >20 mm (Fig. 15). At 25-35 mm length, gizzard shad YOY become omnivores and feed on detritus and algae as well as zooplankton (Yak et al, 1996). The abundance of detritus in the Illinois River and connected floodplain lakes make it likely that clupeid YOY were not food limited after being flushed out of Wasenza Pool. Over 150,000 centrarchid and white bass larvae/early juveniles were estimated to have still been under 20 mm when flushed from Wasenza Pool (Table 1, Fig. 16). The small size of centrarchid and white bass larvae caught by ichthyoplankton net (Fig. 16) suggests that they were still zooplanktivorous after being flushed from Wasenza Pool and may have exhibited low survivorship due to food limitations in the river system. However, at least 98,000 centrarchid and white bass juveniles (hoop net catch) were estimated to have been released from the pool (Table 1). Although largemouth bass <51mm, and YOY white bass continue to rely heavily on zooplankton as a food resource (Becker 1983), some of these juveniles may have been large enough (Fig. 16) to switch to piscivory or and/or begin feeding on benthic invertebrates.

General Assessment: In 1997, Wasenza Pool provided excellent habitat for forage fish production with clupeids being the numerically dominant taxa produced and released into the river. Clupeids were not likely to be food limited after being flushed into the Illinois River as most were large enough to switch to omnivory by this time. The high production of forage fish did not seem to cause a food-limitation bottleneck for later-spawning game fish, and probably provided valuable food resources for those game fish that grew large enough to switch from zooplanktivory to piscivory. However, growth and survival of centrarchids and white bass may have been limited by the size-structure of the zooplankton community (which likely favored clupeids over centrarchids), and by their small size at time of release into the river. An important management recommendation from this year's study, with regards to game fish production, is to delay drainage of Wasenza Pool until a greater proportion of centrarchids and white bass have grown large enough to switch to piscivory and thus take advantage of the high forage fish production.

It was expected at the beginning of this study that the dense stands of willows in 1997 might provide valuable (or degraded) habitat for various fish taxa. However fish abundance patterns did not indicate strong attraction or avoidance patterns between YOY fish and emergent willow habitat, although there was some indication that YOY clupeids preferred open water habitat to willows. Emergent willow stands in Wasenza pool seemed to be neither detrimental nor beneficial to larval fish production, and the results of this study alone do not justify the time and expense necessary to eradicate the willow stands for fisheries development.

In 1996 and 1997, one grass carp (presumably a different one each year) was collected during adult fish sampling. While no YOY grass carp were found in 1996, 48 YOY grass carp were captured the following year, leading to an estimate of over 60,000 YOY grass carp produced and released from Wasenza Pool in 1997. Raibley et al. (1995) found strong evidence that grass carp had recently established reproductive populations in the Illinois River but were unsure as to whether spawning took place in the main-channel or backwaters. To our knowledge, this study is the first to indicate that grass carp are successfully reproducing in at least one floodplain lake of the Illinois River. Because Wasenza Pool is drained every year, making assessment of fish production relatively easy, it may provide a valuable research site for studies on the reproductive biology of this invasive species. One goal of future studies could be to develop management strategies to suppress production of grass carp in managed floodplain lakes.

Another management issue that needs to be addressed further is the effect of sustained flood waters (overtopping the Wasenza pool levees) on fish production. Although zooplankton production was high enough to withstand the predation pressure of clupeids in the low-water study season of 1997, this may not be the case in high-water years. Overtopping of levees by the river for long periods of time may have a detrimental effect on zooplankton due to the flushing out of the pool by zooplankton-poor, sediment-rich river water. On the other hand, flooding of the levees allows adult fish easy access to the backwater habitat, and thus may increase spawning success, resulting in higher initial abundances of larval fish. Over the years, moist-soil units such as Wasenza Pool are likely to exhibit a wide range in YOY fish/zooplankton interactions. At one extreme, extended flooding may allow for high initial fish production (and high zooplanktivory rates) while at the same time suppressing zooplankton production. Under this scenario, YOY fish would experience reduced growth and survivorship rates due to food limitation. At the other extreme, if levees are not overtopped and zooplankton production is high, limited access to the lake by adult fish may result in low spawning success. Under this scenario, fewer YOY fish would be produced, but they would presumably exhibit higher growth rates and higher survivorship due to increased food abundance. In 1996, we did not obtain zooplankton samples and so were not able to compare zooplankton production between high and low water regimes. However in 1998, Wasenza Pool levees were again overtopped during the majority of the sampling season and zooplankton were collected along with larval fish. Analysis of the 1998 data should provide valuable insight into the effects of sustained flooding on larval fish/zooplankton interactions in Wasenza Pool.

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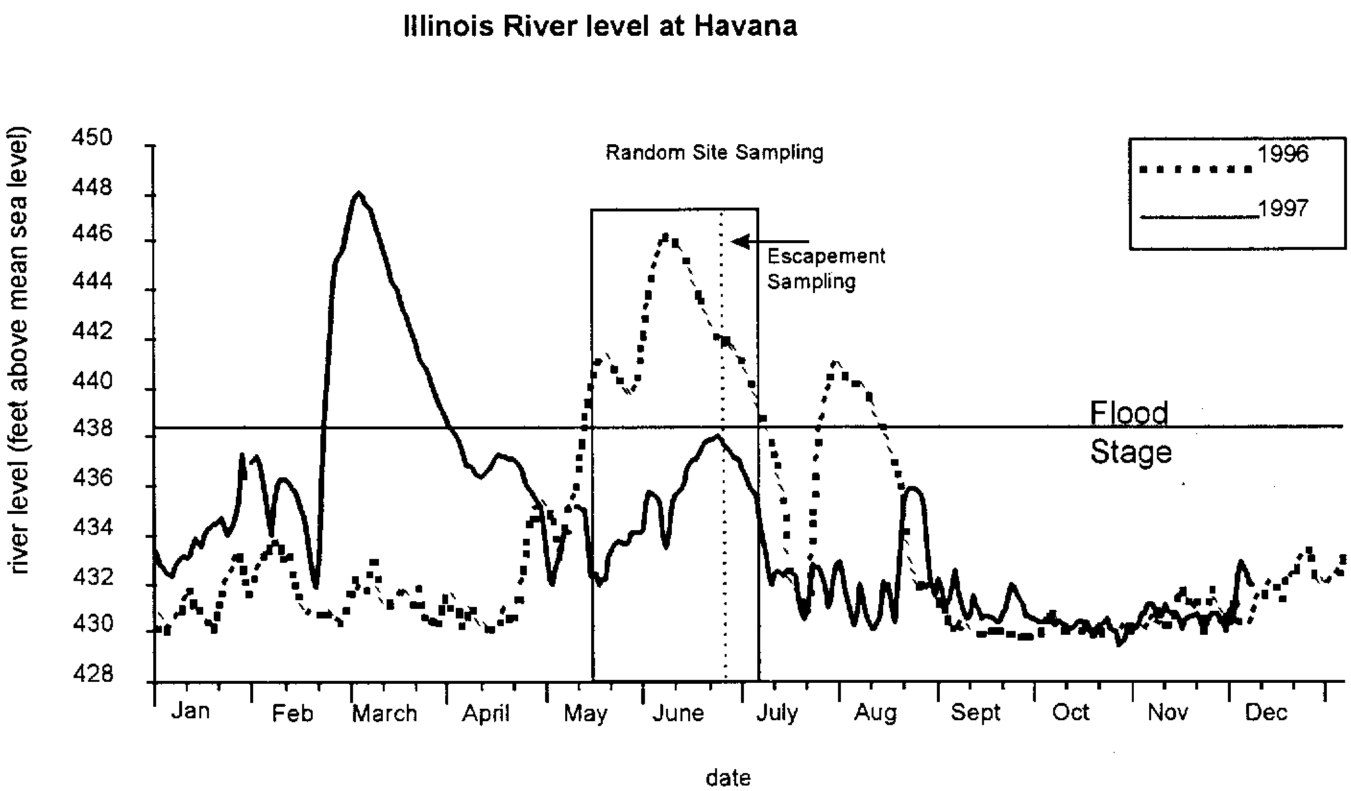


Figure 1. Illinois River levels at Havana, Illinois in 1996 and 1997. Sampling times shown are for sampling in 1997

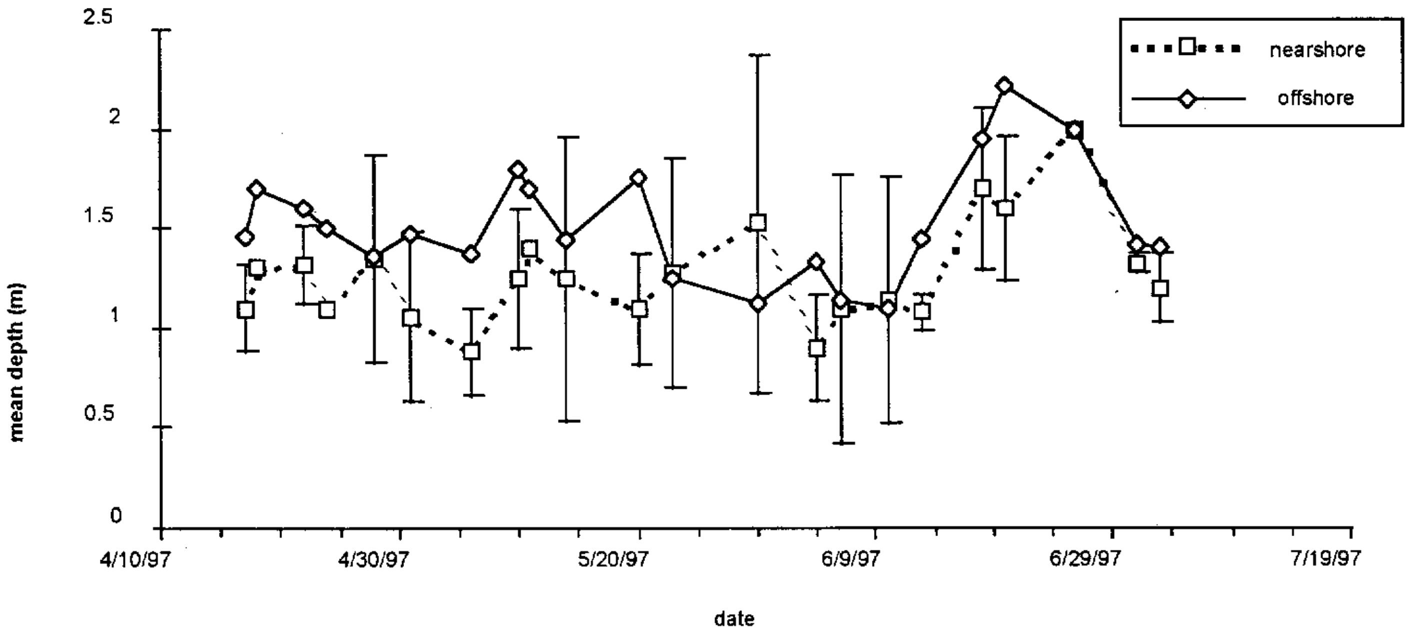


Figure 2. Mean depth of nearshore and offshore sampling sites for random site portion of the study.

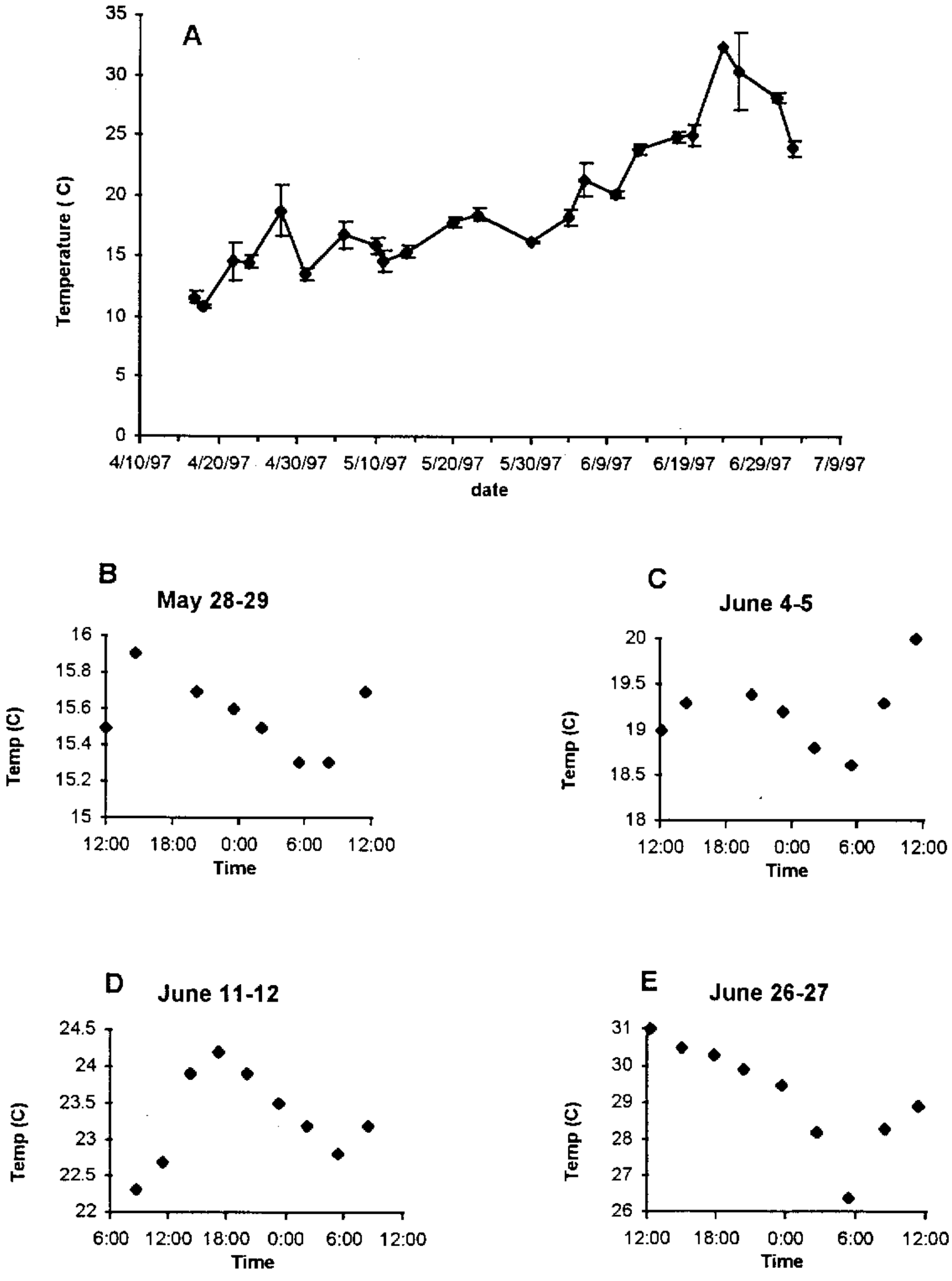


Figure 3. Average temperature at random sites (A) and 24-hr temperature fluctuations at fixed, open-water site during 24-hr sampling periods (B-E).

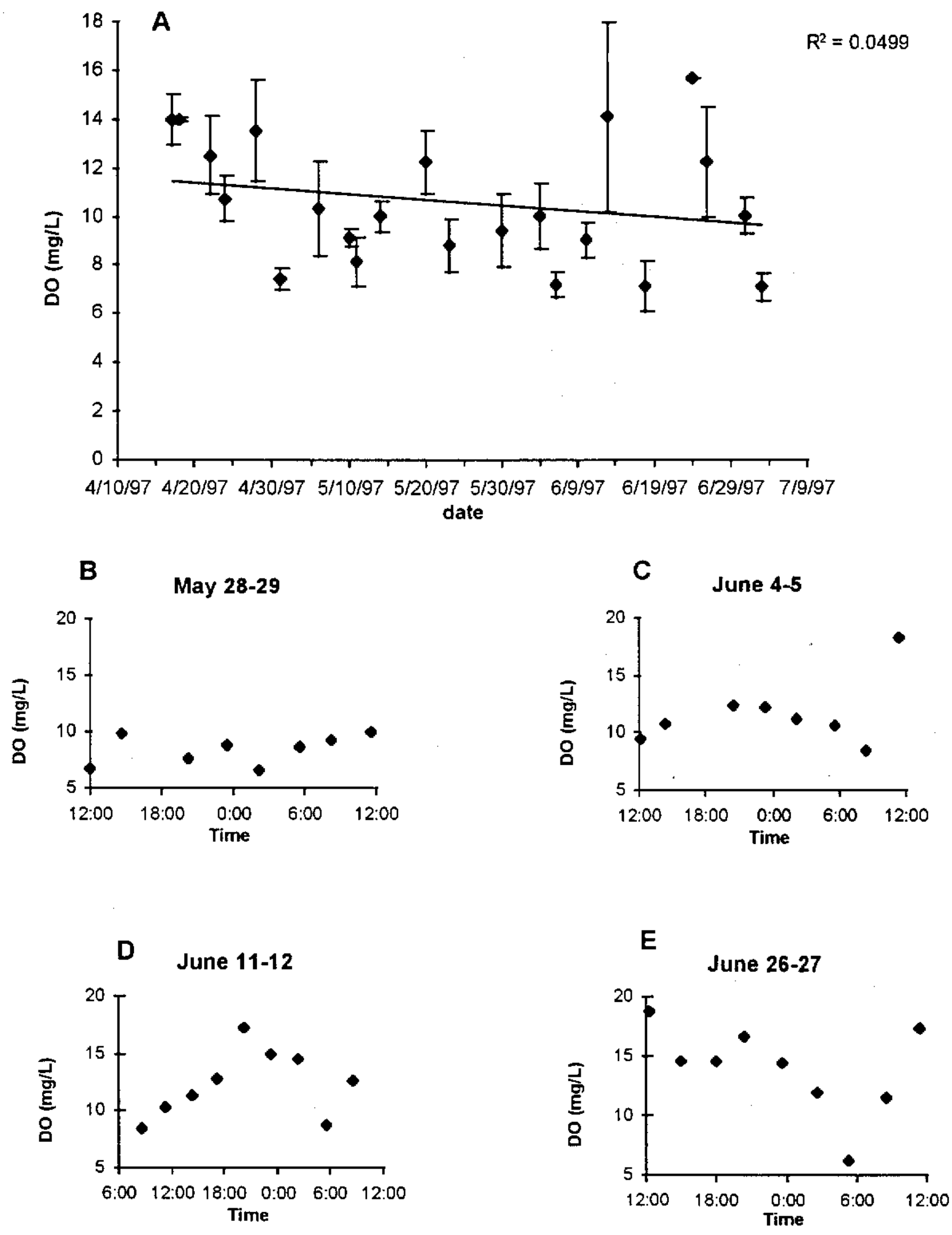


Figure 4. Average dissolved oxygen (DO) at random sites (A) and 24-hr DO fluctuations at fixed, open-water site during 24-hr sampling periods (B-E).

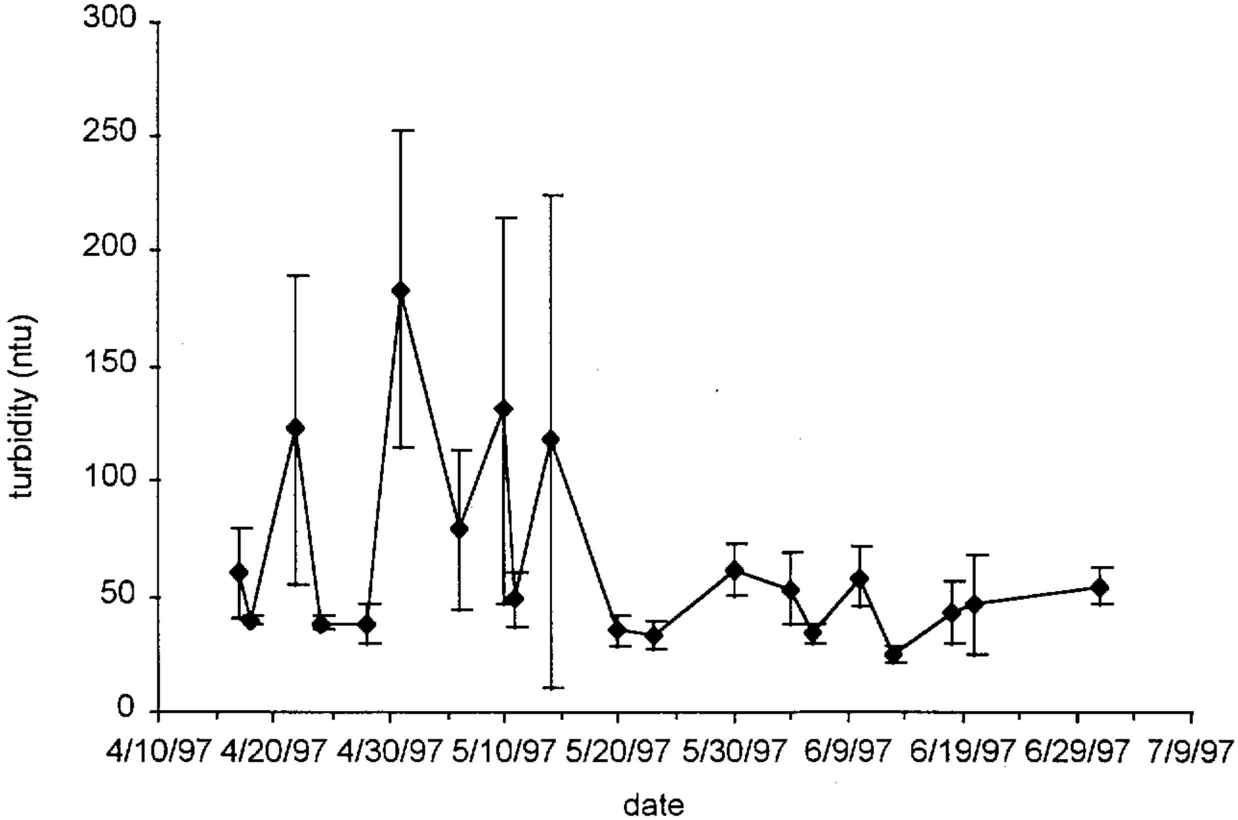


Figure 5. Mean nephpmetric turbidity at random site locations.

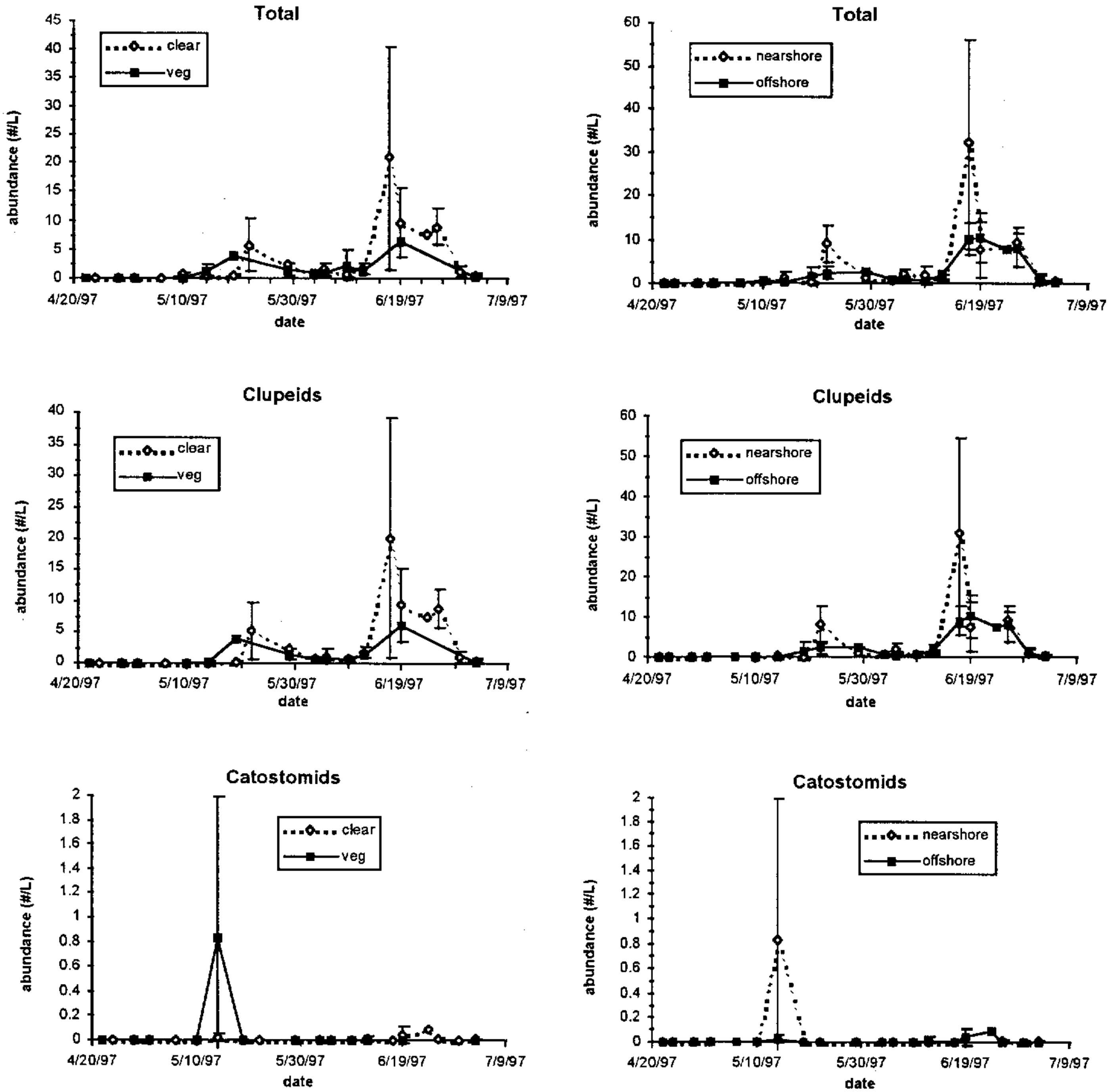


Figure 6. Larval fish abunadances in different habitat types during random site (ichthyoplankton tow) sampling

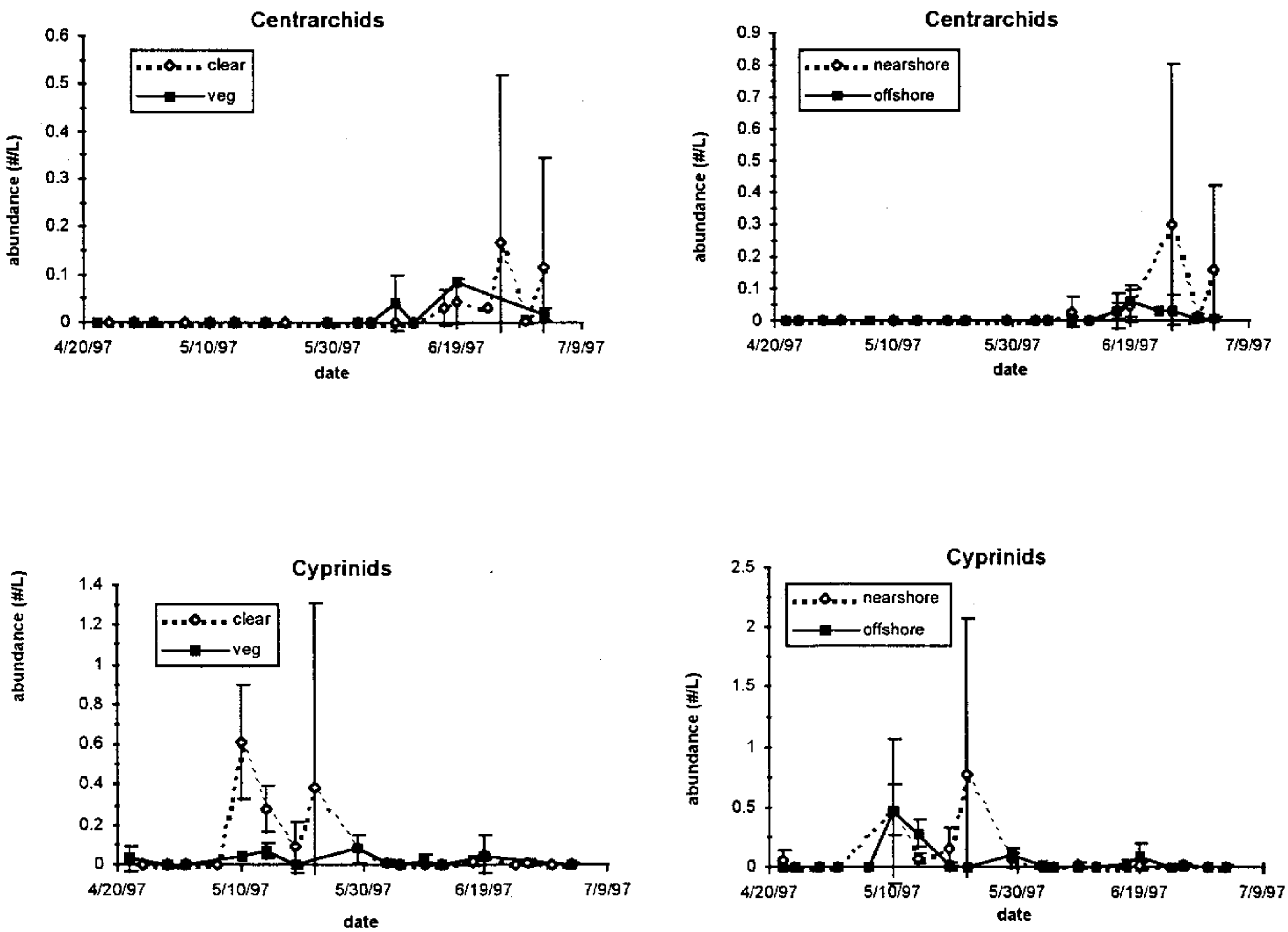


Figure 7. Larval fish abunadances in different habitat types during random site (ichthyoplankton tow) sampling

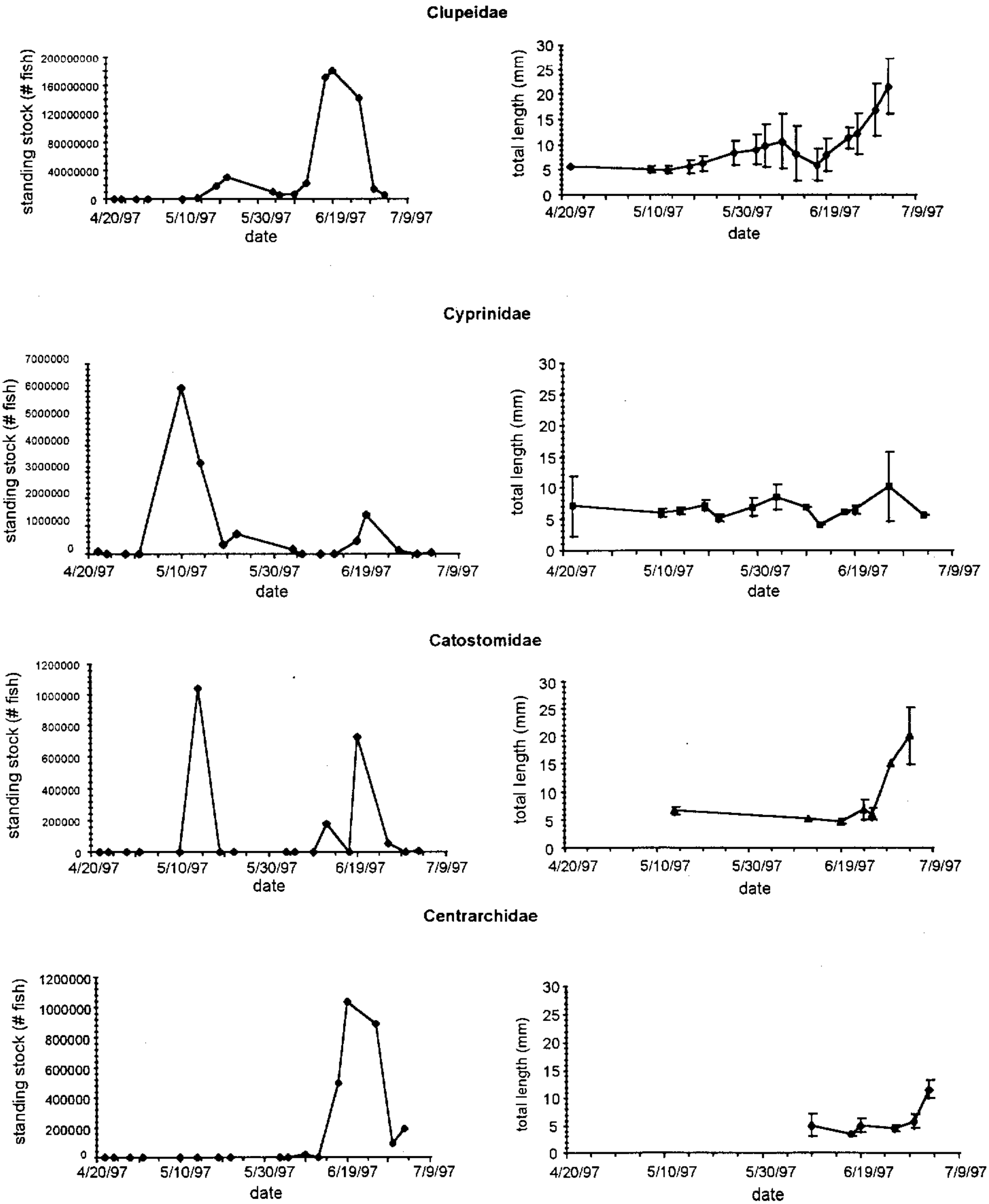


Figure 8. Standing stock and average size of dominant taxa estimated from random site ichthyoplankton tows.

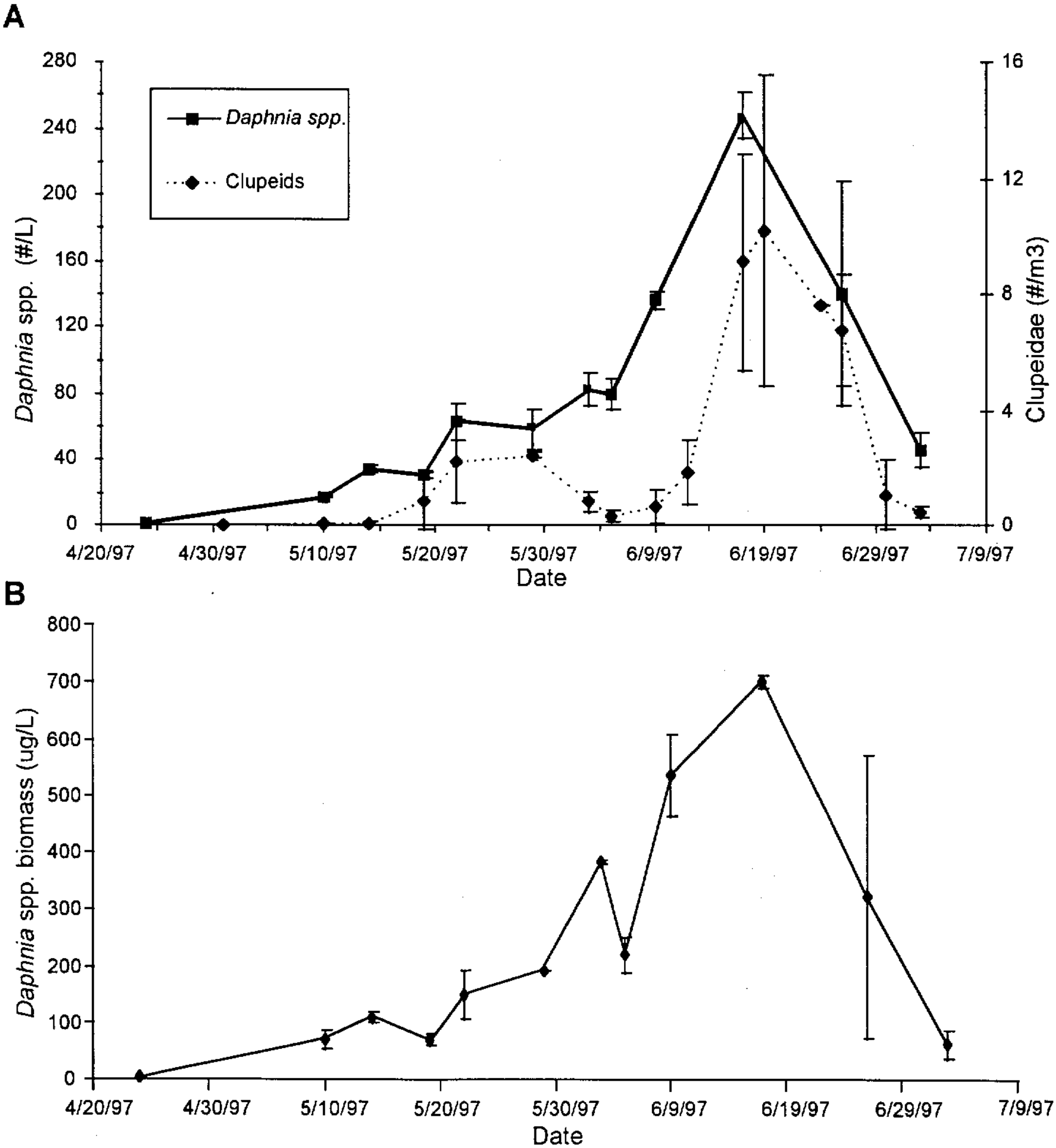


Figure 9. Abundance of *Daphnia spp.* and clupeids (A) and biomass of *Daphnia spp.* (B) estimated from random site collections at offshore, non-vegetated sites

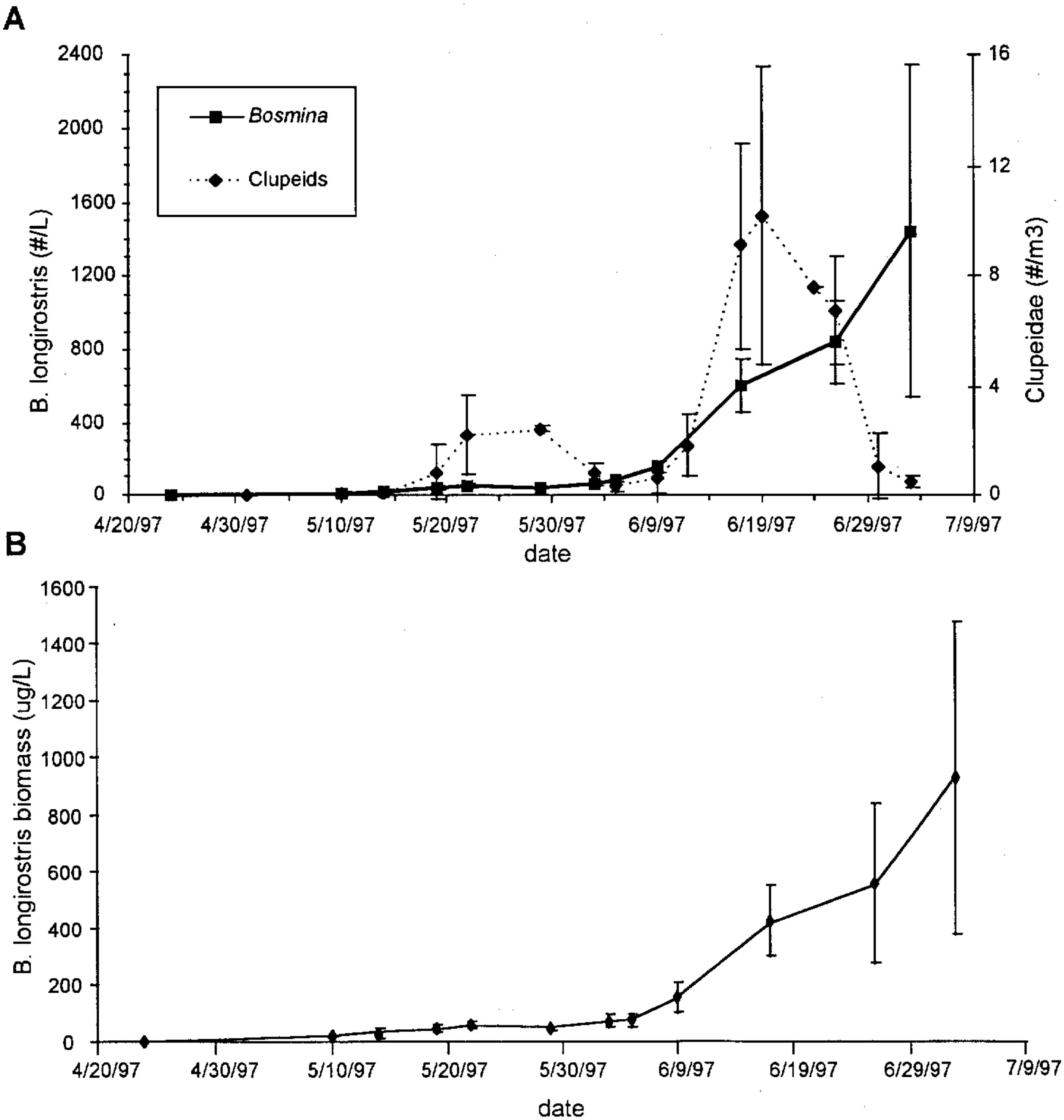


Figure 10. Abundance of *Bosmina longirostris* and clupeids (A), and biomass of *Bosmina longirostris* (B) estimated from random site collections at offshore, non-vegetated sites.

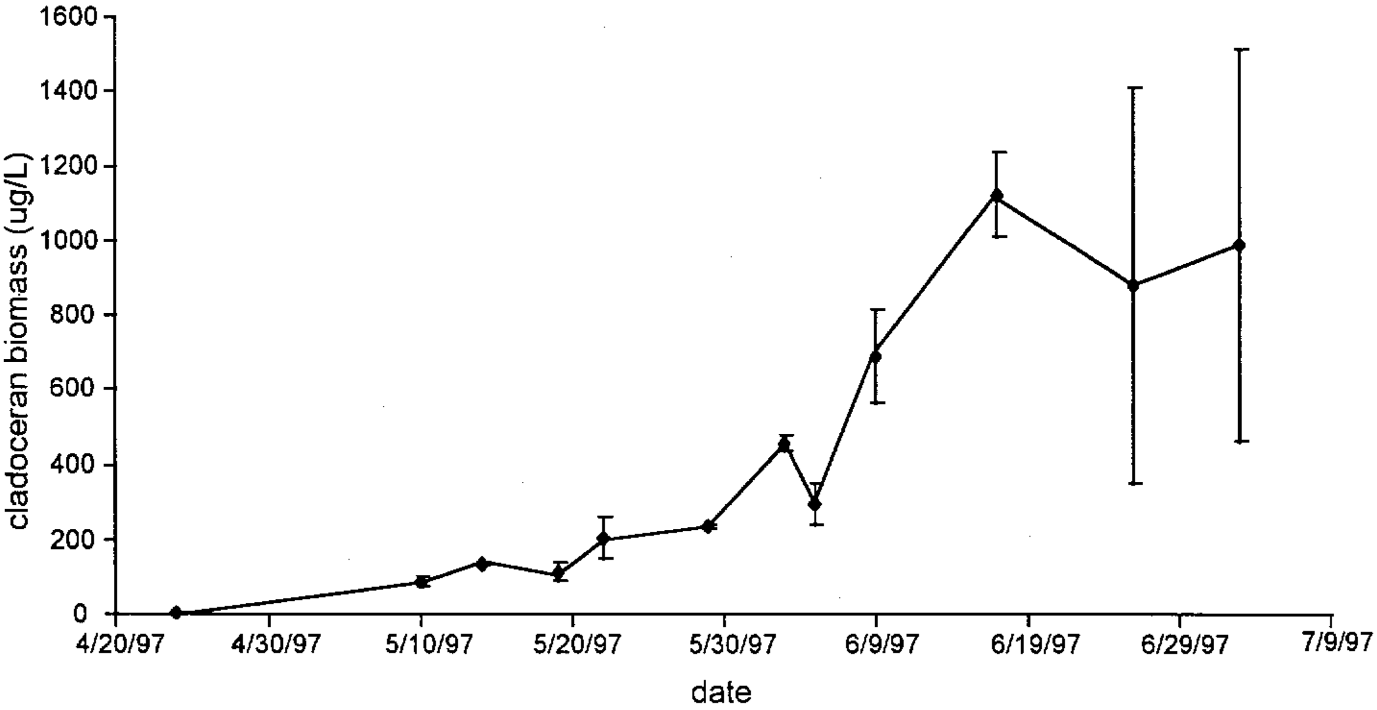


Figure 11. Biomass of cladoceran species from random site collections at offshore, non-vegetated sites.

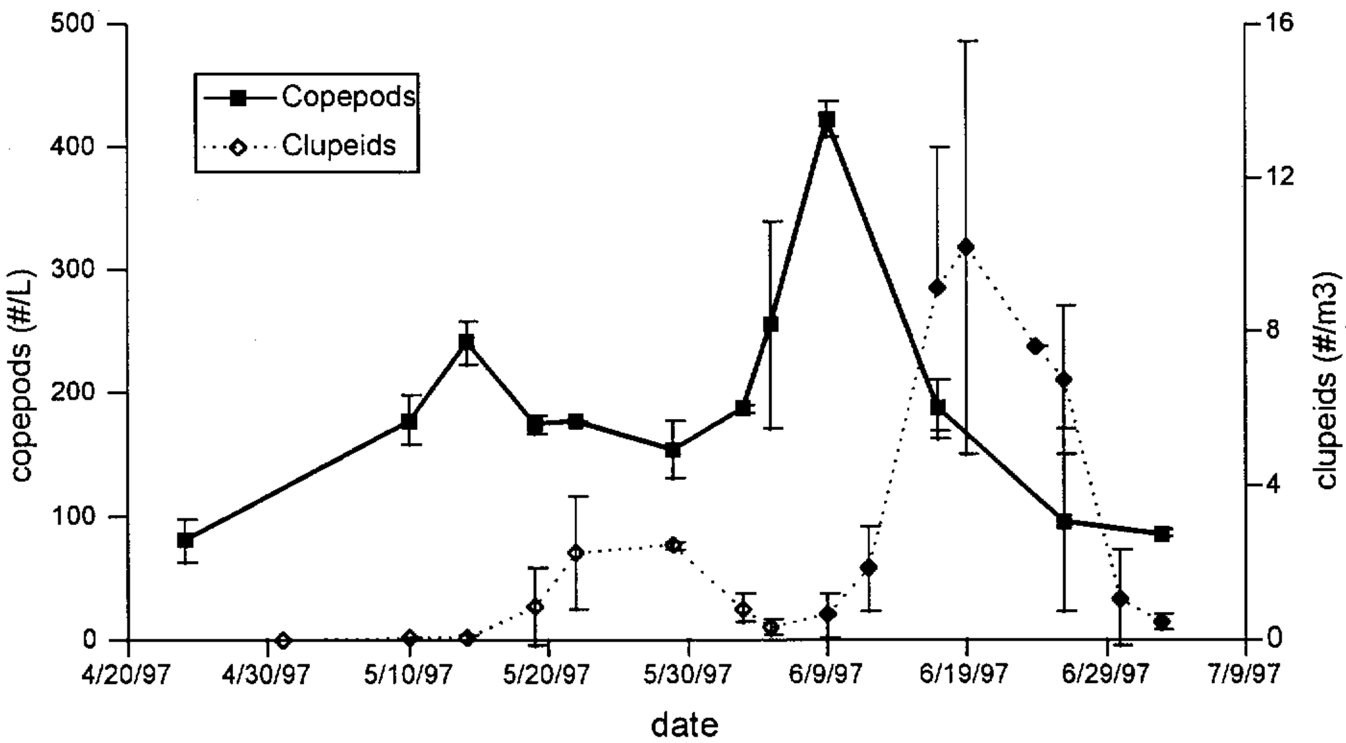


Figure 12. Abundance of copepods and clupeids from random site collections at offshore, non-vegetated sites.

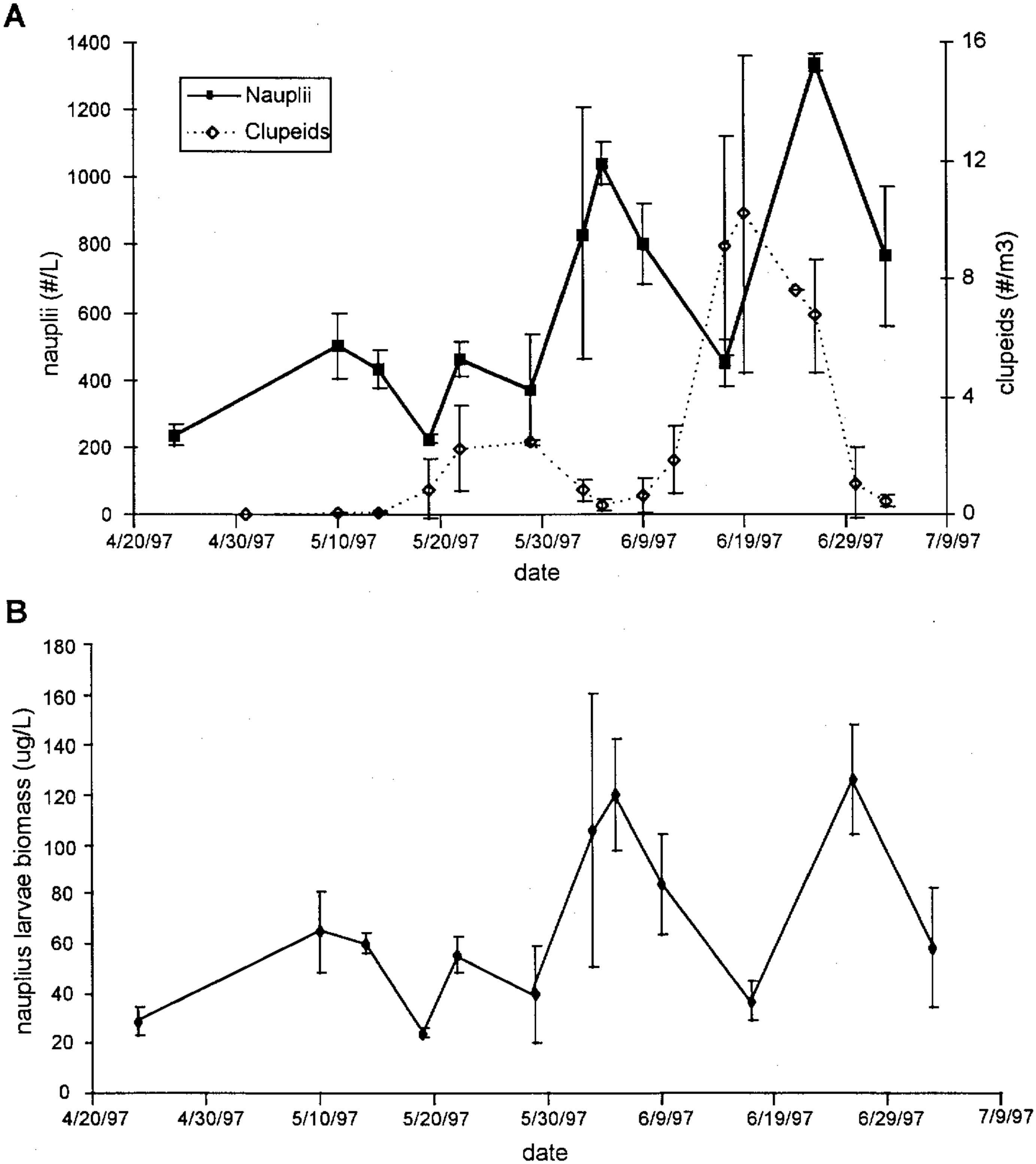


Figure 13. Abundance of nauplius larvae and clupeids (A), and biomass of nauplius larvae (B) estimated from random site collections at offshore, non-vegetated sites.

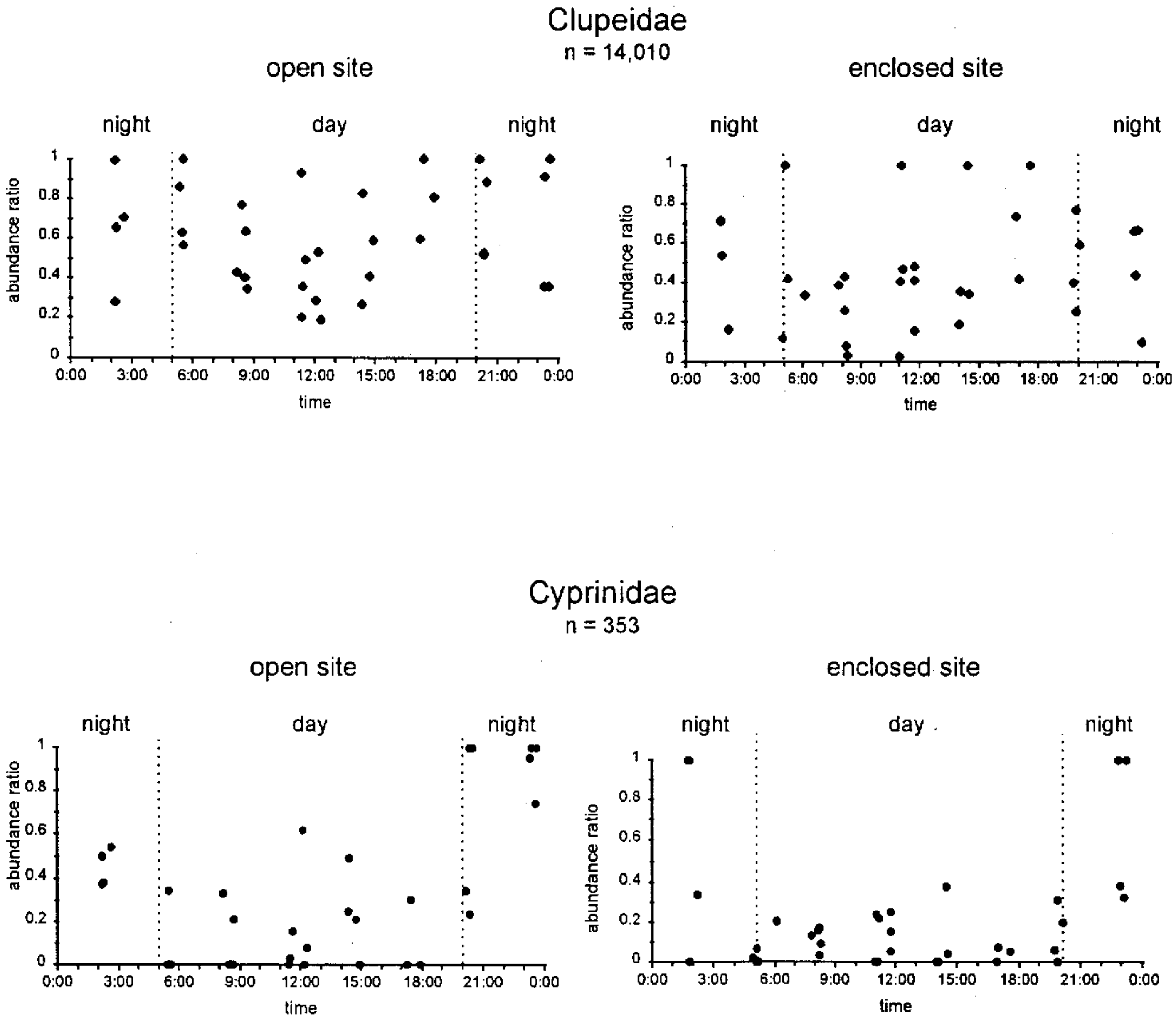


Figure 14. Abundance ratio of clupeids and cyprinids collected during diel sampling at the two fixed sites (open and enclosed). Diel sampling was conducted on four separate occasions at each site. Abundance ratio was calculated by dividing abundance at a specific time by the maximum abundance observed during that diel sampling event. n=total number of fish collected at both sites.

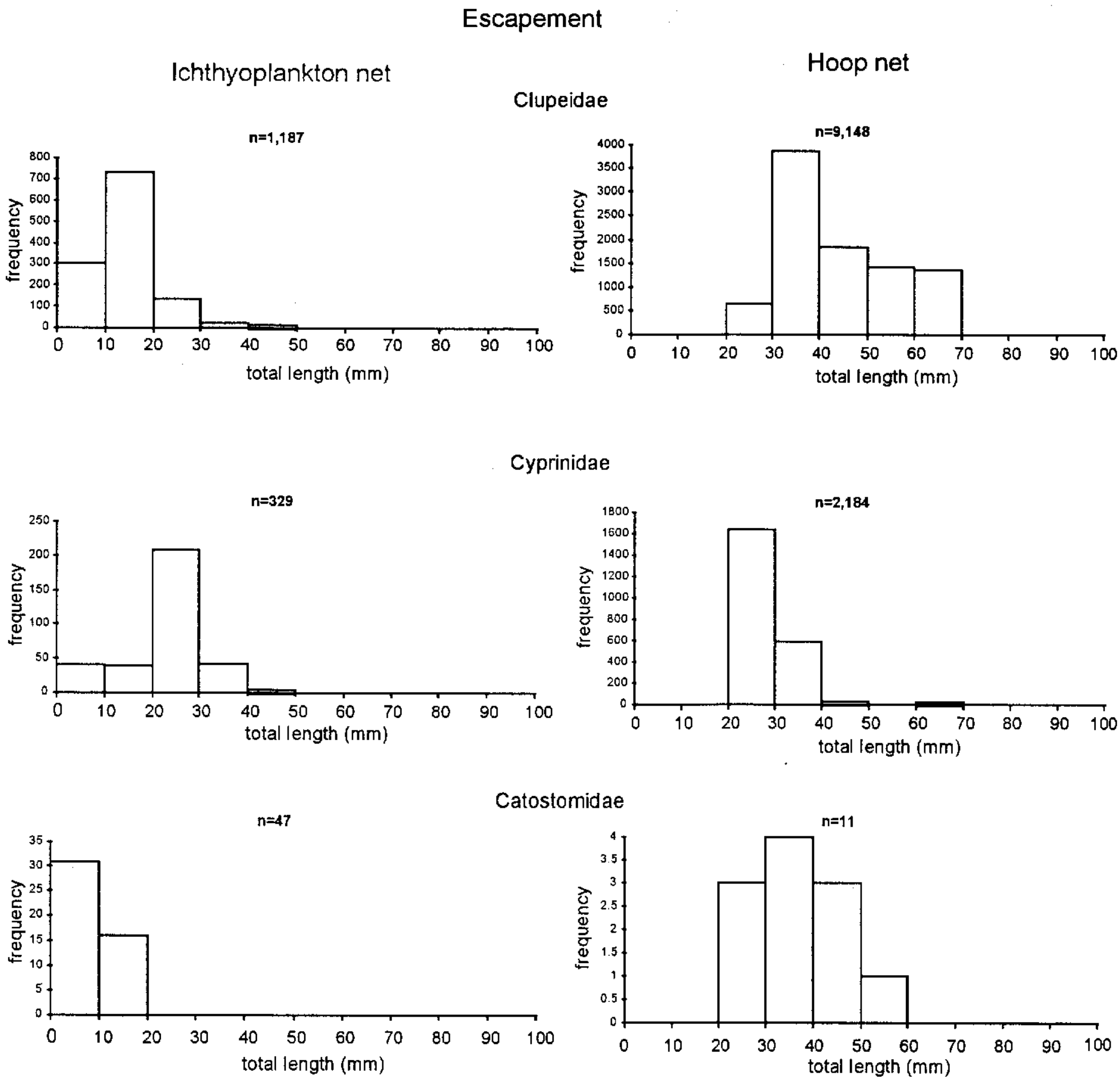


Figure 15. Size distributions of YOY fish caught during escapement sampling (6/24/97-7/5/97) using ichthyoplankton and hoop nets.

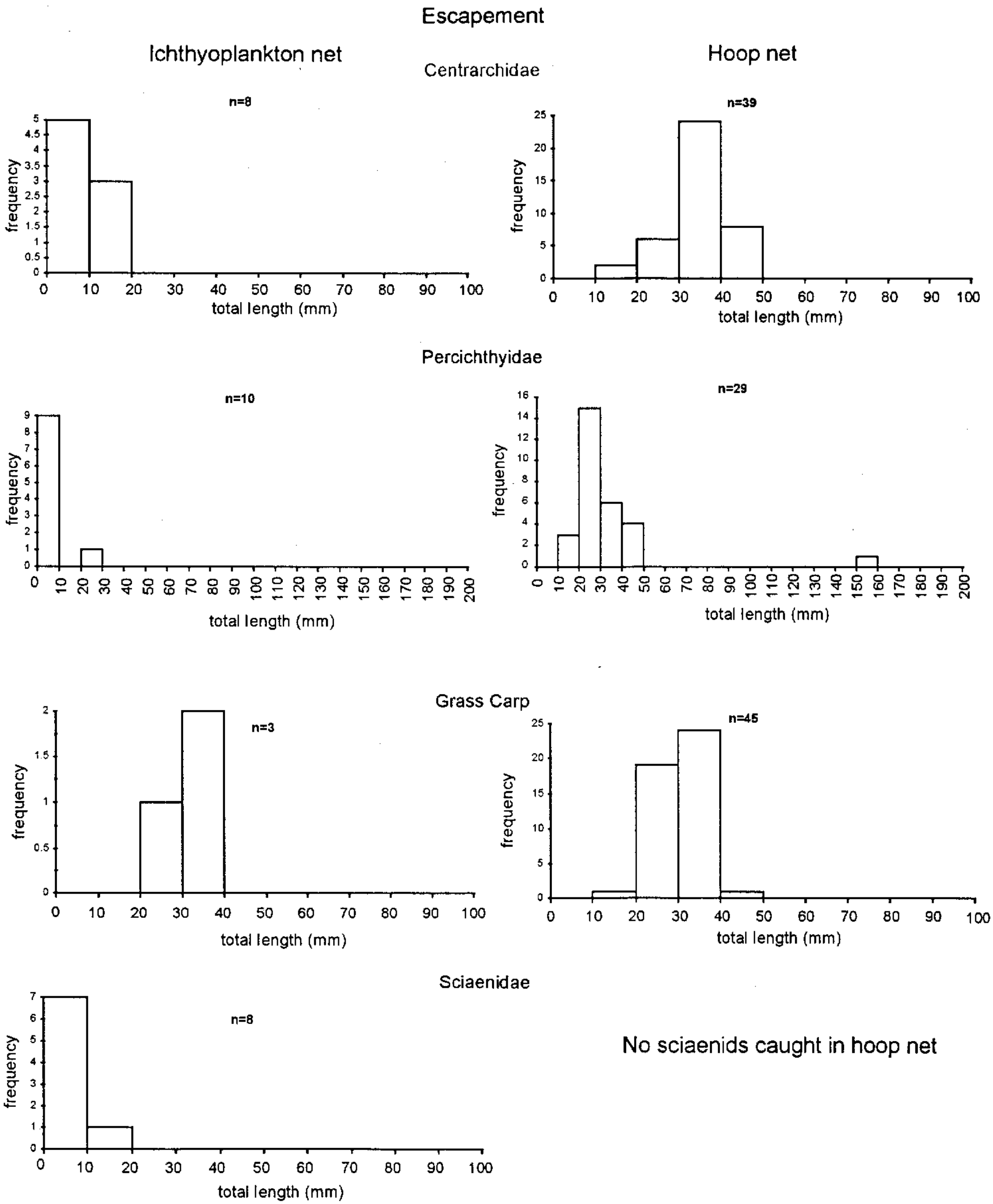


Figure 16. Size distributions of YOY fish caught during escapement sampling (6/24/97-7/5/97) using ichthyoplankton and hoop nets.

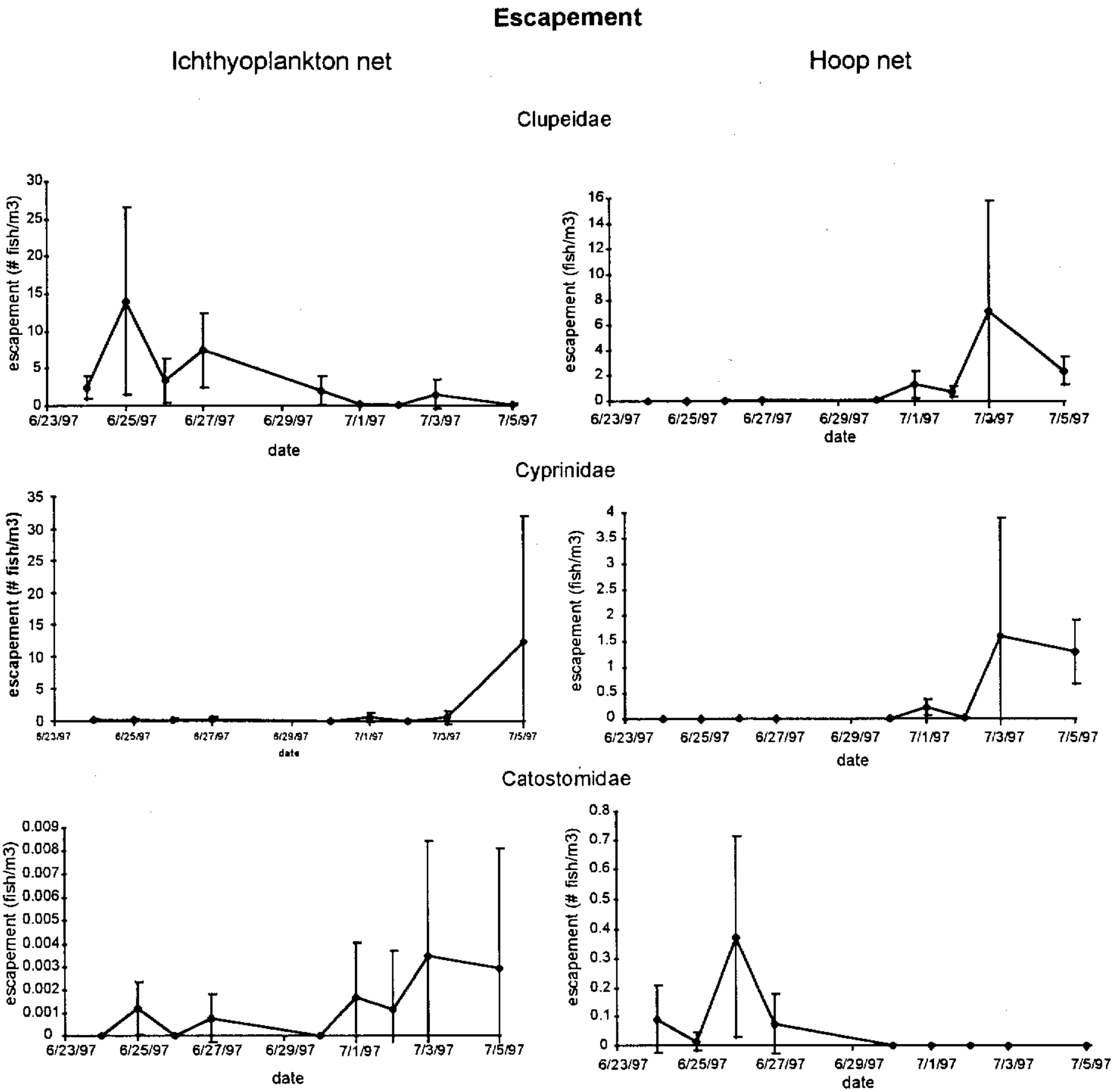


Figure 17. Escapement abundances for various fish taxa collected by ichthyoplankton and hoop nets.

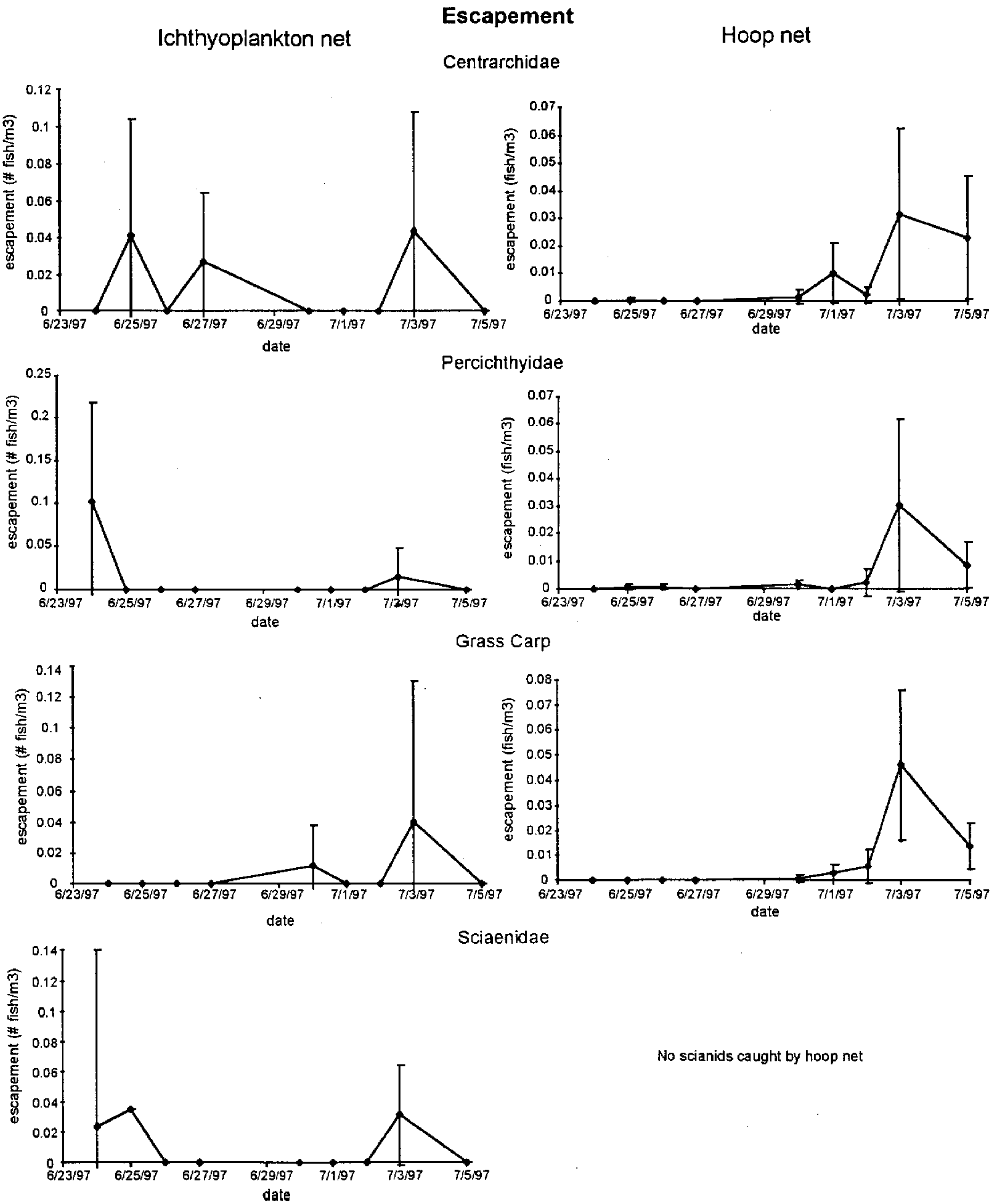


Figure 18. Escapement abundances for various fish taxa collected by ichthyoplankton and hoop nets.

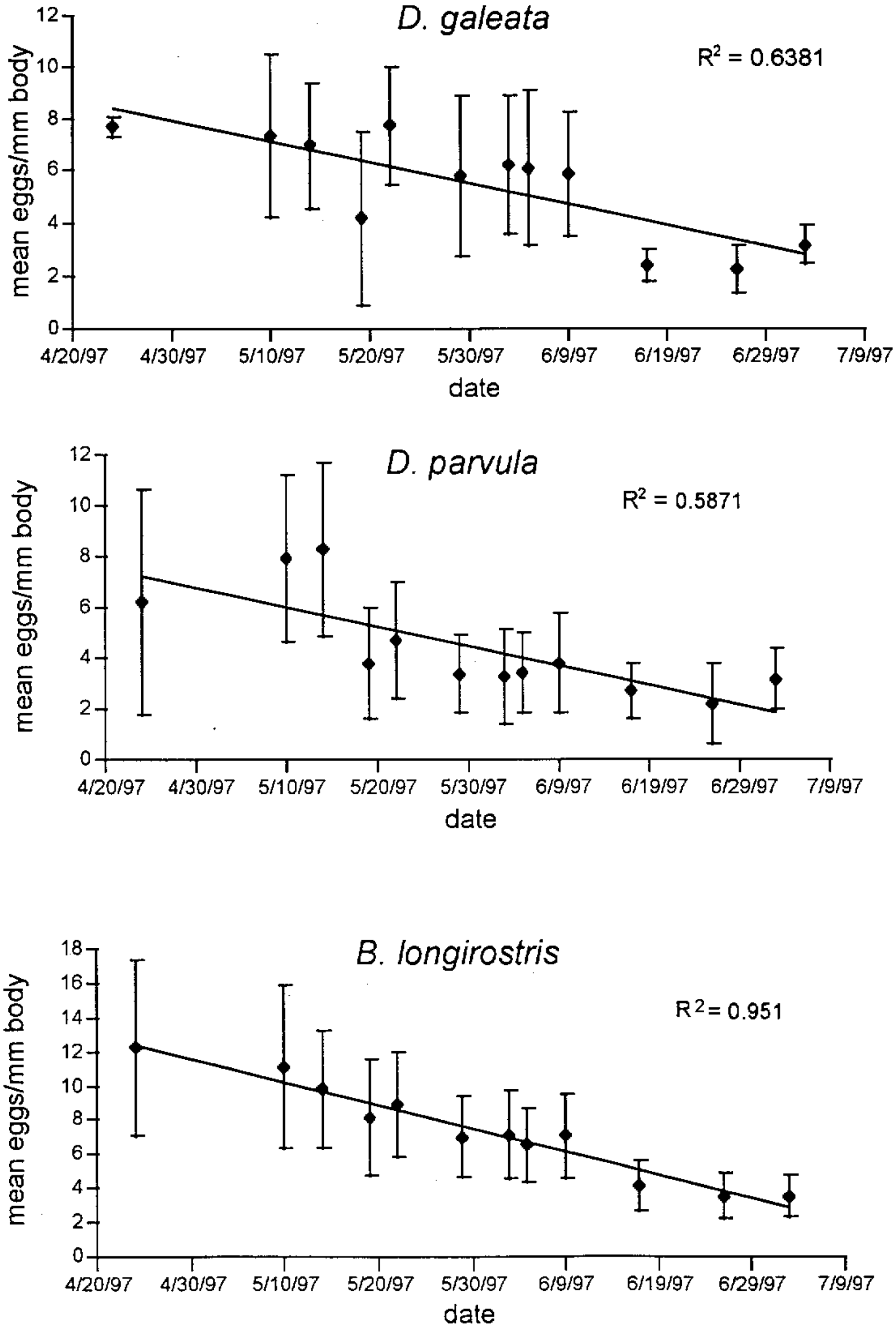


Figure19. Egg production of gravid females from dominant cladoceran taxa.

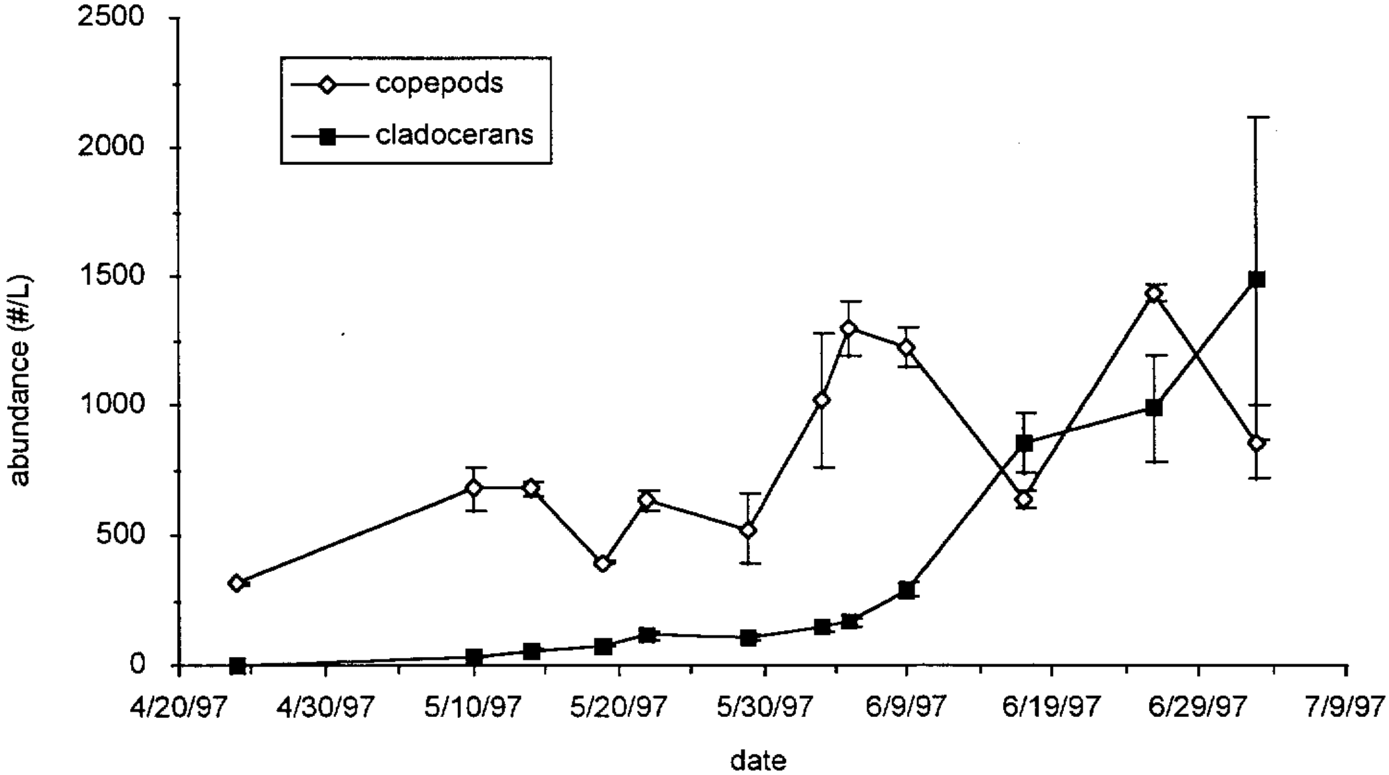


Figure 20. Abundance of cladocerans and copepods (including nauplius larvae) estimated from random site collections at offshore, non-vegetated sites.

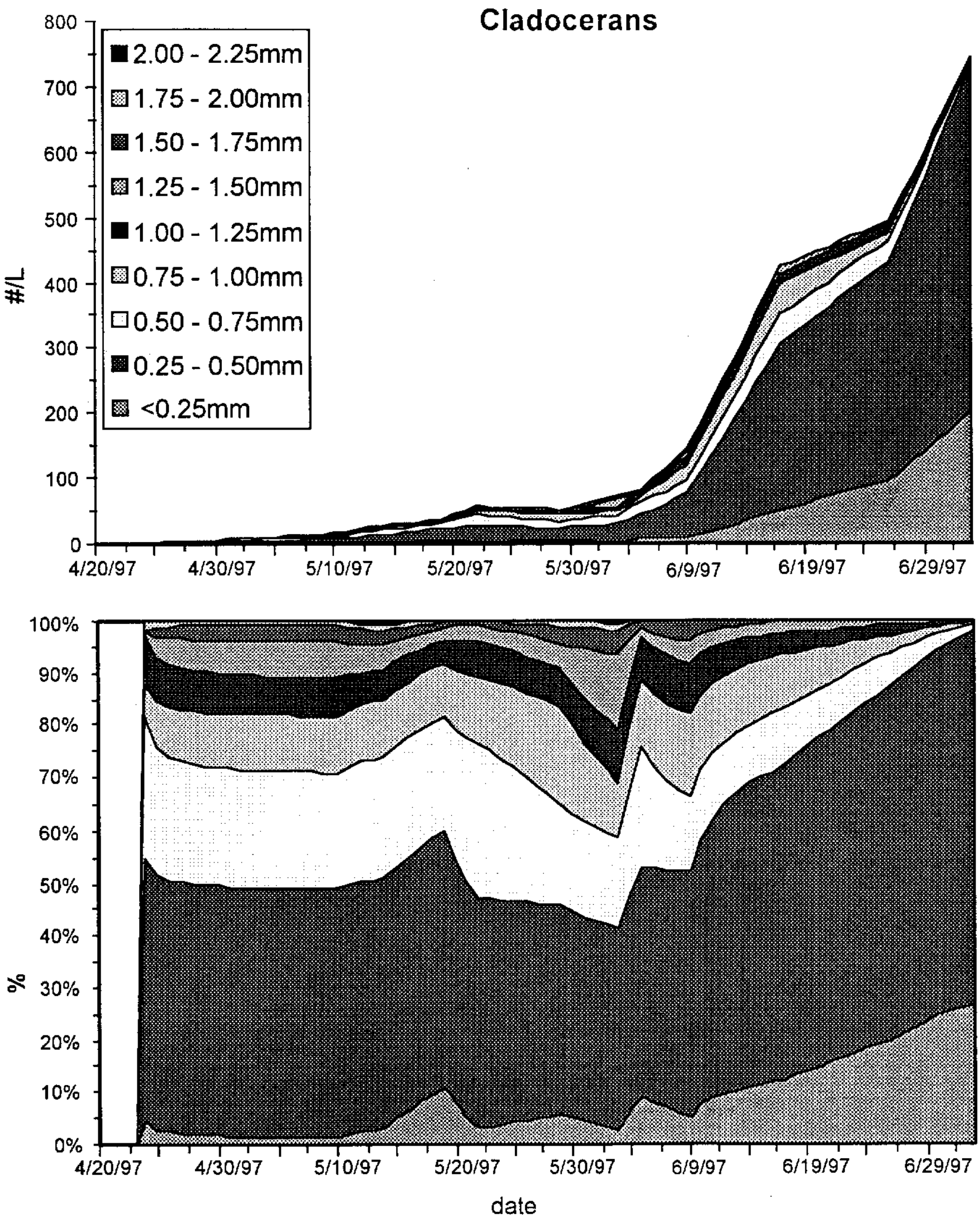


Figure 21. Temporal shifts in size structure of the Wasenza Pool cladoceran community. Data are from offshore, non-vegetated sites only.