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Department of Agriculture, Trade and Consumer Protection
Division of Agricultural Development
Agricultural Development & Diversification Program (ADD)

Grant Project Final Report

Contract Number: 17019

Grant Project Title: Improving Production of Larval Yellow Perch with a Pond Fertilization Schedule

Project Beginning Date: May 1, 2002 Project End Date: April 30, 2003

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Agricultural Development & Diversification (ADD) Grant Final Report

Project Title: Improving Production of Larval Yellow Perch with a Pond Fertilization Schedule

Primary Contact: Chris Hartleb, Ph.D., Associate Professor of Fisheries Biology & Aquaculture

What did you want to accomplish with the grant?

Larval yellow perch culture is one of the riskiest phases of fish farming, but can also be one of the most profitable. The successful growth & production of larval & post-larval yellow perch depends on the quantity and type of food available to them in the culture pond. Bottom-up control in fish culture ponds, through the use of inorganic fertilizer, can influence short-term seasonal changes in the composition of plankton. This can enhance the food chain & ultimately improve growth & survival of yellow perch fry. Nutrient enrichment can alter the abundance & composition of plankton within ponds & result in cascading trophic interactions. Consequently, aquaculturists can better manage culture ponds with appropriately scheduled fertilization times & quantities and with better management in initial stocking density & subsequent grading. Pond culturing remains the most common culturing method in the U.S., but producers have reported early survival by perch fry to be as low as 11%. This bottleneck in production results in greatly reduced quantities of feed-trained fingerlings. The objective of this study was to design and implement a fertilization schedule to greatly enhance the food-base in larval yellow perch culture ponds.

What steps did you take to reach your goal?

Quarter-acre ponds at Willow Creek Aquaculture, Berlin, WI were fertilized weekly with inorganic fertilizer to achieve a 30:1 (N:P) ratio & establish abundant phyto- & zooplankton populations. Nitrogen, phosphorus, temperature, pH, alkalinity, hardness, transparency, phyto- & zooplankton composition/biomass, & yellow perch were sampled weekly. Water chemistry results (nitrogen & phosphorus) were reported to Willow Creek Aquaculture within 24 hours so that modifications to the fertilization schedule could be made. Additional water characteristics were recorded for later analysis. Phytoplankton (algae) and zooplankton were preserved for later analysis. A sample of 50 larval yellow perch were collected weekly from two ponds and preserved for growth and diet analysis.

- **What worked?**

We were successfully able to collect all the water, plankton, and fish samples during each weekly visit to Willow Creek Aquaculture. Water samples were analyzed for nitrogen and phosphorus and results were reported to personnel at Willow Creek within 24 hours. Preserved samples of phytoplankton and zooplankton were identified, enumerated, and weekly composition was graphed for analysis. Growth and diet selection by larval yellow perch were determined and growth was modeled based on length and weight for pond raised yellow perch during the first ten weeks of larval growth. Diet selection by larval yellow perch was determined and compared to available prey as a means of investigating prey choice by the perch.

- **What did not work?**

The 24-hour turnaround on water chemistry results proved to be rigorous, but was needed if a weekly fertilization schedule was to be developed. Analysis of diet items from the stomachs of larval yellow perch proved to be more time-consuming than anticipated. The larval yellow perch consumed a wider variety of prey than anticipated and growth of the perch was limited by the unusual temperatures

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experienced in spring 2002. Ultimately, both unforeseen obstacles were overcome and the results were included in this report.

Two events occurred that delayed or altered the planned methods of the project:

1) Phosphorus levels in the ponds were lower than anticipated, so a different water chemistry analysis had to be performed on the weekly water samples. Therefore, the N:P ratios in the ponds could not be determined from April 23 – May 7. This period represents the initial fertilization time for establishing planktonic food chains in the ponds and may have resulted in the higher N:P ratios reported later in the study.
2) Once nitrogen and phosphorus results were sent to Willow Creek Aquaculture (beginning May 9, 2002), the quantity of fertilizer added to the ponds exceeded the necessary amount and resulted in higher N:P ratios than what was proposed in the project description (30:1). This may have influenced to composition of algal species that developed in the ponds and consequently altered the planktonic food chain.

- **What would you do differently?**

I would have established stricter guidelines on the application of fertilizer to the ponds based on the results of the water chemistry analysis. Traditional application of fertilizer is based on a trial-and-error approach and is measured based on the transparency of the water (secchi disk depth). Farmers often apply fertilizer based on the shade of green that develops in the pond. The precise measurement of nitrogen and phosphorus in the water should provide a better means to apply fertilizer to the ponds. With a short 24-hour turnaround on water chemistry analysis, a farmer should be able to apply the exact amount of fertilizer needed to maintain a N:P ratio of 30:1 for 10 weeks.

What were you able to accomplish?

Weekly visits to Willow Creek Aquaculture resulted in a detailed record of water temperature, dissolved oxygen, pH, secchi depth (transparency), alkalinity, and water hardness (Figures 1a-b and Tables 1a-b). Figures 1a-b showed the effect that the atypical spring weather had on the water temperature, especially during spawning season in late April and early May. Table 1a-b showed the secchi depth (transparency) frequently used by fish farmers to determine fertilizer application. Once fertilizer treatment halted in mid-June, transparency doubled in fish culture ponds.

The pond fertilization schedules (Tables 2a-b) showed the effect that fertilizer application had on the nitrogen and phosphorus levels in the fish culture ponds. Weekly application of fertilizer resulted in nitrogen and phosphorus levels rising throughout the application period. Once applications halted in mid-June, the N:P ratios rapidly declined to below the recommended levels of 30:1. These results show that weekly monitoring of N:P ratios at fish culture ponds can be accomplished, but that application levels must be adjusted often so that a ratio of 30:1 is consistently maintained throughout the larval and post-larval growth stages. The use of nitrogen and phosphorus testing (water chemistry) should supercede the use of transparency (secchi disk) as an indicator of appropriate fertilizer application. What appeared to be the proper "green-water" shade based on transparency for maximum plankton density (May 9 – June 6) actually greatly exceeded the recommended N:P levels of 30:1 and only when fertilizer application was suspended in Pond A did N:P ratios eventually approach the recommended level (June 27 & July 3).

Growth of larval yellow perch (Figures 2a-b) was initially slow until early June when water temperatures rose above 70°F. Variation in growth increased in June and July indicating that not all yellow perch were growing at the same rate. This may result in an increase in cannibalism, which was observed in diet analysis. It also coincides with an increase in occurrence of empty yellow perch stomachs, which may indicate that growth differences are a result in water temperature and food acquisition in culture ponds.

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Algal diversity remained high during the study (Figures 3a-b), with abundant populations of both *Chlorophyta* (green algae) & *Ochrophyta* (diatoms). Algal density peaked in mid-June coinciding with the greatest secchi disk depth (Figure 4). Cyanobacteria and filamentous green algae, both unfavorable algal types, appeared in samples in early and mid-June and may have benefited from the high nutrient levels in the ponds.

Successional changes occurred in both phyto- and zooplankton communities in the culture ponds. Nanno-plankton (<80 *u*m) succession (Figures 5a-b) consisted of copepod nauplii, *Keratella* & abundant free-floating plankton eggs in May; ostracods, *Keratella*, *Kellicottia*, & plankton eggs in early June & *Polyarthra*, *Kellicottia*, *Brachionus*, *Notholca*, & *Lecane* co-dominating the plankton in July. Net plankton (>80 *u*m) was composed of *Brachionus*, young ostracods, & plankton eggs in April (Figures 6a-b). Various copepods appeared in late April & were replaced by ostracods, *Bosmina*, & *Keratella* in May. *Asplanchna* and *Daphnia* appeared in lower densities in mid-May. Ostracods, *Bosmina* & *Keratella* were present in early July, but at lower densities.

Larval perch selected plankton eggs, *Keratella*, *Bosmina*, copepod nauplii, and young ostracods in May & continued feeding on similar prey in June (Table 3a-b). Post-larval perch shifted to ostracods and benthic invertebrate larvae (*Diptera*, amphipods, *Odonata* & *Coleoptera*) in early July. Cannibalism appeared in late June and feed-trained perch were noted by early July. In one pond, post-larval perch fed heavily on *Closterium* (an algae) in late June and early July. This coincided with the peak abundance of *Closterium* in the phytoplankton and may indicate that the perch were prey deprived during this period, since herbivory is not widely seen in yellow perch. The number of yellow perch fry with empty stomachs increased in late June and may also indicate that suitable prey density was not high enough to support the density of yellow perch and that not all yellow perch were accepting feed during the feed-training period.

Rank preference analysis (Figures 7a-b) showed that larval and post-larval yellow perch actively selected ostracods, plankton eggs, *Bosmina*, *Closterium*, and young copepods (nauplii and copepodites) during the ten-week pond culture period. These prey were actively sought by the yellow perch even when they were at low densities in the ponds. Therefore, these prey can be considered favored at certain times during the pond culture period of May to July.

What challenges did you face?

Initially, we had hoped to collect water samples twice a week and fertilize the ponds immediately thereafter. It proved too difficult to sample and fertilize twice weekly, so we adjusted the schedule to once a week. Also, the weather in spring 2002 proved to be erratic and atypical. April was colder than normal with one week of very warm weather that triggered the yellow perch to spawn. Then, a late April snowfall and cool May resulted in slow perch growth. The combined effect of cold weather, difficulty in determining phosphorus levels in the ponds and imprecise application of fertilizer may have contributed to low survival of the yellow perch fry.

What do you plan to do in the future as a result of this project?

The results of this project are being shared with both fisheries biologists and aquaculturists. The results are being presented at the Percis III international conference in Madison, WI (July 20 – 24, 2003). The results will also be shared with WI aquaculturists at the Wisconsin Aquaculture Industry Advisor Council and the WI Aquaculture Association at their quarterly and annual meetings, respectively.
The results of this project have also been applied to two research projects that are using the food chain results to improve yellow perch production. I am currently conducting a project examining the use of

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floating raceways in cranberry reservoirs to raise yellow perch fry and feed-trained fingerlings. Results from this project have helped us readily identify prey present in the cranberry reservoirs and use for comparison when conducting water chemistry analysis.
I have also submitted a proposal to WI Sea Grant to expand this project to two other fish farms where we will fertilize the ponds at four different levels in an attempt to determine the appropriate prey density and composition for improving larval perch production.

How should the agricultural industry or the State of Wisconsin use the results from your grant project?
For this study, plankton & water samples were collected weekly from yellow perch culture ponds. Yellow perch were collected, measured & diet selection determined. Information about weekly plankton succession, nutrient levels, & yellow perch diet composition were compared to better understand the trophic cascade & assist aquaculturists in proper pond management.

Larval and post-larval yellow perch showed distinct diets shifts that did not always match successional changes in plankton composition & abundance. Diets relied heavily on ostracods, *Bosmina*, and plankton eggs, but mouth gape limitations may inhibit the perch from feeding on all prey available. Larval yellow perch required young ostracods and *Bosmina*, but rank preference analysis showed that they were not always available. Previous studies showed that young yellow perch favor rotifers (such as *Brachionus* and *Asplanchna*) and these types of plankton should be enhanced in culture ponds early in the growing season. This study showed that other prey (young ostracods, small *Bosmina*, and plankton eggs) were selected more often by foraging young yellow perch and that fish pond management in Wisconsin may have to be adjusted to enhance their abundance in culture ponds.

Water chemistry analysis also showed that the traditional approach of using transparency (secchi disk depth) as an indicator of fertilization level in fish ponds may not provide an accurate account of nitrogen and phosphorus levels. Individual perception of “green-water” shades may result in over-fertilization of the ponds and promote the growth of unfavorable algal types and plankton composition. Analyses of water samples for ammonia (NH_3), nitrate (NO_3), and phosphorus (PO_4) are a more accurate measure of nutrient levels and may assist the farmer in establishing and maintaining appropriate N:P ratios of 30:1. This may help increase the density of desirable prey types and improve the production of yellow perch fry. Money saved from not over-fertilizing the ponds can be used to accurately test the water for nitrogen and phosphorus and better manage the ponds for increased production.

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Table 1a. Water characteristics from Pond A.

Date	pH	Secchi Depth (feet / meters)	Alkalinity (ppm)	Hardness (ppm)
4/11	8.04	1.31 / 0.4	171.2	308.1
4/18	8.22	1.97 / 0.6	154.1	256.8
4/25	8.12	0.98 / 0.3	171.2	273.9
5/2	8.50	1.64 / 0.5	171.2	256.8
5/9	8.51	1.64 / 0.5	154.1	222.5
5/16	8.20	1.31 / 0.4	154.1	239.7
5/23	8.83	1.96 / 0.6	154.1	222.5
5/30	8.86	0.98 / 0.3	154.1	239.7
6/6	8.48	1.64 / 0.5	136.9	222.5
6/13	8.69	2.62 / 0.8	154.1	222.5
6/20	8.72	2.62 / 0.8	171.2	273.9
6/27	8.29	2.62 / 0.8	171.2	273.9
7/3	8.56	1.97 / 0.6	136.9	239.7
7/11	8.45	1.97 / 0.6	136.9	222.5

Table 1b. Water characteristics from Pond B.

Date	pH	Secchi Depth (feet / meters)	Alkalinity (ppm)	Hardness (ppm)
4/11	7.60	1.31 / 0.4	154.1	205.4
4/18	8.08	1.64 / 0.5	171.2	239.7
4/25	7.64	1.31 / 0.4	222.5	239.7
5/2	8.31	3.94 / 1.2	136.9	256.8
5/9	8.53	4.92 / 1.5	136.9	222.5
5/16	8.23	5.91 / 1.8	154.1	239.7
5/23	8.56	5.25 / 1.6	154.1	273.9
5/30	8.37	5.25 / 1.6	154.1	239.7
6/6	7.82	9.84 / 3.0	154.1	239.7
6/13	8.46	3.28 / 1.0	154.1	239.7
6/20	7.72	4.10 / 1.3	188.3	222.5
6/27	7.60	4.27 / 1.3	171.2	256.8
7/3	7.87	3.94 / 1.2	171.2	239.7

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Table 2a. Pond fertilization schedule showing fertilizer applied (urea-N and phosphoric acid) and measured nitrogen (NH_3-N and NO_3-N) and phosphorus (PO_4-P) levels in Pond A.

Date	Urea-N (lbs)	Phosphoric acid (oz)	PO_4-P (*u*g/L)	NH_3-N (*u*g/L)	NO_3-N (*u*g/L)	N:P Ratio
4/23	25	15				
4/25						
5/1	25	15				
5/2						
5/7	25	14				
5/9			4	30	0	12:1
5/14	30	14				
5/16			7	20	333	50:1
5/20	15	6				
5/23			7	40	533	82:1
5/28	0	11				
5/30			4	120	133	63:1
6/6			7	280	133	59:1
6/13			13	50	200	19:1
6/20			21	0	233	11:1
6/27			19	40	433	25:1
7/3			11	40	300	31:1

Table 2b. Pond fertilization schedule showing fertilizer applied (urea-N and phosphoric acid) and measured nitrogen (NH_3-N and NO_3-N) and phosphorus (PO_4-P) levels in Pond B.

Date	Urea-N (lbs)	Phosphoric acid (oz)	PO_4-P (*u*g/L)	NH_3-N (*u*g/L)	NO_3-N (*u*g/L)	N:P Ratio
4/23	25	15				
4/25						
5/1	25	15				
5/2						
5/7	35	14				
5/9			6	0	233	39:1
5/14	35	14				
5/16			13	20	366	30:1
5/20	12	10				
5/23			10	30	1300	133:1
5/28	0	11				
5/30			20	170	100	14:1
6/6			20	80	100	9:1
6/13			27	20	166	7:1
6/20			14	10	166	13:1
6/27			21	20	366	18:1
7/3			21	0	333	16:1

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Table 3a. Diet items of yellow perch from Pond A.

	Date									
Diet Items	**5/9**	**5/16**	**5/23**	**5/30**	**6/6**	**6/13**	**6/20**	**6/27**	**7/3**	**7/11**
N	50	50	50	50	30	50	50	50	50	50
# Empty	0	0	3	3	0	5	27	14	17	5
Plankton eggs	1.28	3.20	2.34	42.38	88.77					
Brachionus	0.36	0.16		0.16						
Daphnia	0.34	0.10	0.14	0.36						
Keratella		4.00	10.88	63.06	86.90					
Kellicottia		0.20	0.58	0.36					0.02	
Bosmina	0.54	0.44	0.36	1.64	0.57		0.04	0.08	0.44	
Ostracods	0.16	4.76	21.06	34.98	10.47	0.76	0.76	7.58	3.24	1.02
Copepodite		0.04								
Misc					0.73	0.20	0.30			
Diptera						1.92		0.12	0.10	
Chironomid						0.10	0.02	0.04	0.02	
Odonata / Amphipoda/ Coleoptera						0.22	0.02		0.10	
Fish parts								X (3)	X (5)	
Fish food							X (1)	X (2)	X (3)	X (41)

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Table 3b. Diet items of yellow perch from Pond B.

	Date									
Diet Items	**5/2**	**5/9**	**5/16**	**5/23**	**5/30**	**6/6**	**6/13**	**6/20**	**6/27**	**7/3**
N	50	50	50	50	48	50	50	50	50	50
# Empty	0	1	5	1	1	0	6	22	23	18
Yolk sac feeding	50	14								
Nauplii		1.80	0.20	0.42						0.04
Copepodite / Cyclopoid copepod		0.46 / 0.00	1.42 / 0.00							0.00 / 3.00
Plankton eggs		0.32	0.02			1.56	2.23		1.63	3.09
Bosmina		0.14	1.35	18.14	32.83	23.32	0.02	2.50		
Keratella				0.18	0.60					
Daphnia / Ceriodaphnia				0.48 / 0.00	1.98 / 3.56	0.00 / 11.06	0.06 / 0.00			
Closterium			0.06			0.02	4.73	0.02	23.66	36.06
Chydorus					0.04		2.39			
Misc						0.08	0.02		0.14	0.14
Chironomid						0.08	0.08	0.02		0.30
Ostracods							11.02	1.50	6.88	2.94
Fish parts										X (2)
Fish food								X (6)		X (1)

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Figure 1a. Surface Temperature and Dissolved Oxygen of Pond A

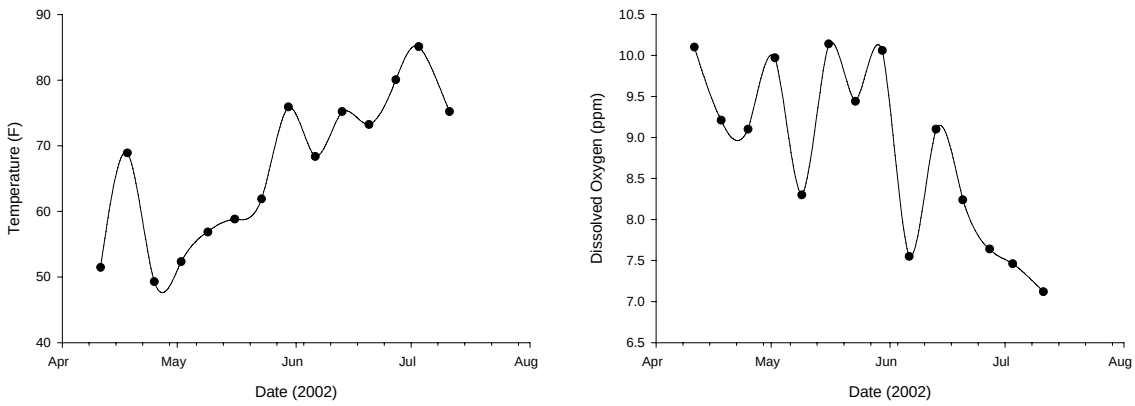

Figure 1b. Surface Temperature and Dissolved Oxygen of Pond B

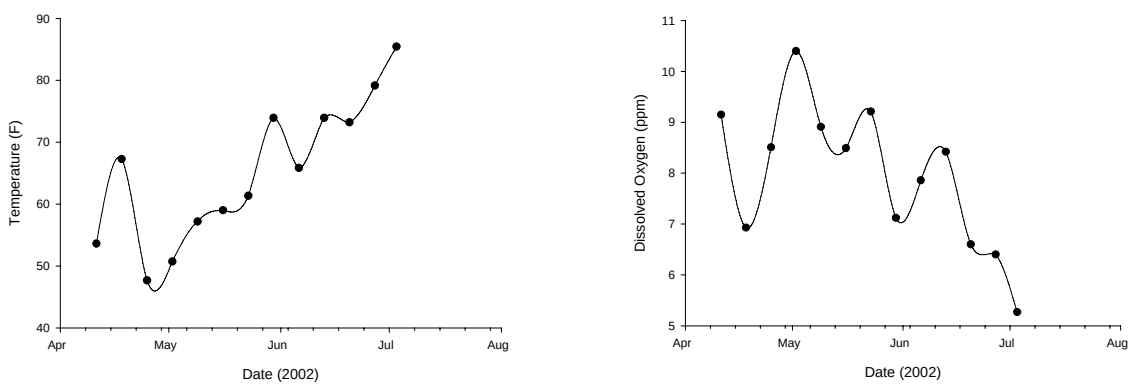

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Figure 2a. Total Length and Wet Weight of Larval Yellow Perch in Pond A

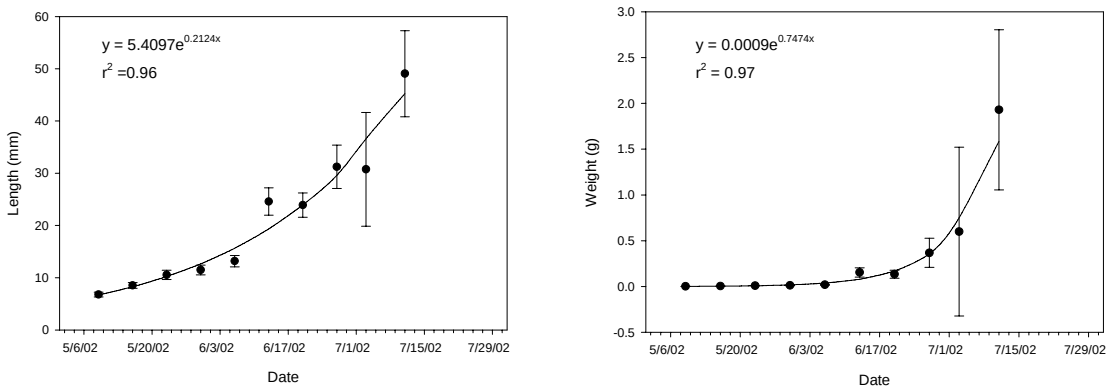


Figure 2b. Total Length and Wet Weight of Larval Yellow Perch in Pond B

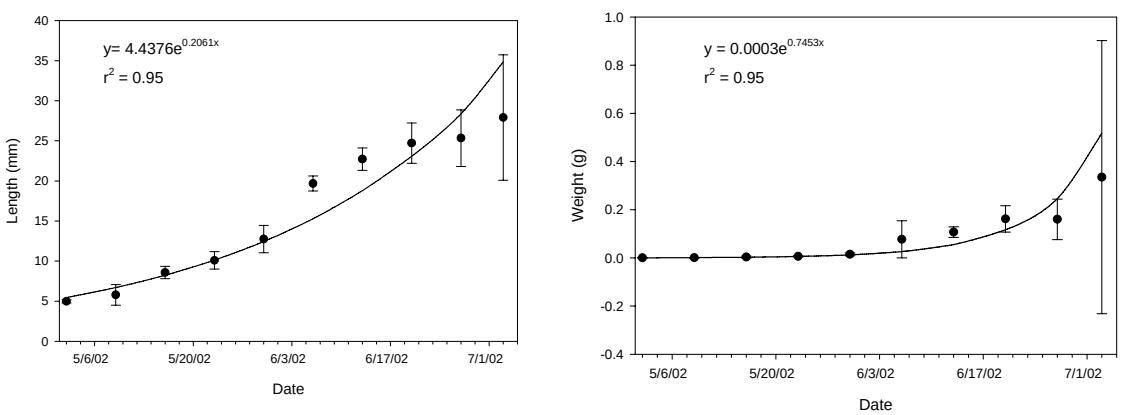
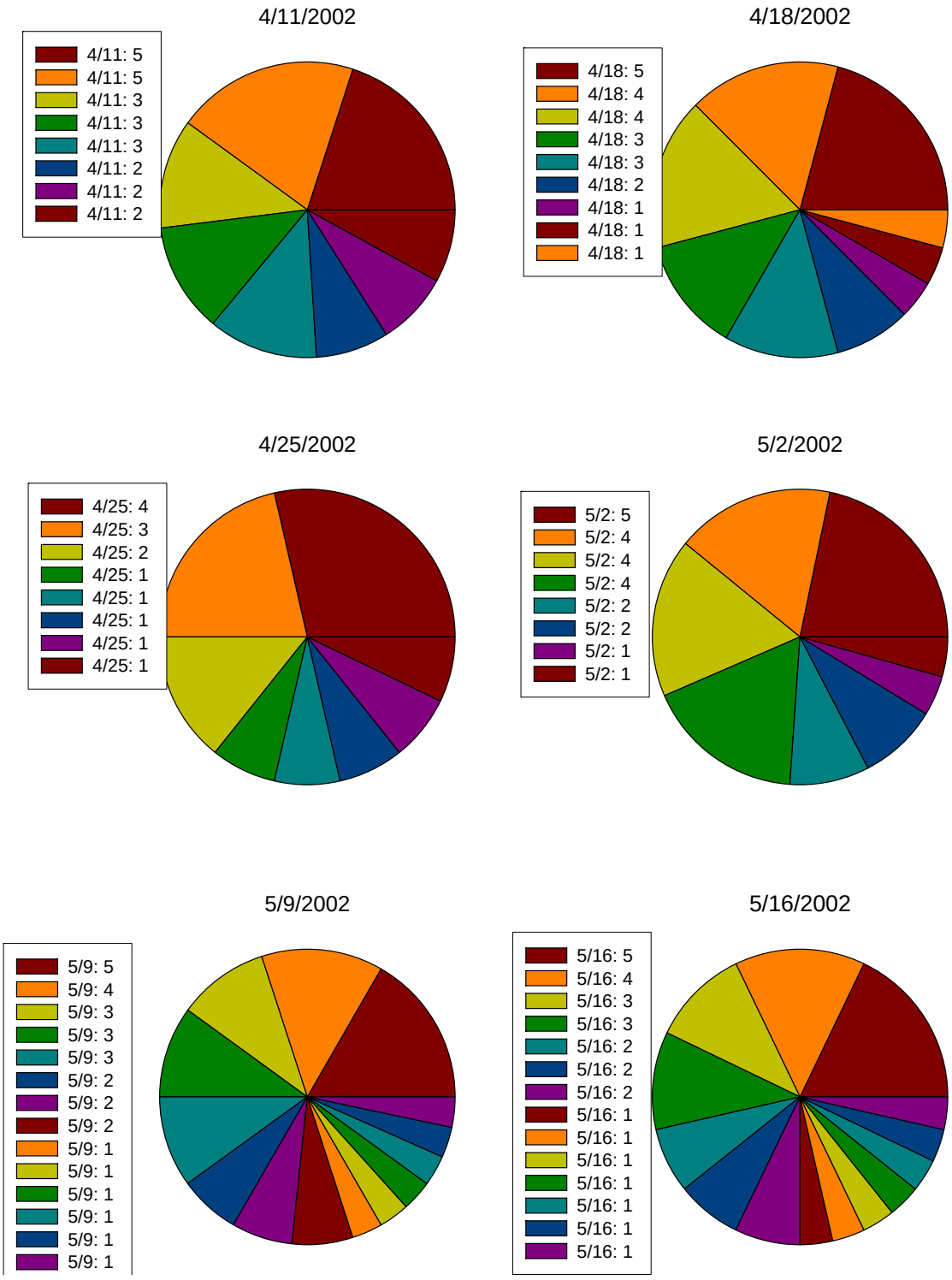


Figure 3a. Algal Composition and Ranked Abundance in Pond A



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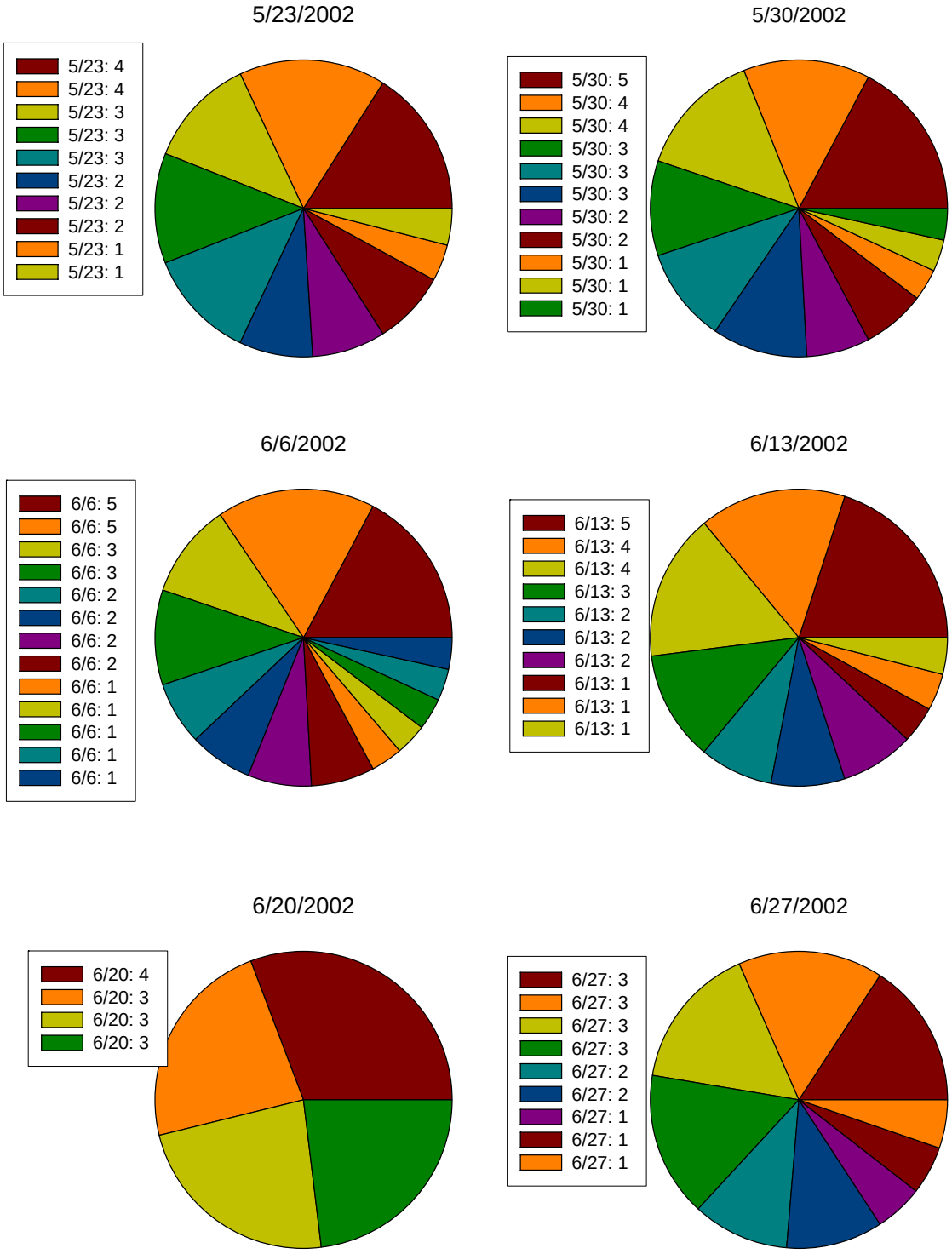

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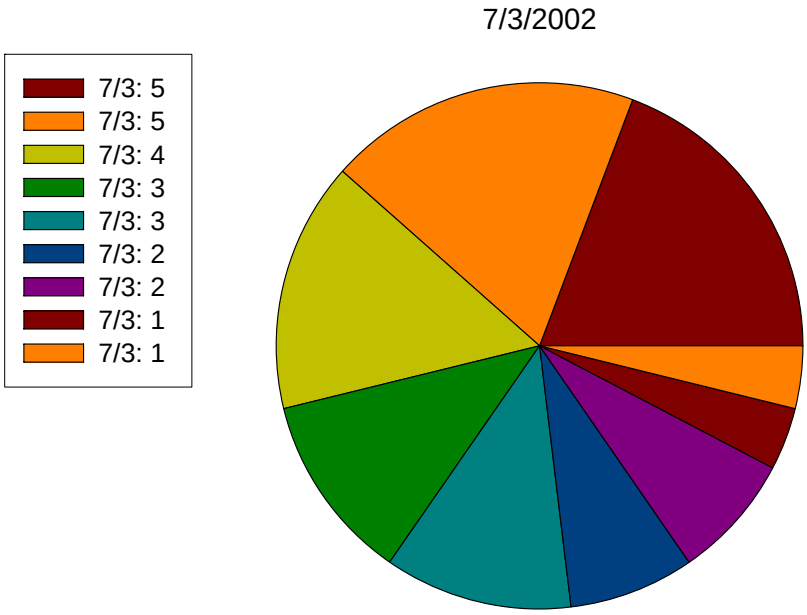

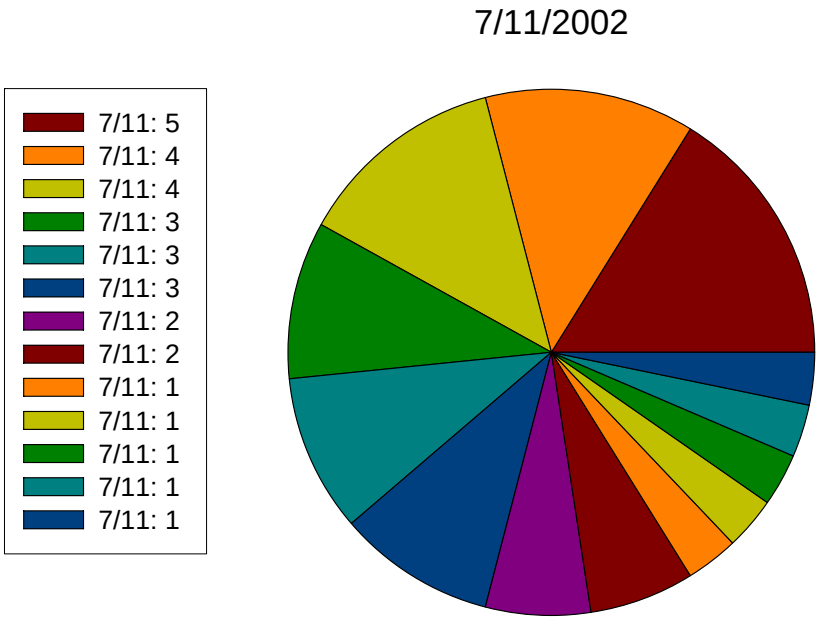

Figure 3b. Algal Composition and Ranked Abundance in Pond B

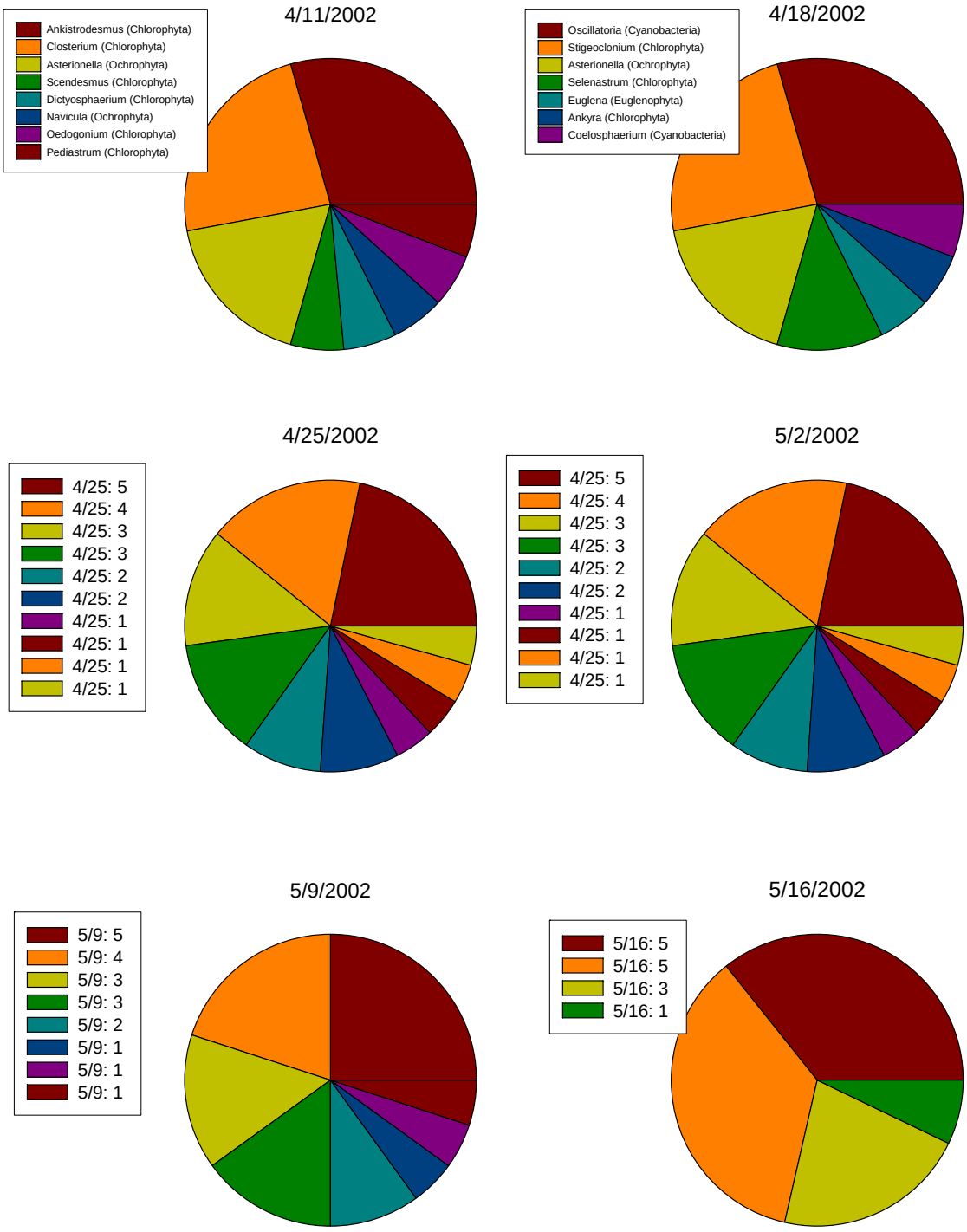

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Figure 3b. Algal Composition and Ranked Abundance in Pond B

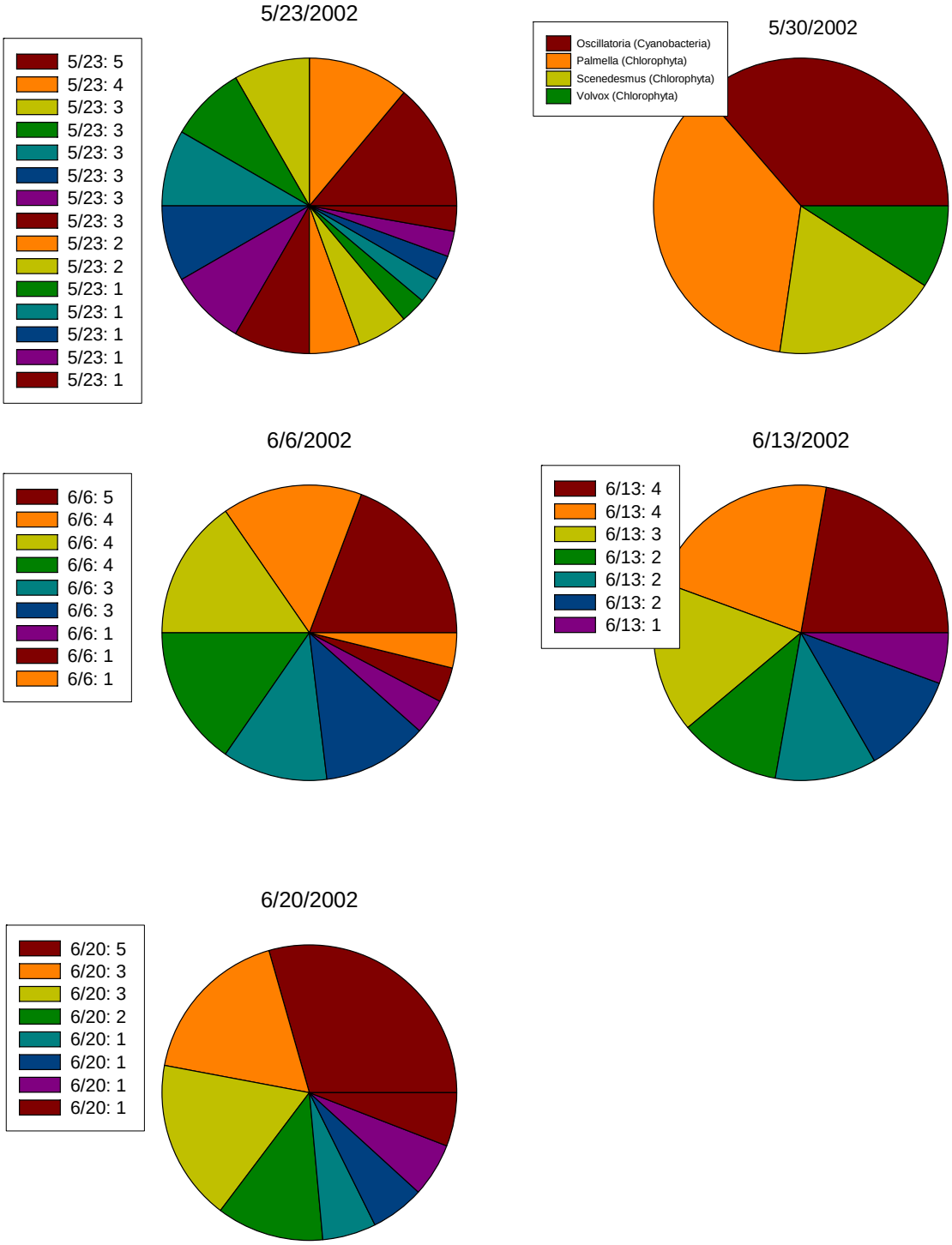

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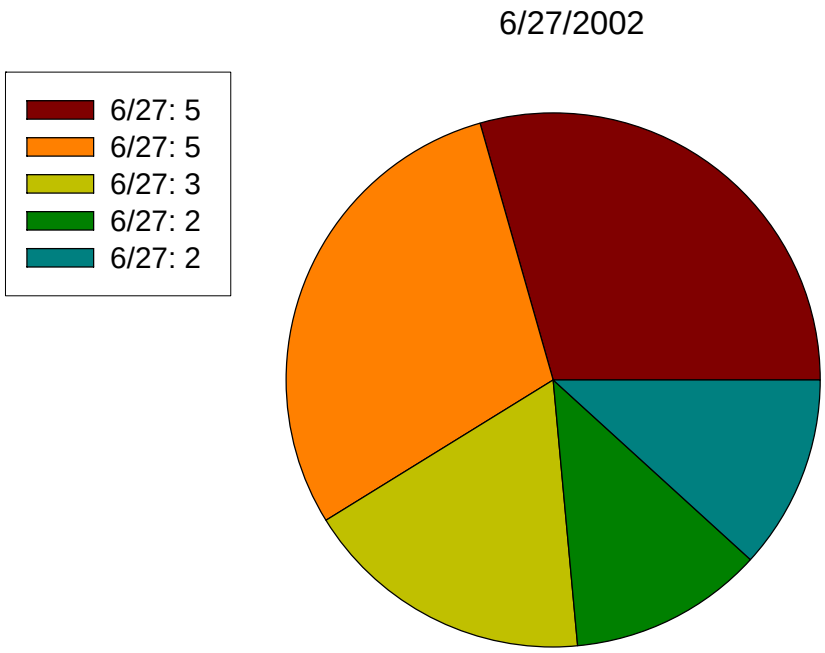
Figure 3b. Algal Composition and Ranked Abundance in Pond B



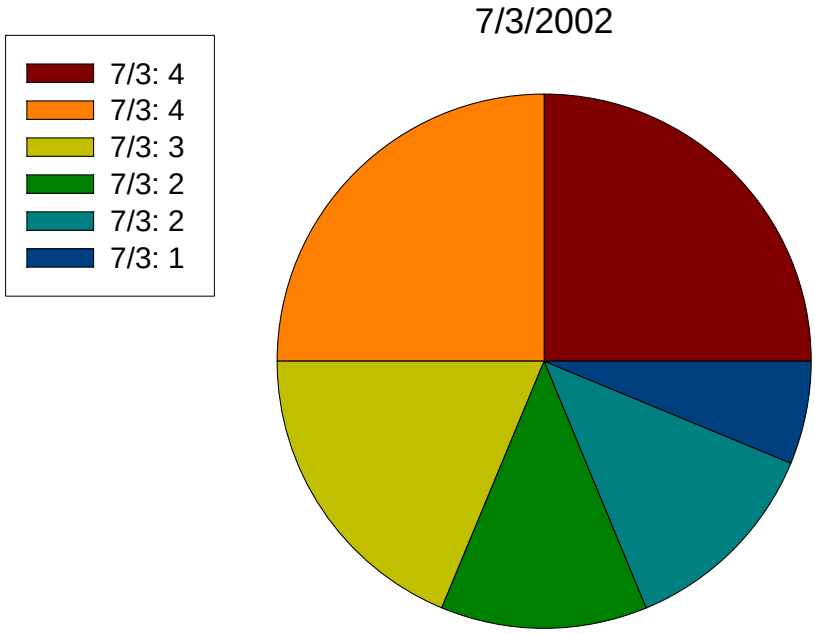


Figure 4. Pond A Chlorophyll *a* Concentration

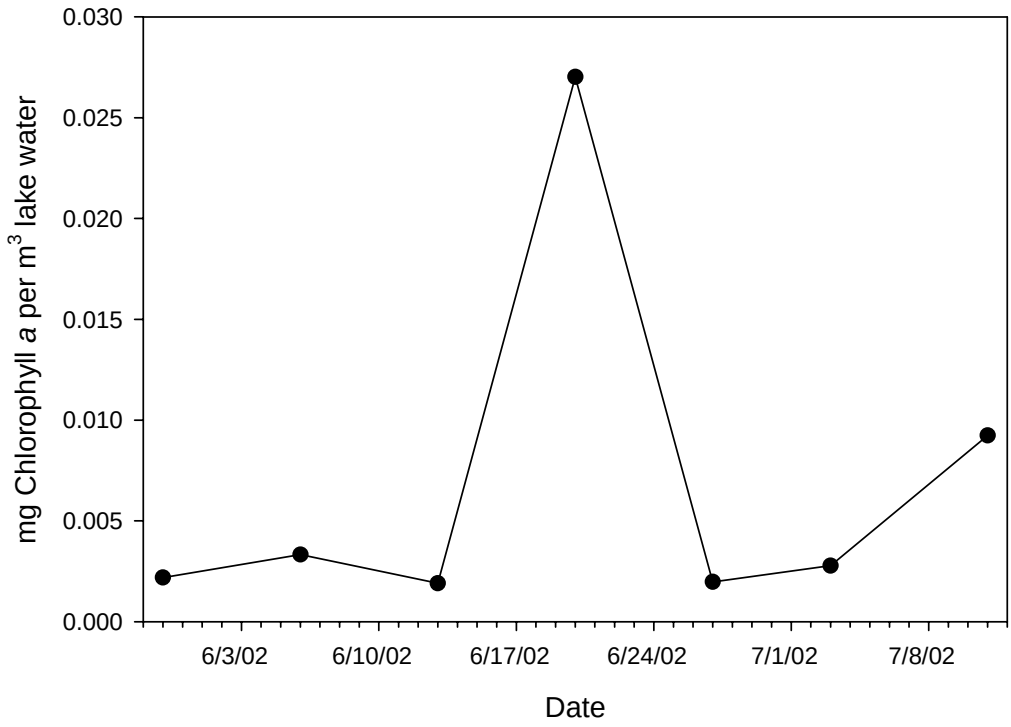


Figure 4. Pond B Chlorophyll *a* Concentration

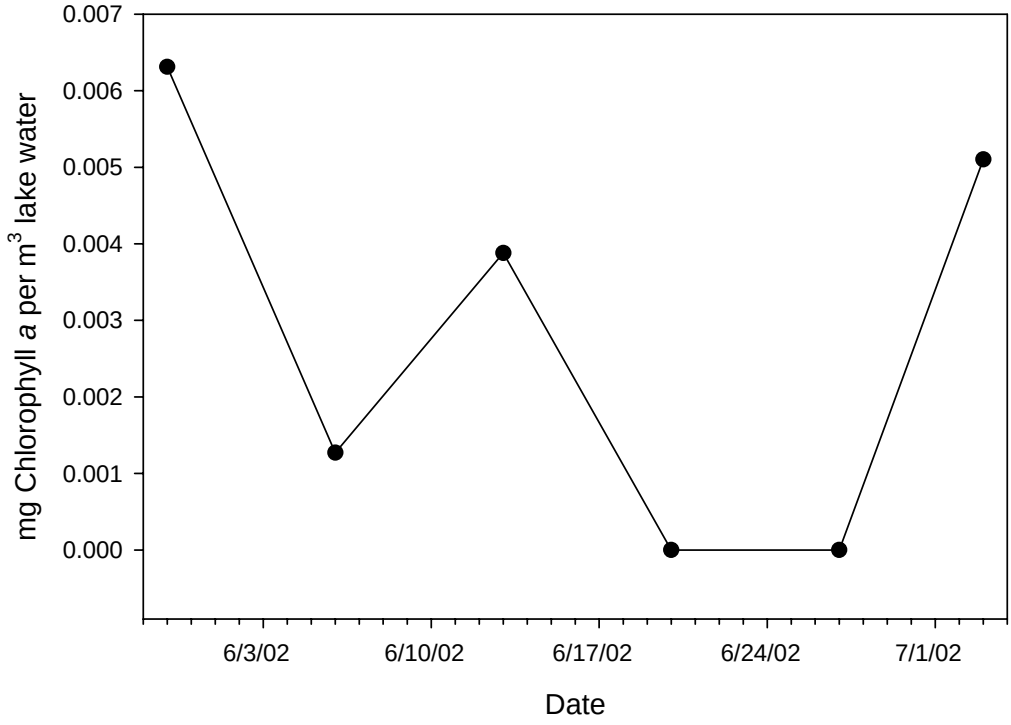


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Figure 5a. Pond A Nannoplankton Composition and Abundance

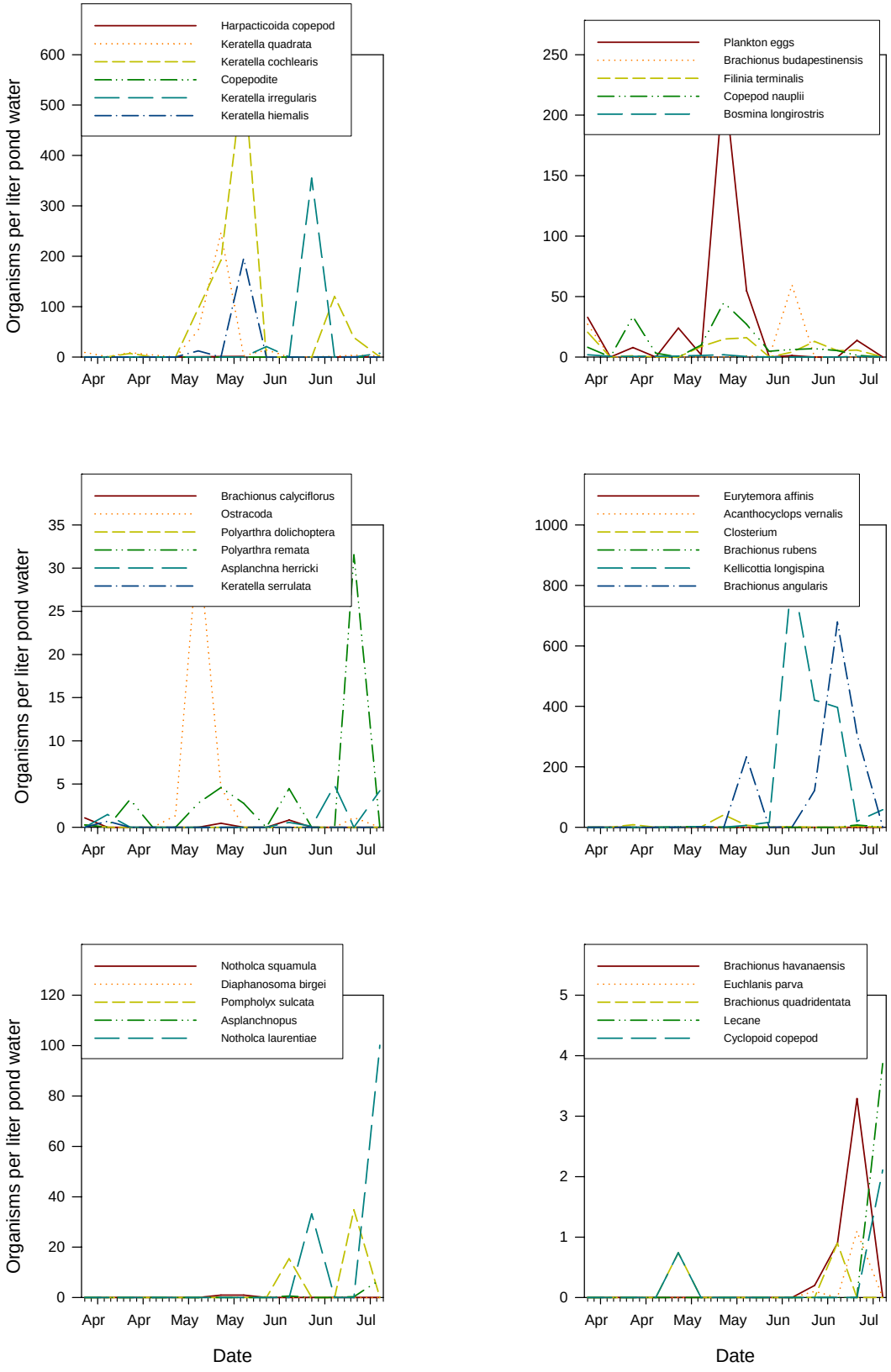

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Figure 5b. Pond B Nannoplankton Composition and Abundance

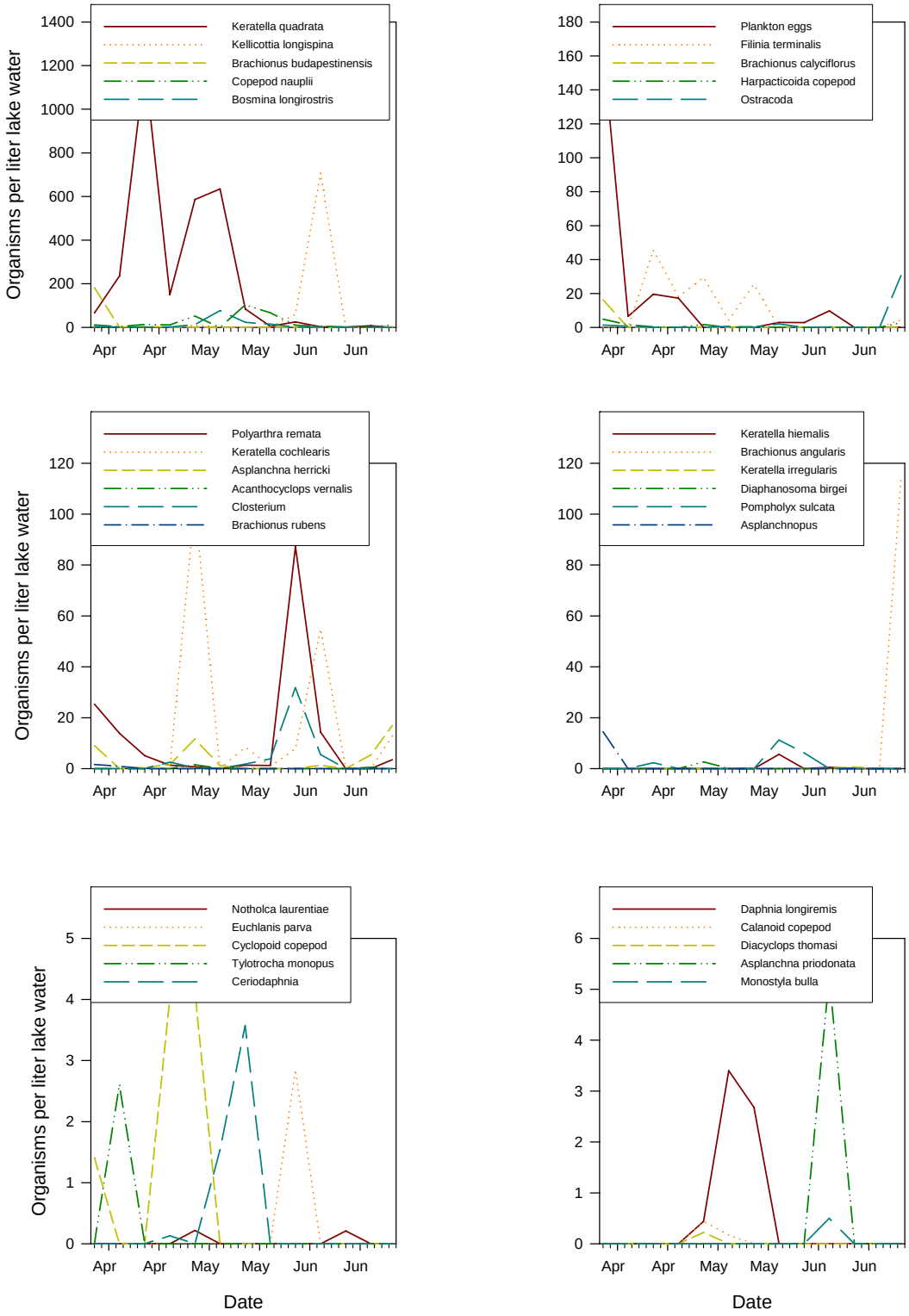

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Figure 6a. Pond A Net Plankton Composition and Abundance

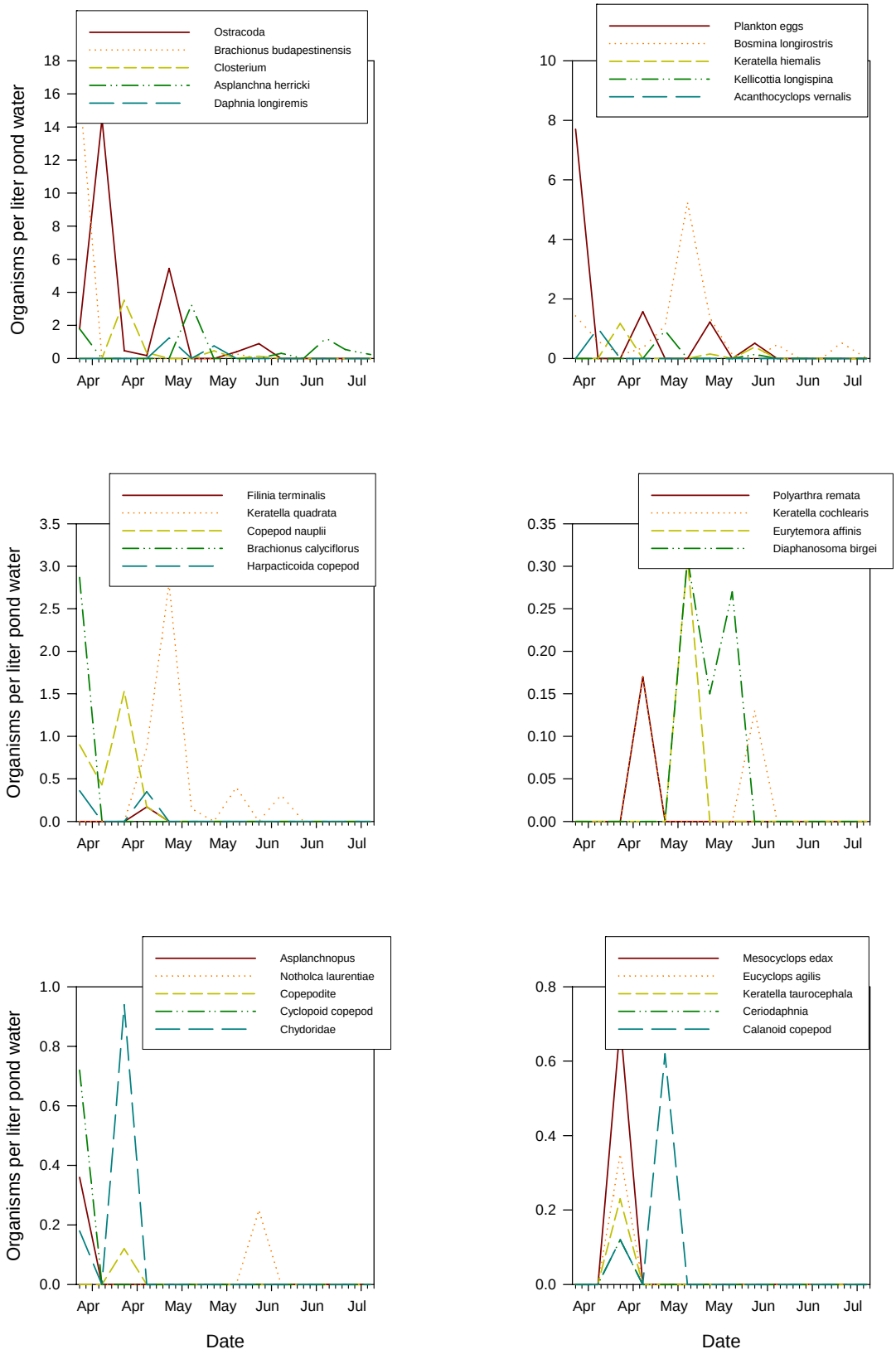

Figure 6b. Pond B Net Plankton Composition and Abundance

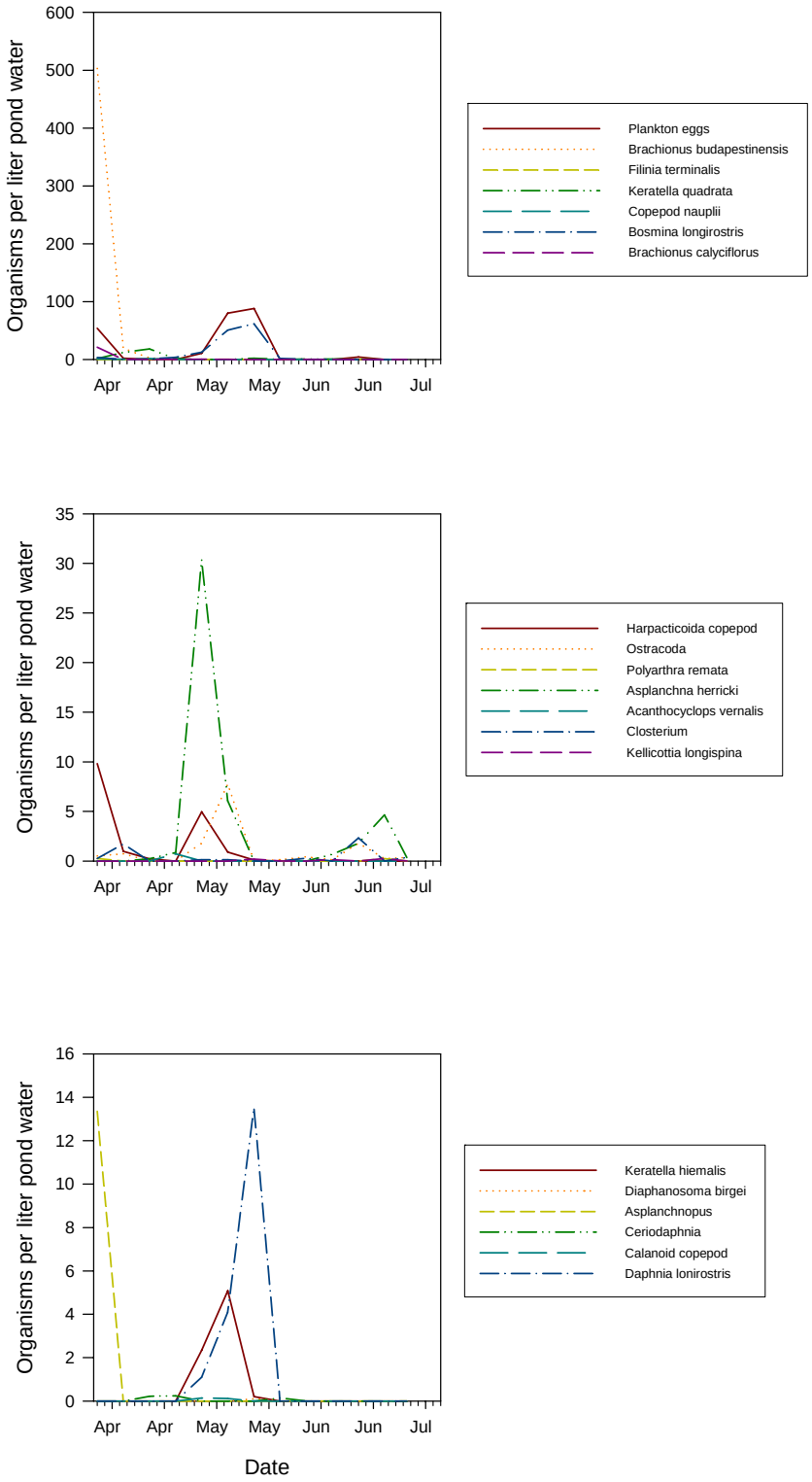

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Figure 7a. Rank Preference Index for Planktonic Prey Consumed by Yellow Perch in Pond A (Lower values indicate the prey were preferred and actively sought)

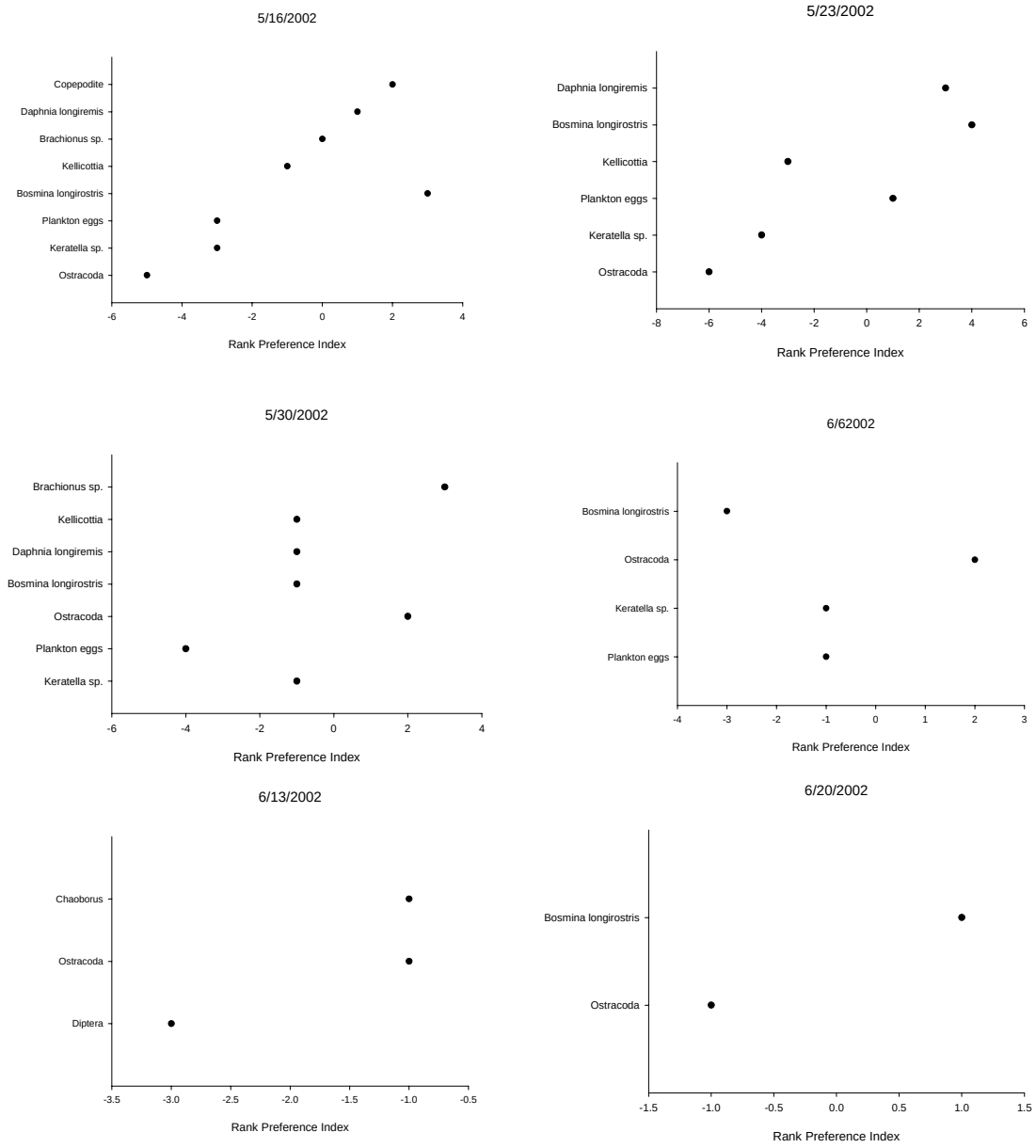

Figure 7a. Rank Preference Index for Planktonic Prey Consumed by Yellow Perch in Pond A (Lower values indicate the prey were preferred and actively sought)

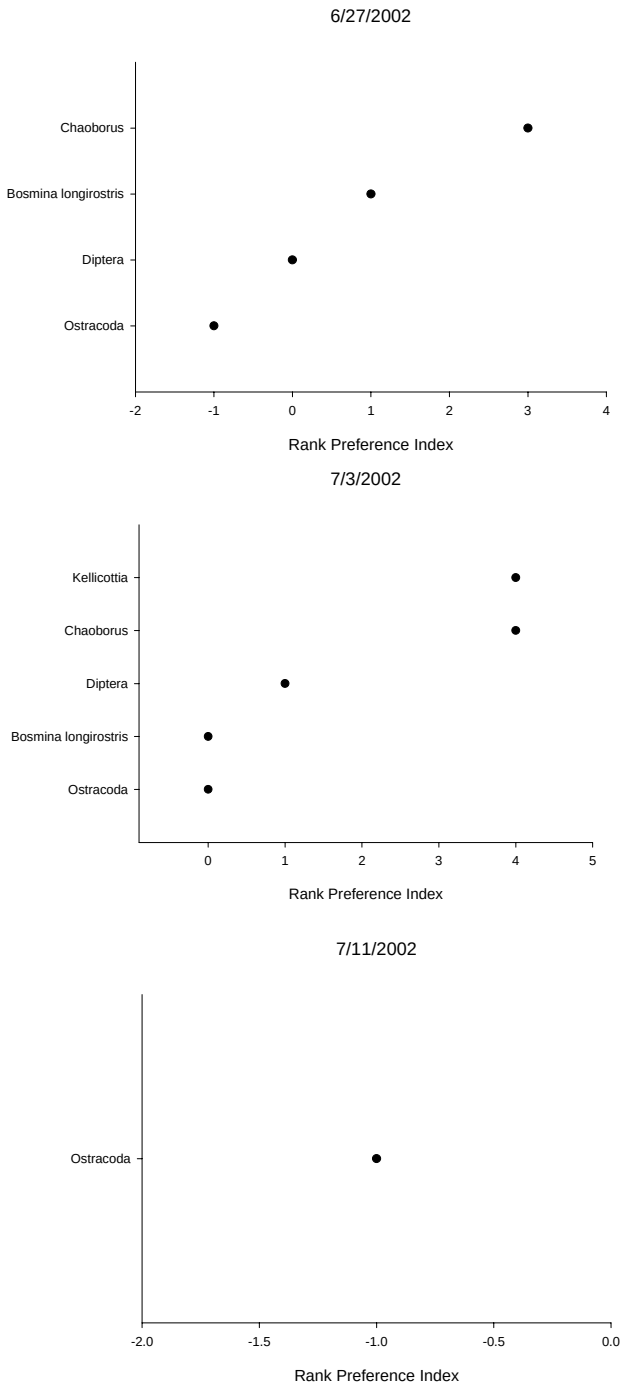

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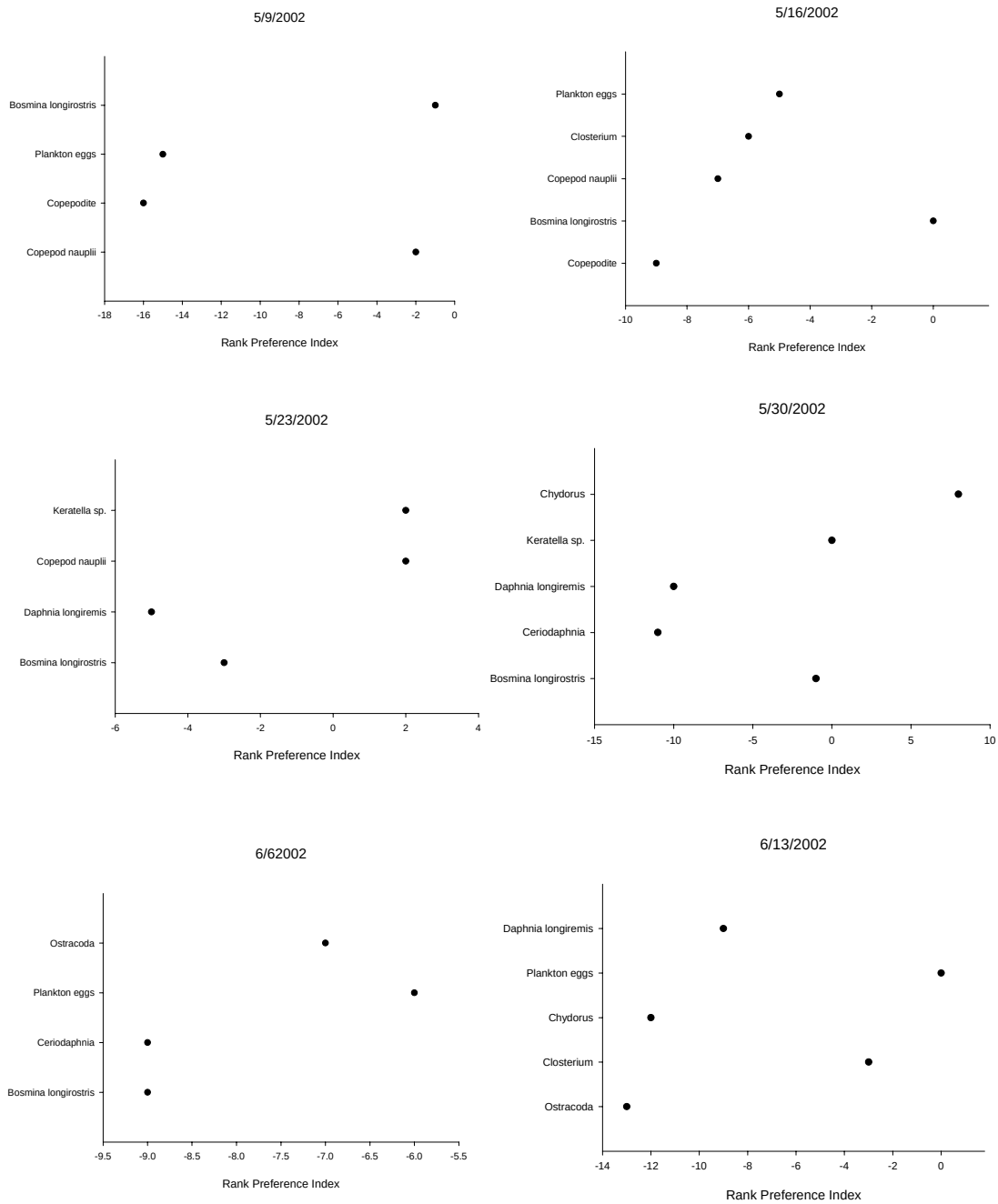
Figure 7b. Rank Preference Index for Planktonic Prey Consumed by Yellow Perch in Pond B (Lower values indicate the prey were preferred and actively sought)



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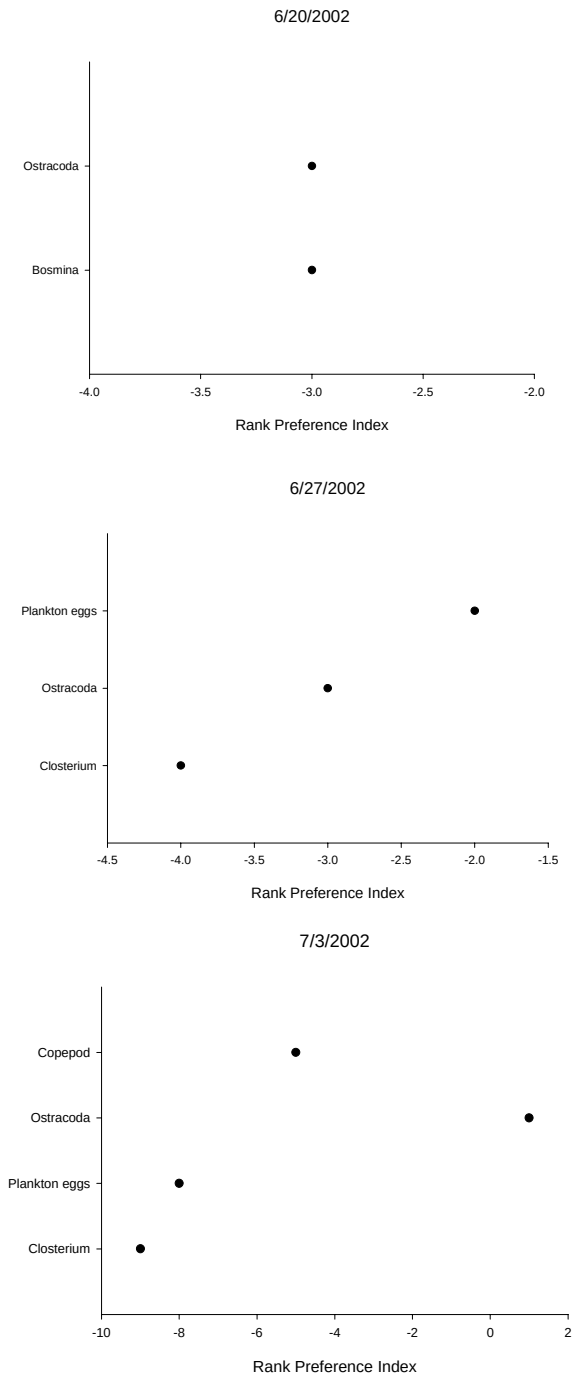
Figure 7b. Rank Preference Index for Planktonic Prey Consumed by Yellow Perch in Pond B (Lower values indicate the prey were preferred and actively sought)