Fort Belvoir Aquatic Studies
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Final Report

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To

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Bioassessment of Stream Reaches: Baseline and Long-term Monitoring

I. Introduction

The goal of this portion of the project was to provide baseline information on the health of flowing stream communities at Fort Belvoir. Bioassessment was selected as a tool for determining long-term trends in base streams. Bioassessment has several attributes which make it an appropriate tool to examine stream quality. Biological communities reflect the overall ecological integrity of aquatic systems. They integrate the effects of different pollutant and habitat stressors and provide a holistic measure of aggregate impact. Routine monitoring of biological communties is relatively inexpensive compared with the cost of assessing toxic pollutants. The status of biological communities is also of direct interest to the public (Plafkin et al. 1989).

Fishes are good indicators of long-term effects and broad habitat conditions because they are relatively long-lived and mobile. Fish communities generally include a range of species representing several trophic strategies (omnivores, herbivores, insectivore, planktivores, piscivores). Fishes are at the top of the aquatic food chain and are consumed by humans. Fishes are relatively easy to collect and identify to the species level in the field. Fish life histories, environmental requirements, and distributions are fairly well known making results more interpretable. Fishes are certainly of great interest to the general public (Plafkin et al. 1989). The streams of Fort Belvoir are known to support good populations of fishes (Parsons, Brinckerhoff, Quade and Douglas 1973, 1975, 1976). Some 49 species of fishes have a geographic distribution which covers Fort Belvoir and live in small streams (Jenkins and Burkhead 1994, Jones and Kelso, 1998).

Macroinvertebrates are good indicators of localized conditions because of their limited migration ability and sessile nature. They integrate effects of intermediate-term (weeks to months) changes in environmental conditions. Sampling of macroinvertebrates does not require sophisticated equipment and these organisms are normally abundant in small streams. By sampling both fish and macroinvertebrates in this study we were able to cover a broad range of conditions.

II. Methods

Fish bioassessments were conducted using Rapid Bioassessment Protocol (RBP) V (Plafkin et al. 1989). The specific methodology utilized is described in the following sentences. At each site a 200 m reach containing riffles, runs, and pools was measured from a reference point such as a bridge crossing or other easily distinguishable landmark to serve as the sample area. Sampling was accomplished using backpack mounted battery-powered electroshocking gear in 50 m subreaches. Boundary nets were set at either end of the stream reach when the reach boundaries coincided with deep pools or a wide channel. Once collected, the fishes were measured to the nearest half cm (standard length) and identified to species. The incidence of hybrids and diseased or anomalous individuals was also noted before the fishes were released.

An Index of Biotic Integrity (IBI) was calculated using the RBP V procedure. This involves calculating metrics from the community composition data and comparing metric scores from the test sites to those for a local reference stream or regional benchmark. The reference stream or benchmark represents the best attainable environmental conditions for a specific stream type and general location (ecoregion).

In this study, two indices of biotic integrity were calculated for each sampling station. This was done because of the location of the sampling sites and the stream systems. The first index is based on work done in piedmont streams of Prince William County, Va. (Jones and Kelso 1997). The justification for using this index is that most of the watershed of Accotink and Pohick Creeks is located in the piedmont. The sampling stations are not far from the Fall Line, and several of the species collected are more typical of piedmont locations. The second index is based on work done in coastal plain streams of Maryland (Hall et al. 1993). The justification for using this index is that all three of the sampling stations are located in the coastal plain, and some of the species that were collected are more typical of coastal streams. The Dogue Creek watershed lies entirely in the coastal plain, although the northern and western edges have elevations around 200 feet above sea level. The metrics employed in RBP V for the two indices are shown in Tables 1 and 2. The only modification to the general IBI (Plafkin et al. 1989) made by Jones and Kelso (1997) was substitution of % generalists for % omnivores and % specialist for % insectivores. Hall et al. (1993) made changes in six of the orignial metrics. In each index, after the metrics were calculated, they were compared to the reference site or regional benchmarks. A value of 5, 3, or 1 was assigned to each of the sampling sites for each metric based on this comparison. These metric values were summed separately for each index to arrive at the IBI scores. Since there are 12 metrics and the highest score of each is 5 and the lowest score of each is 1, the maximum IBI value is 60 and the minimum IBI value is 12. The IBI scores were then used to assign an integrity class of excellent (58-60), good (48-52), fair (40-44), poor (28-34), or very poor (12-22) to each sampling test site.

Macroinvertebrates were collected using a 44 cm x 22 cm kick net. The net was held in areas of flowing water while substrates were disturbed upstream allowing dislodged animals to drift into the net. A variety of productive habitats were sampled at each site including organic debris, underwater plants, and gravel/cobble. A 20-30 m reach was sampled for a total of about 5 minutes. Total stream bottom sampled was 10-20 ft^2. At each site two separate reaches were sampled. Organisms collected were preserved in 5% formalin for later identification and enumeration. In the lab, all organisms were removed from the preserved sample and sorted into major taxonomic groups. For most groups all taxa were identified to family and enumerated. Oligochaetes and chironomids in some samples were so numerous that subsamples were enumerated and this value extrapolated to the whole sample.

There is currently no tested bioassessment protocol for coastal plain streams in Virginia. However, Maryland DNR has done an extensive survey of streams in their coastal plain and has produced a draft protocol (D.M Boward, Maryland DNR, personal communication). The sampling methodology was similar to that employed in the current study and we believe that the Maryland protocol constitutes a workable framework in which to analyze the Belvoir samples. Similar to other protocols, the Maryland index analyzes the macroinvertebrate collection at a site by calculating a set of metrics (Table 3). For the Maryland index there are seven metrics: family richness, EPT richness, mayfly richness, diptera richness, intolerant taxa richness, percent mayflies, and Maryland metric.

Habitat assessment was conducted using methods outlined in the EPA bioassessment document (Plafkin et al. 1989).

Fish and macroinvertebrates were sampled at three sites in 1997 (Figure 1): Accotink Creek at Poe Road (A@P), Pohick Creek about 1 km downstream of Colchester Rd.in managment area T9A (P@T9A), and Dogue Creek at Meers Road (D@M). Each site was sampled once in May. A@P and D@M were previously sampled in 1995. As stated above the reach for fish sampling was 200 m while the reach for benthic macroinvertebrates was 20-30 m. The two benthic reaches at each site were located within the fish reach. All sites were above the head of tide, but below the fall line which situates them on the coastal plain physiographic province. Concurrently collected data from sites above the Fall Line in Quantico Creek in Prince William County were used to establish reference conditions for the piedmont index. Quantico Creek has a watershed whose surface area is similar to that of Accotink Creek, and the creek also drains directly into the freshwater tidal Potomac. Because Quantico Creek has a forested watershed it is expected to represent optimal conditions for a piedmont fish community in this region. The benchmark used for the determination of the metric values of the coastal plain fish index was a synthesis of historic data on fish communities in Maryland coastal plain streams. The reference condition for the Maryland coastal plain macroinvertebrate index was established by examining 13 sites in less disturbed watersheds (D.M. Boward, Maryland DNR, personal communication).

III. Results

A list of the fish species that were collected in 1997 from each creek and the number of individuals of each are shown in Table 4.

At Accotink Creek at Poe Road, 188 fishes of 20 species were collected in May, 1997. The most abundant species was American eel, with 57 individuals. The second and third most abundant species were the banded killifish, which produced 25 individuals and the tessellated darter, with 24 specimens.

At Dogue Creek at Meers Road, 265 individuals in 18 species were collected in 1997. The most abundant species was bluegill, followed by spottail shiner and tessellated darter.

At Pohick Creek in Area T9, 330 individuals in 14 species were taken in 1997. the three most abundant species were, in decreasing order, banded killifish, American eel, and pumpkinseed.

Metric scores for both the piedmont IBI and the coastal plain IBI are found in Table 5 for all three stations. The piedmont IBI value calculated from these metrics for Accotink Creek was 34 (Poor), for Pohick Creek was 32 (Poor), and for Dogue Creek was 48 (good). The Coastal Plain IBI value calculated for Accotink Creek was 44 (Fair), for Pohick Creek was 40 (Fair), and for Dogue Creek was 46 (Fair/Good).

The results of macroinvertebrate sampling are shown in Table 6. A total of 21 insect families, 4 crustacean families, 5 mollusc families, and 4 other taxa were identified from the samples. Chironomids (midges) and oligochaetes (worms) were by far the most common taxa. Simulids (blackflies), aquatic sow bugs, and caenid mayflies were also abundant at some stations. The greatest number of families was found at the Dogue Creek site followed by Pohick and then Accotink. Pooling the data from both samples at each site made this trend even clearer. Unusual taxa of note were the freshwater shrimp (*Palaemonetes*) found in Dogue Creek and the stonefly (Nemouridae) observed in Accotink.

Metric calculations are shown in Table 7. Dogue Creek generally had higher metric values than the other two streams. The only exception to this was Intolerant Family Richness where Pohick scored slightly higher. Accotink Creek was consistently at or below the value of the other two creeks. Pohick Creek was intermediate. The overall Maryland Coastal Plain Index reinforced the trend observed in the individual metrics. Dogue scored 3.29, well within the Fair range. Pohick came in at 3.00, on the border between Fair and Poor, while Accotink was substantially lower, near the end of the Poor range.

Results of habitat assessment are shown in Table 8. Despite all being on the coastal plain, the sites differed from each other in numerous ways. The Accotink site was somewhat shaded and the stream was quite wide with rather deep pools and runs. The pH was rather low and the water was slightly turbid. The substrate had substantial components of cobble and gravel. Overall, the habitat score was highest of the three sites. The Pohick site was open, had a high conductivity, had a very limited amount of cobble and gravel, and had a chemical odor. This site had the lowest overall score. The Dogue site was also open, had a low DO, was turbid, and had an intermediate amount of cobble and gravel. This site had an intermediate overall score.

IV. Discussion

Fish collections were made in 1995 at Poe Road on Accotink Creek and at Meers Road on Dogue Creek. A comparison of the results of these samples with those made in 1997 at these same sites is shown in Table 4. In December, 1995, 1763 individuals were collected at the Poe Road site on Accotink Creek, but 1304 were in one species, the banded killifish. Eleven species which had been collected in 1995 were not collected in 1997 (goldfish, longnose dace, fallfish, common shiner, spottail shiner, creek chubsucker, northern hogsucker, mummichog, brwon bullhead, black crappie, and redbreast sunfish). Seven species which were taken in 1997 were not collected in 1995 (gizzard shad, rosyside dace, satinfin shiner, eastern silvery minnow, eastern mudminnow, white perch, and largemouth bass). Thus, the results of the two samples are very different. One major factor could have been the seasonal difference in the time of collections. Little is known about the movements of resident species of fishes within these creeks during the year. The populations of fishes in headwater tributaries are reduced during low flow periods and perhaps during very cold periods, also. The displaced fishes must move downstream, but how far is not known. Perhaps, in December, 1995, the collection included species and individuals that normally would live further upstream during the spring. Or perhaps the results simply reflect daily or weekly variations in the local populations of stream fishes.

Similar total abundances of individual fishes were collected in Dogue Creek at Meers Road in both 1995 and 1997. The most abundant species in both years was bluegill. However, 10 species were collected in 1995 and 18 species in 1997. Thus, eight new species were collected in 1997 (common shiner, swallowtail shiner, spottail shiner, eastern mudminnow, mummichog, largemouth bass, green sunfish, and yellow perch). There is no evidence here of movement of species down from headwater tributaries during November, 1995. Instead, there is perhaps a movement of species into the creek from the Dogue embayment during May, 1997.

The general geographic distributions of the species of fishes collected at the three stations in 1997 and at the two stations in 1995 are shown in Table 9. Of the 20 species collected in Accotink Creek in 1997, seven have geographic distributions which are generally in the piedmont (Jenkins and Burkhead 1994). Another seven species have distributions which are generally in the coastal plain. The final six species have distributions in both provinces. This represents a shift toward more coastal plain species than were collected in 1995, and implies that either the coastal plain IBI or the piedmont IBI could be considered for use at this station. The presence of piedmont species appears to artificially raise the coastal plain index (Jones and Kelso 1998), but the presence of coastal plain species may not have an elevating effect on the piedmont index. If this is true, then the piedmont index may still be better to use for the Accotink Creek station. This ranks the Biotic Integrity as poor, and represents a lower quality level than the fair ranking based on the 1995 collection. The ranking derived from the coastal plain index is also lower for the 1997 collection (fair) than it was for the 1995 collection (good).

Of the 18 species of fishes collected in Dogue Creek in 1997, eight have distributional affinities with the coastal plain and three are more typical of the piedmont (Table 10). The piedmont-related species were not collected in the 1995 samples. An additional seven species have distributions which are found in both provinces. The coastal plain index seems more appropriate to this creek and was chosen to be more applicable to the 1995 collection. The ranking based on the 1995 collection was fair. However, the three piedmont species collected in 1997 (swallowtail shiner, warmouth, and green sunfish) all contribute to metrics which raise the coastal plain index, even though they were not included in the studies which developed the coastal plain index (Hall et al. 1993). The 1997 coastal plain index ranks Dogue Creek as fair/good. The piedmont index rates the biotic integrity level as good. The capture of the larger number of species in 1997 raises the coastal plain index and also the piedmont index, which rated the site as poor in 1995 and good in 1997. In sum, we believe that the coastal plain index rank of fair to good is appropriate, but perhaps is a little over-rated.

Twelve species of fishes were collected in Pohick Creek in 1997. Of these, eight have distributions which predominate in the coastal plain, and six are typically found in both the coastal plain and the piedmont (Table 9). No typically piedmont species were collected. The coastal plain index rates the station on Pohick Creek as having fair biotic integrity. Earlier collections of fishes were made near this site on May 22, 1973 with seine nets (Parsons, Brinckerhoff, Quade and Douglas 1974). Only mummichog and common carp were collected below the outfall of the Lower Potomac Pollution Control Plant. Later examination of this section of Pohick Creek showed no evidence of any fishes until after the wastewater treatment plant began to secondarily remove the chlorine it added to its effluent to kill bacteria (Jones and Kelso, 1988). The current stydy indicates that the fish fauna in Pohick has improved noticeably since dechlorination was initiated.

The macroinvertebrate index generally ranks the sites as more degraded than do the fish indices. Dogue Creek is ranked as fair/good to fair by the fish indices and fair by the macroinvertebrate index. Pohick Creek is ranked as fair by the fish IBI and fair to poor by the macroinvertebrate index. Accotink Creek is ranked as poor by the fish IBI and poor by the macroinvertebrate index. The habitat assessment for the sites shows local evidence of stream degradation (Table 9). The Dogue Creek site had moderately low concentrations of dissolved oxygen, beaver ponds and channelization, and location in a residential area. The Pohick Creek site showed the lowest total RBP Index of Habitat, and high conductivity values. Accotink Creek, however, seems to have the highest quality habitat of the three sites. It appears that in these creeks, the ecological conditions in the watershed are more significant than the local habitat. It is important to note that many chemical and even physical factors of importance to the biota would require much more detailed sampling and analysis to adequately assess.

Macroinvertebrate collections indicate that Dogue Creek has the highest biological integrity of the three streams surveyed and Accotink Creek has the lowest. The Dogue Creek site contained a variety of habitats including gravel riffles, macrophytes, and organic debris. This diversity of habitats may have been responsible for the more diverse community observed.This is not to say that the other sites were deficient in habitat or that their habitats were obviously less diverse. Macrophytes and organic debris were observed at Pohick Creek and gravel riffles and organic debris were surveyed at Accotink Creek. Watershed processes may also explain the observed differences. The Dogue Creek watershed is located entirely on the coastal plain and contains a significant amount of park land (ex., Huntley Meadows Park), whereas the other watersheds contain a large amount of highly suburbanized piedmont. Watershed development has been shown to be a potent factor degrading stream macrobenthos communities (Jones and Clark 1987). No obvious agents of stream degradation were observed in the immediate vicinity of any of the sample sites other than the channelization which had occured historically at the Dogue

Creek site.

The condition of the three streams ranged from Fair to Poor using the Maryland Coastal Plain Macroinvertebrate Index. Differences in sampling protocols between the current study and Maryland DNR do not appear to be sufficient to explain the suboptimal scores observed. This indicates that all streams are degraded relative to the best streams in the mid-Atlantic coastal plain. Although not all reaches of each stream within the base were walked, the observed degradation appears to be due mainly to activities upstream from Fort Belvoir. It is interesting to note that Pohick Creek was less degraded than Accotink Creek even though the former receives large quantities of treated effluent from the Noman Cole Pollution Control Plant (formerly Lower Potomac) operated by Fairfax County. This suggests that nonpoint pollution from suburban areas farther upstream is the prime degrading factor. This hypothesis is consistent with a stronger effect on Accotink which has a larger and more heavily developed watershed than Pohick.

Literature Cited

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Figure 1. Location of Sample Sites for Fish and Macroinvertebrate Bioassessment.

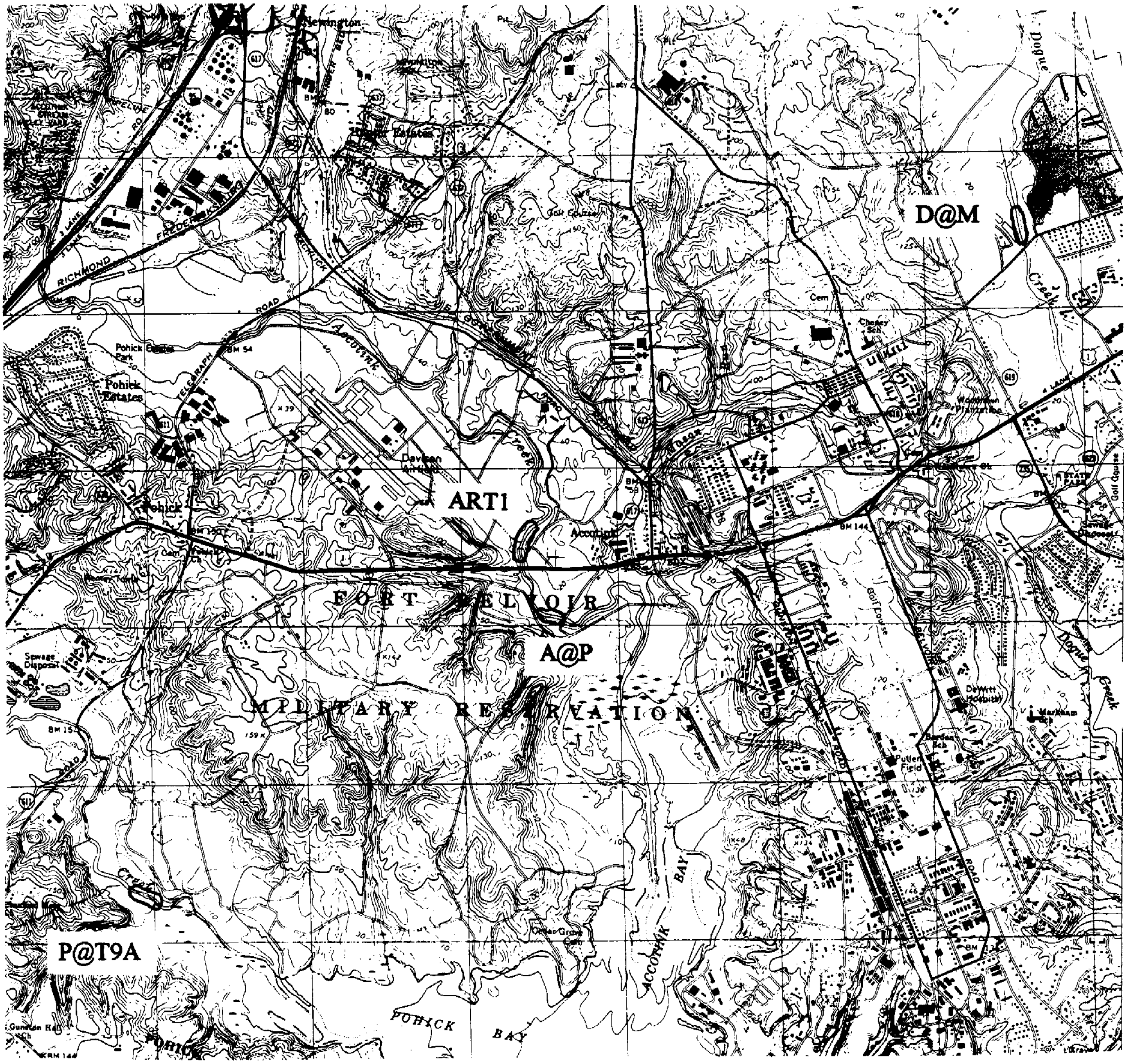

Table 1. Metrics used in Piedmont Index of Biotic Integrity with Criteria
(From Jones and Kelso 1997)

Metrics	IBI Score with Criteria		
	5	3	1
1. Number of native fish species	>67%*	33-67%*	<33%*
2. Number of darter species	>67%*	33-67%*	<33%*
3. Number of sunfish species	>67%*	33-67%*	<33%*
4. Number of sucker species	>67%*	33-67%*	<33%*
5. Number of intolerant species	>67%*	33-67%*	<33%*
6. Proportion green sunfish individuals	<10%#	10-25%#	>25%#
7. Proportion generalist individuals	<20%#	20-45%#	>45%#
8. Proportion specialist individuals	>45%#	20-45%#	<20%#
9. Proportion top carnivore individuals	>5%#	1-5%#	<1%#
10. Total number of individuals	>67%*	33-67%*	<33%*
11. Proportion hybrid or exotic individuals	0%#	0-1%#	>1%#
12. Proportion of individuals with disease/anomalies	<1%#	1-5%#	>5%#

*Percentage of Reference Site Value
#Proportion of Total Individuals in Sample
Metrics 1-5 are scored relative to watershed area.

Index of Biotic Integrity is computed as sum of scores for each metric. Maximum possible score is 60. Integrity classes are based on IBI as follows: Excellent: IBI=58-60. Good: IBI=48-52. Fair: IBI=40-44. Poor: IBI=28-34. Very Poor: IBI=12-22.

Reference: Jones, R.C. and D.P. Kelso. 1997. Bioassessment of Prince William County Watersheds. Final Report submitted to Prince William County by George Mason University.

Table 2. Metrics used in Coastal Plain Index of Biotic Integrity with Criteria (From Hall et al. 1993)

Metrics	IBI Score with Criteria		
	5	3	1
1. Number of fish species	>13	10-12	<9
2. Number of darter and sculpin species	≥3	1-2	0
3. Number of sunfish species	≥3	2	0-1
4. Number of shiner species	≥2	1	0
5. Number of intolerant species	≥2	1	0
6. Proportion tolerant individuals	≤33%#	33-56%#	≥56%#
7. Proportion omnivore individuals	<20%#	20-45%#	>45%#
8. Proportion insectivore individuals	>65%#	30-65%#	<30%#
9. Proportion pioneering individuals	>30%#	15-30%#	<15%#
10. Number of fish collected per 100 m	>147	83-147	<83
11. Proportion simple lithophilic individuals	>36%#	18-36%#	<18%#
12. Proportion of individuals with disease/anomalies	<2%#	2-5%#	>5%#

#Proportion of Total Individuals in sample

Index of Biotic Integrity is computed as sum of scores for each metric. Maximum possible score is 60. Integrity classes are based on IBI as follows: Excellent: IBI=58-60. Good: IBI=48-52. Fair: IBI=40-44. Poor: IBI=28-34. Very Poor: IBI=12-22.

Reference: Hall, L.W., Jr., S.A. Fischer, W.D. Killen, Jr., M.C. Scott, M.C. Ziegenfuss, and R.D. Anderson. 1993. A Pilot Study to Evaluate Biological, Physical, Chemical, and Land-use Characteristics in Maryland Coastal Plain Streams. University of Maryland Wye Research and Education Center. Queenstown, MD 21658.

Table 3. Metrics used in Maryland Coastal Plain Macroinvertebrate Index with Criteria (From Jones and Kelso 1997)

Metrics	IBI Score with Criteria		
	5	3	1
1. Family Richness (# of families)	>16	8-16	<8
2. EPT Richness (# of EPT* families)	>6	3-6	<3
3. Mayfly Family Richness (# of mayfly families)	>2	1-2	<1
4. Diptera† Family Richness (# of diptera families)	>3	2-3	<2
5. Intolerant Family‡ Richness (# of intol. families)	>5	2-5	<2
6. Proportion Mayfly Individuals	>11.4%	2-11.4%	<2%
7. Maryland Metric	>9	4-9	<4

*EPT=Mayflies (Ephemeroptera), Stoneflies (Plecoptera), and Caddisflies (Trichoptera)
†Diptera are referred to as "flies" or "two-winged flies"
‡Intolerant families are those with a Hilsenhoff tolerance value of 0-3 (Plafkin et al. 1989)

Maryland Coastal Plain Index is computed as sum of scores for each metric and then divided by the number of metrics. Maximum possible score is 35 and maximum average score is 5.0. Integrity classes are based on average score as follows: Good: 4.0-5.0. Fair: 3.0-3.9. Poor: 2.0-2.9. Very Poor: 1-1.9.

Reference: Daniel M. Boward. Ecological Assessment Program. Monitoring and Non-tidal Assessment Division. Maryland Department of Natural Resources. Tawes State Office Building, C-2. Annapolis, MD 21401. dboward@dnr.state.md.us. 410-260-8605.

Table 4. Results of Fish Sampling in Fort Belvoir Streams in 1995 and 1997

Species	Common Name	Pohick Cr. at T9 Area P@T9A	Accotink Cr. at Poe Rd. A@P		Accotink Cr. at Rt. 1 bridge ART1	Dogue Cr. at Meers Rd. D@M	
		05/12/97	12/04/95	05/24/97	11/10/95	11/06/95	05/19/97
Anguilla rostrata	American eel	106	19	57	10	5	15
Lepisosteus osseus	longnose gar	2	0	0	0	0	0
Dorosoma cepedianum	gizzard shad	2	0	1	0	0	0
Umbra pygmaea	eastern mudminnow	0	0	3	0	0	2
Carassius auratus	goldfish	10	4	0	10	0	0
Clinostomus funduloides	rosyside dace	0	0	4	0	0	0
Hybognathus regius	eastern silvery minnow	1	0	7	0	1	24
Notemigonus crysoleucas	golden shiner	0	0	0	1	0	0
Rhinichthys cataractae	longnose dace	0	6	0	2	0	0
Rhinichthys atratulus	blacknose dace	0	15	4	6	0	0
Semotilus atromaculatus	creek chub	0	2	5	5	0	0
Semotilus corporalis	fallfish	0	1	0	0	0	0
Luxilus cornutus	common shiner	0	18	0	31	0	1
Cyprinella spiloptera	spotfin shiner	0	133	8	157	0	0
Cyprinella analostana	satinfin shiner	0	0	4	0	0	0
Notropis procne	swallowtail shiner	0	42	13	98	0	3
Notropis hudsonius	spottail shiner	0	2	0	0	0	41
Erimyzon oblongus	creek chubsucker	1	5	0	6	1	22
Hypentelium nigricans	northern hogsucker	0	1	0	0	0	0
Catostomus commersoni	white sucker	0	5	15	4	0	0
Fundulus diaphanus	banded killifish	113	1304	25	1213	65	0
Fundulus heteroclitus	mummichog	29	84	0	90	0	2
Gambusia holbrooki	eastern mosquitofish	0	3	1	1	26	7
Ameiurus natalis	yellow bullhead	0	1	2	0	6	28
Ameiurus nebulosus	brown bullhead	18	1	0	1	0	0
Morone americana	white perch	0	0	1	0	0	0
Micropterus salmoides	largemouth bass	0	0	1	0	0	3
Pomoxis nigromaculatus	black crappie	0	1	0	0	0	0
Lepomis gulosus	warmouth	0	0	0	1	1	2
Lepomis cyanellus	green sunfish	0	4	1	0	0	4
Lepomis auritus	redbreast sunfish	1	3	0	0	8	9
Lepomis macrochirus	bluegill	2	6	4	29	71	50
Lepomis gibbosus	pumpkinseed	32	58	8	64	48	18
Perca flavescens	yellow perch	1	0	0	0	0	2
Etheostoma olmstedi	tessellated darter	12	45	24	52	3	32
Total		330	1763	188	1781	235	265

Table 5. IBI Calculations for Fort Belvoir Stream Sites: 1997

Piedmont IBI

Metric	A@P		P@T9A		D@M	
Number of native species	17	(3)	11	(3)	15	(5)
Number of darter species	1	(3)	1	(3)	1	(5)
Number of sunfish species	3	(1)	3	(1)	5	(5)
Number of sucker species	1	(3)	1	(3)	1	(5)
Number of intolerant species	3	(5)	2	(3)	2	(3)
Proportion green sunfish individuals	0.5%	(5)	0%	(5)	1.5%	(5)
Proportion generalist individuals	53.2%	(1)	83.9%	(1)	23.8%	(3)
Proportion specialist individuals	46.8%	(5)	16.1%	(1)	76.2%	(5)
Proportion top carnivore individuals	0.5%	(1)	0.6%	(1)	1.1%	(3)
Total number of individuals	188	(1)	330	(3)	265	(3)
Proportion hybrid/exotic individuals	1.6%	(1)	0.9%	(3)	1.1%	(1)
Proportion with disease/anomalies	0%	(5)	0%	(5)	0%	(5)
IBI Score		(34)		(32)		(48)
IBI Rating	Poor		Poor		Good	

Coastal Plain IBI

Metric	A@P		P@T9A		D@M	
Number of fish species	20	(5)	14	(5)	18	(5)
Number of darter and sculpin species	1	(3)	1	(3)	1	(3)
Number of sunfish species	4	(5)	3	(5)	6	(5)
Number of shiner species	4	(5)	0	(1)	3	(5)
Number of intolerant species	3	(5)	1	(3)	2	(5)
Proportion of tolerant individuals	47.3%	(3)	42.1%	(3)	26.0%	(5)
Proportion of omnivorous individuals	9.0%	(5)	9.4%	(5)	24.2%	(3)
Proportion of insectivorous individuals	26.1%	(1)	4.5%	(1)	35.5%	(3)
Proportion of pioneering species	17.6%	(3)	3.9%	(5)	20.4%	(3)
Number of fish collected per 100 m	50.5	(1)	83	(3)	96	(3)
Proportion simple lithophils individuals	19.1%	(3)	0%	(1)	0%	(1)
Proportion with disease/anomalies	0%	(5)	0%	(5)	0%	(5)
IBI Score		(44)		(40)		(46)
IBI Rating	Fair		Fair		Fair/Good	

Table 6. Results of Benthic Macroinvertebrate Sampling

Belvoir Stream Benthos - 1997

			Individual Samples						Pooled Data		
		Tol.	Dogue @ Meers		Accotink @ Poe		Pohick@T9a				
	Taxon	Class	Upstr	Downstr	#1	#2	Main Br	East Br	Dogue	Accotink	Pohick
Flies	Chironomidae	6	213	990	289	333	2592	1750	1203	622	4342
	Simulidae	6	60	85	209	93	23	2	145	302	25
	Empididae	6	1						1		
	Stratiomyidae		1						1		
	Tipulidae	3	1				1		1		1
Caddisflies	Hydropsycidae	4	55	46			1		101		1
	Hydroptilidae	4		6					6		
Mayflies	Baetidae	4			3	1	2			4	2
	Caenidae	7	13	48					61		
	Ephemerellidae	1					1				1
Stoneflies	Nemouridae	2			1					1	
Beetles	Gyrinidae	4	2	4					6		
	Haliplidae	5	1	1					2		
	Hydrophilidae	5	1	2					3		
	Elmidae	4		2	1		1	3	2	1	4
	Noteridae							1			1
	Hydrochidae			1					1		
Springtails	Collembola			2					2		
Dragonflies	Coenagrionidae	9		1			1	1	1		2
	Libelulidae	9					1				1
Moths	Noctuidae			1					1		
Sow bugs	Asellidae	8	20	239	1			1	259	1	1
Scuds	Gammaridae	4	1	4					5		
Shrimps	Palaemonetes		1						1		
Crayfish	Cambaridae							1			1
Water mites	Hydrachnida		3	5	2				8	2	
Snails	Physidae	8	1	4			29	12	5		41
	Hydrobiidae			1					1		
	Planorbidae	7		3					3		
	Viviparidae				1					1	
Bivalves	Sphaeridae	8		8	1		1	1	8	1	2
Oligochaetes	Oligochaeta	10	77	1046	1330	354	7160	1513	1123	1684	8673
Nematodes	Nematoda			1		1	16		1	1	16
Leeches	Hirudinea						1				1

Table 7. Calculation of Maryland Coastal Plain Macroinvertebrate Index

	Individual Samples						Pooled Data		
	Dogue @ Meers		Accotink @ Poe		Pohick@T9a				
Metric Values	Upstr	Downstr	#1	#2	Main Br	East Br	Dogue	Accotink	Pohick
Family Richness	16	22	10	5	14	10	26	11	17
EPT Richness	2	3	2	1	3	0	3	2	3
Mayfly Richness	1	1	1	1	2	0	1	1	2
Diptera Richness	5	2	2	2	3	2	5	2	3
Intolerant Richness	1	0	1	0	2	0	1	1	2
% Mayflies	2.9%	1.9%	0.2%	0.1%	0.0%	0.0%	2.1%	0.2%	0.0%
Maryland Index	4	5	3	1	5	1	6	3	6
Metric Scores									
Family Richness	3	5	3	1	3	3	5	3	5
EPT Richness	1	3	1	1	3	1	3	1	3
Mayfly Richness	3	3	3	3	3	1	3	3	3
Diptera Richness	5	3	3	3	3	3	5	3	3
Intolerant Richness	1	1	1	1	3	1	1	1	3
% Mayflies	3	3	1	1	1	1	3	1	1
Maryland Index	3	3	1	1	3	1	3	3	3
Maryland Coastal Plain Index Total	19	21	13	11	19	11	23	15	21
Maryland Coastal Plain Index Average	2.71	3.00	1.86	1.57	2.71	1.57	3.29	2.14	3.00
Narrative Description	Poor	Fair	Very Poor	Very Poor	Poor	Very Poor	Fair	Poor	Fair

Table 8. Results of Habitat Assessment for Fort Belvoir Stream Sites

STATION	A@P	P@T9a	D@M
Date	27-May-97	12-May-97	13-May-97
Local Land Use	Forest	Forest	Residential
Local Erosion	Moderate	Moderate	Moderate
Local Nonpoint Pollution	Some	None	Some
Stream Width (m)	13.81	5.83	4.10
Riffle Depth (cm)	15.0	15.3	22.0
Run Depth (cm)	76.5	72.0	47.3
Pool Depth (cm)	156.0	135.0	83.5
High Water Mark (cm)	105	74	39.5
Velocity (m/sec)	1.24	0.69	0.68
Dam Upstream	No	No	Beaver
Channelized	No	No	Yes
Canopy Cover	Most Open	Open	Open
Temp (oC)	15.8	22.0	22.7
DO (mg/L)	9.74	8.95	4.25
DO (% saturation)	99	102	49
pH	5.55	7.17	6.87
Conductivity (umho/cm)	108	520	195
Water Odors	Normal	Chemical	None
Surface Oils	None	None	None
Turbidity	Slight Turbid	Clear	Turbid
Color	Brown	None	Dark Brown
Sediment Odors	None	Normal	Normal
Sediment Oils	Absent	Absent	Absent
Sediment Deposits	Sand	Sand	Sand
Black Stones	No	No	No
Percentage of Particle Sizes in Bottom Substrate			
Bedrock	0	0	0
Boulder	0	0	0
Cobble	30	5	5
Gravel	30	5	20
Sand	30	80	60
Silt	10	5	10
Clay	0	5	5
RBP Index of Habitat (Plafkin et al. 1989)			
Substrate and Cover	15	6	11
Embeddedness	6	4	7
Channel Alteration	8	5	4
Scour & Deposition	6	3	4
Pool/riffle	11	9	9
Bank Stability	5	5	7
Bank Vegetation	7	9	8
Stream Cover	6	5	5
Overall Score (115 possible)	64	46	55

Table 9. General geographic distribution of fish species collected in Fort Belvoir creeks. Number of species of fish classified as coastal plain species, piedmont species, or those typically found in both for each station and year. (based on Jenkins and Burkhead 1994)

General geographic distribution	Accotink Creek		Pohick Creek		Dogue Creek	
	1995	1997	1995	1997	1995	1997
coastal plain	5	7	--	8	7	8
piedmont	10	7	--	0	0	3
both coastal plain and piedmont	9	6	--	6	4	7
total	24	20	--	14	11	18

Baseline Characterization of Accotink Bay and the North Shore of Gunston Cove 1997

I. Introduction

Gunston Cove is an embayment of the tidal Potomac River, a major subestuary of the Chesapeake Bay. The cove is located in the freshwater zone of the river within the Commonwealth of Virginia about 20 km downstream of the District of Columbia. The cove stretches from the river mainstem in a northwesterly direction for about 3 km before dividing into a northern arm known as Accotink Bay and a western arm known as Pohick Bay. Fort Belvoir borders the northern side of Gunston Cove, completely surrounds Accotink Bay and borders the northern side of Pohick Bay.

The cove receives runoff from Accotink and Pohick Creeks. Accotink Creek drains a 13,134 ha (32,454 acre) watershed consisting mostly of suburban development of moderate density (Parsons et al. 1975). Moderate suburban development also characterizes the 8,806 ha (21,760 acre) Pohick Creek watershed (Parsons et al. 1973). Annual mean discharge from Acootink and Pohick Creeks has been estimated as 1.59 and 1.07 m^3/sec, respectively (Kelso et al. 1985). Just above the head of tide on Pohick Creek the County of Fairfax has sited the Lower Potomac Pollution Control Plant which currently discharges an average of 2 m^3/sec of treated sewage (Elaine Schaeffer, personal communication). Data for 1995 (Jones and Kelso 1996) indicate a rather high level of treatment with Pohick Creek immediately downstream of the outfall showing BOD averaging 6.1 mg/L, DO near saturation, total P of 0.11 mg/L, total suspended solids less than 5 mg/L, and pH near neutral. Nitrogen levels are elevated with ammonia nitrogen averaging over 6 mg/L and nitrate at 1.7 mg/L.

Rising sea levels flooded the cove some 5000-8000 years ago. The valley has since accumulated sediments and today is remarkably flat-bottomed (Kelso et al. 1985). The vast majority of Gunston Cove is about 2 m deep at mean high tide with Pohick and Accotink Bays being somewhat shallower. Tidal freshwater marshes are located at the head of both creeks. Those of Accotink Creek extend over 64.9 ha (158 acres), while those of Pohick Creek occupy 35.2 ha (89.5 acres). Both contain a mix of plant species judged to be of high value to aquatic and terrestrial animals (Doumlele 1976).

Gunston Cove has been characterized as a phytoplankton-dominated system driven by seasonal temperature and light regimes (Kelso et al. 1985). Chlorophyll concentrations routinely exceed 100 ug/L during summer. Late summer blooms in the mid-1980's were characterized by chlorophyll levels exceeding 250 ug/L. Large diurnal fluctuations in dissolved oxygen and pH during these blooms indicate intense photosynthetic activity. During summer most of the organic N and total P is tied up in algal cells. Macrophytes have normally been restricted to small areas along the margin of the cove. Cyanobacteria (blue-green algae) are the dominant taxa of phytoplankton in the summer, while diatoms are often dominant in the spring (Jones et al. 1992).

The most abundant zooplankters are the small rotifers dominated by *Brachionus*. The small cladoceran *Bosmina* and the immature stages of copepods (nauplii) are the most abundant crustaceans. Larger crustaceans found in the cove include the cladoceran *Diaphanosoma brachyurum*, characteristic of late spring and early summer, and *Eurytemora affinis*, typically found in late winter and early spring. The predaceous cladoceran *Leptodora kindti* often produces short-lived outbreaks in late spring.

The cove is utilized by a variety of resident and anadromous fish species. Fish populations generally increase from late winter through July or August due to the influx of anadromous and semianadromous species in the spring and the maturation of young-of-the-year from the larval to juvenile stage during the summer. White perch has consistently been the most abundant species collected in seine and trawl catches in the cove. This semianadromous species migrates into the area from downriver in early spring and begins spawning. By late March its larvae begin to appear in the plankton. Spawning is generally completed by June. The anadromous clupeids such as blueback herring and alewife migrate into the area and spawn beginning in April. Catches of adults of these species have declined, but larval abundance has remained high. Other important fish species in the cove include gizzard shad, bay anchovy, brown bullhead, channel catfish, banded killifish, bluegill sunfish, pumpkinseed sunfish, and largemouth bass.

A proposed marina development will potentially impact aquatic communities in Gunston Cove and Accotink Bay. George Mason University was asked to determine the importance of the marina area to aquatic communities.

II. Methods

Water quality and plankton were sampled at two stations on a monthly basis in March and semimonthly from April through August of 1997. These stations were located at the mouth of Accotink Bay (Sta. 6) and in Gunston Cove offshore of the proposed marina site (Sta. 19) as shown in Figure 1. Measurements of dissolved oxygen, temperature, and conductivity were made *in situ* at 0.3 m, 1.0 m, and half meter intervals below 1.0 m until reaching the bottom using YSI meters with submersible probes. Secchi depth was determined and a light profile was made by measurements of photosynthetically active radiation at 10 cm increments using a LI-COR submersible photon sensor. Samples were collected at 0.3 m using a submersible pump for the determination of surface chlorophyll. An integrated sample for the determination of chlorophyll, total alkalinity, and pH in the lab was constructed by pumping equal amounts of water from 0.3 m below the surface and 0.5 m above the bottom. A portion of this integrated sample was also preserved for phytoplankton cell counts with acid Lugol's iodine. Suspended solids were determined by filtering a known volume of integrated sample through a preweighed glass fiber filter (Whatman 934AH). Filters were dried at 100°C for total suspended solids and then ashed at 450°C for volatile suspended solids by difference. Chlorophyll was determined fluorometrically and total alkalinity by titration. Phytoplankton were identified and enumerated by species using the settling chamber-inverted microscope technique. Biovolume was computed by measuring dimensions microscopically and refering each species to the appropriate geometric model.

Microzooplankton (consisting of rotifers and small crustaceans) was determined by pumping equal amounts (48L) of water from 0.3 m below the surface and 0.5 m above the bottom through a 44 µm mesh nitex nylon net sieve. Macrozooplankton was sampled by towing a 202 µm mesh net (0.3 m opening) for 1.5 minutes at each of the two depths cited above. The quantity of water sieved was determined using a flow meter in the net mouth. Ichthyoplankton were determined in the spring and early summer using a 333 µm mesh net (0.5 m opening) towed for 3 minutes each at the two depths. Zooplankton and ichthyoplankton were preserved with formalin to a concentration of 4% in the field. Zooplankton were enumerated using a Sedgewick-Rafter counter. Ichthyoplankton samples were picked and enumerated in their entirety or subsampled using a plankton splitter.

Benthic macroinvertebrates were sampled at seven stations (Figure 1) in June: A, B, C, D, E, F, and 6. On each date three samples were collected at each station using an Ekman grab mounted on a metal pole. Samples were sieved in the field through a 0.5 mm stainless steel sieve and resulting animals and debris preserved with formalin to a concentration of 4%.

Fish populations utilizing the Ft. Belvoir shoreline were determined by seining at two locations, B-1 and B-2 (Figure 1). Sampling was initiated at B-1 in April and B-2 in July. The seine was 45-50 feet long, 4 feet high and was made of knotted nylon with a 1/4 inch square mesh. The net was stretched out perpendicular to the shore with the shore end in water no more than a few inches deep. The offshore end of the net was usually in water about 3 feet deep. The net was then pulled parallel to the shore for a distance of 100 feet by a worker at each end moving at a slow walk. At the end of the distance, the offshore end of the net was swung in an arc to the shore, and the net pulled up on the beach to trap the fish. Fish were identified to species, enumerated, and returned to the water except for a few voucher specimens when identification was uncertain.

III. Results

Water temperature followed a similar pattern at both Stations 6 (Accotink Bay) and 19 (Gunston Cove). From a low of 7-8°C in March, water temperature increased to 30°C in late July before dropping somewhat in August (Figure 3). Conductivity (standardized to 25°C) followed a more complicated seasonal pattern (Figure 3). From a spring low of about 270 µS/cm in early April conductivity increased to about 350 µS/cm in late April and May. A gradual decline occurred during June and early July to about 250 µS/cm. Conductivity increased for the remainder of the summer. Differences between the two sites were relatively small.

Dissolved oxygen demonstrated a gradual, but steady decline from April through August (Figure 3). Much, but not all, of this decline was due to the decreasing ability of warming water to hold oxygen. Examining percent saturation of oxygen, which corrects for this temperature effect, revealed a less marked, but still detectable, seasonal decline from values generally above saturation in the spring to values generally below saturation in summer.

pH values were generally in the 7.0-8.5 range (Figure 4). Lab pH indicated rather consistent pH levels of about 8.5 in April and May with slightly lower and more variable pH of about 8.0 in summer. Field pH's were similar, but with greater fluctuations between dates in summer. Total alkalinity increased steadily from March through May at both sites (Figure 4). In Accotink Creek (Station 6) the increase started at much lower levels and was broken by a decline in early May. Both stations peaked at about 100 mg/L as $CaCO_3$ in late May and then declined by late June to about 70 mg/L where they remained through August.

Total suspended solids (TSS), a measure of particulate content of water, was generally in the range 10-30 mg/L at both stations during the study period (Figure 5). Volatile suspended solids, the organic portion of TSS, exhibited a weak seasonal pattern of increase from levels generally below 6 mg/L in early spring to slightly higher values the remainder of the period (Figure 5). A marked increase in VSS was observed in late August at both stations.

A measure of water transparency, Secchi depth was generally highest in the spring (up to 60 cm) and decreased through the summer reaching a low of about 35 cm in August (Figure 6). During late spring and early summer Secchi depth was slightly higher in the cove than in Accotink Bay. Light attenuation coefficient followed a similar seasonal decline (Figure 6).

Chlorophyll *a* levels increased steadily through early August and then more rapidly in late August (Figure 6). Surface and depth-integrated chlorophyll followed almost identical patterns indicating little depth stratification of algal populations. Chlorophyll levels in Accotink Bay were higher than those in Gunston Cove in spring with the reverse true in late July and early August.

Phytoplankton density remained relatively low through early June (Figure 7). From late June through late July, a general increase in phytoplankton was observed to nearly 1,000,000 cells/mL. A marked decline in early August was followed by even higher levels in late August. Cyanobacteria were the overwhelming dominant composing 83% of all cells counted. This dominance was found at both stations and at all times except early spring (Figure 8). Green algae were second in dominance with 9% of cells counted followed by diatoms and then cryptophytes.

Phytoplankton biovolume increased slowly and sporadically from March through August (Figure 7). Accotink Bay values were generally somewhat higher than Gunston Cove during summer. Two groups of algae, greens and diatoms were almost equally represented in cell biovolume overall, together composing about 54% of total. On a seasonal basis, green algae and diatoms were dominant in spring and early summer while cyanobacteria became more abundant in mid summer (Figure 9). Cryptophytes were of greatest importance in spring. Little difference was observed between Accotink Bay (Station 6) and Gunston Cove (Station 19).

Microzooplankton, collected by 44 µm mesh sieve, was dominated by rotifers. *Brachionus* was the most abundant rotifer (36% of all microzooplankton), followed by

Polyarthra (16%) and *Keratella* (11%). The cladoceran *Bosmina* and copepod nauplii were also common in the microzooplankton samples (Figure 10). *Bosmina* was found in samples from May through July with maximum observed values of 350/L in Gunston Cove in late May. In Accotink Bay the maximum was substantially lower (~80/L) and occurred in early June. Copepod nauplii showed a gradual increase from spring through summer and were generally somewhat more numerous in Accotink Bay.

Total rotifer abundance demonstrated a net increase from March through August although several peaks and valleys were observed (Figure 10). Highest densities exceeded 2000/L in late July at both stations. As the most abundant rotifer *Brachionus* tended to follow the pattern for total rotifers reaching maximum density of 800/L in Accotink Bay and 1300/L in Gunston Cove in July (Figure 11). *Polyarthra* exhibited large changes between sampling dates; for example, in Accotink Bay less than 20/L were found in early July followed by over 800/L in mid-July. *Keratella* showed a more consistent pattern increasing steadily from March through June reaching nearly 600/L. *Keratella* remained abundant in Gunston Cove through July, but dropped off more quickly in Accotink Bay. *Filinia* was present from late April through August demonstrating a marked peak in early August of 400-800/L.

Macrozooplankton was dominated by the cladoceran *Diaphanosoma brachyurum* which made up 45% of total abundance and the copepod *Eurytemora affinis* which composed 21%. *Eurytemora* was present throughout the study period, but demonstrated a marked peak in mid-June, reaching over 5000/m^3 in Gunston Cove (Figure 12). Cyclopoid copepods were also present at substantial densities reaching a peak in late June of over 1000/m^3. *Diaptomus pallidus* was much less common never exceeding 500/m^3.

Diaphanosoma was extremely abundant in late June and July reaching maxima of about 5000/m^3 in Accotink Bay and 9000/m^3 in Gunston Cove (Figure 13). Other herbivorous cladocera were much less common. *Daphnia* was most abundant from late May from early July, but never exceeded 600/m^3. *Moina* was most common in June and July, but remained less than 300/m^3. *Ceriodaphnia* never exceed 500/m^3. The predaceous cladoceran *Leptodora* was quite abundant from late may through mid-June exceeding 1200/m^3 in Gunston Cove and 800/m^3 in Accotink Bay (Figure 14).

Oligochaetes were the most numerous group in the benthic macroinvertebrate community representing over 74% of all specimens collected (Figure 15). These numbers are certainly an overestimate since the oligochaetes tend to break apart during processing. Chironomids (aquatic midge larvae and pupae) were the second most abundant group representing about 25% of all specimens. All other taxa comprised less than 1% of the total collections. These included amphipods (Gammaridae), snails, bivalves (*Corbicula*), leeches (Hirudinea), nematodes, springtails (Collembola) and even one mayfly (Baetidae).

Oligochaetes exhibited their lowest levels at the mouth of Accotink Bay (Stations C and 6), as well as along the Gunston Cove shore near the mouth of the bay (Station D). Densities increased moving farther into Accotink Bay (Station A and B) as well as moving down the north shore of Gunston Cove (Stations E and F). Chironomids, on the other hand, showed a distinct peak along the shoreline at the mouth of the cove. Other taxa were very uncommon at Stations C and D and the distribution of individual taxa was sporadic.

The number of fish larvae per 10 m^3 collected at Stations 6 and 19 are shown in Table 1 and Figure 16. Larvae of *Alosa* (herrings) were the most numerous group followed by *Dorosoma* (gizzard shad) and *Morone* (white perch). Scattered individuals of *Menedia* (silversides), *Lepomis* (sunfish) and *Perca* (yellow perch) were also collected. Larvae were not collected at either station in March. In April yellow perch and a few herrings were found. Gizzard shad reached a maximum in late May. White perch were found at variable levels from April through early June. Herrings increased through May and June reaching a peak in early July. Silversides appeared in late June. By late July ichthyoplankton were greatly reduced as most had either advanced to the juvenile stage or fallen victim to mortality.

The fish species and number of individuals of each species that were caught by seining at stations B1 and B2 along the shore of Fort Belvoir are shown in Table 2. The 22 seine hauls collected 1878 fishes, drawn from 18 species. The most abundant species was banded killifish, which represented 48% of the total. The second most abundant species was the inland silversides (26%), followed by spottail shiner (6%), alewife (4%), white perch (4%), and quillback (3%). A greater number of individuals were collected at B2, due to greater numbers of banded killifish and inland silversides. Slightly more species were observed at B2 (16) than at B1(14). Catches were rather low from March through May especially at B1, but increased markedly from June through August.

Macrophyte distribution in Gunston Cove is reflected in Figure 17. Dense populations of *Hydrilla verticillata* with small amounts of *Ceratophyllum demersum* and *Najas minor* were observed throughout most of Accotink Bay and inner Pohick Bay. Macrophyte beds fringing the north shore of Gunston Cove changed from *Hydrilla* dominance to *Vallisneria americana* dominance moving east toward the river channel. These communities continued along the channel fringe with *Vallisneria* dominating then switched back to *Hydrilla* dominance as the shoreline entered Dogue Creek. A gap in the fringing beds was observed in inner Dogue Creek, but another robust patch of *Hydrilla* was observed in the narrow reaches of upper Dogue Creek.

IV. Discussion

Results of this study generally confirm previous work (Kelso et al. 1985, Jones and Kelso 1998b) indicating that Gunston Cove and Accotink Bay are productive systems which harbor a variety of aquatic life at moderate to high abundance. Seasonal temperature patterns were similar in both 1996 and 1997 with early spring registering below 10°C and summer ranging between 25°C and 30°C. Conductivity averaged slightly higher in 1997 than in 1996. Summer dissolved oxygen levels were well above saturation in 1996, but were generally at or below saturation in

1997. This was at least partially due to higher algal densities in 1996 whose photosynthetic activity generated more oxygen. pH was generally 7.5-8.5 during spring and summer of both years. Alkalinity was generally somewhat higher in 1997 than in 1996. Total suspended solids averaged about 20 mg/L during both years. Volatile suspended solids averaged substantially higher over most of the summer in 1996 as compared with 1997. The occurrence of higher algal crops in 1996 would help explain this difference.

Secchi depth was generally greatest in spring and declined through August in 1997. The pattern was more variable in 1996 with less obvious seasonal trends. Light attenuation coefficient, another measure of light penetration, was also more consistent in its pattern in 1997 than in 1996. The difference observed in values between the 1997 data presented here and the 1996 data (Jones and Kelso 1998) is attributable to the fact that 1996 calculations were based on a base 10 log, whereas 1997 coefficients were calculated more properly from base e logs. Multiplying extinction coefficients presented in the 1996 report by 2.3 will make them compatible with those in the 1997 report. When this is done the data strongly overlap between both years.

Chlorophyll *a* followed a similar seasonal pattern in both 1996 and 1997. Spring chlorophyll was generally in the range 0-30 µg/L and summer chlorophyll was above 40 µg/L. In both years one summer date was particularly high. In 1996 this was in mid-July whereas in 1997 it was in late August. Phytoplankton density was very similar at both stations in 1997 and followed a seasonal pattern that was very similar to that observed for chlorophyll *a*. As in 1996 cyanobacteria were responsible for about 80% of all cells counted in 1997. Green algae were the second most abundant group in 1997, whereas diatoms occupied that position in 1996. Cell biovolume followed a general increase from spring through summer at both stations in 1997. In 1997 the major algal groups were more evenly represented in cell biovolume than in 1996, when diatoms accounted for the majority of biovolume. As in 1996 cyanobacteria were most important during summer and other groups were more important in spring.

As is typical of the Gunston Cove area, *Brachionus* was the most important microzooplankter comprising about a third of all individuals counted. The most important subdominants, *Filinia*, *Keratella*, and *Polyarthra*, were the same in both 1996 and 1997. Copepod nauplii and *Bosmina* constituted a somewhat larger proportion of the microzooplankton in 1997 than in 1996. Copepod nauplii followed a generally increasing pattern in 1997 while in 1996 a spring peak was observed with lower values for the rest of the year. The density of all rotifers was substantially lower in 1997 than in 1996, although the seasonal pattern was similar. The incidence of lower values in 1997 was common to all of the dominant rotifer taxa. As in 1996 *Brachionus* showed a generally upward trend through August.

As in 1996 *Diaphanosoma brachyurum* was the dominant cladoceran and *Eurytemora affinis* was the dominant copepod. The very high densities of *Eurytemora* observed in April 1996 were not repeated in 1997. However, a June peak in *Eurytemora* was observed in 1997 that was not found in 1996. *Diaptomus pallidus* was found at lower levels in 1997 than in 1996, whereas similar densities were observed for cyclopoid copepods. Peak levels of *Diaphanosoma* were substantially lower in 1997 than in 1996. This was also observed for the other cladocera except *Leptodora* which was more abundant in 1997.

Oligochaetes exhibited a very similar spatial pattern in both spring 1996 and spring 1997 with higher levels in both inner Accotink Bay and along the Gunston Cove and toward the mouth of the cove. In both years chironomids peaked near the mouth of the bay. Other taxa such as amphipods were much less common in 1997 than in 1996.

As in most previous years ichthyoplankton in 1997 was dominated by larvae of the clupeid family. In particular alosid (herring) larvae comprised over 75% of the population in 1997 followed by another clupeid, the gizzard shad (*Dorosoma cepedianum*). White perch comprised less than 5% of the larval population. In 1996 collections at these same sites white perch was much more important comprising over 30% of the population. This pattern was also observed in collections made at other sites in the Gunston Cove area in the two years (Jones and Kelso 1998a) and appeared to be mainly due to lower white perch densities as opposed to higher clupeid abundances. White perch abundances in 1997 are more typical of previous years than the higher densities observed in 1996.

The seine collections at Stations B1 and B2 continue to indicate a healthy community of fishes. A slight reduction in total catch and number of species was found in 1997 relative to 1996. White perch and blueback herring abundances were substantially reduced in 1997 as compared with 1996, while banded killifish and inland silversides were substantially higher. B2 continued to yield more fish per seine than B1 and in 1997 it had a higher species richness than B1. The slight decline in taxa richness from 1996 to 1997 observed at B1 and B2 was not observed at other seine sites in the Gunston Cove area (Jones and Kelso 1998a). Catch per seine at B1 and B2 was within the range observed at other Gunston Cove area stations in 1997.

Distribution and abundance of macrophytes were similar in both 1996 and 1997 with robust stands in Pohick and Accotink Bay and the north shore of Gunston Cove and the tip of the Belvoir peninsula. *Hydrilla verticillata* was dominant in the inner cove during both years. *Vallisneria americana* was dominant near the river channel in 1997 while *Myriophyllum spicatum* occupied that postion in 1996.

As noted in last year's report (Jones and Kelso 1998b) the study area continues to exhibit an ecological community similar to other portions of the tidal freshwater Potomac River. Water quality variables were similar to values observed in recent years. Summer dissolved oxygen levels were generally lower in 1997 than in 1996. Chlorophyll *a* levels were in the eutrophic range during the summer as is typical of Gunston Cove. Cyanobacteria were the dominant phytoplankton group as in 1996. Green algae were second in importance in 1997 whereas diatoms were subdominant in 1996. Rotifers were the most numerous zooplankton group. *Bosmina* was the most numerous small cladoceran and *Diaphanosoma* the most abundant large cladoceran. *Eurytemora* was again the most abundant copepod. Oligochaetes and chironomids continued to dominate the benthos. Alosids dominated the ichthyoplankton, while banded killifish was the most numerous fish collected by seining. Macrophyte communities continued strong growth in Pohick and Accotink Bays and in narrower bands along most of the Belvoir shoreline.

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Table 1. Fort Belvoir GMU aquatic study. Ichthyoplankton data by date and station

		Ichthyoplankton (#/10m3)									
Date	Station	*Alosa* sp.	*Alosa aestivalis*	*Alosa pseudoharengus*	*Dorosoma cepedianum*	*Menedia beryllina*	*Morone americana*	*Lepomis* sp.	*Lepomis gibbosus*	*Perca flavescens*	Total Larvae
19-Mar	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
09-Apr	6	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.39	4.71
23-Apr	6	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	1.14
07-May	6	5.62	0.00	0.00	11.69	0.00	0.00	0.00	0.00	0.22	17.53
21-May	6	15.67	0.00	3.63	14.90	0.00	0.96	0.96	0.38	0.00	36.49
04-Jun	6	26.55	0.00	0.83	16.60	0.28	3.32	0.00	0.00	0.00	47.57
18-Jun	6	5.50	0.00	0.92	0.92	0.23	0.00	.0.00	2.06	0.00	9.62
02-Jul	6	227.32	2.99	3.29	0.00	2.10	0.00	0.00	0.60	0.00	236.30
16-Jul	6	0.22	0.00	0.00	0.66	0.22	0.00	0.22	0.00	0.00	1.31
19-Mar	19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
09-Apr	19	0.76	0.00	0.00	0.00	0.00	20.17	0.00	0.00	0.95	21.88
23-Apr	19	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85
07-May	19	5.71	0.00	0.00	9.43	0.00	3.43	0.00	0.00	0.00	18.57
21-May	19	33.83	0.00	0.00	46.37	0.00	2.91	0.00	0.00	0.00	83.11
04-Jun	19	74.20	0.52	0.52	6.98	0.00	0.26	0.00	0.00	0.00	82.47
18-Jun	19	85.10	0.00	0.00	2.06	0.23	0.00	0.00	0.23	0.00	87.62
02-Jul	19	170.34	0.00	0.00	0.00	2.16	0.00	0.00	0.00	0.00	172.50
16-Jul	19	0.20	1.18	0.00	3.15	0.20	0.00	0.98	1.18	0.00	6.89
Averages	6	31.45	0.33	0.96	4.97	0.31	0.47	0.13	0.34	0.43	39.41
	19	41.22	0.19	0.06	7.56	0.29	2.97	0.11	0.16	0.11	52.65
	Overall	36.33	0.26	0.51	6.26	0.30	1.72	0.12	0.25	0.27	46.03

Table 2
Adult and Juvenile Fish Collected by Seining
Fort Belvoir Aquatic Study - 1997

		Total Fish Collected	
		Station B1	Station B2
Lepisosteidae			
Lepisosteus osseus	longnose gar	1	0
Clupeidae			
Alosa aestivalis	blueback herring	9	18
Alosa pseudoharengus	alewife	68	11
Dorosoma cepedianum	gizzard shad	0	0
Engraulidae			
Anchoa mitchilli	bay anchovy	0	0
Cyprinidae			
Hybognathus regius	eastern silvery minnow	14	7
Notemigonus crysoleucas	golden shiner	1	5
Notropis hudsonius	spottail shiner	65	48
Catostomidae			
Carpiodes cyprinus	quillback	19	42
Ictaluridae			
Ameiurus nebulosus	brown bullhead	1	2
Ictalurus punctatus	channel catfish	0	0
Cyprinodontidae			
Fundulus diaphanus	banded killifish	160	746
Fundulus heteroclitus	mummichog	0	33
Atherinidae			
Menidia beryllina	inland silverside	101	395
Percichthyidae			
Morone americana	white perch	25	48
Morone saxatilis	striped bass	2	11
Centrarchidae			
Lepomis gibbosus	pumpkinseed	1	0
Lepomis macrochirus	bluegill	30	1
Micropterus dolomieu	smallmouth bass	0	1
Pomoxis nigromaculatus	crappie	0	0
Percidae			
Etheostoma olmstedi	tessellated darter	0	2
Perca flavescens	yellow perch	0	11
TOTAL		497	1381

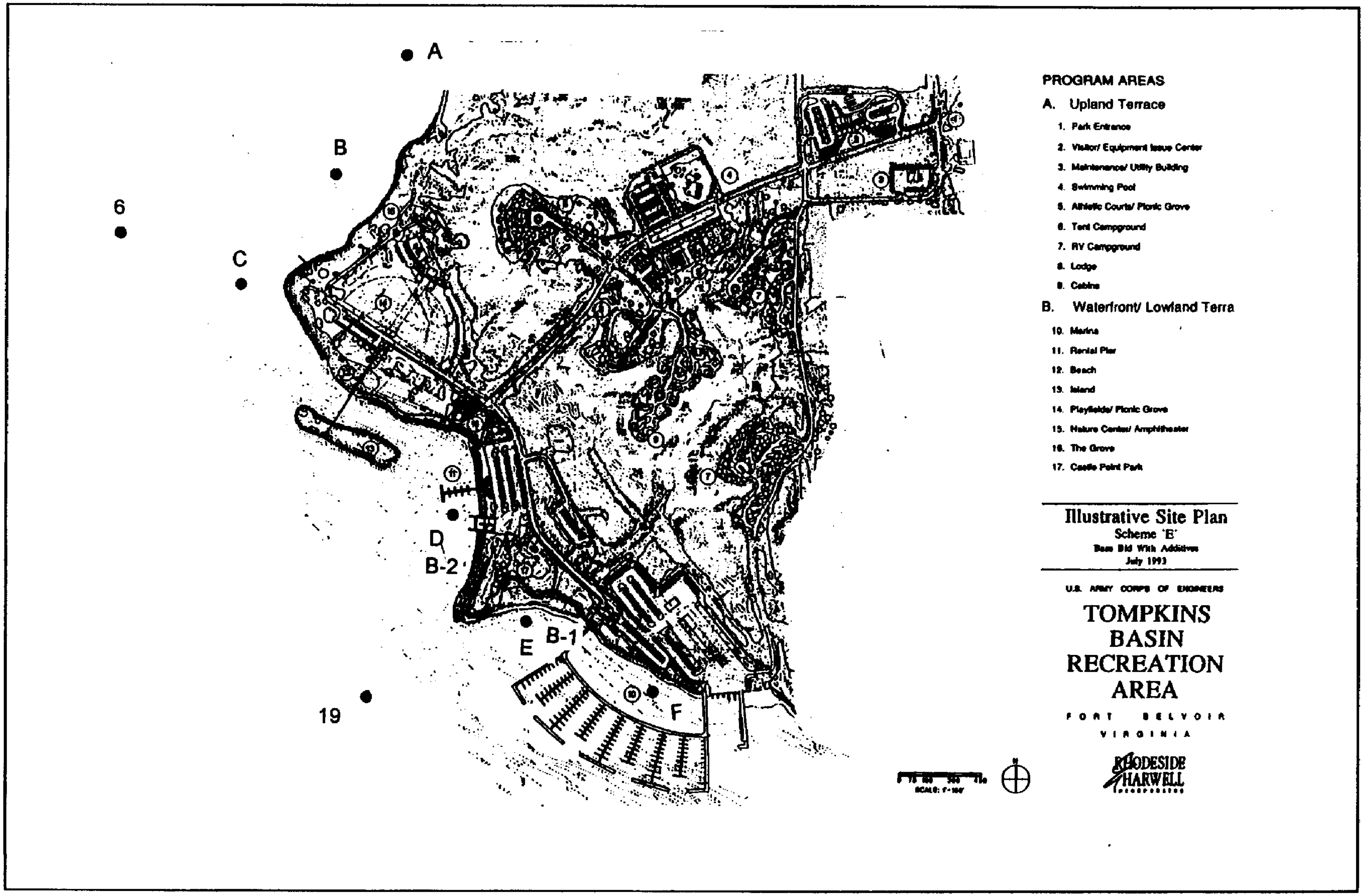


Figure 1. Map of Gunston Cove area of tidal Potomac River showing sampling sites for Fort Belvoir Aquatic Studies.

Figure 2. Map of Ft. Belvoir showing general location of study area.

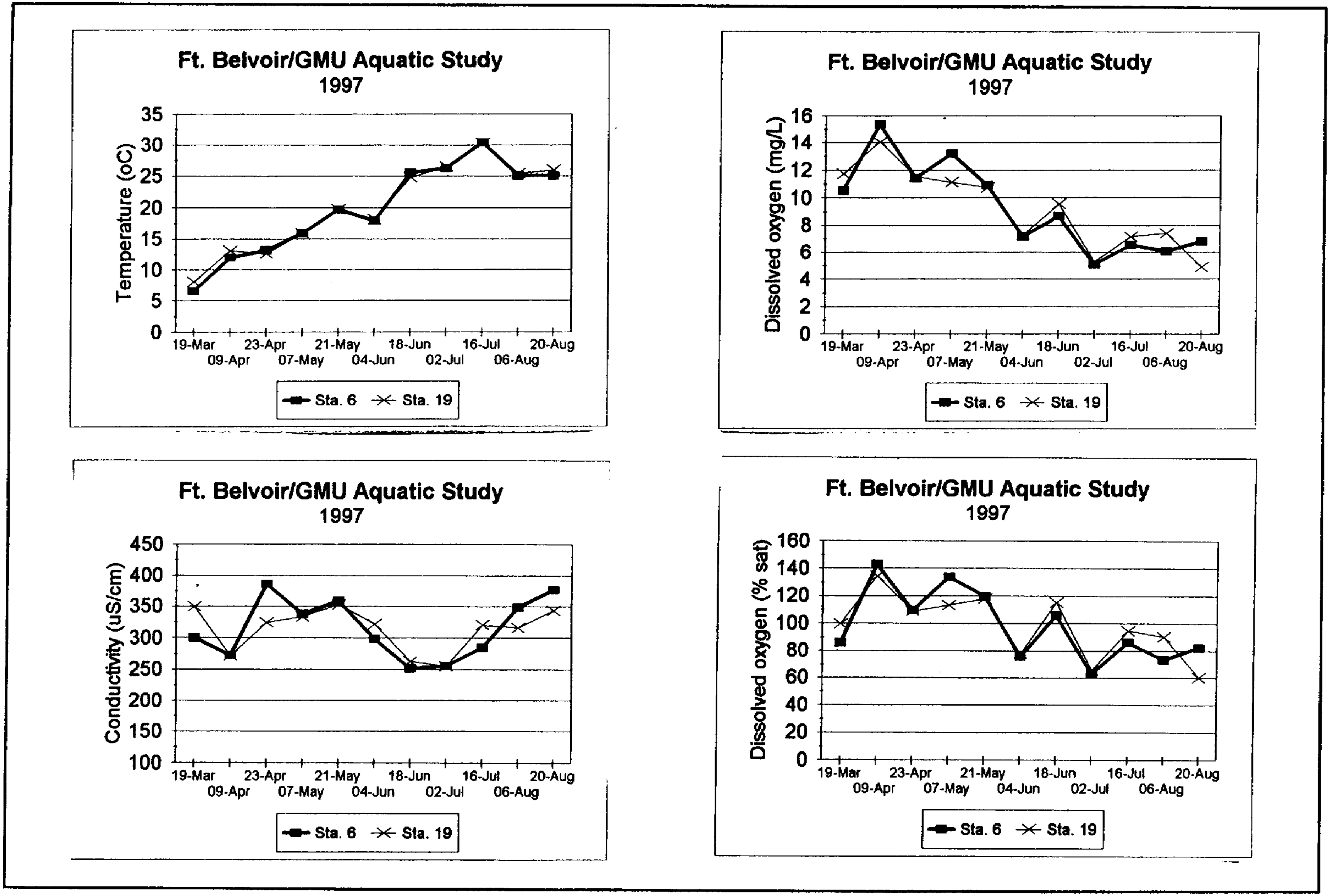


Figure 3. Physico-chemical Parameters by Station and Sampling Date. 1997. Water Temperature (°C), Conductivity (standardized to 25°C), and Dissolved oxygen (mg/L) and (% saturation).

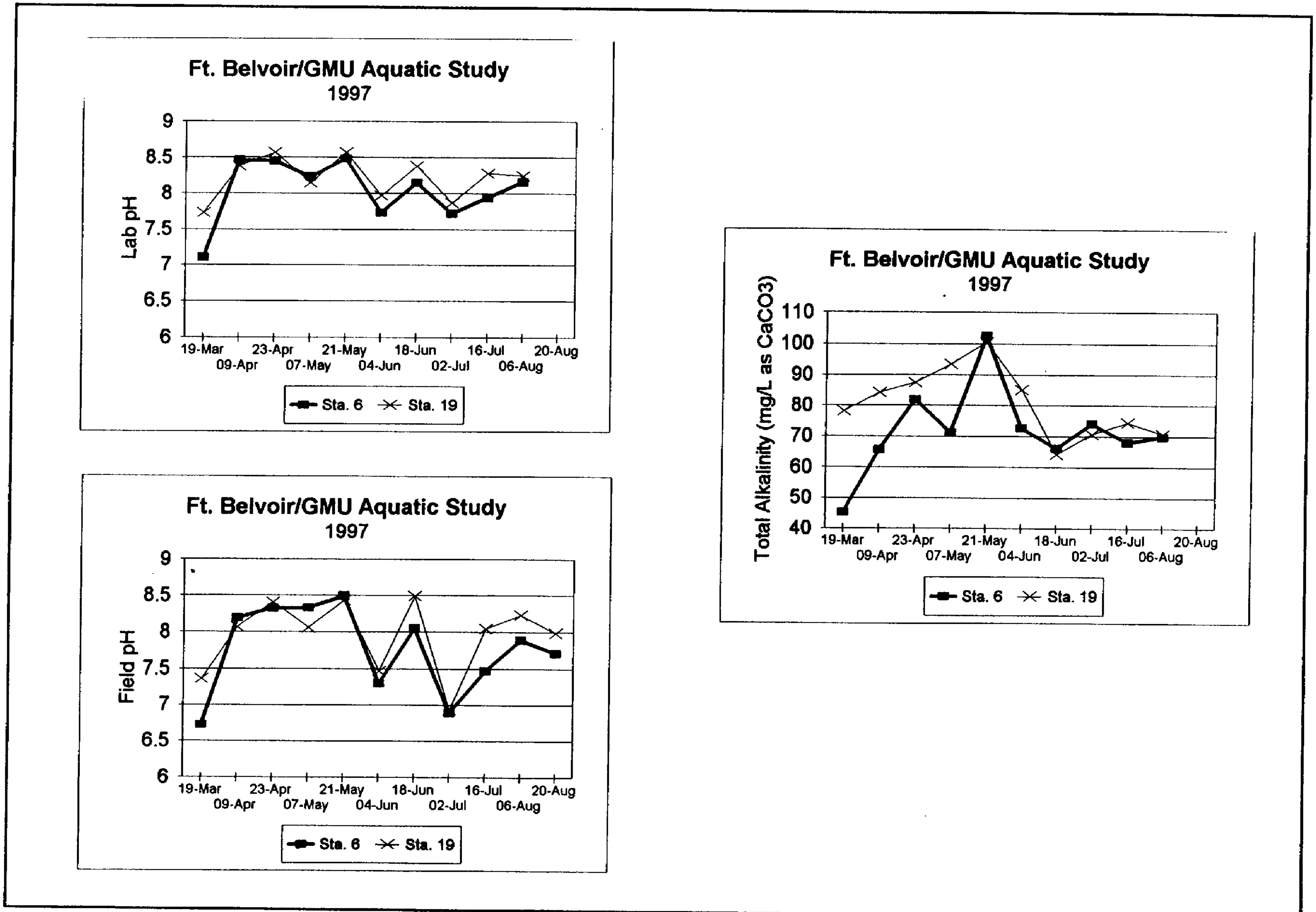


Figure 4. Physico-chemical Parameters by Station and Sampling Date. 1997. Lab pH, Field pH, Total alkalinity (mg/L as $CaCO_3$).

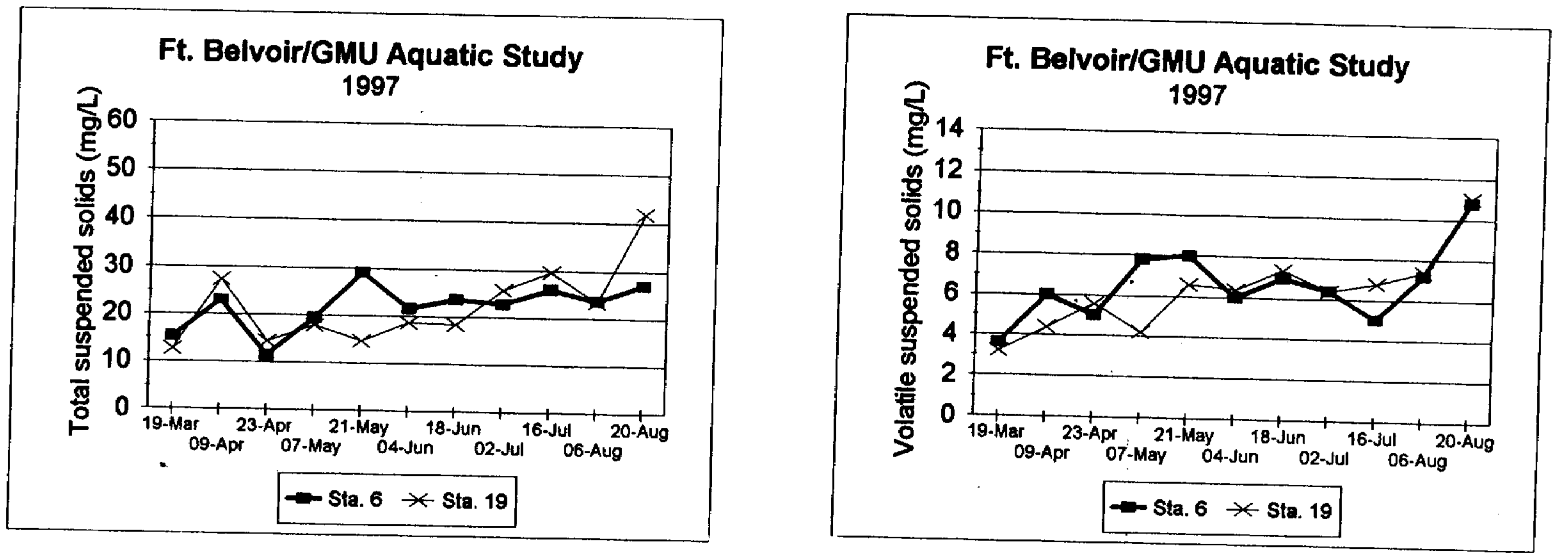


Figure 5. Physico-chemical Parameters by Station and Sampling Date. 1997. Total suspended solids (mg/L), Volatile suspended solids (mg/L).

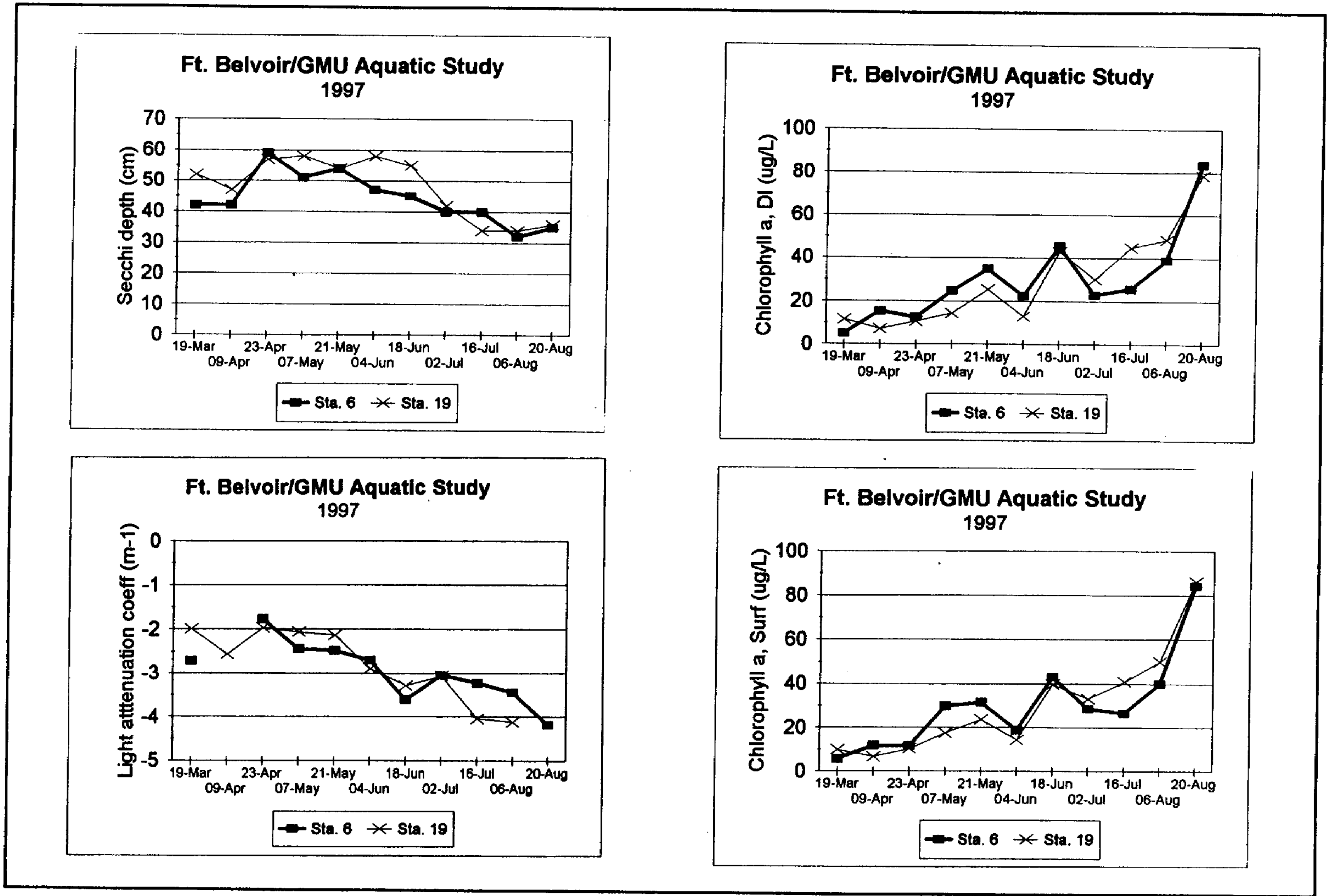


Figure 6. Physico-chemical Parameters by Station and Sampling Date. 1997. Secchi depth (cm), Light attenuation coefficient (m^{-1}), Chlorophyll a, depth-integrated (µg/L), Chlorophyll a, surface (µg/L).

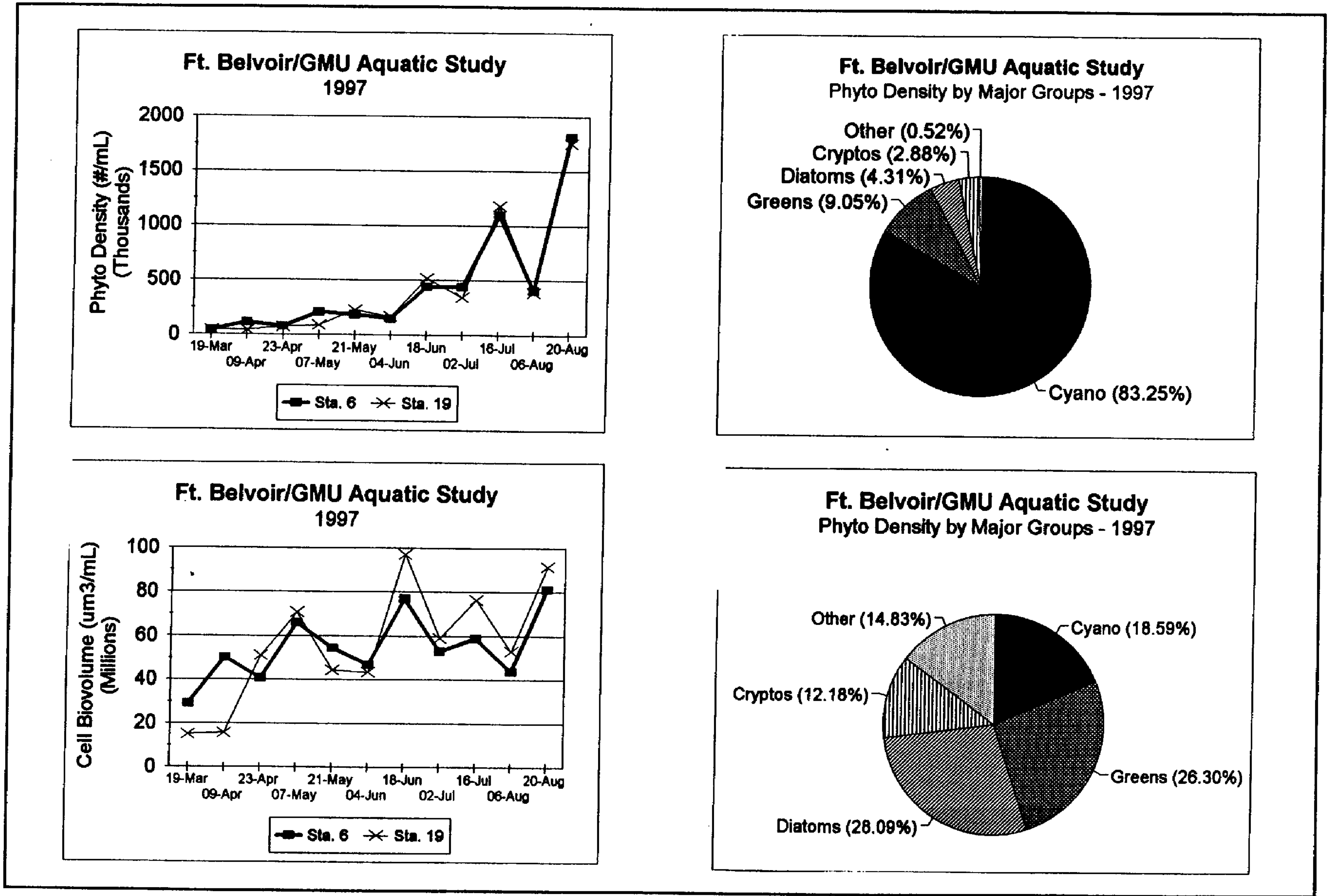
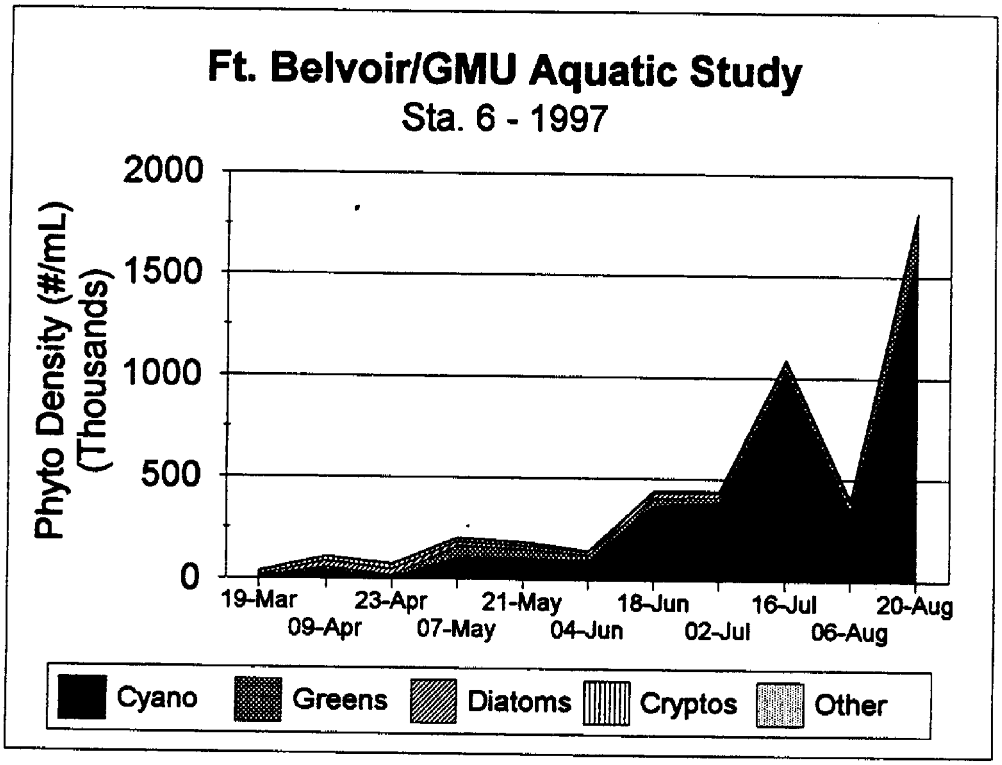


Figure 7. Phytoplankton Parameters by Station and Sampling Date. 1997. Cell density (#/mL), Cell biovolume (um^3/mL), Percentage of cell density in major groups, Percentage of of phytoplankton biovolume in major groups.



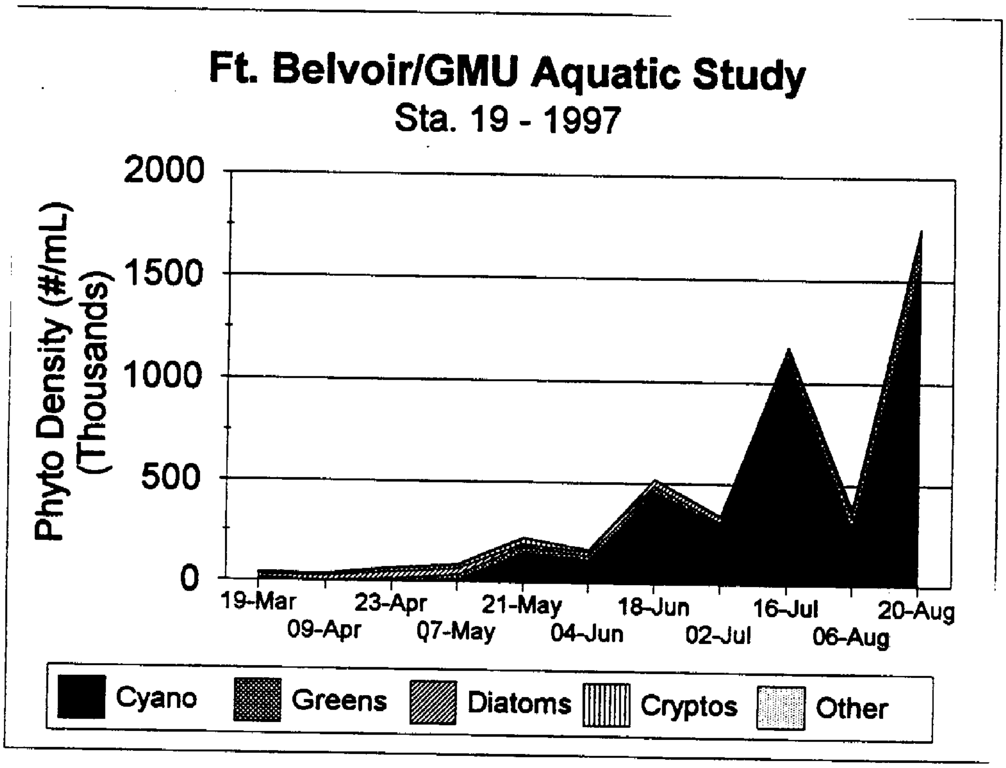


Figure 8. Phytoplankton Density by Major Group and Sampling Date. 1997. Phytoplankton density by major group and sampling date. 1997. (Top) Station 6, (Bottom) Station 19.

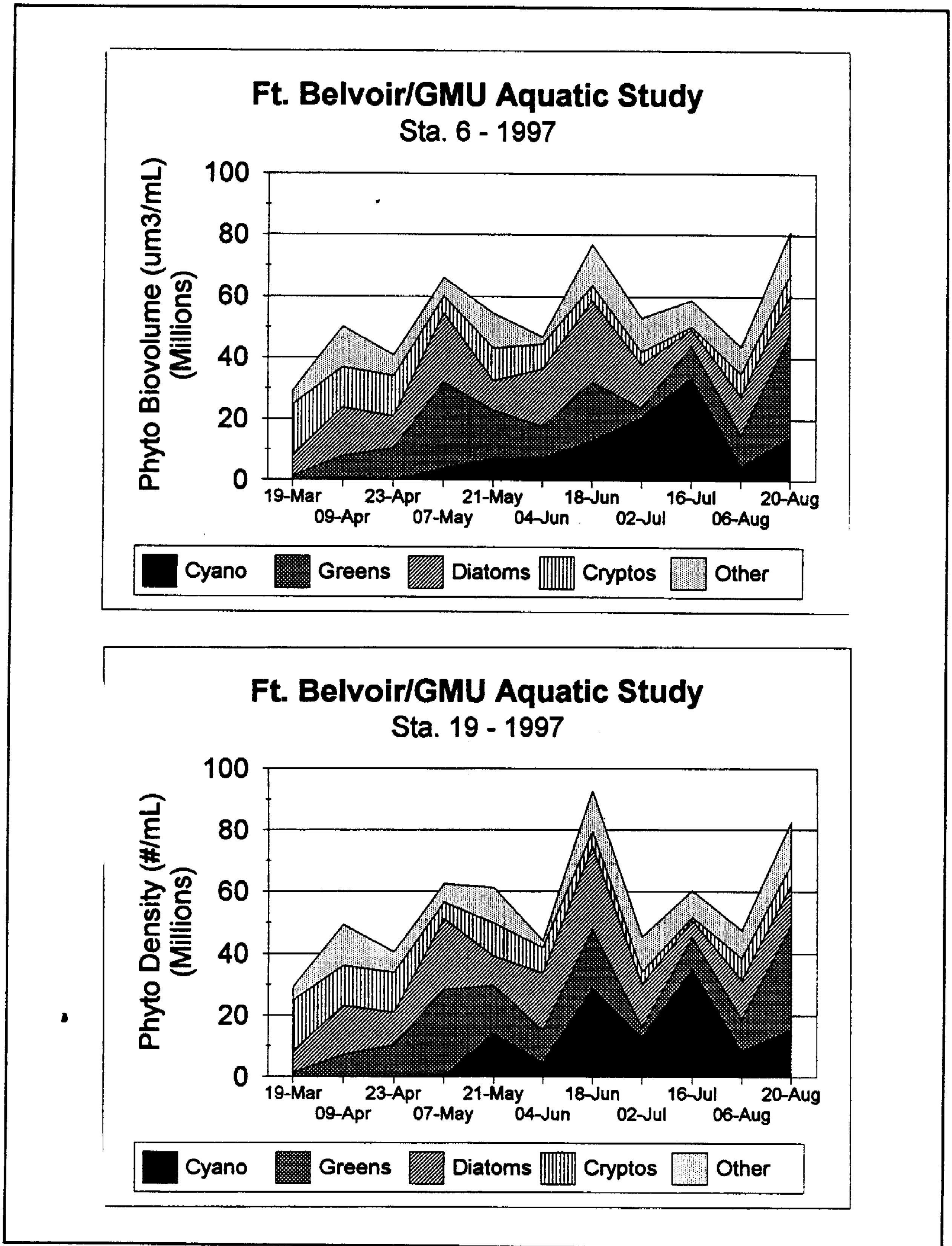


Figure 9. Phytoplankton Biovolume by Major Group and Sampling Date. 1997. (Top) Station 6, (Bottom) Station 19.

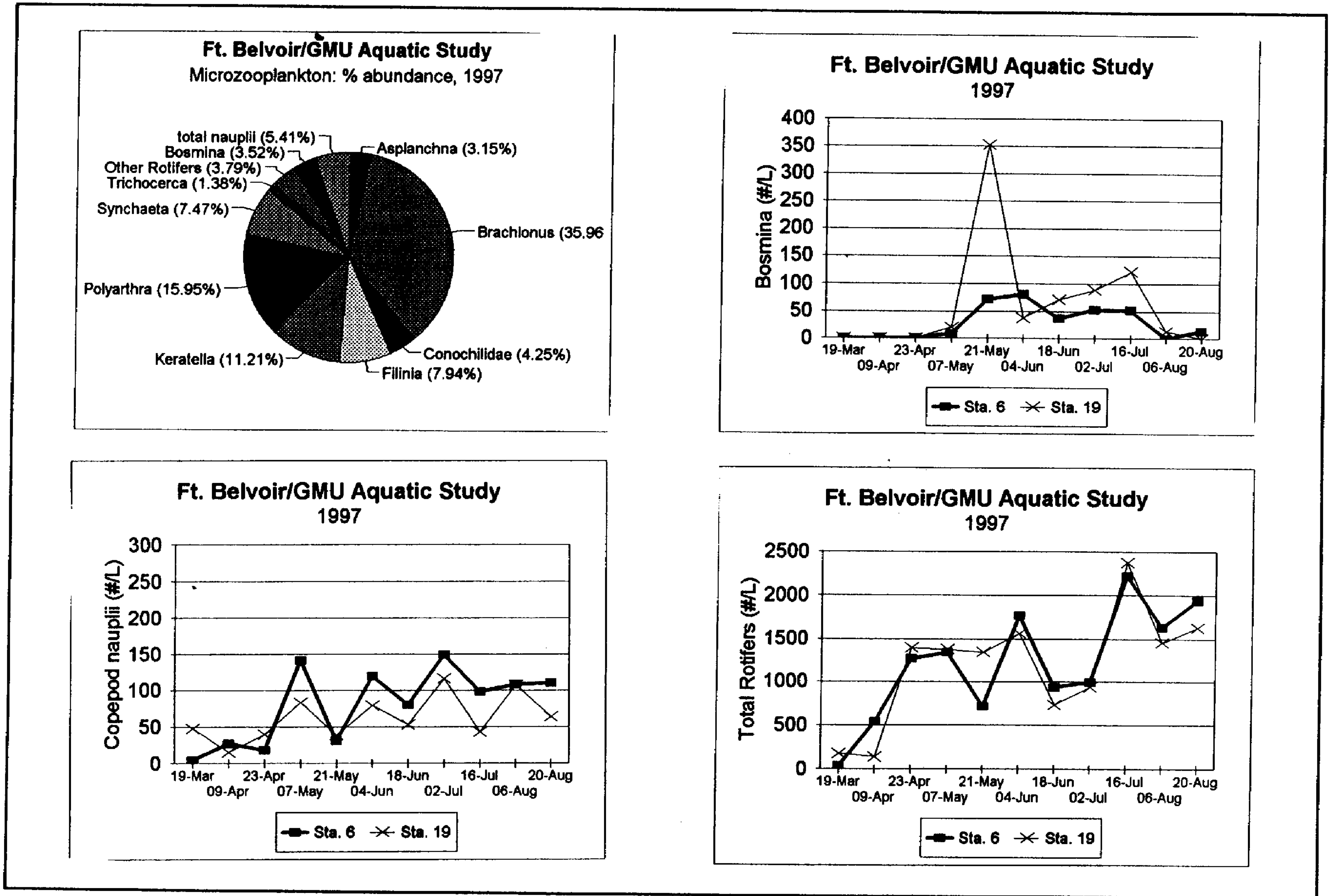


Figure 10. Microzooplankton. 1997. Percentage average abundance by taxa, Copepod nauplii (#/L) by station and date, *Bosmina* (#/L) by station and date, Rotifers by station and date (#/L).

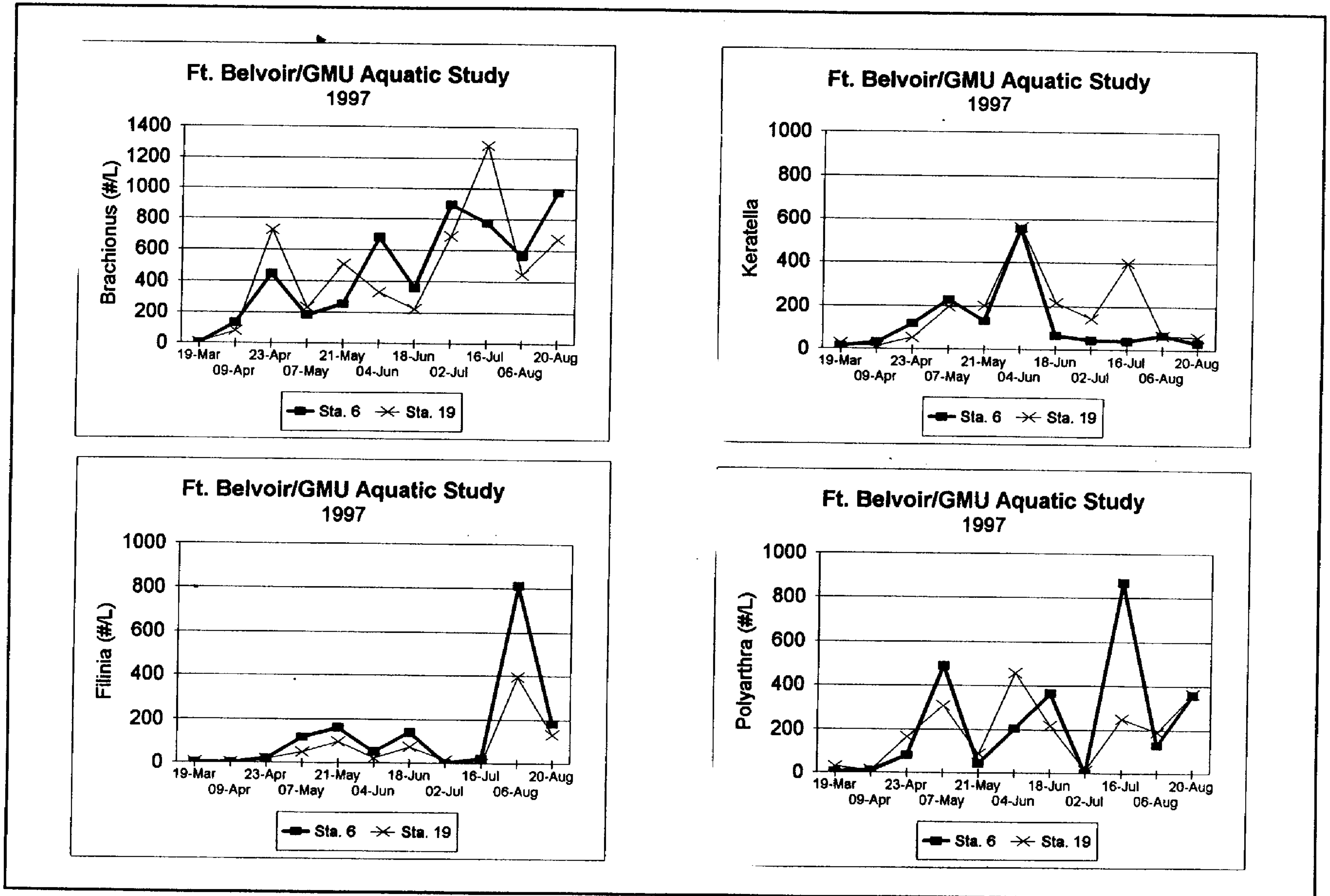


Figure 11. Microzooplankton parameters by Station and Sampling Date. 1997. Rotifers. *Brachionus* (#/L), *Filinia* (#/L), *Keratella* (#/L), *Polyarthra* (#/L).

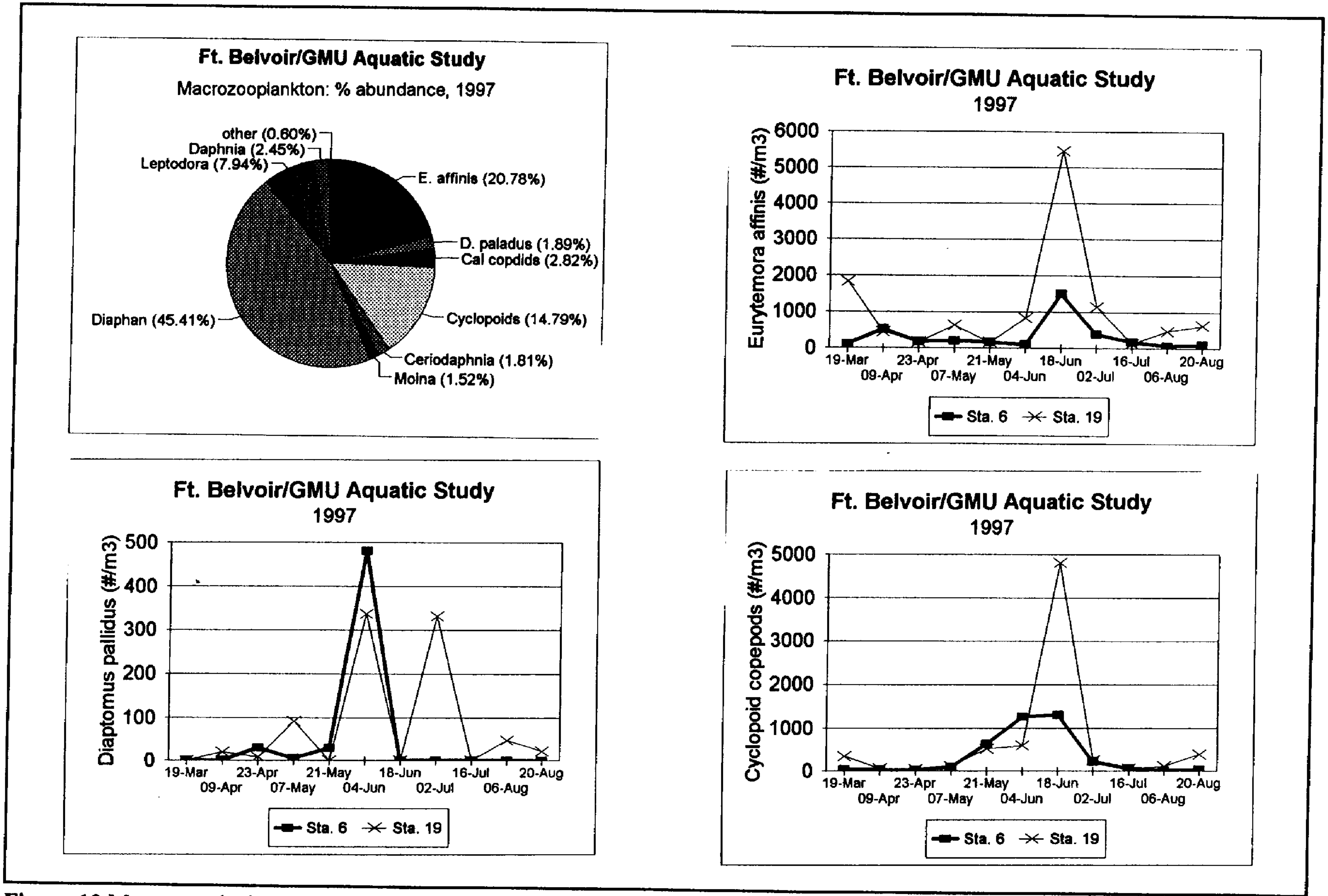


Figure 12.Macrozooplankton parameters. 1997. Percentage of average abundance by taxa, *Diaptomus pallidus*, adults plus copepodids (#/m^3), *Eurytemora affinis*, adults plus copepodids (#/m^3), Cyclopoid copepods, adults plus copepodids (#/m^3)

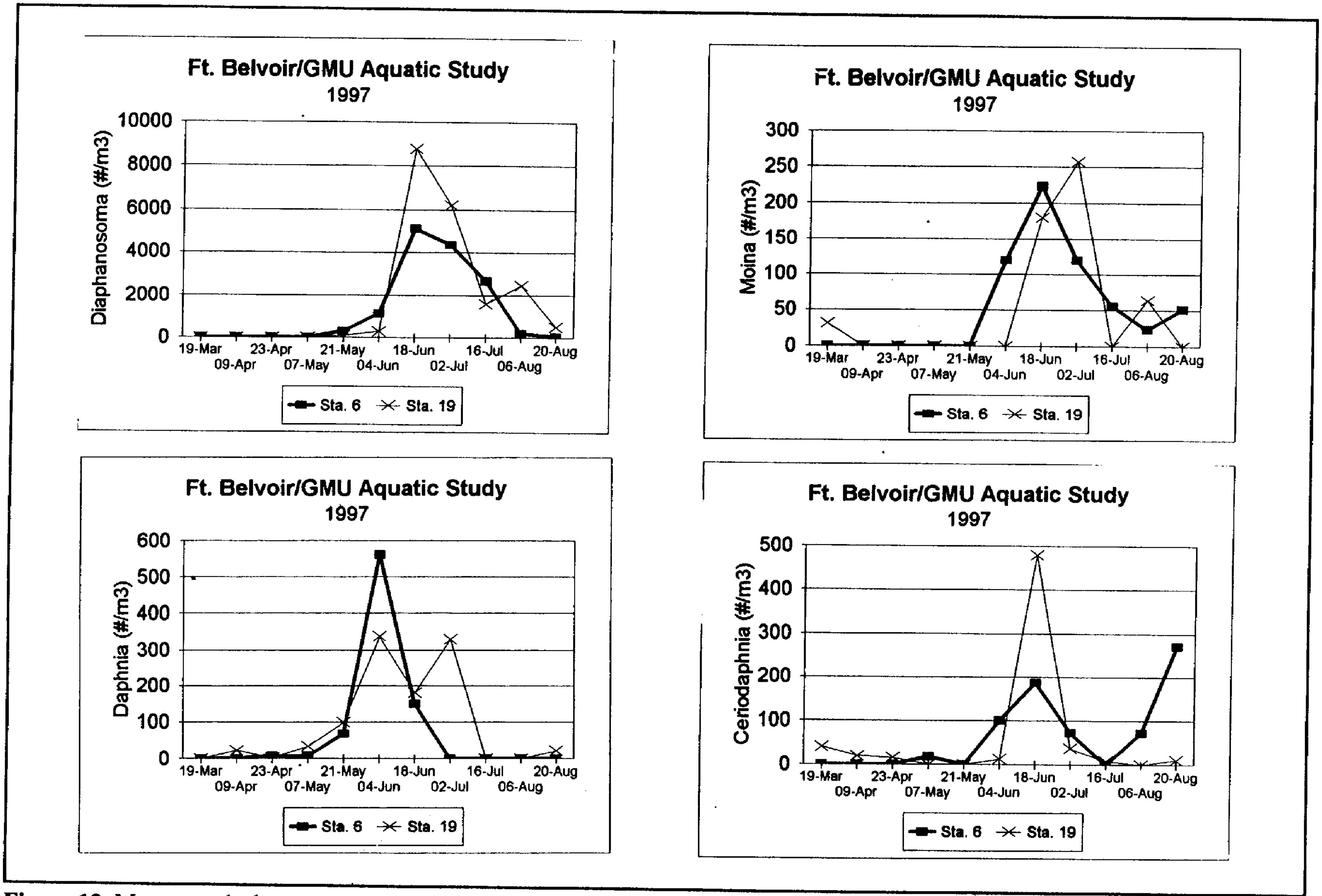


Figure 13. Macrozooplankton parameters by Station and Sampling Date. 1997. *Diaphanosoma* (#/m^3), *Daphnia* (#/m^3), *Moina* (#/m^3), *Ceriodaphnia* (#/m^3)

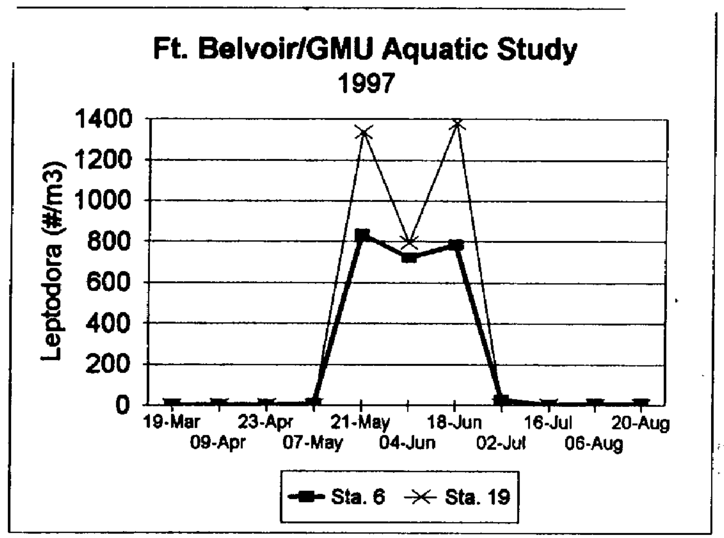


Figure 14. Macrozooplankton parameters by Station and Sampling Date. 1997. *Leptodora* (#/m^3)

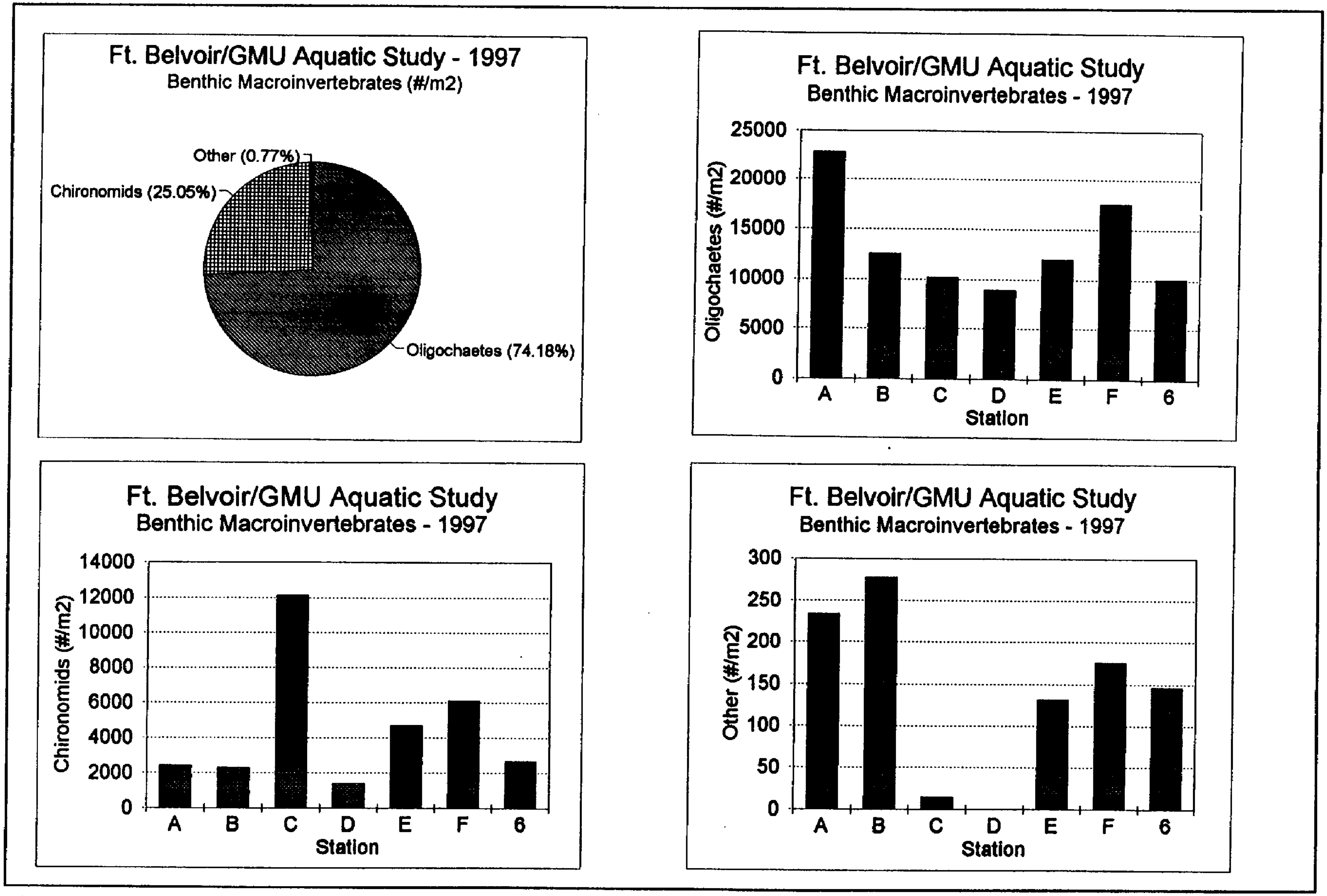


Figure 15.Benthic parameters by Station and Sampling Date. 1997. Percentage average abundance by major group. Oligochaetes (#/m^2), Chironomid larvae (#/m^2), Other animals (#/m^2).

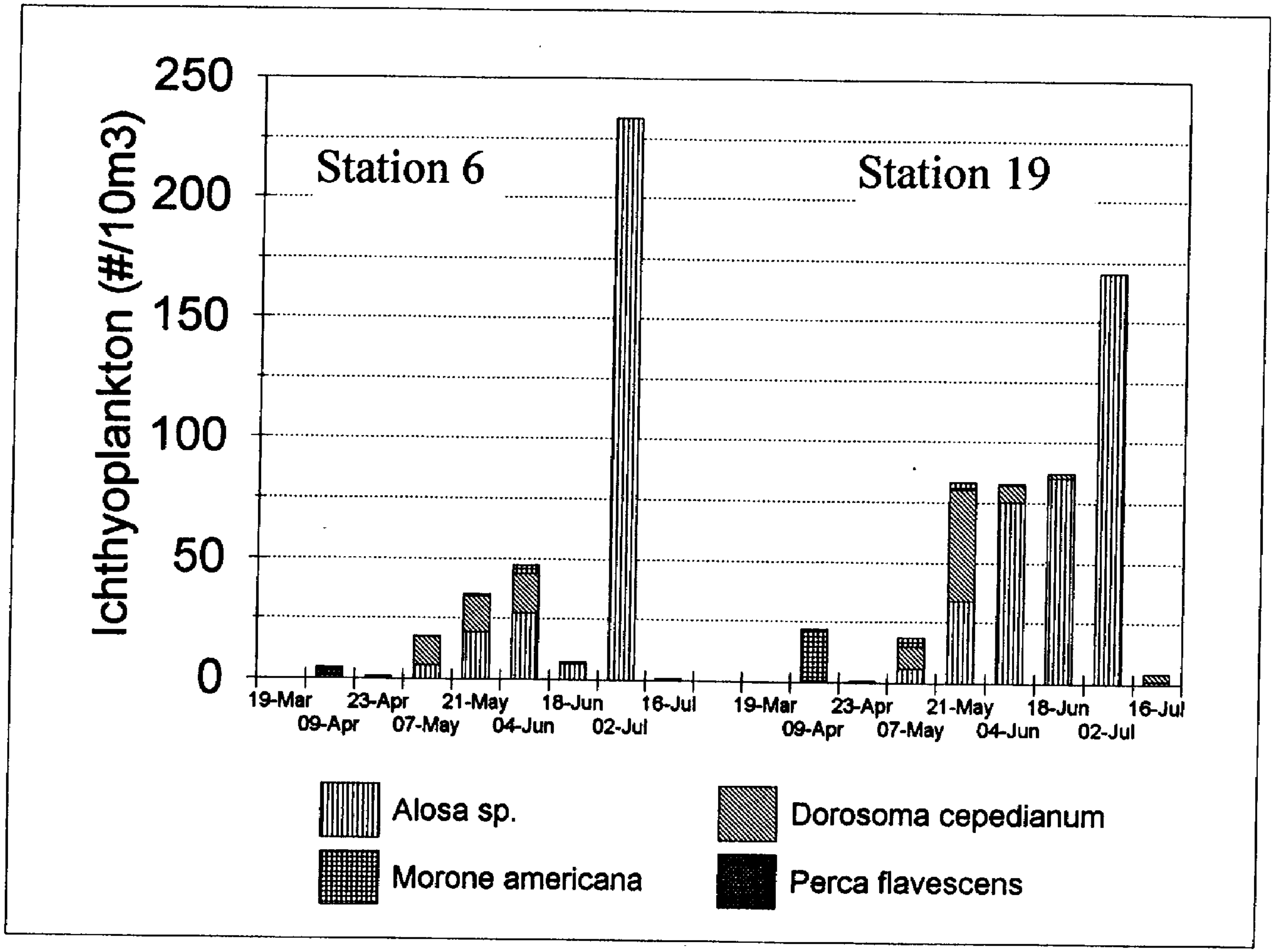


Figure 16. Ichthyoplankton parameters by Station and Sampling Date. 1997. Abundance of dominant taxa (#/10m^3): *Alosa* sp. (Shad and herring), *Dorosoma cepedianum* (gizzard shad), *Morone americana* (white perch), *Perca flavescens* (yellow perch).

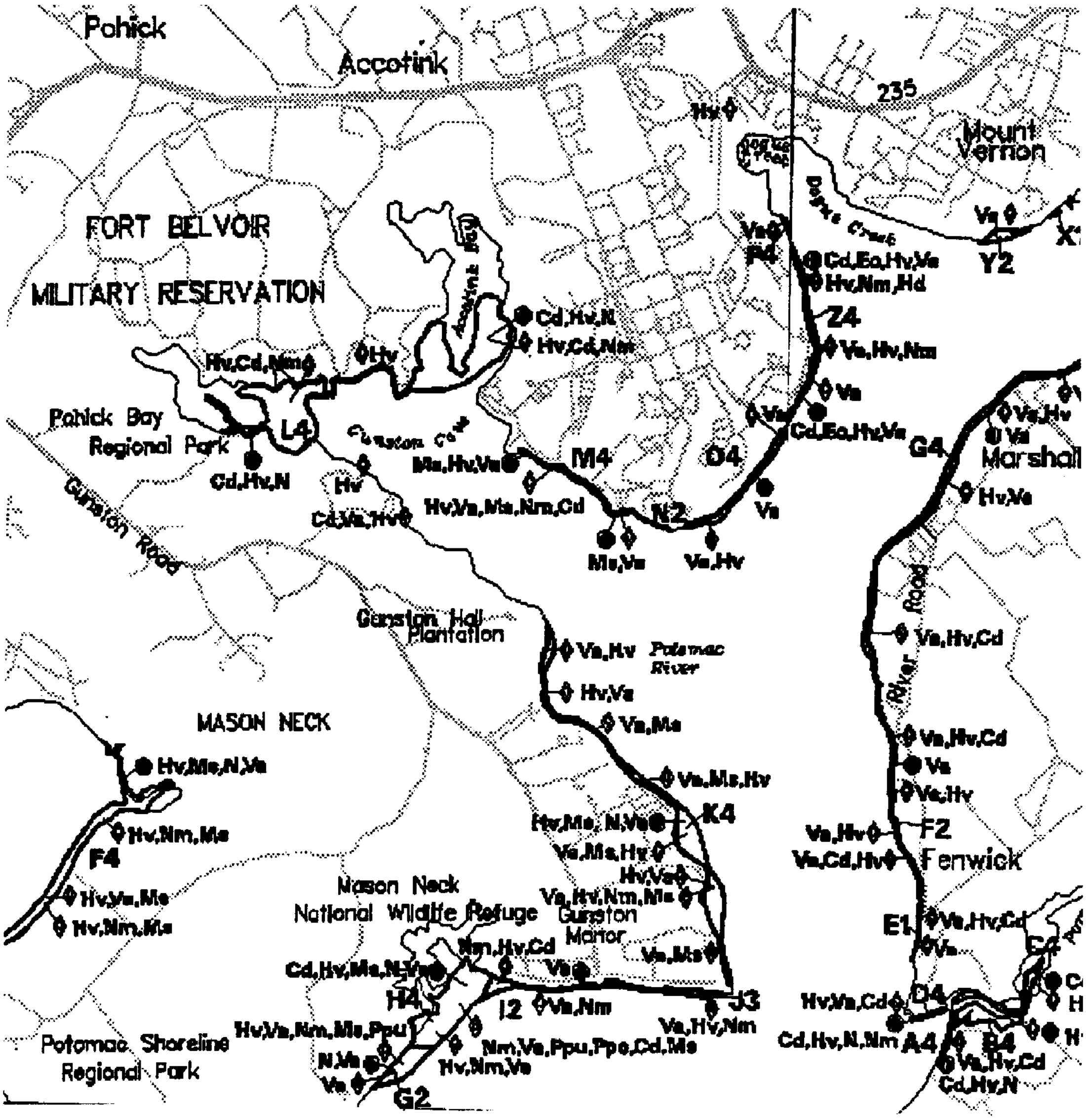


Figure 17. Macrophyte distribution. August 1997. Hv=*Hydrilla verticillata*, Va=*Vallisneria americana*, Cd=*Ceratophyllum demersum*, Ms=*Myriophyllum spicatum*, N=*Nuphar*, Nm=*Najas minor*, Ngu=*Najas gudalupensis*, Hd=*Heteranthera dubia*, Ec=*Elodea canadensis*. Each area of major coverage is given a unique letter followed by a number indicating intensity of coverage ranging from 1 (very sparse) to 4 (dense). Source: U.S. Geological Survey (V. Carter and N. Rybicki), also available at http://www.vims.edu/bio/sav/.

Anadromous Fish Studies

Introduction

Anadromous fishes spawn in freshwater environments and spend most of their adult life in the sea. In the mid-Atlantic area, important anadromous fishes include blueback herring, alewife, hickory shad, and American shad. Blueback herring and alewife commonly spawn in the lower reaches of creeks. This report presents the results of a study to determine if Pohick Creek, Accotink Creek and Dogue Creek supported spawning by these fishes in 1997 and 1998.

Methods

Adult fishes were collected with unbaited hoop nets at stations in Accotink, Pohick, and Dogue Creeks (Figure 1). Each net was 3 feet in diameter and 10 feet long. The mesh size was 0.75 inch square mesh. Whenever the flow rate was low enough to allow placement, a plastic fence material was used as a lead on the hoop nets set in the creeks. The fencing was 3 feet high and had a mesh of 1.25 inch square mesh. The length was about 20 feet. The nets were set in the evening and were taken up the following morning. All adult fishes were identified in the field, measured for standard length, and then released.

Eggs and larval fishes were sampled with a conical plankton net of 0.33 mm square mesh and 0.3 m diameter mouth. The net was set in the creek current for 15 minutes. The plankton net sample was preserved in 5% formalin and transported back to the lab. All sampling in Pohick Creek was done near the head of tidewater, where the water current was generally strong and unidirectional. The site was the same location as 1996, which was about 50 meters further upstream than in previous years. The water depth was about two to four feet deep. The sampling site in Accotink Creek was about 450 m above the head of tidewater, where the stream flows alternately through shallow gravel riffles and moderately deep pools. This is the same as in 1996, but it is slightly downstream of previous years. The hoop nets are more effective in the conditions found in Pohick Creek, in large measure because leads are more easily deployed there. The site in Dogue Creek is located near the head of tidewater above the Mount Vernon Memorial Highway bridge and about 50 meters above the George Washington grist mill. This is the same as 1996. There is usually very little stream flow here, and only slight tidal flow.

Results

1997 fish eggs and larvae

Collections were begun on March 10, 1997 and continued weekly through June 10 in Pohick, Accotink, and Dogue Creeks. A summary of the results is shown in Table 1. A total of 6354 eggs and 349 larval fishes were collected. The number of fish eggs of each taxon collected on each sampling date is shown in Table 2a. The number of larvae of each taxon collected on each sampling date is shown in Table 2b.

Of the eggs, 44% were caught in Dogue Creek, but when adjusted for the volume of water filtered to catch the eggs, Dogue Creek produced 92% of the total. This year we felt less confident of distinguishing *Alosa* eggs from gizzard shad eggs and hence placed more into the unidentified category.This was in part because of the large amount of debris adhering to the eggs and in part because discussions with researchers at the Virginia Institute of Marine Science indicated that they did not feel confident in distinguishing the eggs in their research. Nevertheless, most of the unidentified eggs were thought to be clupeid eggs, because of the number of eggs seen and the belief that the clupeid adults were the only fishes present in the creeks which produce large numbers of eggs at that time of year. Moreover, whenever the eggs were visible or could be picked clean, they looked like clupeid eggs. All of the eggs (123) collected on March 24 in Dogue Creek were identified as *Alosa* sp. eggs, and four each were similarly identified on Apr. 7 and Apr. 21. All of the eggs collected in Dogue Creek on May 19 (4 eggs), May 27 (54), June 2 (34) and June 10 (1) were identified as *Dorosoma* eggs.

Pohick Creek produced 37.5 % of the eggs that were caught, but after adjustment for the volume of water filtered, accounted for 6% of the total. Accotink Creek produced 18.5% of the eggs and 2% of the water volume adjusted total..

Sixty-five larvae were identified as the valuable anadromous *Alosa* sp.. Of these, one came from Pohick Creek, 53 came from Accotink Creek, and 11 came from Dogue Creek. The earliest catches of *Alosa* sp. were made in Dogue Creek on March 31, when 5.5 larvae/10m^3 were taken. These may have been alewife, since this species spawns earlier than blueback herring. A second catch of *Alosa* larvae (0.9 larvae/10m^3) was made in Dogue on April 15. The first catch of *Alosa* larvae in Accotink Creek was made on April 7 (0.9 larvae/10m^3) and continued with small catches every week through May 19. One larva was caught on June 10. The abundances ranged from 0.6 larvae/10m^3 to 8.1 larvae/10m^3 on May 12. The one *Alosa* larva caught in Pohick Creek was taken on May 5 (0.4 larvae/10m^3).

Gizzard shad, a semi-anadromous clupeid fish, was the most abundant larval species, with 147 larvae from Pohick Creek, 53 from Accotink Creek, and 2 from Dogue Creek. Two larvae were collected in March, which may have have been mis-identified as gizzard shad, since that is very early for gizzard shad spawning. Two were collected in Accotink Creek on April 21, but the largest catches were made on May 5, when 126 were caught in Pohick Creek (51.4 larvae/10m^3), 12 in Accotink Creek (2.5 larvae/10m^3) and one in Dogue Creek (1.1 larvae/10m^3). A few were taken in Pohick and Accotink Creeks every week thereafter, except May 27, when no larvae were caught. The last week that samples were collected (June 10) produced moderately high numbers of 13.9 larvae/10m^3 in Pohick Creek and 15.7 larvae/10m^3 in Accotink Creek.

White perch larvae were caught in Dogue Creek on March 31 (37 larvae/10m^3), in Pohick Creek on May 5 (1.6 larvae/10m^3) and May 12 (8.4 larvae/10m^3), and in Accotink Creek on May 19 (1.1 larvae/10m^3).

Other species whose larvae were caught were yellow perch, common carp, striped bass, white sucker, goldfish, and tessellated darter.

1997 adult fishes

The adult fishes were sampled over 15 weeks in 1997. The list of species that were caught in the three creeks is shown in Table 3. Thirteen species were collected. Included were 43 adult alewife, a valuable anadromous species, six of which were collected in Pohick Creek, 21 in Accotink Creek and 16 in Dogue Creek. This was the second most abundant fish species that was collected, representing 12.6% of the total catch. The date of capture and species identification of all anadromous and semi-anadromous individuals are shown in Table 4. The alewife were first collected on March 11 and sporadically over nine of the next 11 weeks. The semi-anadromous gizzard shad was, as usual, the most abundant species caught at all three creeks. A total of 91 individuals of this species was collected in Pohick Creek, while 66 were collected in Accotink Creek, and 88 in Dogue Creek. One adult of the semi-anadromous yellow perch was caught in Accotink Creek. Adult individuals of nine non-anadromous species comprised the remaining 15% of the fishes that were caught. Longnose gar were the most numerous of these.The unusual catch of two large rainbow trout should be noted. These fishes were undoubtedly introduced below Lake Accotink in some previous year in a sport fishing program.

1998 adult fishes

The adult fishes were sampled over 13 weeks (March 3-May 26) in 1998 in Pohick Creek and Accotink Creek. Sampling in Dogue Creek began March 31 and continued until May 26. The list of species and numbers of individuals of each that were caught in the three creeks is shown in Table 5. Nine species were collected. Included were 32 adult alewife, a valuable anadromous species, five of which were collected in Pohick Creek, 15 in Accotink Creek and 12 in Dogue Creek. This was the second most abundant fish species that was collected, as was the case in 1997 (Kelso 1997), and represented 15% of the total catch. The date of capture and species identification of all anadromous and semi-anadromous individuals are shown in Table 6. One alewife was collected on March 3 and the rest were collected from March 25 through April 22, with a peak number on April 13.

The semi-anadromous gizzard shad was, as usual, the most abundant species caught at all three creeks. It accounted for 74% of the total adult fishes. The first individuals were caught on March 31, and at least one was caught on every succeeding day that was sampled. On March 31, the size (standard length) of most of the fishes was less than 10 cm. On April 13 and April 22 the size was mostly greater than 10 cm. Peak numbers of gizzard shad were caught on May 6, when 92 individuals were taken. Both size groups were present in the May 6 capture. Adult individuals of six non-anadromous species comprised the remaining 11% of the fishes that were caught. Bluegill was the most numerous of these. Other species such as eels may have passed through the mesh.

Discussion

1997 fish eggs and larvae

The variation in weekly abundance of adult *Alosa* (alewife in this case) in the creeks in 1997 (Kelso, 1997) implies that spawning occurred in late March to early April. This is consistent with the abundance of *Alosa* eggs and larvae in the creeks in April and May. However, *Alosa* larvae did not peak in density in Gunston Cove until July, 1997 (Jones and Kelso, 1998). Perhaps the larvae move out of the creeks and shoreline areas and into open water as they mature, or perhaps the larvae caught in the Cove were mostly blueback herring, or represent a separate spawning population of alewife.

Adult gizzard shad abundance indicates spawning in the creeks in late April and early May (Kelso, 1997). Eggs and larvae are most abundant in May. In the Cove, gizzard shad larvae peaked in abundance in late May and early June of 1997 (Jones and Kelso, 1998)

White perch adults are never very abundant in the creeks and their eggs are not commonly found there. In 1997 their larvae were most abundant in the creeks in late March and in the Cove in early April.

Alosa sp. were the most abundant fish larvae in the Cove in 1997, followed by gizzard shad and white perch. In the creeks, gizzard shad were most abundant, *Alosa* sp. were next, and white perch were third. However, *Alosa* sp. were the most abundant fish larvae in Accotink Creek, gizzard shad were the most abundant larvae in Pohick Creek, and white perch were the most abundant larvae in Dogue Creek.

The number of fish eggs caught in 1997 was much lower than the record levels that were caught in 1996, but were higher than the catch of other years (Table 7). However, the differences in catch effort and level of identification among years makes interannual comparisons very imprecise. The dates on which samples were collected in each year are shown in Table 8. The identification of both *Alosa* eggs and gizzard shad eggs from Dogue Creek may result from eggs that were carried into the tidal creek from the Dogue Creek embayment. These eggs would be less covered with debris and tannin/humic stains and hence were easier to identify. While it appears that Dogue Creek contained many more fish eggs than the other two creeks, once numbers per volume of water filtered were calculated, it is not certain whether this calculation produces numbers which are indicative of the real density of eggs. In the flowing water of Pohick and Accotink Creeks, the eggs become stained and covered with debris so that identification is very difficult. Moreover, the eggs are probably swept downstream rapidly and the calculated density values may underestimate the real density.

The presence of *Alosa* larvae in Accotink Creek must be evidence of spawning there. It is difficult to accept the alternate idea that the larvae swim upstream at least 0.5 kilometer into this creek from the tidal embayment. On the other hand, the collection site in Pohick Creek is subject to tidal currents which might aid a larva to move up the creek from the embayment. Nevertheless, this would represent a movement within the creek of about 1.4 kilometers. Dogue Creek has such a low stream flow and the collecting site is so close to the tidal embayment that it is easy to accept that the larvae there may come from the embayment.

The catch of *Alosa* larvae in Accotink Creek was larger than any previous year, and the catch in Dogue Creek was slightly higher than that of 1996. The catch in Pohick Creek was slightly lower than that of 1996.

1997 adult fishes

A summary of the adult fishes caught over the last 10 years of sampling in the creeks is presented in Table 9. The catch of more alewife adults in the three creeks is encouraging. This follows last year's catch of alosid larvae in the creeks and certainly appears to document alewife spawning in all three creeks. Spawning may be occurring only out in the embayments or the river or even another tributary, with the larvae swimming into or being swept by currents into the creeks, but this seems unlikely. However, no evidence has been found that blueback herring spawn in any of the creeks as they do in Quantico Creek under similar conditions. Spawning is surely occurring somewhere in the vicinity of Gunston Cove, since very young juvenile bluebacks are very abundant there. In the spring of 1997 the appearance of adult bluebacks in Quantico Creek was sparse and dispersed over an extended time and did not seem as successful a spawning run as in recent years (Joe Gear, personal communication).

Certainly the continued large catches of gizzard shad and non-anadromous species of fish in Pohick Creek indicate that the water quality is greatly improved since 1988.

1998 adult fishes

A summary of the adult fishes caught over the last 11 years of sampling in the creeks is presented in Table 6. A review of the 1988 data showed that adult blueback herring were identified in the catches from Accotink Creek and Dogue Creek. Since they have not been identified in the creeks since, this may have been a mis-identification. Nevertheless, blueback juveniles are abundant in Gunston Cove in most years, so the presence of adults is logical. In 1998 the spawning run of blueback herring in Quantico Creek occurred on April 26-28 (Gear, personal communication), but none were caught in the Gunston Cove area creeks. Alewife were caught in largest numbers in Accotink Creek and Dogue Creek, but five were caught in Pohick Creek. Comparison to the last two years shows stable numbers in Pohick and slight declines in Accotink and Dogue Creeks. Weekly abundance data indicates spawning may have occurred throughout April.

Gizzard shad numbers vary greatly from year to year in Pohick Creek. In 1998 the catch was somewhat lower than average. Their abundance in Accotink Creek is almost always less than that of Pohick Creek, and this is true of 1998 also. Weekly abundance data may indicate spawning in late April and early May.

Summary

The presence of adult alewife and larvae of *Alosa* sp., the sequential timing of their capture, and the locations of the sites of their capture imply spawning by this species in Pohick and Accotink Creeks. Blueback herring spawning may also have occurred, but this was not supported by captures of adult bluebacks. Similar results were found at Dogue Creek, but the spawning activity there may have occurred in the adjacent tidal embayment. The largest numbers of larvae and adults were collected in Accotink Creek. The numbers of larvae collected there were more numerous than in any previous year.

The same kind of evidence indicates that gizzard shad also appeared to have spawned in the three creeks. Indeed, the large numbers of eggs and larvae show that gizzard shad are the primary spawners at or near the collecting sites in the creeks. The largest numbers of larvae were collected in Pohick Creek.

White perch larvae were also collected in all three creeks, and may indicate spawning there, but no eggs and only a few adults were found. The tidal embayment is perhaps a more significant site of spawning than the creek sites are for this species.

The catch of adults and larvae of resident freshwater fish species such as common carp implies that there was some spawning of these species in the creeks. However, most of these species spawn during the summer after our sampling ends.

References Cited

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Kelso, Donald P. 1997. Anadromous fish survey of Pohick, Accotink and Dogue Creeks, pp 67-74 *In* R.Christian Jones and Donald P. Kelso. 1997. An ecological study of Gunston Cove. 1996-97. Department of Public Works, Fairfax County, Virginia.

Figure 1. Location of Anadromous Fish Sampling

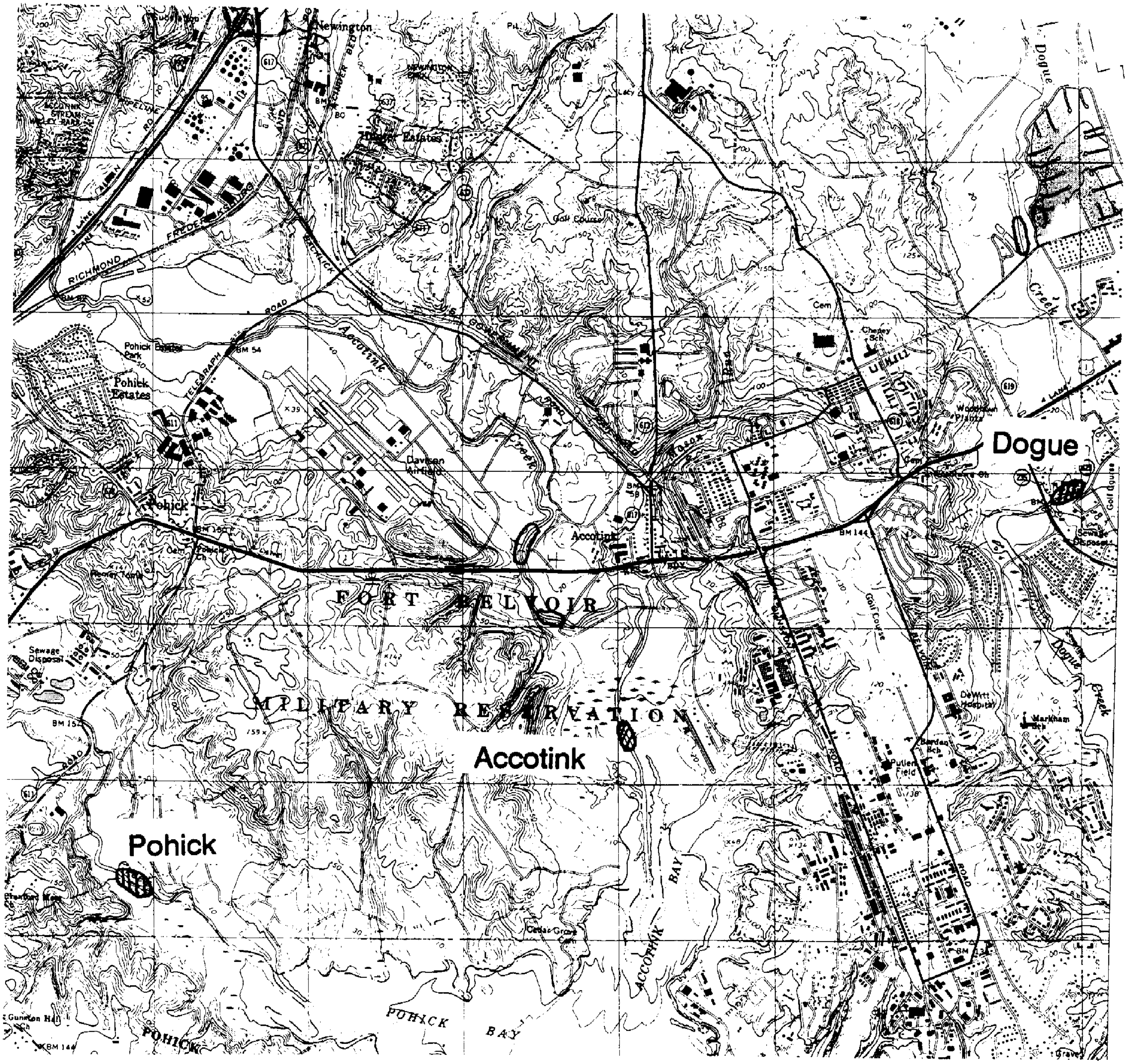

Table 1. Fish eggs and larvae collected in Pohick, Accotink, and Dogue Creeks in 1997

	No. individuals/sample				No. individuals/10m³			
Fish species	Total	Pohick	Accotink	Dogue	Total	Pohick	Accotink	Dogue
EGGS								
Alosa sp.	131			131	896.5			896.5
gizzard shad	93			93	12851.1			12851.1
yellow perch	1			1	0.6			0.6
unknown	6130	2383	1178	2568	5655.4	1235.7	411.9	4007.8
Total	6355	2383	1178	2793				
LARVAE								
Alosa sp.	65	1	53	11	21.7	0.4	14.9	6.4
gizzard shad	202	147	53	2	120.0	82.4	27.8	1.8
white perch	55	7	1	47	48.1	10.1	1.1	37.0
common carp	13	2	11	0	7.4	0.9	0.9	6.5
yellow perch	5	2	0	3	4.6	0.8	0	3.8
goldfish	2	0	2	0	2.1	0	2.1	0
white sucker	1	0	1	0	0.3	0	0.3	0
striped bass	1	0	1	0	0.2	0	0.2	0
tessellated darter	1	0	0	1	163.1	0	0	163.1
unknown	4	0	4	0	2.9	0	2.9	0
Total	349	159	126	64				

Table 2a. The numbers of fish eggs collected during the spring of 1997 in Pohick, Accotink, and Dogue Creeks.

	Pohick			Accotink			Dogue		
	unident.	*Alosa*	*Dorosoma*	unident.	*Alosa*	*Dorosoma*	unident.	*Alosa*	*Dorosoma*
Mar 10	0	0	0	0	0	0	1	0	0
Mar 17	0	0	0	0	0	0	0	0	0
Mar 24	2	0	0	0	0	0	0	123	0
Mar 31	53	0	0	63	0	0	118	0	0
Apr 7	78	0	0	210	0	0	635	4	0
Apr 15	11	0	0	20	0	0	432	0	0
Apr 21	8	0	0	13	0	0	0	4	0
Apr.28	965	0	0	678	0	0	996	0	0
May 5	827	0	0	9	0	0	383	0	0
May 12	145	0	0	8	0	0	4	0	0
May 19	35	0	0	0	0	0	0	0	4
May 27	52	0	0	135	0	0	0	0	54
Jun 2	207	0	0	42	0	0	0	0	34
Jun 10	0	0	0	0	0	0	0	0	1
Total	2383	0	0	1178	0	0	2569	131	93

Table 2b. Fish larvae collected on each sampling date in Pohick, Accotink, and Dogue Creeks in 1997

Date	Taxon identity	No./10m³ (No. of indiv.)		
		Pohick Cr.	Accotink Cr	Dogue Cr.
Mar 10	gizzard shad	8.0 (1)		
Mar 17	no larvae			
Mar 24	yellow perch			3.8 (3)
Mar 31	*Alosa* sp.			5.5 (7)
	gizzard shad			0.8 (1)
	white perch			37.0 (47)
Apr 7	*Alosa* sp.			0.9 (4)
Apr 15	*Alosa* sp.		1.9 (6)	0.9 (4)
	common carp	0.5 (1)		
Apr 21	*Alosa* sp.		0.9 (3)	
	gizzard shad		0.6 (2)	
	common carp		0.6 (2)	
	yellow perch	0.5 (1)		
Apr 28	*Alosa* sp.		0.9 (5)	
May 5	*Alosa* sp.	0.4 (1)	0.6 (3)	
	gizzard shad	51.4 (126)	2.5 (12)	1.1 (1)
	white perch	1.6 (4)		
	striped bass		0.2 (1)	
May 12	*Alosa* sp.		8.1 (30)	
	gizzard shad	14.0 (5)	1.1 (4)	
	white perch	8.4 (3)		
	common carp		0.8 (3)	
	white sucker		0.3 (1)	
May 19	*Alosa* sp.		1.1 (1)	
	gizzard shad	2.7 (7)	4.2 (4)	
	white perch		1.1 (1)	
	common carp		2.1 (2)	
	goldfish		2.1 (2)	
May 27	no larvae			
Jun 2	gizzard shad	0.3 (1)	3.7 (5)	
	common carp		2.9 (4)	
	yellow perch	0.3 (1)		
	tessellated darter			163.1 (1)
Jun 10	*Alosa* sp.		0.6 (1)	
	gizzard shad	13.9 (7)	15.7 (26)	

Table 3. Catch of adult fishes in Pohick Creek, Accotink Creek, and Dogue Creek in 1997

	Pohick Cr.	Accotink Cr.	Dogue Creek
Anadromous fishes			
alewife	6	21	16
Semi-anadromous fishes			
gizzard shad	91	66	88
yellow perch	0	1	0
Non-anadromous fishes			
longnose gar	23	13	0
carp	1	0	1
goldfish	0	0	1
rainbow trout	0	2	0
white sucker	0	3	0
channel cat	0	0	1
brown bullhead	0	0	3
black crappie	0	0	2
largemouth bass	0	0	1
Total	121	106	113

Table 4. Adult anadromous and semi-anadromous fishes caught on each sampling date in Pohick, Accotink and Dogue Creeks in 1997

Date	Fish species	Number of individuals: Pohick Creek Net 1	Pohick Creek Net 2	Accotink Creek	Dogue Creek
Mar 7	gizzard shad	3	1		
	yellow perch				1
Mar 11	alewife	1		4	1
	gizzard shad		2	1	
Mar 18	no fish				
Mar 25	alewife		1		3
Apr 1	alewife		1		
Apr 8	alewife	3		10	3
	gizzard shad	6	3		
Apr 15	alewife			3	1
	gizzard shad	1			
Apr 21	alewife		1	2	3
	gizzard shad	4	1		1
Apr 30	alewife				1
	gizzard shad		2	9	80
May 6	alewife				1
	gizzard shad	3			1
May 13	alewife				1
	gizzard shad	20	1	7	
May 19	no anadromous or semi-anadromous fish				
May 27	alewife				1
	gizzard shad	18	5	33	
Jun 3	gizzard shad	2	7	3	6
Jun 10	gizzard shad	10		13	
Total	alewife	4	2	21	16
	gizzard shad	68	23	66	88
	yellow perch			1	
	combined	72	25	88	104

Table 5. Catch of adult fishes in Pohick Creek, Accotink Creek, and Dogue Creek in 1998

	Pohick Cr.	Accotink Cr.	Dogue Cr.	Total
Anadromous fishes				
alewife	5	15	12	32
Semi-anadromous fishes				
gizzard shad	50	24	87	161
white perch	0	1	2	3
yellow perch	0	0	0	0
Non-anadromous fishes				
longnose gar	1	0	0	1
spottail shiner	0	1	0	1
creek chubsucker	0	0	1	1
brown bullhead	0	0	2	2
bluegill	0	0	15	15
largemouth bass	0	1	0	1
Total	56	42	119	217

Table 6. Adult anadromous and semi-anadromous fishes caught on each sampling date in Pohick, Accotink and Dogue Creeks in 1998

		Number of individuals			
Date	Fish species	Pohick Creek		Accotink Creek	Dogue Creek
		Net 1	Net 2		
Mar 3	alewife			1	no net set
Mar 11	no fish				no net set
Mar 17	no fish				no net set
Mar 25	alewife		1		no net set
Mar 31	alewife		1	5	
	gizzard shad	1			5
Apr 6	alewife			2	5
	gizzard shad		1		
Apr 13	alewife		2	6	2
	gizzard shad	11	3		7
Apr 22	alewife		1	1	5
	gizzard shad			1	16
Apr 28	gizzard shad			2	
May 6	gizzard shad	6	22	14	50
	white perch			1	2
May 12	gizzard shad		2	7	8
May 20	gizzard shad	1			1
May 26	gizzard shad	1	1		
Total	alewife		5	15	12
	gizzard shad	20	30	24	87
	white perch			1	2
	combined	20	35	40	101

Table 7. Catches of eggs and larvae of clupeid species and white perch in tidal or near-tidal waters of Pohick, Accotink, and Dogue Creeks, 1992-1997. Catch effort was not equal in each year nor in each creek.

Number of eggs and larvae collected

Fish species	Year	Pohick Cr eggs	Pohick Cr larvae	Accotink Cr eggs	Accotink Cr larvae	Dogue Cr eggs	Dogue Cr larvae	Total eggs	Total larvae
Alosa sp.	1992	116	0	0	0				
	1993	126	0	271	0				
	1994	0	0	14	9				
	1995	many	0	many	1				
	1996	0	5	3852	2	0	7		
	1997	0	1	0	53	131	11		
gizzard shad	1992	28	128	181	31				
	1993	0	1	15	32				
	1994	104	109	104	64				
	1995	0	2	0	4				
	1996	0	919	0	186	0	342		
	1997	0	147	0	53	93	2		
white perch	1992	464	0	8	0				
	1993	0	0	110	2				
	1994	0	1	0	0				
	1995	0	5	0	0				
	1996	0	17	0	8	0	5		
	1997	0	7	0	1	0	47		
all species	1992	1624	180	430	45			2054	225
	1993	129	6	829	64			958	70
	1994	133	123	173	132			306	255
	1995	many	15	many	36			many	51
	1996	4917	988	4876	453	1145	399	10938	1840
	1997	2383	158	1178	97	2794	64	6355	319

Table 8. Sampling period in each year for spawning studies in Pohick, Accotink and Dogue Creeks

Fish eggs and larvae

Year	Sampling period	Number of sampling dates Pohick Cr	 Accotink Cr	 Dogue Cr
1992	May 2-May 29	5	5	
1993	Apr 2-June 4	9	9	
1994	Apr 22-May 27	6	6	
1995	Apr 14-May 26	6	6	
1996	Apr 19-June 5	7	7	7
1997	Mar 10-June 1	14	14	14

Adult fishes

1988	Mar 11-Jun 10	4	2	1	(gill nets)
1989	Apr 9-May 8	6	5		(gill and hoop nets)
1990	Apr 20-May 25	6	6		(gill and hoop nets)
1991	Mar 26-Jun 1	10	10		(gill and hoop nets)
1992	Mar 6-May 30	10	10		(hoop nets)
1993	Apr 2-Jun 4		7		9 (hoop nets)
1994	Apr 23-May 28	6 (2 nets)	6 (1 net)		(hoop nets)
1995	Apr 15-May 26	6 (2 nets)	6 (1 net)		(hoop nets)
1996	Mar 29-Jun 6	11 (2 nets)	11 (1 net)	6 (1 net)	(hoop nets)
1997	Mar 7-Jun 10	15 (2 nets)	15 (1 net)	15 (1 net)	(hoop nets)
1998	Mar 3-May 26	13 (2 nets)	13 (1 net)	9 (1 net)	(hoop nets)

Table 9. Catches of adult clupeid fishes in tidal and near-tidal waters of Pohick, Accotink, and Dogue Creeks, 1988-1998. Catch effort was not equal in each year nor in each creek.

Fish species	Year	Pohick Cr	Accotink Cr	Dogue Cr
blueback herring	1988	0	9	17
	1989	0	0	
	1990	0	0	
	1991	0	0	
	1992	0	0	
	1993	0	0	
	1994	0	0	
	1995	0	0	
	1996	0	0	0
	1997	0	0	0
	1998	0	0	0
alewife	1988	0	0	
	1989	1	10	
	1990	0	2	
	1991	0	14	
	1992	0	0	
	1993	0	0	
	1994	0	4	
	1995	0	2	
	1996	5	34	0
	1997	6	21	16
	1998	5	15	12
gizzard shad	1988	4	11	46
	1989	131	15	
	1990	67	20	
	1991	52	3	
	1992	410	24	
	1993	322	21	
	1994	96	13	
	1995	183	23	
	1996	257	59	60
	1997	91	66	88
	1998	50	24	87