Peconic River Habitat Assessment and Fish Biomass Prediction

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INTRODUCTION

Brookhaven National Laboratory (BNL) is located on Long Island, New York, 97 km east of New York City (Figure 1). BNL is a multidisciplinary research facility that conducts programs in physics, biomedical, and environmental sciences, as well as in energy technologies (Brookhaven National Laboratory 2002).

Operational wastewaters at BNL are treated at the Sewage Treatment Plant (STP). After treatment, the water is discharged to the western branch of the Peconic River. Historical releases have led to contamination of the river sediment with heavy metals (including mercury), organics (including PCBs) and radionuclides. Their deposition onsite and at closely adjacent sites have led to elevated levels of mercury and PCBs in fish. A Peconic River human health risk assessment indicates that the driver for human health risk is through consumption of contaminated fish. However, uncertainty has been identified in the capacity of this section of the river to support the fish biomass and consumption rates used in the risk assessment.

The aim of this study is to determine the approximate fish biomass that the river can support in the section from the STP to Wading River/Schultz Road under three water level scenarios: low water (current), mid water, and high water. The data from this report will be coupled with an analysis of historic hydrological data for the river to determine the fraction of time the river is expected to be at low, mid and high water levels throughout the year. The results can also be used in tandem with fish contaminant data to estimate exposure to the public through fish consumption. Combined, these analyses can help address uncertainties in the baseline Peconic River human health risk assessment.

The historic origin of the western branch of the Peconic River is west of the BNL property across the William Floyd Parkway. In the sections of the river west of the STP, water flow is controlled by the water table elevation. The functional origin of the Peconic River is the outfall of the BNL STP which routinely provides approximately 800,000 gallons per day of treated effluent to the river. The BNL STP is a tertiary STP which operates under a New York state pollutant discharge elimination system (SPDES) effluent limitations permit. BNL effluent to the Peconic River has routinely met the SPDES release limits since the origin of the permit in 1976. Even with this discharge, substantial portions of the river onsite and immediately offsite may be dry during periods of low water table elevation. Routine river flow occurs at the confluence of the north and west branch of the Peconic River approximately 2 – 2.5 miles downstream from the STP.

As this study was performed during a period of low water, current fish biomass data were not available. Thus, a method is presented to approximate biomass by surveying the aquatic habitats in the 2.8 mile stretch of the Peconic River between the STP and Wading River/Schultz Road and relating information from fish surveys to those habitats. Based upon the habitat and fish survey data, predictions of fish biomass at low, mid, and high water levels are presented. Actual biomass will depend on temporal ecological conditions, life history, and migration patterns. It is important to note that the surveys supplied were not designed to be used for quantitative biomass assessments. Nevertheless, the biomass estimates were made using a sound scientific methodology and the best data available.

METHODS

Two tasks were necessary to approximate fish biomass in the Peconic River: 1) habitat mapping and 2) biomass data collection. The aquatic habitat in the Peconic River was surveyed on October 24 and 25 in 2002 by walking the streambed upstream from Wading River/Schultz Road to the STP on Brookhaven National Laboratory property. This is a distance of approximately 2.8 miles. While walking in the streambed, features were noted such as a change in aquatic habitat (i.e. from pool to run) or a change in vegetation or substrate. At each transition point, the distance (m) from the last change was determined using a tape measure. Bankfull width and wetted width measurements were also obtained using the tape measure at these points. A geographic positioning system (GPS) was used to pinpoint the exact location at each change though it worked intermittently due to the dense tree cover in some areas. However, missing GPS coordinates were augmented with those from well locations and previous survey markers noted during the survey (coordinates were provided later by the BNL Environmental Information Management System (EIMS) group). At Cornell University, the information collected was used to create a habitat map showing the outline of the wetted area with ArcView 3.2 GIS software (ESRI 1999). The wetted width measurements and the distance along the streambed were used to determine the outline of the wetted area at low water. Values of pool, run or glide were assigned to the areas based on observations and measurements at the study site.

The high water map was developed in a similar way except that bankfull width measurements were used. The water outlines were then verified and augmented with information from aerial photos provided by the Brookhaven National Labs EIMS group (NYS Statewide Digital Orthoimagery Program Suffolk County 2001) which indicated inundated areas. Habitat characterizations were assigned based on the following rule: water moves at a run at high water unless the mainstem goes around a bend or into a side channel, in which case refuge area (pools) of slower moving water would occur (Dunne and Leopold, 1978).

The mid water map was created using a digital map of water outlines supplied by Brookhaven National Labs EIMS group. These outlines fell between those already created for low and high water. These habitat characterizations were best guess approximations at how water would move through such areas. Most maps produced inferred water levels and habitats without direct observation so this information must be taken as an approximation of the conditions found under each of the water levels.

Biomass estimates for the Peconic River were computed by first collecting data from fish surveys previously completed in the Peconic River study area (New York Department of Environmental Conservation, Region 1). This data was supplemented with data from the Ipswich River (Massachusetts Division of Fisheries and Wildlife), Hunts Brook, Folwix Brook, and Cold Spring Brook (Connecticut Department of Environmental Protection). Like the Peconic River, these supplemental waterbodies are also in the northeast with sandy, coastal, low gradient channels and thus were deemed suitable analogues. See Appendix A for detailed information on all sites used in this analysis. The following information was obtained for all datasets: species collected, length, weight, equipment used, length and width surveyed, and habitat type. Only surveys accomplished with electrofishing gear were used for this analysis.

Biomass figures for Connecticut sites were already calculated, therefore the following biomass calculation description only applies to the Peconic and Ipswich River datasets. Length-weight regression formulas (Carlander 1969, 1977, 1997; Froese and Pauly 2002) were applied for all individuals for which length information existed but weight information did not. For species where length information was also not recorded, average lengths of same species fish at that site were computed and used for biomass estimates. Next, the number of individuals per site was tallied and used in the following formula to adjust for electrofishing gear inefficiency (Ontario Ministry of Natural Resources 2001):

$$Y = 2.18(X^{1.02})$$

Where

X = number caught in a single pass with electrofishing gear

Y = the population estimate (# of fish)

While electrofishing gear is viewed as the single most effective method for sampling fish communities in streams (Bagenal 1978; Plafkin et al. 1989), it is reported to be size selective, with large fish more susceptible to capture than small ones (Wiley and Tsai 1983).

Following the application of the gear inefficiency formula, all biomass estimates were next divided by the length and width of the surveyed region to gain biomass in grams per square meter. All the Peconic River, Ipswich River and Connecticut sites were then classified by habitat type. Only habitat types of pool, run and glide were used in this analysis in order to reflect those expected in the Peconic River at low, mid and high water levels. Biomass for each species at all sites in each habitat type was then averaged to obtain the average biomass per square meter of each species and the percent biomass of each species. Zeros were used for average biomass per square meter in places where the species was expected but not caught and blanks were used in places where the fish were not expected and not caught. The biomass estimates of fish not expected in the Peconic River study area were merged with the biomass estimates of fish with similar characteristics previously recorded in the region. Therefore, the biomass estimates of yellow bullhead (*Ameiurus natalis*) were merged with those of brown bullhead (*Ameiurus nebulosus*), redfin pickerel (*Esox americanus americanus*) with chain pickerel (Esox niger), green sunfish (*Lepomis cyanellus*) and redbreast sunfish (*Lepomis auritus*) with bluegill (*Lepomis macrochirus*), yellow perch (*Perca flavescens*) with pumpkinseed (*Lepomis gibbosus*), and swamp darter (*Etheostoma fusiforme*) with creek chubsucker (*Erimyzon oblongus*). American eel (*Anguilla rostrata*), sea lamprey (*Petromyzon marinus*) and white sucker (*Catostomus commersoni*) do not have closely related analogues therefore, the biomass estimates of these species were spread among all the previously recorded species in percentages which correspond to the that species' overall representation at that water level and habitat type. These final species percent biomass figures were used to determine the number of fish of each species likely to occur in each habitat type. Finally, the total biomass for all sites in each habitat type was averaged to obtain the predicted biomass per unit area for each habitat type.

The final step was to link the biomass approximations to the habitat types in the Peconic River to enable an estimate of where each type of fish would be located and in what proportions. Biomass approximations were calculated for each square meter so that they could be applied to any size area. For each habitat type at each water level, the area was calculated and multiplied by the predicted biomass per unit area to obtain total biomass in grams and converted to pounds. The number of individuals of each species was then predicted for each habitat type at each water level by multiplying the percent species biomass by the total biomass and then dividing that figure by the median fish size values. The median fish size in grams of each species (Appendix C) was determined from Peconic River data with Ipswich data substitutions for species not commonly occurring in the Peconic River data set.

Length frequency distribution charts were created for all fish combined in the Ipswich River and in the Peconic River and the following common sport fish: bluegill, pumpkinseed, brown bullhead, and chain pickerel. No length frequency information was available for the Connecticut river sites. The length-frequency charts can be used to determine the likely size distribution of individuals of common sport fish species in each habitat at each water level.

RESULTS

Figures 2, 3 and 4 show approximate Peconic River habitat characterizations at low, mid and high water levels respectively. The data indicate that the river is primarily shallow and narrow near both ends of the study area with large pools in the middle sections. Bankfull width measurements for high water ranged from 7 - 169 ft with a mean of 31 ft and wetted width measurements at low water ranged from 0 – 98 ft with a mean of 13 ft. The Peconic River at low water level is expected to have 13% glide, 39% run and 48% pool. At mid water it is expected to have 79% pool and 21% run whereas at high water it has almost the exact inverse with 80% run and 20% pool (Table 1).

Data on fish biomass from a number of sites were used to estimate biomass as a function of river habitat. The Peconic River had eight sites classified as run and five as pool. The Ipswich River had eleven sites with fish data from glides and two from runs. Three sites in the Connecticut rivers dataset qualified as pool habitats (Table 2; Appendix A). Using the data from all sources, the predicted biomass in glides is expected to be 5.69 g/m^2, in runs 3.48 g/m^2 and in pools 2.32 g/m^2.

The predicted biomass by habitat type was combined with the area measurements from the habitat surveys to yield an expected total biomass of approximately 15 lbs (7 kg) for glides in low water, 28 lbs (13 kg) for runs and 23 lbs (11 kg) for pools (Table 1). For mid water, approximately 75 lbs (34 kg) of biomass is expected for runs and 194 lbs (88 kg) for pools and for high water 816 lbs (370 kg) in runs and 128 lbs (62 kg) in pools.

Table 2 also contains the average expected biomass for each species at each water level (glide, run, pool). Examining table 2 indicates that the species with the highest expected biomass in glides are: chain pickerel (48%), bluegill (24%), pumpkinseed (15%), brown bullhead (10%), and creek chubsucker (3%; Figure 5). In runs: chain pickerel (86%), creek chubsucker (7%), and pumpkinseed (5%; Figure 6). Finally, in pools: chain pickerel (43%), brown bullhead (39%), golden shiner (*Notemigonus crysoleucas*, 10%), creek chubsucker (4%), pumpkinseed (2%), and largemouth bass (*Micropterus salmoides*, 2%; Figure 7).

Table 3 shows the expected species composition for each habitat type at all water levels in the Peconic River. Chain pickerel are expected to be found in the highest numbers in all water levels and all habitats. Brown bullhead, chain pickerel, creek chubsucker, and pumpkinseed are predicted to be generalists found in all habitats and all water levels. By contrast, banded sunfish (*Enneacanthus obesus*), bluegill, and largemouth bass are specific to distinctive water levels or habitat types. For instance, largemouth bass are only expected in pools and in very low numbers. The species composition table (Table 3) and percent composition by size class table (Appendix B) can be used together to gain an understanding of the expected numbers of individuals and sizes of each species in each habitat at each water level.

The length frequency distributions for both the Peconic and Ipswich Rivers (Figure 8) indicate high numbers of juveniles and young adults. Figures 9 and 10 show length frequency distributions for common sportfish in the Peconic and Ipswich Rivers. Most bluegill and pumpkinseed in the Ipswich River area were young adults with few individuals larger than 8 inches (200 mm). Most chain pickerel in both the Ipswich and Peconic Rivers were juveniles, however, several individuals were present in most size classes up to 16 inches (400 mm) in length. By contrast, most brown bullheads in the Ipswich were adults with few under 5 inches (120 mm) in length while those in the Peconic River ranged fairly consistently from 3 to 12 inches (70 to 300 mm). Small numbers of largemouth bass were in both rivers with 25 individuals in each and a similar range of 1.5 – 13 inches (42-331 mm) for both populations.

DISCUSSION

This analysis and report provides an overview of the species, population density, and size distributions of fish which existed in the Peconic River study area and similar river systems in past years and an estimate of the likely future fish concentrations to be found in a variety of habitats when water returns. This study assumes that short-term reoccupation of newly wetted habitat will occur from adjacent waters. The habitat characterization in this report indicates that pools will exist with greater frequency at low and mid water and runs will be more prevalent at high water. Glides are only expected when water is low. Biomass is predicted to increase with the amount of water in the Peconic River system. This occurs since the area covered by water is greater during times when water is high and would likely provide more resources for resident fish. Biomass is predicted to be higher in glides than in runs and pools should have the lowest expected biomass per unit area. Through coupling water level with habitat in the Peconic River, total biomass is predicted to be greatest in runs with high water while glides in low water are predicted to have the lowest biomass. These results seem sensible given that runs in high water will cover large areas and only small numbers of fish will be able to crowd into refuge areas (pools) during times of flood. In contrast, only a small percentage of the low water habitat in the Peconic River is expected to be glides and therefore, lower biomass is expected in those habitat types at those water levels.

Though clear reasons are not apparent for the absence of several species from this section of the Peconic River in recent fish surveys, the following species' biomass were merged with existing previously recorded species biomass: American eel, white sucker, green sunfish, redbreast sunfish, yellow bullhead, swamp darter, and sea lamprey. This was done to present a more realistic representation of the likely recolonization scenario upon rewetting of the study area.

The potential number of fish in a stream will vary with the amount of available habitat. The Peconic River has variable flow and often the streambed will dry completely isolating pools within the stream. Over the last two years, water levels have been particularly low. The total biomass of fish in the stream during moderate and high flows will depend largely on the extent of the area affected, sources of repopulation, distances and barriers to movement in the stream from sections with fish, the type and degree of degradation, mobility of the fish in the system, the water level when flow does return and the season in which flow returns (Larimore et al. 1959, Lonzarich et al. 1998).

The fish community in a given isolated pool will depend on the fish that are isolated and the characteristics of the pool (Stanley et al. 1997). In general, isolated pools in dry streambeds increase fish vulnerability to predation (Labbe and Fausch 2000, Larimore et al. 1959). A pool with more predators will have a different community structure than that of an adjacent but isolated pool with relatively few large predators (Stanley et al. 1997). Long periods of dry streambed conditions can actually have a prolonged effect on the fish community once water has returned to the stream and frequent wetting and drying will tend to favor fish with higher dispersal rates (Stanley et al. 1997). The timing of low flow and surrounding habitat can have an important impact on how isolation in a pool will affect fish. Pools isolated in fall, particularly those with large leaf inputs, tend to have decreased dissolved oxygen levels and therefore greater fish mortality (Larimore et al. 1959).

Schlosser (1998) noted that dispersal from a core area also influences the fish community. He found that the dispersal of creek chubs from ponds were important in controlling creek chub populations in the adjacent streams. Lonzarich et al. (2000) found that longer riffles between pools slows recolonization of defaunated pools even when flows are adequate. In a 1959 study where a large number of pools were isolated and then defaunated, Larimore et al. (1959) found that minnow species moved in first and with the lowest flow resumption. Once the stream had experienced bankfull discharge, Larimore et al. (1959) found that recolonization of the species present prior to the isolation and removal of fish was relatively rapid. Twenty-one of 29 species moved back within two weeks after a sudden increase in flow, however, the timing of the high flow event likely influenced this since many fish were migrating upstream at the time that flow resumed. It took much more time for fish abundances to return in the Larimore et al

(1959) study and this was reaffirmed in a 1998 study by Lonzarich et al. (1998). After the drought recolonization, sunfish and bass were less abundant than they were prior to stream drying and darters and minnows were more abundant. The Lonzarich et al. (1998) study found that numerical recovery was faster for the more common species but overall numerical recovery of almost all fish to defaunated pools during normal flow occurred within about 40 days or so. The actual number of fish in a recovery is hard to gauge, however since populations fluctuate seasonally and yearly in many systems (Larimore et al. 1959).

Stanley et al. (1997) reported that they knew of no study which adjusted measurements of fish density or productivity to account for reduced stream sizes associated with drying. Given enough time with a wetted channel, the system could likely sustain relatively large populations of fish. However, with only periodic rewetting, the fish populations and fish biomass in this stream at high flow are likely lower than its maximum potential when based strictly on habitat availability at a given flow.

Fish found in the perennially wetted sections of the stream are capable of extensive movements both upstream and down (Gatz and Adams 1994, Larimore et al. 1959). In a three year study on a stream in Tennessee, Gatz and Adams (1994) found that 12% of all recaptured bluegills and 21% of recaptured largemouth bass moved greater than one kilometer.

Some of the fish species likely to recolonize the study region are chain pickerel, brown bullhead, pumpkinseed, and creek chubsucker, all of which were previously recorded in the Peconic River. Given that largemouth bass were captured in only low numbers in the fish surveys conducted on BNL land, it is unlikely that largemouth bass moved into this section of stream with any regularity, however it is probable, given the capture records, that bluegill sunfish move on and off the property. No studies could be found addressing the movement of chain pickerel, pumpkinseed or brown bullhead. These fish may recolonize from nearby areas, however, if these specific species do not reoccupy the area, other species with similar characteristics will do so in greater abundance.

Conclusions

Estimates of species composition and biomass density of the Peconic River were provided as a function of river flow condition (run, glide, pool). Biomass is predicted to increase with the amount of water in the Peconic River system. Pools are expected to exist with greater frequency at low and mid water and runs will be more prevalent at high water. Glides are only expected when water is low. For the Peconic River study section, the total biomass is expected to be approximately 15 lbs (7 kg) for glides in low water and 28 lbs (13 kg) for runs and 23 lbs (11 kg) for pools. For mid water, approximately 75 lbs (34 kg) of biomass is expected for runs and 194 lbs (88 kg) for pools and for high water 816 lbs (370 kg) in runs and 128 lbs (62 kg) in pools. Chain pickerel is expected to comprise the highest biomass in all habitat types at all water levels. To reach an estimation of the likely community, previously collected data on the Peconic River and four reference rivers were used to help moderate the influence of any one river in defining the species biomass estimates. As such, this is an approximation of the likely species composition, size frequency, and total biomass for given habitats and water levels. The results of this exercise can be used as a basis for planning and assessment for the Peconic River study area.

ACKNOWLEDGEMENTS

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GLOSSARY

Bankfull width: The width of the upper limit of the stream channel during maximum peak flow.

Defaunated: devoid of animal life. In this report defaunated streams refer to streams without fish.

Glide: Nonturbulent water, low to moderate velocity, and low slope; usually present in wide channels lacking a definite thalweg; usually at the transition between a pool and riffle; no major flow obstructions; lacks features associated with pools; moderately shallow.

Pool: Found at a lateral constriction of the channel or sharp drop in water surface profile; usually present in the bend in a channel; large-scale obstructions (e.g., boulder, log); concave in shape; direction of flow caries widely; depth greater than riffles or runs.

Recolonization: A second or renewed colonization.

Riffle: Mostly moderate turbulence but high turbulence at points of channel constriction; moderate velocity; channel profile usually straight to convex.

Run: Nonturbulent water, swift velocity, and low slope; occurs over a definite thalweg flat plane with a uniform channel form; no major flow obstructions; moderately shallow; deeper than riffles.

Thalweg: Line of deepest water in a stream channel as seen from above. Normally associated with the zone of greatest velocity in the stream.

Wetted width (also stream width): The width of the water surface measured at right angles to the direction of flow and at a specific discharge. Widths of multiple channels are summed to represent total wetted width.

REFERENCES

Bagenal, T. 1978. Methods for Assessment of Fish Production in Fresh Waters (3rd edition). IBP Handbook No. 3. Blackwell Scientific Publications, Oxford, U.K. 365 p.

Brookhaven National Laboratory. 2002. 2001 Site Environmental Report, BNL 52691, Brookhaven National Laboratory. Retrieved from http://www.bnl.gov/bnlweb/2001_SER.html.

_________. 2002a. Approaches to Brookhaven National Laboratory. Retrieved from http://www.bnl.gov/bnlweb/PDF/limap.pdf.

Carlander, K. D. 1969. Handbook of freshwater fishery biology: Life history data on freshwater fishes of the United States and Canada, exclusive of the Perciformes. Volume 1. The Iowa State University Press. Ames, Iowa.

_________ 1977. Handbook of freshwater fishery biology: Life history data on centrarchid fishes of the United States and Canada. Volume 2. The Iowa State University Press. Ames, Iowa.

_________ 1997. Handbook of freshwater fishery biology: Life history data on ichthyopercid and percid fishes of the United States and Canada. Volume 3. The Iowa State University Press. Ames, Iowa.

Dunne, T., and L. B. Leopold. 1978. Water in Environmental Planning. W.H. Freeman and Company, New York, New York, USA.

ESRI. 1999. ArcView (Version 3.2). Environmental Systems Resource Institute, Inc. Redlands, California.

Froese, R. and D. Pauly. Editors. 2002. FishBase. World Wide Web electronic publication. www.fishbase.org. 13 November 2002.

Gatz, A. J., and S. M. Adams. 1994. Patterns of movement of centrarchids in two warmwater streams in eastern Tennessee. Ecology of Freshwater Fish 3:35-48.

Labbe, T. R., and K. D. Fausch. 2000. Dynamics of intermittent stream habitat regulate persistence of a threatened fish at multiple scales. Ecological Applications 10:1774-1791.

Larimore, R. W., W. F. Childers, and C. Heckrotte. 1959. Destruction and re-establishment of stream fish and invertebrates affected by drought. Transactions of the American Fisheries Society 88:261-285.

Lonzarich, D. G., M. R. Lonzarich, and M. L. Warren, Jr. 2000. Effects of riffle length on the short-term movement of fishes among stream pools. Can. J. Fish. Aquat. 57: 1508-1514.

Lonzarich, D. G., M. L. Warren, Jr., and M. R. Elger-Lonzarich. 1998. Effects of habitat isolation on the recovery of fish assemblages in experimentally defaunated stream pools in Arkansas. Can. J. Fish. Aquat. Sci. 55: 2141-2149.

NYS Statewide Digital Orthoimagery Program Suffolk County. 2001. Digital orthoimagery of Suffolk County, New York from 2001. Albany, New York.

Ontario Ministry of Natural Resources. 2001. A Rapid Assessment Technique to Estimate Salmonine Populations in Southern Ontario Streams. Habitat Management Series FACT sheet. Ontario, Canada.

Plafkin, J. L., M. T. Barbour, K. D. Porter, S. K. Gross, and R. M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. EPA 440-4-89-001.

Schlosser, I. J. 1998. Fish recruitment, dispersal, and trophic interactions in a heterogeneous lotic environment. Oecologia 113:260-268.

Stanley, E. H., S. G. Fisher, and N. B. Grimm. 1997. Ecosystem expansion and contraction in streams. Bioscience 47(7):427-435

Wiley, M. L., and Chu-Fa Tsai. 1983. The relative efficiencies of electrofishing vs. seines in piedmont streams of Maryland: North American Journal of Fisheries Management, v. 3. p. 243-253.

Figure 1. Brookhaven National Laboratory, Upton, NY. Adapted from: Brookhaven National Laboratory 2002a electronic publication http://www.bnl.gov/bnlweb/PDF/limap.pdf.

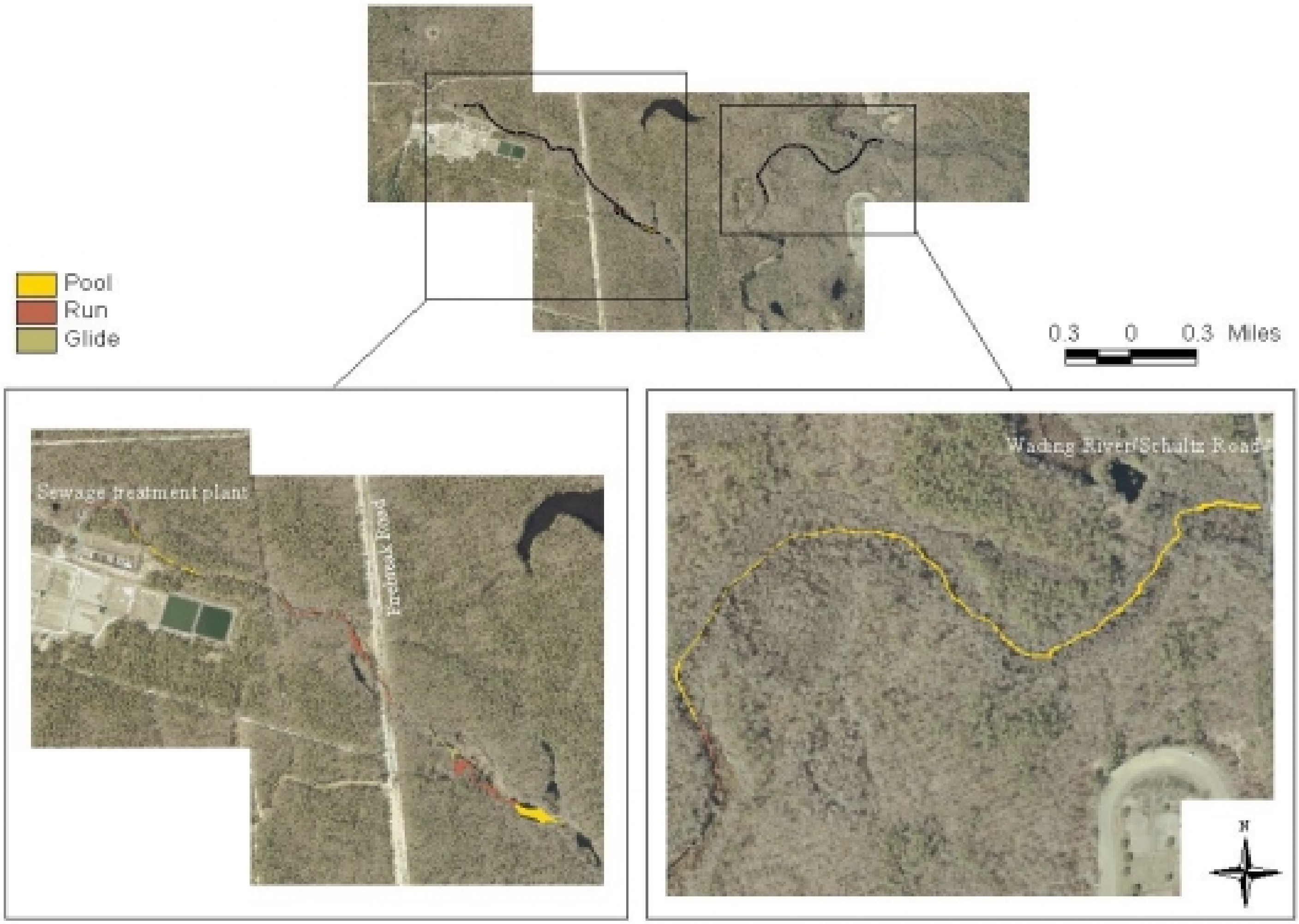


Figure 2. Approximate habitat on the Peconic River from Wading River/Schultz Road to the sewage treatment plant at low water.

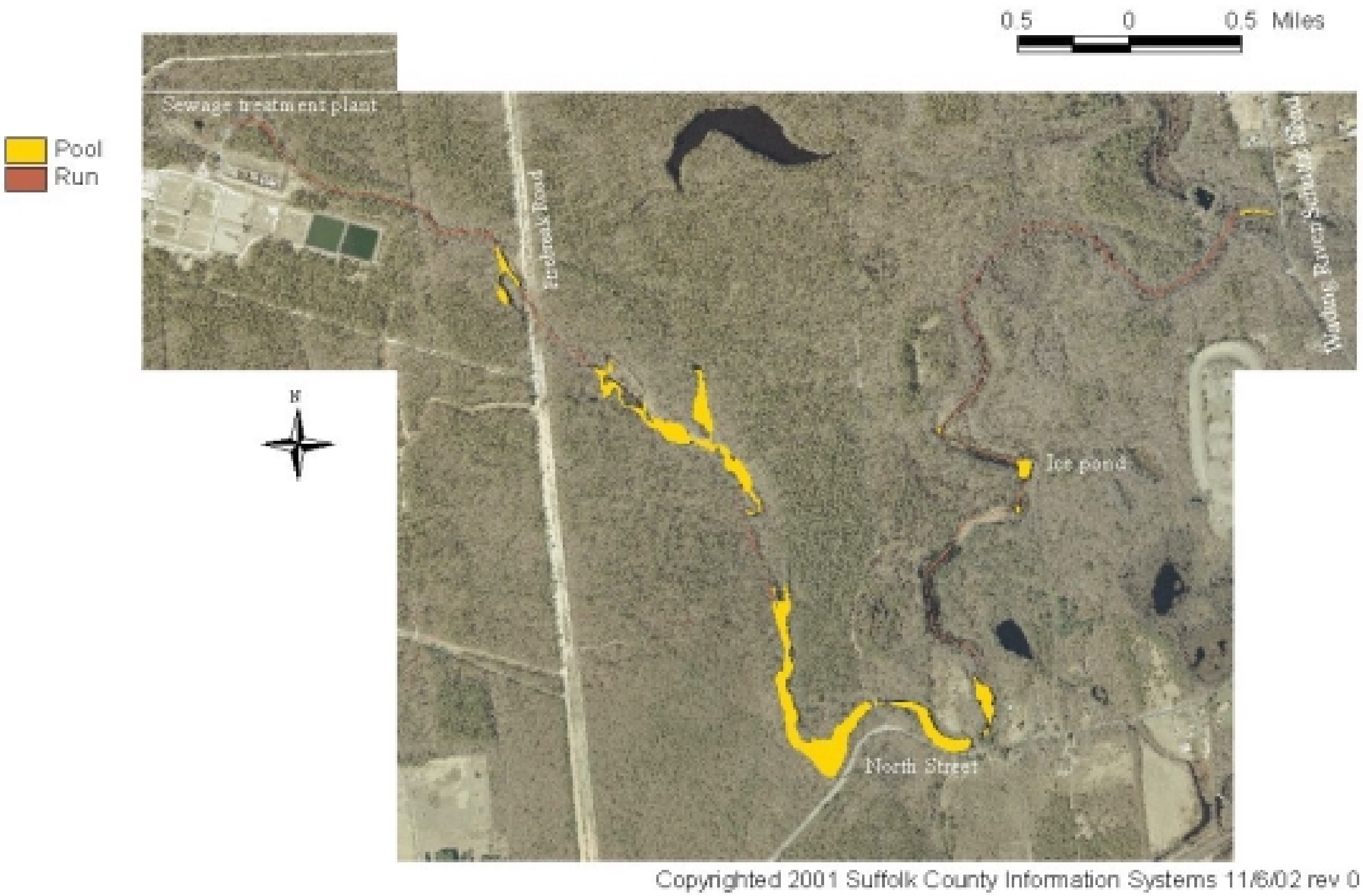


Figure 3. Approximate habitat on the Peconic River from Wading River/Schultz Road to the sewage treatment plant at mid water.

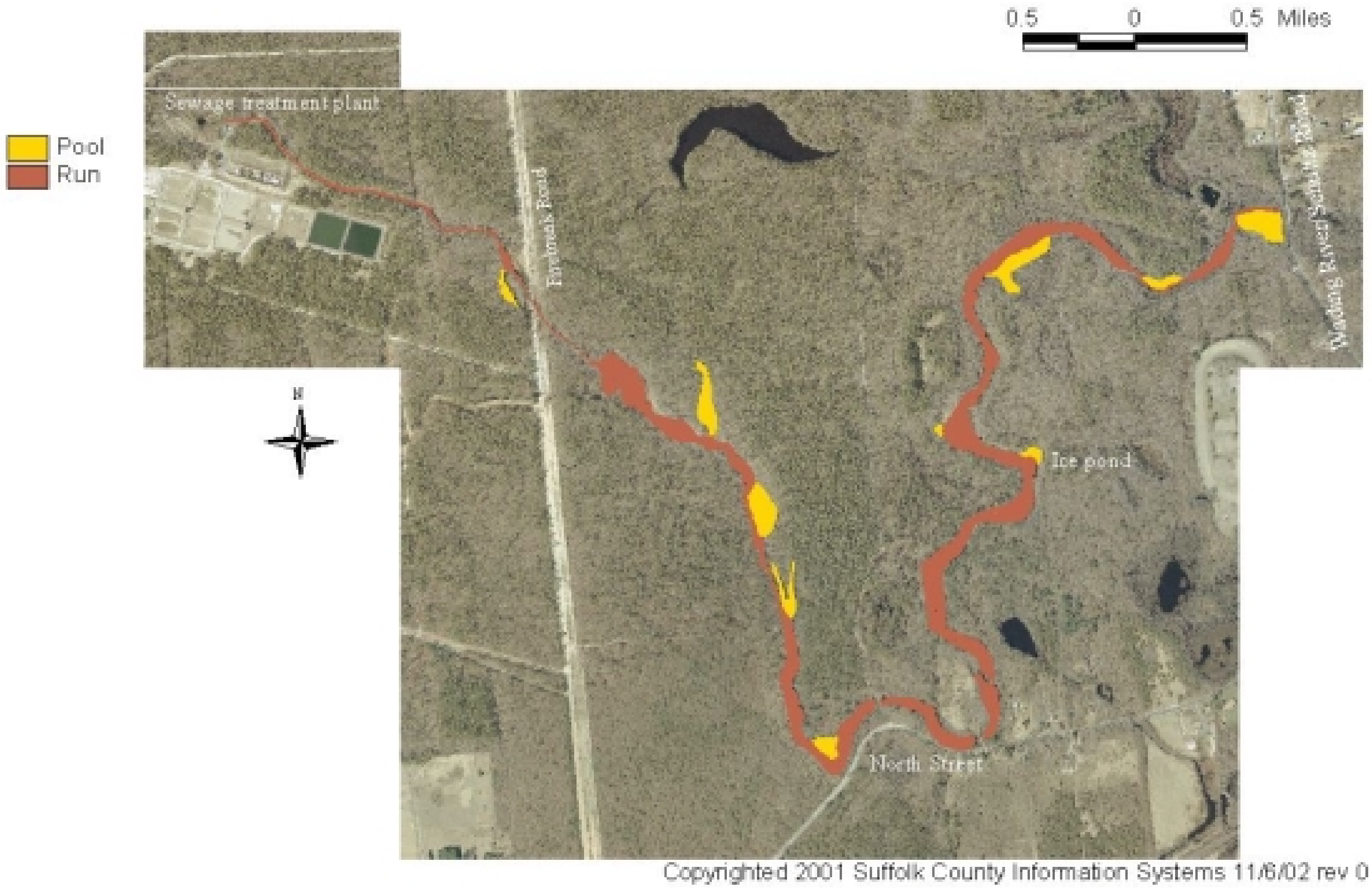


Figure 4. Approximate habitat on the Peconic River from Wading River/Schultz Road to the sewage treatment plant at high water.

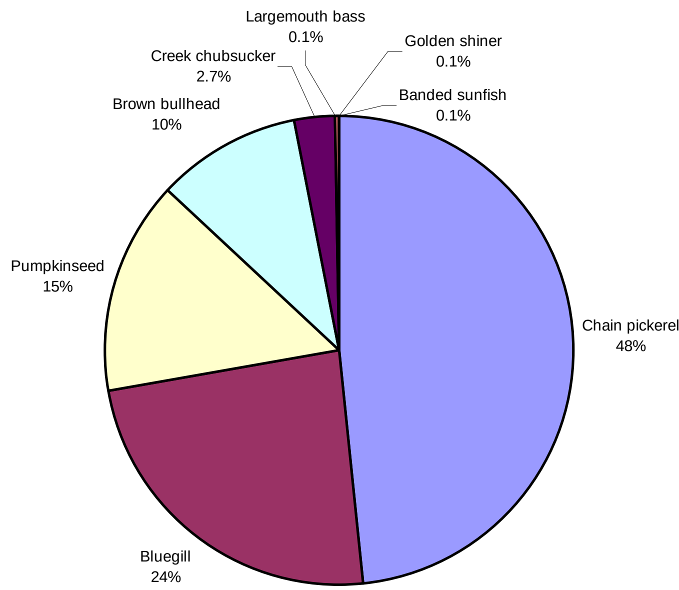


Figure 5. Percentages of the biomass of each species in glide habitats.

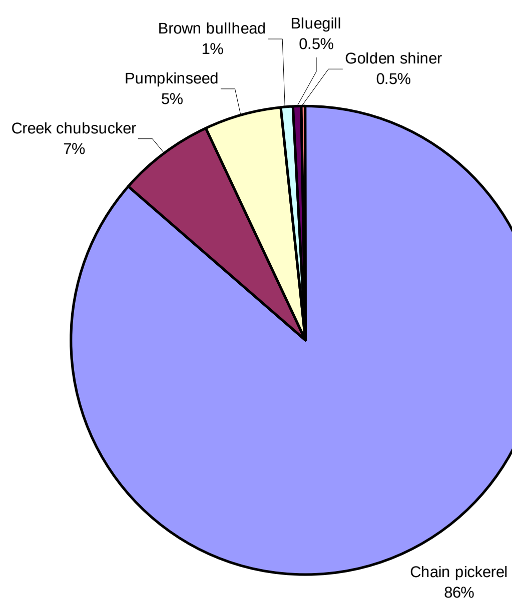


Figure 6. Percentages of the biomass of each species in run habitats.

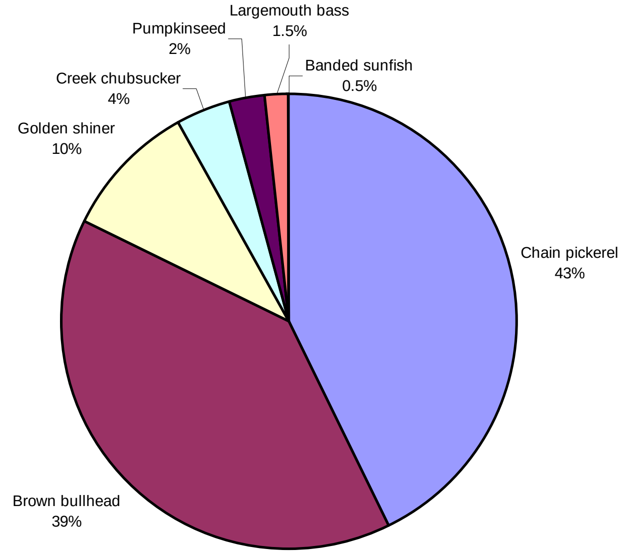
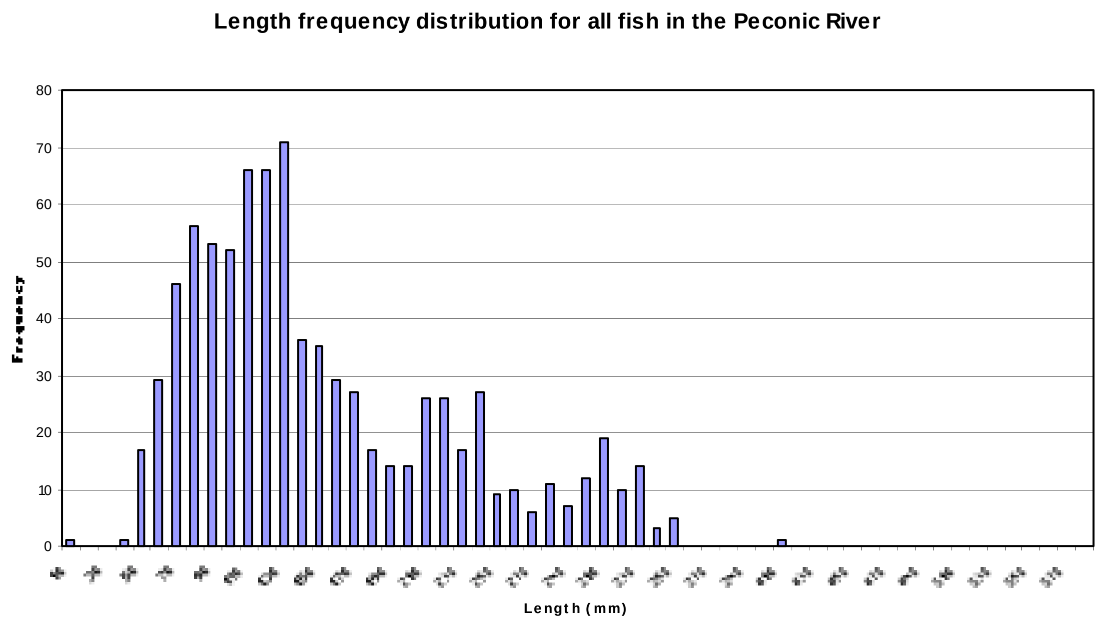


Figure 7. Percentages of the biomass of each species in pool habitats.



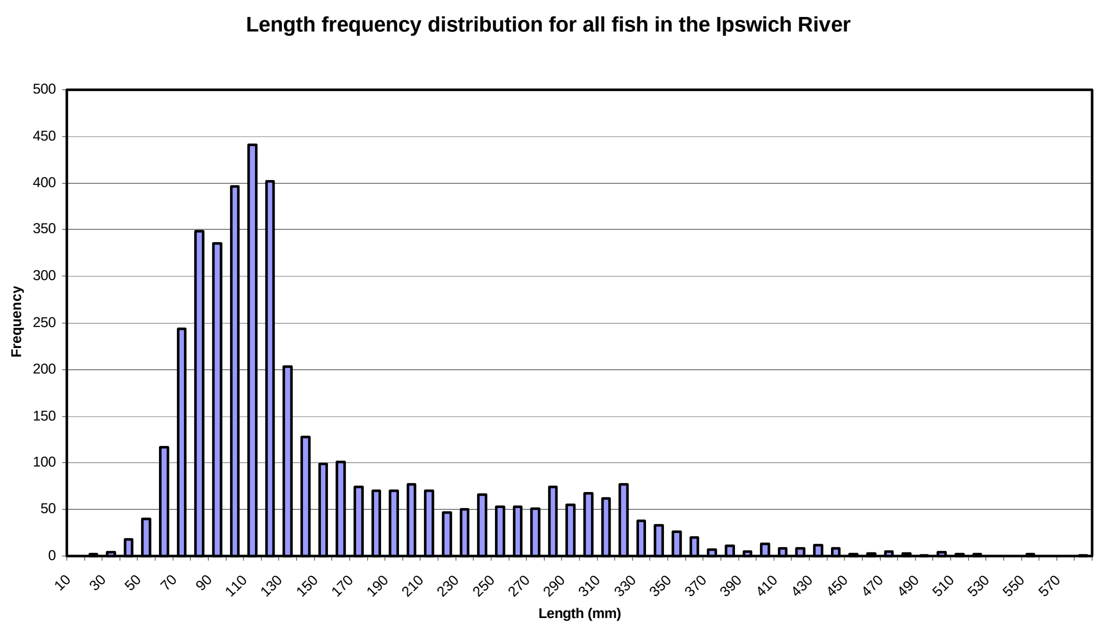


Figure 8. Length-frequency distributions for the fish in the Peconic and Ipswich Rivers.

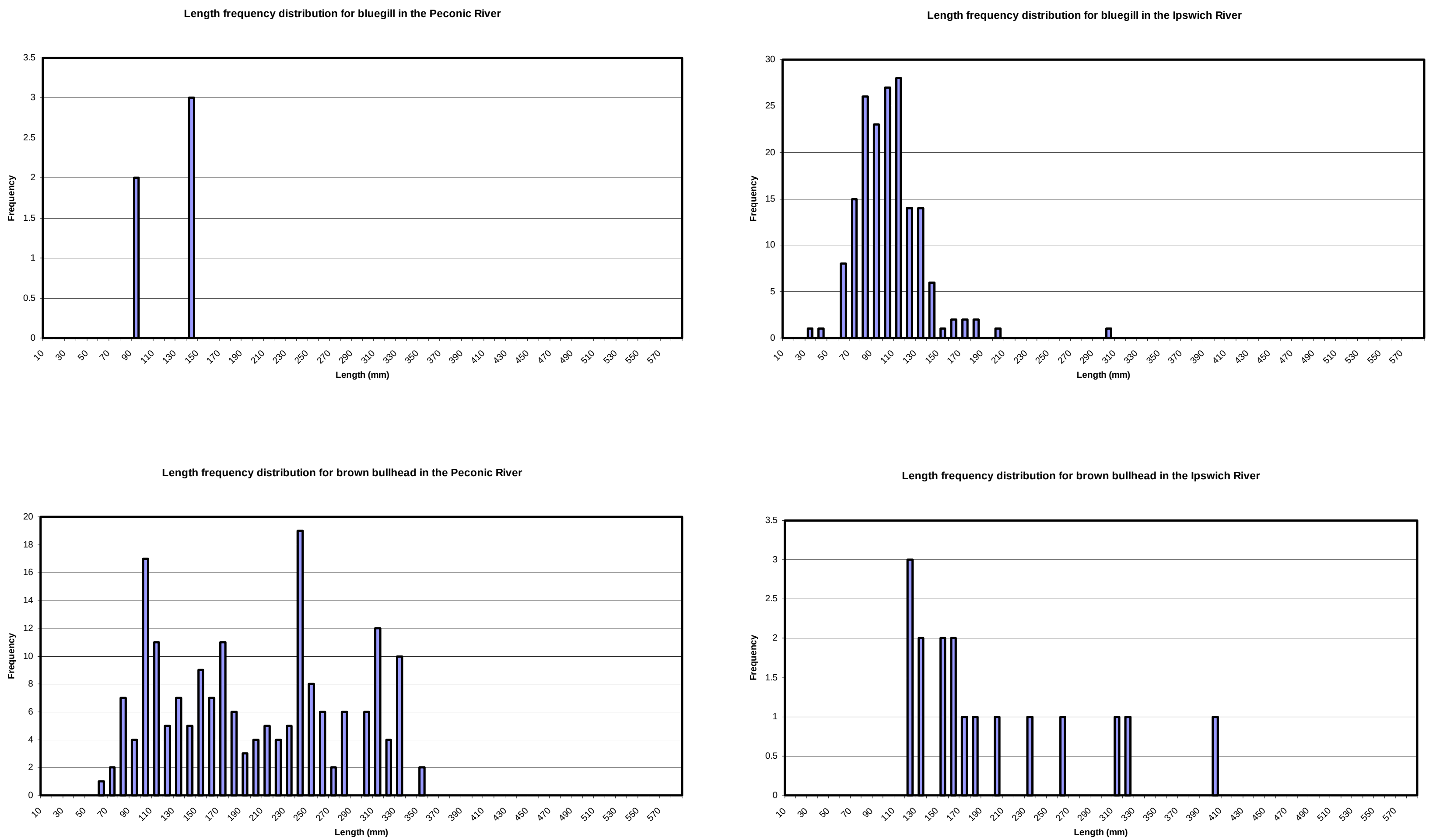


Figure 9. Length-frequency distributions for bluegill and brown bullhead in the Peconic and Ipswich Rivers.

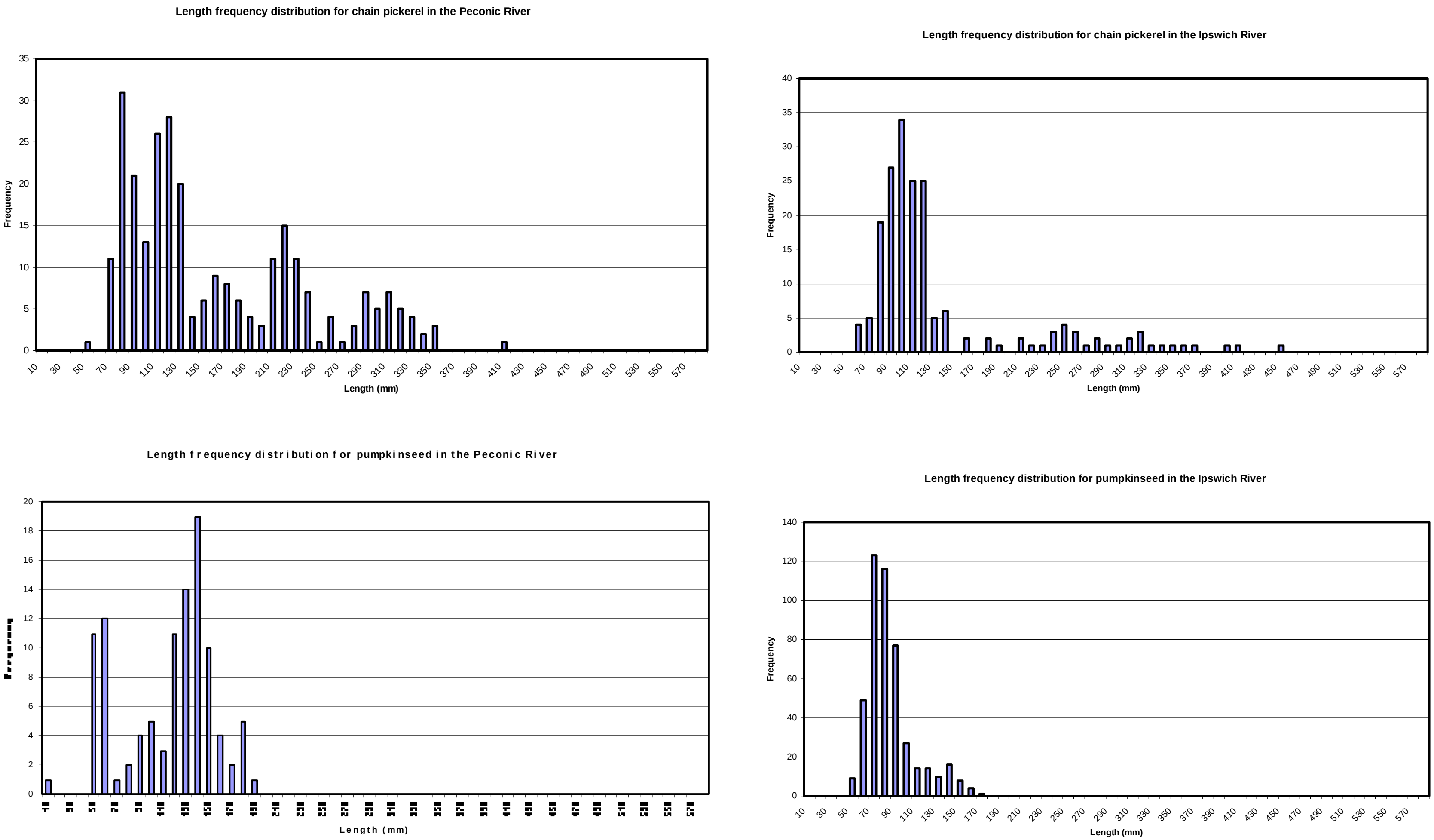


Figure 10. Length-frequency distributions for chain pickerel and pumpkinseed in the Peconic and Ipswich Rivers.

Table 1. Total area and percent of each habitat type and approximate biomass at each water level in the Peconic River.

Water level	Habitat type	Total area (m^2)	Percent of area	Approximate biomass (lbs)
Low	Glide	1207.46	13	15
Low	Run	3681.63	39	28
Low	Pool	4585.79	48	23
Mid	Run	9800.13	21	75
Mid	Pool	37939.56	79	194
High	Run	106378.12	80	816
High	Pool	26898.17	20	138

Table 2. Biomass estimates (g/m2) from field samples in study and reference rivers by habitat type for each species.

Reference site	Habitat	American eel	Banded sunfish	Bluegill	Brown bullhead	Chain pickerel	Creek chubsucker	Golden shiner	Green sunfish	Largemouth bass	Pumpkinseed	Redbreast sunfish	Redfin pickerel	Sea Lamprey	Swamp Darter	White sucker	Yellow bullhead	Yellow perch	Total biomass /site (g/m2)
Ipswich 9	Glide	6.36	0.00	0.00	0.00	0.02	0.29	0.00	0.00	0.00	0.53	2.59	1.96	0.03	0.05	0.00	0.80	0.00	12.63
Ipswich 10	Glide	2.98	0.00	0.01	0.14	0.31	0.07	0.02	0.00	0.00	0.08	0.20	2.14	0.00	0.01	0.00	0.27	0.17	6.39
Ipswich 11	Glide	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	3.01	0.00	0.00	0.00	0.28	0.00	3.49
Ipswich 12	Glide	4.66	0.00	0.05	0.00	0.24	0.05	0.00	0.00	0.02	0.04	1.17	1.60	0.00	0.01	0.00	0.27	0.74	8.86
Ipswich 13	Glide	3.79	0.00	0.00	0.10	0.04	0.00	0.00	0.06	0.00	0.03	0.27	0.53	0.00	0.01	0.00	0.16	0.01	5.01
Ipswich 17	Glide	4.57	0.00	0.08	0.00	0.18	0.00	0.00	0.02	0.01	0.25	0.12	0.54	0.01	0.01	0.00	0.35	0.01	6.15
Ipswich 19	Glide	3.49	0.00	0.23	0.00	0.03	0.00	0.00	0.00	0.00	0.85	0.22	0.20	0.01	0.01	0.00	0.34	0.01	5.39
Ipswich 22	Glide	3.69	0.00	0.08	0.00	0.47	0.20	0.00	0.00	0.00	0.14	0.21	1.45	0.00	0.00	0.00	0.13	0.00	6.37
Ipswich 3	Glide	1.22	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.01	0.17	0.00	1.02	0.00	0.01	0.17	0.00	0.02	2.69
Ipswich 5	Glide	1.19	0.00	0.04	0.00	0.19	0.01	0.00	0.04	0.01	0.38	0.23	0.16	0.01	0.00	0.22	0.08	0.18	2.75
Ipswich 7	Glide	0.76	0.00	0.79	0.00	0.02	0.00	0.00	0.00	0.04	0.21	0.60	0.00	0.00	0.08	0.00	0.00	0.31	2.80
Average spp biomass for glide		2.97	0.00	0.12	0.02	0.14	0.06	0.00	0.01	0.01	0.26	0.51	1.15	0.01	0.02	0.04	0.24	0.13	
%site biomass per spp		0.52	0.00	0.02	0.00	0.03	0.01	0.00	0.00	0.00	0.05	0.09	0.20	0.00	0.00	0.01	0.04	0.02	
% modified biomass for Peconic			**0.00**	**0.24**	**0.10**	**0.48**	**0.03**	**0.00**		**0.00**	**0.15**			**Average biomass for glides (g/m2)**					**5.69**
Ipswich 4	Run	0.87	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.20	0.00	1.00	0.00	0.07	1.21	0.00	0.05	3.77
Ipswich 16	Run	3.69	0.00	0.06	0.00	0.27	0.00	0.00	0.00	0.00	0.74	0.01	6.60	0.08	0.00	0.00	0.00	0.00	11.44
Peconic 195009-1	Run		0.00	0.00	0.07	0.57	0.00	0.00		0.00	0.00								0.64
Peconic 196006-1	Run		0.00	0.00	0.00	0.02	0.09	0.00		0.00	0.00								0.12
Peconic 196006-2	Run		0.00	0.00	0.05	0.67	0.22	0.00		0.00	0.00								0.94
Peconic 197002-1	Run		0.00	0.00	0.00	2.49	0.84	0.00		0.00	0.29								3.62
Peconic 197030-1	Run		0.00	0.28	0.21	1.75	1.90	0.15		0.00	0.78								5.06
Peconic 198008-1	Run		0.00	0.00	0.00	3.25	0.00	0.00		0.00	0.00								3.25
Peconic 198008-2	Run		0.00	0.00	0.00	1.53	0.00	0.00		0.00	0.00								1.53
Peconic 199021-1	Run		0.00	0.00	0.18	2.81	0.63	0.00		0.00	0.85								4.46
Average spp biomass for run		2.28	0.00	0.03	0.05	1.37	0.37	0.01	0.00	0.00	0.28	0.01	3.80	0.04	0.04	0.60	0.00	0.03	
%site biomass per spp		0.26	0.00	0.00	0.01	0.15	0.04	0.00	0.00	0.00	0.03	0.00	0.43	0.00	0.00	0.07	0.00	0.00	
% modified biomass for Peconic				**0.01**	**0.01**	**0.86**	**0.07**	**0.00**			**0.05**			**Average biomass for runs (g/m2)**					**3.48**
Peconic 101006-1	Pool		0.00	0.00	0.17	0.06	0.03	0.02		0.22	0.03								0.53
Peconic 101006-2	Pool		0.01	0.00	0.78	0.12	0.06	0.03		0.06	0.17								1.23
Peconic 101010-1	Pool		0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.16								0.16
Peconic 198041-1	Pool		0.00	0.00	0.00	0.00	0.20	0.00		0.00	0.00								0.20
Peconic 199021-2	Pool		0.00	0.00	5.66	0.54	0.12	0.03		0.00	0.03								6.37
Cold Spring Brook 2066	Pool	5.17		0.00	0.00	0.00		0.00		0.00	0.00	0.00	1.87			0.00		0.00	7.04
Hunts Brook 5163	Pool	0.00		0.00	0.00	1.49		0.00		0.00	0.00	0.00	0.00			0.00		0.00	1.49
Folwix Brook 5166	Pool	0.00		0.00	0.00	0.00		1.54		0.00	0.00	0.00	0.00			0.00		0.00	1.54
Average spp biomass for pool		1.72	0.00	0.00	0.83	0.28	0.08	0.20		0.03	0.05	0.00	0.62			0.00		0.00	
%site biomass per spp		0.45	0.00	0.00	0.22	0.07	0.02	0.05	0.00	0.01	0.01	0.00	0.16	0.00	0.00	0.00	0.00	0.00	
% modified biomass for Peconic			**0.00**		**0.39**	**0.43**	**0.04**	**0.10**		**0.02**	**0.02**			**Average biomass for runs (g/m2)**					**2.32**

Table 3. Expected number of each species in each habitat type at each water level in the study section of the Peconic River.

Water level	Habitat type	Approximate biomass (lbs)	Banded sunfish	Bluegill	Brown bullhead	Chain pickerel	Creek chubsucker	Golden shiner	Largemouth bass	Pumpkinseed	Approximate total number of fish
Low	Glide	15	3	11	2	55	7	0	0	10	88
Low	Run	28	0	1	0	184	31	1	0	7	224
Low	Pool	23	8	0	12	76	15	38	1	2	152
Mid	Run	75	0	2	1	491	82	3	0	18	596
Mid	Pool	194	67	0	100	629	124	314	5	20	1260
High	Run	816	0	17	9	5325	891	34	0	192	6468
High	Pool	138	48	0	71	446	88	223	3	14	893

Appendix A. Site descriptions for datasets used in biomass calculations

Sites	State	Habitat	Sampling gear	Sample reach length (M)	Channel width (M)	Date sampled	Location description
Ipswich 9	MA	glide	backpack electrofishing	61.00	10.06	8/28/1998	Bluleys Corner
Ipswich 10	MA	glide	backpack electrofishing	89.00	15.54	9/24/1998	Middleton Colony
Ipswich 11	MA	glide	backpack electrofishing	130.00	3.35	8/12/1998	Wetland reach between Woburn Street and I- 93
Ipswich 12	MA	glide	backpack electrofishing	97.00	9.14	9/28/1998	Upstream Maple Street (Route 62)
Ipswich 13	MA	glide	backpack electrofishing	95.00	13.94	9/11/1998	Downstream Thunder Bridge
Ipswich 17	MA	glide	backpack electrofishing	127.00	13.41	9/18/1998	Downstream of Salem Street
Ipswich 19	MA	glide	backpack electrofishing	149.00	13.56	9/15/1998	Route 97 canoe launch
Ipswich 22	MA	glide	backpack electrofishing	130.00	8.99	9/17/1998	Audubon canoe launch
Ipswich 3	MA	glide	backpack electrofishing	100.00	5.97	8/26/1998	Upstream of Route 28
Ipswich 5	MA	glide	backpack electrofishing	251.00	11.58	8/28/1998	Just upstream South Middleton gage
Ipswich 7	MA	glide	backpack electrofishing	129.00	7.32	8/26/1998	Downstream of Martins Brook
Ipswich 4	MA	run	backpack electrofishing	69.00	3.96	8/26/1998	Upstream of power line
Ipswich 16	MA	run	backpack electrofishing	127.00	4.88	9/14/1998	Upstream of Rowley Bridge Road (at Fish Brook)
Peconic 195009-1	NY	run	backpack electrofishing	91.44	4.11	9/25/1995	100 yards downstream Chlorine House to same
Peconic 196006-1	NY	run	backpack electrofishing	402.25	7.17	9/5/1996	1/4 mile East of Site 2 (Downstream)
Peconic 196006-2	NY	run	backpack electrofishing	91.44	4.11	9/5/1996	100 yards downstream Chlorine House to same
Peconic 197002-1	NY	run	backpack electrofishing	68.58	2.89	9/22/1997	75 yds downstream Chlorine House to same
Peconic 197030-1	NY	run	backpack electrofishing	114.30	4.18	9/22/1997	100 yds E AND 25 yds W Firebreak
Peconic 198008-1	NY	run	backpack electrofishing	68.58	2.89	6/18/1998	75 yds E Chlorine House to same
Peconic 198008-2	NY	run	backpack electrofishing	68.58	2.89	9/11/1998	75 yds E Chlorine House to same
Peconic 199021-1	NY	run	backpack electrofishing	137.16	2.69	9/29/1999	150 yds downstream of HM north Guaging Station
Peconic 101006-1	NY	pool	backpack electrofishing	200.00	32.92	6/22/2001	200 meters downstream Zeeks Pond Road upstream to Zeeks Pond Road
Peconic 101006-2	NY	pool	backpack electrofishing	68.58	32.92	6/22/2001	Peconic River at North Street behind house # 227 upstream 75 yards
Peconic 101010-1	NY	pool	backpack electrofishing	60.96	30.48	7/16/2001	Small pond 100x200 feet in main channel of Peconic River.
Peconic 198041-1	NY	pool	backpack electrofishing	60.96	10.54	9/11/1998	200 feet downstream guaging station at North Street.
Peconic 199021-2	NY	pool	backpack electrofishing	91.44	7.58	9/29/1999	HM north guaging stating upstream 100 yds
Cold Spring Brook 2066	CT	pool	backpack electrofishing	50.00	1.36		Central coastal
Hunts Brook 5163	CT	pool	backpack electrofishing	50.00	0.81		Eastern Coastal
Folwix Brook 5166	CT	pool	backpack electrofishing	50.00	1.31		Eastern Coastal

Appendix B. Percent composition of catchable fish species by 100 mm size classes from the combined Peconic and Ipswich River datasets.

Species	0-100 mm	100-200 mm	200-300 mm	300-400 mm	400-500 mm	500-600 mm
American eel	3	19	48	26	3	1
Banded sunfish	100	0	0	0	0	0
Bluegill	58	41	1	0	0	0
Brown bullhead	15	39	31	15	0	0
Chain pickerel	36	38	18	7	1	0
Creek chubsucker	28	60	11	1	0	0
Golden shiner	58	42	0	0	0	0
Green sunfish	85	15	0	0	0	0
Largemouth bass	38	34	22	6	0	0
Pumpkinseed	76	24	0	0	0	0
Redbreast sunfish	67	32	1	0	0	0
Redfin pickerel	35	62	3	0	0	0
Sea lamprey	8	92	0	0	0	0
Swamp darter	100	0	0	0	0	0
White sucker	48	13	4	8	26	1
Yellow bullhead	12	72	16	0	0	0
Yellow perch	27	70	3	0	0	0

Appendix C. Median predicted biomass (g) of fish species derived from surveys in the Peconic River

	Banded sunfish	Bluegill	Brown bullhead	Chain pickerel	Creek chubsucker	Golden shiner	Largemouth bass	Pumpkinseed
Average biomass (g)	1.4	148	347	60	28	27	326	100