AN ANALYSIS OF THE DIET OF STEELHEAD TROUT IN LAKE ERIE TO PROVIDE RESOURCE MANAGERS WITH A BASIC UNDERSTANDING OF THEIR ROLE IN LAKEWIDE PREDATOR/PREY DYNAMICS

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BACKGROUND and RATIONALE

Steelhead trout, a lake-run phase of the rainbow trout (*Oncorhynchus mykiss*), were introduced into Lake Erie in the late 1800's (Crawford 2001). Recent stocking history began in mid-1970's with peak stocking numbers of approximately 2.75 million occurring in 1992, making steelhead the most abundant salmonid in Lake Erie. Current stocking numbers have leveled off at about two million fish per year (Ryan et al. 2002), the highest annual steelhead stocking rates of all the Great Lakes (Crawford 2001). The proportion of steelhead stocked relative to total salmonines stocked in Lake Erie has risen from about 35% in 1989 to near 90% in recent years (Figure 1). The population is further supplemented by natural reproduction in New York tributaries (Culligan et al. 2002, Roth 2001). Studies of Cattaraugus Creek by Mikol (1977) and Goehle (1999) concluded that 21.7% and 25%, respectively, of the spring spawning fish were wild. Ohio, Pennsylvania, and Ontario agencies have also observed natural reproduction of steelhead in tributaries to Lake Erie. However, the number of naturally produced recruits is insufficient in these locations to maintain a quality, highly-utilized fishery without supplemental stocking. Thus stocking programs are likely to continue.

Despite the high stocking rate and growing popularity of these fish in Lake Erie, little information on steelhead diets exists for any of the Great Lakes. A large proportion of the studies that have been done are focused on salmonids within lakes Ontario and Michigan (Lantry 2001, Rand et al. 1993, Rand and Stewart 1998, Jude et al. 1987). Lantry (2001) found seasonal and spatial trends in percent composition of steelhead diets collected primarily from western portions of Lake Ontario 1998 and 1999. The overall percent composition of these fish from April through September was heavily dominated (>87%) by yearling and adult alewife (*Alosa pseudoharengus)* followed by invertebrates, rainbow smelt, and three-spined sticklebacks (*Gasterosteus aculeatus*). Similarly, Rand et al. (1998) found from 1984 to 1993 that adult alewife made up from at least 60% to 100% of steelhead diets from spring through summer in Lake Ontario, with rainbow smelt and juvenile alewife never accounting for more than 20%, and generally less than 10% of the diet. While these studies are important, their results do not pertain to Lake Erie due to the differences in available prey items between the lakes.

A few steelhead diet studies have been conducted in Lake Erie (Ohio Division of Wildlife 2003, Ohio Division of Wildlife 2004, Unpublished data – SUNY Fredonia 2003), but none of these have attempted to examine diets of steelhead throughout the three basins of the lake simultaneously. A recent bioenergetics exercise conducted by the bioenergetics sub-group of the Lake Erie Forage Task Group

(FTG) was only able to estimate forage consumption by walleye. Data limitations describing critical population parameters and diet prevented other key species such as lake trout (*Salvelinus namaycush*), steelhead, and burbot (*Lota lota*) from being included in the analysis (Bur et al. 2002). Similarly, an initial bioenergetics modeling effort conducted by Einhouse et al. (1999) to estimate the forage consumption by major predators in eastern Lake Erie from 1985–1991 concluded that their analysis suffered from the scarce information on all salmonine species. Einhouse et al. reported that rainbow smelt (*Osmerus mordax*) were an important part of the diets of both lake trout (*Salvelinus namaycush*) and walleye (*Sander vitreus*) and, based on limited available data, were also important in the diet of steelhead trout. In 2002 the Ohio Department of Natural Resources, Division of Wildlife collected and analyzed over 300 steelhead stomachs from late June to early September from fish caught in the Central Basin of Lake Erie by charter fishers (Ohio Division of Wildlife 2003). This project was repeated in summer 2003 with an additional 115 steelhead stomachs analyzed (Ohio Division of Wildlife 2004). Analysis of the stomachs from both years indicated that steelhead trout have a highly varied diet of fish, invertebrates and zooplankton. The most common item seen in steelhead stomachs was the spiny water flea *Bythotrephes longimanus*, followed by smelt and emerald shiners (*Notropis atherinoides*). However, analysis of the food ingested by biomass indicated that fish comprised the bulk of the diet. While these studies by the ODW provided important information concerning steelhead diets, it also revealed the need for additional collections from other areas of the lake where prey abundances vary in order to produce a better lakewide perspective of steelhead diet habits.

Currently, the amount of steelhead predation on forage fish populations such as rainbow smelt and emerald shiners are not well quantified across the lake. The studies by the ODW provided important information concerning steelhead diets, but it also revealed the need for additional collections from other areas of the lake where prey abundances vary in order to produce a better lakewide perspective of steelhead diet habits. With only limited diet information, it is difficult to determine if steelhead predation on forage species is having an impact on other important native piscivores, such as lake trout and walleye, in Lake Erie.

SAMPLE AREA

Lake Erie is typically divided into three basins (East, Central, West) that differ by habitat, flow, water depth, and water temperature. Steelhead are typically caught during the summer months in both the Central and East Basins, but not in the West Basin where water temperatures are too high. Because of this, the participating agencies concentrated on obtaining data from the Central and Eastern Basins only. Additionally, the Central Basin was split into two areas (West Central and East Central) according to established zones used for the management of walleye, in order to look at differences in diet items that may occur over this large area (Figure 1).

METHODS

Steelhead Stomach Collections

The pelagic nature of steelhead trout makes it difficult for traditional sampling gears to obtain many samples from the open water. Because of the difficulty and high costs associated with executing a directed sampling program for steelhead trout, opportunistic methods were used to collect steelhead stomachs from available sources during May – October, 2004. Agency representatives from the ODW and Pennsylvania Fish and Boat Commission (PFBC) collected stomach samples from sport-caught fish from fish cleaning facilities. ODW also collected stomachs obtained during annual gillnet surveys, and PFBC collected samples obtained by charter boat operators. The Ontario Ministry of Natural Resources (OMNR) obtained samples from two main sources: a creel census and the Partnership Gillnet Index program. In New York waters, individual anglers and charter boat captains were solicited to collect fish information and stomach samples during the course of their summer fishing.

Regardless of sampling methods, all individuals participating in stomach collections were provided with oral and written instructions on data collection and recording (Figure 2). In addition, participants were provided with data record forms, individually numbered cloth stomach storage bags, and Nalgene™ bottles containing preservation solution. Each data form had a unique set of sample identification numbers that corresponded to a numbered collection bag. Information on the data form included date, time of collection, strata, collector name, collection gear, length, weight, sex, and if a scale or otolith sample was collected. Participants collected the stomach by cutting well above and below the stomach and placing the entire stomach in a cloth bag that had been pre-numbered to match the sample ID on the data form. The bag was then placed in the Nalgene™ bottle that had been filled with a 10% solution of buffered formaldehyde or 90% ethanol.

Laboratory Methods

The Chautauqua-Erie Environmental Center at SUNY Fredonia analyzed all collected specimens. Individual fish prey items were identified to the species level whenever digestion state permitted, weighed to the nearest 0.01g, and measured to standard length (mm). A non-parametric code or rank was assigned to indicate the state of each diet item as undigested (0) through fully digested (5). When well-digested fishes were encountered, they were identified through vertebral counts or other morphologically unique skeletal features whenever possible. Invertebrate organisms were identified to as low a taxonomic level as possible. Because these organisms are often soft bodied and lack skeletons, most of the terrestrial invertebrates were identified to Order. Weight and length measurements of invertebrates were taken. Almost all of the identifiable zooplankton consisted solely of *Bythotrephes longimanus*. The durable nature of these zooplankters permitted us to make counts of individuals present in the majority of samples where they were encountered. These counts provide more accurate data than the visual estimate method that was described in the original proposal. Estimates of individual fish and invertebrate dry weight biomass were made from prey length conversions developed in the Ohio Division of Wildlife (2003) steelhead diet studies.

Data Storage and Analysis

A Microsoft Access database containing all of the collection and stomach data was created to store the diet information and for summarizing the data. The database also contains meta-data that defines codes and other descriptive information about the database. The database is currently housed at the New York Department of Environmental Conservation (NYSDEC) Lake Erie Fisheries Unit, Dunkirk, NY.

RESULTS and DISCUSSION

A total of 349 steelhead were sampled from June through October 2004 in the three delineated basins (see Figure 1). All fish sampled in June were from the West Central and East Central Basins in Ohio and Ontario waters (Figure 3). All of the East Central Basin steelhead were from the western end of the area. The majority of July samples were still from the West Central and East Central Basins, but the distribution was spread out more evenly over the East Central Basin compared to June. Two fish were collected from the East Basin in July. The month of August provided the best overall collection of fish with good numbers of steelhead sampled in all three basins. Cool and rainy weather in August probably contributed to the increase in samples in the East as fish started to stage off the mouths of feeder creeks for the fall run. By September, steelhead were only collected in the East Basin, mostly staging off the mouths of the major tributaries. Only one or two fish were sampled in October in each basin.

Size ranges of sampled fish were between 360mm and 840mm with the majority of the fish between 600 and 700mm (Figure 4). Mean total length of fish sampled in the East Basin (657.6mm) was significantly higher than West Central (624.3mm) and East Central Basin (610.8mm) steelhead (ANOVA; $p<0.05$). There were no significant differences in mean length between West Central and East Central Basin fish. Length frequency distributions by basin (Figure 4) also show the larger fish sampled in the East compared to the other two areas. However, this may have been partially due to later collections of fish in the East compared to the other two areas.

The most stomach collections were made by ODW (185) at their fish-cleaning stations while OMNR collected 74 stomachs and PFBC 50 (Table 1). NYSDEC collected the least number of stomachs (40) thru angler participation. Most of the stomachs were collected from the West Central Basin of Lake Erie (159) and the least were from the East Basin (56). Of the steelhead stomachs collected, 250 (72%) contained at least one food item (Table 2). Forty-three of these were from the East Basin, 86 from the East Central Basin, and 111 from the West Central Basin. Ten stomachs with food items were unable to be assigned to a basin due to missing locations and were excluded from further analysis. The majority of the stomachs used in the diet analysis were collected in July (87) and August (91). Most of the stomachs collected in the East Basin were collected in August and September while the majority of the stomachs from the East Central and West Central Basin were from June, July, and August. Only five stomachs that contained food items were collected in October.

Summary Analysis for 2004

There were 10 categories of fish identified from the stomachs collected and 11 categories of invertebrates (Table 3a). A few of the stomachs also contained some non-food items (unidentified objects) that included pieces of plastic and tree seed pods. All of the shiners that were in a state of preservation that permitted identification to the species level were emerald shiners. However, because a number of these fish were identifiable to the genus but not the species level (i.e. *Notropis* species), all of the shiners were treated as a group for this summary. The majority of the overall steelhead diets from each basin were comprised of fish species (93.5% East, 74.4% East Central, 82.1% West Central). Rainbow smelt and shiners were the most frequently encountered diet items, occurring in 82 to 91% in combination of the stomachs in each basin. However, the proportion of shiners to smelt varied between basins with shiners more important in the West Central and smelt most important in the East (Figure 5a). Both species contributed nearly equally in the East Central steelhead diets. Round gobies (*Neogobius melanostomus*) were commonly found in East Basin stomachs, and their presence in diets declined from East to West. Over 30% of the stomachs from East and West Central steelhead and over 15% of East Central fish contained unidentified fish. *Bythotrephes* was the most frequently encountered invertebrate species. Moths, lady bugs, and terrestrial beetles were more commonly found in East Central and West Central stomachs while East Basin fish were generally devoid of invertebrates. Overall, the East Basin fish had the lowest diversity of diet items (four fish species, two invertebrate species) of the three areas, while the East Central fish were the most diverse (eight fish species, nine invertebrate species).

Similar overall trends appeared when analyzing diet items by weight. The bulk of the diet was comprised of fish; invertebrates and zooplankton, although ingested frequently in some months in the East Central and West Central Basins, contributed very little to the overall biomass of food items (Table 3b). Shiners and smelt (combined) comprised over 75% of the biomass in East Central and West Central steelhead, but gobies comprised about half (50.3%) of the dry weight biomass in East Basin fish (Table 3b, Figure 5b). Shiners increased in diet biomass from East to West. Smelt were equally proportioned (42%) in the East and East Central diets but were lower (20%) in West Central diets. Yellow perch made up 6.8% of the steelhead diet biomass in the West Central, and declined to 2.4% in the East Central and none in the East Basin. White perch biomass comprised up to 7.5% of the diets in the East Central steelhead, but declined to 2% in the West Central and none in the East Basin.

Monthly Analyses across Basins

June

Steelhead stomachs were collected only from the East Central and West Central Basins during June. Fish comprised the majority of the diets in each area, with shiners being the most abundant diet item encountered (Figure 6a). Smelt were equally important as shiners in East Central diets, but were less important in West Central fish. Gobies were present in East Central steelhead, but other fish species such as white perch and yellow perch were more frequent in West Central diets. Invertebrate species, especially lady bugs and terrestrial beetles, occurred in a substantial number of the diets, especially in the East Central Basin (50%).

Analysis of the food items showed that shiners comprised the majority of the dry weight biomass in both the East Central and West Central Basins during June (Figure 6b). Smelt comprised the majority of the remaining biomass in East Central fish but contributed very little (2.5%) to the overall biomass of diet items in West Central fish. White perch (11.5%) and yellow perch (17.5%) were other substantial components of the diet biomass in the West Central Basin during June.

July

Steelhead stomachs were collected only from the East Central and West Central Basins during July. Shiners were again the most prevalent item in the diets in both areas, occurring in over 58% of the stomachs (Figure 7a). Smelt occurred in 44% of the East Central stomachs, but only 22.6% of the West Central stomachs. Other fish species were only occasionally encountered. *Bythotrephes* was more frequently encountered during July, especially in the West Central (32.3%). The occurrence of other invertebrate species declined compared to June.

Shiners once again comprised the majority of the steelhead diet biomass in July, making up 50% of the overall biomass in the East Central Basin and over 76% in the West Central Basin (Figure 7b). Smelt became increasingly more important in both areas, and together with shiners comprised over 92% of the ingested biomass. Yellow perch and other fish species were minor portions of the overall diet biomass.

August

Diet information was collected from all three areas during August. Shiners and smelt continued to be the most prevalent items found in steelhead stomachs (Figure 8a). Shiners occurred in over 76% of the stomachs in the West Central, while smelt were the most prevalent in the East (61.5%) and East Central (50%). Other identifiable fish species, including gobies, did not comprise a major portion of the steelhead diet in August. The occurrence of invertebrate species in diets was low in all areas.

Shiners and smelt continued to represent the bulk of overall diet biomass (>69 and 24%, respectively) in the West Central Basin, but other fish species became important in the other two basins (Figure 8b). The East Central steelhead diet biomass was split between smelt (46%), white perch (32%), and shiners (19%). While gobies did not appear in a large proportion of fish stomachs from the East Basin, they did comprise the majority (76%) of the overall biomass due to one fish that had consumed 18 gobies. Shiners and smelt comprised the bulk of remaining biomass (11% each) in East Basin steelhead, but their percentages would have been much higher if we removed that one steelhead with gobies.

September

All of the steelhead stomachs collected in September were from the East Basin. Smelt remained the most prominent diet item, occurring in over 71% of the 28 stomachs (Figure 9a). Shiners were mostly absent, and were replaced by round gobies which were found in 25% of the samples. Other fish species and all invertebrates remained absent in East steelhead stomach samples. Smelt comprised the majority of the biomass (81%) of the diet items found in East Basin steelhead during September (Figure 9b). Gobies made up the most of the remaining biomass.

Within-Basins Analyses

East

The majority of stomachs in the East Basin were collected in August (13) and September (28); only one steelhead stomach with contents was sampled in July and two in October. Rainbow smelt were the most frequently encountered food item (Table 4a) in both August (61.5%) and September (71.4%). Shiners were the next most important prey item in August (38.5%), but declined to 3.6% in September, as round gobies increased to 25%. Invertebrate species were generally not important in East Basin steelhead diets during August and September.

Dry weight biomass analysis indicated that round gobies comprised the majority of the ingested biomass in August (75.8%), but declined to 18% in September (Table 4b). Smelt, on the other hand, increased from 12% in August to 81% in September. Shiners were the only other species that significantly contributed to the overall diet biomass in August (12%), but they were absent in September stomach samples.

East Central

The majority of the steelhead stomachs were obtained in June (16), July (50), and August (18) in the East Central Basin. Smelt and shiners were the most important diet items in all months, occurring in at least 70% of the stomachs (Table 5a). Gobies were somewhat prevalent in June, but declined thereafter. Numerous other fish species occurred only occasionally. A variety of invertebrate species were routinely found in East Central steelhead diets in all three months with *Bythotrephes*, moths, terrestrial beetles, and lady bugs the most prevalent items.

Dry weight biomass analysis showed that smelt and shiners comprised the majority (>92%) of the diet in the East Central Basin in June and July (Table 5b). White perch biomass increased in August to 32%, replacing declines in shiners. Minor contributions of other fish species such as yellow perch, freshwater drum, and round gobies varied from month to month. Invertebrate species, although present in each month, did not have significant contributions to the biomass of the diet.

West Central

Similar to the East Central Basin, adequate numbers of stomach samples were collected in June (18), July (31), and August (60) in the West Central Basin. Smelt and shiners were also the diet items that occurred the most frequently during all months, with shiners more prevalent than smelt (Table 6a). Yellow perch appeared in the diet in all months in low numbers while gobies were absent. *Bythotrephes* occurred in over 30% of the steelhead stomachs in July, but occurred in less than 6% in June and August samples. The occurrence of other invertebrate species declined from June through August with beetles and moths occurring more frequently in June and July, respectively.

Shiners were also the principal forage species in biomass for steelhead in the West Central Basin, comprising over 68% of the overall dry weight biomass in June, July, and August (Table 6b). Biomass contributions of rainbow smelt increased in July and August compared to June. White perch and yellow perch comprised significant portions of the diet biomass in June (11% and 17%, respectively), but declined in July and August. Similar to the East Central Basin, invertebrate species made up an insignificant proportion of the overall diet biomass in all months.

CONCLUSIONS

Although this study was a snapshot from one summer, there are two general conclusions that are evident from the results. First, steelhead are generalists, feeding on a wide array of both fish and invertebrate species that varied from area to area and throughout the summer. At least seven identified fish species and ten invertebrate species were found in steelhead stomachs. The species composition also indicates that steelhead feed throughout the water column. Invertebrate species such as lady bugs, terrestrial beetles, Hemipterans, and flies are only found on or near the surface of the lake, indicating that the fish were feeding at or near the surface. Conversely, other species such as round gobies and *Driessenids* are only found in benthic habitats and would only be consumed if steelhead were actively feeding on the bottom. The majority of the consumed species, including smelt, shiners, and *Bythotrephes*, are found throughout the water column depending on daylight and thermocline depth, and this is where the majority of the feeding most likely occurred.

The second general conclusion from this study is that, although numerous invertebrate species were consumed and frequently in large amounts, fish species were the major diet item consumed by steelhead in all areas, comprising over 99% of the dry weight biomass. Further, rainbow smelt and *Notropis* species were the two principal diet items consumed by steelhead in all areas (smelt more important in East, shiners in West). Other fish species did contribute to the diet at different times of the year, such as gobies in the East and white perch and yellow perch in the East Central and West Central Basins. Conspicuous was the lack of alewife in steelhead diets. Due to their low population levels in Lake Erie compared to the other Great Lakes, or due to steelhead acceptance of other suitable fish species, alewife are not a key component to steelhead diets in Lake Erie. Because other important lake species such as walleye, yellow perch, smallmouth bass, and lake trout are also supported by these same prey species, it is imperative to the lake ecosystem that steelhead are considered during lakewide bioenergetics exercises to determine the impact of all predators on the Lake Erie forage community.

The results of this study are comparable to the results found by the Ohio Division of Wildlife in 2003 and 2004 for the Central Basin of Lake Erie. It should be noted, however, that our data may be biased because of the way that the fish were collected (by anglers). Open water steelhead anglers frequently catch their fish by trolling at or near the thermocline, which incidentally is where pelagic prey species such as smelt and shiners usually reside in the water column during daylight hours. Our data indicate that smelt and shiners are the two most prominent diet items, but this does not necessarily mean that this is where the majority of the steelhead are residing and feeding, just that this is where the majority of the anglers were fishing. Because different diet items were consumed by steelhead at different depths of the water column, it might have been more accurate to obtain an unbiased sample that was proportionate to where steelhead spent most of their time, if this was possible. With this stated, we believe that steelhead do spend most of their time feeding the pelagic zone and that the results of this study are pertinent to the Lake Erie steelhead population.

The movement and location of steelhead during the summer is an important component of the lakewide bioenergetics exercise. We can characterize a steelhead out-migration pattern from the rivers and harbors, an offshore movement from the spring through early summer, and then back to the streams in the fall. However, we do not have a clear picture of summer migration tendencies. Lack of harvest and diet information from where effort was low (in the East Basin in June and July, and in the West Central and East Central in September and October) causes the overall picture and results to be incomplete. We can generalize from existing data that (primarily) the offshore movement in the Central Basin is towards an area of deep, cool offshore habitat that is found in the West Central Basin and may seasonally spill over into the East Central Basin. This area can readily be identified by using thermal model images of the temperature profiles of the central basin provided by the Great Lakes Coastal Forecasting System (NOAA-GLERL 2005). Offshore movement in the East Basin may either be offshore into the deep coldwater habitat of the eastern basin or into the cool habitat in the Central Basin. The amount of fidelity to offshore areas and whether cross migration occurs cannot be described from this project. If offshore migration trends can be defined, then it has important implications for any bioenergetics modeling because of the differences in prey consumed in each basin. Further studies, possibly using a mass-marking technique, are needed to better understand steelhead movement patterns to fully utilize and properly incorporate the diet information that was gathered in this study.

The primary goal of this project has been to establish a lakewide database of steelhead diet information that is useful to Lake Erie stakeholders, with particular emphasis on those stakeholders that are modeling or managing aspects of the lake ecosystem that may be impacted by steelhead feeding patterns. Despite lower than anticipated sample collection numbers, these data amplify previous steelhead diet work done on Lake Erie and will help fill a void that has existed in our understanding of predator prey interactions on Lake Erie.

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Table 1. Number of steelhead stomachs collected in Lake Erie by agency and basin, June – October 2004.

	Basin			
Agency	East	East Central	West Central	Unknown
NYSDEC	40			
PFBC	17	31		2
ODW		58	127	
OMNR		27	32	15
TOTAL	**57**	**116**	**159**	**17**

Table 2. Number of steelhead stomachs with contents collected in Lake Erie by month and basin, 2004.

	Basin			
Month	East	East Central	West Central	Unknown
June	0	16	18	5
July	1	50	31	5
August	13	18	60	
September	28	0	0	
October	2	1	2	
TOTAL	**44**	**85**	**111**	**10**

Table 3a. Frequency of occurrence (%) of diet items found in steelhead stomachs from Lake Erie by basin, June – October 2004. Sample number of fish with stomach contents are listed in parentheses.

	Basin		
Diet Item	East (44)	East Central (85)	West Central (111)
Alewife		1.2	
Emerald shiners	4.5	32.9	47.7
Notropis species	9.1	16.5	19.8
Rainbow smelt	68.2	41.2	19.8
White perch		2.4	1.8
Morone species			0.9
Round gobies	20.5	3.5	
Freshwater drum		1.2	
Yellow perch		3.5	4.5
Unidentified fish	31.8	15.3	33.3
Bythotrephes	4.5	12.9	12.6
Moth		9.4	3.6
Hemipterans		1.2	0.9
Terrestrial beetles		3.5	3.6
Deer/Horse fly			0.9
Lady bugs		5.9	2.7
Fingernail clams		1.2	0.9
Driessenids	2.3	1.2	0.9
Wasp		1.2	
Mayfly		2.4	
Unidentified invertebrate		1.2	
Unidentified object	2.3	1.2	1.8

Table 3b. Dry weight biomass (%) of diet items found in steelhead stomachs from Lake Erie by basin, June – October 2004. Sample number of fish with stomach contents are listed in parentheses.

	Basin		
Diet Item	East (44)	East Central (85)	West Central (111)
Alewife		0.08	
Emerald shiners	0.83	35.98	57.71
Notropis species	6.11	10.10	12.76
Rainbow smelt	42.47	41.76	19.75
White perch		7.53	2.03
Morone species			0.06
Round gobies	50.36	0.26	
Freshwater drum		1.49	
Yellow perch		2.35	6.78
Unidentified fish	0.22	0.41	0.88
Bythotrephes	<0.01	0.05	0.03
Moth		<0.01	<0.01
Hemipterans		<0.01	<0.01
Terrestrial beetles		<0.01	<0.01
Deer/Horse fly			<0.01
Lady bugs		<0.01	<0.01
Fingernail clams		<0.01	<0.01
Driessenids	<0.01	<0.01	<0.01
Wasp		<0.01	
Mayfly		<0.01	
Unidentified invertebrate		<0.01	
Unidentified object	<0.01	<0.01	<0.01

Table 4a. Frequency of occurrence (%) of diet items found in steelhead stomachs from the **East Basin** of Lake Erie by month, 2004. Sample number of fish with stomach contents are listed in parentheses.

	Month				
Diet Item	June (0)	July (1)	August (13)	September (28)	October (2)
Alewife					
Emerald shiners			15.4		
Notropis species			23.1	3.6	
Rainbow smelt		100	61.5	71.4	50
White perch					
Morone species					
Round gobies			7.7	25.0	50
Freshwater drum					
Yellow perch					
Unidentified fish			38.5	32.1	
Bythotrephes			15.4		
Moth					
Hemipterans					
Terrestrial beetles					
Deer/Horse fly					
Lady bugs					
Fingernail clams					
Driessenids				3.6	
Wasp					
Mayfly					
Unidentified invertebrate					
Unidentified object				3.6	

Table 4b. Dry weight biomass (%) of diet items found in steelhead stomachs from the **East Basin** of Lake Erie by month, 2004. Sample number of fish with stomach contents are listed in parentheses.

	Month				
Diet Item	June (0)	July (1)	August (13)	September (28)	October (2)
Alewife					
Emerald shiners			1.53		
Notropis species			10.59	0.81	
Rainbow smelt		100	11.69	81.15	59.54
White perch					
Morone species					
Round gobies			75.78	18.04	40.46
Freshwater drum					
Yellow perch					
Unidentified fish			0.41	<0.01	
Bythotrephes			<0.01		
Moth					
Hemipterans					
Terrestrial beetles					
Deer/Horse fly					
Lady bugs					
Fingernail clams					
Driessenids				<0.01	
Wasp					
Mayfly					
Unidentified invertebrate					
Unidentified object				<0.01	

Table 5a. Frequency of occurrence (%) of diet items found in steelhead stomachs from the **East Central Basin** of Lake Erie by month, 2004. Sample number of fish with stomach contents are listed in parentheses.

	Month				
Diet Item	June (16)	July (50)	August (18)	September (0)	October (1)
Alewife			5.6		
Emerald shiners	43.8	36.0	16.7		
Notropis species	6.3	24.0	5.6		
Rainbow smelt	43.8	44.0	50.0		100
White perch	6.3		5.6		
Morone species					
Round gobies	12.5	2.0			
Freshwater drum		2.0			
Yellow perch		6.0			
Unidentified fish	6.3	16.0	27.8		
Bythotrephes		14.0	16.7		100
Moth		16.0			
Hemipterans			5.6		
Terrestrial beetles	12.5	2.0			
Deer/Horse fly					
Lady bugs	18.8	2.0	11.1		
Fingernail clams	6.3				
Driessenids		2.0			
Wasp		2.0			
Mayfly	12.5				
Unidentified invertebrate		2.0			
Unidentified object	6.3				

Table 5b. Dry weight biomass (%) of diet items found in steelhead stomachs from the **East Central Basin** of Lake Erie by month, 2004. Sample number of fish with stomach contents are listed in parentheses.

	Month				
Diet Item	June (16)	July (50)	August (18)	September (0)	October (1)
Alewife			0.39		
Emerald shiners	58.16	33.07	16.40		
Notropis species	1.04	16.89	2.83		
Rainbow smelt	35.18	42.98	46.20		97.69
White perch	4.57		32.06		
Morone species					
Round gobies	1.04	<0.01			
Freshwater drum		2.72			
Yellow perch		4.28			
Unidentified fish	<0.01	<0.01	2.03		
Bythotrephes		0.05	0.08		2.31
Moth		<0.01			
Hemipterans			<0.01		
Terrestrial beetles	<0.01	<0.01			
Deer/Horse fly					
Lady bugs	<0.01	<0.01	<0.01		
Fingernail clams	<0.01				
Driessenids		<0.01			
Wasp		<0.01			
Mayfly	<0.01				
Unidentified invertebrate		<0.01			
Unidentified object	<0.01				

Table 6a. Frequency of occurrence (%) of diet items found in steelhead stomachs from the **West Central Basin** of Lake Erie by month, 2004. Sample number of fish with stomach contents are listed in parentheses.

	Month				
Diet Item	June (18)	July (31)	August (60)	September (0)	October (2)
Alewife					
Emerald shiners	38.9	45.2	51.7		50.0
Notropis species	16.7	12.9	25.0		
Rainbow smelt	11.1	22.6	21.7		
White perch	11.1				
Morone species			1.7		
Round gobies					
Freshwater drum					
Yellow perch	11.1	3.2	3.3		
Unidentified fish	27.8	32.3	36.7		
Bythotrephes	5.6	32.3	5.0		
Moth		12.9			
Hemipterans					50.0
Terrestrial beetles	11.1		1.7		50.0
Deer/Horse fly	5.6				
Lady bugs	5.6	3.2	1.7		
Fingernail clams			1.7		
Driessenids		3.2			
Wasp					
Mayfly					
Unidentified invertebrate					
Unidentified object	5.6		1.7		

Table 6b. Dry weight biomass (%) of diet items found in steelhead stomachs from the **West Central Basin** of Lake Erie by month, 2004. Sample number of fish with stomach contents are listed in parentheses.

	Month				
Diet Item	June (18)	July (31)	August (60)	September (0)	October (2)
Alewife					
Emerald shiners	53.31	69.27	55.87		<0.01
Notropis species	15.19	7.58	13.46		
Rainbow smelt	2.49	21.02	24.09		
White perch	11.49				
Morone species			0.10		
Round gobies					
Freshwater drum					
Yellow perch	17.50	2.00	5.14		
Unidentified fish	<0.01	<0.01	1.35		
Bythotrephes	0.01	0.14	<0.01		
Moth		<0.01			
Hemipterans					25.0
Terrestrial beetles	<0.01		<0.01		75.0
Deer/Horse fly	<0.01				
Lady bugs	<0.01	<0.01	<0.01		
Fingernail clams			<0.01		
Driessenids		<0.01			
Wasp					
Mayfly					
Unidentified invertebrate					
Unidentified object	<0.01		<0.01		

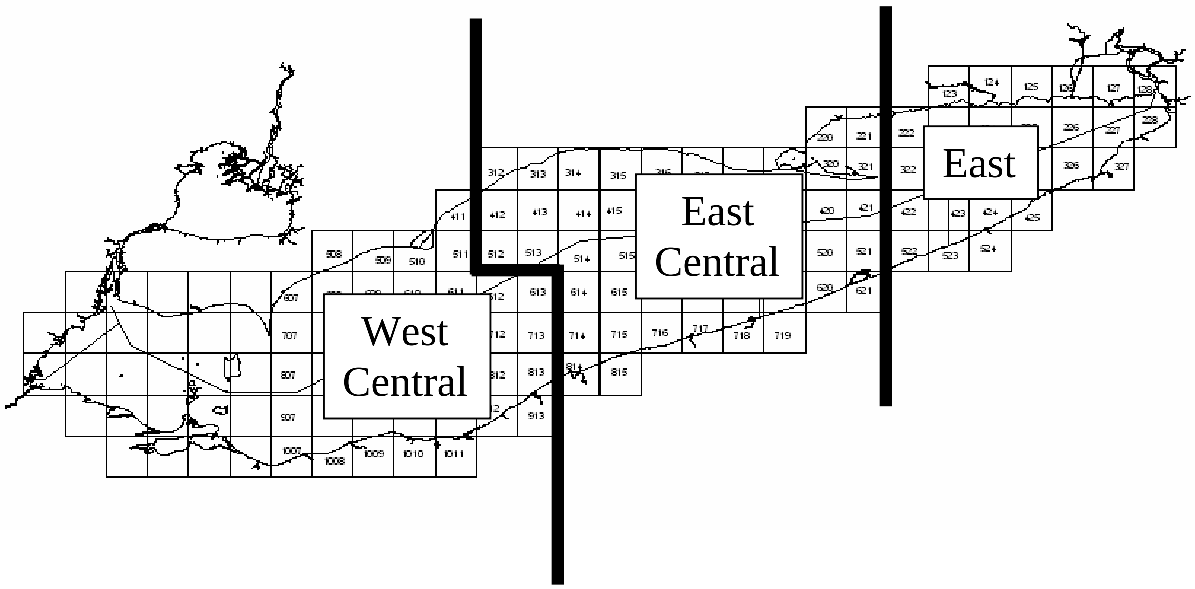


Figure 1. Map of Lake Erie with 10-minute grids delineating the three basins used in a steelhead diet study, June – October 2004.

General Information

Bag #:__________

Date (MDY):____/_____/ 2004

Time (24hr): ____:____

Collector:__________________

Collection Gear: ☐ Angling ☐ Gill Nets ☐ Trawl ☐ Other

Location Information

Location Grid #:_____

Water Depth (ft):_____

Latitude:____:____.____

Longitude:____:____.____

Fish Information

Length (mm TL):______________

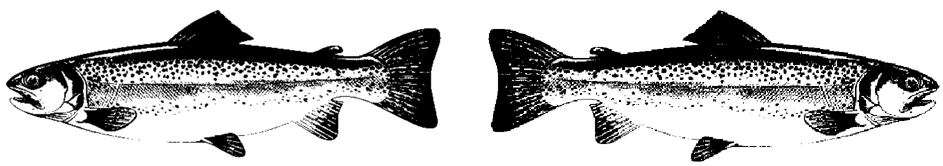
Weight (g):____________________ ☐ Assessment Weight?

Stomach Condition: ☐ Whole ☐ Cut/Sliced

Ageing Structures Collected: ☐ Scales ☐ Otoliths ☐ Fins

Lamprey Wounds: # Fresh __________ # Healed ________

Fin Clips: Circle all that apply



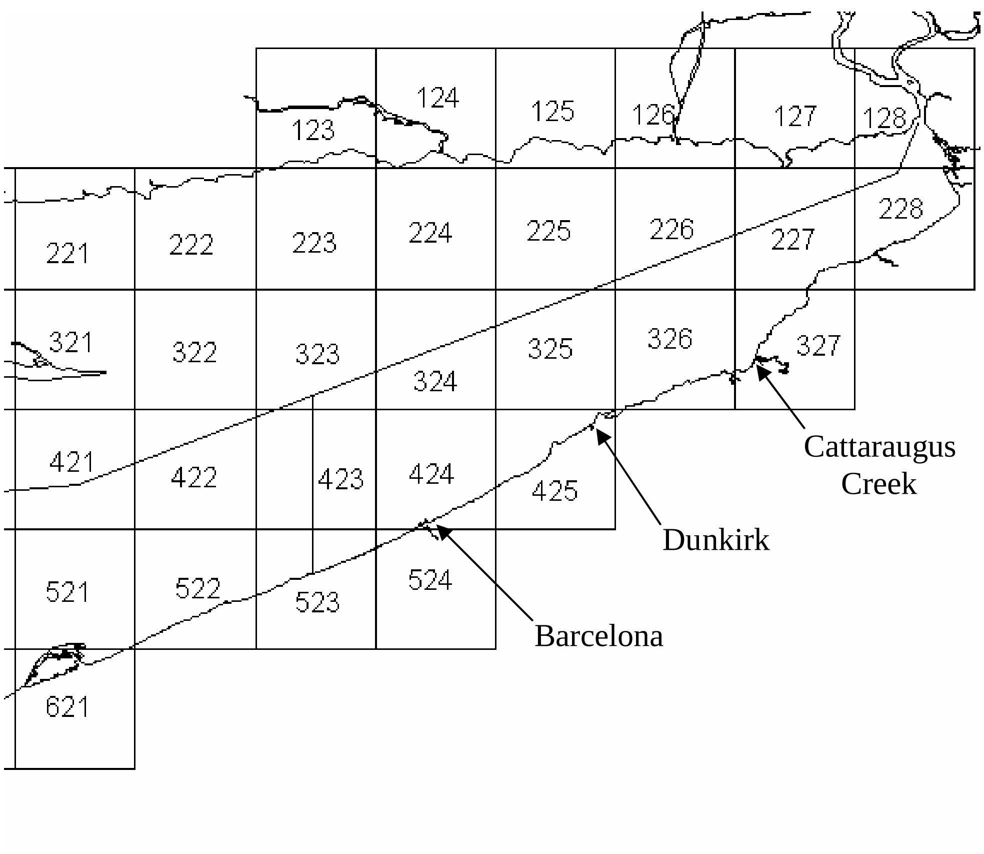


Figure 2. Example of a steelhead diet collection sheet used to record information for an individual fish on Lake Erie, 2004.

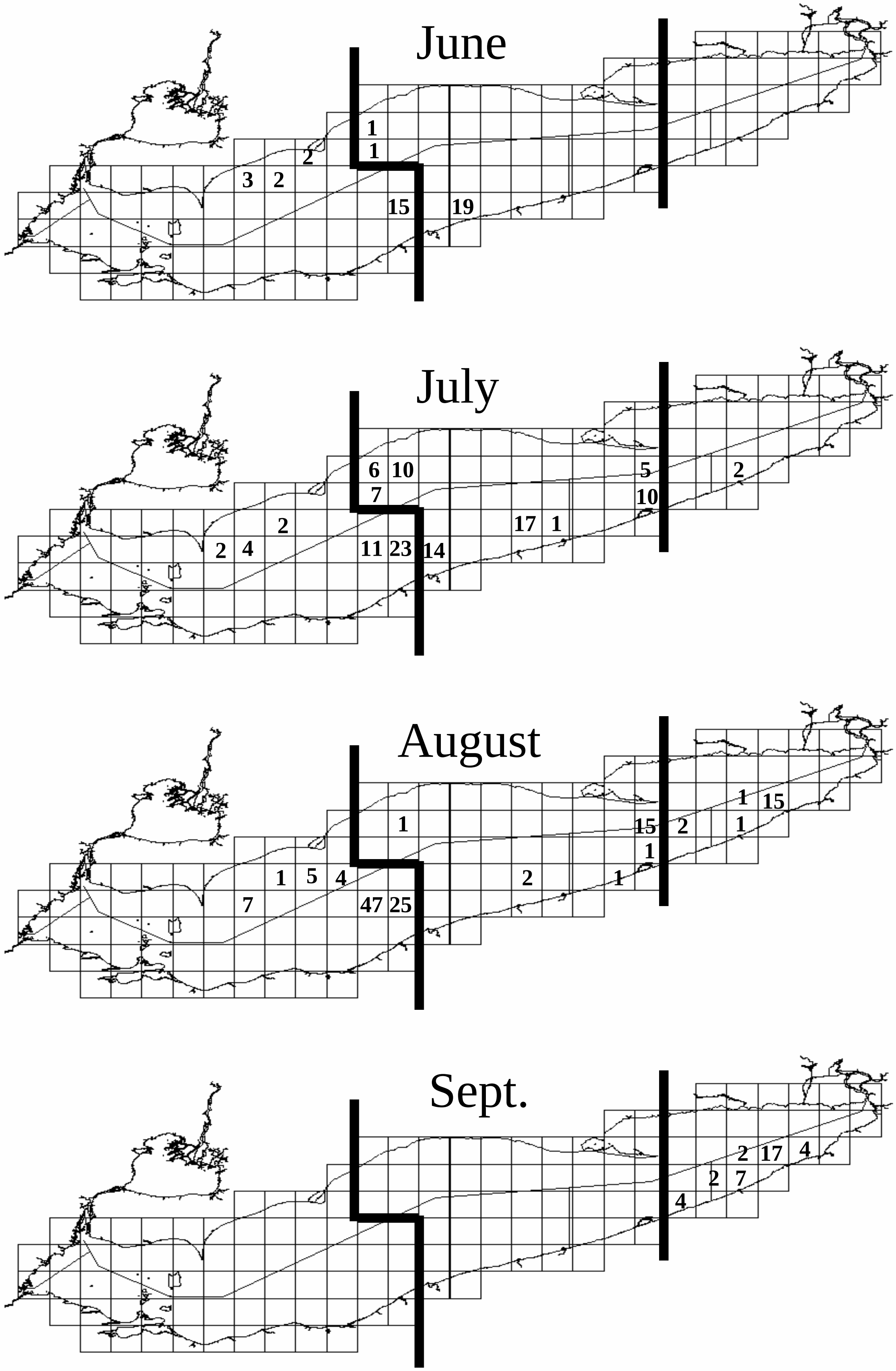
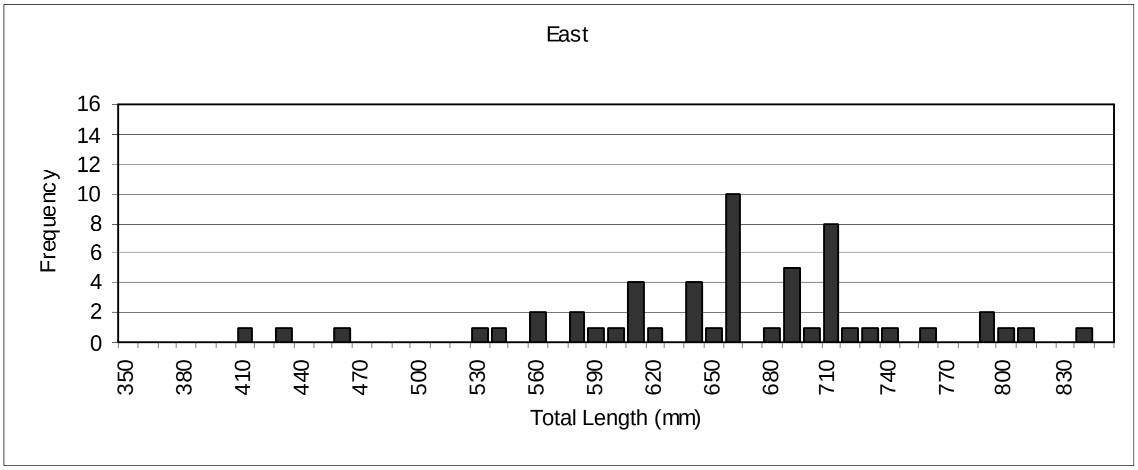
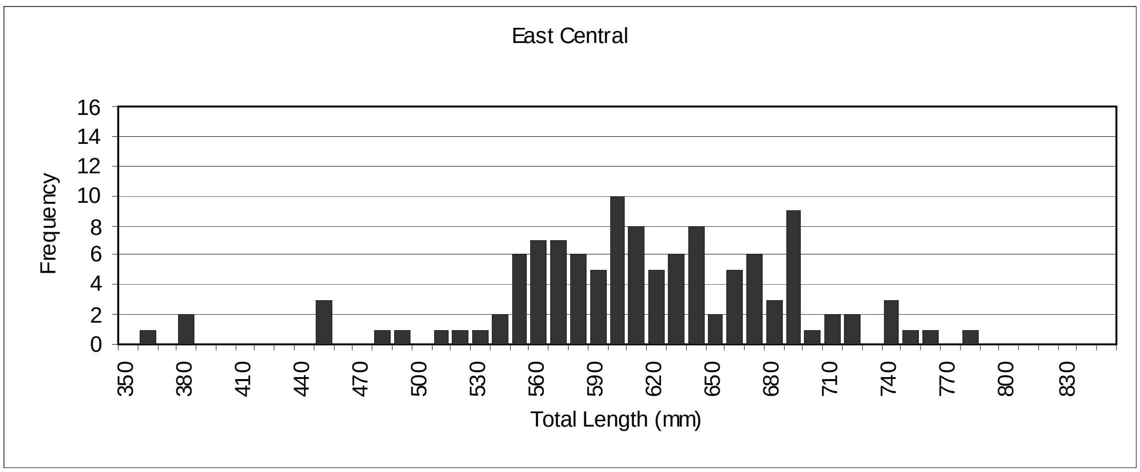


Figure 3. Maps of Lake Erie from June – September 2004 showing the number and location of steelhead sampled for a diet study.





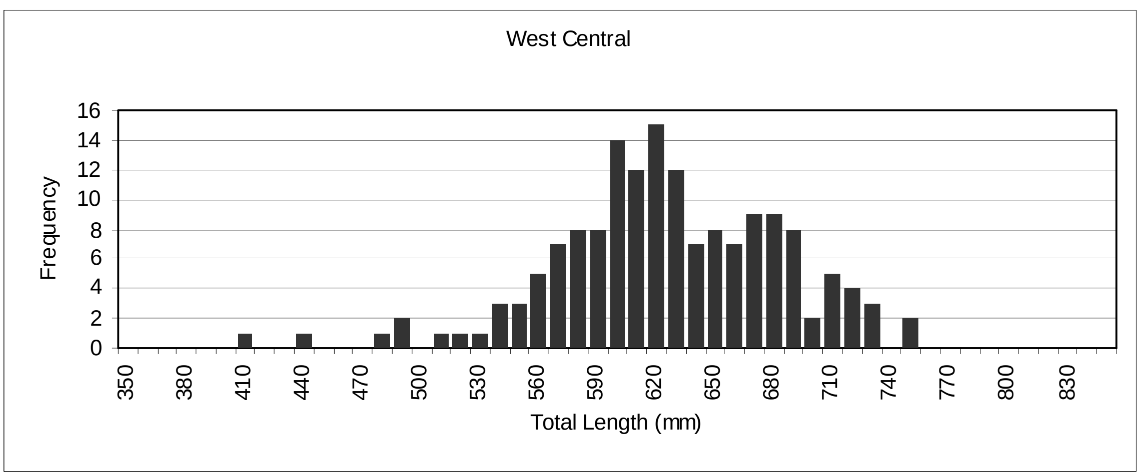


Figure 4. Length frequency distribution by basin of steelhead collected for a diet study in Lake Erie, June – October 2004.

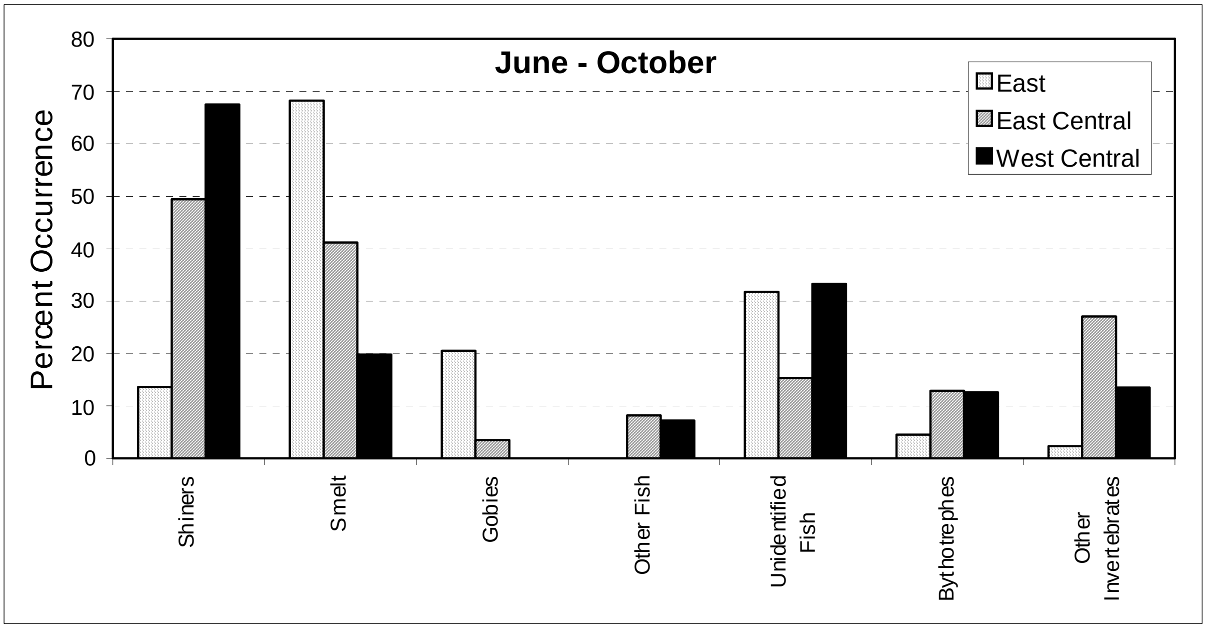


Figure 5a. Frequency of occurrence (%) of diet items found in steelhead stomachs from Lake Erie by basin, June – October 2004.

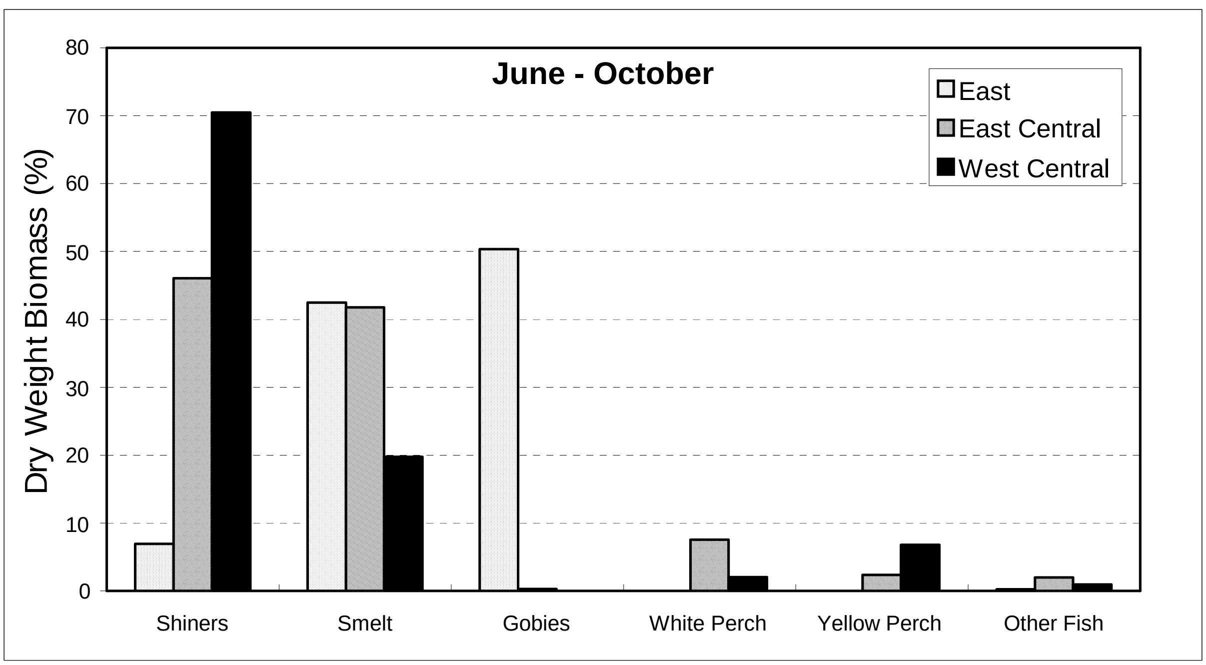


Figure 5b. Dry weight biomass (%) of fish species found in steelhead stomachs from Lake Erie by basin, June – October 2004.

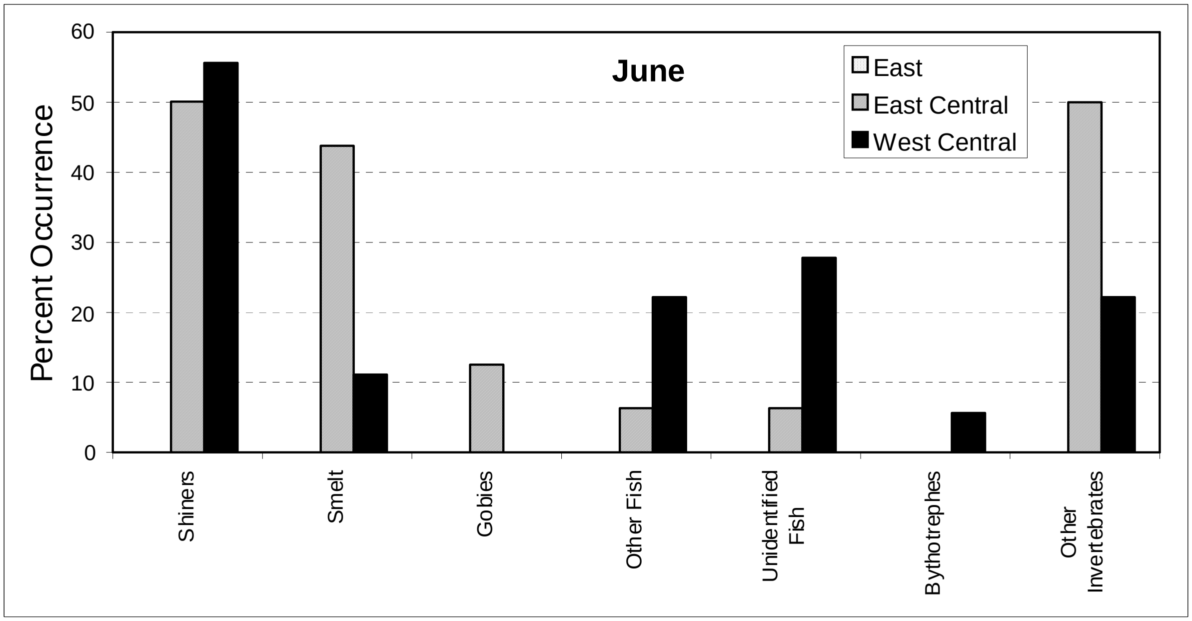


Figure 6a. Frequency of occurrence (%) of diet items found in steelhead stomachs from Lake Erie by basin, **June** 2004.

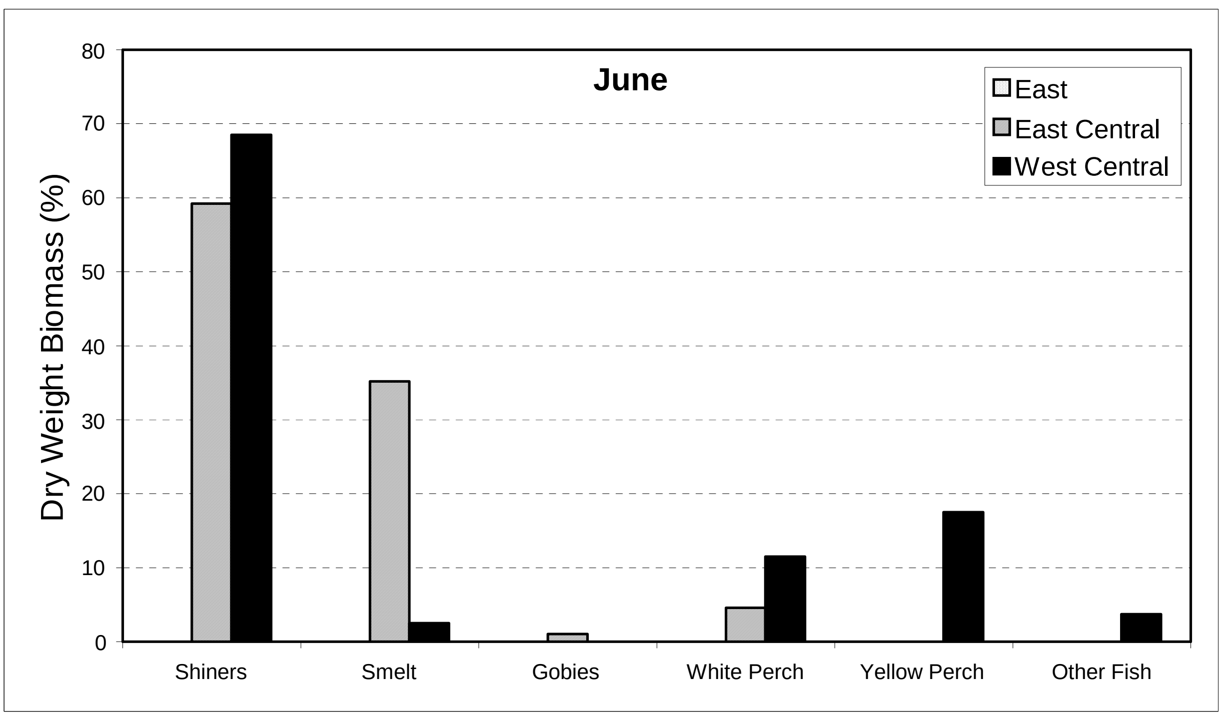


Figure 6b. Dry weight biomass (%) of fish species found in steelhead stomachs from Lake Erie by basin, **June** 2004.

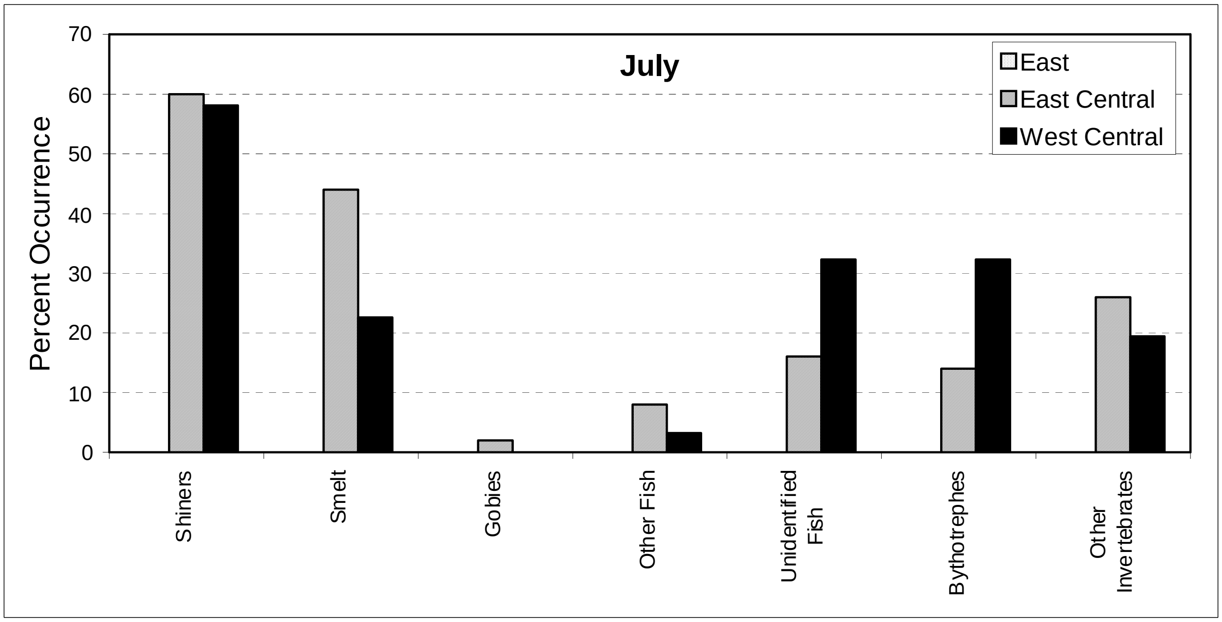


Figure 7a. Frequency of occurrence (%) of diet items found in steelhead stomachs from Lake Erie by basin, **July** 2004.

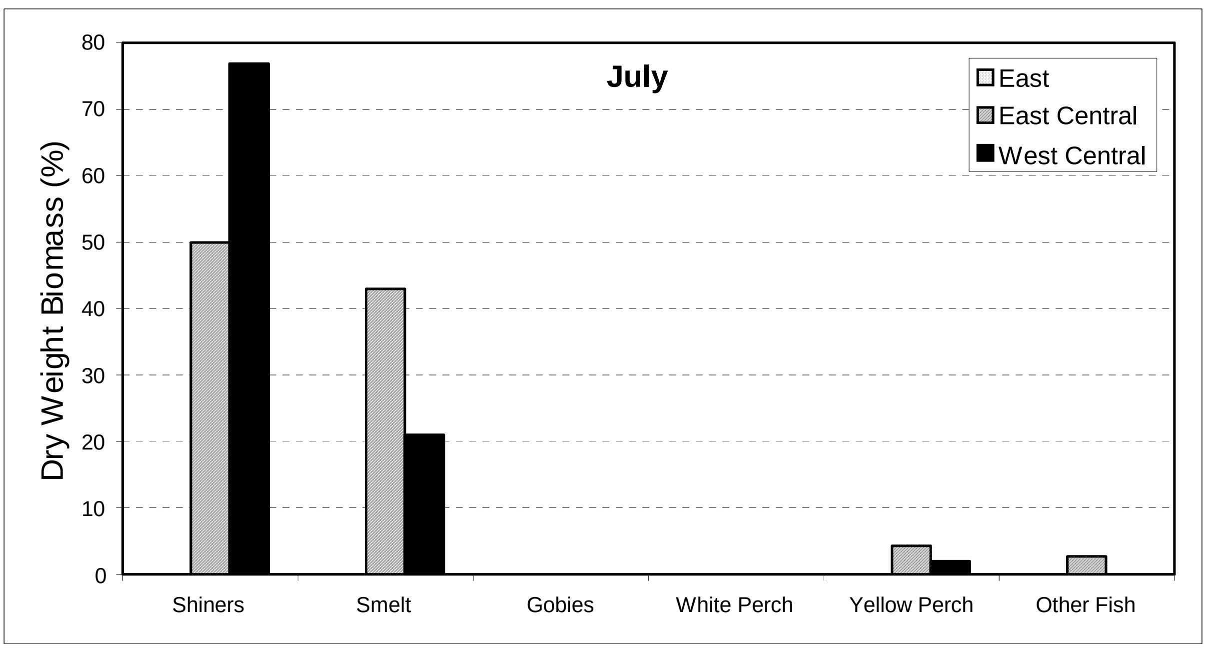


Figure 7b. Dry weight biomass (%) of fish species found in steelhead stomachs from Lake Erie by basin, **July** 2004.

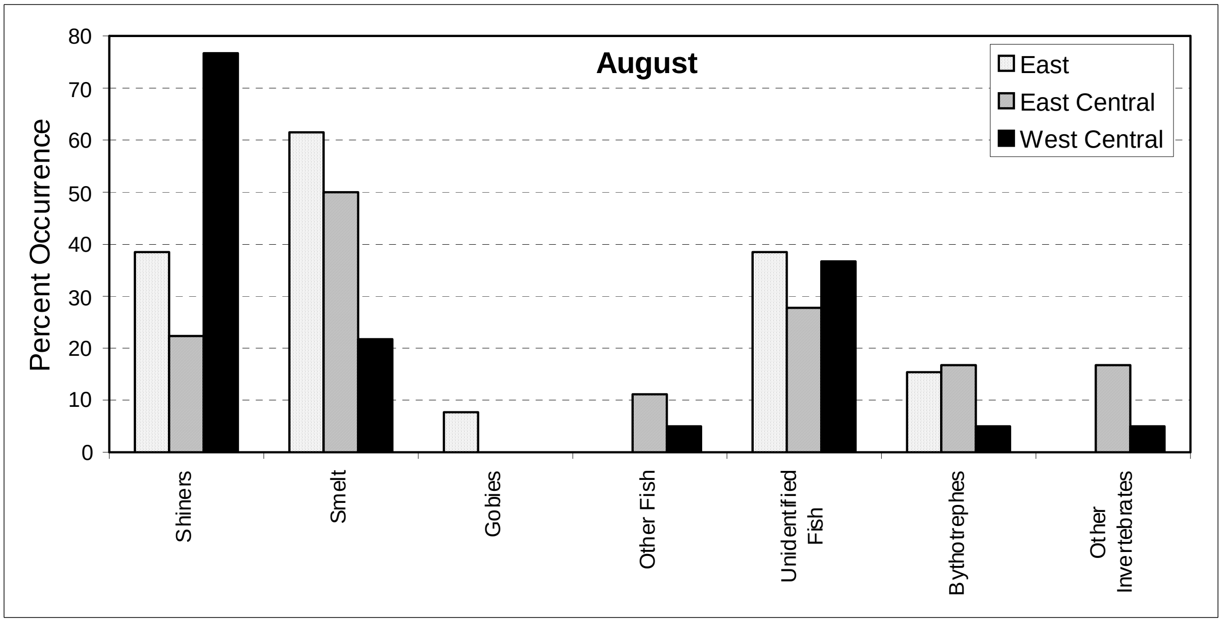


Figure 8a. Frequency of occurrence (%) of diet items found in steelhead stomachs from Lake Erie by basin, **August** 2004.

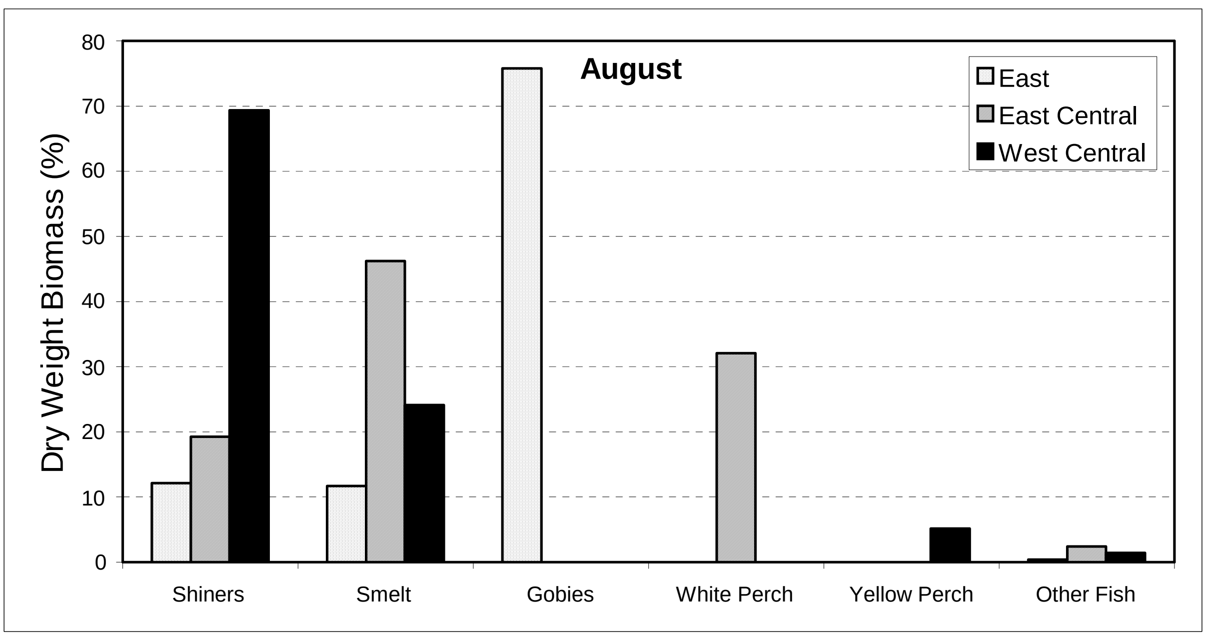


Figure 8b. Dry weight biomass (%) of fish species found in steelhead stomachs from Lake Erie by basin, **August** 2004.

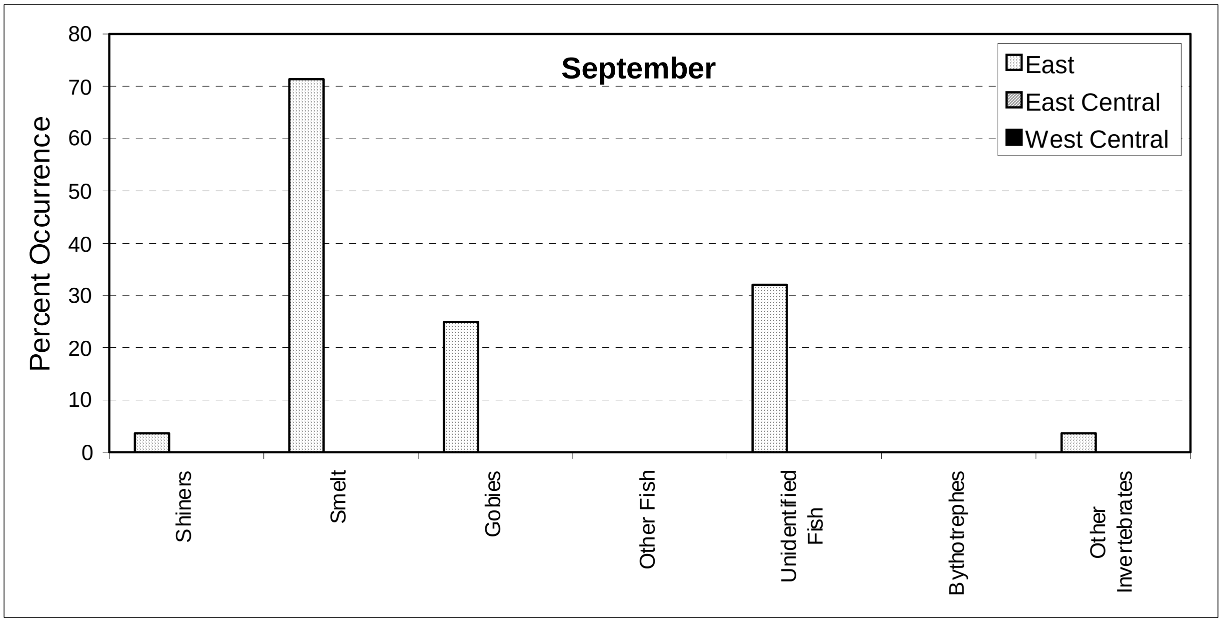


Figure 9a. Frequency of occurrence (%) of diet items found in steelhead stomachs from Lake Erie by basin, **September** 2004.

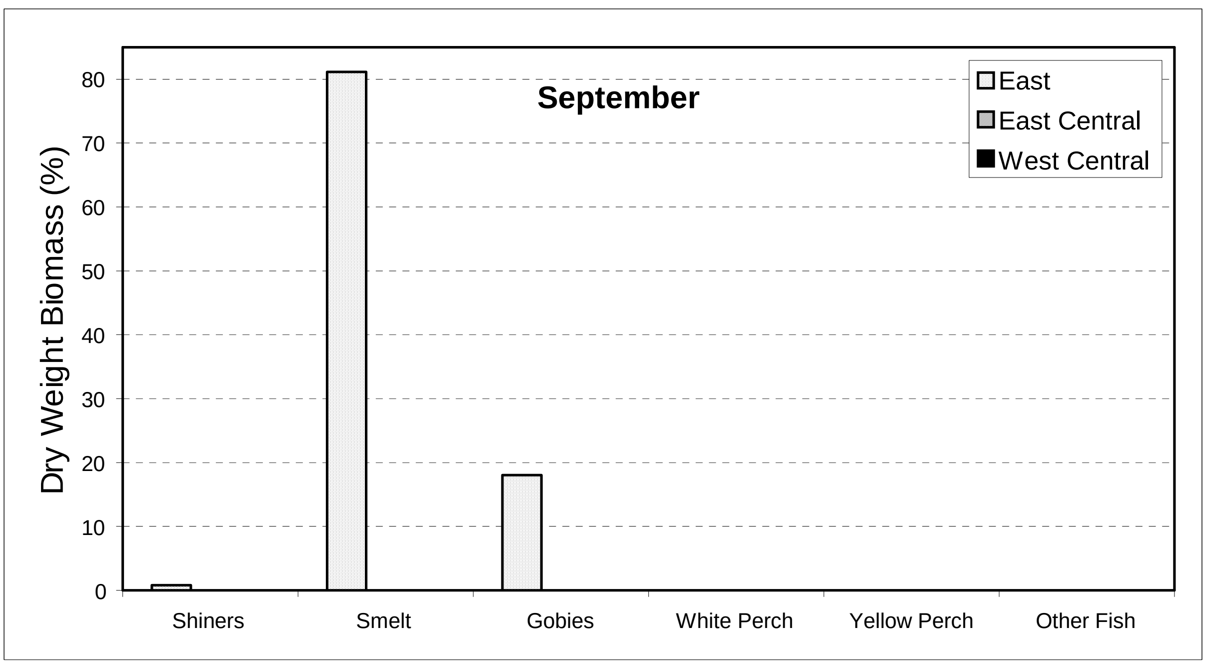


Figure 9b. Dry weight biomass (%) of fish species found in steelhead stomachs from Lake Erie by basin, **September** 2004.