The Navigation Economic Technologies Program

July 27, 2004

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SEASONALITY AND GEOGRAPHIC TRENDS FOR GRAIN SHIPMENT ON THE UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

US Army Corps of Engineers®

IWR Report 04-NETS-P-04

Navigation Economic Technologies

The purpose of the Navigation Economic Technologies (NETS) research program is to develop a standardized and defensible suite of economic tools for navigation improvement evaluation. NETS addresses specific navigation economic evaluation and modeling issues that have been raised inside and outside the Corps and is responsive to our commitment to develop and use peer-reviewed tools, techniques and procedures as expressed in the Civil Works strategic plan. The new tools and techniques developed by the NETS research program are to be based on 1) reviews of economic theory, 2) current practices across the Corps (and elsewhere), 3) data needs and availability, and 4) peer recommendations.

The NETS research program has two focus points: expansion of the body of knowledge about the economics underlying uses of the waterways; and creation of a toolbox of practical planning models, methods and techniques that can be applied to a variety of situations.

Expanding the Body of Knowledge

NETS will strive to expand the available body of knowledge about core concepts underlying navigation economic models through the development of scientific papers and reports. For example, NETS will explore how the economic benefits of building new navigation projects are affected by market conditions and/or changes in shipper behaviors, particularly decisions to switch to non-water modes of transportation. The results of such studies will help Corps planners determine whether their economic models are based on realistic premises.

Creating a Planning Toolbox

The NETS research program will develop a series of practical tools and techniques that can be used by Corps navigation planners. The centerpiece of these efforts will be a suite of simulation models. The suite will include models for forecasting international and domestic traffic flows and how they may change with project improvements. It will also include a regional traffic routing model that identifies the annual quantities from each origin and the routes used to satisfy the forecasted demand at each destination. Finally, the suite will include a microscopic event model that generates and routes individual shipments through a system from commodity origin to destination to evaluate non-structural and reliability based measures.

This suite of economic models will enable Corps planners across the country to develop consistent, accurate, useful and comparable analyses regarding the likely impact of changes to navigation infrastructure or systems.

NETS research has been accomplished by a team of academicians, contractors and Corps employees in consultation with other Federal agencies, including the US DOT and USDA; and the Corps Planning Centers of Expertise for Inland and Deep Draft Navigation.

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Seasonality and geographic trends for grain shipment on the Upper Mississippi River and Illinois Waterway

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Abstract: We examine for geographic and seasonal patterns in the shipment of corn on the Upper Mississippi River and Illinois Waterway between 1990 and 2002. We find that the center of gravity of corn shipments has moved south over this period, though not uniformly. There have been large decreases in corn shipments on the Mississippi above Davenport, small increases on the Upper Mississippi between Davenport and lock 27, small increases on the Illinois River, and large increases shipments on the free-flowing part of the Upper Mississippi below St. Louis. There has also been a change in the seasonal pattern of shipment on the Upper Mississippi. The winter peak for shipments on the free flowing part of the Mississippi has been reduced, primarily due to increases in shipments at other times. The summer peak in the northern part of the river has also been reduced though off-peak months do not seem to have gained traffic lost from peak months. The result of these seasonal shifts is to accelerate the southward shift in the center of gravity of corn shipments both during peak periods as well as off-peak times. This pattern is consistent with increased options for grain shippers in the northern part of the Upper Mississippi, in the form of shuttle trains, increased attractiveness of alternative outlets for corn, and increased local processing opportunities.

INTRODUCTION

Corn is a primary agricultural commodity carried on the Upper Mississippi River/Illinois Waterway system. Typically, corn shipments on this waterway are intended for export at the Gulf of Mexico. In a linear system like this, shipments from up-river locations must pass down-river sites on their way to the ocean. This means that up-river ports must pay the freight charges borne by down-river shippers plus the additional amount due to loading higher-up on the river. However, when the grain is unloaded, the upstream and the downstream shippers will receive the same amount for their goods. This predictable spatial pattern to prices should generate spatial patterns for shipping of grain from different ports, with period of high shipping costs having exaggerated effects upstream compared with downstream.

In this paper, we will look at the seasonal and trend patterns of corn and soybean shipments on the Upper Mississippi River and Illinois waterways. Our intention is simply to find patterns in which shippers closer to Minneapolis behave differently from those closer to Saint Louis.

CHOICE SETTING

Following the tradition in transportation economics, we will model shipping decisions as the result of a sequence of choices. For purposes of exposition, we will characterize the decision maker as the farmer, though we recognize that the authority to divert grain may be passed to others in the system. Also for ease of discussion, we will refer to corn as the commodity shipped, though any grain may be substituted.

1. A farmer decides on the number of acres to devote to corn. This decision is based on the forecast of market conditions for corn at harvest time as well as the forecast of market conditions for other commodities. Farmers in different locations may have alternative crops that they might plant if market conditions for corn are projected to be poor.
2. A farmer decides on the level of attention to devote to the crop based on contemporaneous market conditions as well as growing conditions.

3. A farmer decides how much of his crop to harvest and how much to plow under based on the net price available to him at the elevator that is in a position to offer the highest net price.
4. A farmer decides on the timing of the movement to and release of harvest from storage elevators depending on current conditions and anticipated future market conditions. Some part of the harvest may be held back from normal shipping patterns in response to system congestion or the harvest may be rushed to the river to take advantage of exceptionally high prices.
5. A farmer decides whether to deliver the harvest (or to allow the release of the harvest from the country elevator where it is stored) to the river for export by water. There are many alternatives to river transportation. For example, the farmer could deliver the harvest to an elevator that would send the harvest by rail or truck to an alternative port (e.g., Duluth or Portland), deliver the grain to a local processor, or deliver the grain to an elevator that will load it on a train for delivery to a point that bypasses the lock system. We will give the name "leakage" to the loss of harvest to modes, uses, or destinations other than the delivery to the Upper River for export.
6. A farmer, having decided to deliver the harvest to the river, decides which pool to deliver the harvest to. Farmers can reduce their exposure to congestion by delivering grain to a pool farther south on the system. This decision will be based on the pool whose elevators pay the highest price for the harvest as well as the cost of carrying the corn to the river. It should be noted that the cost of road transportation declined precipitously during the period covered by this study and thus it is should be possible to observe in the data a trend of increased flexibility in the port of delivery. Beyond the inventorying of grain and the price-induced leakages of harvest in decision 5) above, this decision about the river location to which to deliver grain is the third source of flexibility in response to prices that we will measure as we estimate the elasticity of demand for navigation services. We will give the name "lock bypass" to this loss of distance shipped in response to congestion. Ultimately, if the system is extremely congested, delivery of grain to a point below the last lock might be economically justified, in which case the harvest is lost to the lock system and the lock bypass becomes a leakage.

The Upper Mississippi / Illinois Waterway system

The Upper Mississippi River/Illinois Waterway (UMR/IW) system consists of a series of locks and pools between the Twin Cities and Chicago on the north and St. Louis on the south. Beyond St. Louis, the river is free-flowing. A shipper wishing to get grain to market using the system must load a barge with grain and attach it to a towboat for delivery below St. Louis. The last lock in the system, Lock 27, is about 200 miles north of Cairo, IL, where the Mississippi and Ohio Rivers join. Grain loaded on the river below lock 27 bypasses the lock system.

The use of locks and dams on the Upper Mississippi slows traffic and thus increases the cost of barge shipping. Despite the fact that Minneapolis is only about 600 river miles from St. Louis, while St. Louis is 1035 miles north of New Orleans, the price of shipping the much shorter distance on the Upper Mississippi is more than the cost of shipping from St. Louis South. Shipping costs are about one cent per ton-mile through the lock and dam system, but only half a cent per ton-mile on the free-flowing lower river.[1] Transportation costs from Minneapolis to St. Louis approximate 7% of the price that a shipper receives for corn when it is delivered in New Orleans.

The upper Midwest is a major supplier of corn to the world market. Logically, the location of the country to which the grain is exported should determine at least in part the route taken by the grain. Europe buys relatively little grain, and thus exporting using the short route through the Great Lakes is rarely chosen. Grain that is shipped to Africa and South America finds its shortest route through New Orleans, while grain exported to Japan would require the fewest miles if exported through Portland. The choice of exporting through Portland or the Gulf depends on the relative price of rail transportation across the Rockies and on the current price of ocean shipping. As this is written, the price of ocean shipping is at historic highs, thus favoring the rail route to the West Coast in order to economize on ocean distance to Asia. However, high ocean freight rates have placed South American shippers at a larger disadvantage relative to American farmers, thus leaving a robust market for shippers located in the American heartland. This increase in demand for American grain has allowed the port of New Orleans and the river system that

[1] Calculated from data provided in *Grain Transportation Report*, April 22, 2004, United States Department of Agriculture, Transportation and Marketing Programs, Transportation Services Branch.

connects the producing areas with the export location to continue to prosper despite high ocean freight rates.

As noted previously, grain shippers in Minnesota and Wisconsin who wish to get their commodities to the world market must pay higher prices to ship to New Orleans than those in Missouri or Illinois since they use the lock and dam system for more miles. Since transportation costs are a large proportion of the delivered cost of their goods, they are logically more sensitive to the price of river transportation than farmers located farther south. They are thus more likely to take advantages of some of the flexibilities noted previously, notably inventorying grain when transportation costs are high, or choosing the Pacific Northwest as an export location. On the other hand, farmers located farther south are have available to them the ability to ship directly to a loading facility below the last lock, thus bypassing the last lock.

Table 1 shows the location of pool equivalents whose shipping patterns are tracked in this paper. Pools 300 and 301 are on the free-flowing river between Cairo, IL and St. Louis. Pools numbered between 306 and 354 are defined for the stretch of river above each lock. The highest numbered pools are on tributaries of the Mississippi in the Twin Cities areas[2]. Table 1 also shows the pool definitions for the Illinois River. River mileage on the Illinois is measured from the confluence with the Mississippi, which is just north of Lock 26 (in Pool 306) on the Mississippi.

Change in the quantity of shipments 1990-2002

For both rivers, grain shipments originating farther upstream will show shipping patterns that are different from those downstream. How these patterns change over time will give us some insight into the affect that various factors have on shipping decisions. At least the following factors will affect shipping decisions, and the change in shipping patterns should give some insight into the relative importance of these factors in determining the demand for river transportation.

1. Changes in the per-hour charge for using a towboat and barges. Since shippers upstream use more hours to move their barges to the Gulf of Mexico, we would expect that upstream shippers would be more sensitive than downstream shippers to these changes. Since upstream shippers use more river-miles of barge transportation than downstream shippers, congestion should particularly affect upstream shippers.
2. The decline in the per-mile cost of trucking. This gives all shippers greater flexibility in where they access the rivers. The shippers most affected by this change are likely to be those farthest south in the region since they have an increased ability to bypass the lock system completely and deliver their crop to the river below St. Louis.
3. Changes in the location of world markets for grain. The increasing prosperity of Asian countries has shifted the preferred destination of grains to favor export through the Pacific Northwest. In addition, South America is producing an increasing share of the world grain, thus disadvantaging the port of New Orleans, which is closer to South America.
4. Changes in the per-day rental rate on ocean-going dry bulk shipping vessels. These rates are extremely volatile. High daily rental rates have traditionally favored shipping from the Pacific Northwest since movements from New Orleans through the Panama Canal to Asia require more days to market than shipments from Portland.
5. Changes in the price of railroad shipments. Unlike other modes of transportation, railroads can price discriminate between different shipping locations, and thus it is possible for shipping charges from Minnesota to Portland to move in a different direction from the rates quoted for the movement from Peoria to St. Louis. Lower rail rates to the Pacific Northwest would be especially attractive to shippers close to Minneapolis since they pay the highest amount for transportation to the Gulf. Lower rail rates for shuttle train service to St. Louis would be attractive to any shipper in the region who could induce a railroad to quote a lower rate. Railroads have higher costs per

[2] On both the Mississippi and Illinois Rivers, we have used U.S. Army Corps of engineers definitions, with the exception that USACE river mileages on both the Minnesota River and Cal Sags 1 and 2 have been altered to represent distances on the scales used on each of the two rivers in Table 1.

mile than barges, but lower costs per mile than trucks, so a profit maximizing railroad, choosing a location for shuttle service, might offer service at intermediate distances.

6. Changes in the local availability of alternative uses for corn. For example, over this period, there was an increase in the use of corn-based ethanol as a motor fuel. Corn diverted for this use would be lost to barge operators.

In this paper, we do not present information about any of the factors listed above that have the potential for altering shipping patterns. Instead, the focus of this paper is solely on the changes in the geographical structure of shipping patterns.

Figures 1 and 2 show that there have been striking changes in the pattern of corn shipments on the Upper Mississippi River between the early 1990's and the present, while there has been similar but smaller changes on the Illinois. In these figures, the horizontal axis represents the pools from which corn is shipped, ordered by river mile. The first two pools are on the river below St. Louis and below the lock system. One of the most striking features of the figure is the large increase in corn shipments originating on this free-flowing stretch of river. Shipments from the area around St. Louis increased from an average of slightly more than 2 million tons/year in 1990-1992 to an average of about 3.5 million tons in 2000-2002. Shipments farther down the river increased several fold over the same period, but from a much smaller base. Shipments from pools above locks 27 to 17 (Muscatine, IA), all showed increases over this period, but none of these regions are major sources of river traffic in corn. Beginning at the pool above lock 15 (Davenport, IA) and continuing upriver, the pattern of increases begins to reverse. Some of these declines have been precipitous. Major shipping areas like pool 338 above Lock 9 (Prairie du Chien) saw more than half of their corn tonnage disappear between 1990 and 2002. The same pattern of declines extends all the way to the Twin Cities with only occasional small shipping regions showing a reversal of the pattern of decline.

The pattern of changes of corn shipments on the Illinois River is generally one of small increases between 1990-92 and 2000-2002 (figure 2). Remembering that the Illinois empties into the Mississippi above Lock 26, approximately 200 river miles should be added to the Illinois River miles to make them comparably distant to Mississippi miles. This places Illinois River shipments in approximately the same region as that of the Mississippi where there were small increases over the time period of this study. The few slight declines in Illinois River shipments are in the region where there are declines on the Mississippi.

Summarizing, there has been a large increase in corn shipments from the part of the Mississippi below the lock system, small increases in shipments out of the lower reaches of lower reaches of the Mississippi and Illinois made navigable with the lock system, and declines in the upper reaches of the Mississippi, especially in the areas between Dubuque and La Crosse. Nothing in the quantity data presented in this paper will give a determinative explanation for which explanation for this change is most convincing. The large increase in shipments being placed on the river below St. Louis suggests that there has been an increasing use of shuttle trains. These trains apparently have not tapped corn sources adjacent to the Illinois River or in the lower reaches of the Mississippi since there have been no declines from this waterway. Another possible explanation for the pattern seen is a shift in grain towards shipment from the Pacific Northwest. A final possibility is the diversion of corn for the production of ethanol.

The observed pattern is partly consistent with increases in the price of river transportation since upstream locations have generally declined in importance relative to downstream locations. It should be noted, however, that the largest declines were not in the areas that use the most river transportation, suggesting that changes in the cost of river transportation were not the most important factors over this period.

Changes in the seasonality of shipments.

A second source of clues about the relative importance of factors determining shipments on the river system is given by the seasonality of shipments. The Mississippi River system is closed in the winter north of Lock 26, while both the Illinois River and the Mississippi south of St. Louis are open year round. Part of the seasonality of shipping on the locked part of the Mississippi is forced by winter closure, but part is also due to the seasonality of corn harvest. Seasonal congestion can also affect shipping prices, both for rail service (which faces car shortages at peak periods,) and for barge shipping. Barge costs are higher at congested periods both because of equipment shortages as well as due to the fact that movement through the lock system slows when more boats try to use the system. If the changes in shipping patterns are due to changes in barge costs, it should show up in a change in the seasonal pattern of movements.

The seasonal pattern of movements for the eight largest shipping pools on the Mississippi is shown in Table 2. This table contains the results of eight regressions, one for each of the largest shipping pools on the Upper Mississippi River. The dependent variable is the log of tonnage of corn shipped in each month during the two periods 1990-1992 and 2000-2002. The independent variables are dummy variables for month and a trend variable for year (July is used as the reference month) and a dummy variable indicating that the observation is drawn from the second time period.

Since the dependent variable is in logs, the coefficients represent proportionate changes relative to the base. The first column of Table 2 shows that for pool 301 (the area of the free-flowing river around St. Louis) January shipments are on average 1.5 times July shipments. June shipments are, on average, 1.9% lower than July shipments. Corn movements from pool 301 were 66% higher in the average month during the later period than they were a decade earlier.

Table 2 confirms that the rapid growth in corn shipments between the early 1990’s and 2000’s are confined (among large shipping pools) to those lowest down on the river—pools 301 around St. Louis and pool 318 at Keokuk. For all other large pools, there were varying degrees of declining levels of shipping.

Table 2 also shows that, not surprisingly, the seasonal pattern of corn movements out of the pool are different in pool 301, where winter ice does not prevent shipping, from all of the other pools which are closed in winter.

At the bottom of Table 2, an F test is presented to test the hypothesis that the entire group of monthly dummy variables is different in the later period than in the earlier period. This test confirms that there has been a significant shift in the seasonal pattern for pool 301 between the early 1990’s and early 2000’s. In the early period, July was a low shipping month, with a winter peak of movements out of pool 301. All of this variation had softened after 2000.

The regression including shift variables for pool 301 is shown in Table 3. Winter still has more shipments than July, but the pattern of shipping is much more even over the year. This is evidenced by the fact that the constant coefficients on the interactive dummy variables for month and later time period are of the opposite sign as the monthly dummy variables, but of smaller magnitude. Thus, for example, in the later time period January shipments were not 214% larger than the July period, but only twice as large (2.147-1.148.) This reduction in seasonality suggests that the motive for shipping from pool 301 had changed in the later period, tending to reinforce the hypothesis that shuttle trains were providing grain for shipment at times that were unrelated to the winter closure of the waterway.

Table 2 shows that, taken individually, there was no significant change in the seasonality of grain movements from any of the other pools, all of which are subject to winter closure. This can be inferred from the insignificant F-tests for each pool. However, as one reads across the coefficients on monthly dummy variables, there appears to be higher seasonality of shipments upstream than downstream. This is not simply related to the fact that winter closures affect the northern reaches of the river for more months each year than is the case closer to St. Louis. In general, as one reads across the table, the absolute value of the numbers increase for pools farther upstream. Thus, for example, September shipments from pool 318 are 30% lower than in July, but upstream at pool 357, they are 70% lower.

Table 4 confirms that there is greater seasonality of movements at the top of the Mississippi River than farther south. This table presents the results of a regression of log of shipments from the top 8 shipping pools, excluding pool 301. As in Table 2, explanatory variables include monthly dummy variables (July as reference month) and a dummy variable to indicate that the observation comes from 2000-2002 rather than 1990-1992. The regression in Table 4 interacts with the monthly dummy variable with the log of river mile of the pool observed and then further interact these interacted monthly variables with a variable indicating the later time period.

Looking at the second column of Table 4, we can observe that upstream pools have a more seasonal pattern of shipments than those lower down. Early spring and late fall months have strong negative coefficients while summer months have positive coefficients. This says that the summer peak of shipments is higher upstream while the early spring and late fall troughs are lower upstream than closer to St. Louis.

The last column of the table shows that this seasonal pattern was subtly different in the later period than in the earlier. The increased late spring and summer peak associated with upstream pools is diminished in the later period, as can be read by the negative coefficients during the summer months in the last column. An F test for exclusion of the final column shows that this effect is statistically significant.

The change in the seasonal pattern of shipments up and downstream can be seen by comparing Figure 3 (for 1990-1992) and Figure 4 (for 2000-2002). The three lines on each graph are a forecast for the log of tons shipped during each month at different distances upstream. The longer shipping season can be seen in the relatively flat prediction of corn shipments at river mile 150, while upstream at mile 800, shipments during the late fall and winter are below the level seen during the summer. In the later period, shipments upstream had flattened out during the period during which the river is navigable.

Another view of the decreased seasonality of shipments upstream is presented in Figure 5, which graphs predicted tonnage in August and November at different river mileage, again using the regression in Table 4. This graph combines the seasonality effects with southward shift in corn shipments on the Mississippi river. The two upward sloping lines display the fact that in August, larger shipments originate upstream than downstream. However, the slope of this line has been decreasing over time, so that August shipments near Minneapolis in 2000-2002 are significantly smaller than they were earlier. By contrast, shipments from pools close to the bottom of the lock system have seen little shift in August shipments. By November, the shipping pattern on the river changes radically with lower river reaches shipping more than areas bordering Minnesota and Wisconsin. There has been a subtle rotation of this relationship between 1990 and 2000, with river mileage becoming slightly more important over time as a predictor of November shipments. Pools within the lock system close to St. Louis increased their November shipments of corn while locations close to the top of the system decreased their late fall corn shipments.

Figure 5 suggests that the flattening of the seasonal pattern of shipments from the Minnesota end of the Upper Mississippi river is due primarily to a loss of tonnage at the peak rather than a shifting of tons from the peak period to shoulder months. This is consistent with losses of tonnage, perhaps to other destinations, perhaps to shuttle trains to the river below St. Louis, and perhaps to local processing plans like ethanol production.

Conclusion

This paper has presented changes in the geographical and seasonal pattern of corn shipments on the Upper Mississippi River and Illinois Waterways. This data exploration is part of a larger study to try to understand the effect that prices charged for using barge services have on the demand for grain transportation.

Several patterns stand out from the 13 years of data covering 1990-2002. The first is the strong tilt away from corn shipments from the upper reaches of the Mississippi and in favor of corn movements from the lower reaches of the river controlled by lock and dams and particularly in favor of the free-flowing part of the Upper Mississippi below St. Louis. There have been slight increases in shipments from higher numbered pools on the Mississippi and on the Illinois River at locations at approximately the same latitude. The large increases in St. Louis area shipments of corn combined with large decreases between Davenport and Minneapolis and relatively constant movements elsewhere suggests that at least part of the change is due to a transfer of grain from the upriver area to the lower river. The most likely explanation is an increase in the use of shuttle trains carrying corn between the two areas. An alternative explanation is that some grain in upriver locations is being diverted either to local processing or to alternative export locations.

The second pattern highlighted in this paper is the flattening of the seasonality of shipments on the Upper Mississippi. Two different changes are observed. The area below St. Louis in the earlier time period had a strong winter peak with much lower shipments in the summer months. By 2000-2002, this seasonality was considerably reduced. Upstream areas close to Minneapolis had a strong summer peak in 1990, but this peak was reduced in the later period. The pattern suggests that the seasonality of movements was reduced not primarily by a shift of traffic from peak to shoulder period but rather by simple loss of tonnage at the peak. This is consistent with a loss of traffic to the river rather than economizing on river transport costs by choosing to ship at less congested periods.

LIST OF TABLES AND FIGURES

Table 1. Pool Equivalents and River Miles

Pool Equivalents: Mississippi River			
PE	NAME	LOW_MILE	HIGH_MILE
300	U MISS RIV 1	0	137.9
301	ST LOUIS 1	138	185.2
302	ST LOU LD27	185.3	202.8
304	ST LOU LD26	202.9	207.9
306	LD26 POOL	208	241.3
308	LD25 POOL	241.4	273.4
310	LD24 POOL	273.5	301.1
312	LD22 POOL	301.2	324.8
314	LD21 POOL	324.9	343.1
316	LD20 POOL	343.2	364.1
318	LD19 POOL	364.2	410.4
320	LD18 POOL	410.5	437
322	LD17 POOL	437.1	457
324	LD16 POOL	457.1	482.8
326	LD15 POOL	482.9	493.1
328	LD14 POOL	493.2	522.4
330	LD13 POOL	522.5	556.6
332	LD12 POOL	556.7	582.9
334	LD11 POOL	583	615
336	LD10 POOL	615.1	647.8
338	LD09 POOL	647.9	679
340	LD08 POOL	679.1	702.4
342	LD07 POOL	702.5	714.1
344	LD06 POOL	714.2	728.4
346	LD5A POOL	728.5	738
348	LD05 POOL	738.1	752.8
350	LD04 POOL	752.9	796.8
352	LD03 POOL	796.9	815.1
354	LD02 POOL	815.2	829.9
356	ST PAUL	830	846.9
357	MINNESOTA RIVER	847	847.1
365	MINN	847.2	857

Pool Equivalents: Illinois River			
PE	NAME	LOW_MILE	HIGH_MILE
500	ILLINOIS WW	0	55.9
505	ILLINOIS WW	56	80.1
510	LA GRANGE P	80.2	117.9
515	STARVED RK P	118	124.9
520	MARSEILLES P	125	128.9
525	PEKIN	129	157.6
530	PEORIA POOL	157.7	179.9
535	CAL-SAG	180	206.9
540	CS&SC	207	230.9
545	STARVED RK P	231	244.5
550	MARSEILLES P	244.6	254
555	MARSEILLES P	254.1	271.4
560	DRESDEN POOL	271.5	285.8
565	BRANDON RD P	285.9	291.8
570	CHIC SAN&SHIPC1	291.9	321
580	CHICAGO RIVER	321	331.2
585	CAL SAG 1	331.3	331.4
590	CAL SAG 2	331.5	331.6

Table 2.—Seasonality and Time Patterns

Pool Equivalents	301	318	328	332	336	344	356	357
Jan	1.573	-1.984	-3.435	-4.084	-4.713	-3.701	-3.468	-4.645
	(5.41)**	(-5.35)**	(-11.07)**	(-10.19)**	(-17.56)**	(-12.67)**	(-8.84)**	(-15.73)**
Feb	1.413	-0.914	-4.811	-4.04	NA	-3.783	NA	-5.855
	(4.86)**	(-1.81)	(-8.64)**	(-5.62)**		(-6.88)**		(-17.79)**
Mar	1.115	0.358	-0.402	-0.555	-0.962	-1.903	-1.9	-1.914
	(3.83)**	(1.01)	(-1.36)	(-1.45)	(-4.40)**	(-6.21)**	(-6.52)**	(-6.91)**
Apr	0.532	0.284	-0.084	-0.007	-0.211	-0.829	-0.455	-0.488
	(1.83)	(0.8)	(-0.29)	(-0.02)	(-0.96)	(-2.84)**	(-1.56)	(-1.76)
May	0.207	-0.179	-0.151	-0.21	-0.256	-0.459	-0.554	-0.407
	(0.71)	(-0.51)	(-0.51)	(-0.55)	(-1.17)	(-1.57)	(-2)	(-1.54)
June	-0.019	0.093	-0.009	0.011	0.04	0.063	0.188	-0.15
	(-0.07)	(0.26)	(-0.03)	(0.03)	(0.18)	(0.21)	(0.68)	(-0.57)
Aug	-0.057	-0.201	-0.201	-0.501	-0.199	-0.403	-0.233	-0.131
	(-0.2)	(-0.57)	(-0.68)	(-1.31)	(-0.91)	(-1.38)	(-0.84)	(-0.5)
Sep	0.48	-0.308	-0.966	-1.137	-1.012	-1.011	-1.003	-0.706
	(1.65)	(-0.87)	(-3.27)**	(-2.98)**	(-4.62)**	(-3.46)**	(-3.62)**	(-2.67)*
Oct	0.879	-0.012	-1.027	-1.588	-0.884	-0.662	-0.833	-1.096
	(3.02)**	(-0.03)	(-3.47)**	(-4.16)**	(-4.04)**	(-2.27)*	(-3.00)**	(-4.15)**
Nov	0.207	0.336	-0.118	-0.317	-0.234	-0.237	-0.73	-1.507
	(0.71)	(0.95)	(-0.4)	(-0.83)	(-1.07)	(-0.81)	(-2.63)*	(-5.71)**
Dec	-0.034	-0.279	-1.21	-2.956	-3.319	-4.427	-4.537	-5.844
	(-0.12)	(-0.79)	(-4.09)**	(-7.74)**	(-10.73)**	(-13.56)**	(-13.11)**	(-11.74)**
Dum-2000-2	0.664	0.307	-0.742	-0.907	-0.275	-0.022	-0.639	-0.181
	(5.59)**	(2.02)*	(-5.83)**	(-5.52)**	(-2.78)**	(-0.17)	(-4.87)**	(-1.47)
Constant	11.245	11.323	12.904	12.782	12.708	12.496	12.566	13.216
	(52.52)**	(43.33)**	(59.04)**	(45.29)**	(78.25)**	(57.80)**	(60.75)**	(67.24)**
N	72	67	66	66	59	64	57	60
R-squared	0.67	0.55	0.86	0.83	0.92	0.9	0.88	0.94
F-Test (Period Effects)	2.12**	0.59	0.64	0.63	0.71	0.62	1.43	0.46

* Indicates 1%, ** indicates 5%

Table 3. Changes in Seasonality

	Coefficients	Interactions
Constant	10.782	1.59
	(40.75)**	(4.25)**
Jan	2.147	-1.148
	(5.74)**	(-2.17)*
Feb	2.112	-1.398
	(5.64)**	(-2.64)*
Mar	1.747	-1.264
	(4.67)**	(-2.39)*
Apr	1.138	-1.212
	(3.04)**	(-2.29)*
May	0.434	-0.453
	1.16	(-0.86)
Jun	0.262	-0.563
	0.7	(-1.06)
Aug	-0.032	-0.049
	(-0.09)	(-0.09)
Sep	0.846	-0.731
	(2.26)*	(-1.38)
Oct	1.569	-1.38
	(4.19)**	(-2.61)*
Nov	0.891	-1.368
	(2.38)*	(-2.58)*
Dec	0.736	-1.539
	(1.97)	(-2.91)**
Observatio	72	
R-squared	0.78	

Absolute value of t statistics in parentl
* significant at 5%; ** significant at 1%

Table 4. Seasonality and River Miles (Changes across Periods).

	Linear Effect	Interactions with Mile	Interactions of Mile and Period
Dum 200-02	0.558	NA	-0.106
	(0.4)		(-0.49)
Jan	2.841	-1.012	-0.015
	(1)	(-2.28)*	(-0.31)
Feb	18.429	-3.47	-0.309
	(4.15)**	(-5.02)**	(-2.59)**
Mar	9.566	-1.618	-0.071
	(3.85)**	(-4.18)**	(-1.57)
Apr	-1.513	0.23	-0.07
	(-0.61)	(0.6)	(-1.55)
May	-5.568	0.866	-0.095
	(-2.31)*	(2.31)*	(-2.13)*
Jun	-7.716	1.214	-0.01
	(-3.20)**	(3.23)**	(-0.23)
Aug	-8.43	1.282	-0.016
	(-3.49)**	(3.41)**	(-0.37)
Sep	-5.954	0.824	-0.064
	(-2.47)*	(2.19)*	(-1.44)
Oct	-4.569	0.576	0.002
	(-1.89)	(1.53)	(0.05)
Nov	1.901	-0.367	0.016
	(-0.79)	(-0.98)	(0.36)
Dec	27.953	-4.82	-0.077
	(9.42)**	(-10.35)**	(-1.48)
Constant	12.457		
	(87.67)**		
Observations	439		
R-squared	0.78		

t statistics in parentheses
* significant at 5%; ** significant at 1%

Figure 1
Average Annual Tons by River Mile
Mississippi

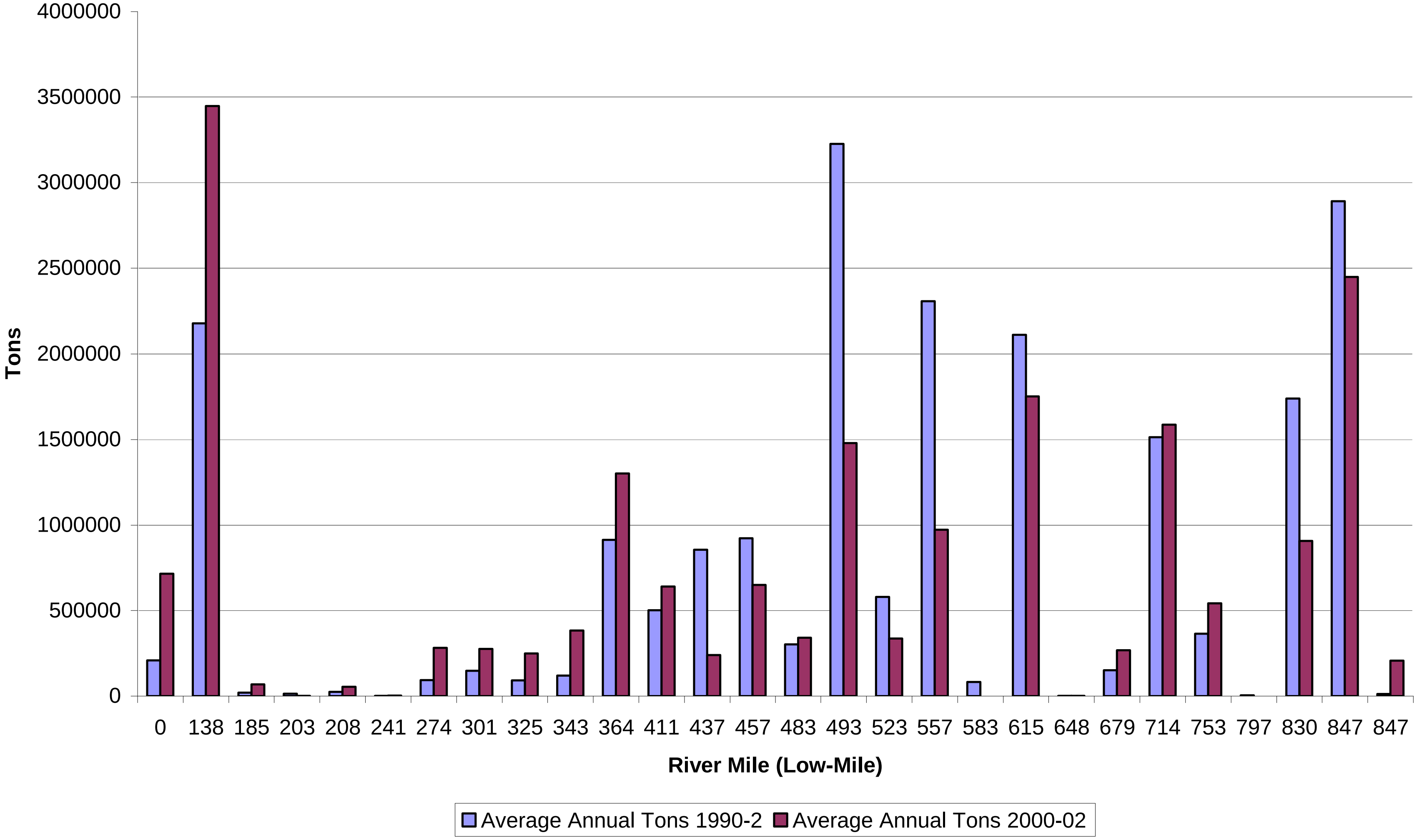


Figure 2
Average Annual Tons by River Mile
Illinois River

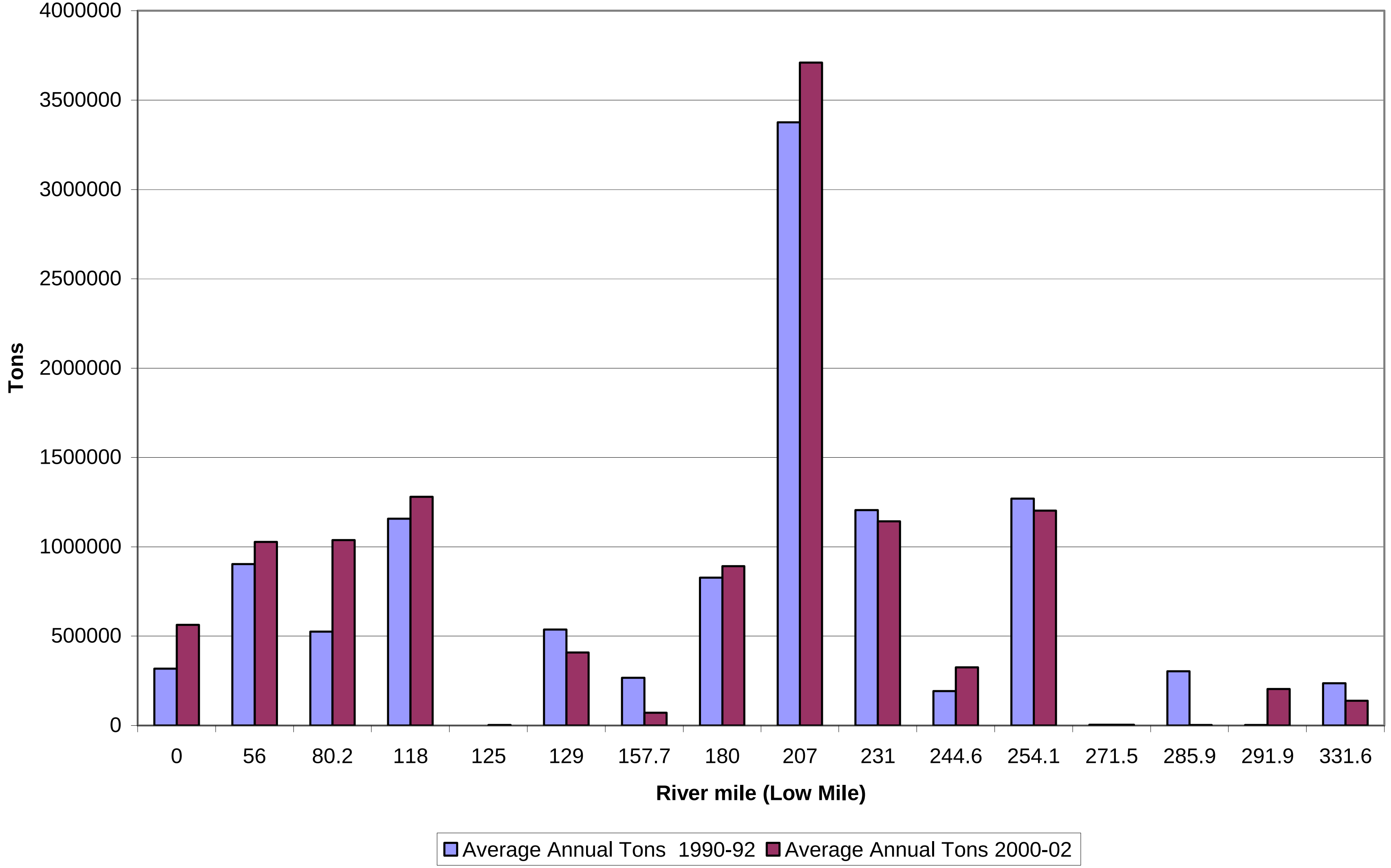


Figure 3
Patterns of Seasonality and River Mile
1990-92

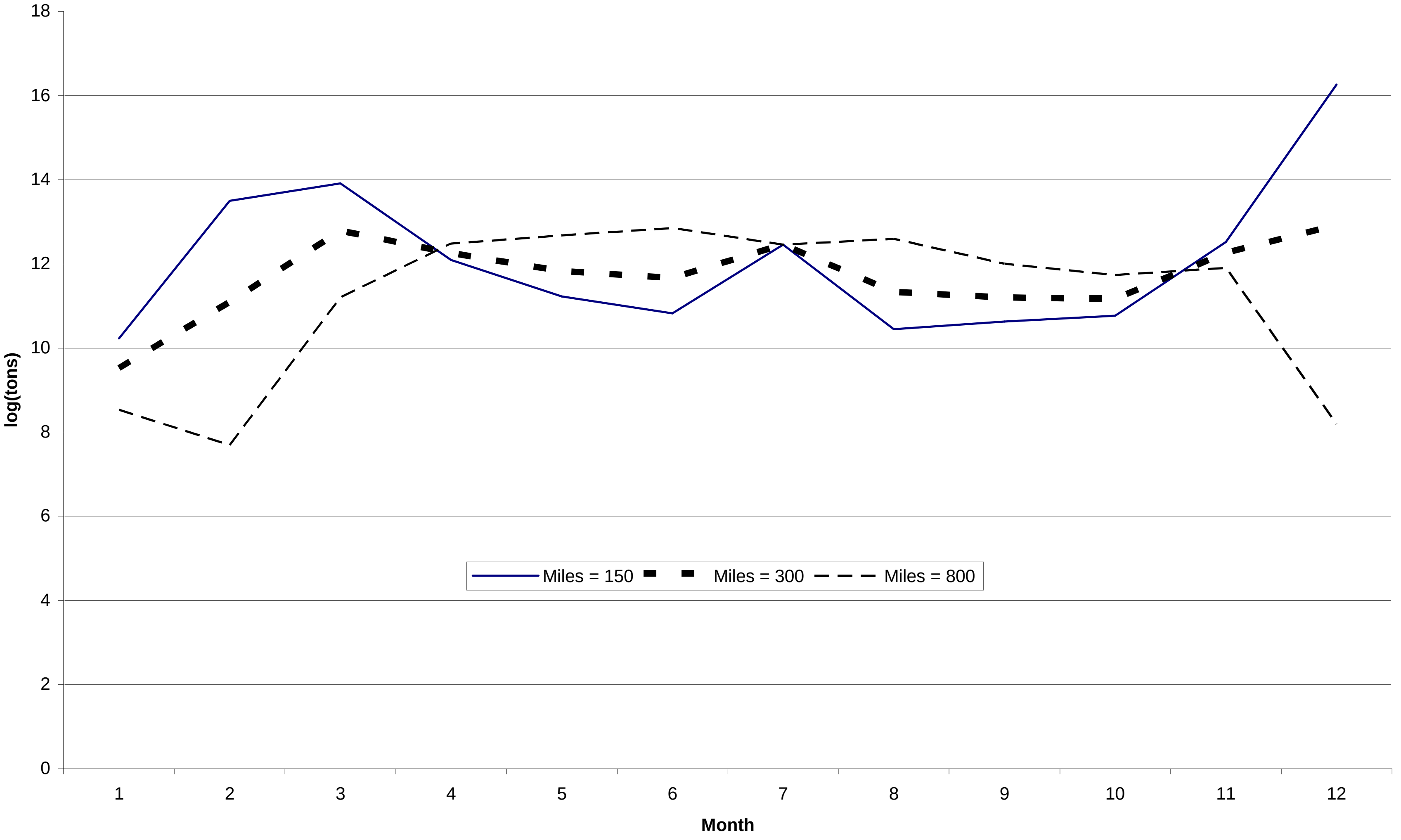


Figure 4
Patterns of Seasonality and River Mile
2000-02

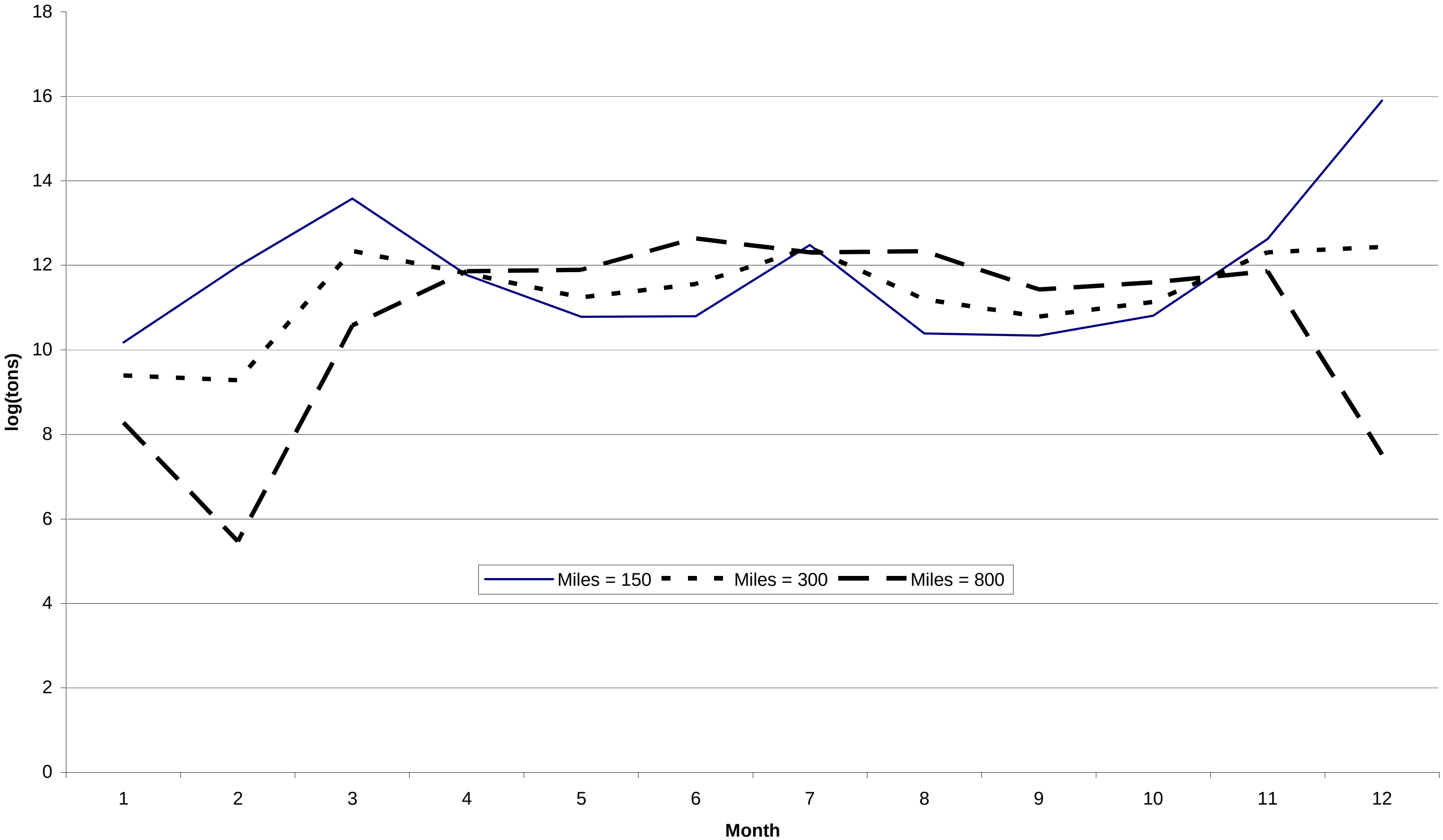
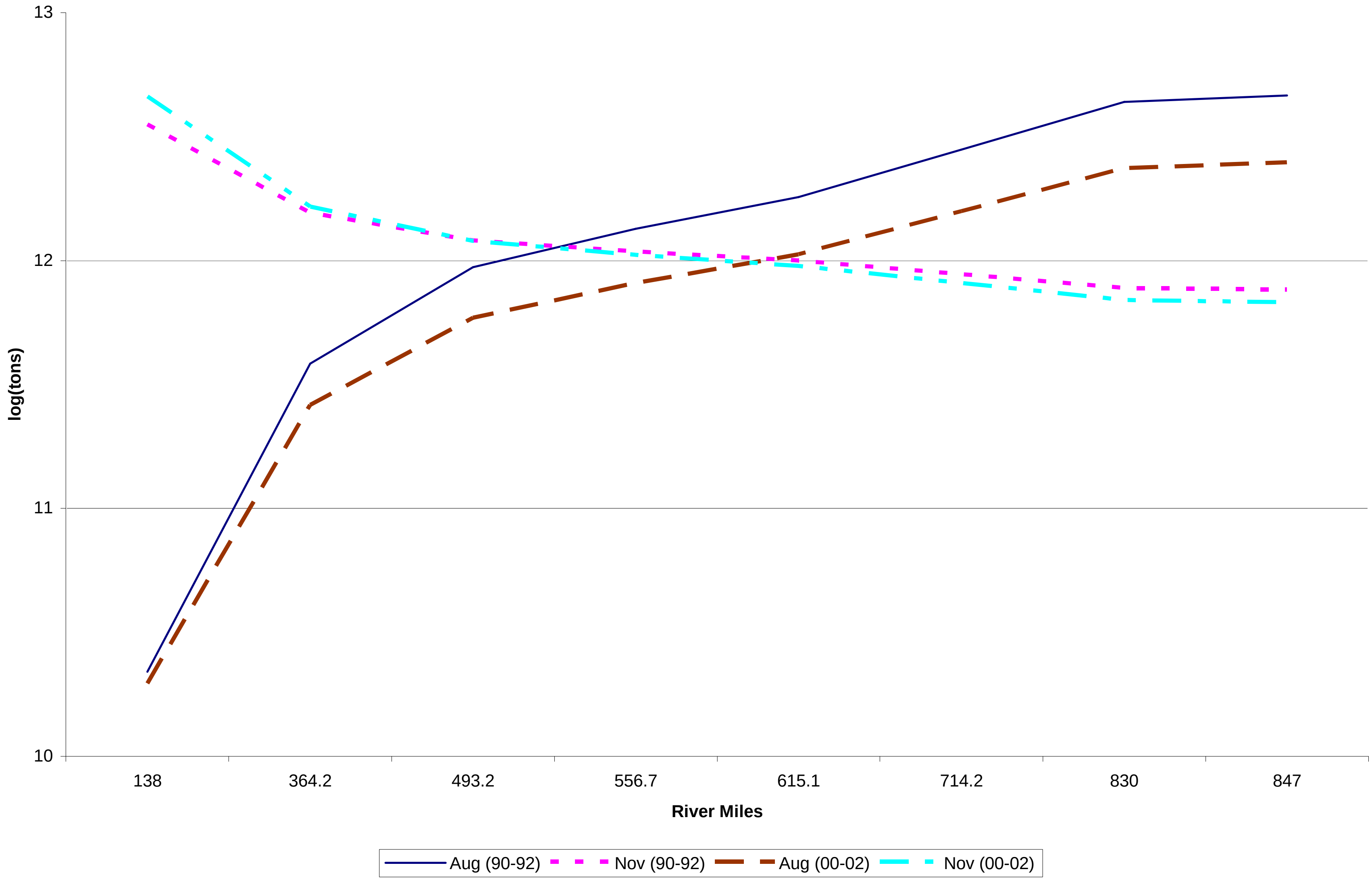


Figure 5
Seasonality and River Miles



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The NETS research program is developing a series of practical tools and techniques that can be used by Corps navigation planners across the country to develop consistent, accurate, useful and comparable information regarding the likely impact of proposed changes to navigation infrastructure or systems.

The centerpiece of these efforts will be a suite of simulation models. This suite will include:

- A model for forecasting international and domestic traffic flows and how they may be affected by project improvements.
- A regional traffic routing model that will identify the annual quantities of commodities coming from various origin points and the routes used to satisfy forecasted demand at each destination.
- A microscopic event model that will generate routes for individual shipments from commodity origin to destination in order to evaluate non-structural and reliability measures.

As these models and other tools are finalized they will be available on the NETS web site:

http://www.corpsnets.us/toolbox.cfm

The NETS bookshelf contains the NETS body of knowledge in the form of final reports, models, and policy guidance. Documents are posted as they become available and can be accessed here:

http://www.corpsnets.us/bookshelf.cfm

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