UNITED STATES
DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region
State, Federal & Constituent Programs Office

FINAL REPORT

Grantee: **NEW HAMPSHIRE FISH AND GAME DEPARTMENT**

Project No: **3-IJ-140**

Grant No: **NA76FI0382**

Project Title: **MONITORING OF AMERICAN LOBSTER RESOURCE AND FISHERY IN NEW HAMPSHIRE**

Period Covered: **01/01/98 - 12/31/00**

Prepared by:

Approved by: **JOHN I. NELSON**

Date: **MARCH 14, 2001**

Statutory Funding Authority:
- ___Anadromous Fish Conservation Act (P.L. 89-304)
- ___Chesapeake Bay Studies
- ___Endangered Species Act
- X Interjurisdictional Fisheries Act (Title III of P.L. 99-659)
- ___Magnuson Act
- ___Oyster Disease Research
- ___Saltonstall-Kennedy
- ___Unallied Industry Projects
- ___Unallied Science Projects
- ___ACFCMA

Monitoring of the American Lobster Resource and Fishery in New Hampshire, (Grant No. NA7FI0382)

SUMMARY

Period: January 1, 1998-December 31, 2000.

The three segments of this project have met the objective to monitor the relative abundance, sex and size composition of SCUBA-caught lobsters in New Hampshire's territorial waters.

Size Composition and Molting:

Mean size was generally smallest during cold water months. The smaller mean length over the late fall and winter is likely due to removal of newly recruited legal lobsters and temperature related migration of larger lobster out of the study area in late fall and through the winter. Growth could account for the increase in the mean lobster length through the summer/fall as supported by molt frequency data, along with the immigration of larger lobsters into the warmer waters of the study area. Of the three areas studied, the coast resulted in the smallest mean sized lobsters. This may be the result of several factors including tidal drift patterns that carry early stage larvae to this area, available cover/habitat for juvenile lobster, and/or lower predator pressure.

The ANOVA run for all areas and all years (except 1994) revealed sex (as a main effect) as a significant variable influencing mean lobster size. Reasons for sex related size differences are likely due to males undergoing molting more frequently than females once sexual maturity is reached. The frequency of female molting is likely slowed by the carrying of eggs plus the physiological demands of egg production requiring energy that otherwise might be converted into greater growth per molt or more frequent molts. There are two molt peaks seen when all sites are combined (early spring/summer and late summer/early fall). This is likely the result of second season molts by small size class lobsters.

Catch Per Unit Effort:

From January 1, 1998-December 31, 2000, catch per unit effort was lower in the winter/early spring (possibly due to cold water that results in an offshore movement of adult lobsters and poor visibility during spring runoff) and higher in the summer/fall. This trend is seen for the years 1992-2000 with the lowest CPUE in April, an increase from May-October and then a decline in November and December. Total annual CPUE has been increasing since 1997, with the year 2000 resulting in the highest annual CPUE for the time series (1992-2000). This may indicate the possibility of increasing settlement of larvae resulting in a healthy future resource in New Hampshire.

UNITED STATES
DEPARTMENT OF COMMERCE
National Marine Fisheries Service
Management Division
State-Federal Relations Branch

PERFORMANCE REPORT

State:	New Hampshire
Project No:	NA382
Contract No:	NA76FI-0382
Project Title:	Monitoring of the American Lobster Resource and Fishery in New Hampshire - 2000.
Period Covered:	January 1, 2000 - December 31, 2000
Project Dates:	January 1, 2000 - December 31, 2000
Prepared By:	Clare D. McBane, Marine Biologist
Approved By:	John Nelson John I. Nelson Chief, Marine Fisheries
Date:	3/26/01

MONITORING OF THE AMERICAN LOBSTER RESOURCE AND FISHERY IN NEW HAMPSHIRE

Abstract

The New Hampshire lobster population was monitored in 2000 by means of SCUBA captured lobsters. Sampling for small, sub-legal lobsters was conducted along the New Hampshire coast and in an estuarine river. Three sampling areas were delineated based on environmental differences in marine habitat. These areas consisted of an upper river estuarine, Portsmouth Harbor (a lower river estuarine), and a near shore coastal location. A total of 1941 lobsters were captured, measured, sexed and checked for shell hardness or signs of premolt. Individuals captured ranged between 11 and 93 mm carapace length (mmCL) and averaged 54.6 mmCL. Mean carapace length was generally higher during the summer for all locations. Sex was a significant variable influencing lobster size when an ANOVA was performed on 8 years of combined data, and when 2000 data was analyzed alone. Site and month were shown by ANOVA to be significant variables influencing lobster sizes in 2000 and in previous years studied. The highest catch per unit effort was found at the harbor for the months of June - December. The catch per unit effort for the coast was the highest of the three locations during January, April and May. Molting took place from June to October with peaks of combined sites observed in July and October.

Introduction

Lobsters are the most economically valuable fishery resource in the northeastern United States. Commercial U.S. harvesting occurs from the Canadian border to the mid-Atlantic United States. Important quantities of lobster are landed at ports in each of the coastal states from Maine to North Carolina. A commercial lobster fishery exists along the New Hampshire coast in both state and federal waters with about 1.4 million pounds harvested in 1999. The estimated dollar value for New Hampshire's 1999 landings exceeded 5.9 million dollars.

In order to have an effective management plan, it is important to determine as much as possible about the stock characteristics of lobsters in New Hampshire waters. Identification of critical habitat and monitoring of population trends is also an important component for making sound management decisions regarding New Hampshire's lobster resource.

The objectives of this study were to:

1. monitor the relative abundance of lobsters, with particular emphasis on juveniles, in the New Hampshire waters; and,
2. obtain information on habitat use by lobsters along the New Hampshire coast.

Study Area

The study area encompasses the lower reach of the Great Bay Estuary System located on the Piscataqua River and the coastal area of New Hampshire (Figure 1). This area is divided into 3 sampling sites based upon overall habitat characteristics:

Area 1 - (upper river) - From Fox Point to the US 1 By-pass bridge. This area is characterized by a deep narrow channel and strong tidal currents. Substrate is composed of rocky outcrops, mud and gravel.

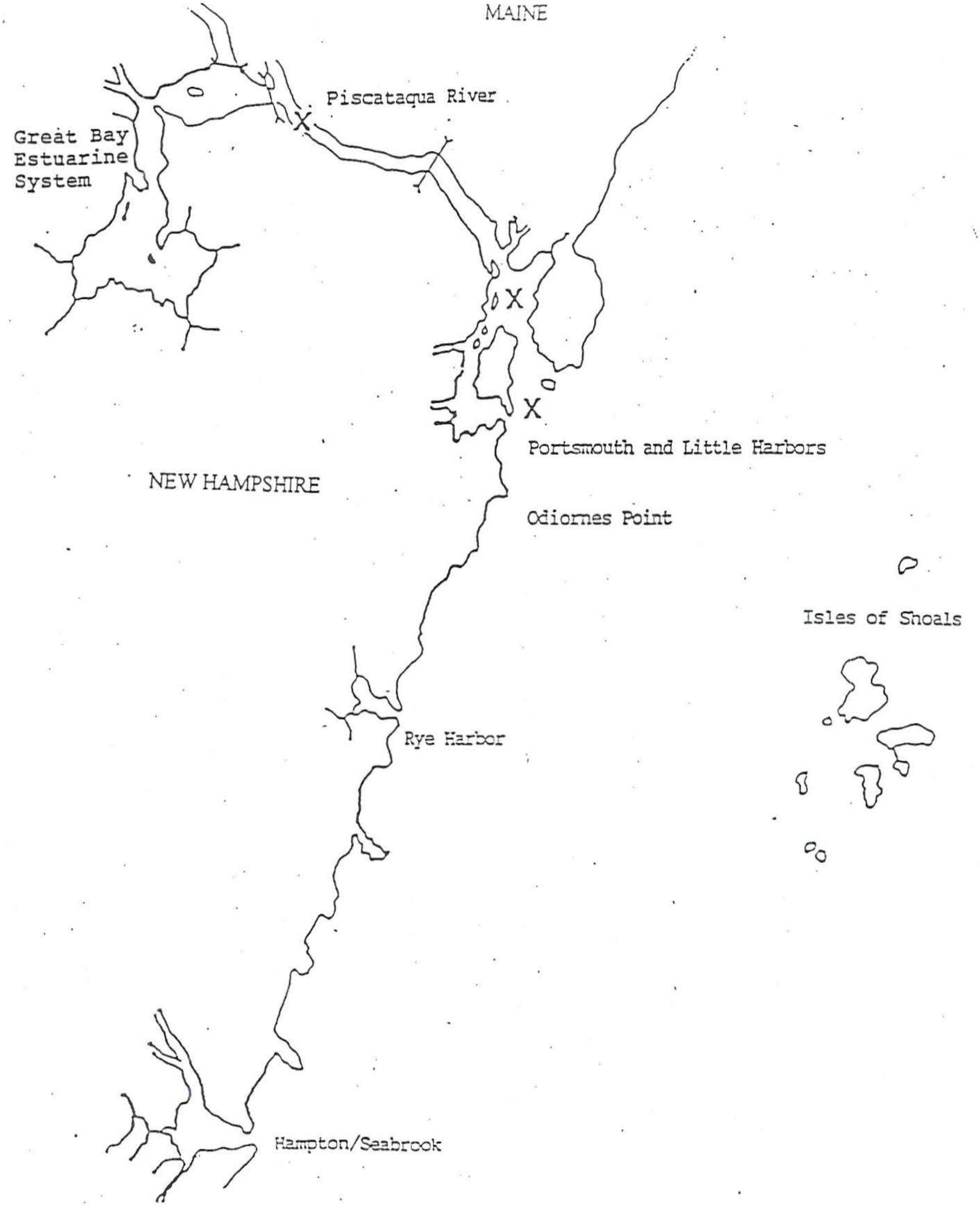

Figure 1. Study area with juvenile lobster sampling stations marked X.

Area 2 - (Portsmouth Harbor - lower river) - From the US 1 By-pass bridge downstream to the mouth of the Piscataqua River at Fort Point. Tidal currents are strong in the main channel, the river is generally wider than in Area 1. Substrate is a variety of rocky outcrops, assorted rocks, sand, gravel, and clay deposits.

Area 3 - (coastal) - Coastal area from the Maine border south to the Massachusetts border within 3 miles of shore. This area is characterized by moderate tidal and wind driven currents. Substrate is composed of outcroppings with assorted rocks and gravel.

Objective

The objective of this project was to monitor the abundance and habitat selection of sub-legal, juvenile lobsters in New Hampshire.

Methods

Lobster were sampled on a monthly basis in January and from April to December at three sample sites (Figure 1). February and March were eliminated from the 2000 sampling (as in 1999) due to unfavorable sampling conditions and low CPUE. Their elimination did not have statistical or biological impacts on project objectives. Analysis of monthly mean CPUE for 1992-1996 using ANOVA indicated significant differences among monthly CPUE. Further pair-wise combinations among months using Tukey's HSD test indicated that the months of February and March had significantly lower CPUE's than other months. Elimination of February and March resulted in less than 10% reduction in catch samples on average over the years 1992-1996. In addition, contingency analysis of catch sex ratio using Chi-square tests showed no significant differences in the sex ratio between February-March and January and April-December.

At each site, samples consisted of two SCUBA divers searching the bottom for lobsters.

Lobsters encountered during dives were captured by hand (capture rates were not 100%) and were stored in catch bags until the end of the dive. Bottom time was measured for each dive and used as a measure of sampling effort. Since the objective of this project was to gather information on smaller, sublegal (i.e. juvenile) lobsters, some large lobsters (those that appeared to have carapace lengths greater than about 80 mm) were not aggressively pursued in favor of capturing greater numbers of small lobsters.

Following completion of the dive, the lobsters were briefly held in the water in catch bags until they were processed. All lobsters captured were sexed, measured (mid-dorsal carapace length to the nearest millimeter), noted for shell hardness or premolt condition (i.e. molt stage) and released. No tagged lobsters were encountered. Lobsters were last tagged in 1994. The date, location, water temperature, water clarity, and salinity were also recorded with each dive.

Differences in lobster size were analyzed using analysis of variance (ANOVA) with sample month, sample area and sex as the categorical variables. An ANOVA was run for all areas and months January and April - December. In addition multi-year ANOVAs were run. Lobster from area 3 (coast) only and months 4 to 12 and years 1992-2000 made up one ANOVA group. The other multi-year ANOVA looked at lobsters from all areas, months 1,4 - 12 and years 92-93 and 95-00. The 1994 data set is incomplete, lacking samples during some months and is therefore unsuitable for year to year comparisons. Length frequency distributions were plotted for the various areas and the mean length was plotted for each month. Mean CPUE was plotted for each area by month. These were done to further analyze possible trends. The number of the sample population with softshells or premolt shells was recorded and percents calculated by month for each area to analyze trends in molting frequency and occurrence.

Results

A total of 1,941 lobsters were captured during sampling in 2000, with 34 of the total catch of legal size (i.e., 83 mmCL or greater). From this total, 875 were females and 1066 were males. All captured lobsters were included in the data analysis.

Size composition

The ANOVA for SCUBA-sampled lobsters from the sample areas (upper river, harbor, and coast) for months 1and 4 through 12 in 2000 revealed significant ($P \leq 0.05$) differences in mean lobster size for sex, sample site and sample month (Table 1). The length frequency plots (Figures 2, 3 and 4) for SCUBA-caught lobsters show discernable differences in the distribution patterns of areas where the greatest number of animals caught were 57 mm at the upper river, 55 mm at the harbor, and 38 mm at the coast. The mean carapace length for the coastal lobsters (total=713) was 45.5 mm; while, the mean carapace length for the upper river (total=369) was 58.3 mm and the mean carapace length for the harbor (total = 859) was 60.6 mm. Figure 5 illustrates an all-areas length frequency plot where the highest number of lobsters caught were 50 mm CL. The total mean carapace length at all locations was 54.6 mm.

The Area 3 (coast) specific ANOVA (Table 2) showed significant differences associated with all categorical variables except for pair-wise combinations of sex with month and year. The ANOVA that looked at all areas and all years except 1994 (Table 3) revealed significance for sex as a main effect and the pair-wise combination of sex with site and month, but showed no significant differences when broken down into pair-wise combinations of sex - year.

Figure 6 illustrates that on an overall area basis, lobster size peaks in the summer, during warm water temperatures (Figure 7). Mean carapace length at the upper river and harbor areas peaks in July following the onset of warm water in June; while, the mean carapace length at the coast peaks in September following the warm water in August. At all sites, small mean carapace length corresponds with cold water temperature.

Table 1. **ANOVA of juvenile lobster carapace length by sex, site and month for areas 1 -3 for the months of 1 and 4 -12 in 2000.***

Source	DF	Sum of Squares	Mean Square	F	Pr+ >F
Sex	1	1803.7	1803.7	12.44	0.0004
Site	2	81773.3	40886.7	282.11	<0.0001
Month	9	18232.1	2025.8	13.98	<0.0001
Error	1928	279429.7	144.9		

* Number of observations in data set = 1941
+ = Probability

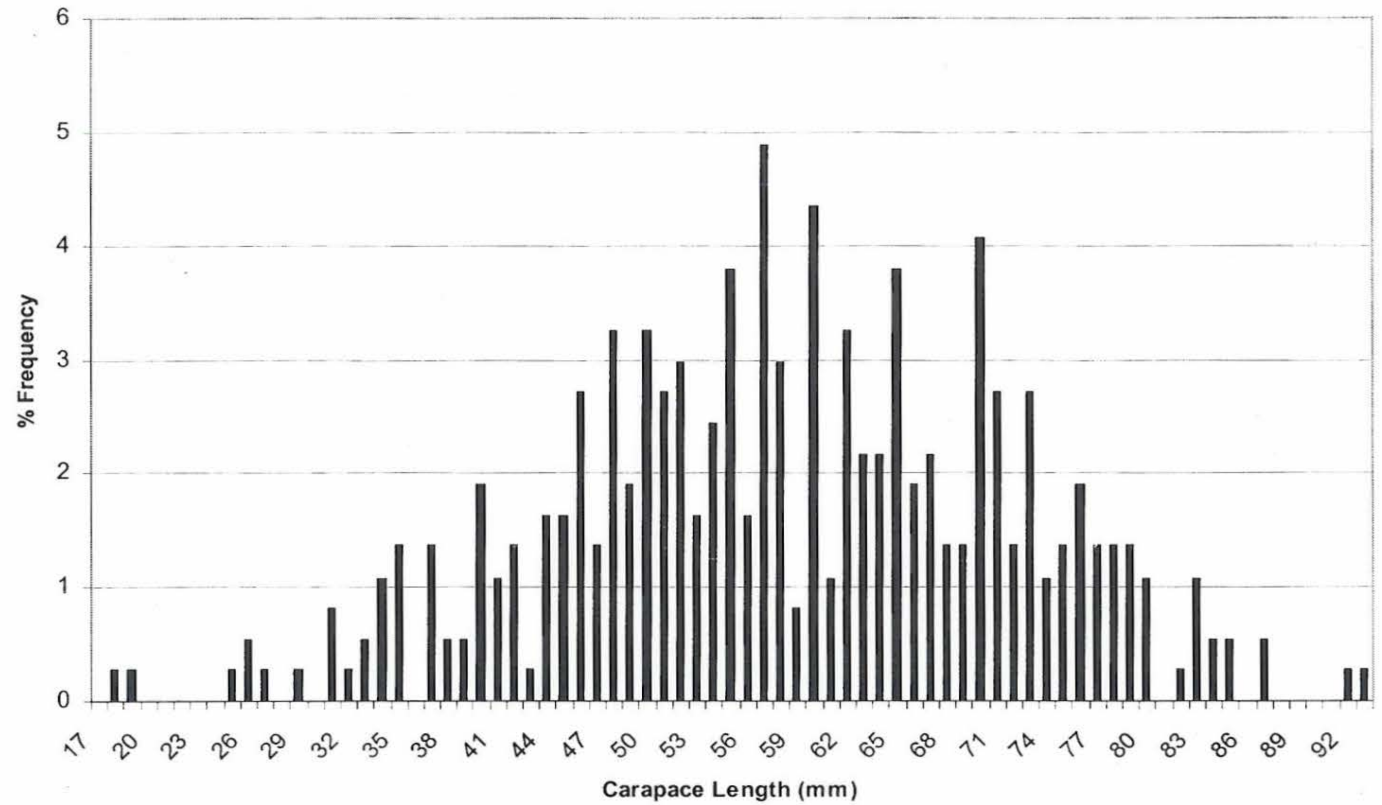

Figure 2: Length frequency distribution of SCUBA caught lobsters in 2000 at the upper river.

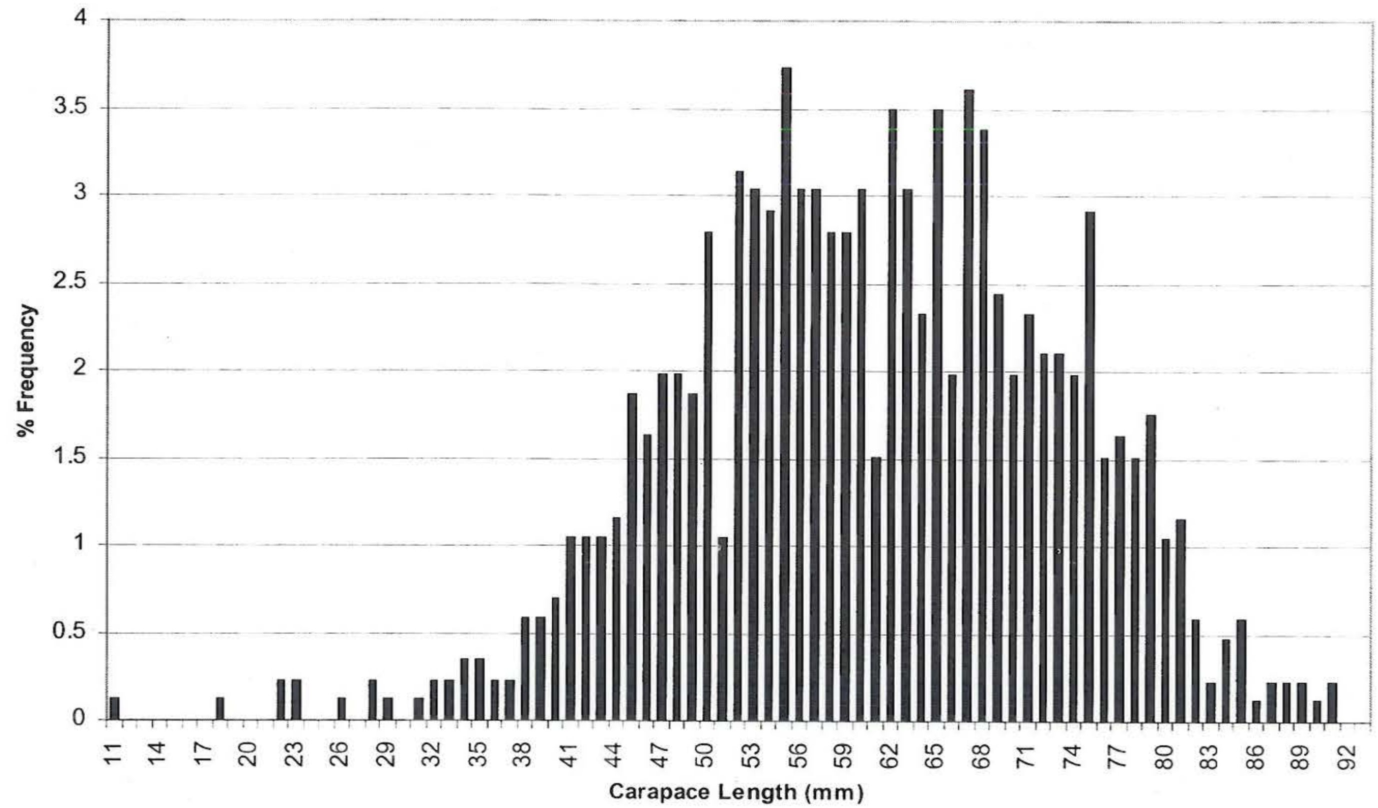

Figure 3. Length frequency distribution of SCUBA caught lobsters in 2000 at the harbor.

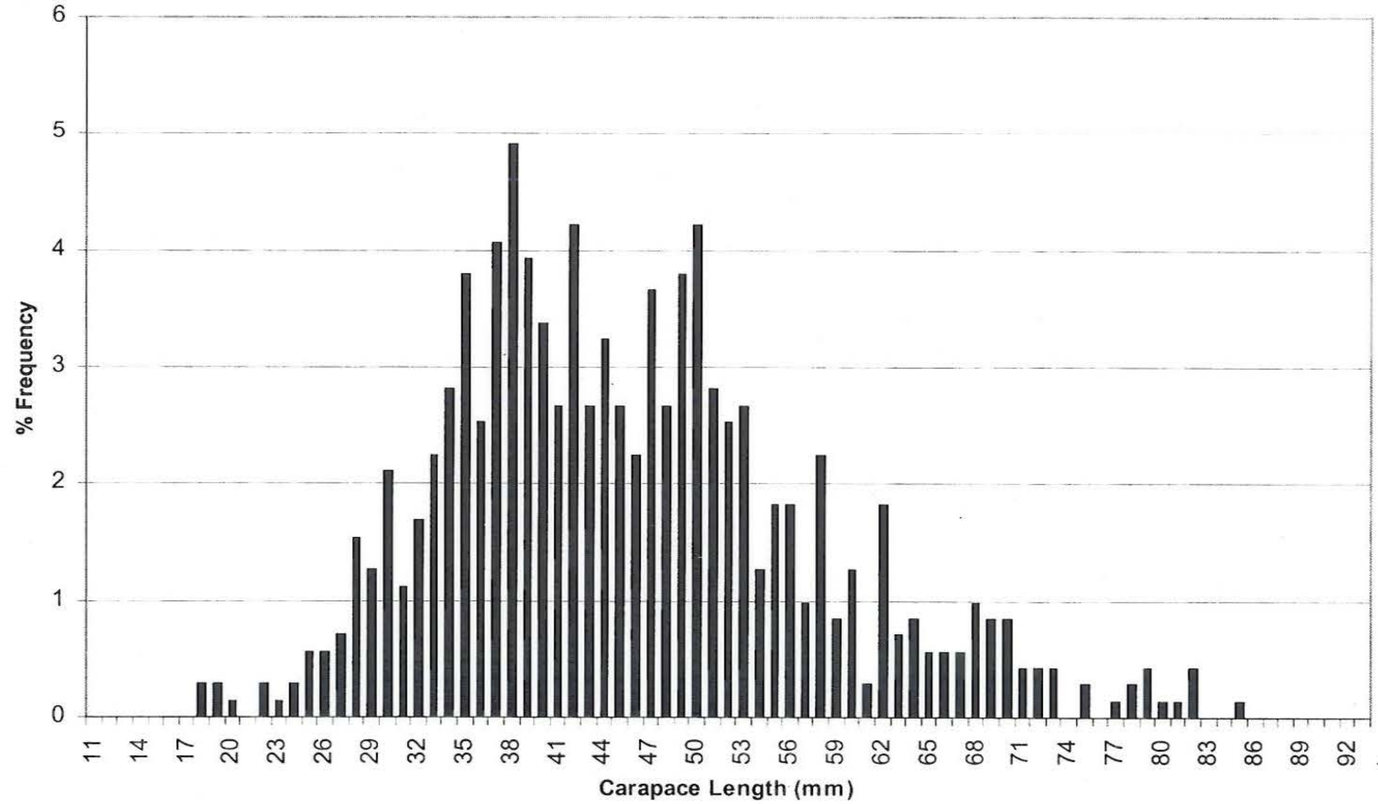

Figure 4. Length frequency distribution of SCUBA caught lobsters in 2000 at the coast.

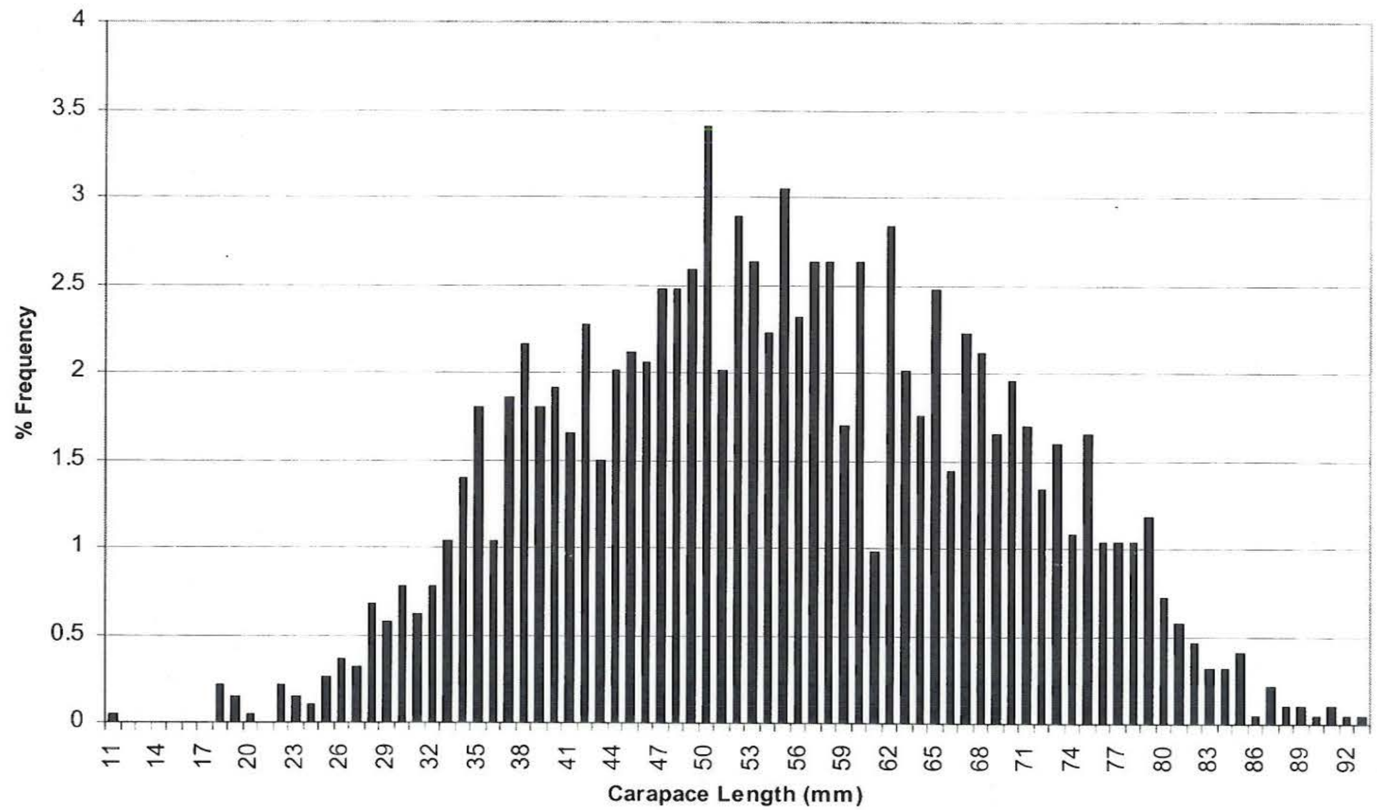

Figure 5. Length frequency distribution of SCUBA caught lobsters in 2000 from all areas.

Table 2. **ANOVA of juvenile lobster carapace length by sex, month and year for sample years 1992 - 2000 and months 4-12 for the coast. ***

Source	**DF**	**Sum of Squares**	**Mean Square**	**F**	**Pr[+] >F**
Sex	1	964.3	964.301	6.2	0.0127
Month	8	42529.3	5316.2	34.3	<0.0001
Year	8	15574.7	1946.8	12.5	<0.0001
Sex-Month	8	1227.0	153.4	1.0	0.4430
Sex-Year	8	2267.2	283.4	1.8	0.0676
Month-Year	64	21049.8	328.9	2.1	<0.0001
Error	4871	756152.3	155.2		

* Number of observation in data set = 4969
[+] = Probability

Table 3. **ANOVA of juvenile lobster carapace length by sex, month and year for sample years 1992 - 1993 and 1995 - 2000 and months 1 and 4-12 in all areas (upper river, harbor, coast).***

Source	DF	Sum of Squares	Mean Square	F	$Pr^{+} > F$
Sex	1	9719.8	9719.8	59.4	<0.0001
Site	2	304427.5	152213.8	930.4	<0.0001
Month	9	135610.7	15067.9	92.1	<0.0001
Year	7	86569.5	12367.1	75.6	<0.0001
Sex-Site	2	1582.8	791.4	4.8	0.0079
Sex-Month	9	3028.9	336.5	2.1	0.0297
Sex-Year	7	689.9	98.6	0.6	0.7545
Site-Month	18	19938.9	1107.7	6.8	<0.0001
Site-Year	14	45845.2	3274.7	20.0	<0.0001
Month-Year	63	43572.8	691.6	4.2	<0.0001
Error	13502	2208978.3	163.6		

*Number of observations in data set = 13,635
$^{+}$ = Probability

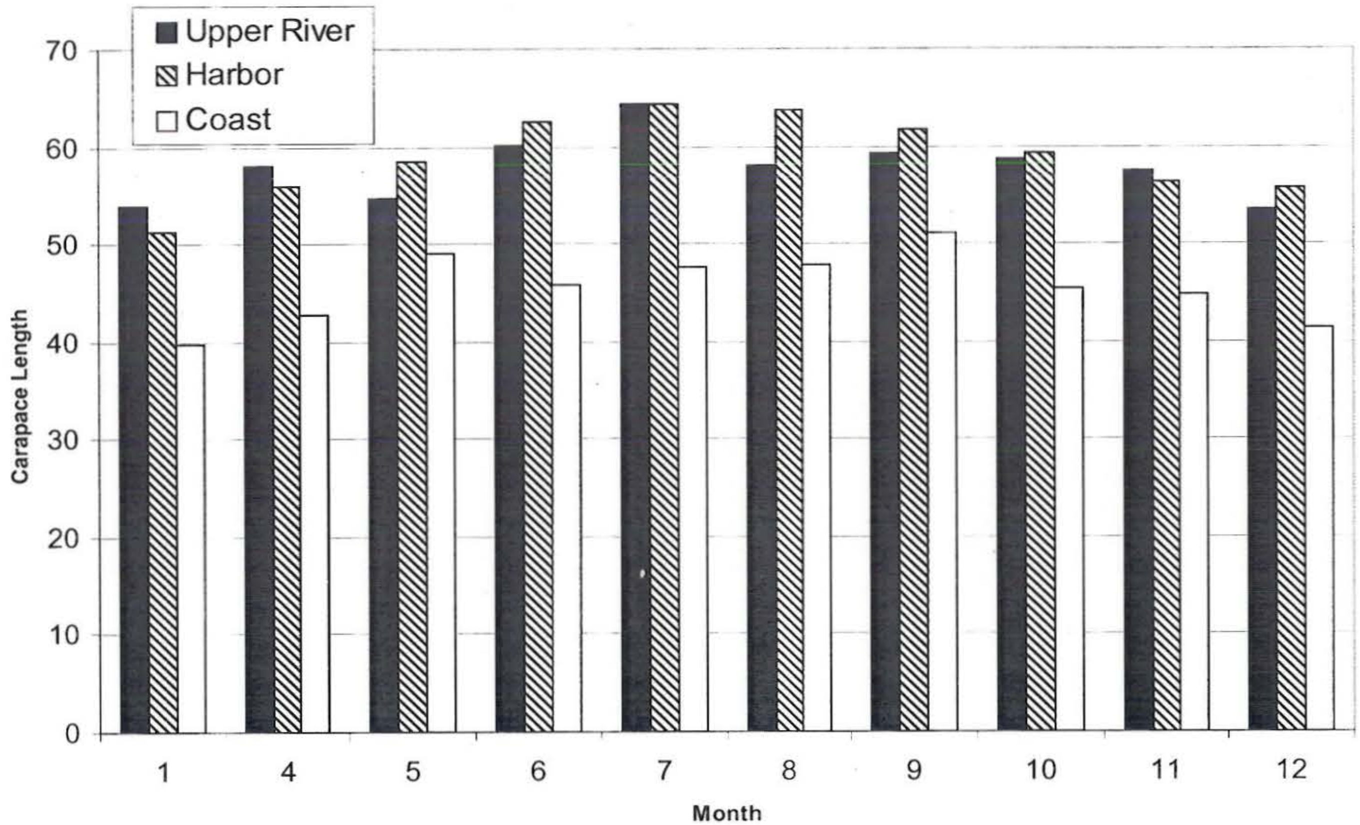

Figure 6. Carapace length by month and area for SCUBA caught lobsters, 2000.

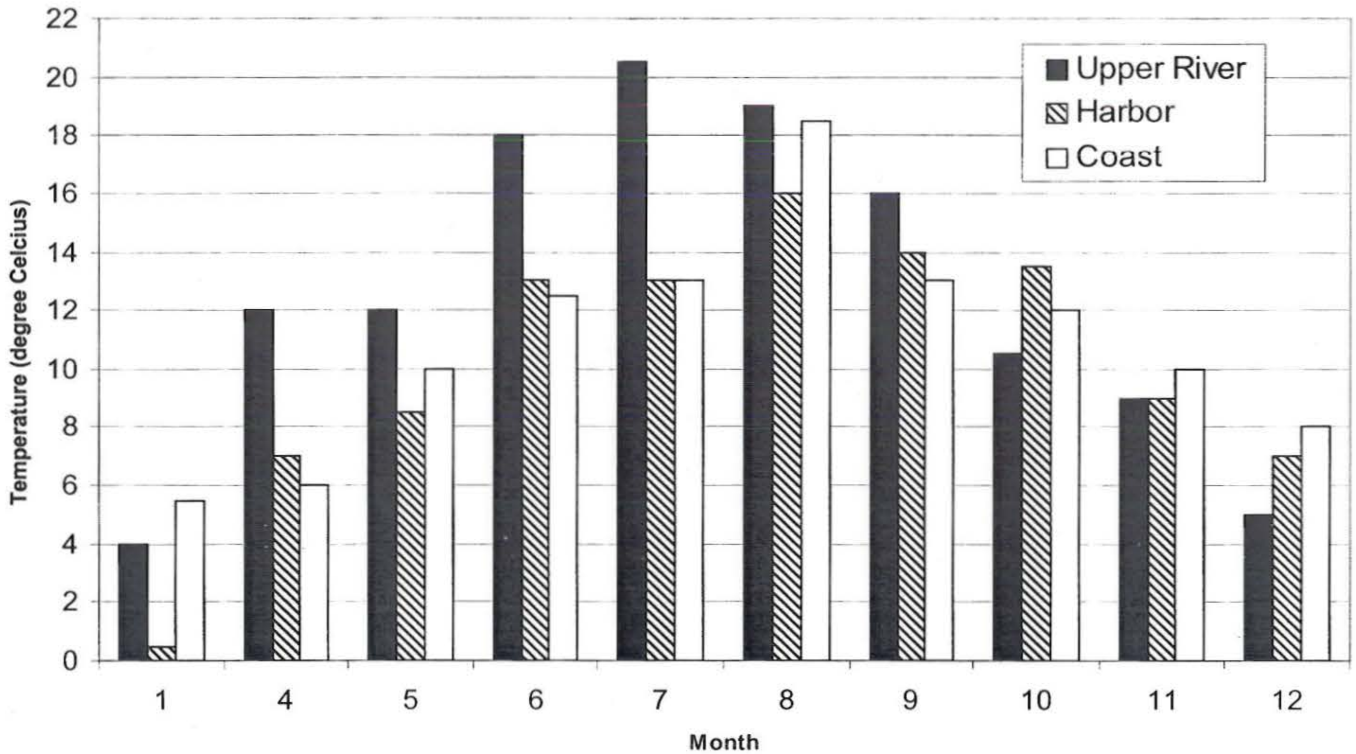

Figure 7. Surface water temperature by month, 2000.

Catch per unit effort

Plots of CPUE for the different areas over the various months suggest some general trends (Figure 8). Data for the upper river and harbor areas showed that CPUE was low in the spring (possibly due to low visibility) and high in the summer. The catch rate for the coast was lower in winter and early spring and higher in summer and fall months. Catch per unit effort for the years 1992 - 2000 (Figure 9) tends to be lowest in April, show increase from May - October and then show a decline in November and December. The year 2000 shows the highest catch per unit effort in the time series for the months of July and August. Figure 10 illustrates that the year 2000 had the highest annual catch per unit effort for the time series (1992-2000).

Molting

Analysis of time of molting (Table 4) indicates that in 2000 there were two molt peaks (July and October) when all sites are combined. Peaks in molting were seen in June and October for the upper river and harbor, while peaks for the coast were observed in July and September. The area displaying the highest incidence of molting over the entire sampling period was the harbor followed by the upper river and coast.

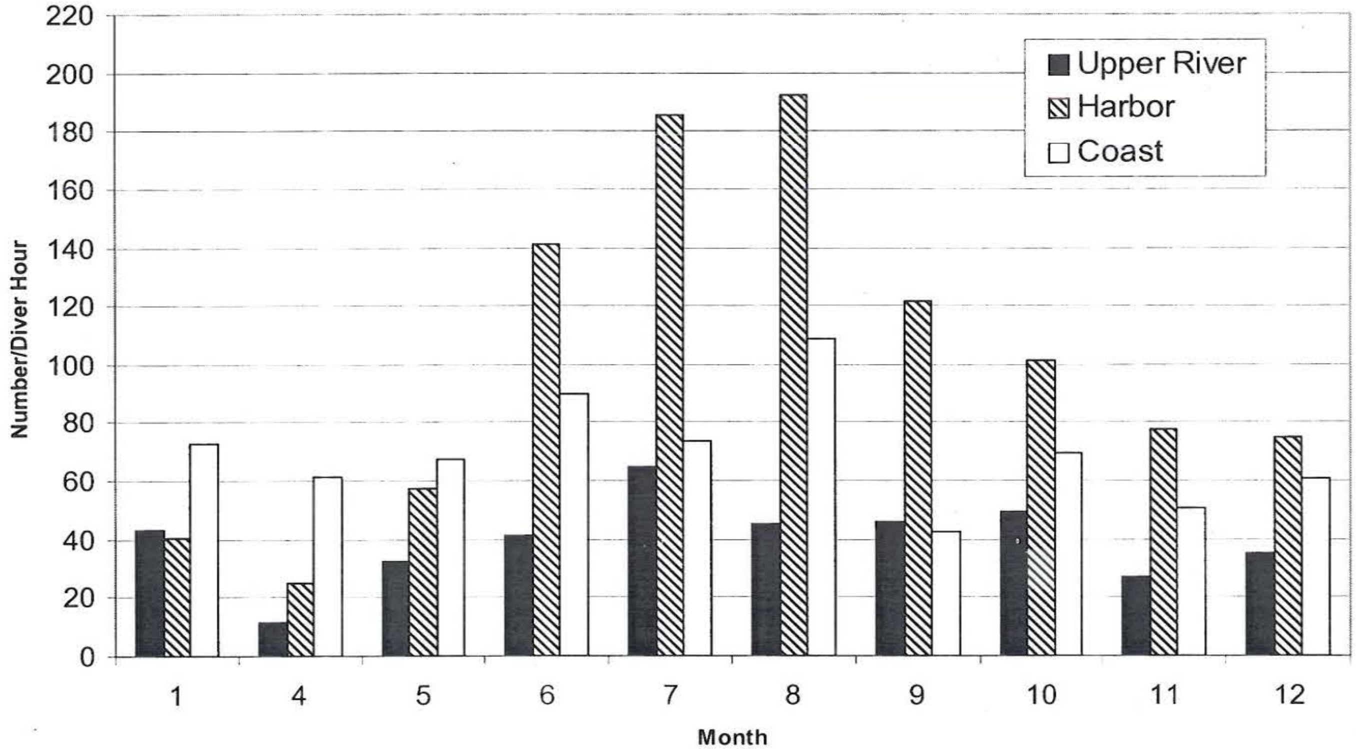

Figure 8. Catch rate of SCUBA caught lobsters by month and area, 2000.

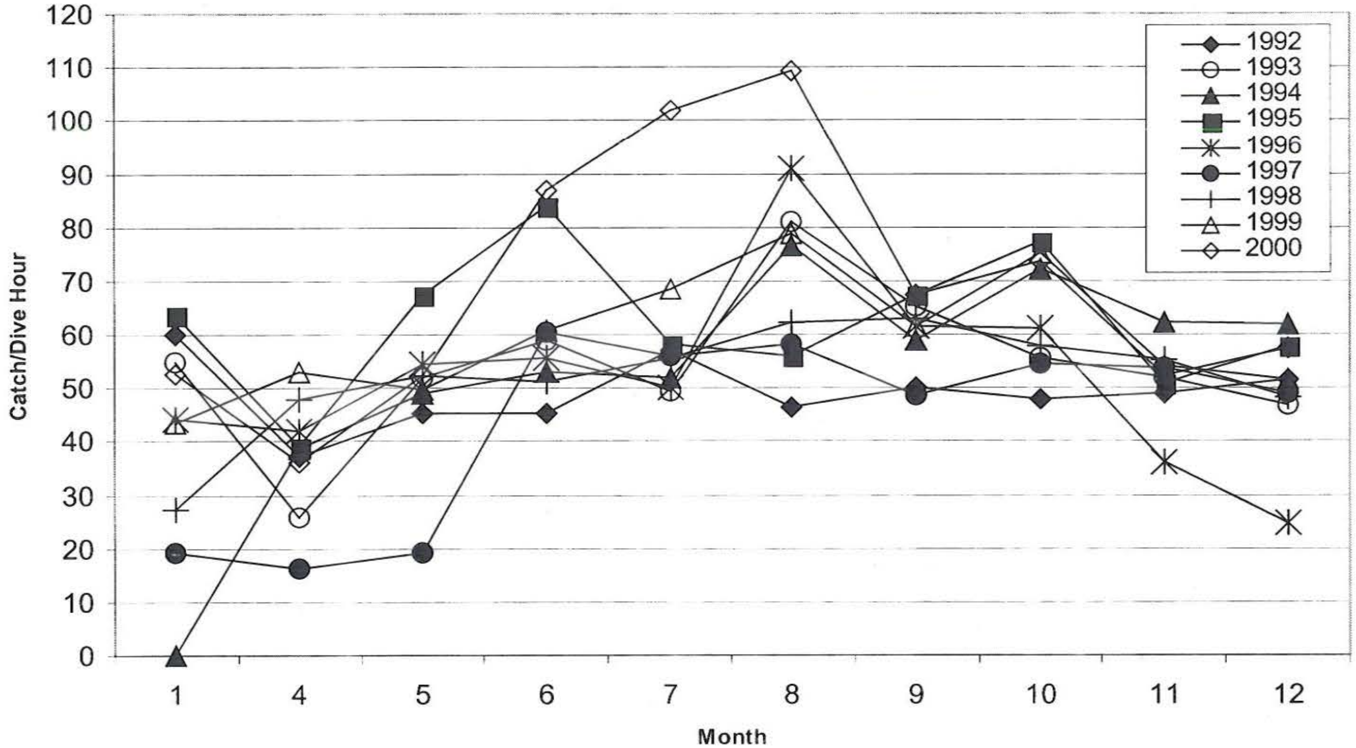

Figure 9. Comparison of SCUBA caught lobster catch per unit effort for all areas in years, 1992-2000.

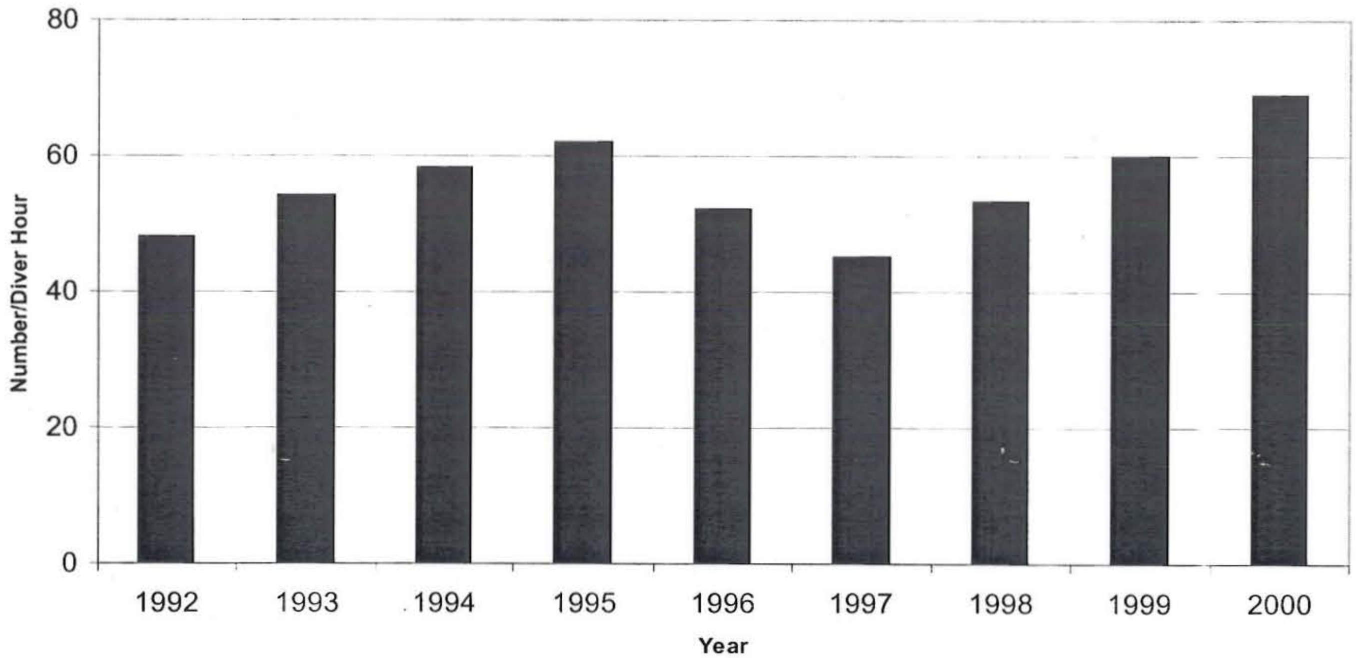

Figure 10. Annual comparison of SCUBA caught lobster catch per unit effort for all areas in years, 1992-2000.

Table 4. Percentage of 2000 SCUBA caught lobsters that were near molt conditions (i.e. recently molted or premolt) by sample site and month.

Month	Upper River	Harbor	Coast	All Sites
May	0	0	0	0
June	15.6	10.7	0	7.7
July	1.9	9.0	18.4	10.3
August	2.2	4.5	4.9	4.3
September	5.6	8.9	8.3	8.1
October	7.7	14.5	2.5	9.1
November	0	0	0	0
All Months	5.3	7.8	4.9	6.3

Discussion

Results from the 2000 SCUBA-caught lobster data show differences in mean lobster size by month and by area. Mean size of SCUBA-caught lobsters by month for 2000 repeated similar patterns observed in all earlier study years (NHF&G 1993-2000). Mean size is generally smallest during cold water months. The reason for this trend is a combination of several factors. Growth could account for increase in lobster mean length through the summer/fall as supported by molt frequency data. The decrease in mean length over the late fall and winter on the coast is probably due to removal of newly recruited legal lobsters and temperature related migration of larger lobsters out of the study area in late fall and through the winter. Following this same logic, the warm water increase corresponding to mean lobster length during summer and early fall could in part be the result of immigration of larger lobsters into the study area. This sort of seasonal movement by larger (i.e. legal-sized) lobsters is well known (Estrella and Morrissey, 1997, Herrick, 1909, Phillips et al., 1980, Duggan and Duggan, 1989, Robichaud and Campbell, 1991,Watson et al 1989, 1999).

Sex was a significant variable influencing lobster size when combining all months and areas sampled in 2000 (Table 1). However, this varied during previous years (NHF&G 1993 - 2000). When including lobsters from 1992 - 2000 and months 4-12 from the coastal area (Table 2), sex as a main effect was a significant variable influencing lobster size. This has varied through the previously studied years (NHF&G 1993-2000). When combining all areas, resulting in the greatest number analyzed from 1992 - 1993 and 1995 - 2000 and months (1, 4-12), sex as a main affect and the pair-wise combination of sex-site and sex-month appeared to be significant variables, influencing lobster size in the population. This is generally supported by previously studied years (NHF&G 1993 - 2000).

Sex related size differences as mentioned above are supported by findings in the literature (Phillips et al, 1980). Reasons for sex related size difference are likely due to the fact that males undergo molting more frequently than females once sexual maturity is reached. In addition to the frequency of molting between sexes which is directly tied to the carrying of eggs by the female (thus delayed molting) there is also the physiological demands of egg production and egg bearing that may require energy that otherwise might be converted into greater growth per molt or more frequent molts.

The results of the analysis of SCUBA-caught lobster by area showed that those with the largest average carapace length were found at the upper river followed by the harbor. The coastal area lobsters were the smallest on average. These results are generally supported by previous study years (NHF&G 1993-2000). This information coupled with an analysis of the length frequency distribution point to the possible importance of the coastal area as a rearing area for juvenile pre-recruit lobsters. The majority of lobsters from this area are in the smaller size classes from 30-53 mm. This size frequency distribution is slightly different from other areas. This may be the result of several factors including tidal drift patterns that carry early stage larvae to this area, available cover/habitat for juvenile lobsters, and/or lower predator pressure. It is also possible that the generally clearer coastal waters provide a better opportunity for capture of smaller lobsters. Further characterization of larval distribution, available habitat, predator abundance, and other environmental conditions that may influence early benthic stage lobster survival would be needed to better understand this.

The results from analysis of catch per unit of effort revealed some general trends in the relative abundance of SCUBA-caught lobsters throughout the season. Catch per unit effort was lower in the winter and early spring (cold water months) at all three locations with an increase in lobsters caught as the water temperatures became warmer. Catch per unit effort for the upper river and harbor was low in the spring (especially April). Perhaps these differences are due to unfavorable visibility days (which make lobster catch difficult), the differences in experience between collectors, or to unfavorable environmental conditions. Catch per unit effort for the years 1992 - 2000 show fluctuating results with lowest levels in cold water months. The drop in catch per unit effort for 1996 in November and December and in January 1997 was most likely due to heavy rains in October and perhaps the July oil spill in the upper river in 1996. Excellent visibility along with warmer water temperatures likely contributed to the highest catch per unit effort in the time series in August 2000 at the coast.

Timing of molting appeared to be temperature dependent with molting occurring in the various areas only after the surface temperature in the respective areas reached above 12°C. The second peak observed in the fall was noted in the earlier years of this study and is likely the result of second season molts by small size class lobsters and the relatively delayed molts of lobsters at those stations offshore where seasonal water temperature rises lag behind those in the river.

In summary, the 2000 SCUBA lobster monitoring program found the size, sex and molt pattern of the New Hampshire coastal and estuarine population to be generally similar to that seen over the past 8 years. Sex appears to be a significant variable influencing lobster size. The increase in number of small sized lobsters caught per unit effort from previous years possibly indicates a healthy future lobster resource for the industry.

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UNITED STATES
DEPARTMENT OF COMMERCE
National Marine Fisheries Service
Management Division
State-Federal Relations Branch

PERFORMANCE REPORT

State: New Hampshire

Project No: NA382

Contract No: NA76FI-0382

Project Title: Monitoring of the American Lobster Resource and Fishery in New Hampshire - 1999.

Period Covered: January 1, 1999 - December 31, 1999

Project Dates: January 1, 1999 - December 31, 1999

Prepared By: Clare D. McBane, Marine Biologist

Approved By: John Nelson
John I. Nelson
Chief, Marine Fisheries

Date: March 10, 2000

MONITORING OF THE AMERICAN LOBSTER RESOURCE AND FISHERY IN NEW HAMPSHIRE

Abstract

The New Hampshire lobster population was monitored in 1999 by means of SCUBA captured lobsters. Sampling for small, sub-legal lobsters was conducted along the New Hampshire coast and in an estuarine river. Three sampling areas were delineated based on environmental differences in marine habitat. These areas consisted of an upper river estuarine, Portsmouth Harbor (a lower river estuarine), and a near shore coastal location. A total of 1698 lobsters were captured, measured, sexed and checked for shell hardness or signs of premolt. Individuals captured ranged between 17 and 97 mm carapace length (mmCL) and averaged 53.9 mmCL. Mean carapace length was generally high during the summer for all locations. Sex was a significant variable influencing lobster size when an ANOVA was performed on 6 years of combined data, and when 1999 data was analyzed alone. Site and month were shown by ANOVA to be significant variables influencing lobster sizes in 1999 and in previous years studied. The highest catch per unit effort was found at the harbor for the months of May, June, July, August, October and December. The catch per unit effort for the coast was the highest of the three locations during April, September and November. Molting took place from June to November with peaks of combined sites observed in the spring and late summer/fall.

Introduction

Lobsters are the most economically valuable fishery resource in the northeastern United States. Commercial U.S. harvesting occurs from the Canadian border to the mid-Atlantic United States. Important quantities of lobster are landed at ports in each of the coastal states from Maine to North Carolina. A commercial lobster fishery exists along the New Hampshire coast in both state and federal waters with about 1.2 million pounds harvested in 1998. The estimated dollar value for New Hampshire's 1998 landings exceeded 4.7 million dollars.

In order to have effective management plans it is important to determine as much as possible about the stock characteristics of lobsters in New Hampshire waters. Identification of critical habitat and monitoring of population trends is also an important component for making sound management decisions regarding New Hampshire's lobster resource.

The objectives of this study were to:

1. monitor the relative abundance of lobsters, with particular emphasis on juveniles, in the New Hampshire waters; and,
2. obtain information on habitat use by lobsters along the New Hampshire coast.

Study Area

The study area encompasses the lower reach of the Great Bay Estuary System located on the Piscataqua River and the coastal area of New Hampshire (Figure 1). This area is divided into 3 sampling sites based upon overall habitat characteristics:

Area 1 - (upper river) - From Fox Point to the US 1 By-pass bridge. This area is characterized by a deep narrow channel and strong tidal currents. Substrate is composed of rocky outcrops, mud and gravel.

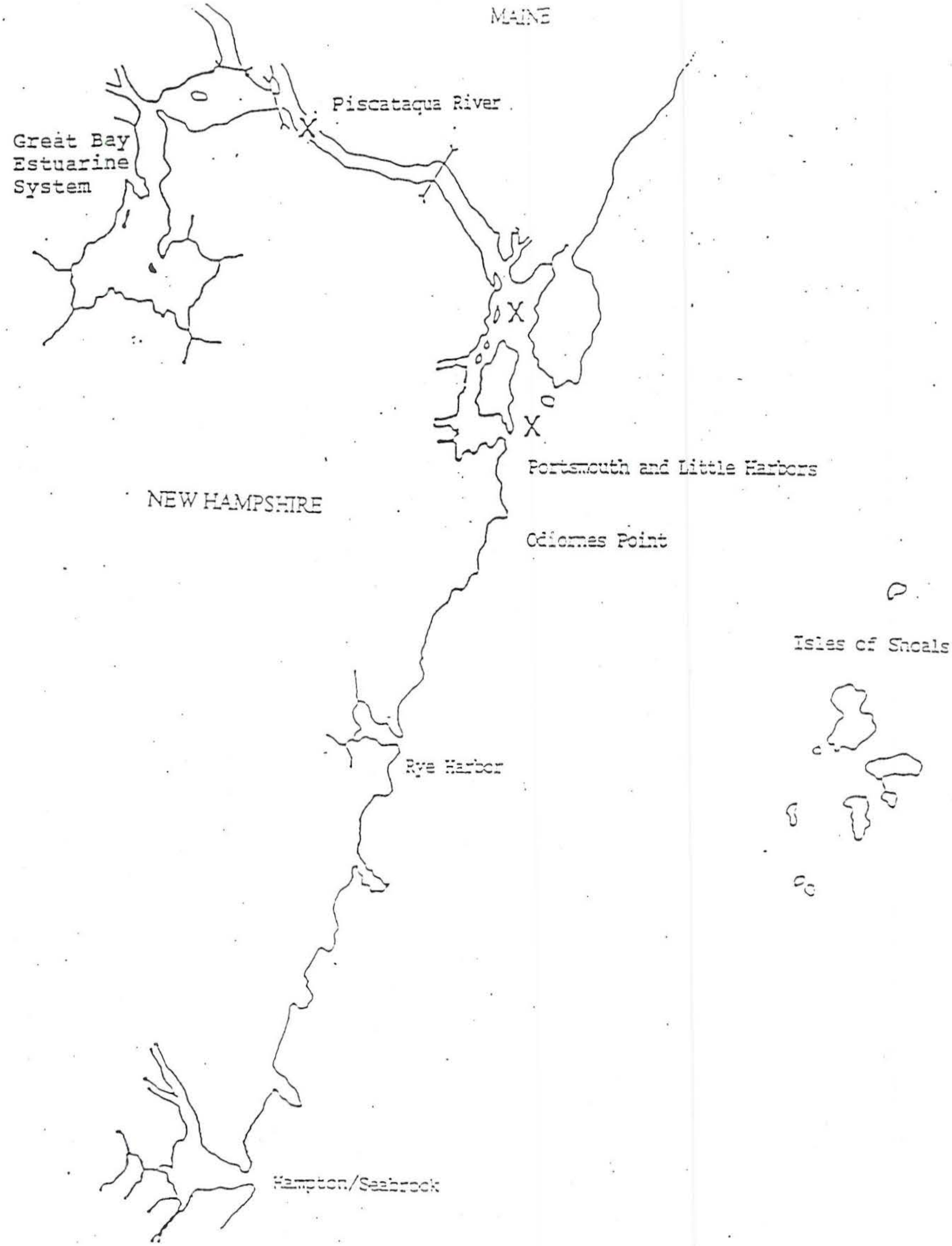

Figure 1. Study area with juvenile lobster sampling stations marked X.

Area 2 - (Portsmouth Harbor - lower river) - From the US 1 By-pass bridge downstream to the mouth of the Piscataqua River at Fort Point. Tidal currents are strong in the main channel, the river is generally wider than in Area 1. Substrate is a variety of rocky outcrops, assorted rocks, sand, gravel, and clay deposits.

Area 3 - (coastal) - Coastal area from the Maine border south to the Massachusetts border within 3 miles of shore. This area is characterized by moderate tidal and wind driven currents. Substrate is composed of outcroppings with assorted rocks and gravel.

Objective

The objective of this project was to monitor the abundance and habitat selection of sub-legal, juvenile lobsters in New Hampshire.

Methods

Lobster were sampled on a monthly basis in January and from April to December at three sample sites (Figure 1). February and March were eliminated from the 1999 sampling due to unfavorable sampling conditions and low CPUE. Their elimination did not have statistical or biological impacts on project objectives. Analysis of monthly mean CPUE for 1992-1996 using ANOVA indicated significant differences among monthly CPUE. Further pair-wise combinations among months using Tukey's HSD test indicated that the months of February and March had significantly lower CPUE's than other months. Elimination of February and March resulted in less than 10% reduction in catch sample on average over the years 1992-1996. In addition, contingency analysis of catch sex ratio using Chi-square tests showed no significant differences in the sex ratio between February-March and January and April-December.

At each site, samples consisted of two SCUBA divers searching the bottom for lobsters. Lobsters encountered during dives were captured by hand (capture rates were not 100%) and were stored in catch bags until the end of the dive. Bottom time was measured for each dive and used as a measure of sampling effort. Since the objective of this project was to gather information on smaller, sublegal (i.e. juvenile) lobsters, some large lobsters (those that appeared to have carapace lengths greater than about 80 mm) were not aggressively pursued in favor of capturing greater numbers of small lobsters.

Following completion of the dive, the lobsters were briefly held in the water in catch bags until they were processed. All lobsters captured were sexed, measured (mid-dorsal carapace length to the nearest millimeter), noted for shell hardness or premolt condition (i.e. molt stage) and released. No tagged lobsters were encountered nor were any tagged in 1999. The date, location, surface temperature, and salinity were also recorded with each dive.

Differences in lobster size were analyzed using analysis of variance (ANOVA) with sample month, sample area and sex as the categorical variables. An ANOVA was run for all areas and months January and April - December. In addition multi-year ANOVAs were run. Lobster from area 3 (coast) only and months 4 to 12 and years 1992-1999 made up one ANOVA group. The other multi-year ANOVA looked at lobsters from all areas, months 1,4 - 12 and years 92-93 and 95-99. The 1994 data set is incomplete, lacking samples during some months and is therefore unsuitable for year to year comparisons. Length frequency distributions were plotted for the various areas and the mean length was plotted for each month. Mean CPUE was plotted for each area by month. These were done to further analyze possible trends. The percent of the sample population with softshells or premolt shells was recorded by month for each area to analyze trends in molting frequency and occurrence.

Results

A total of 1,698 lobsters were captured during sampling in 1999, with 26 of the total catch of legal size (i.e., 83 mmCL or greater). From this total, 756 were females and 942 were males. All captured lobsters were included in the data analysis.

Size composition

The ANOVA for SCUBA-sampled lobsters from the sample areas (upper river, harbor, and coast) for months 1and 4 through 12 in 1999 revealed significant ($P \leq 0.05$) differences in mean lobster size for sex, sample site and sample month (Table 1). The length frequency plots (Figures 2, 3 and 4) for SCUBA-caught lobsters show discernable differences in the distribution patterns of areas where the greatest number of animals caught were 60 mm at the upper river, 63

Table 1. **ANOVA of juvenile lobster carapace length by sex, site and month for areas 1 -3 for the months of 1 and 4 -12 in 1999.***

Source	DF	Sum of Squares	Mean Square	F	Pr+ >F
Sex	1	2017.5	2017.5	12.53	0.0004
Site	2	60458.4	30229.2	187.67	0.0001
Month	9	22933.9	2548.2	15.82	0.0001
Error	1685	271411.3	161.0		

* Number of observations in data set = 1698

+ = Probability

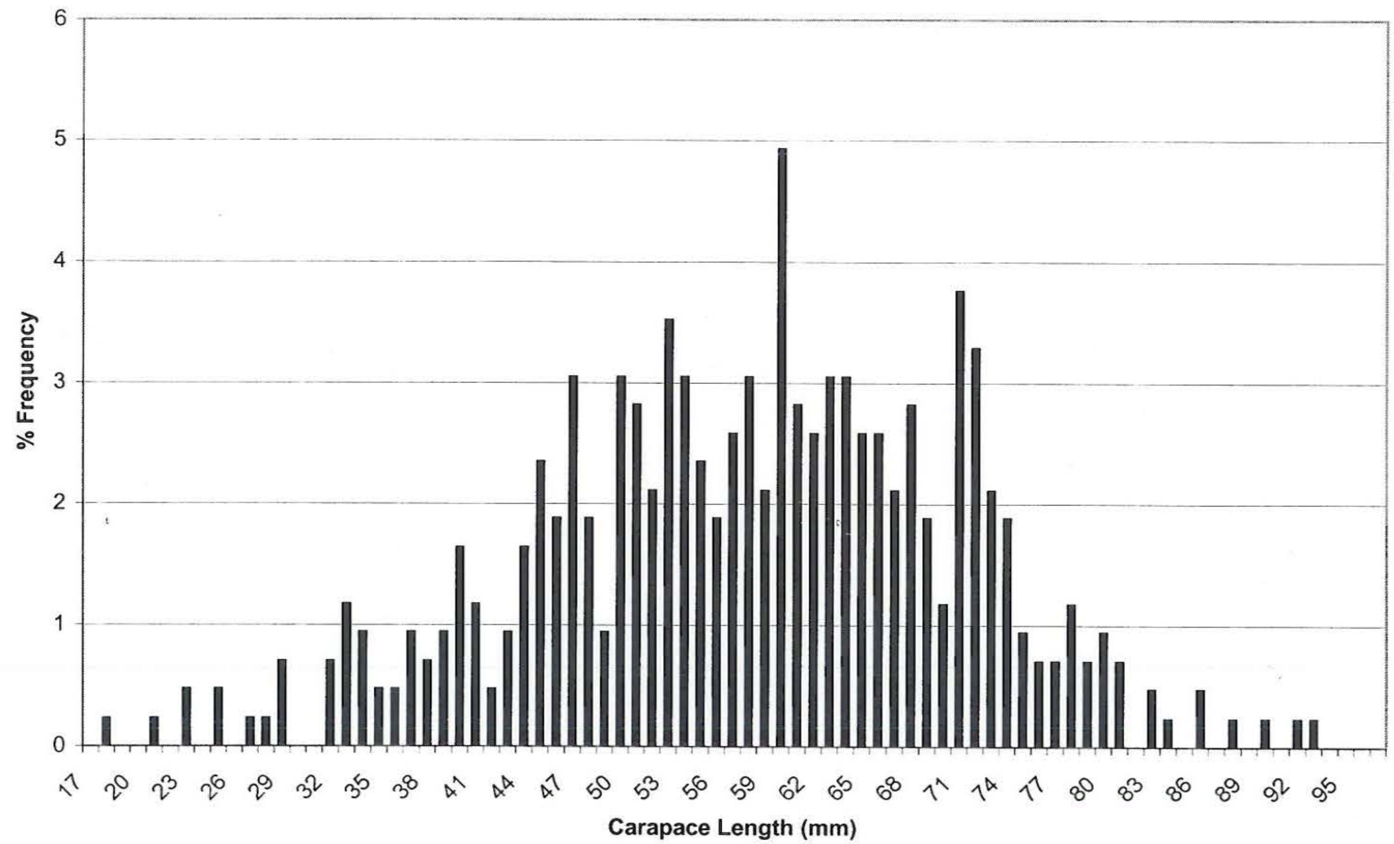

Figure 2. Length frequency distribution of SCUBA caught lobsters in 1999 at the upper river.

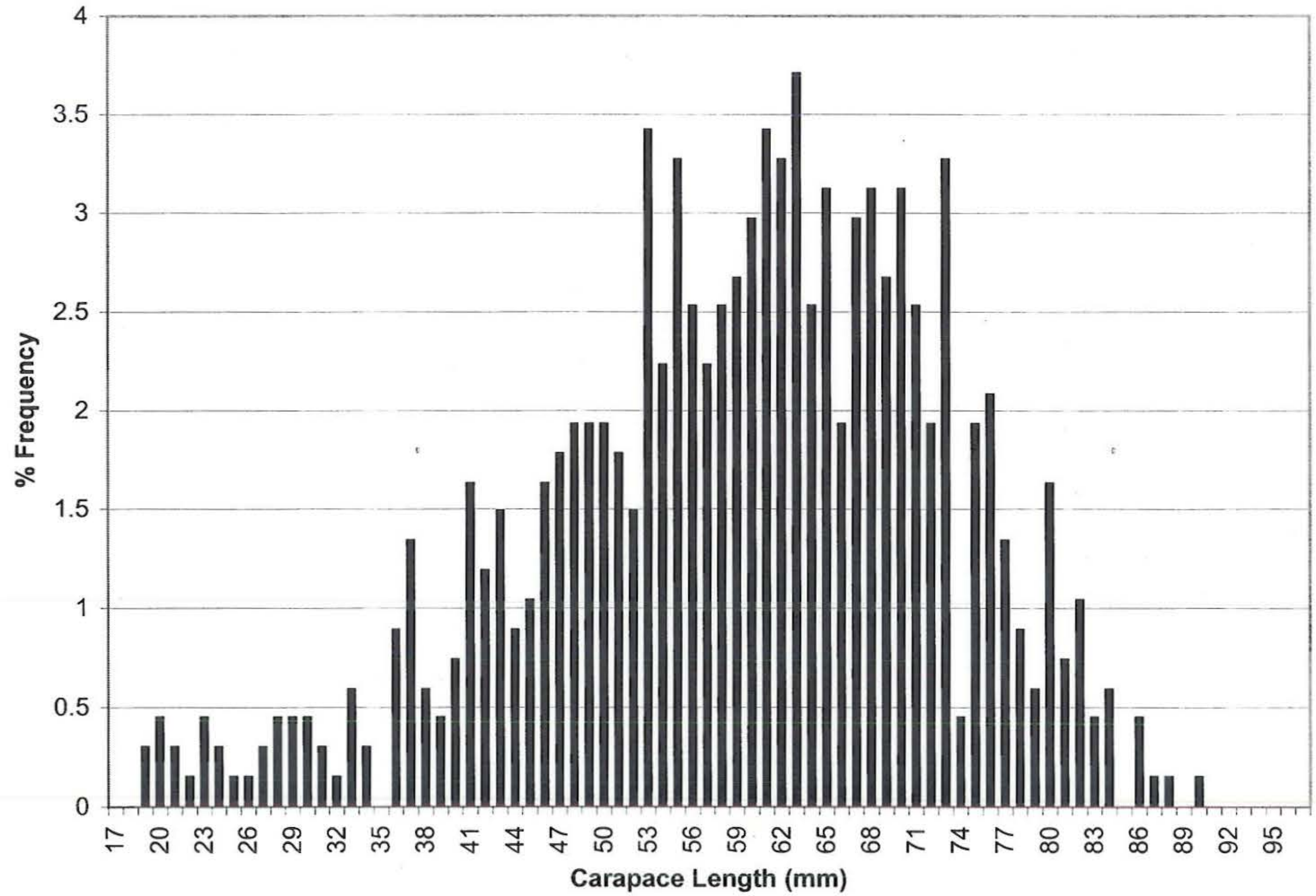

Figure 3. Length frequency distribution of SCUBA caught lobsters in 1999 at the harbor.

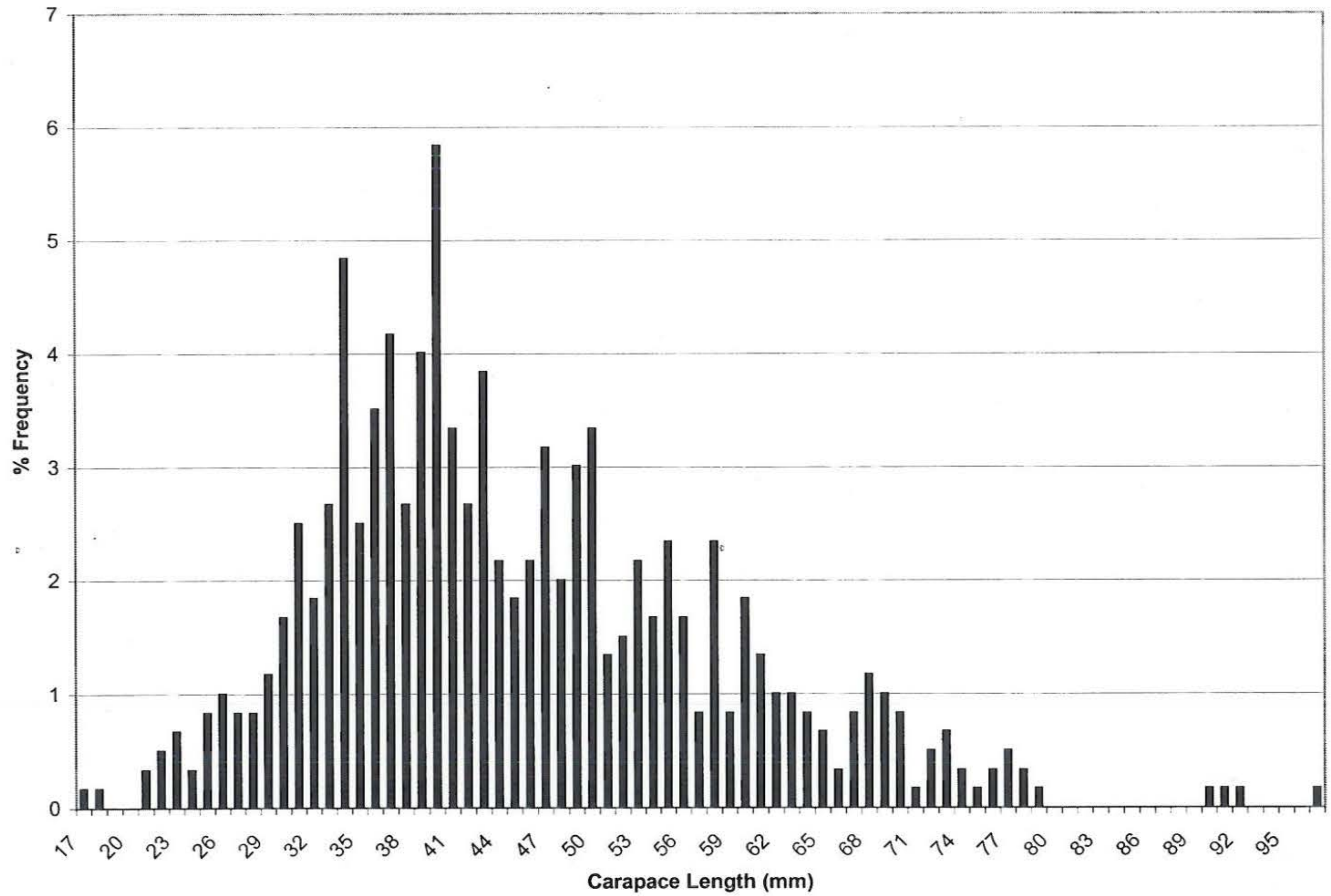

Figure 4. Length frequency distribution of SCUBA caught lobsters in 1999 at the coast.

mm at the harbor, and 40 mm at the coast. The mean carapace length for the coastal juveniles (total=599) was 45.3 mm; while, the mean carapace length for the upper river (total=426) was 57.8 mm and the mean carapace length for the harbor (total = 673) was 59.1 mm. Figure 5 illustrates an all-areas length frequency plot where the highest number of lobsters caught were 60 mm CL. The total mean carapace length at all locations was 53.9 mm.

The Area 3 (coast) specific ANOVA (Table 2) showed significant differences associated with all categorical variables except for sex. The ANOVA that looked at all areas and all years except 1994 (Table 3) revealed significance for sex as a main effect and the pair-wise combination of sex and site, but showed insignificant differences when broken down into pair-wise combinations of sex - month and sex - year.

Figure 6 illustrates that on an overall area basis, juvenile lobster size peaks in the summer, during warm water temperatures (Figure 7). Mean carapace length at the upper river peaks in July following the warm water in June, while the smaller mean carapace lengths in April and May occur at a time of colder water temperature. The mean carapace length of juveniles and the water temperature from the Harbor area, both peak in the summer months (July and August) and both are the lowest in January. The same trend of maximum mean juvenile carapace length and corresponding water temperature occurs with a high in August and September and the smallest captured juveniles (seen in April and May) during the lower water temperatures at the coastal area.

Catch per effort

Plots of CPUE for the different areas over the various months suggest some general trends (Figure 8). Data for the upper river area showed that CPUE was low in the spring (possibly due to low visibility) and high in the fall. The catch rate for the Harbor was lower in winter and early spring and higher in summer and fall months. Catch per unit effort on the coast

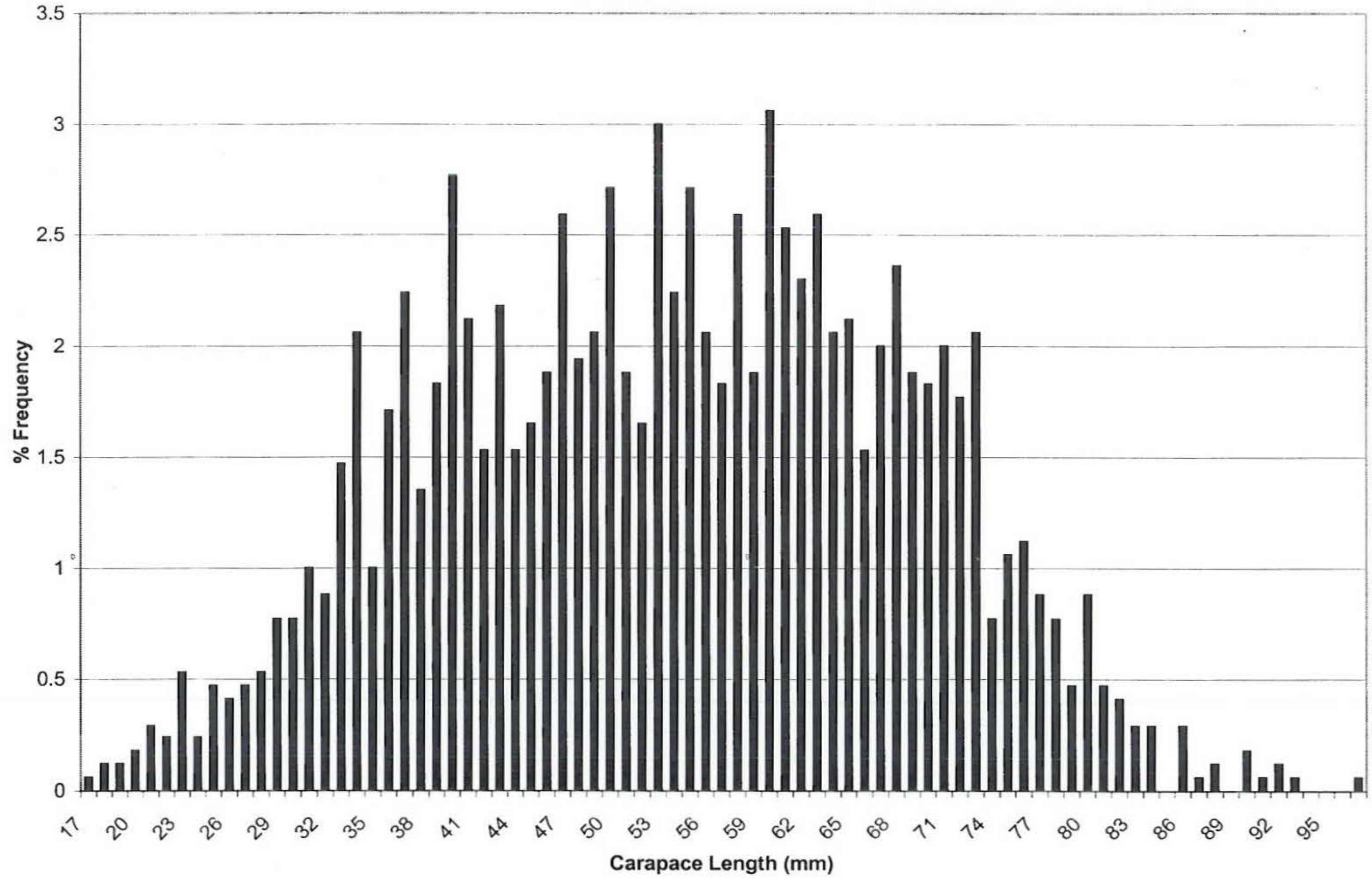

Figure 5. Length frequency distribution of SCUBA caught lobsters in 1999 from all areas.

Table 2. **ANOVA of juvenile lobster carapace length by sex, month and year for sample years 1992 - 1999 and months 4-12 for the coast . ****

Source	DF	Sum of Squares	Mean Squares	F	Pr+ >F
Sex	1	528.9	528.9	3.4	0.0674
Month	8	39989.1	4998.6	31.6	0.0001
Year	7	13657.0	1951.0	12.4	0.0001
Sex *Month	8	1177.5	147.2	0.9	0.4888
Sex *Year	7	1858.0	265.4	1.7	0.1091
Month *Year	56	18374.4	328.1	2.1	0.0001
Error	4236	669305.3	158.0		

** Number of observation in data set = 4325

+ = Probability

Table 3. **ANOVA of juvenile lobster carapace length by sex, month and year for sample years 1992 - 1993 and 1995 - 1999 and months 1 and 4-12 in all areas (upper river, harbor, coast). ****

Source	DF	Sum of Squares	Mean Squares	F	Pr+ >F
Sex	1	8145.5	8145.5	48.9	0.0001
Site	2	243976.6	121988.3	731.9	0.0001
Month	9	125074.4	13897.2	83.4	0.0001
Year	6	59396.5	9899.4	59.4	0.0001
Sex *Site	2	2040.7	1020.1	6.1	0.0022
Sex *Month	9	2655.9	295.1	1.8	0.0684
Sex *Year	6	612.3	102.0	0.6	0.7207
Site *Month	18	20293.3	1127.4	6.8	0.0001
Site *Year	12	36468.7	3039.1	18.2	0.0001
Month *Year	54	38896.5	720.3	4.3	0.0001
Error	11574	1929007.7	166.7		

**Number of observations in data set = 11,694

+ = Probability

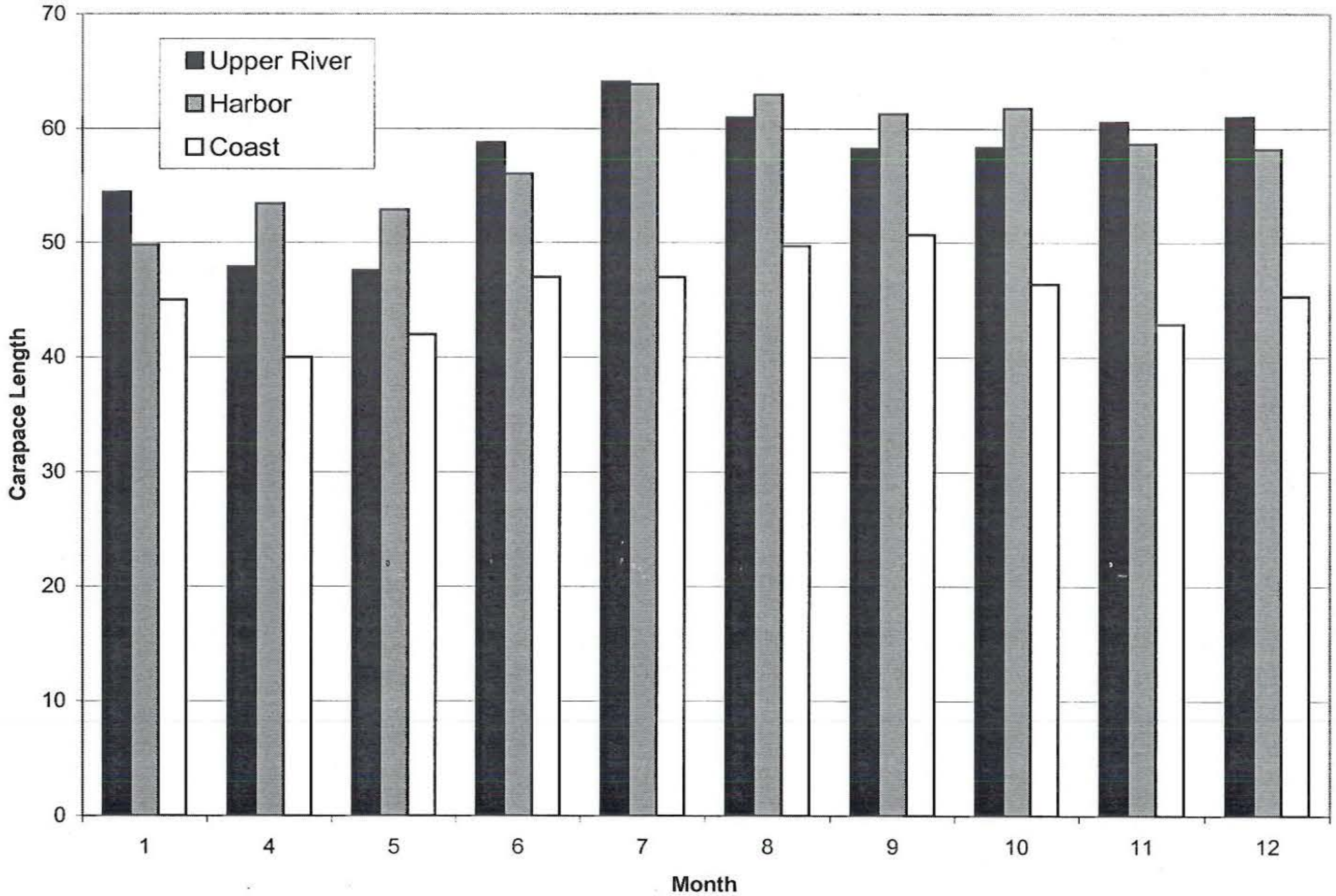

Figure 6. Carapace length by month and area for SCUBA caught lobsters, 1999.

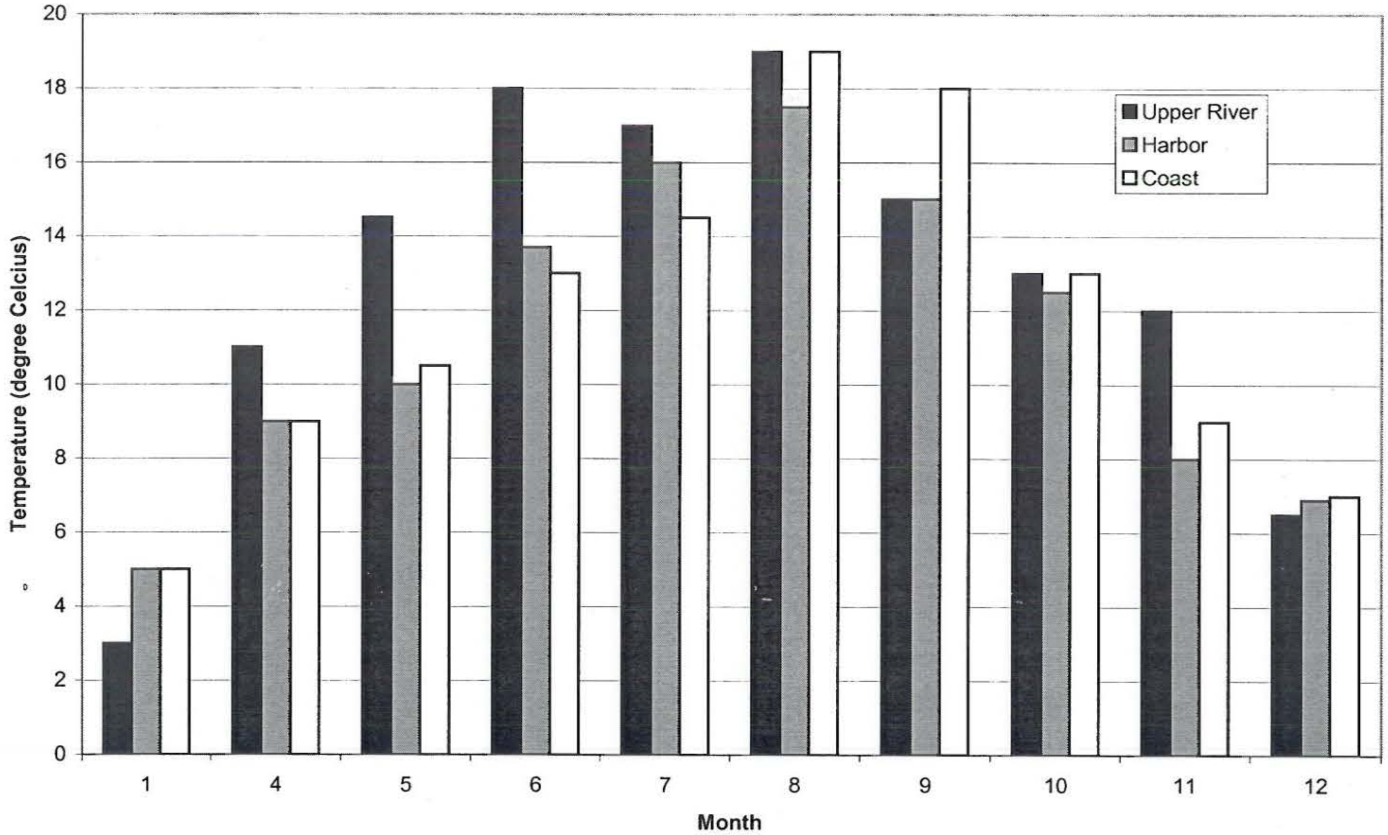

Figure 7. Water temperature by month, 1999.

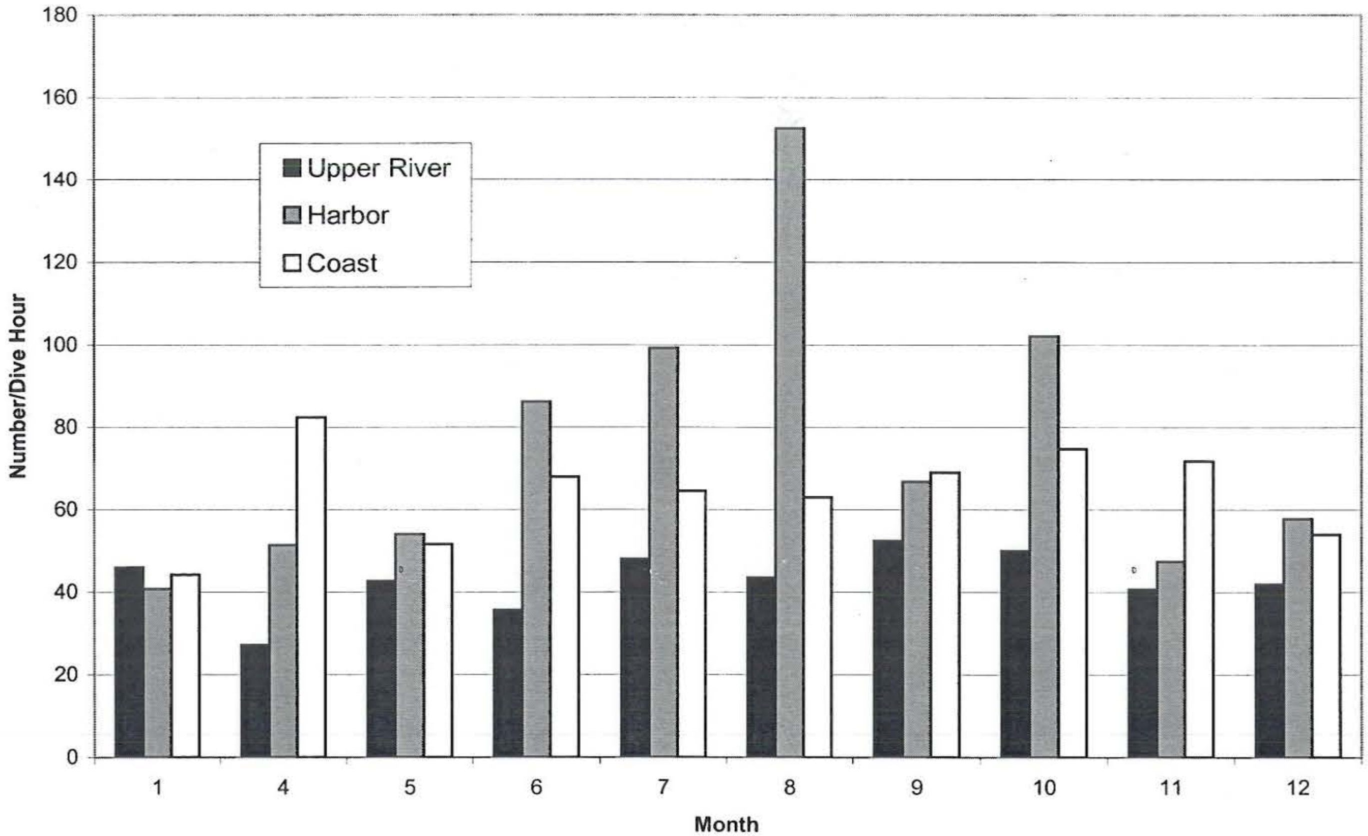

Figure 8. Catch rate of SCUBA caught lobsters by month and area, 1999.

fluctuated with highs in April and October and a low in January. Catch per unit effort for the years 1992 - 1999 (Figure 9) tends to be lowest in April, show increase from May - October and then show a decline in November and December.

Molting

Analysis of time of molting (Table 4) indicates that in 1999 there were two molt peaks when all sites are combined. One peak occurred in the spring with a higher peak seen in the fall. Individual area highest peak molt times also occurred in the fall for the Harbor and coast locations. The upper river showed its highest molt in June while the harbor and coast showed secondary high molts in July. The area displaying the highest incidence of molting over the entire sampling period was the upper river followed by the harbor and coast.

Discussion

Results from the 1999 SCUBA-caught lobster data show differences in mean lobster size by month and by area. Mean size of SCUBA-caught lobsters by month for 1999 repeated similar patterns observed in all earlier study years (NHF&G 1993-1999). Mean size is generally smallest during cold water months. The reason for this trend is a combination of several factors. Growth could account for increase in juvenile lobster mean length through the summer/fall as supported by molt frequency data. The decrease in mean length over the late fall and winter on the coast is probably due to removal of newly recruited legal lobsters and temperature related migration of larger lobsters out of the study area in late fall and through the winter. Following this same logic, the warm water increase corresponding to mean juvenile lobster length during summer and early fall could in part be the result of immigration of larger lobsters into the study area. This sort of seasonal movement by larger (i.e. legal-sized) lobsters is well known (Herrick, 1909, Phillips et al., 1980, Duggan and Duggan, 1989, Robichaud and Campbell, 1991).

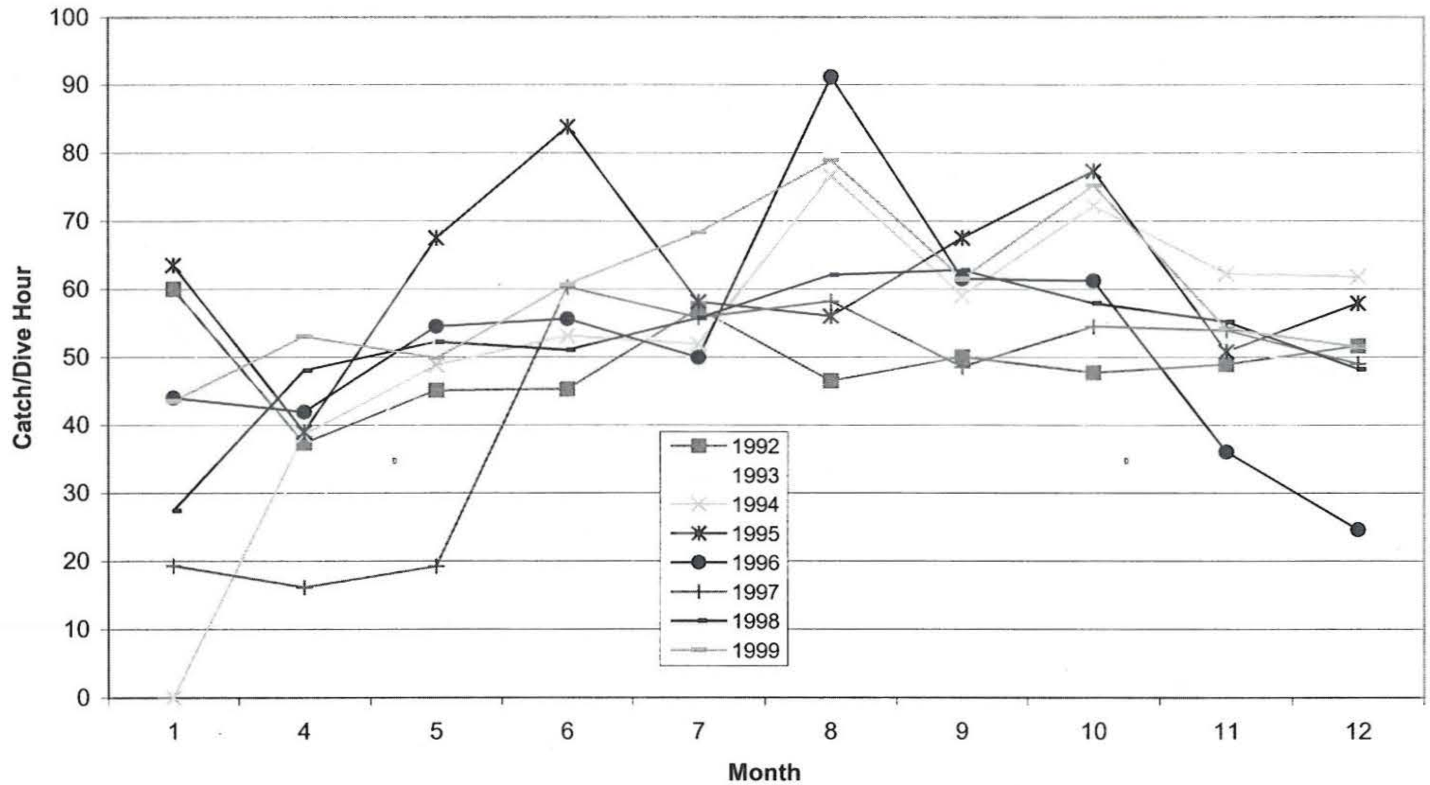

Figure 9. Comparison of SCUBA caught lobster catch per unit effort for all areas in years, 1992-1999.

Table 4. **Percentage of 1998 SCUBA caught lobsters that were near molt conditions (i.e. recently molted or premolt) by sample site and month.**

Month	Upper River	Harbor	Coast	All Sites
May	0	0	0	0
June	17.1	1.3	2	5.3
July	0	6.2	5.3	4.2
August	4	2.6	0	2.2
September	3.6	11.9	17.4	10.6
October	6	9.3	7.9	8.1
November	5.3	0	0	1.2
All Months	4.9	4.7	4.2	4.6

Sex was a significant variable influencing lobster size when combining all months and areas sampled in 1999 (Table 1). However, this varied during previous years (NHF&G 1993 - 1999). When including lobsters from 1992 - 1999 and months 4-12 from the coastal area (Table 2), sex was not a significant variable influencing lobster size. A similar outcome was seen for the majority of the previously studied years (NHF&G 1993 - 1999). When combining all areas, resulting in the greatest number analyzed from 1992 - 1993 and 1995 - 1999 and months (1, 4-12), sex as a main affect and the pair-wise combination of sex and site appeared to be significant variables, influencing lobster size in the population (Table 3). This is generally supported by previously studied years (NHF&G 1993 - 1999).

Sex related size differences as mentioned above are supported by findings in the literature (Phillips et al, 1980). Reasons for sex related size difference are likely due to the fact that males undergo molting more frequently than females once sexual maturity is reached. In addition to the frequency of molting between sexes which is directly tied to the carrying of eggs by the female (thus delayed molting) there is also the physiological demands of egg production and egg bearing that may require energy that otherwise might be converted into greater growth per molt or more frequent molts.

The results of the analysis of SCUBA-caught lobster by area showed that those with the largest average carapace length were found at the harbor station followed by the upper river. The coastal area lobsters were the smallest on average. These results are supported by previous study years (NHF&G 1993-1999). This information coupled with an analysis of the length frequency distribution point to the possible importance of the coastal area as a rearing area for juvenile pre-recruit lobsters. The majority of lobsters from this area are in the smaller size classes from 30-50 mm. This size frequency distribution is slightly different from other areas. This may be the result of several factors including tidal drift patterns that carry early stage larvae to this area, available cover/habitat for juvenile lobsters, and/or lower predator pressure. It is also possible that the generally clearer coastal waters provide a better opportunity for capture of smaller lobsters. Further characterization of larval distribution, available habitat, predator abundance, and other environmental conditions that may influence early benthic stage lobster survival would be needed to better understand this.

The results from analysis of catch per unit of effort revealed some general trends in the relative abundance of SCUBA-caught lobsters throughout the season. Catch per unit effort was low in January (cold water month) at the harbor and coast locations with an increase in lobsters caught as the water temperatures became warmer. Catch per unit effort for the upper river was low in the spring (especially April). Perhaps these differences are due to unfavorable visibility days (which make lobster catch difficult), the differences in experience between collectors, or to unfavorable environmental conditions. Catch per unit effort for the years 1992 - 1999 show fluctuating results with lowest levels in cold water months. The drop in catch per unit effort for 1996 in November and December and in January 1997 was most likely due to heavy rains in October and perhaps the July oil spill in the upper river in 1996.

Timing of molting appeared to be temperature dependent with molting occurring in the various areas only after the surface temperature in the respective areas reached about 15°C. The second peak observed in the fall was noted in the earlier years of this study and is likely the result of second season molts by small size class lobsters and the relatively delayed molts of lobsters at those stations offshore where seasonal water temperature rises lag behind those in the river.

In summary, the 1999 SCUBA lobster monitoring program found the size, sex and molt pattern of the New Hampshire coastal and estuarine population to be generally similar to that seen over the past 7 years. It is shown that in examining a large sample size, sex is seen as a significant variable influencing lobster size

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UNITED STATES
DEPARTMENT OF COMMERCE
National Marine Fisheries Service
Management Division
State-Federal Relations Branch

PERFORMANCE REPORT

State: New Hampshire

Project No: NA382

Contract No: NA76FI-0382

Project Title: Monitoring of the American Lobster Resource and Fishery in New Hampshire - 1998.

Period Covered: January 1, 1998 - December 31, 1998

Project Dates: January 1, 1998 - December 31, 1998

Prepared By: Clare D. McBane, Marine Biologist

Approved By: John Nelson
John I. Nelson
Chief, Marine Fisheries

Date: 16 Feb 99

MONITORING OF THE AMERICAN LOBSTER RESOURCE AND FISHERY IN NEW HAMPSHIRE

Abstract

The New Hampshire lobster population was monitored in 1998 by means of SCUBA captured lobsters. Sampling for small, sub-legal lobsters was conducted on a monthly basis along the New Hampshire coast and in an estuarine river. Three sampling areas were delineated based on environmental differences in marine habitat. These areas consisted of an upper river estuarine, Portsmouth Harbor (a lower river estuarine), and a nearshore coastal location. A total of 1632 lobsters were captured, measured, sexed and checked for shell hardness or signs of premolt. Individuals captured ranged between 10 and 92 mm carapace length (mmCL) and averaged 49.5 mmCL. Sex was a significant variable influencing lobster size when an ANOVA was performed on 5 years of combined data, but was not significant when 1998 data was analyzed alone. Site and month were shown by ANOVA to be significant variables influencing lobster sizes in 1998 and in previous years studied. During January - July, the highest catch per unit effort was at the coastal location; while in August, the highest catch was the same at both the upper river and coastal location. From September - December, the highest catch per unit effort was at the Harbor location. Mean carapace length was generally high during the summer/fall months and lower in the winter/spring months. Molting took place from June to November with peaks of combined sites observed in July and October.

Introduction

Lobsters are the most economically valuable fishery resource in the northeastern United States. Commercial U.S. harvesting occurs from the Canadian border to the mid-Atlantic United States. Important quantities of lobster are landed at ports in each of the coastal states from Maine to North Carolina. A commercial lobster fishery exists along the New Hampshire coast in both state and federal waters with about 1.4 million pounds harvested in 1997. The estimated dollar value for New Hampshire's 1997 landings exceeded 5.5 million dollars.

Management of the northeastern U.S. lobster stock in offshore federal waters is accomplished under a Fishery Management Plan developed by the New England Fishery Management Council. In addition, lobsters from waters out to 3 miles from shore are managed by various state regulations which are generally made consistent by interstate agreement through the Atlantic States Marine Fisheries Commission. In order to have effective management plans it is important to determine as much as possible about the stock characteristics of lobsters in New Hampshire coastal waters. Identification of critical habitat and monitoring of population trends is also an important component for making sound management decisions regarding New Hampshire's lobster resource.

The objectives of this study were to:

1. monitor the relative abundance of juvenile lobsters in the New Hampshire waters; and,
2. obtain information on habitat use by lobsters along the New Hampshire coast.

Study Area

The study area encompasses the lower reach of the Great Bay Estuary System located on the Piscataqua River and the coastal area of New Hampshire (Figure 1). This area is divided into 3 sampling sites based upon overall habitat characteristics:

Area 1 - (upper river) - From Fox Point to the US 1 By-pass bridge. This area is characterized by a deep narrow channel and strong tidal currents. Substrate is composed of rocky outcrops, mud and gravel.

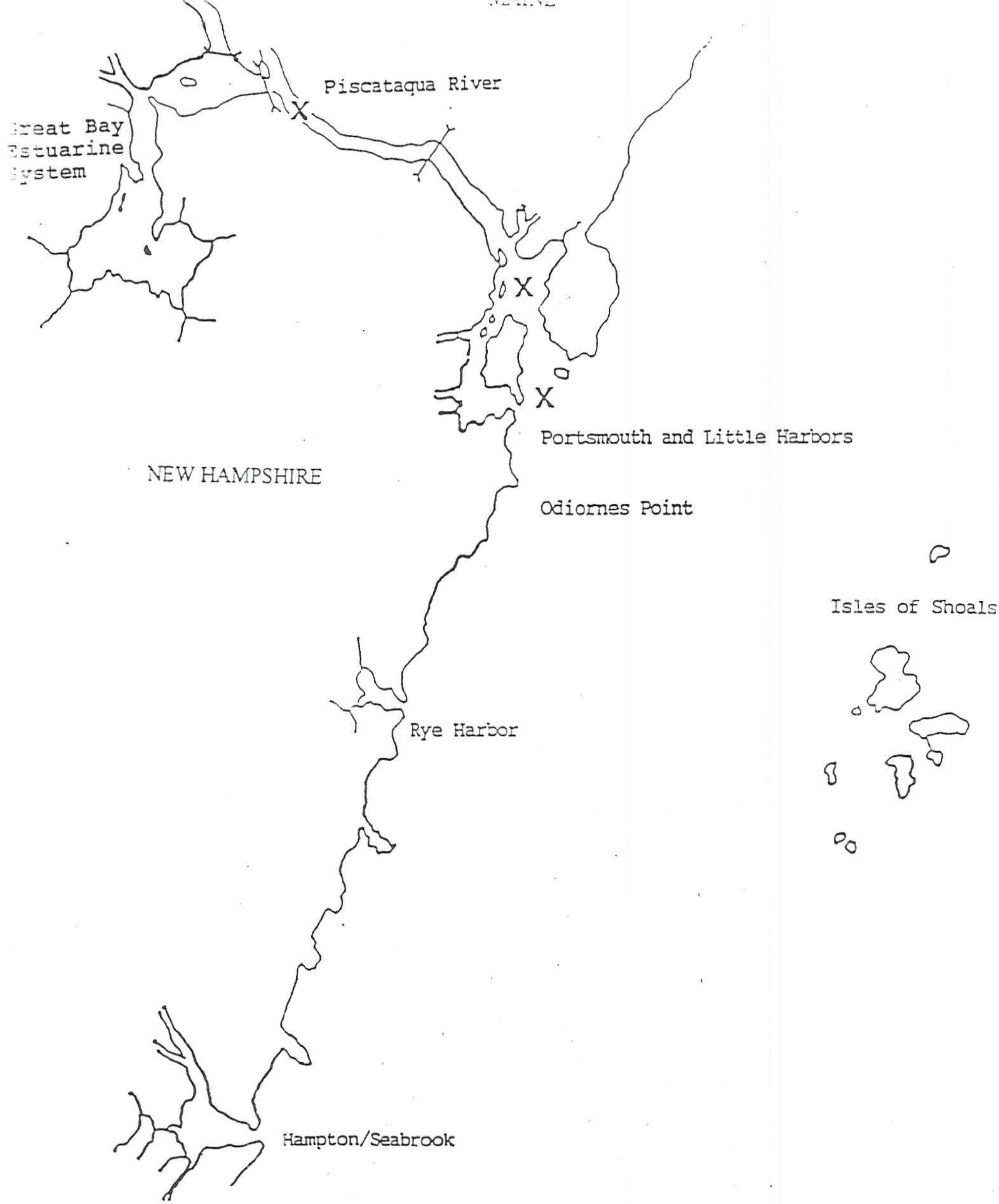

Figure 1. Study area with juvenile lobster sampling stations marked X.

Area 2 - (Portsmouth Harbor - lower river) - From the US 1 By-pass bridge downstream to the mouth of the Piscataqua River at Fort Point. Tidal currents are strong in the main channel, the river is generally wider than in Area 1. Substrate is a variety of rocky outcrops, assorted rocks, sand, gravel, and clay deposits.

Area 3 - (coastal) - Coastal area from the Maine border south to the Massachusetts border within 3 miles of shore. This area is characterized by moderate tidal and wind driven currents. Substrate is composed of outcroppings with assorted rocks and gravel.

Objective

The objective of this project was to monitor the abundance and habitat selection of sub-legal, juvenile lobsters in New Hampshire.

Methods

Lobster were sampled on a monthly basis from January to December at three sample sites (Figure 1). At each site, samples consisted of two SCUBA divers searching the bottom for lobsters. Lobsters encountered during dives were captured by hand (capture rates were not 100%) and were stored in catch bags until the end of the dive. Bottom time was measured for each dive and used as a measure of sampling effort. Since the objective of this project was to gather information on smaller, sublegal (i.e. juvenile) lobsters, some large lobsters (those that appeared to have carapace lengths greater than about 80 mm) were not aggressively pursued in favor of capturing greater numbers of small lobsters.

Following completion of the dive, the lobsters were briefly held in the water in catch bags until they were processed. All lobsters captured were sexed, measured (mid-dorsal carapace length to the nearest millimeter), noted for shell hardness or premolt condition (i.e. molt stage) and released. No tagged lobsters were encountered nor were any tagged in 1998. The date, location, surface temperature, and salinity were also recorded with each dive.

Differences in lobster size were analyzed using analysis of variance (ANOVA) with sample month, sample area and sex as the categorical variables. An ANOVA was run for all areas and months January to December. In addition multi-year ANOVAs were run. Lobster from area 3 only and months 2 to 12 and years 1992-1998 made up one ANOVA group. The other multi-year ANOVA looked at lobsters from all areas, months 1-12 and years 92-93 and 95-98. The 1994 data set is incomplete, lacking samples during some months and is therefore unsuitable for year to year comparisons. Where ANOVA detected significant differences in mean length among categories, either length frequency distributions were plotted for the various categories (e.g. sample area) or the mean length was plotted for each category (e.g. sample month mean). This was done to further analyze possible trends. Mean CPUE was plotted for each area by month to analyze trends. The percent of the sample population with softshells or premolt shells was recorded by month for each area to analyze trends in molting frequency and occurrence.

Results

A total of 1,632 lobsters were captured during sampling in 1998, with 11 of the total catch of legal size (i.e., 83 mmCL or greater). From this total, 768 were females and 864 were males. All captured lobsters were included in the data analysis.

Size composition

The ANOVA for SCUBA-sampled lobsters from the sample areas (upper river, harbor, and coast) for months 1 through 12 in 1998 revealed significant ($P \leq 0.05$) differences in mean lobster size for sample site and sample month (Table 1). The length frequency plots (Figures 2, 3 and 4) for SCUBA-caught lobsters show discernable differences in the distribution patterns of areas. The mean carapace length for the coastal juveniles (total=654) was 42.0 mm; while, the mean carapace length for the upper river (total=344) was 54.4 mm and the mean carapace length for the Harbor (total = 634) was 54.5 mm. Figure 5 illustrates an all-areas length frequency plot. The total mean carapace length at all locations was 49.5 mm.

Figure 6 illustrates that on an overall area basis, juvenile lobster size peaks in late summer - early fall, coupled with a trend of smallest mean carapace length during cold water months (Figure 7). Mean carapace length at the upper river peaks in September and October following the warmest water of the year in July and August. The smallest mean carapace length coincides with the coldest water temperature in March. The mean carapace length of juveniles

Table 1. **ANOVA of juvenile lobster carapace length by sex, site and month for areas 1 -3 for the months of 1 -12 in 1998.***

Source	DF	Sum of Squares	Mean Square	F	Pr+ >F
Sex	1	422.1	422.1	3.02	0.0826
Site	2	54282.4	27141.2	194.0	0.0001
Month	11	26312.3	2392.03	17.1	0.0001
Error	1617	226228.7	139.91		

* Number of observations in data set = 1632
+ = Probability

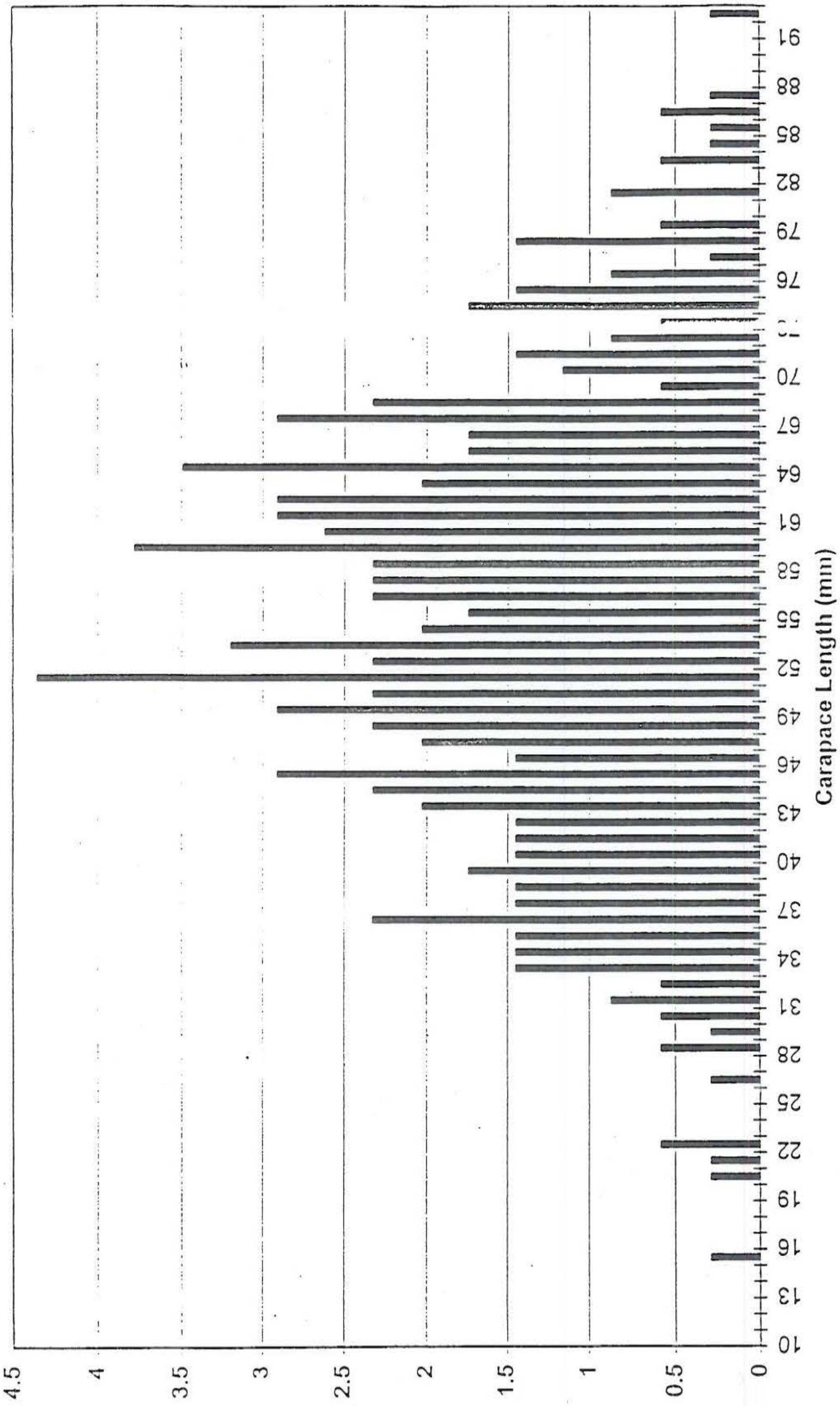

Figure 2. Length Frequency Distribution of SCUBA Caught Lobsters in 1998 at the Upper River.

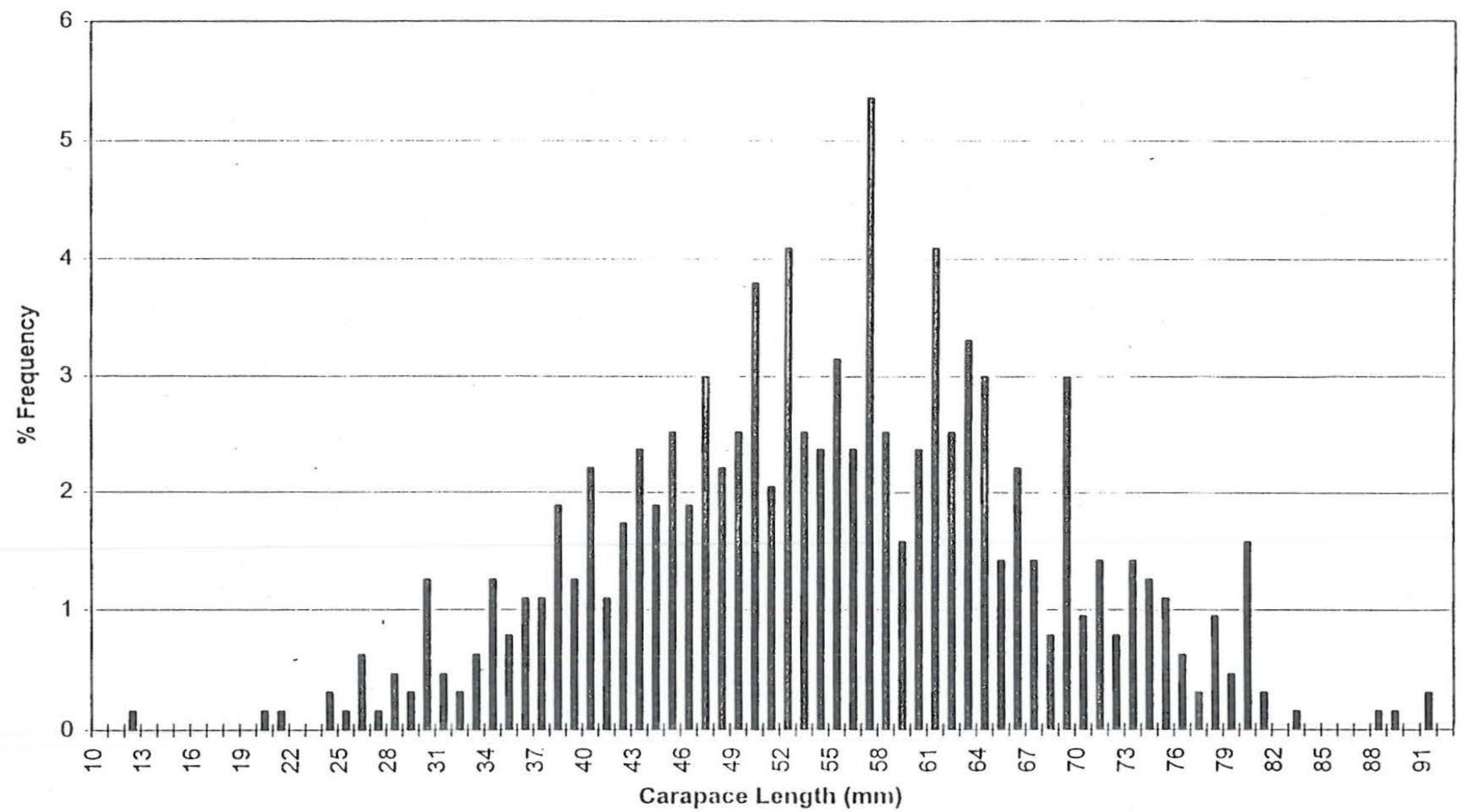

Figure 3. Length Frequency Distribution of SCUBA Caught Lobsters in 1998 at the Harbor.

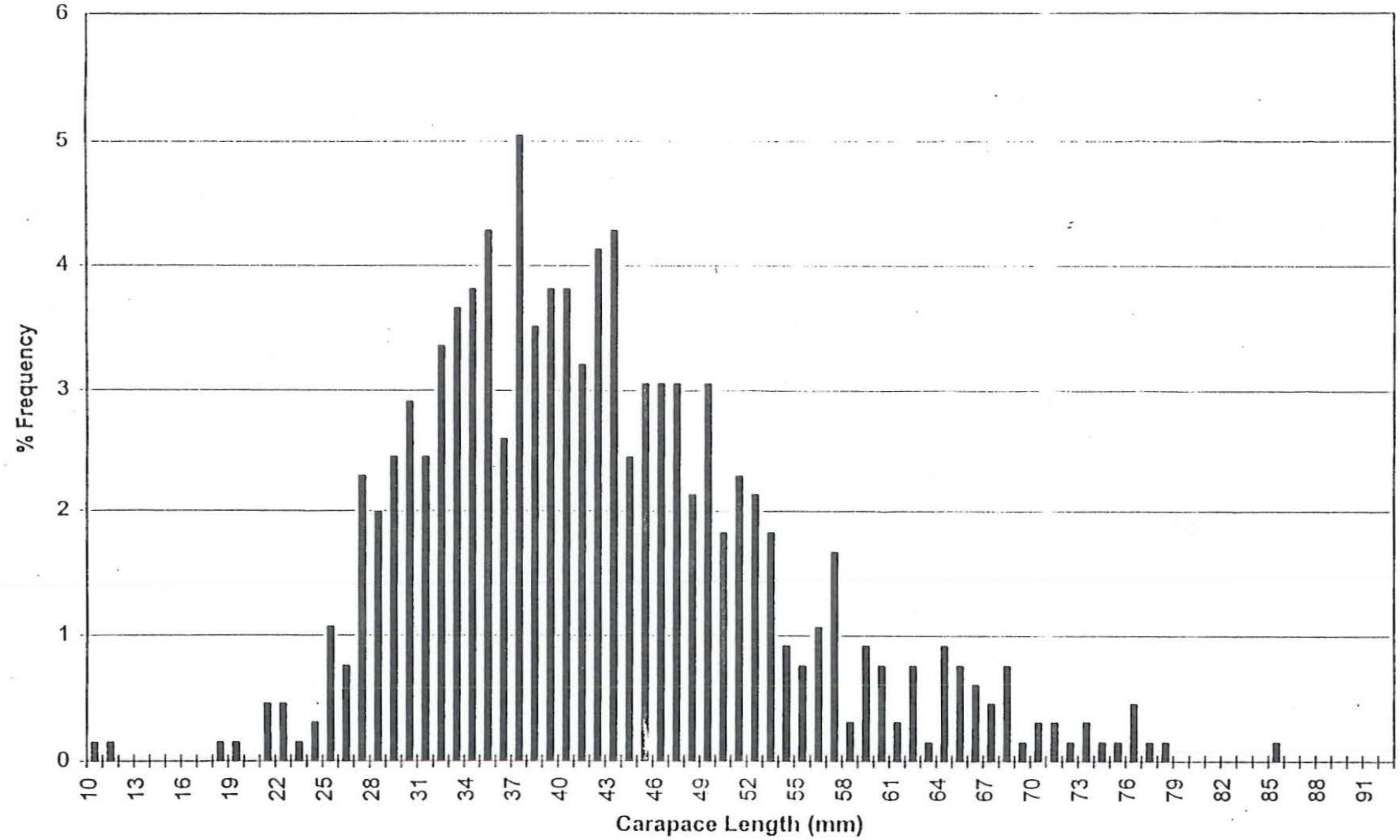

Figure 4. Length Frequency Distribution of SCUBA Caught Lobsters in 1998 at the Coast.

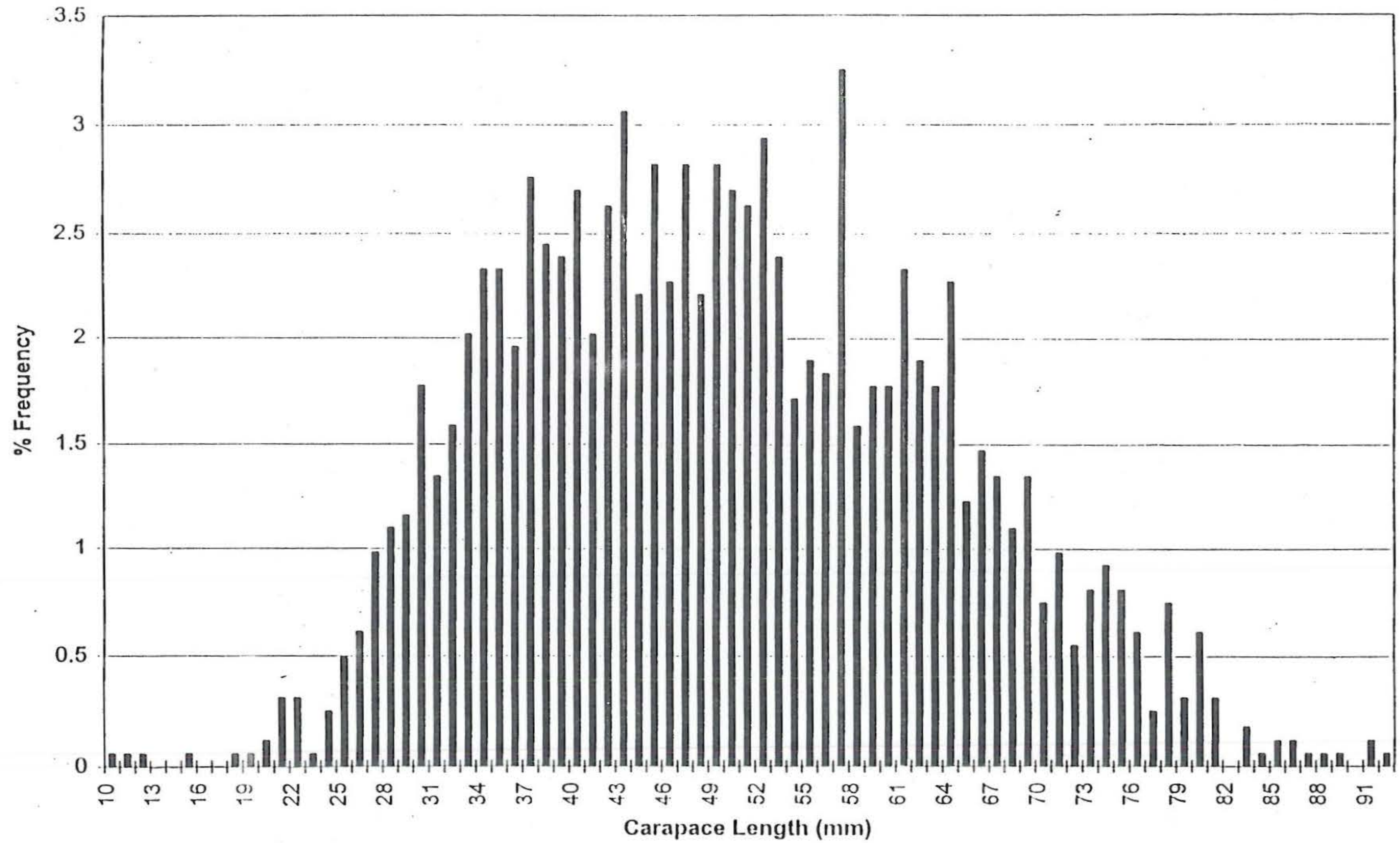

Figure 5. Length Frequency Distribution of SCUBA Caught Lobsters in 1998 from all areas.

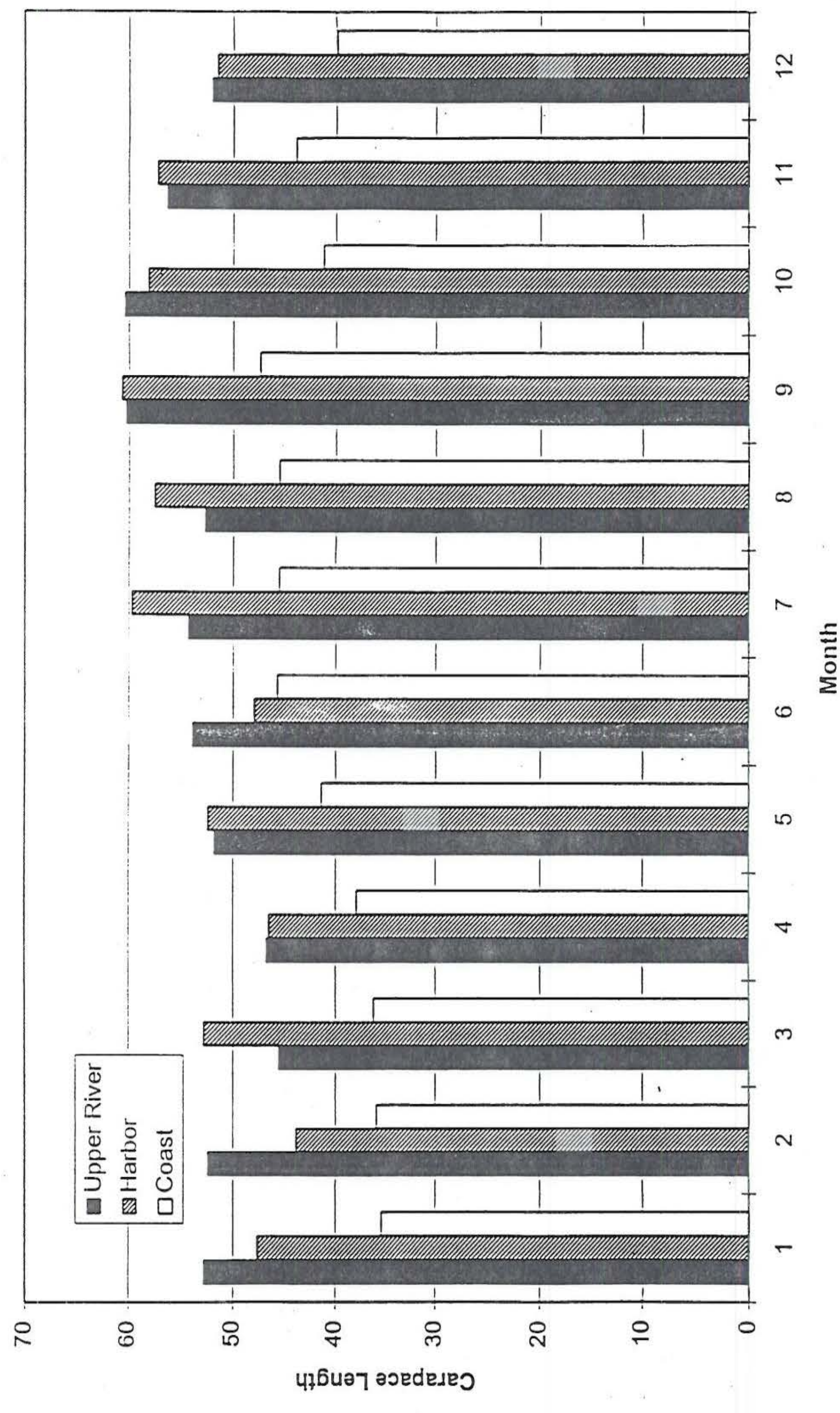

Figure 6. Carapace Length by Month and Area for SCUBA Caught Lobsters, 1998.

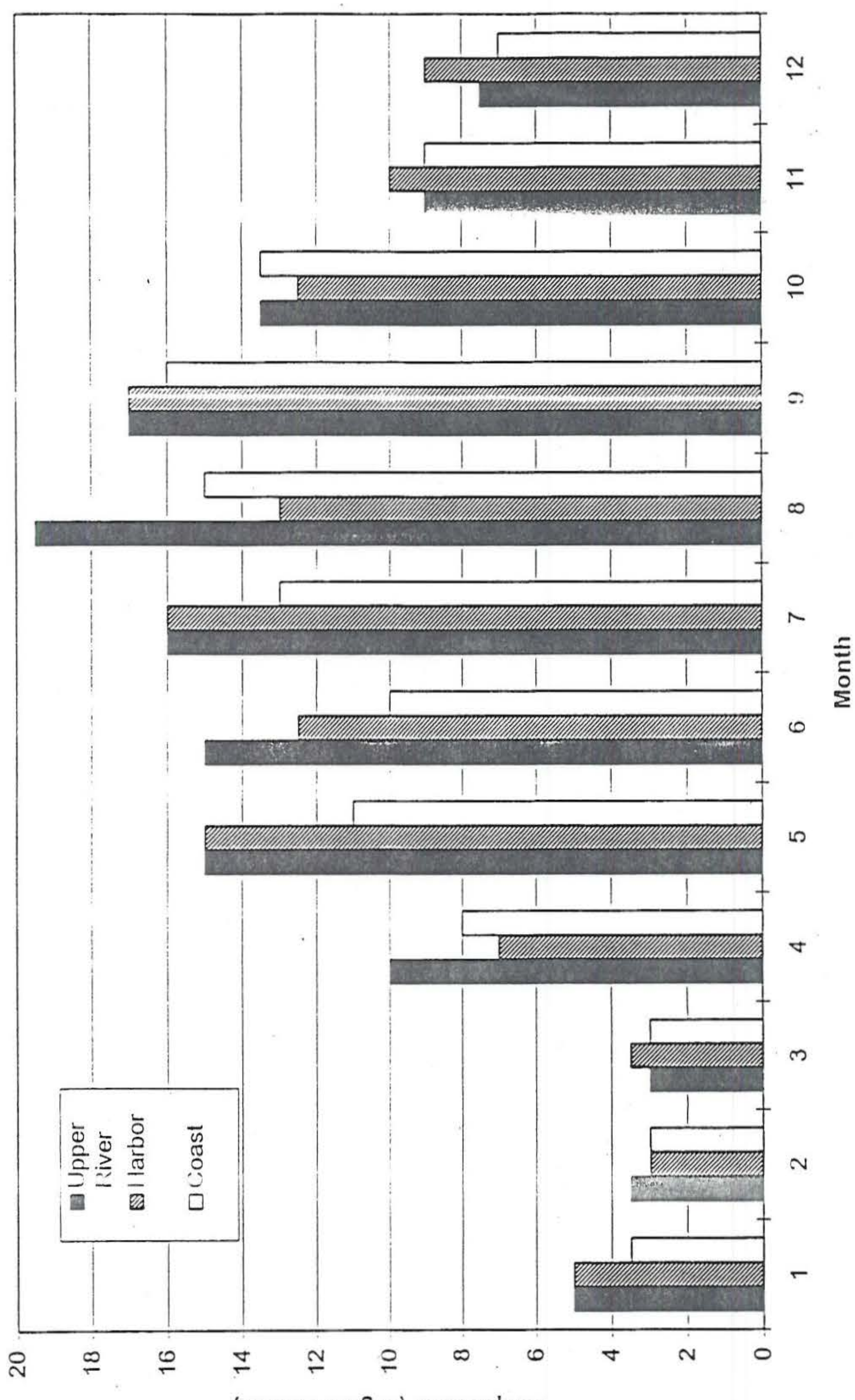

Figure 7. Water Temperature by Month, 1998.

and the water temperature from the Harbor area, both peak in September and both are the lowest in February. The same trend of maximum mean juvenile carapace length and corresponding water temperature occurs with a peak in September and the smallest captured juveniles (seen in January, February, and March) coinciding with the lowest water temperatures at the coastal area.

The ANOVAs comparing juvenile lobster data for the years 1992 through 1998 were done in two ways because of an incomplete data set for the 1994 season. Area 3, the coastal station, was analyzed for months 2-12 and years 1992-1998 (Table 2). Also analyzed (Table 3) were all areas, months 1-12 and years 1992-93 and 1995-98. The Area 3 specific ANOVA (Table 2) showed significant differences associated with all categorical variables except for sex. The ANOVA that looked at all areas and all years except 1994 (Table 3) revealed significance for sex as a main effect, but showed insignificant differences when broken down into pair-wise combinations.

Catch per effort

Plots of CPUE for the different areas over the various months suggest some general trends (Figure 8). Data for the upper river area showed that CPUE was extremely low in winter months, increased in May and June, fell in July, possibly due to low visibility, reached a peak in August and then fluctuated up and down throughout the fall and early winter. The catch rate for the Harbor was low for January and June and peaked in September. The coastal area showed high catch rates in January and February and then again in June and July. Catch per unit effort for the years 1992 - 1998 (Figure 9) tends to be lowest in March and April, show increase from May - October and then show a decline in November and December.

Table 2. **ANOVA of juvenile lobster carapace length by sex, month and year for sample years 1992 - 1998 and months 2-12 for the coast (area 3). ****

Source	DF	Sum of Squares	Mean Squares	F	Pr+ >F
Sex	1	400.2	400.2	2.6	0.1042
Month	10	47711.2	4771.1	31.5	0.0001
Year	6	11858.5	1976.4	13.04	0.0001
Sex *Month	10	1294.5	129.4	0.85	0.5761
Sex *Year	6	1283.7	213.9	1.4	0.2059
Month *Year	59	18811.9	318.8	2.1	0.0001
Error	4129	625702.3	151.5		

** Number of observation in data set = 4227
+ = Probability

Table 3. **ANOVA of juvenile lobster carapace length by sex, month and year for sample years 1992 - 1993 and 1995 - 1998 and months 1-12 in all areas (upper river, lower river, coastal)****

Source	DF	Sum of Squares	Mean Squares	F	Pr+ >F
Sex	1	5211.5	5211.5	31.3	0.0001
Site	2	212889.5	106444.7	639.8	0.0001
Month	11	119790.8	10890.1	65.5	0.0001
Year	5	30101.1	6020.2	36.2	0.0001
Sex *Site	2	2420.2	1210.1	7.3	0.0007
Sex *Month	11	2356.5	214.2	1.3	0.2242
Sex *Year	5	500.3	100.1	0.6	0.6989
Site *Month	22	21583.9	981.1	5.9	0.0001
Site *Year	10	25971.4	2597.1	15.6	0.0001
Month *Year	55	36907.8	671.1	4.0	0.0001
Error	10870	1808390.1	166.4		

**Number of observations in data set = 11,008
Only 10,995 observations were used
+ = Probability

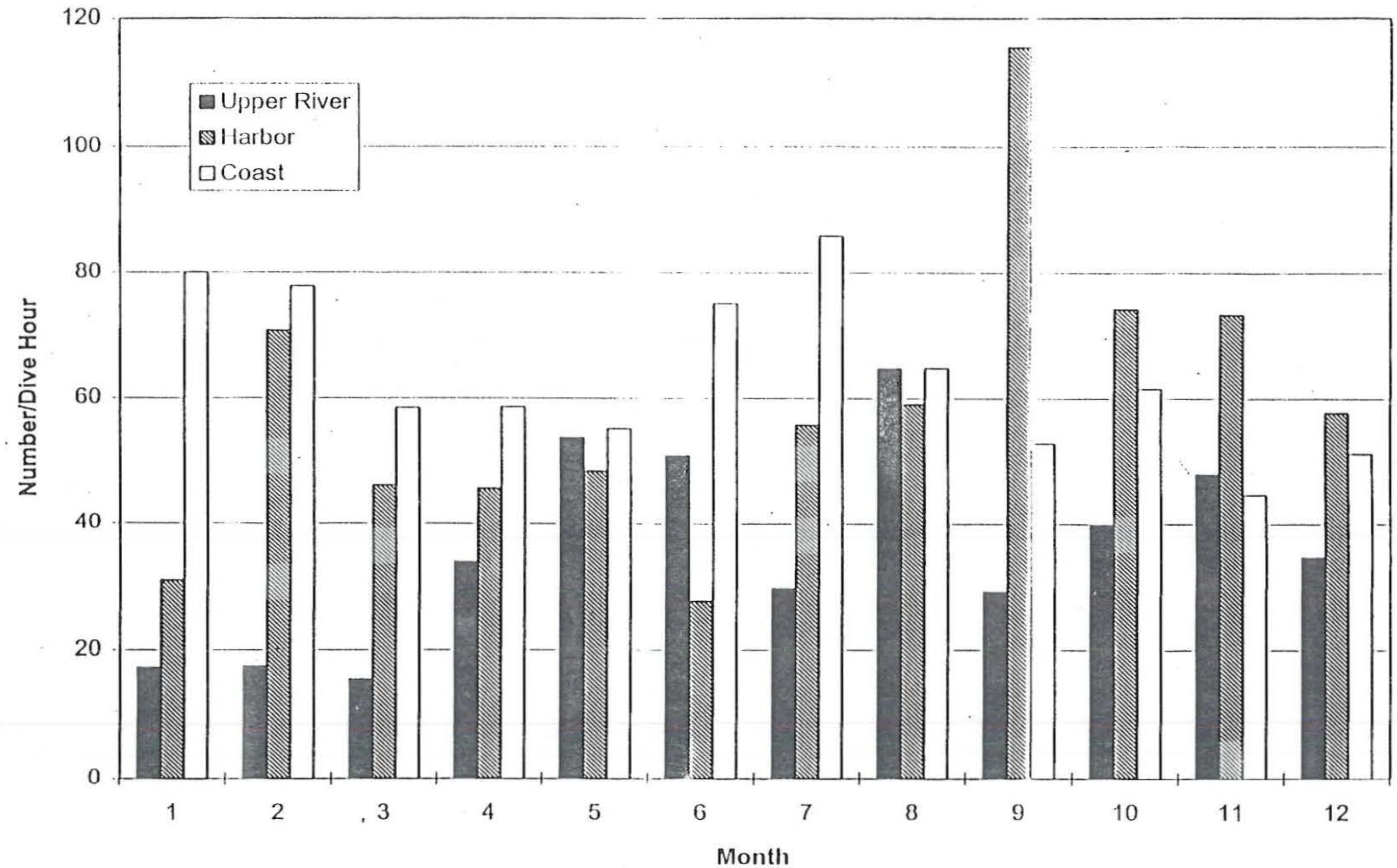

Figure 8. Catch Rate of SCUBA Caught Lobsters by Month and Area, 1998.

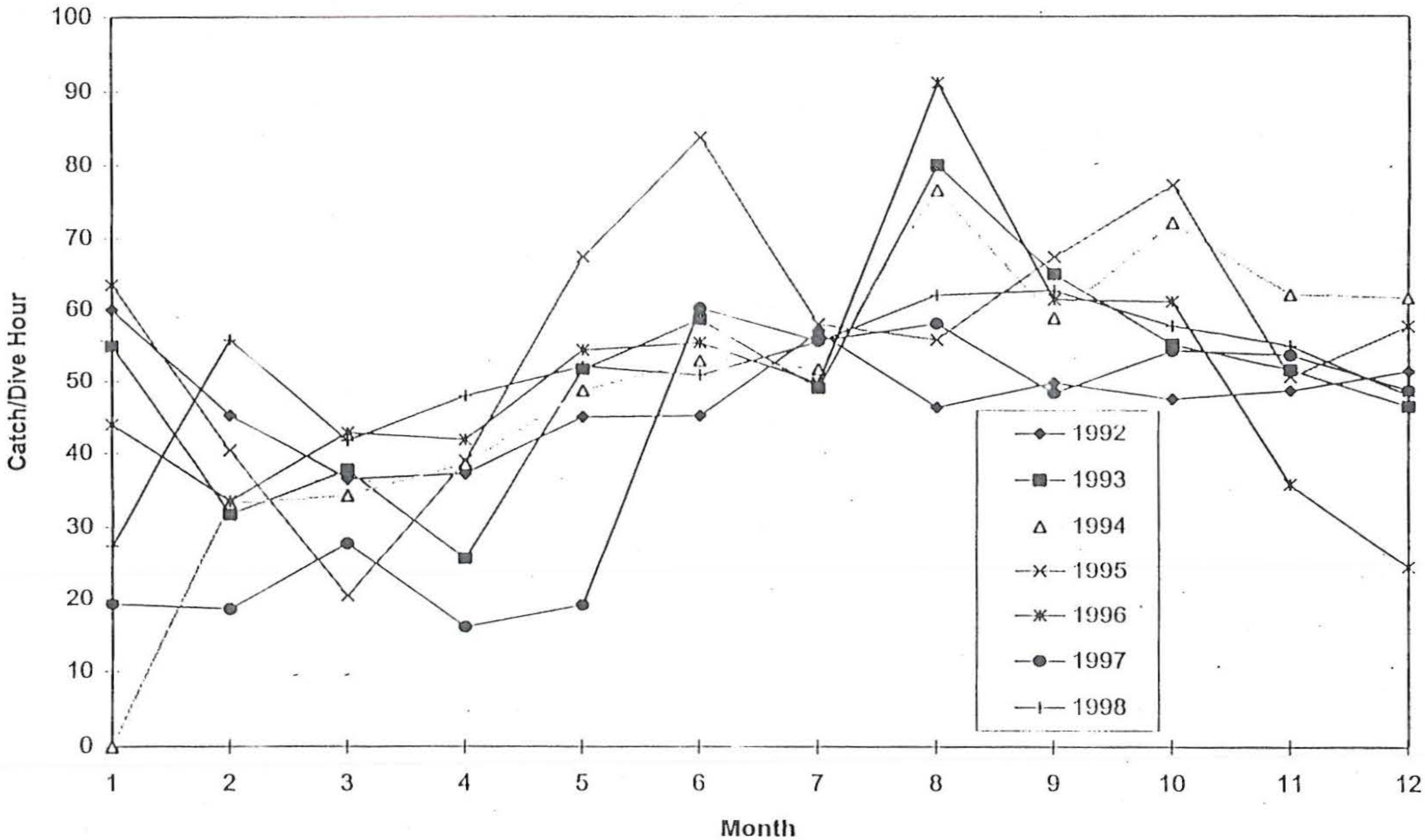

Figure 9. Comparison of SCUBA caught lobster catch per unit effort for all areas in years, 1992-1998.

Molting

Analysis of time of molting (Table 4) indicates that in 1998 there were two molt peaks when all sites are combined. One peak occurred in July and a higher peak was seen in October. Individual area peak molt times also occurred at these times for the Harbor and coastal locations. Molting peaked for the upper river in August and October. The area displaying the highest incidence of molting over the entire sampling period was the Harbor followed by the coast and upper river.

Discussion

Results from the 1998 SCUBA-caught lobster data show significant differences in mean lobster size by month and by area. Mean size of SCUBA-caught lobsters by month for 1998 repeated similar patterns observed in all earlier study years (NHF&G, 1993, 1994, 1995, 1996 and 1997). Mean size is generally smallest during cold water months. The reason for this trend is a combination of several factors. Growth could account for increase in juvenile lobster mean length through the summer/fall as supported by molt frequency data. The decrease in mean length over the late fall and winter is probably due to removal of newly recruited legal lobsters and temperature related migration of larger lobsters out of the study area in late fall and through the winter. Following this same logic, the warm water increase corresponding to mean juvenile lobster length during summer and early fall could in part be the result of immigration of larger lobsters into the study area. This sort of seasonal movement by larger (i.e. legal-sized) lobsters is well known (Herrick, 1909, Phillips et al., 1980, Duggan and Duggan, 1989, Robichaud and Campbell, 1991).

Sex was not a significant variable influencing lobster size (total lobster # = 1632) when combining all months and areas sampled in 1998 (Table 1). However, this varied

Table 4. **Percentage of 1998 SCUBA caught lobsters that were near molt conditions (i.e. recently molted or premolt) by sample site and month.**

Month	Upper River	Harbor	Coast	All Sites
May	0	0	0	0
June	4.4	0	0	1.4
July	4.0	9.4	7.9	7.8
August	7.3	4.5	2.4	4.7
September	0	5.0	2.7	3.5
October	9.3	13.2	18.5	14.6
November	0	4.5	0	2
All Months	3.8	5.7	5.3	5.1

during previous years (NHF&G 1993 - 1997). When including lobsters (total # = 4227) from 1992 - 1998 and months 2-12 from the coastal area (Table 2), again sex was not a significant variable influencing lobster size. A similar outcome was seen for the majority of the previously studied years (NHF&G 1993 - 1997). However, when combining all areas, resulting in the greatest number analyzed (total # = 10,995) from 1992 - 1993 and 1995 - 1998 and all months (1-12), sex appeared to be a significant variable influencing lobster size in the population (Table 3). This is supported by previously studied years (NHF&G 1993 - 1997).

The results from the larger sample sizes mentioned above are supported by findings in the literature (Phillips et al, 1980). Reasons for sex related size difference are likely due to the fact that males undergo molting more frequently than females once sexual maturity is reached. In addition to the frequency of molting between sexes which is directly tied to the carrying of eggs by the female (thus delayed molting) there is also the physiological demands of egg production and egg bearing that may require energy that otherwise might be converted into greater growth per molt or more frequent molts.

The results of the analysis of SCUBA-caught lobster by area showed that those with the largest average carapace length were found at the Harbor station followed by the upper river. The coastal area lobsters were the smallest on average. These results are supported by previous study years (NHF&G 1993-1998). This information coupled with an analysis of the length frequency distribution point to the possible importance of the coastal area as a rearing area for juvenile pre-recruit lobsters. The majority of lobsters from this area are in the smaller size classes from 30-50 mm. This size frequency distribution is slightly different from other areas. This may be the result of several factors including tidal drift patterns that carry early stage larvae to this area, available cover/habitat for juvenile lobsters, and/or lower predator pressure. It is also possible that the generally clearer coastal waters provide a better opportunity for capture of smaller lobsters. Further characterization of larval distribution, available habitat, predator abundance, and other environmental conditions that may influence early benthic stage lobster survival would be needed to better understand this.

The results from analysis of catch per unit of effort revealed some general trends in the relative abundance of SCUBA-caught lobsters throughout the season. Catch per unit effort was low in cold water months (i.e. January, February, March) at the upper river location with an increase in lobsters caught as the water temperatures became warmer. Catch per unit effort appeared to be somewhat random for the Harbor and coastal areas. Perhaps these differences are due to unfavorable visibility days (which make lobster catch difficult), the differences in experience between collectors, or to unfavorable environmental conditions. Catch per unit effort for the years 1992 - 1998 show fluctuating results with lowest levels in cold water months. The drop in catch per unit effort for 1996 in November and December is most likely due to heavy rains in October of that year.

Timing of molting appeared to be temperature dependent with molting occurring in the various areas only after the surface temperature in the respective areas reached about 15°C. The second peak observed in October was noted in the earlier years of this study and is likely the result of second season molts by small size class river station lobsters and the relatively delayed molts of lobsters at those stations offshore where seasonal water temperature rises lag behind those in the river.

In summary, the 1998 SCUBA lobster monitoring program found the size, sex and molt pattern of the New Hampshire coastal and estuarine population to be generally similar to that seen over the past 6 years. It is shown that in examining a large sample size, sex is seen as a significant variable influencing lobster size.

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