

FINAL REPORT



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DEPARTMENT OF COMMERCE

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Managed Species in New Hampshire

Project Dates: January 1, 2002 - March 31, 2003

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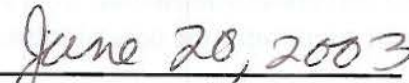
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INTRODUCTION

The passage of the Atlantic Coastal Fisheries Cooperative Management Act (ACFCMA) in 1993 placed additional responsibilities on Atlantic coast states to cooperatively manage interjurisdictional species through the Atlantic States Marine Fisheries Commission (ASMFC). Currently there are eleven ASMFC species management plans that the state of New Hampshire is required to be in compliance with under the ACFCMA. They include fisheries management plans for: American lobster, American eel, Atlantic menhaden, Atlantic sturgeon, bluefish, northern shrimp, shad and river herring, winter flounder, striped bass, horseshoe crabs and Atlantic sea herring.

The following programs were implemented to improve recreational and commercial data collection and implement a new fisheries independent monitoring project.

The objectives of the projects are as follows:

1. To collect marine recreational fishing statistics in New Hampshire that will be comparable with other state, regional and coastwide estimates.
2. To monitor the relative abundance of juvenile finfish utilizing New Hampshire estuaries for nursery habitat.
3. To enhance the fisheries dependent data collected for New Hampshire's commercial fisheries.
4. To collect catch and effort information from New Hampshire's lobster fishery via logbooks in order to monitor the coastal lobster resource.
5. To characterize trends in annual recruitment of young-of- the-year American eel over time in New Hampshire waters.
6. To identify potential spawning and nursery habitat for horseshoe crab within New Hampshire waters.

**JOB 1: COOPERATIVE MARINE RECREATIONAL STATISTICS DATA
COLLECTION
Final Report**

ABSTRACT

Since 1997, the New Hampshire Fish and Game Department (NHFG) has cooperated with the National Marine Fisheries Service to conduct the field intercept portion of the Marine Recreational Fishing Statistical Survey (MRFSS). A total of 2,424 surveys were conducted in 2002, which was approximately a 3X increase over the 785 baseline surveys allocated by NMFS for New Hampshire.

During 2002, marine recreational fishers in New Hampshire caught an estimated 1.0 million fish with less than half of those fish being harvested. Thirty one different species or families of fish were reported caught during this year's survey but five species - Atlantic mackerel, pollock, Atlantic cod, striped bass and spiny dogfish - accounted for 82% of the catch. In the harvest category, 93% consisted of Atlantic mackerel, pollock, Atlantic cod, haddock and bluefish. Catches were highest in Wave 3 (May/June) driven by large catches of Atlantic mackerel and pollock. Anglers in the private/rental mode accounted for the largest share of the catch followed by party/charter and shore anglers.

Total annual effort in New Hampshire was estimated to be 318,430 angler trips in 2002 with private boat and shore anglers accounting for near equal contributions to the total. Participation in New Hampshire's marine recreational fishery was estimated at 136,634 anglers in 2002 with non-residents comprising roughly half those individuals.

NHFG continued to conduct a separate survey for estimating effort in its party boat fishery using similar methods to those used in previous years as part of the NH-MRFS. In 2002, it was estimated that 48,968 angler trips were taken aboard New Hampshire party boats.

INTRODUCTION

Information concerning the recreational segments of marine fisheries is vital for making management decisions concerning the resource and the associated fisheries. Since 1979, the National Marine Fisheries Service (NMFS) has conducted a Marine Recreational Fishing Statistical Survey (MRFSS) to gather regional and coast wide information concerning marine

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recreational fishing in the United States. Due to the regional emphasis of this survey, it has not produced state specific information that is sufficiently precise or accurate, particularly in states with small coastal areas like New Hampshire.

As a result, the New Hampshire Fish and Game Department (NHFG) initiated a state survey of New Hampshire's marine recreational fishery in 1979. The survey was conducted annually from 1979 to 1996 (with the exception of 1983 and 1985), to obtain estimates of total catch, total effort, catch per unit effort, percent species composition of the catch, and length frequency data for harvested fish. During these surveys, between 2,000 and 3,000 marine recreational anglers were interviewed, annually.

In 1995, a side-by-side comparison was conducted of New Hampshire's Marine Recreational Fishing Survey (NH-MRFS) and the MRFSS. For this comparison, both the number of field intercepts and the number of phone surveys for effort were increased in an attempt to improve the precision of the state level catch and effort estimates of the MRFSS to levels comparable to those obtained by the NH-MRFS. The results of that comparison study suggested that the MRFSS underestimated the effort and catch in the party/charter (PC) mode during 1995 while the NH-MRFS underestimated the effort and catch in the shore (SH) and private/rental (PR) modes (Grout and Heckman 1996).

The results of this study, combined with the desire to eliminate duplication of effort, prompted the New Hampshire Fish and Game Department to discontinue the NH-MRFS in favor of cooperating with NMFS in conducting the MRFSS in New Hampshire beginning in 1997. However, due to the continuing concerns about accuracy of the MRFSS methods used to estimate effort in the party/charter mode in New Hampshire, the Department elected to continue to conduct its own effort estimation program for party boats.

The objective of this study was to collect marine recreational statistics in New Hampshire that will be comparable with other state, regional and coast wide estimates derived from the federal survey (NMFS's Marine Recreational Fisheries Statistical Survey).

PROCEDURES

The MRFSS has two basic components: a random telephone survey of coastal-county households for estimating fishing effort and an on-site intercept survey to collect catch data from marine recreational anglers. In 2002, NHFG personnel conducted the field intercept portion of

the MRFSS in New Hampshire while Macro International, Inc. was contracted to conduct the telephone survey. In addition to the 785 base line surveys allocated by NMFS for New Hampshire, NHFG planned to conduct an additional 1,166 field intercepts (~ 1.5 X increase) during 2002 (Table 1-1). The additional on-site interviews were conducted in Waves 3-5 and allocated between wave and fishing mode in direct proportion to the NMFS base line allocation developed by NMFS. The intent of the additional surveys was to improve the precision (as measured by the percent standard error or PSE) of the catch estimates for six important recreational species in New Hampshire: bluefish (*Pomatomus saltatrix*), Atlantic cod (*Gadus morhua*), Atlantic mackerel (*Scomber scombrus*), pollock (*Pollachius virens*), striped bass (*Morone saxatilis*), and winter flounder (*Pleuronectes americanus*).

Standard MRFSS procedures were used as outlined in the Intercept Interviewer Procedures Manual of the MRFSS.

In an attempt to address the chronic interview shortfall experienced in the Wave 5 shore mode, the May and September assignment draw was split into two parts beginning in 2000: one for the first half of the month and one for the second half of the month. Having two assignment draws allowed more assignments to be scheduled during the half of the month when fishing pressure is much greater.

During 2002, phone surveys of households in the four "coastal" counties (Hillsborough, Merrimack, Rockingham and Strafford) in New Hampshire were made to obtain estimates of effort. The number of surveys conducted during waves 4 and 5 were 1956 and 940 respectively. Due to problems involving the contractor, no estimates were made using data generated from the phone calls made for wave 3 in 2002. As an alternative, an average of the wave ~~three~~³ estimates from data collected between 1999-2001 was used for the wave 3 estimate in 2002.

MRFSS estimates presented in this report for catch, harvest, effort, and participation as well as length frequency information were all collected from the NMFS web site <http://www.st.nmfs.gov/recreational>.

Additionally, the NH-MRFS procedures for attaining effort estimates for New Hampshire party boats were continued this year to provide an alternative to the MRFSS effort estimates for this segment of the fishery. The estimates were obtained by a two part survey: 1) a telephone survey and/or website check was conducted for each party boat company to determine the number of boat trips scheduled to be taken each month and 2) randomly selected field intercept

surveys to count the number of anglers on a party boat trip.

The telephone portion of the survey involved contacting each party boat company prior to the start of each month to obtain their anticipated schedule of boat trips each month by trip type (full day, half day, evening, overnight, etc.). The total number of trips were then summed by trip type and then adjusted up or down based on follow up information obtained during the field intercept survey or, in some cases a follow up phone call. Adjustments to the monthly boat trip numbers were made due to changes in the boat schedules implemented by companies subsequent to the initial phone call or scheduled trips that didn't go out because of bad weather, boat malfunction, lack of customers, etc.. All adjustments were made on a trip-by-trip basis with the exception of bad weather days in which it was assumed that all scheduled trips for that day for each party boat company were canceled if one company canceled due to weather.

The field intercept surveys to determine angler counts were conducted in conjunction with scheduled MRFSS field intercepts at the sites with party boat operations. During the survey, interview personnel obtained the number of anglers on the party boat by counting the passengers coming off the vessel or by querying the vessel captain or vessel passengers. In addition, it was determined whether the boat took a half day, full day, evening, or overnight trip. This information was collected for every party boat trip encountered during an assignment.

To estimate the total number of angler trips for New Hampshire party boats, the data were stratified by month and half or full day trip types. For the purposes of this survey, full day and overnight trips were classified as full day trips while all other trip types (half day, evening, and two hour trips) were considered as half day trip types. For each strata, the total number of boat trips was multiplied by the mean number of anglers per boat trip to obtain an estimate of the number of anglers trips. The estimates by strata were then summed to obtain an annual estimate of party boat effort.

RESULTS

A total of 2,424 anglers were interviewed in New Hampshire during 2002 for the MRFSS field intercept survey (Table 1-1). Total allocated interview levels were exceeded in all waves and modes.

At least 31 different species or families were reported or identified as being caught by recreational anglers in 2002 (Table 1-2). Just over 1 million fish were caught by marine

recreational anglers in New Hampshire during 2002. Less than half of the fish caught were harvested. Atlantic mackerel, pollock, Atlantic cod, striped bass, and spiny dogfish accounted for 82 % of the catch (Table 1-3). The top five species harvested were Atlantic mackerel, pollock, Atlantic cod, haddock and bluefish (Table 1-4). These species accounted for 93% of the harvest. The largest catches occurred in Wave 3 (May/June) and were primarily the result of sizeable catches of mackerel in the PR and PC modes. Catches of striped bass, pollock, and cod from private boats and cod from party and charter boats were also substantial during this wave. Wave 4 catch was dominated by large numbers of Atlantic mackerel and pollock in the PR mode. In wave 5, catch was dominated by bluefish taken in the PR mode. Anglers fishing in the PC and PR modes landed high numbers of Atlantic cod, Atlantic mackerel, and pollock as well.

Atlantic mackerel made up by far the largest portion of the marine anglers harvest in New Hampshire (52%) followed by pollock and cod. Atlantic mackerel harvest was highest in waves 3 and 4 but dropped off in wave 5. Other significant contributions to the total harvest were pollock in the PR mode during all three waves as well as Wave 3 harvest of cod and haddock by PC and PR anglers.

The MRFSS estimated more than 318,000 angler trips taken in New Hampshire during the 2002 season (Table 1-5). Shore anglers accounted for nearly half of the trips, the majority of which occurred in July and August (Wave 4). Participation was estimated at over 136,000 anglers during 2002 with roughly half of these anglers being non-residents (Table 1-6).

Effort estimates for the 2002 party boat fishery in New Hampshire derived from the NH-MRFS procedures are presented in Table 1-7. The survey estimated 48,968 angler trips were taken aboard party boats in New Hampshire during 2002. The peak effort in August consisted of roughly two times more half-day trips than full day trips.

Length frequency data derived from MRFSS for selected species harvested by New Hampshire anglers in 2002 are presented in Table 1-8. It should be noted that MRFSS length data are measured and presented as *fork length* (tip of the nose to the posterior tip of caudal fin at its center line) as opposed to total length measurements (tip of the nose to the most posterior portion of the caudal fin). Sample sizes for this figure are generally low as well. Atlantic mackerel ranged in size from 8 to 15 inches with modes at 11 and 13 inches. The striped bass distribution was bimodal as well with lengths ranging from 24 to 39 inches fork length and modes at 27 and 30 inches.

DISCUSSION

The numbers of fish caught dropped from roughly 2.4 million in 2001 to just over 1.0 million in 2002 primarily due to a decrease in Atlantic mackerel catch (Table 1-3). The decreased catch was evident in all three waves. Mackerel catch over the entire north Atlantic region, as estimated by MRFSS, declined by nearly 1 million fish from 4.6 million in 2001 to 3.8 in 2002, which can partially explain the decrease estimated for NH waters. Timing of movement is another potential explanation evident from MRFSS data. The wave 5 catch in Maine was estimated to be 1,014,993 in 2002, an abnormally large estimate for Maine in any wave. This suggests that mackerel may have delayed southward migration in 2002 subsequently decreasing the wave 5 catch estimate for NH.

Another interesting occurrence in the catch data was the appearance of spiny dogfish replacing haddock as number 5 on the list of most commonly caught species. The remaining species on this list in order of abundance were Atlantic mackerel, striped bass, pollock, and Atlantic cod. Haddock numbers decreased slightly in 2002 to 62,221 while spiny dogfish numbers increased to 64,924. Haddock catch has remained strong since 2000 when compared to catch estimates from the 1990's (Table 1-9).

Catch estimates for the 7 species of special interest were split with 3 species increasing in number over the 2001 estimates and 4 species decreasing (Table 1-9). Bluefish, striped bass, and winter flounder catch estimates all increased while decreases were recorded for Atlantic cod, Atlantic mackerel, pollock, and haddock.

The estimated number of fish harvested by recreational anglers in NH during 2002 was less than half of the 2001 number (Table 1-4). The drop in Atlantic mackerel discussed above is a likely contributing factor. Time series patterns for harvest of the 7 species of special interest were similar to those reported for catch with the exception of striped bass and winter flounder (Table 1-9). For these two species, the catch estimate increased while harvest estimates for both number and weight represent decreases compared to 2001 values.

The patterns apparent in length data presented in Tables 1-8 and 1-9 reveal some limitations associated with small sample sizes. It is, however, still possible to see the effect of regulatory changes for specific species in the length data. For example, an increase was seen in

the mean length of Atlantic cod (N=62) measured as part of MRFSS. The mean length of Atlantic cod measured as part of MRFSS was 698.7 mm, the largest value ever recorded. This could be in response to an increase in the size limit to 23 inches (584.2mm) in state and federal waters. The mean haddock length (N=10) actually decreased from 560.7 mm to 536 mm possibly due to the limited number of fish measured. The striped bass value (N=69) of 770.3 mm dropped for the second straight year from 902.6 in 2000. Pollock had the smallest sample size of any species of special interest at N=7 with a mean size of 629.4, the largest value on record by this survey in NH. Finally, the mean length of bluefish (N=28) dropped to the lowest level on record at 652.3 mm.

The precision of NH catch and harvest estimates for 7 species of special interest are generally good with a few exceptions (Table 1-9). There has been an overall improvement in the precision levels for all estimates since 1995 when intercept numbers were tripled and phone survey numbers were first increased in New Hampshire (Tables 1-9 and 1-10). The percent standard error (PSE) estimated for winter flounder is the only one in the catch category to exceed the target value of 20% at 29.2. This is due to a low number of winter flounder recorded by MRFSS intercepts. Harvest estimate PSE's were above 20% for bluefish, pollock, and winter flounder. Again, the high error is likely due to low sample size.

The estimate of effort, described by MRFSS as the number of angler trips, decreased slightly for the second year in a row (Table 1-10). The increasing trend in effort in recent years has been credited to substantial increases in the shore and to a lesser extent private boat modes. As a general rule, shore effort has been the dominant fishing pressure reported by MRFSS since the mid to late 1990's. In 2002, however, private boat and shore anglers accounted for a near equal number of trips for the first time since 1995.

The MRFSS PC mode effort estimate decreased from 83,327 in 2001 to 29,120 angler trips in 2002. The estimate produced by NH-MRFS PC mode, however, shows PC effort essentially level at roughly 50,000 trips per year. The precision and accuracy of the MRFSS generated PC estimate has been in question for a number of years and steps are being taken to rectify the issues associated with this estimate. In coming years this mode will be split forming two new modes for party boats and charter boats separately. Further, effort estimates for these new modes will be generated using a direct survey of the boat captains rather than a telephone survey of anglers that have taken trips in the PC mode as is currently done.

Precision levels for effort estimates have improved in response to increases in sample size and the spatial distribution of the phone survey in recent years. Similar trends have been observed for the precision levels of the participation estimates. The 2002 values remained low after many hit the lowest mark on record in 2001 (Tables 1-6 and 1-10). The first improvements were observed in 1995 when the number of phone surveys allocated to New Hampshire was increased by 400-500 calls to 2,000 phone calls. Further improvements in the PSE's were observed in 1997 when sample size was further increased to nearly 3,000 calls. The number of phone surveys conducted in NH was increased to 3,812 in 1998 and the calling area was expanded to include the entire state (as opposed to just coastal counties) as a part of a pilot project for the (ACCSP). Current phone survey sample is nearly 4,000 calls with the 2001 PSE for effort being the lowest on record.

In summary:

- 1) The numbers of fish caught and harvested during 2002 were less than half of the values estimated during the 2001 season due in large part to a drop in Atlantic mackerel.
- 2) Spiny dogfish replaced haddock as the fifth most commonly caught fish over the past season.
- 3) Interpretation of length data remains limited because of low #'s of fish measured for selected species. Regulatory changes are still evidenced by the data, however, in instances where sample size is sufficient.
- 4) The estimate of effort decreased for the second straight year but remains high compared to the long-term trend.
- 5) Precision levels of the catch, harvest, effort, and participation estimates in New Hampshire have all improved since increases in the number of field intercepts and telephone surveys conducted in the state have been increased beginning in 1995.

REFERENCE:

Grout, D.E. and K. Heckman. 1996. Programs Improving Management of ASMFC Managed Species in New Hampshire. 1995 Final Report. NMFS Federal Aid Project 3-ACA-006. NH Fish and Game Dept. 34pp.

Table 1-1. Interviews allocated by NMFS, interviews allocated by New Hampshire State, interviews obtained, allocation shortfalls, and effort information for MRFSS field intercept surveys collected in New Hampshire during 2002.

NEW HAMPSHIRE	INTERVIEWS ALLOCATED			INTERVIEWS OBTAINED	SHORT FALLS		EFFORT HOURS	EFFORT PER INTERVIEW
	NMFS	STATE	TOTAL		NMFS	STATE		
WAVE 2 (Mar/Apr)								
SH	0	0	0	0	0	0	0	0
PC	67	0	67	79	0	0	21.75	0.28
PR	0	0	0	0	0	0	0	0
TOTAL	67	0	67	79	0	0	21.75	0.28
WAVE 3 (May/June)								
SH	61	102	163	203	0	0	93.75	0.46
PC	78	130	208	233	0	0	58.50	0.25
PR	105	175	280	379	0	0	126.75	0.33
TOTAL	244	407	651	815	0	0	279.00	0.34
WAVE 4 (July/Aug)								
SH	85	142	227	266	0	0	88.00	0.33
PC	87	145	232	308	0	0	89.00	0.29
PR	91	152	243	344	0	0	102.00	0.30
TOTAL	263	439	702	918	0	0	279.00	0.30
WAVE 5 (Sept/Oct)								
SH	76	95	171	177	0	0	162.50	0.92
PC	69	115	184	237	0	0	58.75	0.25
PR	66	110	176	198	0	0	98.75	0.50
TOTAL	211	320	531	612	0	0	320.00	0.52
GRAND TOTAL	785	1166	1951	2424			899.75	0.37

Table 1-2. List of fish species or fish types reported caught by anglers in New Hampshire's marine recreational fishery from 2002.

SUPERGROUP NAME	COMMON NAME	SCIENTIFIC NAME
BLUEFISH	BLUEFISH	<i>Pomatomus saltatrix</i>
CARTILAGINOUS FISHES	SPINY DOGFISH	<i>Squalus acanthias</i>
	UNIDENTIFIED (SHARKS)	
	LITTLE SKATE	<i>Raja erinacea</i>
	SKATES GENUS	<i>Raja</i>
CODS AND HAKES	ATLANTIC COD	<i>Gadus morhua</i>
	COD FAMILY	<i>Gadidae</i>
	CUSK	<i>Brosme brosme</i>
	HADDOCK	<i>Melanogrammus aeglefinus</i>
	HAKE GENUS	<i>Urophycis</i>
	SILVER HAKE	<i>Merluccius</i>
	WHITE HAKE	<i>Urophycis tenuis</i>
	POLLOCK	<i>Pollachius virens</i>
	RED HAKE	<i>Urophycis chuss</i>
FLOUNDERS	UNIDENTIFIED FLOUNDERS	<i>Pleuronectiformes</i>
	YELLOWTAIL FLOUNDER	<i>Limanda ferruginea</i>
	SUMMER FLOUNDER	<i>Paralichthys dentatus</i>
	WINTER FLOUNDER	<i>Pleuronectes americanus</i>
HERRINGS	AMERICAN SHAD	<i>Alosa sapidissima</i>
	ATLANTIC HERRING	<i>Clupea harengus</i>
SCULPINS	SCULPIN FAMILY	<i>Cottidae</i>
	SEA RAVEN	<i>Hemitripterus americanus</i>
SEAROBINS	SEAROBIN GENUS	<i>Triglidae</i>
TEMPERATE BASSES	STRIPED BASS	<i>Morone saxatilis</i>
TUNAS AND MACKERELS	ATLANTIC MACKEREL	<i>Scomber scombrus</i>
WRASSES	CUNNER	<i>Tautoglabrus adspersus</i>
OTHER FISHES	ATLANTIC WOLFFISH	<i>Anarhichas lupus</i>
	GOLDEN REDFISH	<i>Sebastes norvegicus</i>
	GOOSEFISH	<i>Lophius americanus</i>
	OCEAN POUT	<i>Macrozoarces americanus</i>
	UNIDENTIFIED BOTTOM FISH	

Table 1-3. Estimates of total catch, by wave, mode and species, from New Hampshire's marine recreational fishery derived from the MRFSS during 2002.

CATCH - 2002

SUPERGROUP NAME	COMMON NAME	Wave 3				Wave 4				Wave 5				ANNUAL TOTAL	PSE
		SH	PC	PR	TOTAL	SH	PC	PR	TOTAL	SH	PC	PR	TOTAL		
BLUEFISH	BLUEFISH			3,775	3,775		1,179	4,330	5,509	127	6,713	16,989	23,829	33,113	18.8
CARTILAGINOUS FISHES	SPINY DOGFISH		10,205	8,003	18,208		2,622	22,074	24,696		8,384	13,636	22,020	64,924	16.9
CARTILAGINOUS FISHES	UNIDENTIFIED (SHARKS)				0			6,032	6,032				0	6,032	55.3
CARTILAGINOUS FISHES	LITTLE SKATE	726			726	241			241				0	967	51.8
CARTILAGINOUS FISHES	SKATES GENUS	10,509		2,416	12,925	5,790		483	6,273	254		3,577	3,831	23,029	22.1*
CODS AND HAKES	ATLANTIC COD		36,534	26,106	62,640		5,365	18,176	23,541		9,109	12,965	22,074	108,254	11.9
CODS AND HAKES	COD FAMILY		489		489				0				0	489	72.9
CODS AND HAKES	CUSK		1,956	600	2,556		674	241	915		2,647	2,682	5,329	8,800	23
CODS AND HAKES	HADDOCK		19,740	8,749	28,489		2,767	14,829	17,596		8,982	7,153	16,135	62,221	15.3
CODS AND HAKES	HAKE GENUS				0				0		32		32	32	98.5
CODS AND HAKES	SILVER HAKE				0				0		95	447	542	542	61.8
CODS AND HAKES	WHITE HAKE				0			959	959				0	959	53.6
CODS AND HAKES	POLLOCK	2,662	2,321	71,123	76,106	1,985	3,464	56,805	62,254	1,780	8,447	3,800	14,027	152,386	12.6
CODS AND HAKES	RED HAKE				0				0		32	224	256	255	88.6
FLOUNDERS	UNIDENTIFIED FLOUNDER	943		151	1,094	2,986		482	3,468					4,562	33.8*
FLOUNDERS	YELLOWTAIL FLOUNDER				0		48	121	169				0	169	76.9
FLOUNDERS	SUMMER FLOUNDER				0			241	241				0	241	73.3
FLOUNDERS	WINTER FLOUNDER	1,387		11,986	13,373	2,467		2,159	4,626	290			290	18,289	29.2
HERRINGS	AMERICAN SHAD	242			242				0				0	242	100
HERRINGS	ATLANTIC HERRING		122		122				0				0	122	100.2
SCULPINS	SCULPIN FAMILY	1,936	183	3,020	5,139		24	2,292	2,316		95	1,118	1,213	8,668	22.7
SCULPINS	SEA RAVEN	484	122	1,359	1,965	284	168	241	693			1,341	1,241	4,000	38.9
SEAROBINS	SEAROBIN GENUS		183		183	567	144	241	952		95		95	1,231	39.2
TEMPERATE BASSES	STRIPED BASS	30,519	2,258	123,002	155,779	29,624	337	43,763	73,724	4,195	1,292	15,871	21,358	250,860	12
TUNAS AND MACKERELS	ATLANTIC MACKEREL		69,532	156,991	226,523		12,197	34,982	47,179	7,245			7,245	280,947	10.6
WRASSES	CUNNER	242		604	846			2,270	2,270	381	32	5,141	5,554	8,670	33.2
OTHER FISHES	ATLANTIC WOLFFISH		489	298	787			235	235	126			126	1,148	30.3
OTHER FISHES	GOLDEN REDFISH		1,037	755	1,792		24	1,327	1,351		126	224	350	3,493	30.2
OTHER FISHES	OCEAN POUT			453	453				0		32		32	485	93.6
OTHER FISHES	GOOSEFISH				0		24	121	145				0	145	84.8
OTHER FISHES	UNIDENTIFIED BOTTOM FISH			302	302									301	NA

Table 1-4. Estimates of harvest, by wave, mode and species, from New Hampshire's marine recreational fishery derived from the MRFSS during 2002.

		HARVEST – 2002													
SUPERGROUP NAME	COMMON NAME	Wave 3				Wave 4				Wave 5				ANNUAL TOTAL	PSE
		SH	PC	PR	TOTAL	SH	PC	PR	TOTAL	SH	PC	PR	TOTAL		
BLUEFISH	BLUEFISH			453	453		1,107	2,037	3,144	127	4,917	10,506	15,550	19,147	27.4
CARTILAGINOUS FISHES	SPINY DOGFISH		121		121			117	117				0	238	60.5
CARTILAGINOUS FISHES	UNIDENTIFIED (SHARKS)				0				0				0	0	
CARTILAGINOUS FISHES	LITTLE SKATE				0				0				0	0	
CARTILAGINOUS FISHES	SKATES GENUS				0				0				0	0	
CODS AND HAKES	ATLANTIC COD		13,554	11,156	24,710		1,925	4,664	6,589		3,877	3,77	7,454	38,752	11.8
CODS AND HAKES	COD FAMILY		306		306				0				0	306	99.9
CODS AND HAKES	CUSK		733	298	1031		529		529		2,143	224	2,367	3,927	30.2
CODS AND HAKES	HADDOCK		7,883	4,068	11,951		794	2,524	3,318		3,246	894	4,140	19,409	17.2
CODS AND HAKES	HAKE GENUS				0				0				0	0	
CODS AND HAKES	SILVER HAKE				0				0		63		63	63	77.9
CODS AND HAKES	WHITE HAKE				0			476	476				0	476	70.5
CODS AND HAKES	POLLOCK		1,221	51,190	52,411		1,780	28,093	29,873	1,398	4,192	1,118	6,708	88,992	16.6
CODS AND HAKES	RED HAKE				0				0			224	224	224	99.9
FLOUNDERS	UNIDENTIFIED FLOUNDER				0				0				0	0	
FLOUNDERS	YELLOWTAIL FLOUNDER				0		48		48				0	48	100.2
FLOUNDERS	SUMMER FLOUNDER				0				0				0	0	
FLOUNDERS	WINTER FLOUNDER	419		5,492	5,911	525		1,556	2,081				0	7,992	35.2
HERRINGS	AMERICAN SHAD				0				0				0	0	
HERRINGS	ATLANTIC HERRING		122		122				0				0	122	100.2
SCULPINS	SCULPIN FAMILY				0				0				0	0	
SCULPINS	SEA RAVEN				0				0				0	0	
SEAROBINS	SEAROBIN GENUS				0				0		32		32	32	98.5
TEMPERATE BASSES	STRIPED BASS	842	1,036	6,578	8,456	567	217	3,107	3,891		63	447	510	12,857	14.5
TUNAS AND MACKERELS	ATLANTIC MACKEREL		34,572	130,415	164,987		11,235	30,035	41,270	5,974			5,974	212,231	11.9
WRASSES	CUNNER				0			822	822			224	224	1,046	81.5
OTHER FISHES	ATLANTIC WOLFFISH		489	147	636			235	235		32		32	902	33.6
OTHER FISHES	GOLDEN REDFISH		793		793				0		95	0	95	887	43.7
OTHER FISHES	OCEAN POUT			453	453				0				0	453	100
OTHER FISHES	GOOSEFISH				0				0				0	0	
OTHER FISHES	UNIDENTIFIED BOTTOM FISH				0				0				0	0	

Table 1-5. Estimates of effort (angler trips), by wave and mode, in New Hampshire's marine recreational fishery during 2002 as derived from the MRFSS.

EFFORT (angler trips)					
MODE	WAVE			TOTAL	PSE
	3	4	5		
SHORE	49,119	75,148	22,498	146,766	14.6
PARTY/CHARTER	14,241	7,410	7,470	29,120	15.8
PRIVATE/RENTAL	57,230	41,500	43,813	142,543	9.0
TOTAL	120,590	124,058	73,781	318,430	8.0

Table 1-6. Estimates of participation in New Hampshire's marine recreational fishery from 1992 - 2002 as derived from the MRFSS.

PARTICIPATION								
Year	Coastal	PSE	NonCoastal	PSE	Out-of-State	PSE	Total	PSE
1992	30,455	21.5	5,964	77.8	16,720	48.3	53,138	21.4
1993	33,913	20.7	10,428	67.8	31,687	40.1	76,028	21.2
1994	38,444	28.8	16,413	97.6	67,383	60.1	122,240	36.8
1995	49,676	18.4	7,550	21.1	50,873	26.2	108,099	15.0
1996	48,771	18.1	6,079	29.3	47,031	24.4	101,882	14.3
1997	59,060	14.5	8,151	18.4	67,324	19.6	134,534	11.7
1998	57,085	14.7	7,581	20.1	58,195	19.9	122,861	11.7
1999	54,713	17.6	8,356	22.7	59,832	24.6	122,901	14.4
2000	76,759	13.2	10,464	17.6	84,814	16.5	172,037	10.1
2001	67,809	12.4	12,623	15.6	73,830	12.8	154,262	8.3
2002	60,186	10.9	11,003	14.9	65,446	15.1	136,634	8.8

Table 1-7. Estimated effort (angler trips), by month, in New Hampshire's party boat fishery derived from the NH-MRFS party boat survey during 2002.

MONTH	EXPANSION #s		MEAN #		EFFORT (angler trips)				
	(# boat trips)		ANGLERS/TRIP		BY MONTH			BY WAVE	
	Full	1/2&Eve	Full	1/2&Eve	Full	1/2&Eve	TOTAL	TOTAL	Variance
APR	70	0	34.0	0.0	2,377	-	2,377	2,377	9,140
MAY	87	51	28.8	24.3	2,502	1,241	3,743		
JUN	88	184	22.4	40.3	1,971	7,413	9,384	13,127	119,257
JUL	89	297	35.2	37.6	3,130	11,181	14,311		-
AUG	89	289	31.0	36.3	2,759	10,487	13,246	27,557	202,629
SEP	82	105	26.2	26.6	2,151	2,793	4,944		-
OCT	36	4	23.5	29.5	846	118	964	5,908	43,807
TOTALS	541	930			15,736	33,232	48,968	48,968	374,834

Table 1-8. Length frequency data (fork length in inches) collected during the MRFSS in New Hampshire during 2002 for selected species.

Fork Length (in.)	Atlantic Mackerel	Bluefish	Pollock	Striped Bass	Winter Flounder
2					
3					
4					
5					
6					
7					
8	1.1				
9	6.8				
10	20.8				
11	23.2				4.8
12	21.0				29.5
13	24.0		14.1		44.9
14	2.9				7.3
15	0.1				10.0
16					1.8
17					
18		0.9	15.6		
19		3.9			1.5
20					
21					
22		7.8			
23		4.8			
24		12.6	7.8	1.3	
25		32.0			
26		13.6	15.6	9.8	
27		10.2	15.6	14.8	
28		9.9		14.2	
29		0.7		9.2	
30		0.9	31.2	18.5	
31		2.8		7.4	
32				5.1	
33				6.7	
34				3.8	
35				1.3	
36				3.7	
37					
38				2.4	
39				1.8	
40					
41					
42					
N	93	28	7	69	39

Table 1-9. Annual estimates of catch, harvest, and mean length of selected species caught by marine anglers in New Hampshire derived from the MRFSS 1992-2002.

Species	Year	CATCH (TYPE A + B1 + B2)		HARVEST (TYPE A + B1)				Mean Fork Length (mm)
		Numbers	PSE	Numbers	PSE	Weight (lbs)	PSE	
Bluefish	1992	36,329	34.6	23,518	42.9	171,785	47.0	695.3
	1993	49,271	29.4	27,622	40.6	368,664	40.8	777.0
	1994	26,524	26.4	18,343	29.4	178,321	29.2	686.6
	1995	18,613	17.0	11,745	18.3	109,342	18.9	705.8
	1996	6,052	41.7	3,449	44.2	17,355	56.3	402.9
	1997	28,185	17.7	25,329	19.4	240,934	20.3	692.8
	1998	3,371	24.2	2,856	27.3	30,864	27.7	699.7
	1999	8,923	20.5	3,830	29.9	33,054	40.8	652.3
	2000	2,328	32.0	1,372	33.8	9,006	37.1	736.1
	2001	21,906	23.3	8,029	24.5	52,824	25.4	674.3
	2002	33,113	18.8	19,147	27.4	137,765	27.1	652.3
Atlantic cod	1992	121,923	31.1	50,517	39.5	248,344	39.0	552.2
	1993	114,549	30.2	83,470	38.4	249,733	40.9	495.4
	1994	146,256	31.3	54,583	36.3	222,956	33.2	561.9
	1995	95,695	16.3	37,286	19.6	111,575	19.9	502.0
	1996	171,017	20.2	68,340	31.3	276,000	32.3	551.9
	1997	135,358	23.8	62,053	39.1	327,601	49.4	571.9
	1998	75,010	17.9	23,645	25.0	99,286	27.5	551.4
	1999	106,909	14.7	39,119	20.0	253,999	22.1	600.6
	2000	218,173	12.6	70,067	17.8	424,330	20.4	641.9
	2001	348,115	10.6	164,242	15.2	764,306	16.3	592.1
	2002	108,254	11.9	38,752	11.8	307,330	19.5	698.7
Atlantic mackerel	1992	25,976	38.4	14,281	49.4	10,695	66.2	235.5
	1993	128,313	36.1	112,114	39.7	118,727	42.2	344.3
	1994	836,842	47.7	815,293	48.9	861,410	50.5	352.0
	1995	166,174	17.2	144,927	19.0	115,177	23.6	311.3
	1996	630,512	21.0	549,344	23.5	474,869	25.6	334.7
	1997	484,543	23.3	412,383	26.8	467,247	26.5	345.7
	1998	328,105	13.8	255,406	14.6	197,786	17.5	322.4
	1999	554,970	12.9	446,202	15.3	344,147	17.5	321.6
	2000	701,158	10.5	581,327	12.2	365,904	15.4	286.0
	2001	1,124,463	10.1	827,723	12.5	492,982	13.7	303.6
	2002	280,947	10.6	212,231	11.9	143,387	11.8	301.0

Table 1-9 (continued).

Species	Year	CATCH		HARVEST				Mean Fork Length (mm)
		(TYPE A + B1 + B2)		(TYPE A + B1)				
		Numbers	PSE	Numbers	PSE	Weight (lbs)	PSE	
Pollock	1992	66,685	26.7	46,895	34.5	63,779	49.3	347.5
	1993	75,209	28.4	53,099	36.3	35,351	40.9	304.4
	1994	550,760	30.5	355,856	38.3	444,225	73.5	297.6
	1995	135,888	15.8	73,461	20.3	61,277	23.1	308.5
	1996	261,900	20.3	142,262	24.2	119,935	32.0	284.2
	1997	95,547	15.2	42,211	22.5	66,590	35.5	297.3
	1998	141,997	15.0	62,603	26.1	37,615	51.7	258.3
	1999	183,546	13.0	73,608	18.2	55,699	23.3	301.8
	2000	470,749	11.8	177,349	15.5	88,444	32.3	249.9
	2001	432,608	10.7	167,280	16.7	451,066	46.6	396.3
	2002	33,113	18.8	19,147	27.4	264,797	28.1	629.4
Striped bass	1992	29,826	32.1	2,213	56.2	44,612	56.4	949.0
	1993	16,518	38.1	1,540	84.4	28,115	84.5	974.0
	1994	46,524	26.4	3,023	53.2	66,017	52.7	908.2
	1995	289,388	18.9	3,902	22.7	67,992	22.9	866.6
	1996	299,281	24.7	6,461	28.2	102,271	27.8	861.7
	1997	292,844	14.9	13,546	50.3	206,904	45.9	914.1
	1998	249,229	16.1	5,929	21.8	114,342	22.3	889.4
	1999	150,371	16.9	4,641	20.3	84,255	20.8	907.8
	2000	213,868	14.4	4,262	23.1	71,370	23.9	902.6
	2001	179,628	12.6	15,291	17.0	223,072	17.7	808.3
	2002	250,860	12	12,857	14.5	152,342	15	770.3
Winter Flounder	1992	17,854	54.4	16,605	58.0	28,230	61.3	355.0
	1993	23,077	50.0	17,849	60.9	20,031	62.2	315.8
	1994	29,098	34.8	22,847	41.8	27,527	44.9	339.5
	1995	13,302	20.5	7,673	28.0	8,576	27.0	337.8
	1996	12,842	30.5	8,181	42.0	11,111	45.7	354.0
	1997	21,435	26.1	10,569	28.1	12,672	28.1	343.8
	1998	40,620	33.1	28,959	43.0	25,523	45.5	327.8
	1999	16,565	30.1	10,895	42.1	13,611	41.5	349.4
	2000	15,814	25.4	7,944	34.6	8,605	34.3	327.1
	2001	15,438	30.2	9,489	42.4	14,780	46.8	345.4
	2002	18,289	29.2	7,992	35.2	9,716	35.6	345.3
Haddock	Estimate was zero for 1991-93							
	1994	146	100.1	146	100.1	-	0.0	-
	1995	4,978	26.6	3,119	32.0	9,958	35.0	492.0
	1996	5,002	34.1	1,990	40.3	6,808	40.2	528.3
	1997	34,876	28.7	19,143	45.1	91,740	49.1	547.0
	1998	14,603	21.7	10,285	27.8	43,226	28.7	590.5
	1999	13,980	17.1	7,130	24.2	29,544	25.1	583.5
	2000	45,847	19.5	17,093	24.7	65,371	33.2	577.0
	2001	85,691	14.5	35,827	19.8	108,881	23.6	560.7
2002	62,221	15.3	19,409	17.2	69,560	21.6	536.0	

Table 1-10. Annual estimates of effort (angler trips) in New Hampshire and the percent standard error (PSE) of those estimates, by fishing mode and year, derived from the MRFSS, 1992-2002.

Year	SHORE		PARTY/CHARTER		PRIVATE/RENTAL		TOTAL	
	No.Trips	PSE	No.Trips	PSE	No.Trips	PSE	No.Trips	PSE
1992	51,808	38.5	33,027	47.3	106,740	21.4	191,575	17.8
1993	29,538	28.4	35,002	37.4	132,540	16.3	197,080	13.5
1994	117,565	27.5	120,346	52.7	76,123	18.7	314,034	23.1
1995	142,284	29.1	15,226	26.4	142,254	14.6	299,764	15.5
1996	99,678	25.2	32,574	25.0	132,813	14.8	265,065	12.4
1997	154,242	20.6	56,274	28.2	127,321	11.7	337,837	11.4
1998	126,505	20.7	29,647	21.9	120,518	12.2	276,670	11.1
1999	147,449	23.5	25,426	20.5	112,428	13.3	285,303	13.4
2000	188,818	15.8	34,148	20.6	144,933	11.2	367,899	9.4
2001	99,770	17.4	83,327	16.7	177,001	10.1	360,098	7.9
2002	146,766	14.6	29,120	15.8	142,543	9	318,430	8

Table 1-11. Comparison of effort estimates (angler trips), by wave, from the party/charter mode of the MRFSS and from the NH-MRFS party boat survey, 1993-2002 and the percentage that MRFSS differs from NH-MRFS.

YEAR	MODE	SURVEY	WAVE				TOTAL	PSE	% DIFF.
			2	3	4	5			
1993	PARTY/CHARTER	MRFSS	0	8,417	23,779	2,809	35,005	37.4	-37%
	PARTY BOATS	NH-MRFS	601	14,093	31,393	9,310	55,397	11.0	
1994	PARTY/CHARTER	MRFSS	0	102,556	11,212	6,578	120,346	52.7	159%
	PARTY BOATS	NH-MRFS	855	10,947	29,220	5,479	46,501	11.8	
1995	PARTY/CHARTER	MRFSS	0	2,947	5,059	6,826	14,832	27.7	-62%
	PARTY BOATS	NH-MRFS	562	9,084	25,014	4,654	39,314	9.9	
1996	PARTY/CHARTER	MRFSS	NE	15,942	20,382	2,817	40,261	26.0	-7%
	PARTY BOATS	NH-MRFS	1,120	10,646	27,499	4,101	43,366	14.2	
1997	PARTY/CHARTER	MRFSS	NE	21,485	33,047	1,742	57,048	28.2	13%
	PARTY BOATS	NH-MRFS	774	11,517	32,095	5,951	50,337	11.8	
1998	PARTY/CHARTER	MRFSS	NE	7,379	20,632	1,175	29,185	21.9	-49%
	PARTY BOATS	NH-MRFS	939	16,208	33,113	7,641	57,901	7.7	
1999	PARTY/CHARTER	MRFSS	NE	7,886	15,989	1,551	25,426	20.5	-52%
	PARTY BOATS	NH-MRFS	1,219	14,774	30,213	6,405	52,612	10.4	
2000	PARTY/CHARTER	MRFSS	NE	14,202	19,947	0	34,149	20.6	-26%
	PARTY BOATS	NH-MRFS	1,580	16,069	23,621	4,672	45,940	9.7	
2001	PARTY/CHARTER	MRFSS	NE	16,427	34,384	32,516	83,327	16.7	64%
	PARTY BOATS	NH-MRFS	2,025	13,697	29,526	5,563	50,811	12.1	
2002	PARTY/CHARTER	MRFSS	NE	14,241	7,410	7,470	29,120	15.8	41%
	PARTY BOATS	NH-MRFS	2,377	13,127	27,557	5,908	48,968	11.1	

NE – Not estimated

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ABSTRACT

Seine hauls were conducted on a monthly basis from June to November 2002 at fourteen fixed location sites and one auxiliary site in New Hampshire estuaries. Seine hauls resulted in the collection of 33 finfish species and two crustacean species of special significance. Four new species of fish were encountered during this year's survey: silver hake (*Merluccius bilinearis*), mackerel scad (*Decapterus macarellus*), four-beard rockling (*Enchelyopus cimbrius*), and black crappie (*Pomoxis nigromaculatus*).

Relative abundance indices, calculated as the geometric mean catch per seine haul, were highest for Atlantic silverside (*Menidia menidia*), and winter flounder (*Pleuronectes americanus*). The most abundant crustacean encountered was the green crab (*Carcinus maenas*). Species diversity was greatest in the Little Bay/Great Bay area and overall abundance was highest in the Piscataqua River location. Seasonally, September has the largest abundance level for all species combined. Overall abundance increased to the third highest level in the six years of the survey. Of the eleven most abundant species sampled in 2002, green crab, alewives (*Alosa pseudoharengus*) and little sculpin (*Myoxocephalus aeneus*) experienced their highest levels of abundance since the inception of the survey while four other species, winter flounder, smooth flounder (*Pleuronectes putnami*), Atlantic menhaden (*Brevoortia tyrannus*), and striped killifish (*Fundulus majalis*) had their second highest levels of abundance. Only blueback herring (*Alosa aestivalis*) experienced a time series low in abundance this year.

INTRODUCTION

Estuaries are among the most productive natural resource systems and are known to be nursery areas for many recreationally and commercially important marine species as well as many forage fish that they feed upon. Monitoring the annual reproductive recruitment of these species provides important information used by fisheries scientists and managers to effectively manage these species.

Beach seines are one of the more common sampling procedures for estuarine-based finfish surveys (NHFG 1981, NHFG 1982, NAI 1995, Howell and Molnar 1993, Young et al. 1994, MD DNR 1994). Seines have the advantages of being a relatively simple sampling device and captured specimens can be retained for positive identification and/or collection of biological information (length, weight, age structures, etc.). When surveys are designed with sound scientific sampling methods, an index of relative abundance can be calculated from the catches. These indices can provide an indication of relative spawning success for species such as winter flounder (*Pleuronectes americanus*), striped bass (*Morone saxatilis*) and river herring (*Alosa pseudoharanguis* and *Alosa aestivalis*) whose juvenile life history stage utilizes the estuary as a nursery area (Young et al. 1994, MD DNR 1994).

The juvenile finfish survey described in this report was initiated in 1997. It was designed as a fixed station survey, as opposed to a stratified random survey, because strong tidal currents, rocky shorelines, and various anthropogenic shoreline structures limit the amount of suitable seining areas particularly in the Great Bay Estuary. In addition, many of the fixed sampling locations chosen for this survey were sites used by beach seine surveys conducted in New Hampshire estuaries in the past (NAI 1979, NHF&G 1981, NHF&G 1982, Grout and Heckman 1996). This provides the opportunity to compare data from the current program with historical data from previous surveys.

The objective of this project is to implement a beach seine survey that will annually monitor the relative abundance of juvenile finfish utilizing New Hampshire estuaries for nursery habitat. Although the survey is designed to be a general-purpose survey, the primary species of interest will be winter flounder, rainbow smelt, river herring, American shad (*Alosa sapidissima*), and Atlantic silverside.

PROCEDURES

Seine samples were conducted on a monthly basis from June to November at 15 fixed location stations in New Hampshire's estuaries. Four of these stations were located in the Hampton-Seabrook Estuary and eleven were located in the Great Bay Estuary (Figures 2-1 to 2-3, Table 2-1). Within the Great Bay Estuary, three stations were located in Little Harbor, three stations were located in the middle to upper Piscataqua River, and five stations were located in Little Bay/Great Bay area. Station locations were chosen using one or more of the following

criteria: the presence of historical seine sampling data from a given location, spatial distributions of the sites within an area, and the suitability of the site for seining. For example, all stations except stations 39 and 147 had previously been used for seine sampling locations in other studies (NAI 1979, NHF&G 1981, NHF&G 1982, Grout and Heckman 1996). The location of these two stations were chosen because they were in areas of the estuary not sampled by the historical studies, they were close in proximity to the mouths of important rivers in Great Bay Estuary (Cocheco/Salmon Falls Rivers and Oyster River), and it was relatively easy to set a seine at the locations.

Beach seine hauls were conducted by boat using a 30.5 m long by 1.8 m high bag seine with 6.4 mm mesh deployed 10 - 15 m from the beach. A single seine haul was made at each station during the months of June through November. Seine hauls were all conducted during daylight hours and constrained to the period of approximately two hours before to two hours after low tide. Seines were set into the current and in water depths less than six feet to prevent the foot rope of the net from coming off the bottom.

With each seine haul, surface salinity (ppt) and temperature (°C) were measured and substrate type at the station was observed and recorded.

All fish captured were identified to the lowest possible taxon (species level was the target) and enumerated. All finfish captured were measured total length to the nearest millimeter up to a maximum of 25 individuals per species per seine haul sample. In addition, if the following invertebrate species of special interest were captured, they were identified and enumerated: rock crab (*Cancer irroratas*), Jonah crab (*Cancer borealis*), green crab (*Carcinus maenas*), horseshoe crab (*Limulus polyphemus*), and American lobster (*Homarus americanus*).

RESULTS

During 2002, all stations were sampled in all months for a total of 90 seine samples. A total of 33 finfish species and two crustacean species of special interest were captured during the project (Table 2-2). Atlantic silverside (*Menidia menidia*), winter flounder, Atlantic menhaden (*Brevoortia tyrannus*), and striped killifish (*Fundulus majalis*) were the most abundant finfish species while green crab was the most abundant crustacean encountered. Atlantic silverside and green crab were the only species collected at all sampling stations (Table 2-3). Four new species of fish were encountered during this year's survey: mackerel scad (*Decapterus macarellus*),

four-beard rockling (*Enchelyopus cimbrius*), silver hake (*Merluccius bilinearis*), and black crappie (*Pomoxis nigromaculatus*).

Sampling stations in the Little Bay/Great Bay area generally had the highest abundance levels while Hampton/Seabrook estuary generally had the lowest (Table 2-3). Species diversity was greatest in the Great Bay/ Little Bay area.

Little Bay/Great Bay station 72 had the greatest species diversity with 21 different species being captured this year. Piscataqua River station 35 had the highest abundance levels for all species combined (Table 2-3). Its number one ranking for abundance was the result of having the highest catches of rainbow smelt and green crabs and the second highest catch of Atlantic silversides of all the sites.

Samples during the months of September, October, and November (in decreasing order of abundance) had the largest catches for all species combined (Table 2-4). The largest single catch of any one species in a seine haul occurred September at station 39 when over 2,300 juvenile menhaden were captured.

Length data were obtained from more than 3,500 individuals and 33 finfish species (Table 2-5). Length frequencies weighted by catch were plotted for eight finfish species of special interest (Figures 2-4 to 2-6).

Temperatures during sampling ranged from a low of 4°C at station 107 in the Little Bay/Great Bay Estuary during November to a maximum of 26°C at station 147 in the Little Bay/Great Bay area in July and again at station 39 in the Piscataqua River in August (Table 2-6). Salinity measurements ranged from 2 ppt at station 107 in November to a high of 32 ppt seven different times during the sampling season (Table 2-7). Salinity measurements generally remained at 24 ppt or above this year with the exception of stations 39 and 107. Substrates at the seine stations were, for the most part, dominated by sand, mud, or a sand/mud mixture (Table 2-1).

DISCUSSION

The objective of this project is to annually monitor the relative abundance of juvenile finfish utilizing New Hampshire estuaries for nursery habitat. Although the survey is designed to be a general purpose survey, the primary species of interest are winter flounder, rainbow smelt, river herring, American shad, and Atlantic silverside.

During 2002, 33 species of finfish and two crustacean species of special interest were captured during the project (Table 2-2). However, as has been observed in the past, three or four species accounted for vast majority of fish caught during the survey (Grout and Smith 1998). Arithmetic mean catch per seine haul values for all species combined indicate Atlantic silverside and Atlantic menhaden account for more than 80% of the catch (Table 2-2).

Catch distributions for many forage species or juveniles of some species can be heavily skewed due to a few large catches as a result of schooling behavior. In these instances, one or two very large catches can often inflate the value of an arithmetic mean by orders of magnitude resulting in a false characterization of the true relative abundance of a species. To compensate for this potential bias, the data can be log transformed to produce a normal (as opposed to skewed) catch distribution and the resulting mean of the log transformed data can be transformed back to produce a geometric mean (Sokal and Rohlf 1969). In recent years, the geometric mean has often replaced the arithmetic mean as a measure of relative abundance for juvenile finfish because it is a more statistically robust value (NAI 1995, Howell and Molnar 1993, Young et al. 1994, MD DNR 1994).

Using the geometric mean as an index of relative abundance, the abundance of all species combined increased in 2002 to the third highest level in the six years of this survey (Table 2-8). Of the eleven most abundant species, green crab, alewives and little sculpin (*Myoxocephalus aeneus*) experienced their highest levels of abundance since the inception of the survey while four other species, winter flounder, smooth flounder (*Pleuronectes putnami*), menhaden, and striped killifish (*Fundulus majalis*), had their second highest levels of abundance. Only blueback herring experienced a time series low in abundance this year.

Seasonally, September had the abundance levels of over all abundance driven primarily by large catches of silversides and to a lesser extent by the arrival of juvenile menhaden to New Hampshire's coastal and estuarine areas. By area, the stations in the Piscataqua River and Little Bay/Great Bay sampling areas had higher overall abundance levels than those stations in the Little Harbor and Hampton/Seabrook areas. Site # 35 had the highest overall abundance driven by silversides and to a lesser extent by green crabs, menhaden, and rainbow smelt. In the Little Harbor and Hampton/Seabrook Estuary, silversides, green crabs and winter flounder were consistently the three most abundant species.

The Atlantic silverside has consistently been the most abundant fish species encountered in the seine survey (Table 2-8 and Figure 2-7). They were the most numerous species at 10 of the 15 stations sampled and in the top three at all stations but one. Abundance levels in 2002 remained relatively low in June and July. Catches began to increase in August and by September, October, and November their abundance levels were more than an order of magnitude higher than any other species captured (Table 2-4). Increased abundance levels appear to be the result of recruitment of young-of-the-year (YOY) to the sampling gear following spawning in June and July (Bigelow and Schroeder 2002). Length frequencies of silversides were dominated by 6 to 10 cm individuals with an overall mean length of 8.3 cm.

The winter flounder abundance index for 2002 was the second highest in the time series; surpassed only by 2000 value (Table 2-8 and Figure 2-7). This species was one of the three most abundant species at every station in the Little Harbor and Hampton/Seabrook areas and the most abundant species at stations 7, 25, and 29 in those areas (Table 2-3). Abundance levels were also relatively high at three of the five stations in the Little Bay/Great Bay area and two of the three stations in the Piscataqua River area indicating that juvenile winter flounder abundance levels were high throughout the New Hampshire seacoast. Length frequencies of winter flounder captured in the survey were dominated by fish less than 9 cm (Figure 2-4). Age length keys developed from the Northeast Fisheries Science Center (NEFSC) Fall Trawl Survey indicate that all fish less than 9 cm are age 0 (Paul Nitschke, personal comm.). Thus the high abundance of winter flounder observed in the survey this year is the result of strong recruitment of the 2002 year class. A recent assessment of the Gulf of Maine stocks of winter flounder revealed that spawning stock biomass for this species is estimated to be at a 20 year high (NEFSC 2003) which explains the relatively good recruitment of juvenile winter flounder abundance observed two of the past three years in this survey.

Green crab abundance this year was the highest level observed in the six years of conducting the survey (Table 2-8 and Figure 2-7). It was one of the top three species encountered at all stations except one (Table 2-3). Seasonally, abundance peaked in August and then declined to low levels by October and November.

Atlantic menhaden also experienced an increase in abundance this year to the second highest level in the six year time series (Table 2-8 and Figure 2-7). Spatially, the highest catches were in the Piscataqua River area. Unlike most of the more abundant species sampled in this

survey, juvenile menhaden are captured only during the latter three months of the survey when they move into New Hampshire estuaries. Menhaden captured in this survey were less than 12 cm in length (Table 2-5) and thus are all YOY individuals based on age-length data presented in Bigelow and Schroeder (2002). However, unlike previous years when most of the menhaden captured were 5-7 cm in length, this years catch had significant numbers of 8-11 cm individuals (Figure 2-5).

Temperature data taken over the course of the 2002 seine survey had an average of 16.2°C which was a slight increase from the average temperature measured in 2001 but more than a full degree below the highest average temperatures recorded in 1999 and 2000 (Table 2-10). In contrast, the average salinity this year was the second lowest measured during the tenure of the survey (Table 2-10). Very low salinities of 2-5 ppt experienced during June and November samples at the Lamprey River (site 107) and Upper Piscataqua River (site 39) sites contributed to this years lower mean salinity level.

In summary:

- 1) Geometric mean catch per seine haul, used as an index of relative abundance, indicated Atlantic silverside and green crab were the two most abundant species followed by winter flounder. Arithmetic mean values showed Atlantic silverside and Atlantic menhaden comprised greater than 80% of the total catch.
- 2) The relative abundance index for all species combined increased to the third highest value in the six years of the survey.
- 3) Of the eleven most abundant species sampled in 2002, green crab, alewives and little sculpin experienced their highest levels of abundance since the inception of the survey while four other species, winter flounder, smooth flounder, Atlantic menhaden, and striped killifish had their second highest levels of abundance. Only blueback herring experienced a time series low in abundance this year.
- 4) Four new species of fish were encountered during this year's survey: mackerel scad (*Decapterus macarellus*), four-beard rockling (*Enchelyopus cimbrius*), silver hake (*Merluccius bilinearis*), and black crappie (*Pomoxis nigromaculatus*).
- 5) Diversity, by number of species captured, was greatest at station 72 in the Little Bay/Great Bay area. The Piscataqua River area held the highest overall abundance of all

species, driven by Atlantic silverside, green crab, Atlantic menhaden, and rainbow smelt abundance.

6) Seasonally, September had the highest overall abundance levels for all species combined.

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Table 2-1. Station number, location, area, and substrate type as well as the presence or absence of historical seining data for fixed location stations for New Hampshire Fish and Game Department seine survey conducted in New Hampshire estuaries, 2002.

STATION #	AREA	STATION LOCATION	LATITUDE / LONGITUDE	SUBSTRATE	HISTORICAL DATA
5	GBE1	Fort Stark (Little Harbor)	43° 03' 28.0"N 070° 42' 51.7"W	Sand	Grout & Heckman (1996)
7	GBE1	Wentworth (Little Harbor)	43° 03' 25.6"N 070° 43' 25.7"W	Mud/Sand	Grout & Heckman (1996)
9	GBE1	Odiorne Beach (Little Harbor)	43° 03' 07.9"N 070° 43' 22.9"W	Sand	Grout & Heckman (1996)
30	GBE2	Schiller Plant (Piscataqua)	43° 05' 59.3"N 070° 47' 15.5"W	Sand/Gravel	NAI (1979)
35	GBE2	General Sullivan Bridge Cove (Piscataqua)	43° 07' 00.1"N 070° 49' 23.6"W	Mud	NHFG (1981); NHFG (1982)
39	GBE2	Upper Piscataqua (Power Lines)	43° 10' 16.2"N 070° 49' 43.9"W	Mud/Sand	None
54	GBE3	Broad Cove (Little Bay)	43° 06' 56.8"N 070° 50' 49.1"W	Mud/Sand	NHFG (1981)
72	GBE3	Fox Point (Little Bay)	43° 07' 03.1"N 070° 51' 15.1"W	Mud/Sand	NHFG (1981); NHFG (1982)
93	GBE3	Herods Cove (Great Bay)	43° 04' 26.5"N 070° 51' 16.1"W	Mud/Sand	NHFG (1981); NHFG (1982)
107	GBE3	Moody Point (Lamprey/Squamscott)	43° 03' 55.5"N 070° 54' 49.6"W	Mud	NHFG (1981)
147	GBE3	Oyster River	43° 07' 16.6"N 070° 52' 26.7"W	Mud/Gravel	None
23	HSE	Smith & Gilmore (Hampton)	42° 53' 58.1"N 070° 49' 05.4"W	Sand	Grout & Heckman (1996)
25	HSE	Yankee Coop (Seabrook)	42° 53' 33.0"N 070° 49' 12.1"W	Sand	Grout & Heckman (1996)
29	HSE	Blackwater River	42° 53' 26.3"N 070° 49' 34.4"W	Sand	Grout & Heckman (1996)
33	HSE	Brown's River	42° 53' 56.3"N 070° 49' 33.4"W	Sand	Grout & Heckman (1996)

AREA CODES	AREA NAMES
HSE	HAMPTON/SEABROOK ESTUARY
GBE1	LITTLE HARBOR
GBE2	PISCATAQUA RIVER
GBE3	LITTLE BAY/GREAT BAY

Table 2-2. Annual geometric and arithmetic mean catch per seine haul, plus the standard deviation of those values, for all species caught in a juvenile finfish seine survey conducted in New Hampshire's estuaries during 2002.

COMMON NAME	SCIENTIFIC NAME	GEOMETRIC		ARITHMETIC	
		MEAN	STD	MEAN	STD
SILVERSIDE, ATLANTIC	<i>Menidia menidia</i>	22.95	14.05	260.2	469.96
MENHADEN, ATLANTIC	<i>Brevoortia tyrannus</i>	1.37	7.31	124.43	447.16
CRAB, GREEN	<i>Carcinus maenas</i>	6.86	2.94	17.51	28.13
KILLIFISH, STRIPED	<i>Fundulus majalis</i>	1.24	3.27	16.06	68.91
FLOUNDER, WINTER	<i>Pleuronectes americanus</i>	3.14	3.33	15.13	43.36
SMELT, RAINBOW	<i>Osmerus mordax</i>	0.69	2.51	12.41	63.31
KILLIFISH, COMMON	<i>Fundulus heteroclitus</i>	0.68	2.31	7.56	34.66
HERRING, ATLANTIC	<i>Clupea harengus</i>	0.24	1.38	4.27	26.95
HERRING, BLUEBACK	<i>Alosa aestivalis</i>	0.26	1.20	2.90	17.56
ALEWIFE	<i>Alosa pseudoharengus</i>	0.34	1.21	1.82	8.75
STICKLEBACK, NINESPINE	<i>Pungitius pungitius</i>	0.25	0.95	1.61	11.61
FLOUNDER, SMOOTH	<i>Pleuronectes putnami</i>	0.39	0.88	0.88	2.45
SCULPIN, LITTLE	<i>Myoxocephalus aeneus</i>	0.31	0.75	0.66	1.77
PERCH, WHITE	<i>Morone americana</i>	0.16	0.69	0.50	1.98
TOMCOD, ATLANTIC	<i>Microgadus tomcod</i>	0.13	0.55	0.33	1.38
STICKLEBACK, THREESPINE	<i>Gasterosteus aculeatus</i>	0.11	0.38	0.19	0.63
STICKLEBACK, FOURSPINE	<i>Apeltes quadracus</i>	0.09	0.36	0.18	0.79
PIPEFISH, NORTHERN	<i>Sygnathus fuscus</i>	0.11	0.34	0.18	0.55
FLOUNDER, WINDOWPANE	<i>Scophthalmus aguosus</i>	0.08	0.32	0.14	0.61
HAKE, RED	<i>Urophycis chuss</i>	0.04	0.23	0.08	0.40
BASS, STRIPED	<i>Morone saxatilis</i>	0.04	0.21	0.07	0.33
LUMPFISH	<i>Cyclopterus lumpus</i>	0.04	0.18	0.06	0.27
CRAB, ROCK	<i>Cancer irroratus</i>	0.04	0.18	0.06	0.27
FOURBEARD ROCKLING	<i>Enchelyopus cimbrius</i>	0.02	0.18	0.04	0.33
CUNNER	<i>Tautoglabrus adspersus</i>	0.02	0.13	0.03	0.18
LANCE, SAND	<i>Ammodytes americanus</i>	0.01	0.12	0.02	0.21
SHAD, AMERICAN	<i>Alosa sapidissima</i>	0.01	0.12	0.02	0.21
GUNNEL, ROCK	<i>Pholis gunnellus</i>	0.02	0.11	0.02	0.15
BLUEFISH	<i>Pomatomus saltatrix</i>	0.01	0.08	0.01	0.11
FLOUNDER (UNCLASSIFIED)	<i>Pleuronectiformes sp.</i>	0.01	0.08	0.01	0.11
HAKE, WHITE	<i>Urophycis tenuis</i>	0.01	0.08	0.01	0.11
MACKEREL SCAD	<i>Decapterus macarellus</i>	0.01	0.08	0.01	0.11
HAKE, SILVER	<i>Merluccius bilinearis</i>	0.01	0.08	0.01	0.11
HERRING (UNCLASSIFIED)	<i>Clupeidea</i>	0.01	0.08	0.01	0.11
CRAPPIE, BLACK	<i>Pomoxis nigromaculatus</i>	0.01	0.08	0.01	0.11
RAVEN, SEA	<i>Hemitripteris americanus</i>	0.01	0.08	0.01	0.11
SCULPIN, SHORTHORN	<i>Myoxocephalus scorpius</i>	0.01	0.08	0.01	0.11
ALL SPECIES		118.31	5.36	467.46	814.61

Table 2-3A. Geometric mean catch per seine haul (CPUE), by species and station, for all months combined from a juvenile finfish seine survey conducted in New Hampshire estuaries during 2002.

SPECIES	STATION #														
	Little Harbor			Hampton/Seabrook Estuary				Piscataqua River			Little Bay/Great Bay				
	5	7	9	23	25	29	33	30	35	39	54	72	93	107	147
SILVERSIDE, ATLANTIC	3.30	12.85	11.98	14.22	2.32	0.55	3.89	42.40	114.11	20.41	444.72	174.44	16.27	38.45	288.03
CRAB, GREEN	6.22	5.69	10.54	6.88	2.43	1.08	1.52	9.24	20.57	15.32	4.16	14.91	17.95	2.17	18.27
FLOUNDER, WINTER	1.87	23.79	11.51	9.72	5.09	2.83	1.14	0.35	3.31	1.22	4.04	4.44	0	0.41	6.67
KILLIFISH, STRIPED	0.12	0.26	0.12	0	0	0	0	0.12	0.20	3.96	5.91	0.35	26.27	6.70	7.80
MENHADEN, ATLANTIC	0	1.78	0.26	0.12	0	2.19	0.69	12.39	17.36	7.06	0	0.12	0.20	1.37	2.18
SMELT, RAINBOW	0	0.35	0.12	0	0	0	0	0.86	12.53	0.65	2.67	1.50	0.62	0	1.81
KILLIFISH, COMMON	0	0.12	0	0	0	0	0	0	0.26	1.45	4.13	0	8.22	2.60	3.18
FLOUNDER, SMOOTH	0.59	0.26	0.35	0	0.12	0	0	0	0	0.26	0.26	0.41	3.60	1.60	0.70
ALEWIFE	0	0	0	0	0	0.20	0.38	0.44	0	4.59	0.41	0.59	0	0.26	1.18
SCULPIN, LITTLE	0.12	0.26	1.62	0.31	0	0	0	0.99	0	0.59	0.12	0.26	0.12	0	1.40
STICKLEBACK, NINESPINE	0	0	0	0.12	0	0	0	0.12	1.80	0.12	0	0	0.38	0.26	2.96
HERRING, BLUEBACK	0	0	0.12	0	0	0	0	1.81	0	0.47	0.41	0.20	0.12	1.79	0.26
HERRING, ATLANTIC	0	0	0.12	0.12	0	0.12	0.12	0	1.49	0.47	0	1.11	0	0.93	0.12
PERCH, WHITE	0	0	0	0	0	0	0	0	0	0	0.31	0.12	1.15	1.17	0.41
TOMCOD, ATLANTIC	0	0	0.12	0	0	0	0	0	0	1.40	0.20	0.26	0	0	0.44
PIPEFISH, NORTHERN	0.12	0	0	0	0	0	0	0	0	0.65	0.41	0.26	0.12	0.12	0.20
STICKLEBACK, THREESPINE	0	0.12	0	0	0	0	0	0	0.41	0.20	0	0.26	0.26	0.20	0.26
STICKLEBACK, FOURSPINE	0	0	0	0	0	0	0	0	0	0	0	0	0.26	0.65	0.74
FLOUNDER, WINDOWPANE	0	0.12	0	0	0.35	0.26	0.12	0	0.20	0	0.12	0.12	0	0	0
HAKE, RED	0	0.26	0.20	0	0	0	0	0.12	0	0	0.12	0	0	0	0
BASS, STRIPED	0	0.2	0	0	0	0.12	0.20	0	0	0.12	0	0	0	0	0
CRAB, ROCK	0.51	0	0.12	0	0	0	0	0	0	0	0	0	0	0	0
LUMPFISH	0	0	0	0	0	0	0	0	0	0	0.35	0.26	0	0	0
FOURBEARD ROCKLING	0	0	0	0	0	0	0	0	0.26	0	0	0.12	0	0	0
CUNNER	0	0	0.12	0	0	0	0	0.12	0	0	0	0.12	0	0	0
GUNNEL, ROCK	0	0	0	0	0	0	0	0	0	0	0	0.26	0	0	0
LANCE, SAND	0	0	0	0	0	0	0	0.20	0	0	0	0	0	0	0
SHAD, AMERICAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.20
BLUEFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0.12	0
CRAPPIE, BLACK	0	0	0	0	0	0	0	0	0	0	0	0	0	0.12	0
FLOUNDER (UNCLASSIFIED)	0	0	0	0	0	0	0	0.12	0	0	0	0	0	0	0
HAKE, SILVER	0	0	0	0	0	0	0	0	0.12	0	0	0	0	0	0
HAKE, WHITE	0	0	0.12	0	0	0	0	0	0	0	0	0	0	0	0
HERRING (UNCLASSIFIED)	0	0	0	0	0	0	0	0	0	0	0	0.12	0	0	0
MACKEREL SCAD	0	0	0	0	0	0	0	0.12	0	0	0	0	0	0	0
RAVEN, SEA	0	0	0	0	0	0	0	0	0	0.12	0	0	0	0	0
SCULPIN, SHORTHORN	0	0	0.12	0	0	0	0	0	0	0	0	0	0	0	0
ALL SPECIES	23.82	115.69	116.44	90.10	22.16	27.01	12.61	278.16	727.04	156.30	550.76	329.80	129.70	128.33	522.67

Table 2-3B. Arithmetic mean catch per seine haul (CPUE), by species and station, for all months combined from a juvenile finfish seine survey conducted in New Hampshire estuaries during 2002.

SPECIES	STATION #														
	Little Harbor			Hampton/Seabrook Estuary				Piscataqua River			Little Bay/Great Bay				
	5	7	9	23	25	29	33	30	35	39	54	72	93	107	147
SILVERSIDE, ATLANTIC	11.00	157.17	109.17	103.67	112.50	2.17	15.50	661.17	773.00	66.00	800.17	547.67	35.33	138.33	370.17
MENHADEN, ATLANTIC	0	15.83	0.33	0.17	0	174.17	3.67	610.33	443.17	416.67	0	0.17	0.33	29	172.67
CRAB, GREEN	14.50	10.00	32.50	12.50	7.00	2.00	2.17	17.50	47.50	28.17	8.00	21.17	27.67	4.50	27.50
KILLIFISH, STRIPED	0.17	0.50	0.17	0	0	0	0	0.17	0.33	5.67	17.00	0.50	68.17	50.17	98.00
FLOUNDER, WINTER	5.83	25.50	32.33	18.83	30.67	12.83	1.67	0.50	25.67	2.50	5.67	5.17	0	0.50	59.33
SMELT, RAINBOW	0	0.50	0.17	0	0	0	0	1.50	116.33	1.17	19.17	5	1.50	0	40.83
KILLIFISH, COMMON	0	0.17	0	0	0	0	0	0	0.33	3.33	13.50	0	26.33	19.67	50.00
HERRING, ATLANTIC	0	0	0.17	0.17	0	0.17	0.17	0	39.50	0.83	0	14.50	0	8.33	0.17
HERRING, BLUEBACK	0	0	0.17	0	0	0	0	20.50	0	0.83	1.17	0.33	0.17	19.83	0.50
ALEWIFE	0	0	0	0	0	0.33	1.00	1.33	0	16.33	0.67	1.00	0	0.50	6.17
STICKLEBACK, NINESPINE	0	0	0	0.17	0	0	0	0.17	2.17	0.17	0	0	1.00	0.50	20.00
FLOUNDER, SMOOTH	0.83	0.50	0.50	0	0.17	0	0	0	0	0.33	0.50	0.67	5.17	3.50	1.00
SCULPIN, LITTLE	0.17	0.33	3.33	0.67	0	0	0	1.67	0	1.33	0.17	0.33	0.17	0	1.67
PERCH, WHITE	0	0	0	0	0	0	0	0	0	0	0.67	0.17	2.17	3.33	1.17
TOMCOD, ATLANTIC	0	0	0.17	0	0	0	0	0	0	2.67	0.33	0.50	0	0	1.33
STICKLEBACK, THREESPINE	0	0.17	0	0	0	0	0	0	0.50	0.33	0	0.50	0.50	0.33	0.50
PIPEFISH, NORTHERN	0.17	0	0	0	0	0	0	0	0	1.00	0.50	0.33	0.17	0.17	0.33
STICKLEBACK, FOURSPINE	0	0	0	0	0	0	0	0	0	0	0	0	0.33	1.00	1.33
FLOUNDER, WINDOWPANE	0	0.17	0	0	0.83	0.33	0.17	0	0.33	0	0.17	0.17	0	0	0
HAKE, RED	0	0.5	0.33	0	0	0	0	0.17	0	0	0.17	0	0	0	0
BASS, STRIPED	0	0.33	0	0	0	0.17	0.33	0	0	0.17	0	0	0	0	0
CRAB, ROCK	0.67	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0
LUMPFISH	0	0	0	0	0	0	0	0	0	0	0.50	0.33	0	0	0
FOURBEARD ROCKLING	0	0	0	0	0	0	0	0	0.50	0	0	0.17	0	0	0
CUNNER	0	0	0.17	0	0	0	0	0.17	0	0	0	0.17	0	0	0
GUNNEL, ROCK	0	0	0	0	0	0	0	0	0	0	0	0.33	0	0	0
LANCE, SAND	0	0	0	0	0	0	0	0.33	0	0	0	0	0	0	0
SHAD, AMERICAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33
BLUEFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0
CRAPPIE, BLACK	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0
FLOUNDER (UNCLASSIFIED)	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0
HAKE, SILVER	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0
HAKE, WHITE	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0
HERRING (UNCLASSIFIED)	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0
MACKEREL SCAD	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0
RAVEN, SEA	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0
SCULPIN, SHORTHORN	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0
ALL SPECIES	33.33	211.67	180.00	136.17	151.17	192.17	24.67	1315.83	1449.50	547.67	868.33	599.33	169.00	280.00	853.00

Table 2-4A. Geometric mean catch per seine haul (CPUE), by species and month, for all stations combined from a juvenile finfish seine survey conducted in New Hampshire estuaries during 2002.

SPECIES	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER
SILVERSIDE, ATLANTIC	2.97	1.31	12.51	145.66	111.56	91.30
CRAB, GREEN	9.15	14.06	15.80	9.14	2.95	1.29
FLOUNDER, WINTER	0.96	4.82	13.22	3.10	1.85	1.67
MENHADEN, ATLANTIC	0	0	0	7.44	6.16	1.95
KILLIFISH, STRIPED	1.51	0.78	2.59	1.96	0.74	0.55
SMELT, RAINBOW	0	0.18	0.25	0.20	1.22	4.93
KILLIFISH, COMMON	0.80	0.80	1.71	1.26	0	0.15
HERRING, ATLANTIC	2.54	0	0	0	0.05	0
FLOUNDER, SMOOTH	1.09	0.48	0.24	0.25	0.21	0.24
ALEWIFE	0.16	0.20	0.50	0.90	0.20	0.23
SCULPIN, LITTLE	0.49	0.59	0.40	0.05	0.15	0.28
HERRING, BLUEBACK	0	0.11	0.44	0.82	0.15	0.18
STICKLEBACK, NINESPINE	0.05	0.27	0.54	0.10	0.26	0.33
PERCH, WHITE	0	0	0.74	0.25	0	0.14
TOMCOD, ATLANTIC	0.64	0	0.08	0.15	0	0
PIPEFISH, NORTHERN	0.28	0.13	0.10	0.10	0.10	0
STICKLEBACK, THREESPINE	0.24	0.10	0.24	0	0.05	0.05
STICKLEBACK, FOURSPINE	0	0.10	0.14	0.10	0	0.22
FLOUNDER, WINDOWPANE	0	0.10	0.33	0.10	0	0
HAKE, RED	0	0	0	0	0	0.29
BASS, STRIPED	0	0	0	0.27	0	0
CRAB, ROCK	0.05	0	0	0.05	0.05	0.08
LUMPFISH	0	0.05	0.05	0.08	0	0.05
CUNNER	0	0	0.05	0.05	0	0.05
FOURBEARD ROCKLING	0	0	0	0	0	0.15
GUNNEL, ROCK	0	0.05	0.05	0	0	0
LANCE, SAND	0	0	0	0	0	0.08
SHAD, AMERICAN	0	0	0	0.08	0	0
BLUEFISH	0	0	0.05	0	0	0
CRAPPIE, BLACK	0.05	0	0	0	0	0
FLOUNDER (UNCLASSIFIED)	0.05	0	0	0	0	0
HAKE, SILVER	0	0	0	0	0	0.05
HAKE, WHITE	0.05	0	0	0	0	0
HERRING (UNCLASSIFIED)	0	0	0	0.05	0	0
MACKEREL SCAD	0	0	0	0.05	0	0
RAVEN, SEA	0	0	0	0	0	0.05
SCULPIN, SHORTHORN	0	0.05	0	0	0	0
ALL SPECIES	38.32	44.05	125.95	352.28	184.12	195.13

Table 2-4B. Arithmetic mean catch per seine haul (CPUE), by species and month, for all stations combined from a juvenile finfish seine survey conducted in New Hampshire estuaries during 2002.

SPECIES	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER
SILVERSIDE, ATLANTIC	30.60	14.13	189.67	393.07	536.13	397.60
MENHADEN, ATLANTIC	0	0	0	466.33	207.27	73
CRAB, GREEN	14.27	26.27	35.80	20.80	4.80	3.13
KILLIFISH, STRIPED	4.67	5.07	42.73	38.33	1.40	4.13
FLOUNDER, WINTER	2.80	16.47	55.40	6.53	5.53	4.07
SMELT, RAINBOW	0	0.27	0.67	0.40	12.87	60.27
KILLIFISH, COMMON	2.60	7.53	22.27	12.73	0	0.20
HERRING, ATLANTIC	25.53	0	0	0	0.07	0
HERRING, BLUEBACK	0	0.27	7.80	8.80	0.27	0.27
ALEWIFE	0.53	0.93	5.13	3.4	0.4	0.53
STICKLEBACK, NINESPINE	0.07	0.67	7.53	0.20	0.47	0.73
FLOUNDER, SMOOTH	2.20	1.33	0.40	0.53	0.33	0.47
SCULPIN, LITTLE	0.93	1.13	1.07	0.07	0.20	0.53
PERCH, WHITE	0	0	1.60	1.00	0	0.40
TOMCOD, ATLANTIC	1.40	0	0.13	0.47	0	0
STICKLEBACK, THREESPINE	0.40	0.20	0.40	0	0.07	0.07
PIPEFISH, NORTHERN	0.47	0.20	0.13	0.13	0.13	0
STICKLEBACK, FOURSPINE	0	0.13	0.40	0.13	0	0.40
FLOUNDER, WINDOWPANE	0	0.13	0.60	0.13	0	0
HAKE, RED	0	0	0	0	0	0.47
BASS, STRIPED	0	0	0	0.40	0	0
CRAB, ROCK	0.07	0	0	0.07	0.07	0.13
LUMPFISH	0	0.07	0.07	0.13	0	0.07
FOURBEARD ROCKLING	0	0	0	0	0	0.27
CUNNER	0	0	0.07	0.07	0	0.07
GUNNEL, ROCK	0	0.07	0.07	0	0	0
LANCE, SAND	0	0	0	0	0	0.13
SHAD, AMERICAN	0	0	0	0.13	0	0
BLUEFISH	0	0	0.07	0	0	0
CRAPPIE, BLACK	0.07	0	0	0	0	0
FLOUNDER (UNCLASSIFIED)	0.07	0	0	0	0	0
HAKE, SILVER	0	0	0	0	0	0.07
HAKE, WHITE	0.07	0	0	0	0	0
HERRING (UNCLASSIFIED)	0	0	0	0.07	0	0
MACKEREL SCAD	0	0	0	0.07	0	0
RAVEN, SEA	0	0	0	0	0	0.07
SCULPIN, SHORTHORN	0	0.07	0	0	0	0
ALL SPECIES	86.73	74.93	372	954	770	547.07

Table 2-3. Mean, minimum, and maximum total length (cm), by species, as well as sample size (N), for fish species measured during a juvenile finfish seine survey conducted in New Hampshire estuaries during 2002.

SPECIES	TOTAL LENGTH (cm)			N
	MEAN	MINIMUM	MAXIMUM	
ALEWIFE	7.9	3.1	24.9	104
BASS, STRIPED	53.7	40.9	71.1	6
BLUEFISH	13.1	13.1	13.1	1
CRAPPIE, BLACK	4.9	4.9	4.9	1
CUNNER	3.4	2.9	3.7	3
FLOUNDER (UNCLASSIFIED)	2.0	2.0	2.0	1
FLOUNDER, SMOOTH	7.0	1.9	15.4	78
FLOUNDER, WINDOWPANE	5.9	1.7	29.5	13
FLOUNDER, WINTER	5.0	1.8	27.7	584
FOURBEARD ROCKLING	3.0	2.5	3.3	4
GUNNEL, ROCK	11.4	11.3	11.5	2
HAKE, RED	6.1	5.3	6.9	7
HAKE, SILVER	10.0	10.0	10.0	1
HAKE, WHITE	9.0	9.0	9.0	1
HERRING, ATLANTIC	7.6	3.4	17.2	85
HERRING, BLUEBACK	6.7	2.0	22.8	74
KILLIFISH, COMMON	5.7	2.2	10.4	213
KILLIFISH, STRIPED	5.8	2.1	13.1	327
LANCE, SAND	11.2	10.2	12.2	2
LUMPFISH	3.2	2.0	5.2	5
MACKEREL SCAD	7.6	7.6	7.6	1
MENHADEN, ATLANTIC	6.3	3.3	11.8	305
PERCH, WHITE	6.1	3.5	11.3	44
PIPEFISH, NORTHERN	16.1	7.6	21.7	16
RAVEN, SEA	44.5	44.5	44.5	1
SCULPIN, LITTLE	4.8	2.6	10.2	57
SCULPIN, SHORTHORN	4.2	4.2	4.2	1
SHAD, AMERICAN	4.7	4.4	4.9	2
SILVERSIDE, ATLANTIC	8.3	4.1	15.1	1258
SMELT, RAINBOW	6.5	3.8	13.1	195
STICKLEBACK, FOURSPINE	3.9	3.2	5.2	16
STICKLEBACK, NINESPINE	4.6	3.6	5.6	60
STICKLEBACK, THREESPINE	4.3	3.2	6.4	14
TOMCOD, ATLANTIC	8.5	6.2	13.1	30

Table 2-6. Surface temperature measurements (°C), by station and month, collected during a juvenile finfish seine survey conducted in New Hampshire estuaries, 2002.

MONTH	Little Harbor			Hampton/Seabrook Estuary				Piscataqua River			Little Bay/Great Bay				
	5	7	9	23	25	29	33	30	35	39	54	72	93	107	147
JUNE	17	16	16	13	14	16	15	17	15	19	15	16	17	16	17
JULY	14	14	15	14	16	17	18	19	19	24	21	22	24	25	26
AUG.	20	20	20	20	22	22	23	20	23	26	20	21	24	24	25
SEPT.	18	18	18	16	18	19	17	15	14	17	22	22	24	25	22
OCT.	10	9	9	13	12	13	12	13	11	10	13	13	13	13	14
NOV.	9	10	10	10	10	10	9	9	9	8	10	9	10	4	10

Table 2-7. Surface salinity measurements (ppt), by station and month, collected during a juvenile finfish seine survey conducted in New Hampshire estuaries, 2002.

MONTH	Little Harbor			Hampton/Seabrook Estuary				Piscataqua River			Little Bay/Great Bay				
	5	7	9	23	25	29	33	30	35	39	54	72	93	107	147
JUNE	32	28	29	31	30	30	30	26	23	5	21	19	15	3	16
JULY	32	31	32	31	32	31	30	25	24	11	24	24	20	12	20
AUG.	30	31	30	32	30	31	32	30	30	24	31	31	30	26	32
SEPT.	31	30	31	30	31	28	31	31	30	23	30	31	29	23	30
OCT.	26	26	26	30	30	30	30	27	27	5	26	28	27	25	28
NOV.	28	25	25	26	25	25	25	24	25	5	24	23	24	2	22

Table 2-8. Annual geometric mean catch per seine haul, plus the standard deviation of those values for all species caught in a juvenile finfish seine survey conducted in New Hampshire's estuaries from 1997 to 2002.

COMMON NAME	VARIABLE	1997	1998	1999	2000	2001	2002
ALEWIFE	MEAN	0.07	0.04	0.27	0.26	0.14	0.34
	STD	0.38	0.33	1.56	0.87	0.74	1.21
ANCHOVY, BAY	MEAN	0	0	0	0	0.01	0
	STD					0.08	
BASS, STRIPED	MEAN	0.01	0	0.01	0.02	0.01	0.04
	STD	0.08		0.08	0.13	0.08	0.21
BLUEFISH	MEAN	0	0	0.20	0.04	0.12	0.01
	STD			0.89	0.26	0.71	0.08
BUTTERFISH	MEAN	0	0	0.01	0	0	0
	STD			0.08			
COD, ATLANTIC	MEAN	0	0	0	0	0.03	0
	STD					0.27	
CRAB, GREEN	MEAN	2.36	2.77	6.08	5.63	3.81	6.86
	STD	2.33	2.73	3.33	2.55	2.24	2.94
CRAB, HORSESHOE	MEAN	0.07	0.01	0	0.06	0.02	0
	STD	0.31	0.08		0.31	0.13	
CRAB, JONAH	MEAN	0	0	0	0.01	0.01	0
	STD				0.08	0.08	
CRAB, ROCK	MEAN	0.09	0.05	0.01	0.06	0	0.04
	STD	0.35	0.32	0.08	0.26		0.18
CRAPPIE, BLACK	MEAN	0	0	0	0	0	0.01
	STD						0.08
CREVALLE	MEAN	0	0	0	0	0.02	0
	STD					0.11	
CUNNER	MEAN	0.05	0.02	0.02	0.04	0	0.02
	STD	0.29	0.11	0.13	0.18		0.13
FLOUNDER (UNCLASSIFIED)	MEAN	0.01	0	0	0	0	0.01
	STD	0.12					0.08
FLOUNDER, SMOOTH	MEAN	0.18	0.14	0.50	0.34	0.31	0.39
	STD	0.49	0.61	1.30	0.98	0.82	0.88
FLOUNDER, WINDOWPANE	MEAN	0	0.01	0.01	0.01	0	0.08
	STD		0.08	0.12	0.08		0.32
FLOUNDER, WINTER	MEAN	0.94	1.63	0.83	3.44	1.68	3.14
	STD	1.35	1.95	1.13	2.85	1.44	3.33
FOURBEARD ROCKLING	MEAN	0	0	0	0	0	0.02
	STD						0.18
GUNNEL, ROCK	MEAN	0.01	0.02	0	0.01	0	0.02
	STD	0.08	0.11		0.08		0.11
HAKE, RED	MEAN	0	0	0.06	0.01	0.02	0.04
	STD			0.21	0.08	0.18	0.23
HAKE, SILVER	MEAN	0	0	0	0	0	0.01
	STD						0.08
HAKE, WHITE	MEAN	0.06	0.02	0.02	0	0.04	0.01
	STD	0.33	0.13	0.15		0.26	0.08

Table 2-8. (cont)

COMMON NAME	VARIABLE	1997	1998	1999	2000	2001	2002
HERRING (UNCLASSIFIED)	MEAN	0.03	0	0	0	0	0.01
	STD	0.17					0.08
HERRING, ATLANTIC	MEAN	0.28	0.16	0.82	0.37	0.12	0.24
	STD	2.63	1.14	5.59	2.08	0.89	1.38
HERRING, BLUEBACK	MEAN	0.49	0.66	0.97	0.74	0.89	0.26
	STD	1.72	3.13	3.74	2.90	3.15	1.20
KILLIFISH, COMMON	MEAN	1.71	0.58	2.00	1.10	0.58	0.68
	STD	2.88	2.10	3.08	2.09	1.39	2.31
KILLIFISH, STRIPED	MEAN	0.23	0.05	1.46	0.82	1.18	1.24
	STD	1.06	0.36	3.70	2.32	2.26	3.27
LANCE, SAND	MEAN	0.02	0.02	0.15	0.03	0.04	0.01
	STD	0.15	0.18	0.84	0.17	0.18	0.12
LOBSTER, AMERICAN	MEAN	0	0	0.02	0.01	0	0
	STD			0.11	0.08		
LUMPFISH	MEAN	0.07	0.03	0.01	0.02	0.06	0.04
	STD	0.4	0.17	0.08	0.13	0.23	0.18
MACKEREL SCAD	MEAN	0	0	0	0	0	0.01
	STD						0.08
MENHADEN, ATLANTIC	MEAN	0.06	0	0.57	2.15	0.30	1.37
	STD	0.47		3.14	8.45	1.85	7.31
OTHER FISH (UNCLASSIFIED)	MEAN	0	0.01	0	0	0	0
	STD		0.08				
PERCH, WHITE	MEAN	0.11	0.02	0.02	0.12	0	0.16
	STD	0.51	0.15	0.13	0.56		0.69
PIPEFISH, NORTHERN	MEAN	0.05	0.12	0.07	0.14	0.09	0.11
	STD	0.23	0.42	0.27	0.43	0.36	0.34
POLLOCK	MEAN	0	0	0.02	0	0	0
	STD			0.26			
RAVEN, SEA	MEAN	0.02	0.01	0	0	0	0.01
	STD	0.16	0.08				0.08
SCULPIN, LITTLE	MEAN	0.15	0.29	0.1	0.09	0.30	0.31
	STD	0.49	0.69	0.34	0.51	0.65	0.75
SCULPIN, LONGHORN	MEAN	0	0	0.01	0	0	0
	STD			0.08			
SCULPIN, SHORTHORN	MEAN	0.04	0	0.01	0	0	0.01
	STD	0.25		0.08			0.08
SHAD, AMERICAN	MEAN	0.02	0	0.12	0.04	0.02	0.01
	STD	0.11		0.95	0.35	0.18	0.12
SILVERSIDE, ATLANTIC	MEAN	17.81	7.93	56.21	30.16	23.03	22.95
	STD	10.28	8.65	17.62	15.56	10.77	14.05
SMELT, RAINBOW	MEAN	0.59	0.85	0.39	1.50	1.27	0.69
	STD	2.75	3.81	1.67	4.62	4.49	2.51

Table 2-8. (cont)

COMMON NAME	VARIABLE	1997	1998	1999	2000	2001	2002
STICKLEBACK, FOURSPINE	MEAN	0.34	0.13	0.18	0.16	0.31	0.09
	STD	1.43	0.49	0.61	0.48	0.92	0.36
STICKLEBACK, NINESPINE	MEAN	0.30	0.28	0.45	0.31	0.23	0.25
	STD	1.44	0.91	1.73	0.78	1.07	0.95
STICKLEBACK, THREESPINE	MEAN	0.19	0.08	0.08	0.06	0.07	0.11
	STD	0.94	0.35	0.32	0.26	0.31	0.38
TOMCOD, ATLANTIC	MEAN	0.14	0.11	0.06	0.18	0.10	0.13
	STD	0.77	0.52	0.49	0.52	0.45	0.55
TROUT, BROWN	MEAN	0	0	0	0.01	0	0
	STD				0.08		
ALL SPECIES	MEAN	64.24	34.70	223.60	146.56	87.57	118.31
	STD	5.64	6.04	7.24	5.61	4.67	5.36

Table 2-10. Mean, minimum, and maximum temperature and salinity measurements from juvenile finfish seine survey conducted in New Hampshire estuaries, 1997 - 2002.

Year	Temperature (°C)			Salinity (ppt)		
	Mean	Min	Max	Mean	Min	Max
1997	16.5	3	25	26.8	4	31
1998	15.9	6	26	23.4	0	35
1999	17.4	4	28	*	*	*
2000	17.5	10	25	28.4	9	34
2001	15.6	6	26	28.6	9	33
2002	16.2	4	26	25.8	2	32

* Salinity measurements inaccurate due to faulty refractometer.

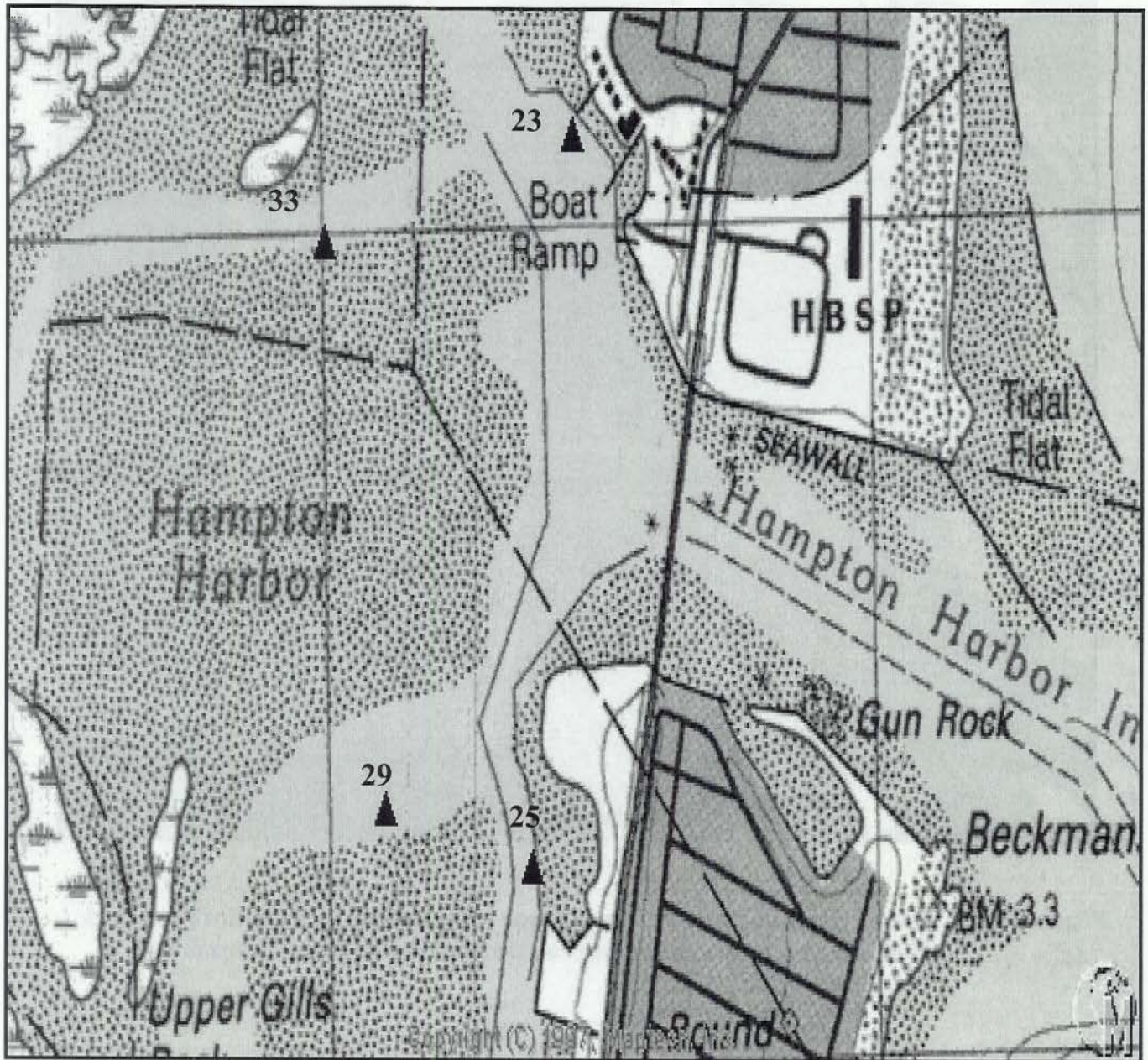


Figure 2-1. Sampling stations in Hampton/Seabrook Estuary for the New Hampshire Fish and Game Department seine survey conducted in New Hampshire estuaries, 2002.

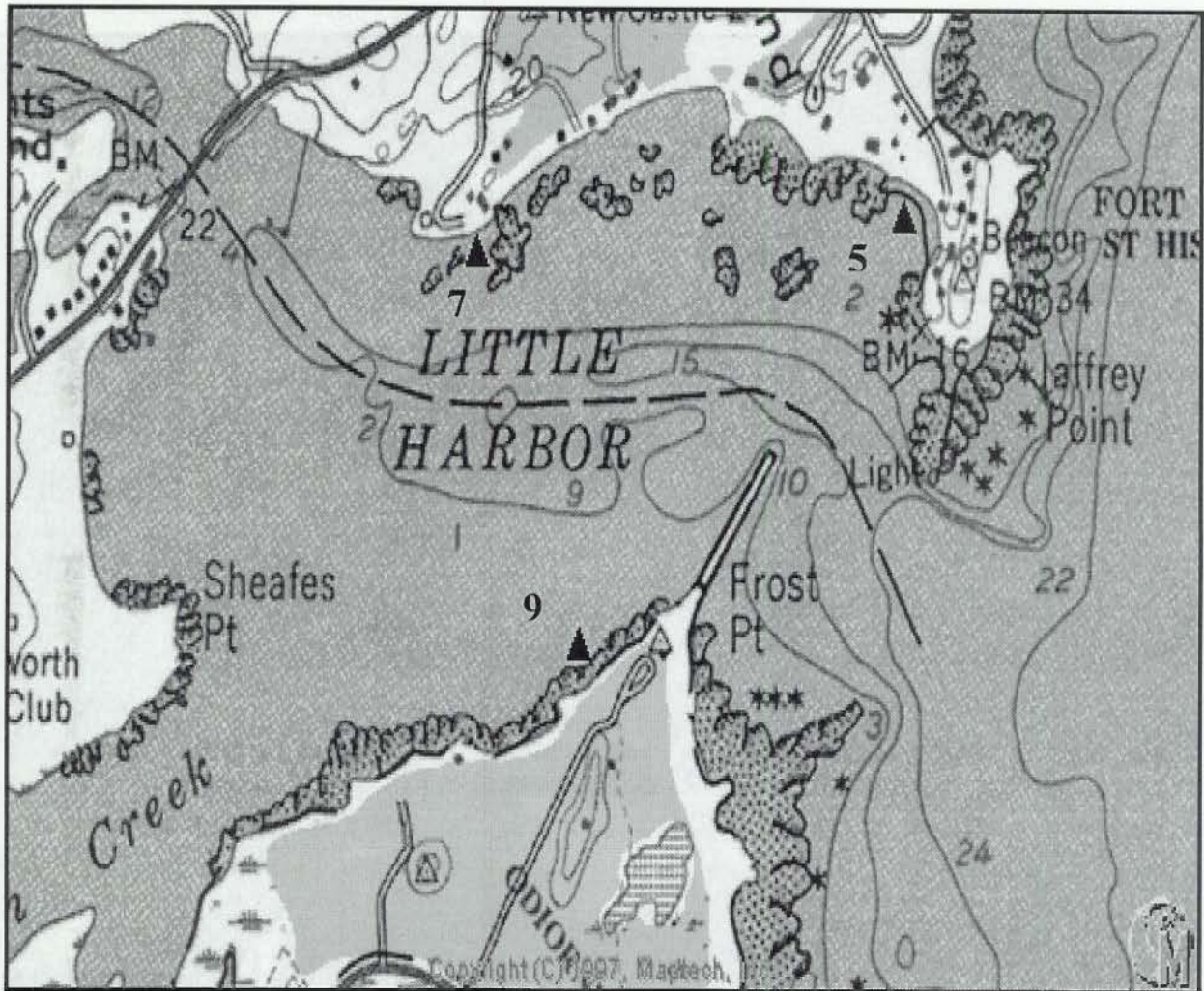


Figure 2-2. Sampling stations in Little Harbor for the New Hampshire Fish and Game Department seine survey conducted in New Hampshire estuaries, 2002.

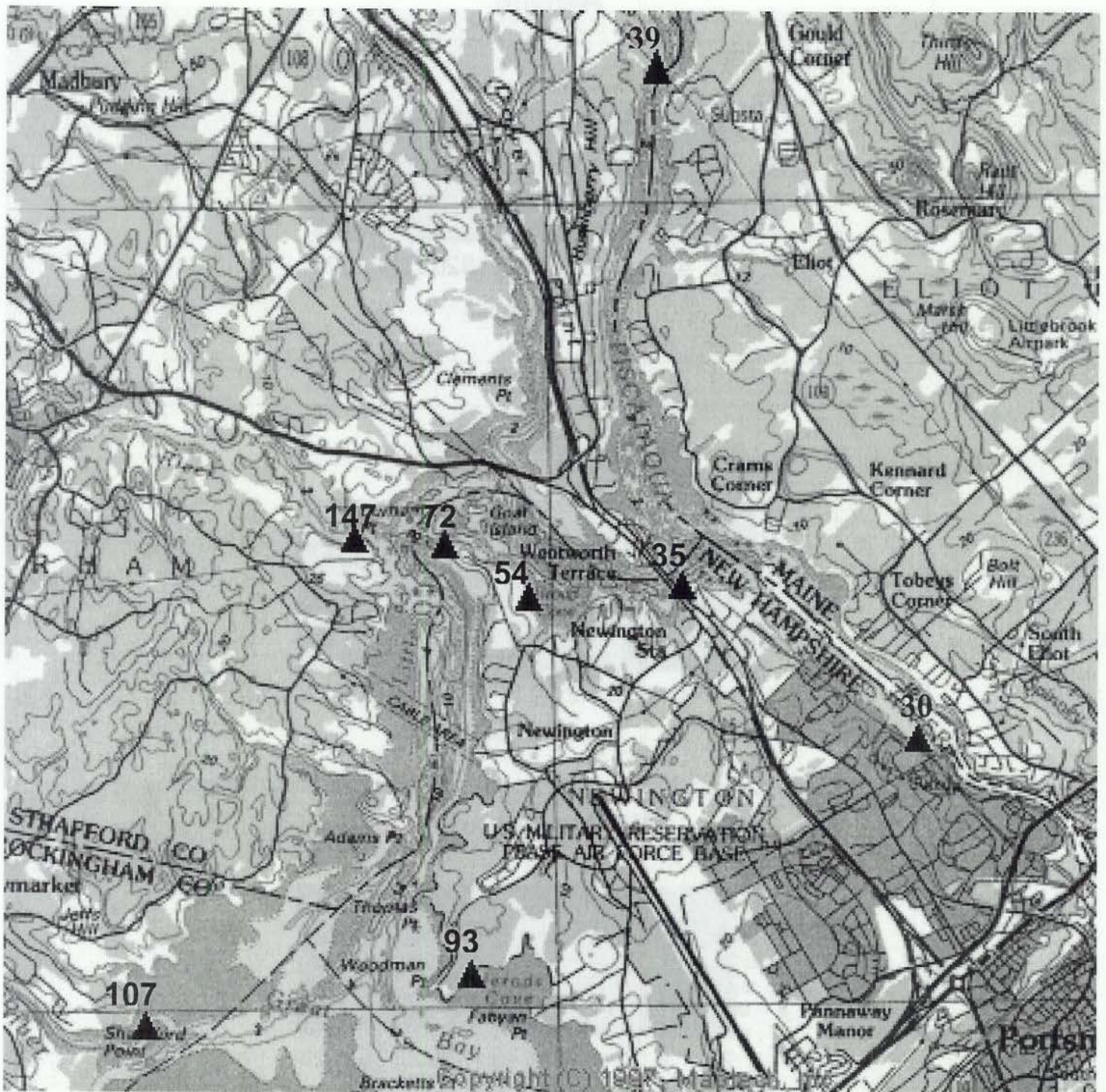


Figure 2-3. Sampling stations in the Piscataqua River and Little Bay/Great Bay area for the New Hampshire Fish and Game Department seine survey conducted in New Hampshire estuaries, 2002.

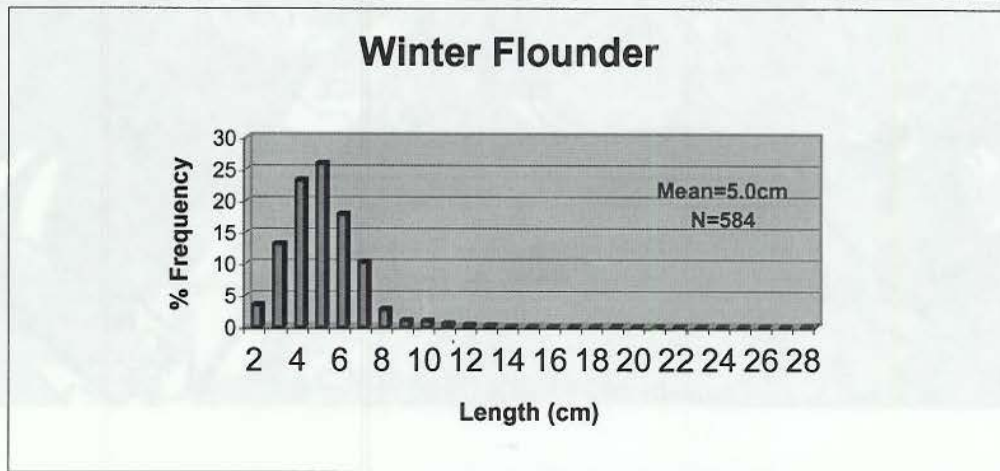
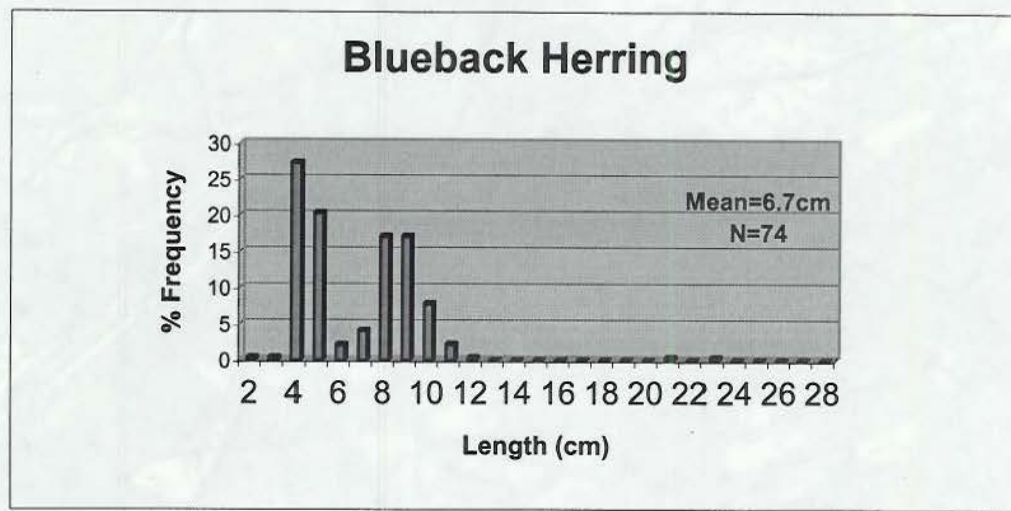
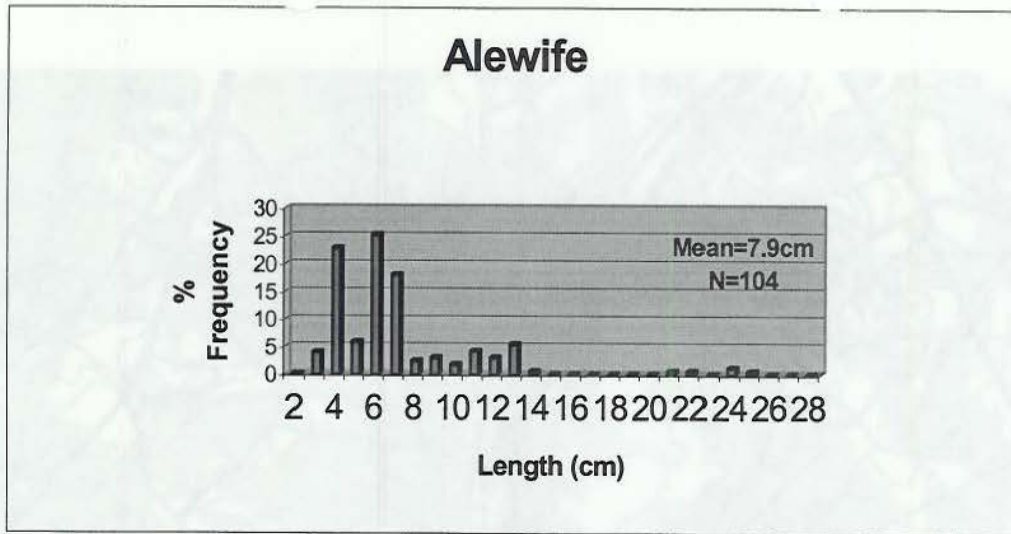


Figure 2-4. Weighted length frequencies of alewife, blueback herring, and winter flounder collected during a juvenile finfish seine survey conducted in New Hampshire estuaries in 2002.

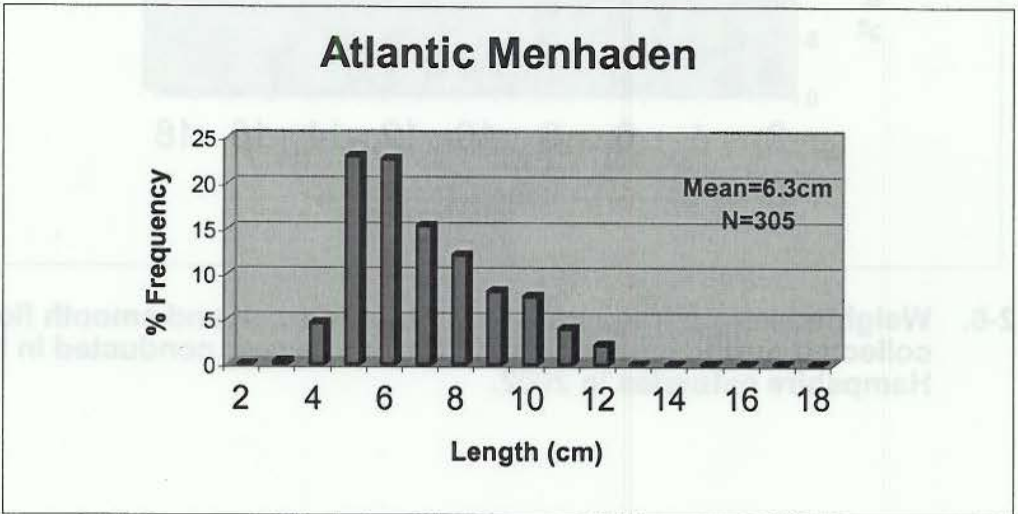
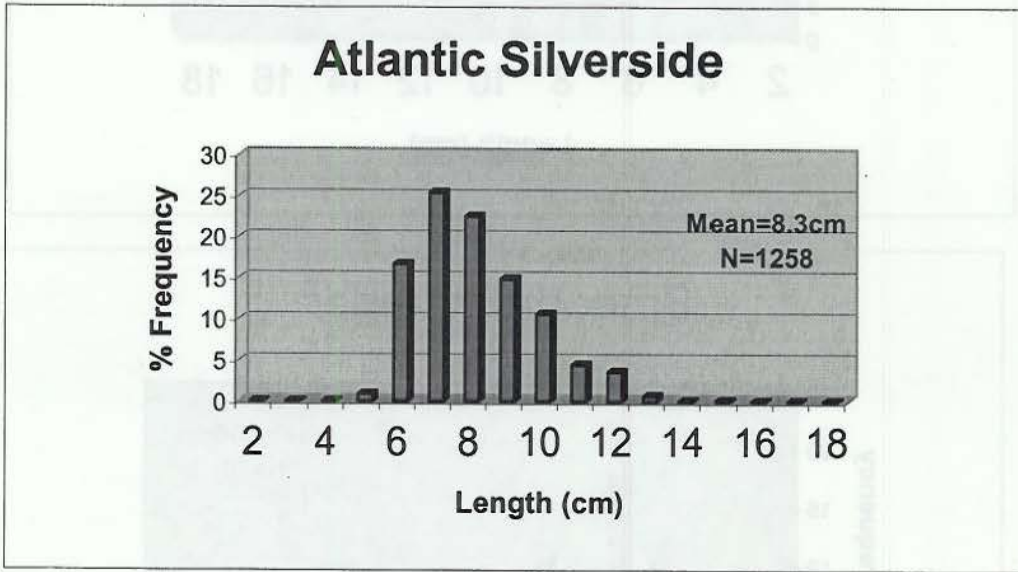
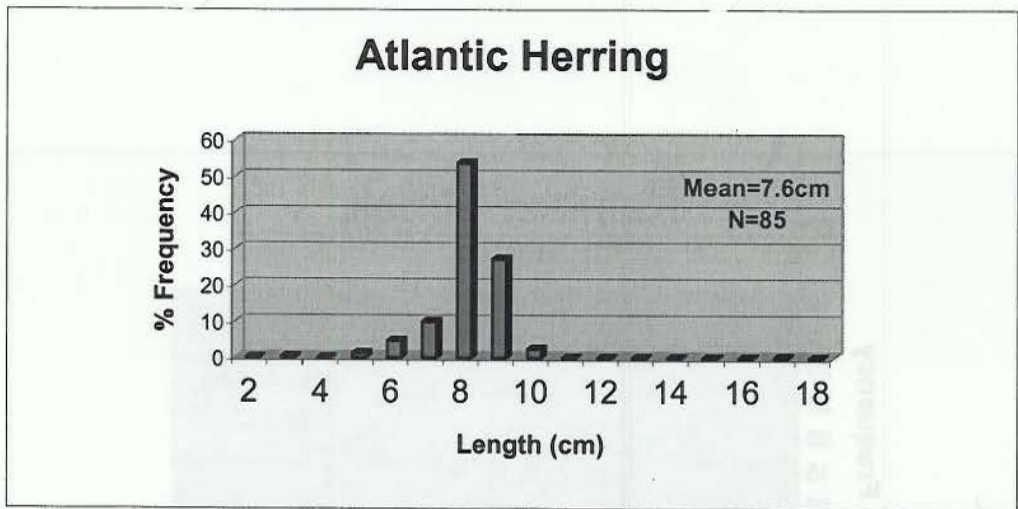


Figure 2-5. Weighted length frequencies of Atlantic herring, Atlantic menhaden, and Atlantic silverside collected during a juvenile finfish seine survey conducted in New Hampshire estuaries in 2002.

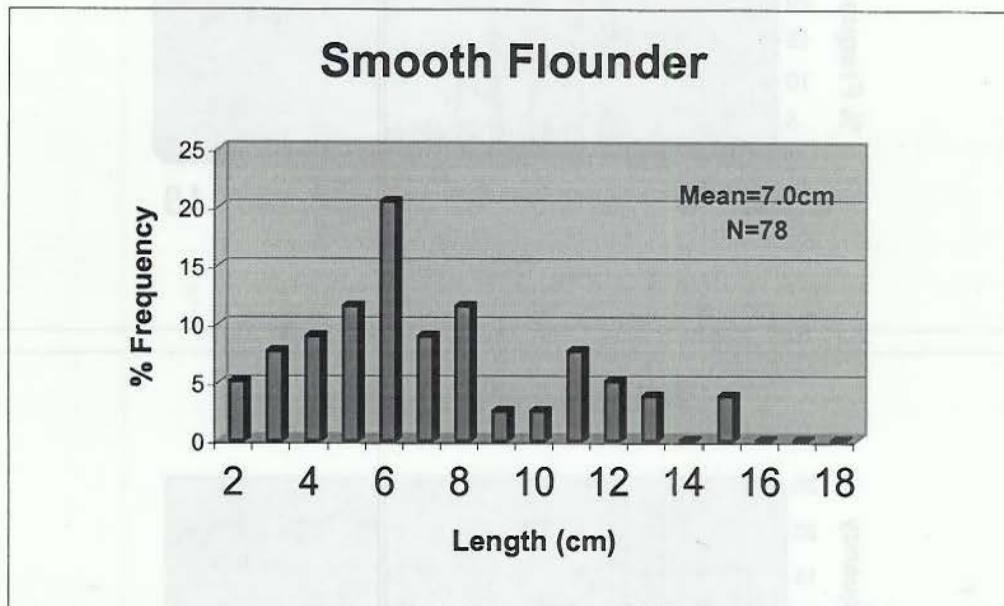
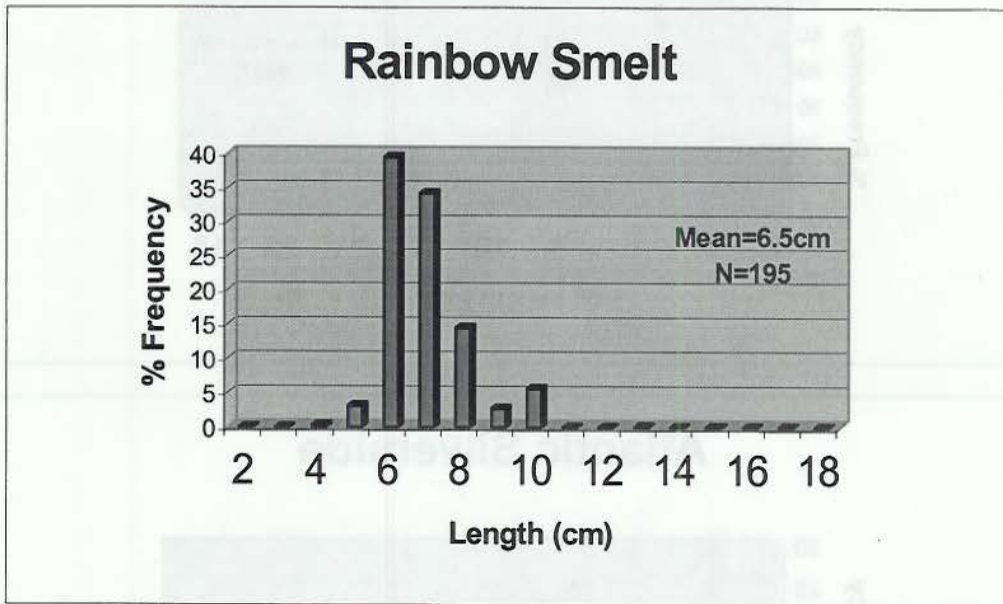


Figure 2-6. Weighted length frequencies of rainbow smelt and smooth flounder collected during a juvenile finfish seine survey conducted in New Hampshire estuaries in 2002.

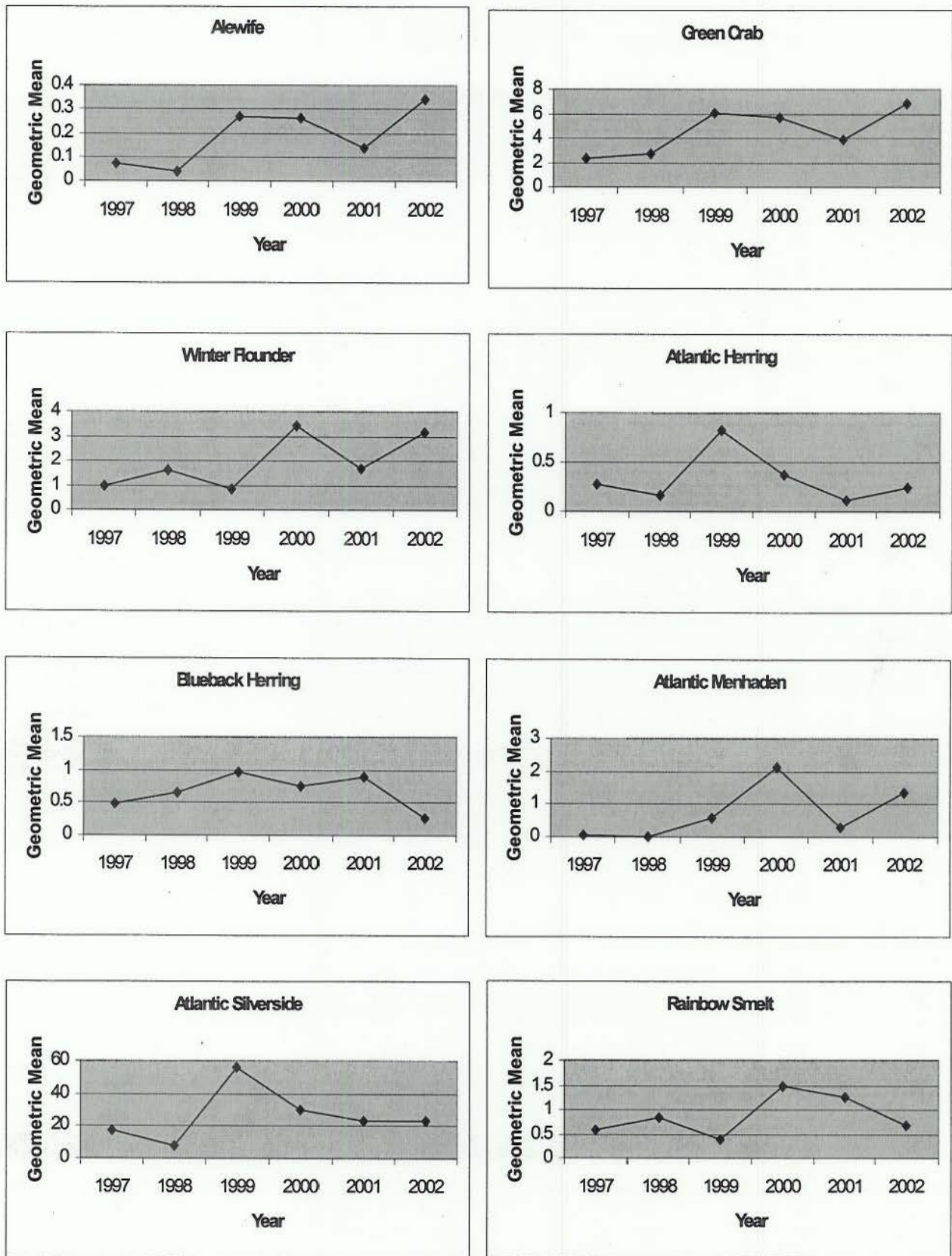


Figure 2-7. Geometric mean catch per seine haul for selected species during seine surveys conducted in New Hampshire estuaries from 1997 to 2002.

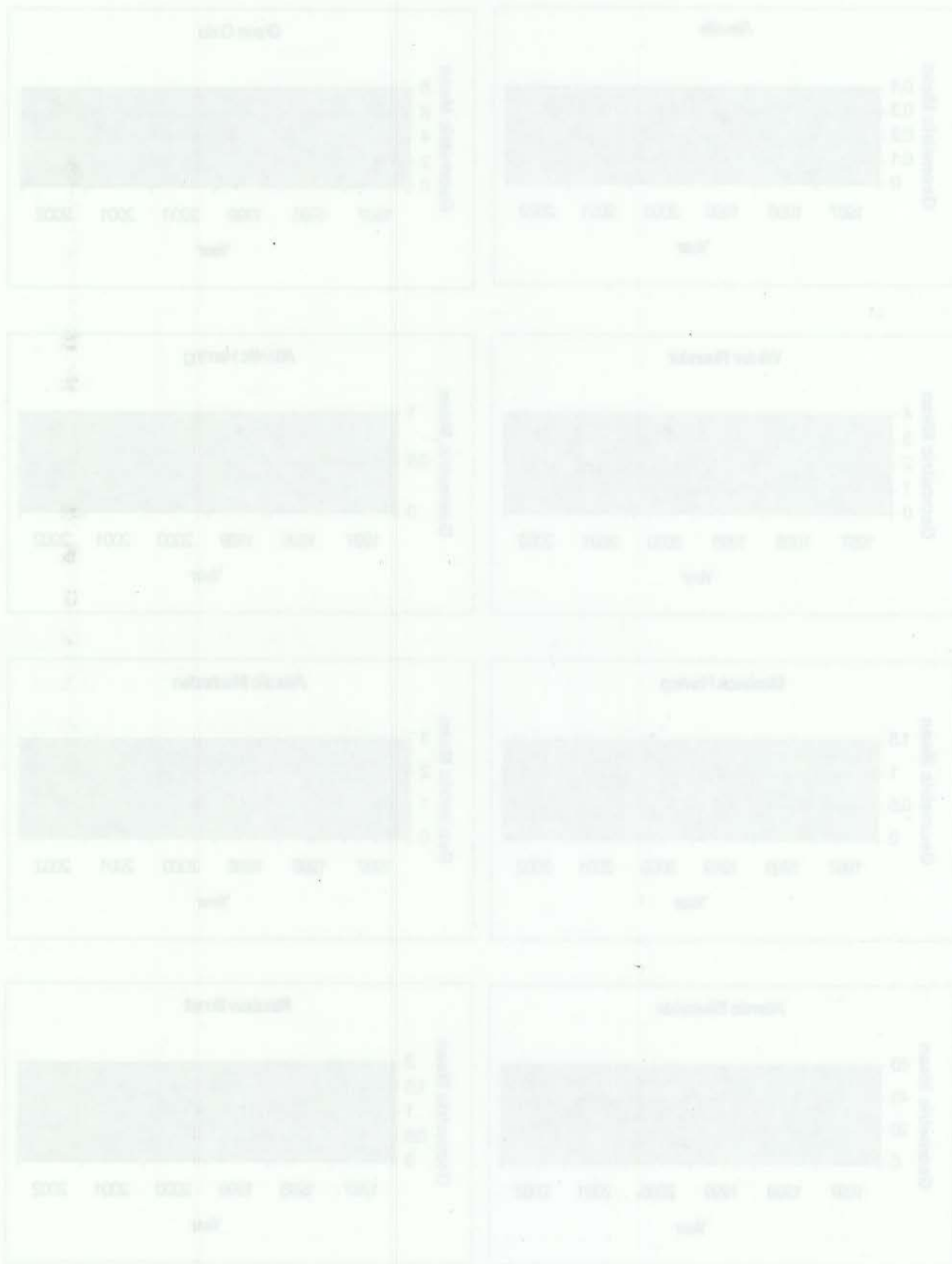


Figure 3-7. Geometric mean catch per unit effort for selected species during seine surveys conducted in New Hampshire estuaries from 1987 to 2002.

**JOB 3: COMMERCIAL FISHERIES DATA COLLECTION -
NORTHERN SHRIMP PORT SAMPLING**

Final Report

ABSTRACT

Northern shrimp port sampling was conducted weekly during the 2002 and 2003 northern shrimp fishing season (total 25 and 38 days, respectively) from February 15 - March 11, 2002 and January 15 - February 27, 2003. Vessel information was recorded and at least 1 kilogram (2.2 pounds) of northern shrimp was processed weekly to provide information on the size and age composition of the catch. Based on the information generated, the 2002 fishing year illustrated that catches were composed primarily of female II's that were likely early maturing females from the moderately sized 1999 year class, while catches sampled from the 2003 fishery appear to be composed primarily of females with eggs in January and female II's in February, most likely again from the moderately sized 1999 year class. The very strong 2001 year class (assumed 2 year old males, transitionals, and early maturing females) composed the smaller component of the bimodal distribution pattern seen in 2003.

INTRODUCTION

Historically, Gulf of Maine northern shrimp have provided the local fishing community a source of income. This fishery generally peaks in late winter when egg bearing (ovigerous) females move into inshore waters (Clark et al. 2000).

The northern shrimp, *Pandalus borealis*, is hermaphroditic, maturing and functioning as males at approximately age two, passing through transitional stages and maturing as females at approximately age 3. Mature females may bear eggs up to two to three times during their lifetime (~5 years).

The northern shrimp resource in the Gulf of Maine is considered to be a single stock. Mating occurs offshore during summer months and eggs are extruded and fertilized. Ovigerous females migrate inshore where hatching occurs in late winter. "Spent" females (female II's with hatched eggs) return to deeper water offshore. After the pelagic larvae metamorphosize during

the summer, they become bottom dwellers and usually remain as juveniles until the end of their second summer (age 2) when they mature as males, migrate into deeper waters and mate with older females and the life cycle continues (McInnes, 1986; Clark, et al, 2000). It is the movement inshore of the large egg bearing females that allows an inshore New England northern shrimp fishery during this time frame.

The Gulf of Maine fishery for northern shrimp is managed through agreement between the states of Maine, New Hampshire and Massachusetts through the Atlantic States Marine Fisheries Commission's (ASMFC) Interstate Fishery Management Program. New Hampshire Fish & Game Department biologists conduct port sampling to furnish biological and catch/effort information for the ASMFC Technical Committee. The New Hampshire data along with similar information from Maine and Massachusetts are the basis of a technical report used to advise fishery managers on the status of the fishery.

PROCEDURES

Weekly samples of northern shrimp were collected from vessels during the 2002 and 2003 shrimp fishery seasons by managers of the New Hampshire fishery co-operatives (Portsmouth Fishermen's and Yankee Fishermen's). The following information was recorded from each vessel that participated in this program: date, vessel name, landing location, catch weight (pounds), hours towed, number of tows, towed depth and area fished.

A New Hampshire Fish & Game Department biologist collected the northern shrimp sample from the co-op and a minimum of 1 kilogram of the northern shrimp was processed in the laboratory to provide information on the size and age composition of the catch. Data collected included: sex, stage of maturity, carapace length (mid-dorsal carapace length to the nearest one hundredth of a millimeter) and egg bearing condition. Lengths were placed within 0.5mm intervals. The count per pound (commercial count) of northern shrimp was determined and the number of northern shrimp in the boat catch was extrapolated by multiplying the number of northern shrimp counted from the lab sample by the ratio of the total boat catch weight divided by the total lab sample weight. Both weights include all components of the catch including "trash" consisting of small pieces of body parts, etc. A representative collection sheet is found in Table 3-1.

RESULTS

The New Hampshire northern shrimp 2002 fishery was primarily an inshore water (<55 fathoms) fishery during February with boats moving offshore (>55 fathoms) as the fishing season progressed in March; while, the 2003 fishery was likely an inshore fishery. During the 25 day fishery in 2002, 89,710 pounds with an ex-vessel value of \$103,860 were landed in New Hampshire. Monthly, this amounted to 59,120 lbs. (\$59,143) in February and 30,590 lbs. (\$44,717) in March 2002 (NMFS data). During the 38 day fishery in 2003, 223,256 pounds with an ex-vessel value of \$212,185 were landed in New Hampshire. Monthly, this amounted to 59,086 lbs. (\$54,087) in January and 164,170 lbs. (\$158,098) in February, 2003 (NMFS preliminary data).

Boats landing northern shrimp in New Hampshire ranged in size from 34 feet to 50 feet. The number of tows per trip for each boat ranged from 2-3 in both years. Commercial count in 2002 was found to be highest in March (Table 3-2). Commercial count in 2003 in both months of the season was similar. Catch per unit effort (CPUE) was highest in March during 2002 and highest in February in 2003 (Table 3-2).

Table 3-3 illustrates the size characteristics of the northern shrimp caught during the 2000-2003 northern shrimp seasons. Females with eggs in 2003 had the smallest minimum size over this time period. Females with eggs in 2002 were not present in March catches. All other population components were present during the 2002 and 2003 fishing seasons.

On a monthly basis, the catch was primarily comprised of female II's in February and March 2002 and egg bearing females in January 2003. In February 2003, the catch was dominated by female II's (Figures 3-1, 3-2, 3-3, 3-4). In 2003, a bimodal distribution of sizes of the shrimp sampled from New Hampshire landings was observed.

DISCUSSION

Recruitment of northern shrimp has been poor since 1993 with the exception of the 1996 and 1999 year classes (ASMFC NSTC 2000). Based on the 2002 assessment (ASMFC NSTC 2002), the 2001 year class appears to be very strong and the poor landings (preliminary data) observed in 2002 were the lowest in the Gulf of Maine since 1993.

Catches from New Hampshire port sampling were composed primarily of female II's in the 2002 shrimp season. The majority of female II's are likely early maturing females (smaller,

mean size) from the moderate 1999 year class. No females with eggs were sampled from March 2002 port samples. The majority of the females had likely dropped their eggs and moved offshore. One hundred percent of the fishery was inshore in February 2002 (ASMFC NSTC 2002).

There were relatively good catches per hour in 2002 landed in New Hampshire and in the Gulf of Maine (ASMFC NSTC 2002). The relatively high counts seen in NH port samples were likely due to the moderately abundant 1999 year class. Based on the 2002 assessment (ASMFC NSTC 2002) the catch from the 2002 Gulf of Maine fishery was composed of the weak 1997 and 1998 year classes consisting of 4 and 5 year old females, the moderate 1999 year class consisting of 3 year old males, transitionals and early maturing females, and a large quantity of 1 year old shrimp from the 2001 year class that were so abundant that the industry could not avoid them. Two year old shrimp from the 2000 year class were generally absent.

Catches sampled from New Hampshire port sampling in 2003 were composed primarily of females with eggs in January and female II's in February. Based on New Hampshire port sampling, it appears that the 2003 fishery was primarily an inshore fishery (<55 fathoms). The very few males, transitionals and the female I's likely represent the limited 2000 year class. The early maturing females (small sized females with eggs and female II's) are also likely from this 2000 year class.

Maine port samplers reported that a high percentage of small shrimp were "shaken" out of the catch at sea. In some instances, a sieve was used to separate out the smaller shrimp and these smaller shrimp were thrown overboard. It is not known whether this occurred with the port samples that were collected from catches landed in New Hampshire. Port samples landed in Maine known not to have been "shaken" at sea will be compared with samples that were "shaken" at sea.

The bimodal distribution in the sizes of shrimp sampled from New Hampshire landings in 2003 is composed primarily of assumed 4 year old females from the moderate 1999 year class and the assumed 2 year old males, transitionals and early maturing females from the 2001 year class as was predicted in the assessment report (ASMFC NSTC 2002).

There were relatively good catch rates and low counts per pound in New Hampshire landed port samples during 2003. The low counts were due to the abundance of females with eggs and female II's from the 1999 year classes that dominated the catch.

What was available to the 2003 Gulf of Maine fishery was the assumed 5 year old females from the very weak 1998 year class, assumed 4 year old females from the moderate 1999 year class, assumed 3 year old males, transitionals and early maturing females from the very limited 2000 year class, assumed 2 year old males, transitionals and early maturing females from the very strong 2001 year class and the unknown (juveniles) 2002 year class (ASMFC NSTC 2002).

In summary:

- 1) The number of tows per trip for each boat sampled from New Hampshire ranged from 2-3 in both years.
- 2) New Hampshire port samples resulted in the highest count in March for 2002, and was similar in both months of the season in 2003.
- 3) Catches sampled from New Hampshire port sampling were composed primarily of female II's in the 2002 shrimp season from the weak 1997 and 1998 year classes and the early maturing females from the moderately abundant 1999 year class.
- 4) A bimodal distribution in sizes of shrimp sampled from New Hampshire landings was seen for 2003. The larger peak was composed of female II's and females with eggs (likely from the moderately sized 1999 year class, assumed 4 year old females) while the smaller peak was composed of males, transitionals, and early maturing females from the very strong 2001 year class.

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- Clark, S.H., S.X. Cadrin, D.F. Schick, P.J. Diodati, M.P. Armstrong and D. McCarron.
2000. The Gulf of Maine Northern Shrimp (*Pandalus borealis*) Fishery- a Review of the Record. Journal of Northwest Atlantic Fishery Science 27: 193-226.
- McInnes, D. 1986. Interstate Fishery Management Plan for the Northern Shrimp (*Pandalus borealis* Kroyer) Fishery in the Western Gulf of Maine. ASMFC Fishery Management Report No. 9, 192pp.

Table 3-1. Representative of northern shrimp data collection sheet for New Hampshire port samples (confidential items removed).

Catch date	Dealer code	Port or county	Boat name	Sample I.D	Catch weight factor	unused	unused
	Portsmouth	Portsmouth		NH200303		unused	unused
Location X	Location Y	Depth (min)	Depth (max)	Catch location	Small Sample Mass (g)	Small unmeasured mass (g)	Small unmeasured factor
					1		1
Gear type	# of Trawls	Days Set-over	# hours trawling	Data Entry date	Large Sample Mass (g)	Large unmeasured mass (g)	Large unmeasured Factor
Trawl	3		7		1		1
Tot catch wt (lbs)	Samp frz mass (g)	Samp thw mass (g)	CPUE (lbs/hr)	Data entry tech	Trash mass (g)	unused	unused
1200		1092	171.4	JC,KMS	2	unused	unused
Males	Transitionals	Female I	Female II	Female w/ eggs	Dichelo	Montagui	Crangon
	19	18.77	23.87	24.63			
	18.26	17.79	25.54	25.37			
	18.34	20.82	29.14	28.23			
	17.76	18.91	24.42	27.69			
	20.47	19.42	25.16	22.36			
	19.84	20.02	25.26	25.23			
	18.79	20.19	19.14	26.93			
	18.21	20.03	23.84	25.32			
	19.82	20	25.52	27.92			
	17.29		26.15	25.38			
	17.29		23.67	23.89			
	15.88		20.86	26.82			
			23.62	28.07			
			25.95	25.65			
			20.52	24.48			
			19.33	27.41			
			20.65	23.86			
			18.97	25.25			
				18.3			
				24.79			
				25.44			
				24.03			
				27.55			
				24.49			

Table 3-1 (continued).

				27.49			
				24.86			
				27.31			
				23.41			
				22.41			
				26.28			
				24.77			
				25.81			
				25.93			
				19.5			
				23.48			
				25.36			
				24.79			
				27.33			
				25.25			
				23.86			
				25.59			
				25.8			
				28.84			
				26.82			
				24.36			
				24.24			
				25.77			
				19.4			
				25.67			
				24.39			
				23.7			
				27.37			
				30.32			
				25.49			
				24.6			
				27.44			
				24.46			
				27.82			
				24.48			
				25.55			
				26.36			
				24.65			
				26.73			
				24.67			
				24.85			
				25.49			

Table 3-1 (continued).

Weights and Masses	# / unit	
Total catch weight	lb	1200
Total shrimp sample mass (frozen)	g	1092
Males	g	
Transitionals	g	49
Females I	g	43
FemalesII	g	160
Egg-bearing female Non-Borealis	g	809
Dichelo:	g	19
Montagui:	g	
Crangon:	g	
Discarded mass	g	2
Mass Loss:	g	10
Summary		
Males	avg	
a10:a1000	min	
	max	
	tot. #	0
Transitionals	avg	18.4125
b10:b1000	min	15.88
	max	20.47
	tot. #	12
Females I	avg	19.55
c10:c1000	min	17.79
	max	20.82
	tot. #	9
Females II	avg	23.42277778
d10:d1000	min	18.97
	max	29.14
	tot. #	18
Egg-bearing Female	avg	25.33015152
e10:e1000	min	18.3
	max	30.32
	tot. #	66

Table 3-2. Monthly number of samples, commercial count, boat catch and CPUE of northern shrimp port samples from New Hampshire from 2000-2003.

2000

Month	# of Samples	Commercial Count (#)*	Boat Catch (#)**	CPUE (Pounds/Trawling Hour)
January	2	45	164,305	361.9
February	4	42	346,112	260.7
March	3	55	175,086	173.8

* Count per pound of raw shrimp.

** Expanded number of shrimp.

2001

Month	# of Samples	Commercial Count (#)*	Boat Catch (#)**	CPUE (Pounds/Trawling Hour)
January	4	58	178,918	126.7
February	4	52	148,577	132.1
March	1	72	131,815	487.5
April	3***	69	551,534	299.4

* Count per pound of raw shrimp.

** Expanded number of shrimp.

*** Two samples were taken in one week.

2002

Month	# of Samples	Commercial Count (#)*	Boat Catch (#)**	CPUE (Pounds/Trawling Hour)
February	3	51	174,529	190.6
March	3***	58	170,801	380.4

* Count per pound of raw shrimp.

** Expanded number of shrimp.

*** Three samples were taken in one week.

2003

Month	# of Samples	Commercial Count (#)*	Boat Catch (#)**	CPUE (Pounds/Trawling Hour)
January	5***	47	196,095	138.6
February	5****	46	175,773	146.1

* Count per pound of raw shrimp.

** Expanded number of shrimp.

*** Two samples were taken in two weeks.

****Two samples were taken in one week.

Table 3-3. New Hampshire northern shrimp carapace length (mm) summary by life stage from 2000-2003 port samples.

2000

Month	Males			Transitionals		
	Carapace Length			Carapace Length		
	Min	Max	Mean	Min	Max	Mean
January	12.00	19.50	15.79	18.00	23.00	20.02
February	9.50	13.00	11.12	17.50	20.50	18.50
March	9.50	15.00	11.95	16.00	22.50	19.32

Month	Female I (primiparous)			Female II (<100 eggs)			Female with Eggs (> 100 eggs)		
	Carapace Length			Carapace Length			Carapace Length		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
January	19.50	24.50	21.79	21.00	30.50	24.84	21.50	30.00	25.56
February				20.50	31.00	25.44	21.50	31.00	26.27
March	19.50	24.00	21.98	21.00	30.50	24.76	27.00	30.00	28.50

2001

Month	Males			Transitionals		
	Carapace Length			Carapace Length		
	Min	Max	Mean	Min	Max	Mean
January	9.56	18.48	16.53	11.36	22.74	18.28
February	10.91	18.72	16.84	15.88	20.15	18.16
March	10.17	18.59	13.82	16.42	19.76	17.95
April	10.01	20.95	17.87	15.88	23.98	19.70

Month	Female I (primiparous)			Female II (<100 eggs)			Female with Eggs (> 100 eggs)		
	Carapace Length			Carapace Length			Carapace Length		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
January	16.10	23.31	19.24	19.09	28.85	24.30	21.9	30.69	25.29
February	17.33	26.13	20.05	20.38	29.22	24.61	20.42	29.94	24.93
March	17.50	23.81	20.00	21.61	29.31	25.08			
April	18.42	26.17	21.49	21.04	29.95	25.36			

Table 3-3 (continued).

2002

Month	Males			Transitionals		
	Carapace Length			Carapace Length		
	Min	Max	Mean	Min	Max	Mean
February	11.05	15.24	13.99	11.13	21.70	17.59
March	10.03	20.77	15.91	13.01	22.92	18.42

Month	Female I (primiparous)			Female II (<100 eggs)			Female with Eggs (> 100 eggs)		
	Carapace Length			Carapace Length			Carapace Length		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
February	17.73	24.55	21.23	19.34	29.77	23.38	21.00	29.12	24.71
March	18.09	26.25	21.80	16.61	29.20	23.92			

2003

Month	Males			Transitionals		
	Carapace Length			Carapace Length		
	Min	Max	Mean	Min	Max	Mean
January	13.92	20.54	17.55	13.28	23.02	18.02
February	16.73	16.73	16.73	15.68	20.83	18.20

Month	Female I (primiparous)			Female II (<100 eggs)			Female with Eggs (> 100 eggs)		
	Carapace Length			Carapace Length			Carapace Length		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
January	16.14	23.13	19.34	18.64	29.15	24.21	18.10	30.32	25.24
February	15.65	23.35	19.53	18.89	29.61	25.13	18.58	30.67	25.51

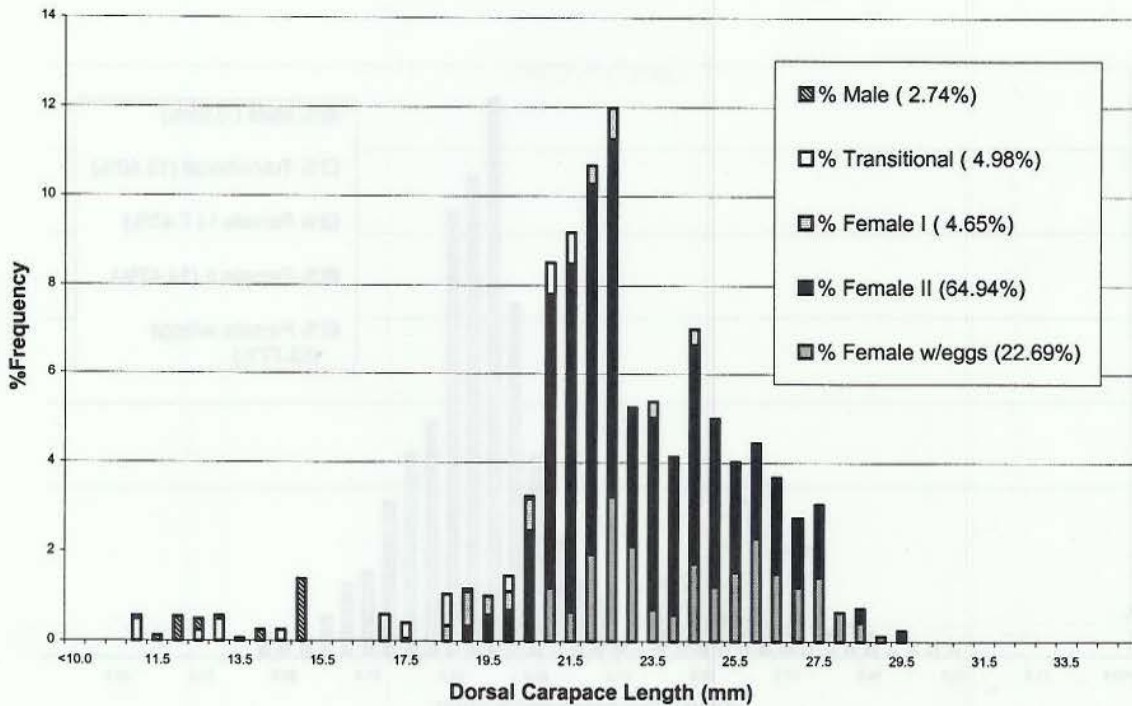


Figure 3-1. February length frequency distribution derived from New Hampshire port sampling of the landings of northern shrimp during the 2002 season.

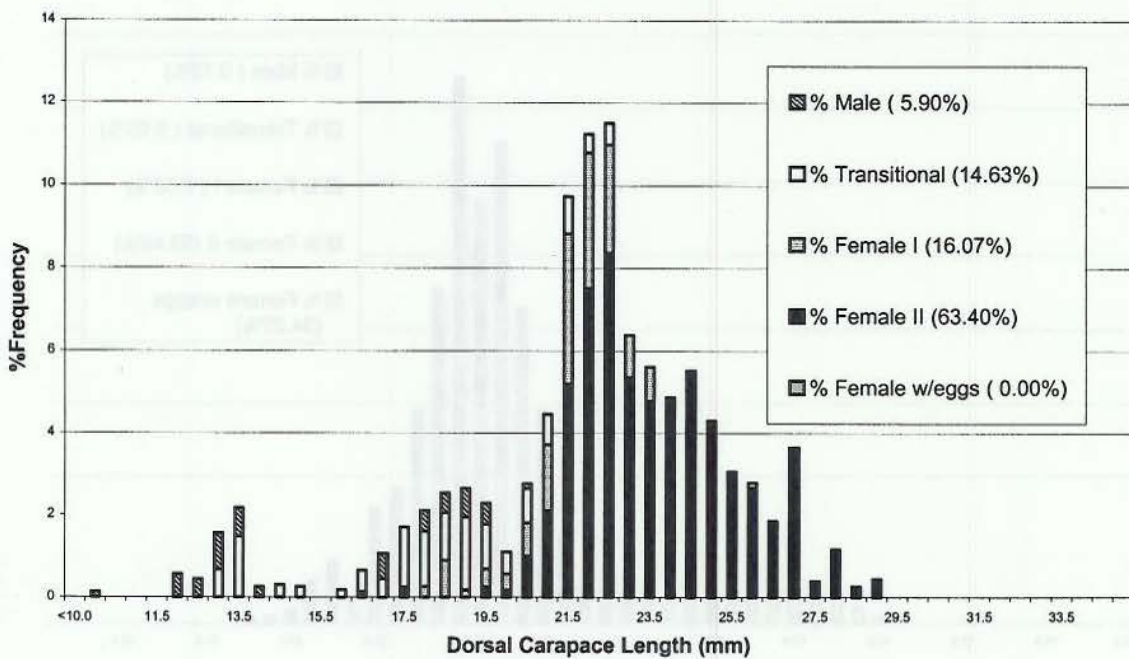


Figure 3-2. March length frequency distribution derived from New Hampshire port sampling of the landings of northern shrimp during the 2002 season.

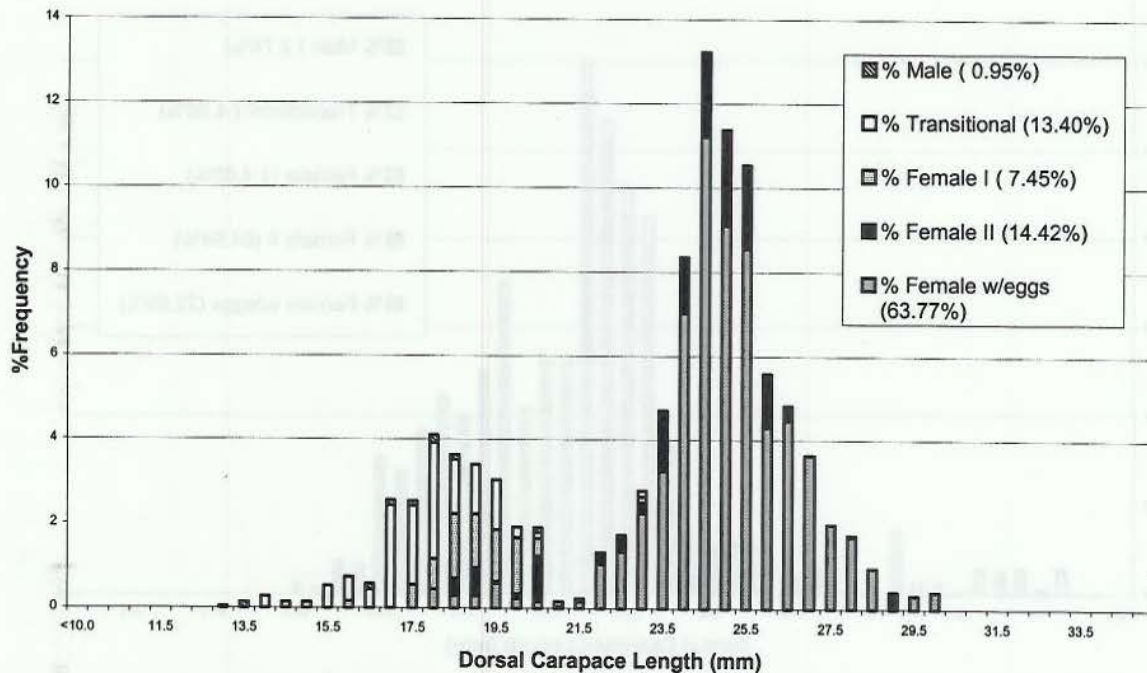


Figure 3-3. January length frequency distribution derived from New Hampshire port sampling of the landings of northern shrimp during the 2003 season.

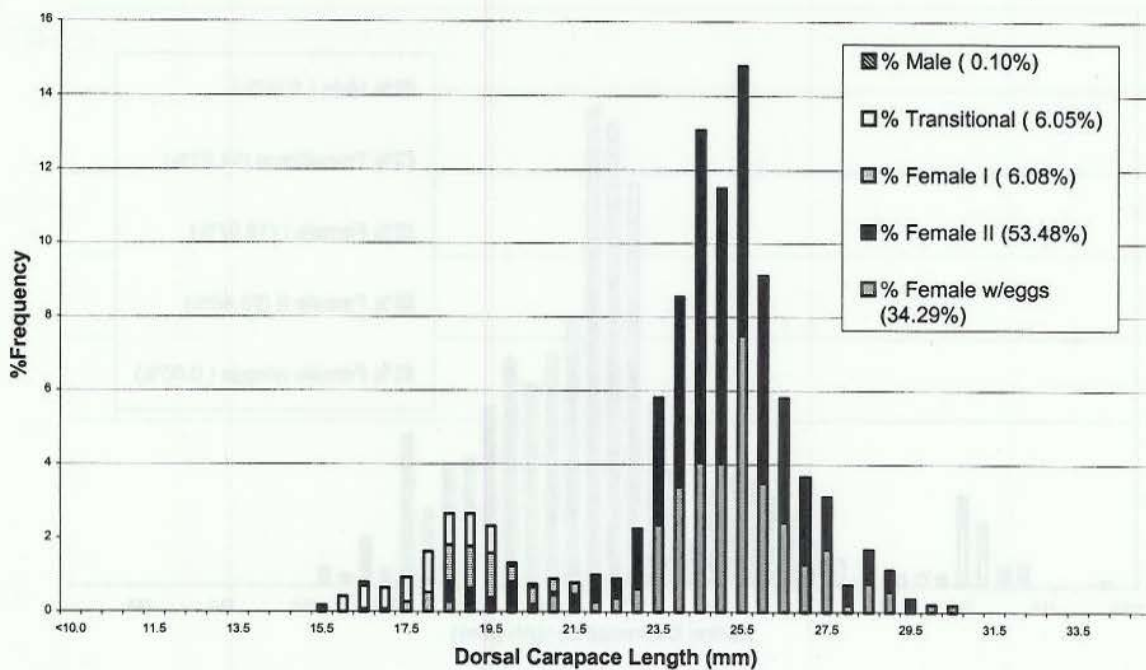


Figure 3.4. February length frequency distribution derived from New Hampshire port sampling of the landings of northern shrimp during the 2003 season.

JOB 4: LOBSTER LOG BOOKS

Final Report

ABSTRACT

Monitoring of the lobster fishery in state waters was conducted through mandatory logbook reporting of daily catch and effort from a stratified sample of previous lobster license holders. Lobster fishers are stratified into group categories based on their annual harvest. In addition, newly licensed entrants into the lobster fishery are required to file annual reports summarizing their catch and effort by month.

From these reports, an estimated 1,262,830 lbs of lobsters were harvested from New Hampshire waters in 2002. The commercial lobster fishery harvested 99.6% of this total. Group 3 individuals, who historically land 5000⁺ pounds of lobster annually, harvested approximately 80% of the total estimated poundage from state waters.

The average catch per unit effort (CPUE) has been 0.14 lbs/trap haul set over day (THSOD) since 1999, but increased to 0.17 in 2002. The average CPUE within the categorized groups varied slightly between 0.13 and 0.18 lbs/THSOD in 2002 with the recreational fishery (Group 4) and Group 1 representing the lowest and the Group 3 representing the highest yearly CPUE. Effort in the commercial fishery in state waters, as measured by THSOD and total pots, was focused mainly during the months June through November, with the highest CPUE occurring in October at 0.23 lbs/THSOD. The recreational fishery's effort was largely concentrated between June and September with the highest CPUE occurring in November at 0.25 lbs/THSOD.

The 2002 expanded bycatch estimates of both sublegal lobsters and crabs decreased, with the catch of sublegal lobsters being the lowest since 1998. Using the conversion factor of 1.3 lbs/harvested pounds of lobster, the ratio of sublegal to legal lobsters for 2002 was 2.2:1, down from 3.3:1 in 2001 and the lowest to date.

INTRODUCTION

The American lobster (*Homarus americanus*) fishery is the largest and most important commercial fishery within New Hampshire's state waters. Monitoring the annual harvest of American lobsters from New Hampshire's waters is important for both state and federal

management. Information from lobster harvester logbooks provides annual harvest and effort information that improve the quality of stock assessments and the fishery management of lobsters.

New Hampshire residents harvesting American lobsters and crabs must obtain a lobster license from the New Hampshire Fish and Game Department. A portion of each year's license holders is randomly selected to complete monthly logbooks on their effort and harvest. Collection of this information is an important part of the coast-wide fishery dependent data collection program. The vast majority of the resident lobster harvesters fish exclusively in state waters thus the information is not captured by the National Marine Fisheries Service's (NMFS) commercial weigh-out program.

PROCEDURES

New Hampshire residents harvesting lobsters from state waters are required to purchase a lobster license from the New Hampshire Fish and Game Department. Previous year's license holders are stratified into four group categories based on their historical yearly landings (Table 4-1). A percentage of individuals from each group is randomly selected from the previous year's lobster harvester license list to participate in the monthly logbook reporting system for the current year. At least two extra individuals per category are chosen from Groups 1, 2 and 4, as well as, one extra for Group 3 in case not all random selected individuals purchase a current year's license. This helps to insure the random selection percentages for each group category is attained.

A packet of monthly logbooks, each labeled with the individual's name, license number, month and year, are sent within one week of the selected license holders purchase of the current years license. The monthly logbooks detailing trip level harvest and effort information are due by the 10th of the following month for each month the license is held. When the reports are received, the label and report are date stamped. To maintain confidentiality, the name label is removed. In preparation for key entering, the report is stamped with a coded number and the month the report designates. At the end of each year, a sheet of each individual's monthly reporting labels is mailed to the license holder as confirmation of completion of the mandatory reporting.

The mandatory trip level report used for randomly selected harvesters details gear size, total pots fished per month, each day fished, number of pots hauled per day, the number of days pots fished between hauls, weight (lbs.) or quantity of harvested lobsters, area fished within state waters and estimated quantity of incidental catch of crabs and sublegal lobsters (Figure 4-1). The National Marine Fisheries Service (NMFS) conversion factor of 1.3 lbs./lobster is applied if quantity is reported.

All newly licensed lobster harvesters are required to submit an annual report summarizing monthly catch and effort data by January 10 of the succeeding year (Figure 4-2). The report is given to the individual along with the purchased license. The month level data collection form details the total number of pots fished per month, the average number of pots fished per day, the average number of days the pots fished between hauls, average number of days the pots were checked per month, weight or quantity of harvested lobsters and area of fishing activity. The new entrant is placed in one of the group categories described in Table 4-1 based on their reported annual catch for future random selection processes. If a new entrant reports no fishing activity for the year, their "new entrant" status remains until landings are reported in future years.

Those individuals who have not submitted monthly reports on a timely basis are notified by mail in mid-July and mid-December as well as follow up phone calls requesting the late reports be filed immediately. New entrants are sent reminder letters of the mandatory January 10th submittal date and another blank report form in December. Follow up phone calls requesting the reports from delinquent reporters start after the January 10th deadline.

The reported data are expanded to estimate total harvest, effort (trap haul set over days), total pots and bycatch of sublegal lobsters and crabs for the fishery. Estimates are calculated using the arithmetic mean of the data from randomly selected license holders and new entrant reports. The mean values from each group category are multiplied by the total number of license holders in each group category. The estimates from each group category are then summed to provide total annual estimates for the New Hampshire fishery.

RESULTS

In 2002, 86 lobster harvesters were randomly selected from the 2001 license list to complete monthly logbooks. Seventy-eight of the randomly selected individuals obtained a

license in 2002; thirty-seven reported from Group 1, thirteen from Group 2, seventeen from Group 3 and eleven from the recreational fishery (Table 4-2). Five of the 78 randomly selected harvesters have not submitted reports. Of the 123 new entrants in the fishery, 111 reported catch/effort data. Between the random selected lobster fisherman and new entrants, 41% of all license holders reported lobster harvest and effort data in 2002.

From these harvest reports, an estimated of 1,262,830 pounds of lobster was harvested from New Hampshire waters in 2002 (Table 4-3). The estimated effort was 7,567,851 THSOD with an annual CPUE of 0.17 lbs/THSOD. The majority of lobsters were harvested between July and November. The highest monthly CPUE's occurred between July and November ranging from 0.19 to 0.23 lbs/THSOD. The total number of lobster pots fishing within state waters ranged from 6,723 pots in February to 40,186 pots in July. Lobster traps fishing in state waters in 2002 caught an estimated bycatch of 2,179,742 sublegal lobsters and 404,568 crabs.

The commercial lobster fishery harvested 1,258,161 lbs of lobster (99.6% of the total harvest) while the recreational fishery harvested 4,669 lbs (Tables 4-4 and 4-5). The period of greatest directed effort (THSOD and total pots fished) for the commercial fishery appeared between June and November. The recreational fishery directed most of its effort between June and September with no reported effort in January and February (Table 4-5). CPUE's ranged from 0.03-0.23 lbs/THSOD within the commercial fishery and from 0.04-0.25 within the recreational fishery

Within the three commercial group categories, Group 3 landed 1,006,160 lbs or 80% of the harvested lobsters from state waters in 2002, followed by Group 1 with 165,824 lbs and 86,176 lbs from Group 2 (Tables 4-6, 4-7 and 4-8). Group 1 had an annual CPUE of 0.13 lbs/THSOD, Group 2 had a CPUE of 0.14 and Group 3 had a CPUE of 0.18 lbs/THSOD.

Effort (THSOD and total pots fished) varied slightly between commercial groups (Tables 4-6, 4-7, 4-8). Groups 1 and 2 expended most of their effort during June through October whereas Group 3 individuals fished most heavily from May through November.

DISCUSSION

A total of 495 lobster licenses were issued in 2002; an increase of 41 licensees since 1996 (Table 4-9). One hundred twenty-three were new entrants and 372 were harvesters that had been in the lobster fishery for at least one year and had previously been assigned categorized groups

(Table 4-2). The majority of licensed individuals harvested between 0 and 999 pounds of lobster per year (Group 1), followed by the recreational licensees, Group 3 individuals (5000⁺ lbs. caught yearly) and lastly Group 2 harvesting between 1000 and 4999 lbs. per year.

The estimated annual harvest and effort (lbs/THSOD) was derived from expanding the data collected from both random selected harvester reports and new harvester reports. Altogether, 41% of the total licensees reported catch and effort data in 2002: 78 randomly selected individuals reported daily catch and effort information and 123 new entrants reported monthly catch and effort data (Table 4-2). Seventeen individuals are delinquent in reporting for 2002 and will not be issued a new license in the future until their reporting obligations have been fulfilled.

Ninety percent of the random selected harvesters from the 2001 license list purchased a license in 2002 (Table 4-2). Within the categorized groups of random selected harvesters who were required to report trip level information, only Group 3 did not reach/exceed its reporting target percentage of 40%, only having 35% of the licensed harvesters reporting.

The New Hampshire lobster fishery landed an estimated 1,262,830 pounds of lobster in 2002 (Table 4-3). After showing a nearly steady increase in harvest levels within the commercial fishery since 1996, the expanded commercial harvest dropped slightly to 1,258,161 lbs; a 17% decline from 2001 (Table 4-9). Similarly, the recreational harvesters landed slightly less lobsters in 2002 than 2001, dropping from 4,929 lbs to 4,669 lbs, respectively. The majority of the harvest in 2002 came from commercial Group 3 (Table 4-8). These individuals fish year-round although they reduce their effort during winter months. Some Group 3 harvesters move their effort to federal waters to harvest the larger migrating lobsters to offshore waters during these months (Herrick, 1909, Phillips et al., 1980, Duggan and Duggan, 1989, Robichaud and Campbell, 1991). These individuals report their catch and effort in federal waters to NMFS.

Group 4 individuals (recreational) harvested the least amount of lobsters, 4,669 lbs. The recreational lobster fishery is limited to fishing 5 traps or less. Most recreational harvesters fish June through September (Table 4-5) once lobsters have migrated inshore and possibly in preference to summer daylight hours and warm temperatures. In 2001, effort in the recreational fishery did not occur until May, however in 2002, selected recreational harvesters reported effort beginning in March, which is more consistent with effort in past years.

The majority of Group 1 did not start lobstering until June and slowed their efforts after

October, as most of the individuals within this group are part-time fishers that are likely to wait until the lobsters have migrated to inshore waters (Table 4-6).

The primary months of fishing effort for Group 2 were between July and November (Table 4-7). The individuals within Groups 1 and 2 fish less than 600 traps, which is more limiting than Group 3 individuals who may fish up to 1200 traps.

The average CPUE increased to 0.17 lbs/THSOD in 2002, after remaining stable since 1999 (0.14 lbs/THSOD). Within 2002, CPUE varied slightly between all the groups from 0.13 to 0.18 lbs/THSOD. This could be due to the CPUE reported by the selected harvesters within the individual groups were similar and did not have any outliers to dramatically lower or raise the average.

Using the conversion factor of 1.3 lbs./harvested lobster, an estimated 971,407 lobsters were harvested from New Hampshire's waters in 2002. The estimated incidental catch of sublegal lobsters released back into New Hampshire waters was approximately 2.2 million lobsters, representing a 2.2:1 ratio of sublegal to legal sized lobsters. This is the lowest ratio occurring to date, with the previous low being 2.4 sublegals to 1 legal lobster harvested in 2000. In 2001, this bycatch was largely from the Group 3 harvesters, with a ratio of 2.5:1. The ratio from Groups 1 and 2 were 1.5:1 and 1.3:1, respectively. These numbers may not be truly representative of the fishery as a whole because not all random selected reporters or any of the new entrants estimated the numbers of incidental sublegal lobsters.

The estimated bycatch of crabs caught in state waters in 2002 was 404,568 (Table 2-9). This represented a 44% decline from the time series high catch of 720,641 crabs experienced in 2001. Again, these numbers may not be truly representative of the fishery as a whole because not all random selected reporters or any of the new entrants estimated the numbers of incidentally caught crabs.

In Summary:

- 1) The New Hampshire lobster fishery landed an estimated 1,262,830 pounds of lobster in 2002. The harvest levels decreased after a continual increase from 1997 through 2001.
- 2) The commercial lobster fishery landed 99.6% of the total harvested lobster, with Group 3 individuals harvesting approximately 80%.

- 3) The average CPUE in 2002 was 0.17, with the average CPUE in 2002 ranging from 0.13 to 0.18 within the categorized groups of harvesters within the lobster fishery.
- 4) Bycatch estimates of sublegal lobsters were the second lowest to date and that of crabs decreased by approximately 44% from 2001.

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Table 4-1. Group categories of lobster harvesters and percentage of license holders in each group required to report each year.

Group	Lbs. Caught yearly	Target Random Selection Percentage
1	0-999	15%
2	1,000-4,999	25%
3	5,000	40%
4	Recreational	5%

Table 4-2. The number of licensed harvesters, new entrants, # of randomly selected harvesters (RSH), actual number of RSH who reported, percentage of RSH reporting, reporting target percentages and total reporting percentage per group category for 2002.

Group	2002 Licensed Harvesters	# New Entrants Reporting	RSH			Reporting Target Percentage	Total Reporting Percentage ⁵
			# Selected ²	Actual # Reporting	Percentage of RSH Reporting ⁴		
1	243	58	41	37	15%	15%	39%
2	45	6	14	13	29%	25%	42%
3	51	1	18	17	33%	40%	35%
4	156	58	13	11	7%	5%	44%
Totals	495	123 ¹	86	78 ³			41%

¹ - 12 new entrants did not report, 8 recreational license holders and 4 commercial license holders. For estimate expansion purposes the delinquent commercial license holders were placed in Group 1.

² - Selected from 2001 license holders list.

³ - 8 RSH did not buy licenses and five RSH are delinquent in reporting.

⁴ - Percentages are the relation of the actual # of reporting RSH's and the total 2002 licensed harvesters.

⁵ - Percentages are the relation of RSH's + New Entrants that reported from the total 2002 licensed harvesters.

Table 4-3. Month, expanded weight (lbs.), expanded trap haul set over days (THSOD), expanded total pots fished, CPUE, expanded sublegal lobsters and expanded crabs from New Hampshire's lobster fishery, 2002

MONTH	EXPANDED WEIGHT (lbs.)	EXPANDED THSOD	EXPANDED TOTAL POTS FISHED	CPUE	EXPANDED SUBLEGALS (quantity)	EXPANDED CRABS (quantity)
JANUARY	16,895	198,992	7,897	0.08	28,421	3,616
FEBRUARY	7,192	137,829	6,723	0.05	5,136	932
MARCH	6,145	182,429	8,110	0.03	2,272	892
APRIL	13,534	246,674	10,959	0.05	6,307	1,597
MAY	32,573	526,049	20,694	0.06	45,655	9,746
JUNE	115,027	927,936	32,004	0.12	186,382	48,152
JULY	232,161	1,166,079	40,186	0.20	467,166	64,959
AUGUST	210,526	1,015,877	38,383	0.21	513,242	77,397
SEPTEMBER	235,613	1,141,018	39,996	0.21	374,082	74,706
OCTOBER	199,471	877,753	35,967	0.23	279,692	62,907
NOVEMBER	135,223	696,000	27,642	0.19	181,863	50,387
DECEMBER	58,470	451,215	22,997	0.13	89,524	9,276
YEARLY EXPANDED TOTALS	1,262,830	7,567,851		0.17	2,179,742	404,568

Table 4-4. Month, expanded weight (lbs.), expanded trap haul set over days (THSOD), expanded total pots fished, CPUE, expanded sublegal lobsters and expanded crabs from New Hampshire's commercial lobster fishery, 2002.

MONTH	EXPANDED WEIGHT (lbs.)	EXPANDED THSOD	EXPANDED TOTAL POTS FISHED	CPUE	EXPANDED SUBLEGALS (quantity)	EXPANDED CRABS (quantity)
JANUARY	16,895	198,992	7,897	0.08	28,421	3,616
FEBRUARY	7,192	137,829	6,723	0.05	5,137	933
MARCH	6,134	182,336	8,106	0.03	2,272	892
APRIL	13,510	246,407	10,947	0.05	6,307	1,596
MAY	32,430	524,390	20,619	0.06	45,624	9,747
JUNE	114,469	922,901	31,756	0.12	186,084	47,617
JULY	230,755	1,157,106	39,845	0.20	465,502	63,576
AUGUST	208,964	1,005,857	37,981	0.21	511,508	76,320
SEPTEMBER	234,906	1,134,627	39,742	0.21	374,017	74,183
OCTOBER	199,289	875,372	35,866	0.23	279,692	62,868
NOVEMBER	165,151	695,721	27,630	0.19	181,863	50,387
DECEMBER	58,466	451,124	22,989	0.13	89,524	9,277
YEARLY EXPANDED TOTALS	1,258,161	7,532,622		0.17	2,175,951	401,012

Table 4-5. Month, expanded weight (lbs.), expanded trap haul set over days (THSOD), expanded total pots fished, CPUE, expanded sublegal lobsters and expanded crabs from New Hampshire's recreational lobster fishery, 2002.

MONTH	EXPANDED WEIGHT (lbs.)	EXPANDED THSOD	EXPANDED TOTAL POTS FISHED	CPUE	EXPANDED SUBLEGALS (quantity)	EXPANDED CRABS (quantity)
JANUARY	*	*	*	*	*	*
FEBRUARY	*	*	*	*	*	*
MARCH	11	93	4	0.12	*	*
APRIL	24	267	12	0.09	*	*
MAY	143	1,658	75	0.09	31	*
JUNE	557	5,036	248	0.11	298	534
JULY	1,407	8,973	341	0.16	1,664	1,382
AUGUST	1,563	10,020	401	0.16	1,734	1,077
SEPTEMBER	708	6,391	254	0.11	65	523
OCTOBER	181	2,381	101	0.08	*	39
NOVEMBER	71	280	13	0.25	*	*
DECEMBER	4	91	8	0.04	*	*
YEARLY EXPANDED TOTALS	4,669	35,191		0.13	3,792	3,555

*- None Reported

Table 4-6. Month, expanded weight (lbs.), expanded trap haul set over days (THSOD), expanded total pots fished, CPUE, expanded sublegal lobsters and expanded crabs from New Hampshire's Group 1 commercial lobster fishery, 2002.

MONTH	EXPANDED WEIGHT (lbs.)	EXPANDED THSOD	EXPANDED TOTAL POTS FISHED	CPUE	EXPANDED SUBLEGALS (quantity)	EXPANDED CRABS (quantity)
JANUARY	1,218	20,300	725	0.06	761	1,033
FEBRUARY	484	16,400	820	0.03	226	275
MARCH	535	25,215	1,405	0.02	652	429
APRIL	1,304	54,525	1,461	0.02	1,499	1,239
MAY	3,542	49,470	2,216	0.07	6,346	2,880
JUNE	13,892	149,687	6,061	0.09	12,358	31,582
JULY	37,681	230,509	8,470	0.16	40,927	32,290
AUGUST	35,077	219,763	8,199	0.16	55,679	29,773
SEPTEMBER	29,227	228,778	7,759	0.13	47,757	29,622
OCTOBER	19,134	135,743	5,965	0.14	17,730	23,201
NOVEMBER	13,297	75,102	2,999	0.18	6,324	16,896
DECEMBER	10,433	57,069	2,328	0.18	4,377	*
YEARLY EXPANDED TOTALS	165,824	1,262,562		0.13	194,635	169,221

*- None Reported

Table 4-7. Month, expanded weight (lbs.), expanded trap haul set over days (THSOD), expanded total pots fished, CPUE, expanded sublegal lobsters and expanded crabs from New Hampshire's Group 2 commercial lobster fishery, 2002.

MONTH	EXPANDED WEIGHT (lbs.)	EXPANDED THSOD	EXPANDED TOTAL POTS FISHED	CPUE	EXPANDED SUBLEGALS (quantity)	EXPANDED CRABS (quantity)
JANUARY	23	192	32	0.12	*	*
FEBRUARY	1,600	11,200	700	0.14	*	*
MARCH	1,302	11,160	465	0.12	*	*
APRIL	1,051	6,091	368	0.17	*	*
MAY	2,363	29,048	1,371	0.08	2,241	2,633
JUNE	5,775	54,763	1,843	0.11	7,449	6,596
JULY	13,998	96,696	3,590	0.14	16,421	13,350
AUGUST	15,833	110,891	3,991	0.14	17,958	17,154
SEPTEMBER	16,575	107,843	3,495	0.15	18,595	15,326
OCTOBER	15,777	96,311	3,548	0.16	12,160	16,464
NOVEMBER	8,866	63,207	2,719	0.14	4,045	3,444
DECEMBER	3,012	31,276	1,232	0.10	355	465
YEARLY EXPANDED TOTALS	86,176	618,676		0.14	79,225	75,432

*- None Reported

Table 4-8. Month, expanded weight (lbs.), expanded trap haul set over days (THSOD), expanded total pots fished, CPUE, expanded sublegal lobsters and expanded crabs from New Hampshire's Group 3 commercial lobster fishery, 2002.

MONTH	EXPANDED WEIGHT (lbs.)	EXPANDED THSOD	EXPANDED TOTAL POTS FISHED	CPUE	EXPANDED SUBLEGALS (quantity)	EXPANDED CRABS (quantity)
JANUARY	15,654	178,500	7,140	0.09	27,660	2,583
FEBRUARY	5,108	110,229	5,203	0.05	4,911	658
MARCH	4,297	145,961	6,236	0.03	1,620	463
APRIL	11,155	185,791	9,118	0.06	4,808	357
MAY	26,525	445,872	17,032	0.06	37,037	4,234
JUNE	94,802	718,451	23,852	0.13	166,277	9,439
JULY	179,076	829,901	27,785	0.22	408,154	17,936
AUGUST	158,054	675,203	25,791	0.23	437,871	29,393
SEPTEMBER	189,104	798,006	28,488	0.24	307,665	29,235
OCTOBER	164,378	643,318	26,353	0.26	249,802	23,203
NOVEMBER	112,988	557,412	21,912	0.20	171,494	30,047
DECEMBER	45,021	362,779	19,429	0.12	84,792	8,812
YEARLY EXPANDED TOTALS	1,006,160	5,651,423		0.18	1,902,090	156,360

Table 4-9. Total number of commercial and recreational lobster licenses, expanded commercial harvest (lbs.), expanded recreational harvest (lbs.), expanded total harvest (lbs.), expanded trap haul set over days (THSOD), CPUE, expanded sublegal lobsters and expanded crabs from New Hampshire's lobster fishery from 1996-2002.

YEAR	# LICENSES			EXPANDED COMMERCIAL HARVEST (lbs.)	EXPANDED RECREATIONAL HARVEST (lbs.)	EXPANDED TOTAL HARVEST (lbs.)	EXPANDED THSOD	CPUE	EXPANDED SUBLEGALS (quantity)	EXPANDED CRABS (quantity)
	Commercial	Recreational	Total							
1996	310	144	454	960,712	5,814	966,526	9,322,963	0.10	2,335,327	289,364
1997	303	157	460	1,053,291	4,541	1,057,834	10,308,300	0.10	2,901,418	377,275
1998	311	155	466	933,338	6,637	939,974	9,907,992	0.09	1,744,434	290,093
1999	297	161	458	1,216,892	7,388	1,224,280	8,877,626	0.14	3,461,865	580,881
2000	309	166	475	1,252,578	4,528	1,257,105	8,860,378	0.14	2,295,040	384,700
2001	325	155	480	1,521,300	4,929	1,526,229	10,908,352	0.14	3,907,746	720,641
2002	339	156	495	1,258,161	4,669	1,262,830	7,567,851	0.17	2,179,742	404,568

Month: (circle one)

Jan Feb March April May June July Aug Sept Oct Nov Dec

Gear Size: _____

Total Number of Pots Fished for the Month: _____

Date	D N F	Area (see key)	Number of pots hauled on day indicated.	Average set over days/pot (24 hour period)	Weight or number (specify)	Incidental Catch – estimate if necessary (i.e. finfish, short lobsters)
1		(Back				
2		Channel)				
3		9	100	2	150 lbs.	30 shorts, 2 cusk, 10 crabs
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
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Figure 4-1. Randomly selected lobster monthly reporting form.



NH Fish and Game Department
 225 Main Str
 Marine Fisheries Division
 Durham NH 03824
 (603)868-1095

LOBSTER REPORT FOR NEW ENTRANTS

Name: _____

License #: _____

Address: _____

Year: _____

Signature: _____

INSTRUCTIONS: Please complete the form below for the year 1992 on a monthly basis with the following information:

Number of pots fished..... Enter total number of pots/traps fished. Enter DNF if you did not fish for the month.

Average number of pots pulled.. Enter average number of pots/traps pulled on the days pots were checked.

Days fished..... Enter number of days pots/traps were checked.

Average # of days soaked per pot or trap..... Enter average number of days pots/traps were left in water between checking catch.

Weight..... Enter pounds caught (if showing quantity instead of weight please specify).

Area (use appropriate #).....

1-Great Bay/Little Bay	5-Rye
2-Piscataqua River	6-Hampton
3-Portsmouth Harbor/Newcastle	7-Seabrook
4-Little Harbor	8-Isles of Shoals
	9-Other

MONTH	# OF POTS FISHED	AVERAGE # POTS PULLED	DAYS FISHED	AVG. # DAYS POTS SOAKED	WEIGHT (POUNDS)	AREA
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						

PLEASE RETURN THIS REPORT TO THE ADDRESS ABOVE DUE BEFORE
 JANUARY 10TH OF THE FOLLOWING YEAR

Figure 4-2. Reporting form for new entrants into the lobster fishery

JOB 5: AMERICAN EEL YOUNG OF THE YEAR SURVEY

Final Report

ABSTRACT

The annual American eel (*Anguilla rostrata*) young-of-the-year survey was conducted at the Lamprey River in Newmarket, NH. An Irish elver trap was set adjacent to the fish ladder at the Lamprey River dam. The timing of the survey coincided with the peak onshore migration of young-of-the-year eels during a six week period of time. A total of 17,799 elvers were caught in an Irish elver trap and released upstream. Two waves of migration occurred during the sampling period. The first and largest wave occurred in mid-April 2002 with a peak catch per unit effort (CPUE) of 391.84 elvers/hour. The second wave occurred in early May with a peak CPUE of 19.44 elvers/hour. Over 97% of the elvers trapped were caught during these two waves of migration. Increases in CPUE coincided with increases in water temperature. Water temperatures below 12°C and river flows above 450 ft³/sec prior to these waves of eels may have inhibited eel migration.

INTRODUCTION

A number of recent studies have drawn attention to a possible coast wide decline in the American eel population. Castonguay et al. (1994) indicated that juvenile eel recruitment had declined drastically between 1985 and 1992 on the upper St. Lawrence River, while Haro et al. (2000) found evidence of significant decline in the population of American eel over the same relative time period at various sites from Virginia to Nova Scotia. However, the lack of long-term eel abundance data make establishing a population trend difficult. To address this problem and to characterize trends in annual recruitment of American eel to the U.S. Atlantic coast, the Atlantic States Marine Fisheries Commission (ASMFC 2000a) recommended that an annual American eel young-of-the-year survey be conducted by each state on the east coast.

Due to the mating strategy of the American eel, trends in recruitment abundance at individual rivers may reflect abundance trends for the entire eel population

(Castonguay et al. 1994). The ASMFC American Eel Technical Committee determined that one sampling site per state should be monitored for juvenile eel recruitment. The State of New Hampshire has established an annual survey of juvenile eels (elvers) migrating up the Lamprey River in Newmarket, NH. The first survey was conducted in the spring of 2001. Over time the survey will help distinguish natural variation in annual American eel recruitment from a long-term trend in eel numbers. Natural variation may be caused by annual changes in ocean currents, river flow, or water temperature, while an overall decline in American eel recruitment may be the result of human impacts such as commercial harvesting or habitat modification (Haro et al. 2000).

PROCEDURES

The study was carried out according to the ASMFC (2002b) procedures for the American eel young-of-the-year survey. An Irish elver trap was set up adjacent to the fish ladder at the Lamprey River dam on April 18, 2002. The trap was placed in an enclosed protected area (a structural component of the fish ladder) where elvers swim through three holes at the base of a cement wall. Drawn to the fresh water flowing down the ramp of the Irish elver trap, the elvers climb the trap's ramp and eventually fall into a bucket. The sampling period of April 19-May 23 was established to coincide with the peak onshore migration of elvers. During this period, the trap was monitored four days per week by daily counts of the number of elvers caught in the bucket of the elver trap. Following enumeration, the elvers were placed above the dam. The total count was divided by the number of hours since the trap was last emptied to obtain a catch per unit effort (CPUE).

Careful attention was paid to the performance of the trap over each sampling period. For the trap to work properly, there must be a consistent flow of fresh water, about 1 to 2 mm in depth, down the mesh-covered ramp. Fresh water was provided by a hose attached at one end to a screen covered funnel on the freshwater side of the dam and to a perforated tube placed along the upper horizontal surface of the ramp of the Irish elver trap.

The perforated tube, which distributes an even stream of water down the ramp, will periodically become clogged with debris. Each time the bucket was emptied, a

qualitative judgment was made on the trap performance. Trap performance at the time of the survey was rated as good, fair, or poor. The ratings were an attempt to account for the effect of ramp performance on the number of captured eels. Good indicated a steady, even flow down the ramp. Fair indicated more than 50% of the holes were clogged and flow was restricted to one side of the ramp, while a poor rating indicated that more than 90% of the holes were clogged and very little water was reaching the trap entrance.

Before the end of each sampling period, every effort was made to return the trap to good performance by cleaning the tube and adjusting the flow.

If the elvers in the bucket were too numerous to count, their numbers were estimated using a volumetric sampling technique recommended by the ASMFC (2000b) and similar to the method used by Jessop (2000). In this method, elvers were placed into a graduated cylinder until an elver volume of 25 ml was reached. The elvers in the graduated cylinder were counted and released. This was repeated six times and the mean number of elvers per milliliter was calculated. The remaining elvers were then placed into a graduated cylinder and the total volume of elvers was recorded. The final estimated number of elvers was the total volume of elvers (in milliliters) multiplied by the calibrated average number of elvers per milliliter plus the number of elvers counted in each 25 ml calibration.

During each site visit, water temperature and depth of the river was checked above the dam. The depth taken above the dam reflects the intensity of the river flow at the time the site was visited. In addition, discharge flows (ft³/sec) were downloaded from the USGS Lamprey River station upriver from the sampling location which provides continuous discharge flow data for the Lamprey River. Moon phase was also recorded.

RESULTS

A total of 17,799 elvers were caught and passed upstream in 2002 (Table 5-1). Two peaks occurred in 2002 with the first peak between April 19 and April 23, 2002 and the second peak between May 3 and May 13, 2002. The first peak occurred 7 days before the full moon on April 27, while the second peak occurred approximately 3 days before the new moon on May 12. The highest CPUE recorded occurred on April 20, 2002.

Fresh water temperature in the Lamprey River ranged from 7⁰C to 16⁰C during the sampling period. Only 143 elvers were counted at temperatures lower than 12⁰C. River discharge ranged from 148.3 ft³/sec to 1033.4 ft³/sec. After heavy rainfall (Table 5-2) river discharge flow increased and the fresh water depth increased accordingly. The river depth taken above the dam varied with river flow, ranging from 35.5 inches to 61.5 inches. Ramp performance was good throughout most of the sampling period.

DISCUSSION

In 2002, the initial surge of elvers occurred two to three weeks earlier than the initial surge in 2001 (refer to Appendices I and II). Deelder (1958) observed that the timing of elver migration varied with the severity of the winter. Elvers arrived earlier after mild waters than after colder winters. The relatively mild winter of 2001–2002 may have resulted in an unusually early upstream movement of elvers at the Lamprey River. The peak CPUE for 2002 was 391.84, which was over 3 times that of 2001 (111.79). The total number of elvers caught and counted in 2002 was 17,799 compared to 6,356 in 2001. Perhaps the entire eel population was more abundant in 2002.

Ramp performance remained good over the majority of the sampling period. Clogged tubes caused the few ratings of poor and fair. Although ramp performance was good through most of the study, there was a problem with competing flows. From April 19 to approximately May 2, 2002, water from a broken town water pipe was draining into the eel trap area. The two sources of fresh water provided a natural experiment in which the elvers were free to choose between treated drinking water and natural river flow. No eels were observed following the chlorinated town drinking water. This is consistent with the findings of Sorensen (1986) and Sola (1995), who demonstrated that juvenile eels are strongly attracted to vegetable odorants in fresh water.

When the trap was set up on April 18, 2002, the flow of fresh water down the Irish elver trap was also competing with fresh water leaking from a crack in the adjacent fish ladder. On April 19, 2002 a fist-sized ball of elvers was observed on a ledge below the leak. The elvers were able to follow the leak up a vertical cement wall and enter the fish ladder through the crack. The leak was partially plugged by a Fish and Game employee on the following day. Although some eels were still observed to be climbing

the wall, most elvers were attracted to the heavier flow from the elver trap. The leak was fixed completely on April 24, 2002.

In the spring of 2002, the bulk of the elvers were observed early during the sampling period with the initial surge in mid-April of upstream migration followed by a smaller surge in early May. Over 97% of the elvers were caught during these two periods. The two waves of migration separated by about two weeks are consistent with the findings of Sorensen and Bianchini (1986) and Ciccotti et al. (1994). A similar pattern of one large peak followed by a smaller peak was also observed in 2001, but the peaks were closer together. The roughly 14 day period between waves of migration in 2002 suggests a lunar cycle, yet the two peaks in capture rates did not occur during the full or new moon. Sorensen and Bianchini (1986) noted that peaks in eel migration were out of phase with spring tides in a Rhode Island stream. Perhaps the moon phase acts upon the migration of elvers in an indirect way where higher tides carry elvers further upstream (Deelder 1958). In addition, elvers have been observed accumulating in the brackish water below dams where they may go through a transition period before moving upstream (Deelder 1958). This transition period, where elvers initially show no tendency to migrate into fresh water, may partially explain the observed difference between the peak flood tides associated with the full and new moon phases and the peaks in CPUE.

Before reaching the dam, elvers alternate periods of rest in the substrate with periods of activity (Barbin and Krueger, 1994). The relative strength of the annual spring tides and the freshwater discharge may influence the number of elvers that accumulate below the Lamprey River dam, thereby affecting the number of elvers captured in the elver trap. Catch per unit effort was generally lower in 2002 when the water discharge flow increased.

The first peak in CPUE in 2002 coincided with the highest temperature of the sampling period (16⁰C) and tapered off as the water temperature fell. The second highest peak again coincided with an increase in water temperature. Sorensen and Bianchini (1986), Moriarty (1987) and Haro and Krueger (1988) noted that the onset of migration into fresh water coincided with an increase in water temperature. Sorensen and Bianchini

(1986) found that once the water temperature exceeds a threshold of 10-15⁰C, water temperature appeared to have minimal, if any, influence on migration.

It is difficult to separate the influence of water temperature from that of river flow because the rains, which increase river flow, also appear to coincide with a lowering of the river water temperature. As an example of rainfall influence, the discharge went from 182 ft³/second on April 26, 2002 to 450.3 ft³/second on April 30, 2002 and the fresh water temperature decreased from 10⁰C to 7⁰C. Peak CPUE in 2001 also coincided with an increase in water temperature. Low water temperature and high velocity currents may slow migration rates by inhibiting elver activity. The decrease in water temperature and increase in discharge velocity may counter elver attraction to rainfall as suggested by Weeder (personal communication).

Environmental factors, such as moon phase, fresh water discharge flow rates, precipitation and water temperature, appear to influence the eel young-of-the-year migration. Further annual surveys in New Hampshire and in other states along the east coast of the U.S. will characterize trends in this recruitment over time. These studies will hopefully allow the Atlantic States Marine Fisheries Commission to establish a qualitative appraisal of the annual recruitment of American eel to the U.S. Atlantic coast.

In summary:

- 1) A total of 17,799 elvers were caught in an Irish elver trap at the Lamprey River dam in Newmarket, N.H. from April 19, 2002 - May 23, 2002.
- 2) Two surges of elvers occurred approximately two weeks apart with 97% of the total number of elvers caught during these two periods.
- 3) Water temperature appeared to influence the arrival of elvers at the Irish elver trap and influence the timing of the second surge of elvers.
- 4) Ramp performance was primarily good during the sampling period.

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Table 5-1. New Hampshire young-of-the-year American eel survey, Lamprey River, 2002.

Date	Set Time (nearest 0.25 hour) {previous day}	Pull Time (nearest 0.25 hour)	Moon Phase	Fresh Water Temp. (°C)	Fresh Water Depth (inches)	Discharge (ft ³ /sec) time = 0015	Water Flow Ramp Performance	Total Number Elevs	CPUE (#/soak time)
4/19/02	1230	1145	new-1 st quarter	16.0	37.50	205.2	good	15	0.65
4/20/02	1145	1215	1 st quarter	16.0	37.50	203.1	good	9600*	391.84
4/21/02	1215	1430	1 st quarter-full	15.0	37.50	169.8	good	4714*	179.58
4/22/02	1430	1345	1 st quarter-full	13.0	37.00	150.2	good	1556*	66.92
4/23/02	1345	1145	1 st quarter-full	12.0	35.75	154.1	good	196	8.91
4/24/02	1145	0930	1 st quarter-full	10.0	35.75	148.3	good	42	1.93
4/25/02	0930	0945	1 st quarter-full	11.0	35.50	148.3	fair	19	0.78
4/26/02	0945	1430	1 st quarter-full	10.0	41.00	182.0	good	19	0.66
4/30/02	1100	1045	full-last quarter	7.0	47.50	450.3	good	2	0.08
5/1/02	1045	1100	full-last quarter	8.5	47.00	470.6	good	0	0.00
5/2/02	1100	1315	full-last quarter	9.0	46.00	431.8	good	7	0.27
5/3/02	1315	0900	full-last quarter	7.0	48.00	503.2	good	10	0.51
5/6/02	1230	1000	last quarter-new	12.5	44.25	413.5	good	295	13.72
5/7/02	1000	0945	last quarter-new	13.0	42.25	344.7	good	370	15.58
5/8/01	0945	0930	last quarter-new	14.5	40.25	285.5	good	342	14.40
5/9/02	0930	1030	last quarter-new	14.5	39.00	243.0	good	486	19.44
5/13/02	1430	1145	new-1 st quarter	13.0	38.00	175.9	poor	77	3.62
5/14/02	1145	1200	new-1 st quarter	10.0	58.00	539.6	good	38	1.57
5/15/01	1200	1015	new-1 st quarter	9.0	61.50	971.6	good	4	0.18
5/16/02	1015	0945	new-1 st quarter	9.5	61.25	1033.4	good	1	0.04
5/20/02	0915	0915	1 st quarter-full	10.0	52.25	677.6	fair	0	0.00
5/21/02	0915	1045	1 st quarter-full	10.5	50.00	624.9	good	1	0.04
5/22/02	1045	1230	1 st quarter-full	11.5	47.00	515.2	good	0	0.00
5/23/02	1230	1445	1 st quarter-full	13.0	44.00	410.7	good	5	0.19

* = estimated

Table 5.2. Precipitation (inches) during the 2002 American eel young-of-the-year survey (taken from the UNH Weather Station, Durham, NH, at <http://www.weather.unh.edu>).

<u>Date</u>	<u>Daily Precipitation Total*</u>
April 15, 2002	0.5
April 18, 2002	0.01
April 19, 2002	0.01
April 20, 2002	0.03
April 22, 2002	0.17
April 25, 2002	0.9
April 26, 2002	0.15
April 28, 2002	0.46
April 29, 2002	0.28
April 30, 2002	0.01
May 2, 2002	0.62
May 3, 2002	0.02
May 9, 2002	0.04
May 10, 2002	0.13
May 12, 2002	0.29
May 13, 2002	1.6
May 14, 2002	0.55
May 18, 2002	0.87

* Amount of rain since the last sample (previous day).

Appendix I. New Hampshire young-of-the-year American eel survey, Lamprey River, 2001.

Date	Set Time (nearest 0.25 hour) {previous day}	Pull Time (nearest 0.25 hour)	Moon Phase	Fresh Water Temp. (°C)	Fresh Water Depth (inches)	Discharge (ft ³ /sec) time = 0015	Ramp Performance	Total Number Elvers	CPUE (#/soak time)
5/1/01	1230	1015	1 st quarter - full	13.5	38.5	220.5	good	4	0.18
5/2/01	1015	0945	1 st quarter - full	13.5	36.0	209.5	good	4	0.17
5/3/01	0945	1015	1 st quarter - full	14.5	37.5	184.1	good	1	0.04
5/4/01	1015	1430	1 st quarter - full	20.0	35.0	161.9	good	72	2.55
5/7/01	1000	0945	full	18.0	35.0	138.9	good	2655*	111.79
5/8/01	0945	1400	full - last quarter	20.0	34.5	124.2	good	1209*	42.80
5/9/01	1400	1515	full - last quarter	19.5	35.0	113.7	good	737*	29.19
5/10/01	1515	0900	full - last quarter	16.0	34.0	106.8	good	118	6.65
5/14/01	1515	1200	full - last quarter	17.5	32.75	87.3	good	233	11.23
5/15/01	1200	1230	last quarter	14.5	32.5	79.5	good	492	20.08
5/16/01	1230	0945	last quarter - new	14.5	32.0	73.5	good	603	28.38
5/17/01	0945	1130	last quarter - new	13.0	32.0	76.5	good	55	2.14
5/21/01	1345	1715	last quarter - new	14.0	31.0	67.7	good	9	0.33
5/22/01	1715	1145	last quarter - new	15.0	31.0	62.1	good	11	0.59
5/23/01	1145	0915	new	16.0	30.75	59.4	good	4	0.19
5/24/01	0915	1215	new - 1 st quarter	15.5	30.5	58.0	good	112	4.15
5/28/01	0930	0915	new - 1 st quarter	14.0	33.0	100.1	good	9	0.39
5/29/01	0915	1130	new - 1 st quarter	16.0	33.5	96.9	good	7	0.27
5/30/01	1130	1200	1 st quarter	14.5	33.0	96.9	good	7	0.29
5/31/01	1200	1115	1 st quarter - full	14.0	33.0	95.2	poor	4	0.17
6/4/01	1415	1345	1 st quarter - full	12.5	45.5	388.7	fair	0	0.00
6/5/01	1345	1315	1 st quarter - full	14.0	44.0	369.8	good	5	0.21
6/6/01	1315	1015	full	14.5	41.75	330.5	good	3	0.14
6/7/01	1015	1400	full - last quarter	16.5	38.5	222.7	good	2	0.07

* = estimated

Appendix II. Precipitation (inches) during the 2001 American eel young-of-the-year survey (taken from the UNH Weather Station, Durham, NH, at <http://www.weather.unh.edu>).

<u>Date</u>	<u>Daily Precipitation Total*</u>
May 4, 2001	0.1
May 5, 2001	0.11
May 12, 2001	0.25
May 15, 2001	0.13
May 16, 2001	0.01
May 24, 2001	0.03
May 27, 2001	0.63
May 28, 2001	0.24
May 29, 2001	0.01
May 30, 2001	0.06
June 2, 2001	1.54
June 3, 2001	0.24
June 4, 2001	0.01

* Amount of rain since the last sample (previous day).

**JOB 6: IDENTIFICATION OF POTENTIAL
HORSESHOE CRAB SPAWNING AND
NURSERY HABITAT.**

Final Report

ABSTRACT

Over harvesting of the current populations of horseshoe crabs on the Atlantic coast of the United States is a major concern to the Atlantic State Marine Fisheries Commission (ASMFC). The purpose of the investigation was to continue to identify potential horseshoe crab habitat (both spawning and nursery habitat) within New Hampshire waters of the Great Bay Estuary. Surveys were conducted at five locations during May - September 2002 during the new and full moon as close to the time of high tide as possible at each location. At each location, the number and various activities (past and present) of the horseshoe crabs were recorded over a designated distance along the shore. A maximum of ten individuals (when present) from each location on each sampling date were randomly selected, sexed and measured for the widest prosomal width. In addition, various climatological and water conditions were recorded. During 2002, a total of 188 horseshoe crabs were observed at the five locations with 98% observed during May and June. Males were smaller in size than females with the mean widest prosomal width being 129mm compared to 169mm for females. Amplexus was observed at all five locations while nest excavation and eggs were observed in the high intertidal substrate at four locations. Juveniles were not observed in 2002. Evidence from this survey indicates that Great Bay Estuary is used as both spawning and nursery habitat for horseshoe crabs.

INTRODUCTION

The geographical range of the bottom dwelling horseshoe crab, *Limulus polyphemus*, spans broadly from the northern Maine coast to Florida as well as the Yucatan Peninsula where this animal inhabits estuaries, bays and near-shore continental

habitats (Manion et al. 2000, Pierce and Gaffney 2000, Sekiguchi 1988, Thompson and O'Connell 2000, Widener and Barlow 1999). Adults come to shore to spawn intertidally during high tide during the new and full moon (spring-summer season) where nursery habitats are likely to be established nearby (Brockmann et al. 2000, Thompson and O'Connell 2000).

Horseshoe crabs are an important component of the ecosystem as shorebirds rely on horseshoe crab eggs to replenish their fat reserves during their spring migration and finfish use their eggs as important food sources (ASMFC 1998a). Horseshoe crabs are also dietary components of the threatened loggerhead turtle (ASMFC 1998a).

Horseshoe crabs are important to medical research, the pharmaceutical products industry, wildlife viewing (birding), ecotourism and the commercial conch and eel pot fisheries where egg bearing females are regarded as superior bait (ASMFC 1998a, Botton and Ropes 1987, Manion et al. 2000, Thompson and O'Connell 2000). These economic activities affect the regional economics of the Atlantic coast (Manion et al. 2000).

The growing concentration of humans along the Atlantic coast can bring about natural habitat destruction and modification with environmental changes (sea wall construction, dredging, beach re-nourishment, increased boat traffic, oil spills, etc.) affecting all life stages of horseshoe crabs (Thompson and O'Connell 2000). Over harvesting of the current populations of horseshoe crabs is a major concern (ASMFC 1998a, Thompson and O'Connell 2000). This animal is susceptible to catastrophic declines when harvested extensively, for it takes ten or more years to mature, has a relatively low fecundity (breeds once per year) and a high natural predation (Thompson and O'Connell 2000). As a species, horseshoe crabs are extremely vulnerable to overexploitation because spawning adults are easily harvested during the spring and summer months as they come to shore (ASMFC 1998b, Botton and Ropes 1987) and usually before they completely spawn (Thompson and O'Connell 2000).

An increase in the harvest rate over the last 10+ years has heightened the concern for the horseshoe crab in many areas of the U.S. (Thompson and O'Connell 2000). Widener and Barlow (1999) found a noticeable decline in spawning activity and spawning season duration at Mashnee Dike in Bourne, MA on Cape Cod where there has been extensive harvesting. The increase in harvest rate has led the Atlantic State Marine

Fisheries Commission (ASMFC) to collect information through a state-wide monitoring program to assist in future management decisions (ASMFC 1998a). One of the components of Section 3.5 of the Interstate Fishery Management Plan for Horseshoe Crab requires Atlantic coastal states to identify potential horseshoe crab habitat (both spawning and nursery habitat).

The objective of this project is to continue to identify potential horseshoe crab spawning and nursery habitat within New Hampshire waters of the Great Bay Estuary. This 2002 survey was carried out during May-September during the new and full moon at five sites chosen most likely to be spawning and nursery habitats.

PROCEDURES

In 2002, a day-time survey was conducted in the Great Bay Estuary, NH by Fish and Game personnel in order to identify potential horseshoe crab spawning and nursery habitats. Five locations were visited on the new and full moon from May-September as close to the time of high tide as possible at each location (Table 6-1).

A representative of the field data sheet is found in Table 6-2. At each location, the number and type of various past and present activities of the horseshoe crabs were recorded over a designated distance along the shore at high tide. A maximum of ten individuals from each location on each sampling date were randomly selected and sexed, measured for the widest prosomal width and weighed. In addition, various climatological and water conditions were recorded.

Five locations (Figure 6-1) were chosen as the most likely to be spawning and nursery habitats in the Great Bay Estuary based on a survey conducted in 2000 (Figure 6-2). Information in 2002 was complemented by observations of individual volunteers and volunteers associated with Great Bay Coast Watch (funded by UNH Sea Grant and UNH Cooperative Extension).

RESULTS

A total of 188 horseshoe crabs (112 males, 76 females) were observed at the five locations in 2002 (Table 6-3). The greatest number (111) were observed at Sandy Point and the least number (2) were observed at Wagon Hill Farm. During the five month

survey period, 98% were observed during May and June. Males were smaller in size than females with a mean prosoma width (widest measurement) of 129mm compared to 169mm for females. The sex ratio of males and females in the 2002 survey varied. Generally, there was a 1:1 ratio, or if unequal ratios, there were more males present.

Amplexus was observed in May and/or June at all five locations and at one location in July and one location in September. Nest excavation and eggs were observed in the substrate at four locations in the high intertidal area. Juveniles were not observed in 2002.

Water temperature and salinity at the five locations was generally highest in August or September (Tables 6-4, 6-5). Locations surveyed are all estuarine intertidal, generally consisting of mud, sand, gravel and cobble (Table 6-6).

DISCUSSION

Observations of horseshoe crab presence in the Great Bay Estuary began in 1998 but did not develop into the present format until 2001. In 2000, fifteen locations were surveyed for horseshoe crab habitat, and from this study five sites were chosen to be most likely to support breeding and nursery habitats.

Males in the NH 2002 survey were found to be smaller than females. Similar sizes were found in the NH 2001 survey. Mature male horseshoe crabs in an adult population are generally smaller than females (Botton and Loveland 1992), and larger sized horseshoe crabs and larger populations tend to be found in the middle portion of their distribution along the eastern U.S. coast (Shuster 1982). The size differentiation found between males and females may be due to various factors, including males in amplexus sacrificing feeding time, males maturing earlier and thus at a smaller size or the larger female body size evolving in response to the female towing the male(s) around, or her need to hold the eggs before releasing them (Botton and Loveland 1992). Sizes of amplexed males and suitors (those males not attached to a female) in any of the four populations of horseshoe crabs studied by Botton and Loveland (1992) were not found to be significantly different in size and they did not notice morphological constraints which might limit amplexus between any male and any female in a given population. Suggs et

al. (2002) found that for the majority of animals, size did not appear to affect mate selection.

The sex ratio of males and females for the 2002 survey (and 2001 survey, Appendix 6-1) varied. In most instances the ratio was close to 1:1 or more males were present. Botton and Loveland (1992) observed that the sex ratio is male-biased because of the surplus of unpaired males during spawning. Their 1988 and 1989 studies in Great Bay, NH indicated that unattached males and attached pairs (amplexus) with one or two males per female were most common. More than 1 male attached to 1 female was not observed in 2002 or during previous observations in the Great Bay Estuary.

Male horseshoe crabs appear to have two mating tactics (Brockmann and Penn 1992, Brockman 2002) where those in good condition with fewer encrusting epibionts covering the prosoma and eyes arrive attached to females while those in poorer conditions come ashore unattached as “satellites”. Males observed in this study were generally free of epibionts regardless of whether they were observed attached to females or not. Recently it has been shown that male horseshoe crabs use chemical cues as well as visual cues to locate mates (Hassler and Brockman 2001).

Spawning time varies latitudinally with more southern latitudes having an earlier spawning time, but generally it peaks in May and June (Shuster 1982). This spawning time was observed in 2002 and in 2001 in the Great Bay Estuary.

Spawning sites are usually near locations where food is available, large numbers of animals can aggregate, mate pairing can occur, beach access is easy and there are generally no swift currents or heavy wave action (Thompson and O’Connell 2000). Shuster (1982) stated that large spawning groups could assemble on the shore only during periods of relatively calm water. The Great Bay Estuary is a wave protected area when compared to coastal beaches. Thus, one would not expect wave height to affect horseshoe crab spawning here. In more exposed locations, overturning of horseshoe crabs can occur when there is high wave action (Botton and Loveland 1989).

This study was carried out during daylight hours. There are mixed findings on whether the most abundant breeding activity is during the day or night (Cohen and Brockmann 1983, Rudloe 1980). Maio (1998) did not find daylight to influence spawning activity.

Horseshoe crabs begin spawning at the time of increased water temperature or change in water temperature (Sekiguchi 1988, Thompson and O'Connell 2000). The rising surface water temperatures recorded during periods of peak horseshoe crab observations on May 26, 2002 and June 10, 2002 support this trend, as does information collected in 2001 (Table 6-3, 6-4, and Appendix 6-2). Maio (1998) observed horseshoe crabs in Maryland in May when water temperatures were about 14°C.

Horseshoe crabs are tolerant of a wide range of salinity levels (Sekiguchi 1988). The eggs and juveniles can be exposed to heavy rainfall. The Maryland Department of Natural Resources, as cited in ASMFC 1998a, indicated that horseshoe crabs are restricted to areas that exceed 7 ‰ salinity. Salinities measured during this years surveys of Great Bay ranged from 7 to 40 ‰. However, the higher values (marked *) in Table 6-4 are possibly due to equipment malfunction. Salinity values in Table 6-5 are likely more realistic.

The number of horseshoe crabs found along a particular distance of shore in the 2002 and 2001 studies are only estimates of the number of horseshoe crabs at a particular location. The time of the arrival of the observer(s) does not necessarily represent the abundance of horseshoe crabs spawning at a particular location on a particular day. Different numbers of horseshoe crabs could have been present at a location just prior to or just after the arrival of the observer(s). However, the number present at the time of the survey can indicate the use of the area as a breeding habitat. In 2002, the greatest number of horseshoe crabs were observed at Sandy Point suggesting that this area is an appropriate area for breeding.

Horseshoe crabs are able to lay eggs in the gravel/cobble in the Great Bay Estuary as seen in this study. Horseshoe crabs have been noted to dig beneath shells and make nests in underlying sand (Thompson and O'Connell 2000).

Parameters affecting egg development include temperature, salinity, oxygen concentration, substrate moisture content, stability of the beach and the presence of bacteria and parasites (Thompson and O'Connell 2000). Muddy substrates (with high organic content and less oxygen) and areas with high erosion would not support successful egg development. Active saltmarsh areas have been found unsuitable or at best marginal for horseshoe crab reproduction and horseshoe crabs avoid this type of

habitat for spawning (Botton et al. 1988). The Great Bay Estuarine shoreline is fringed with abundant patches of saltmarsh areas which may limit available spawning habitat, however available cobble and gravel substrate is also abundant.

Field experiments have demonstrated that beach slope was more significant than vision for horseshoe crabs returning to the water after spawning and orientation was severely impaired on spawning beaches with no slope (Botton and Loveland 1987). This does not appear to be a concern in NH since all shores surveyed were sloped downward towards the water.

Evidence of juvenile horseshoe crabs have been rare over the tenure of this study. No juvenile horseshoe crabs were observed in 2002 and 2001. However, one volunteer did observe juveniles in 2000 at the Sandy Point location. This area provides a sandy beach, cobble/gravel and saltmarsh habitat. In addition, one juvenile sized exuvium (molt) was found in 2002 at the Emery Point study site in 2002.

In summary:

- 1) A total of 188 horseshoe crabs were observed during daylight hours at five locations in Great Bay, NH. The greatest number were observed at Sandy Point.
- 2) Locations surveyed were all estuarine intertidal, generally consisting of mud, sand, gravel and cobble.
- 3) Ninety eight percent of the horseshoe crabs were observed during May and June and amplexus was observed during this time.
- 4) Males were smaller in size than females.
- 5) Amplexus was observed at all five locations.
- 6) Nest excavation and eggs were visible in the substrate at four locations at the high tide level.
- 7) No juveniles were observed in 2002.

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Table 6-1. Dates of moon phase during 2002.

Date	Moon Stage
May 12	New
May 26	Full
June 10	New
June 24	Full
July 10	New
July 24	Full
August 8	New
August 22	Full
September 7	New
September 21	Full

Table 6 - 2. Horseshoe crab survey data collection sheet.

**Horseshoe Crab
Survey 2002**

Site Information

Location _____
 Date _____
 Time _____
 Distance measured: (circle)
 150', 300', 450' (1 pace = 3')

Climatology

Air Temp (⁰C) _____
 Weather ² _____
 Cloud cover (%) _____
 Solar state ¹ _____
¹ - solar state: 0 = dark
 1 = 1 hr. before or after
 sunrise/sunset
 2 = daylight
² - clear, fog and haze, showers,
 downpour

Observer(s) _____

Water conditions

Water temp ⁰C _____
 Salinity (⁰/₀₀) _____
 Wave height ³ _____
³ = Calm, ripple, waves, white caps, color

Site Characteristics

Beachfront orientation (N,S,E,W) _____
 Habitat type* _____
 Beach slope + _____

* mud, cobble, sand, bedrock, saltmarsh, beach
 + steep, gentle

Measured Individuals (random 10)

#	Sex (m/f)	Widest prosoma width (mm)	Weight	
			kg	lbs
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Spawning Survey

Total estimated _____
 # males estimated _____
 # females estimated _____
 Nests marked
 - indentations in sediment? (Y/N)
 - smoke rings in water? (Y/N)
 Exuvia (molts)? (Y/N)
 Dead/stranded animals on beach?(Y/N)
 Amplexus? (Y/N)
 Travel trails?(Y/N)
 Juveniles? (Y/N)
 Eggs? (Y/N)

Area Map

Comments: _____

Table 6-3. Biological data collected during horseshoe crab survey in 2002.

Location	Survey Date	Total	# Males	# Females	Distance Measured (ft.)	Amplexus	Eggs	Nests	Exuvia	Dead	Trails	Juveniles
Wagon Hill (1)	5/13	0	0	0	150	no	no	no	yes	no	no	no
Wagon Hill	5/26	0	0	0	150	no	no	no	no	no	no	no
Wagon Hill	6/10	2	1	1	150	yes	no	no	no	no	no	no
Wagon Hill	6/23	0	0	0	150	no	no	no	no	no	no	no
Wagon Hill	7/10	0	0	0	150	no	no	no	no	no	no	no
Wagon Hill	7/24	0	0	0	150	no	no	no	no	no	no	no
Wagon Hill	8/8	0	0	0	150	no	no	no	no	no	no	no
Wagon Hill	8/22	0	0	0	150	no	no	no	no	no	no	no
Wagon Hill	9/6	0	0	0	150	no	no	no	no	no	no	no
Wagon Hill	9/20	0	0	0	150	no	no	no	no	no	no	no
Adams Point (2)	5/13	0	0	0	150	no	no	no	no	no	no	no
Adams Point	5/26	17	8	9	150	yes	no	yes	no	no	no	no
Adams Point	6/10	5	4	1	150	yes	yes	yes	no	no	no	no
Adams Point	6/23	0	0	0	150	no	no	no	no	no	no	no
Adams Point	7/10	0	0	0	150	no	no	no	no	no	no	no
Adams Point	7/24	0	0	0	150	no	no	no	no	no	no	no
Adams Point	8/8	0	0	0	300	no	no	no	no	no	no	no
Adams Point	8/22	0	0	0	300	no	no	no	no	no	no	no
Adams Point	9/6	0	0	0	300	no	no	no	yes	no	no	no
Adams Point	9/20	2	1	1	300	yes	no	no	no	no	no	no
Chapman's Ldg. (3)	5/13	0	0	0	150	no	no	no	no	no	no	no
Chapman's Ldg.	5/26	2	1	1	150	yes	yes	yes	no	no	no	no
Chapman's Ldg.	6/10	8	4	4	150	yes	no	no	no	no	no	no
Chapman's Ldg.	6/23	0	0	0	150	no	no	no	no	no	no	no
Chapman's Ldg.	7/10	2	1	1	150	yes	yes	yes	no	no	no	no
Chapman's Ldg.	7/24	0	0	0	150	no	no	no	no	no	no	no
Chapman's Ldg.	8/8	0	0	0	150	no	no	no	no	no	no	no
Chapman's Ldg.	8/22	0	0	0	150	no	no	no	no	no	no	no
Chapman's Ldg.	9/6	0	0	0	150	no	no	no	no	no	no	no
Chapman's Ldg.	9/20	0	0	0	150	no	no	no	no	no	no	no
Sandy Point (4)	5/13	0	0	0	150	no	no	no	no	no	no	no
Sandy Point	5/26	23	12	11	150	yes	yes	yes	no	no	no	no
Sandy Point	6/10	88	59	29	150	yes	yes	yes	no	yes	no	no
Sandy Point	6/23	0	0	0	150	no	no	no	no	yes	no	no
Sandy Point	7/10	0	0	0	150	no	yes	yes	no	no	no	no
Sandy Point	7/24	0	0	0	150	no	no	no	yes	no	no	no
Sandy Point	8/8	0	0	0	350	no	no	no	no	no	no	no

Sandy Point	8/22	0	0	0	300	no	no	no	no	yes	no	no
Sandy Point	9/6	0	0	0	450	no	no	no	no	no	no	no
Sandy Point	9/20	0	0	0	300	no	no	no	yes	no	no	no

Table 6-3 (Continued)

Emery Point (5)	5/13	0	0	0	150	no	no	no	yes	yes	no	no
Emery Point	5/26	27	15	12	150	yes	yes	yes	no	yes	no	no
Emery Point	6/10	12	6	6	150	yes	yes	yes	yes	yes	no	no
Emery Point	6/23	0	0	0	150	no	no	no	yes	yes	no	no
Emery Point	7/10	0	0	0	150	no	no	no	no	no	no	no
Emery Point	7/24	0	0	0	150	no	no	no	yes	no	no	no
Emery Point	8/8	0	0	0	300	no	no	no	yes	yes	no	no
Emery Point	8/22	0	0	0	150	no	no	no	yes	no	no	no
Emery Point	9/6	0	0	0	150	no	no	no	no	no	no	no
Emery Point	9/20	0	0	0	150	no	no	no	yes	no	no	no

Emery Point	5/13	0	0	0	150	no	no	no	yes	yes	no	no
Emery Point	5/26	27	15	12	150	yes	yes	yes	no	yes	no	no
Emery Point	6/10	12	6	6	150	yes	yes	yes	yes	yes	no	no
Emery Point	6/23	0	0	0	150	no	no	no	yes	yes	no	no
Emery Point	7/10	0	0	0	150	no	no	no	no	no	no	no
Emery Point	7/24	0	0	0	150	no	no	no	yes	no	no	no
Emery Point	8/8	0	0	0	300	no	no	no	yes	yes	no	no
Emery Point	8/22	0	0	0	150	no	no	no	yes	no	no	no
Emery Point	9/6	0	0	0	150	no	no	no	no	no	no	no
Emery Point	9/20	0	0	0	150	no	no	no	yes	no	no	no

Table 6-4. Climatological and water conditions recorded during horseshoe crab survey in 2002.

Location	Survey Date	Air Temperature (°C)	Weather	Cloud Cover (%) (qualitative)	Surface Water Temperature (°C)	Salinity (‰)*	Wave Height (qualitative)
Wagon Hill Farm (1)	5/13	7.5	rain	100	11	25	waves
Wagon Hill Farm	5/26	22	cloudy	70	18	23	ripples
Wagon Hill Farm	6/10	31	clear	30	16	24	calm
Wagon Hill Farm	6/23	19	haze	100	16	24	ripples
Wagon Hill Farm	7/10	23	sunny	1	20	30	ripples
Wagon Hill Farm	7/24	20	clear	30	20	33	waves
Wagon Hill Farm	8/8	27	clear	40	22	35	ripples
Wagon Hill Farm	8/22	31.5	haze	95	24	35	ripples
Wagon Hill Farm	9/6	24.5	clear	0	19	38*	ripples
Wagon Hill Farm	9/20	25	clear/haze	50	20	35	ripples
Adam's Point (2)	5/13	7.5	rain	100	11	22	waves
Adam's Point	5/26	28	overcast	100	13.5	25	ripples
Adam's Point	6/10	21	clear	80	20	22	calm
Adam's Point	6/23	19	haze	100	17.5	23	ripples
Adam's Point	7/10	23	sunny	1	22	27	ripples
Adam's Point	7/24	20	clear	10	20	34	waves
Adam's Point	8/8	22	clear	70	25	37*	ripples
Adam's Point	8/22	27	haze	95	23	37*	ripples
Adam's Point	9/6	22	clear	0	21	37*	ripples
Adam's Point	9/20	24	clear/haze	50	20	34	calm
Chapman's Ldg (3).	5/13	7.5	rain	100	11	21	waves
Chapman's Ldg.	5/26	21	overcast	100	16	25	ripples
Chapman's Ldg.	6/10	20	clear	80	18	10	calm
Chapman's Ldg.	6/23	19	haze	100	18.5	7	ripples
Chapman's Ldg.	7/10	23	sunny	1	24	23	ripples
Chapman's Ldg.	7/24	20	clear	20	21	31	ripples
Chapman's Ldg.	8/8	21	clear	70	23.5	30.5	calm
Chapman's Ldg.	8/22	32	haze	95	24	35*	ripples
Chapman's Ldg.	9/6	24	clear	0	20	35*	calm
Chapman's Ldg.	9/20	27	clear/haze	50	22	35*	ripples

Table 6-4. (continued)

Sandy Point (4)	5/13	7.5	rain	100	11.5	22	ripples
Sandy Point	5/26	20	overcast	100	15	15	ripples
Sandy Point	6/10	23	clear	80	20	15	ripples
Sandy Point	6/23	18	haze	100	18	11	ripples
Sandy Point	7/10	23	sunny	1	24	26	waves
Sandy Point	7/24	20	clear	30	21	32	ripples
Sandy Point	8/8	23	clear	40	24	35.5	slight ripples
Sandy Point	8/22	27.5	haze	95	25.5	35	ripples
Sandy Point	9/6	22.5	clear	0	21	39*	calm/slight
Sandy Point	9/20	29	clear/haze	80	22	34	calm
Emery Point	5/13	7.5	rain	100	11.5	22	ripples
Emery Point	5/26	21	overcast	70	17	18	ripples
Emery Point	6/10	25	haze/clear	80	24	17	ripples
Emery Point	6/23	17	haze	100	17	9	calm
Emery Point	7/10	23	sunny	1	24	25	white caps
Emery Point	7/24	20	clear	40	22	30	calm/slight
Emery Point	8/8	25	clear	7	27	35	ripples
Emery Point	8/22	27	haze	95	24	40*	waves
Emery Point	9/6	21	clear	0	24	37	ripples
Emery Point	9/20	25	clear/haze	50	24	35	ripples/waves

* High recorded salinities are likely due to equipment malfunction.

Table 6-5. Averaged salinities over three days including the day before and after each new and full moon from May - September 2002 (Data taken from the Great Bay NERR sites in Great Bay ¹ and the Squamscott River ²).

<u>Dates</u>	<u>Mean Salinity</u>	
	<u>Greay Bay</u>	<u>Squamscott River</u>
5/11 - 5/13	19.7*	13.9
5/25 - 5/27	18.9	11.7*
6/9 - 6/11	20.8	13.2
6/23 - 6/25	20.5	13.8
7/9 - 7/11	24.0	22.1*
7/23 - 7/25	32.6*	27.4
8/7 - 8/9	33.7	30.6
8/21 - 8/23	34.6	32.0
9/6 - 9/8	**	31.8
9/20 - 9/22	34.7	32.2

1 = Located in central Great Bay.

2 = Located mid-channel at the Boston and ME railroad bridge, Stratham, NH.

* = Data incomplete

** = No salinity recorded

Table 6-6. Site characteristics of locations surveyed in 2002.

Location	Beachfront Orientation	Habitat Type	Beach Slope
Wagon Hill Farm (1)	south	mud/sand/saltmarsh	gentle and steep
Adam's Point (2)	northeast	mud/cobble/saltmarsh	gentle
Chapman's Landing (3)	northeast	mud/gravel/cobble/saltmarsh	steep
Sandy Point (4)	northeast	mud/sand/cobble/saltmarsh	gentle
Emery Point (5)	northwest	mud/cobble/saltmarsh	gentle



Figure 6-1. The 2002 survey of potential crab habitat in the Clear Bay Estuary. 1 = Wagon Hill Farm, 2 = Adam's Point, 3 = Chapman's Landing, 4 = Sandy Point, 5 = Emery Point. * = potential crab habitat, ** = potential crab habitat with high density.

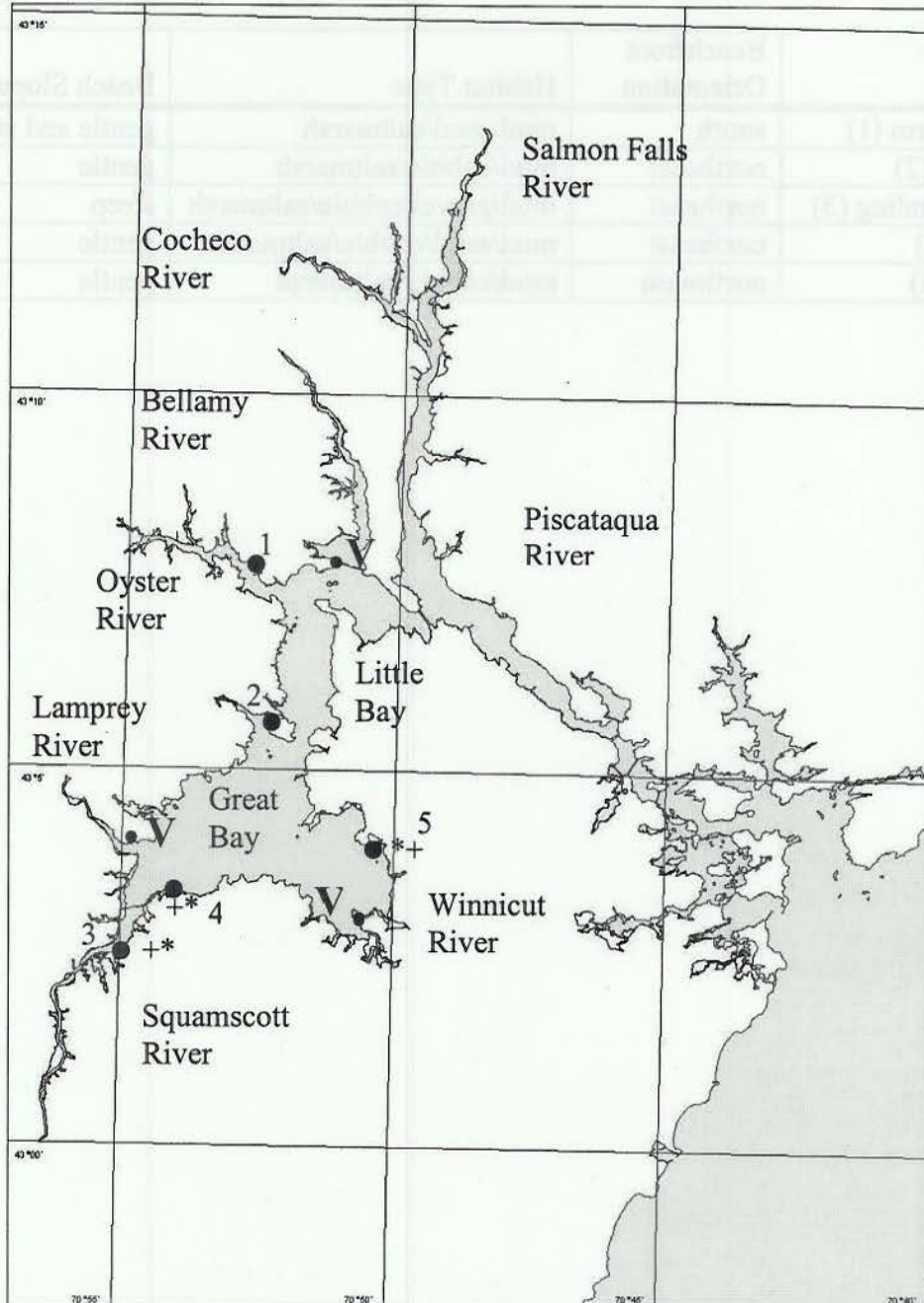


Figure 6-1. The 2002 survey of horseshoe crab habitat in the Great Bay Estuary.
 (1 = Wagon Hill Farm, 2 = Adams Point, 3 = Chapman's Landing, 4 = Sandy Point, 5 = Emery Point;
 ● = locations surveyed; + = nest excavating; * = eggs observed; ●V = additional volunteer observation)

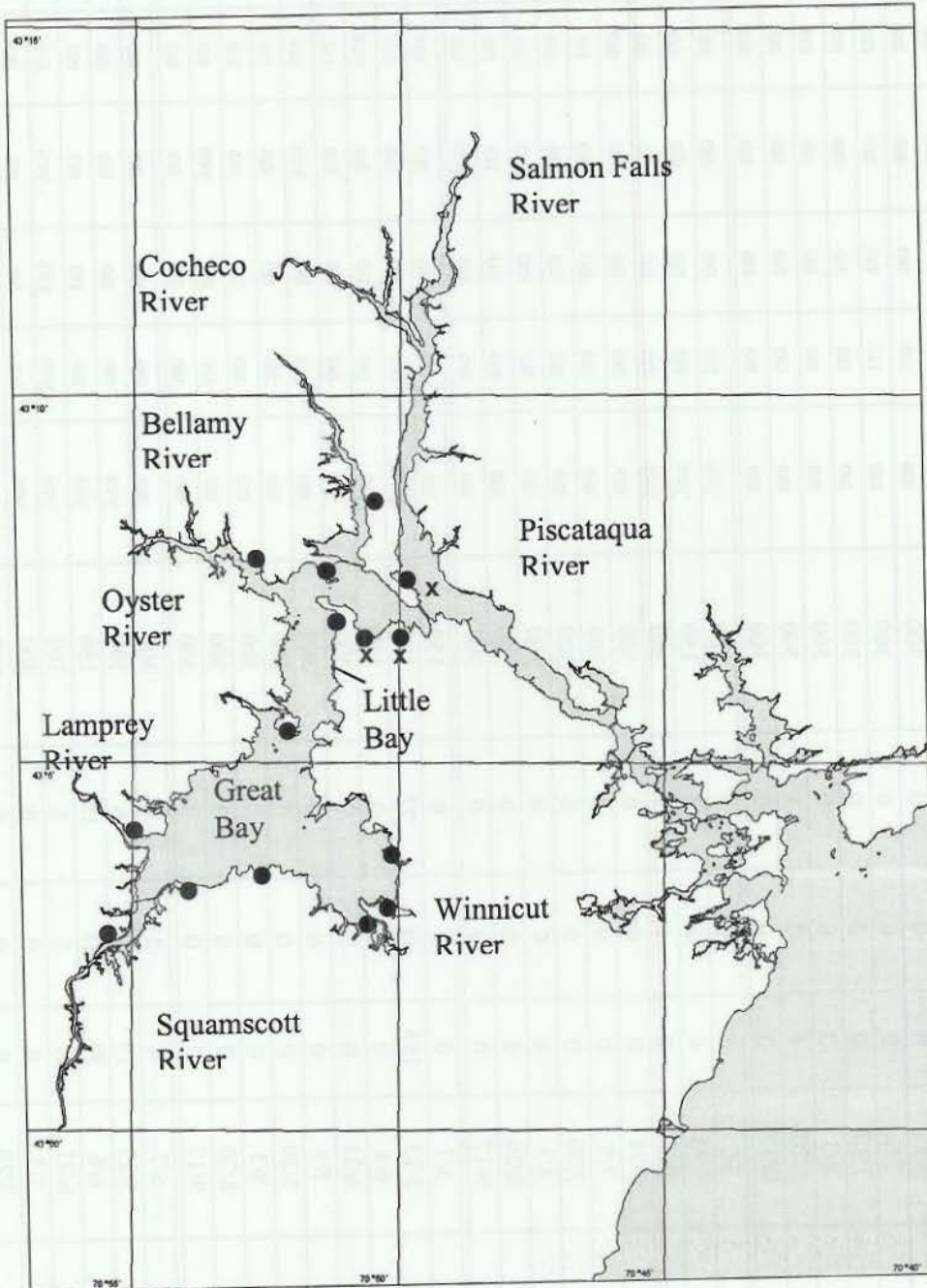


Figure 6-2. The 2000 survey of horseshoe crab habitat in the Great Bay Estuary.
 (x = no horseshoe crabs observed)

Appendix 6-1. Biological data collected during horseshoe crab survey in 2001.

Location	Survey Date	Total	# Males	# Females	Distance Measured (ft.)	Amplexus	Eggs	Nests	Exuvia	Dead	Trails	Juveniles
Wagon Hill Farm (1)	5/7	0	0	0	150	no	no	no	yes	no	no	no
Wagon Hill Farm	5/23	16	12	4	300	yes	no	no	no	no	no	no
Wagon Hill Farm	6/6	0	0	0	300	no	no	no	no	no	no	no
Wagon Hill Farm	6/21	0	0	0	300	no	no	no	no	no	no	no
Wagon Hill Farm	7/5	0	0	0	300	no	no	no	no	no	no	no
Wagon Hill Farm	7/20	0	0	0	300	no	no	no	no	no	no	no
Wagon Hill Farm	8/3	0	0	0	300	no	no	no	no	no	no	no
Wagon Hill Farm	8/20	1	0	1	300	no	no	no	no	no	yes	no
Wagon Hill Farm	9/17	0	0	0	300	no	no	no	no	no	no	no
Adams Point (2)	5/7	4	3	1	150	yes	no	no	no	no	no	no
Adams Point	5/23	4	2	2	150	yes	no	no	no	no	no	no
Adams Point	6/6	2	1	1	300	yes	no	no	no	no	no	no
Adams Point	6/21	0	0	0	300	no	no	no	no	no	no	no
Adams Point	7/5	0	0	0	300	no	no	no	no	no	no	no
Adams Point	7/20	0	0	0	300	no	no	no	no	no	no	no
Adams Point	8/3	0	0	0	300	no	no	no	no	no	no	no
Adams Point	8/20	0	0	0	300	no	no	no	no	no	no	no
Adams Point	9/17	0	0	0	300	no	no	no	yes	no	no	no
Chapman s Ldg.(3)	5/7	0	0	0	150	no	no	no	no	no	no	no
Chapman s Ldg.	5/23	155	78	77	150	yes	no	no	no	no	no	no
Chapman s Ldg.	6/6	0	0	0	150	no	no	no	no	yes	no	no
Chapman s Ldg.	6/21	0	0	0	300	no	no	no	no	no	no	no
Chapman s Ldg.	7/5	0	0	0	300	no	no	no	yes	no	no	no
Chapman s Ldg.	7/20	0	0	0	300	no	no	no	no	no	no	no
Chapman s Ldg.	8/3	0	0	0	300	no	no	no	no	no	no	no
Chapman s Ldg.	8/20	0	0	0	300	no	no	no	yes	no	no	no
Chapman s Ldg.	9/17	0	0	0	300	no	no	no	no	no	no	no
Sandy Point (4)	5/7	4	2	2	300	no	no	no	no	no	no	no
Sandy Point	5/23	13	7	6	300	yes	no	no	no	no	yes	no
Sandy Point	6/6	39	21	18	150	yes	no	no	no	no	no	no
Sandy Point	6/21	11	5	6	300	yes	yes	yes	yes	no	no	no
Sandy Point	7/5	0	0	0	300	yes	no	no	no	no	no	no
Sandy Point	7/20	0	0	0	300	no	no	no	no	no	no	no
Sandy Point	8/3	0	0	0	300	no	no	no	no	no	no	no
Sandy Point	8/20	0	0	0	300	no	no	no	no	no	no	no
Sandy Point	9/17	0	0	0	150	no	no	no	no	no	no	no

Appendix 6-1 (Continued)

Emery Point	5/7	1	1	0	300	no	no	no	no	no	no	no
Emery Point	5/23	12	6	6	450	yes	no	no	no	no	no	no
Emery Point	6/6	132	70	62	150	yes	yes	yes	yes	yes	no	no
Emery Point	6/21	2	1	1	300	yes	yes	yes	yes	yes	no	no
Emery Point	7/5	0	0	0	300	no	yes	yes	yes	no	no	no
Emery Point	7/20	0	0	0	300	no	no	no	yes	no	no	no
Emery Point	8/3	0	0	0	300	no	no	no	yes	no	no	no
Emery Point	8/20	0	0	0	300	no	no	no	yes	no	no	no
Emery Point	9/17	0	0	0	300	no	no	no	yes	no	no	no

Emery Point	5/7	1	1	0	300	no	no	no	no	no	no	no
Emery Point	5/23	12	6	6	450	yes	no	no	no	no	no	no
Emery Point	6/6	132	70	62	150	yes	yes	yes	yes	yes	no	no
Emery Point	6/21	2	1	1	300	yes	yes	yes	yes	yes	no	no
Emery Point	7/5	0	0	0	300	no	yes	yes	yes	no	no	no
Emery Point	7/20	0	0	0	300	no	no	no	yes	no	no	no
Emery Point	8/3	0	0	0	300	no	no	no	yes	no	no	no
Emery Point	8/20	0	0	0	300	no	no	no	yes	no	no	no
Emery Point	9/17	0	0	0	300	no	no	no	yes	no	no	no

Appendix 6-2. Climatological and water conditions recorded during horseshoe crab survey in 2001.

Location	Survey Date	Air Temperature (°C)	Weather	Cloud Cover (%)	Surface Water Temperature (°C)	Salinity (‰)	Wave Height (qualitative)
Wagon Hill Farm (1)	5/7	17	clear	0	17	25	ripples
Wagon Hill Farm	5/23	18	clear	70	16	30	ripples
Wagon Hill Farm	6/6	24	clear	40	18	26	ripples
Wagon Hill Farm	6/21	22	haze	100	20.5	25	ripples/waves
Wagon Hill Farm	7/5	27	clear	50	19.5	26	ripples/waves
Wagon Hill Farm	7/20	30	clear	20	24	30	ripples
Wagon Hill Farm	8/3	30	haze	100	22	31	ripples
Wagon Hill Farm	8/20	24.5	haze	90	21	32	ripples
Wagon Hill Farm	9/17	27	clear	0	17	35	calm
Adam's Point (2)	5/7	21	clear	0	16	25	ripples
Adam's Point	5/23	17	clear	40	18	29	ripples
Adam's Point	6/6	25	clear	40	20	25	ripples
Adam's Point	6/21	17	haze/showers	100	20	22	ripples/waves
Adam's Point	7/5	29	clear/haze	60	25	28	ripples/waves
Adam's Point	7/20	25	clear	20	23	30	ripples
Adam's Point	8/3	26	haze/t-storm	100	24	30	waves
Adam's Point	8/20	26	haze	90	24	30	ripples
Adam's Point	9/17	25	clear	0	20	33	ripples
Chapman's Ldg (3)	5/7	22	clear	0	16	18	calm
Chapman's Ldg.	5/23	22	clear	10	17	25	ripples
Chapman's Ldg.	6/6	24	clear	40	18	11	calm
Chapman's Ldg.	6/21	16.5	haze/showers	100	24	18	ripples/waves
Chapman's Ldg.	7/5	21	showers	100	23	25	calm/ripples
Chapman's Ldg.	7/20	30	clear	20	24	25	calm
Chapman's Ldg.	8/3	29	haze	100	24	30	calm/ripples
Chapman's Ldg.	8/20	25	haze	100	23	33	ripples
Chapman's Ldg.	9/17	24	clear	0	18.5	32	ripples

Appendix 6-2. (continued)

Sandy Point (4)	5/7	22	clear	0	16	24	calm
Sandy Point	5/23	19	clear	20	16.5	25	waves
Sandy Point	6/6	25	clear	40	21	16	ripples/waves
Sandy Point	6/21	16	haze/showers	100	21	20	waves
Sandy Point	7/5	21	clear/haze	100	24	26	ripples
Sandy Point	7/20	29	clear	20	25	27	ripples/waves
Sandy Point	8/3	24	haze	100	26	30	ripples
Sandy Point	8/20	22	haze	95	24	33	ripples
Sandy Point	9/17	26	clear	0	22	34	calm
Emery Point (5)	5/7	20	clear	0	18	21	ripples
Emery Point	5/23	21	clear	10	17	28	calm
Emery Point	6/6	22	clear	40	24	21	ripples/waves
Emery Point	6/21	16.5	haze	100	24	25	ripples
Emery Point	7/5	21	haze	90	24.5	28	ripples/waves
Emery Point	7/20	29	clear	20	26	28	calm
Emery Point	8/3	29	haze	100	24	30	ripples
Emery Point	8/20	25	haze	90	25	31	calm
Emery Point	9/17	25	clear	0	19	35	calm