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American Lobster, *Homarus americanus*, population characteristics in the lower Bay of Fundy (Lobster Fishing Areas 36 and 38) based on fishery independent sampling

Caractéristiques de la population d'homard, *Homarus americanus*, de l'avant-baie de Fundy (zones de pêche du homard 36 et 38) d'après l'échantillonnage indépendant de la pêche

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Abstract

Two diving-based research studies are reviewed that form a 10-yr+ time series of observations of lobster recruitment, and spawning area use, respectively. Additionally, two new research studies (one diving-based, the other a collaborative trapping study with industry) are described, each of which commenced in 2000, but which allow decadal-scale contrasts with results from historical studies. In addition to providing insights into recruitment trends in the Bay of Fundy lobster fishery, the four research studies provide important information for determining sensitive areas from a lobster fishery perspective in relation to coastal zone planning issues. In particular, these studies were designed to provide information that could be utilized in advising on salmon aquaculture development proposals.

Résumé

Nous passons en revue une série temporelle d'observations couvrant plus d'une décennie, faites en plongée dans le cadre de deux études de recherche sur le recrutement du homard et l'utilisation des lieux de ponte. Nous décrivons aussi deux nouvelles études de recherche (l'une faite en plongée et l'autre, par pêche au casier en collaboration avec l'industrie); bien que lancées toutes deux en 2000, elles permettent des comparaisons à l'échelle décennale avec les données historiques. En plus de donner un aperçu des tendances du recrutement à la pêche dans la baie de Fundy, ces quatre études de recherche sont une importante source d'information pour identifier les zones fragiles de la perspective de la pêche du homard par rapport aux questions de planification de l'aménagement des zones côtières. Ces études ont notamment été conçues pour obtenir de l'information qui pourrait servir à fournir des avis au sujet des propositions de développement de la salmoniculture.

Introduction

From the late 1970's to the mid-1980's a considerable number of biological studies were conducted on the Bay of Fundy lobster fishery. Major emphases were lobster movement (reviewed by Lawton and Lavalli 1995), lobster growth and maturity determination (reviewed by Waddy and Aiken 1995), within-year and between area comparisons of trap size frequencies of lobsters (Robichaud and Campbell 1991), and documentation of berried lobster aggregations (Campbell 1990). Diving-based approaches were limited (Campbell 1990) and most studies relied on observations and collections from trap samples. This investment in biological research could not be maintained through into the early to mid-1990's due to budgetary constraints. There have been some issue-driven studies (e.g. Annapolis Basin baseline monitoring; Lawton et al 1995), but few studies have been maintained over the long-term.

This paper briefly reviews two studies that were maintained through the 1990's, forming a 10-yr+ time series of observations of lobster recruitment, and spawning area use, respectively. Additionally, two new studies are reviewed, each of which commenced in 2000, but which allow decadal-scale contrasts with results from earlier studies. In addition to providing insights into recruitment trends in the Bay of Fundy lobster fishery, each of these studies provides important information for determining sensitive areas from a lobster fishery perspective in relation to coastal zone planning issues. In particular, these studies were designed to provide information that could be utilized in advising on salmon aquaculture development proposals.

Methods

While at-sea trap sampling can provide significant information on the location of various segments of the lobster population, trap size-selectivity (e.g. Miller 1990), behavioural interactions (e.g. Richards et al 1983), and seasonal movement patterns (e.g. Robichaud and Campbell 1991) interact to affect the sampled size distribution. There are two segments of lobster life history which are not well represented in trap catches: juvenile (sub-legal) lobsters, and berried females. Additionally, trap samples (whether from the fishery or research trap surveys) do not provide direct absolute estimates of lobster abundance, nor do they identify lobster:habitat relationships, except in the most general sense. Juvenile lobsters tend to occupy shallow subtidal habitats year-round. After their initial recruitment to the benthos they are subject to predation pressure, particularly from fish predators (Wahle and Steneck 1992), and remain cryptic (hidden) within shelters (Wahle and Steneck 1991). Typically, they can only be censused by direct *in-situ* sampling techniques (see review by Lawton and Lavalli 1995).

During 1990 to 1993, a synoptic survey of inshore lobster population distribution in relation to habitat type was undertaken in the Fundy Isles region of the Bay of Fundy (Lawton 1993; Fig. 1). Lobsters were sampled by divers searching along 150m x 2m belt transects set across a range of bottom types and depths from 20 m to the shallow subtidal. Records of lobsters captured were kept separately for each 25 m segment of the transect (the minimum sampling unit was thus 50 m^2). The primary and secondary substrate type, and depth range of each segment was also recorded. Between 40 and 88 transects were sampled annually. Over 5000 lobsters were sampled using transect and other hand-collection approaches (timed dive searches in defined areas which gave relative abundance estimates).

The original diving survey was designed to respond to a period of rapid expansion in the local salmon aquaculture industry by providing initial information on potential sensitive areas. Two general types of lobster habitat were considered sensitive to coastal zone development impact: **nursery areas** where lobsters settle to the seabed and spend their early benthic period on a year-round basis; and **spawning areas** where adult lobsters move into shallow coastal sites on a seasonal basis to complete reproductive functions.

Subsequent to this initial survey, three specific diving studies have been undertaken:

Time-series on lobster settlement: Air-lift suction sampling of small (0.25 m^2) quadrats set in juvenile nursery areas has been conducted in the Fundy Isles Region of the Bay of Fundy since 1991 (following techniques described by Wahle and Steneck 1991) to document annual lobster settlement patterns. However, from 1996, diving-based studies were reduced in the Bay of Fundy, due to the extension of these sampling techniques to other areas of the Maritimes under a DFO High Priority Research Program on lobsters (Canadian Lobster Atlantic-Wide Studies; CLAWS). Emphasis in the Bay of Fundy has been on maintaining an annual time series on juvenile lobster abundance at one study area in Lobster Fishing Area, LFA, 36 (Beaver Harbour; Fig. 2).

Time-series on lobster spawning area use: A study site within Flagg Cove, adjacent to the port of North Head, Grand Manan, was revisited in 1989 to provide advice on potential impacts of a recently established salmon aquaculture site. Prior DFO sampling in the area was undertaken by diving and trapping in the early 1980's (Campbell 1986, 1990). Transects were deployed perpendicular to the shoreline, the shallowest end placed at approximately 3 m below the mean low water mark, extending out to a maximum depth of 14-20 m. Divers recorded all lobsters found within 1 m either side of the 300m line (for a total 600 m^2 of sea bottom searched). Lobster size (carapace length, CL, mm) and sex, moult stage and egg maturity stage on berried females were recorded on underwater slates. Sampling at Flagg Cove was conducted monthly from June to October in 1989, but subsequently, an annual time series was established by surveys conducted in September.

Resampling of coastal habitats: During 2000, a subset of the original synoptic dive survey locations documented by Lawton (1993) were resampled under funding provided by the CLAWS project. Survey locations were defined in Passamaquoddy Bay, Maces Bay, and Seal Cove Sound where there were still no salmon aquaculture sites directly adjacent to original survey locations. For this paper, results are presented for Maces Bay area only (where the most extensive sampling was conducted; Fig. 3). The survey approach was consistent with that undertaken in the early 1990's, but refined in terms of the capability to define prospective survey areas in advance, allocate dive locations by a randomised design, and to undertake finer resolution habitat and lobster distribution data collection. All 2000 data was fully geo-referenced, and efforts are underway to georeference the 1990's survey data.

In the 2000 survey, lobster counts and habitat categories were defined by 5 m (10 m^2) transect sections. However, to provide direct comparisons with the 1990's data, the 2000 data were regrouped into 25m (50 m^2) sections for decadal-scale contrasts by defined habitat types.

Closed season trapping survey: In 2000 the Grand Manan Fishermens Association came forward to DFO Science with a proposal to conduct a closed season trapping survey in inshore waters of Grand Manan (LFA 38). Under funding provided from the CLAWS project, the following objectives were developed:

1. Determine the size frequency and sex ratio of lobsters trapped with commercial lobster gear during the summer closed season in key coastal locations off Grand Manan. Locations were selected where data existed from historical studies, or where recent scientific and industry data indicated likelihood of seasonal aggregation of berried female and other mature lobsters (spawning areas), and/or significant abundance of juveniles (nursery areas).

2. Provide information to assist in the scientific assessment of the LFA 38 lobster fishery by providing decadal-scale comparisons of lobster size frequency in trap catches, and in particular the size composition and relative abundance of berried females.

3. Initiate collaborative studies with the LFA 38 lobster fishing community that provide the basis for a more participatory environment for lobster stock assessment and conservation management.

Four fishermen set up to 50 commercial traps each during September and October, 2000, hauling this gear up to 10 times during the survey period. Escape vents were closed on a portion of the gear to sample juvenile lobster distribution in presumptive nursery areas. Additionally, participants used two types of gear, setting traps rigged for inshore fishing alongside traps rigged for deepwater fishing. Fishermen were responsible for recording trapping locations, individual lobster size and sex condition (male, female, berried lobster) in trap catches, as well as the incidence of v-notched female lobsters. Also, by tagging of a portion of the lobsters captured, fishermen assessed recapture rates. DFO Science technicians participated in initial sea trips to ensure consistency in data acquisition.

Recapture rates were assessed by recording the size and sex of a lobster selected for release, and placing a regular commercial claw band (different colours used by each fisherman) over one claw prior to its release. On subsequent recapture, another band was placed over the claw and the lobster was released again. The experimental protocol included adding additional bands at each subsequent recapture and release event. This approach allowed for analysis of recapture rates by size and sex category and by number of recaptures, but not on an individual lobster basis (as the initial bands were not numbered).

Results and Discussion

Time series on lobster settlement: Since 1991, between 2 and 12 specific sites in the Beaver Harbour area of LFA 36 have been sampled annually in late September/early October for lobster settlement density (Fig. 4). At each sampling site a minimum of twelve 0.25 m^2 quadrats were sampled in complex cobble-boulder habitats between 5 to 15 m water depth, and grouped into West Harbour and East Harbour locations. Settlement densities are comparable to or higher than those recorded in similar cobble-boulder habitats sampled at mid-coast Maine and Rhode Island study sites by U.S. researchers over a similar time period (Fig. 5). The US data (provided by R.A. Wahle, Bigelow Laboratory for Ocean Sciences, Boothbay Harbor, Maine) was obtained from 8 sites in mid-coast Maine and 6 sites in Rhode Island. The low point in settlement recorded in 1996 at Beaver Harbour is consistent with the reduced settlement pattern seen in mid-coast Maine and Rhode Island in that year (Fig. 5). However, settlement densities at Beaver Harbour showed a recovery from 1997 to 1999 (although dropping again in 2000), whereas settlement densities in the Maine and Rhode Island series continued to decline.

In addition to benthic settlement monitoring, Maine researchers established time series on other lobster life history stages in the early 1990's, including annual postlarval production. Consistent with the signal seen in regional benthic settlement patterns, annual postlarval production estimates for Seabrook, NH (obtained by L.S. Incze, Bigelow Laboratory for Ocean Sciences, and colleagues) also show a progressive decline over the last decade (Fig. 6; from a manuscript in prep. by Wolf and Incze).

Based on an apparent consistent pattern of declining recruitment emerging from their postlarval monitoring, settlement monitoring, and diving studies on later benthic stages, three US researchers (Incze, Wahle, and R. S. Steneck) issued a press release on their research findings in January 2001 (Appendix 1). The release of this article stimulated considerable discussion in the scientific and fishing communities in early 2001 prior to the latest stock assessment of the Bay of Fundy lobster fishery, and during the assessment itself (DFO 2001; Lawton et al 2001; O'Boyle 2001; Pezzack et al 2001). The authors of the press release considered their observations to be reflective of regional recruitment trends, but other researchers, including D. Cowan (Lobster Conservancy, Friendship, Maine) have challenged this conclusion. Time series collected by Cowan and volunteer observers on lobster settlement and juvenile abundance at a range of intertidal New England sites do not match the trend reported by Incze and colleagues (Appendix 1).

The uncertainty in regional recruitment trends was increased subsequent to the 2001 stock assessment, when settlement sampling in New England and at Canadian sites showed increased settlement density over 2000 levels (in the case of mid-coast Maine, the highest settlement density in the time series was recorded, R. Wahle, pers communication).

Time series on lobster spawning area use: Use of shallow water locations around Grand Manan for seasonal spawning sites was first reported from studies in the early 1980's which used trap-based and limited dive sampling approaches to document sex ratios, size structure, and lobster relative distribution (Campbell 1986, 1990). A sex ratio highly skewed towards female lobsters (of which most were berried) was discovered among primarily adult assemblages of lobsters occupying sandy bottom areas of several coves in the vicinity of the port of North Head, Grand Manan. Subsequently, the approval of a salmon aquaculture site in Flagg Cove (immediately adjacent to North Head) in 1989 prompted a new series of studies to monitor this lobster habitat use and advise on potential impacts.

Divers sampled belt transects (300 m x 2m) along a series of sites within Flagg Cove (Fig. 7). Depths ranged from 20m to <5 m water depth. During 1990, surveys were conducted monthly from June to October, then on an annual basis in September each year up to 1999. In 2000 in addition to completing the September survey, an additional site visit was made in July to provide berried females for use in projects on the genetic structure of lobster populations, and CLAWS research projects on the egg quality of large lobsters.

During the period the aquaculture site was in operation (1989-1991) lobster distribution shifted away from locations which had historically been documented as high density sites (Area A in Fig. 7 had higher densities than Areas B and C). In years subsequent to site removal, the historical pattern of lobster habitat use seen in September was re-established (Fig. 7). Although this change in distribution was consistent with an effect from the aquaculture operation, there were no concurrent experimental studies to establish cause-effect relationships for the observed changes.

Over the period of investigation (1982 to 2000) local densities in Area A have increased progressively (Fig. 7). Most recently, we have noted the appearance of sub-legal lobsters in Flagg Cove sampling sites (Fig. 8), which were not encountered at this soft bottom habitat during initial studies in the early 1980's and 1990's. Sub-legal lobsters have also been encountered in recent years in greater numbers at another soft bottom sampling area in Seal Cove Sound, Grand Manan (Lawton, personal observation). Such population density and size structure changes at Flagg Cove and Seal Cove Sound during the summer closed season provide corroborative evidence in support of fishery-dependent indices documented by Lawton et al (2001) which indicate a significant recruitment event affected the Bay of Fundy lobster population during the 1990's.

Resampling of coastal habitats: In 2000 a total of 41 benthic transects were completed in three study areas (Passamaquoddy Bay, Maces Bay, Seal Cove Sound), with a total of 884 lobsters sampled. Based on a review of sampling dates, locations, and habitat characteristics, there were a total of 90 transects (1450 lobsters measured) from the early 1990's survey available for contrasts. For Maces Bay (study areas in Fig. 3), contrasts were possible across several months and for both soft bottom and hard bottom environments (Fig. 9) and only data for this area is reported.

In each case where there was a direct contrast by month and habitat characteristics, densities in the 2000 survey were higher than those obtained in the original survey. Due to the need to undertake the comparison at a coarse scale (50 m^2 units) there was considerable variability in the results. Of the lobsters sampled in the early 1990's, 25-40% were in the 20-49 mm CL size range, and 25-36% in the 50-79 mm CL size range, on a monthly basis. In 2000, higher percentages of small lobsters were encountered (61-64% lobsters 20-49 mm CL; 19-32% 50-79mm CL).

Increases in population density and changes in size structure of lobsters observed in the Maces Bay area on different habitat types provide additional corroborative evidence for improved recruitment conditions in the Bay of Fundy area during the 1990's.

Closed season trapping survey: A total of 22,772 lobsters were measured out of 1669 trap hauls made during the 4-week survey (Table 1). Catch rates were extremely high (compared to commercial season catch rates) with individual catches up to 40 lobsters per trap haul and 50 lb. per trap haul. These catch rates are the highest yet encountered in trap sampling projects on lobsters in the Bay of Fundy (Appendix 2 provides a trip by trip summary of the sampled size distributions). Average catch rate for all sizes over the survey period was 4 lobsters per trap haul for northern Grand Manan, and between 14 and 20 lobsters per trap haul for three fishers operating in southern Grand Manan (Table 1). Recapture rates during the survey were extremely low. Single recaptures varied between fishermen from 1.2 to 5.9% of the lobsters tagged. Only one lobster of the 5243 lobsters tagged was recaptured twice.

Historical data on trap catches of lobsters for equivalent time periods was accessed and made available in a georeferenced format. Whereas current survey data is resolvable by individual trap (or string) location, historical data is known only from certain broadly-defined study areas (Fig. 10). For the northern Grand Manan survey there is a direct spatial overlap between 2000 trap locations and historical sampling areas, whereas for southern Grand Manan the historical data is from areas to the southwest, and further offshore than the 2000 survey which was focussed in inshore areas (Fig. 10).

Figures 11 and 12 provide a detailed comparison of historical and current lobster size distribution in the trap catches in terms of number of lobsters per mm size category per trap haul (males, females, and berried females considered separately). In relation to the commercial fishery and stock assessment of lobsters it is also relevant to consider catch rates in terms of lobster moult groups (discussed by Lawton et al 2001). Moult groups define size classes of lobster in relation to the range of size increments that typically occur at each moult. Moult groups are also defined relative to the minimum catchable size (Lawton et al 2001; Pezzack et al 2001). There was a shift to higher catch rates of lobsters in the first and second molt groups (81-94; 95-109 mm CL) in 2000 compared to the historical studies (Fig. 13). Catch rates of third molt group and greater (110+ mm CL) lobsters were also substantially higher in northern Grand Manan. Trapping in southern Grand Manan was dominated by lobsters in the first molt group, which reached approx. 10 per trap haul over the sampling period (Fig. 13). Catch rates were higher in southern Grand Manan for all molt groups except the largest (Fig.13).

A number of trap hauls were made in shallow water locations in Flagg Cove adjacent to areas surveyed by DFO divers in the week prior to trapping. Figure 14 shows a comparison of the trap and diver samples. Trap catches in Flagg Cove were principally composed of berried females (72 Male: 63 Female: 151 Berried), as compared to trap catches from Whale Cove, to the north of the port of North head (309 Male: 205 Female: 106 Berried). Differential catchability of berried females accounts for the lower catch rates in North Head vs Whale Cove. Both diving and trapping surveys intercepted sub-legal lobsters <83 mm CL.

Changes in trap types and fishing strategy influence this decadal-scale contrast. However, the generally higher catch rates are consistent with industry observations of higher numbers of lobsters in these inshore areas in recent years. Industry surveys can provide important information on closed season distribution of lobsters and show promise in gaining a better understanding of the relative abundance of large mature lobsters.

Summary and Research Recommendations

Major diving surveys were conducted on inshore lobster habitats in the Fundy Isles Region of the Bay of Fundy between 1989 and 1993. The presence of significant numbers of small juvenile lobsters in shallow water habitats indicated the presence of local lobster nursery areas. Additionally, in certain inshore locations within the Bay of Fundy, for example North Head, St.

Martins and Alma, N.B., seasonal aggregations of berried female lobsters were documented. Information on these inshore lobster spawning areas was obtained by trap sampling (Campbell 1990; Robichaud and Campbell 1991), bottom trawl survey (Lawton and Robichaud, unpublished data), and by direct diving observations (Campbell 1990; Lawton 1993).

Taken in aggregate the additional diving studies conducted up to 2000, and the recent closed season trapping survey on Grand Manan indicate that current densities of lobsters in inshore waters of the lower Bay of Fundy are either comparable to or significantly higher than levels originally documented in the early 1990's. These new studies provide provide corroborative evidence for recent recruitment trends seen in fishery dependent sampling (Lawton et al 2001). As these research studies are conducted in a few locations, their use in general stock assessment is exploratory.

In relation to the Bay of Fundy time series on settlement densities there is a signal of depressed settlement strength in the mid-1990's consistent with observations seen in similar diving-based studies in Maine. While the subsequent settlement data from the Beaver Harbour site suggests that this may have been of limited duration, Canadian settlement monitoring is very limited. Though there was insufficient time in 2000 to conduct suction sampling surveys in the Maces Bay area, anecdotal observations by divers with over 15 years experience of diving in lobster settlement habitats were that densities of small juvenile lobsters were very high in that region.The conflicting trends in the currently available time series on recruitment trends in the Gulf of Maine underscore the need for a more comprehensive program of settlement monitoring. The State of Maine has recently expanded its settlement monitoring effort to other locations to the north and south along the coast in 2000, and the State of Massachusetts established a settlement monitoring program in 1995 at sites north and south of Cape Cod (R. Wahle, personal communication). Canadian settlement monitoring efforts in the Bay of Fundy and S.W. Nova Scotia should be expanded, but developed as part of an integrated regional program to mesh with similar efforts in the US portion of the Gulf of Maine. There are significant logistic issues related to commiting to such an expansion, which can not be effected within current research program operating levels.

The successful completion of a major trapping survey by Industry on Grand Manan has provided the first comprehensive survey of closed season lobster distribution in LFA 38 since the early 1980's. Some limited contrasts with historical data have been possible to date, but as with the diving-based contrasts, it is critical that historical data is georeferenced to the maximum extent possible so that appropriate contrasts can be made.

As with the diving surveys, the recent closed season trapping survey provides strong evidence that abundances of lobster in inshore waters of the lower Bay of Fundy are high relative to observations made in the early to mid-1980's. This is consistent with general fishery monitoring data and landings trends in these fisheries (Lawton et al 2001). Similar closed season trapping surveys were conducted in other locations in the Bay of Fundy as part of a comprehensive suite of fishery studies initiated by DFO and the Province of New Brunswick in the late 1970's. Based on the success of the current project with Grand Manan Fishermen's Association, similar studies could be conducted in other areas of the Bay of Fundy.

Based on information as of March 2001 (Lawton et al 2001; this study) the short-term outlook for the Bay of Fundy lobster fishery is for landings to remain high. Over the mid-term (3-5 yr.) the Bay of Fundy lobster fisheries may experience a decline. This is based on the time series on sub-tidal benthic settlement from the lower Bay of Fundy, Maine and Rhode Island, which show low settlement levels in the mid-1990's – animals expected to recruit to the fishery through the mid-2000's. It is uncertain how representative these data are of regional trends, or how enhanced settlement in Fall 2001 observed after completion of the stock assessment report may offset lower settlement documented in the mid-1990's.

References

Campbell, A. 1986. Migratory movements of ovigerous lobsters, *Homarus americanus*, tagged off Grand Manan, eastern Canada. Can. J. Fish. Aquat. Sci. 43: 2197-2205.

Campbell, A. 1990. Aggregations of berried lobsters (*Homarus americanus*) in shallow waters off Grand Manan, eastern Canada. Can. J. Fish. Aquat. Sci. 47: 520-523.

DFO 2001. Bay of Fundy Lobster (LFAs 35, 36, and 38). DFO Science Stock Status Report C3-61 (2001).

Lawton, P. 1993. Salmon aquaculture and the traditional invertebrate fisheries of the Fundy Isles Region: Habitat mapping and impact definition.. Report to the New Brunswick Dept. of Fisheries and Aquaculture, COOP Agreement of Fisheries and Aquaculture Development Contract 291.303, 84p.

Lawton, P., and K. L. Lavalli. 1995. Postlarval, juvenile, adolescent, and adult ecology, p. 47-88. In J. R. Factor [ed.] Biology of the lobster *Homarus americanus.* Academic Press, Inc., San Diego California.

Lawton, P., D.A. Robichaud, and M. Moisan. 1995. Characteristics of the Annapolis Basin, Nova Scotia, lobster fishery in relation to proposed marine aquaculture development. Can. Tech. Rep. Fish. Aquat. Sci. 2035: iii + 26p.

Lawton, P., Robichaud, D.A., Strong, M.B., Pezzack, D.S., and C.F. Frail. 2001. Spatial and temporal trends in the American lobster, *Homarus americanus*, fishery in the Bay of Fundy (Lobster Fishing Areas 35, 36, and 38). DFO Can. Sci. Adv. Sec. Res. Doc. 2001/094.

Miller, R.J. 1990. Effectiveness of crab and lobster traps. Can. J. Fish. Aquat. Sci. 47:1228-1251.

O'Boyle [Ed.]. 2001. Proceedings of a Maritimes Regional Advisory Process Meeting on LFA 33 – 41 Lobster. DFO Can. Sci. Adv. Sec. Proceed. Ser. 2001/020, 59p.

Pezzack, D.S., C.F. Frail, P. Lawton, D.A. Robichaud, and M.B. Strong. 2001. Update on Stock Status of American Lobster, Homarus americanus, Lobster Fishing Area 34. DFO Can. Sci. Adv. Sec. Res. Doc. 2001/156.

Richards, R.A., J.S. Cobb, and M.J. Fogarty. 1983. Effects of behavioral interactions on the catchability of American lobster (*Homarus americanus*) and two species of *Cancer* crabs. Fish. Bull. 81: 51-60.

Robichaud, D. A. and A. Campbell. 1991. Annual and seasonal size-frequency changes of trap-caught lobsters (*Homarus americanu*s) in the Bay of Fundy. J. Northw. Atl. Fish. Sci. 11: 29-37.

Waddy, S.L., and D.E. Aiken 1995. Control of growth and reproduction, p. 217-266. In J. R. Factor [ed.] Biology of the lobster *Homarus americanus.* Academic Press, Inc., San Diego California.

Wahle, R.A. and Steneck, R.S. 1991. Recruitment habitats and nursery grounds of the American lobster *Homarus americanus*: A demographic bottleneck? Mar. Ecol. Prog. Ser. 69: 231-243.

Wahle, R.A. and Steneck, R.S. 1992. Habitat restrictions in early benthic life: Experiments on habitat selection and in situ predation with the American lobster. J. Exp. Mar. Biol. Ecol. 157: 91-114.

Table 1. Summary of lobster catches in closed season trapping survey, Grand Manan, September-October 2000. Total number of trap hauls (TH), total number of lobsters measured, and mean number of lobsters per trap haul for trips conducted by fishermen from each port indicated. North Head information presented in the text as northern Grand Manan. Information from the three other ports is collectively termed southern Grand Manan. Trip identifier (Tripno) from Oracle database (Crustacean Research Information System); specific trip catch size frequencies are provided in Appendix 2, referenced by Tripno.

North Head			White Head		
Tripno	**Date**	**TH**	**Tripno**	**Date**	**TH**
3050	11-Sep-00	48	3060	11-Sep-00	49
3051	13-Sep-00	48	3061	14-Sep-00	50
3052	15-Sep-00	48	3062	16-Sep-00	30
3053	19-Sep-00	47	3063	18-Sep-00	28
3054	22-Sep-00	49	3064	20-Sep-00	30
3055	25-Sep-00	51	3065	22-Sep-00	26
3056	27-Sep-00	51	3066	25-Sep-00	31
3057	29-Sep-00	51	3067	27-Sep-00	30
3058	02-Oct-00	49	3068	29-Sep-00	29
3059	04-Oct-00	51	3069	02-Oct-00	28
	Total TH =	493		Total TH =	331
	Total Lobsters =	2199		Total Lobsters =	5651
	Mean no. lobsters\TH =	4.46		Mean no. lobsters\TH =	17.07

Ingalls Head			Seal Cove		
Tripno	**Date**	**TH**	**Tripno**	**Date**	**TH**
3070	11-Sep-00	44	3080	12-Sep-00	49
3071	12-Sep-00	48	3081	14-Sep-00	45
3072	14-Sep-00	49	3082	16-Sep-00	45
3073	16-Sep-00	50	3083	21-Sep-00	36
3074	18-Sep-00	49	3084	29-Sep-00	46
3075	20-Sep-00	50	3085	01-Oct-00	44
3076	23-Sep-00	50	3086	03-Oct-00	44
3077	25-Sep-00	50	3087	10-Oct-00	48
3078	27-Sep-00	49			
3079	30-Sep-00	49			
	Total TH =	488		Total TH =	357
	Total Lobsters =	9803		Total Lobsters =	5119
	Mean no. lobsters\TH =	20.09		Mean no. lobsters\TH =	14.34

Total number of traps hauled = 1669

Total no. of lobsters measured = 22,772

Figure 1. General location of dive surveys conducted in Fundy Isles region in early 1990's and place names used in the text.

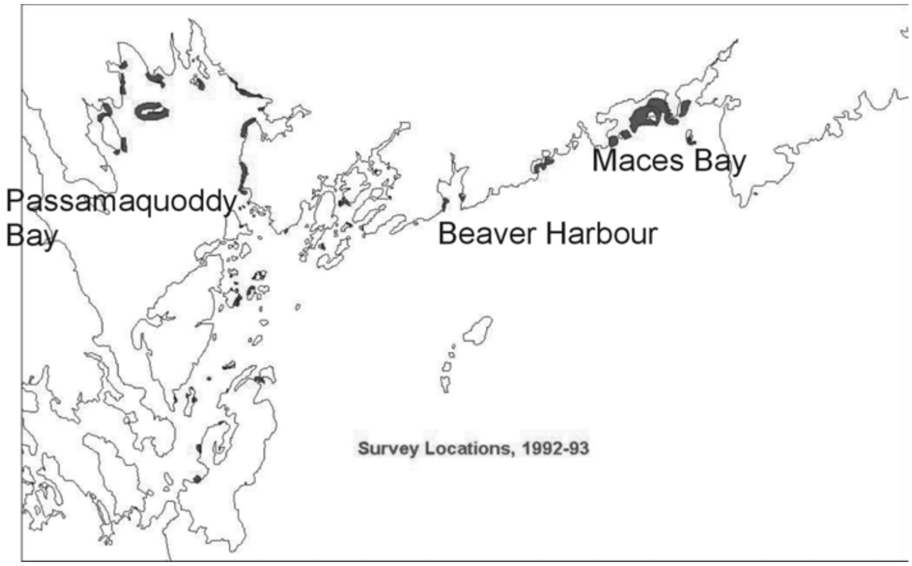


Figure 2. Sampling areas at Beaver Harbour, based on 2000 sampling locations. Indicated are the positions of specific dive samples taken in October 2000 (filled squares). These locations, and several other specific sites in Beaver Harbour were sampled annually from 1991 to 2000.

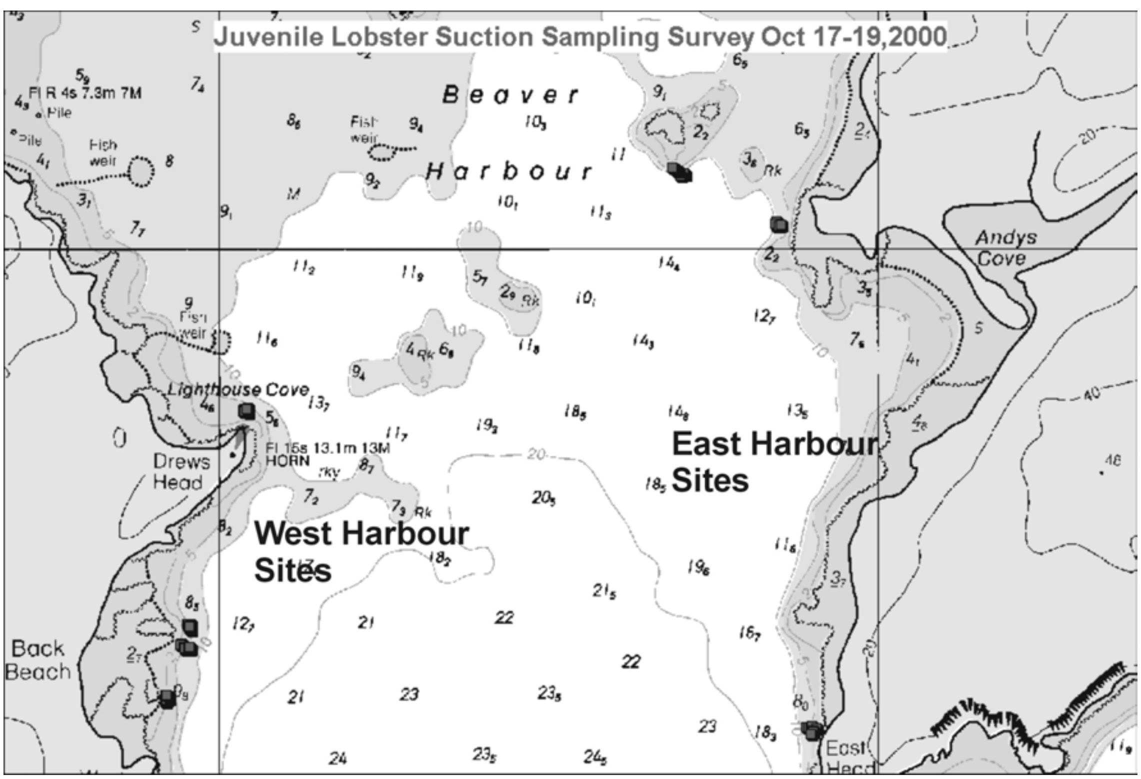


Figure 3. Dive study areas in Maces Bay for resampling of coastal habitats in 2000.

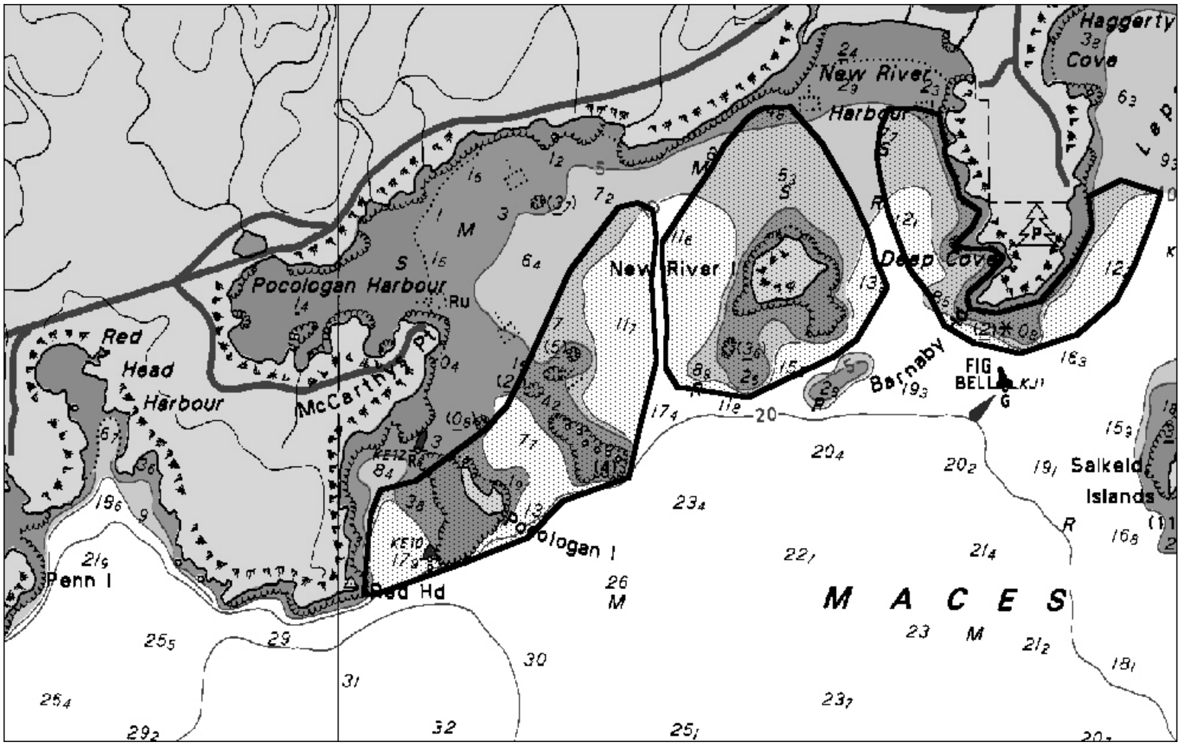


Figure 4. Annual settlement density at Beaver Harbour (lobsters < 13 mm CL).

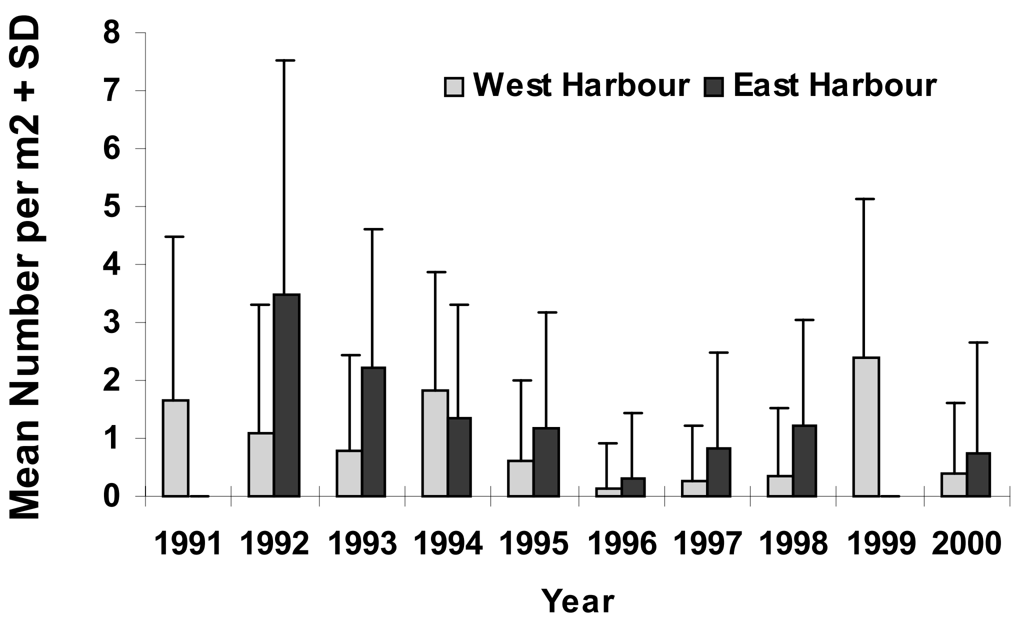
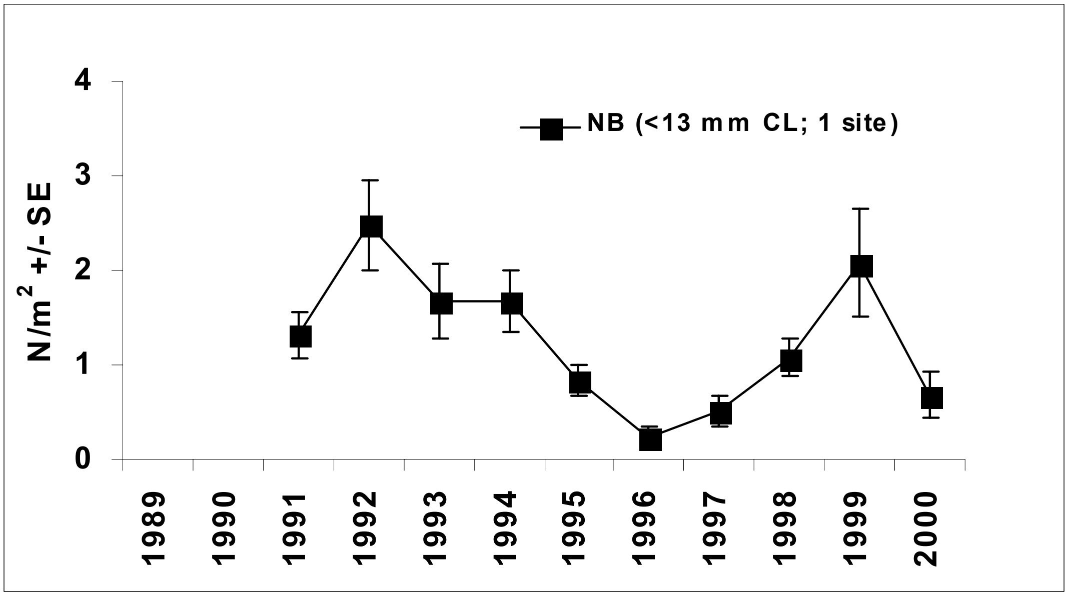


Figure 5. Comparison of Beaver Harbour, New Brunswick (NB), lobster settlement time series with similar time series for mid-coast Maine and Rhode Island, provided by R. Wahle. The error bars represent 1SE. Data were collected at the 8 sites in mid-coast Maine and 6 sites in Rhode Island. Note the difference in size category of lobsters considered to represent settling year-class. This is based on settlement timing, benthic sampling time, and lobster growth rates following settlement.



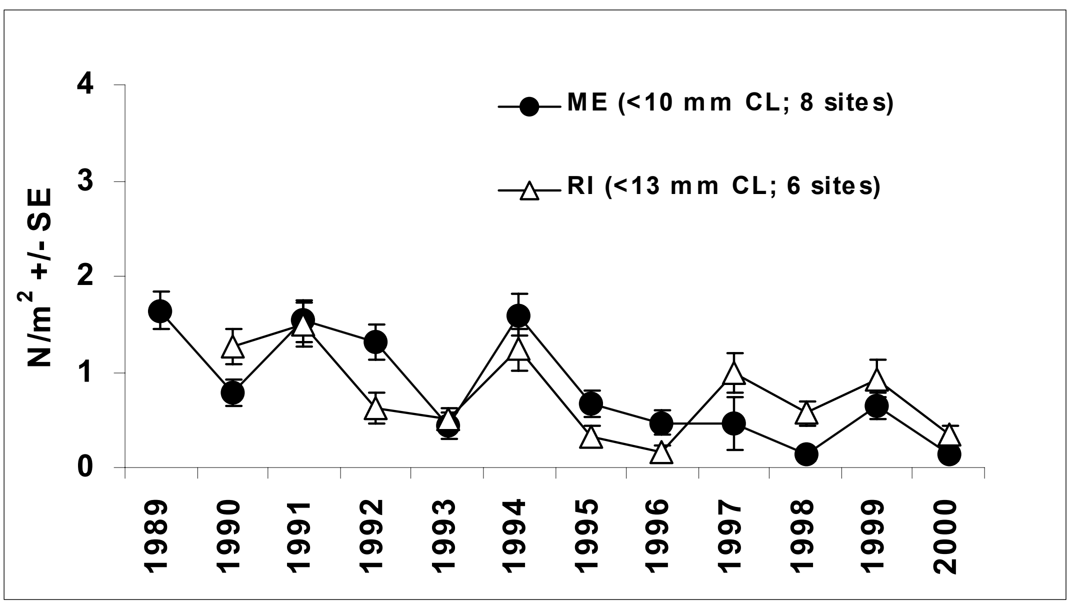


Figure 6. Integrated postlarval (PL) lobster abundance for the entire sampling season (May through October; heavy line) and for the main PL period (DOY 184 – 239; dotted line) from sampling conducted for postlarval lobsters in the Seabrook, NH area and used for interannual climatic comparisons. Data from Wolff and Incze, 2001, in prep. The data are trapezoidal sums of the weekly abundance data.

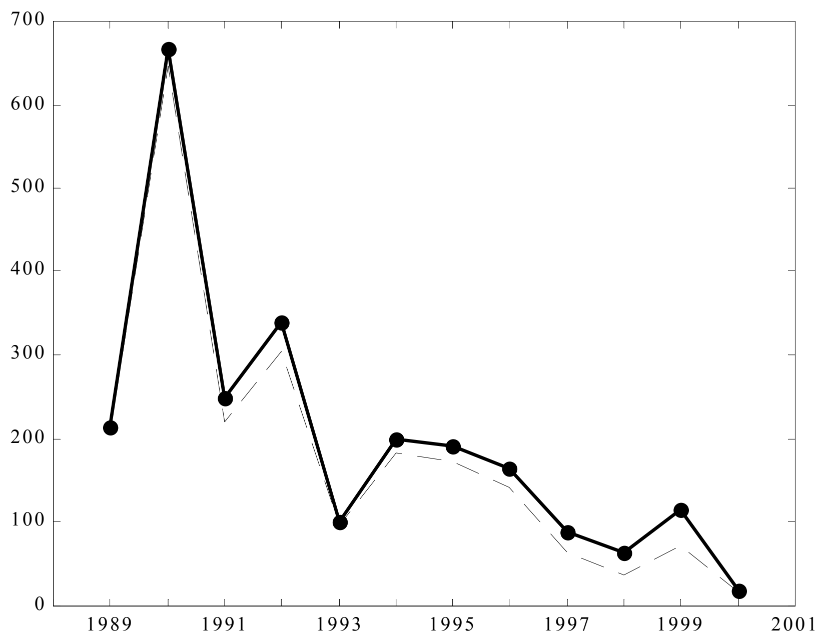


Figure 7. Lobster density during summer months, 1982-2000, at Flagg Cove, adjacent to the port of North Head, Grand Manan. Map indicates general location of dive transects (300m x 2m) placed in three sampling areas of Flagg Cove, relative the location of a salmon aquaculture site, active between 1989 and 1991. The graph presents the average density of lobsters in each area, expressed by the minimum sampling unit (25 m transect section; 50m^2), and based on 3 – 4 transects in each area (12 sampling units per transect).

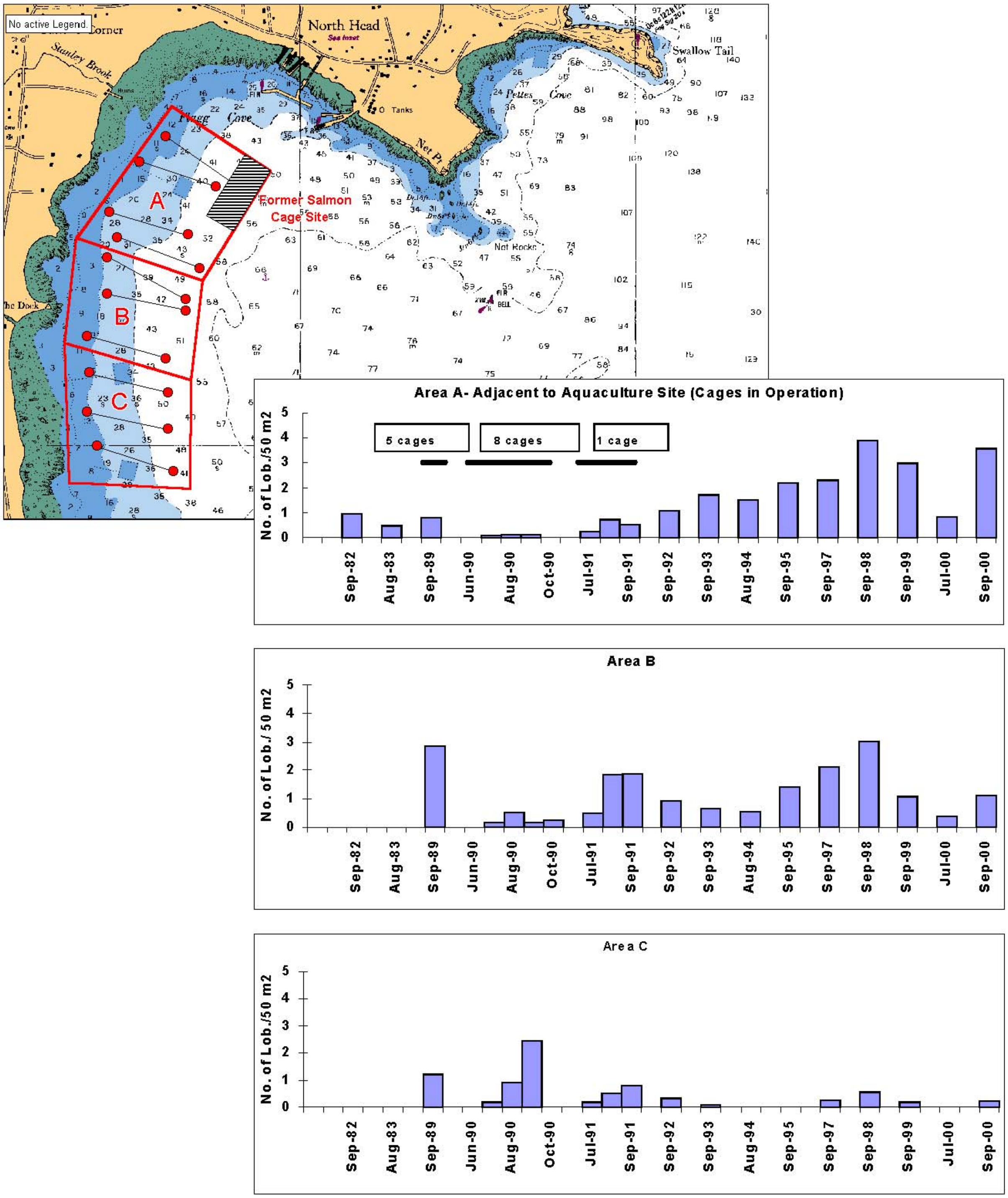
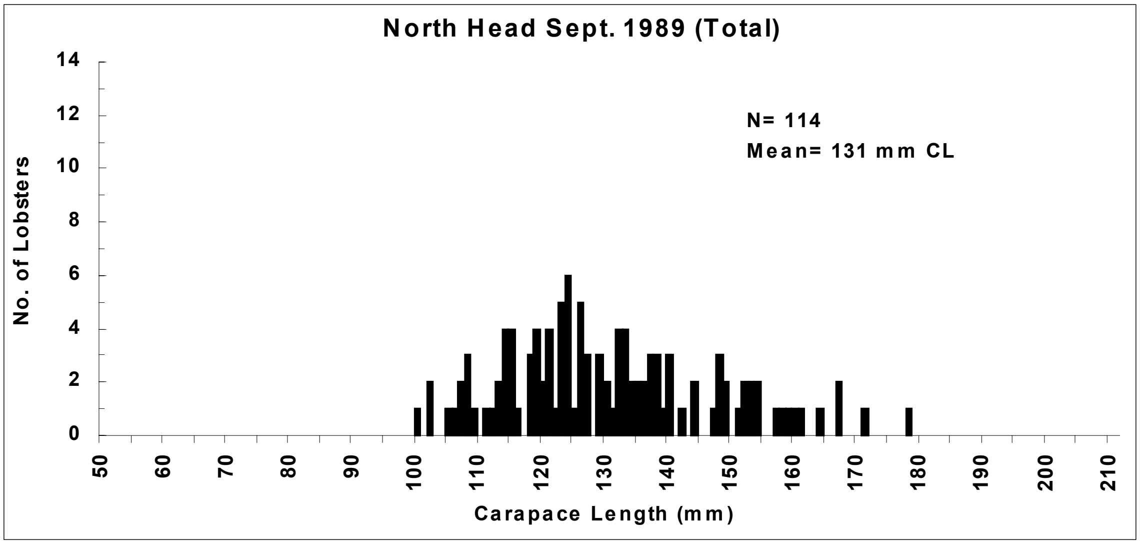


Figure 8. Size frequency observed from transect-based diving surveys at Flagg Cove, North Head, 1989, and 2000.



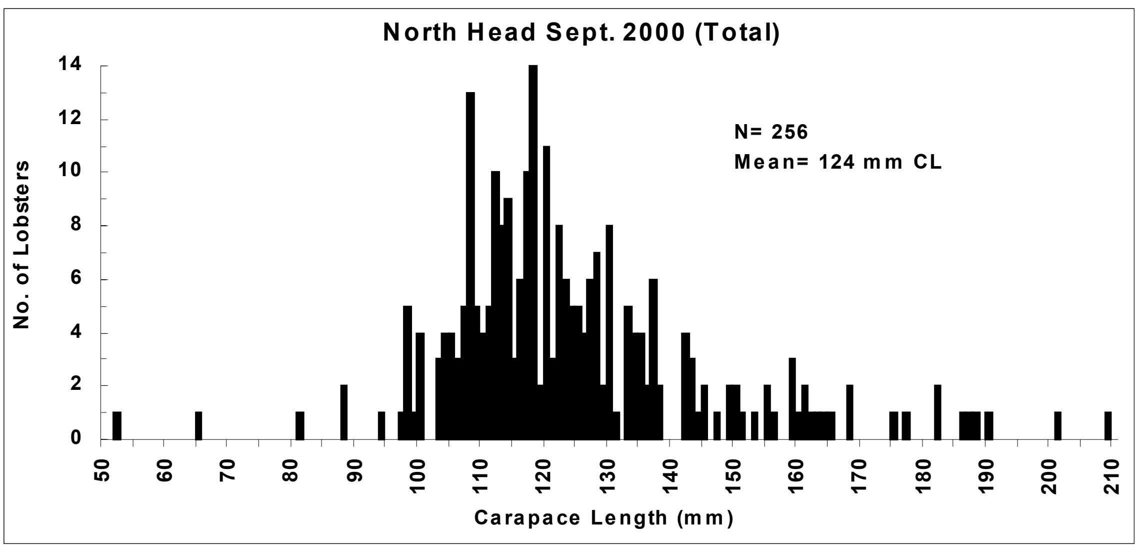
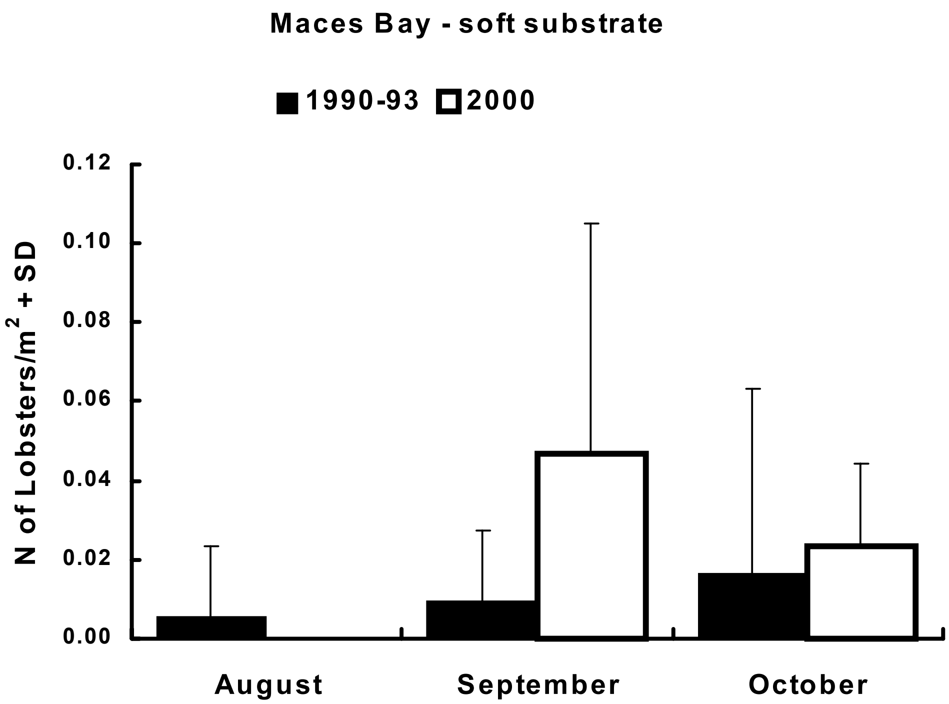


Figure 9. Contrasts in coastal habitat use by lobsters in Maces Bay, early 1990's and 2000. Lobsters collected by transect-based diving approaches (150 m x 2m; minimum sampling unit 25 m; 50 m^2) ranged from 7-142mm carapace length. Number of units sampled for each time and habitat category ranged from 5 – 82; thus zero densities were observed for some months and habitats. Note the difference in scale for lobster density on soft and rocky substrates.



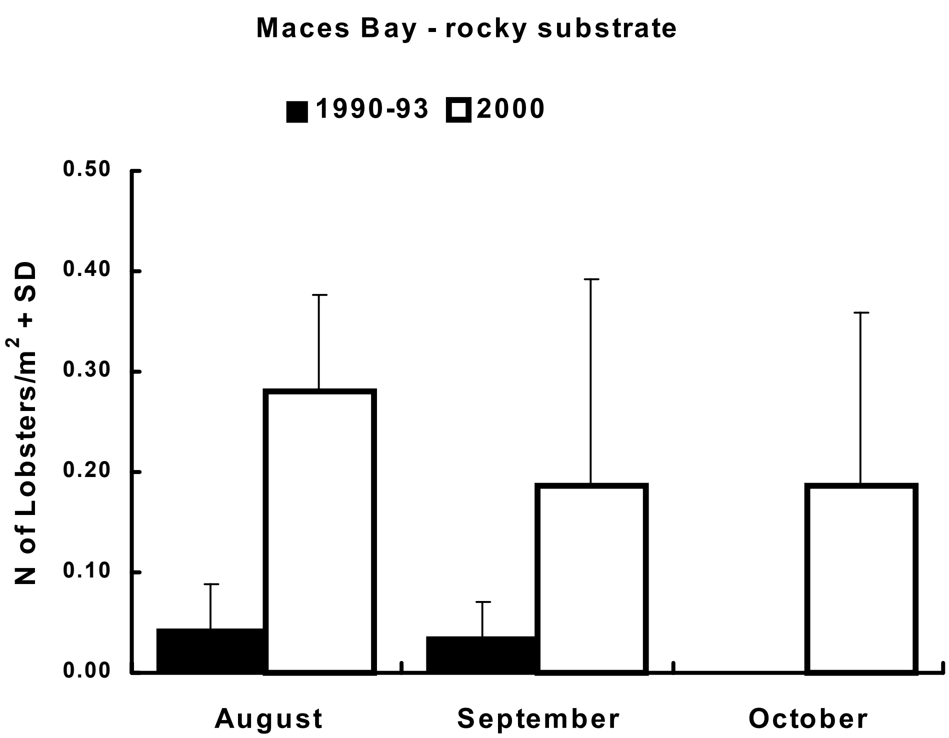
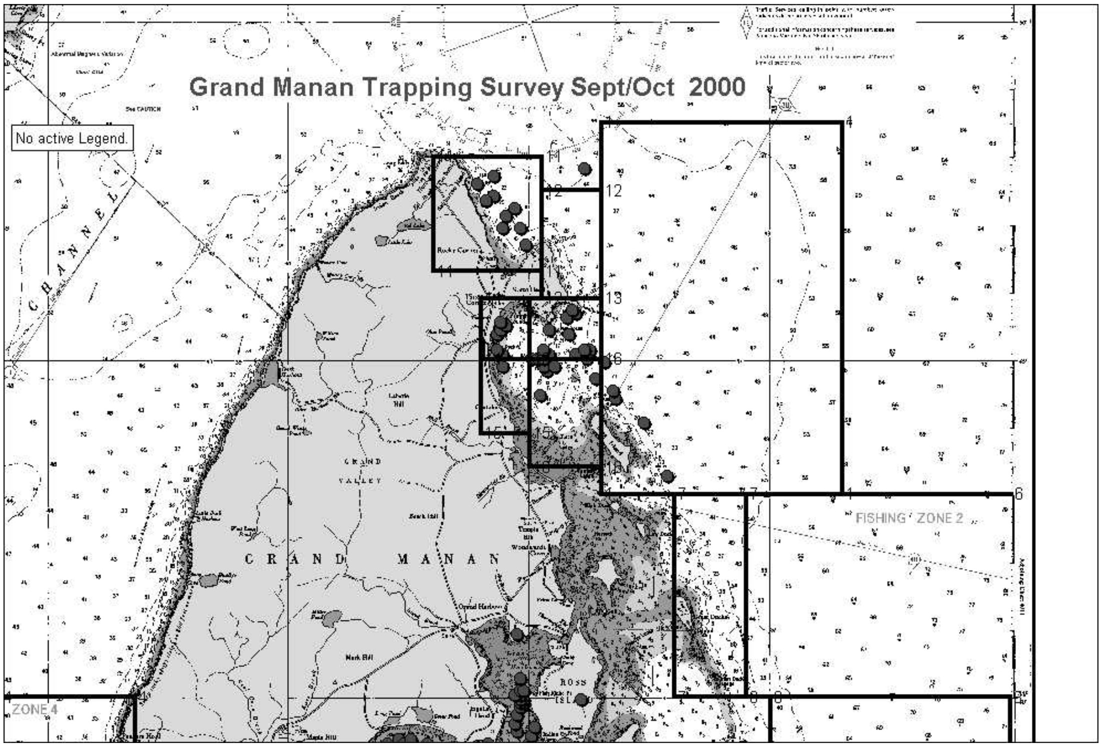


Figure 10. Trapping areas on Grand Manan in 2000 (dots); historical trapping areas (boxes).



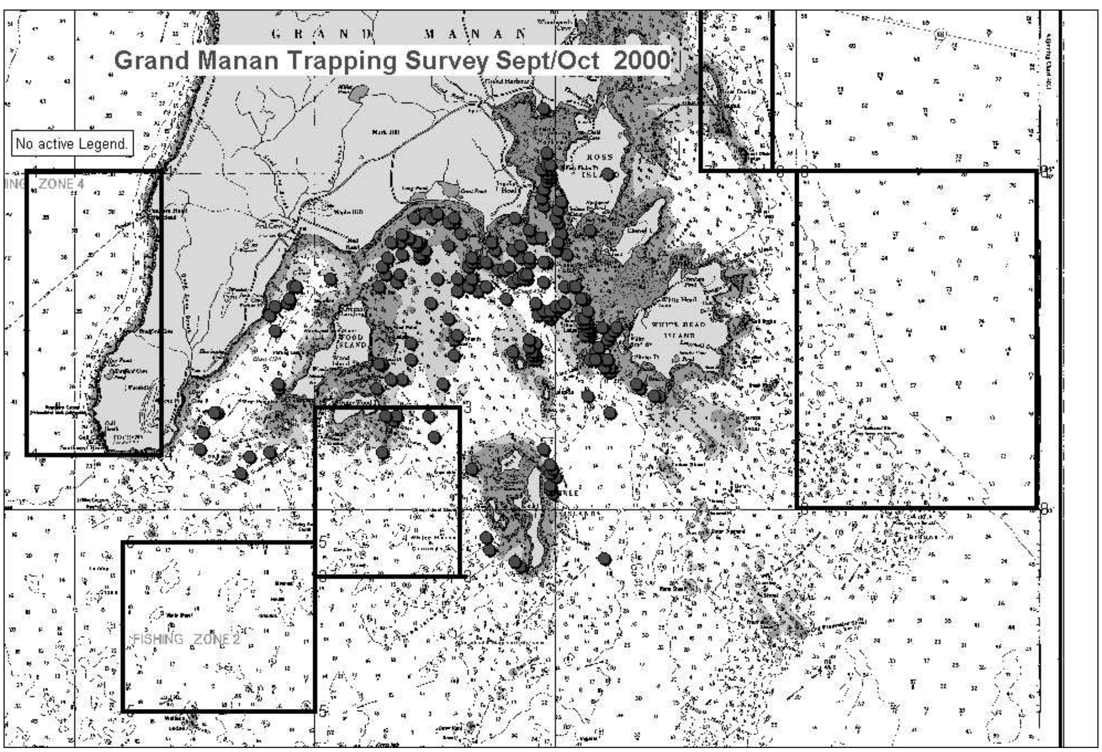


Figure 11. Comparison of trap size frequency in northern Grand Manan trapping locations, 1982 and 2000.

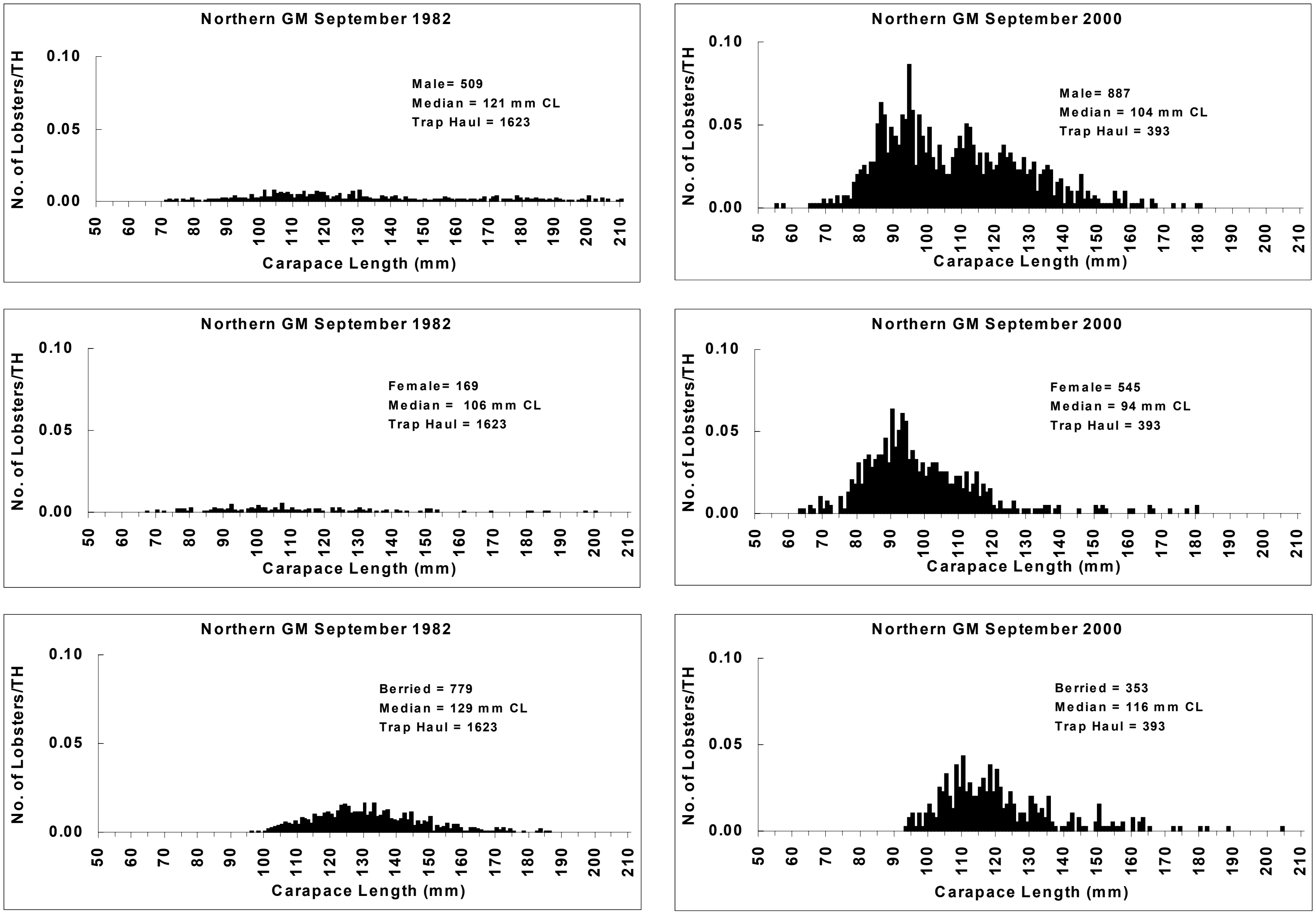


Figure 12. Comparison of trap size frequency in southern Grand Manan trapping locations, 1982 and 2000.

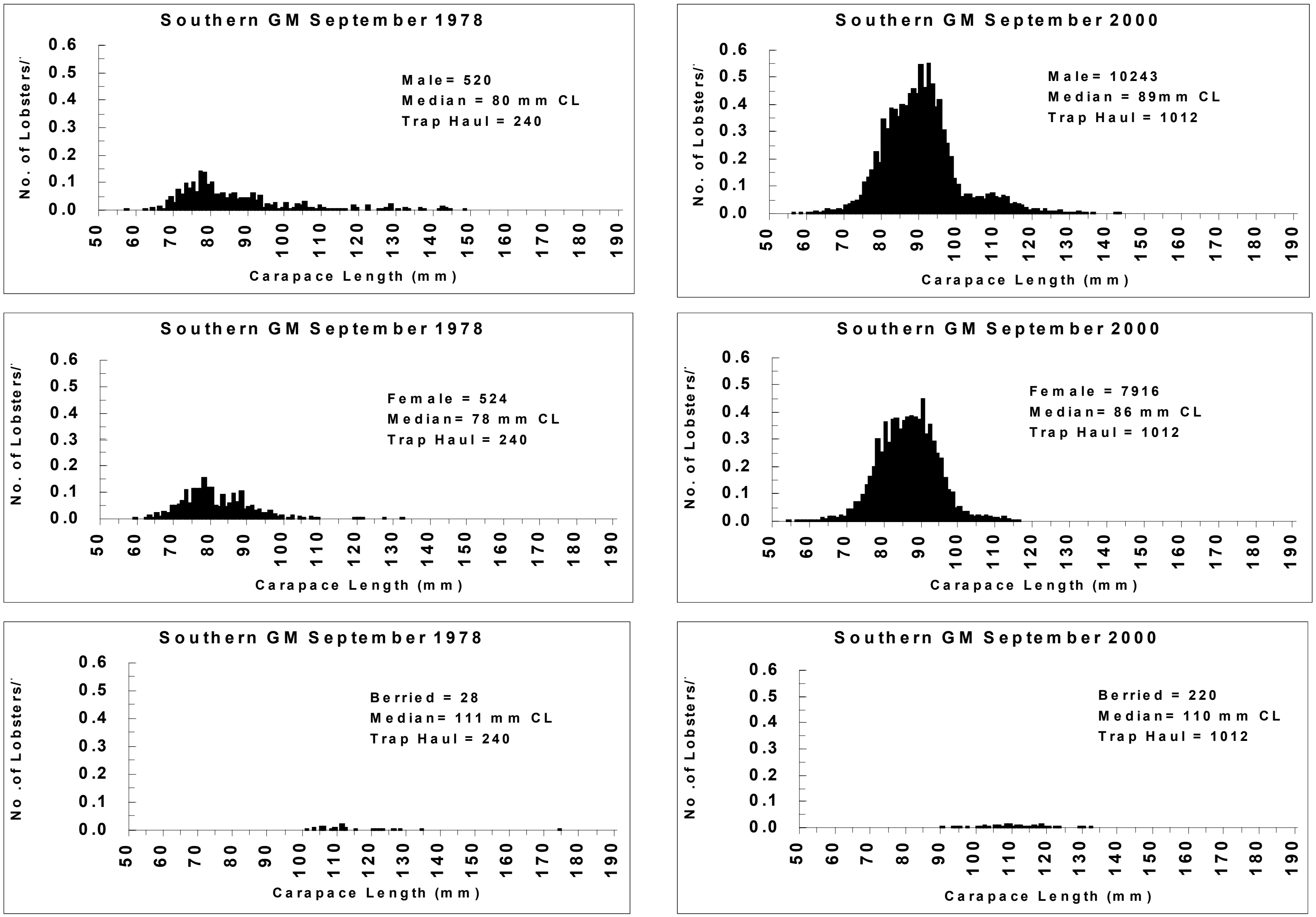


Figure 13. Catch rates of lobsters (males, females, berried females combined) in closed season trapping off Grand Manan by moult group category (fishable sizes), and a pre-recruit size category (75-80 mm CL).

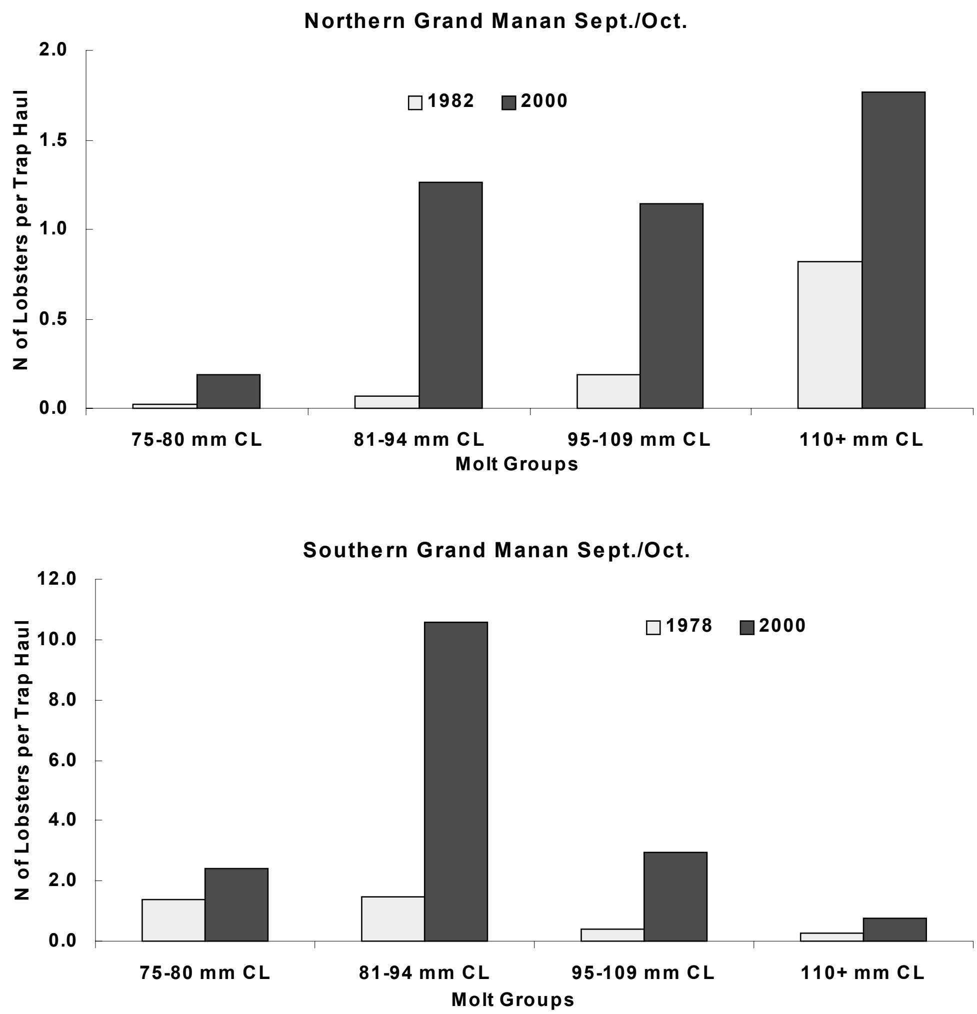
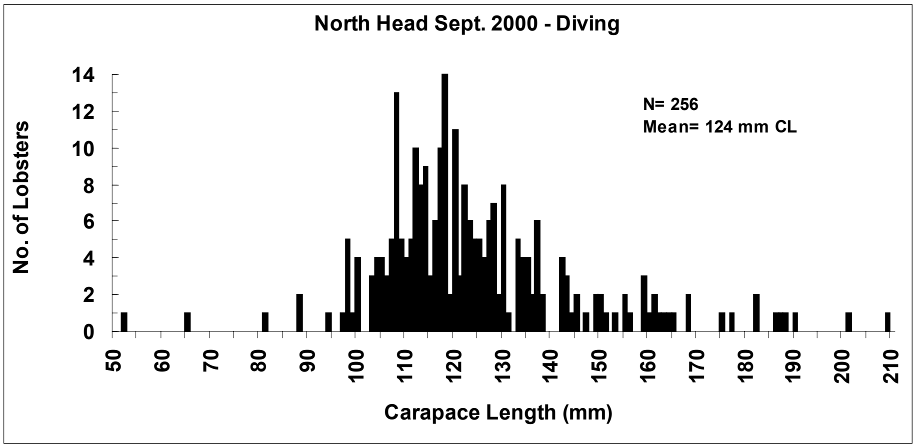
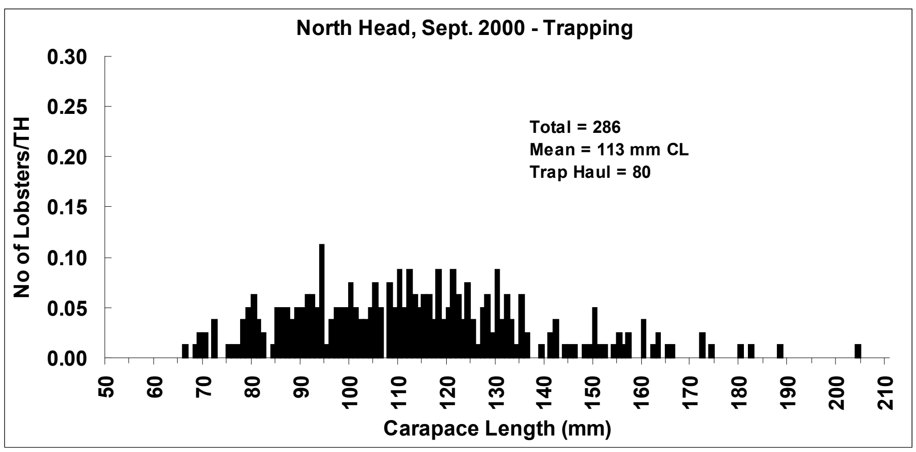


Figure 14. Comparison of trap-caught and diver-sampled lobster size distribution, September 2000. Size frequencies include all sex categories (males, females, and berried females).

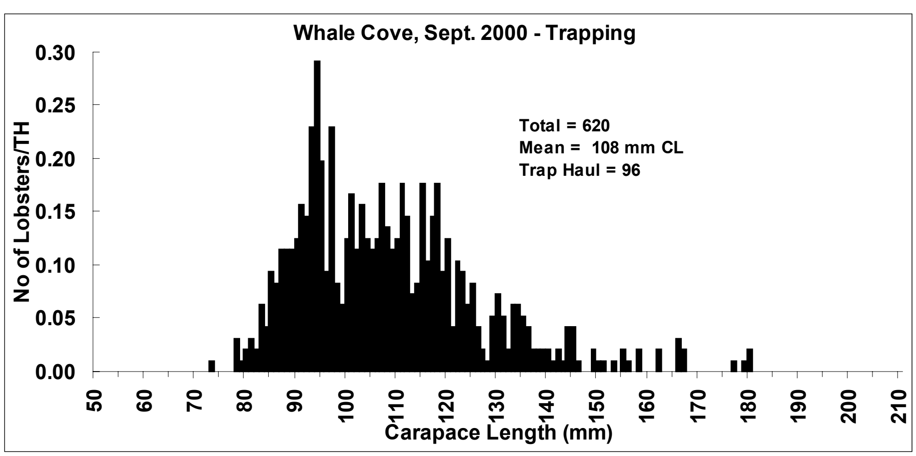
(A) Diver samples, Flagg Cove (within historical trapping area 14).



(B) Trap-caught lobsters, historical trapping area 14, Flagg Cove.



(C) Trap-caught lobsters, historical trapping area 11, Whale Cove.



Appendix 1. Press release issued in January 2001 by US lobster research scientists active in lobster recruitment monitoring in Maine coastal waters.

Potential slowdown in lobster landings

The abundance of juvenile lobsters in key lobster producing regions of mid-coast Maine appears to be declining. We expect landings in those regions and possibly elsewhere to decline sometime during the next two to four years. Given that lobsters are the single most valuable species to Maine's fisheries, we think it is important to alert the lobstering industry, state managers, policy makers and the general public to our findings.

For more than a decade, scientists from the University of Maine and Bigelow Laboratory for Ocean Sciences have been working to develop means of predicting lobster abundance and landings. Our approach differs from those traditionally used in Maine and New England by independently monitoring three different life stages: 1) larvae in the water, 2) newly settled individuals on the bottom and 3) older juvenile lobsters. Our research measured linkages between each of these three successive stages. Larval lobsters in coastal zones dive down to become the new year-class of lobsters on the bottom, and if these lobsters survive, they will become juvenile lobsters, and eventually comprise our future landings. In concept it's similar to counting the number of seeds you sow in your garden and finding that they correspond to some reduced number of seedlings and eventually the plants you harvest.

Predicting lobster abundances or landings is no easier than predicting the economy or the weather. While local lobster landings may generally reflect local lobster abundance, measuring abundance is fraught with uncertainty. We can never be sure that we "know" the abundance of any phase in a lobster's life. However, by going to the same locations and using the same methods over many years, we can detect trends. Since any single measure of abundance may be flawed, we monitored abundance of three distinct stages, each requiring a different means of detection. Censusing different developmental stages in juvenile lobster populations over time is similar to monitoring the total number of students in elementary schools as an indicator of future high school class sizes. If significant changes occur in the abundance of lobster larvae they should immediately translate to changes in that year-class on the bottom. A couple of years later, changes should be evident in the older juvenile lobsters.

Since 1995 newly settled lobsters on the bottom have been declining in the Boothbay monitoring region. Similar trends were detected in larvae in New Hampshire and new settlers in Rhode Island. The larvae and settlement studies suggest widespread declines at least west of Penobscot Bay (no larval monitoring has been done east of there). Censuses of juvenile lobsters that are 2 to 4 years old (2 to 5 years prior to harvest) have been conducted statewide at nearly 40 sites distributed from York to Jonesport. Most troubling is the consistent decline since 1997 of juvenile lobsters from eastern Muscongus Bay, throughout Penobscot Bay and Hancock County. This broad swath includes Maine's most-productive lobster-producing regions. While not all of our indicators at all of our study regions are consistent, enough are for us to announce that signals of a widespread decline in landings are now evident.

Many lobstermen will quickly point out that they have seen more egg-bearing lobsters over the past decade than ever before, and we agree. In fact, in the most recent lobster stock assessment there is evidence that the reproductive potential of lobster stocks is currently high. The decrease in larval lobsters and year-classes on the bottom must be the result of other factors, possibly changes in the ocean environment itself which could affect survival or delivery of the larval stages. However, just as we cannot explain the dramatic increase in lobster abundances and landings over the past two decades throughout the northeast, from Delaware to Newfoundland Canada, we cannot explain the pending decline. Further, larvae and young of the year lobsters in Rhode Island and Maine are showing similar patterns of change despite being two oceanographically and reproductively distinct systems separated by Cape Cod. Thus the environmental factor(s) responsible appear to be very wide-spread.

What should be done? This question is best addressed by the lobstering community and state managers. As scientists we feel it's important to alert the public and stakeholders. No one has prior experience with the type of data we have. So we can't be sure how closely the harvest will follow our findings. However, if the patterns we see turn out to be accurate predictors of declining harvest and are primarily controlled by the environment, then some traditional management actions such as increasing egg production may do little or nothing to reverse the situation. Nevertheless, steps should be taken to preserve existing broodstock. Certainly, a decline in lobster stocks given the large fishing capacity that exists could threaten the reproductive potential of the stock and reduce chances of recovery. If lobster landings are to decline, it might be a good idea to wait before making large new financial commitments. Nature may still have more surprises for us and this trend could turn around. However, this is an excellent time for industry and managers to discuss the most appropriate actions so that the stocks and the fishermen both survive the fluctuations inherent in nature.

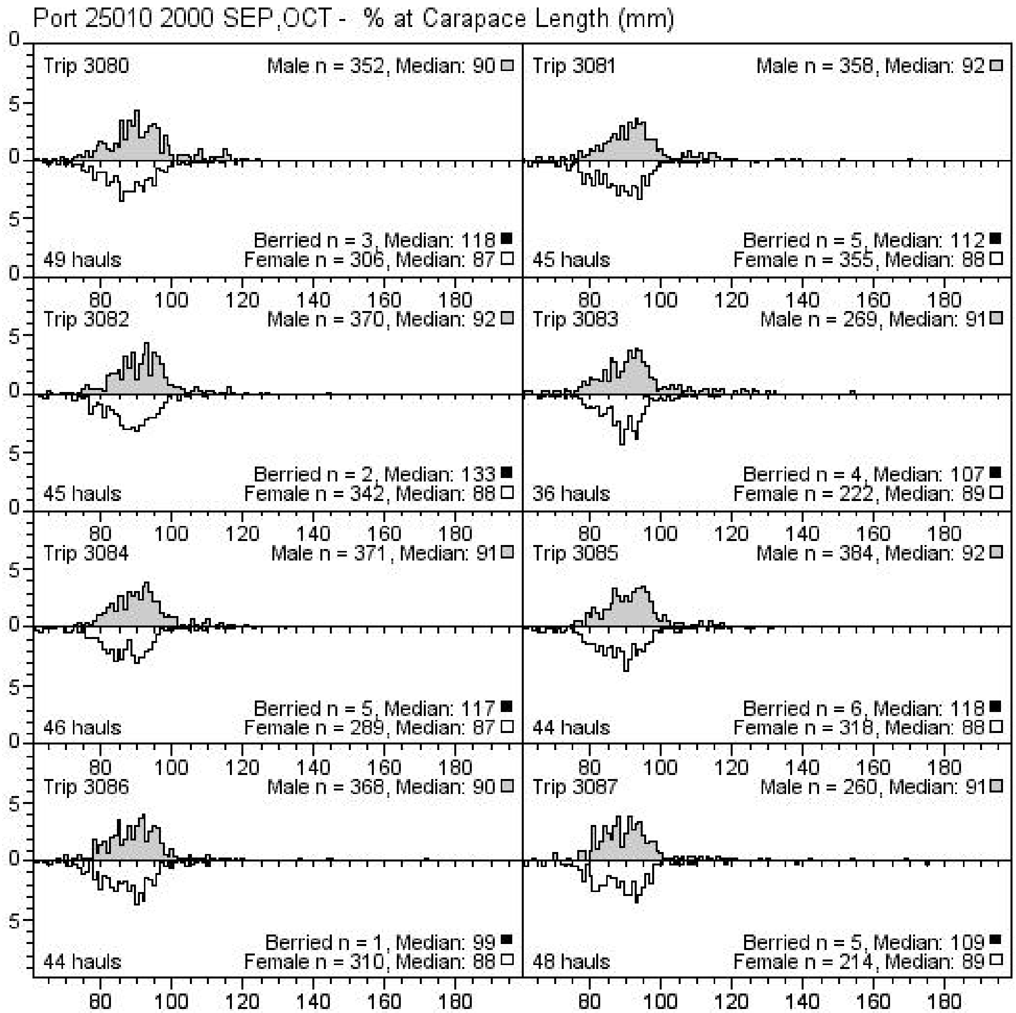
Robert S. Steneck, Ph.D. Professor, University of Maine School of Marine Sciences

Richard A. Wahle, Ph.D. Research Scientist, Bigelow Laboratory for Ocean Sciences

Lewis S. Incze, Ph. D. Research Scientist, Bigelow Laboratory for Ocean Sciences

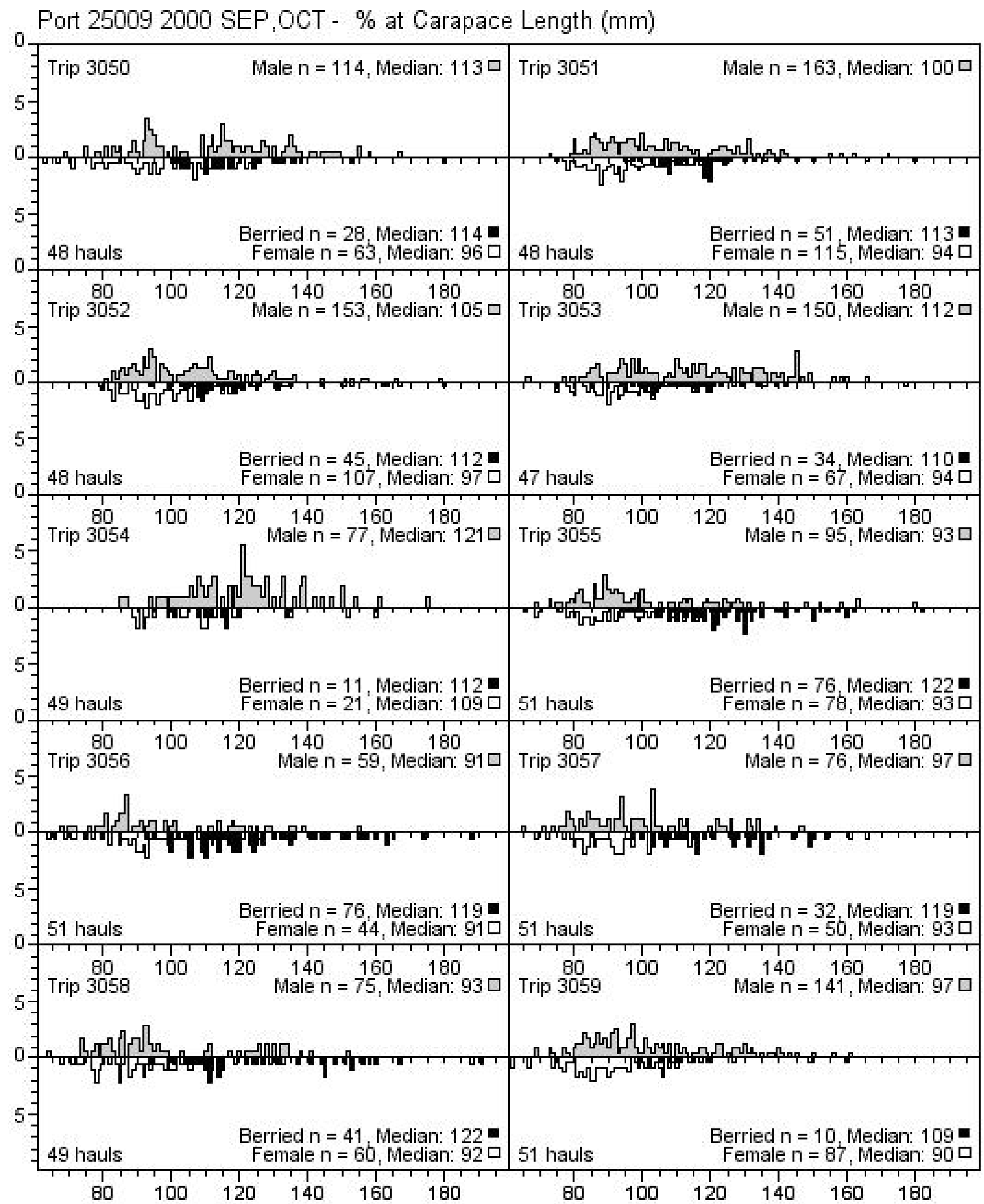
Appendix 2. Individual trip size frequency summaries from the closed season trapping survey.

(A) Seal Cove



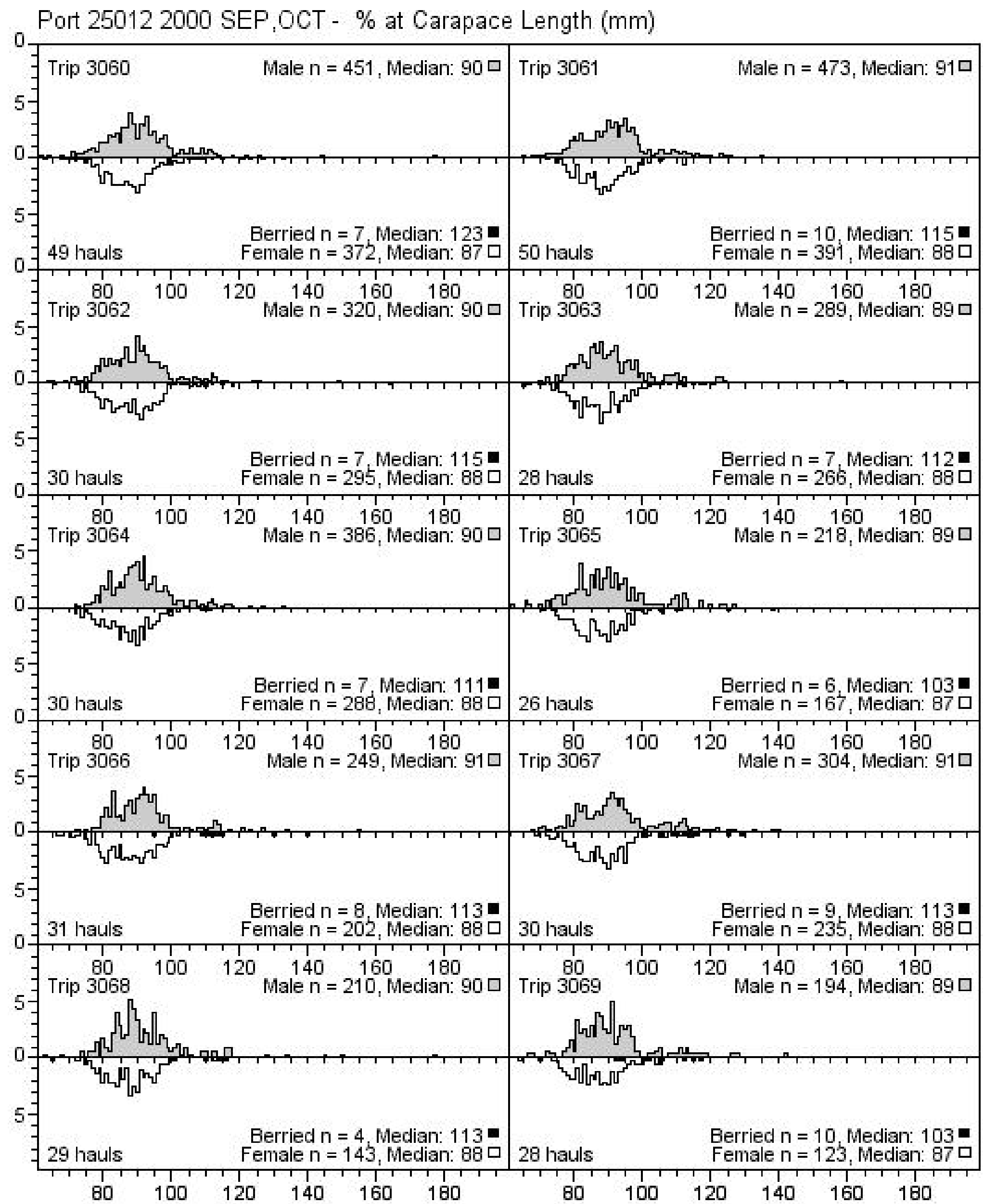
Appendix 2 (cont.)

(B) North Head



Appendix 2 (cont.)

(C.) White Head



Appendix 2 (cont.)

(D) Ingalls Head