Final Project Report
Northeast Consortium
April 2004

"Inshore/Offshore Patterns of Lobster (*Homarus americanus*) Larvae and Postlarvae in the Northern Gulf of Maine, with Implications for Spatial Relationships Between Egg Production and Settlement."

Lead PI: Lewis S. Incze
Senior Scientist
Bioscience Research Institute
University of Southern Maine
96 Falmouth St.
Portland, ME 04104-9300
Tel. 207-228-8070
e-mail: lincze@usm.maine.edu

Co-PIs: Proctor Wells, Phippsburg, ME
Matthew Thomson, Monhegan Island, ME

With: Nicholas Wolff, Bioscience research Inst., Univ. of Southern Maine, Portland, ME 04104-9300
and
Eric Annis, Inst. Marine and Coastal Sciences, Rutgers University, 71 Dudley Rd., New Brunswick, NJ 08901-8521

Field Work, 2001

In 2001 we collected hydrographic data and neustonic lobster postlarvae at 93 stations between Cape Small (69 ° 55 ′ W) and Lubec (69 ° 07 ′ W), Maine from July 30 to August 13 (Wolff, Wells, Incze; see Fig. 1 for locations refered to in this report). The neuston sampler was 2m wide x 0.5 m deep (submerged portion) and was equipped with a 1 mm mesh net (small enough to retain all larval stages of lobsters) and a General Oceanics mechanical flowmeter. All tows were timed with a stopwatch so that a regression of tow *vs*. time could be used to estimate flow when the flowmeter became fouled during a tow (e.g., by seaweed). Previous work had been done with a 1m wide net towed approximately 600-800 m. We knew from previous work that postlarvae were much less abundant in the EMCC, so we doubled the width of the net and increased the distance towed in order to increase the area sampled by a factor >3. Our average limit of detection per tow was ≤0.4 PL/1000 m^2 (e.g., 1 PL/2500 m^2). Stage I larvae are often caught in the neuston, although this represents a varying fraction of the water column population. Postlarvae

are more concentrated in the neuston layer, and this report focuses on that final planktonic stage.

Sampling stations were organized in across-shelf transects that extended from near the coast out past the 100 m isobath. In addition, a series of 17 stations was sampled weekly from Cape Small to Penobscot Bay from June 5 to October 2 (246 samples in all; Annis and Thomson). With a separate small grant from the UpEast Foundation (funded through the Island Institute, Rockland, ME), we also collected weekly samples at 18 stations in the western approaches to Penobscot Bay from early July to mid September (work done by Corrie Roberts and Mike Day). The five transects in outer Penobscot Bay were a continuation of work done there in 1999 and 2000 under a grant from NOAA/NESDIS to L. Incze.

In the area sampled throughout the season by E. Annis and by Roberts and Day (Cape Small to Penobscot Bay), the peak in postlarval abundance occurred in early August, which agrees with the average timing of this peak observed in earlier years in the waters off Boothbay Harbor (see Incze et. al. 2000a). A composite distribution for Year-Days 211-225 (= July 30-August 13), which includes the coast up to Lubec, is shown in Figure 2A. The greatest concentrations of postlarvae occurred in coastal waters west of Penobscot Bay, consistent with earlier but more limited observations contrasting the eastern and western waters. Figure 2B shows how these distributions are related to temperature patterns along the coast. These temperature patterns reflect major circulation features, specifically, the (cold) Eastern Maine Coastal Current and the seasonally stratified and warmer Western Maine Coastal Current (see "Significance of Results" for further discussion).

As part of the work along the Washington County coast (Fig. 1), we made several transects into the coastal bays. Postlarval abundances were low almost everywhere along this section of coast, but occasionally the abundances were a little higher inside of the coastal headlands where the residence time is probably greater (as evidenced by warmer surface temperatures) and the warmer temperatures lead to faster development.

Eric Annis caught a sufficient number of Stage I larvae in his seasonal work between Penobscot Bay and Cape Small that he was able to construct a seasonal hatching curve for this region. He found a peak of SI abundance around YD 200 (mid July). This timing has since been validated by data on ovigerous females. Coupled with the postlarval data, this indicates a <u>much</u> faster rate of *in situ* larval development than has been assumed based on published laboratory results. See further discussion in the section entitled "Significance".

Field Work, 2002

Our second NEC cruise (Nick Wolff and Lew Incze with Proctor Wells) focused on the transition from coastal current to nearshore and inshore waters from Cape Small to Machias Bay, 5-22 August. This complemented our 2001 cruise, which did only a small amount of exploratory sampling in the bays. This cruise also was shifted later by a week because we felt that lower temperatures would lead to slower development and possibly later hatching than in the western part of the state. In 2002 we sampled at 115 stations with CTD and a neuston net. Few postlarvae were found east of Penobscot Bay despite extensive sampling (Fig. 2). Interpretation of these results is given in the "Significance" section..

Field Work, 2003

Field work in 2003 was co-funded by NEC and OAR/Sea Grant and was not part of the original proposal. NEC paid for labor and supplies, while the latter purchased boat time (again with Proctor Wells). Due to limited funds remaining, we had less boat time than in 2002. We sampled a subset of stations sampled in the previous year, sampling 34 stations from Cape Small to Prospect Harbor. We also shifted this cruise later in the season, from September 3-7. This corresponds to the tail end of the postlarval season measured during many years at stations from Penobscot Bay to the west. As in 2002, we caught postlarvae at relatively few stations east of Penobscot Bay. Positive stations ranged from .33 to 2.02 PL/1000 m^2 east of Penobscot Bay, and from 0.47-1.44 from Cape Small to Isle au Haut.

Significance of Results

Our research has shown that the settled abundance of Young-of-Year lobsters is determined to a significant degree by the abundance and delivery of postlarvae to appropriate settlement habitats (Incze et al. 1997, 2000b). Settlement densities and the productivity of the lobster fishery in Maine are distinctly different east and west of Penobscot Bay (Steneck and Wilson 2000; R. Wahle et al., unpubl. Data, in prep.). We want to understand the mechanisms behind these differences, the connections between lobster populations in the northern and central coastal Gulf (that is, transboundary connections in the stock), and the factors that might cause patterns of recruitment to vary (that is, interannual and decadal patterns of change). The data collected with NEC support and other grants is documenting the postlarval supply patterns between the east and west, and those data are being used in a current synthesis effort that includes egg production, circulation modeling, settlement, growth and fisheries production (under a grant from NOAA's Coastal Ocean Program to L. Incze and ten Co-PIs, 2003-2004).

The goal is to understand the spatial and physical relationships between egg production and the patterns (spatial and temporal) of recruitment and production in the lobster population. The current synthesis effort is being carried out by U.S. and Canadian scientists (contact L. Incze for further. A paper on postlarval distributions is in prep by Eric Annis (who just completed his Ph.D. at the Uiversity of Maine), L. Incze and others.

Disposition of Data

Data from 2001 and 2002 are held in an NEC database and available to the public. This includes CTD and larval data. Postlarval data from 2003 are given here in Table 1 and will be submitted with CTD data to NEC's database.

Presentations and Publications

Data from this project have been presented at a number of industry for a, including the Fishermen's Forum (2002 and 2004) and invited presentations to the industry organized by the Island Institute and the Gulf of maine Research Institute (formerly Gulf of Maine Aquarium). NEC also was acknowledged in a poster and a talk presented at the International Conference on Lobster Biology and management in Hobart, Australia, February 2004. NEC was acknowledged for its support in a paper published last year in Fisheries Research ("Can scientific observations of early life stages be scaled up to the level of a fished population? A case study using *Homarus americanus*." Fish. Res. 65 (2003): 33-46). The data are being presented in a paper in prep. By E. Annis, L. Incze, R. Steneck, N. Wolff and C. Wilson that combines all data we have collected and/or analyzed for coastal Maine from 1989-2003 from all sources of funding (total n= 3687 tows; 488 (13%) come from NEC funded or co-funded work).

Future Use of Data

The data are being used in a large-scale, international modeling effort funded under NOAA's Coastal Ocean program in its program area called "Synthesis." The grant is led by L. Incze with 10 co-PIs.

Citations

Incze, L.S., Naimie, C.E., 2000. Modeling the transport of lobster (*Homarus americanus*) larvae and postlarvae in the Gulf of Maine. Fish. Oceanogr. 9, 99-113.

Incze, L.S., Wahle, R.A., Cobb, J.S., 1997. Quantitative relationships between postlarval production and benthic recruitment in lobsters, *Homarus americanus*. Mar. Freshwater Res. 48, 729-743.

Incze, L. S., Aas, P., Ainaire, T., and Bowen, M. 2000a. Neustonic postlarval lobsters, *Homarus americanus*, in the western gulf of maine: spatial and interannual variations. Can. J. Fish. Aquat. Sci. **57**: 755-765.

Incze, L.S., Wahle, R.A., Palma, A., 2000b. Advection and settlement rates in a benthic invertebrate: recruitment to first benthic stage in *Homarus americanus*. ICES J. Mar. Sci. 57, 430-437.

Incze. L.S., N. Wolff and R.A. Wahle. In press. Can scientific observations be scaled up to the level of a fished population? A case study using *Homarus americanus*. J. Fish. Res.

Steneck, R.S. and C.J. Wilson. 2001. Large-scale and long-term spatial and temporal patterns in demography and landings of the American lobster, *Homarus americanus*, in Maine. Mar. Freshwater Res. 52: 1301-1319.

Fig. 1. Coast of Maine with counties and place names refered to in the text.

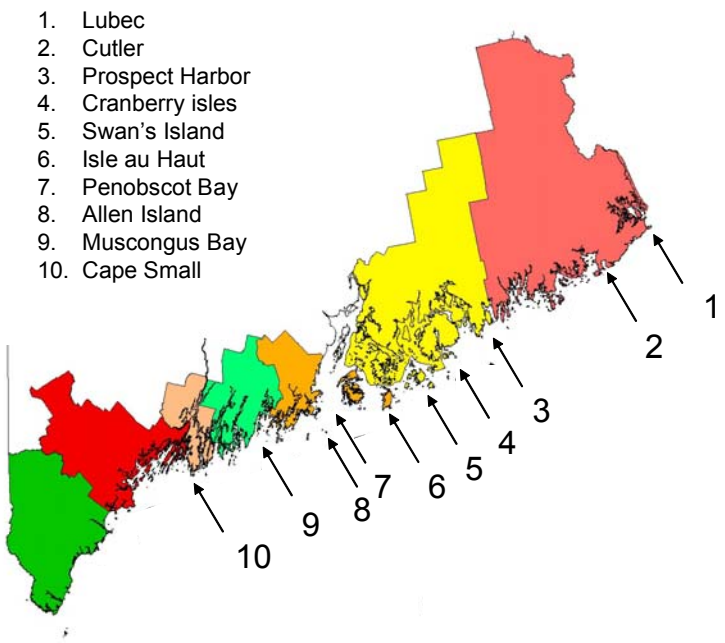
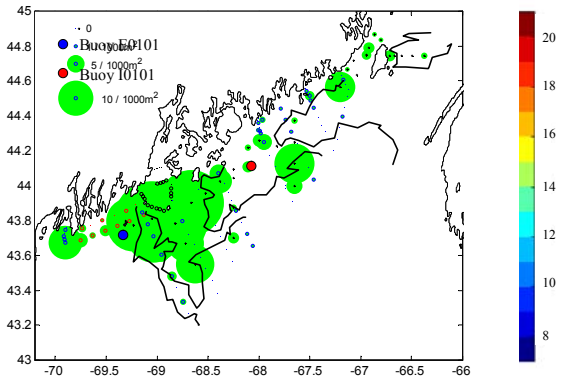


Figure 2.

A. AVHRR August 1, 2001



B. PL Density July 31 – August 13, 2001
with select temperature (°C) contours

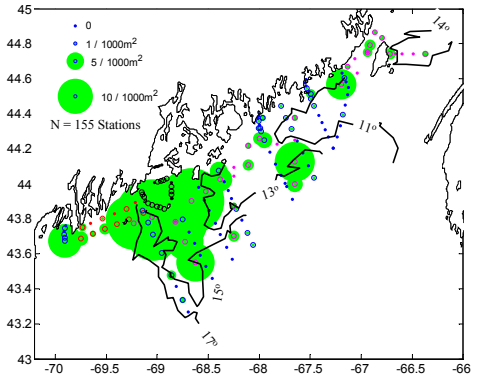


Table 1. Lobster larvae data from joint NEC-Sea Grant cruise, September 2003.

Month	Day	YD	Sta.	Lat_(dec. degrees)	Lon_(dec. degrees)	Tow	Stage	Number	Area Swept (10^3m^2)	PL/1000 m^2	General Location
9	3	246	1	44.4001	-68.0058	1	4	0	2685	0	Prospect Harbor
9	3	246	2	44.3814	-67.9992	2	4	0	2685	0	Prospect Harbor
9	3	246	3	44.3605	-68.0043	3	4	1	3056	0.33	Prospect Harbor
9	3	246	4	44.3363	-67.9992	4	4	1	2685	0.37	Prospect Harbor
9	3	246	5	44.2745	-68.209	5	4	0	2593	0	Cranberry Islands
9	3	246	6	44.2651	-68.2597	6	4	0	2685	0	Cranberry Islands
9	3	246	7	44.2273	-68.2712	7	4	0	3334	0	Cranberry Islands
9	3	246	8	44.2265	-68.2411	8	4	0	3222	0	Cranberry Islands
9	3	246	9	44.2272	-68.2071	9	4	0	2685	0	Cranberry Islands
9	3	246	10	44.2175	-68.3454	10	4	0	3043	0	Cranberry Islands
9	5	248	11	44.138	-68.5022	1	4	0	2642	0	Swan’s Island
9	5	248	12	44.1283	-68.4735	2	4	0	2747	0	Swan’s Island
9	5	248	13	44.1095	-68.4488	3	4	0	2922	0	Swan’s Island
9	5	248	14	44.1266	-68.4048	4	4	0	2732	0	Swan’s Island
9	5	248	15	44.1216	-68.377	5	4	0	2652	0	Long Island
9	5	248	16	44.0971	-68.3603	6	4	6	2974	2.02	Long Island
9	5	248	17	44.1395	-68.3408	7	4	0	2649	0	Long Island
9	5	248	18	44.1639	-68.3252	8	4	0	4095	0	Black Island
9	5	248	19	44.188	-68.343	9	4	0	2844	0	Black Island
9	5	248	20	44.1922	-68.4323	10	4	0	2509	0	Swan’s Island
9	6	249	21	44.1194	-68.5867	1	4	0	2718	0	Merchant Row
9	6	249	22	44.1152	-68.6227	2	4	0	2243	0	Merchant Row
9	6	249	23	44.1197	-68.6642	3	4	0	2962	0	Merchant Row
9	6	249	24	44.0994	-68.6562	4	4	0	2836	0	Merchant Row
9	6	249	25	44.0666	-68.6515	5	4	1	474	2.11	Isle au Haut
9	6	249	26	44.0418	-68.6544	6	4	0	2439	0	Isle au Haut
9	6	249	27	44.0031	-68.6402	7	4	2	2711	0.74	Isle au Haut
9	6	249	28	43.8365	-69.3193	8	4	1	2656	0.38	Muscongus Bay
9	6	249	29	43.8302	-69.3906	9	4	1	3345	0.3	Muscongus Bay
9	6	249	30	43.8234	-68.4669	10	4	2	2726	0.73	Muscongus Bay
9	7	250	31	43.6796	-69.8988	1	4	2	2488	0.8	Small Point
9	7	250	32	43.7259	-69.8744	2	4	10	3445	2.9	Small Point
9	7	250	33	43.7594	-69.8754	3	4	5	2901	1.72	Small Point
9	7	250	34	43.7917	-69.879	4	4	1	2901	0.34	Small Point