Lobsters and the Maine Coastal Current

Tidal mixing and multiple river plumes

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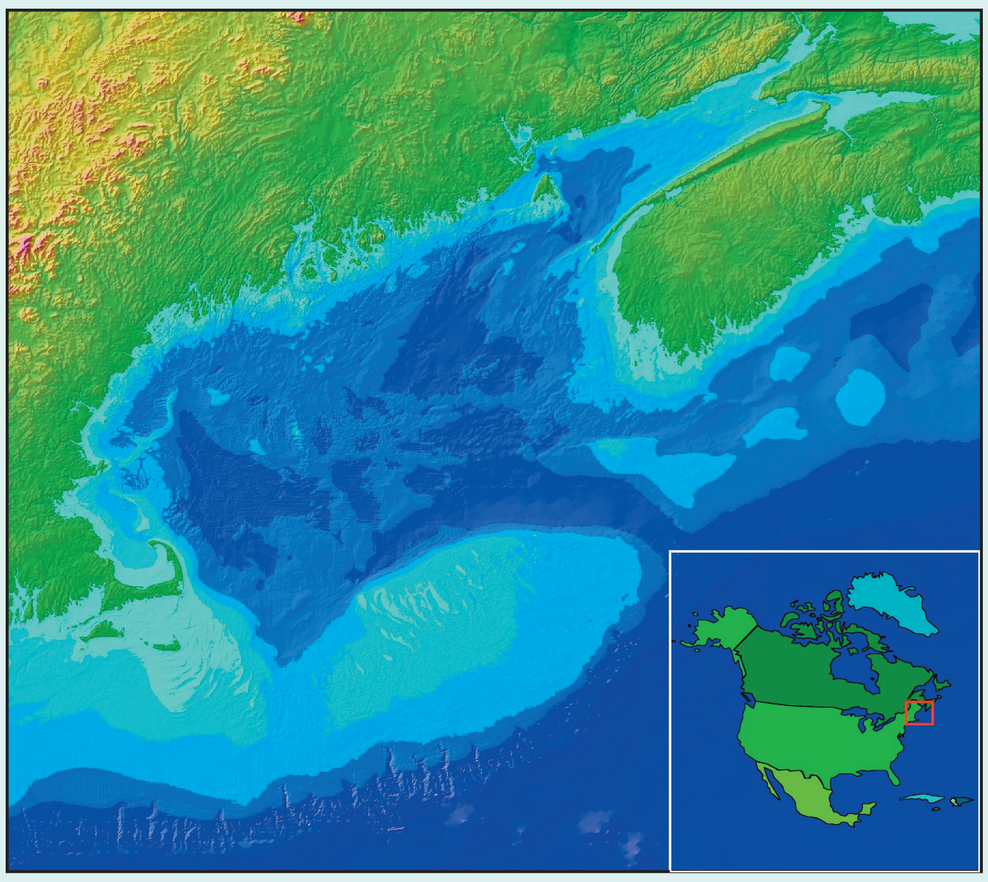
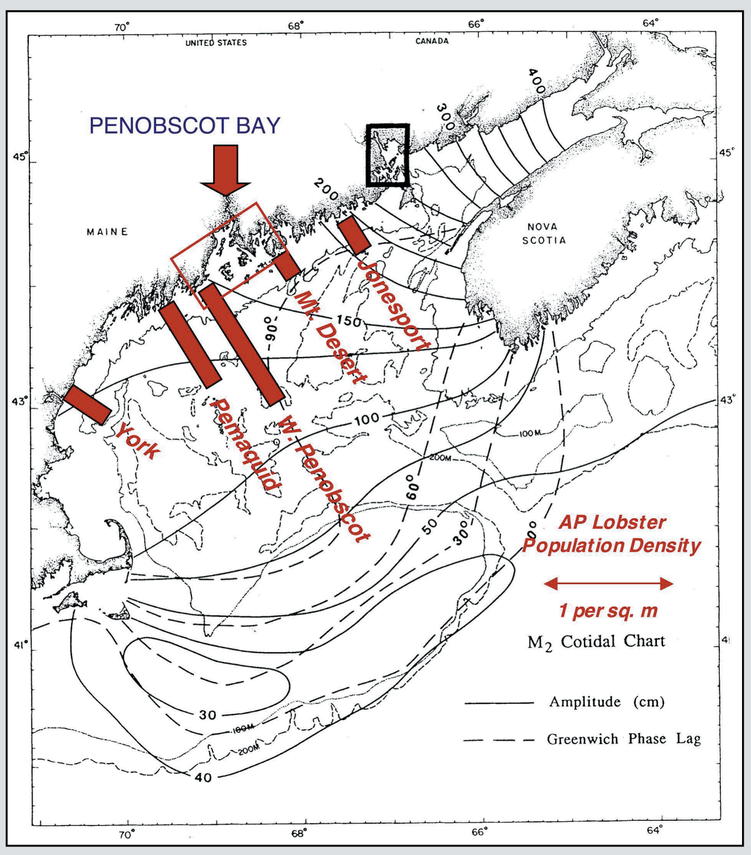


Northeast Fisheries Science Center

Photo: NOAA

Photo: Jessica Stevens; Lobsterman: Brian McClain, F/V *Silver Bullet*



Lobster Population Density (per sq. m) 1989-1999

Adolescent Phase (AP) (40-89 mm carapace)

DATA: Steneck and Wilson (2001)

Homarus Americanus

<= Gulf of Maine/Bay of Fundy region, co-tidal map

° Population density of adolescent lobsters is consistently larger by a factor of four or more in central coastal region

° Lobsters represent the most important and rapidly-growing fishery in the Gulf of Maine

° Sustainable management of the fishery requires understanding of the physical-biological factors controlling the resource distribution

° These factors include tidal and non-tidal currents, seasonal water mass influences, winds, and run-off from principal rivers, in addition to fishing pressure, disease, licensing, marketing and regulations

Non-tidal surface circulation in spring/summer =>

° The Eastern Maine Coastal Current (EMCC) is associated with outflow from the Saint John River

° Other rivers, particularly the Penobscot (P), interrupt or deflect the coastal current, which becomes weaker and more variable west of Penobscot Bay.

° Lobster larvae, which drift with the surface currents in their early life stages, are prominently hatched near the mouth of the Bay of Fundy

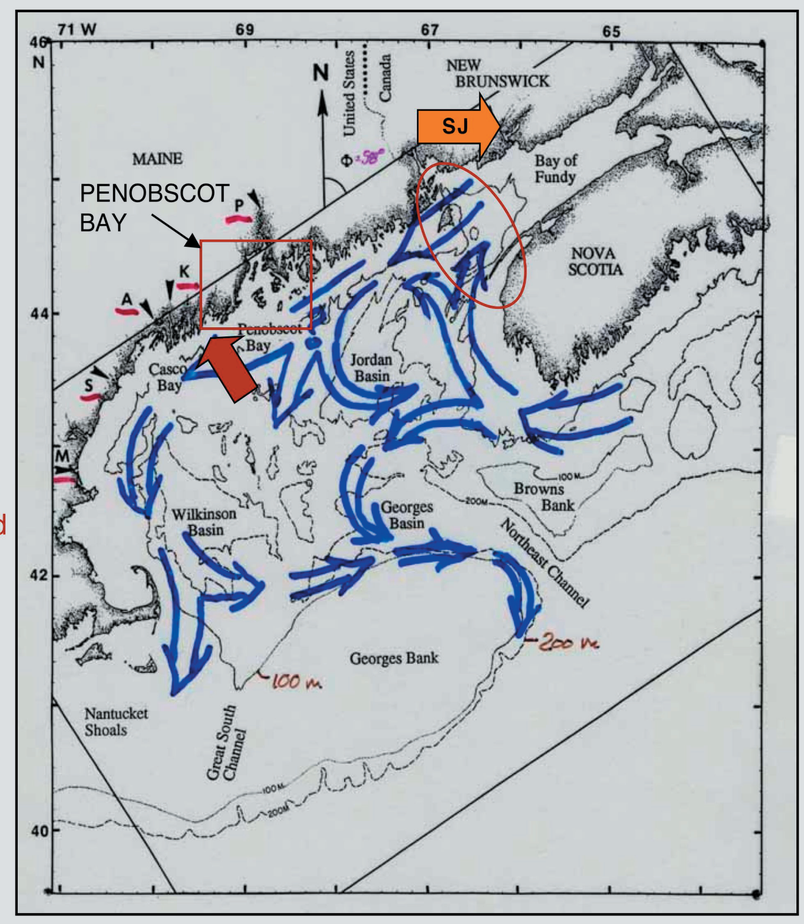
° The coastal current transports larvae to the mid-coast region in 20-30 days, about the time required to reach settlement stage in their development

Gulf of Maine Surface Currents (spring-summer)

Saint John River

Transverse transport
Mean non-tidal speed
V=5 cm/s

Significant hatching region
(Steneck and Wilson, 2001)



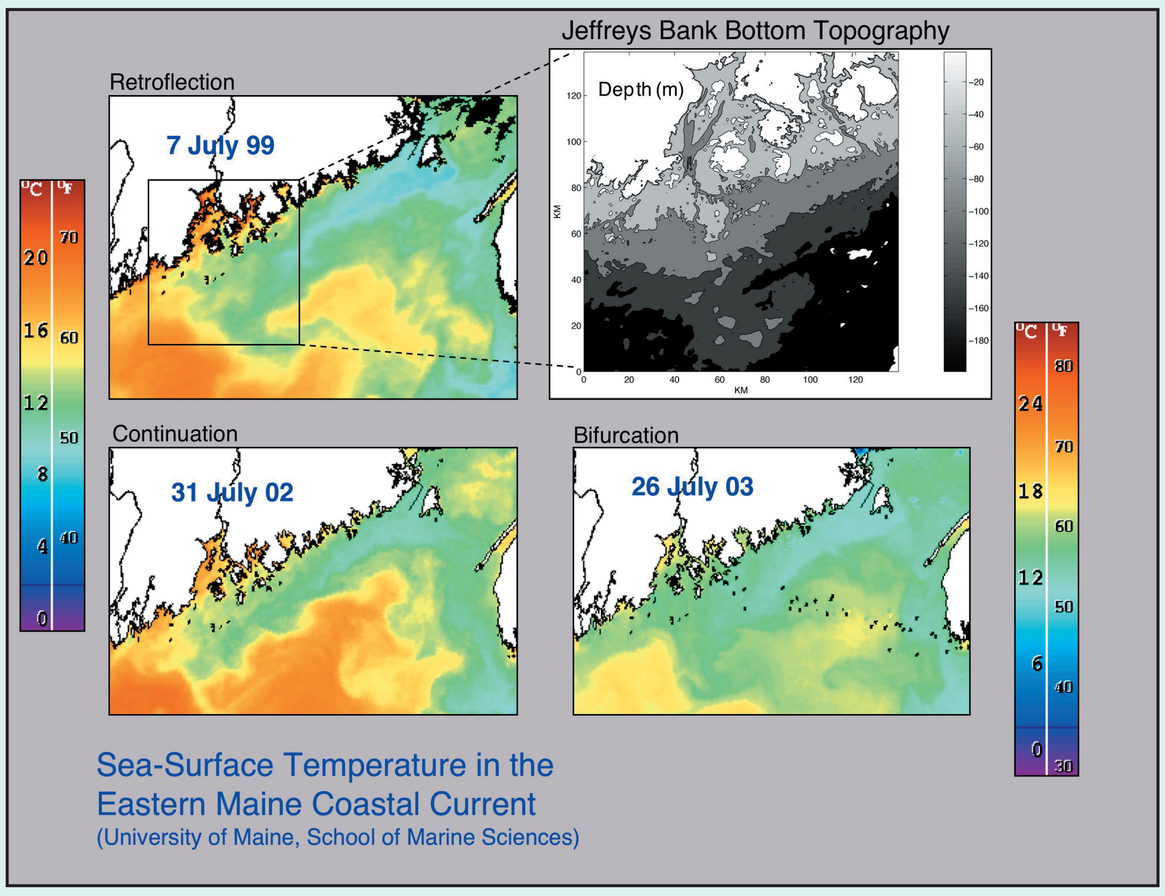
<= Sea-surface temperature in the coastal current

° Cold surface temperatures show the effects of strong tidal mixing in the eastern Gulf

° The EMCC interacts with the thermohaline plume from the Penobscot River, leading to different degrees of deflection and re-formation of the current west of Penobscot Bay

° The EMCC may also be influenced by a shoaling ridge south of Penobscot Bay, leading to a clockwise eddy and shoreward flow west of the bay.

° The deflection and degree of connectedness of the eastern and western coastal currents depends on seasonal hydrographic structure in the Gulf, as well as run-off timing and distribution and the winds



Sea-Surface Temperature in the Eastern Maine Coastal Current
(University of Maine, School of Marine Sciences)

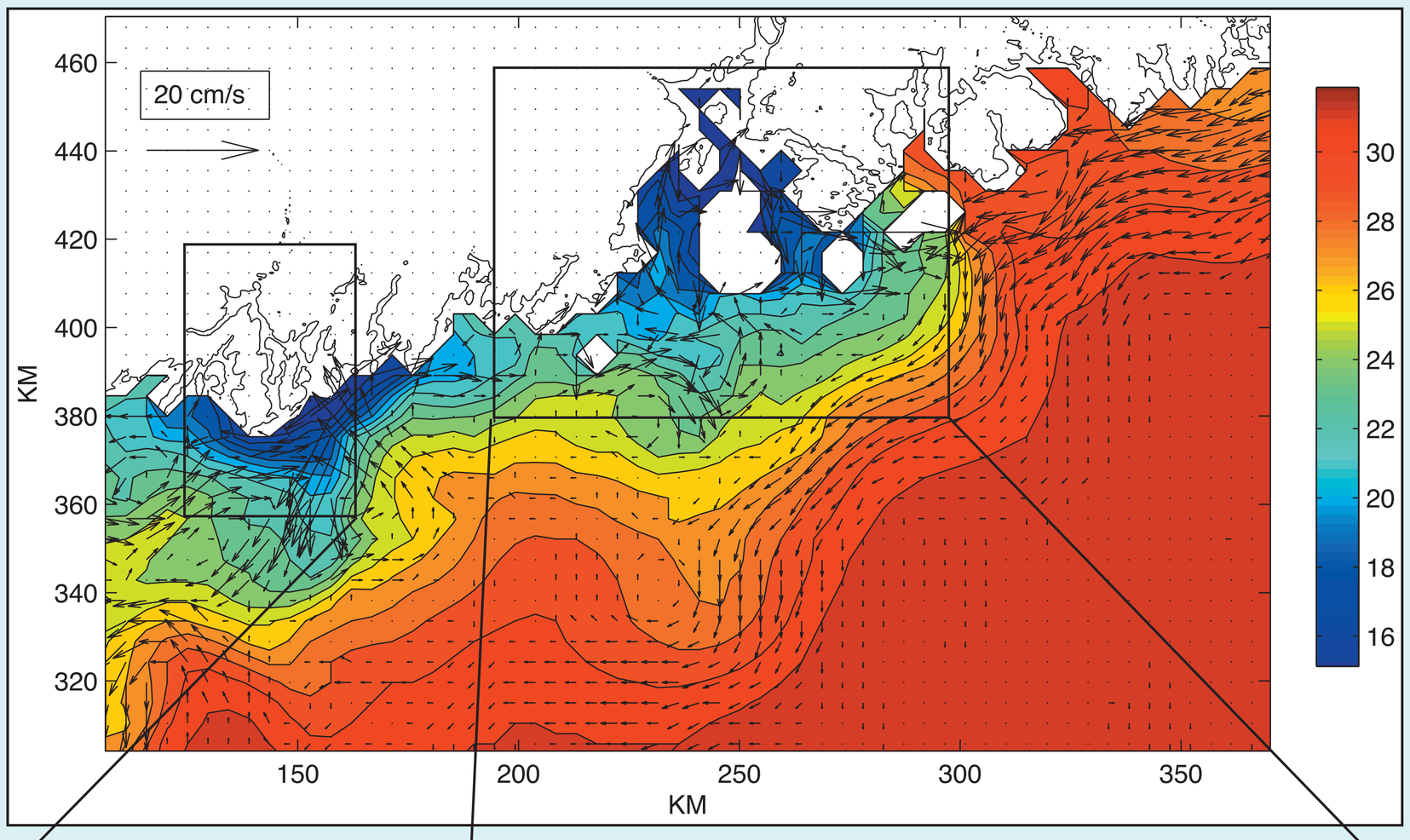
Model surface current and salinity =>

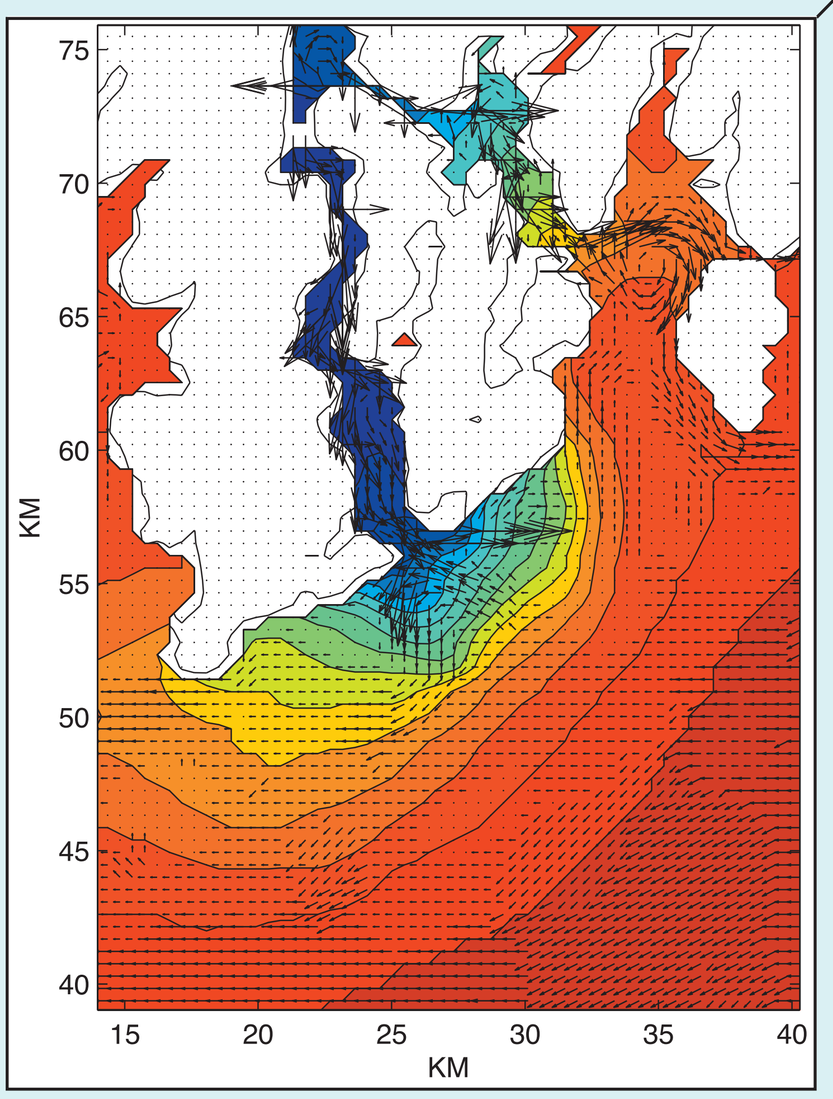
° EMCC is deflected offshore around the thermohaline front defining the Penobscot River plume

° Interacting plumes produce convergence and shoreward flow between the Penobscot and Kennebec-Androscoggin Rivers

° Upstream interaction with the Penobscot plume depends on the timing and volume of flux relative to that of the Saint John River

° 3-D sigma-coordinate baroclinic circulation model with 10 levels and 4.6 km resolution





10X Detail Penobscot Bay =>

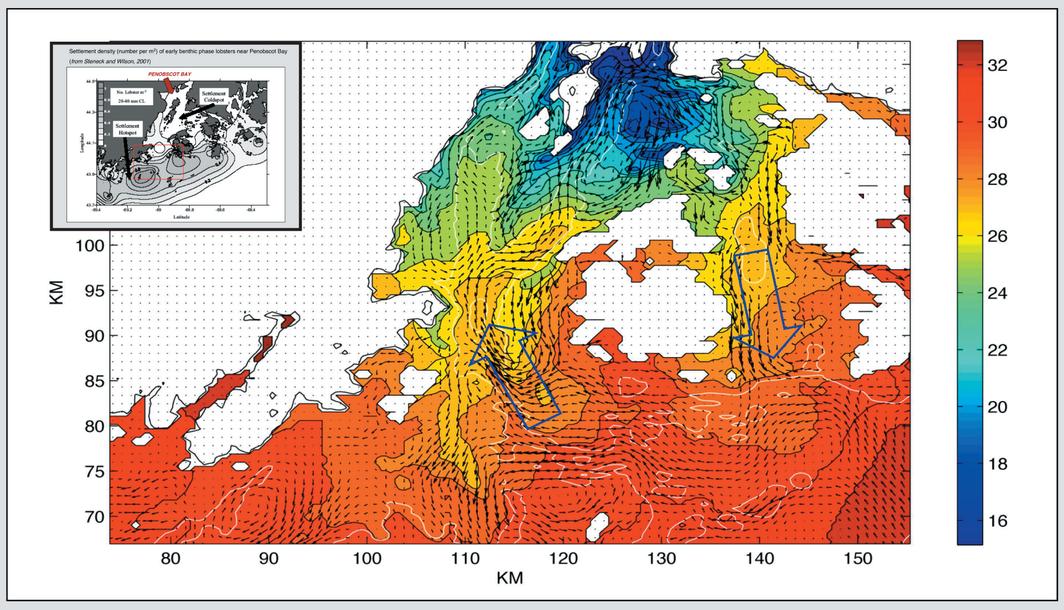
° Surface convergence on west side, consistent with larval settling patterns

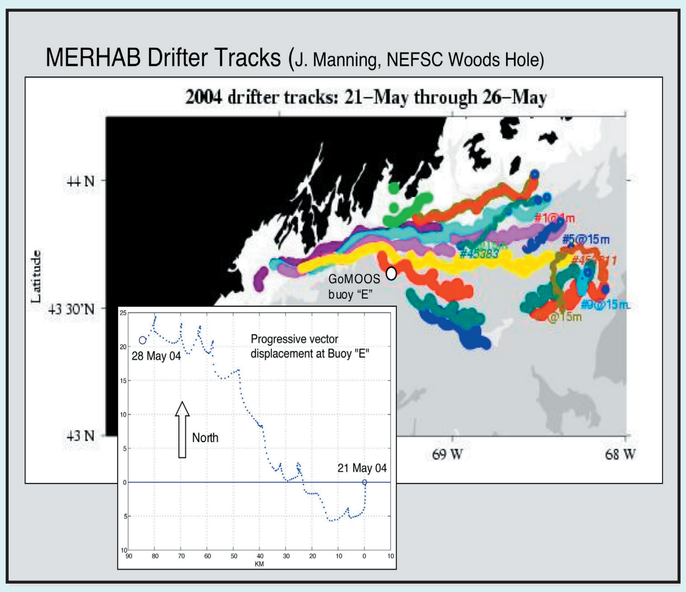
<= Kennebec/Androscoggin

° K-A plume interrupts coastal current

Tidal-residual model surface currents at the entrance to Penobscot Bay, t=25 days

(velocity vectors decimated 2x)





<= Drogued surface drifter tracks

° Show the shoreward near-surface convergence west of Penobscot Bay

° Consistent with simultaneous current measurements at GoMOOS (Gulf of Maine Ocean Observing System) mooring

Conclusions: A Working Management Hypothesis

° Maine Coastal Current (MCC) 'pipeline' for lobster larvae hatched near Grand Manan Island influenced by the Saint John River outflow

° 25-35 days required for neutral particles (e.g. pre-settlement larvae) to travel from spawning region to mid-coast

° Diffusive transfer time of ~30 days for nearshore larval densities to reach ~30% of MCC values 20 km offshore ($t \sim x^2/K_h$)

° Back-eddy associated with MCC passage over Jeffreys Ledge may increase shoreward larval flux west of Penobscot Bay

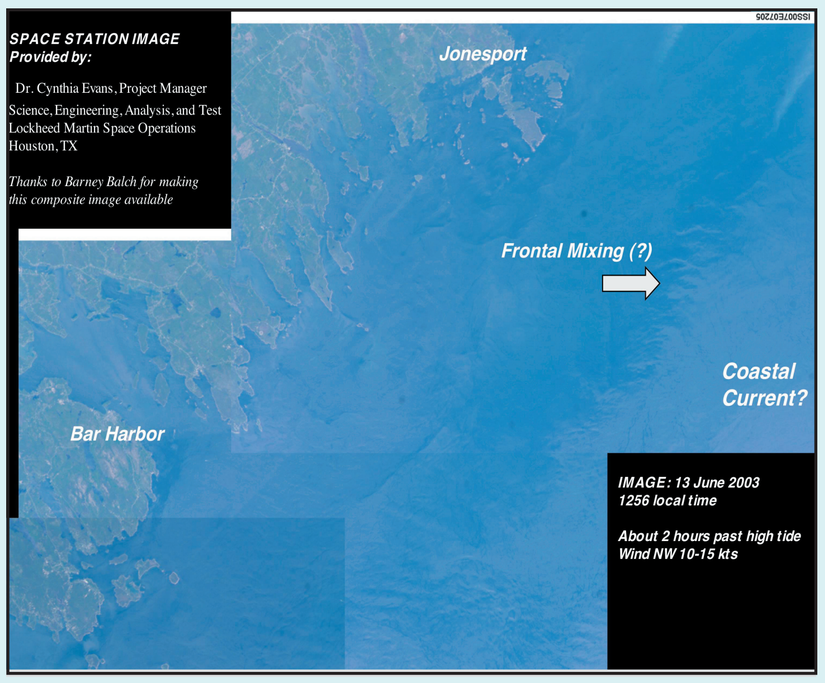
° Tidal-residual flow favors inshore movement of larvae on west side of Penobscot Bay

° Recruitment success west of Penobscot Bay probably is affected by the seasonal development of the MCC deflection and convergence in the Penobscot and Kennebec-Androscoggin River plumes

Space Station photo of the EMCC =>

° Filamentous frontal boundary suggests interleaving between nearshore and coastal current waters

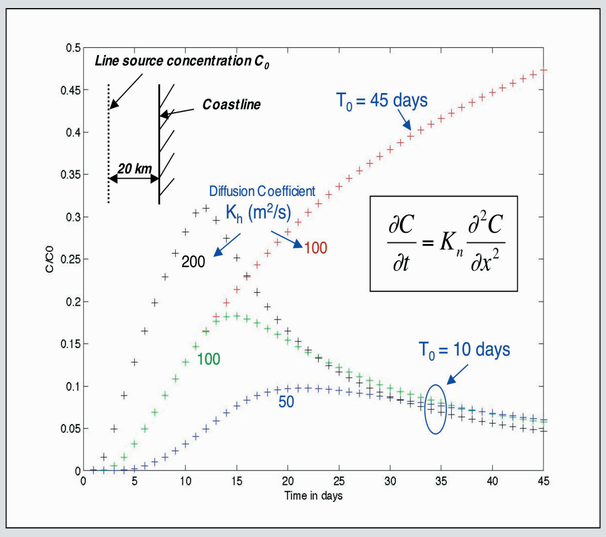
° Lateral mixing by the tides an important source of shoreward larval transport



Acknowledgements
NOAA Coastal Ocean Program

Participants
Annette deCharon, Dave Greenberg, Lew Incze, Peter Lawton, Fred Page, Neal Pettigrew, Bob Steneck, Dave Townsend, Carl Wilson, Huijie Xue, Steve Cousins, Tracey Wysor, Nick Wolff, Eric Annis, Dave Brooks

Relative larval concentration C 20 km distant from a line source C_0 active for T_0 days



<= 1-D analytical mixing model

° Offshore line source in "EMCC" axis turned on for 10 or more days

° Parameter is lateral diffusion coefficient

° Coastal concentration reaches about 30% in 10-15 days -- about half the time required for larvae to be advected from the Bay of Fundy to the central coast region