Flood Tide Transport of Blue Crab Postlarvae: Limitations in a Lagoonal Estuary

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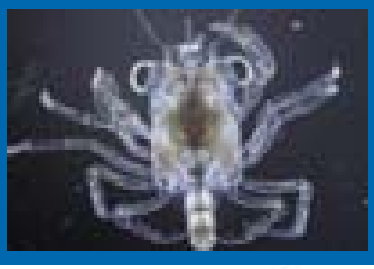


Blue Crab

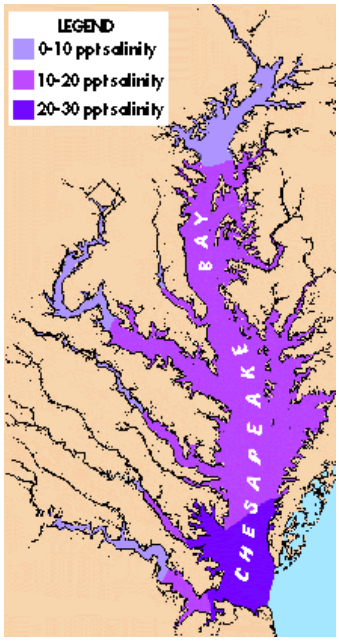
- spawns in the ocean
- matures in the estuary
- how does it get there?

Flood Tide Transport

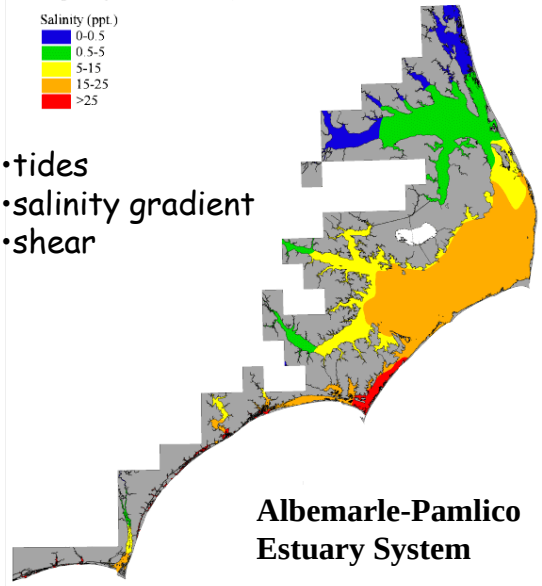
- up on flood, salinity cue
- down on ebb, turbulence
- net motion up-estuary

http://www.esva.net/~tomthumbworkshps/emailtrav.htm
http://www.naturalvisions.co.uk/pictures/

Chesapeake Bay



North Carolina Estuaries:
Biologically-Based Salinity Zones



- tides
- salinity gradient
- shear

Albemarle-Pamlico Estuary System

Prepared for South Atlantic Fishery Management Council
NOAA SEA Division
January 1998

Prior Studies: Tankersley and Forward

vertical migration cues in lab

- negative phototaxis
- salinity cue = negative halotaxis
- pressure increase >> tidal

settlement studies, Beaufort

- settle at end of flood => swim during flood
- more settle on neap ⇔ timing of night flood
- predicted constant neap/phase relationship

Prior Study: Reyns, Eggleston Luettich

spatial distributions, field/model

- large area
- day/night, not flood/ebb
- surface at night => negative phototaxis
- in western part of Sound => might need FTT

New Questions about Pamlico Sound

Physics

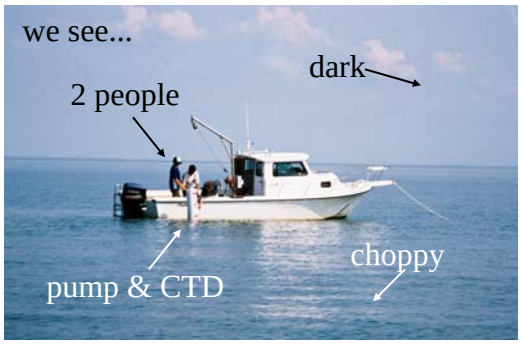
- currents driven by tide or wind?
- vertical shear?
- salinity increase on early flood?

Blue crab behavior

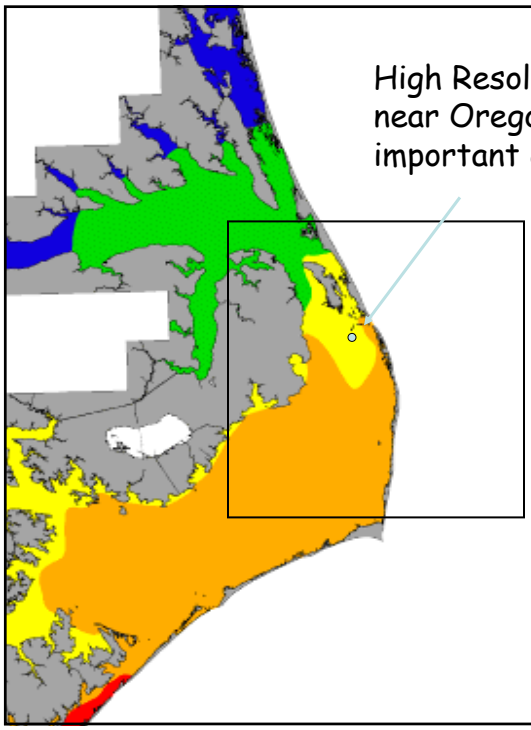
- swim on flood, not ebb?
- what depth?
- respond to salinity and light?

Transport Implications?

ADCP
- bottom mounted
- upward looking
- currents all depths
- 3 month timeseries
- CTD attached



Dave and Gayle
- 7 nights in September
- hourly crab counts, 4 depths
- 1/2 hourly CTD profiles

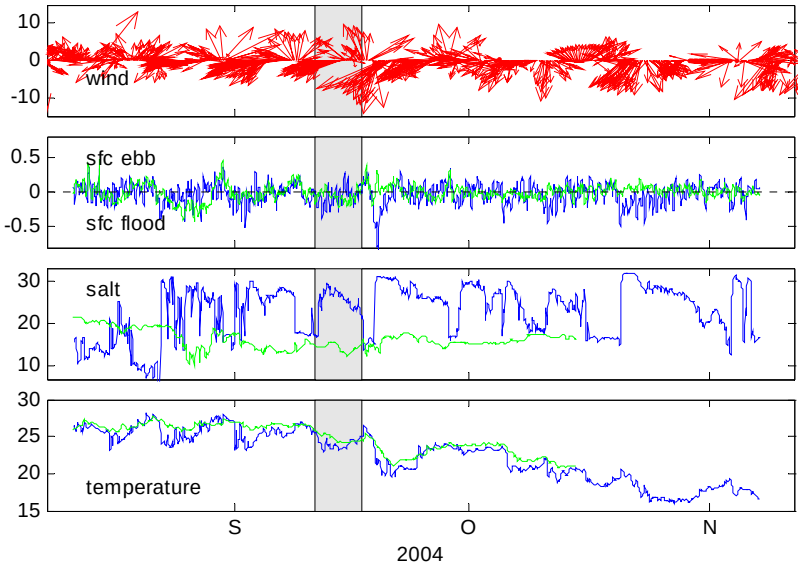


High Resolution Sampling
near Oregon Inlet
important crab source

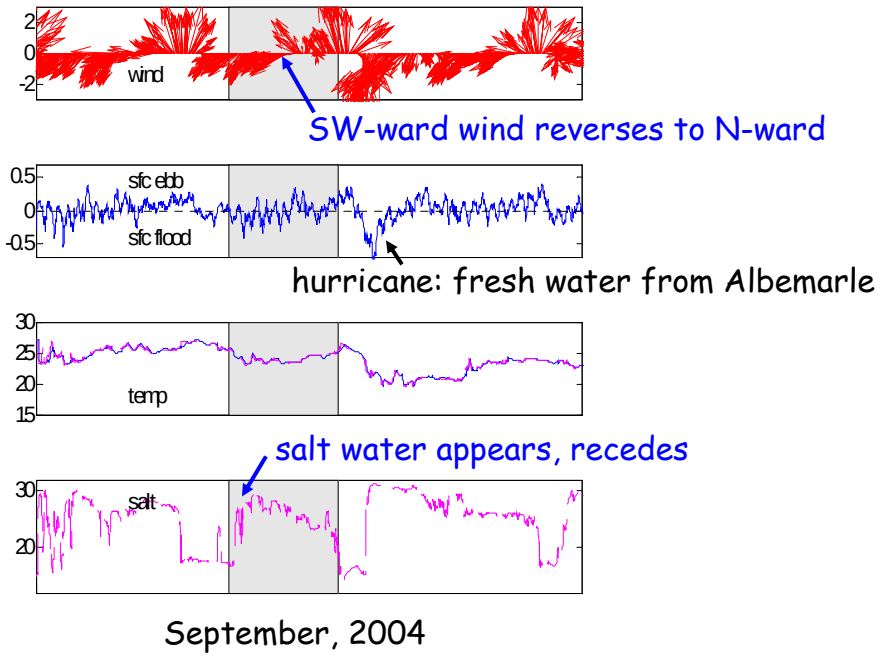
Ocean >28 psu
Pamlico 15 – 25 psu
Albemarle < 5 psu

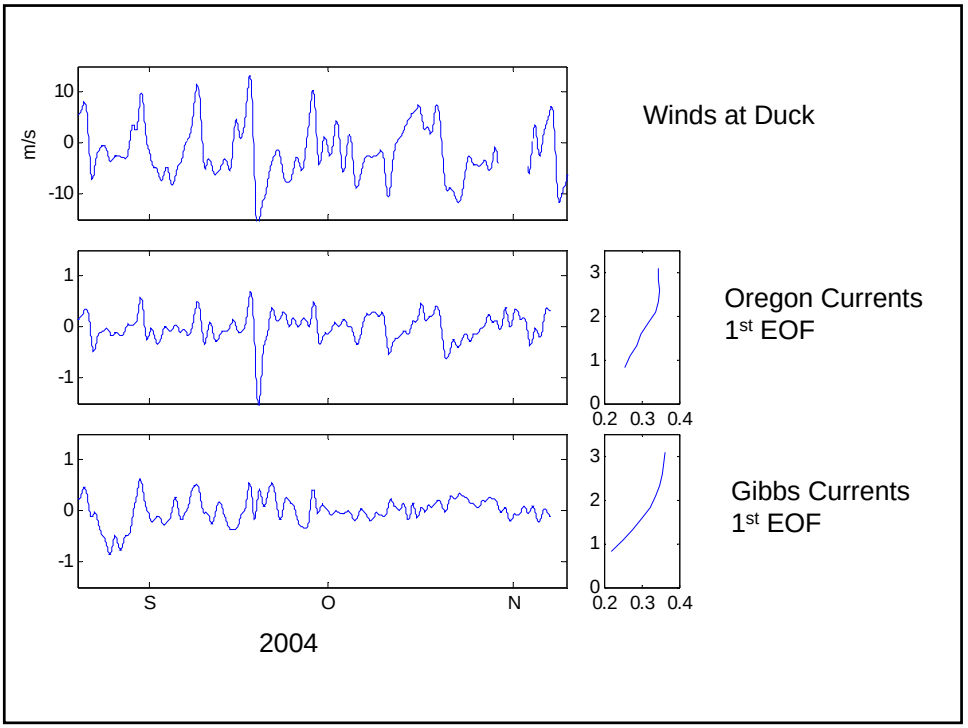
Wind from NE: salt
Wind from NW: fresh
Wind from S: brackish

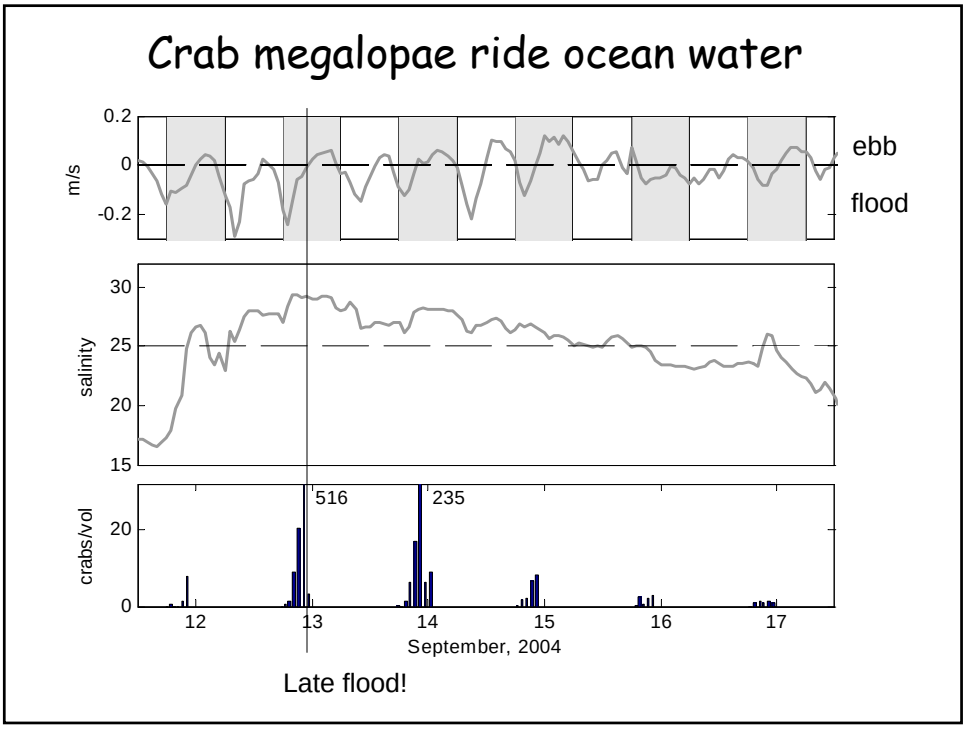
Currents ⇔ winds and tides, Salinity ⇔ mostly wind, less tide



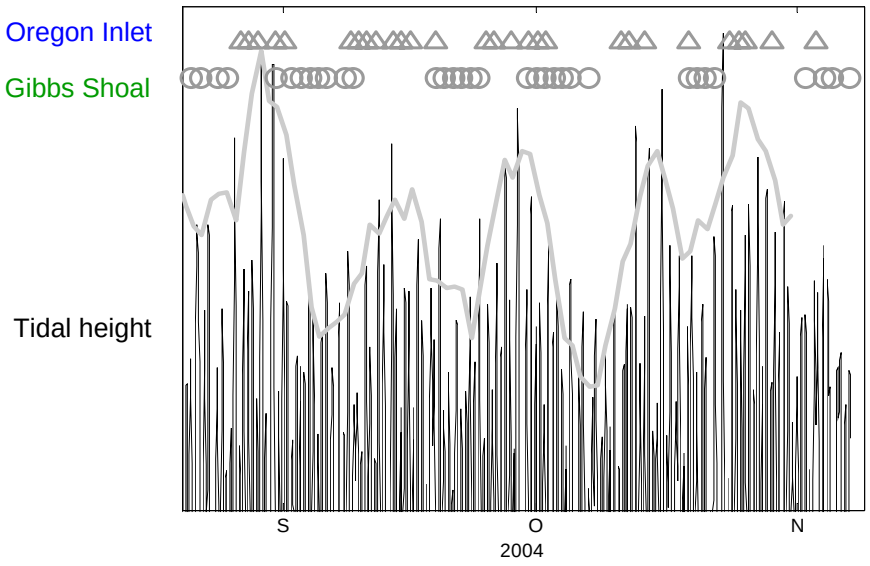
Blue = Oregon Inlet, Green = Gibbs Shoal




m/s
10
0
-10
Winds at Duck
1
0
-1
3
2
1
0
0.2 0.3 0.4
Oregon Currents
1st EOF
Gibbs Currents
1st EOF
S
O
N
2004


Crab megalopae ride ocean water
m/s
0.2
0
-0.2
ebb
flood
salinity
30
25
20
15
crabs/vol
516
235
20
0
12
13
14
15
16
17
September, 2004
Late flood!

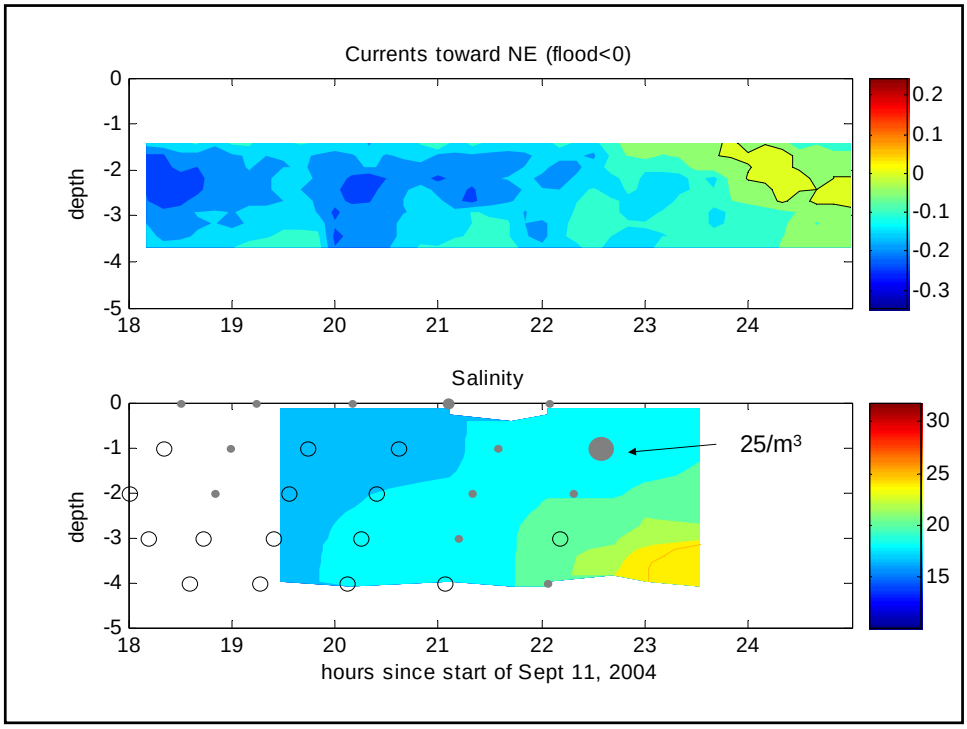
Does flood end after midnight on spring or neap? Depends on location!

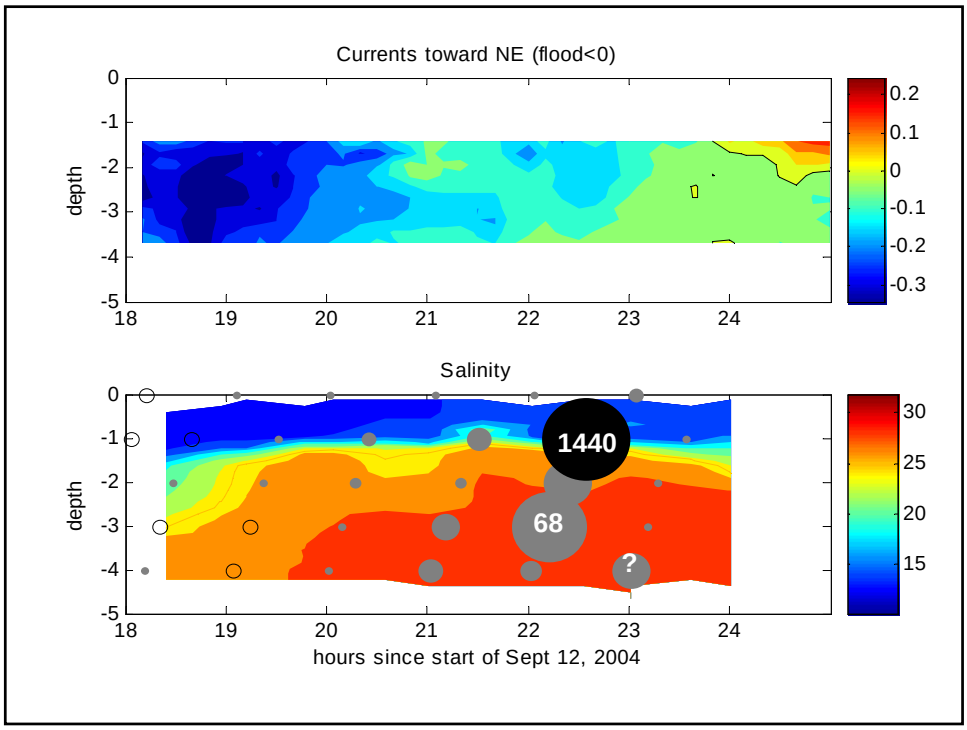


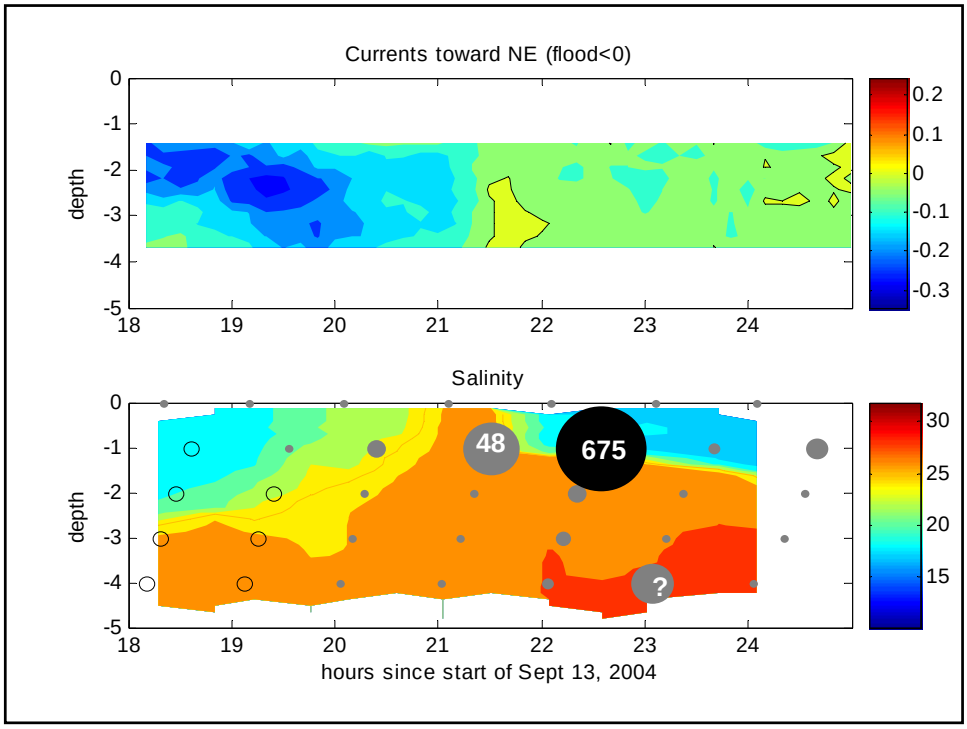
Answers about Pamlico Sound

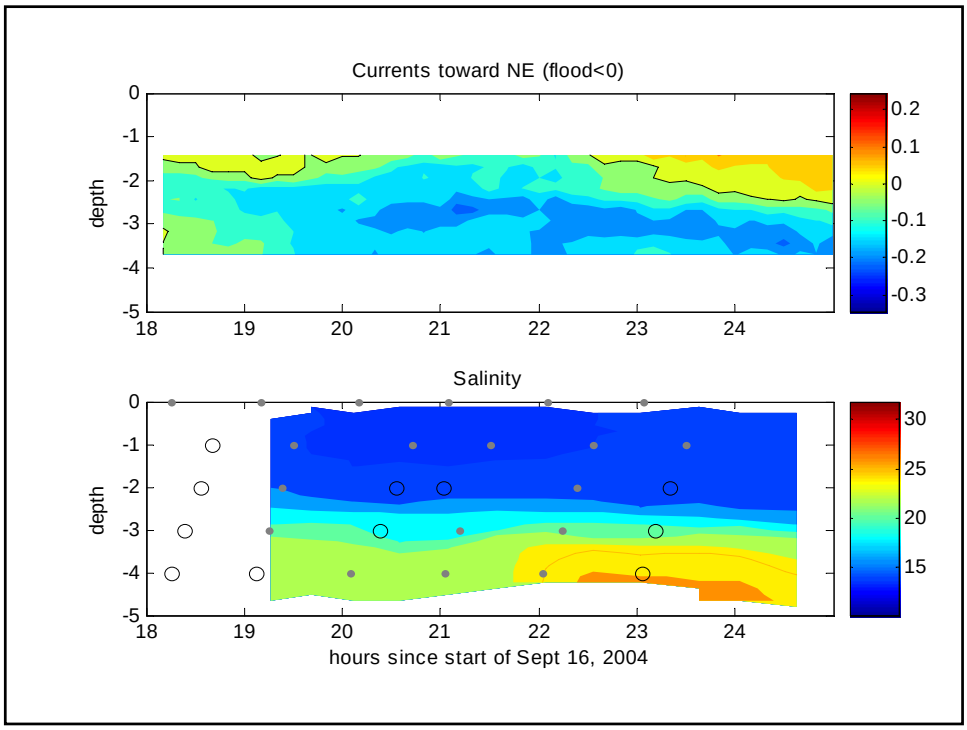
Physics

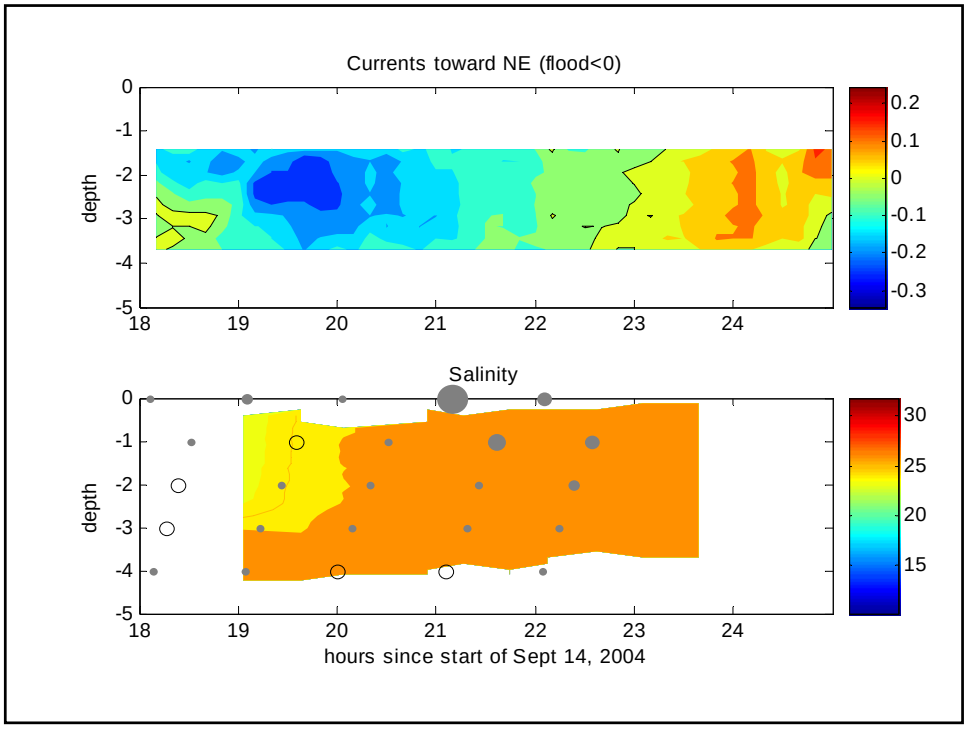
- currents driven by tide and wind
- vertical shear ⇔ friction (surface fast)
- salinity strongly wind driven, weakly tidal
- high salinity & crabs on late flood
- night flood timing: on neap only near inlet

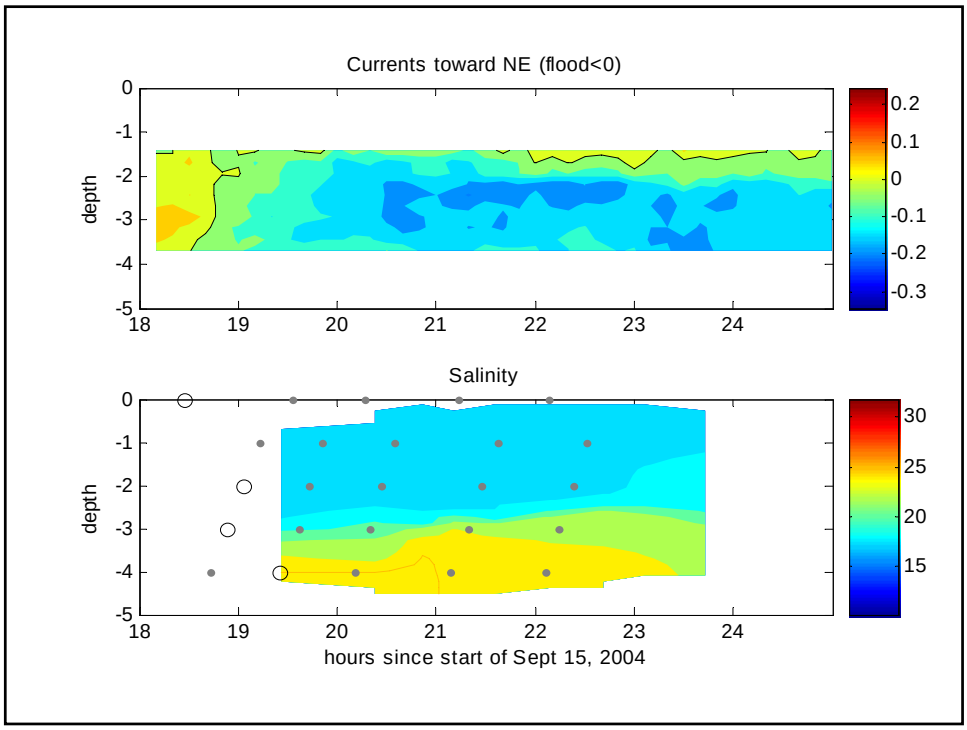

Currents toward NE (flood<0)
depth
0
-1
-2
-3
-4
-5
18
19
20
21
22
23
24
0.2
0.1
0
-0.1
-0.2
-0.3
Salinity
25/m3
30
25
20
15
hours since start of Sept 11, 2004

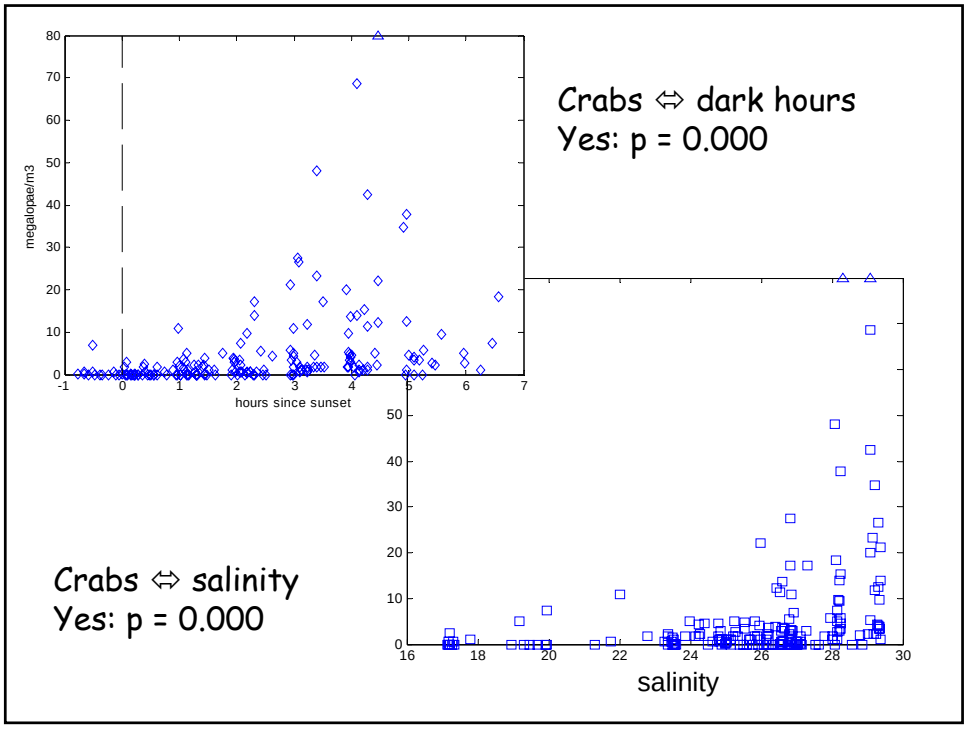

Currents toward NE (flood<0)
depth
0
-1
-2
-3
-4
-5
18
19
20
21
22
23
24
0.2
0.1
0
-0.1
-0.2
-0.3
Salinity
1440
68
?
30
25
20
15
hours since start of Sept 12, 2004

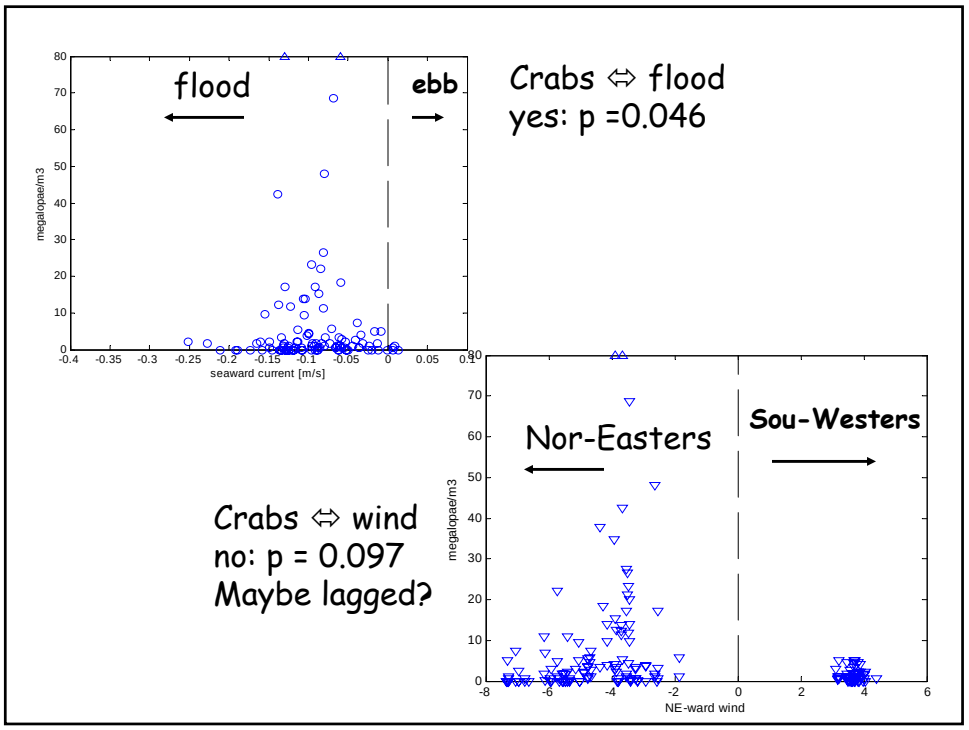

Currents toward NE (flood<0)
depth
0
-1
-2
-3
-4
-5
18
19
20
21
22
23
24
0.2
0.1
0
-0.1
-0.2
-0.3
Salinity
48
675
?
30
25
20
15
hours since start of Sept 13, 2004


Currents toward NE (flood<0)
depth
0
-1
-2
-3
-4
-5
18
19
20
21
22
23
24
0.2
0.1
0
-0.1
-0.2
-0.3
Salinity
30
25
20
15
hours since start of Sept 16, 2004


Currents toward NE (flood<0)
depth
0
-1
-2
-3
-4
-5
18
19
20
21
22
23
24
0.2
0.1
0
-0.1
-0.2
-0.3
Salinity
depth
0
-1
-2
-3
-4
-5
18
19
20
21
22
23
24
30
25
20
15
hours since start of Sept 14, 2004


Currents toward NE (flood<0)
depth
0
-1
-2
-3
-4
-5
18
19
20
21
22
23
24
0.2
0.1
0
-0.1
-0.2
-0.3
Salinity
depth
0
-1
-2
-3
-4
-5
18
19
20
21
22
23
24
30
25
20
15
hours since start of Sept 15, 2004


Crabs ⇔ dark hours
Yes: p = 0.000
megalopae/m3
hours since sunset
Crabs ⇔ salinity
Yes: p = 0.000
salinity


flood
ebb
Crabs ⇔ flood
yes: p =0.046
megalopae/m3
seaward current [m/s]
Nor-Easters
Sou-Westers
Crabs ⇔ wind
no: p = 0.097
Maybe lagged?
NE-ward wind

Transport Velocity

< U * c > / <c> = 0.13 m/s landward

<U> = 0.1 m/s landward

Swim to surface => transport advantage

Biology Answers

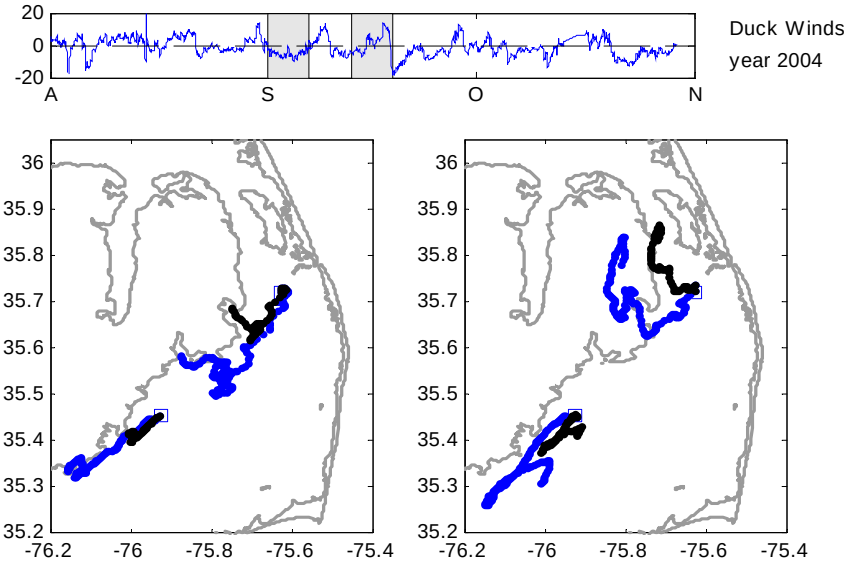
- NE-erly winds: S> 25, crabs from ocean
- most crabs near surface, late flood

- Correlations: crabs/dark & crabs/salt
- crabs/flood – yes?
- crabs/wind – no, but maybe with lag

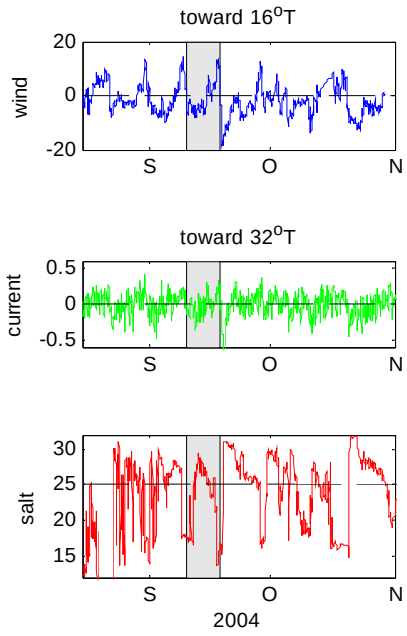
- transport velocity 30% faster than mean

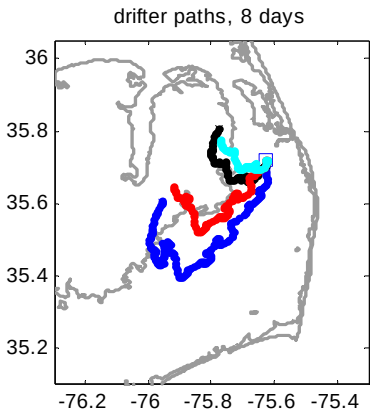
Transport Model

- Use observed currents
- Integrate forward in time
- Passive = always at surface
- Negative phototaxis = surface 1800-0600
- Negative halotaxis = S>25 + 6 hours

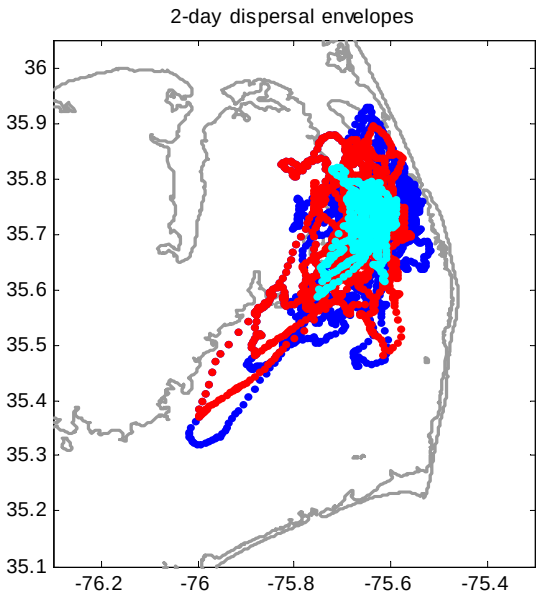


Negative phototaxis => end up NE of passive





Negative halotaxis reduces transport



Any behavior: 2 days to cross northern Pamlico Sound

Transport Conclusions

- Vertical swimming reduces transport distance in Pamlico Sound
- All larvae can cross P.S. in two days
- if it ain't broke, don't fix it