Variability of the North Equatorial Current (NEC) and its Implications on Japanese Eel Larval Transport

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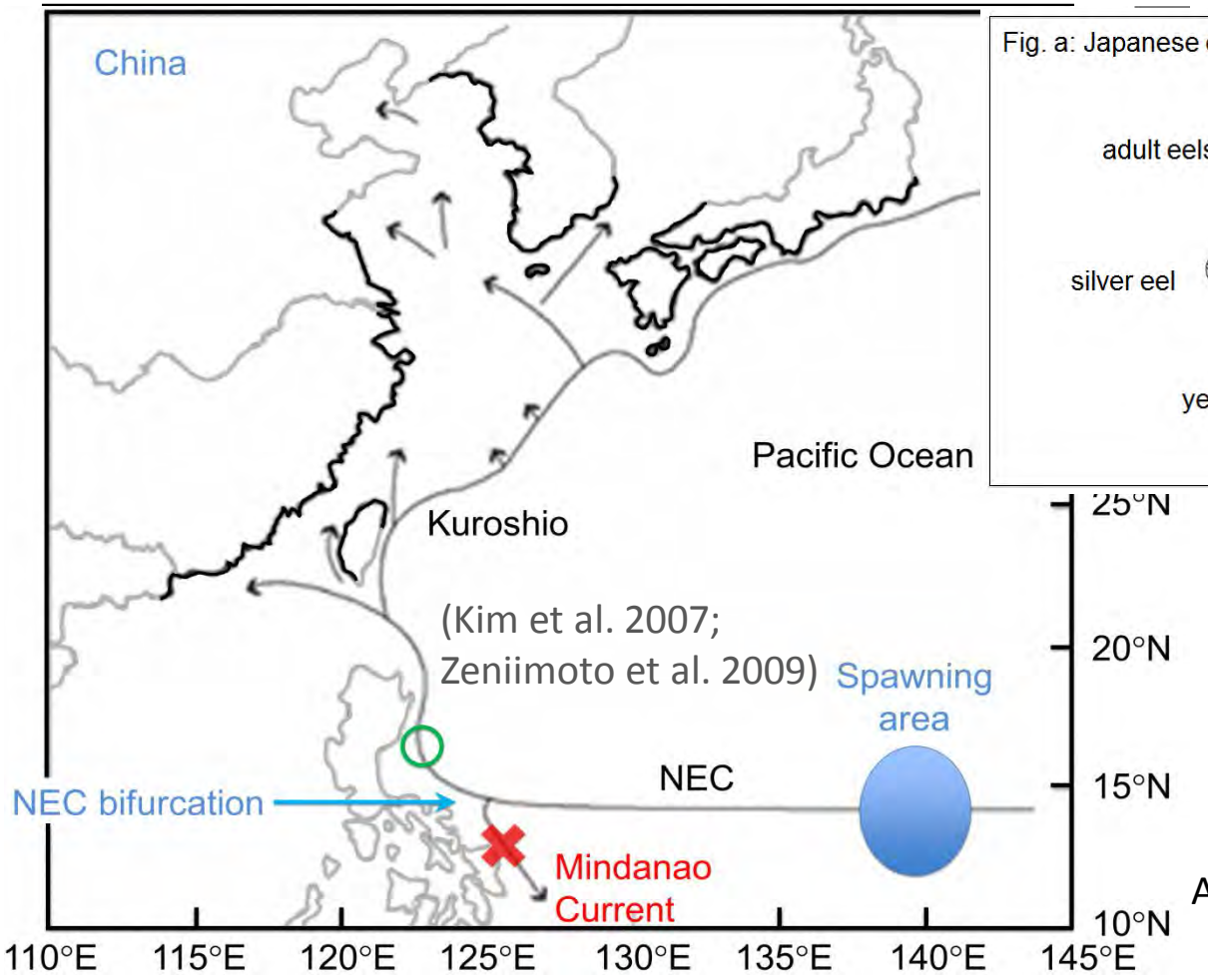
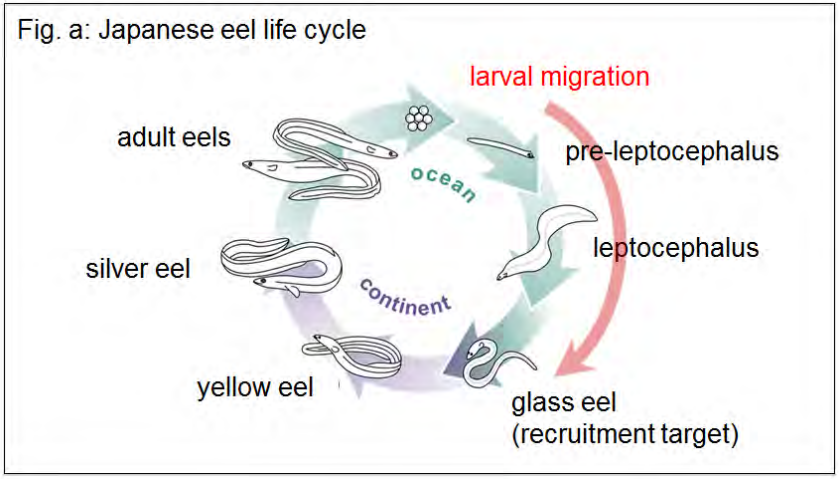
Japanese Eel - Life Cycle and Habitats

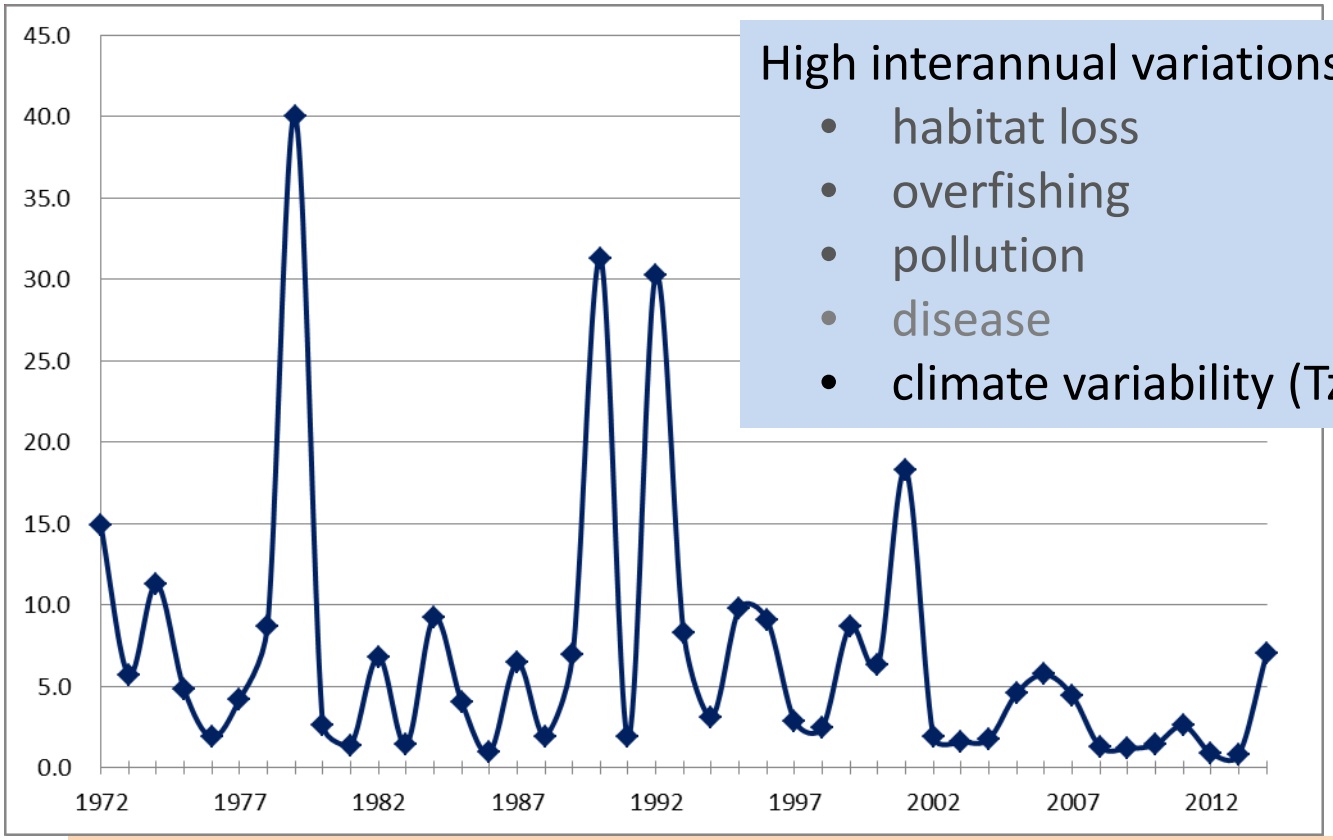




Adapted from Han *et al*. (2012)

- Spawning occurs during new moons between Apr and Aug
- Larvae reach Taiwan in 4 – 6 months (Tsukamoto 1992, 2006, 2009)

Glass Eel Catch in Taiwan



High interannual variations and overall declining:

- habitat loss
- overfishing
- pollution
- disease
- climate variability (Tzeng et al. 2011)

Courtesy of Prof. WN Tzeng

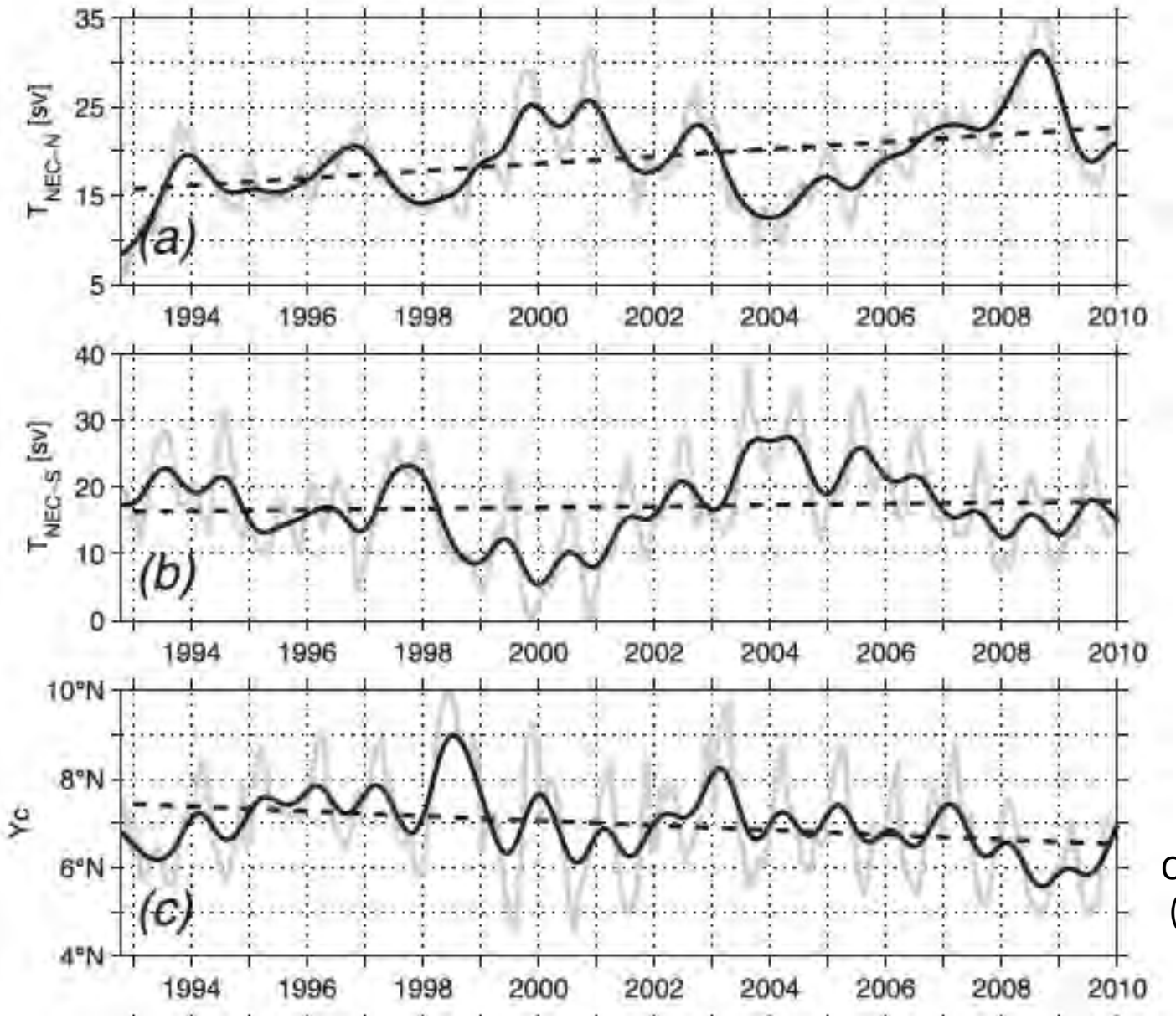
Objectives:

Understand oceanic effects (NEC, SF, etc.) on the variability of the glass eel recruitment to Taiwan

Approaches:

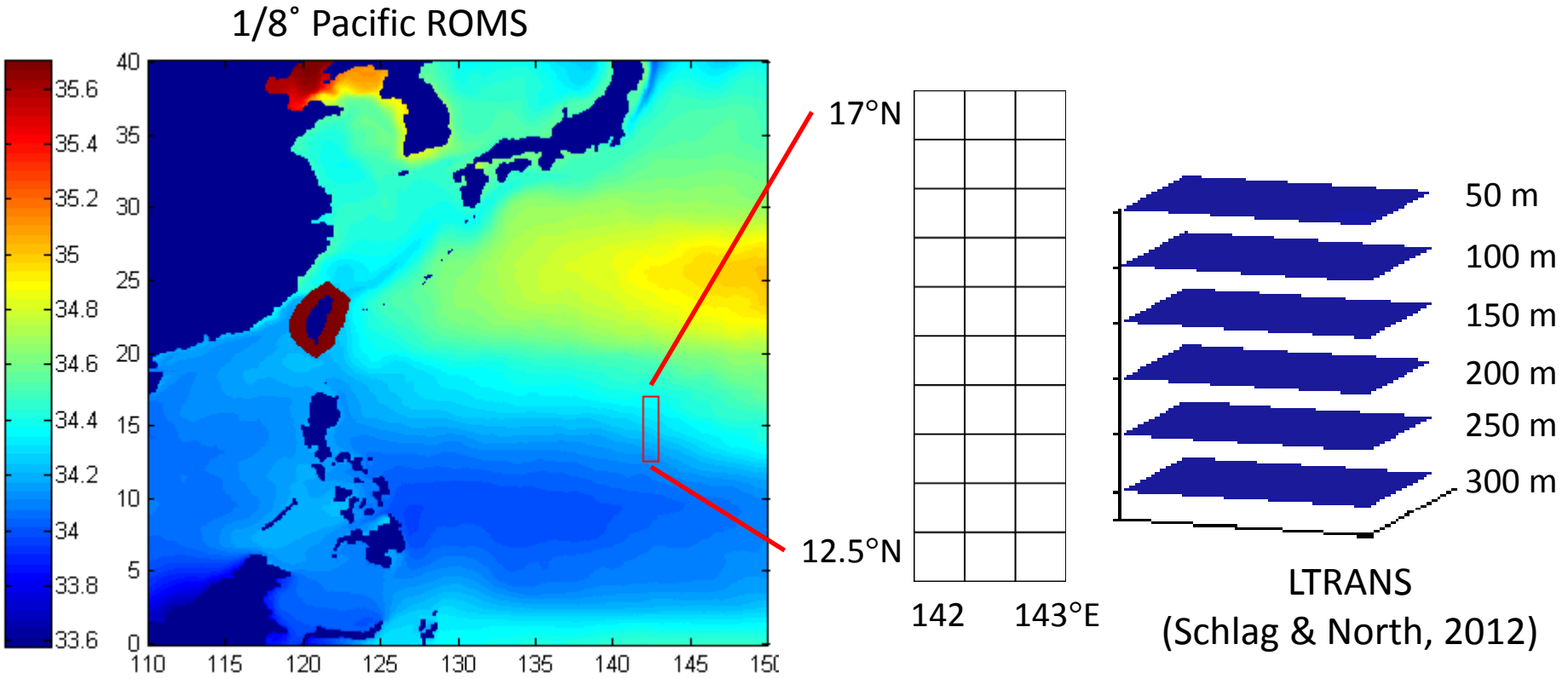
Individual Based Model simulations (passive, DVM, bioenergetics)

Variability of the NEC



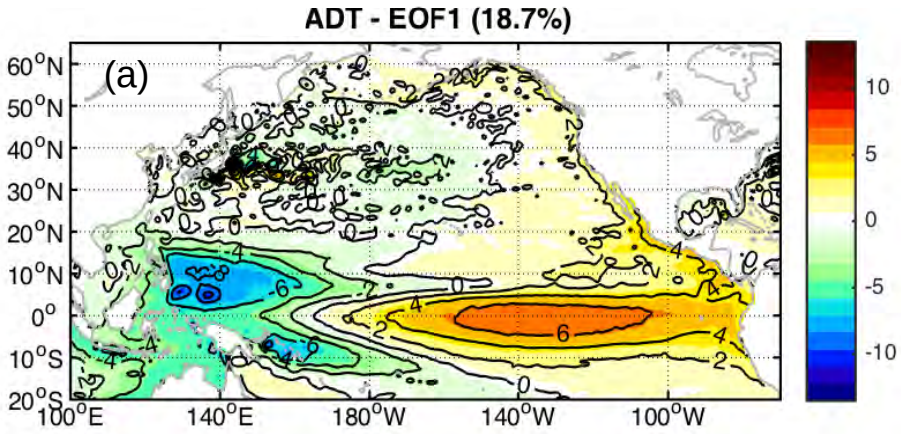
Qiu & Chen (2012)

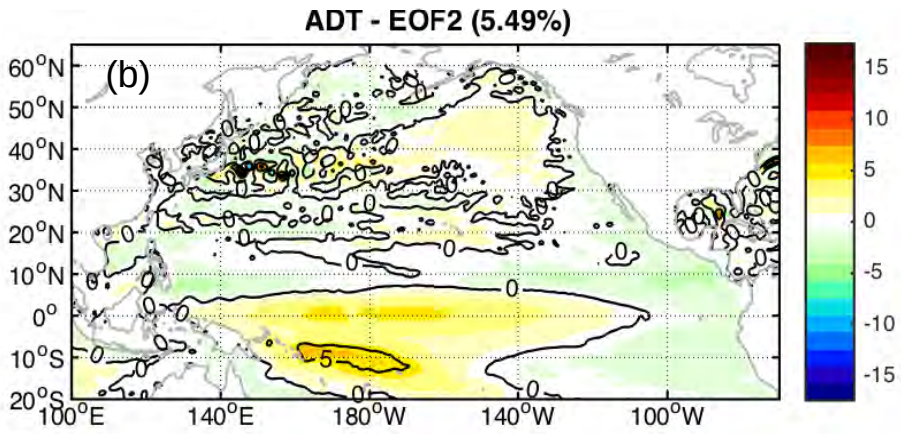
IBM Simulations

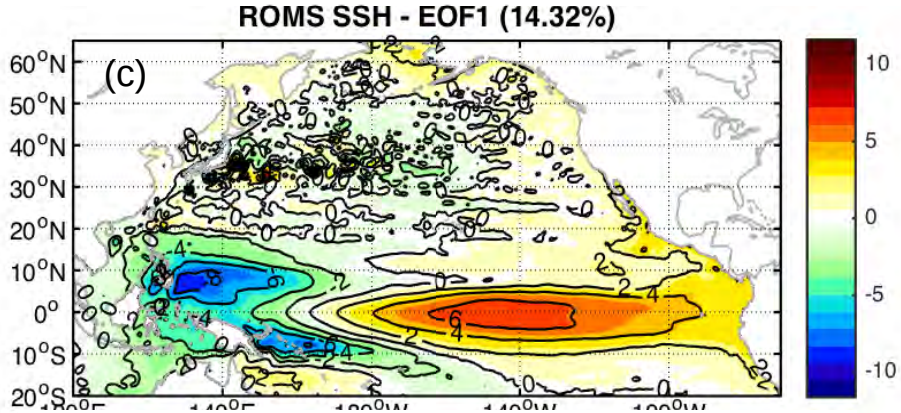


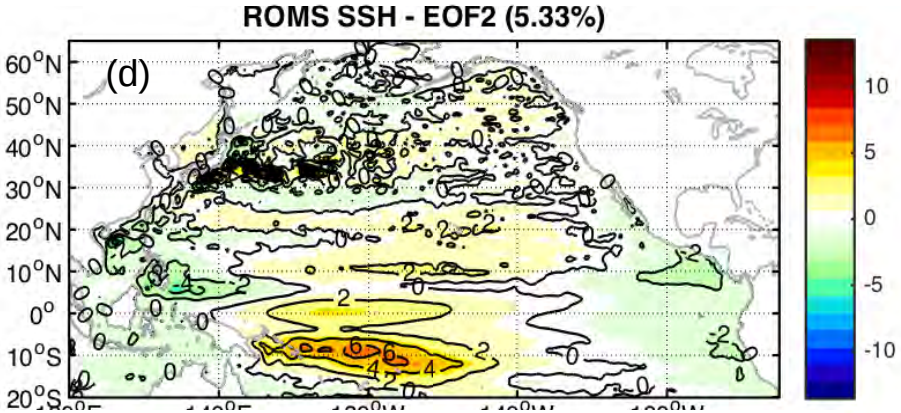
- For 20 years (1993 – 2012), 100 particles were released in each cell every month between Apr. – Aug., fixed at 6 depths (50, 100, …, 300 m), and tracked for 8 months
- Another set of experiments with DVM between 50-250

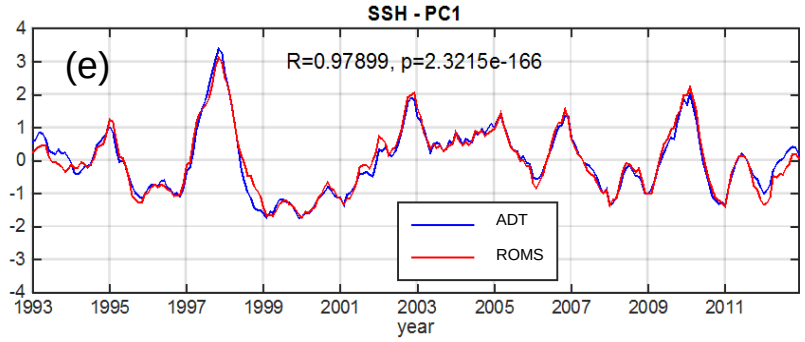
1/8° Pacific ROMS

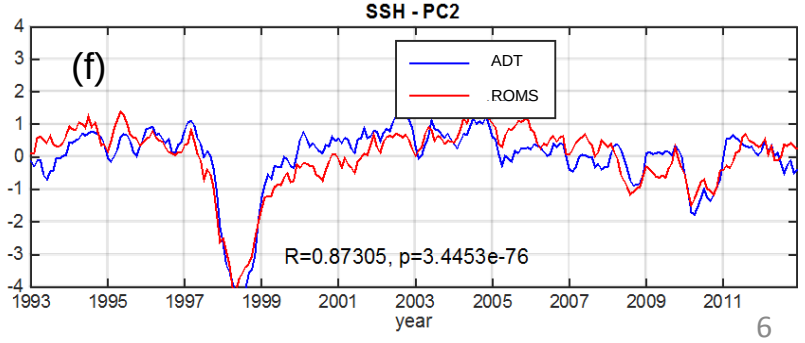




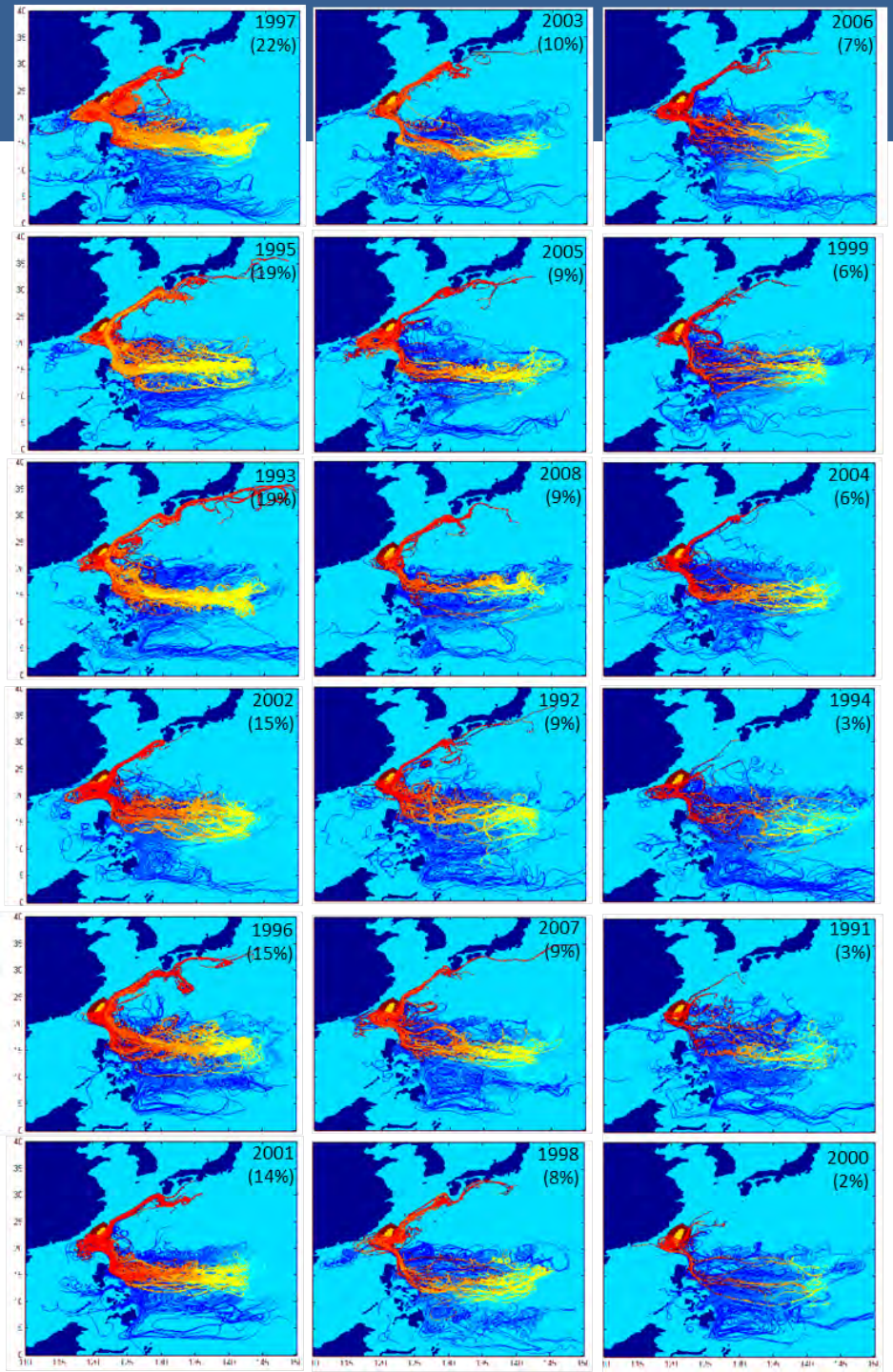








Passive Particles

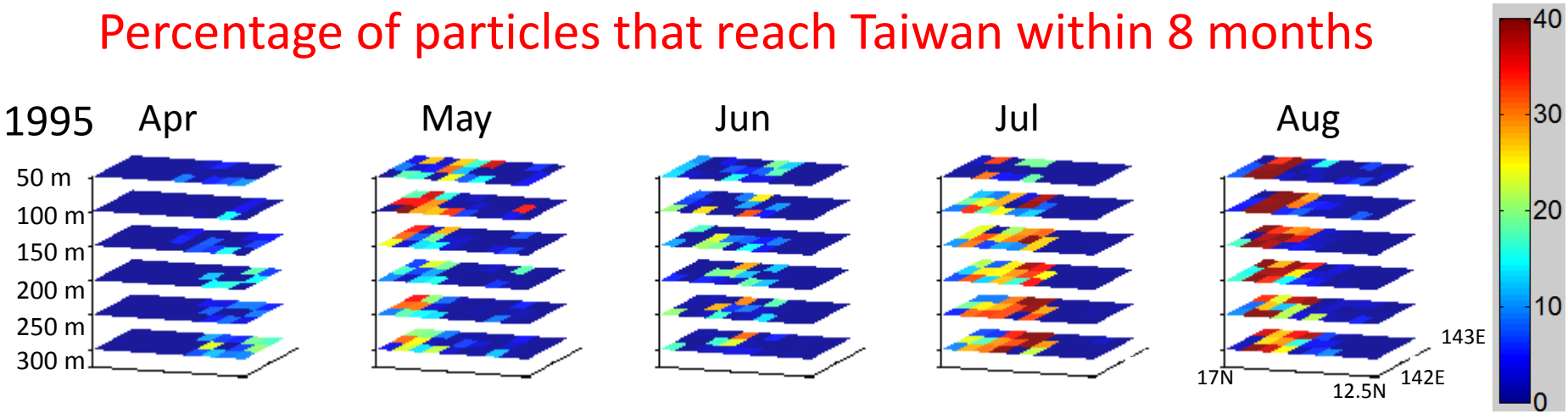


Annual composite of paths

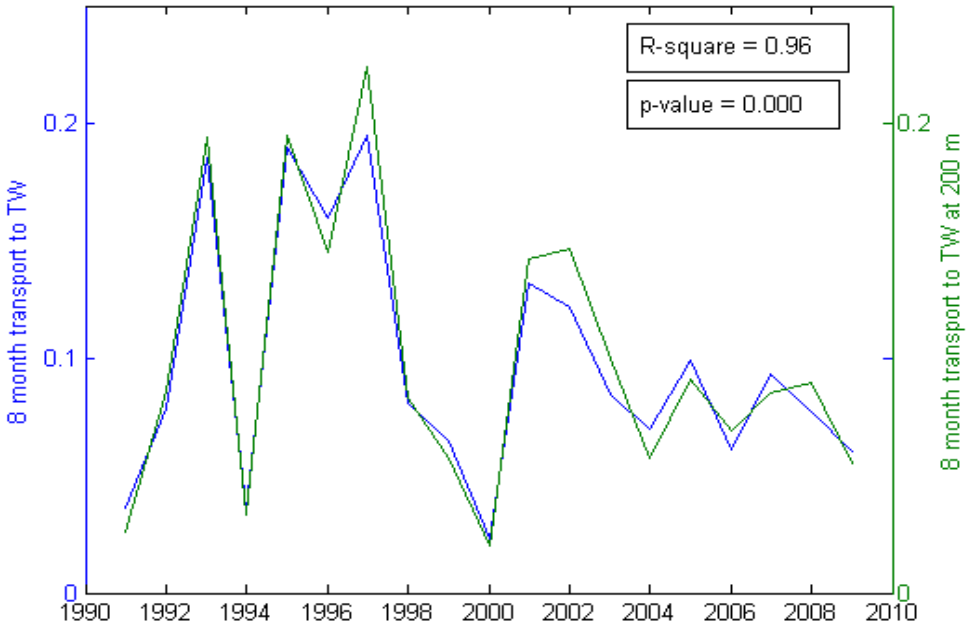
- Particles tended to travel through a specific latitudinal range to reach Taiwan (warm colors).
- In years of more particles reaching Taiwan, particles were transported across the NEC region sooner, implying the importance of NEC to the success of particle transport.

"Success" Particle Transport

Percentage of particles that reach Taiwan within 8 months

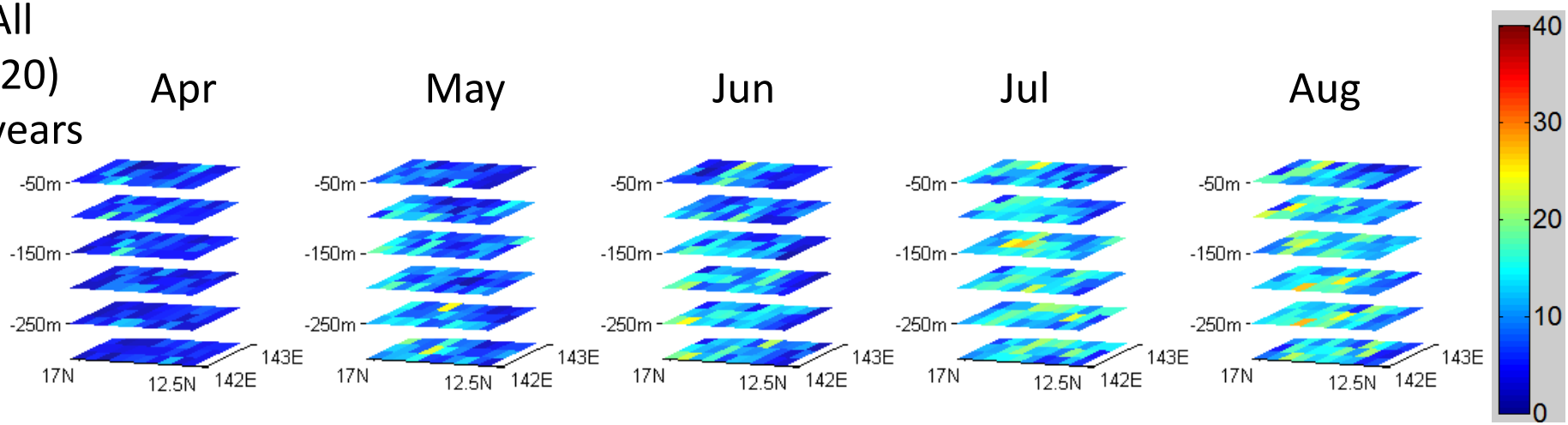


- Jul and Aug have higher success rates.
- In 1995 northern end of the releases have higher success rates.
- Patterns are highly coherent in the vertical such that the annual mean success rate for particles released at 200m represents well that of the vertical mean.

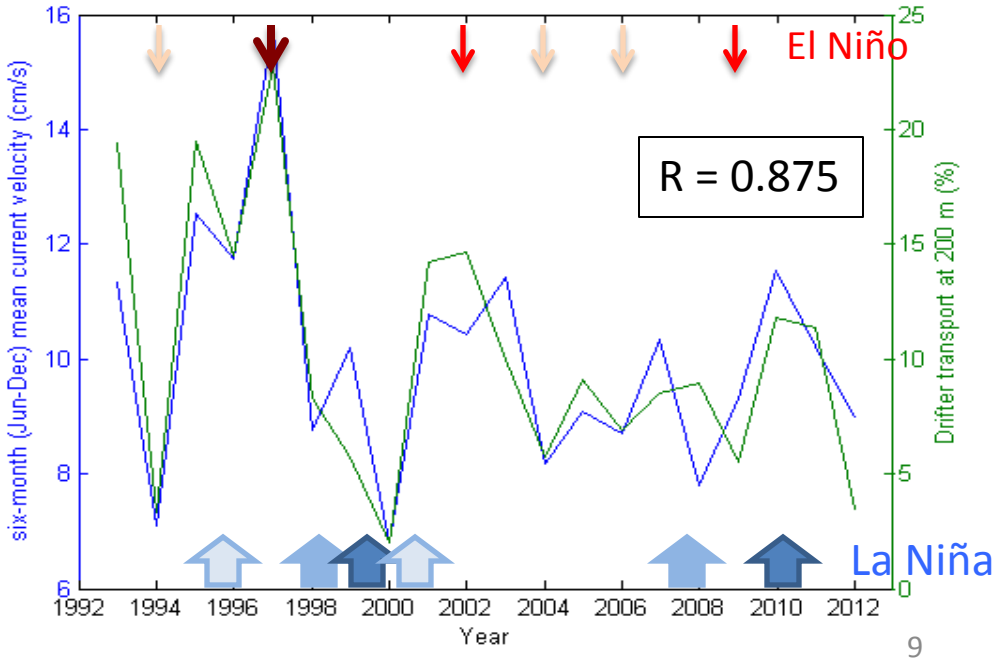


"Success" Particle Transport

All (20) years

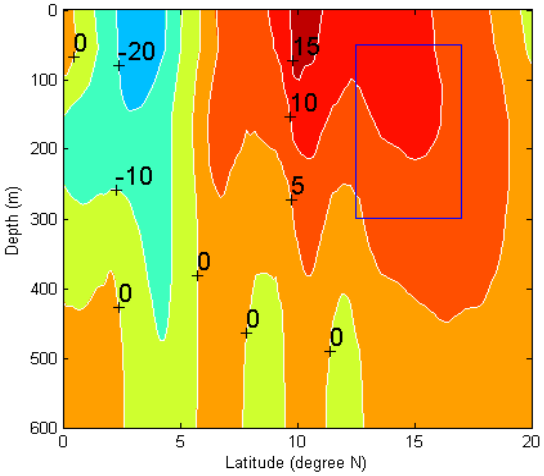


- Northern end of the releases still have slightly higher success rates.
- Patterns are again coherent in the vertical.
- The annual mean success rate is highly correlated with the zonal speed averaged in the area: (13.6 – 17N, 125 – 143E).

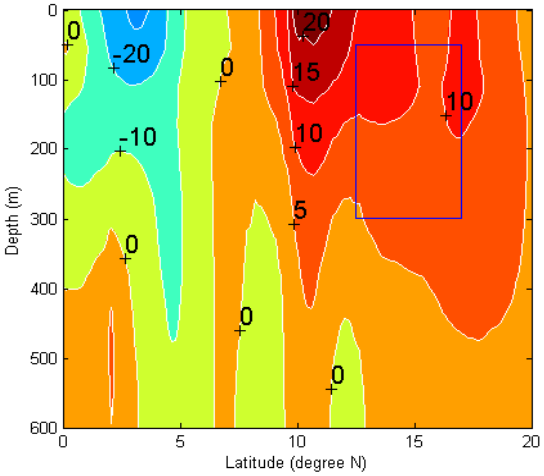


Zonally Averaged Westward Velocity

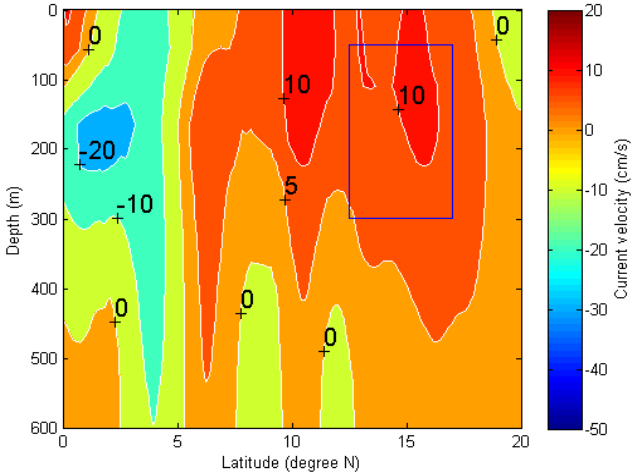
20-Year Mean



Mean of El Niño Years



Mean of La Niña Years

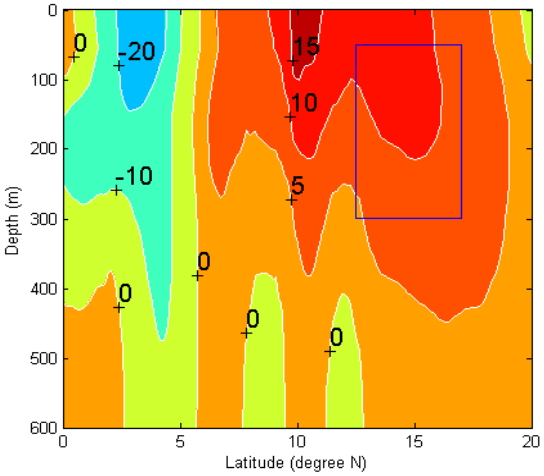


Westward (NEC: positive) velocity averaged between 125 and 143˚E.

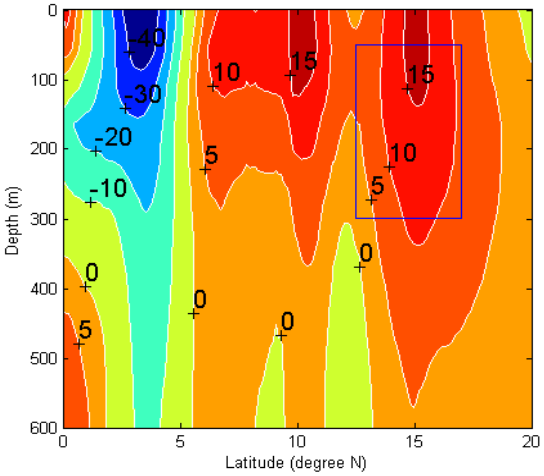
- NEC is stronger (weaker) and shifts northward (southward) slightly during El Niño (La Niña) years.
- However, the averaged zonal velocity in the key latitudinal band (12.5 – 17˚N) changes little between years.

Zonally Averaged Westward Velocity

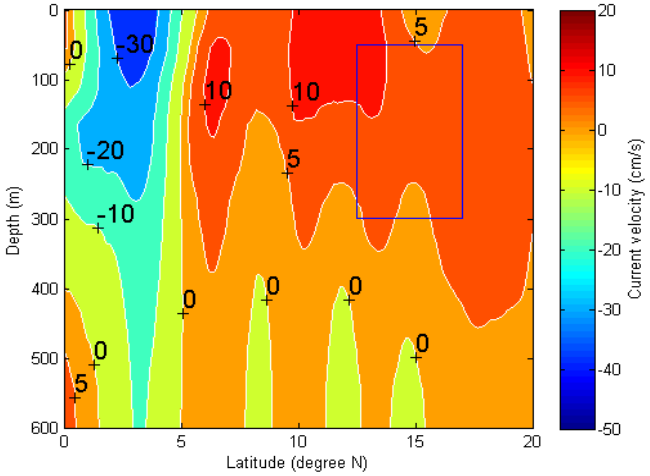
20-Year Mean



Mean of High Success PT Years

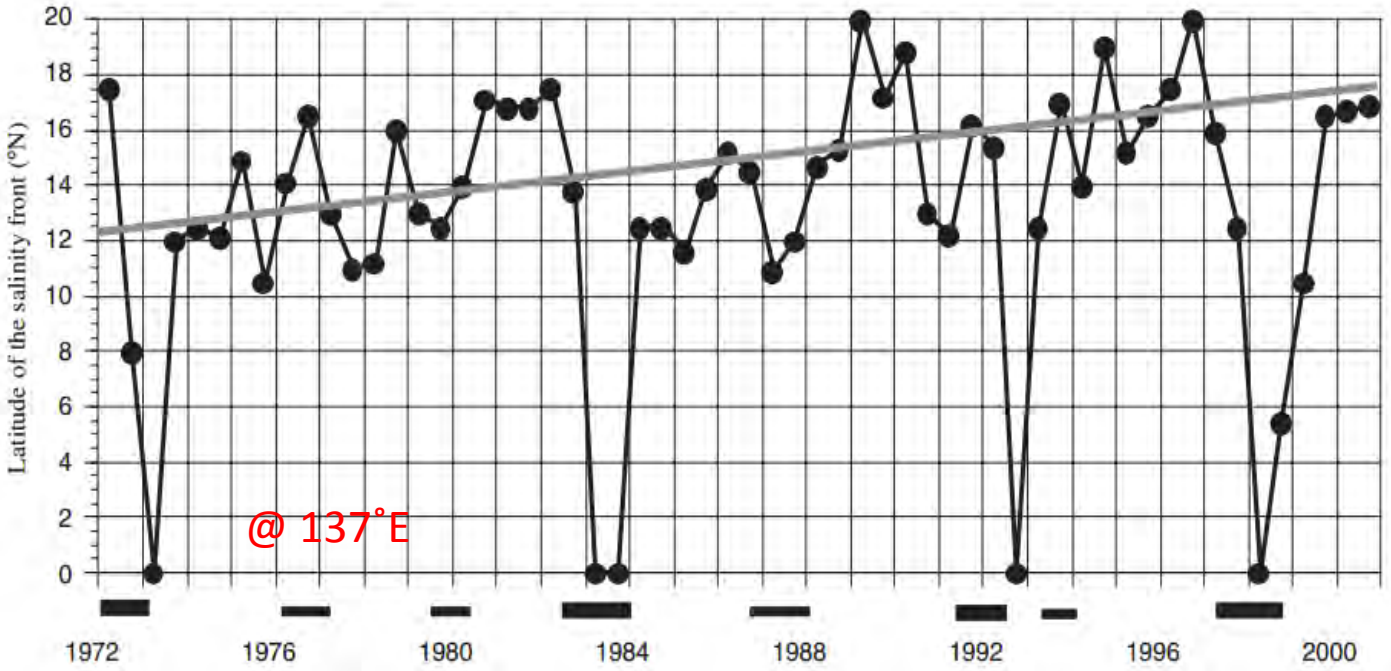


Mean of Low Success PT Years

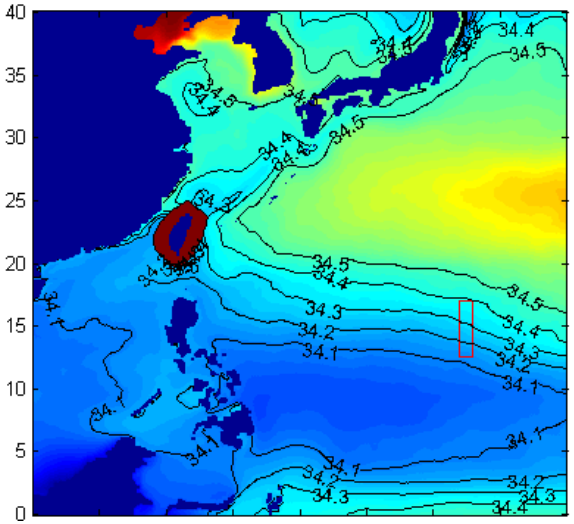


- NEC is stronger especially for the northern core during the high success particle transport (PT) years.
- Moreover, the zonal velocity in the latitudinal band (12.5 – 17˚N) changes significantly between the higher success years (93, 95, 96, 97, 01, and 02) and low success years (94, 00, 04, and 12) .

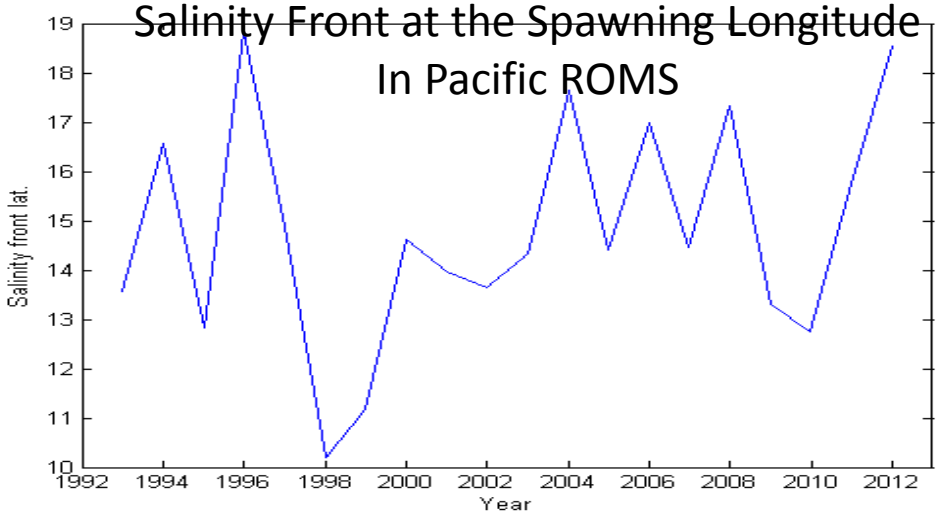
Salinity Front



Kimura & Tsukamoto, 2006

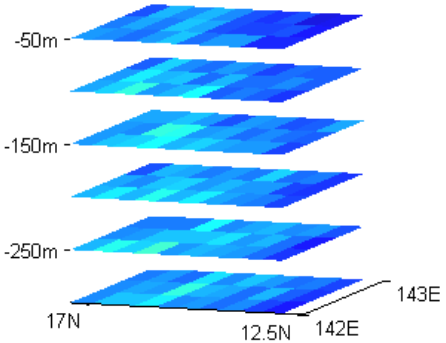


Salinity Front at the Spawning Longitude In Pacific ROMS

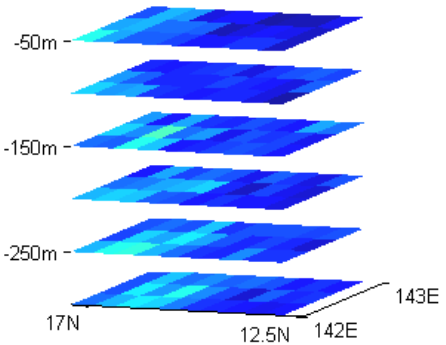


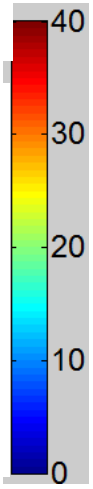
Salinity Front & Particle Transport

All years

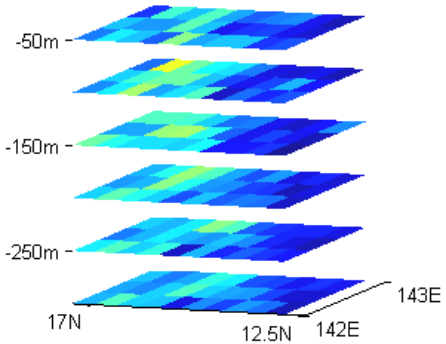


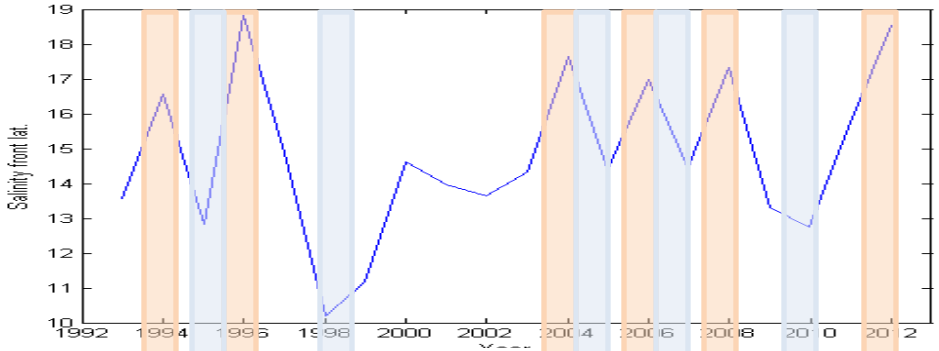
Northerly front years

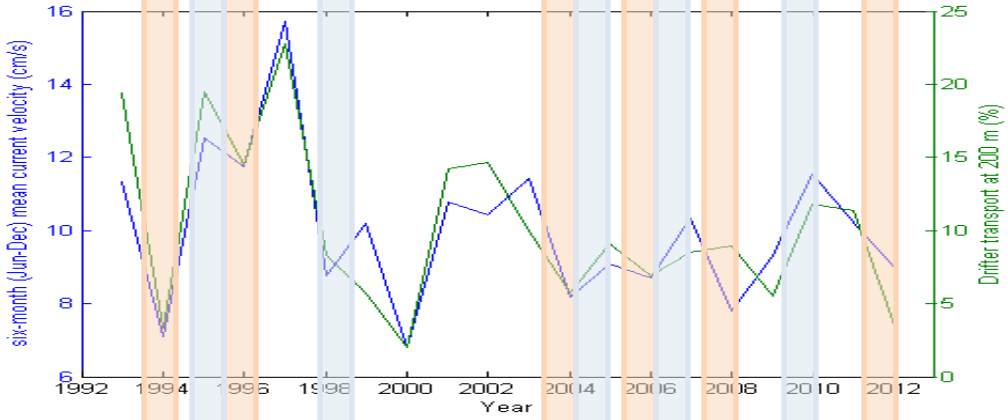


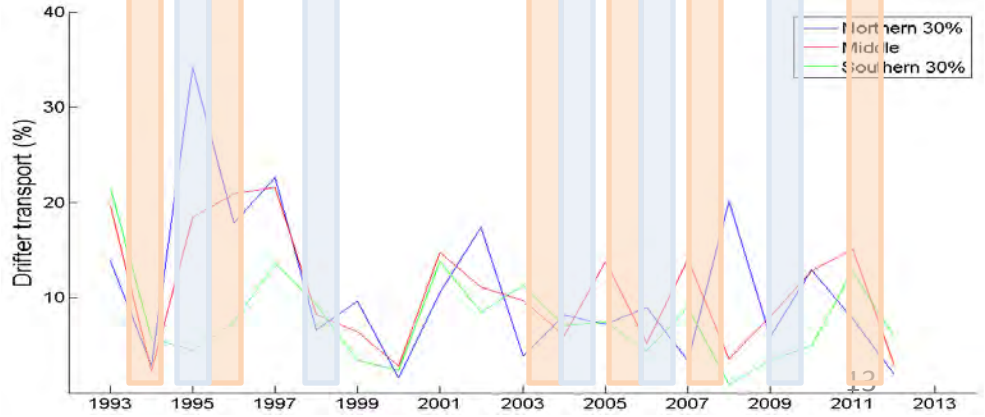


Southerly front years

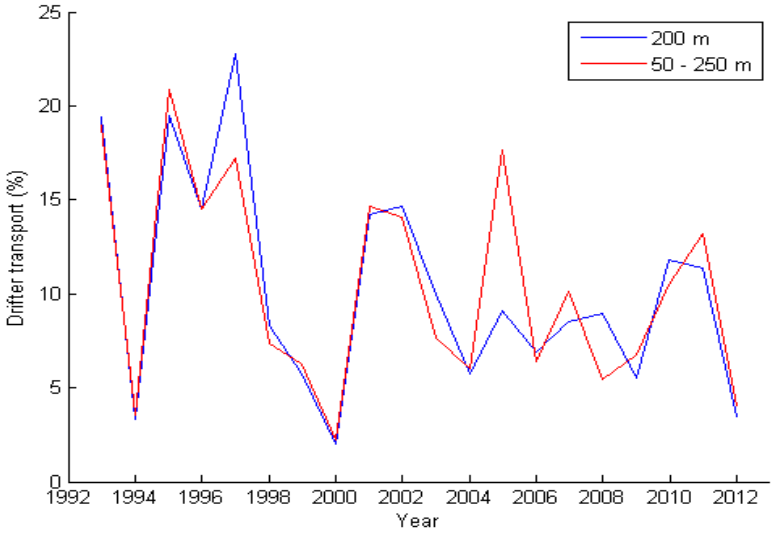


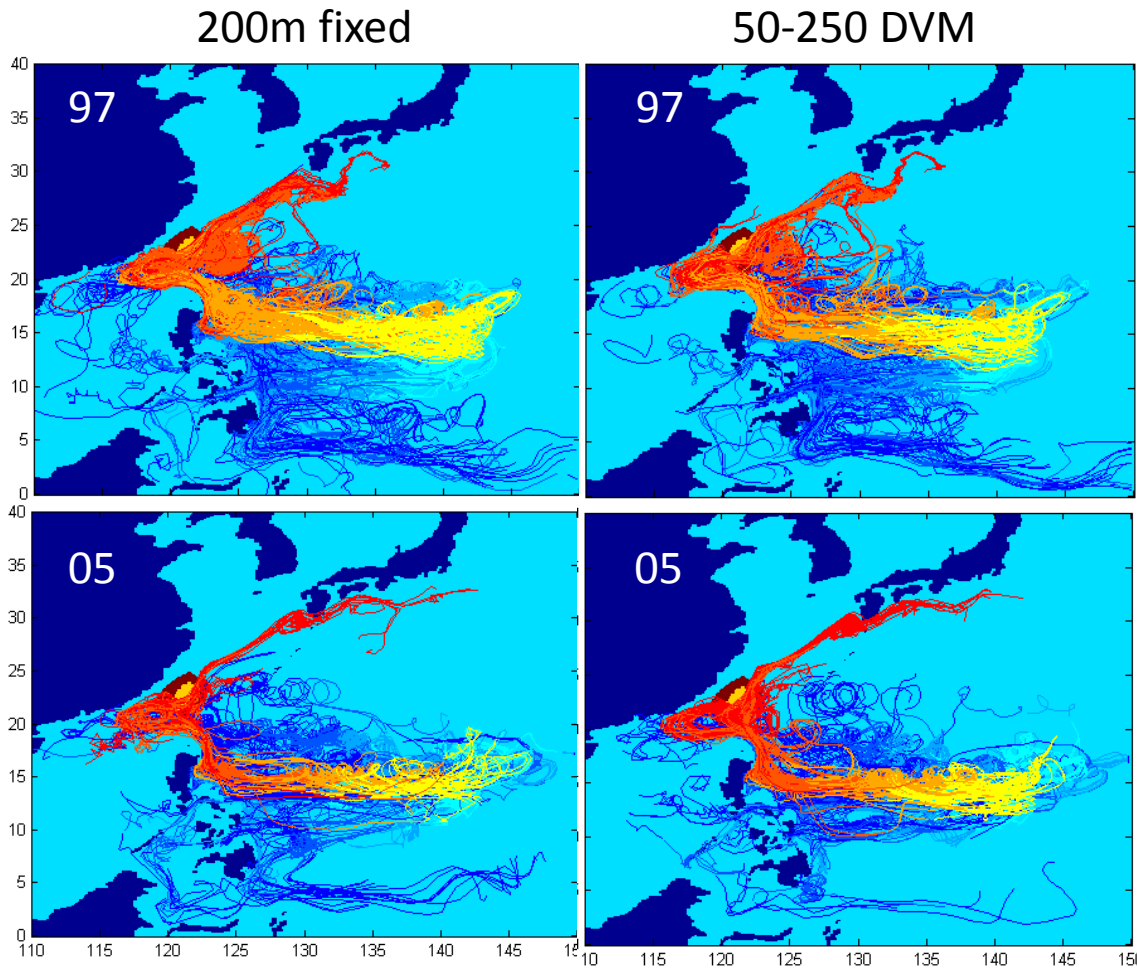






Diel Vertical Migration





DVM doesn't influence the success rate of particle transport!

Conclusions

- Particle transport is rather coherent in the vertical such that those released at 200m can represent the mean of all particles in the top 300m.
- 6-month mean (Jun-Dec) zonally averaged NEC speed in the northern 75% of the spawning latitude is a good indicator for the percentage of particles successfully transported to Taiwan.
- Considering advection alone, spawning at the salinity front doesn't seem to be an effective strategy.
- Considering movement alone, DVM doesn't influence the annual mean success rate of particle transport.