Final Exam 16:712:501 Introduction to Physical Oceanography

Administered by Andreas Münchow for ~~Krista Longnecker~~ everyone on Dec. ~~10~~ 22, 1998

1. (10 pts) Write down and discuss the balance of forces as well as the continuity equation that form the basis of Ekman dynamics.

2.(10 pts) What assumptions must be made for this balance to hold (list at least 5).

3.(10 pts) The solution to the Ekman equations in indefinitely deep water are

$$u(z) = -V * \exp(z/\delta) * \cos(z/\delta)$$
$$v(z) = V * \exp(z/\delta) * \sin(z/\delta),$$

where u and v are east and north velocity component and z is the vertical co-ordinate counted positive upwards.

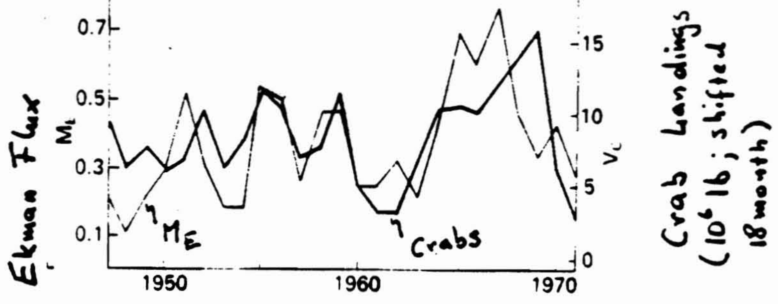
(a) Which way does the wind blow?

(b) What is the physical significance of $\delta = (2A/f)^{1/2}$ where A is a vertical eddy viscosity and f is the Coriolis parameter? What are its units?

4.(10 pts) The figure below (from Tomzcak and Godfrey, 1994) shows the mean off-shore Ekman flux and the landings of Dungeness crabs off Oregon both as a function of time.

(a) Explain physically the reason for the strong correlation of the two time series.

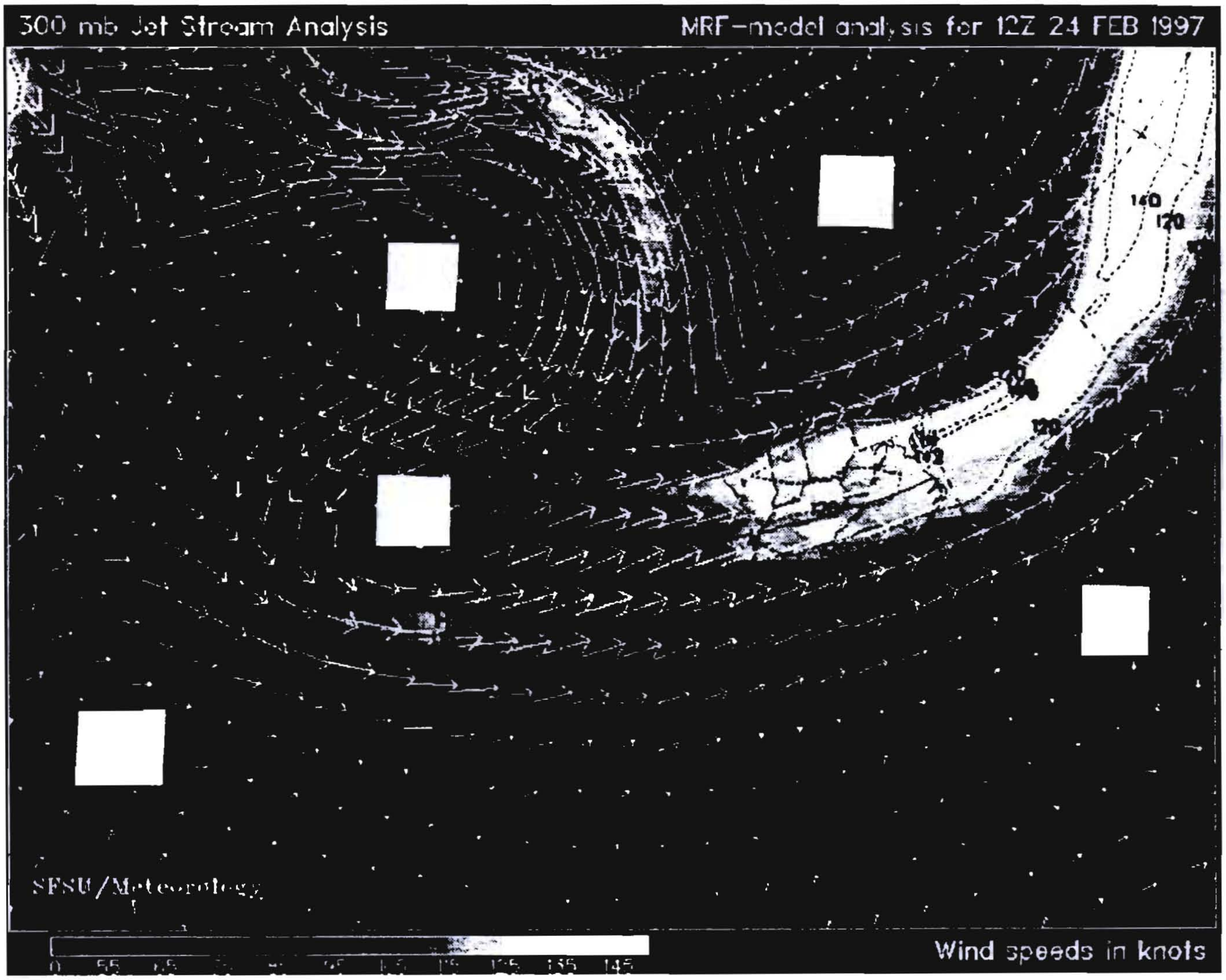
(b) How would you explain the interannual and decadal variations in both the crab landings and the Ekman fluxes?



5. (5 pts) What is the net displacement of a particle in a linear wave over 5 wave periods?

6.(10 pts) Explain the factors and physical causes that determine how many intense western boundary currents exist in a closed ocean basin. Sketch the wind field for an ocean basin with 5 such currents.

7.(10 pts) Indicate on the map below the atmospheric High (H) and Low (L) pressure systems. The map shows the wind velocities associated with the jet stream. You may assume a geostrophic force balance.



8. (10 pts) Estimate the error in the phase speed estimate of a "shallow water wave" that has a wavelength of 500-m and propagates in 50-m deep water. Hint: $\tanh(x) = [\exp(x)-\exp(-x)]/[\exp(x)+\exp(-x)]$

9. (10 pts) How can you reconcile the fact that the gravitational attractive force of the moon that causes a bulge towards the moon also causes a bulge away from the moon on the side of the earth facing away from the moon?

10. (15 pts) Please edit the following text to make it physically sound

"Kelvin waves in the northern hemisphere propagate along the coast as shallow water waves with a phase speed $c=g/k$ where g is the constant of gravity and the the wave number $k=2\pi/\lambda$ is related to the wave length λ. Kelvin waves are non-dispersive, i.e., their phase velocity equals their group velocity. They can travel only in the direction with the coast to its left looking in the direction of wave phase propagation. The wave form of a Kelvin wave is very peculiar since at any instant in time sea level oscillations occur both along and across the shelf. This is the result of a geostrophic force balance in the along-shore direction and acceleration balancing a pressure gradient in the across-shore direction. Friction is generally negligible for such waves except adjacent to the coast. Here the Kelvin wave describes a frictional or Ekman balance."