Problem 240D

Consider a rudimentary yacht travelling downwind (with the wind). Assume that the major component of resistance to motion through the water is the skin friction drag on the hull of the yacht. Estimate this drag force for any velocity, U, by assuming that

1. the hull/water interface is like a flat plate with a length of 10 m and a width of 1 m.
2. that the boundary layer on the hull remains laminar (even though in practice this would not be the case) and unseparated.
3. the water density and kinematic viscosity are respectively 1000 kg/m^3 and 10^{-6} m^2/s.

If the yacht is propelled by a spinaker sail (a flat surface normal to the direction of motion) with a frontal area of 5 m^2 estimate the forward speed of the yacht in a wind of 5 m/s (assume an air density of 1 kg/m^3). If a human is capable of a rate of output of work of 0.1 HP (1 $HP = 746\ kg\ m^2/s^3$) how many humans would it take to row the boat at the same speed if the efficiency of their rowing process was 20%?