# Foil Design Research

***Document prepared by Lauren Thelen***

Assuming travel of 10-12 knots average

NACA 0012 optimized for 3-6 knots in water (most common profile used)

Faster travel = lower % foil (such as 0010 or 0008)

Slower travel = higher % foil (such as 0018 or 0021)

Reynolds number for 10-12 knots (about 17-20 ft/s):

R = VL/Kv (v=velocity, L=length of foil, $k_v$=kinematic viscocity)

$k_v \sim 10^{-5}$ ft$^2$/s for water and $\sim 10^{-4}$ ft$^2$/s for air

1,700,000-2,000,000 (rudders)

340,000-400,000 (sail profiles)

<u>Airfoiltools.com</u>

Reynolds # range: 200,000-500,000

NCrit value: 9 (most commonly used value)

Max Cl/Cd:

**NACA 0012: 41.5 @ 7.50 degrees – 63.7 @ 8.00 degrees**

NACA 0008: 41.1 @ 3.25 degrees – 50.2 @ 5.75 degrees

NACA 0009: 45.6 @ 3.25 degrees – 55.9 @ 5.25 degrees

NACA 0010: 44.4 @ 4.25 degrees – 55.2 @ 4.25 degrees

NACA 0015: 49.6 @ 6.25 degrees – 66.4 @ 7.50 degrees

NACA 0018: 50.1 @ 7.00 degrees – 65.8 @ 9.25 degrees

NACA 0021: 48.9 @ 8.75 degrees – 60.6 @ 10.25 degrees

NACA 0024: 43.0 @ 10.00 degrees – 52.1 @ 10.25 degrees

This website doesn't give the option for Reynolds numbers higher than 2,000,000 so I could not use it for the rudders. However, we assume the difference in the NACA 0012 profile as opposed to the 0010 or 0008 is insignificant compared to the drag from the boat hull.

Decided on NACA 0012 profile for rudders

Bidirectional foil

Using Tom Speer Proa-3 series (p30012) because the simulations are most similar to performance of the NACA 0012

25% scale dimensions:

- 2 rudders: 12” long x 3” wide x approx. 0.3” thick
- 1 bidirectional: 18” long x 4.5” wide x approx. 0.5” thick