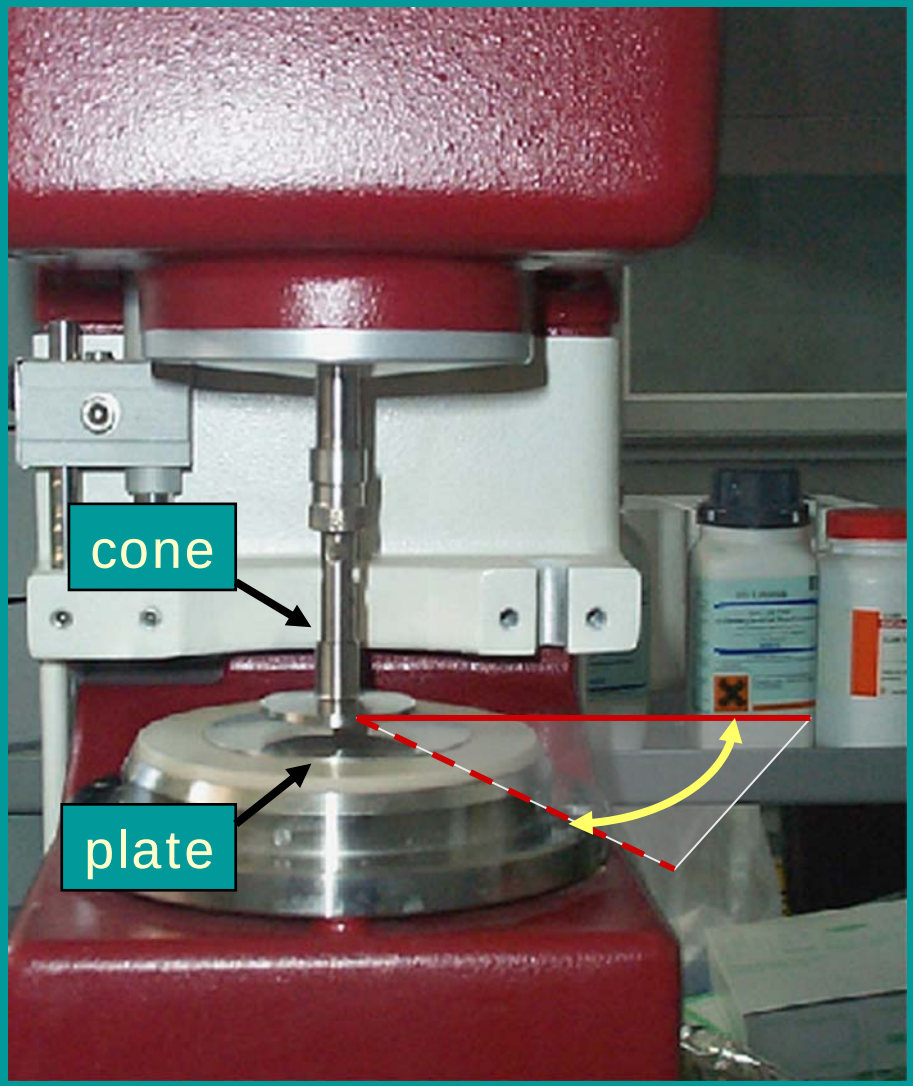
ALFRED WEGENER INSTITUTE FOR POLAR AND MARINE RESEARCH in the Hermann von Helmholtz Association (HGF)

Biophysical properties of the dolphin skin reveal an eco-friendly defouling cycle

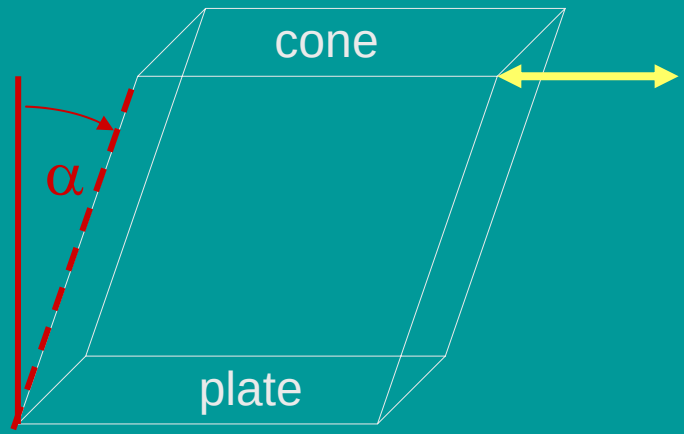
Christof Baum

The biomimetic potential of Bingham fluids

Rheological parameters

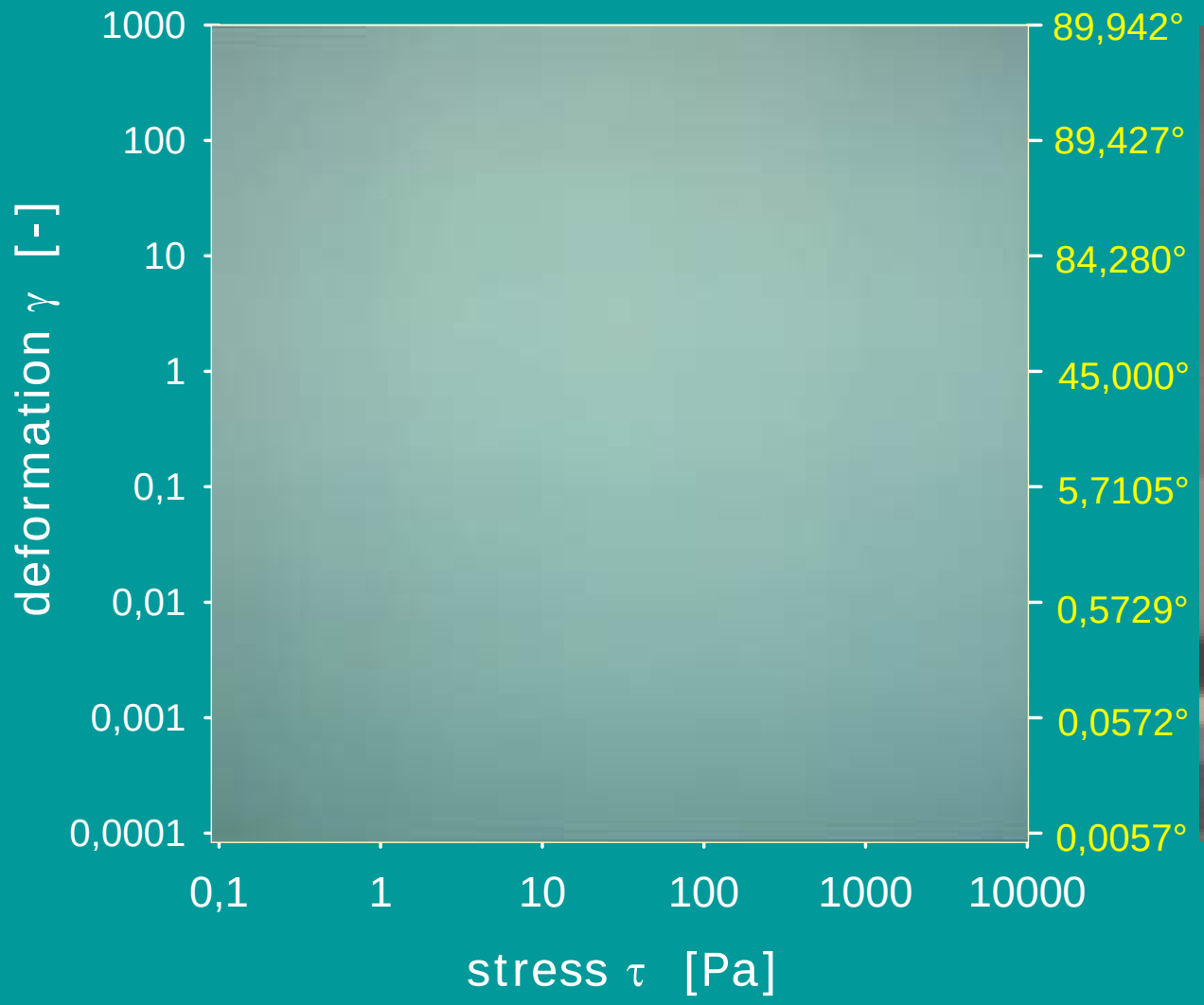


stress $\tau \leftrightarrow$ deformation γ



$\gamma = \tan \alpha$

Real-time rheology



Dolphin facts

- Dolphin skin surface
  - Gel covered
  - Intercellular glycoproteins

- Transformation:

  ... fluidal state → visco-elastic solid ...

  ... solid state → irreversible cohesive failure

- Yield point, σ_{yield} = 3-8 x 10^3 Pa

  Bingham equation $\sigma = \sigma_{yield} + \eta_p \dot{\gamma}$

Stress parameters

- Swimming (3-8 m/s) = 20-80 Pa*

  *J. Rohr et al., Journal of Experimental Biology **1998**, 201, 1447–1460

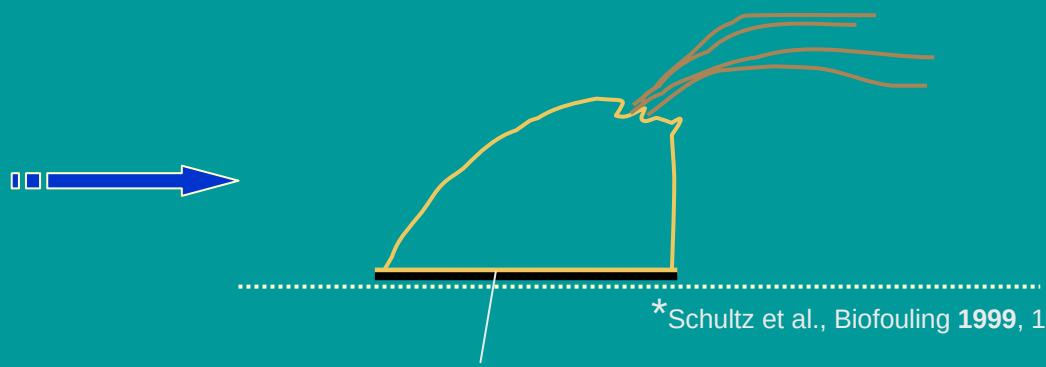
- Jumping ≤ 3-8 x 10^3 Pa

- ≥ 3-8 x 10^3 Pa definitely barnacle-free !

Stress at a barnacle base plate

Does the stress exceed the limit of cohesive failure

at swimming speed 3-8 m/s?

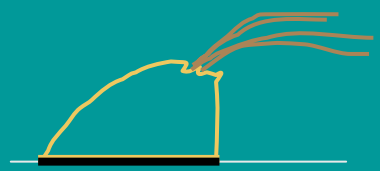


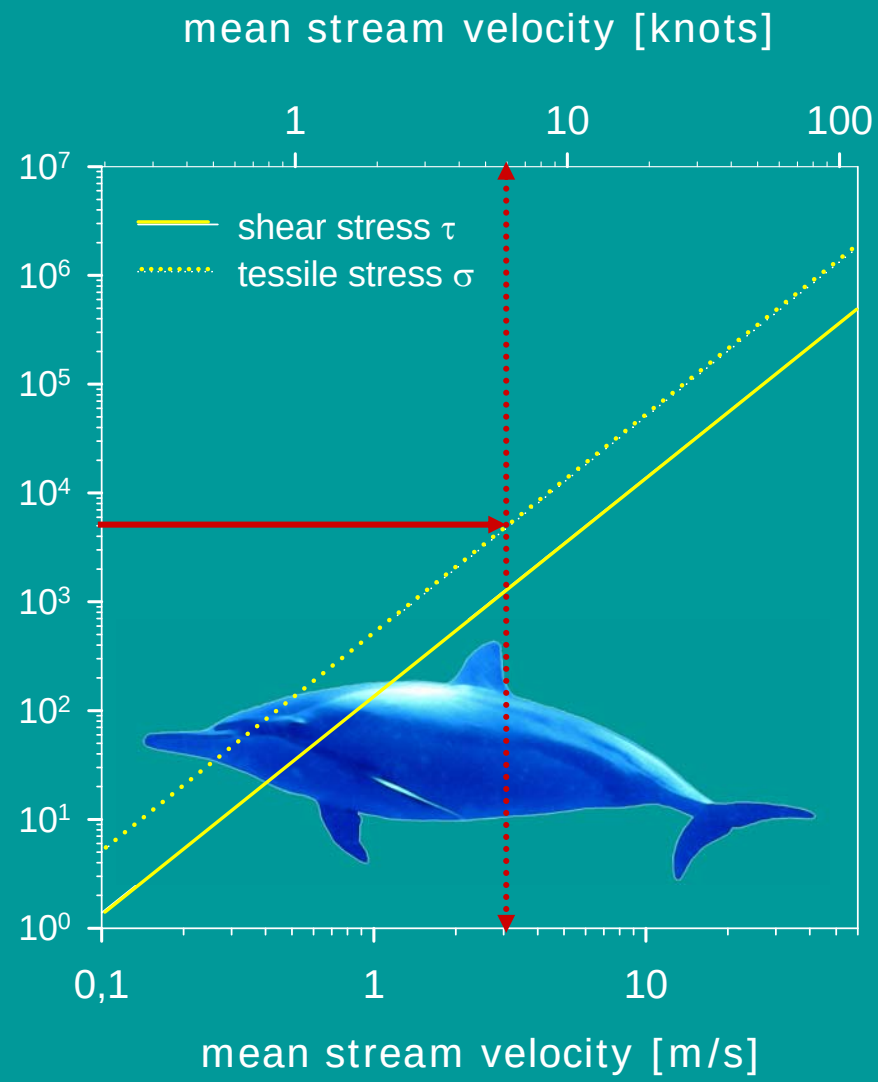
*Schultz et al., Biofouling **1999**, 13, 323-335

barnacle base plate

Stress – Velocity – Correlation*

stress [Pa]
at the base of a barnacle



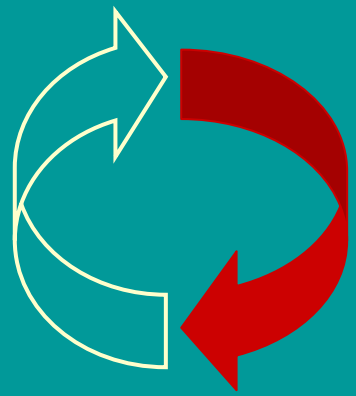


Basic equation of defouling

$$\sigma_{\text{non-fouled}} < \sigma_{\text{yield}} < \sigma_{\text{fouled}}$$

Bio-cycle → Bingham Fluids

Irreversible cohesive failure of the covalently cross-linked gel



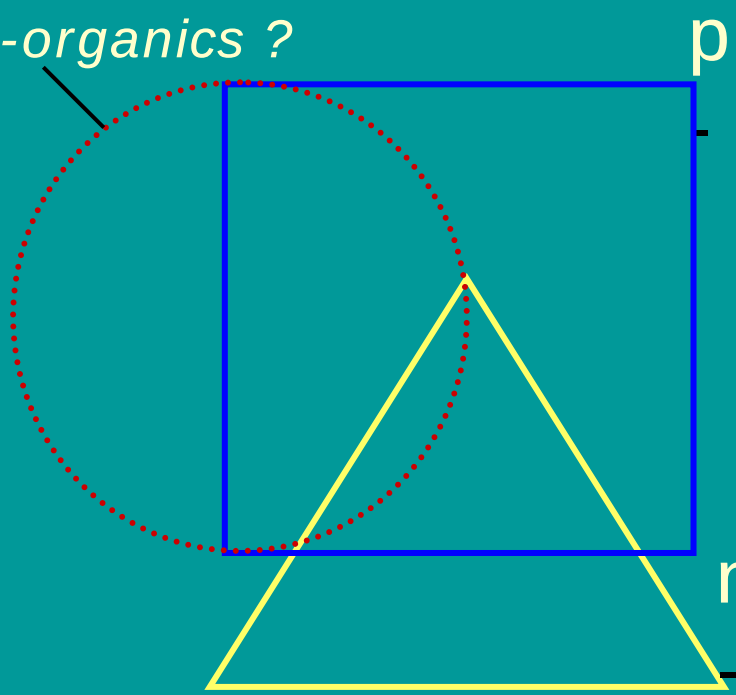
perpetual renewal of skin

Biomimetic | *transformation*

Reversible cohesive failure of the Bingham Fluid

thickness of the fluid

Application notes



polymer base

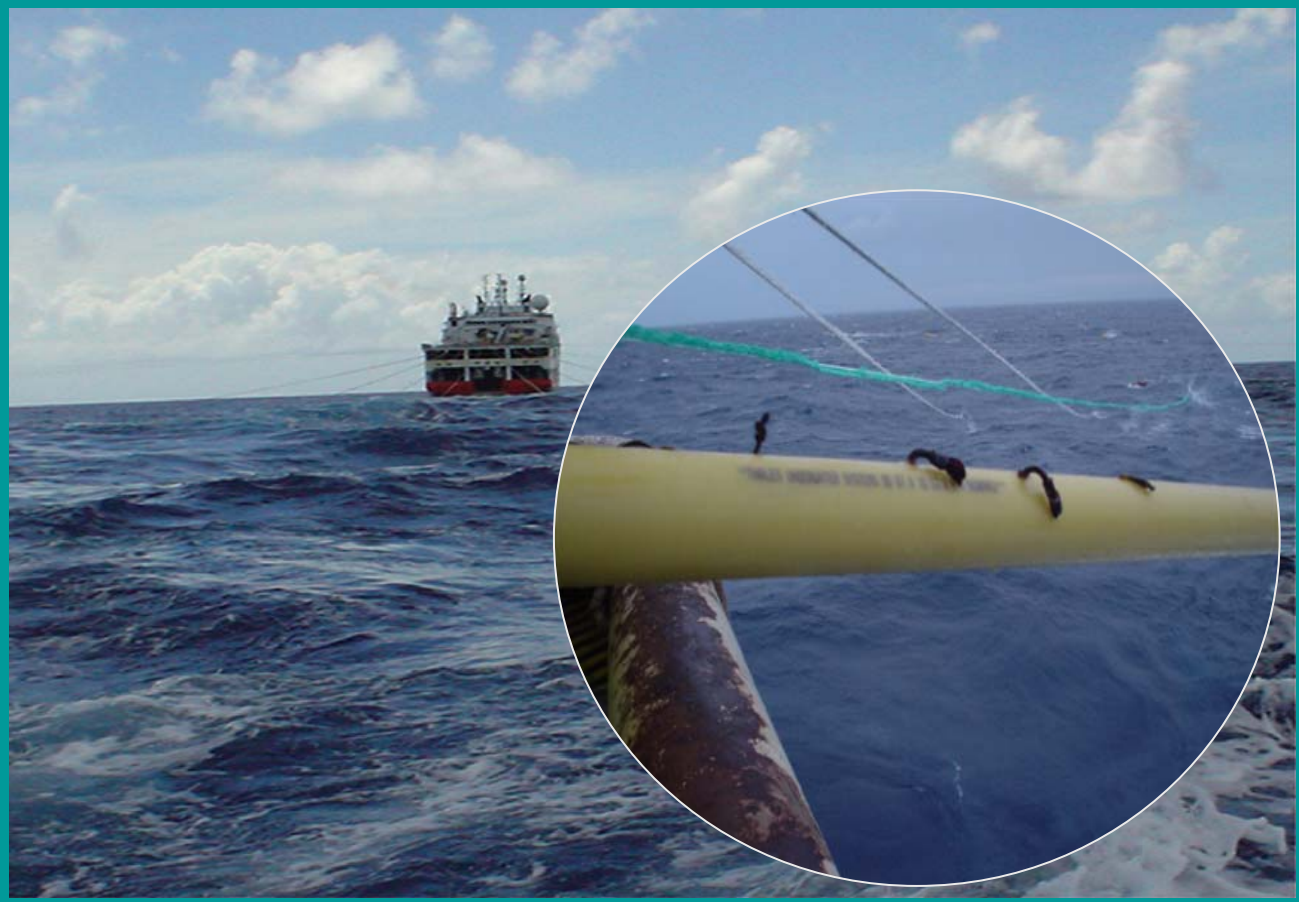
- vaseline or silicone oil ...

nanoparticles

- modified silica or TiO_2...

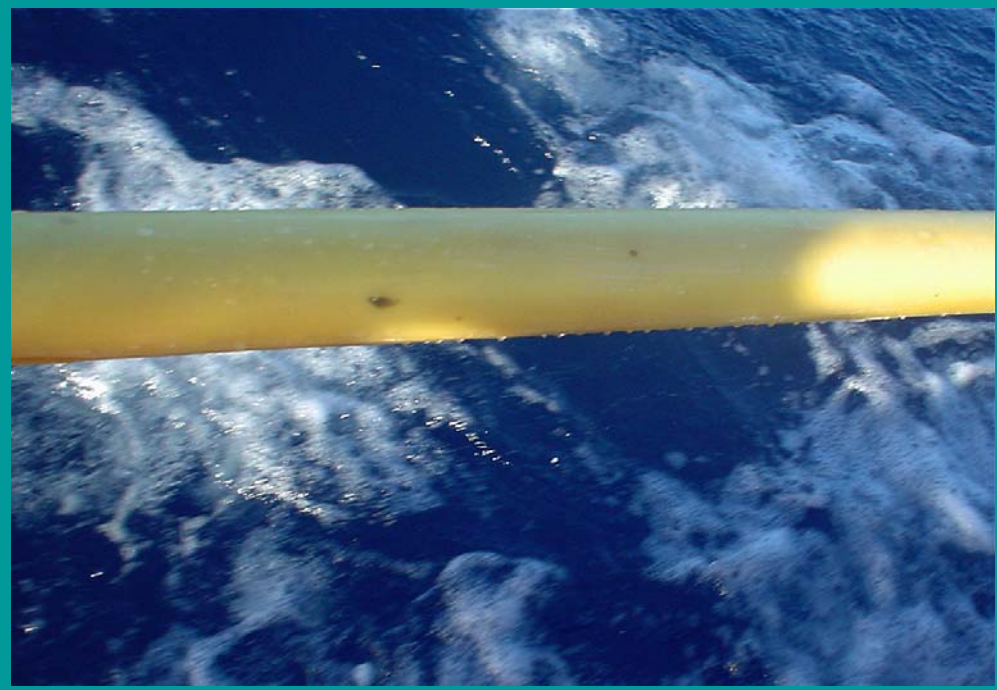
Field tests

- Seismic surveys (Morocco and Brazil)
  - Coating seismic streamer cables



Barnacle-free streamer cable

- 2.5 - 3 month
- but seawater C° !
- ... pending patent*



*AWI + Veritas Geophysical DGC
PCT/ DE2004/ 000299

Future requirements

- Focus on the wall shear stress of marine constructions
- Measurements on drag and lift
- Evaluation of non-toxic impact
- New markets