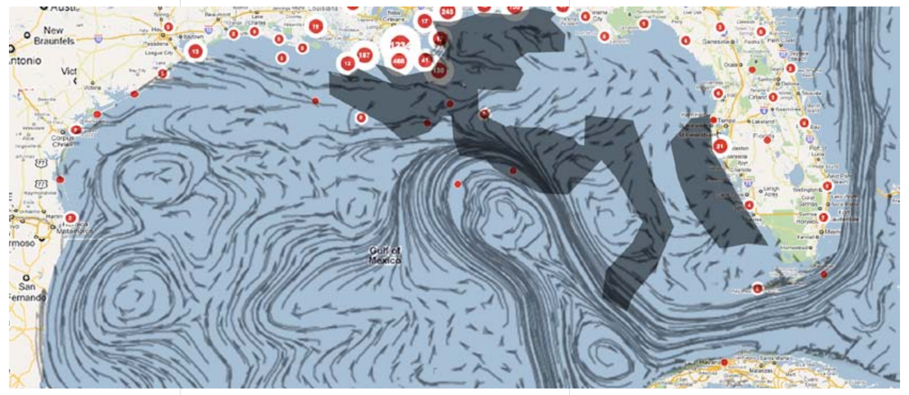
Oil Spill

The 20th of April 2010, the Deepwater Horizon oil rig exploded, killing 11 and injuring 17 men, precipitating the worst man-made environmental catastrophe in the history of the North American continent. During 3 months, gushing from the depths, 4.9 million barrels (780,000 m^3) of crude oil mixed with toxic dispersant created a 80sq mi (210 km^2) "kill zone". The spill was easily distinguishible from space but scientists also reported immense underwater plumes of dissolved oil not visible at the surface, causing extensive damage to marine and wildlife habitats, to the Gulf's fishing and tourism industries, It will affect the health of the Gulf residents for a long time.

It was analyzed that the clean up effort would have been a lot more efficient if we had a better understanding of natural patterns (wind, current, chemistry) and relied more on local fishermen knowledge.

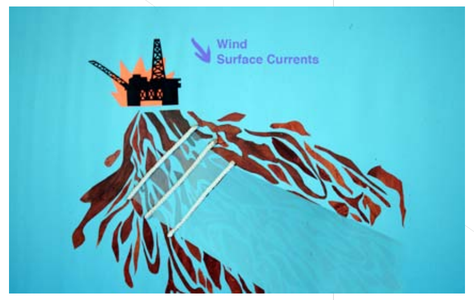
The map belows shows the extend of the oil sheens (black area), surface currents (black arrows) and the local residents reporting oil spill issues (red dots).



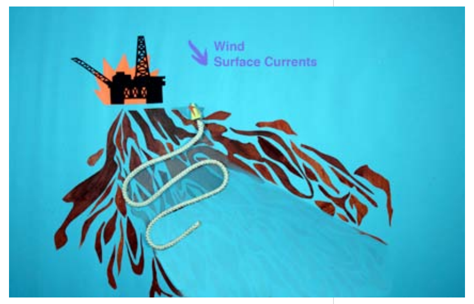
Concept

To collect light oil on the surface, repurposed fishing vessels dragged a combination of oil sorbent (white) and oil containment booms (orange). Hundreds of these vessels were deployed by fishermen who exposed their health by manually manipulating the contaminated booms. They would visually spot oil and they would not be able to operate at night, far from shore nor in rough weather conditions.

While this oil spill was a man-made disaster, but the way it behaved depended on natural forces. Oil spilled at sea spreads and drifts downwind under the influence of surface currents. We believe that the most efficient use of an equivalent length sorbent would be to push it upwind to capture the oil.



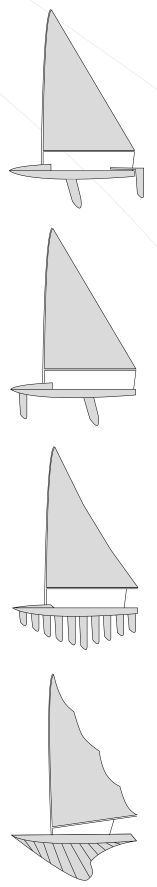
A solution would be to drag successive layers of sorbent dragged upwind, capturing oil drifting downwind. But it is very difficult to move such a large unstable structure against the strong wind and surface currents.



The initial concept for Protei was to pull a long oil sorbent boom behind a sail boat that would tack upwind, capturing the oil drifting downwind in the successive folds of sorbents.

Using the power of nature to remediate a man-made disaster.

Evolution - Versions

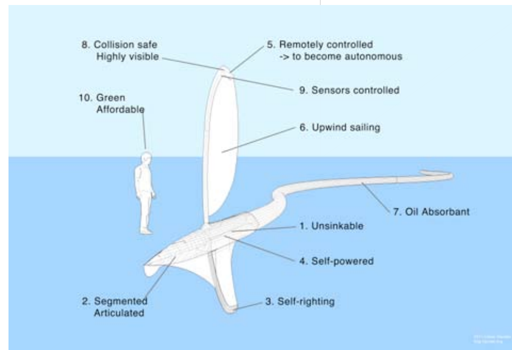


When a conventional sailboat pulls a long heavy load, it gradually looses steering (direction) and traction (pulling power). The centerboard can no longer act as axis of rotation, the rudder can no longer act as a lever on this axis of rotation, resulting in the loss of steering. The energy accumulated in the sail can no longer be transfered into general motion, resulting in the loss of traction.

What we tried first was to move the rudder at the front of the vessel (Protei_001). We observed that a front-rudder on a remote controlled boat could pull a long heavy load.

Inspired by these results we made the hypothesis that multiple surfaces of control (rudders) would likely enhance steering, traction and fullfill the function of a centerboard as well. We build Protei_002 as a fully articulated hull sailing vessel that had remarkable sailing properties.

Protei_003 was a very large inflatable flexible sailing boat. With it's extreme light weight, and large sail surface, it had great pulling power. It gave us the confidence to scale up and envison Protei as a viable technology for autonous sailing and oil spill clean-up applications.



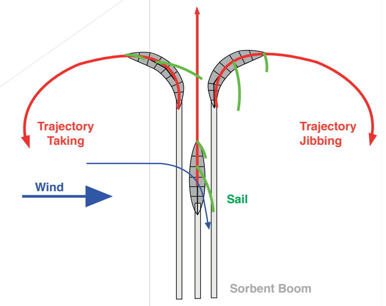
Protei version 006 (on the back of this print) is the most recent of this young series of experiments. Our engineering priorities are :

- Unmanned : to not expose cleaners health.
- Self-righting : to operate in any weather, day and night, far from shore
- Energy autonomous : using renewable energies (solar, wind) instead of oil engine.
- Affordable and green.
- Open Hardware : so the technology can evolve and be deployed fast in different locations.

Sailing innovations?

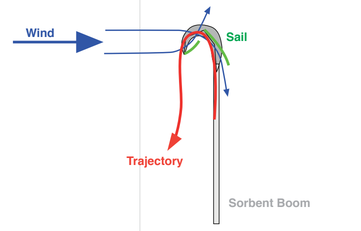
Shape-shifting Hull?

At this stage, Protei's intriguing shape-shifting hull poses a lot of questions and could potentially contribute innovations to the science of sailing. Could Protei's bending hull enhance steering and traction? Would Protei's continuous hull lines (no rudder, no centerboard) provoke less flow separation, create less turbulences hence less resistance?



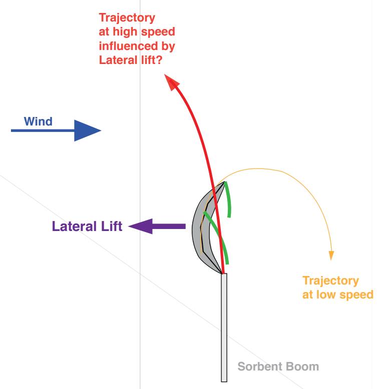
Upwind Sailing?

When a conventional sailboat tacks, there is a short moment it faces the wind, and the sails are in irons. The bending hull is meant to avoid this problem: when pulling a long load, what if Protei stops, or even pulls back, entangling in its tail? On Protei_002, our first prototype with a fully articulated hull, we observed that bending the bow into the wind when tacking helped the jib to tack much faster, while the mainsail was still powered. Can we achieve a continuous traction and minimize speed losses during tacking, even when pulling heavy loads?



Lateral Lift at High Speed?

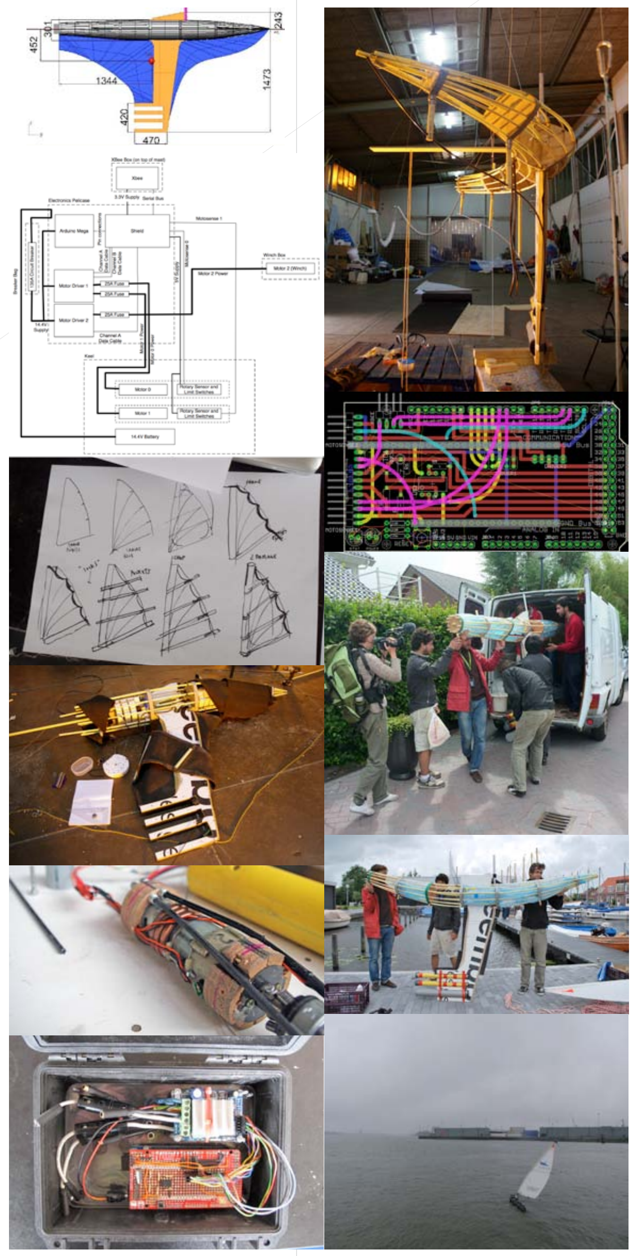
In order to optimize speed, could we make the entire hull a lifting profile, like an airplane or an hydrofoil? If we were going at sufficient speed, would the entire profile of Protei act as a hydrofoil and create lateral lift? If that was the case, could Protei's hull curvature allow Protei to sail faster and closer to the wind?



Flexible = Rugged?

Protei is flexible, unstable but self-rights easily. The hull follows the movement of waves suggesting a new and radical approach to the engineering of autonomous sailing vessels.

Protei_006 Design



Protei_006 is a 3m remote-controlled sail boat. It has a segmented, shape-shifting hull, constructed of flexible spines that run lengthwise through cross sectional bulkheads and bend under stress. A flexible EPDM-Foam skin encases the skeleton. For steering and control, Protei_006 has three motors. The first one rotates a winch to control the trim of the sail. The other two are attached to linear actuators that each control the articulation of the bow and the stern independently. The battery and linear actuators are at the bottom of the keel, along with a 25kg lead ballast providing the stability and self-righting moment. The main electronics, the winch, and the GPS are housed in the waterproof compartments of the hull.

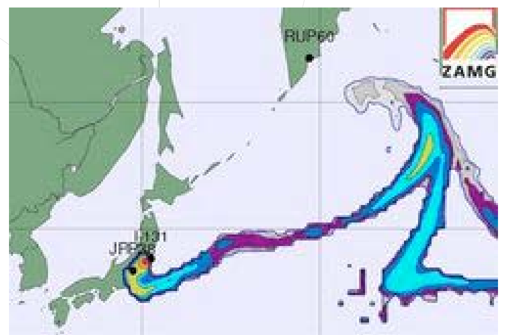
We learned a lot from designing, building and testing this prototype . We will use this knowledge to build the next prototypes of Protei.

Length overall : 3.0 m
Beam : 0.42 m
Mast height : 3.78 m
Max draft : 1.47 m
Voltage : 14.4 V
Max current draw : 45 A
Displacement : 120 kg
Desired steady state speed: 2 knots
Passengers : 0
Radio com range : 500 m
Microcontroller : Arduino Mega 2560
Wireless com : Xbee Pro 900 Serie1
GPS : MediaTek MT3329 GPS

Other Applications

It is not about asking ourselves IF another oil spill will happen, but WHERE and WHEN it will hit. Oil spills are happening all the time, everywhere. The oil spill risk is getting more intense as we always need more oil, drilling deeper and in more isolated and poorer areas. We need technologies that can adapt to these different contexts.

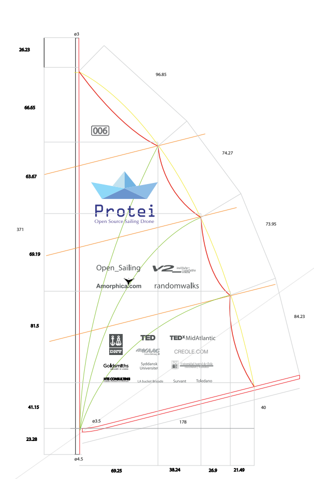
On March 11th 2011, a magnitude 9.0 undersea megathrust earthquake hit off the coast of Japan, followed by a series of tsunamis. More than 20.000 people died instantly. The tsunami also hit the Fukushima Daiichi Nuclear power plant causing a class 7 nuclear accident. The Tohoku region is currently in the most dramatic nuclear crisis since Chernobyl. Most radiation is currently being carried to the ocean by the dominent winds and we need more radioactivity measurments at sea. It is critical to have "disposable" drones for this purpose.



Estimates say that between 7 and 15 millon square kilometres in the North Pacific Ocean contain unusualy high accumulation of small suspended plastic particles (Marks, Kathy 2008). Sea creatures can mistakenly ingest plastic debris instead of food and step by step the plastic moves up the food chain to end up in our plates where they return us the toxic we produced. Similarly to oil, pastic moves with the wind and surface currents to reach these areas of convergence called "gyres". Autonomous boats that use these natural patterns (wind, surface current) could do the very repetitive task of pulling fine nets to collect the millions of tons of plastic with which we have contaminated our oceans (Moore 2008).

We hope that Protei can be integrated and fill gaps in diverse oceanographic research projects as well as being a technology that is sufficiently reliable and affordable to serve as a platform for new research.

Open Hardware & Crowd-sourcing



At Protei we believe that a good environmental technology should be made available for everyone. We have chosen the Open_Hardware licensing, so that everyone is invited to use, modify and distribute our designs for free. The only obligation is to mention "protei.org" and share back with the community the improvements you have made to the technology. By using Protei concepts and technologies, you implicity agree with these terms, which are aimed at making sharing simple and fair to everyone involved, for greater good.

Since Open_Hardware is a recent form of intellectual property setup, we have covered our different productions with appropriate regulations (below). Thank you for your interest and for using Protei Technologies, an Open_Sailing Project.

Object, mechanical design	Documentation, texts, photos, videos, communication materials	Source code	Name, trademark
open hardware	Creative Commons BY-SA	GNU General Public License, version 3 (GPL-3.0)	US trademark regulation #85339997

Protei_006 | 2011 09 02

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All our 300+ Kickstarter backers !, Florentijn Hofman and Kim Engbers, Shannon Dosemagen, Marnix de Nijs, Diana Wieser, Dana Braff, Jasper van Maede, Jean-Grégoire Kherian, Earl Scionneaux III, Jessica Rohloff, Nae Morita, Nick Kaufmann, Kinia Adamczyk, Justin Stahlman, Transocean, NASA, Greenpeace, Google, NOAA, LA Bucket Brigade, Rutgers U, Willem Plet, ZAMG, Algalita Foundation,

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