MARITIME ROBOTICS

lilafisch

- 32c3: Graphs, Drones and Phones
- 32c3: So you want to build a satellite
- 32c3: REXUS/BEXUS – Rocket and Balloon Experiments for University Students
- 31c3: Rocket science – how hard can it be?
- 31c3: Living Drones
- 31c3: Space Hacker
- 30c3: Drones
- 30c3: Die Drohnenkriege
- 30c3: Lasers in space

  …

Robots are crawling the lands...
And flying through the air...
Some of them even made it to space...
So what about the sea?

Gated Communities of the Oceans

'Ocean Floor Factory'

- Oil & Gas
- Military
- Other resource mining (fish, diamonds, minerals ...)

Image from http://www.macleans.ca/wp-content/uploads/2013/04/MAC16_OILRIGS01www.jpg

Hackers, I call thee to our oceans,
where (while?) there are still dragons to find!

The Squidworm - A New Species

The squidworm (*Teuthidodrilus samae*), a swimming polychaete, was first discovered by Census of Marine Life researchers in the Celebes Sea at about 2800 meter depth in 2007.

Credit:

L. Madin, Woods Hole Oceanographic Inst. (WHOI)

(www.cmarz.org)

Hackers, I call thee to our oceans, where (while?) there are still dragons to find!

Flapjack Octopus

Opisthoteuthis sp.

This cool-looking creature belongs to an unusual group of octopuses that have webbing between their arms. Often observed sitting on the seafloor, this octopus swims by flapping its fins to hover just above the bottom. It can pulse the web of arms and push water through its funnel for more rapid escapes. MBARI scientists think this is a new species of flapjack octopus. We've collected some specimens to study here at the Aquarium.

Depth range: 984 to 1,476 ft. (300 to 450 m)

Size: diameter to 7 in. (18 cm)

Hackers, I call thee to our oceans,
where (while?) there are still dragons to find!

Can we update the "95% unexplored oceans" meme, I wonder?
theconversation.com/just-how-littl ...

Moon — 100% mapped
...at ~100 m resolution (NASA)
& at ~7 m resolution? (China)

Mars — 100% mapped
...at ~100 m resolution &
~60% at ~20 m resolution

Earth's ocean — ~~5% mapped~~
100% mapped at max ~5 km resolution
~10-15% mapped at ~100 m resolution
<0.05% mapped at 1-2 m resolution

RETWEETS 103   LIKES 58

8:24 AM - 9 Oct 2014

Jon Copley
@expeditionlog

Biologist exploring deep-sea vents & new species of marine life around the world; 1st British person to dive beyond 5 km (3.1 miles) deep.

Joined January 2009

Home   About
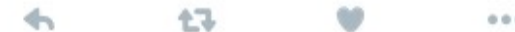
Image sources (in order of appearance):
- http://ocean.si.edu/slideshow/census-marine-life-wild-and-wonderful-creatures
- http://www.montereybayaquarium.org/animals-and-experiences/exhibits/mission-to-the-deep
- https://twitter.com/expeditionlog/status/520233310753419265
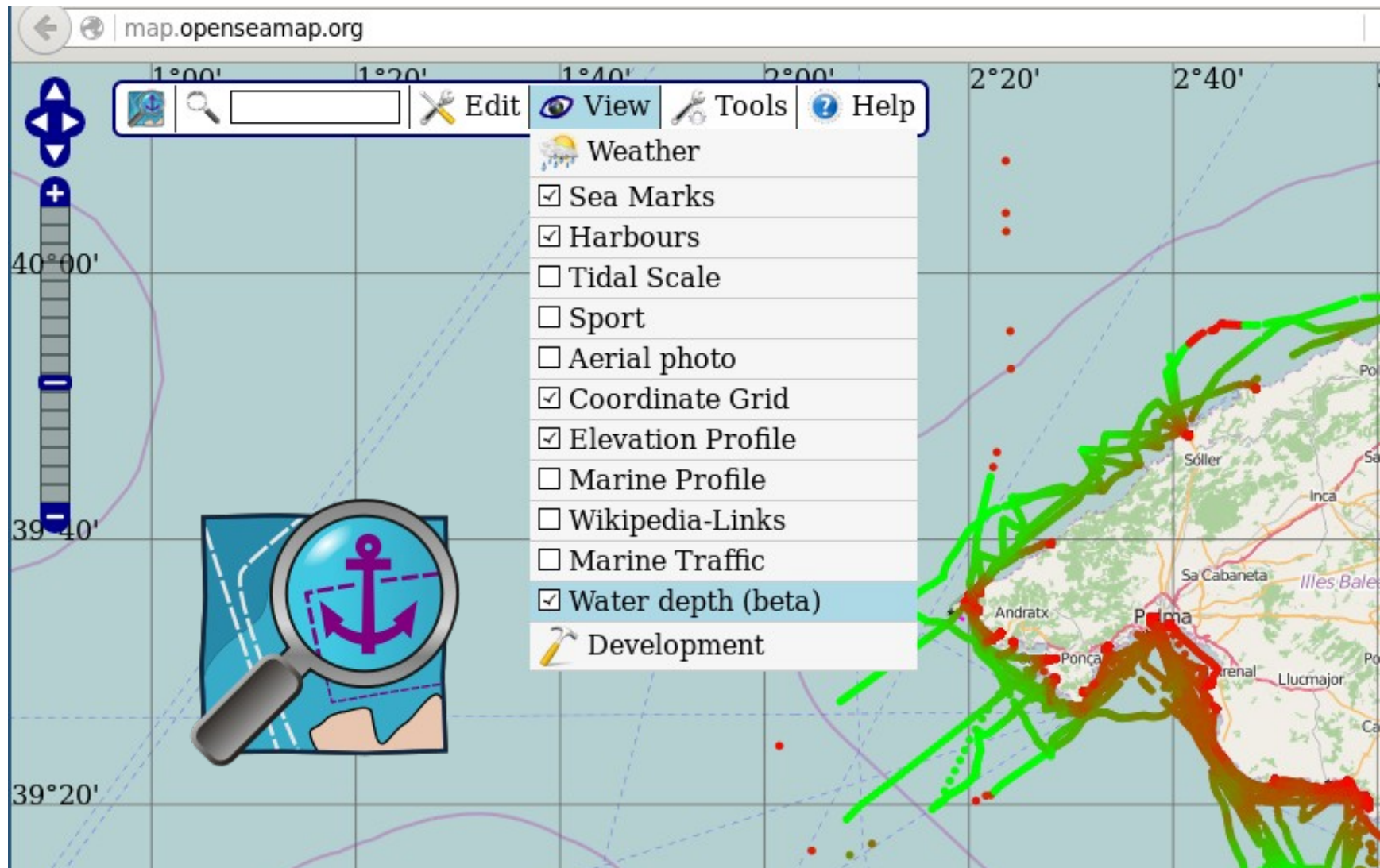
And so much more to do!

- Challenge – Because just building a robot isn't difficult enough!

  TODO: FIND IMPRESSIVE PIC OF BROKEN MARITIME ROBOT!!!!!!

And so much more to do!

- Challenge – Because just building a robot isn't difficult enough!

TODO: FIND IMPRESSIVE PIC OF BROKEN MARITIME ROBOT!!!!!!
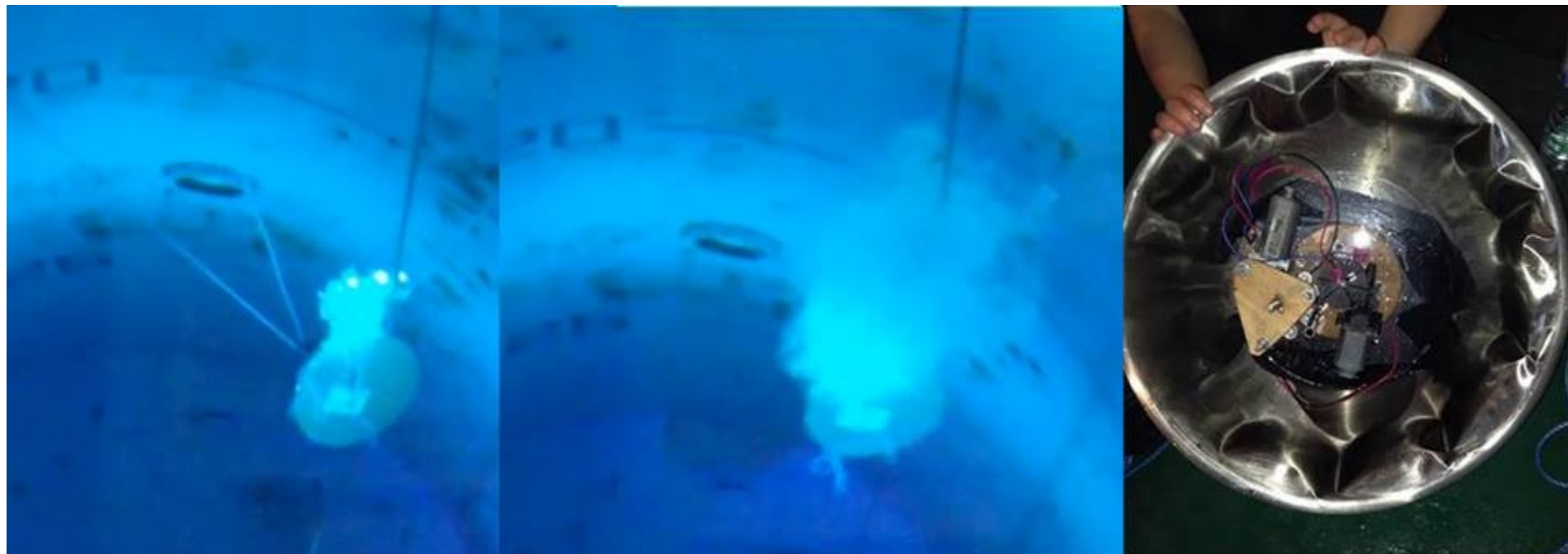
And so much more to do!

- Challenge
- Generate more data – And share it openly!

globalfishingwatch.org

AIS Automatic Identification System

https://www.vesselfinder.com/

And so much more to do!

- Challenge
- Generate more data
- Archeology – Check out the hidden treasures in your nearest puddle/lake/ocean!

(Monkey Island 2 gameplay screenshot)

And so much more to do!

- Challenge
- Generate more data
- Archeology
- Environmental monitoring
  - Why does the water coming out of this pipe next door glow in the dark?
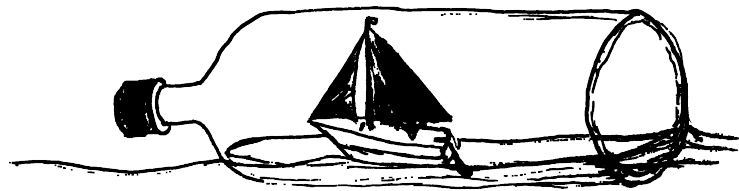
(Day of The Tentacle gameplay screenshot)

Maritime Robots Family Tree
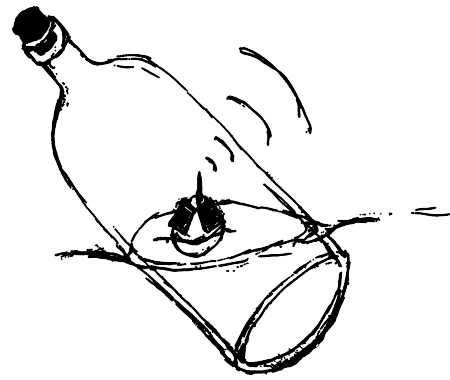
– The Sensor Buoy

http://www.bornhoeft.de/en/newsneu.html

Maritime Robots Family Tree

– The Sensor Buoy

http://www.oceanor.no/seawatch/buoys-and-sensor/wavescan

Maritime Robots Family Tree

- The Sensor Buoy

- The Traveler

http://www.automarinesys.com/recent-testing/

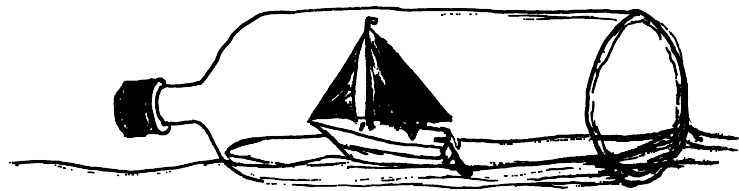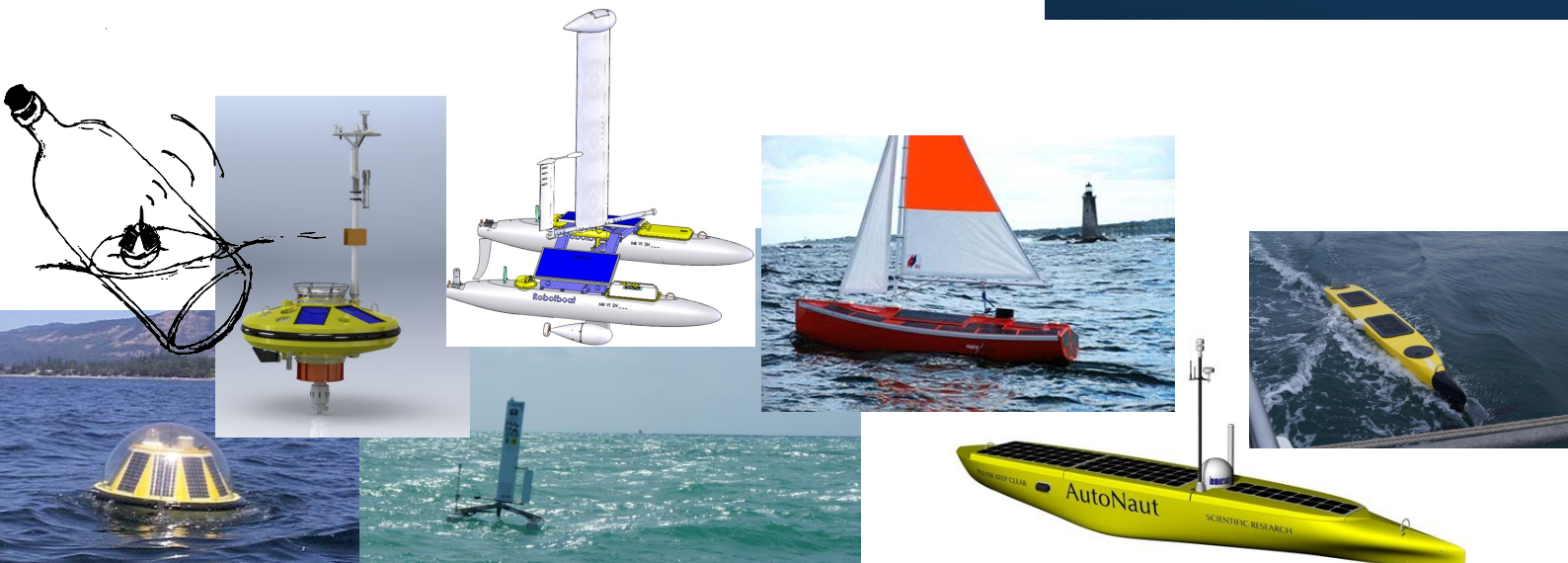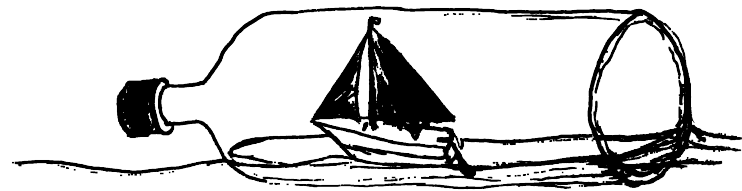https://www.kickstarter.com/projects/robotboat/robotboat-mark-vi/description

Maritime Robots Family Tree

- The Sensor Buoy

- The Traveler

http://navocean.com/tag/waveglider/

Maritime Robots Family Tree

- The Sensor Buoy
- The Traveler

http://www.autonautusv.com/wp-content/uploads/2013/11/DSC04717-800x530.jpg
https://twitter.com/AutoNautUSV/status/585437452254478336
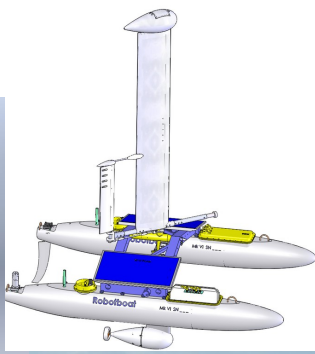
Maritime Robots Family Tree

- The Sensor Buoy

- The Traveler

https://cdn3.dogonews.com/pictures/9197/content/gliderWaveGliderMotion.jpg?1321224868

http://www.liquidr.com/images/galleryfull/lri-img-MidLaunchWaveGlider.jpg
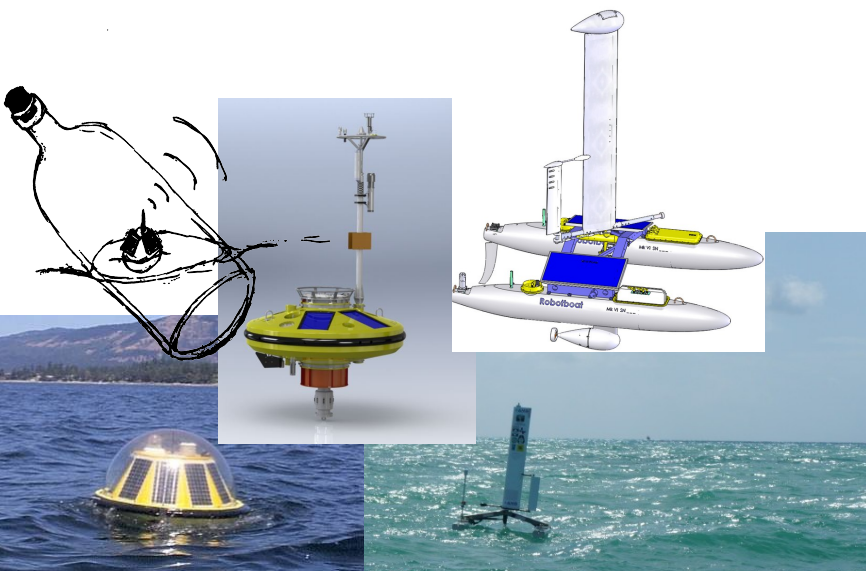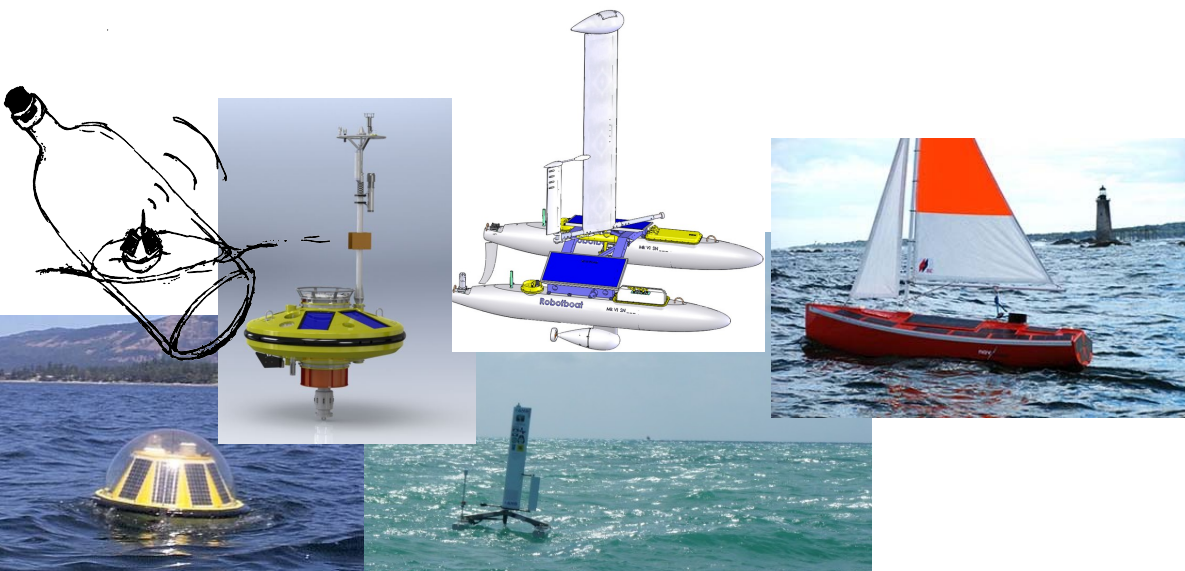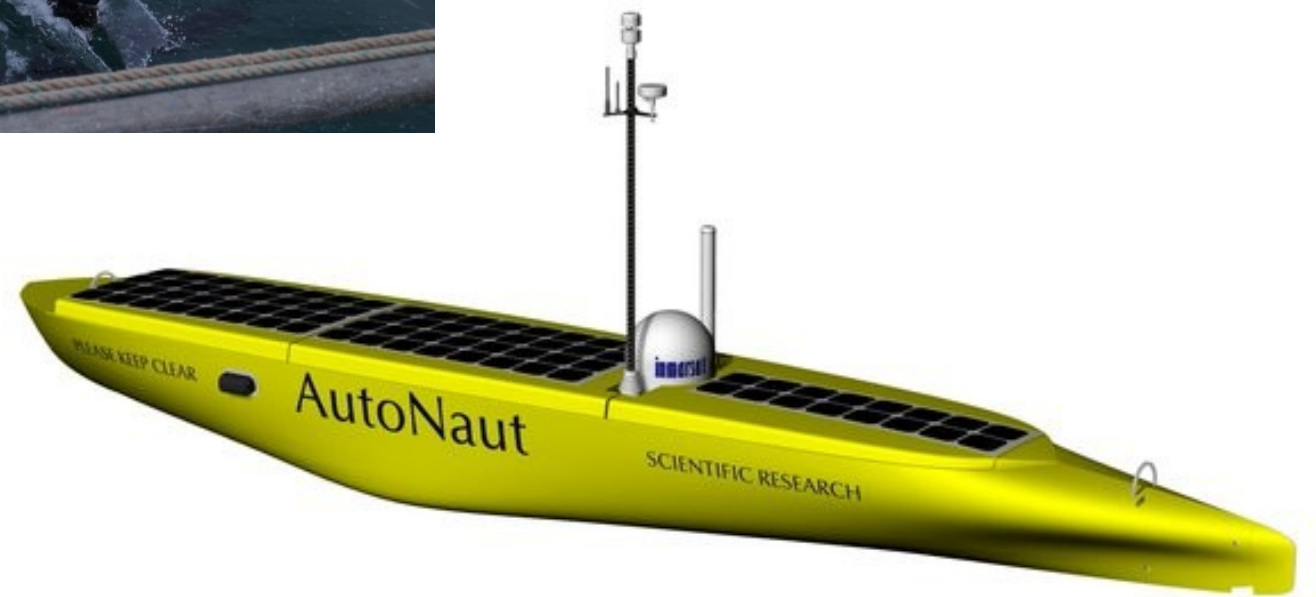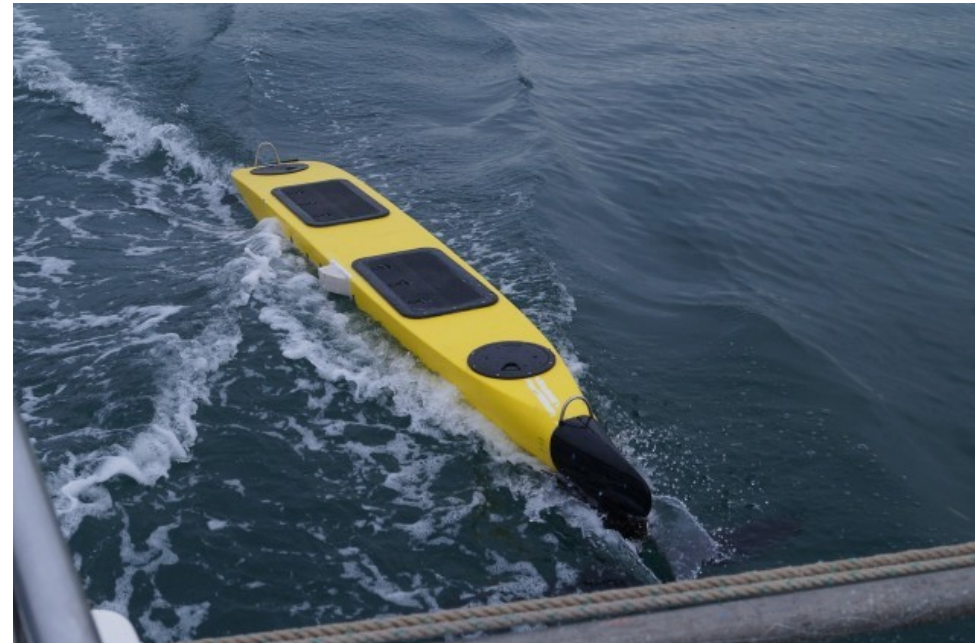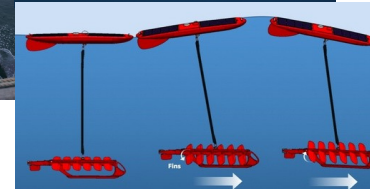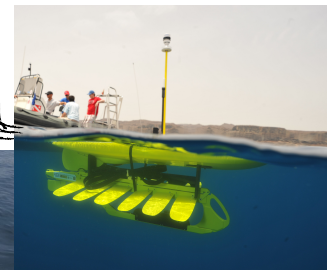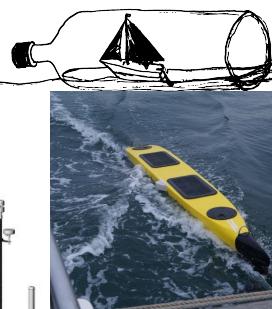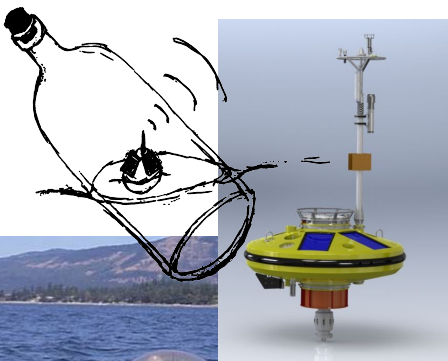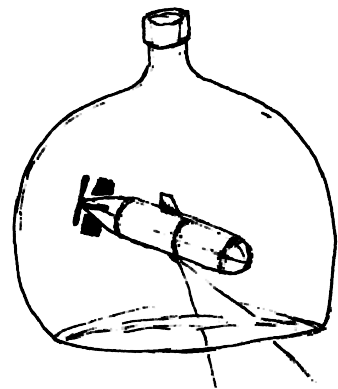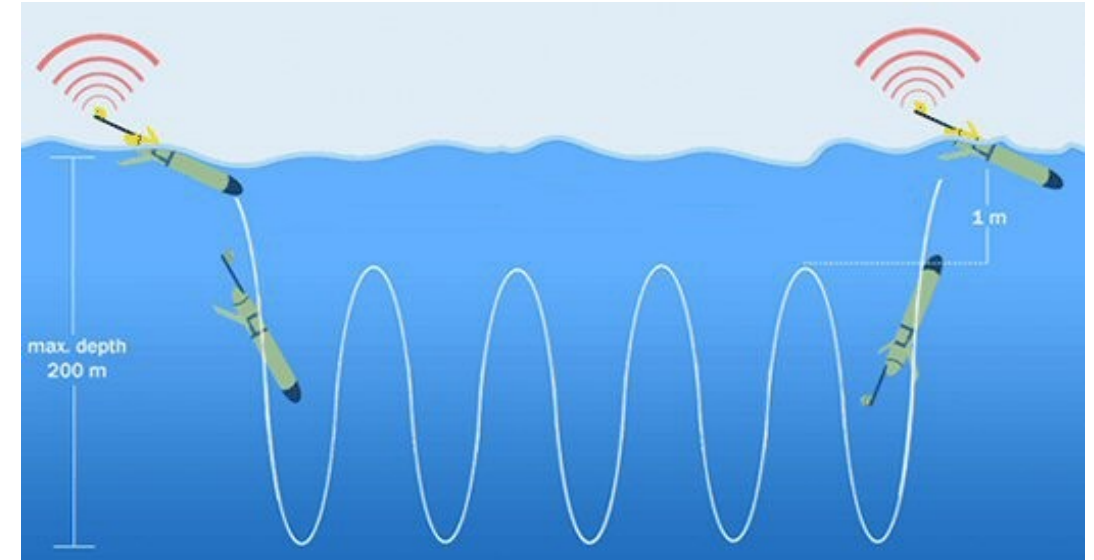
Maritime Robots Family Tree

- The Sensor Buoy
- The Traveler
- The Underwater Airplane

Maritime Robots Family Tree
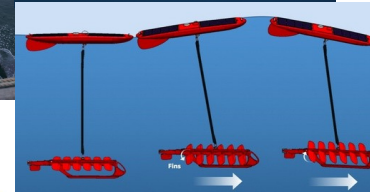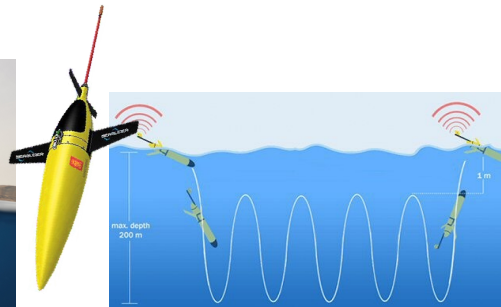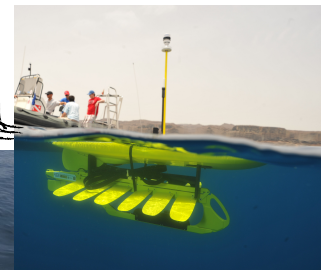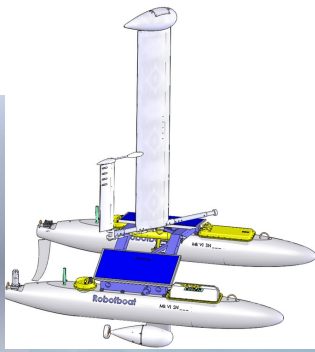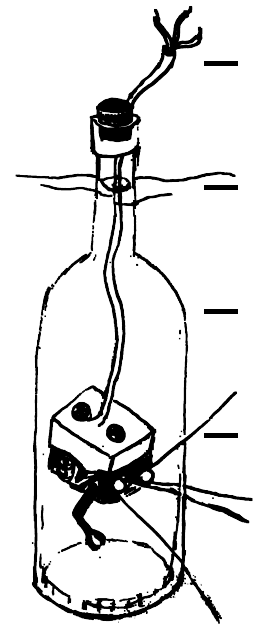
- The Sensor Buoy
- The Traveler
- The Underwater Airplane

http://noc.ac.uk/news/autosub-long-range-auv-completes-its-first-sea-trials
https://www.srcf.ucam.org/polarauvguide/auvs/caseStudies/usips.php

Maritime Robots Family Tree

- The Sensor Buoy
- The Traveler
- The Underwater Airplane
- The Diving Box

http://www.auv2016.org/

Maritime Robots Family Tree

- The Sensor Buoy
- The Traveler
- The Underwater Airplane
- The Diving Box

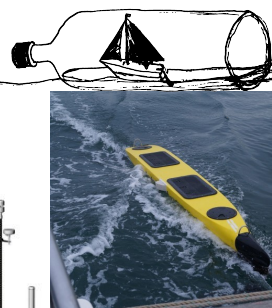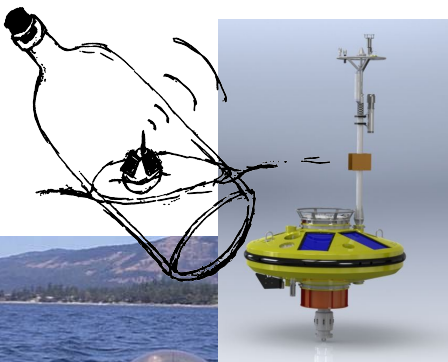http://www.bbc.com/news/magazine-24457875
http://www.mbari.org/dmo/vessels_vehicles/rov.html

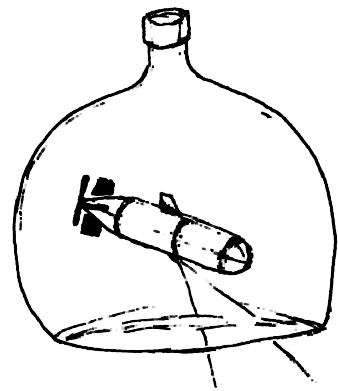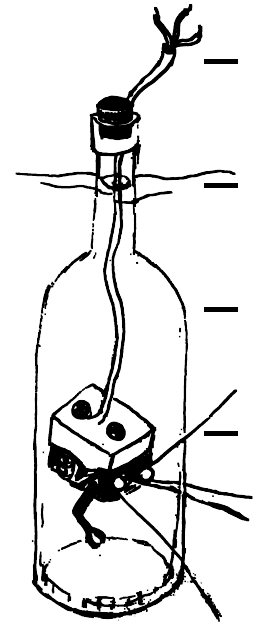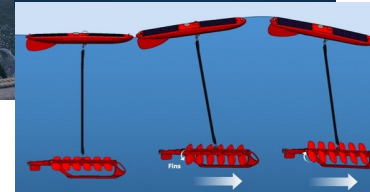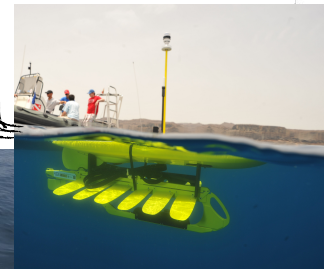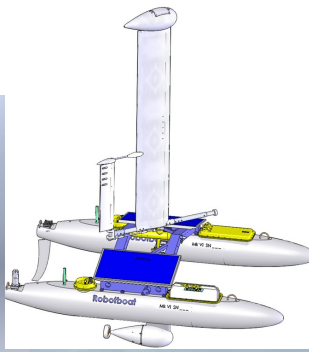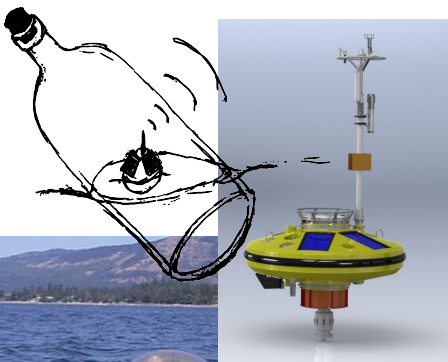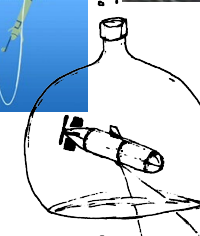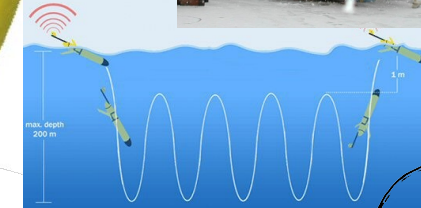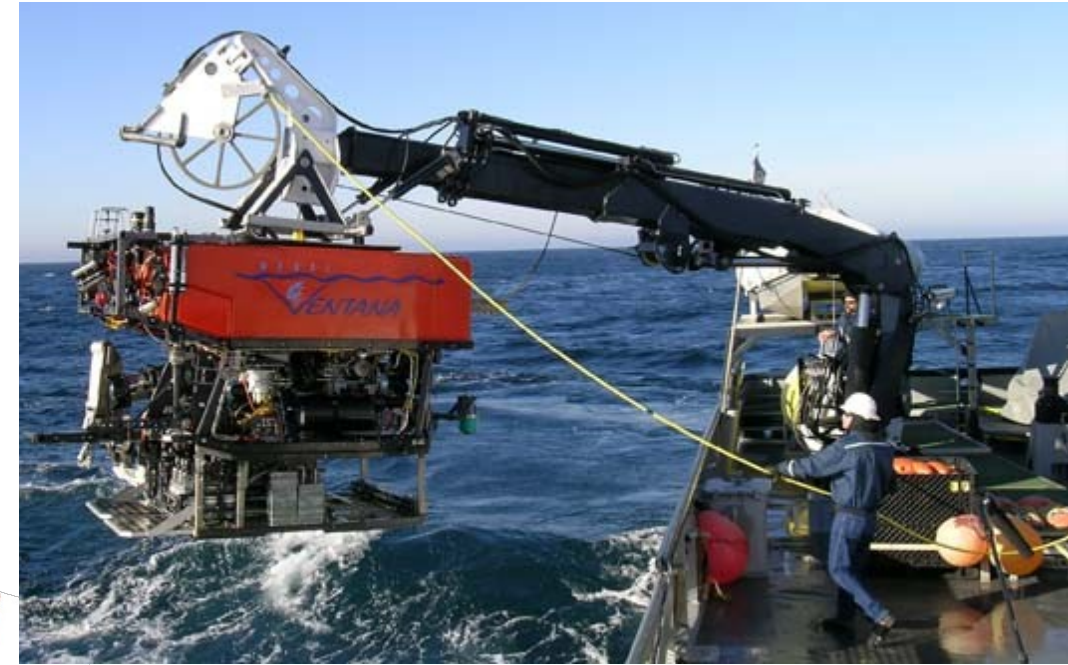# Maritime Robots Family Tree

- The Sensor Buoy
- The Traveler
- The Underwater Airplane
- The Diving Box
- The Wild Cards

http://sepios.org/
http://www.ics.forth.gr/cvrl/octopus/gallery.html
http://scoutbots.com/blogs/news/15204209-test-of-protei-011-1-at-sea
http://mechatronic.me/robotics/74-underwater-walking-robot-crabster-cr200

Buoyancy

+ You can be positive about your robot coming back.

0 Gravity free floating :D

- No need to feel negative, as long as you can drop some weight
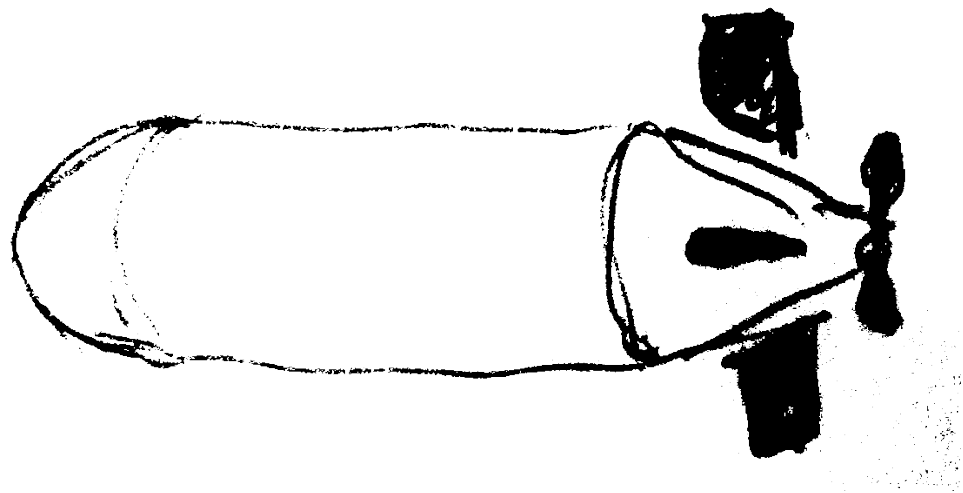
Buoyancy

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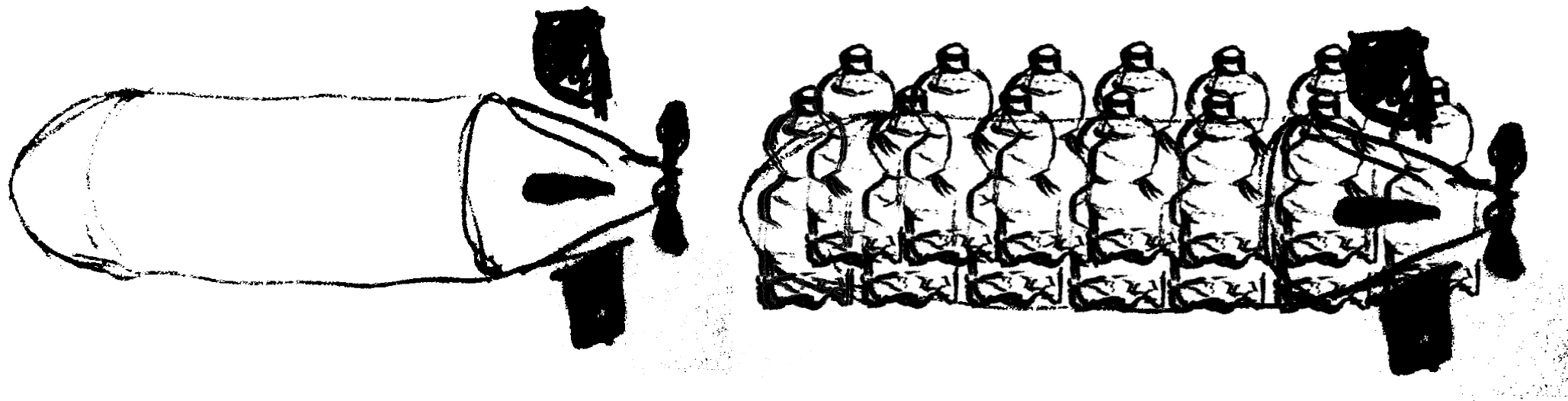
Buoyancy

\+   You can be positive about your robot coming back.

0   Gravity free floating :D

\-   No need to feel negative, as long as you can drop some weight

Pressure

- Rule of thumb: Earth athmosphere $\triangleq$ 10 metres water depth $\triangleq$ 1 bar

- Buckling Pressure for Sphere $\sim \left(\dfrac{Thickness}{Radius} \right)^2$

- Ping pong balls: ~ 25 m depth
- Average Ocean Depth: 4 km
- Maximum Ocean Depth: 11 km
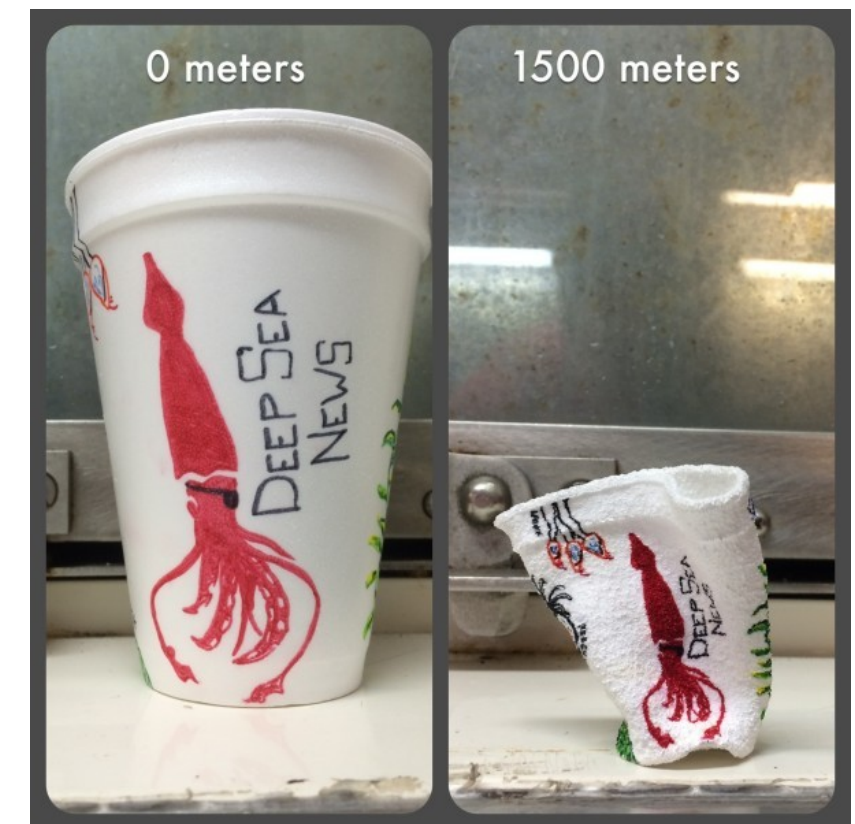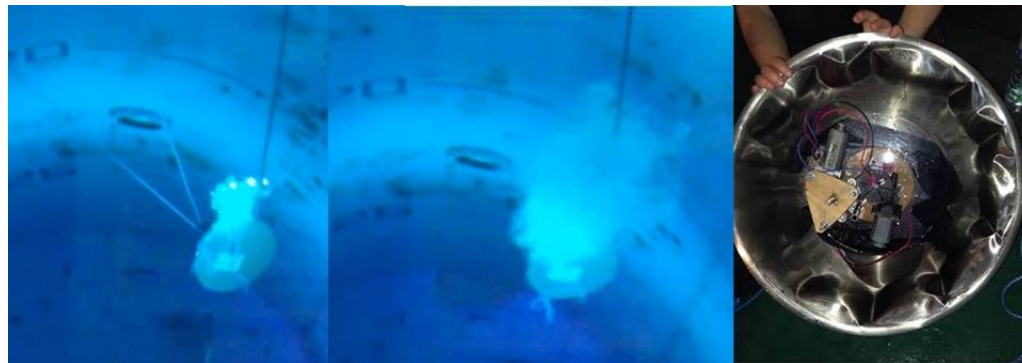
http://kwc.org/mythbusters/2004/11/mythbusters_ping_pong_balls_an.html

http://www.deepseanews.com/2014/05/how-to-shrink-a-styrofoam-cup-and-other-side-effects-of-deep-ocean-pressure/

Pressure

- Rule of thumb: Earth athmosphere $\hat{=}10$ metres water depth $\hat{=}1$ bar

- Buckling Pressure for Sphere $\sim \left(\dfrac{Thickness}{Radius} \right)^2$

- Implosion -> Replace air with water
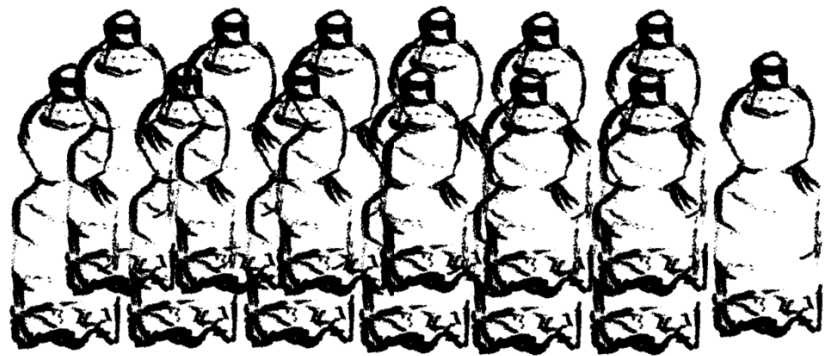
Pressure

- Rule of thumb: Earth athmosphere $\triangleq$ 10 metres water depth $\triangleq$ 1 bar

- Buckling Pressure for Sphere $\sim \left(\dfrac{Thickness}{Radius} \right)^2$

- Implosion -> Replace air with water
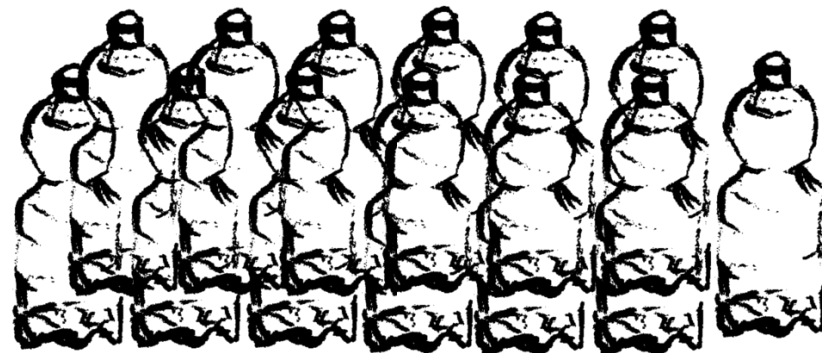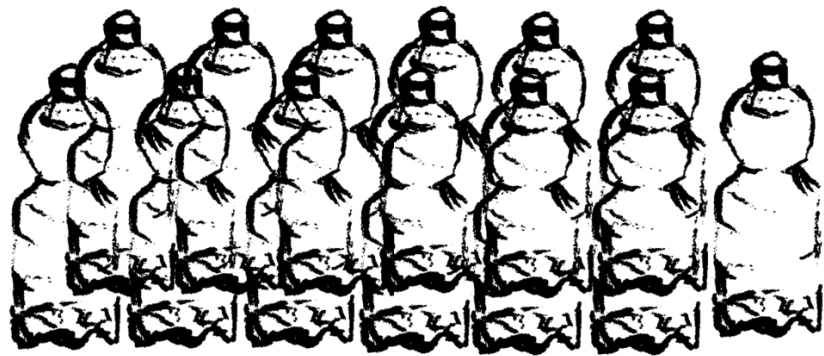
Pressure

- Rule of thumb: Earth athmosphere ≜10 metres water depth ≜1 bar

- Buckling Pressure for Sphere $\sim\left(\dfrac{Thickness}{Radius}\right)^2$

Robotic Deep-sea Vehicle Lost on Dive to 6-Mile Depth

Scientists think *Nereus* imploded exploring the Kermadec Trench

FOR IMMEDIATE RELEASE

May 10, 2014   Media Relations Office
(508) 289-3340   media@whoi.edu

On Saturday, May 10, 2014, at 2 p.m. local time (10 p.m. Friday EDT), the hybrid remotely operated vehicle *Nereus* was confirmed lost at 9,990 meters (6.2 miles) depth in the Kermadec Trench northeast of New
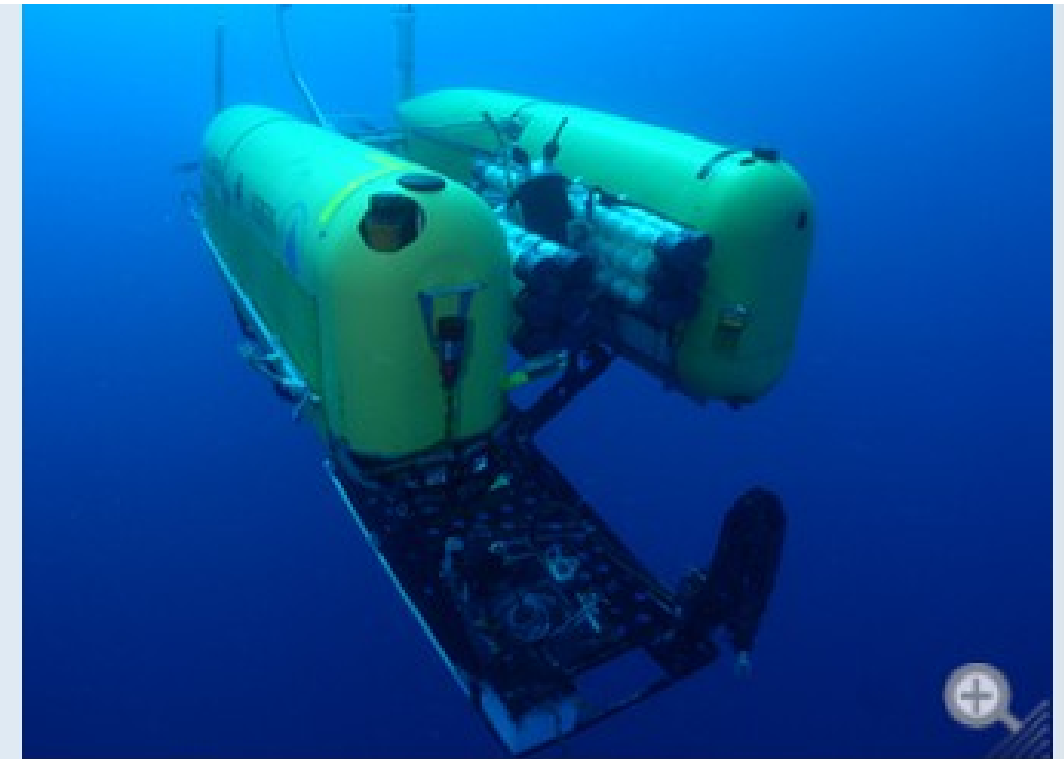
Nereus's mission was to undertake high-risk, high-reward

http://www.whoi.edu/news-release/Nereus-Lost

Communication & Orientation

Sensor Buoy & Traveler:
– GPS & Wireless communication (→ iridium SBD)

Underwater Airplane & Diving Box:
  Goodbye radio waves...

  UV/blue best candidate in EM spectrum

Communication & Orientation

Sensor Buoy & Traveler:
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Underwater Airplane & Diving Box:
Goodbye radio waves...

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Communication & Orientation

Sensor Buoy & Traveler:
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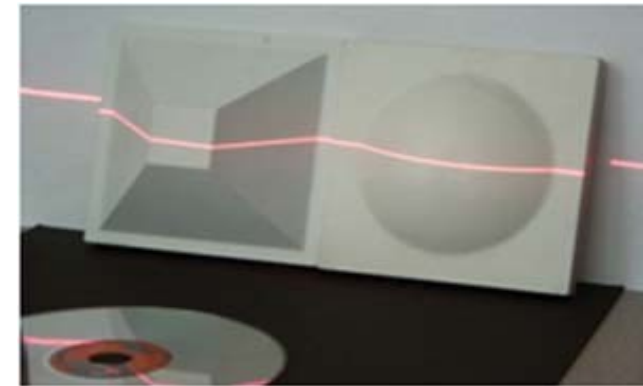Underwater Airplane & Diving Box:
Goodbye radio waves...

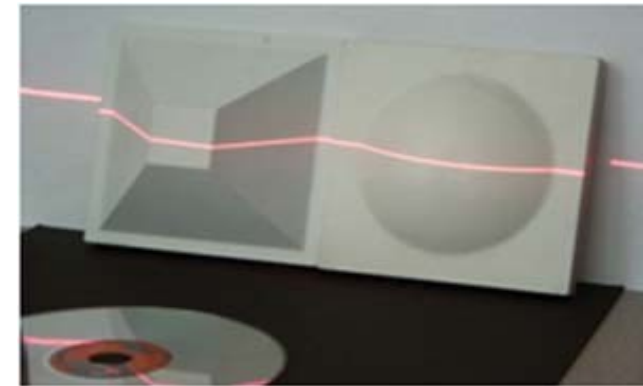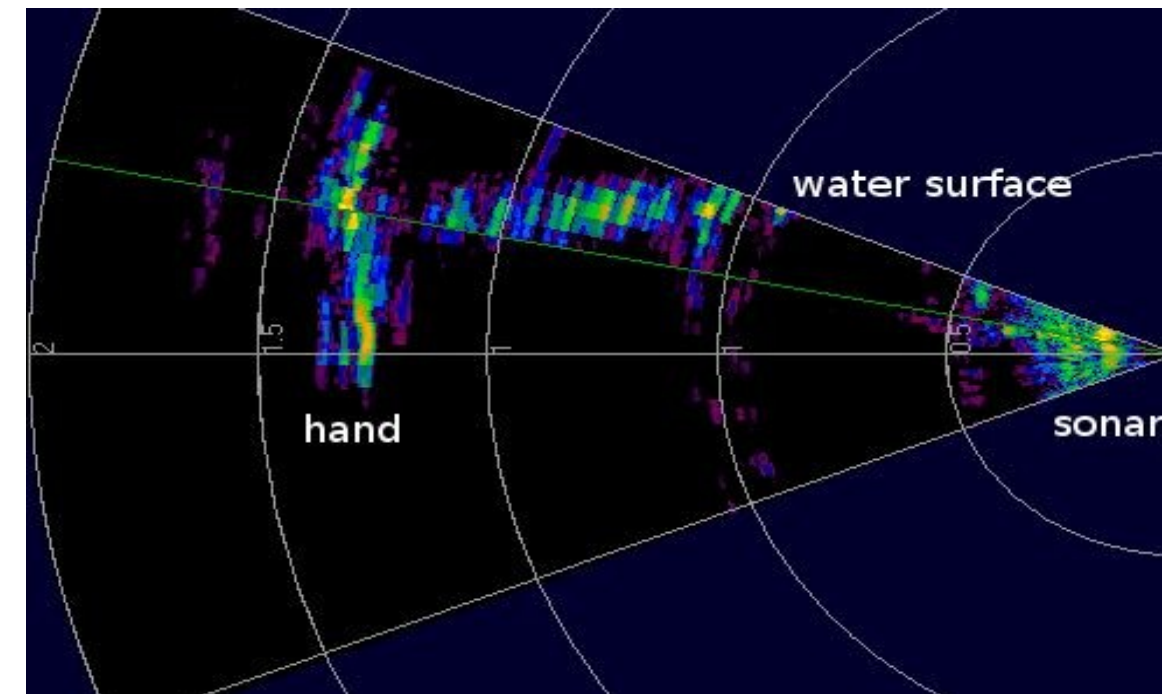UV/blue best candidate in EM spectrum

… hello acoustic waves

Sonar

Speed of sound in water: ~1500 m/s (light speed: 3* 10^^8 m/s)

Beam opening angle: 1 degree → Pixel width: sin(1°) * Δx

- 10 m: ~20 cm
- 100 m: ~2 m

1 m long, 20 cm wide robot

2m

2m

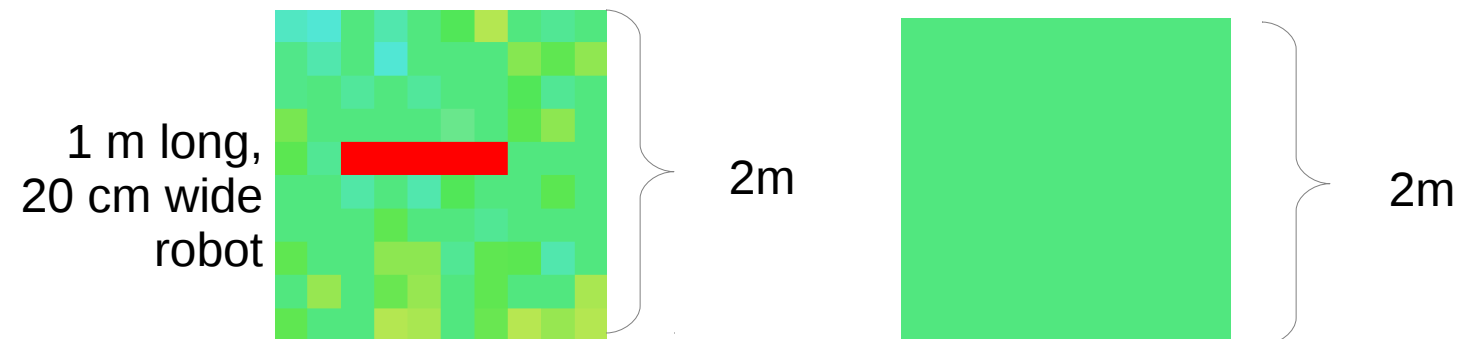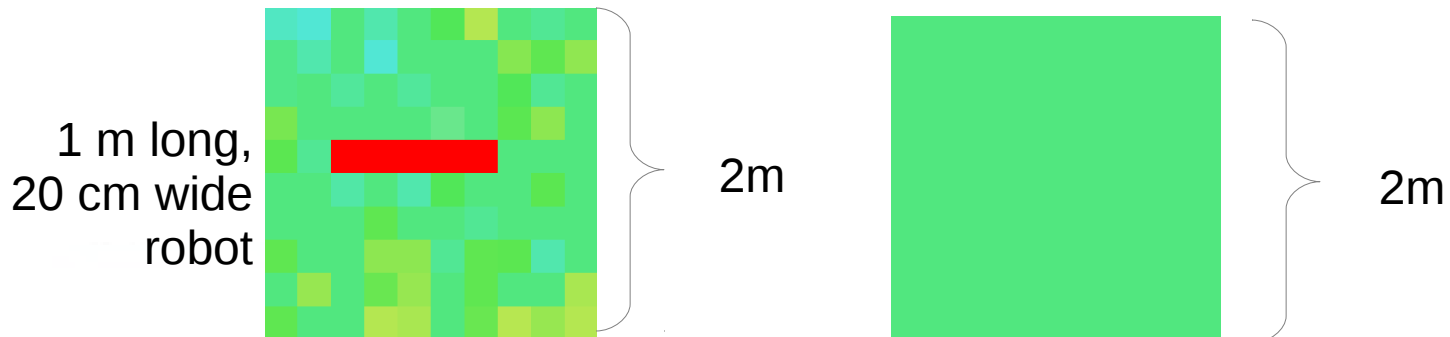# Sonar
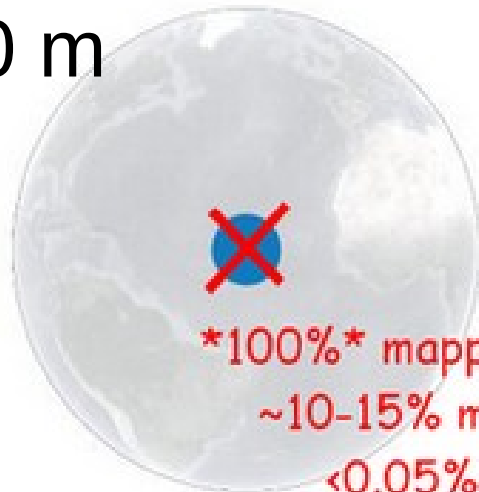
Speed of sound in water: ~1500 m/s (light speed: 3* 10^^8 m/s)

Beam opening angle: 1 degree → Pixel width: sin(1°) * Δx

- 10 m: ~20 cm
- 100 m: ~2 m
- 10 km: ~200 m

1 m long, 20 cm wide robot

2m

2m

Earth's ocean

~~5% mapped~~

100% mapped at max ~5 km resolution
~10-15% mapped at ~100 m resolution
<0.05% mapped at 1-2 m resolution

Listen!

- Communication of robots, animals
- Changes in sound propagation (~ salinity, temperature, 'stuff')
- The lower the frequency, the further it travels
- Noise:
  - Wind, Waves, Earthquakes
  - Propeller, Engine, other human noise
  - Dragons

Listen to Mediterranean Sea
check species detected

http://listentothedeep.com

- Whale song listening!
  http://www.oceannetworks.ca/sights-sounds/live-audio/ : "Hydrophone recordings are not continually available because they may sometimes contain sensitive data with national security implications. … Recordings that are deemed low risk are then returned to our archives at a later time."
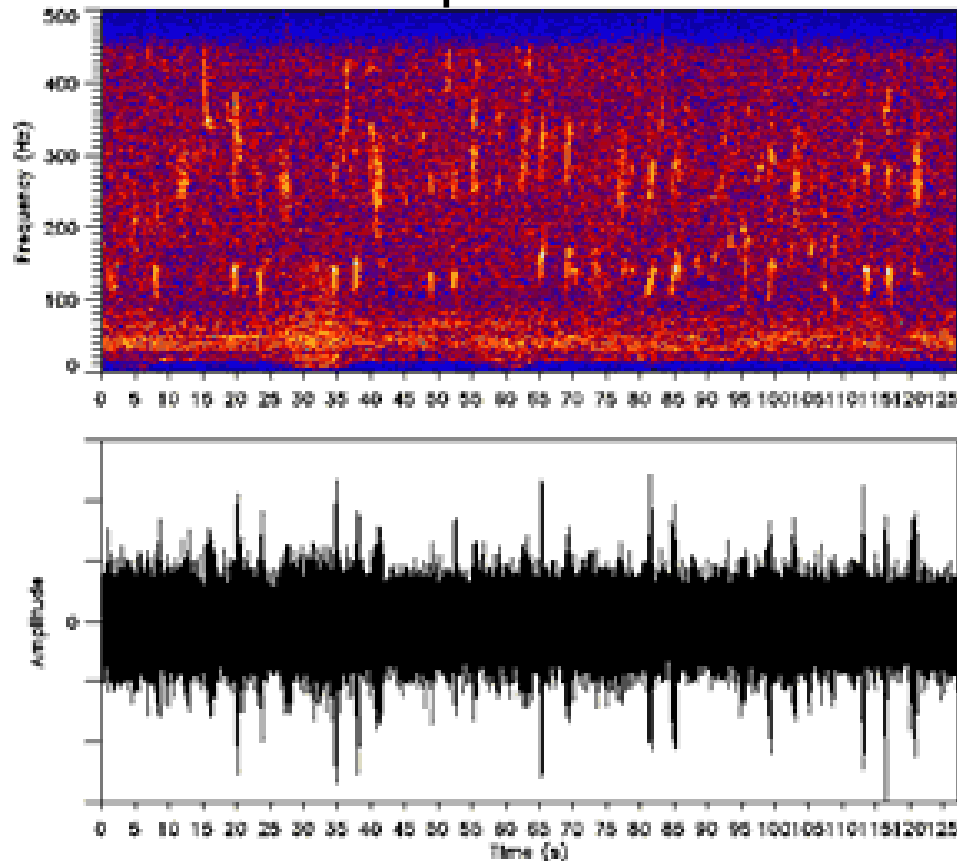
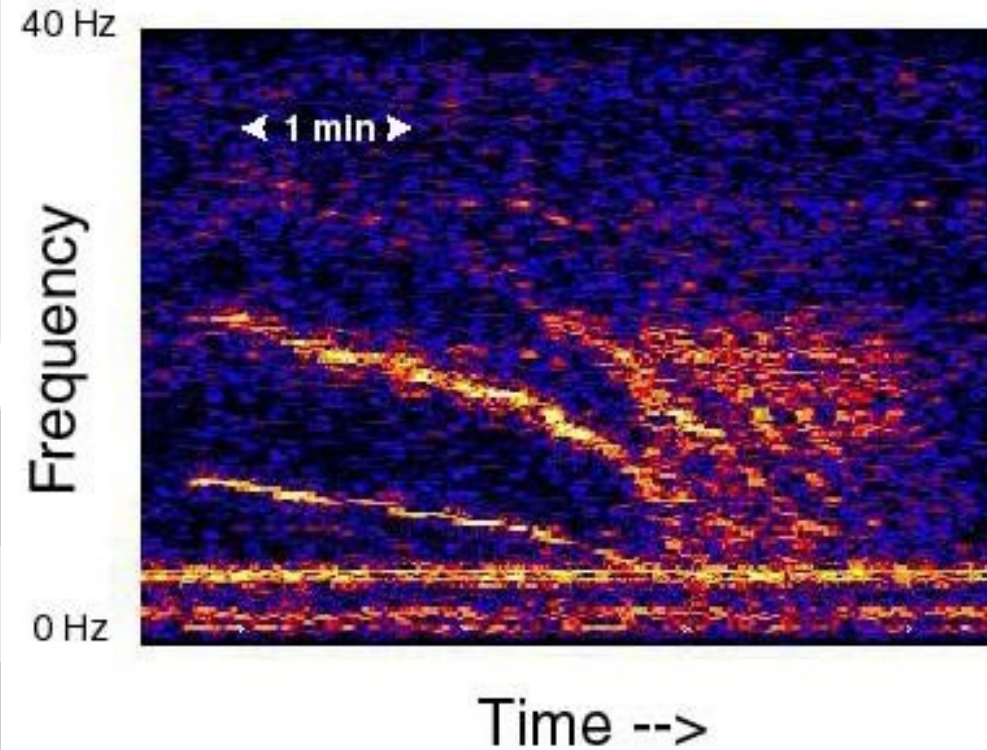# Listen!

Alaska humpback whale call

Iceberg grounding on seafloor

Airguns (explore geologic structure below seafloor)
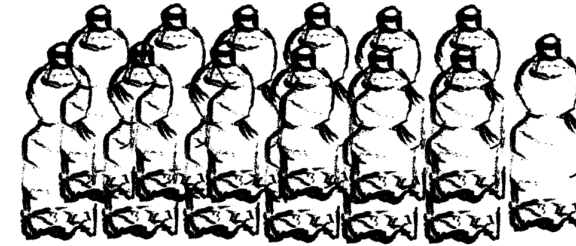

Sped up 10 times
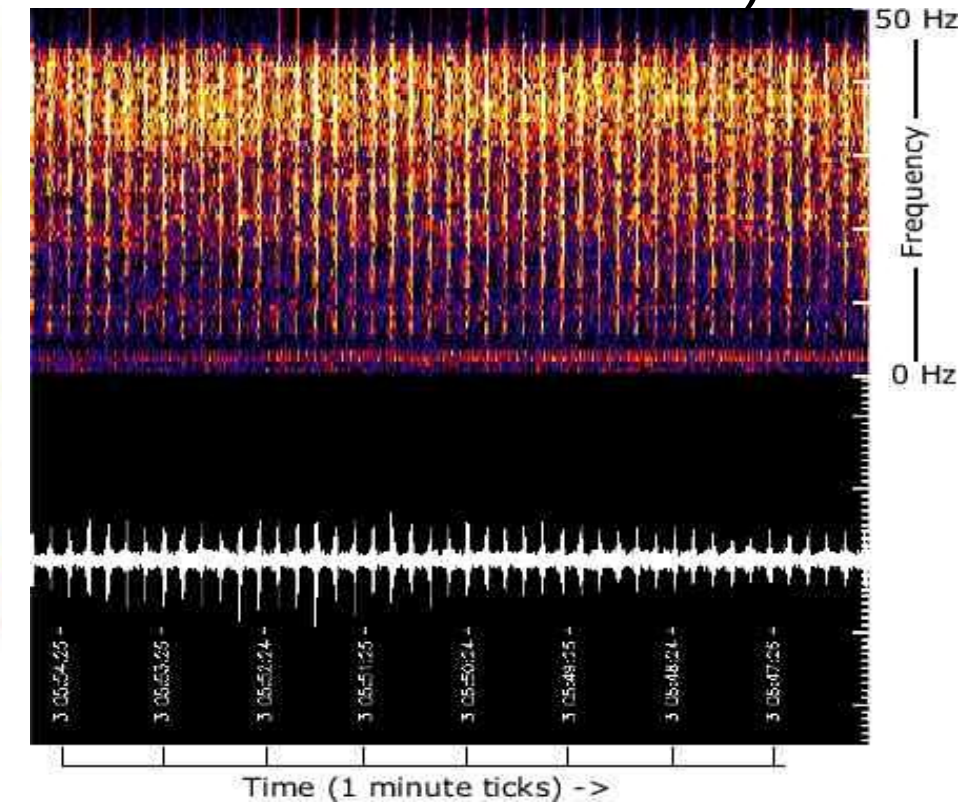
Sped up 16 times

Sped up 10 times

Sounds and spectrograms from:
http://oceanexplorer.noaa.gov/explorations/sound01/background/seasounds/seasounds.html

Not all that difficult and expensive???

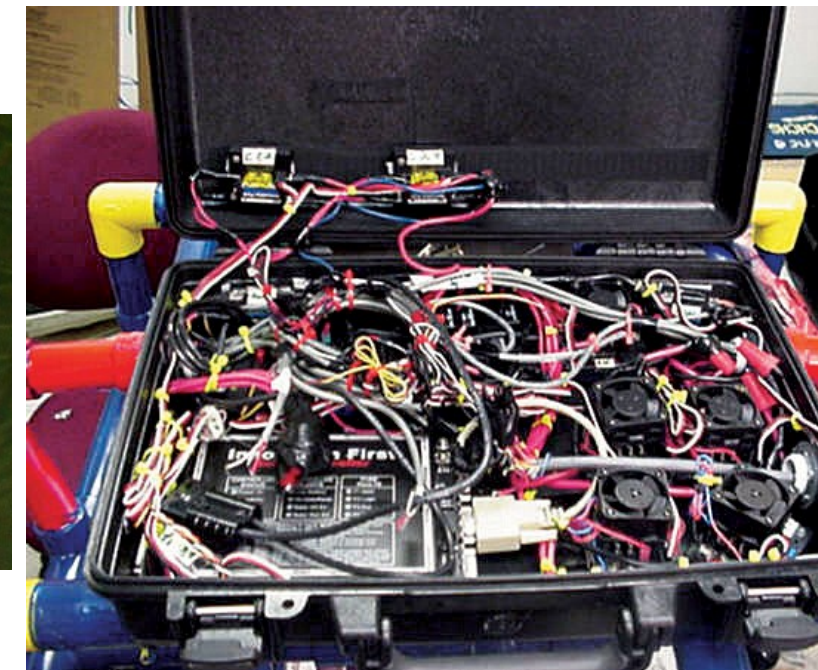Buckling Pressure ~ $\left(\dfrac{Thickness}{Radius}\right)^2$

Size is (almost) all that matters!

- Small scale, low power consumption Linux computers

- High energy density batteries

→ Smaller, lighter vehicles can be tested in/on smaller puddles

- Model Boats

- Tupperware & Pelicase

- Pipes & Bottles

- Surringes

- Tampons

- Fishfinders

- Aquarian Audio

http://www.seaglide.net/

http://www.wired.com/2014/12/4-mexican-immigrant-kids-cheap-robot-beat-mit

Communities?

- Forums
  - http://www.homebuiltrovs.com/rovforum/

  - https://forum.openrov.com/

  - http://diydrones.com/group/arduboat-user-group/forum

Communities?

- Forums
- Competitions → papers by teams
  - World Robotic Sailing Competition (Portugal, http://www.roboticsailing.org/)
  - EURathlon (Italy, http://www.eurathlon.eu/ previously sauc-e)
  - RoboBoat & RoboSub (USA, http://www.auvsifoundation.org , registration fee, 'College & High School teams') → papers from teams
  - Singapore AUV competition (http://www.sauvc.org/)
  - MATE ROV competition (USA, http://www.marinetech.org)

http://www.wired.com/2014/12/4-mexican-immigrant-kids-cheap-robot-beat-mit

Communities?

- Forums
- Competitions → papers by teams
- Challenges
  - Microtransat
  - Shell Ocean XPrize

Boat	Team	Direction	Status	Latitude	Longitude	Last Update Time	Time Sailing	End Time/Status
Snoopy	Joker	West	Started: 2015-03-18 10:57:00	50.819	-0.1453	2015-03-30 21:32:34	12 days, 9 hours, 35 minutes	Ran aground 2015-03-30 21:32:35
ABoat Time	US Naval Academy	East	Started: 2015-06-13 22:02:00	43.797	-66.157	2015-06-23 07:28:21	9 days, 9 hours, 26 minutes	Picked up by fishing boat. 2015-06-23 07:29:00
Breizh Tigresse	ENSTA-Bretagne and Dalhousie University	East	Started: 2015-09-01 18:30:00	43.784	-56.318	2015-10-04 01:01:09	32 days, 6 hours, 31 minutes	Disqualified, no position report for 10 days 2015-10-14 01:01:09

Shell OCEAN DISCOVERY XPRIZE®
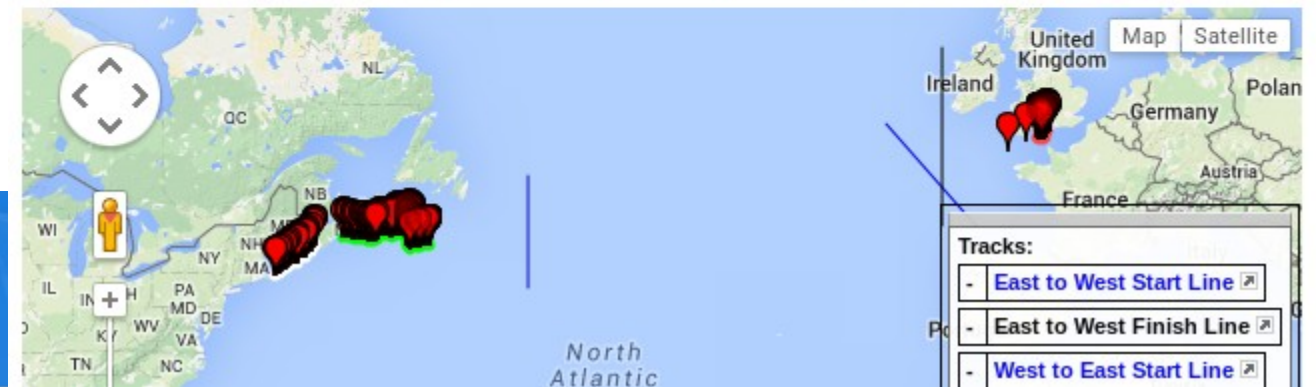
The $7 Million Shell Ocean Discovery XPRIZE is a global competition challenging teams to advance deep-sea technologies for autonomous, fast and high-resolution ocean exploration.

The success of this prize will allow us to fully explore and map the ocean floor, and uncover our planet's greatest wonder and resource for the benefit of humanity. The National Oceanographic and Atmospheric Administration's (NOAA) $1 million bonus prize will incentivize teams to develop technologies to detect the source of chemical and biological signals underwater.

Responsibility

- Legal $STUFF
- Do not litter!
- Materials harmful to maritime environment?
- Invasion of maritime life forms
- Conductivity of (salty) water
  - → skin resistance reduced

Can twitter help us find the owner of this ROV that washed ashore in Belize? Please RT! #LostROV

RETWEETS 194 LIKES 39

6:24 PM - 12 Mar 2015

Reply to @JacobLevenson

Jake Levenson @JacobLevenson · Mar 15
@JacobLevenson sounds like the #LostROV belongs to Deep Tech Oil Services...sounds like they're in touch w folks to recover it.

https://twitter.com/jacoblevenson/status/577071653982740480

Call for Community

- IRC: #maritimerobotics on freenode
- Twitter: @lilafisch
- Email: lilafisch @ muc.ccc.de
  1BB7 7178 15E8 94AC C08C 4FD8 315C 714C 0C7F 4570