EMERGING OPPORTUNITIES & CHALLENGES IN OCEAN TECHNOLOGY

Rick Spinrad, Ph.D., CMarSci

- *President-Elect, Marine Technology Society*
- *Professor of Oceanography & Senior Advisor to the Vice President for Research Oregon State University*

2017 STRONGMAR CONFERENCE

Porto, Portugal // 16 November 2017

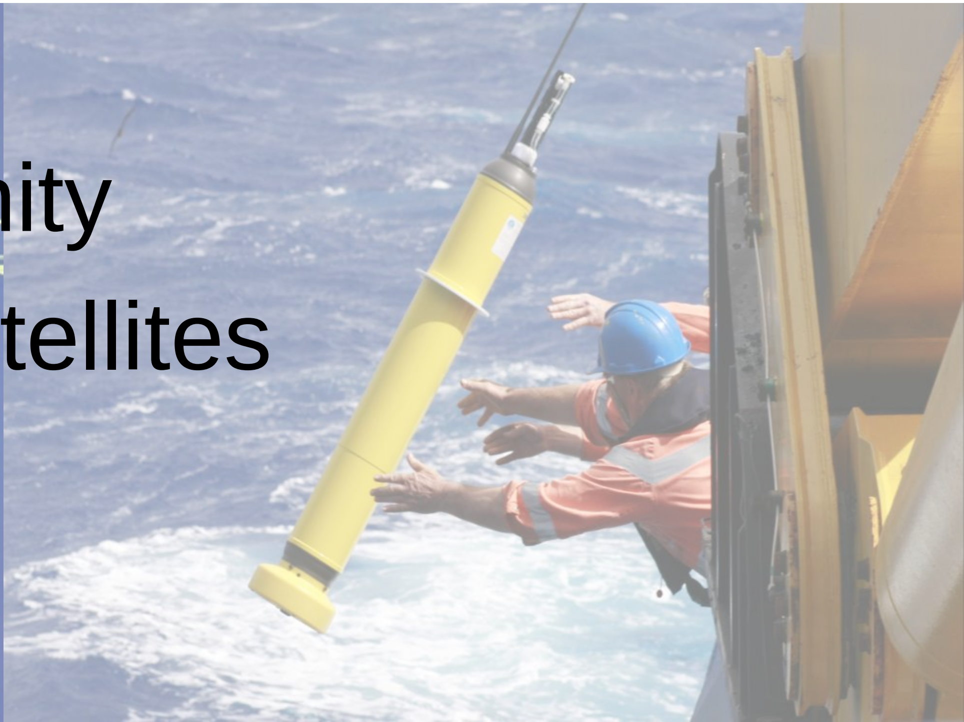
STRONG
MAR

Where will we see it?

- Platforms
- Sensors
- Information/Informatics
- “Seemingly disparate” technologies
- Citizen Science – Hybrid vigor
- *The* ***New*** *Blue Economy*

Platforms

- Unmanned vehicles
  - Sampling strategies
  - Swarming technology
  - Power systems
- Nav systems
- Vessels of Opportunity
- Micro/Nano/Pico Satellites



- $7M Global Competition
- $1M NOAA Bonus Prize
- Air/Shore launched AUV to competition area (2000-4000m)
    - Hi-res bathy map
    - Imagery of targets
    - ID archaeological, biological or geo features

TECH INFORMATION

The team is aggregating Portuguese technologies developed at INESC TEC (Porto) and CINTAL (Algarve) to create the PISCES system that leverages cooperative robotics.

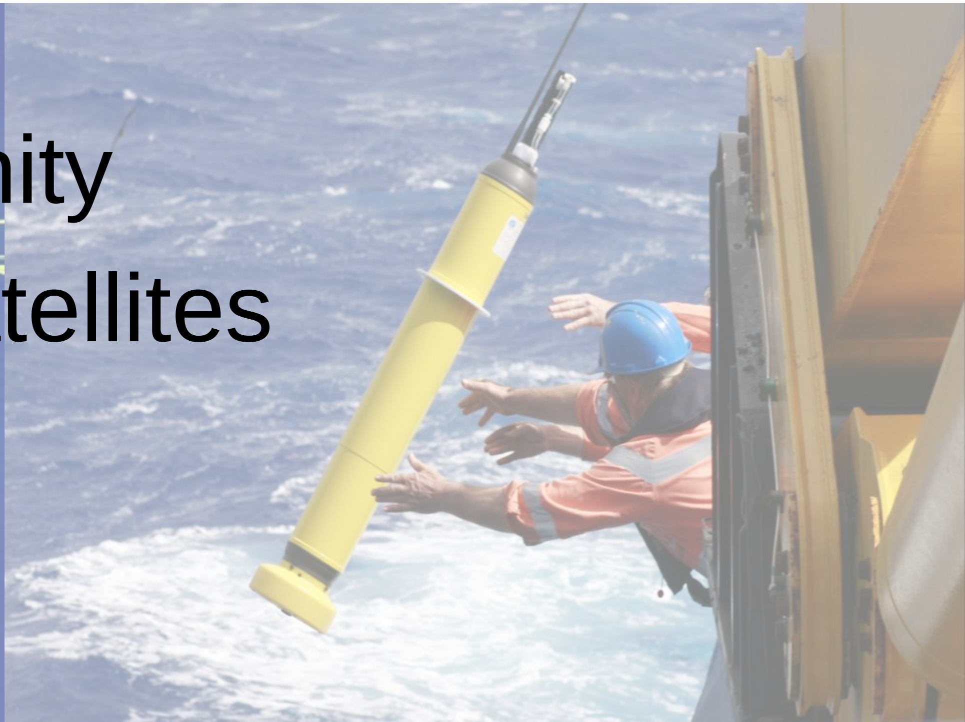
SHELL OCEAN DISCOVERY XPRIZE pisces OFFICIAL TEAM

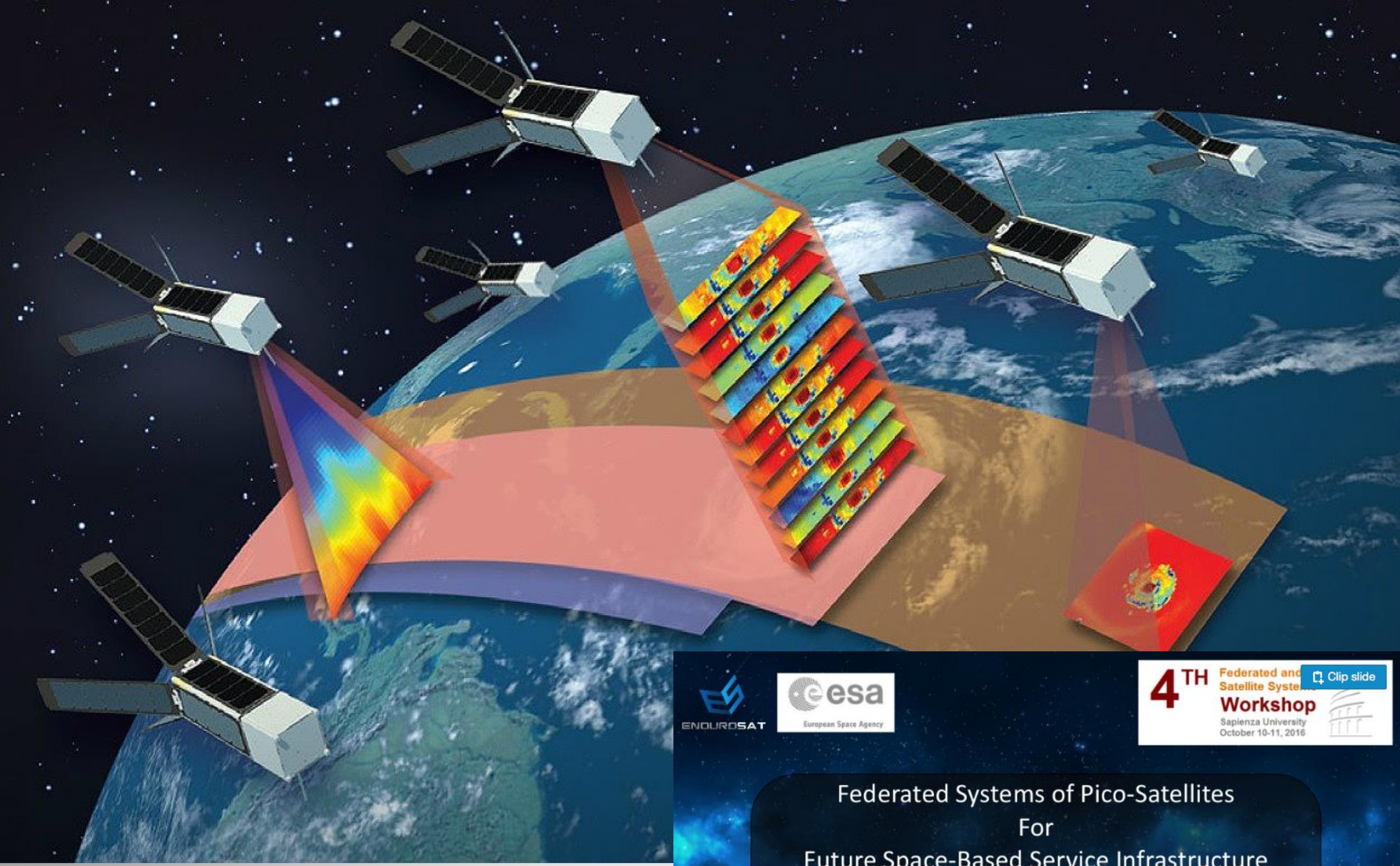
TEAM LEADER:
Nuno Cruz

LOCATION:
Porto, Portugal

Platforms

- Unmanned vehicles
  - Sampling strategies
  - Swarming technology
  - Power systems
- Nav systems
- Vessels of Opportunity
- Micro/Nano/Pico Satellites





ENDUROSAT

esa
European Space Agency

4TH Federated and Satellite Syste[...] Workshop
Sapienza University
October 10-11, 2016

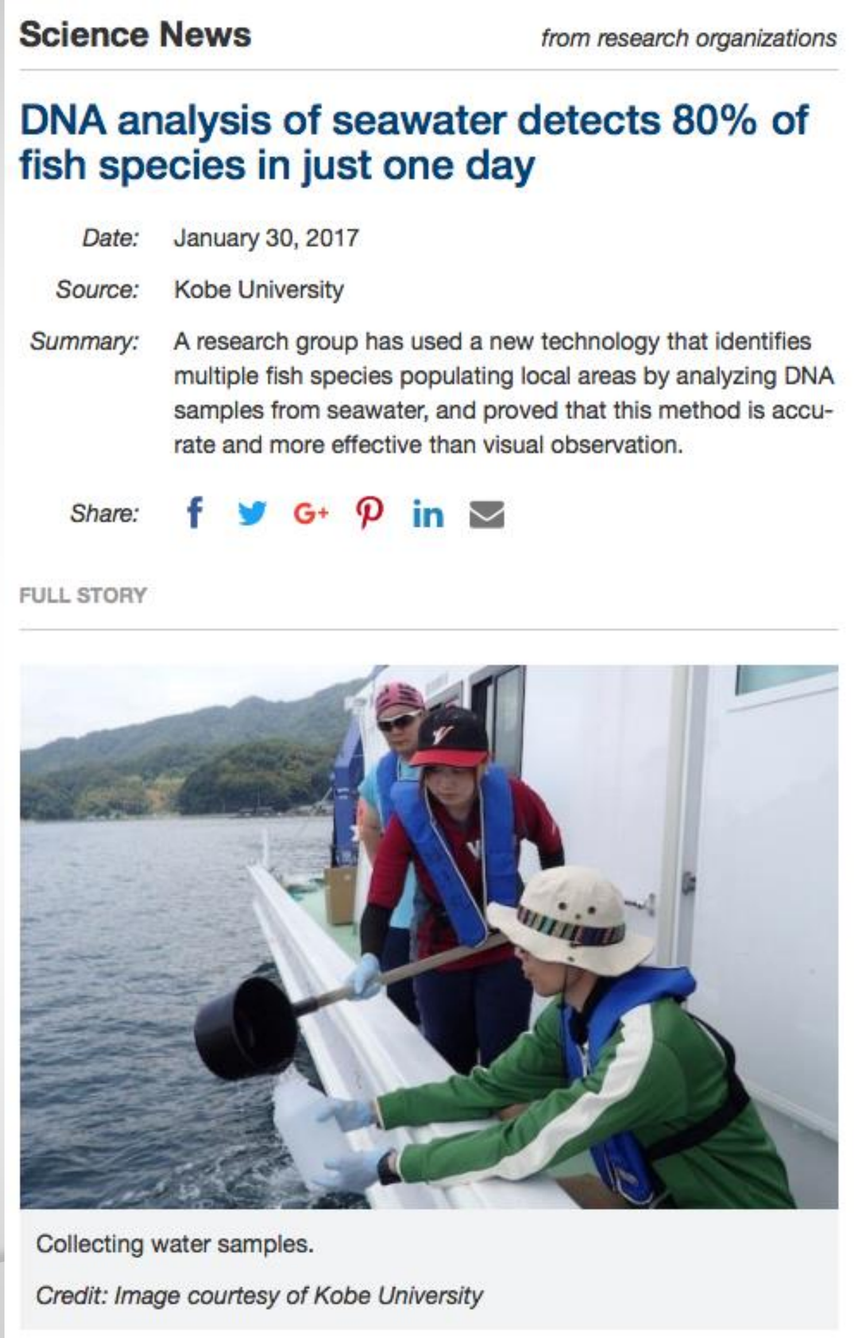
Federated Systems of Pico-Satellites For Future Space-Based Service Infrastructure

Raycho Raychev, Aleksandar Kolev
Endurosat

Marco Lisi
European Space Agency

Sensors

- New parameters
  - Ocean DNA
- New techniques
  - Expendable/degradable
  - Biomimetics



Science News *from research organizations*

DNA analysis of seawater detects 80% of fish species in just one day

Date: January 30, 2017

Source: Kobe University

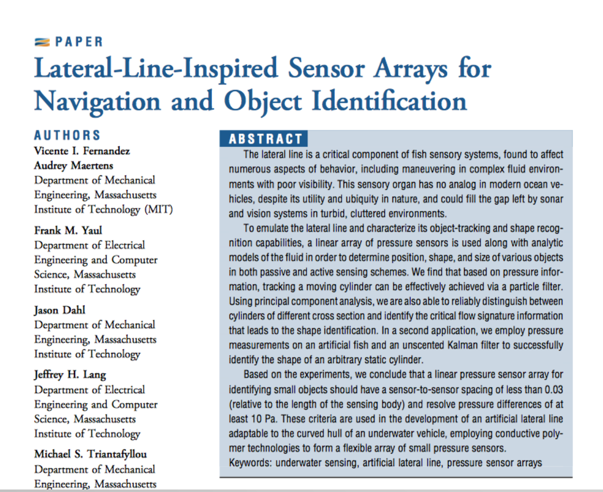
Summary: A research group has used a new technology that identifies multiple fish species populating local areas by analyzing DNA samples from seawater, and proved that this method is accurate and more effective than visual observation.

Share:

FULL STORY

Collecting water samples.

Credit: Image courtesy of Kobe University



PAPER

Lateral-Line-Inspired Sensor Arrays for Navigation and Object Identification

AUTHORS

Vicente I. Fernandez
Audrey Maertens
Department of Mechanical Engineering, Massachusetts Institute of Technology (MIT)

Frank M. Yaul
Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology

Jason Dahl
Department of Mechanical Engineering, Massachusetts Institute of Technology

Jeffrey H. Lang
Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology

Michael S. Triantafyllou
Department of Mechanical Engineering, Massachusetts

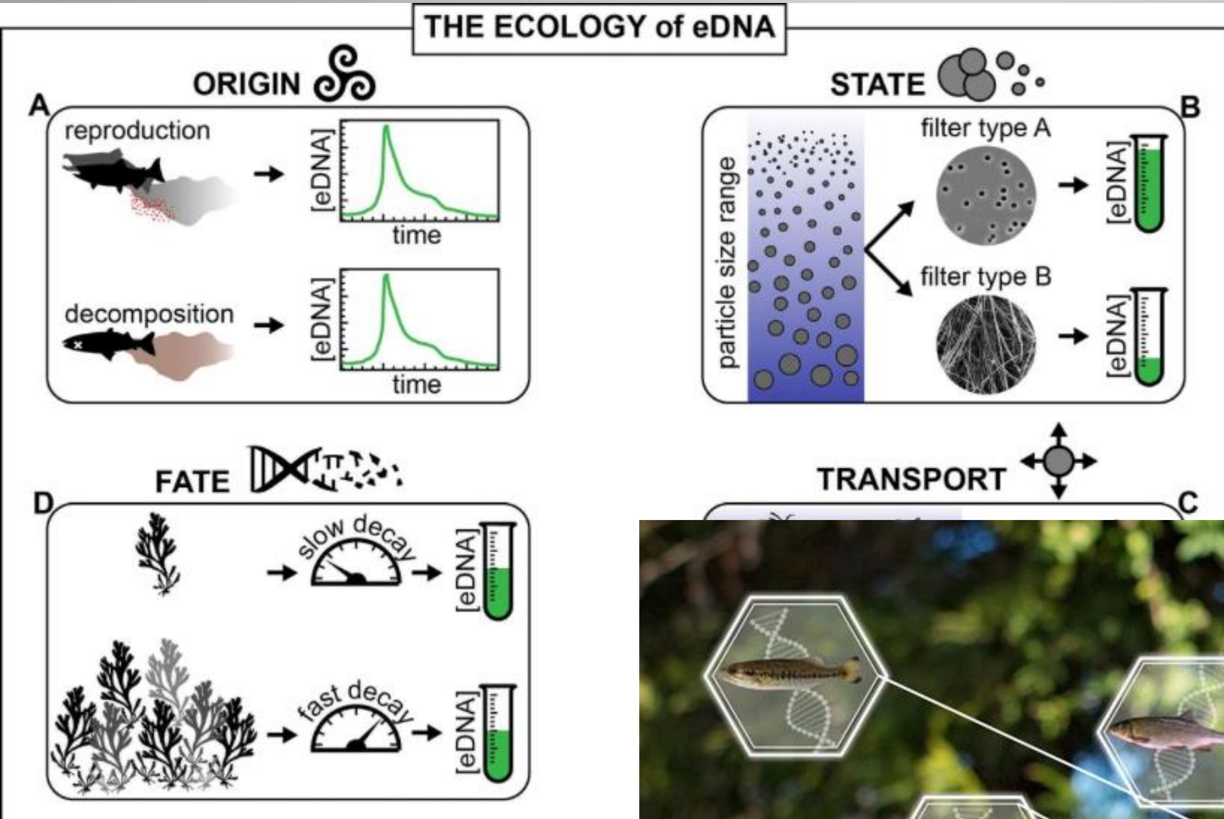
ABSTRACT

The lateral line is a critical component of fish sensory systems, found to affect numerous aspects of behavior, including maneuvering in complex fluid environments with poor visibility. This sensory organ has no analog in modern ocean vehicles, despite its utility and ubiquity in nature, and could fill the gap left by sonar and vision systems in turbid, cluttered environments.

To emulate the lateral line and characterize its object-tracking and shape recognition capabilities, a linear array of pressure sensors is used along with analytic models of the fluid in order to determine position, shape, and size of various objects in both passive and active sensing schemes. We find that based on pressure information, tracking a moving cylinder can be effectively achieved via a particle filter. Using principal component analysis, we are also able to reliably distinguish between cylinders of different cross section and identify the critical flow signature information that leads to the shape identification. In a second application, we employ pressure measurements on an artificial fish and an unscented Kalman filter to successfully identify the shape of an arbitrary static cylinder.

Based on the experiments, we conclude that a linear pressure sensor array for identifying small objects should have a sensor-to-sensor spacing of less than 0.03 (relative to the length of the sensing body) and resolve pressure differences of at least 10 Pa. These criteria are used in the development of an artificial lateral line adaptable to the curved hull of an underwater vehicle, employing conductive polymer technologies to form a flexible array of small pressure sensors.

Keywords: underwater sensing, artificial lateral line, pressure sensor arrays


THE ECOLOGY of eDNA
ORIGIN
A
reproduction
[eDNA]
time
decomposition
[eDNA]
time
STATE
B
particle size range
filter type A
[eDNA]
filter type B
[eDNA]
FATE
D
slow decay
[eDNA]
fast decay
[eDNA]
TRANSPORT
C

Information/Informatics

- Data
  - Big data
- Processing
  - Compressive Sensing
  - Quantum Computing

Big Data

nature
human behaviour

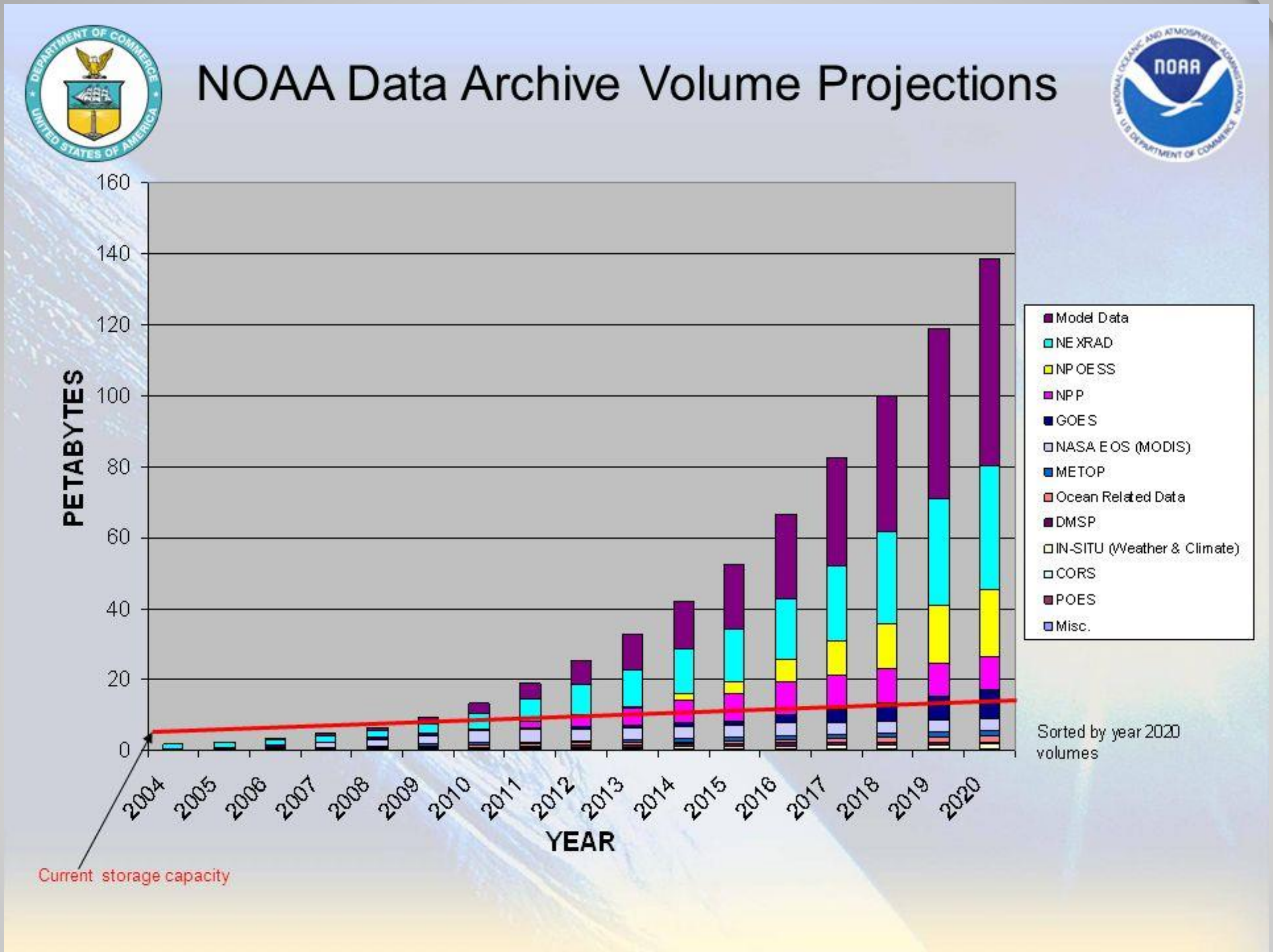
- *Machine learning of neural representations of suicide and emotion concepts identifies suicidal youth*

Marcel Adam Just, Lisa Pan, Vladimir L. Cherkassky, Dana L. McMakin, Christine Cha, Matthew K. Nock & David Brent

Nature Human Behaviour (2017)
doi:10.1038/s41562-017-0234-y

This study used machine-learning algorithms (Gaussian Naive Bayes) to identify such individuals (17 suicidal ideators versus 17 controls) with high (91%) accuracy, based on their altered functional magnetic resonance imaging neural signatures of death-related and life-related concepts. The most discriminating concepts were ‘death’, ‘cruelty’, ‘trouble’, ‘carefree’, ‘good’ and ‘praise’.

Watson, come quick, *we* need you!



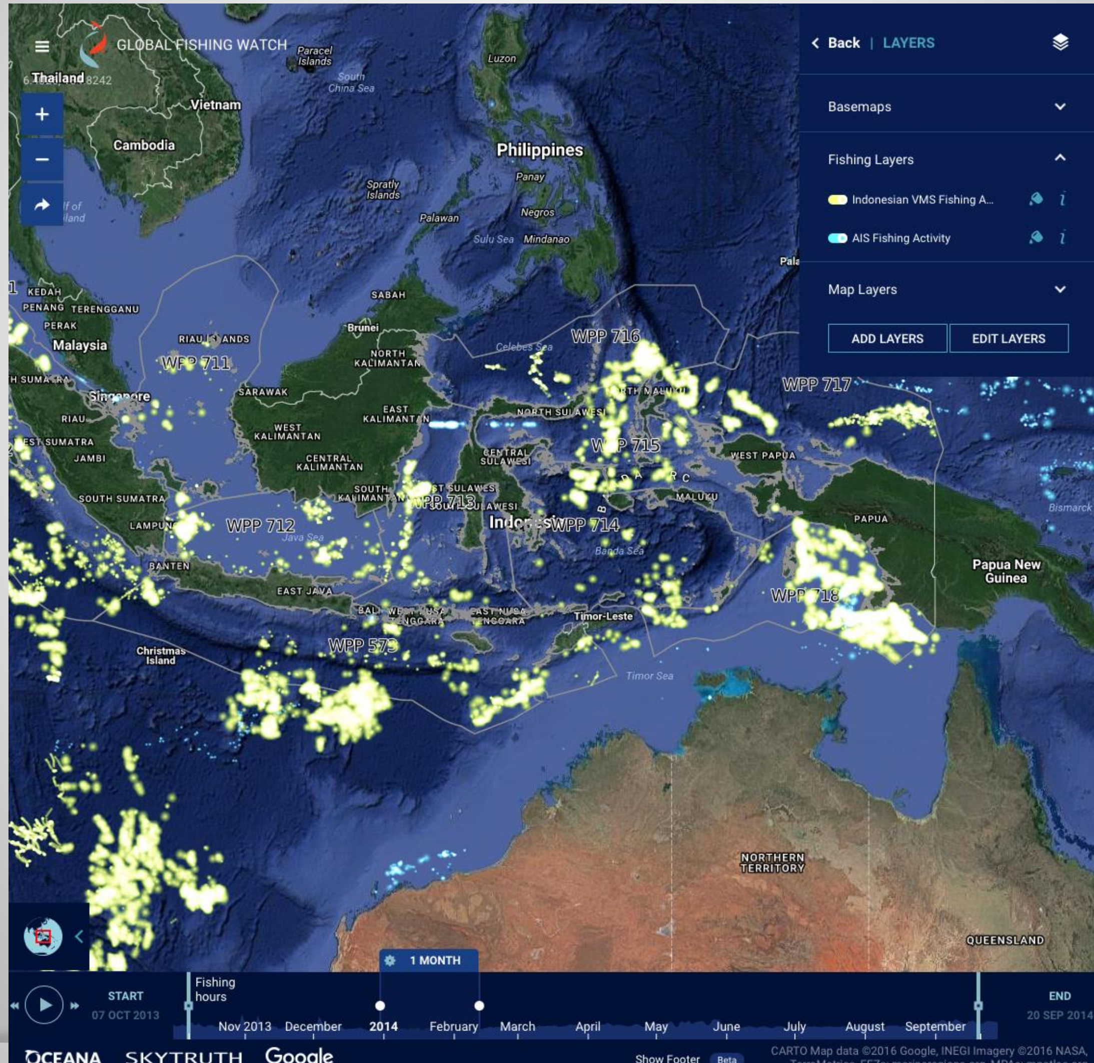
✓Climate Change
✓Resource Management
✓Hazard Mitigation
✓New Blue Economy

GLOBAL FISHING WATCH

Founding Partners

OCEANA SKYTRUTH Google

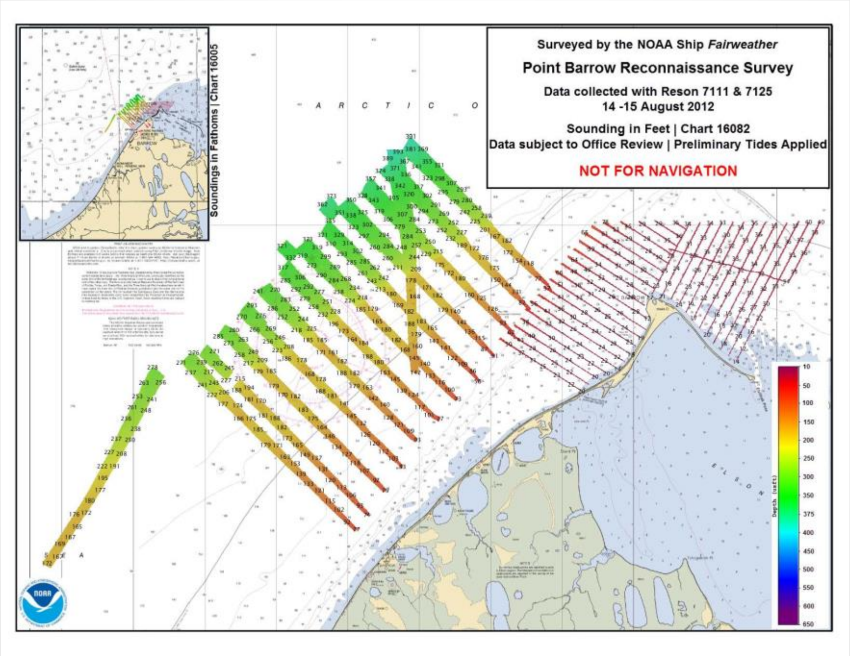
LEONARDO DICAPRIO FOUNDATION

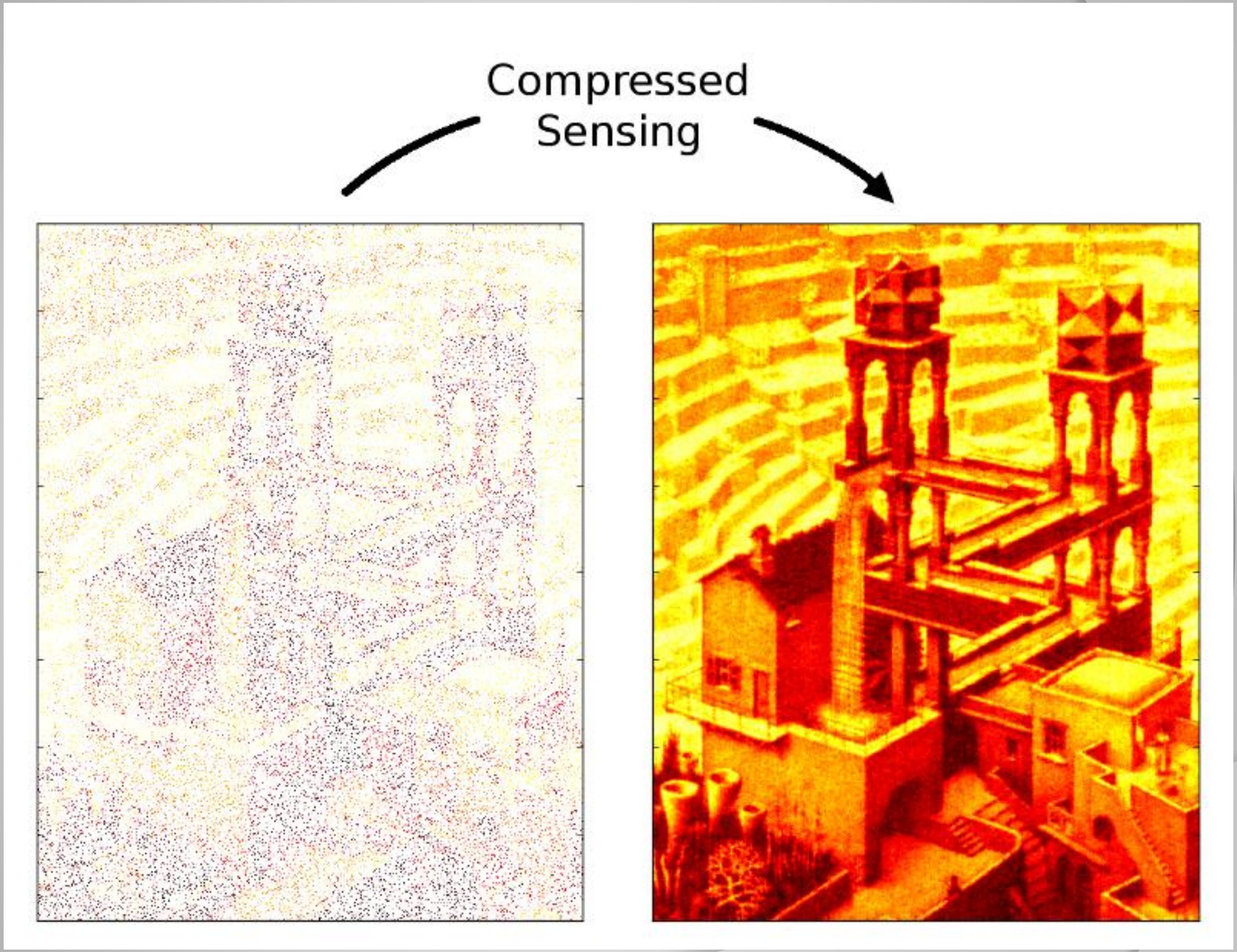


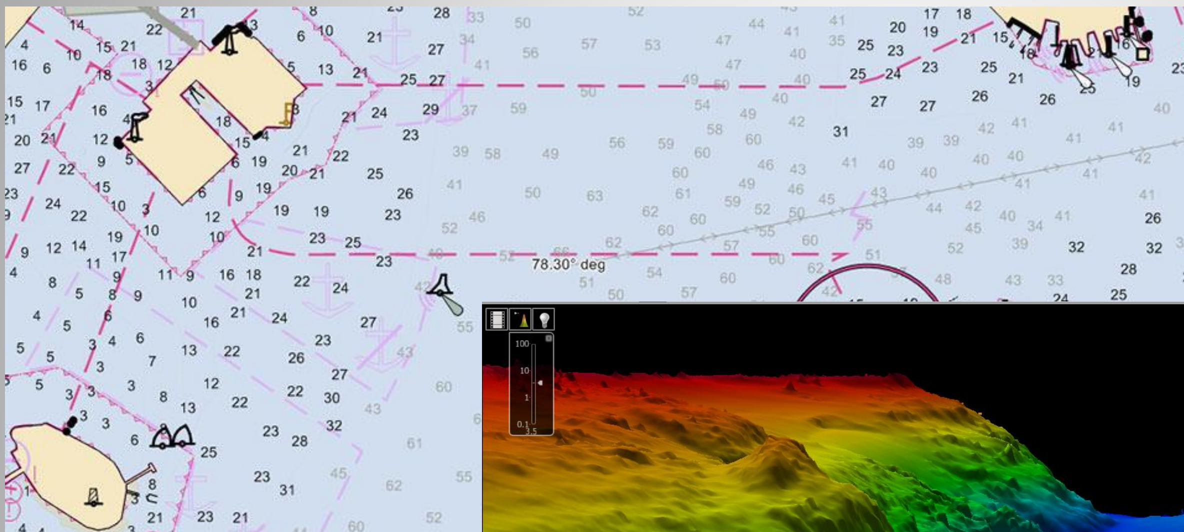
Compressive Sensing

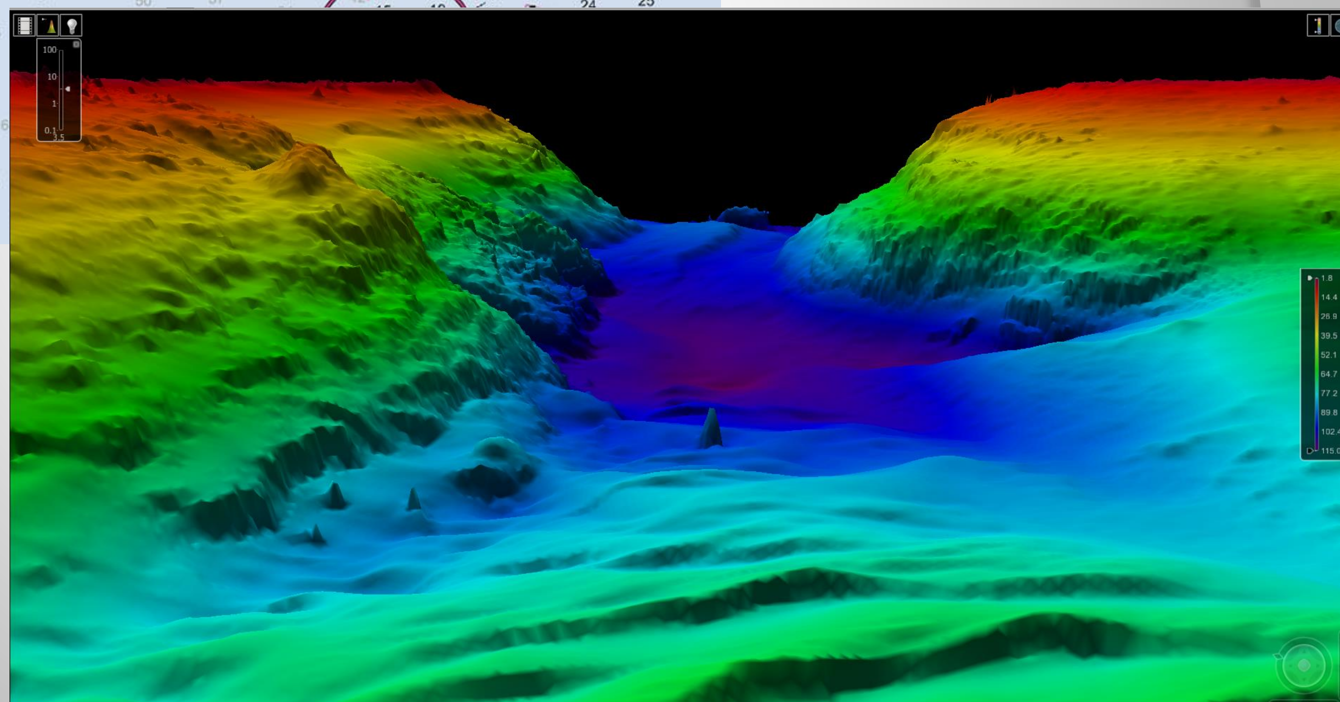
- … a signal processing technique for efficiently acquiring and reconstructing a signal, by finding solutions to underdetermined linear systems.
  - Sparse data
  - Incoherent data

“Mowing the lawn”




Compressed
Sensing


78.30° deg


1.8
14.4
26.9
39.5
52.1
64.7
77.2
89.8
102.4
115.0

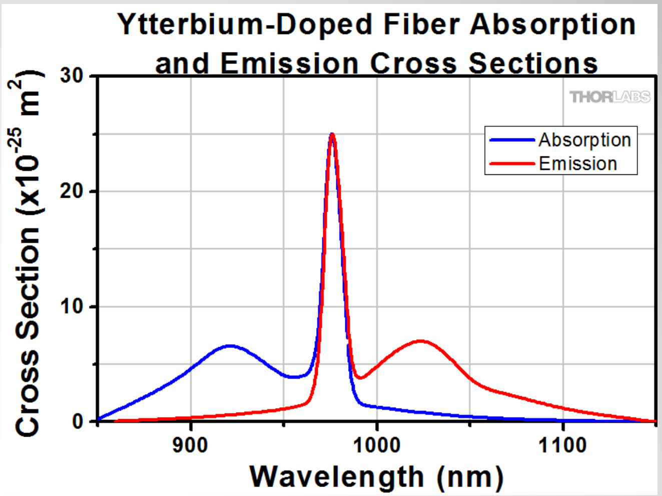
Quantum computing

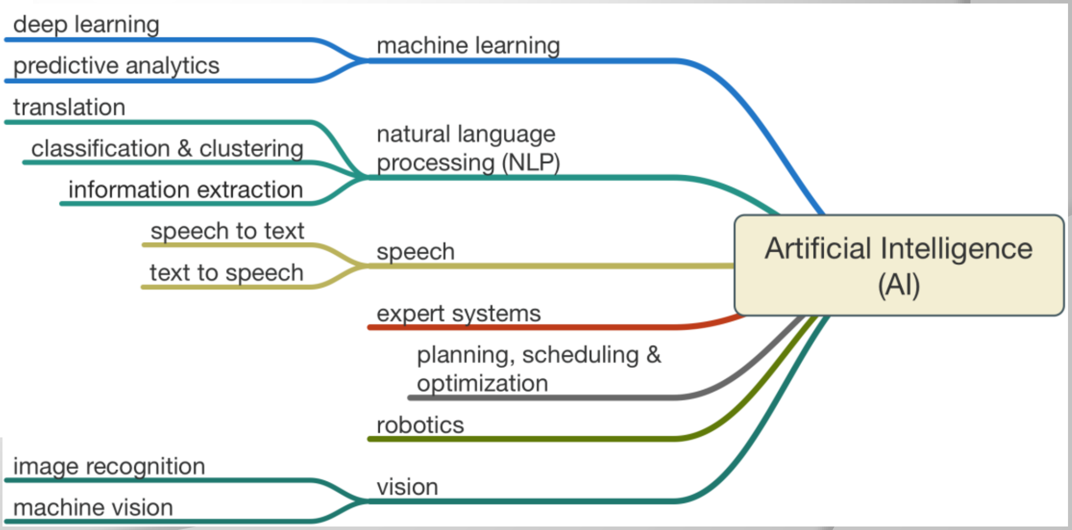
- Quantum computers aren't limited to two states; they encode information as quantum bits, or qubits, which can exist in superposition. Qubits represent atoms, ions, photons or electrons and their respective control devices that are working together to act as computer memory and a processor. *Because a quantum computer can contain these multiple states simultaneously, it has the potential to be millions of times more powerful than today's most powerful supercomputers*.

Quantum computing

“Seemingly disparate” technologies

- Materials
- Biomedicine
- AI

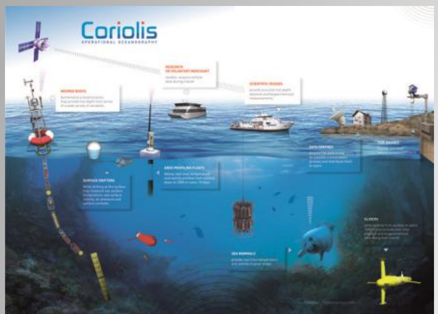




Citizen science

- Boyan Slat
- James Cameron
- Nainoa Thompson


A vision of the future



PROVIDERS
observations

INTERMEDIARIES
value-added products

END USERS
emergency managers, developers, city planners, private sector

THE *NEW* BLUE ECONOMY

THE MARKET

Service-based

Information-dependent

Prediction-critical

IS GLOBAL

WHAT'S NEEDED?

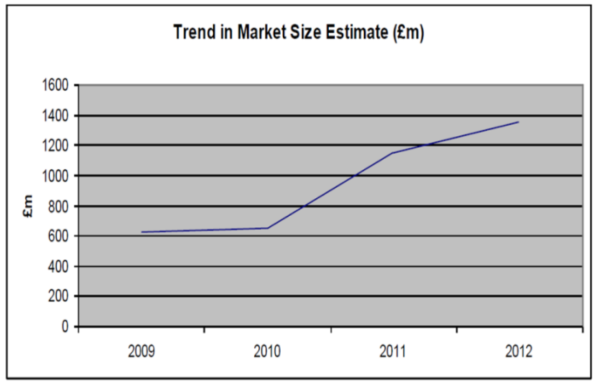
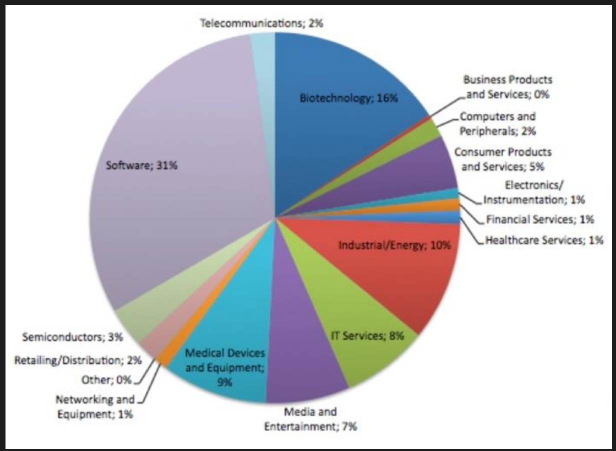


Fig. 1 MST Market size over the past 4 years.



OBSERVATIONS & TOOLS

MARKET & RISK ANALYSIS

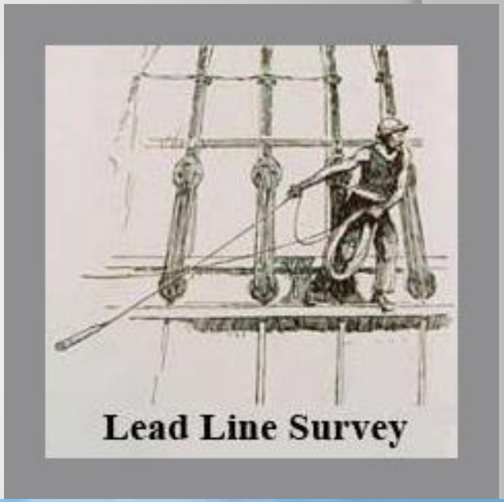
CAPITAL INVESTMENT

CASE STUDY	MARKET OPPORTUNITY	PRODUCT
DEEPWATER HORIZON	• Regulatory compliance • Response/Restoration service & support	High-resolution, archived, & real-time OBSERVATIONAL DATA in KML formats
PORTLAND GRAIN SHIPPING	Commodity-specific load-out & transit intelligence	Short-term, COUPLED MODELS (ocean, river, hydrological)
SUPERSTORM SANDY	Natural infrastructure architecture	Site-specific ECOSYSTEM SERVICES VALUATION
HARMFUL ALGAL BLOOM FORECASTS	Derivatives for public health, tourism, seafood safety, etc.	Coupled ecological & behavioral forecasts
NUISANCE FLOODING	Resilience planning & guidance	•Down-scaled sea level rise projections •Risk translation

BIG OCEAN BUTTON CHALLENGE

Emerging Opportunities and Challenges in Ocean Technology

- Important "Take-Away" Messages:
  - We ARE:
    - Creative
    - Intelligent
    - Curious
    - *Insular*
    - *Enterprising (too much?)*
  - We are NOT:
    - Idea-limited
    - Resource-limited



Thank you!

www.strongmar.eu

RICK SPINRAD// rick.spinrad54@gmail.com

The STRONGMAR project is funded by the European Commission under the H2020 EU Framework Programme for Research and Innovation (H2020-TWINN-2015, 692427).

Backup slides

What's needed for innovation to be meaningful?

- ***Requirements***
- ***Resources*** and financial commitments for such (up front and sustained … risk tolerance)
- ***Processes***:
  - Integrated project management
  - "Rules" – e.g. T&E procedures

What can go wrong?

- Unmatched expectations
- No dedicated resources/leadership to the “transition”
- Unclear roadmap
  - Off ramps
  - Exit strategies
  - Decision points

Renewable Energy

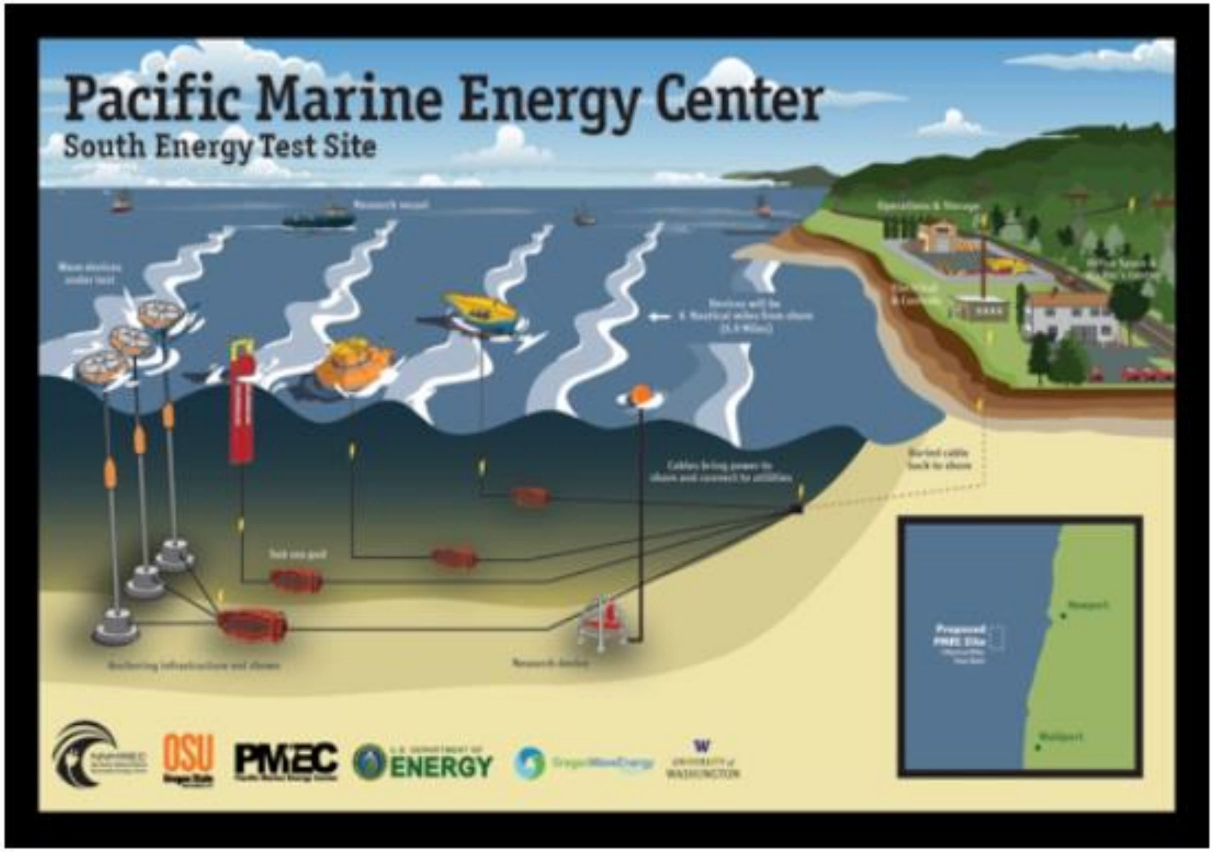


Figure 1. PMEC-SETS conceptual design: four berths, cables to shore, onshore facility, grid connection

Compressive sensing

1 Undersample

A camera or other device captures only a small, randomly chosen fraction of the pixels that normally comprise a particular image. This saves time and space.

2 Fill in the dots

An algorithm called l_1 minimization starts by arbitrarily picking one of the effectively infinite number of ways to fill in all the missing pixels.

3 Add shapes

The algorithm then begins to modify the picture in stages by laying colored shapes over the randomly selected image. The goal is to seek what's called sparsity, a measure of image simplicity.

4 Add smaller shapes

The algorithm inserts the smallest number of shapes, of the simplest kind, that match the original pixels. If it sees four adjacent green pixels, it may add a green rectangle there.

5 Achieve clarity

Iteration after iteration, the algorithm adds smaller and smaller shapes, always seeking sparsity. Eventually it creates an image that will almost certainly be a near-perfect facsimile of a hi-res one.

Photos: Obama: Corbis; Image Simulation: Jarvis Haupt/Robert Nowak