Session GC33: 14 December 2010
AGU Fall Meeting, San Francisco, CA

Global Biogeochemical Fluxes Program for the Ocean Observatories Initiative: A Proposal.

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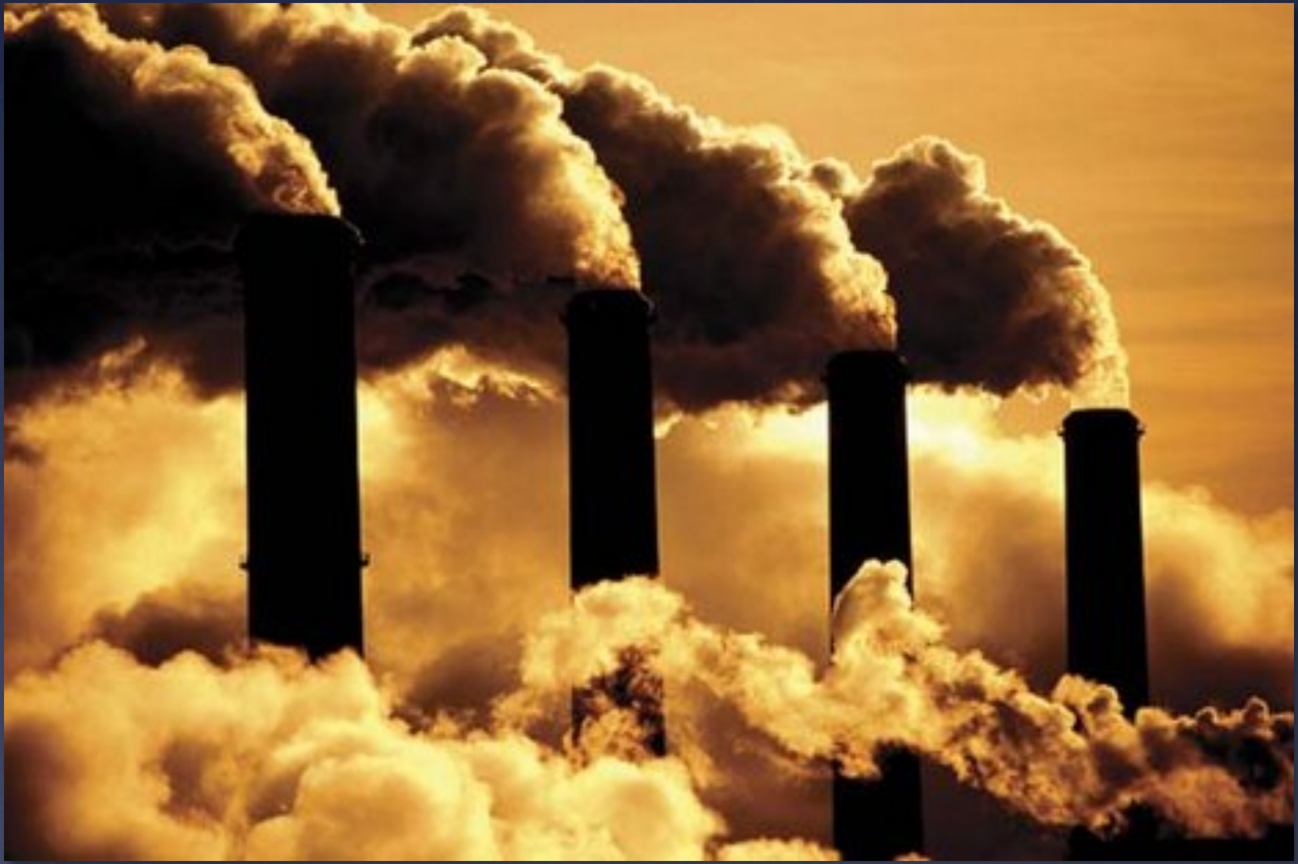
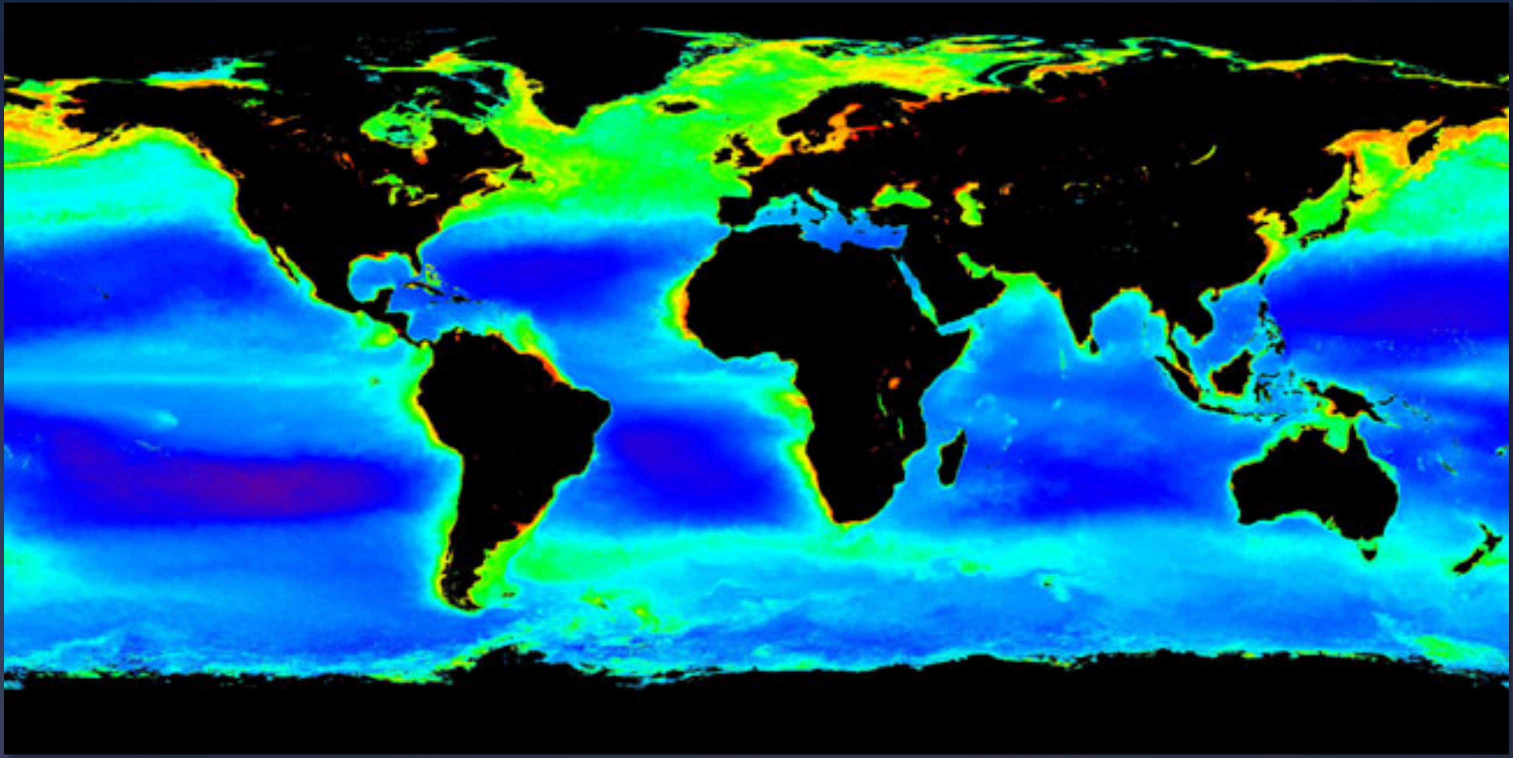
Where will all the CO_2 go?



Much will end up in the sea…

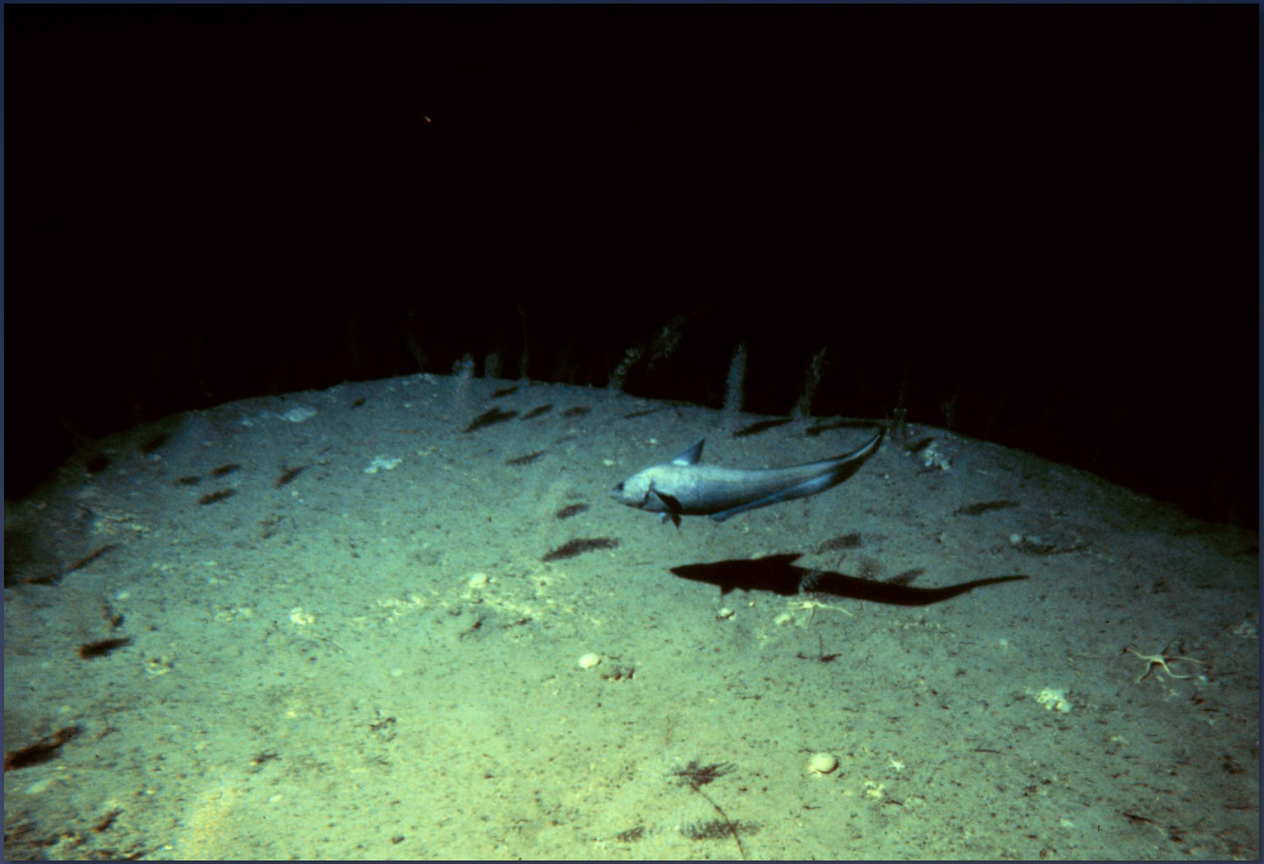
…but how much will be captured by photosynthesis?



Global distribution of phytoplankton. Lowest concentration is purple and blue, middle concentration is green, highest concentration is yellow and red.

[Source http://www.nasa.gov/vision/earth/environment/0702_planktoncloud.html](http://www.nasa.gov/vision/earth/environment/0702_planktoncloud.html)

…and how much will eventually be sequestered in the deep ocean?



Life on the abyssal sea floor (depths ranging from 4000-6000 m) near the Hudson Canyon off the coast of New Jersey. Photo taken using the Deep Submersible Research Vessel (DSRV) *Alvin's camera system. Image courtesy of Deep East 2001, NOAA/OER.*

What happens to it on the way down?

S. Honjo – “Marine Snow & Fecal Pellets” (1997) *Oceanus* WHOI

…and how will it effect the biology and chemistry of the sea?

- Ocean acidification
- Impact on global primary productivity
- Phytoplankton population changes
- Changes to ballast particles & transport rates
- Impact on coral reef ecosystems
- Repercussions throughout the food web
- Implications for human fish & shellfish consumption

Ocean Acidification

- CO_2 is corrosive to the shells and skeletons of many marine organisms

Corals

Calcareous plankton

PMEL CO_2 Program NOAA

The base of the ocean food chain

MORE THAN ONE HALF

of total animal protein consumed in many small island developing states, as well as in Bangladesh, Cambodia, Equatorial Guinea, French Guiana, the Gambia, Ghana, Indonesia and Sierra Leone comes from fish (FAO, 2008).

2.9 BILLION

people depend on fish for at least 15 percent of their average animal protein intake (FAO, 2008).

Turning the Tide

The State of Seafood Monterey Bay Aquarium

Mission:

Assess the role of oceanic carbon, both living and non-, in the Earth climate system through better quantitative understanding of the transport and transformation of carbon from the fixation of atmospheric CO_2 by surface ocean primary production through its removal to deep waters via the "biological pump".

Goals:

- Greatly improve constraints on estimates of global marine primary production (PP), a critical factor in understanding the global CO_2 cycle and for developing accurate estimates of export production (EP).
- Explore the spatiotemporal links between PP, EP and the biogeochemical processes that attenuate particulate organic carbon (POC) flux.
- Characterize microbial community structure and dynamics both in the surface and deep ocean.
- Develop a comprehensive picture of the chemical and biological processes that take place from the surface ocean to the sea floor.
- Provide unique time-series samples for detailed laboratory-based chemical and biological characterization and tracer studies that will enable connections to be made between the operation of the biological pump at present and in the geologic past.

The Value

The primary goal is to provide high-quality biological and biogeochemical observational data for the modeling and prediction efforts of the global CO_2 cycle research community.

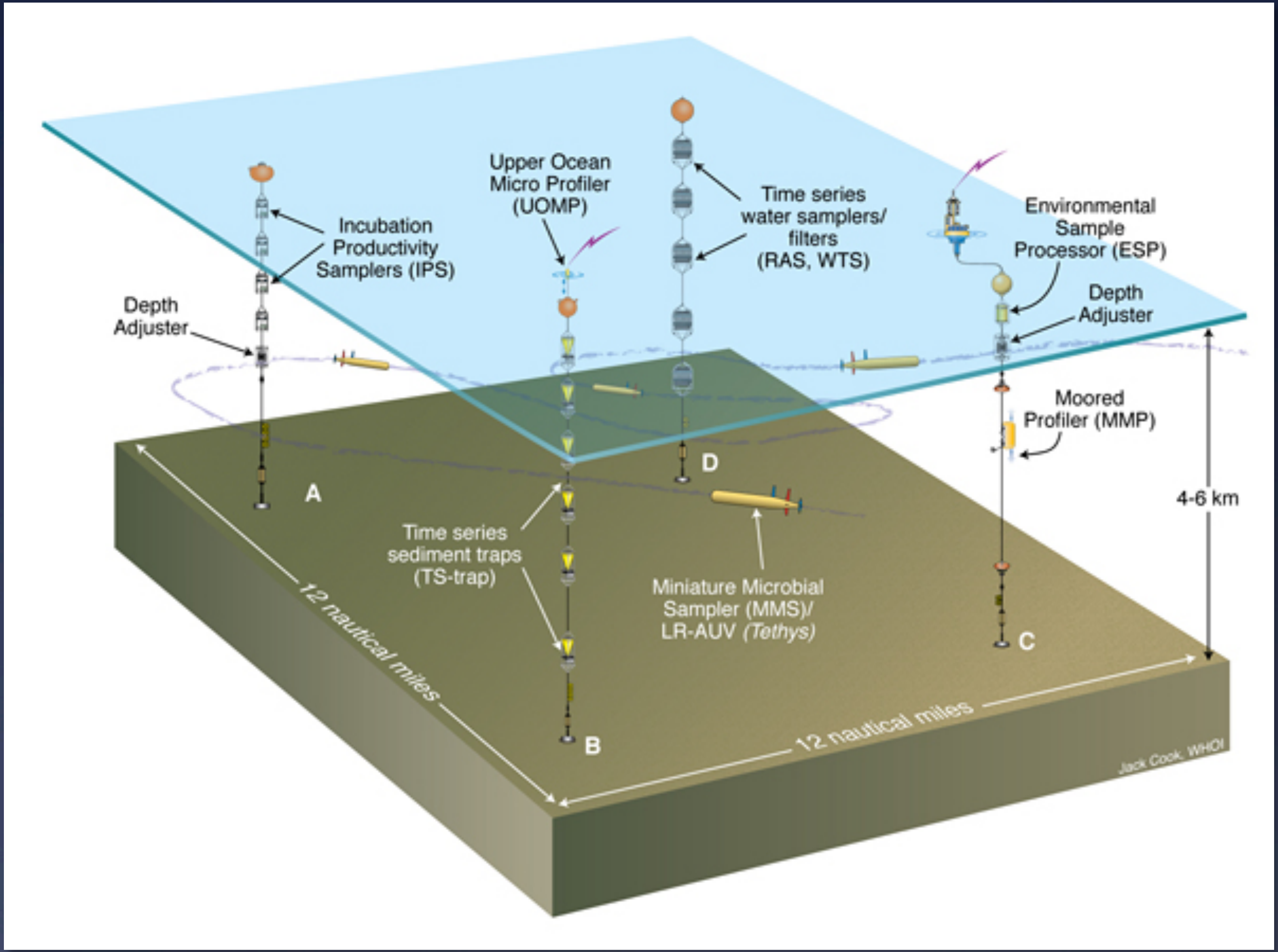
How will we do it?

Extend the currently-funded OOI array infrastructure to include state-of-the-art biological and biogeochemical sensors and samplers.

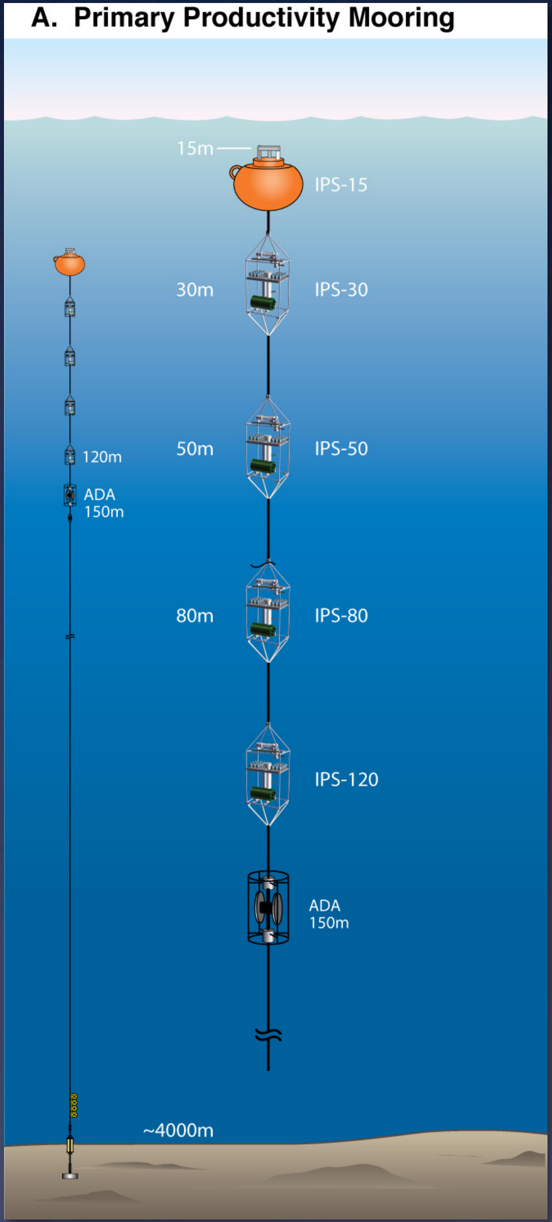
CONSORTIUM FOR Ocean Leadership
DISCOVERY · UNDERSTANDING · ACTION

OCEAN OBSERVATORIES INITIATIVE

Time Series Sensors & Samplers

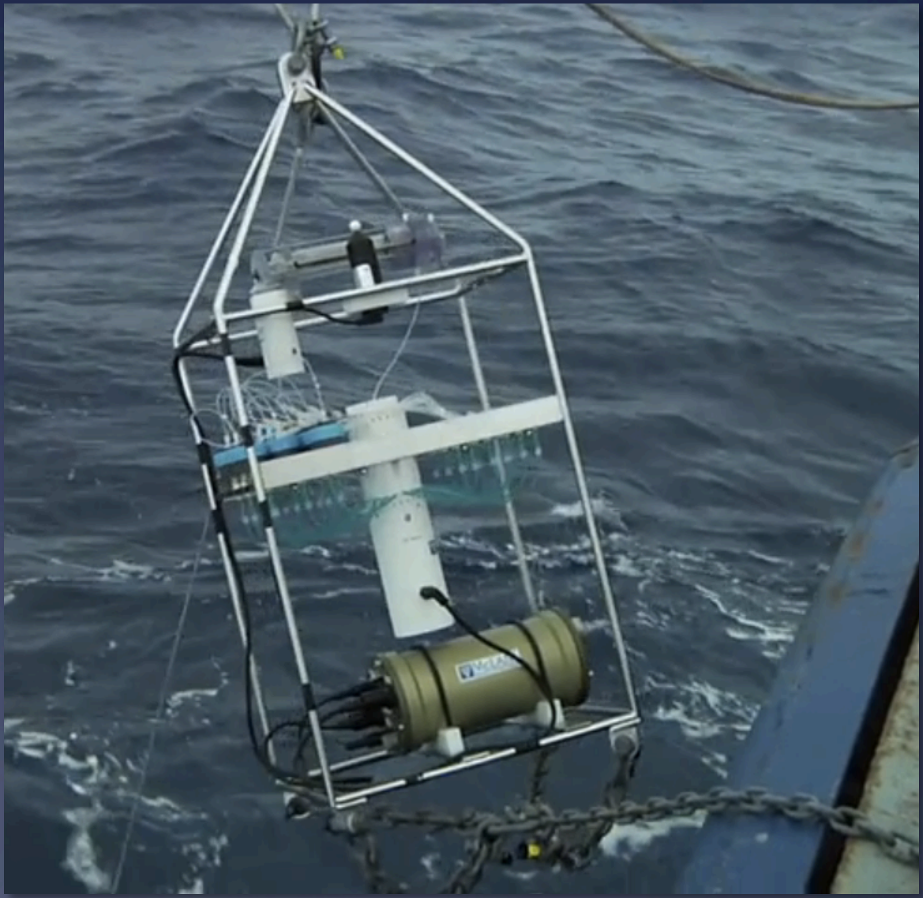


Primary Production



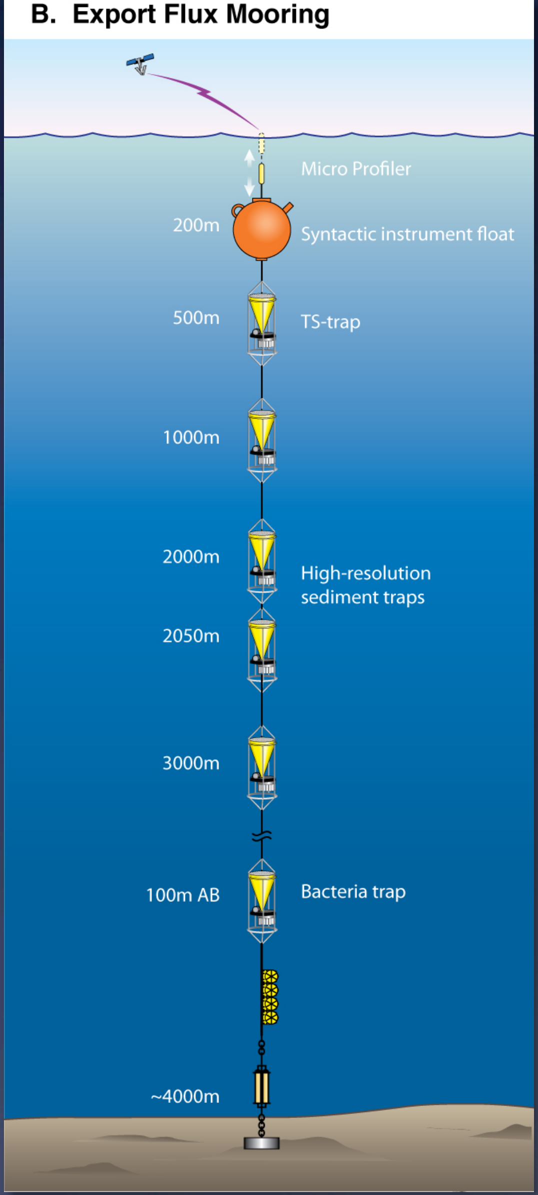
A. Primary Productivity Mooring

Incubating Productivity System (IPS)

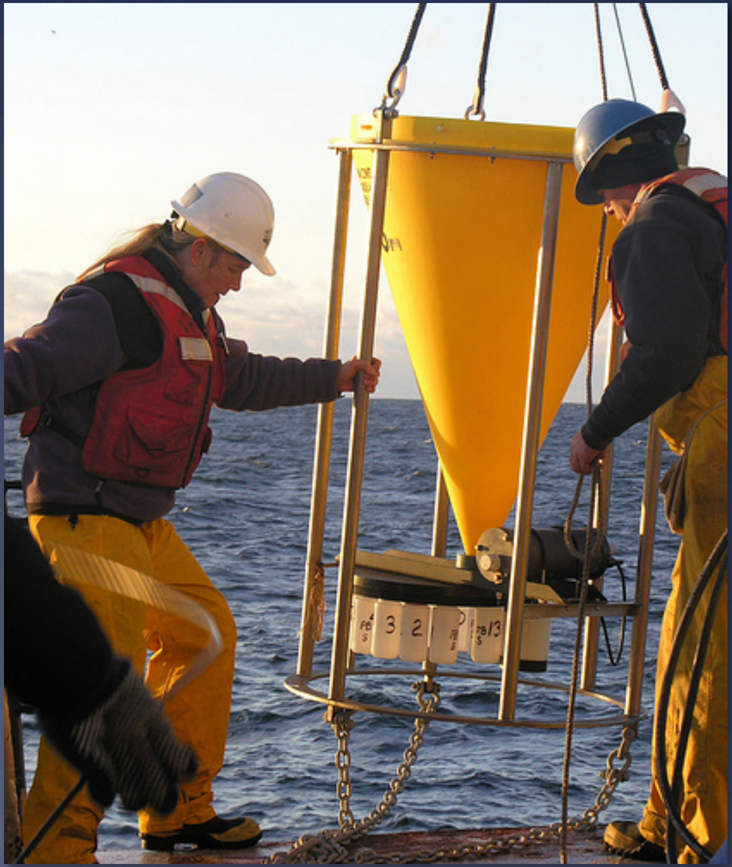


Eric Grabowski - University of Hawaii

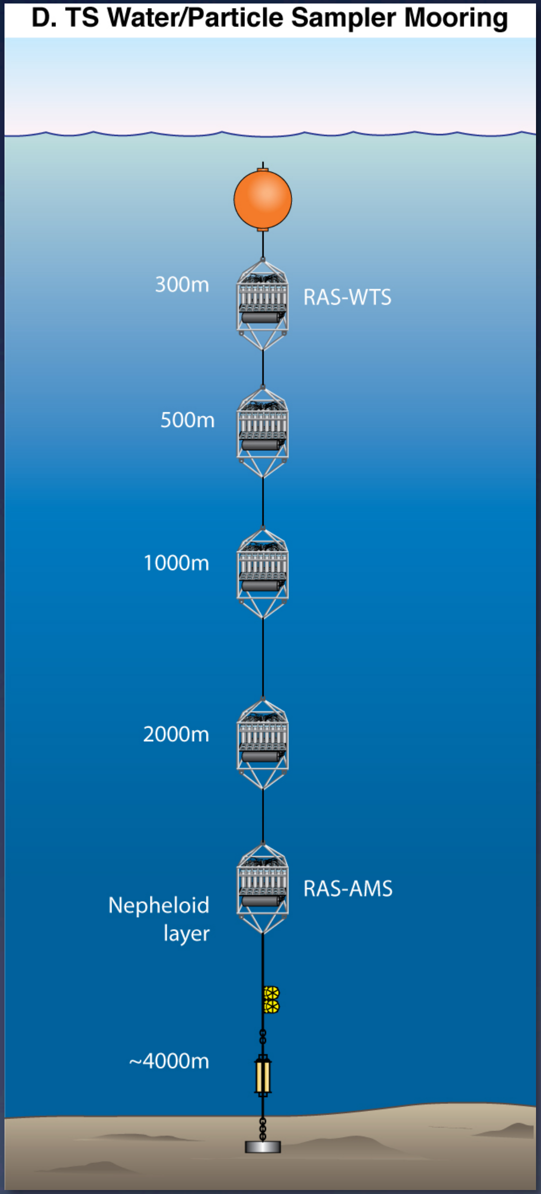
Export Flux


B. Export Flux Mooring

Time Series
Sediment Traps

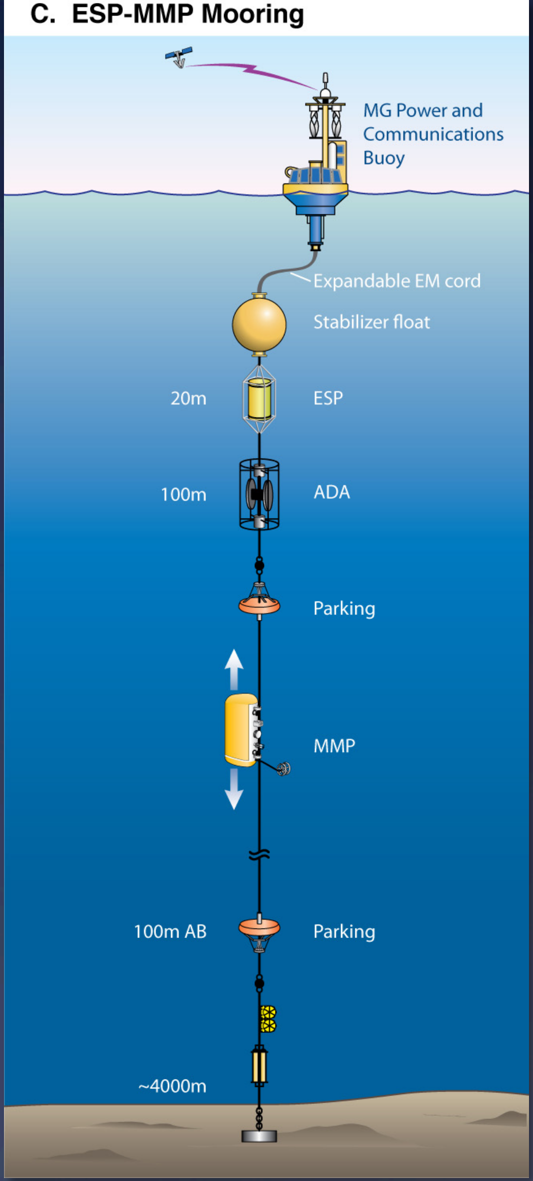


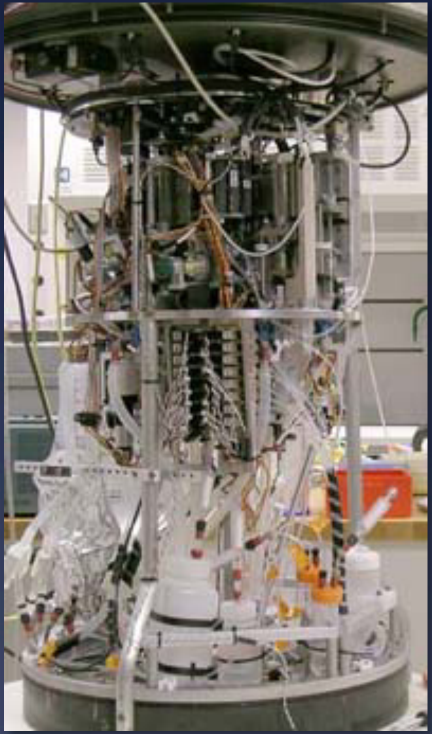
Water & Particulates



Remote Access Sampler (RAS)

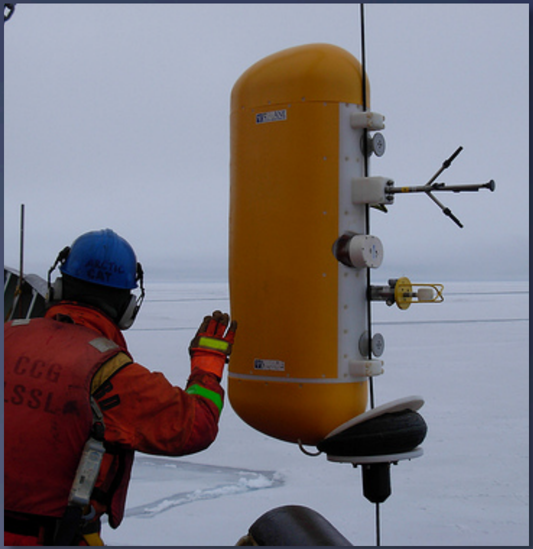
Microbes





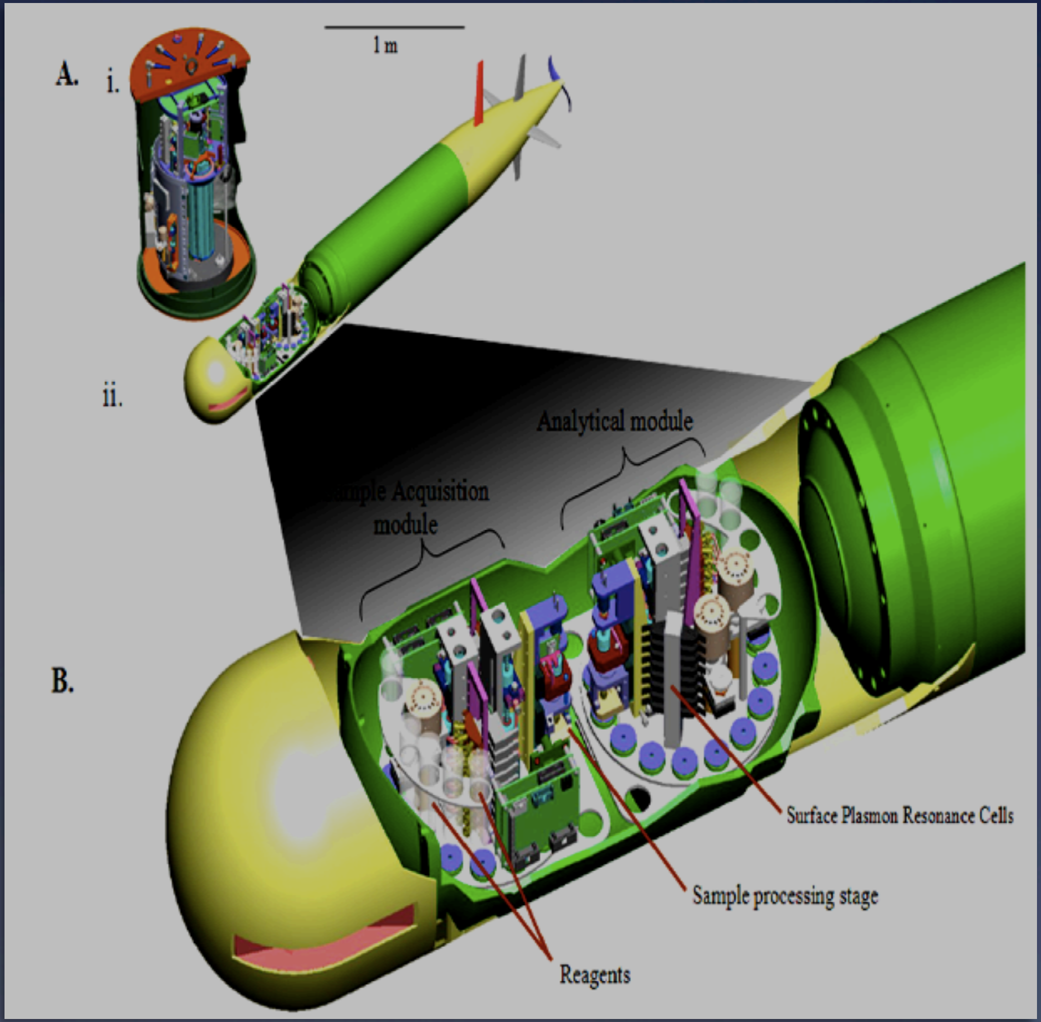
Environmental Sample Processor (ESP)

McLane Moored Profiler (MMP)

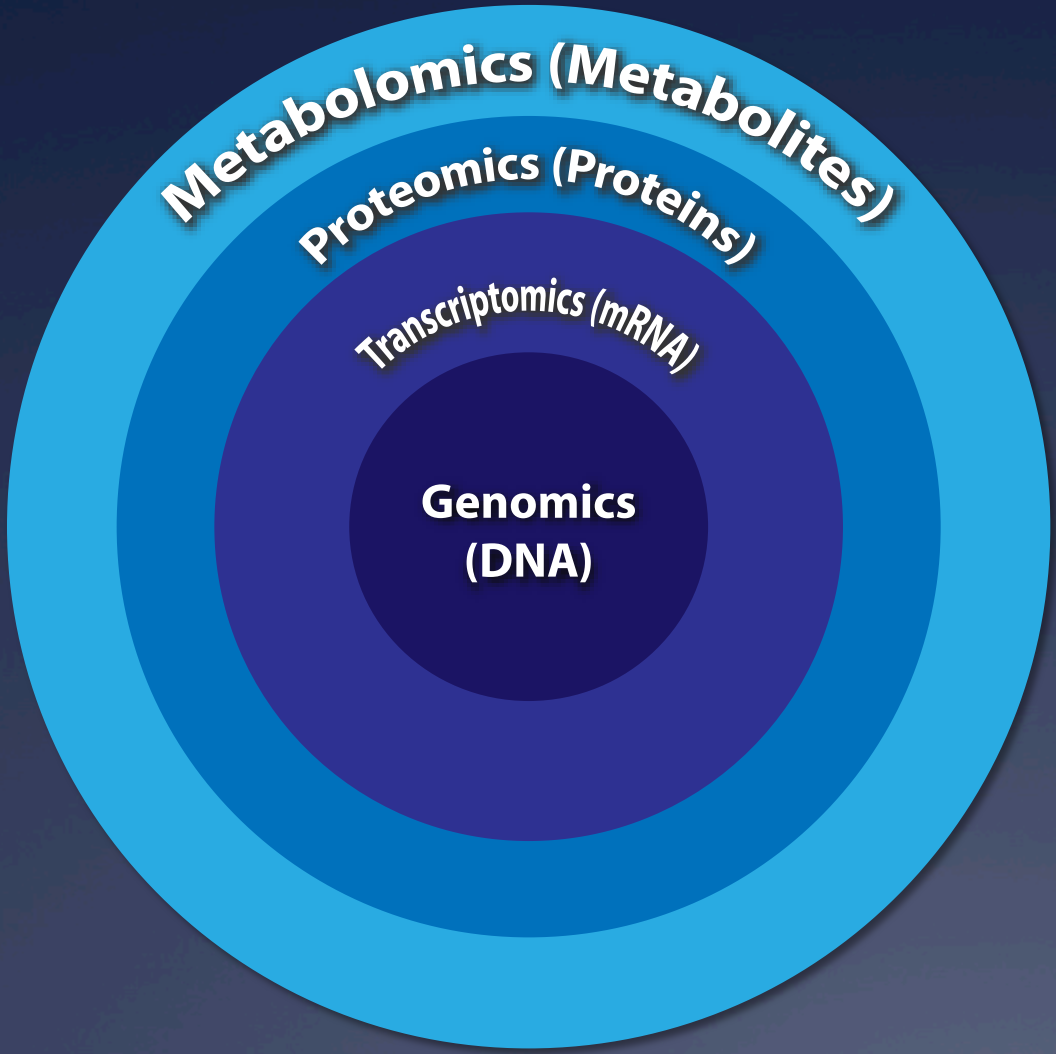


Gen III ESP + *Tethys* Long-Range AUV

- Drifters
- Gliders
- AUVs



The role of marine “omics”

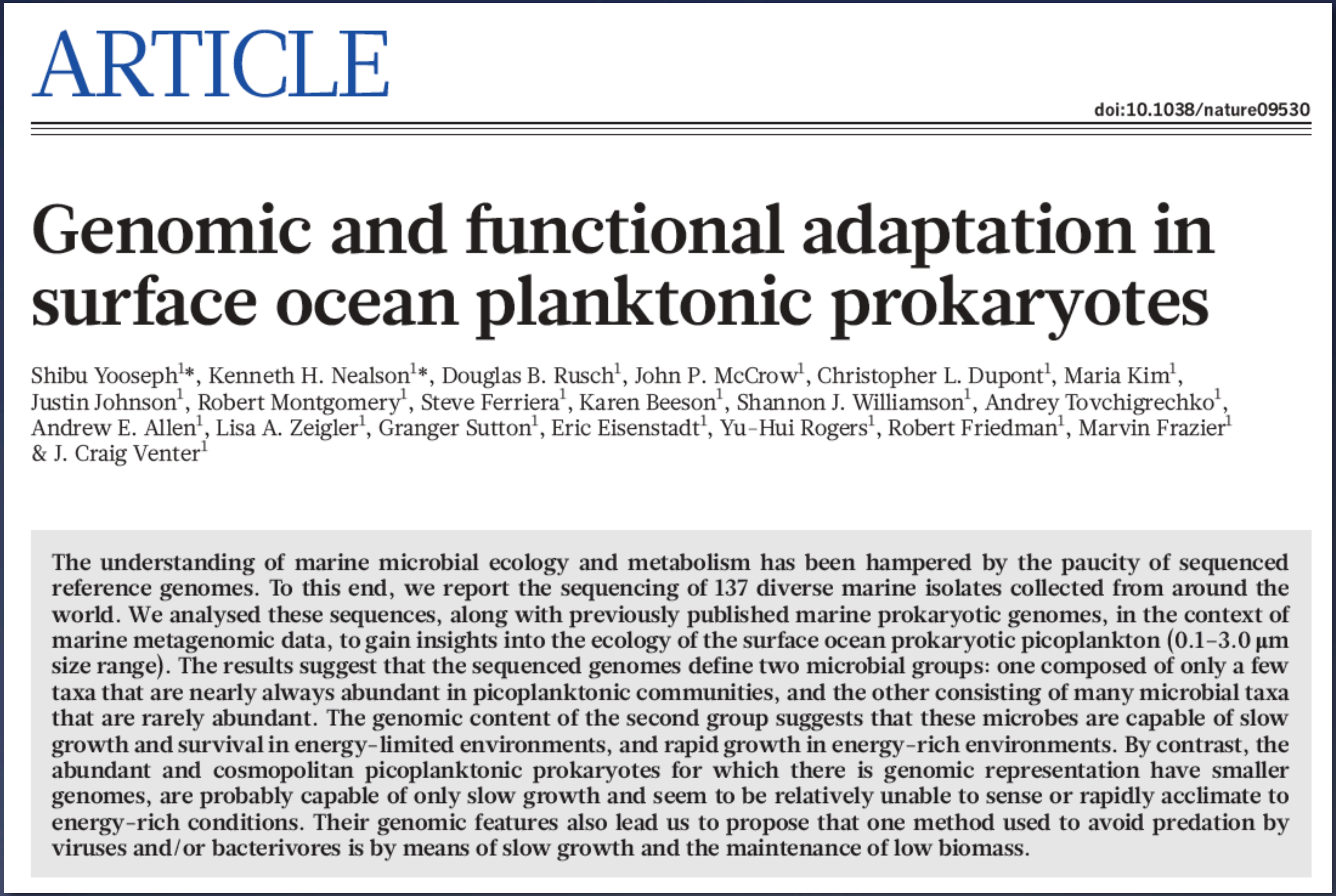


- ❖ Species identification & enumeration
- ❖ Metabolic potential
- ❖ Physiological status
- ❖ Protein production
- ❖ Metabolite production
- ❖ Metagenomics
- ❖ Microbes to whales
- ❖ Culture independent
- ❖ Single-cell sensitivity
- ❖ Metabolic networks
- ❖ Systems biology

Metagenomics

J. Craig Venter™
INSTITUTE

GORDON AND BETTY
MOORE
FOUNDATION



ARTICLE

doi:10.1038/nature09530

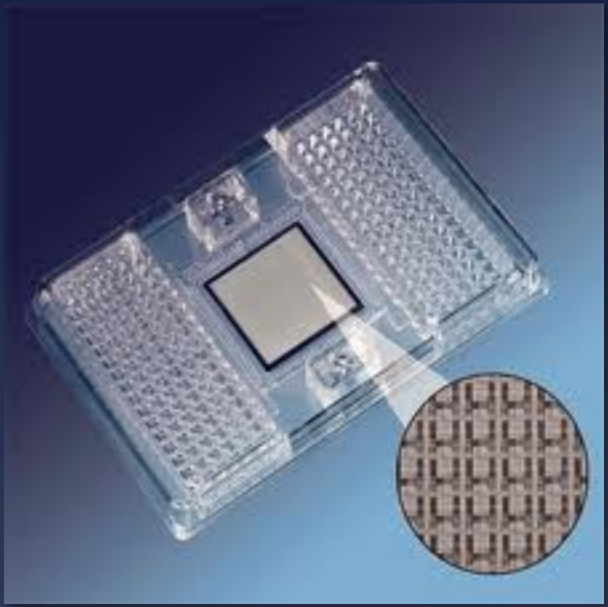
Genomic and functional adaptation in surface ocean planktonic prokaryotes

Shibu Yooseph[1]*, Kenneth H. Nealson[1]*, Douglas B. Rusch[1], John P. McCrow[1], Christopher L. Dupont[1], Maria Kim[1], Justin Johnson[1], Robert Montgomery[1], Steve Ferriera[1], Karen Beeson[1], Shannon J. Williamson[1], Andrey Tovchigrechko[1], Andrew E. Allen[1], Lisa A. Zeigler[1], Granger Sutton[1], Eric Eisenstadt[1], Yu-Hui Rogers[1], Robert Friedman[1], Marvin Frazier[1] & J. Craig Venter[1]

The understanding of marine microbial ecology and metabolism has been hampered by the paucity of sequenced reference genomes. To this end, we report the sequencing of 137 diverse marine isolates collected from around the world. We analysed these sequences, along with previously published marine prokaryotic genomes, in the context of marine metagenomic data, to gain insights into the ecology of the surface ocean prokaryotic picoplankton (0.1–3.0 µm size range). The results suggest that the sequenced genomes define two microbial groups: one composed of only a few taxa that are nearly always abundant in picoplanktonic communities, and the other consisting of many microbial taxa that are rarely abundant. The genomic content of the second group suggests that these microbes are capable of slow growth and survival in energy-limited environments, and rapid growth in energy-rich environments. By contrast, the abundant and cosmopolitan picoplanktonic prokaryotes for which there is genomic representation have smaller genomes, are probably capable of only slow growth and seem to be relatively unable to sense or rapidly acclimate to energy-rich conditions. Their genomic features also lead us to propose that one method used to avoid predation by viruses and/or bacterivores is by means of slow growth and the maintenance of low biomass.

Close the genomics technology gap

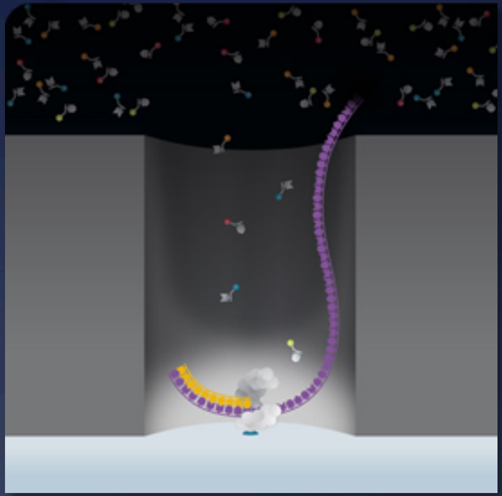
Microfluidics



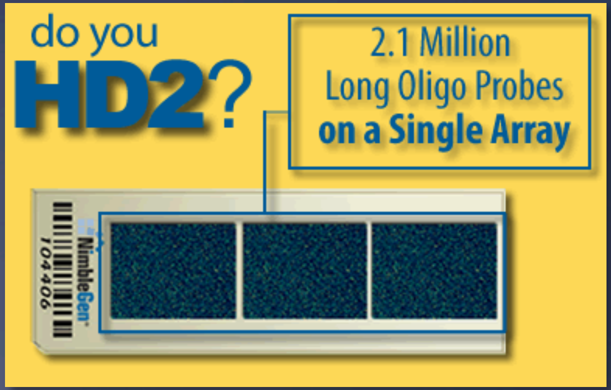
Fluidigm

PACIFIC BIOSCIENCES™

Single-molecule Analysis



High-Density Microarrays

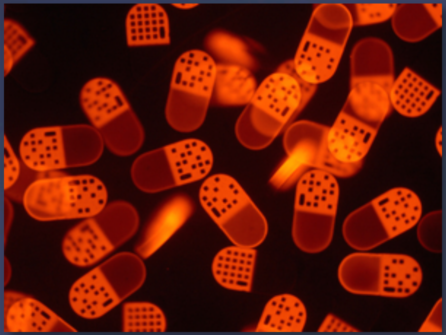


do you HD2?

2.1 Million Long Oligo Probes on a Single Array

NimbleGen® SYSTEMS, INC.

Microencapsulation



Firefly Bioworks

Our "Hubble" for the Sea

- Autonomous operation in remote, extreme environments
- Precise positioning
- Multitude of sensors
- Complex control & data acquisition networks
- Torrents of data
- Long-term observatories = decades
- Service & repair missions for consumables & instrument upgrades

$6 Billion

Budget Priorities & Inequities

$6 Billion

Wide-Field Infrared Telescope (builds on Joint Dark Energy Mission)

Goal: Investigating dark energy, searching for exoplanets
Total cost: $1.6 billion
Cost to U.S. government (2012–2021): $1.6 million
Launch date: 2020

Augmenting the Explorer program

Goal: Small to midsize missions that target specific topics such as brown dwarfs and gamma-ray bursts
Total cost: $463 million
Cost to U.S. government (2012–2021): $463 million
Launch date: Rolling

CREDITS (LEFT TO RIGHT): NASA; JAXA

Laser Interferometer Space Antenna (LISA)

Goal: Detecting gravitational waves and black-hole mergers; testing general relativity
Total cost: $2.4 billion
Cost to U.S. government (2012–2021): $852 million
Launch date: 2025

CREDITS (LEFT TO RIGHT): NASA

International X-ray Observatory (IXO)

Goal: Studying black-hole accretion and neutron-star physics; stellar astrophysics
Total cost: $5.0 billion
Cost to U.S. government (2012–2021): $200 million
Launch date: 2020s

SPACE-BASED PROJECTS

ASTRONOMY

U.S. Astronomers Unveil Stripped-Down 'Short List'

In 2008, when a committee of U.S. astronomers led by Stanford University astrophysicist Roger Blandford was asked to recommend funding priorities in astronomy and astrophysics for the next decade, it was clear what the panel was not supposed to do. "The message from Congress was: Don't give us a list of 50 things to fund," says panelist Debra Elmegreen, an astronomer at Vassar College in Poughkeepsie, New York. "Give us the things you really, really want to do."

That's exactly what the panel says it has done in its report of the sixth decadal survey, released last week by the National Research Council. Unlike previous decadal surveys, which often produced unrealistically long "wish lists" of priorities, the new report claims to have made some hard choices that hew to the realities of a tough budgetary climate. And for the first time, the survey had estimates of project costs vetted independently, which the panelists say makes those figures more realistic than in [illegible].

The report identified [illegible]s each in the space- and gro[illegible]sed cat[illegible]es (see graphic). The top choi[illegible]oth groups concern dark energy, the myste[illegible]e that is accelerating the expansion of t[illegible] On land, the panel chose the $463 milli[illegible]ynoptic Survey Telescope (LSST), an 8.4-me[illegible]tical telescope that will help investigate da[illegible]rgy, supernovae, and othe[illegible]s. In spa[illegible] top choice was the $1.6 [illegible]rared Survey Telescope (WFIRS[illegible]w known as the Joint Dark Energy Missio[illegible]which should enable researchers to study d[illegible]energy, find Earth-like planets, and survey galaxies, including our own.

"It's great that the committee saw the excitement an[illegible]possibility of studying dark [illegible]" says A[illegible]ss, an astrophysicist at Joh[illegible]kins [illegible]ity in Baltimore, Maryland. R[illegible] he [illegible]cially pleased with the endo[illegible]t fo[illegible]ST, which he calls a "crucial capa[illegible]n [illegible]umber of disparate invest[illegible]nce."

Both pro[illegible]ve been in the works [illegible]w [illegible]rs and ha[illegible]eived public and priva[illegible]ds [illegible]lannin[illegible]esign. In fact, LSST wa[illegible] [illegible]d-based initiatives recom[illegible] fo[illegible] the 2001 decadal survey. [illegible] consortium of institutions headed by astronomer J. Anthony Tyson of the University of California, Davis, the project has already picked out a site in Chile and finished casting its primary mirror.

"We are recommending that the National Science Foundation enter LSST into its MREFC line as soon as possible," says Blandford, referring to the account through which NSF funds the construction of major research facilities. NSF offi[illegible]em re[illegible]e to th[illegible]ssage[illegible]e very [illegible] by H[illegible] LSST [illegible]mber[illegible]nong ground-base[illegible]ects," [illegible]m Ulves[illegible], NSF's [illegible] for a[illegible]mical[illegible]es.

[illegible]RST's [illegible]ppear[illegible]less c[illegible]partly [illegible]e del[illegible]the $[illegible]llion [illegible]Webb [illegible]Telesc[illegible]chedu[illegible] laun[illegible]2014 [illegible]urtail[illegible]s abil[illegible]und n[illegible]sions [illegible]er, th[illegible]ct tha[illegible]RST b[illegible]n has [illegible]pport[illegible]h NA[illegible] the [illegible]tment [illegible]gy. Th[illegible]agen[illegible]e in ta[illegible]h the European Space Agency about a possible partnership, which would boost WFIRST's prospects of being launched by the panel's recommended date of 2020. "The U.S. should play a leading role in such a partnership," Blandford says.

Blandford says the panel considered two budget scenarios: one in which U.S. funding for the physical sciences doubles over the next decade, and one that sees only modest increases. All of the projects recommended in the report could be implemented under a doubling. In the less-rosy scenario, Blandford says, a number of existing observatories—particularly ground-based ones—should be shut dow[illegible]oom for the ne[illegible]initiativ[illegible] [illegible]ability of [illegible]uations h[illegible] the ac[illegible]cost e[illegible]tes of the dif[illegible]projec[illegible]ious surv[illegible]ve drawn fire f[illegible]viding [illegible]tes as low[illegible]fth of the ultim[illegible]sts for[illegible]missions. T[illegible]rt's estim[illegible]more b[illegible]le, Blandfo[illegible]were eva[illegible] by an inde[illegible]pend[illegible]ractor, Aerosp[illegible]orp., instea[illegible] of by other astronomers as in previous surveys. "Astronomers are not really good business managers," says panelist Marcia Rieke, an astronomer at the University of Arizona, Tucson. In this survey, some of the estimates submitted to the panel "drew gasps from the independent evaluators," she says. "They looked at some of the concepts and said it was impossible to cost them because so much engineering needed to be done to even begin to estimate the project cost."

Blandford says the panel also tried to strike a balance between large and small projects. "We strove to protect the smaller and nimbler activities," he says. That's why ranked second in the space category is a proposed augmentation to the Explorer program, which supports small- and medium-sized missions with specific science goals. Similarly, in the category of large-scale, ground-based projects, right behind LSST is a recommendation to fund a Mid-Scale Innovations Program within NSF to fund projects that cost more than $4 million and less than $135 million.

–YUDHIJIT BHATTACHARJEE

GROUND-BASED PROJECTS

Large Synoptic Survey Telescope

Goal: Studying dark energy, dark matter, supernovas, near-Earth objects
Total construction cost: $465 million
Cost to U.S. government (2012–2021): $421 million
Annual operating cost: $42 million
Science begins: Late 2010s

Mid-Scale Innovation Program

Goal: Funding projects that cost between $4 million and $135 million, such as a new radio array to study the sun
Total cost: $93 million to $200 million
Science begins: Mid-to-late 2010s

CREDITS (LEFT TO RIGHT): T. MASON, MASON PRODUCTIONS INC. / LSST CORP.; FASR

Giant Segmented Mirror Telescope

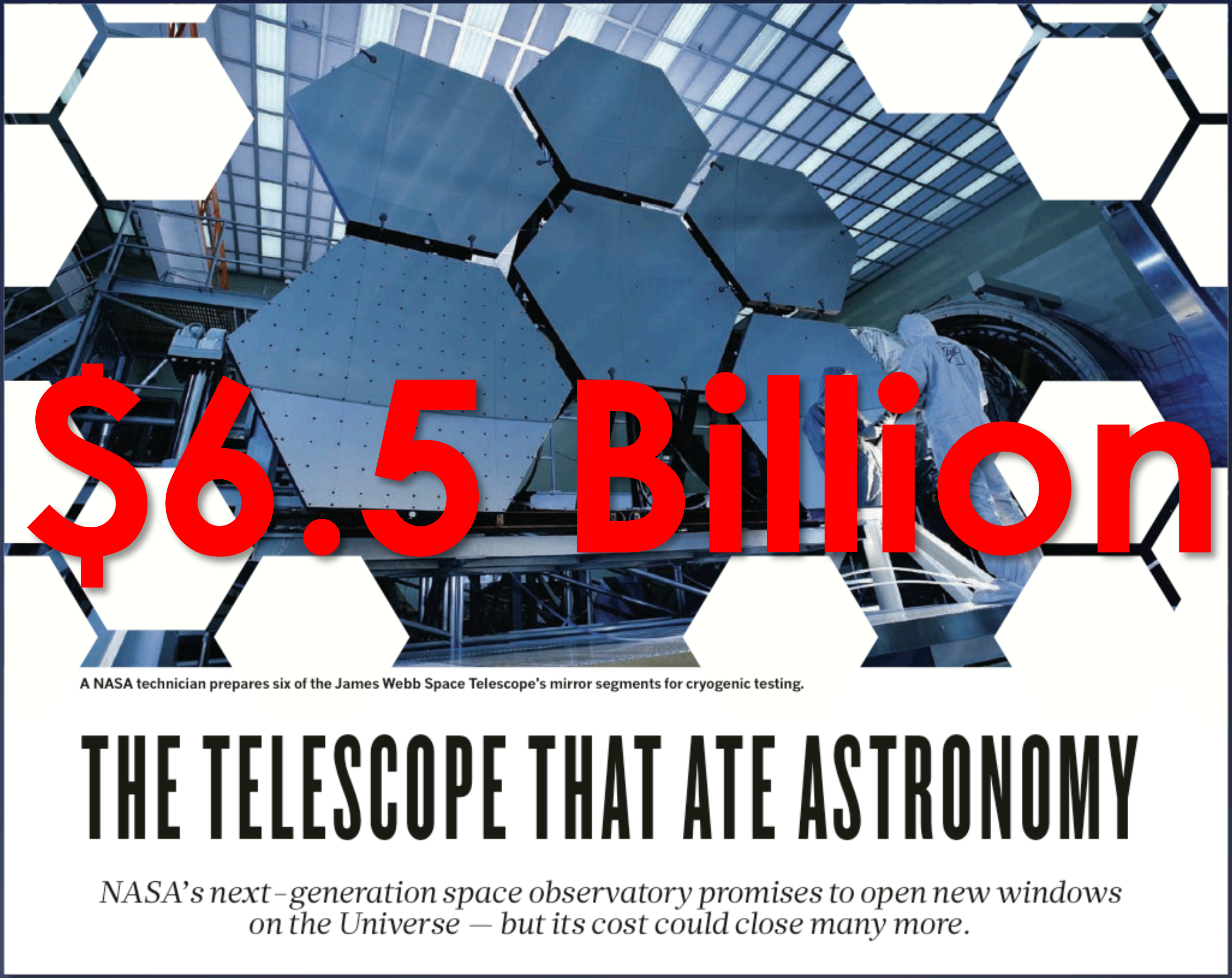
Goal: Studying the earliest galaxies and galaxy evolution; detecting and characterizing planetary systems
Total construction cost: $1.1 billion to $1.4 billion
Cost to U.S. government (2012–2021): $257 million to $350 million
Annual operating cost: $36 million to $55 million
Science begins: Mid-2020s

Atmospheric Čerenkov Telescope Array

Goal: Detecting dark matter, investigating active galactic nuclei
Total construction cost: $400 million
Cost to U.S. government: $100 million
Operating cost: Unknown
Science begins: Early 2020s

CREDITS (LEFT TO RIGHT): TMT; GIANT MAGELLAN TELESCOPE/GMTO CORP.; AGIS

Searching for Oceans on Distant Planets



$6.5 Billion

A NASA technician prepares six of the James Webb Space Telescope's mirror segments for cryogenic testing.

THE TELESCOPE THAT ATE ASTRONOMY

NASA's next-generation space observatory promises to open new windows on the Universe — but its cost could close many more.

Nature 28 October 2010

GBF-OOI

- Requires a budget commensurate with the critical importance of the data for assessment of the current impacts of global warming and for better prediction of its future time course and likely consequences.
- Plan for a *century* of ocean observation – the time frame of relevance for global warming.
- Must be truly international in participation and global in scope.
- Immediate deployment is required if the data are to overcome skeptics and provide any opportunity for mitigation.

Learn More, Contribute!

- GBF-OOI Community White Paper
- http://www.whoi.edu/GBF-OOI/page.do?pid=41475
- Comments, suggestions & questions
- gbf-ooi@whoi.edu

Get political!

- Major roles for NASA, DOE & NIH – not just NSF & NOAA – as well as foreign counterparts
- Contact your Senators & Congressmen
- Stress the urgency, scope & scale needed
- Push for major funding increases & reallocation
- Raise awareness among your peers
- Educate the public
- Bring the best possible science to bear