

Molecular Microbiology to explore biodiversity, understand ecological function, and protect health



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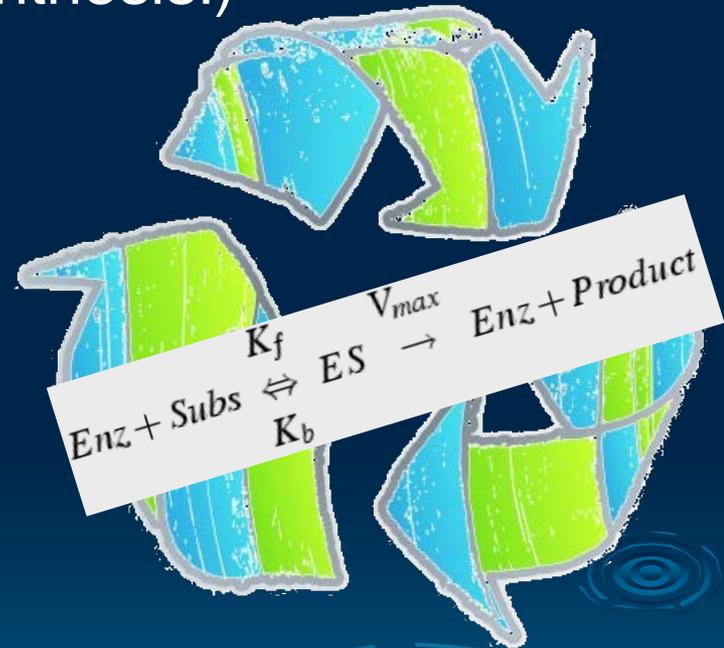
stationed at SWFSC

Microbes Are Essential

They control....pretty much *everything*

Good:

- **Nutrient** Cycles (including photosynthesis!)
- **Climate**-controlling gases
- **Ozone**-depleting gases
- **Waste Treatment**
- **Degrade toxic** compounds
- **Life-saving** medicines



Bad:

- Impair **Water Quality** (including oxygen depletion)
- **Diseases** of Fish, Protected Species, Corals
- Human **Infections**

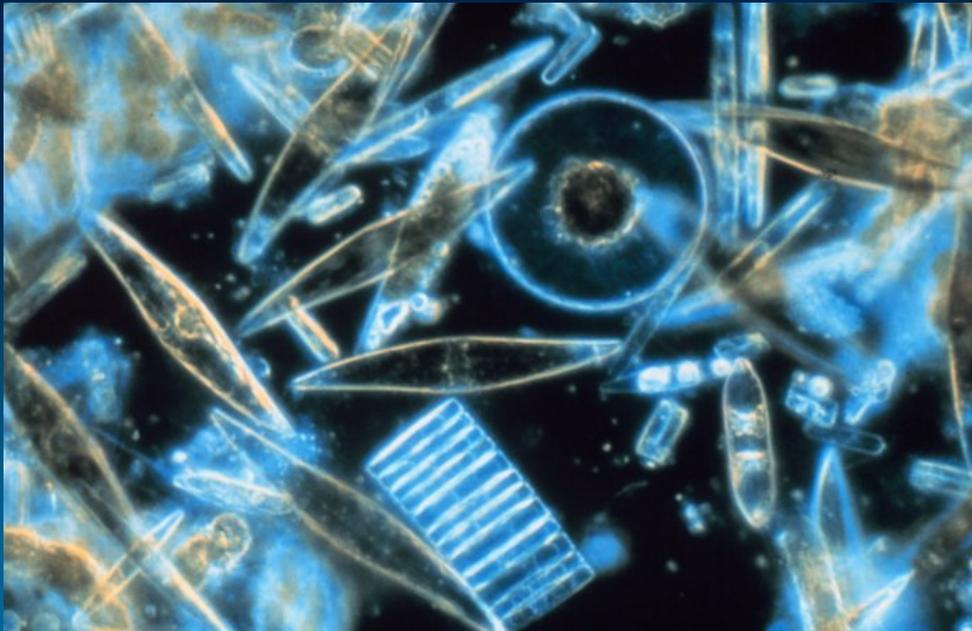
Bacteria in the News

- **“Marine microbes regulate the composition of the atmosphere, influence climate, recycle nutrients, and decompose pollutants”**
 - 2010 Census of Marine Life
- **“Bacteria sucked up 200,000 tons of oil after BP spill”**
 - 2012 CBS headline
- **“Bacteria play crucial roles in the ocean ecosystem services [food, climate]...we have to pay attention to shifts in bacterial distributions”**
 - 2013 Polar biogeography



How we understand the microbial world is changing

- Previously, we only understood what could be grown in the lab
- <1% of the microbial world



The Genomic Era



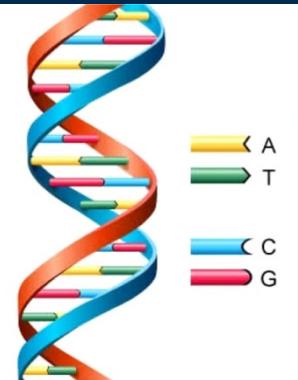
<1%

from this



to this

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AGTCGAGCGGTAGCACAAGGAGA
GCTTGCTCTCTGGGTGACGAGCG
GCGGACGGGTGAGTAATGTCTGG
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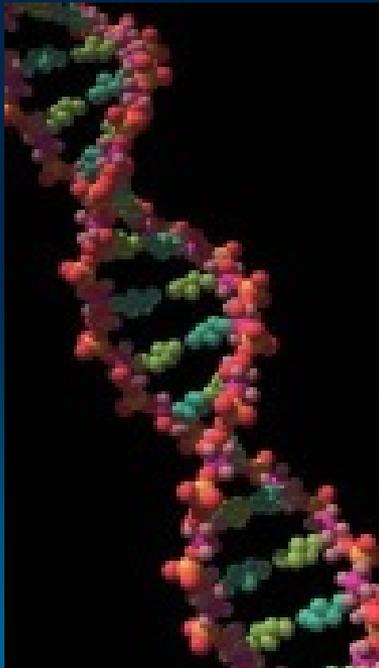


**Circumvents
the obstacle
of laboratory
cultivation**

The genomic revolution

Transformational Research

“...Revolutionizing entire disciplines, creating entirely new fields, or disrupting accepted theories and perspectives.” —National Science Foundation



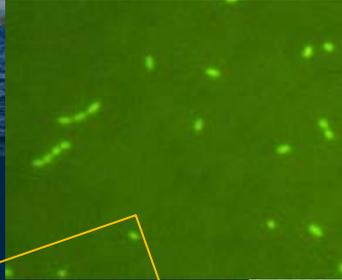
- **Medicine**
- **Food**
- **Energy**
- **Environment**

Environmental Genomics = **Metagenomics**

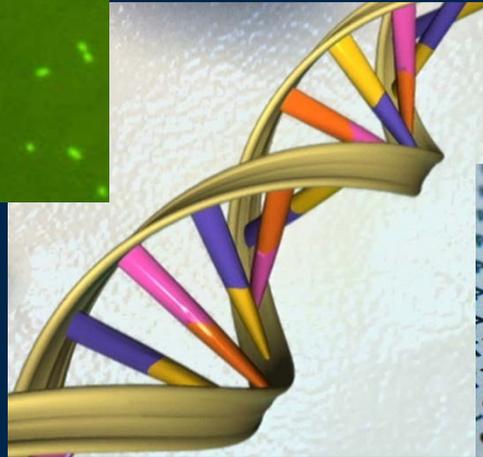
a next step in the revolution



Microbial
Community



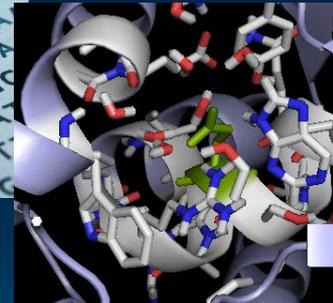
Extract
all DNA



Next-Gen
Sequencing



Identify
Proteins



**Uncovering
hidden diversity
and structure**

To answer broad ecological questions

Who? Where?

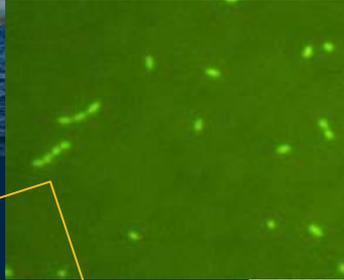
What are they doing?

How might it change?

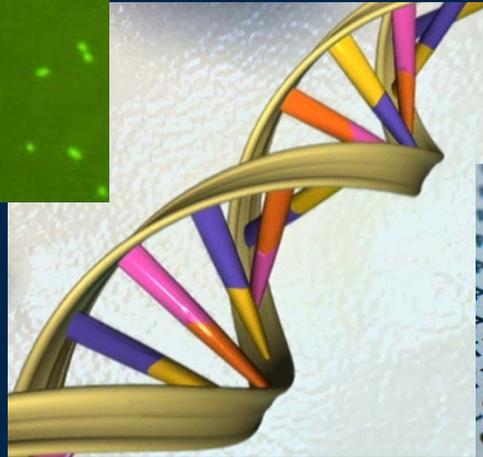
Metagenomics



Microbial
Community



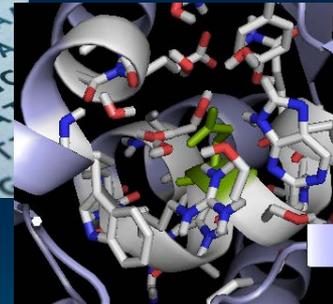
Extract
all DNA



Next-Gen
Sequencing



Identify
Proteins



**Technology
Driven.
Staggering
computational
Demands.**

In 10 years:
100 DNA sequences to
100 Million DNA sequences per run

Microbiology in NOAA



Innovate, Incubate, Integrate
noaa research

NOAA's OFFICE OF OCEANIC AND ATMOSPHERIC RESEARCH

OAR

Mission

Conduct research to understand and predict the Earth system;
develop technology to improve NOAA science, service and
stewardship; and translate the results so they are useful to society

**NOAA One
Health Working
Group**

**NOAA Microbe and
Ecosystem Health
Working Group**

NOAA mandates

**Governor's
Alliances**

**Regional Working
Groups**

**Holistic
Understanding,
Ecosystem
Forecasting,
Coastal IP,
Healthy Oceans**

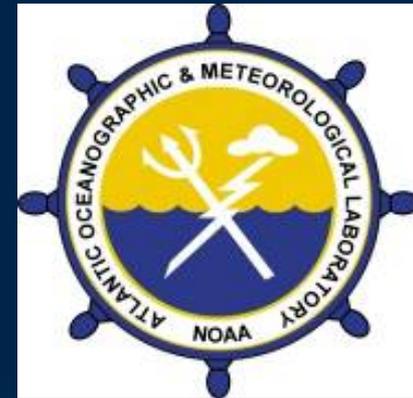
Marine Molecular Microbiology

Examples from NOAA

Office of Oceanic & Atmospheric Research (OAR)

Atlantic Oceanographic & Meteorological Laboratory (AOML)

- Next-generation sequencing techniques to better understand **biodiversity**
- Metagenomic analysis to understand **ecosystem function**
- Molecular approaches to identify water contamination sources to help managers devise **mitigation** strategies, **decrease risks to health**, and **preserve coastal economies**



Biodiversity: Methane Ice Worm Microbiome



- NOAA mission for discovery and exploration
- Metagenomic analysis reveals metabolic capabilities (organics, sulfur, AND methane) in extreme environment (ephemeral methane hydrates)
- Technology Development (computational methods to deal with these enormous and complex data sets)
- Workforce Development (NOAA-Smith College Intern)

Providing Workforce Opportunities for the Next Generation

Science Education and Research Mentorship at NOAA AOML:

- NOAA Hollings Scholars (Oceans & Human Health)
- NOAA-Smith College Program Interns
- Environmental Protection Agency Interns
- University Research Assistants
- NSF Research Experience for Undergraduates
- High School Research Interns



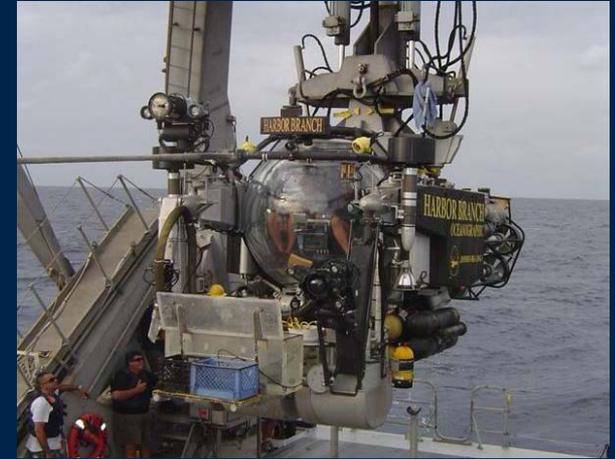
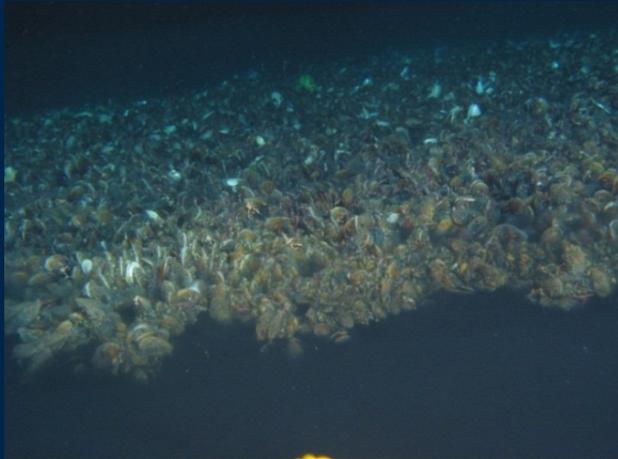
Cutting-edge

Interdisciplinary

State of the Art

High Tech

Ecosystem Function: GoM Water Column



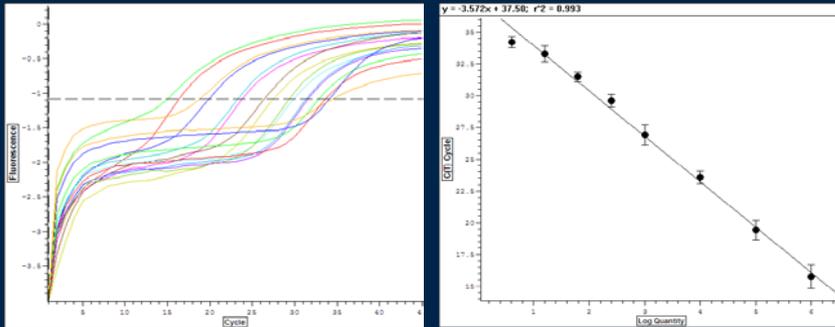
- Collected pre-DWH, includes methane brine pool
- On-going metagenomic analysis of metabolic pathways and bacterial types
- Fortuitous comparison before & after spill for insight into ecological response to spill

Protecting Health

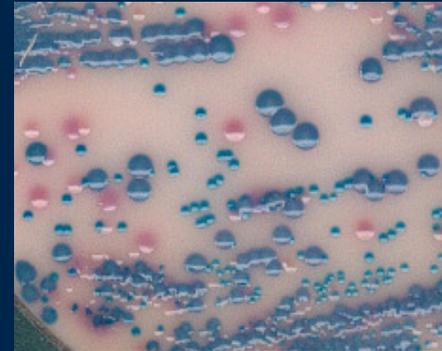
- Many applications: recreational water, seafood safety, diseases of protected species & commercial fish
 - **Coastal Waters are Important to the Nation.** U.S. coastal tourism and recreation created 1.6 million jobs in 2000. In CA only: >100 million visitors and ~\$9 billion annually.
- Repercussions of degraded **water quality**:
 - Bacterial contamination makes people sick.
 - Millions \$\$ spent annually on mandated monitoring.
 - Mitigation costs can be 100's of millions \$\$\$\$.



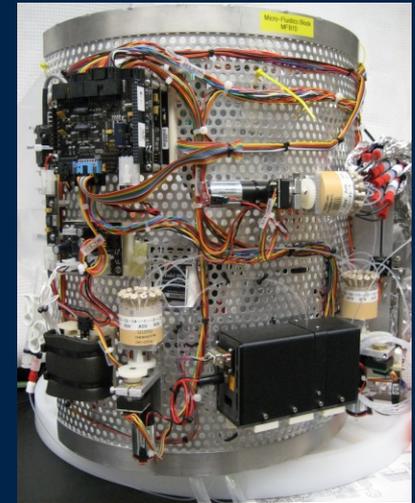
AOML Microbial Water Quality Applications



Assay Development



Pathogen & HAB
Detection



Automated
Biosensors



Water Quality Assessment

linking to land-based sources of pollution

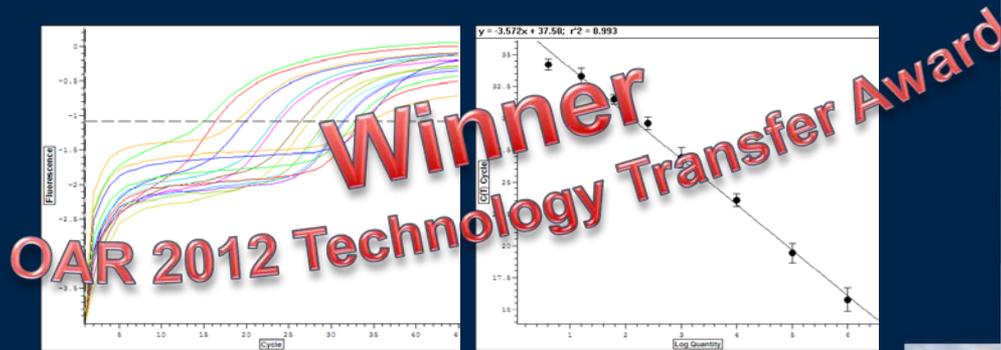


Protected Species Health



Inter-laboratory Validation, Inter-Agency
Collaboration, & Stakeholder Training

AOML Technology Development & Transfer



Assay Development

Transferred to academia
& industry



Microbial Source Tracking -- tools to identify contamination sources (e.g., birds, dogs). Help managers devise mitigation strategies to decrease risks to health and to preserve coastal economies.

Molecular Tools Used by Stakeholders

- Assays used in multiple watershed studies.
- Part of a recent international evaluation of MST assays.

- Knowledge gained through this and related research has led to money saved in Microbial Water Quality Assessments (MWQA), and is helping stakeholders manage and mitigate water quality issues.



Cabrillo Beach, Los Angeles

Study is part of a Cooperative Research and Development Agreement (CRADA)

Molecular Tools for NOAA Summary

- Provide new understanding of biodiversity to aid exploration and stewardship
- Improved evaluation of baseline and changed ecosystem function
- Help stakeholders manage and mitigate contamination issues to protect health and economies

