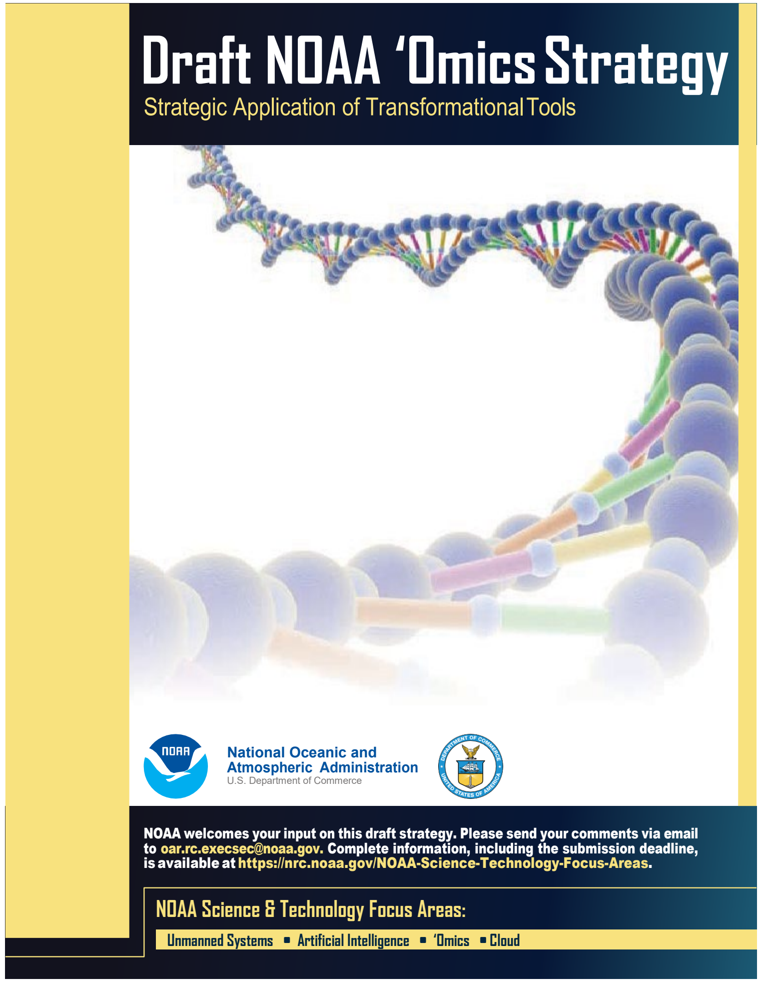
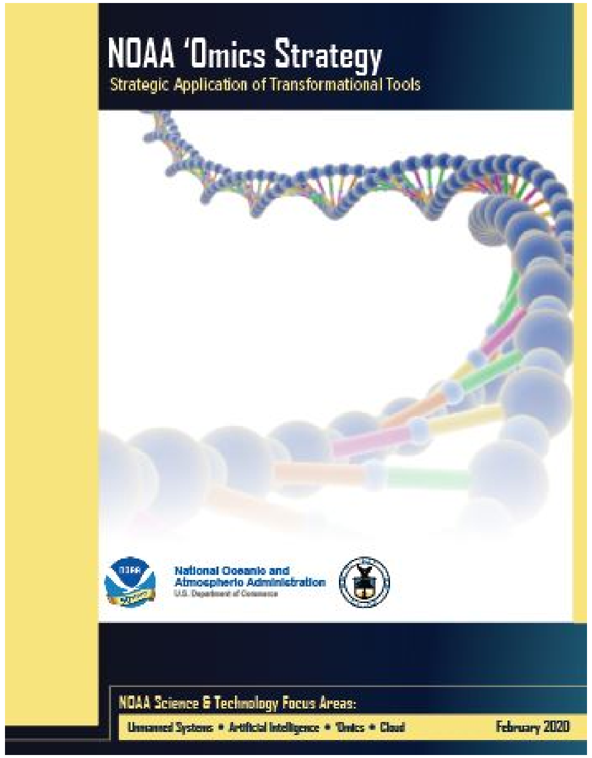
NOAA ‘Omics Strategy

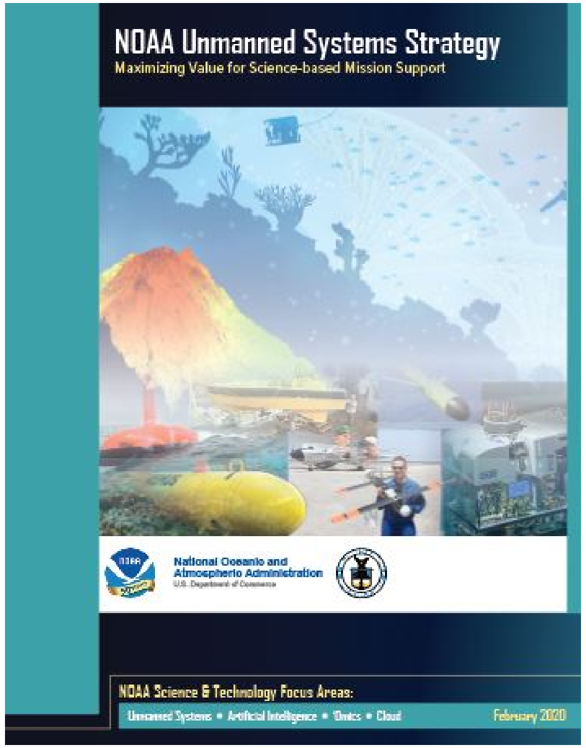


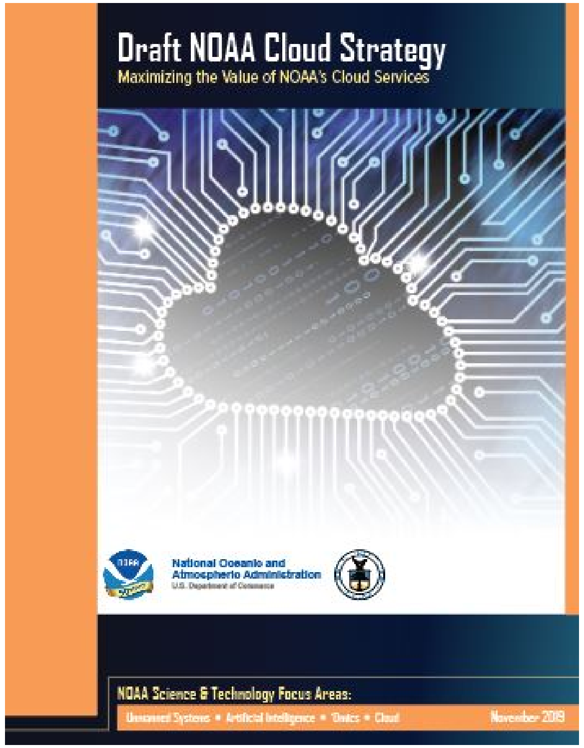
Kelly D. Goodwin
Kelly.Goodwin@noaa.gov

National Oceanic and Atmospheric Administration (NOAA)
Atlantic Oceanographic & Meteorological Laboratories (AOML)
(stationed at SWFSC)

https://nrc.noaa.gov/NOAA-Science-Technology-Focus-Areas

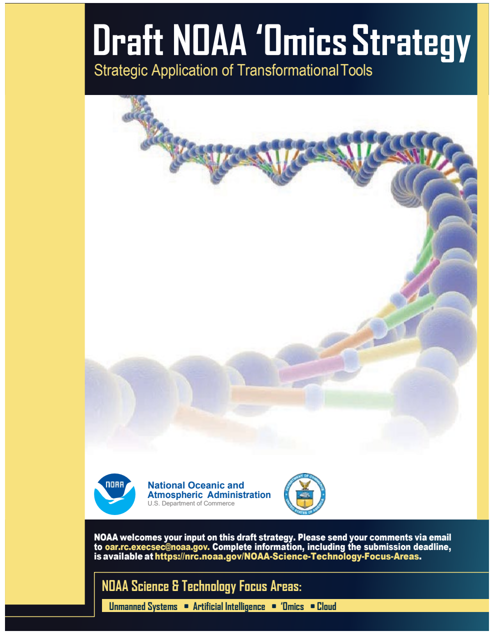






NOAA ‘Omics Strategy

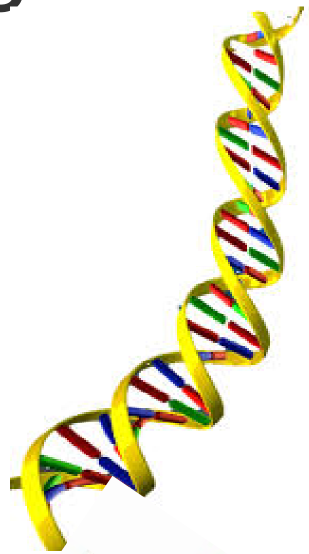
Strategic Application of Transformational Tools



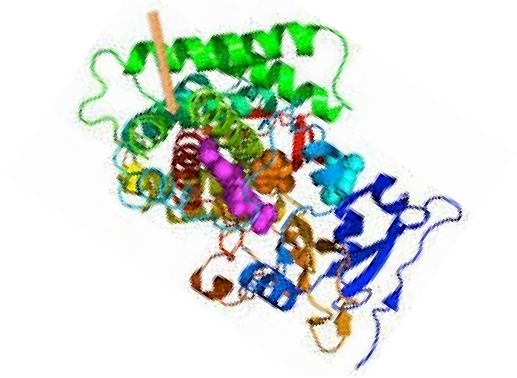
‘Omics Strategy Vision

NOAA will integrate modern ‘omics technologies across the agency, transforming its approach to biological investigation and accelerating sustainable management of ecosystem resources for the benefit of people, communities, and economies.

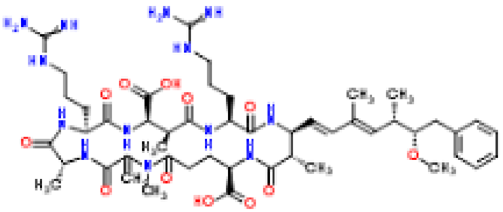
‘Omics Definition and Benefits



- A suite of advanced methods used to analyze material such as DNA, RNA, proteins, or metabolites.



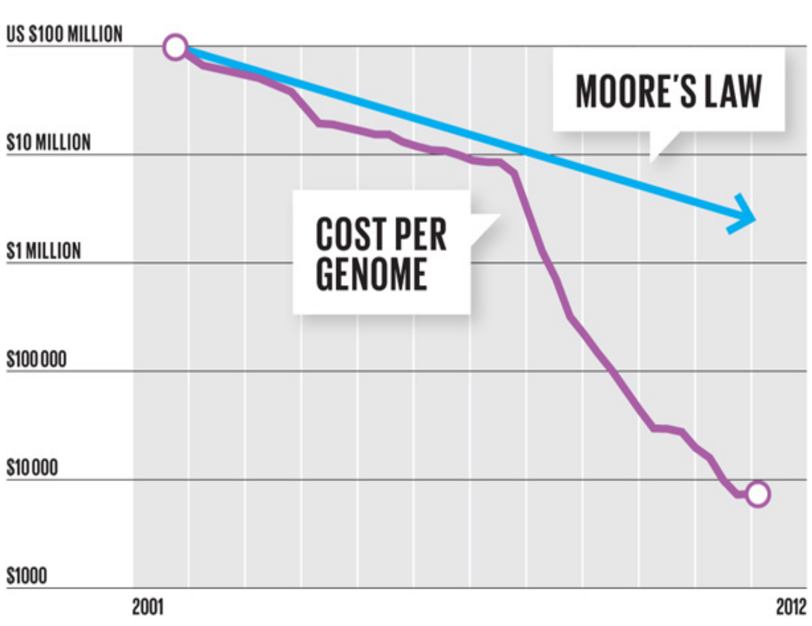
- These tools that have revolutionized biological study, with benefits applied to medicine, agriculture, and other industries.

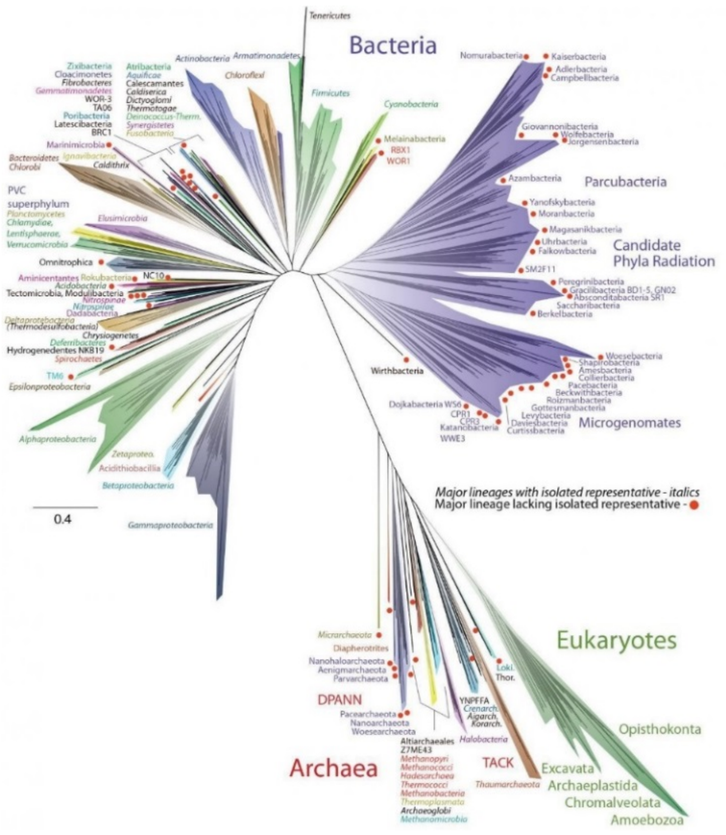


- NOAA is using these tools to understand how to sustain and grow the benefits we receive from our oceans and Great Lakes.

Sequencing Technology: Fast, Cheap, Massive

Science advances tied to developments in ‘omics methodologies





- DNA sequencing reveals unanticipated complexity, diversity, and relationships
- Identify organisms, activities, and mechanisms that keep oceans and Great Lakes ecosystems healthy and productive

‘Omics Applications for the Blue Economy

The US Blue Economy Adds

$304 Billion

to the Gross Domestic Product

The US Blue Economy Provides

3.3 Million

Jobs Annually

Protect

from harmful algae, bacteria, invasive

Sustain

Fish, coral, marine mammals & turtles

Promote

Aquaculture, fishing, bioprospecting

Improve

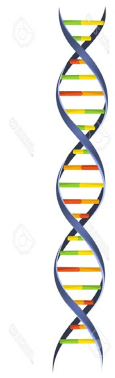
Labor & ship costs, time to data products

‘Omics Strategy Goals

Goal 1: Enhance infrastructure to meet the analytical demands of ‘omics data.

Goal 2: Execute **‘omics research** targeted to support and advance the U.S. Blue Economy.

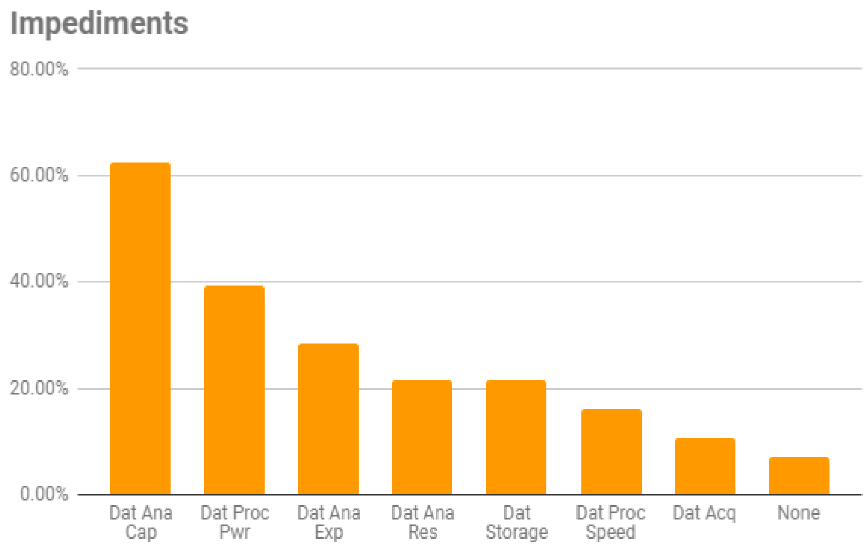
Goal 3: Accelerate **transition of ‘omics research** into operations.

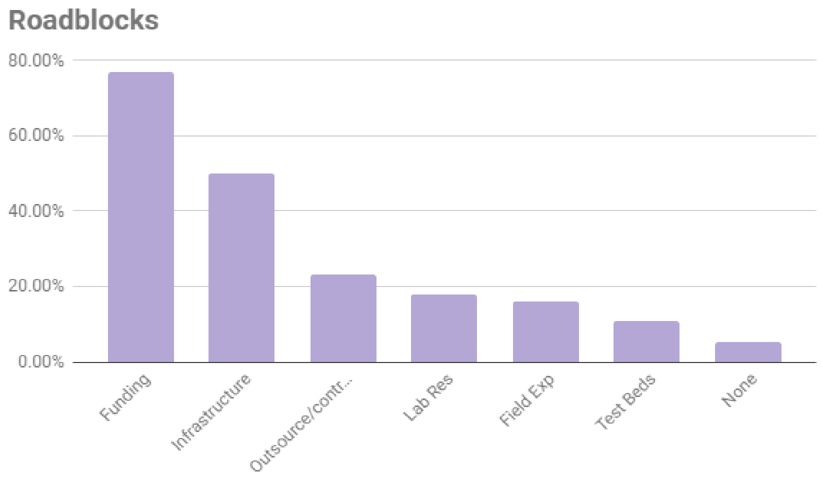


Goal 4: Expand partnerships to advance ‘omics research and applications across the agency.

Goal 5: Promote workforce proficiency in ‘omics.

NOAA ‘Omics Taskforce Survey Results





- A 2018 survey of NOAA staff revealed that gaps in infrastructure and computing power (**Goal 1**) & staffing and bioinformatics expertise* (**Goal 5**) impede implementation of ‘omics
- Results were consistent with a cross-agency analysis conducted in 2015 by the Microbiome Interagency Working Group (Stulberg et al. 2016 doi: 10.1038/NMICROBIOL.2015.15)

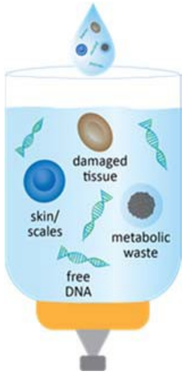
*Number of FTE bioinformaticians in NOAA = *zero*

Goal 1 – Enhance Infrastructure

***Objective 1.1*. LABS, SHIPS, AND VEHICLES**

Provide adequate laboratory space in facilities and ships to collect, process, and store samples for ‘omics analyses, and increasingly leverage UxS (unmanned systems) for data collection (**see UxS Strategy**)

***Objective 1.2*. COMPUTING POWER and STORAGE**

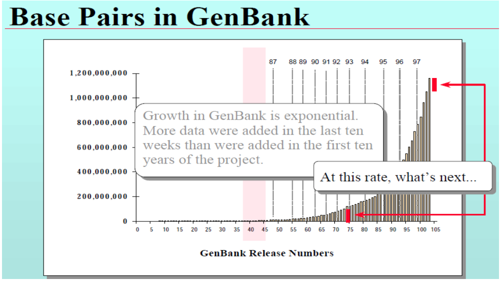


Procure the analytical and computational infrastructure needed to generate, analyze, and manage massive ‘omics data sets, and increasingly leverage the commercial cloud for computation and data storage (**see Cloud Strategy**).

***Objective 1.3*. BIOINFORMATICS and DATABASES for ‘OMICS TIME SERIES**

Expand the databases that identify genetic sequences and develop bioinformatics tools needed to manage and interpret time series data, including impacts of large-scale environmental change through biodiversity monitoring.

***Objective 1.4*. SHARED REPOSITORIES**



Create a central repository to share protocols, standards, and house bioinformatics pipelines to support a community of practice across laboratories and programs.

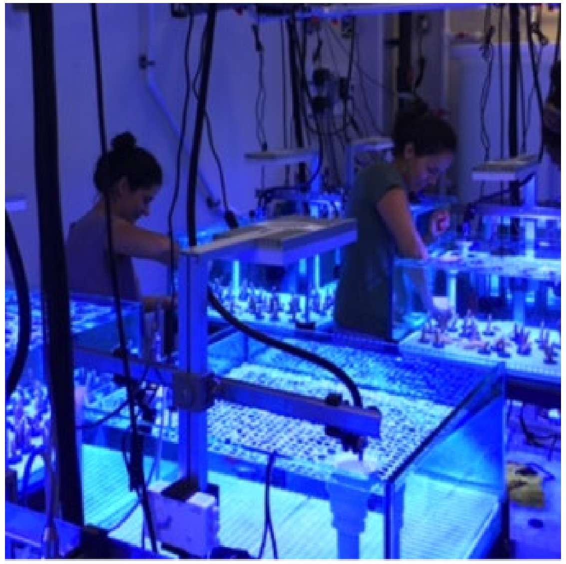
***Objective 1.5*. MACHINE LEARNING AND AI**

Leverage computational approaches such as machine learning and artificial intelligence (**see AI Strategy**) to help interpret genetic variation and recognize relationships with environmental data.

Infrastructure Enhancement

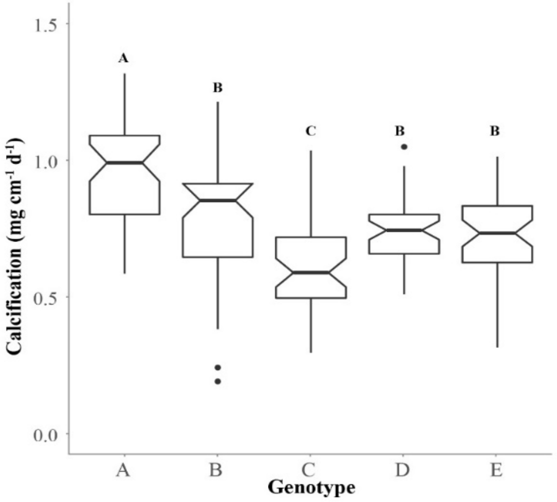
SE Florida coral: $8.5 billion and 70,400 jobs annually

Coral reefs are in crisis globally, but some corals show resilience, providing hope for restoration

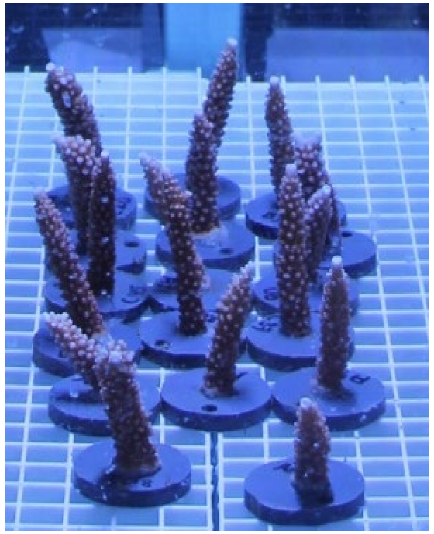


Futures Reef Lab, Miami FL

An experimental aquarium was constructed to help identify the genes that allow some corals to resist bleaching and disease



resilient genotypes



informed restoration

Goal 2 – Research to Support US Blue Economy

Objective 2.1. **BIO-SURVEILLANCE**

Improve detecting and monitoring of harmful algal blooms, toxins, pathogens, and invasive species to protect health and coastal economies.

Objective 2.2. **SEAFOOD FORENSICS**

Support consumer protection and sustainable fishing practices by using genetic analysis to identify fraudulent and illegally sourced seafood products.

Objective 2.3. **SUSTAINABLE AQUACULTURE**

Foster the development of aquaculture by using ‘omics to optimize animal health, yield, and product characteristics while supporting safe and sustainable farming practices.

Objective 2.4. **FOOD WEBS, FISHERIES, and PROTECTED RESOURCES**

Sustain fisheries resources and protect vulnerable species using ‘omics to increase the breadth, depth, and throughput of information used to evaluate target populations’ structure and distribution, generate indices of abundance, and characterize the food webs that support them.

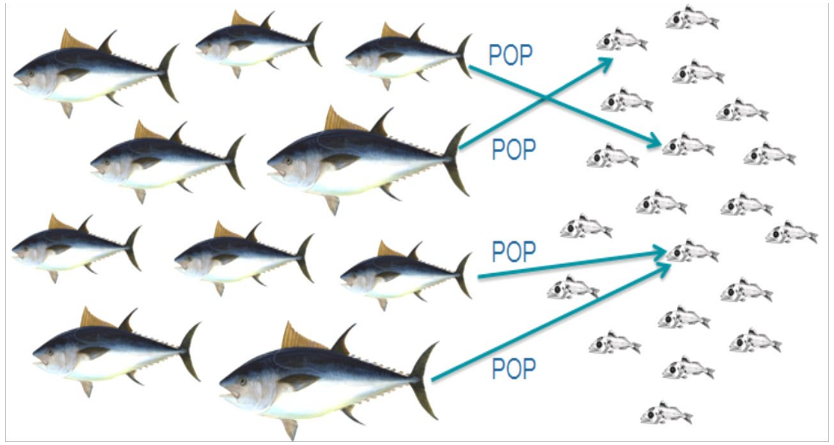
Objective 2.5. **BIODIVERSITY AND BIOPROSPECTING**

Advance the exploration of biodiversity and bioprospecting to discover natural products that may have medical or other commercial value and provide international leadership in the use of marine genetic resources while protecting biodiversity.

Fisheries Applications – Highly Migratory Species

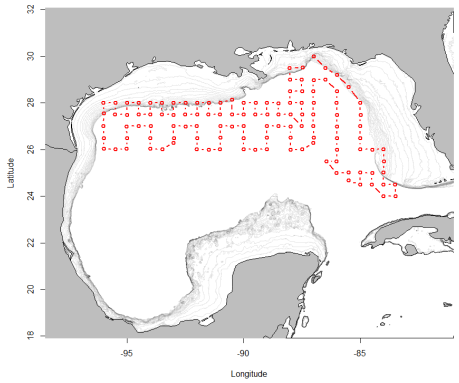
West Atlantic Bluefin Tuna close-kin mark-recapture (CKMR) for FISHERIES INDEPENDENT stock assessments

NOAA FISHERIES

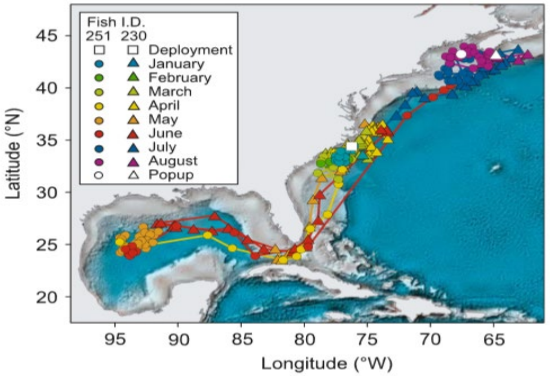


NOAA RESEARCH
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION

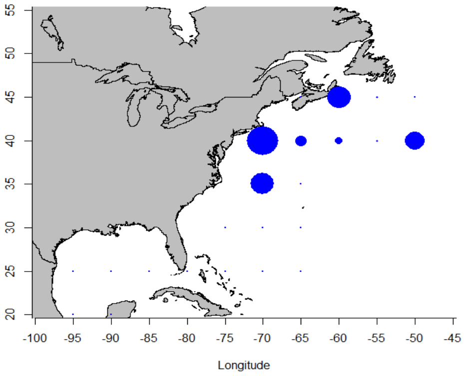
1) Adults spawn in GOM, larvae **genotyped**



2) Fish migrate to the NW Atlantic



3) Bluefin adults caught and **genotyped**



Matt Lauretta – Matt.Laureta@noaa.gov and John Walter, SEFSC; Chris Kelble, AOML

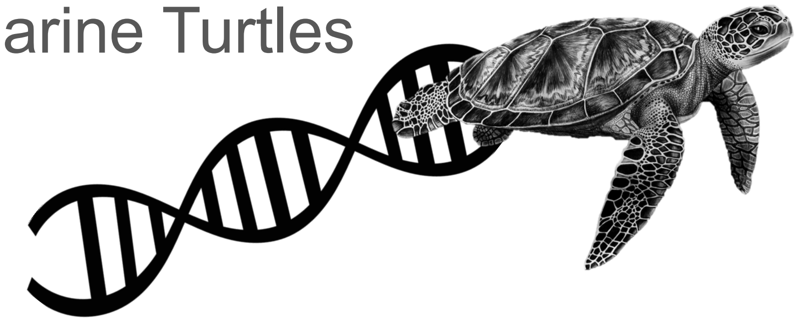
eDNA for Protected Resources

The microbiome **and higher trophic levels**, such as fish or marine mammals, can be gleaned from seawater – from the DNA in sloughed or excreted cells

eDNA Benefits:

- Sensitive
- Less invasive (no tissue, no trawls)
- Extended sampling reach (deep, poles, protected)
- Detect multiple trophic levels from single sample ("microbes to mammals")
- Amenable to autonomous platforms

Marine Turtles



- Mandated monitoring
- Surveys are laborious, expensive, stressful to animal
- Suitability of eDNA for marine amphibians unknown
- Despite carapace, eDNA detected and consistent with animal presence

Harper et al. 10.3389/fmars.2019.00810/full

NOAA RESEARCH NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION

NOAA FISHERIES

Goal 3 – Accelerate transition of ‘omics research into operation

MIND THE GAP

Objective 3.1. **UNDERSTAND AND FULFILL MISSION REQUIREMENTS**

Conduct field trials to define operational requirements, calibrate ‘omics approaches with traditional methodologies, and clarify design specifications to accelerate production of validated approaches.

Objective 3.2. **STANDARDIZED, INTEROPERABLE AND AVAILABLE DATA**

Promote a unified approach to sample and metadata collection, sample processing, and data deposition in publicly searchable archives to promote interoperability and time series establishment.

Objective 3.3. **INDICATORS AND ACTIONABLE EVIDENCE**

Develop and integrate ‘omics ecosystem indicators into reports, models, and forecasts to benefit seafood safety, public health, and economic protection.

Objective 3.4. **COMBINE TECHNOLOGIES TO ACCELERATE SUCCESS**

Combine ‘omics with existing and emerging technologies to synergize the strengths of individual approaches and thus hasten the innovation of operations.

Objective 3.5. **UTILIZE R2X PROCESS**

Develop transition plans with NOAA Line Office Transition Managers (LOTMs) to outline steps for technology transfer and provide incentives and support for ‘omics R2X.

Autonomous 'Omics

"Accelerate transition of 'omics research into operations" – NOAA 'Omics Strategy

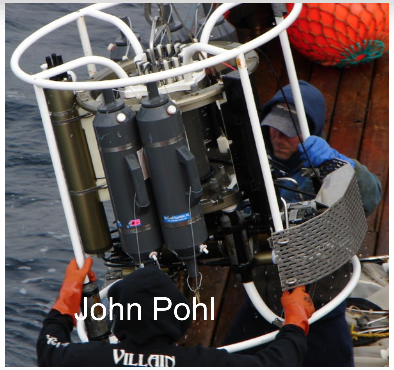
- eDNA is amenable to integration into autonomous platforms
- Augment spatial and temporal sampling to improve models while combating costs

Engineering Advancement

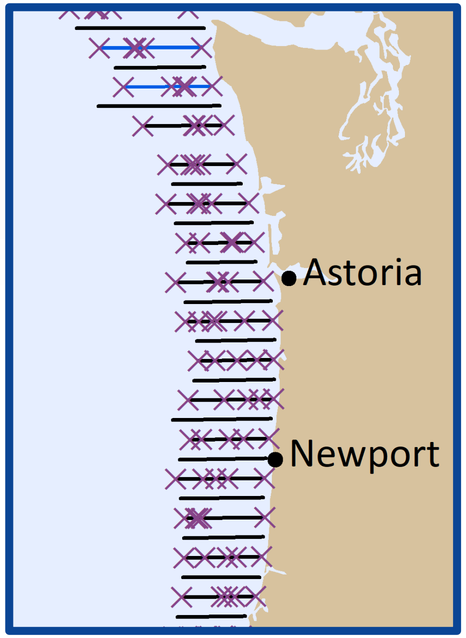
Demonstrated equivalency to hand sampling

Increase in readiness level (~RL4 → RL5)

- 2017: 5-sample capacity
- 2018: 60-sample capacity
- 2019: combined with acoustics



Joint US/Canada Pacific Hake Survey



Acoustic transects (━)
CTD stations (✕)

Yamhara et al. 2019, 10.3389/fmars.2019.00373

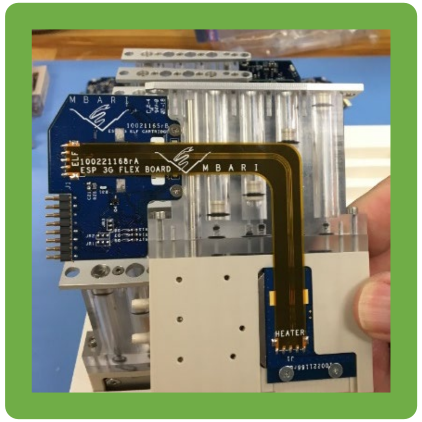
MBARI = Monterey Bay Aquarium Research Institute

Team Leads:
MBARI ESP – J. Birch
MBARI MBON Lead – F. Chavez
NOAA AOML – K. Goodwin

Great Lakes Missions

Protecting Drinking Water from Harmful Algae Toxins

- Transition from open ocean to shallow freshwater
- 2 cartridges:
  - **On-board detection of HAB toxin**
  - **eDNA archival**



MBARI TEAM – J. Birch, B. Ussler, C. Scholin et al.; NOAA TEAM – K. Goodwin (AOML), G. Doucette (NCCOS/ CCEHBR), S. Ruberg (GLERL), P. DeUnyl (CIGLR); L. Thompson (NGI/AOML); Tim Davis (Bowling Green)

Goal 4 – Expand partnerships to advance ‘omics research and applications across the agency.

Objective 4.1. INTERNAL COMMUNICATION AND CHAMPIONSHIP

Establish a NOAA ‘Omics Executive Committee, chaired by the Chief Scientist, to guide the ‘Omics Working Group (OWG) to share information opportunities, and promote the priorities outlined in this strategy across the agency.

Objective 4.2. ENGAGE USER COMMUNITIES

Engage existing national and international groups working to enhance ‘omics technology improvement, standardization, long-term observations, and data and sample archival.

Objective 4.3. INTERAGENCY FUNDING OPPORTUNITIES

Prioritize ‘omics research in existing interagency funding opportunities to advance ‘omics research and development.

Objective 4.4. NATIONAL AND INTERNATIONAL ENGAGEMENT

Foster coordinated and collaborative projects across agencies and internationally to advance ‘omics applications.

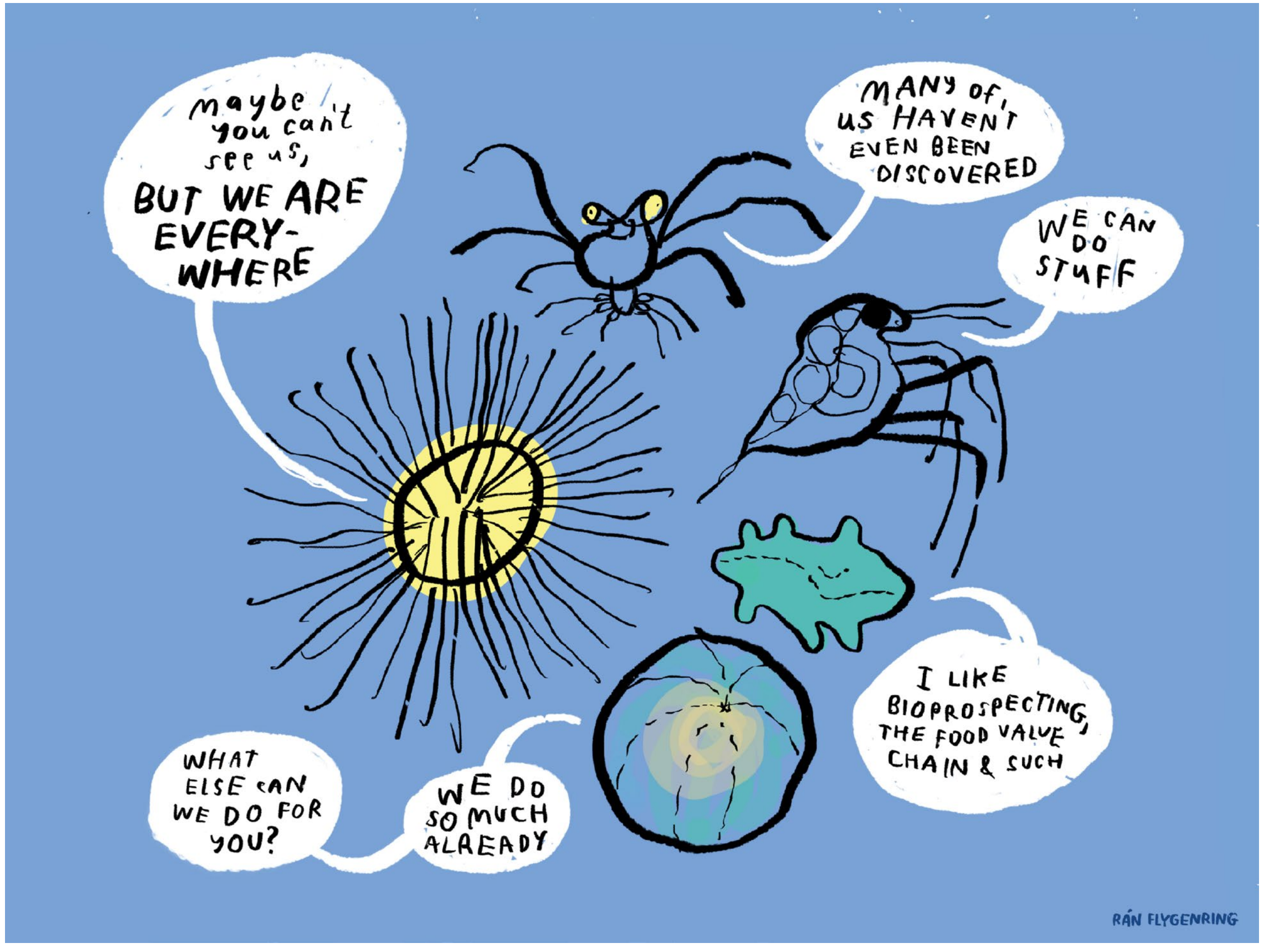
Objective 4.5. TECHNOLOGY TRANSFER PARTNERSHIPS

Build and sustain partnerships with the private and academic sectors using existing vehicles to encourage engagement with federal ‘omics research and development and to increase the potential for commercialization.

International Collaboration

"Expand Partnerships to Advance 'Omics Research and Application Across the Agency"

AORA
ATLANTIC OCEAN RESEARCH ALLIANCE
THE ATLANTIC:
OUR SHARED RESOURCE
MAKING THE VISION REALITY



Marine Microbiome Roadmap

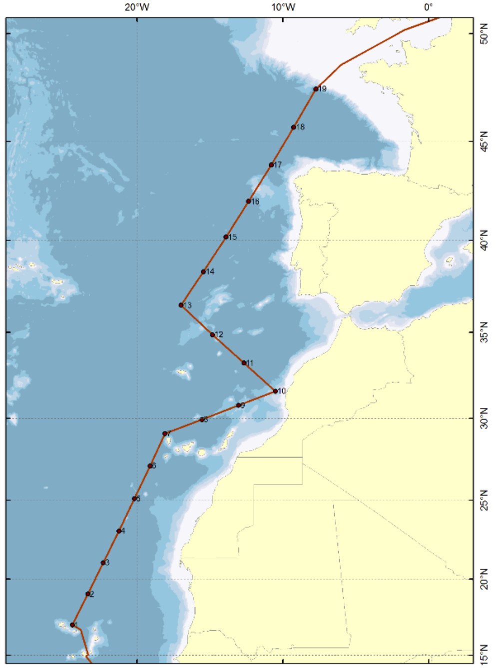
https://doi.org/10.5281/zenodo.3632526

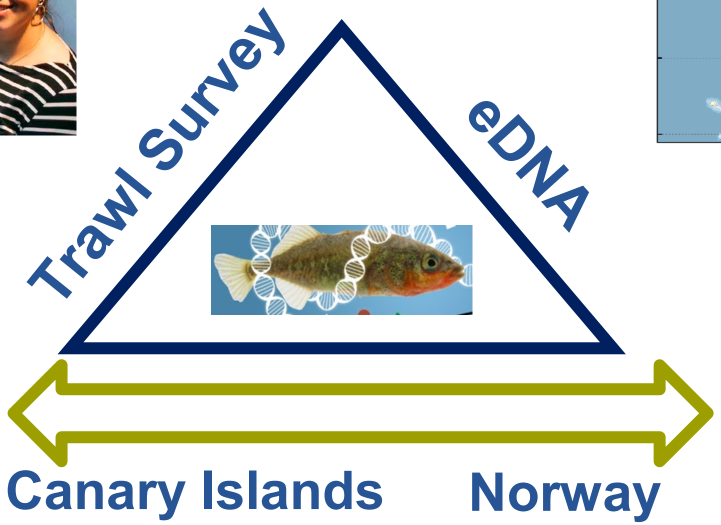
www.atlanticresource.org

International Collaboration

US-Norway Bilateral on eDNA

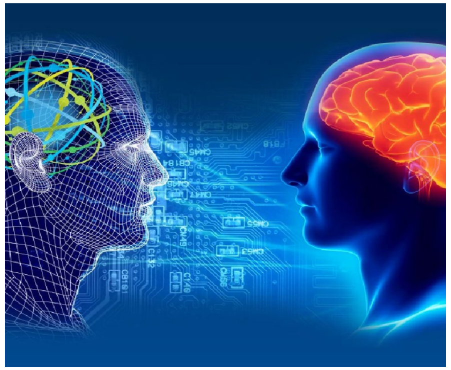
Joint mission May 2019. Focus on eDNA investigation of potential mesopelagic fisheries





United States: L. Thompson, K. Goodwin - AOML, **Norway**: J-I Westgaard, T Johansen – IMR; K. Praebel, O. Wangensteen UiT

Goal 5 – Promote Workforce Proficiency in ‘Omics



***Objective 5.1*. NEEDS ASSESSMENT**

Conduct a baseline needs assessment to inform goal implementation.

***Objective 5.2*. TRAINING**

Provide training for ‘omics data collection and bioinformatics analysis to increase expertise within the current workforce.

***Objective 5.3*. RECRUIT AND RETAIN**

Recruit and retain information technology (IT) professionals and scientists with bioinformatics expertise to address current gaps in the ability to analyze and provide biological or environmental context to sequence data.

***Objective 5.4*. DEVELOPMENT OPPORTUNITIES**

Develop opportunities for job details in laboratory facilities to provide career development for staff, interns, and fellows, and to promote ‘omics projects and data integration.

***Objective 5.5*. SHARE EXPERTISE**

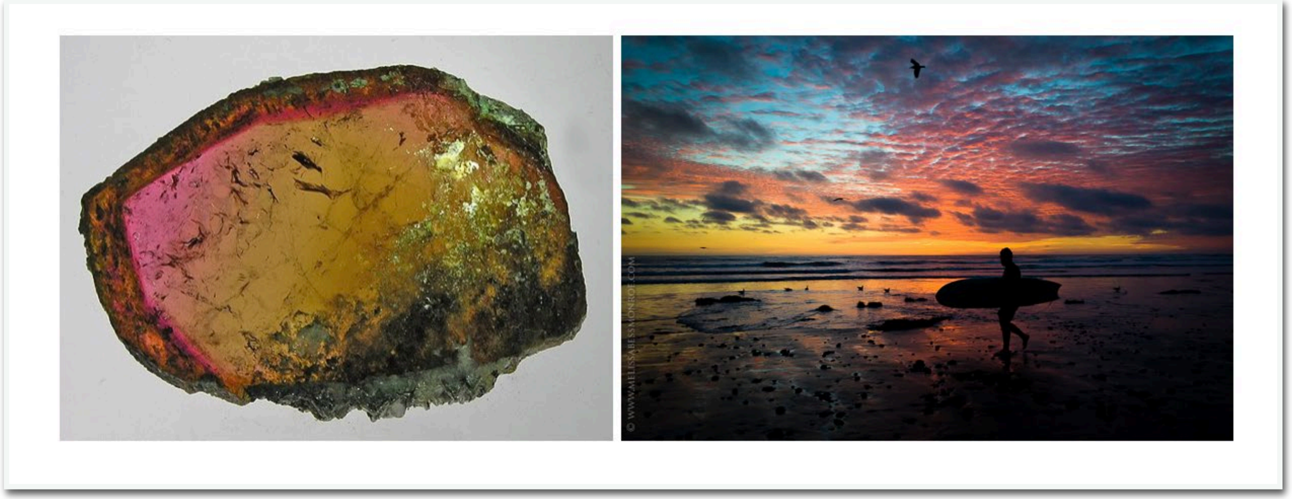
Focus assignments in the NOAA Rotational Assignment Program (NRAP) to target offices where a cross-pollination of ‘omics expertise would raise overall proficiency.

Bioinformatics

Workforce and Infrastructure Enhancement

Bioinformatics expertise and computing capacity remain primary needs

Tourmaline



Bioinformatic workflow “tourmaline” for amplicon sequences

Available on GitHub

Contact Luke.Thompson@noaa.gov for more information https://nrc.noaa.gov/NOAA-Science-Technology-Focus-Areas

What’s Next:

NOAA ‘Omics Implementation Plan

Thank you!

NEXT STEPS – IMPLEMENTATION PLAN CONSTRUCTION

NOAA ‘Omics Taskforce: across lines, labs, and programs

Organization	Member
OAR	Kelly Goodwin, co-Chair
NMFS	Mark Strom, co-Chair
NESDIS	Kirsten Larsen
NMFS-S&T	Jeanette Davis
NMFS-Big Data Project	Jonathan ONeil
NOS	Thomas Greig
NOS-NCCOS	Felipe Arzayus
NOS-IOOS, MBON	Gabrielle Canonico
NOS-CRCP	Jennifer Koss
OAR-OER	Margot Bohan
OAR-OAP	Shallin Busch
OAR-Sea Grant	Rebecca Certner, Ex. Sect
OCIO	David Layton
OCIO, Chief Data Officer	Ed Kearns
TPO	Derek Parks

Abbreviations
CRCP – Coral Reef Conservation Program
EDMC – Environmental Data Management Committee
IOOS – Integrated Ocean Observing System
NESDIS – National Environmental Satellite, Data, and Information Service
NMFS – National Marine Fisheries Service
NOS – National Ocean Service
OAP – Ocean Acidification Program
OAR – Ocean & Atmospheric Research
OCIO – Office of the Chief Information Officer
OER – Office of Ocean Exploration & Research
S&T – Science and Technology
TPO – Technology Partnerships Office