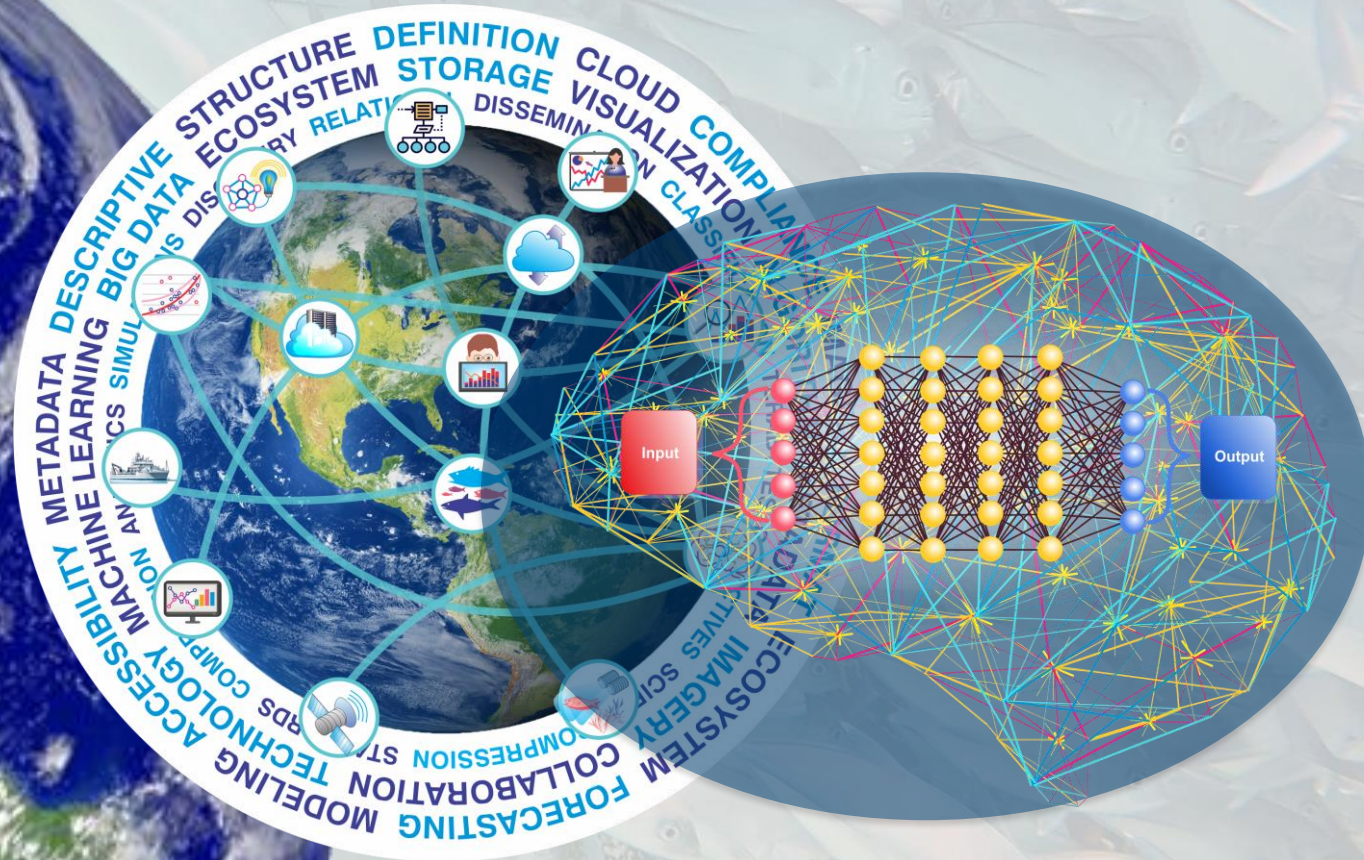


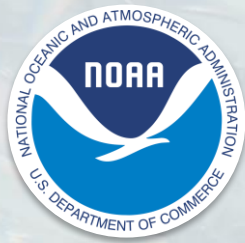


Where is Machine Learning Going in Marine Science?

Application of Machine Learning (ML) to Ecosystem Change Issues.

William L. Michaels and Cisco Werner





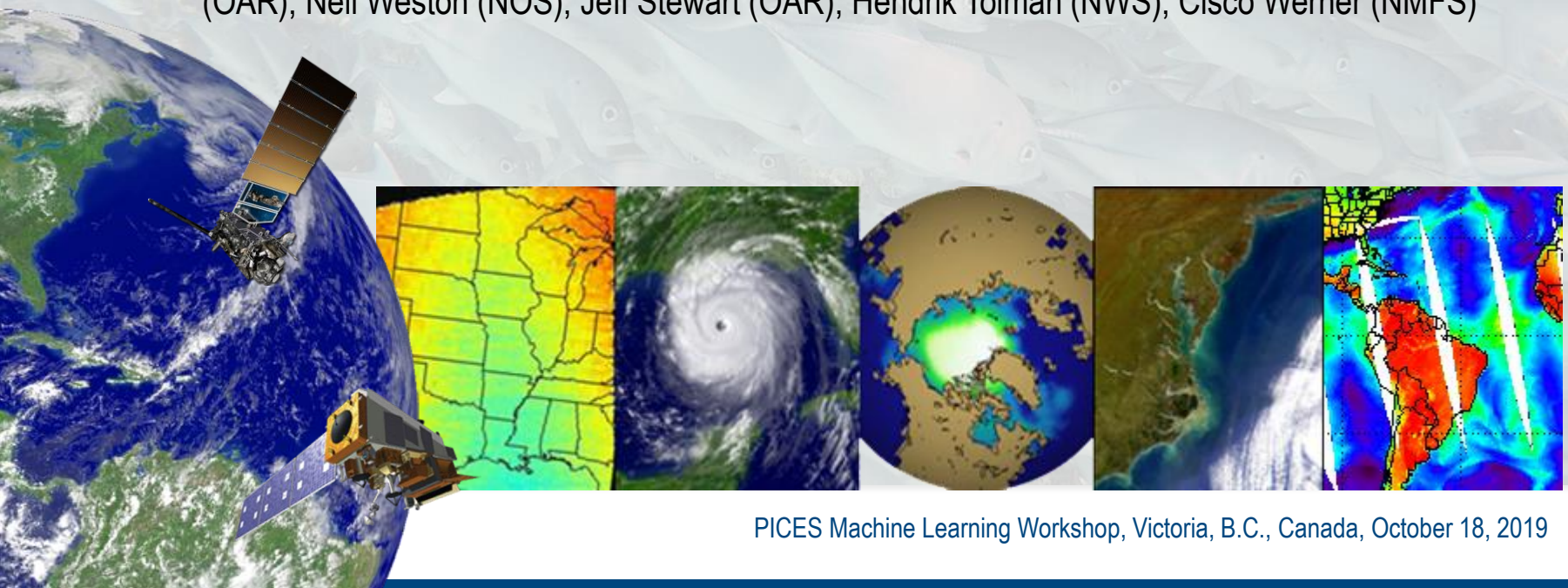
NOAA Artificial Intelligence (AI) Strategy

Expand the application of AI in every NOAA mission area in order to achieve transformational improvements in performance, skill, computational efficiency, and cost effectiveness.

NOAA AI Executive Committee:

RDML Timothy Gallaudet (NOAA Deputy USEC, AI Exec. Committee Lead),
Sid Boukabara (Co-chair, NESDIS), Bill Michaels (Co-chair, NMFS),

Charly Alexander (OMAO/USEC), Greg Dusek (NOS), Frank Indiviglio (OAR/OCIO), Ed Kearns (SO),
Vladimir Krasnopolsky (NWS), Mashkooor Malik (OAR/OER), John Mcdonough (OMAO), V. 'Ram' Ramaswamy
(OAR), Neil Weston (NOS), Jeff Stewart (OAR), Hendrik Tolman (NWS), Cisco Werner (NMFS)





NOAA AI Strategy - Goals





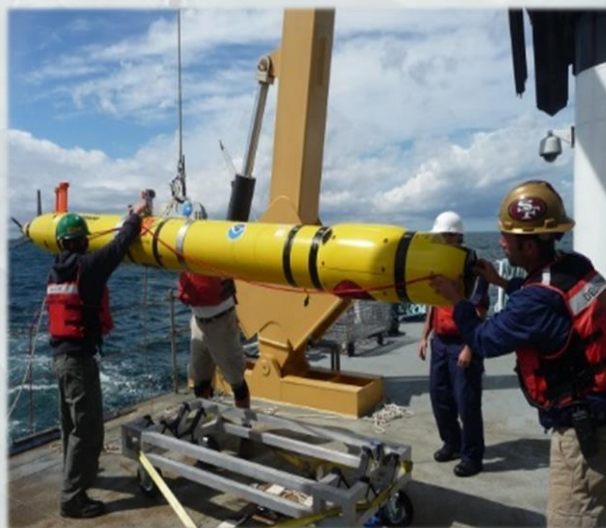
NOAA Strategies – Integrated Approach

NOAA's cross-functional mission priorities include integrated AI, UxS, and Omics technologies, and modernization of its data enterprise.

AI



UxS



OMICS



Cloud + Big Data



NOAA AI Strategy – Benefits

**Streamline
Data Processing**

**Data Fusion &
Assimilation**

**Enhanced quality and
timeliness of scientific
products**

**Predictive
Forecasting**

Knowledge Discovery



NOAA AI Applications – Data Assimilation

Pilot Project: MIIDAPS-AI

Multi-Instrument Inversion and Data Assimilation Preprocessing System

Use of Deep Neural Network (DNN) for Geophysical Retrieval and Quality Control Purposes

NOAA/NESDIS POC:
Sid.Boukabara@noaa.gov

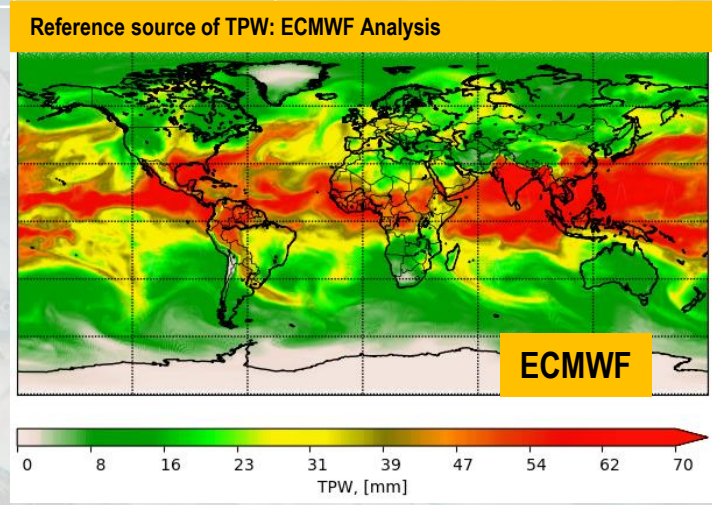
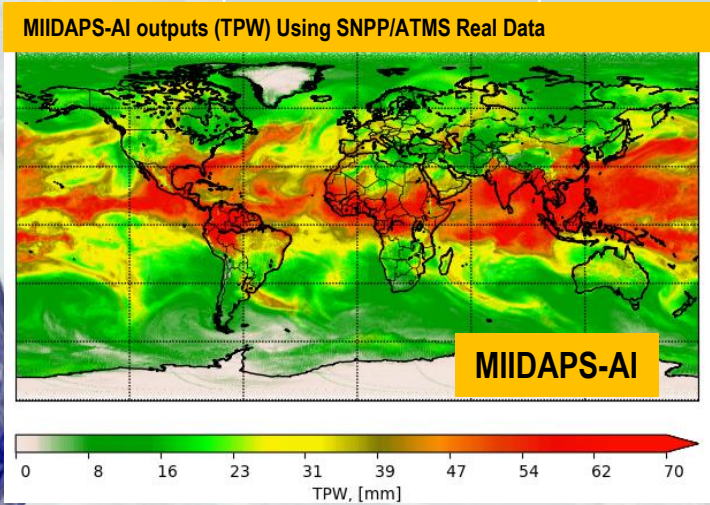
How to assess that AI-based output (Satellite Analysis) is valid?

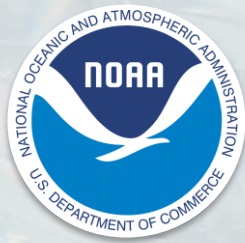
- (1) Assessing quality by comparing against independent analyses
- (2) Assessing Radiometric Fitting of Analysis
- (3) Assessing analysis spatial coherence
- (4) Assessing inter-parameters correlations

Google TensorFlow/KERAS
Tools used for MIIDAPS-AI

99.9% reduction in
data processing

	MIIDAPS-AI	MiRS
Processing Time for a full day data. A single sensor (ATMS). Excluding I/O	~5 seconds	~ 2 hours





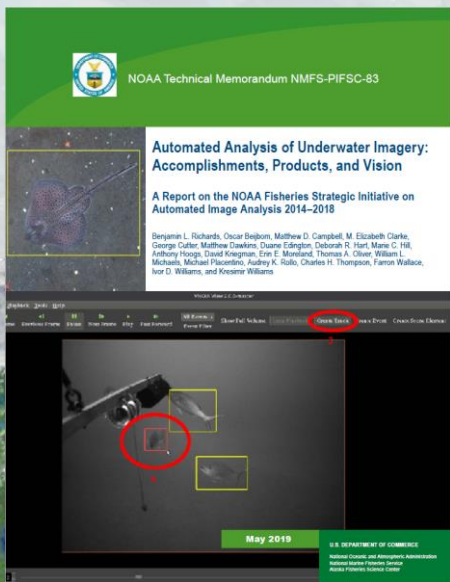
Automated Processing of Underwater Imagery

Requirement: Develop and implement advances in computer vision and artificial intelligence (AI) to automate processing and analysis of underwater still and video imagery for stock and habitat assessments.

NOAA Fisheries Strategic Initiative WG members:

NOAA Fisheries: William Michaels (Program Manager, OST), Ben Richards (Chair, PIFSC), Elizabeth Clark (NWFSC), George Cutter (SWFSC), Deborah Hart (NEFSC), Charles Thompson (SEFSC), Kresimir Williams (AFSC)

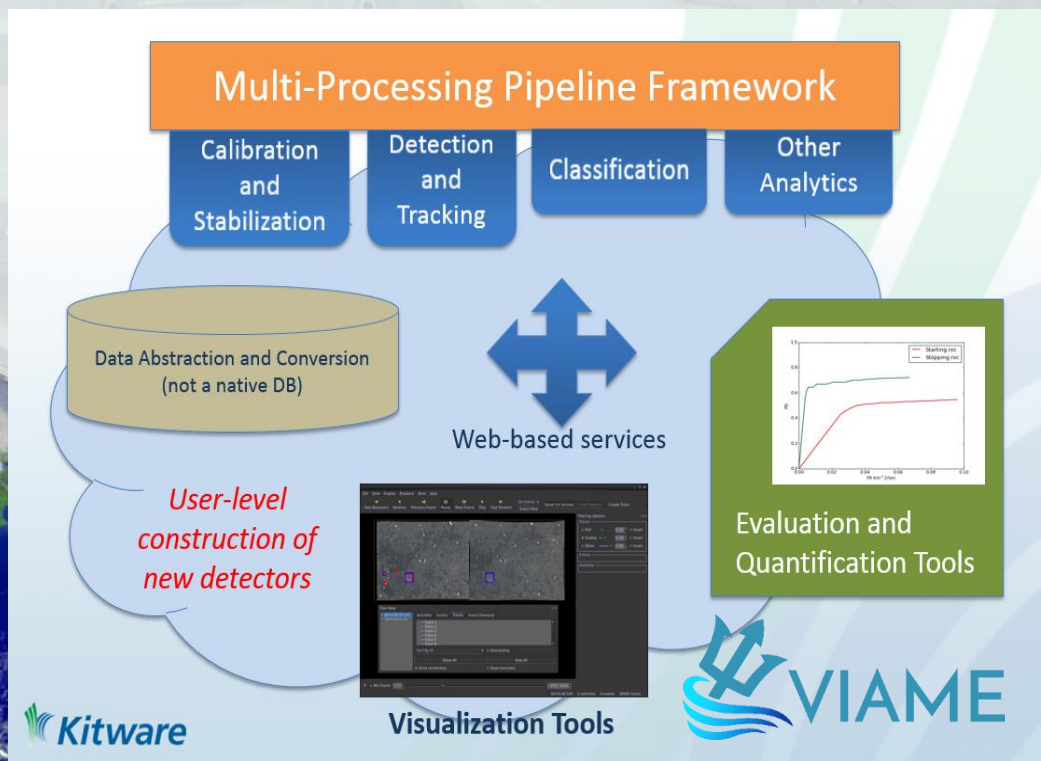
External Experts: Alexandra Branzan Albu (Univ. Victoria), Duane Edgington (MBARI), Anthony Hoogs (Kitware Inc.), David Kriegman (UCSD), Michael Piacentino (SRI International), Lakshman Presad (Los Alamos National Laboratory)





Video & Image Analytics for Marine Environments (VIAME)

Software to automate image processing, detection, classification, and rapid model generation using machine learning algorithms in a graph-like pipeline architecture.



VIAME Kitware Inc.:

<http://www.viametoolkit.org/>

VIAME GitHub:

<https://github.com/Kitware/VIAME>

VIAME Instruction Document:

<https://viame.readthedocs.io/en/latest/>

Contacts:

Anthony.Hoogs@Kitware.com

Matt.Dawkins@Kitware.com

Presentation material does not constitute an endorsement by NOAA.



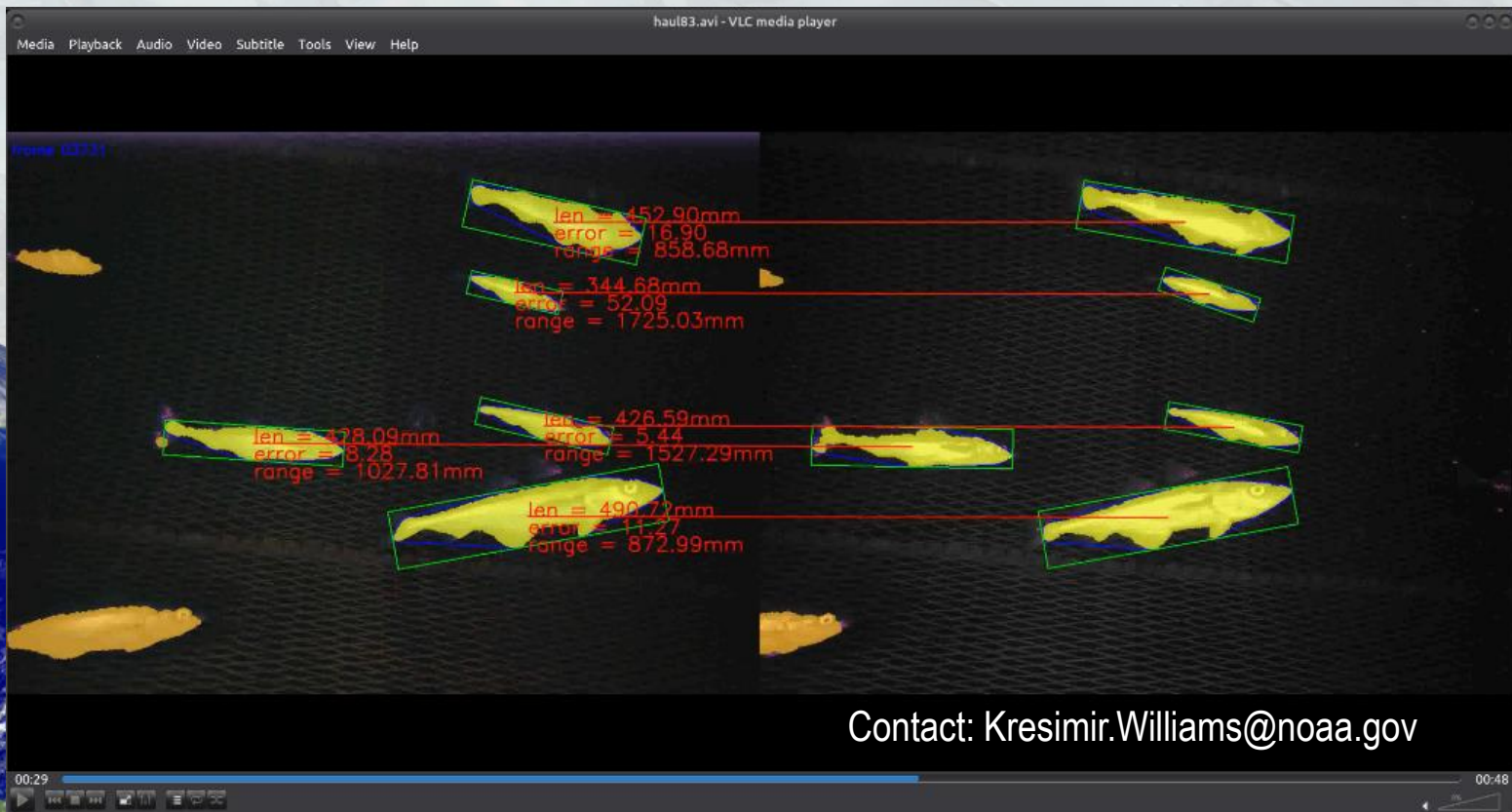
NOAA





NOAA AFSC Bering Sea pollock survey

NOAA Alaska Fisheries Science Center utilizes VIAME to automate processing of video images from the Bering Sea pollock survey. Recent upgrades include improved precision with classification, stereo measurements, and 93% reduction in data processing (2.5 million images per survey, post-processing reduced from 3 months to 4 days).

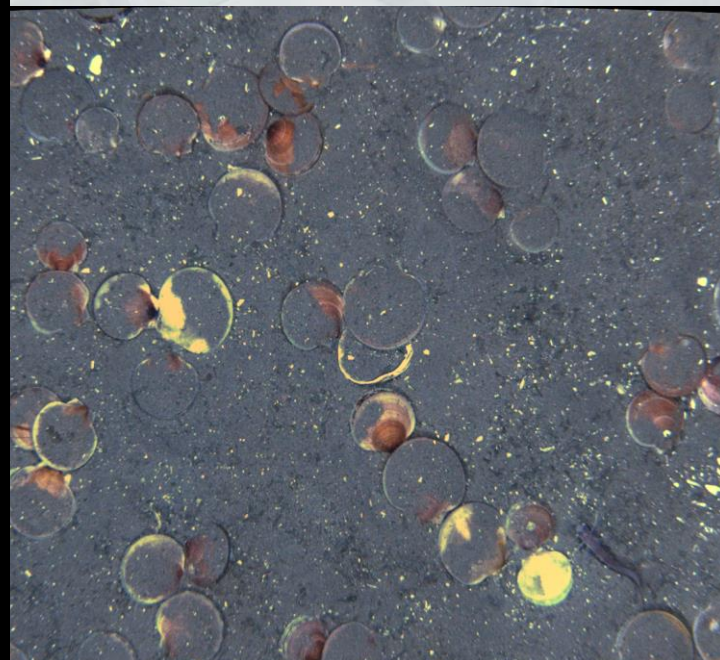
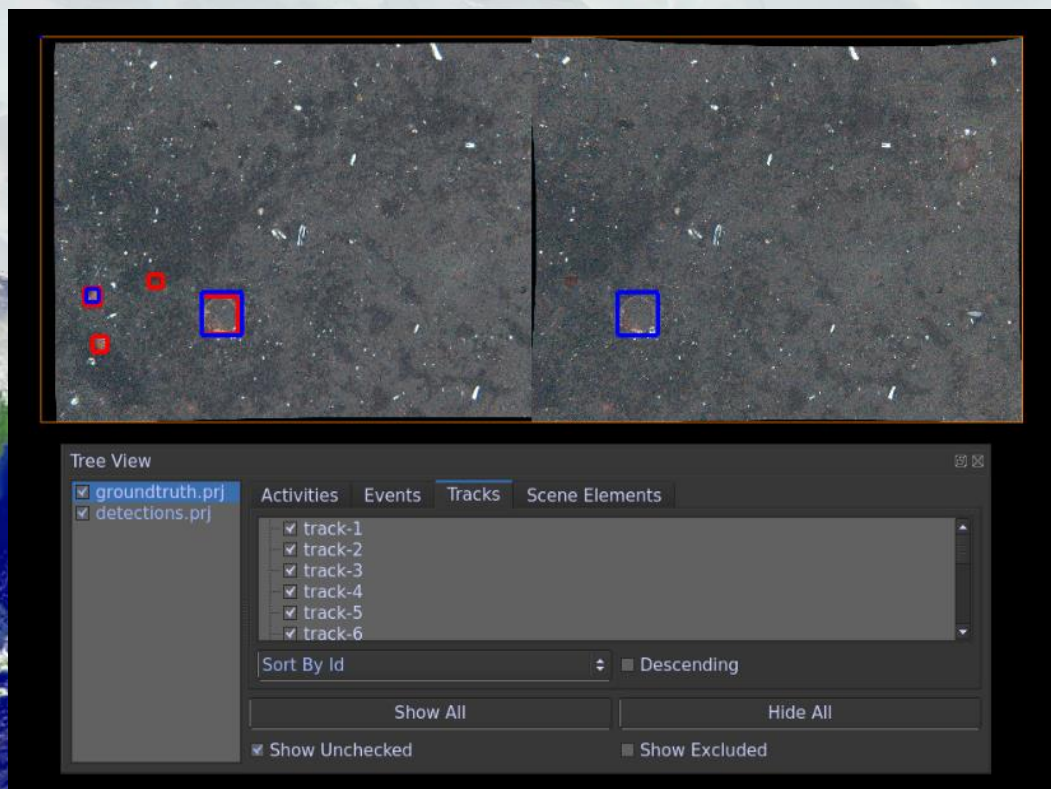




NOAA NEFSC Optical Scallop Survey

NOAA Northeast Fisheries Science Fisheries made progress with VIAME, including clustering-based web GUI for rapid annotation (50% reduction from manual annotations), updated object detection training API, and improved scallop detection model performance (99%). Approximately 2.5 million images are collected per survey, and VIAME has reduced post-processing by 98% (4 months to 4 days).

Contact: Deborah.Hart@noaa.gov



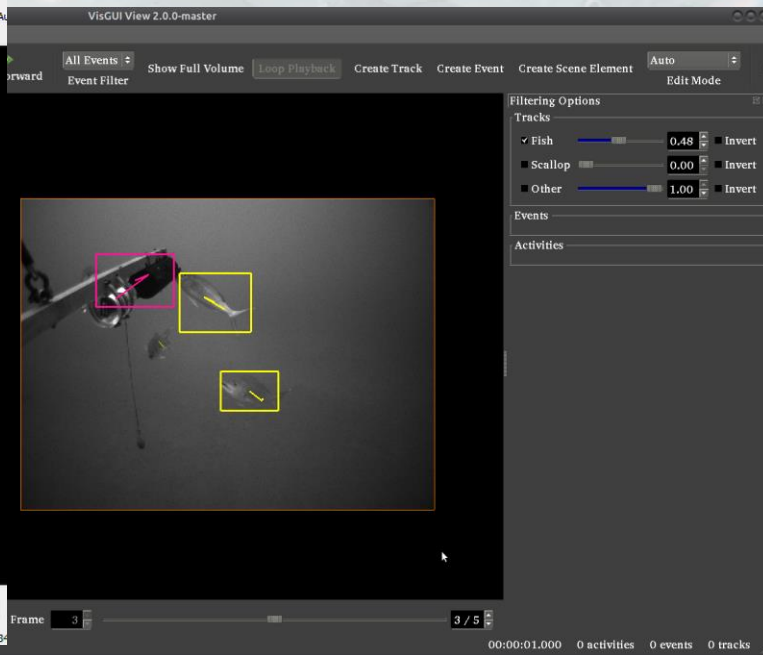
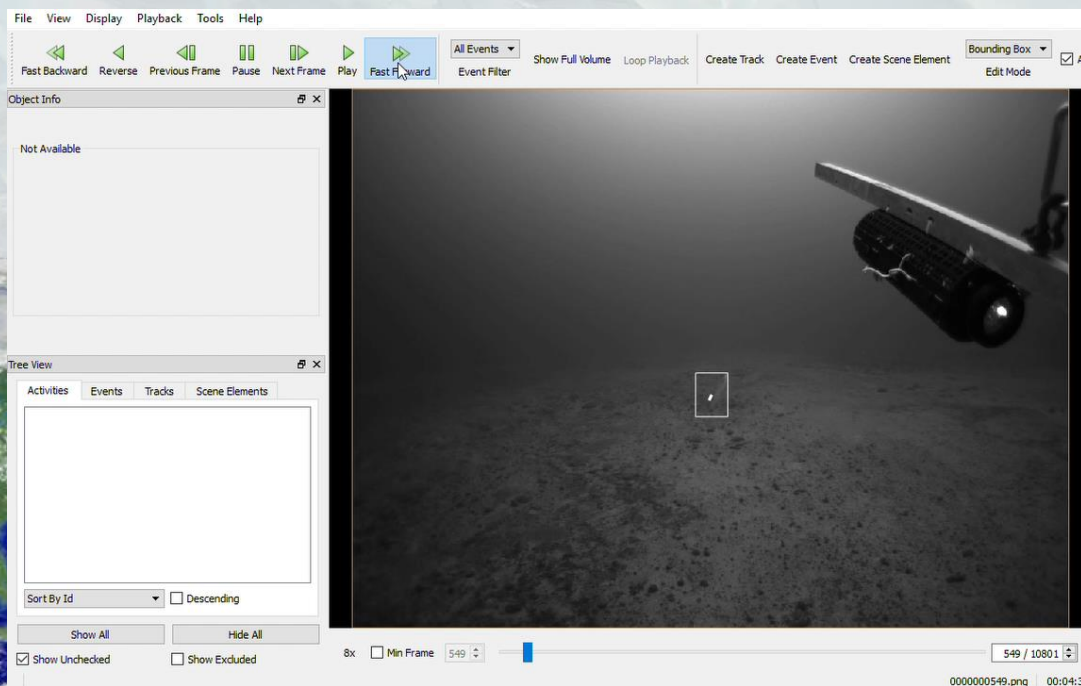


Automated Processing of Underwater Imagery

NOAA Southeast Fisheries Science Center is using VIAME for automated fish detection and classification during their annual video fish surveys in the Gulf of Mexico region.

VIAME recently used for developing image training datasets for red snapper and other commercially important fish species.

Contact: Charles.H.Thompson@noaa.gov





Automated Processing of Underwater Imagery

User friendly end-to-end pipeline using computer vision and deep learning for automated detection and classification.

VisGUI Query Interface 2.0.0-master

Query Layers View Settings Help

powered by Screencastify

Video Query

Query Video

Track Interval Video Region

Name (Type)	Source	Start Time	End Time
Track 0:1			
Track 0:10			
Track 0:11			
Track 0:12			
Track 0:13			
Track 0:14			
Track 0:15			
Track 0:16			
Track 0:17			
Track 0:18			
Track 0:19			
Track 0:2			
Track 0:20			
Track 0:21			
Track 0:22			
Track 0:23			
(unrecognized) (1)			

Show All Hide All Hide All Descriptors

Set Start Time Constraint Set End Time Constraint Clear Time Constraints

Selected

Name (Type)	Source
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Processing exemplar image...

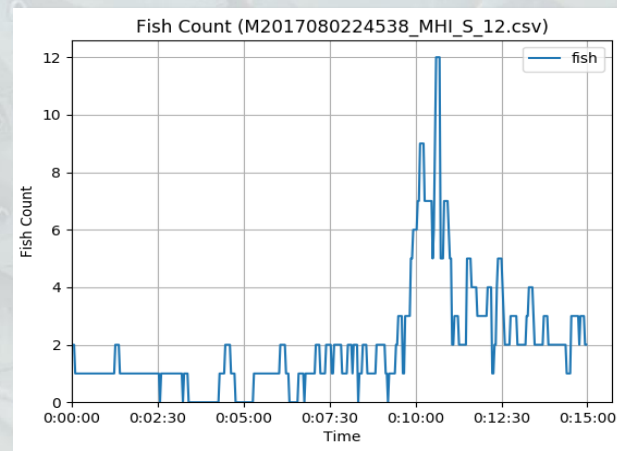
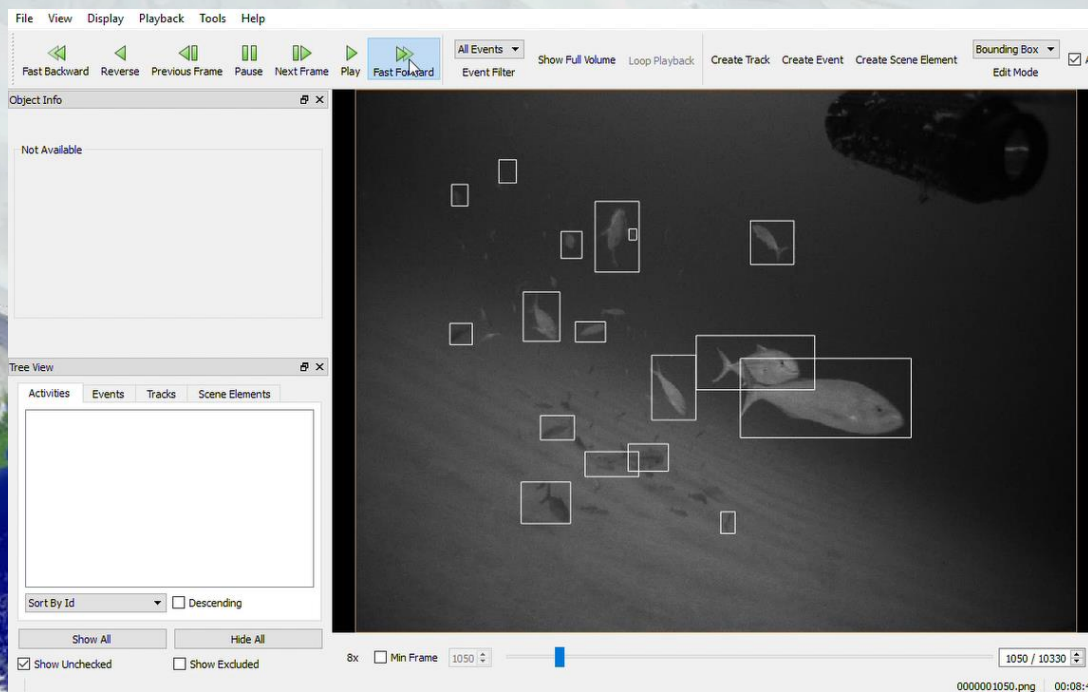
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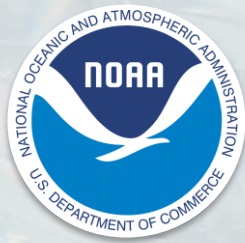
7:33 AM 9/8/2018



Automated Processing of Underwater Imagery

Capability: Abundance estimates



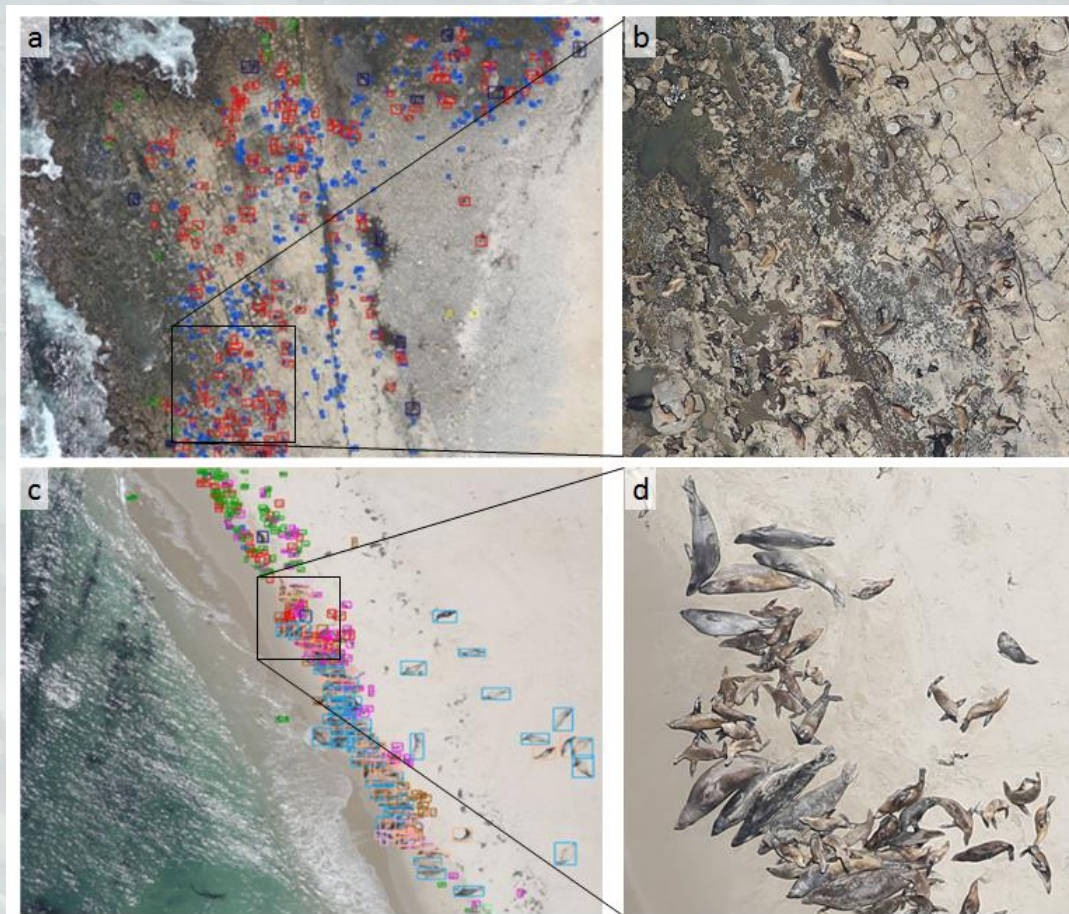


NOAA SWFSC Aerial Pinniped Survey

NOAA Southeast Fisheries Science Center is using VIAME for automated fish detection and classification during their annual video fish surveys in the Gulf of Mexico region.

There is recent success in single detector pinniped models (training with 27 annotated images of 5,428 pinnipeds). Work continues to improve the GUI annotation module of VIAME, and need to improve the performance from a single detector model to a multi-class detector model.

Contact:
Beth.Jaime@noaa.gov



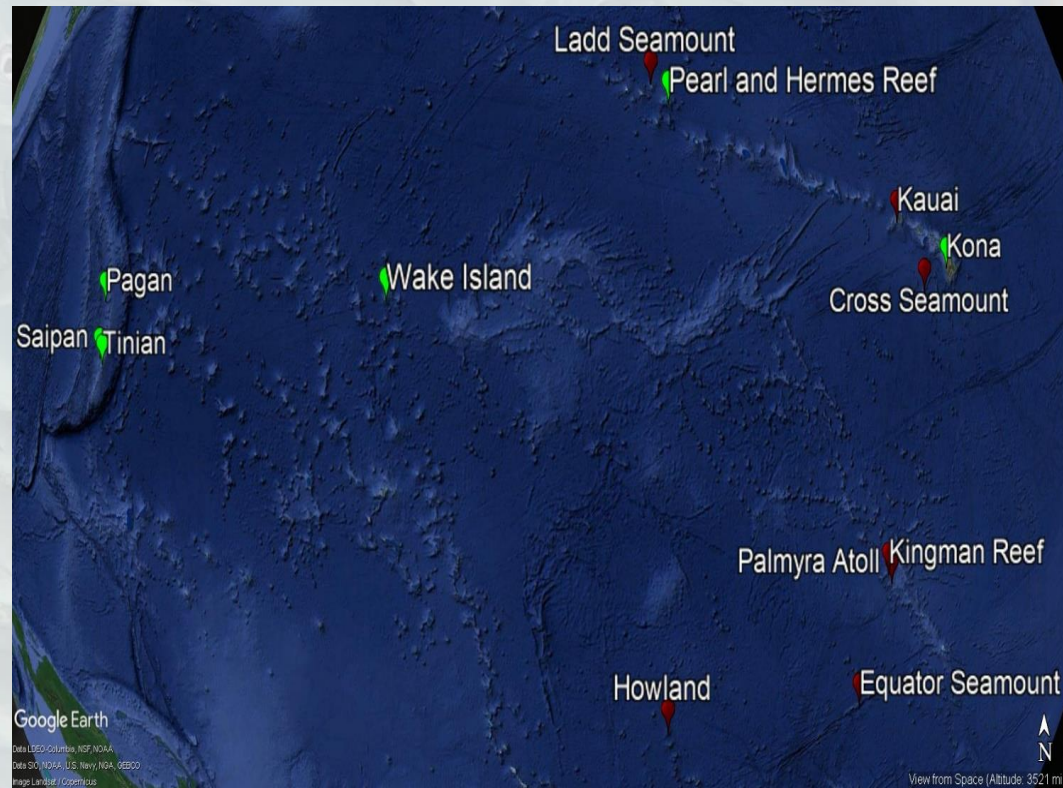


NOAA PIFSC Marine Mammal Survey

NOAA Pacific Islands Fisheries Science Center's Cetacean Research Program surveys marine mammals, and collected >170,000 of passive acoustic recordings from monitoring instruments throughout the Pacific Islands.

Google Artificial Intelligence (AI) to develop machine learning model to recognize and annotate humpback whale songs. Significant savings in processing with 90% in precision and recall. Presently expanding with for other whale species.

Contacts:
Ann.Allen@noaa.gov
Erin.Oleson@noaa.gov





NOAA PIFSC Coral Reef Surveys

NOAA Fisheries collaborated with scientists at the University of California San Diego (UCSD) to develop the CoralNet software as a web-based image classification system for coral reef habitats.

CoralNet has reduced PIFSC manual processing by at least 28% with potential cost savings for processing 525K coral benthic images from 11 person years (\$1.4m) to 3 person years (\$0.4m).

<https://coralnet.ucsd.edu>
 CoralNet VIMEO channel:
<https://vimeo.com/105839824>

Contacts:

Thomas.Oliver@noaa.gov
 Courtney.S.Couch@noaa.gov
 David Kriegman, UCSD
kriegman@cs.ucsd.edu

Year	Region	Island	Site	Priority	Analyst
2015	PRIAs	Palmyra	PAL-742	3	BDS

Annotation points: Stratified random, 2 rows x 5 columns of cells, 1 points per cell (total of 10 points)
 Annotation area: X: 5 - 95% / Y: 5 - 95%



Automated Processing of Underwater Imagery



NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION



GOLD MEDAL

SCIENTIFIC/ENGINEERING ACHIEVEMENT

**Benjamin Richards
Kresimir Williams
M. Elizabeth Clarke
George Cutter
Deborah Hart
Charles Thompson
William Michaels**

*National Marine Fisheries Service
National Oceanic and Atmospheric
Administration*

The group is honored for working across NOAA line offices to develop the Video and Image Analytics for Marine Environment (VIAME) and CoralNet toolkit. This is the first automated image recognition software using advanced computer vision and machine learning technology for the marine environment. Scientific programs across NOAA have begun using the toolkit, resulting in immediate cost-savings of 50 percent in processing time, with more precise, consistent, and timely scientific information to enhance knowledge discovery, and more confident decision-making for ocean stewardship.



GOLD MEDAL

This award, the highest honorary award given by the Department, is granted by the Secretary for distinguished performance characterized by extraordinary, notable, or prestigious contributions that impact the mission of the Department and/or one or more operating units.



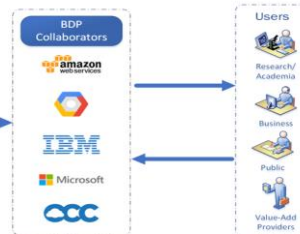
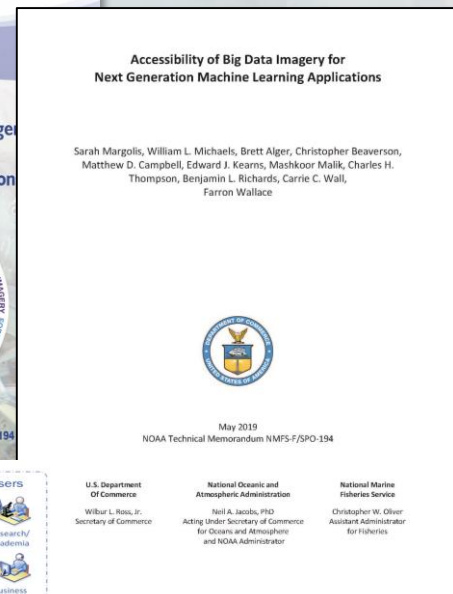
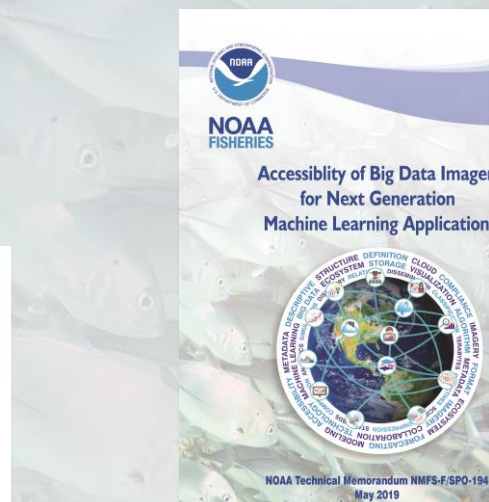
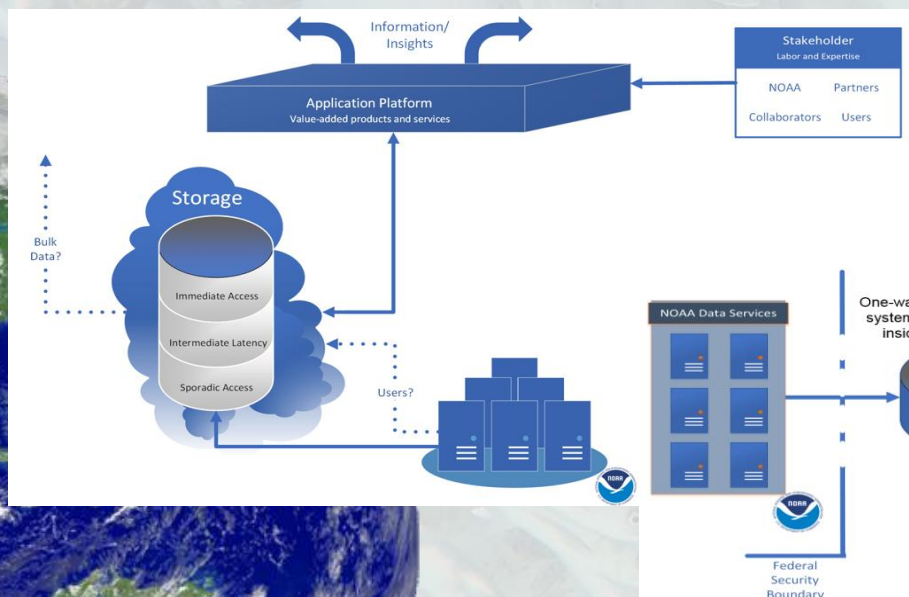
NOAA Fisheries Data Modernization Initiative

NOAA Fisheries Data Modernization Initiative will be working with the NOAA Big Data Program to evaluate how to improve data accessibility for AI-ML analytics.

Federally verified and trusted third party commercial cloud providers have scalable platforms with quick data dissemination allowing greater usage of NOAA data.

NOAA Fisheries contact: Frank.Schwing@noaa.gov

NOAA Big Data Program: Ed.Kearns@noaa.gov



Distributing a single copy of data can support all users. Reallocate resources to support the mission



2019 Norway-US Machine Learning Workshop

Participants provided inclusive and diverse perspectives from the government, academic and private sector for building partnerships to advance the ML applications for fisheries and marine science.

ML analytics are available, and will revolutionize our ability to process data more effectively with significant cost savings.

Improvements in the data management enterprise are required for enhanced data storage and accessibility, including annotated training datasets to improve ML classifiers.

Partnerships must be build on mutual understanding of value drivers.



Machine Learning to Improve Marine Science for the Sustainability of Living Ocean Resources *Report from the 2019 Norway - U.S. Workshop*

William L. Michaels, Nils Olav Handegard, Kelli Malde, Hege Hammersland-White
(Editors)

Contributors (alphabetical order): Brett Alger, Vaneeda Aiken, Olav Brautaset, Jeremy Cook, Courtney S. Couch, Matt Dawkins, Sebastien de Halleux, Roger Fosse, Rafael Garcia, Ricard Prados Guillemin, Hege Hammersland, Hege Hammersland-White, William L. Michaels, Kim Halvorsen, Nils Olav Handegard, Deborah R. Hart, Kine Iversen, Andrew Jones, Kristoffer Levall, Kelli Malde, Endre Mober, Nichole Rossi, Arnt Berre Saiberg, Arnt Berre Saiberg, Annette Fagerhaug Stephansen, Ibrahim Umar, Hilvard Vilgatel, Farron Wallace, Benjamin Woodward



June 2019

NOAA Technical Memorandum NMFS-FSPD-xxx

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Acting Under Secretary of Commerce
for Oceans and Atmosphere
and NOAA Administrator

National Marine
Fisheries Service
Christopher W. Oliver
Assistant Administrator
for Fisheries



US-Norway Bilateral Meeting, Bergen Norway, May 6-8, 2019