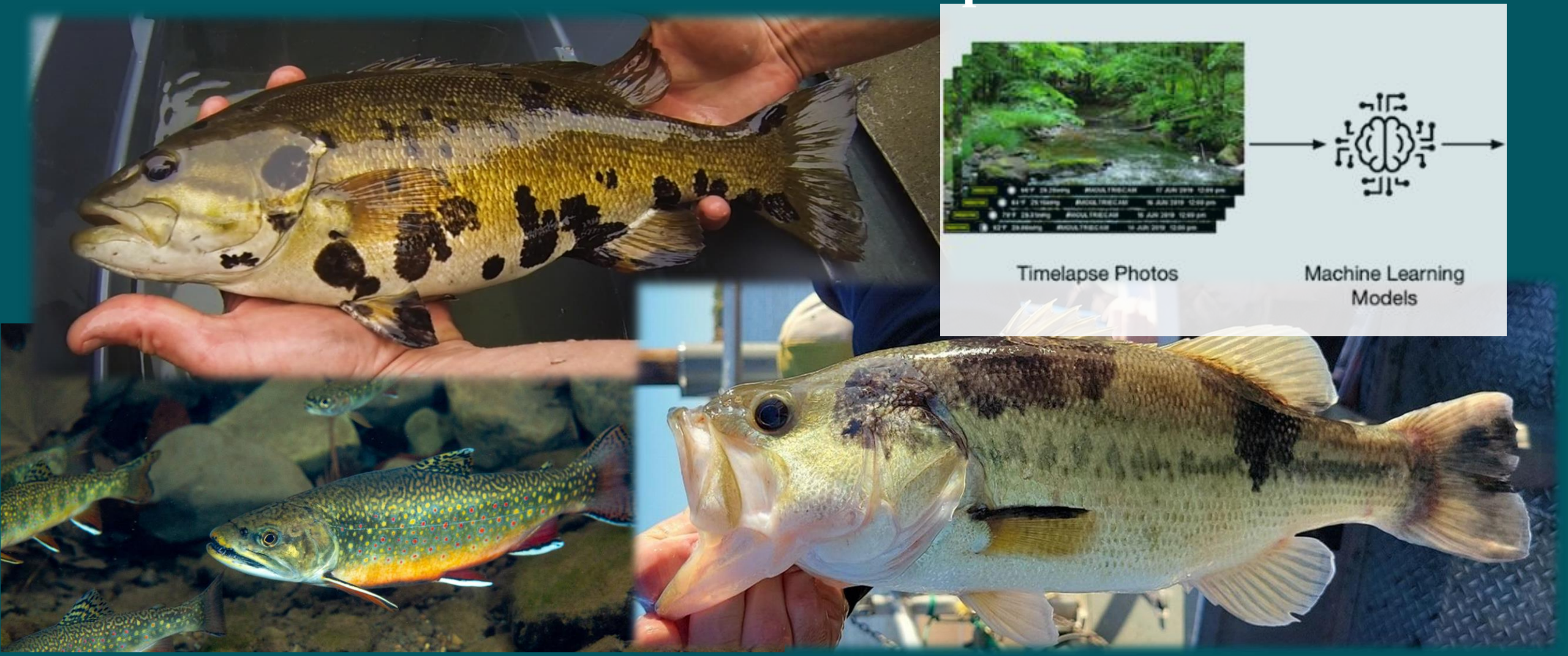
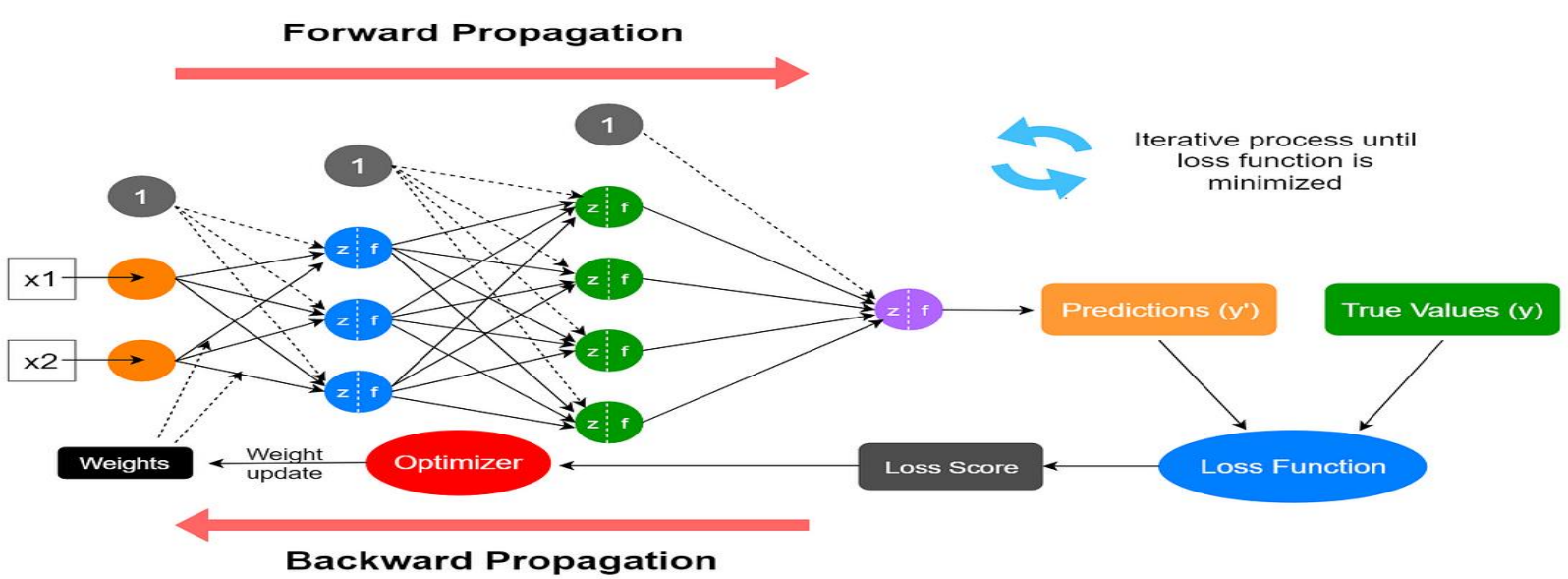
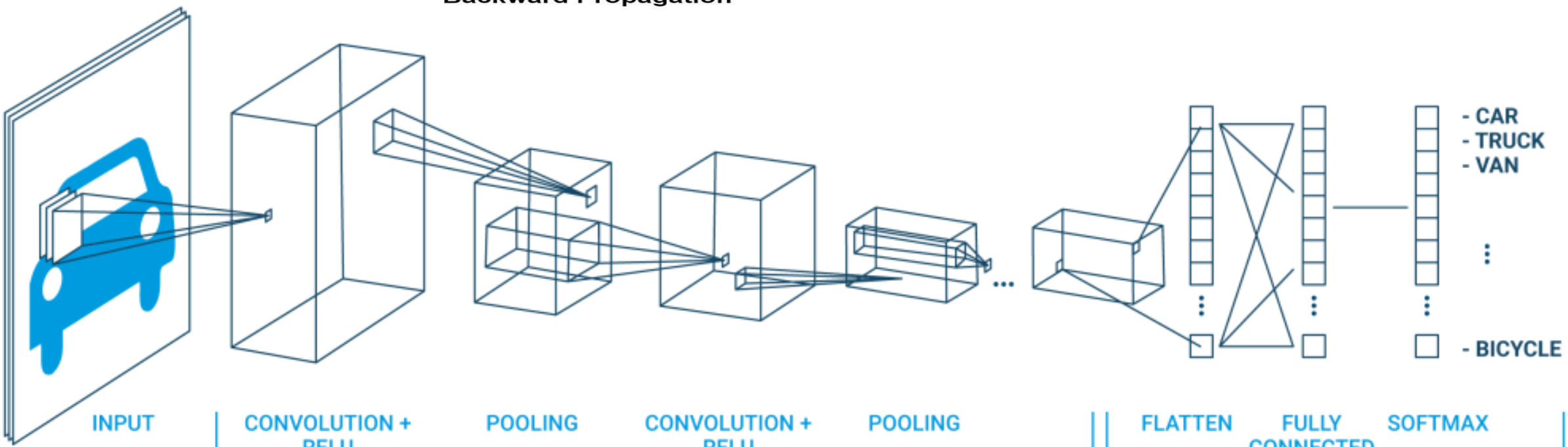
Participatory Science, Biosurveillance, and Prospective Applications of AI/ML for Force Multiplication



USGS

Clay Raines- USGS Eastern Ecological Science Center

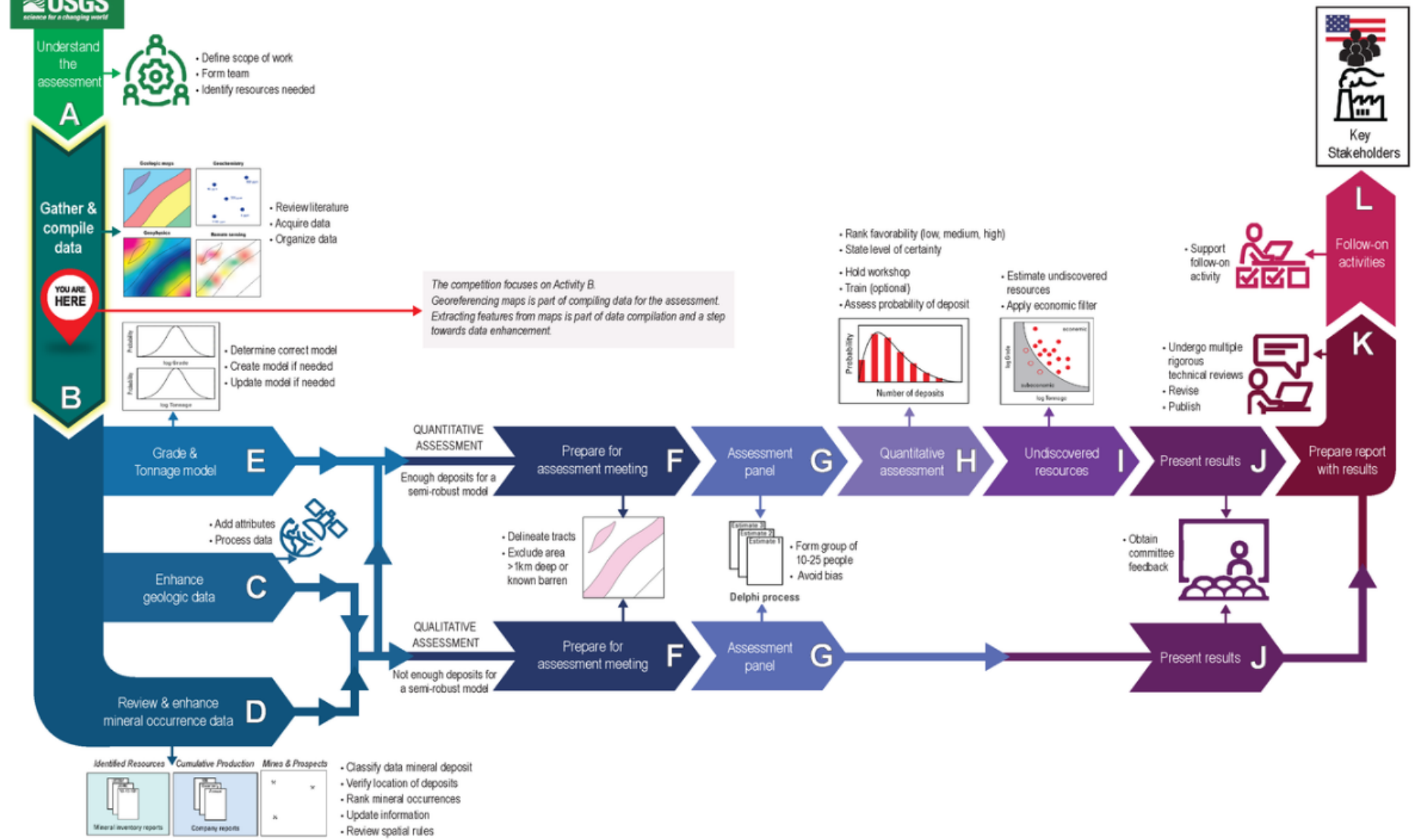

Forward Propagation
1
1
1
x1
x2
z f
Iterative process until loss function is minimized
Predictions (y')
True Values (y)
Loss Function
Loss Score
Optimizer
Weight update
Weights
Backward Propagation


- CAR
- TRUCK
- VAN
- BICYCLE
INPUT
CONVOLUTION + RELU
POOLING
CONVOLUTION + RELU
POOLING
FLATTEN
FULLY CONNECTED
SOFTMAX
FEATURE LEARNING
CLASSIFICATION

USGS

USGS Mineral Resource Assessment As-Is Workflow

Segment lengths represent estimated duration of activity: ≤5%, between 5% and 19%, and ≥20%



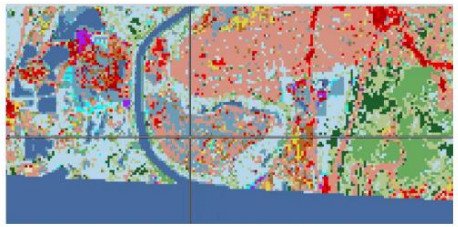
USGS

NLCD Land Cover

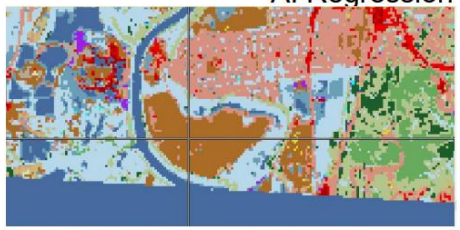
NLCD testing of AI/ML models to land cover classification

Google Earth

See5

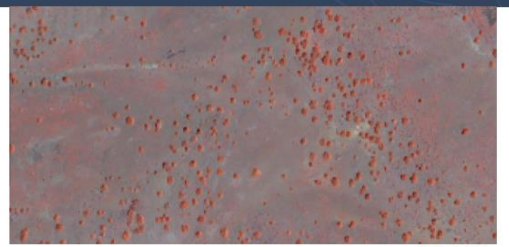


AI Regression

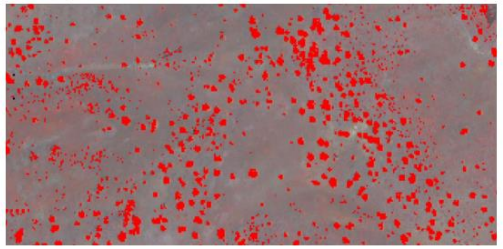


High-Resolution UNET Tree Cover

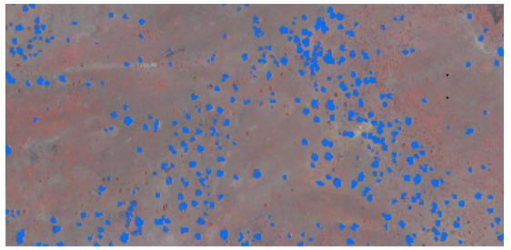
Application of Convolutional Neural Networks (UNET) to WorldView 2-m imagery (right) compared to traditional classification using unsupervised classification.



Unsupervised Classification

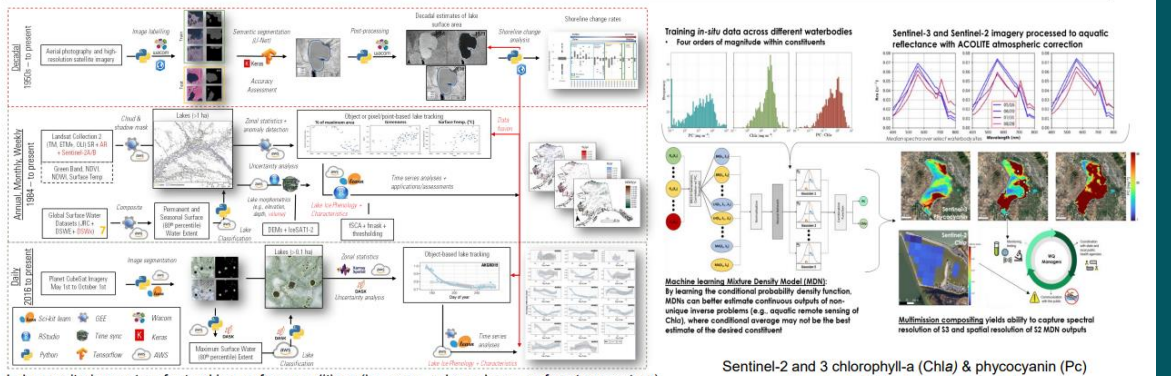


UNET



Surface Water Conditions

Cloud and DL-enabled lake monitoring



Lake monitoring system for tracking surface conditions (i.e., area, color, volume, surface temperature)

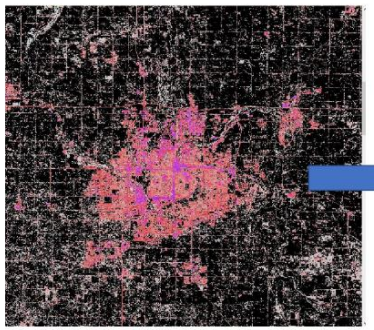
Sentinel-2 and 3 chlorophyll-a (Chl*a*) & phycocyanin (Pc) retrievals via MDNs trained on field obs.

- **Inputs**: Field and high-resolution observations of surface water conditions and remotely-sensed data (e.g., Sentinel 2-3, Landsat, Planet, Maxar, IceSAT-2).
- **Compute**: AWS + GEE + USGS HPCs
- **Models**: Autoencoders + U-Nets & Mixture Density Networks (MDNs)

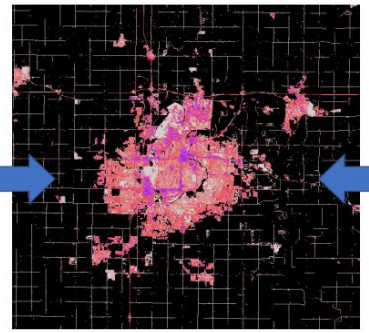
Improvements in Impervious Surface mapping for National Land Cover DB 2021

AI Approach Trained on entire CONUS

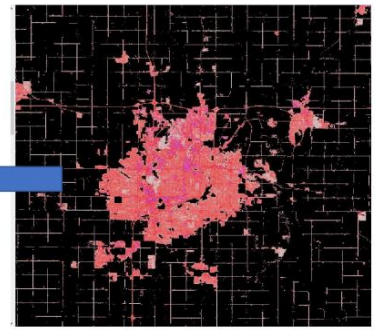
Cubist Model Outputs (NLCD 2019)



NLCD Final Product Hand edited from Cubist

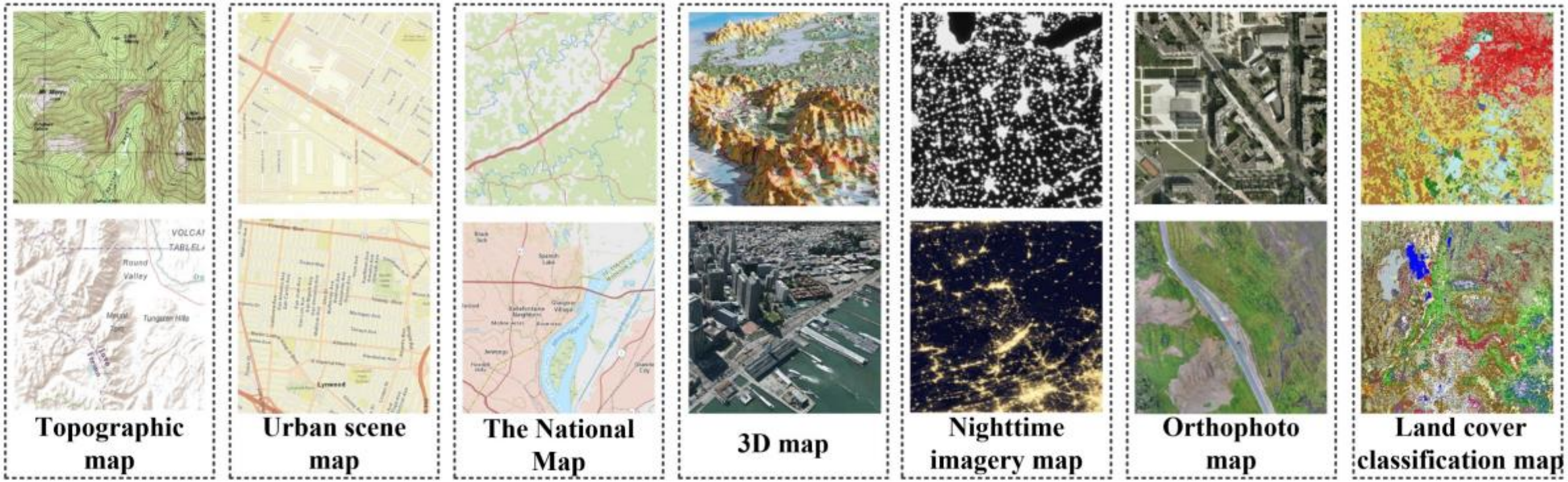


Artificial Intelligence Outputs (NLCD 2021)

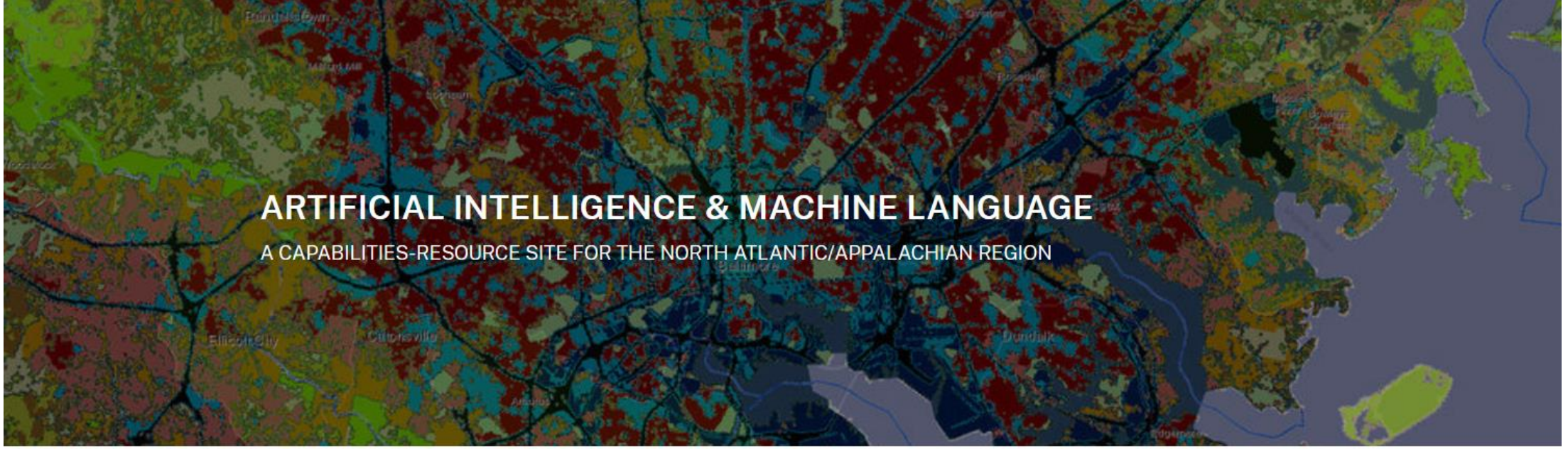


Map dataset

- 7 types map
- 250-350 samples for each map type
- ≈ 2,200 samples in total



USGS



ARTIFICIAL INTELLIGENCE & MACHINE LANGUAGE

A CAPABILITIES-RESOURCE SITE FOR THE NORTH ATLANTIC/APPALACHIAN REGION

Artificial Intelligence (AI) and Machine Learning (ML) includes a broad suite of flexible data-driven empirical approaches to perform tasks that are difficult to implement using conventional methods. AI and ML harness the power of computing resources to evaluate the underlying patterns and relationships within a dataset without explicit instructions.

The North Atlantic-Appalachian AI/ML Capability Team is comprised of staff with a wide variety of scientific backgrounds who are united by the desire to improve how data is collected and interpreted using AI and ML. As AI/ML is a rapidly changing and evolving field of data science, the capability team is a resource for sharing information, connecting problems with expert knowledge, and lowering the barriers for entry into applying AI/ML to solve earth science problems.

Contacts

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Benjamin H Letcher
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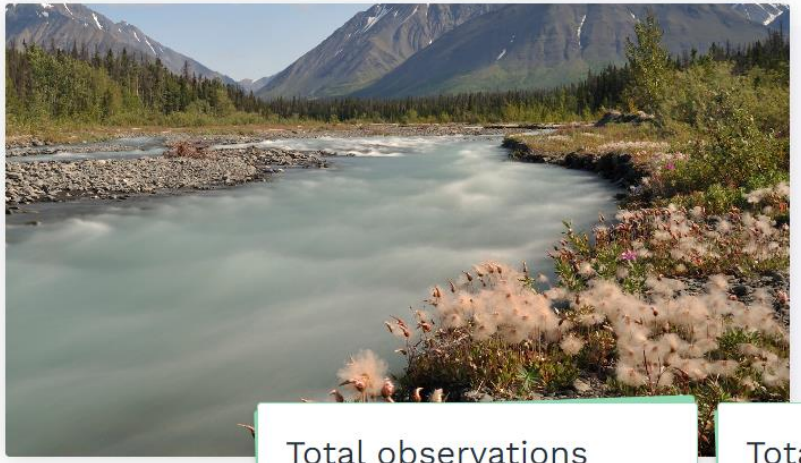
Eastern Ecological Science Center
Email: bletcher@usgs.gov
Phone: 413-863-3803

USGS

Home | Visualizations | Data | Help | Log in



the Indigenous Observation Network

The Indigenous Observation Network (ION) is the largest international, Indigenous initiative combining Indigenous Knowledge and western science to research, sustain and protect the Yukon River Watershed, its resources and cultures.

Total observations

2,615

Total contributors

72

About Yukon Inter-Tribal Watershed Council Water Quality

→ Project overview

A general description of the project

The Indigenous Observation Network (ION) is the largest international, Indigenous initiative combining Indigenous Knowledge and western science to research, sustain and protect the Yukon River Watershed, its resources and cultures. ION is a network of communities along the Yukon River and its tributaries who conduct research and monitoring that is applicable at the community, watershed, circumpolar and global scales; an amazing feat in the world of science.

USGS

USGS science for a changing world

NAS – Nonindigenous Aquatic Species

Home | Alert System | Database & Queries | Taxa Information | Report a Sighti

Welcome to the Nonindigenous Aquatic Species (NAS) information resource for the United States Geological Survey. Located at Gainesville, Florida, this site has been established as a central repository for spatially referenced biogeographic accounts of introduced aquatic species. The program provides scientific reports, online/realtime queries, spatial data sets, distribution maps, and general information. The data are made available for use by biologists, interagency groups, and the general public. The geographical coverage is the United States.

Search
Search for NAS records via our custom spatial query map.

NAS FaST
(Flood and Storm Tracker)
Explore how flooding events can potentially impact the spread of nonindigenous aquatic species.

Environmental DNA
eDNA comprises genetic material that has been released into the environment and can be detected in water, soil, and air.

General search for nonindigenous aquatic species information

Invertebrates

Bryozoans

Coelenterates

Crustaceans

Mollusks

Vertebrates

Amphibians

Fishes

Marine Fishes

Mammals

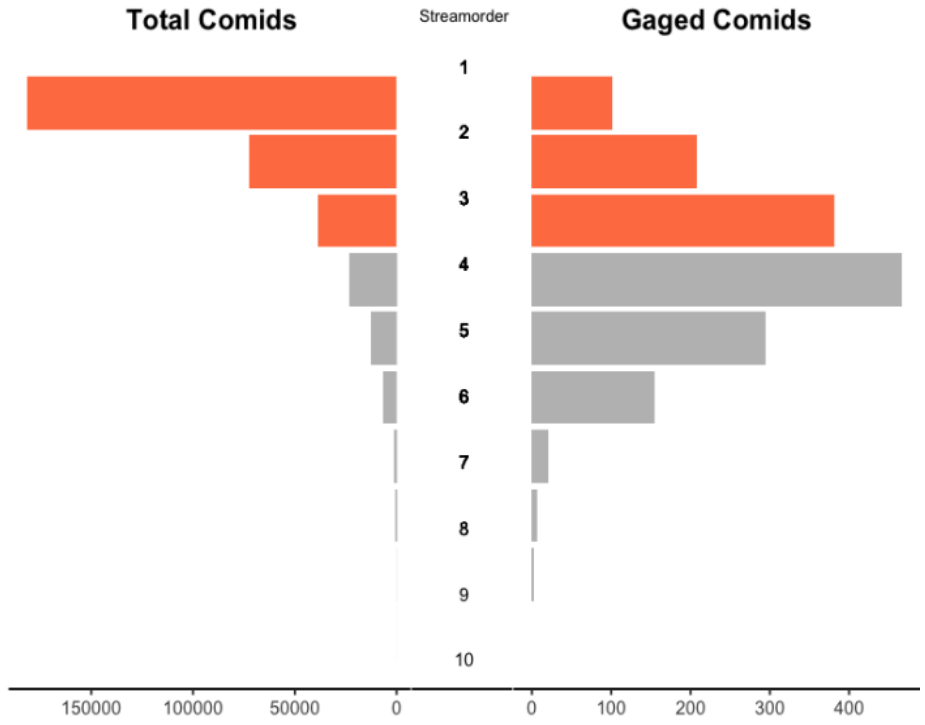
Reptiles

Plants

Plants

Headwater streams are under-monitored

- There is a gap between where we monitor streamflow (large streams) and where the most stream-miles are (small streams).
- Inexpensive cameras can **extend** existing monitoring networks to fill this monitoring gap.
- The imagery can be turned into quantitative streamflow estimates using innovative AI-based techniques.

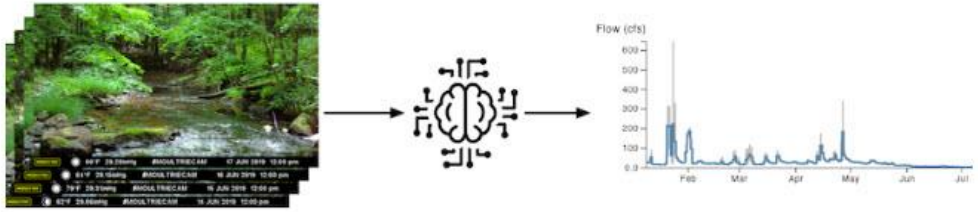


Relative number of USGS gages by stream order for the northeastern United States. Smallest stream are at the top. Number of streams is on the left and number of gaged streams is on the right. Headwaters in orange. Sources: USGS NWIS and NHD+. Figure developed in collaboration with Cee Nell.

Welcome to the Flow Photo Explorer

The **Flow Photo Explorer** is an integrated database, machine learning, and data visualization platform for monitoring streamflow and other hydrologic conditions using timelapse images.

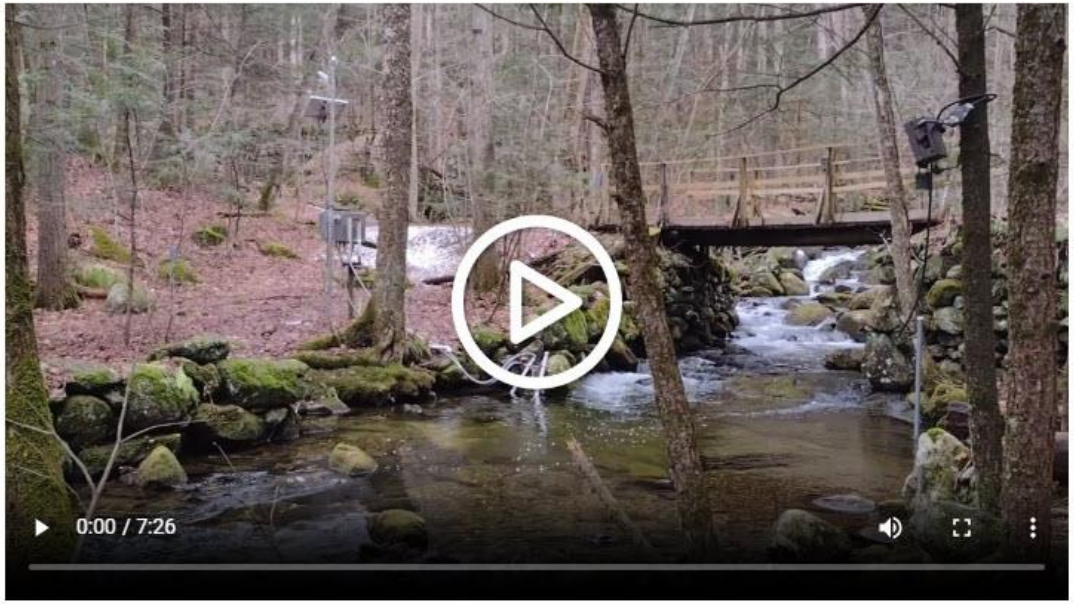
The goal of this project is to develop new approaches to hydrologic monitoring in streams and rivers where flow data are historically sparse or non-existent.



Timelapse Photos | Machine Learning Models | Continuous Streamflow

START EXPLORING ›

Do you have flow photos to contribute? Request an account to upload your photos.
Already have an account? Log in.
Questions? You can reach us at ecosheds@usgs.gov.



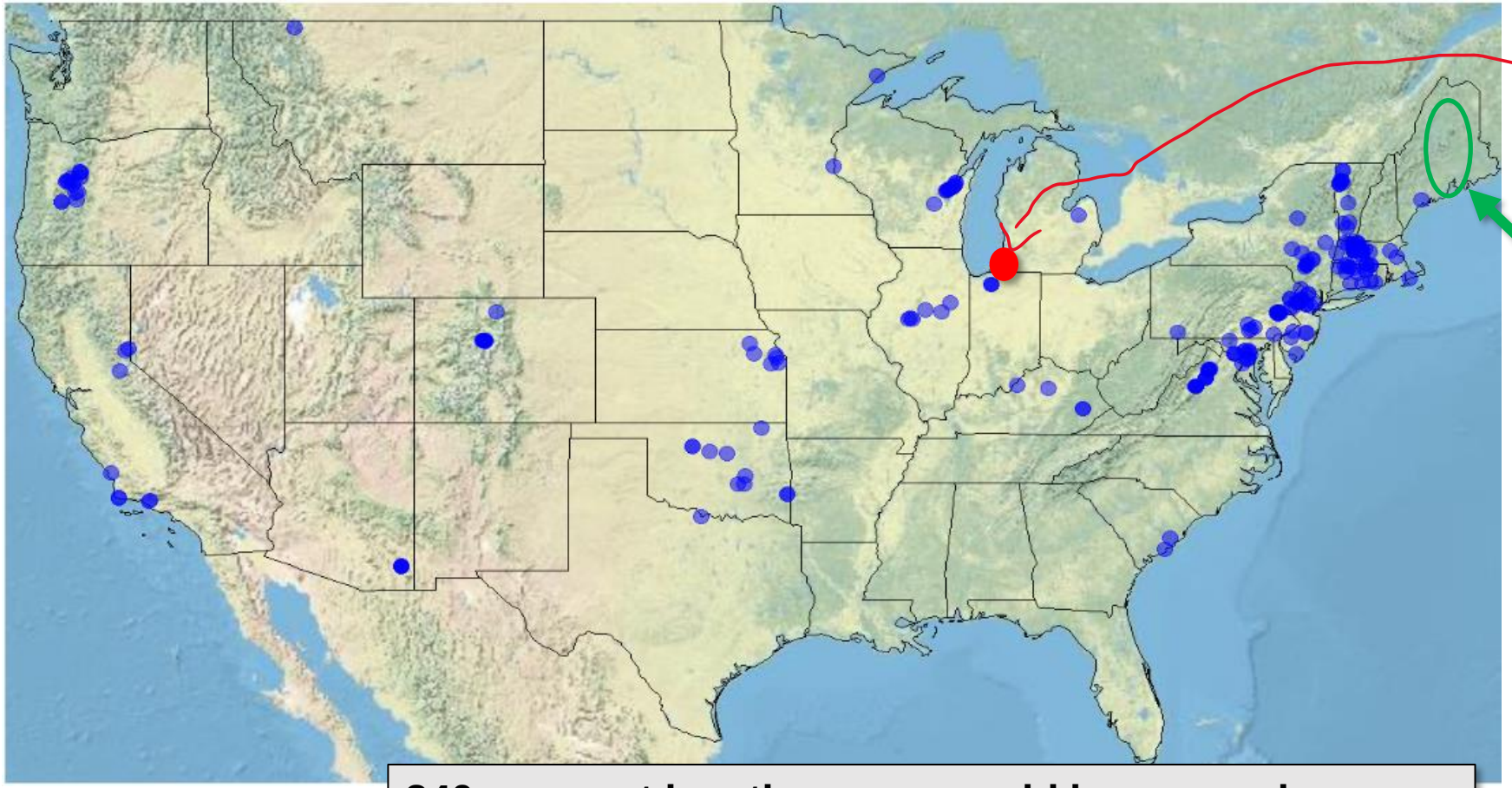
Video produced by the USGS MD-DE-DC Water Science Center

The Flow Photo Explorer project is a collaboration between U.S. Geological Survey, U.S. Environmental Protection Agency, Walker Environmental Research, Microsoft Research, and many contributing partners. Funding was provided by U.S. Geological Survey, U.S. Environmental Protection Agency, and National Geographic Society. See About for more information.

Deep Learning Model

What's New?

Current Trail Camera Network
March 2024



Peavine Creek
Images submitted by **Pokagon Band of Potawatomi, Dept. of Natural Resources**

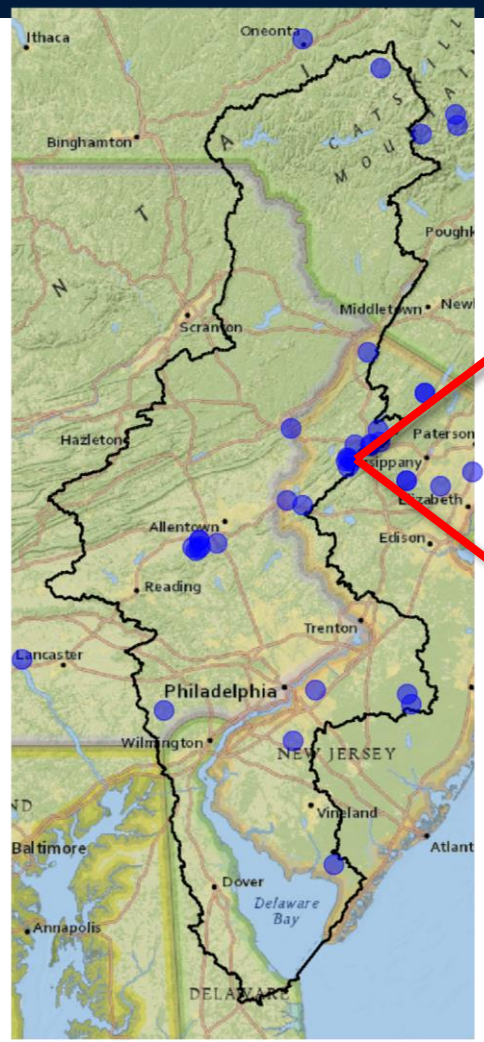
Coming soon (funded project underway): Intensive Ponobscot watershed monitoring by **Penobscot Indian Nation Dept. of Natural Resources**

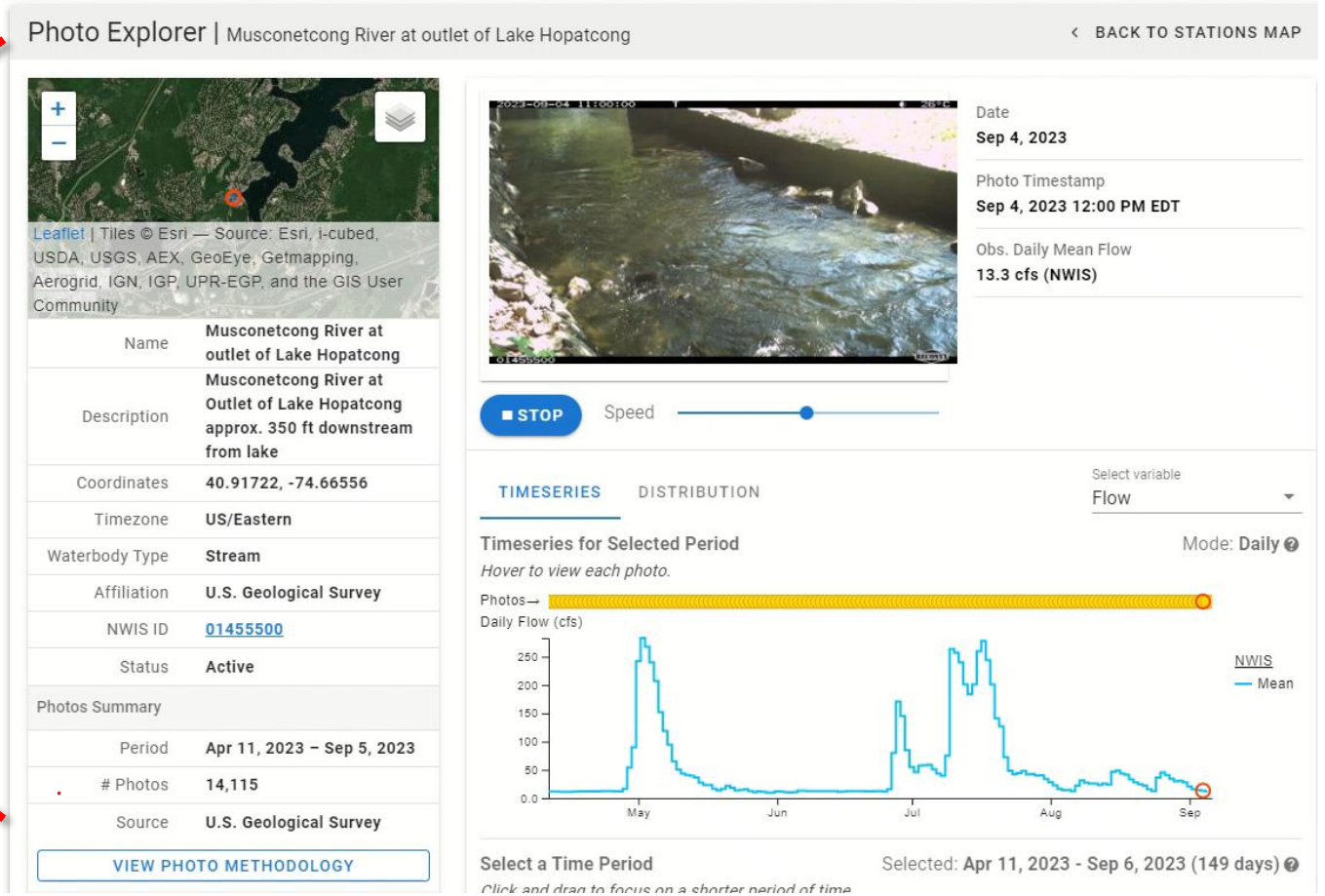
State agencies in 10 states, 7 NGO's, 4 federal agencies, 6 universities and local and tribal agencies all submit imagery.

240+ current locations, we would love more images to continue to fill in this map! Contact us at ecosheds@usgs.gov if you have questions or want to discuss setting up your monitoring station.

USGS

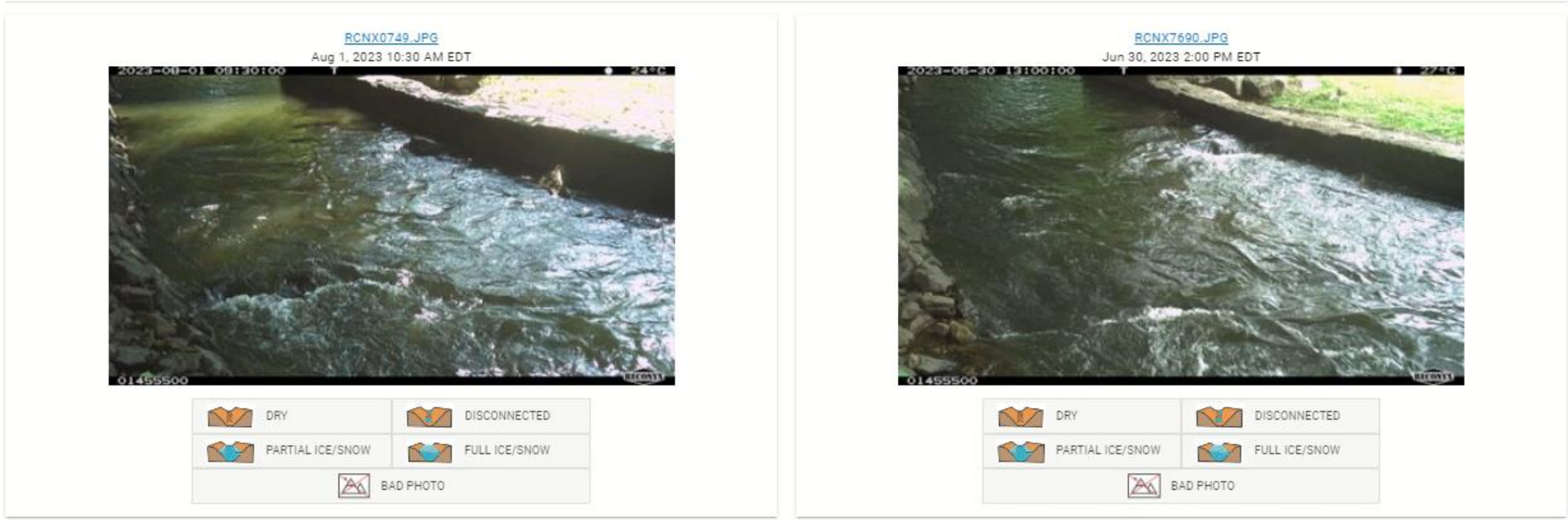
Visualizing imagery with NWIS data



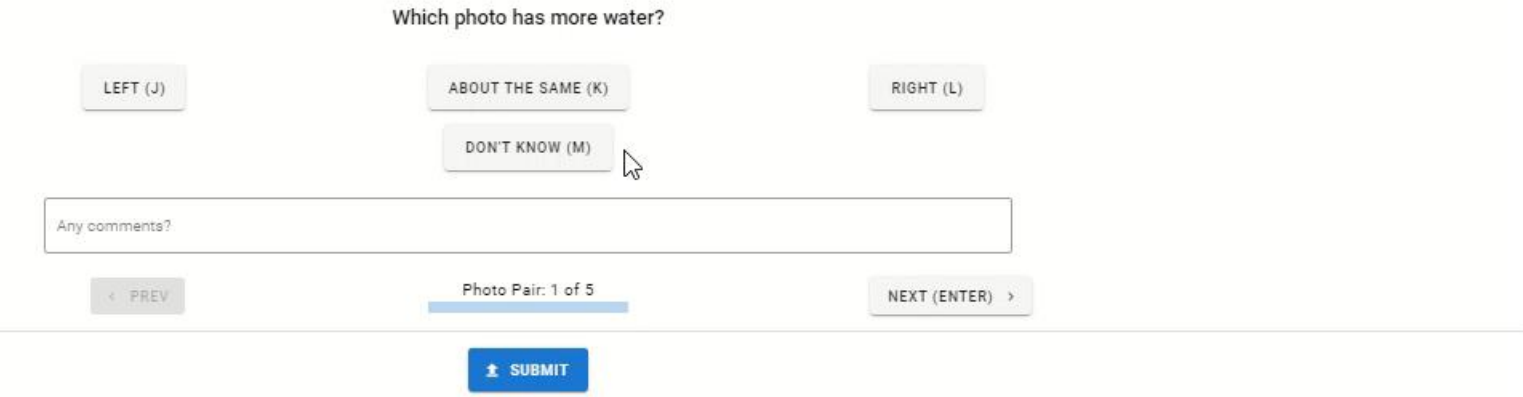


Musconetcong River at outlet of Lake Hopatcong

Annotating imagery to train model

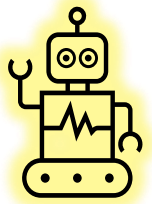


Users annotate approximately 5,000 image pairs to train the model (when no observation data are available). This is easy to do with the web interface!



Turning photos into flow

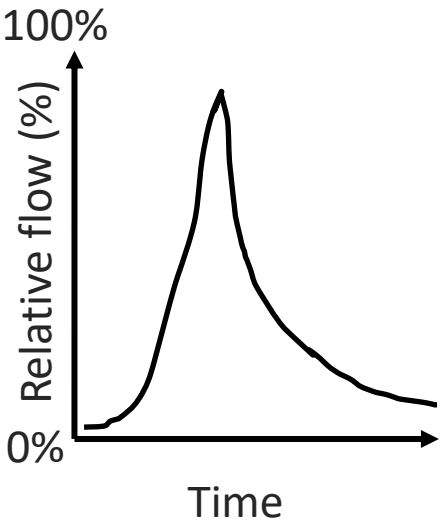
The model can **rank images** from high to low flow



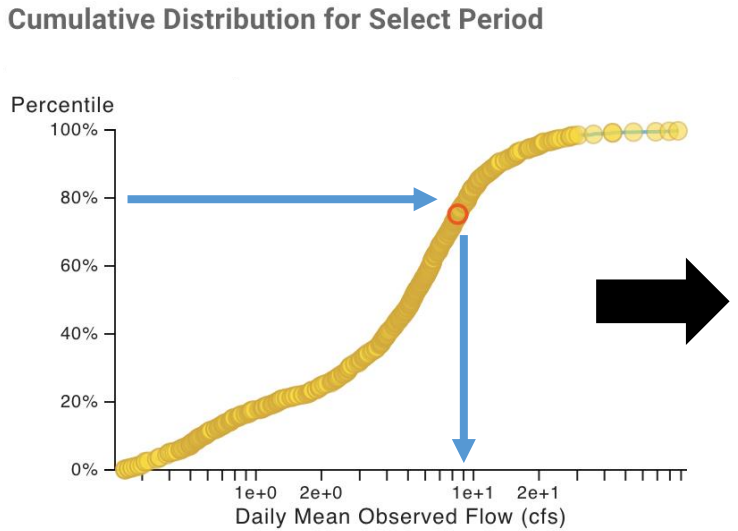
High flow (100%)

Low (0%)

Arranging the ranks over time gives us **relative flow:**
Useful for timing of peak flows
Identifying intermittent flows, low-flow durations, and more.

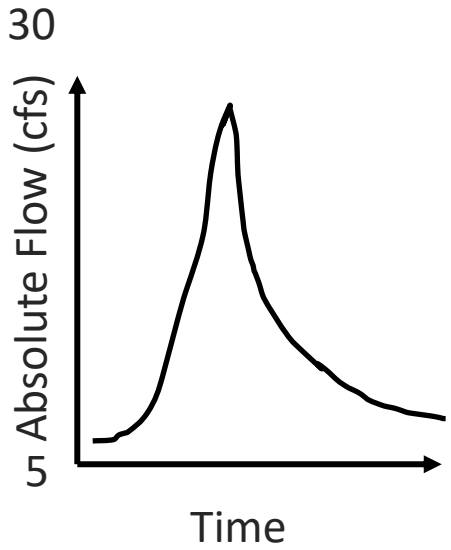


Optional Step



Research question: minimum # of absolute flow observations required

Absolute flow:
Important for when actual estimates of flow volume are needed



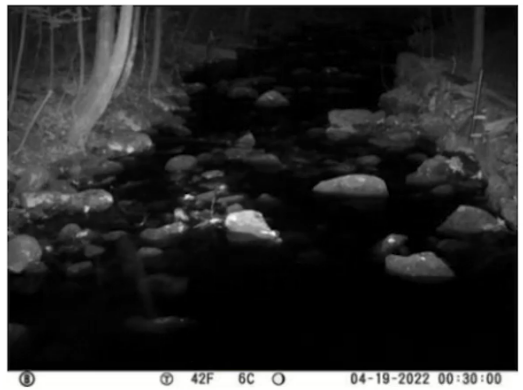


Photo Timestamp
Apr 19, 2022 1:30 AM EDT

1.

Obs. Flow
7.72 cfs (NWIS)

■ STOP Speed

Photo Timestamp
Apr 19, 2022 5:45 PM EDT

3.

Obs. Flow
19.6 cfs (NWIS)

■ STOP Speed

TIMESERIES DISTRIBUTION

Select variable
Flow

Timeseries for Selected Period

Mode: **Inst**

Hover to view each photo.

Photos→

Instantaneous Flow (cfs)

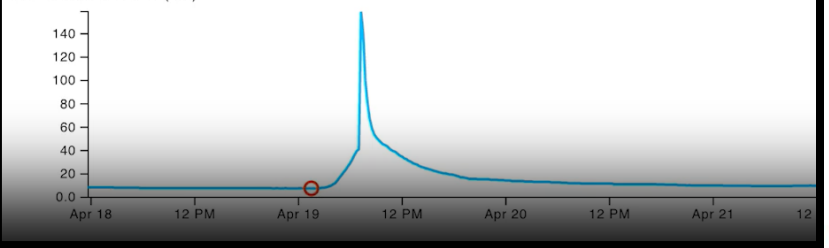


Photo Timestamp
Apr 19, 2022 7:30 AM EDT

2.

Obs. Flow
140 cfs (NWIS)

■ STOP Speed

TIMESERIES DISTRIBUTION

Select variable
Flow

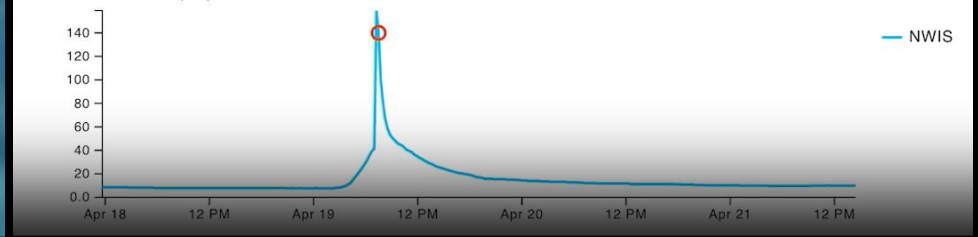
Timeseries for Selected Period

Mode: **Instantaneous**

Hover to view each photo.

Photos→

Instantaneous Flow (cfs)



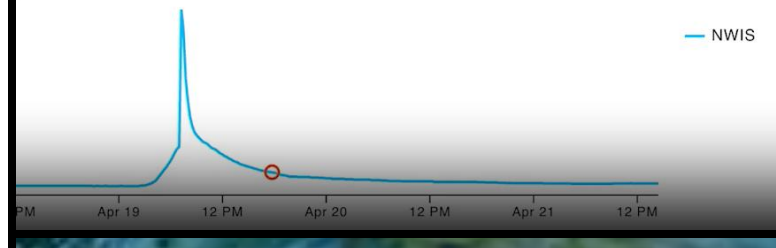
DISTRIBUTION

Select variable
Flow

cted Period

Mode: **Instantaneous**

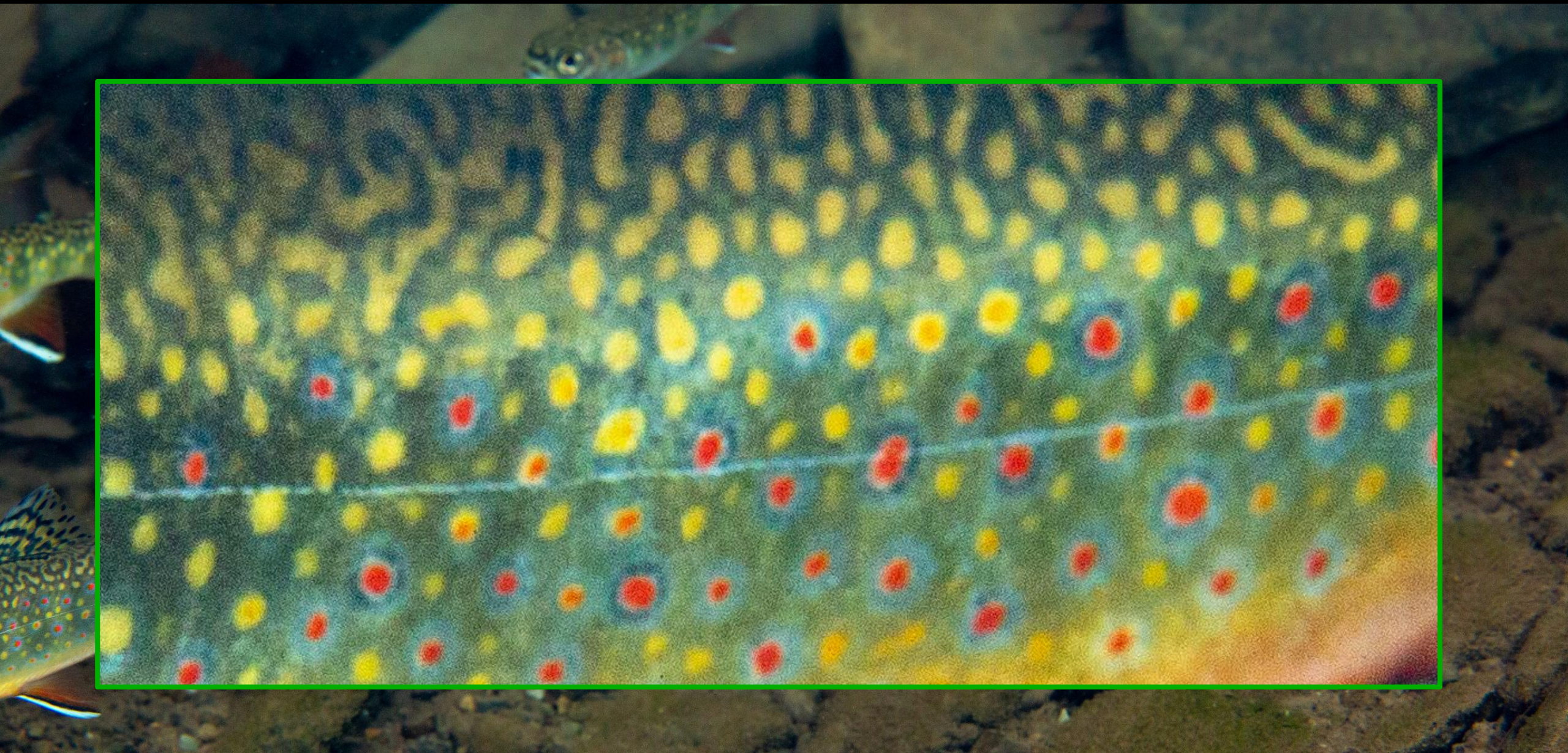
oto.



USGS

Individually diagnostic pigmentation

Individually diagnostic pigmentation



TroutSpotter framework

TROUT UNLIMITED

Angler engagement

Mobile platform for image submission

Convolutional neural networks

WILDME

Deep learning for individual fish recognition

Mark-recapture modeling

Status and trends

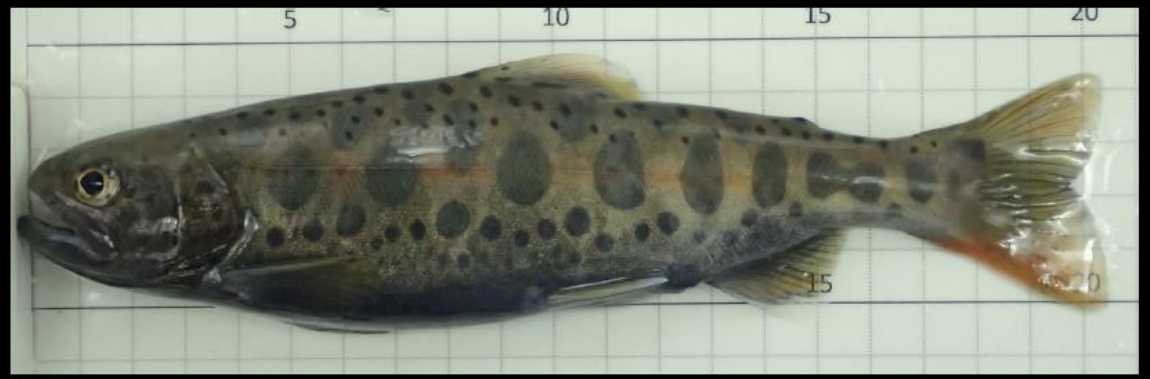
USGS
science for a changing world

Fish population dynamics

Spring
2020

Autumn
2020

Spring
2021



Autumn
2021

Spring
2020

Autumn
2020

Spring
2021

Autumn 2021

Parr mark extraction and prediction

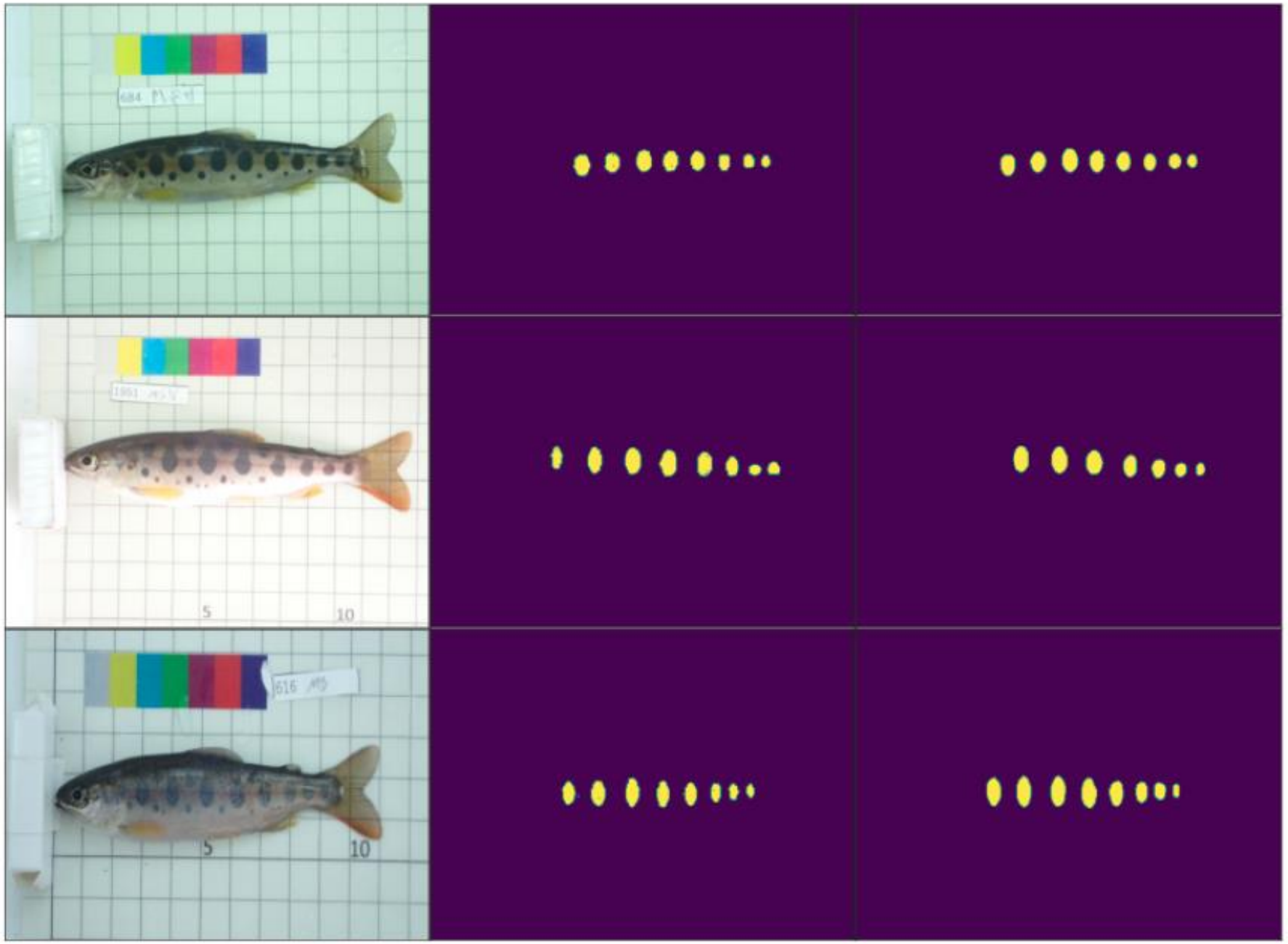
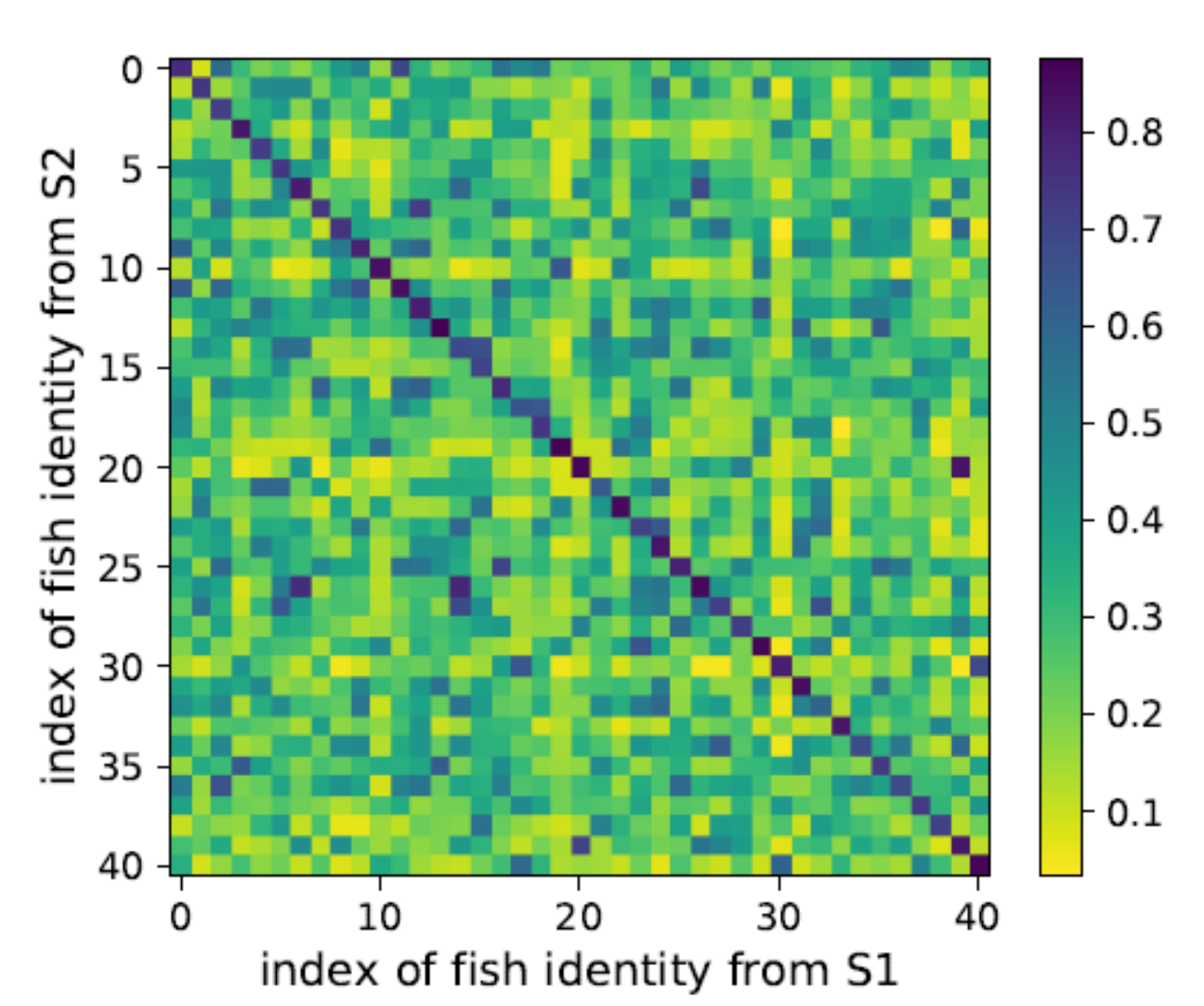


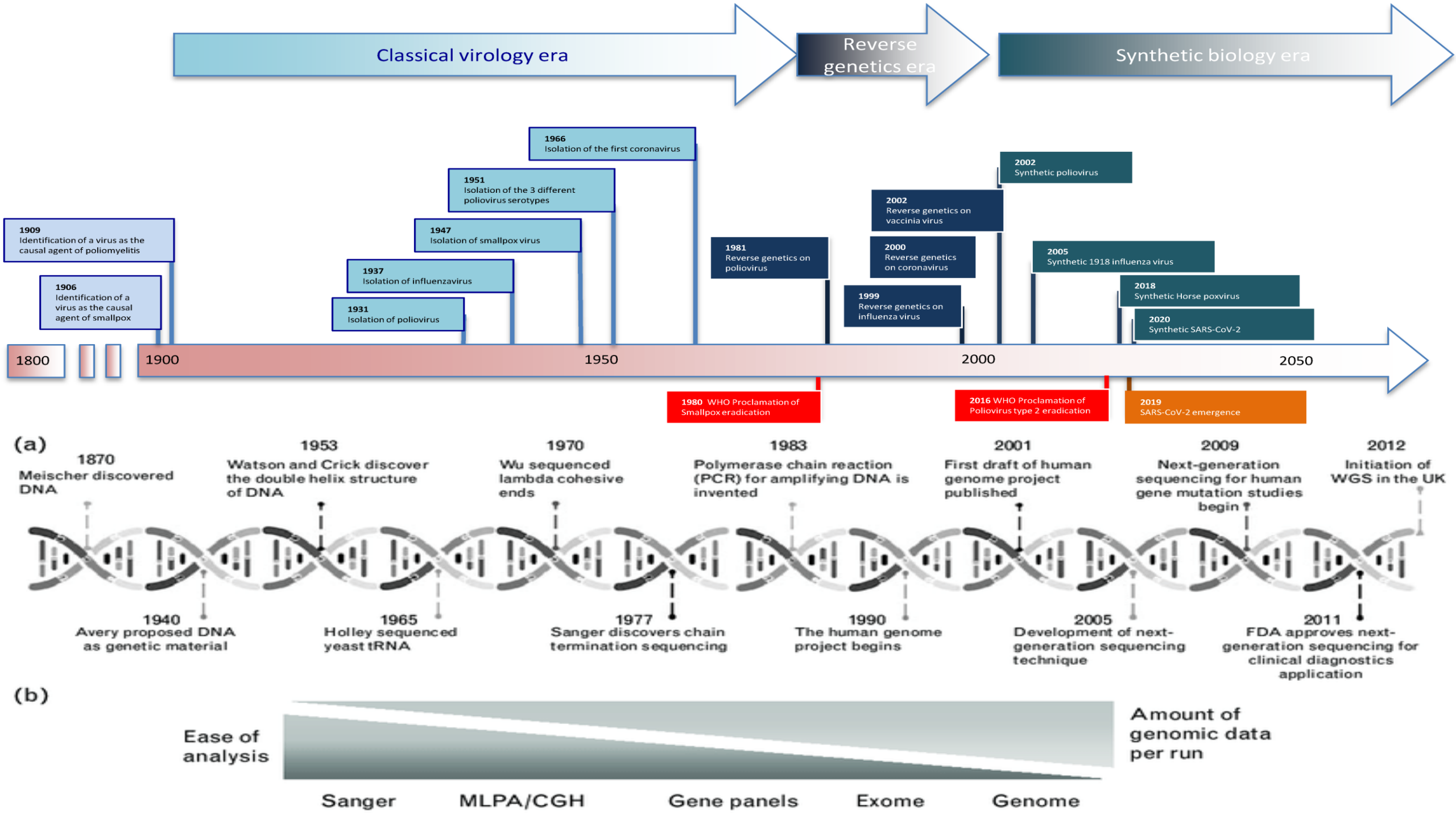
image | ground truth mask | predicted mask

Individual re-identification accuracy > 90%



USGS

Nathaniel (Than) Hitt
USGS Eastern Ecological Science Center
nhitt@usgs.gov
304-724-4463


Classical virology era
Reverse genetics era
Synthetic biology era
1909
Identification of a virus as the causal agent of poliomyelitis
1906
Identification of a virus as the causal agent of smallpox
1931
Isolation of poliovirus
1937
Isolation of influenzavirus
1947
Isolation of smallpox virus
1951
Isolation of the 3 different poliovirus serotypes
1966
Isolation of the first coronavirus
1981
Reverse genetics on poliovirus
1999
Reverse genetics on influenza virus
2000
Reverse genetics on coronavirus
2002
Reverse genetics on vaccinia virus
2002
Synthetic poliovirus
2005
Synthetic 1918 influenza virus
2018
Synthetic Horse poxvirus
2020
Synthetic SARS-CoV-2
1800
1900
1950
2000
2050
1980 WHO Proclamation of Smallpox eradication
2016 WHO Proclamation of Poliovirus type 2 eradication
2019
SARS-CoV-2 emergence
(a)
1870
Meischer discovered DNA
1940
Avery proposed DNA as genetic material
1953
Watson and Crick discover the double helix structure of DNA
1965
Holley sequenced yeast tRNA
1970
Wu sequenced lambda cohesive ends
1977
Sanger discovers chain termination sequencing
1983
Polymerase chain reaction (PCR) for amplifying DNA is invented
1990
The human genome project begins
2001
First draft of human genome project published
2005
Development of next-generation sequencing technique
2009
Next-generation sequencing for human gene mutation studies begin
2011
FDA approves next-generation sequencing for clinical diagnostics application
2012
Initiation of WGS in the UK
(b)
Ease of analysis
Amount of genomic data per run
Sanger
MLPA/CGH
Gene panels
Exome
Genome

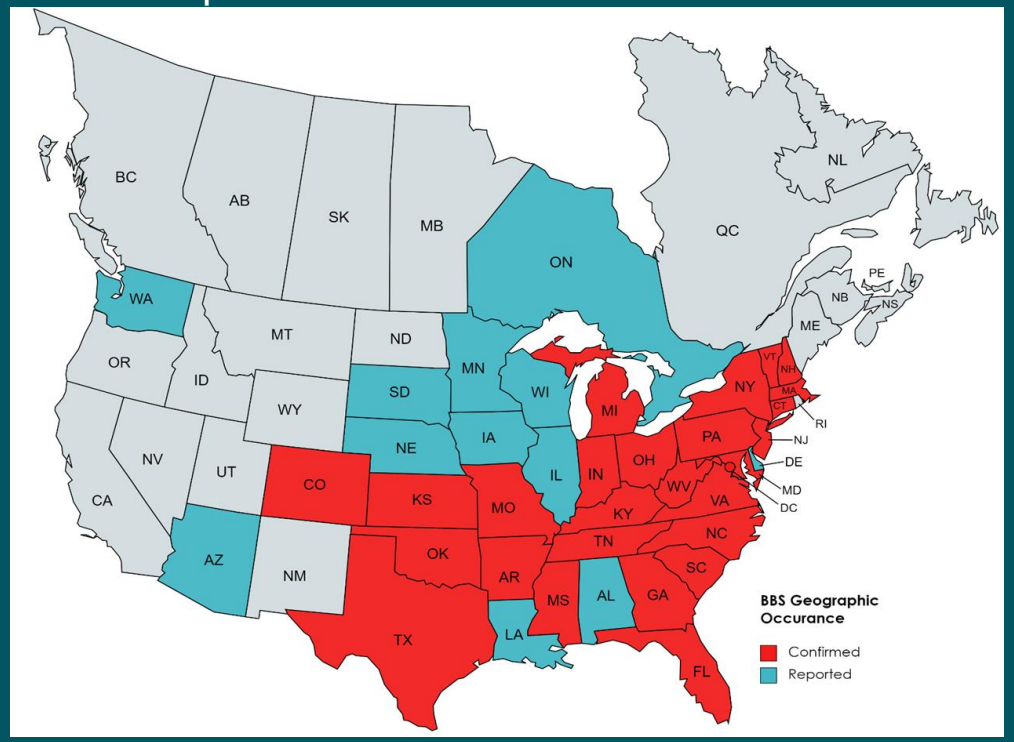
Blotchy Bass Syndrome

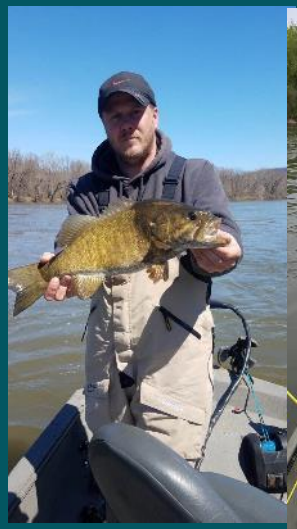
History:

- ‘Blotchy’ largemouth bass were first reported in the 1980’s (Hudson River, NY)

Affected fish:

- Reported in both adult largemouth and smallmouth bass (> 175 mm).
- Casual reports in rock bass and sunfishes



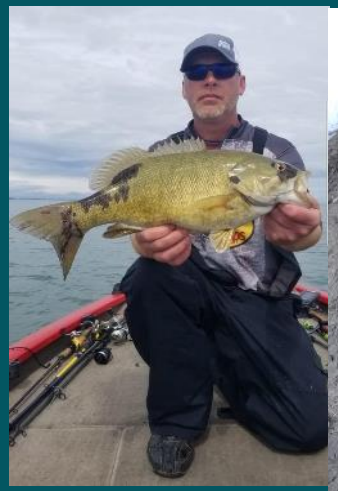


Potomac River, MD

Susquehanna River, PA

Lake Erie, OH

Ohio River, WV



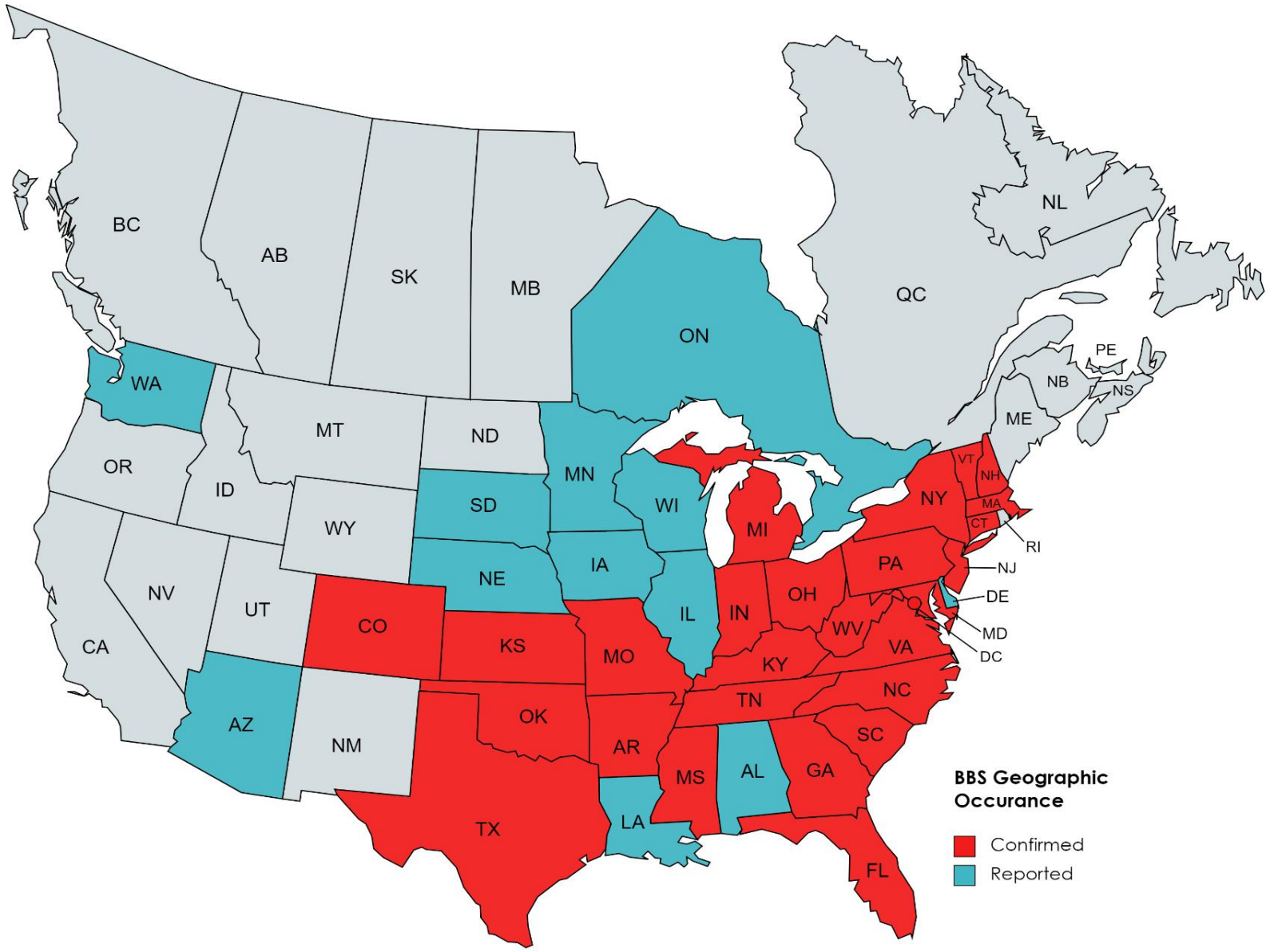
Lake St. Clair, MI

Connecticut River, VT

Georgia

Carlson, D. M. 1989. Unusual pigmentation on largemouth bass. Presentation to the 45th Annual NE Fish and Wildl. Conf., Ellenville, NY, (Mimeo) 8p.

Skinner, K. M., L. Pagels, and K. A. Peregrim. 1994. Black blotch largemouth bass in the Hudson River, New York. Presentation given at the New York natural History Conference III, April 13-16,1994. (Mimeo) 29p.


BC
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AL
OH
WV
GA
FL
SC
NC
VA
PA
NY
VT
NH
MA
CT
RI
NJ
DE
MD
DC
BBS Geographic Occurance
Confirmed
Reported

Introduction to Adomaviruses

- The first adomavirus was reported in 2018
- These viruses are not only ‘new’ to fish disease science, but the scientific community in general
- They are similar to the ‘small DNA tumor viruses’ (adenovirus, papillomavirus and polyomavirus)
- Some are associated with lethal disease, or skin diseases of unknown consequence. While most are of unknown significance…

USGS

AMERICAN SOCIETY FOR MICROBIOLOGY | mBio®
OBSERVATION
May/June 2018 Volume 9 Issue 3 e00185-18
https://doi.org/10.1128/mBio.00185-18

Microscopic and Molecular Evidence of the First Elasmobranch Adomavirus, the Cause of Skin Disease in a Giant Guitarfish, *Rhynchobatus djiddensis*

Jennifer A. Dill, Alvin C. Camus, John H. Leary, Terry Fei Fan Ng *

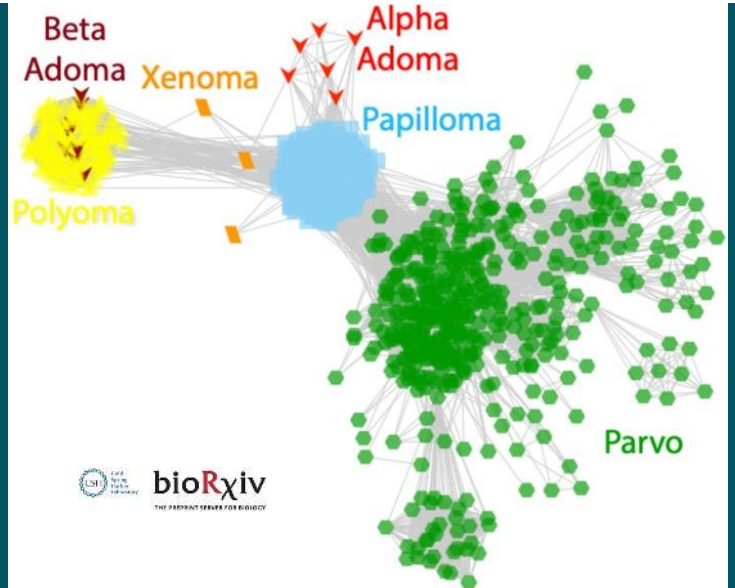
Department of Pathology, College of Veterinary Medicine, University of Georgia, Athens, Georgia, USA

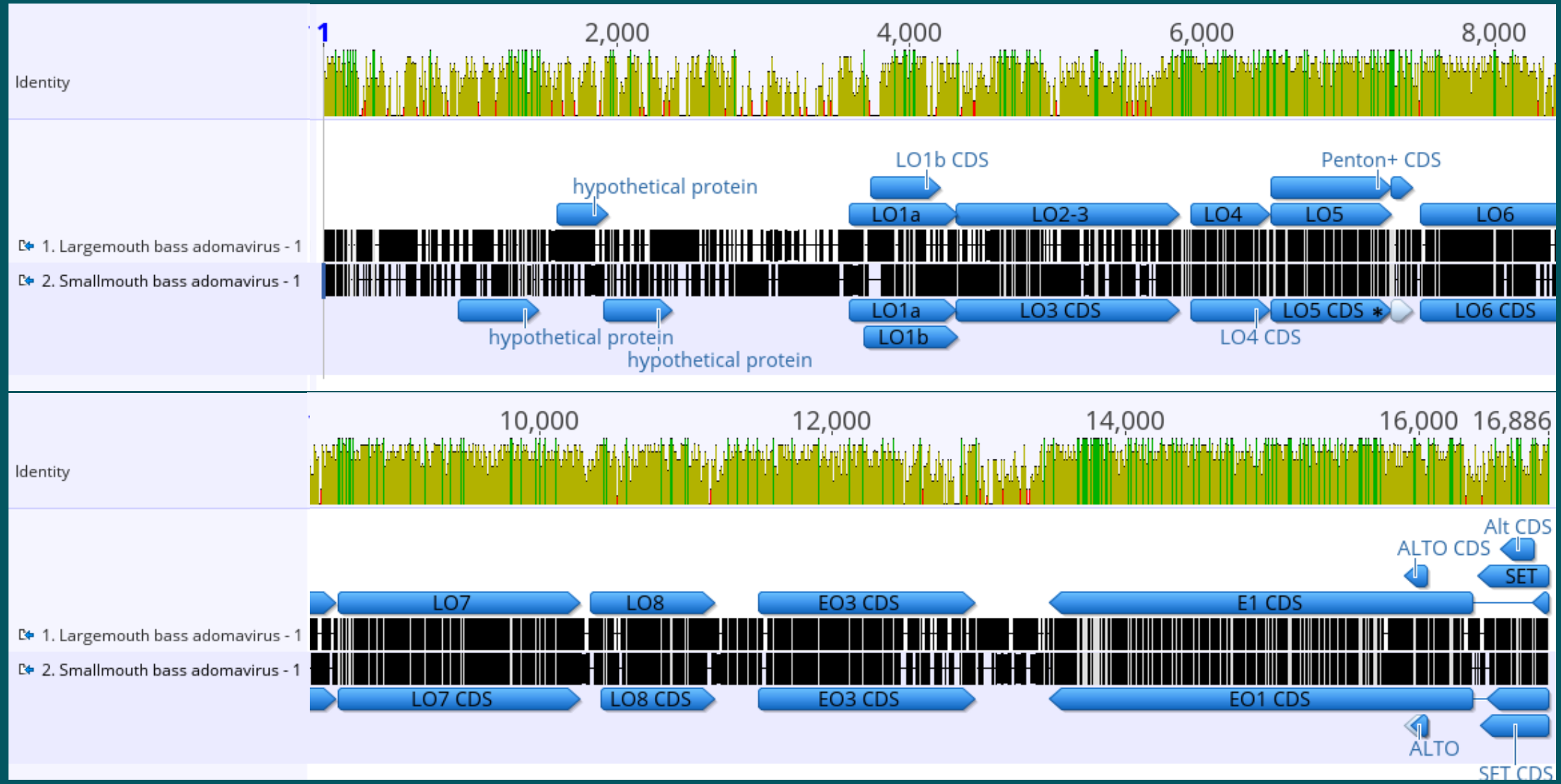
AMERICAN SOCIETY FOR MICROBIOLOGY | Microbiology Resource Announcements
GENOME SEQUENCES
April 2020 Volume 9 Issue 14 e01479-19
https://doi.org/10.1128/MRA.01479-19

Draft Genome Sequence of an Adomavirus Associated with Raised Mucoid Skin Lesions on Smallmouth Bass (*Micropterus dolomieu*)

Luke R. Iwanowicz [a], Kelsey T. Young [b], Cynthia R. Adams [a], Vicki S. Blazer [a], Geoffrey D. Smith [c], and R. Scott Cornman [d]

[a] U.S. Geological Survey, Leetown Science Center, Kearneysville, West Virginia, USA
[b] Pennsylvania Sea Grant College Program, Pennsylvania State University, Erie, Pennsylvania, USA
[c] Pennsylvania Fish & Boat Commission, Division of Fisheries Management, Harrisburg, Pennsylvania, USA
[d] U.S. Geological Survey, Fort Collins Science Center, Fort Collins, Colorado, USA





USGS

Alignment of the smallmouth bass adomavirus –1 and largemouth bass adomavirus –1.
While organizationally these viruses are similar, they are only ~69% identical

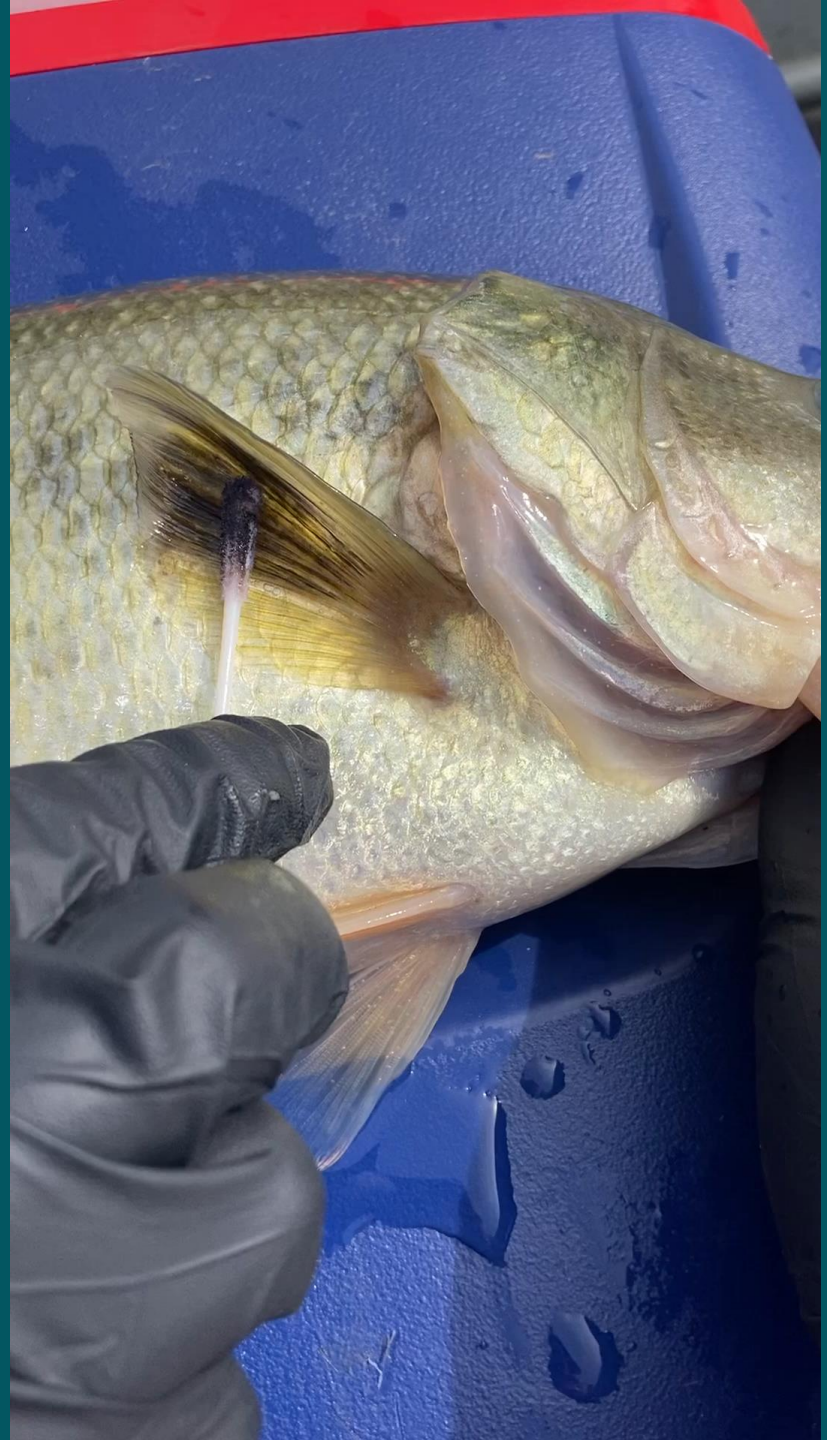
Provisional Data

Application of minimally invasive sampling methods

USGS

Application of minimally invasive sampling methods

- Note the transfer of melanin to the swab.
- Black swab = sufficient sample for PCR analysis
- The fragility of these HPMLs during the Spring is notable



Training of Machine Learning Approaches

USGS

Harvest of Smartphone image data

https://www.inaturalist.org/

KeAi
CHINESE ROOTS GLOBAL IMPACT

Artificial Intelligence in Agriculture

Volume 1, March 2019, Pages 27-34

Application of artificial intelligence for separation of live and dead rainbow trout fish eggs

Abbas Rohani [a], Morteza Taki [b], Ghasem Bahrami [a]

ELSEVIER

Optik

Volume 223, December 2020, 165499

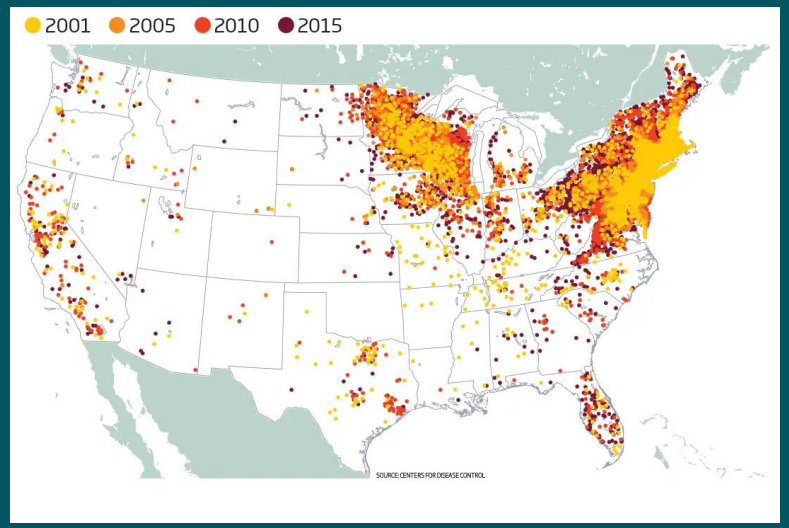
Original research article

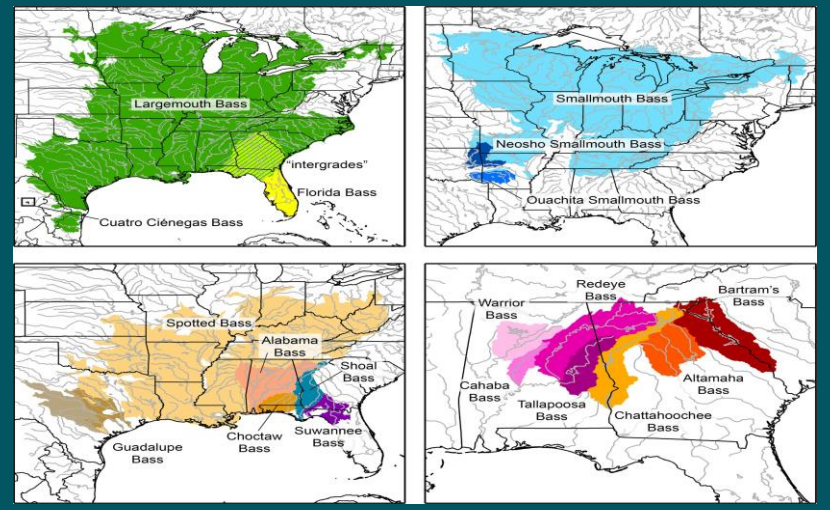
Fish species recognition using an improved AlexNet model

Zhiyong Ju, Yongjie Xue

https://aldercreek.com/oregon-kayak-bass-fishing-tournament/

GettyImages-917786154 iStock-876112880 iStock-931643150 iStock-908271854





USGS

Moving Forward: Bass Pro Shops and TPWD efforts

Allen

Ft Worth

El Paso

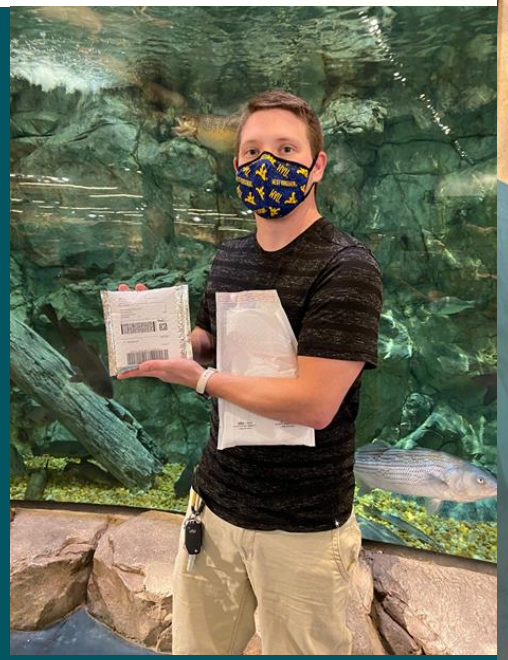
Grapevine

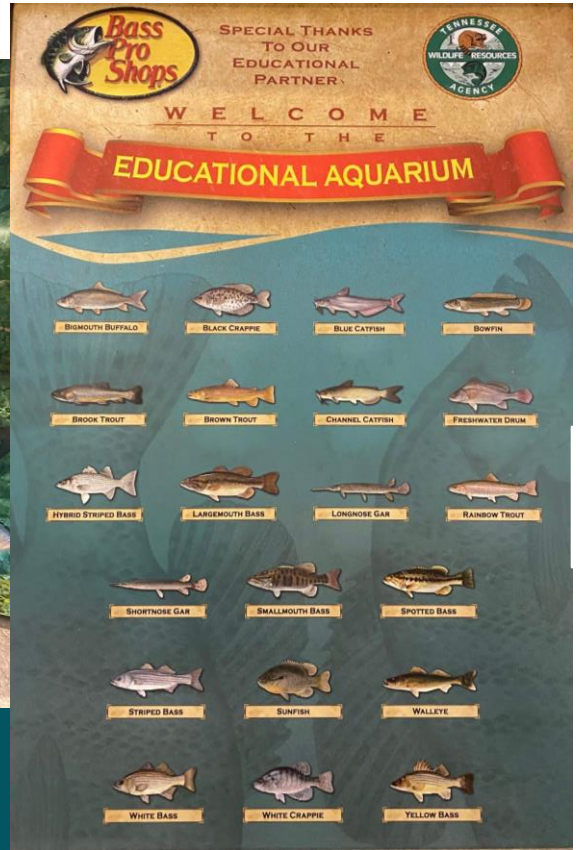
Harlingen

League City

Pearland

Round Rock 1





USGS

Seeing bass with spots?

PLEASE REPORT BLOTCHY BASS SYNDROME

Johnny Morris Bass Pro Shops

Cabela's

WestVirginiaUniversity

TEXAS PARKS & WILDLIFE

What is Blotchy Bass Syndrome?

Hyperpigmentation/melanosis, aka Blotchy Bass Syndrome (BBS) is the occurrence of black ink-like spots on the skin of freshwater bass species. Blotchy Bass Syndrome has been documented in 18 states, including Texas.

While the hyperpigmentation on these fish is associated with a virus, these fish routinely appear to be in great condition and are actively feeding.

Are the fish safe to touch and eat?

Yes, the viruses that are associated with BBS have never been identified in humans or common domestic pets (dogs, cats, birds). They are also safe to eat as long as they are properly cooked.

How does BBS spread?

How the virus spreads between fish is currently under investigation. USGS scientists are researching how the virus reproduces and is transmitted. In any case, anglers should never move fish between water bodies. It is unlawful to place any game fish into public waters other than the body of water where the fish was caught.

How can you help?

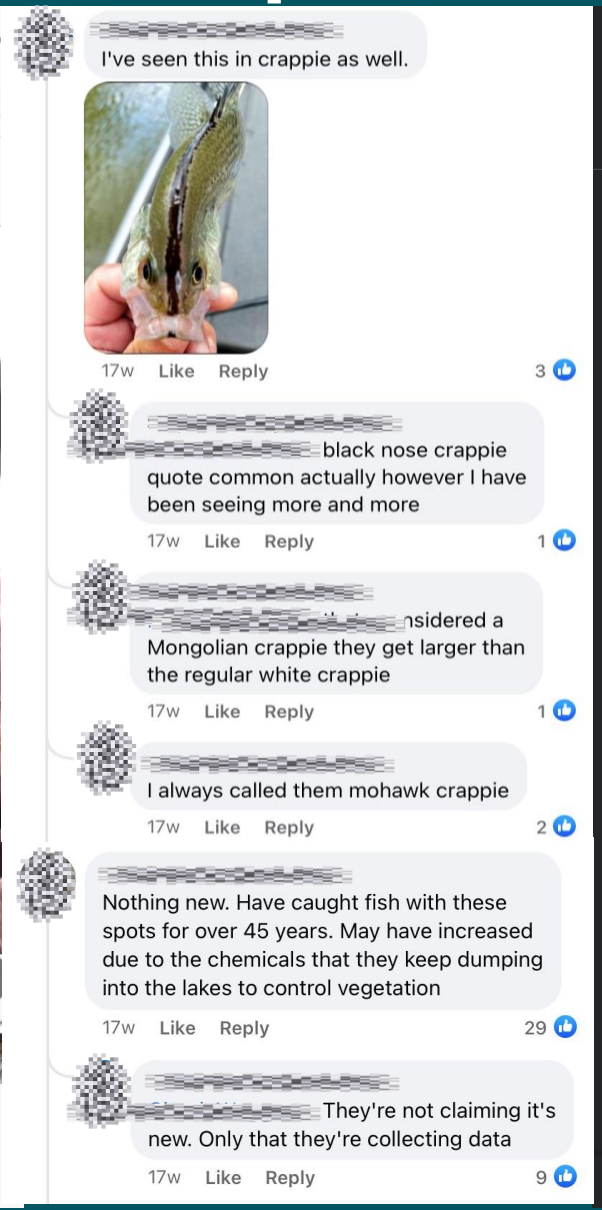
Send photos of fish with blotches and the name of the waterbody to:

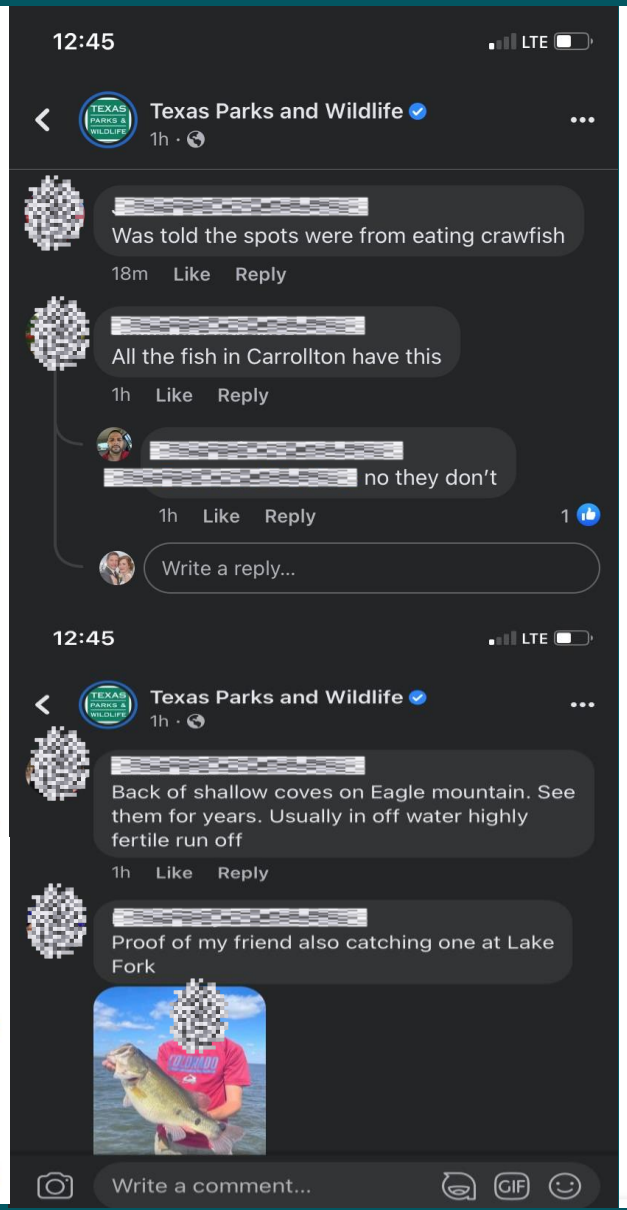
Cynthia.Fox@tpwd.texas.gov

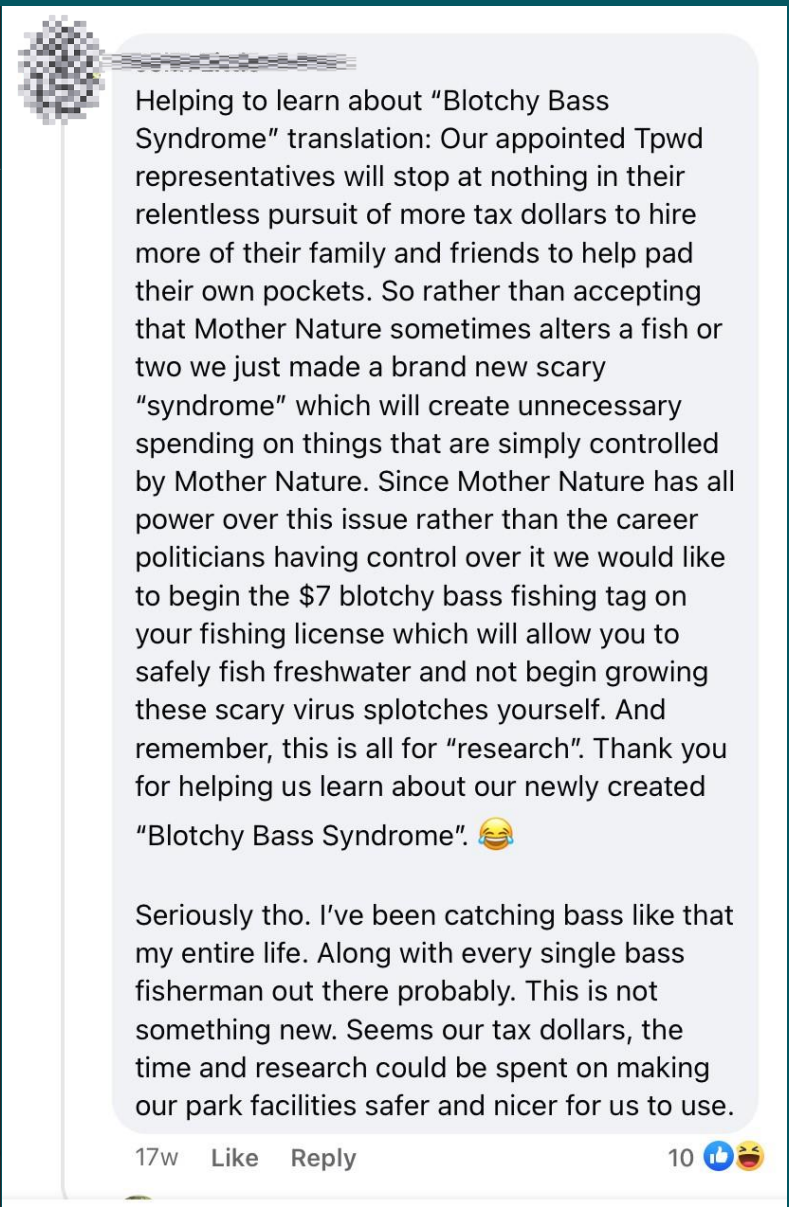
For More Information on BBS:

BP22780750

Unexpected Issues and Pitfalls







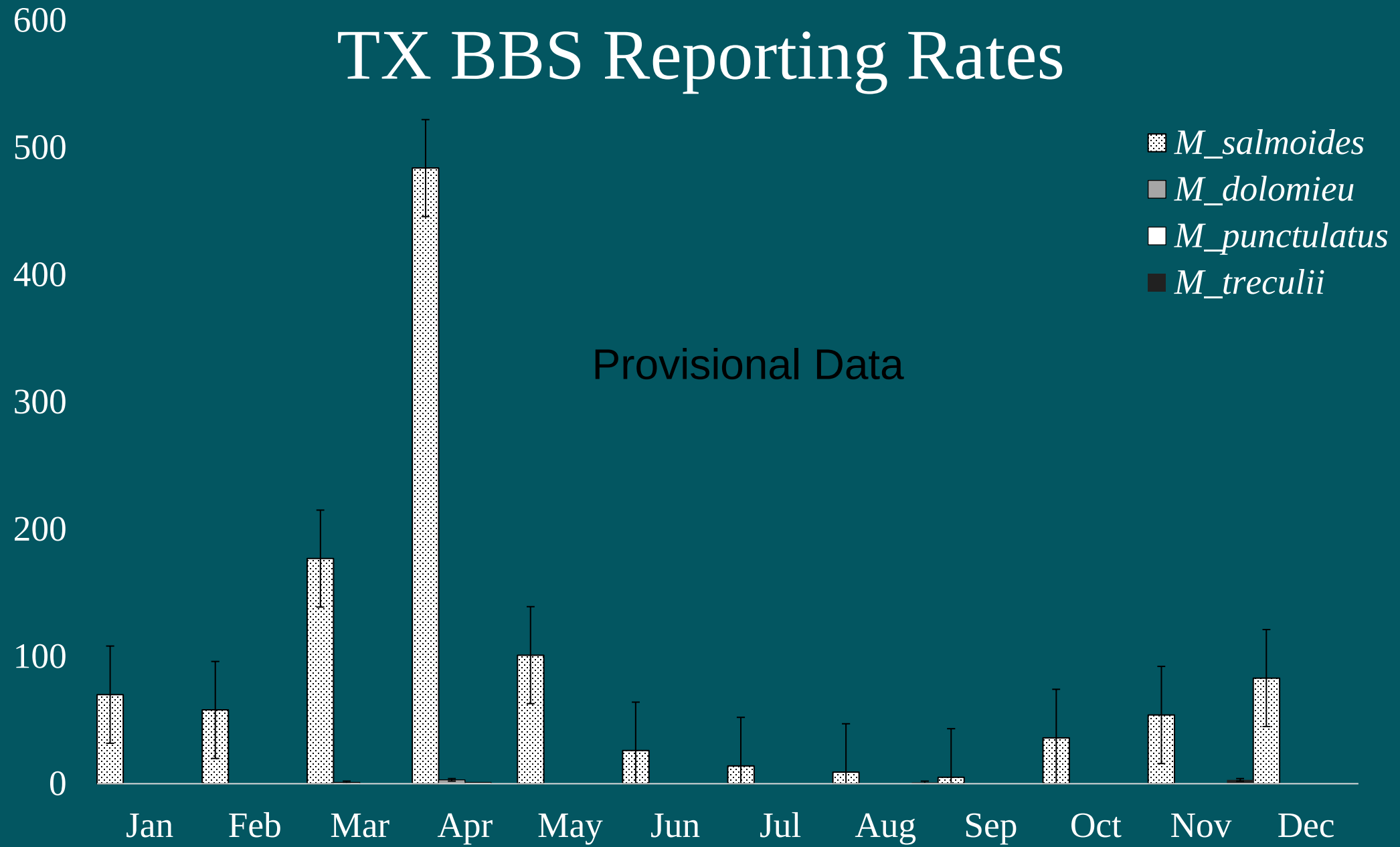
USGS

WV

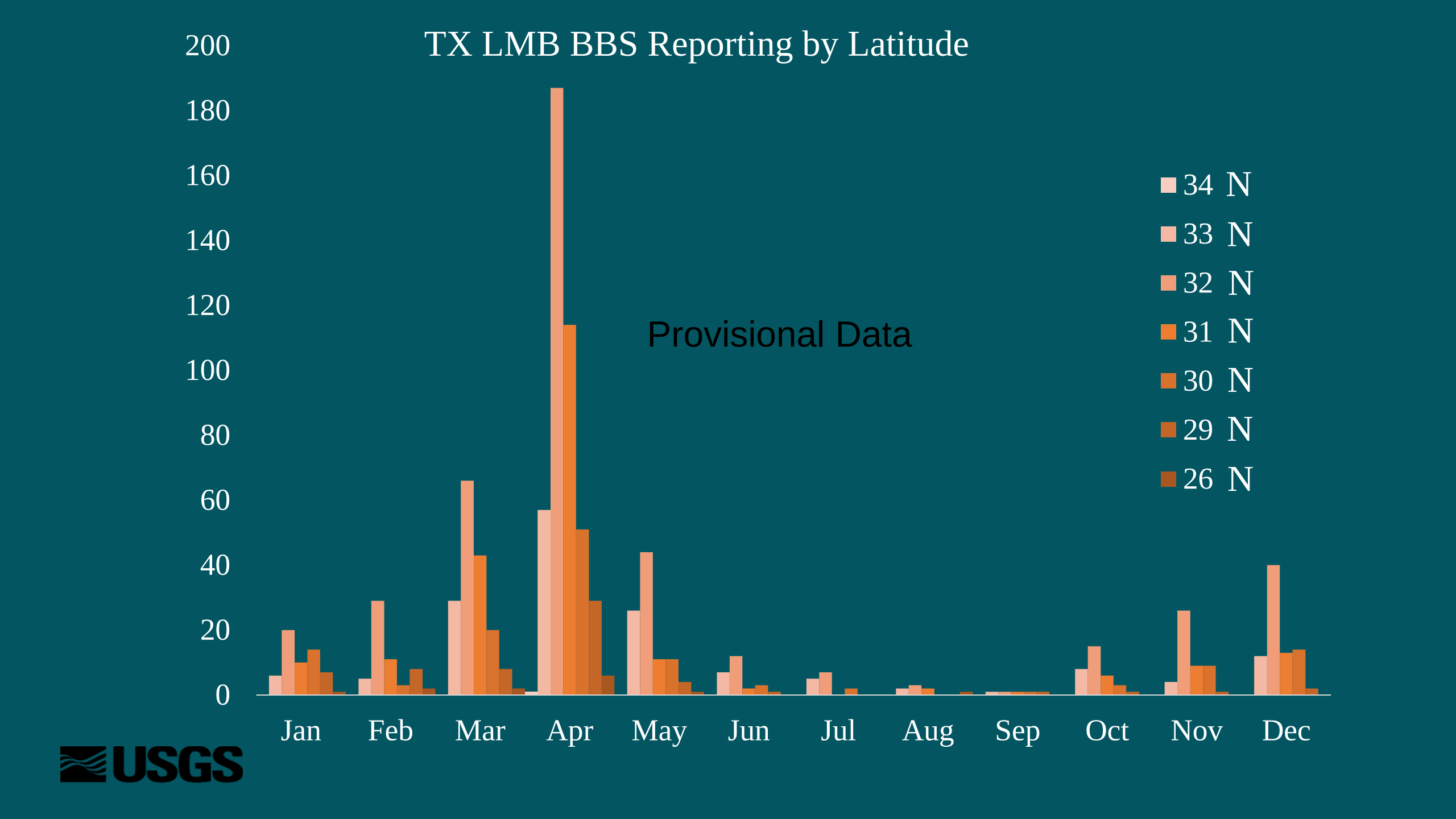
District/Page	Rank	Total Posts	Reach	Reactions	Comments	Shares
Corpus Christi	-	8	-	-	-	-
Amarillo	11	15	2,258	8	0	13
Wichita Falls	37	47	2,308	16	3	23
San Marcos/Austin	10	17	992	8	0	5
Denison	14	25	772	1	0	4
Jasper	7	22	173	0	0	1
Tyler	-	-	-	-	-	-
Waco	9	18	1,514	9	2	15
Dallas/Fort Worth	1	107	158,533	483	141	265
Main	2	362	1,142,528	11,291	3,736	12,101

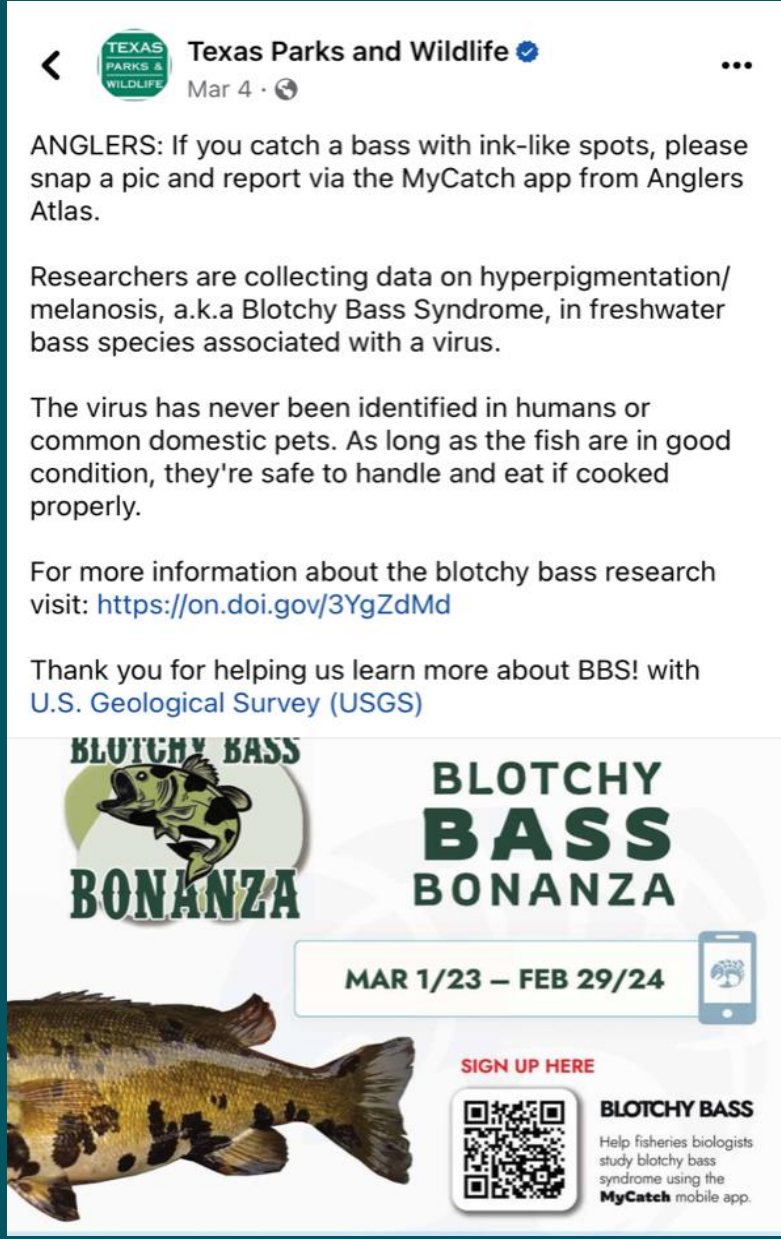
Social Media Reach

TX BBS Reporting Rates



USGS


TX LMB BBS Reporting by Latitude
Provisional Data
200
180
160
140
120
100
80
60
40
20
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
34 N
33 N
32 N
31 N
30 N
29 N
26 N
USGS



USGS

Consolidation of Efforts

Angler's Atlas

Search for a location or species

Events Places Fish Research Log in

Featured Article

TRACKING BLOTCHY BASS SYNDROME ACROSS NORTH AMERICA USING MYCATCH

By Sean Simmons

Read Now →

WHAT WE ARE PASSIONATE ABOUT:

Primary Research

MyCatch is working with fisheries scientists from around the world to answer important fisheries research questions. Learn how angler catch data is fueling this new area of research.

Read More →

Working With Angler Data

We are able to use angler data while protecting the privacy of our anglers. These resources allow users and managers to learn more about the state of their fisheries.

Read More →

Recognizing Citizen Scientists

We recognize the contribution of angler and scientist participation as they help us chart new ways of monitoring and understanding our fisheries.

Read More →

LATEST TOPICS

Sort By Most Recent

USGS

Overview: Angler's Atlas Blotchy Bass Bonanza

BLOTCHY BASS BONANZA

Event ended at 18:00, Nov 30, 2022

Overview | Blotchy Bass | Prizes | Rules | Checklist

Overview

Event Boundary

LOCATIONS
Canada, United States

START DATE
Jul 1, 2022

TOTAL PRIZE VALUE
$15,000 USD

ENTRY FEE
Free

Eligible Species

Smallmouth Bass

Largemouth Bass

Rock Bass

Spotted Bass

Shoal Bass

Suwannee Bass

Redeye Bass

Chattahoochee Bass

Tallapoosa Bass

Alabama Bass

Guadalupe bass

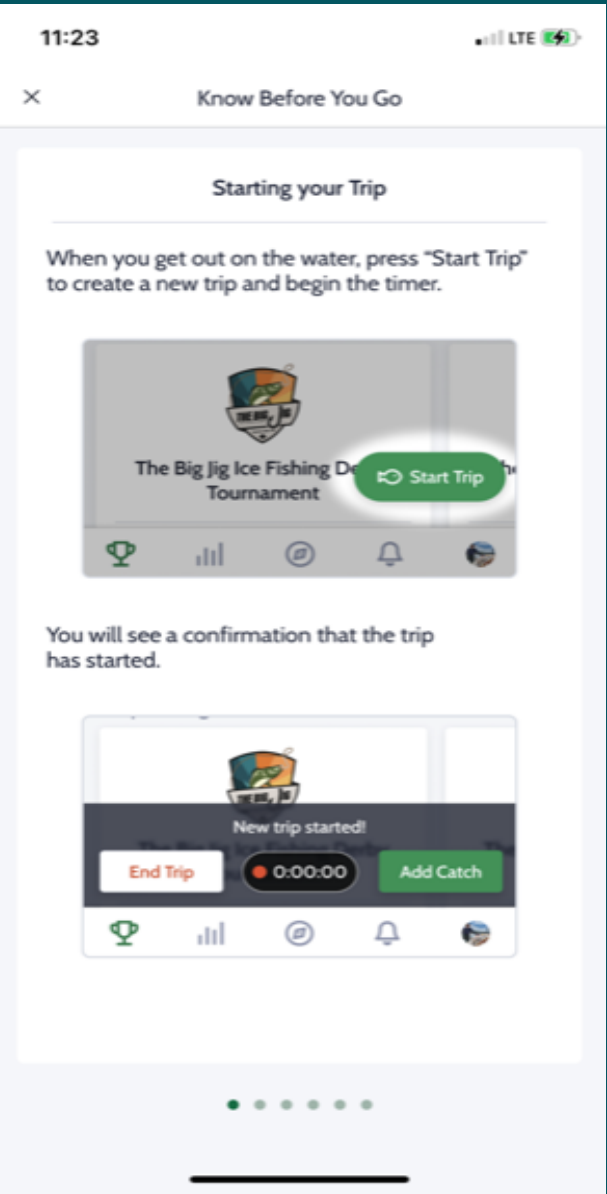
Sponsored By

See All Sponsors

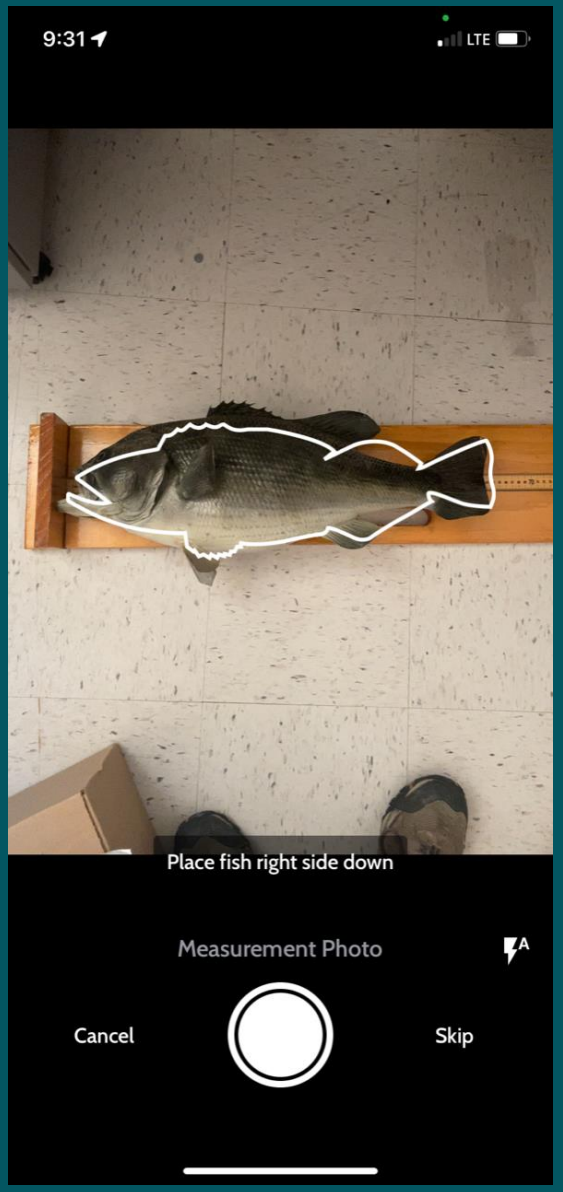
LEADERBOARD
Largemouth Bass Entries

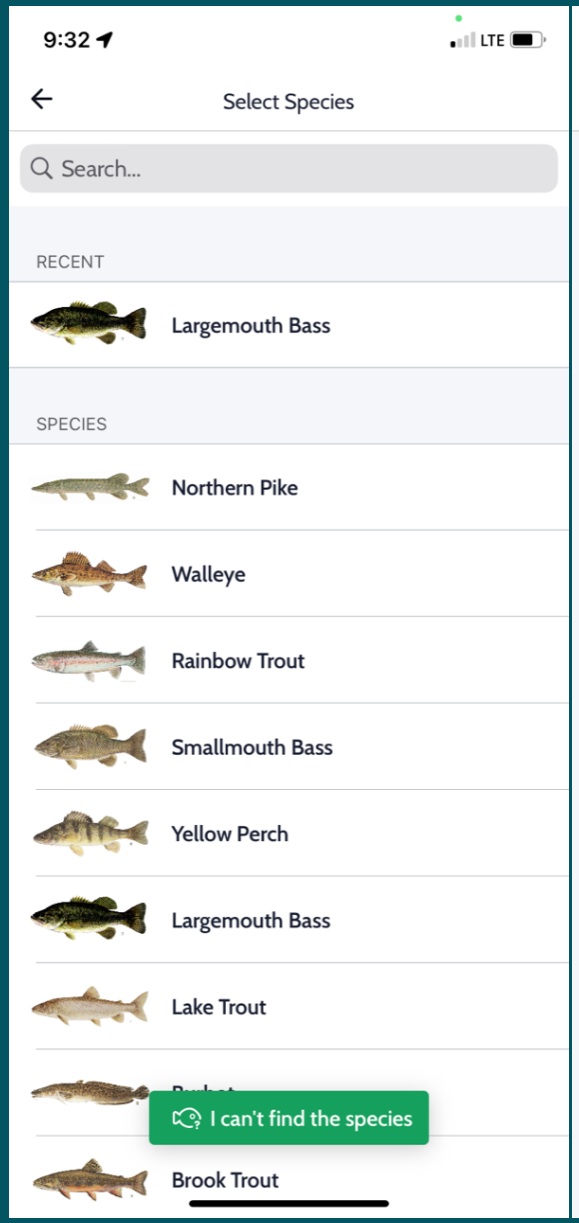
1	Lucas Carter	24 in
2	Mack Ray	21.8 in
3	Jeff Little	21.5 in
4	VerDon Nelson Nelson	20.5 in
5	Joseph Beason	20.2 in

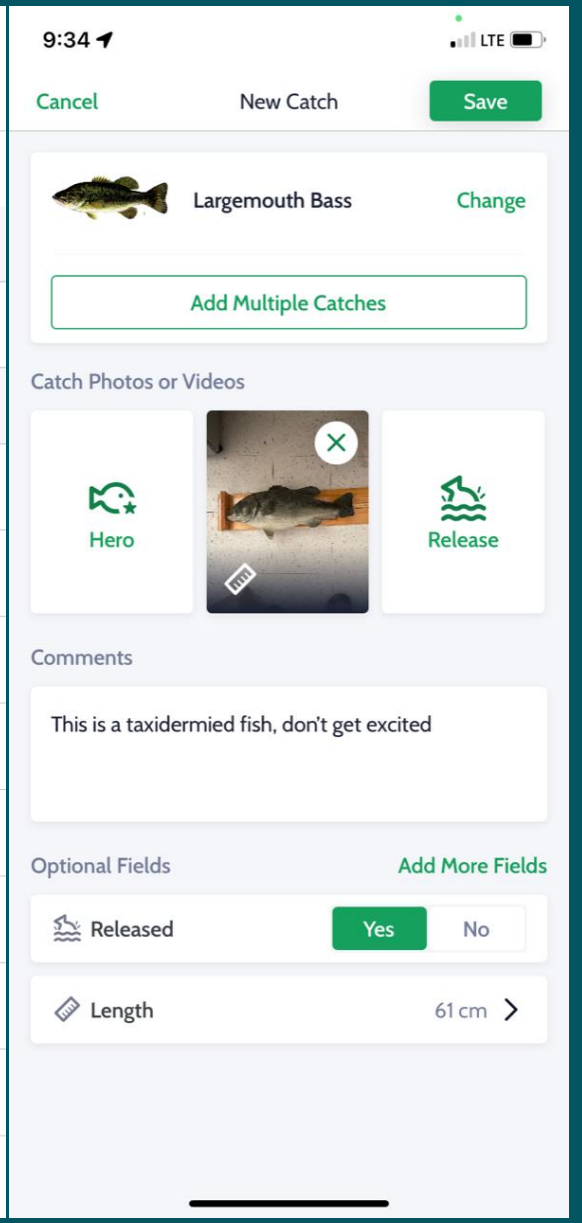
View Full Leaderboard

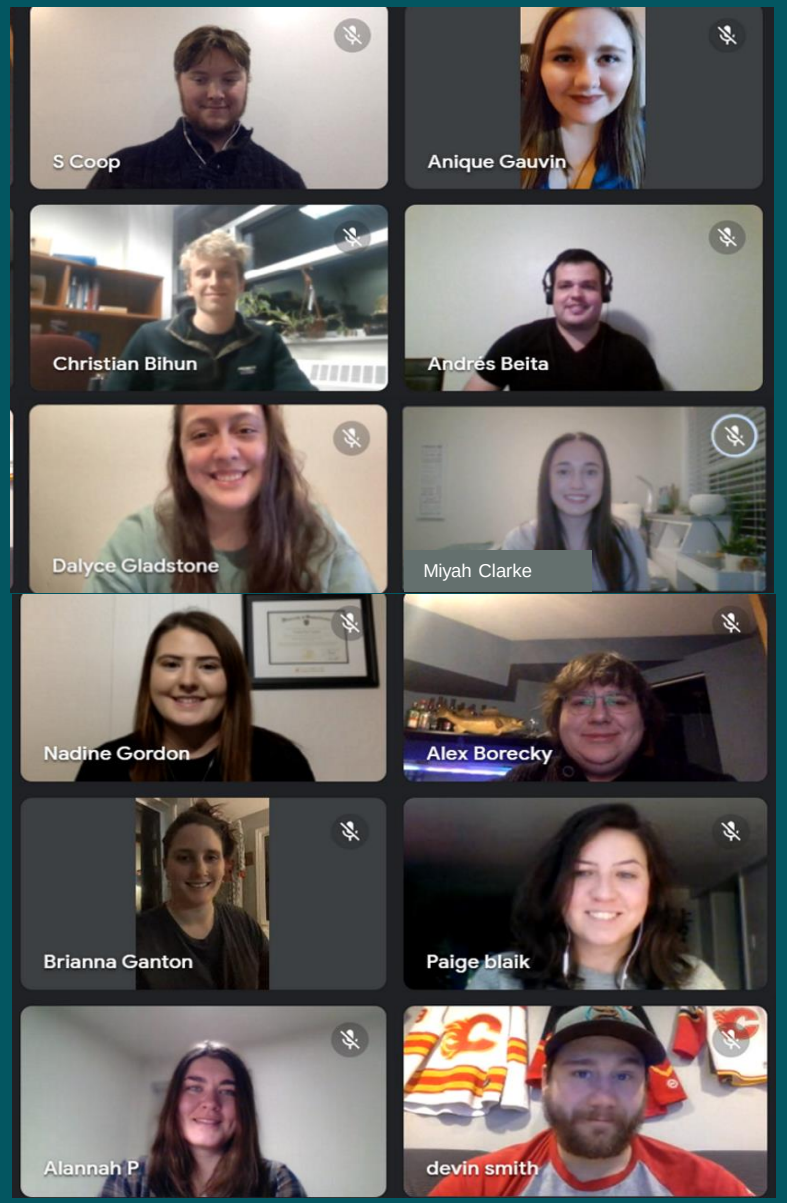


Methods: Submitting an entry to the Catch Team









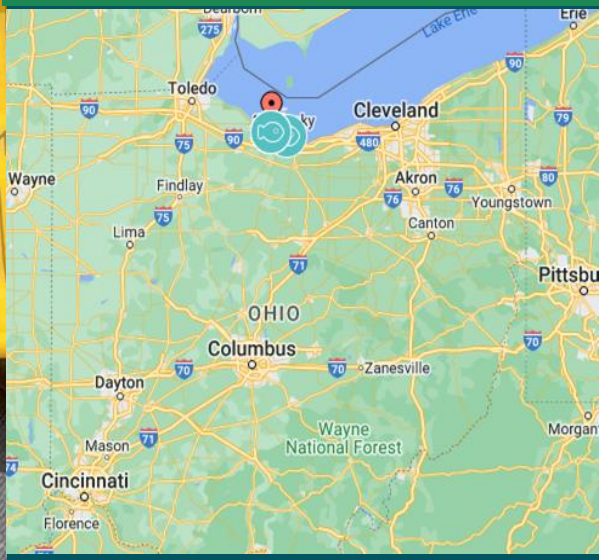
What an ideal submission looks like

WATERBODY: LAKE ERIE, OH

OCTOBER 1, 1:38 PM (EDT)

REVIEW COMMENTS:

- *Blotches are visible in both the measurement and hero photos*
- *TEXTBOOK EXAMPLE.*

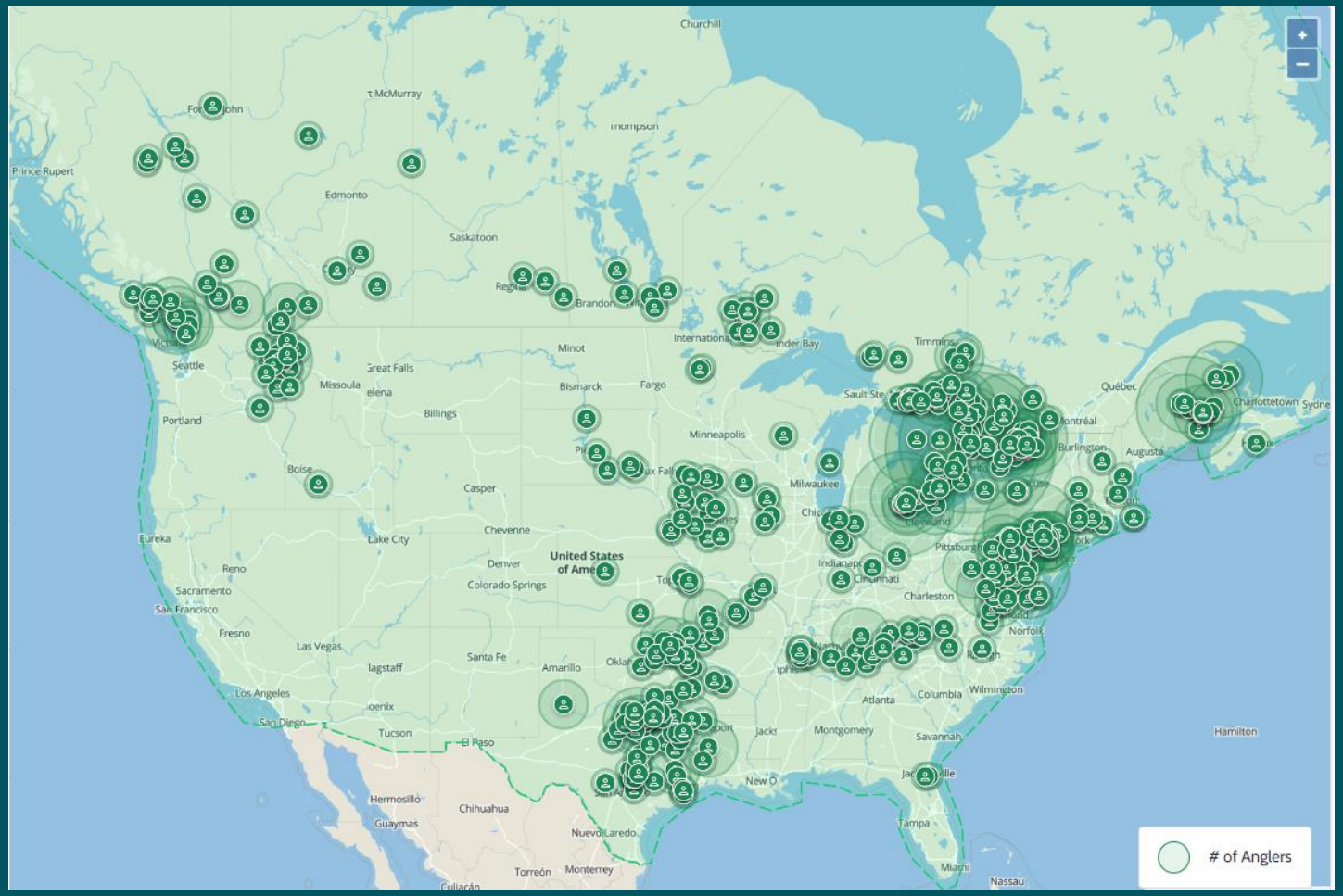


USGS

MyCatch by Angler's Atlas

2023 Blotchy Bass Bonanza at end of event

- Participants:
  - 311 anglers reported at least one trip so far
- Trips:
  - 1789 trips reported
  - 425 trips had zero fish caught
- Fish:
  - 5,946 fish reported
  - 3,552 black bass reported
  - 6069 angler hours contributed
    - Bass CPUE 0.59 fish/hour
      Overall CPUE 0.98 fish/hour
  - 252 confirmed signs of BBS
  - Overall BBS prevalence = 7.1%



Provisional Data

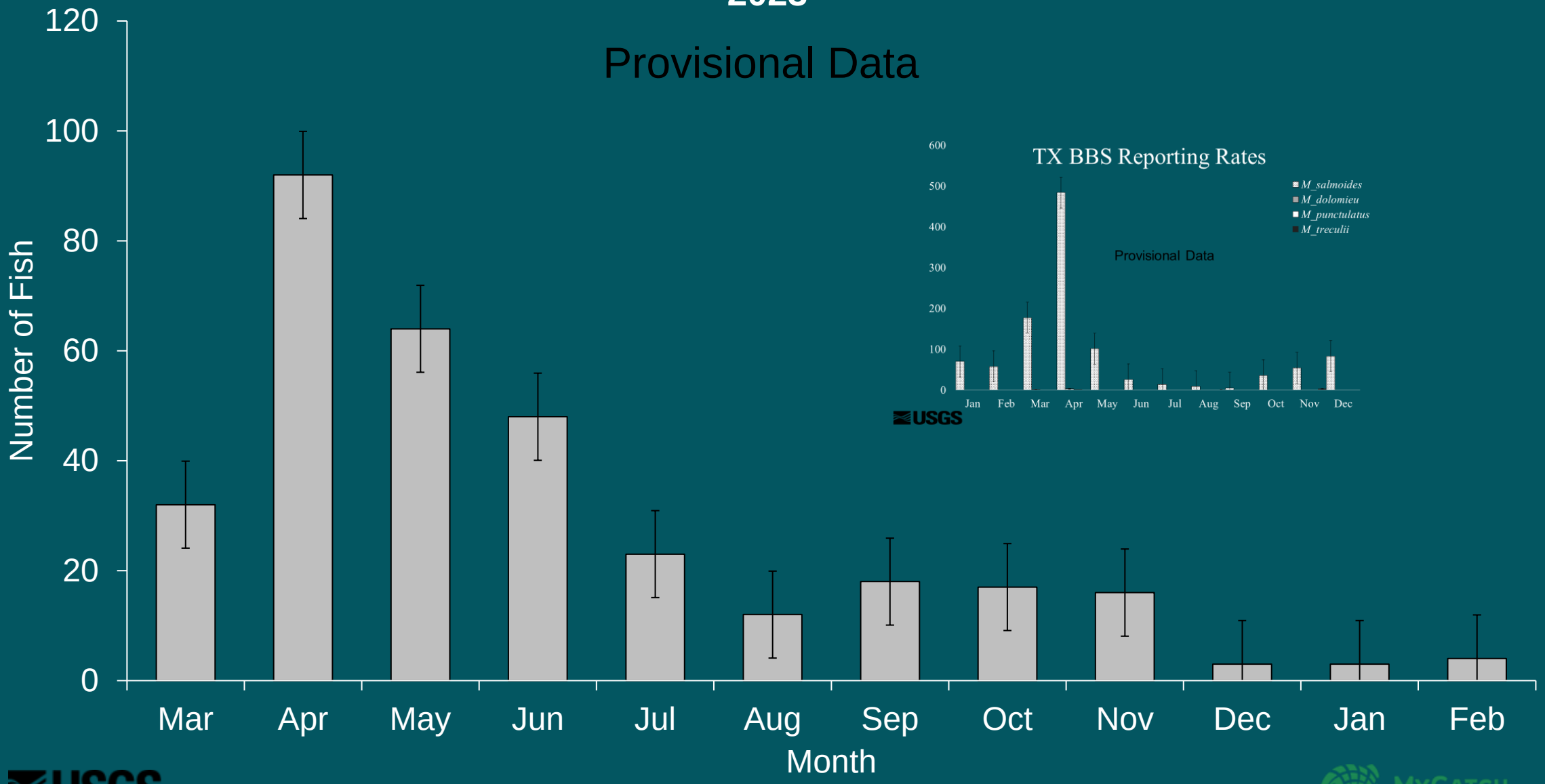
USGS

MyCatch by Angler's Atlas

MyCatch BBS Reports by Month

2023

Provisional Data

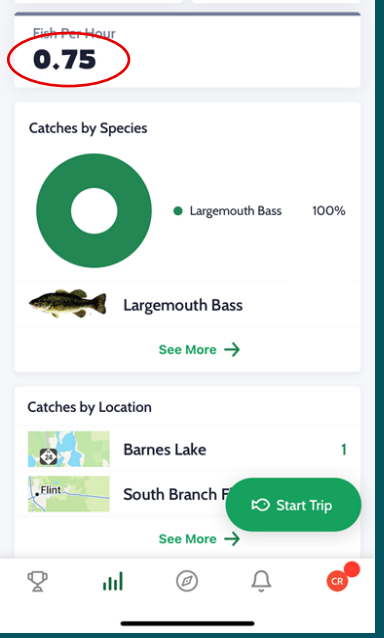


TEXAS PARKS & WILDLIFE

USGS science for a changing world

MyCatch by Angler's Atlas

Let's get Transitive!



Overall black bass CPUE 0.58 Fish per hour

- 7,825 total black bass caught in 12,891 hours
- 4.7% BBS prevalence (composite specific to this effort)

TPWD Citizen Science BBS project yielded 1016 additional BBS

- Applying the Angler's Atlas CPUE

→ 22,915 angled bass or ~39,508 angling hours

Convert to state personnel time

- 39,508 hours x median state F&G pay rate ($29.20hr)
  - $1,153,652 in added value (real cost ~$68,000)

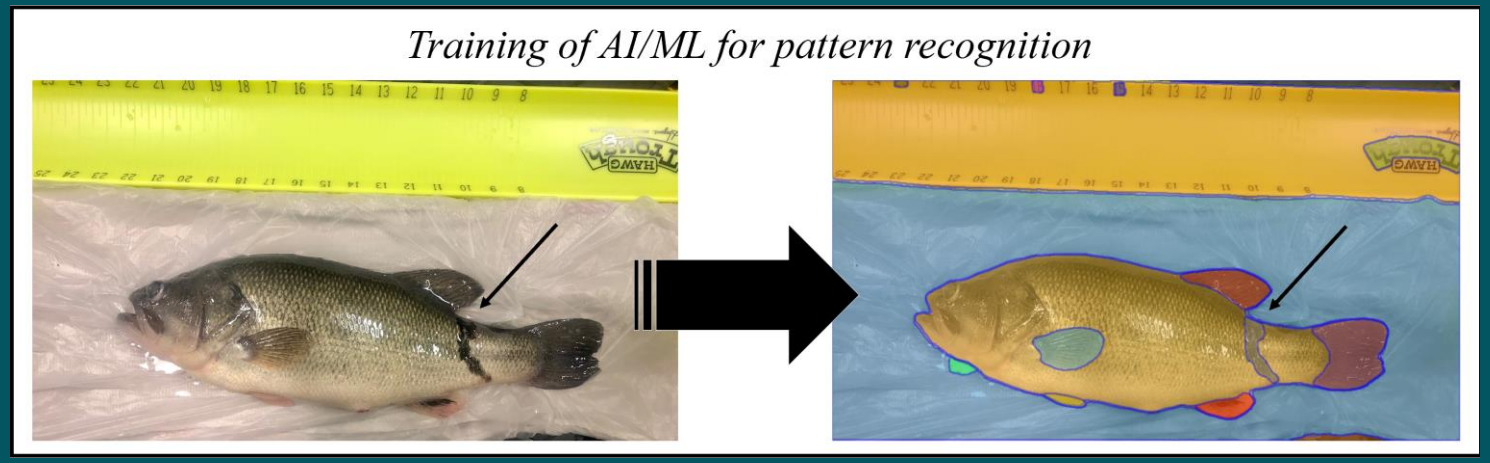
+(12,891* 29.2=$376,417.20) from the Blotchy Bass Bonanza

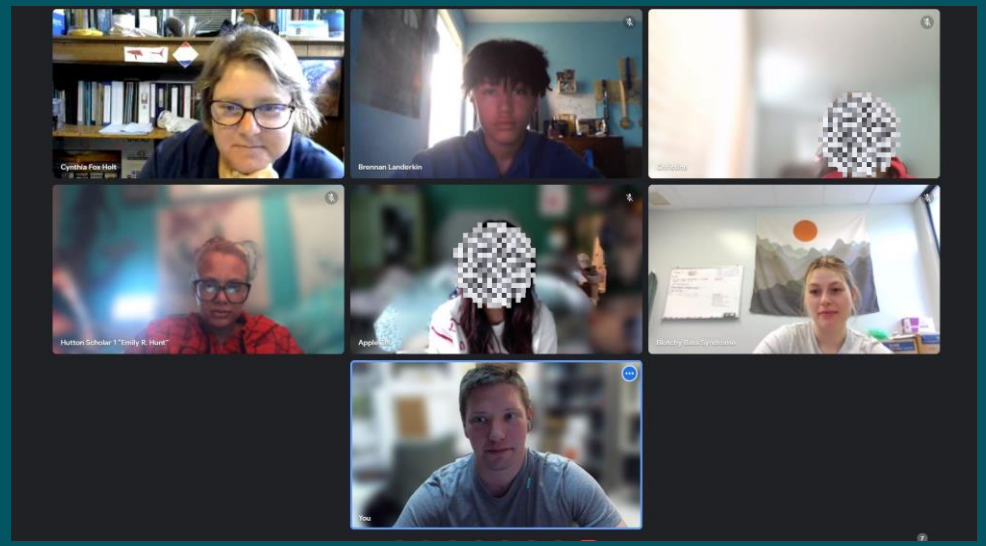
$1.53 Million in total added value! Provisional Data

USGS

MyCatch by Angler's Atlas

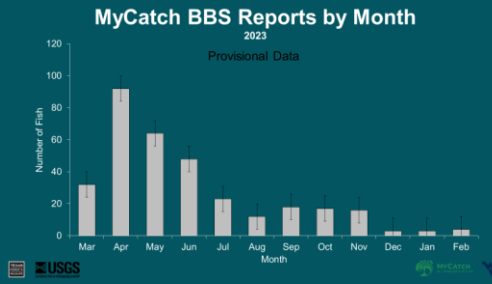
Quantifying Macroscopic Lesions





USGS

Visible Blotch Percent Coverage



Provisional Data

M_salmoides

M_dolomieu

M_punctulatus

0.07

0.06

0.05

0.04

0.03

0.02

0.01

0

Mar

Apr

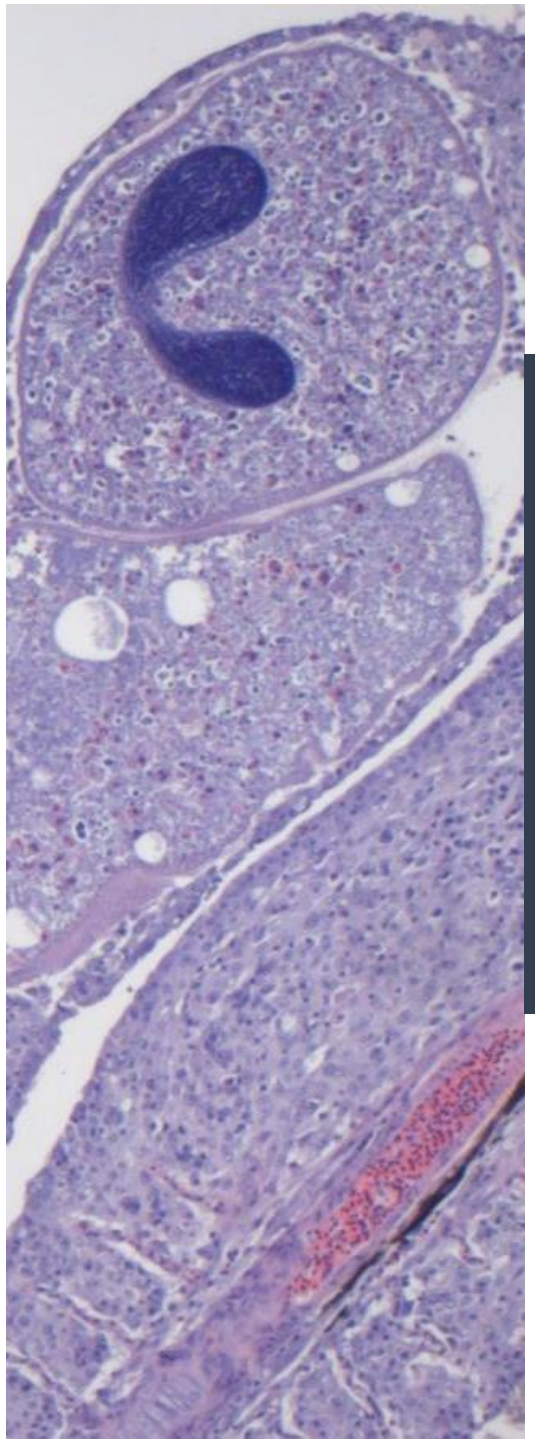
May

Jun

Jul

USGS

MyCatch
BY ANGLER'S ATLAS



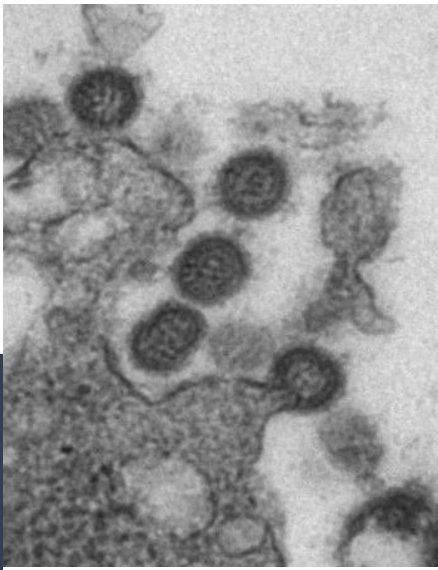
AquaDePTH: Aquatic Disease and Pathogen Repository
A New Public Resource

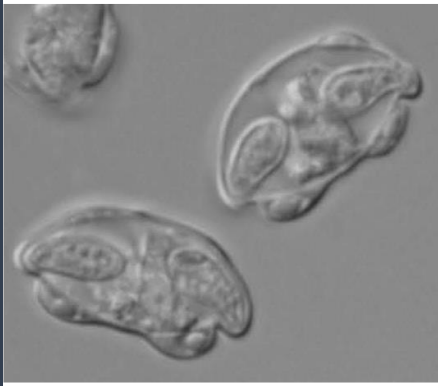
Wes Daniel and Matthew Neilson
USGS Wetland and Aquatic Research Center, Gainesville, FL

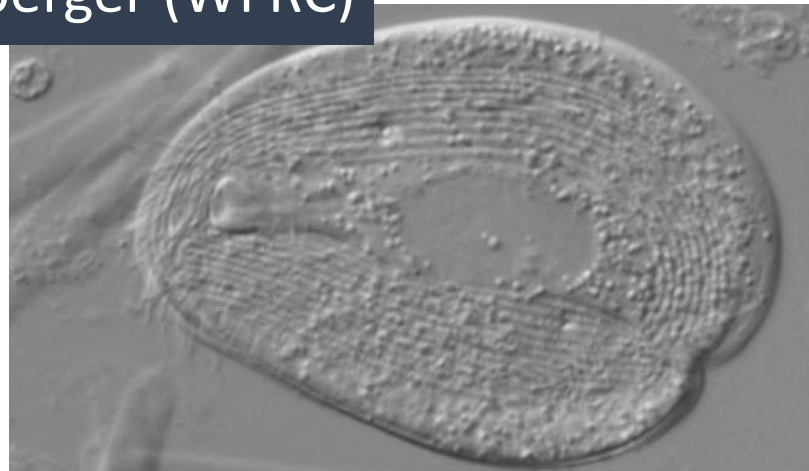
Jan Lovy
USGS Western Fisheries Research Center, Seattle WA

***Clay Raines**
USGS Eastern Ecological Science Center, WV

Collab: Maureen Purcell (FRESC) & Paul Hershberger (WFRC)







AquaDePTH goals

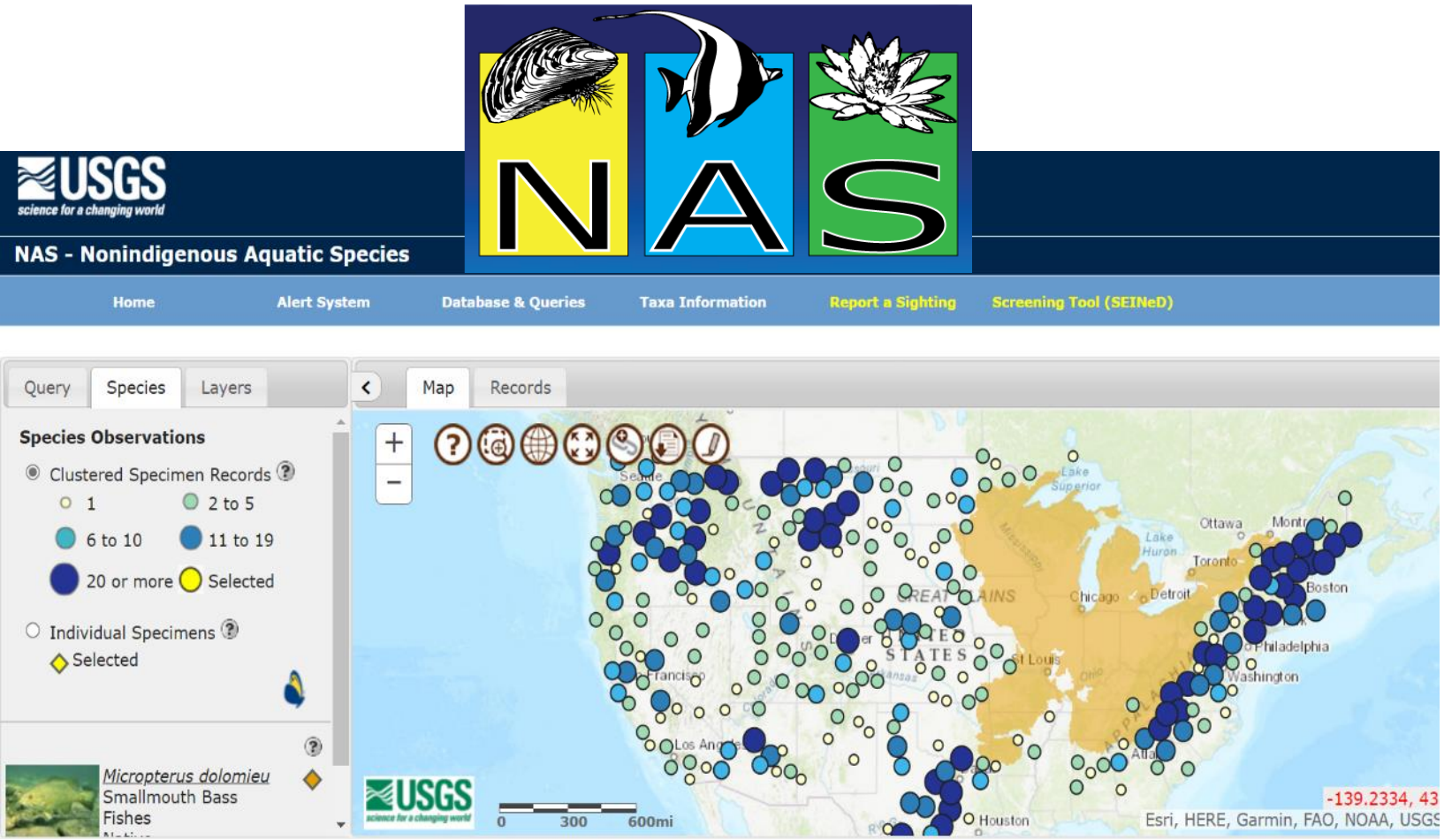
- A repository to help monitor spatial and temporal aquatic animal health trends
  - Tracking detections of aquatic pathogens
  - Tracking mortality data
  - Monitor for trends over time- climate change
- Curate aquatic animal health data in a single common source for aquatic animal health professionals, researchers, and the public
  - USGS and other federal agencies
  - Tribal, state, and provincial agencies
  - Academic institutions
- Interoperability with other relevant databases
  - USFWS National Wild Fish Health Survey
  - USGS WHISPers (wildlife disease database)

Data from a variety of aquatic hosts

- Data from a variety of aquatic host species
- Early data sets and efforts are on finfish
- Including past data (reports and publications) and new data
- Include other species as needed
  - Corals, freshwater mussels...

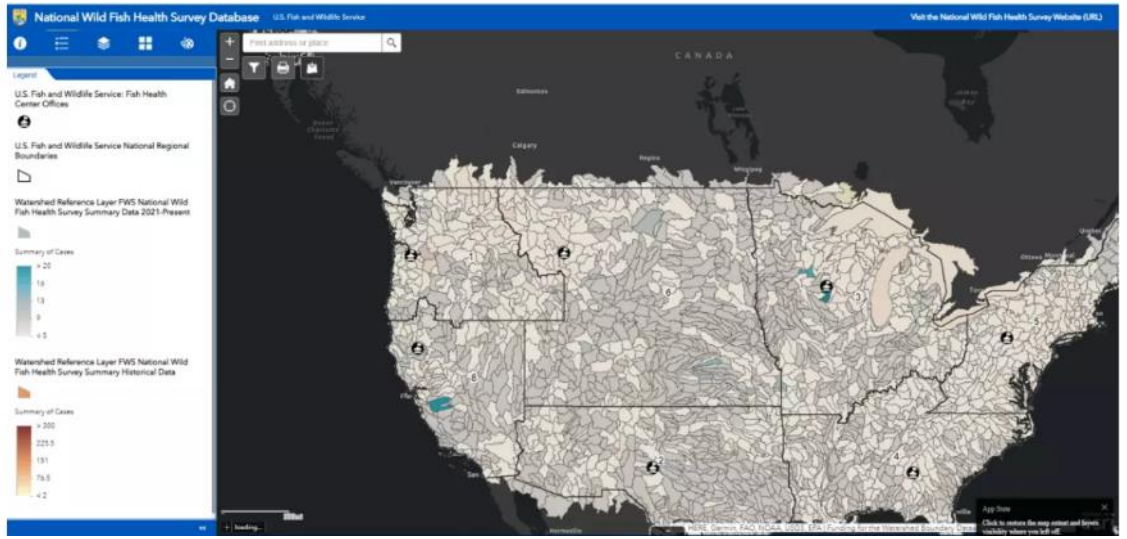
Photo Credits: McDowell and Sousa (Frontiers 2019); Steve Fradkin, National Park Service

AquaDePTH to be built on NAS platform



- Trusted partners to Federal, State, Regional and Tribal fisheries managers responsible for aquatic animal health and aquatic invasive species
- NAS is flexible, transparent, accessible and valued
- Watershed resolution and meaningful search filters to explore aquatic connectivity
- NAS upgrades in progress
- Actionable tools to track and predict aquatic transmission pathways
- Threat of aquatic invasive species and pathogens may not be mutually exclusive

Interoperable with other databases



- Overlay data with existing resources
  - USFWS National Wild Fish Health Survey
  - WHISPers USGS wildlife health protal
- Inclusive of diverse aquatic species

USGS
science for a changing world

AquaDePTH: Timeline

FY22

Building advisory group to inform database development for the duration of the project

FY24

Develop required elements including public landing page and dashboard

FY26

Finalize database and public launch

Preliminary Information-Subject to Revision. Not for Citation or Distribution.

Photo Credit: Theresa Liedtke USGS

Questions???