Artificial Intelligence and Machine Learning Innovation in Fisheries and Protected Species Monitoring in the Gulf of Mexico

NOAA Fisheries Service (NMFS)
Galveston, Texas

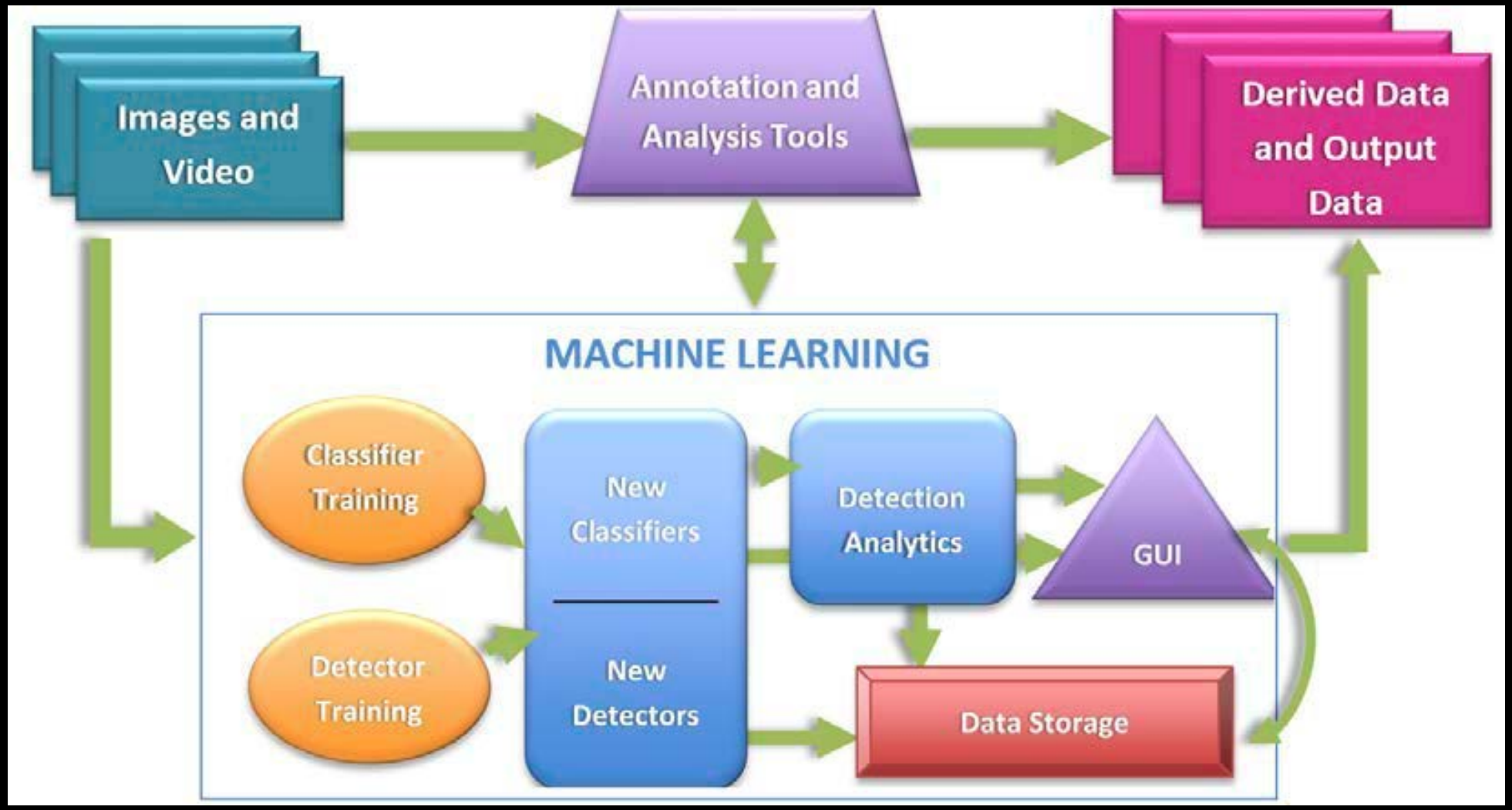
Artificial Intelligence and Machine Learning in Fisheries and Protected Species Management

- Artificial Intelligence (AI):
  - *using computer systems to perform tasks that normally require human intelligence (Everyday: Siri, Tesla, Netflix, Nest, Drones, Facebook)*
- Machine Learning (ML):
  - *application of AI that provides systems the ability to automatically learn and improve from experience without being explicitly programmed*
- There is an increasing need for industry and marine researchers to build collaborative partnerships to optimize AI/ML capacity for multiple uses
- These projects build upon previous developments made by the Alaska Fisheries Science Center (AFSC) and the Southeast Fisheries Science Center (SEFSC)

Artificial Intelligence and Machine Learning in Fisheries and Protected Species Management

- These projects focus on the application of a newly released open-source Video and Image Analytics for Marine Environments (VIAME) toolbox, a tool used widely in ML analytics for automated object detection, tracking, and classification of marine species
- VIAME was initially applied to underwater fisheries surveys to improve the effectiveness and quality of abundance indices for stock assessments
- VIAME's computer vision library and ML algorithms streamlined the processing of still photos and video imagery data, resulting in up to 75% cost-savings for some survey programs

Artificial Intelligence and Machine Learning in Fisheries and Protected Species Management



Artificial Intelligence and Machine Learning in Fisheries and Protected Species Management

- **V**ideo and **I**mage **A**nalytics for **M**arine **E**nvironments (VIAME)
- In cooperation with NOAA's Automated Image Analysis Strategic Initiative (AIASI), Kitware and it's partners have developed VIAME, an open-source system for analysis of video and imagery for fisheries stock assessment and a variety of other applications.

- https://youtu.be/y3G19ltgaiU

Artificial Intelligence and Machine Learning in Fisheries and Protected Species Management

Use of AI/ML to Reduce Protected Species and Large or Rare Bycatch in Commercial Fisheries in the Gulf of Mexico

Use of AI/ML to Reduce Protected Species and Large or Rare Bycatch in Commercial Fisheries in the Gulf of Mexico

- The Gulf Mexico (GOM) shrimp fishery is one of the Nation's most economically valuable fisheries.

- NMFS Shrimp and Reef Fish Observer Programs provide bycatch data that are critical to both the Gulf of Mexico Fishery Management Council (Council) and NMFS in performing annual assessments of target and bycatch species, including undersize target species and protected species.

- Preliminary testing on contracted commercial shrimp trawl vessels in the GOM found that electronic monitoring (EM) performed well in capturing video for more than 109 hauls. The hardware held up for the duration of the trips with no water ingress to the deck components. Through further testing of this system in 2017, EM reviewers documented catch of a loggerhead sea turtle, guitarfish, angel shark, black tip shark, red snapper, mutton snapper, rock shrimp, toadfish, filefish and spiny lobsters.

Use of AI/ML to Reduce Protected Species and Large or Rare Bycatch in Commercial Fisheries in the Gulf of Mexico

- Current shrimp observer coverage rate is low (2% of the annual commercial effort)
- Bycatch estimates of rare events (e.g., protected species interactions) require large sample sizes
    - *For example, sample size estimates required for an observed sawfish with a coefficient of variation (CV)=0.3 were calculated at 11,380 tow hours / year*
- Applying the current average cost per sea day, results in a prohibitive cost of about $1,000,000 to increase observer coverage in the eastern GOM alone
- In light of the costs associated with observer coverage and given the rare event takes, increasing observer coverage to refine take estimates is not practical
- Using ML tools in conjunction with Electronic Monitoring (EM) provides a valid alternative if the goal of increased observer coverage is strictly to monitor the interactions with large bycatch and rare events

US Gulf of Mexico Shrimp and Menhaden Observer Programs

US Gulf of Mexico Shrimp and Menhaden Observer Programs

- Objective: Collaborate with SEFSC to research, deploy, and evolve innovative AI and ML electronic monitoring solutions to the US GOM Shrimp and Menhaden fisheries. These systems would:
  - Document rare and protected species interactions
  - Improve bycatch volume and composition estimation
- In May 2011, SEFSC implemented federal observer coverage for the GOM menhaden fishery during one season to characterize fishery bycatch
  - Prior to this observer pilot effort, limited data existed with no established federal observer program
  - The pilot observer study completed fifty-four sea days documenting rare (three) marine mammal and (two) turtle interactions

US Gulf of Mexico Shrimp and Menhaden Observer Programs

Phase 1: Develop and deploy camera and housing systems

- Develop compact catch imaging environment (sorting or conveying chute/housing)
- Deploy imaging systems to shrimp & menhaden vessels
- Develop image management data systems

Phase 2: Annotate imagery and train detector

- Develop or enhance image annotation software as necessary
- Annotate Phase 1 image data
- Train models to detect menhaden and shrimp
- Tune image data collection systems

US Gulf of Mexico Shrimp Effort Data Collection Program

- Objective: Collaborate with SEFSC to research, develop, deploy, and evolve innovative effort data collection solutions
- The Cellular Electronic Logbook (cELB) Program provides data on Gulf shrimp fishing effort that is critical to the Council and NMFS in performing annual assessments
- The cELB program is a key component in the Council's red snapper rebuilding plan because accurate estimates of juvenile red snapper mortality attributable to the shrimp fishery are essential to the plan

US Gulf of Mexico Shrimp Effort Data Collection Program

- Selected vessels (currently 605 federal permit holders) must carry a cELB, which is a time-stamped global positioning system (GPS) unit that records and stores a vessel's location at 10-minute intervals
- When the vessel is within non-roaming cellular range, the data are transmitted to NOAA National Centers for Environnemental Information (NCEI) servers
- From these time-stamped locations, vessel speed can be estimated and used to determine vessel activity (i.e., stopped, towing, moving between towing points)
- Thus, fishing effort by location can be calculated for a given trip
- Shrimp catch data for the trip are then used to estimate catch-per-unit-effort (CPUE) for the trip at various fishing locations

US Gulf of Mexico Shrimp Effort Data Collection Program

- Current 3G cellular service is being replaced by 4G; current cELBs will need to be replaced. Possible alternatives:
  - Upgrade cELB to a 4G compatible device
  - Convert to commercial off-the-shelf Automatic Identification System (AIS) or Vessel Monitoring (VMS) devices

US Gulf of Mexico Shrimp Effort Data Collection Program

Phase 1: Develop, test and deploy a modernized cELB instrument

- Purchase, program, and deploy modernized cELBs (4G / AIS / VMS)

Phase 2: Modernize and enhance system security features and research alternatives

- Security review of database—work with SEFSC to address deficiencies
- Validate fishing effort calculation
- Modernize web application
- Research alternatives such as AIS and VMS

US Gulf of Mexico Shrimp Effort Data Collection Program

Automatic Identification System (AIS) Overview:

- Shipboard AIS transceivers automatically broadcast information, such as position, speed, and course, at regular intervals via a VHF transmitter
- Information, such as the vessel name and VHF call sign, is programmed when installing the equipment and is also transmitted regularly
- The signals are received by AIS transceivers fitted on other ships or on land based systems
- The original purpose of AIS was solely collision avoidance but many other applications have since developed

US Gulf of Mexico Shrimp Effort Data Collection Program

- AIS integration and testing work:
  - Compare AIS & cELB data to determine if AIS data could be used to calculate effort
  - Notify Council of conversion to AIS
  - Prepare a report of the comparison

- Comparison of 3G / 4G data
  - Similar to AIS comparison—compare the 3G and 4G data on dual equipped vessels to validate 4G system

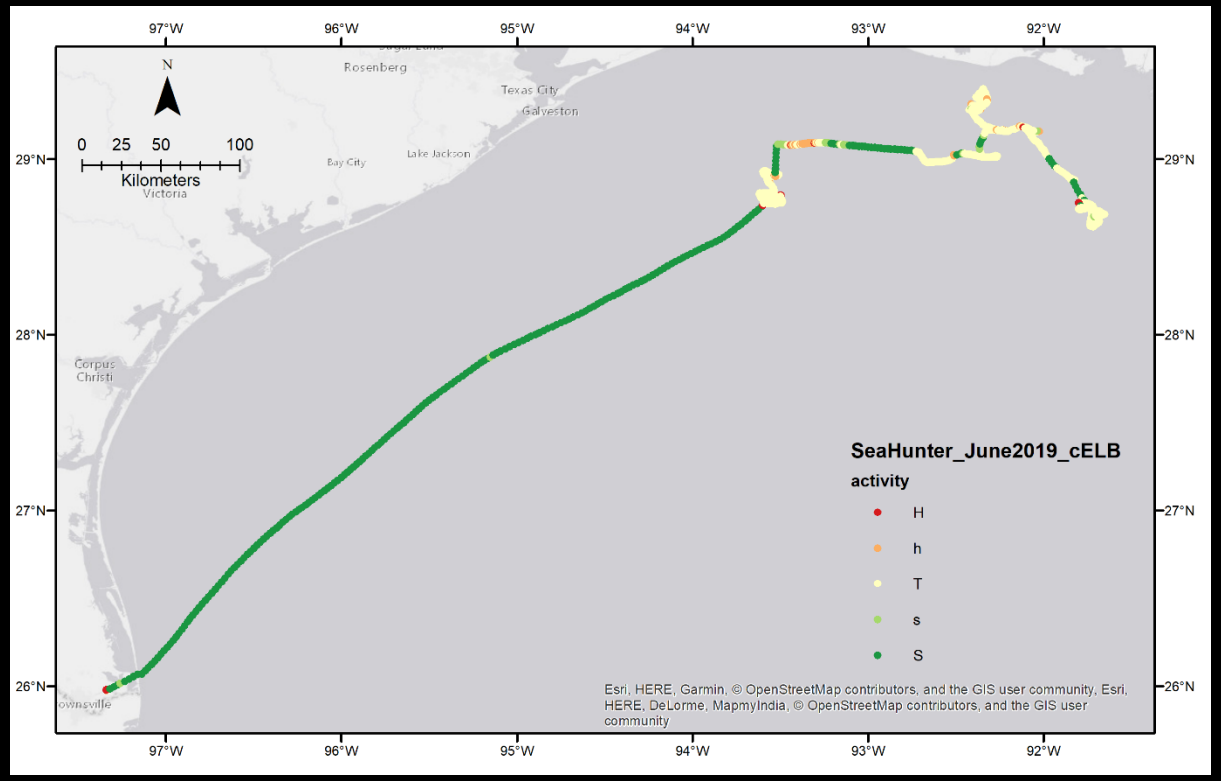
3G cELB

AIS

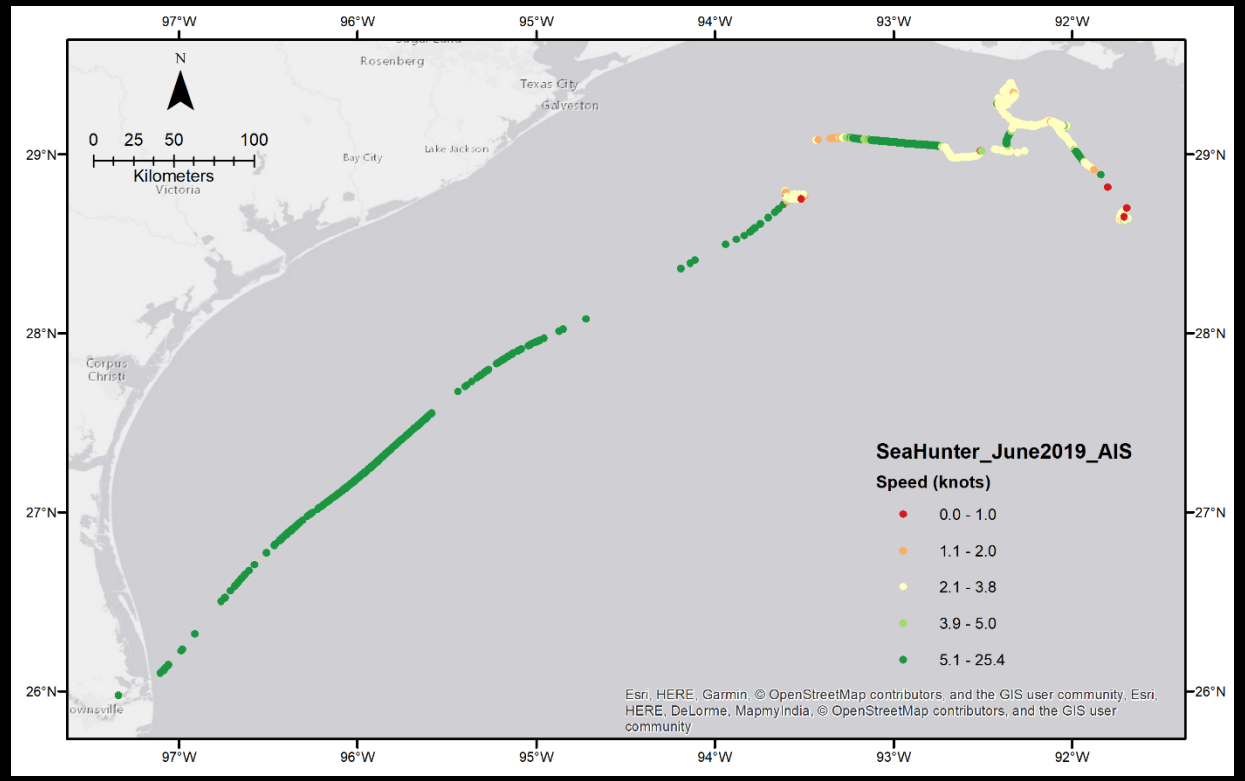
4G cELB

US Gulf of Mexico Shrimp Effort Data Collection Program

cELB

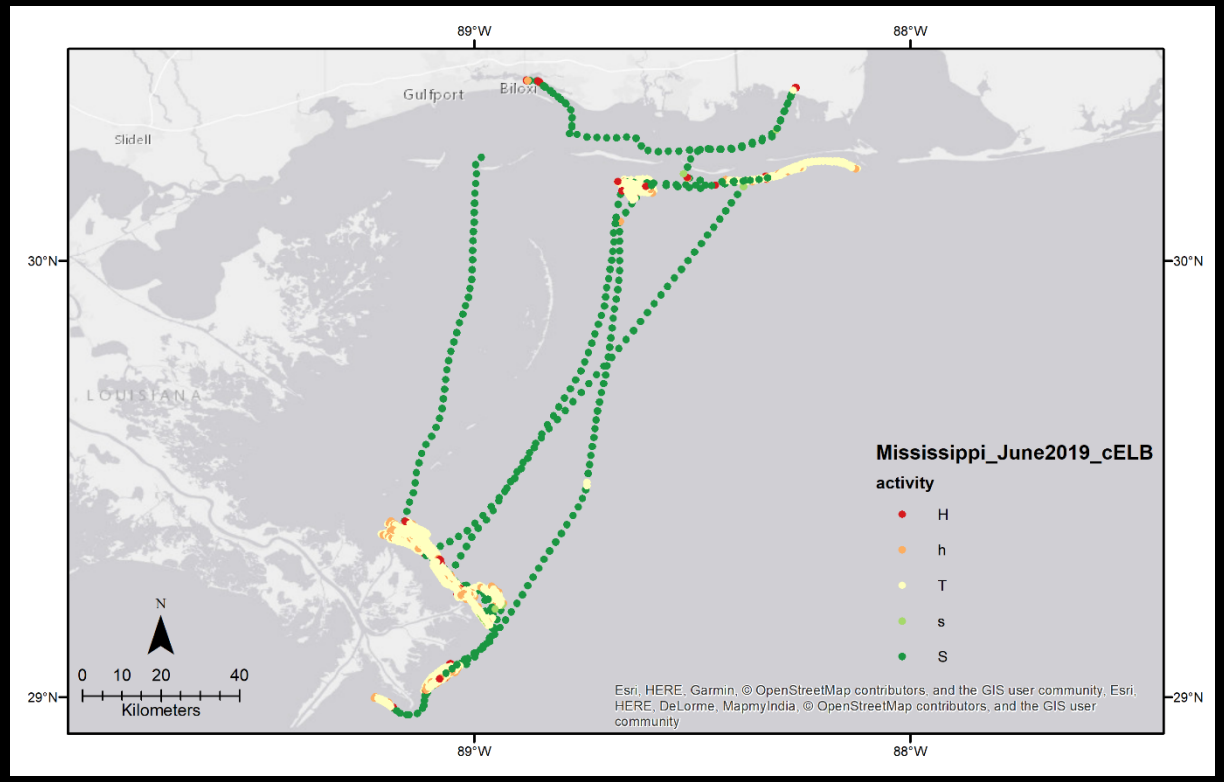


AIS

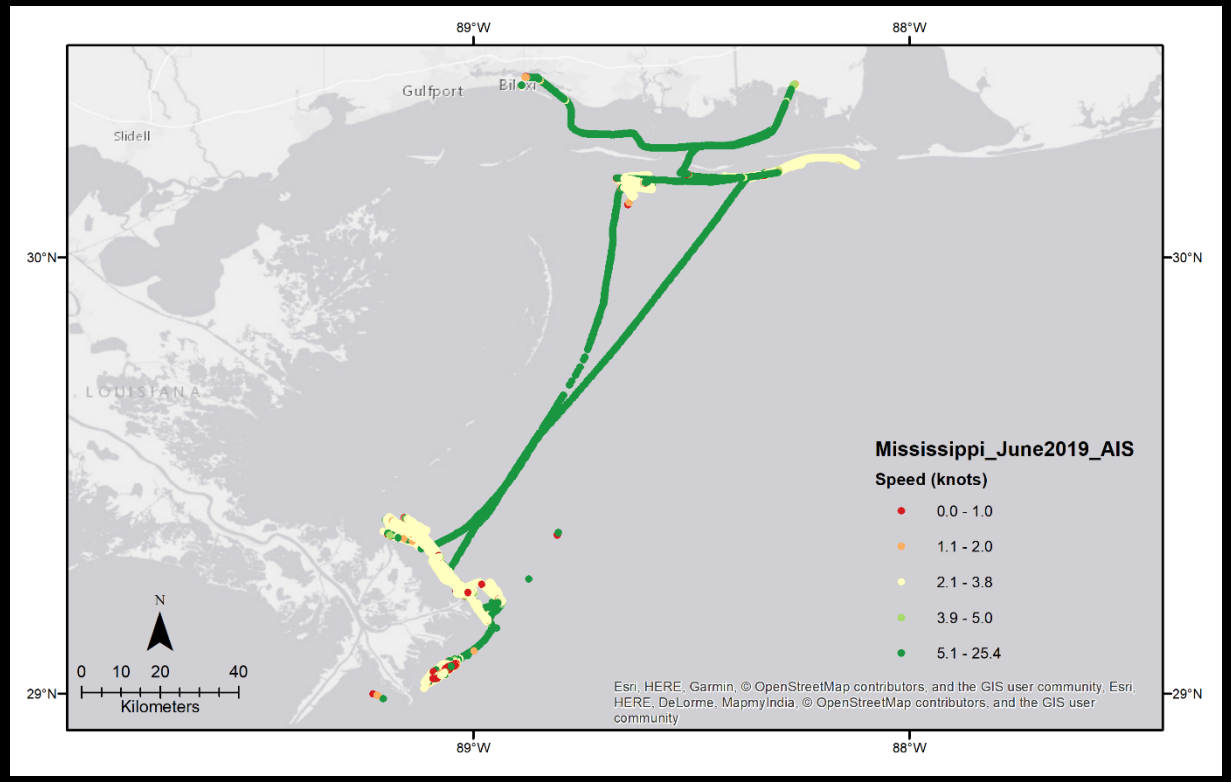


US Gulf of Mexico Shrimp Effort Data Collection Program

cELB



AIS



US Gulf of Mexico Platform Removal Observer Program (PROP) Sea Turtle & Marine Mammal AI/ML Innovation Program

- Explosives are frequently utilized in the salvage and removal of offshore oil and gas platforms in the US GOM

US Gulf of Mexico Platform Removal Observer Program (PROP) Sea Turtle & Marine Mammal AI/ML Innovation Program

- To minimize explosive impacts to protected and endangered sea turtles and marine mammals, observers perform visual surveys from vessels and helicopters to detect the presence of these species inside the impact zone around the platform

US Gulf of Mexico Platform Removal Observer Program (PROP) Sea Turtle & Marine Mammal AI/ML Innovation Program

- This project will:
  - Develop AI software programs to identify these target species
  - Develop systems to conduct real-time automated surveys
  - Compare the effectiveness of the AI system at detecting these species compared with that of human observers
- Potential advantages include:
  - Reduction in long term costs by using Unmanned Autonomous Vehicles (UAVs, drones) equipped with video cameras instead of more expensive helicopters
  - Increased safety resulting from reducing risk associated with human exposure time in helicopters

US Gulf of Mexico Platform Removal Observer Program (PROP) Sea Turtle & Marine Mammal AI/ML Innovation Program

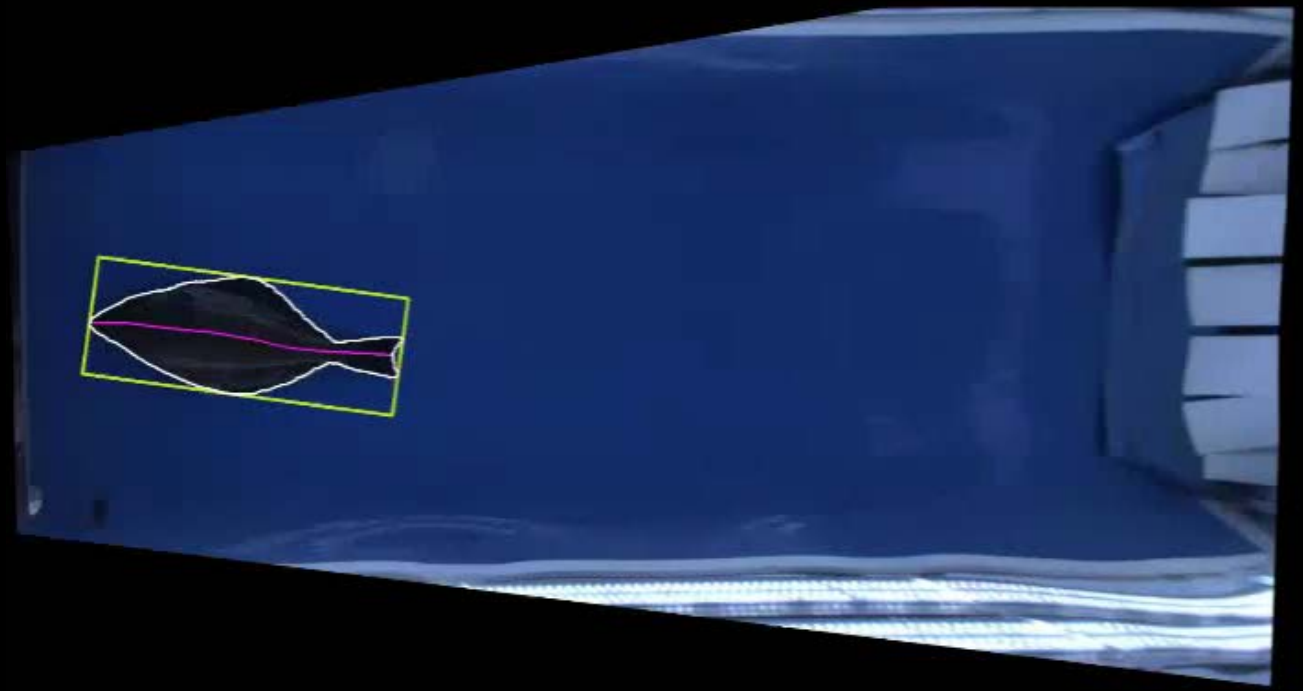
Phase 1: Construct image library (photos & videos) of target marine species

- Mine existing data sets and internet for sea turtle and marine mammal images
- Purchase and deploy video cameras at offshore platforms to autonomously collect images of target species
- PROP observers collect additional images during surveys performed at explosive removal of platforms

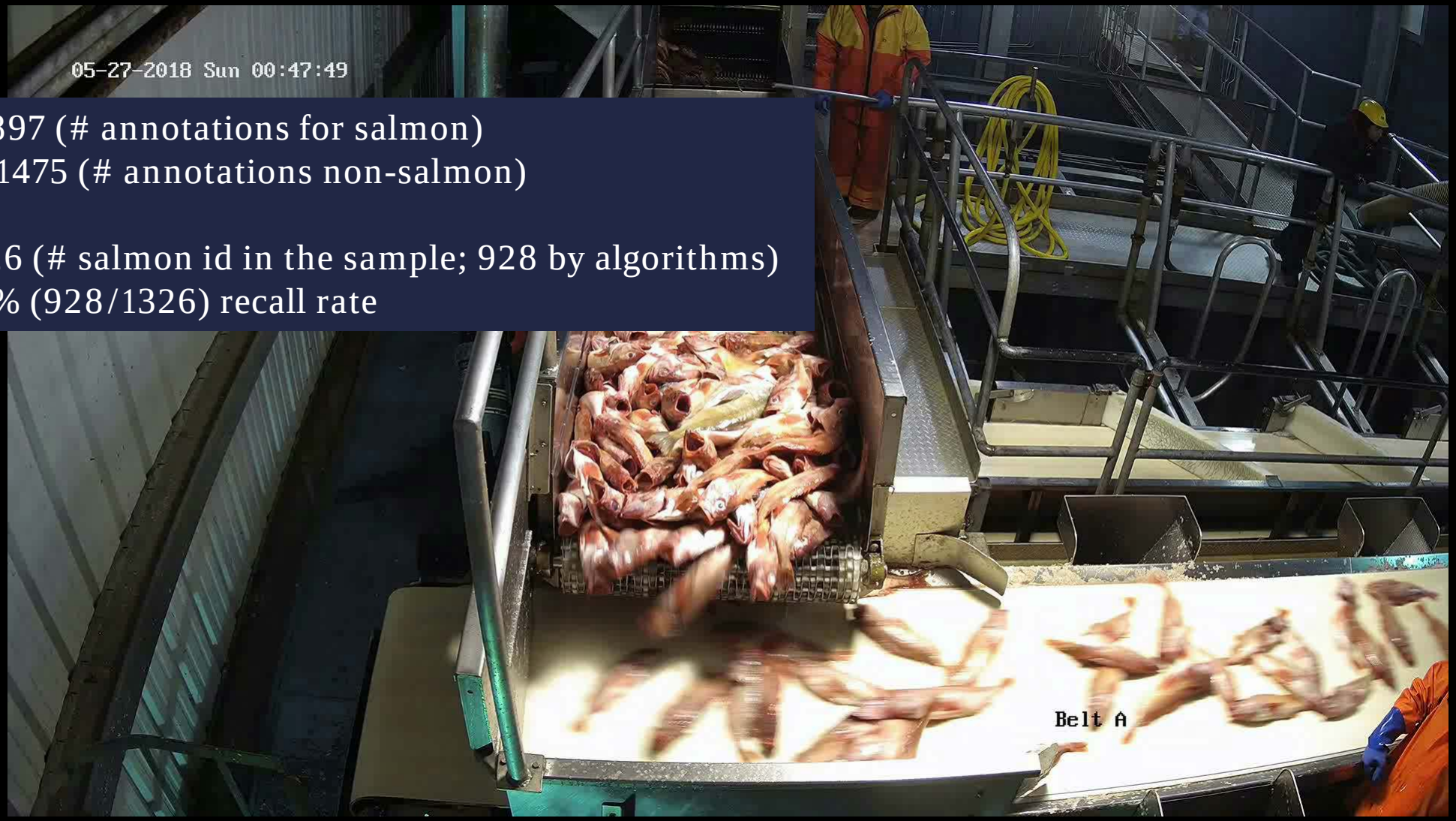
Phase 2: Develop detector system

- Test/evaluate capability of AI software to detect /identify target species
- Adjust algorithms as needed
- Using images collected from UAV (unmanned aerial vehicle) equipped with mounted camera, evaluate and compare target detection efficiency of AI to human observers conducting surveys in helicopters

Easy Example of Automation to expedited release of halibut



Increased complexity : PSC Monitoring



Training: 5897 (# annotations for salmon)
Validation: 1475 (# annotations non-salmon)

Testing: 1326 (# salmon id in the sample; 928 by algorithms)
Recall: ~70% (928/1326) recall rate

Very Complex Longline Vessels Rail - Questions