

Using Underwater Cameras & AI to Count Migrating River Herring

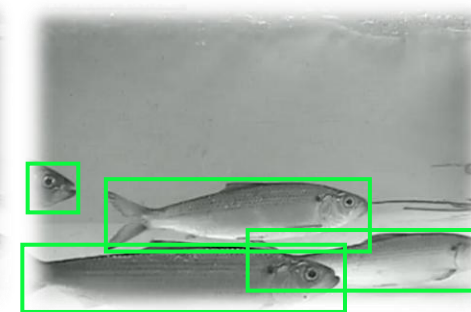
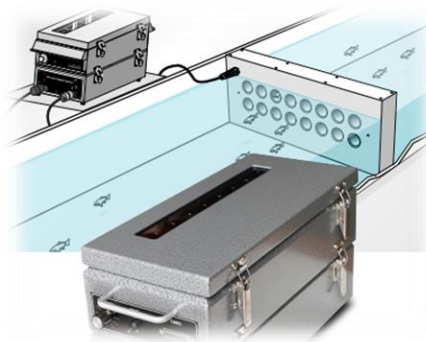
DMF River Herring workshop, New Bedford, MA

Zhongqi Chen

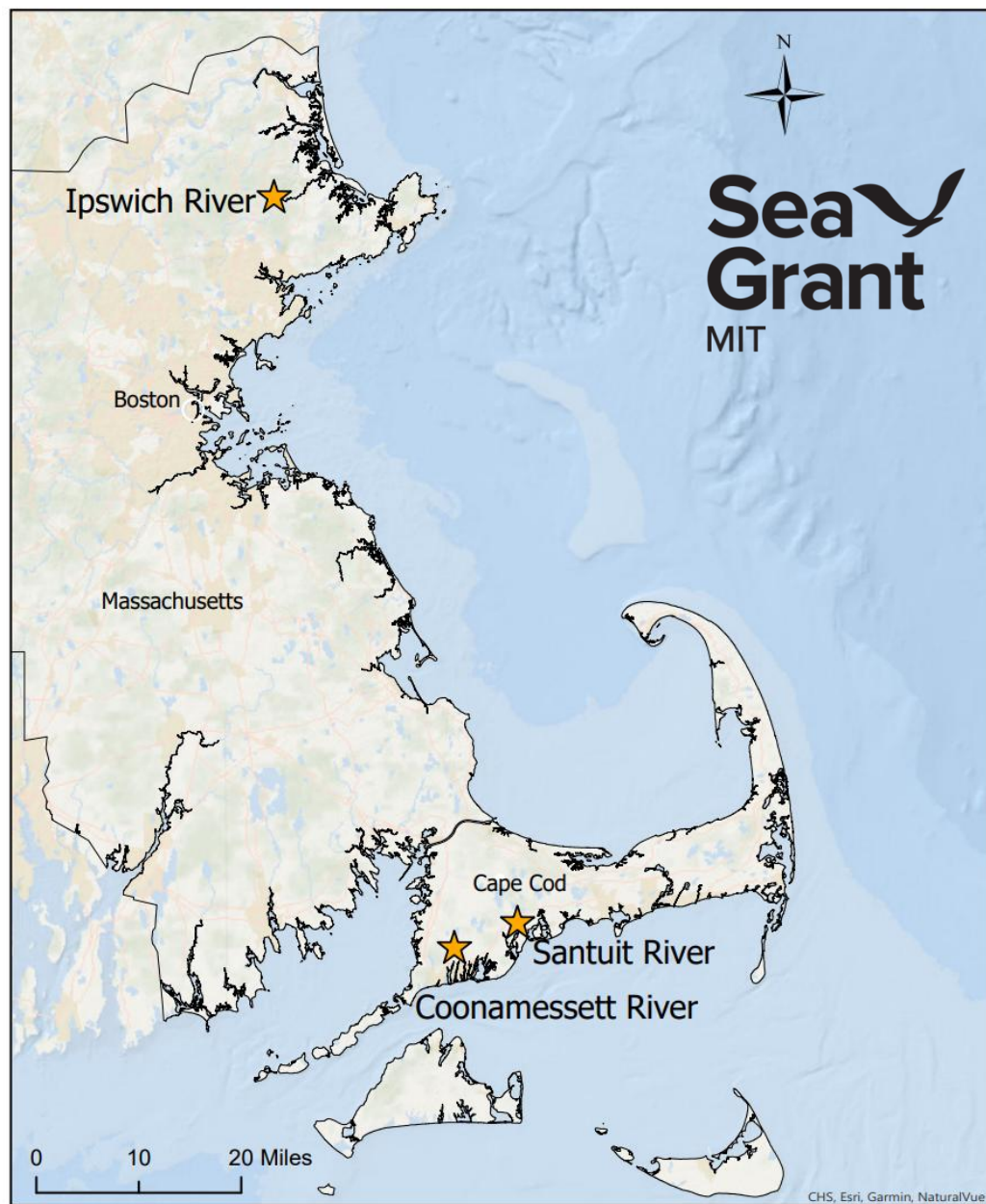
zchen@woodwellclimate.org

Sea
Grant
MIT





	Visual Count 63%	Fish counter 27%	Video 4%	Video with AI
Operate 24/7	✗	✓	✓	✓
Species ID	✓	✗	✓	✓
Data Processing time	short	short	Long	Short
Real-time count	✗	✗	✗	✓
Scalability	Low	n/a	Low	High



AI-Driven Counting of River Herring

Camera system

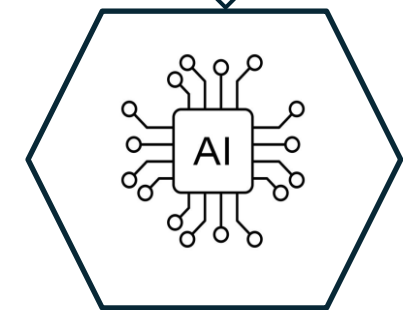


Training Dataset



time	label	count_in	count_out
1160	77.36 in	1	0
1163	77.566 in	2	0
1168	77.896 in	3	0
1174	78.299 in	4	0
4108	274.142 in	5	0
4112	274.407 in	6	0
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4116	274.675 in	8	0
4118	274.806 in	9	0
4119	274.872 in	10	0
4125	275.271 in	11	0
4127	275.404 in	12	0

Fish counting



AI model training



IPSWICH RIVER
WATERSHED ASSOCIATION

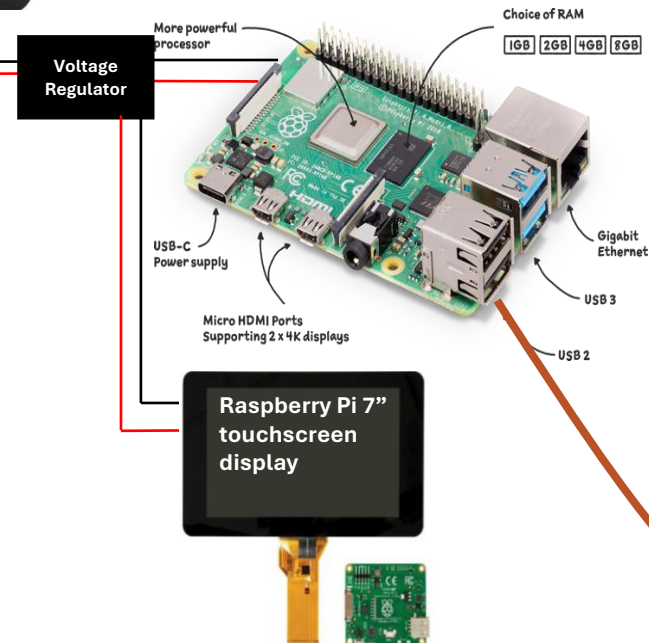
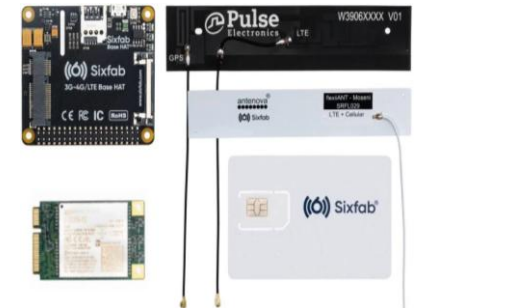




Kevin Bennett
Umass Dartmouth

Video Recording system:

- Compact
- Low power consumption
- Economy
- Scalable



Camera

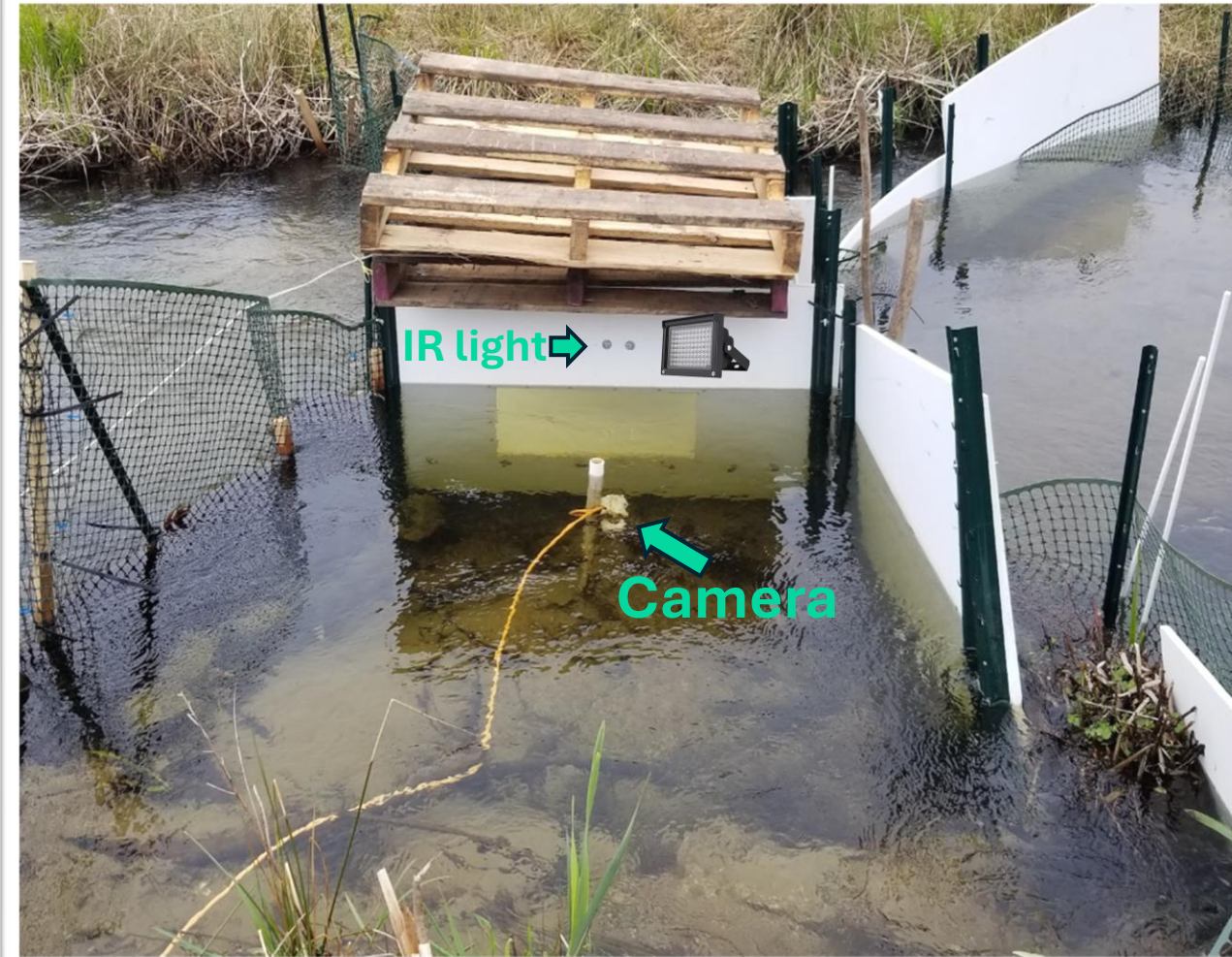


Ipswich River, Ipswich, MA



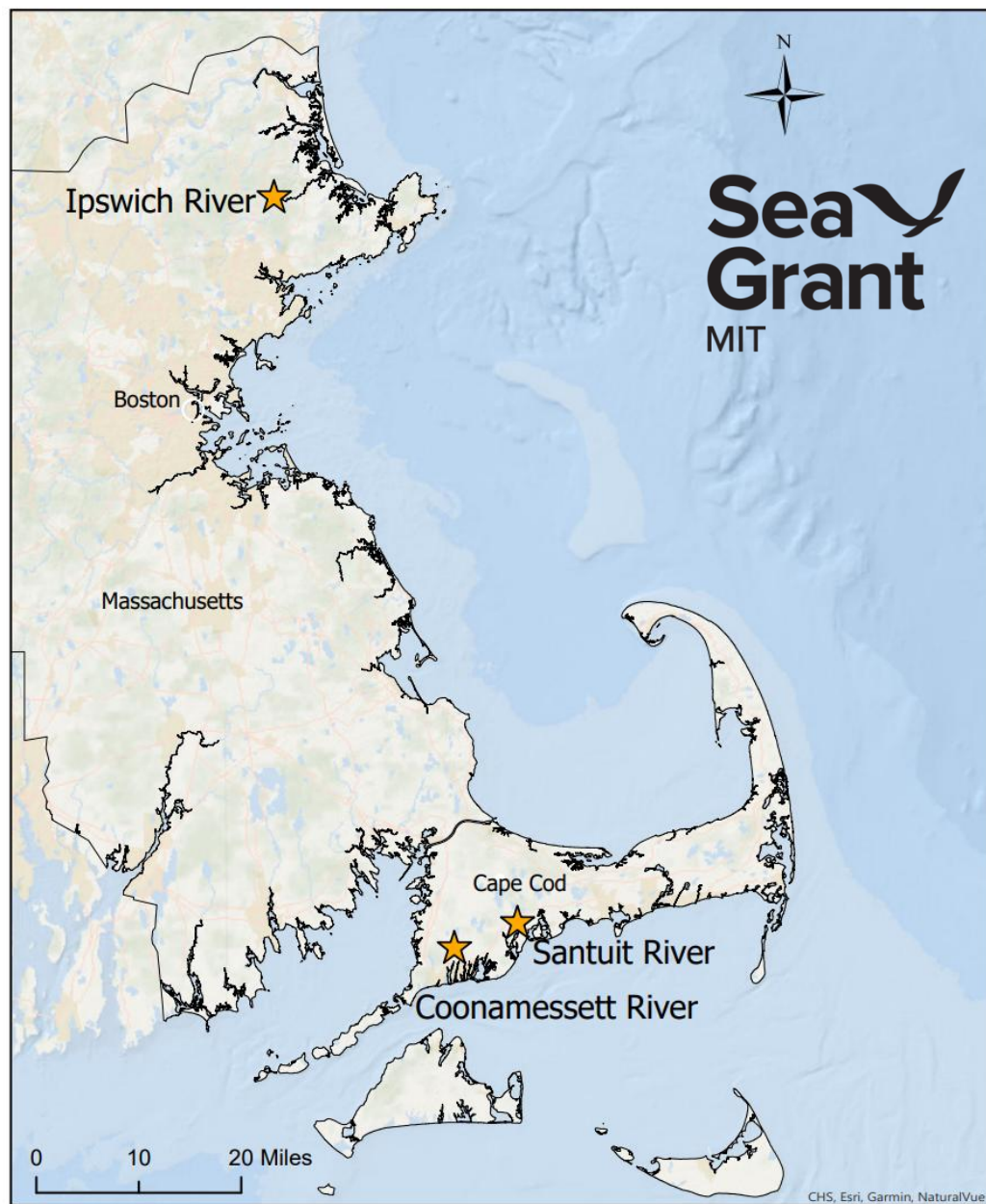
Santuit River, Mashpee, MA





Coonamessett River, Falmouth, MA

4/15 – 6/6 2024, **51** days, **1238** hours of videos

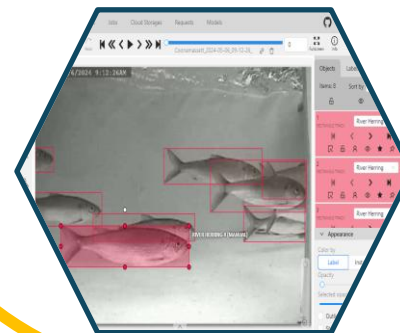


AI-Driven Counting of River Herring

Camera system

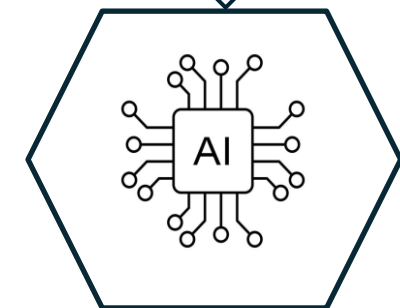


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Fish counting



AI model training



IPSWICH RIVER
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Example videos for labeling

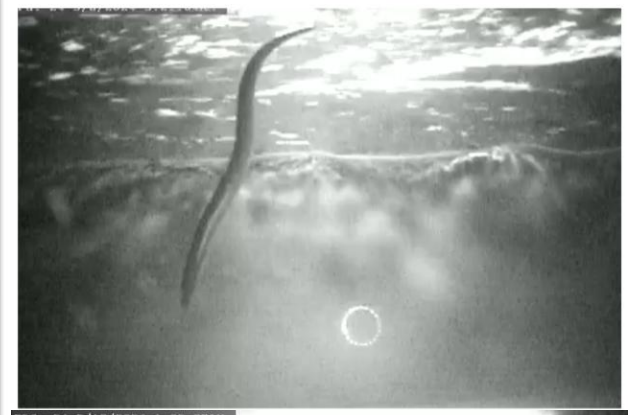
1,435 videos selected for labeling



FPS: 24 5/7/2024 5:21:54PM



FPS: 24 5/8/2024 3:36:37PM



FPS: 24 5/18/2024 1:32:37AM



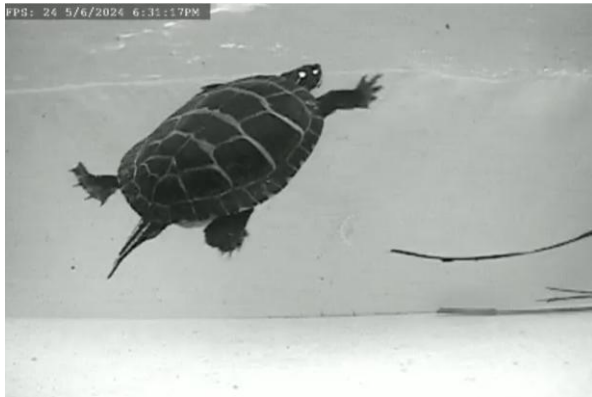
FPS: 24 5/6/2024 6:31:17PM



FPS: 24 5/8/2024 4:46:03AM

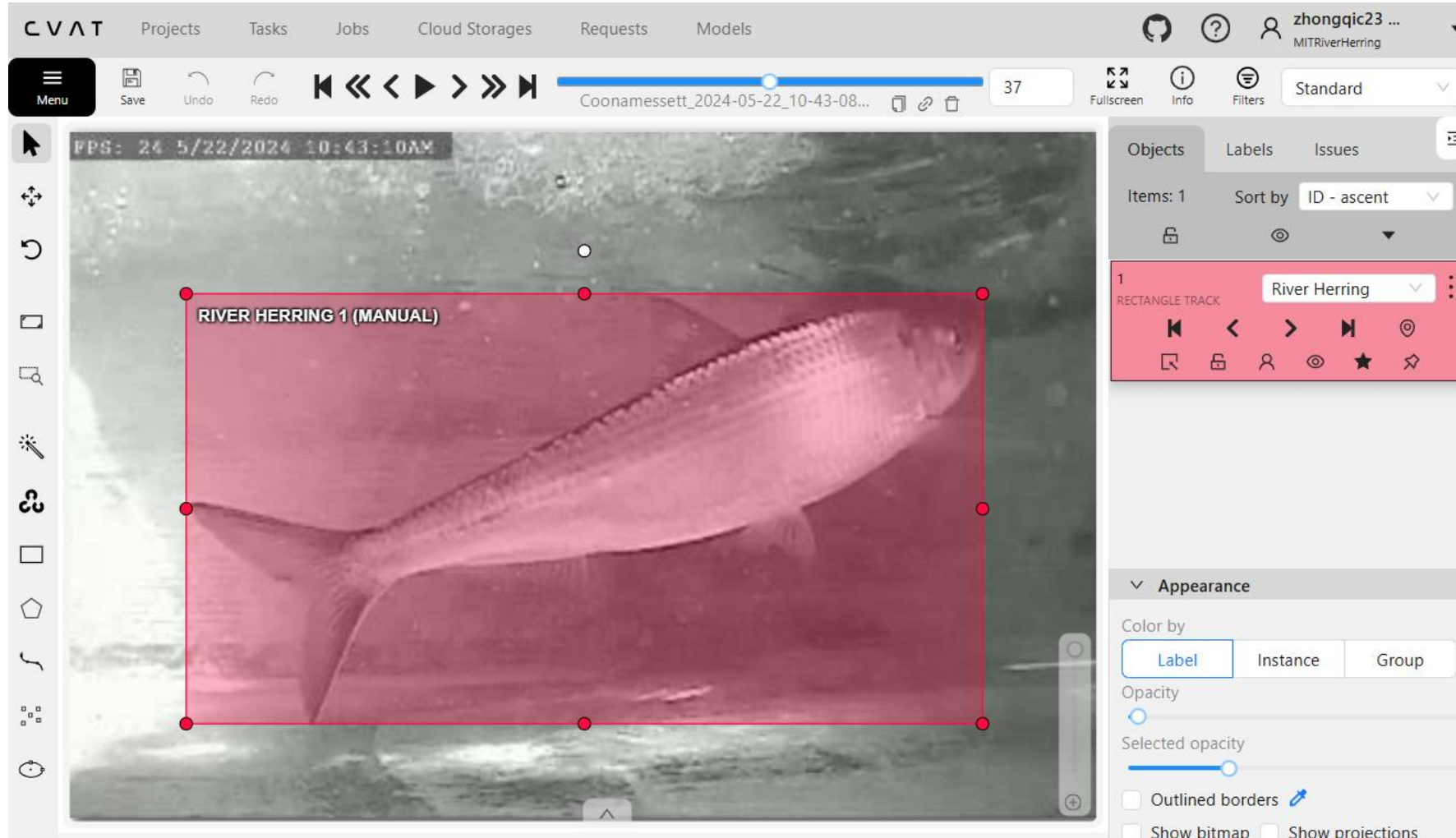


FPS: 24 5/16/2024 12:14:13AM



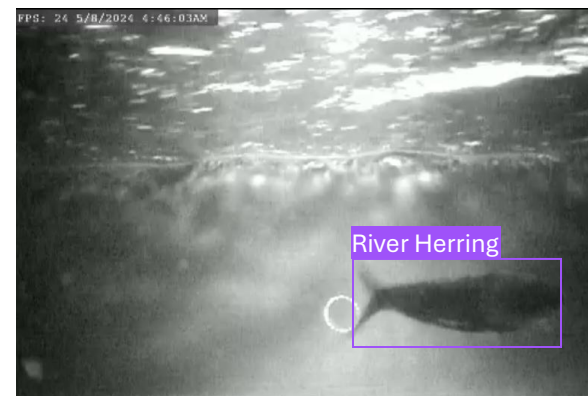
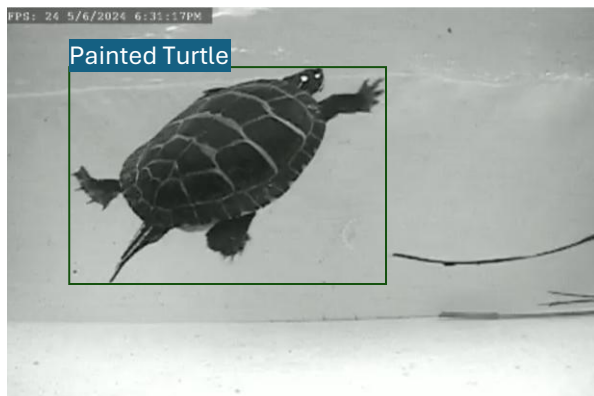
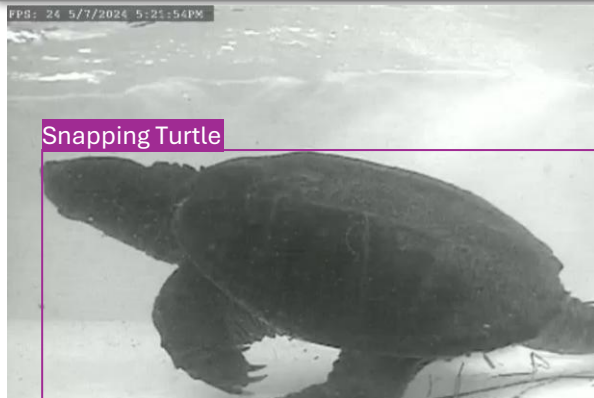
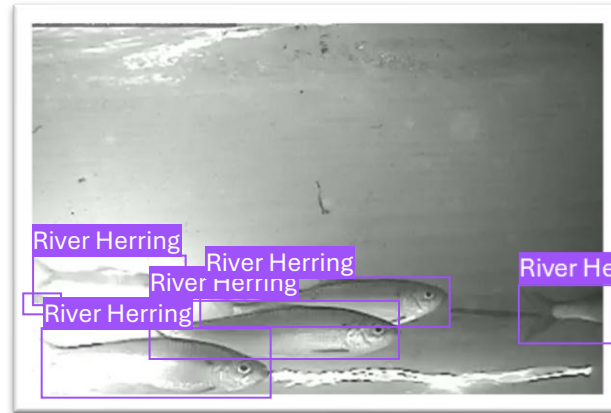
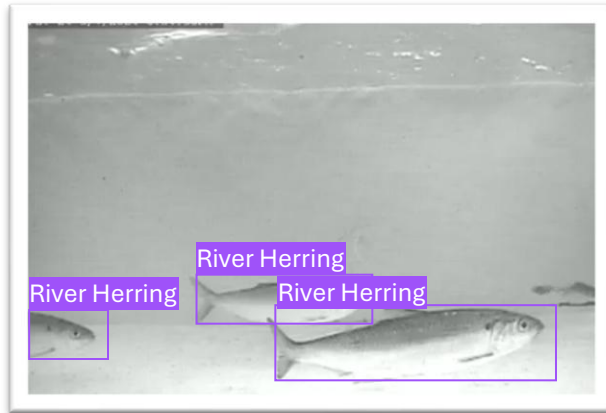
Labeling on CVAT.ai

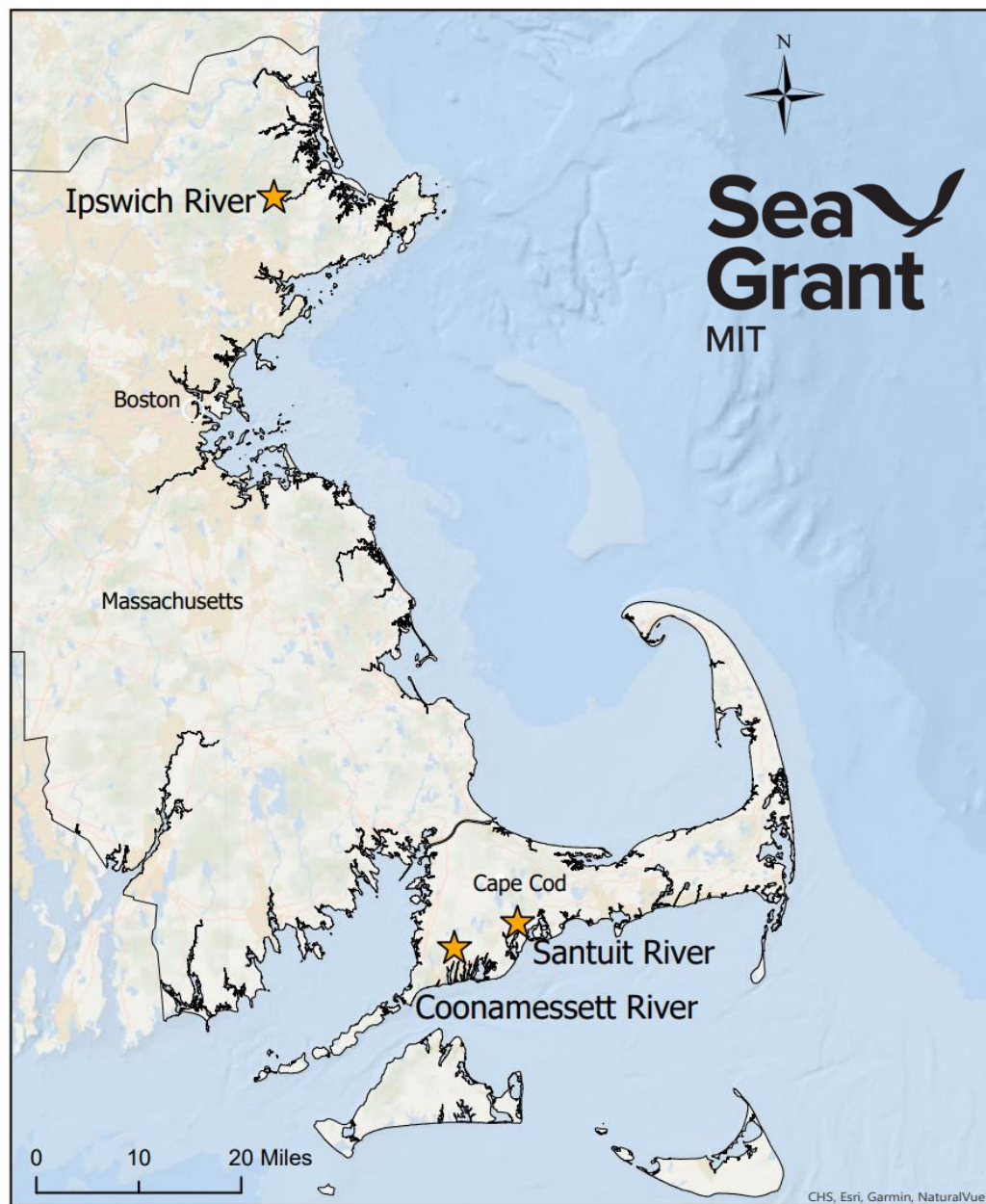
59,850 frames containing fish labeled



Labelled data for training

59,850 frames containing fish labeled





AI-Driven Counting of River Herring

Camera system

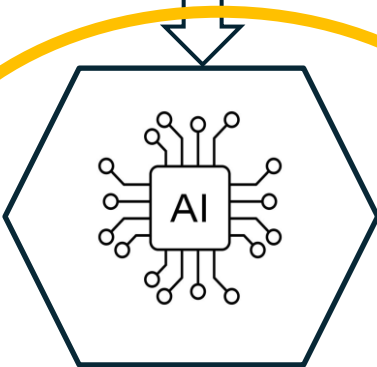


Training Dataset



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Fish counting



AI model training



IPSWICH RIVER
WATERSHED ASSOCIATION



AI model training

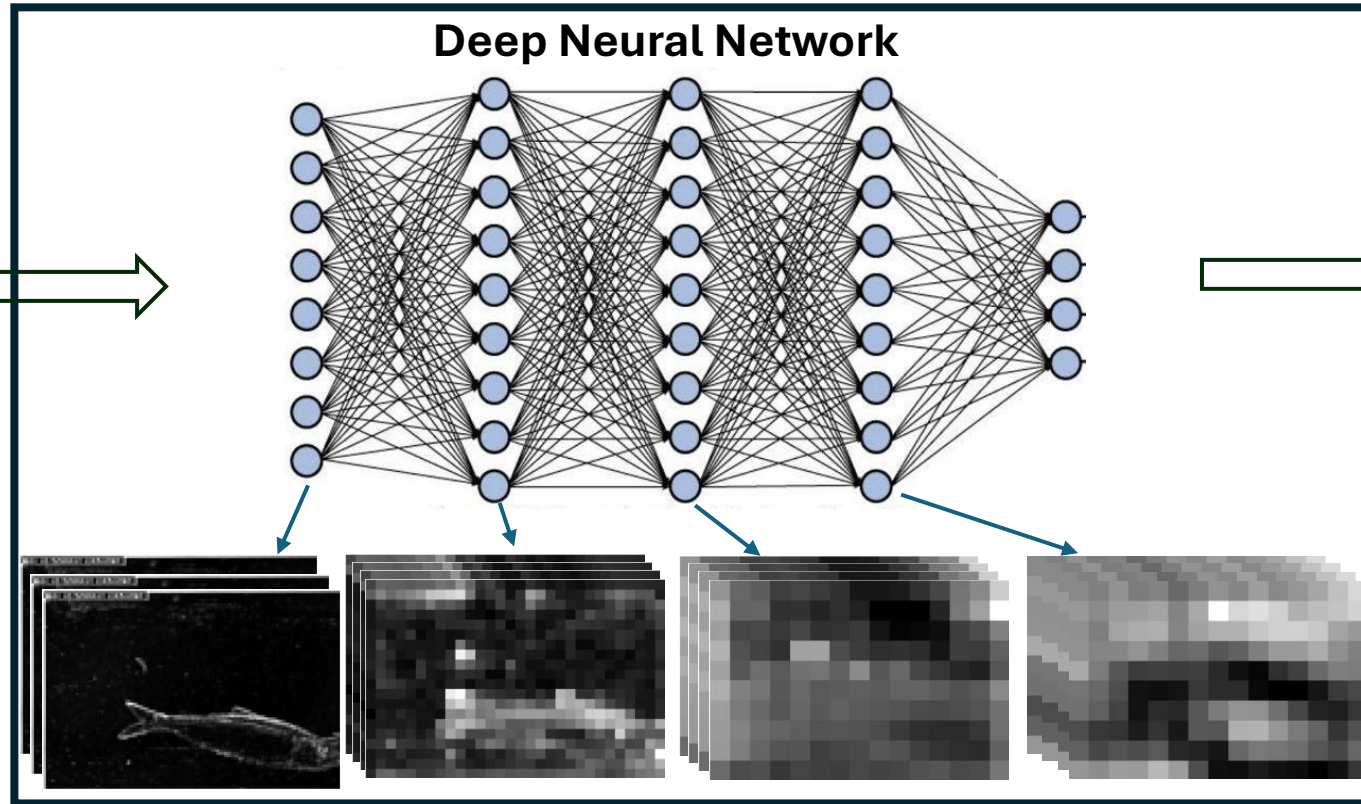
Input

Labeled data



Function

Deep Neural Network



Prediction **Output**



<https://github.com/ultralytics/ultralytics>



Model	size (pixels)	mAP ^{val} 50-95	Speed CPU ONNX (ms)	Speed T4 TensorRT10 (ms)	params (M)	FLOPs (B)
YOLO11n	640	39.5	56.1 ± 0.8	1.5 ± 0.0	2.6	6.5
YOLO11s	640	47.0	90.0 ± 1.2	2.5 ± 0.0	9.4	21.5
YOLO11m	640	51.5	183.2 ± 2.0	4.7 ± 0.1	20.1	68.0
YOLO11l	640	53.4	238.6 ± 1.4	6.2 ± 0.1	25.3	86.9
YOLO11x	640	54.7	462.8 ± 6.7	11.3 ± 0.2	56.9	194.9

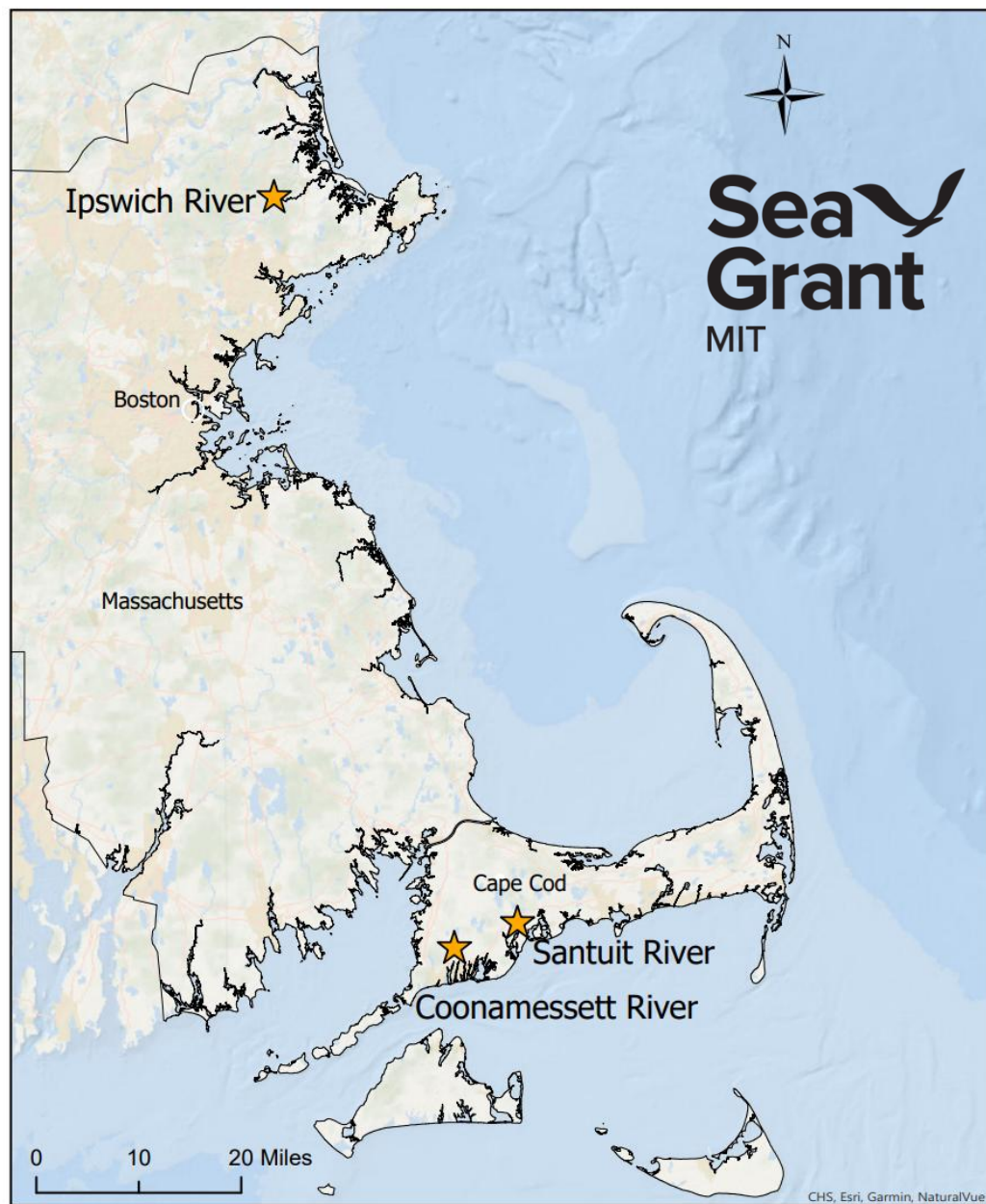
- MIT Supercloud, Nvidia Volta V100 32G GPU
- < 24 hours training time for each model

YOLO model performance

YOLOv11l trained on	Videos	Non-background Frames	mAP ^{test} for all classes			
			Ipswich	Coonamesett	Santuit	Combined
Ipswich	629	32,897	86.7	29.7	41.4	57.5
Coonamesett	509	18,588	21.8	85.1	61.8	42.9
Santuit	297	8,392	2.6	8.2	92.4	13.9
Combined	1,435	59,850	88.3	84.7	92.7	87.5

Ipswich River 2015-2018

YOLOv11 trained on	Videos	Non-background Frames	mAP ^{test} for all classes				
			2015	2016	2017	2018	2015-2018
2015	161	8,042	92.5	91.8	32.4	35.7	44.1
2016	67	3,213	35.5	97.9	46.0	44.6	46.3
2017	233	16,360	38.2	92.4	76.7	56.3	62.5
2018	168	5,282	17.2	83.2	54.2	93.8	54.0
2015-2018	629	32,897	93.1	99.1	77.3	92.2	86.7

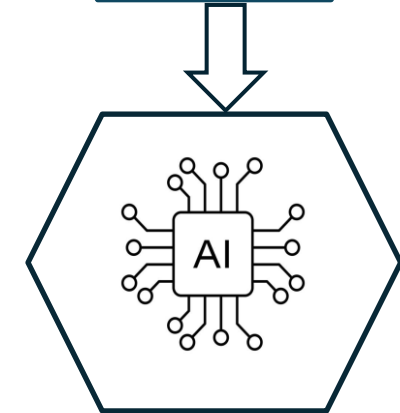


AI-Driven Counting of River Herring

Camera system



Training Dataset



AI model training

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Fish counting



**IPSWICH RIVER
WATERSHED ASSOCIATION**



Monitoring River Herring at Coonamessett River

Visual Counts 2005 -



Pit Tagging 2015 -

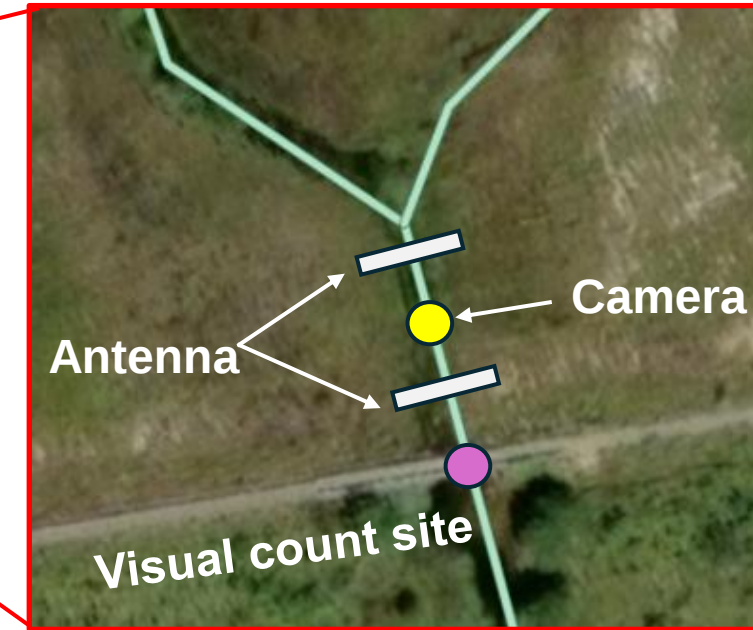
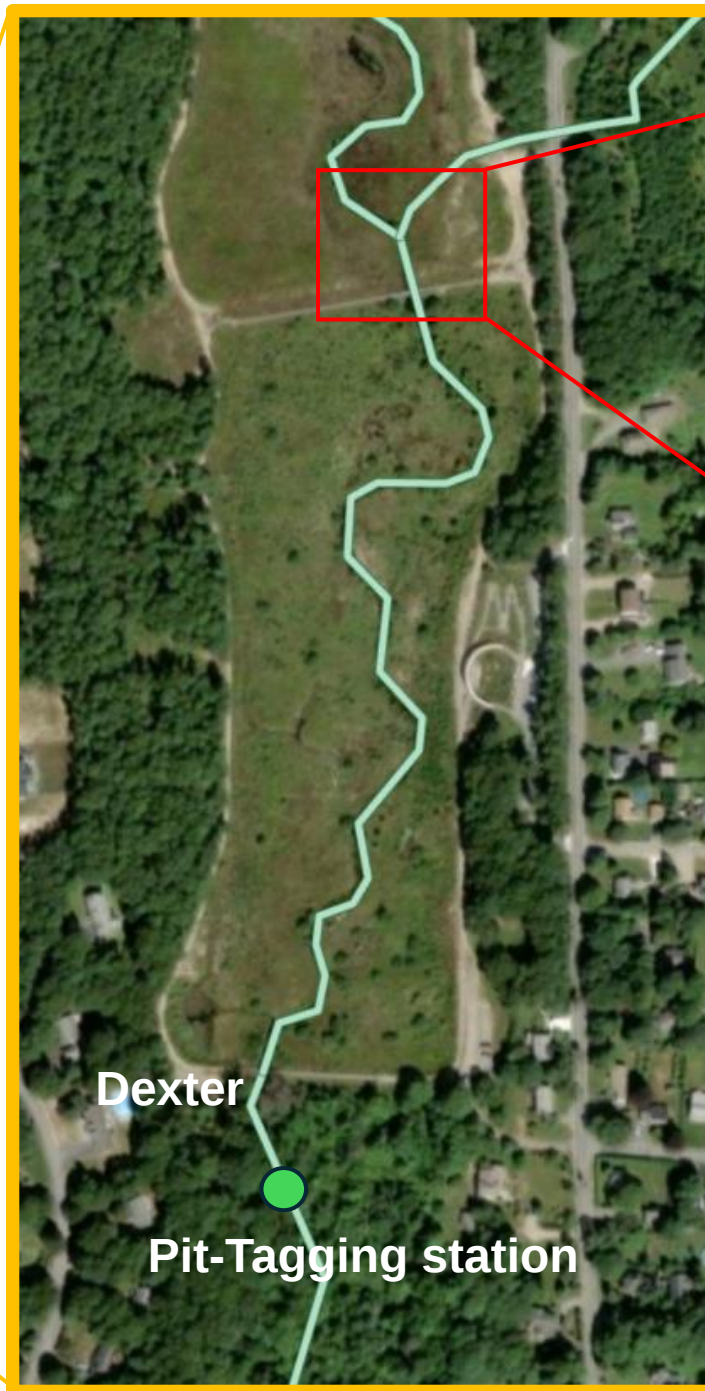
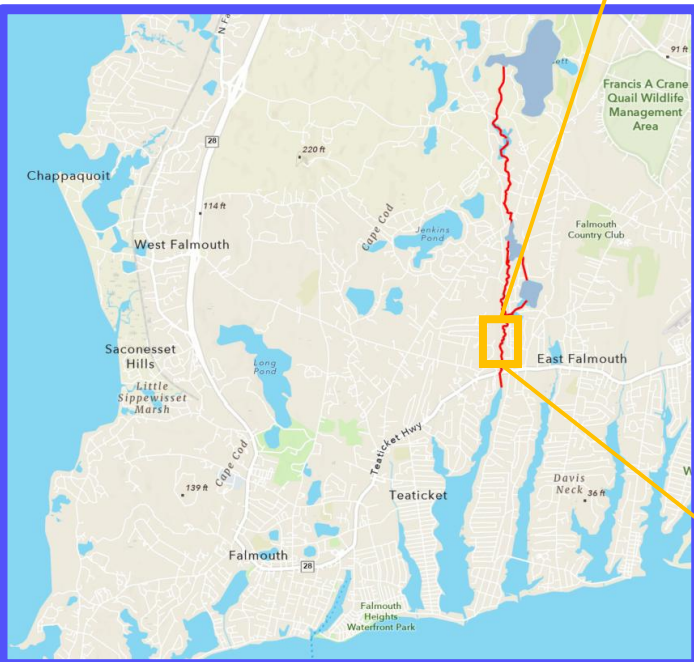


Video + AI 2024 -



2024 River Herring migration

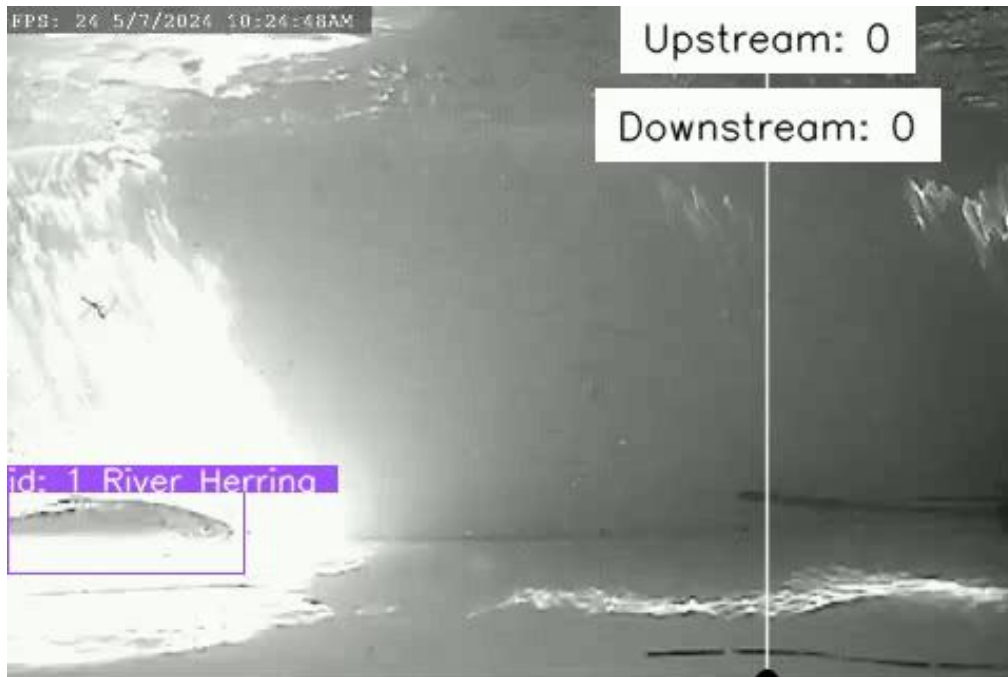
1. Visual Count
2. Pit tagging
3. **AI count on video**



- 4/15 – 6/6 2024
- **51** days
- **1238** hours of videos

Use AI to Count River Herring

- April 16 – June 6,
- 1328 Hours videos continuous
- ~2 weeks processing time
- Nvidia RTX 4070 laptop GPU

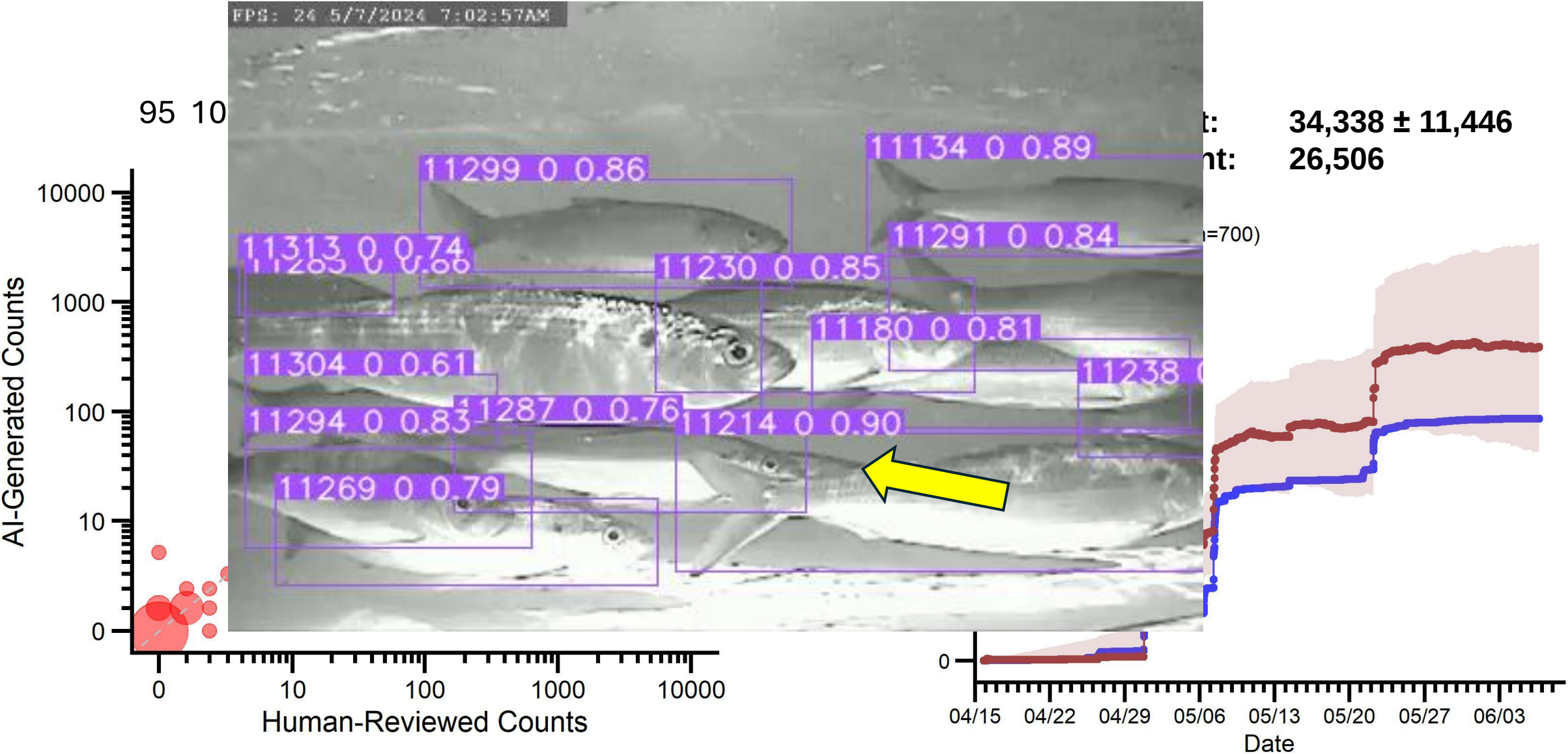


frame	time	label	count_in	count_out
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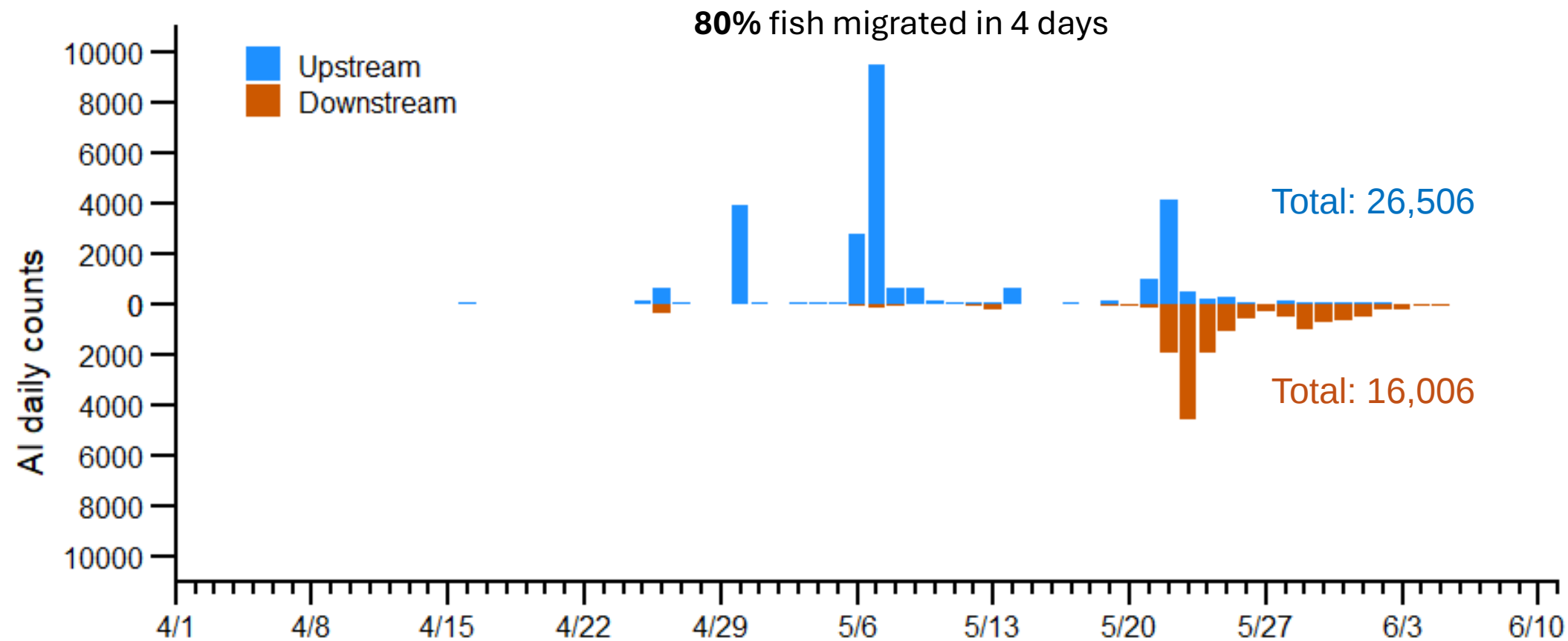
Total upstream: 26,506
Total Downstream: 16,000

Verify and correct AI count

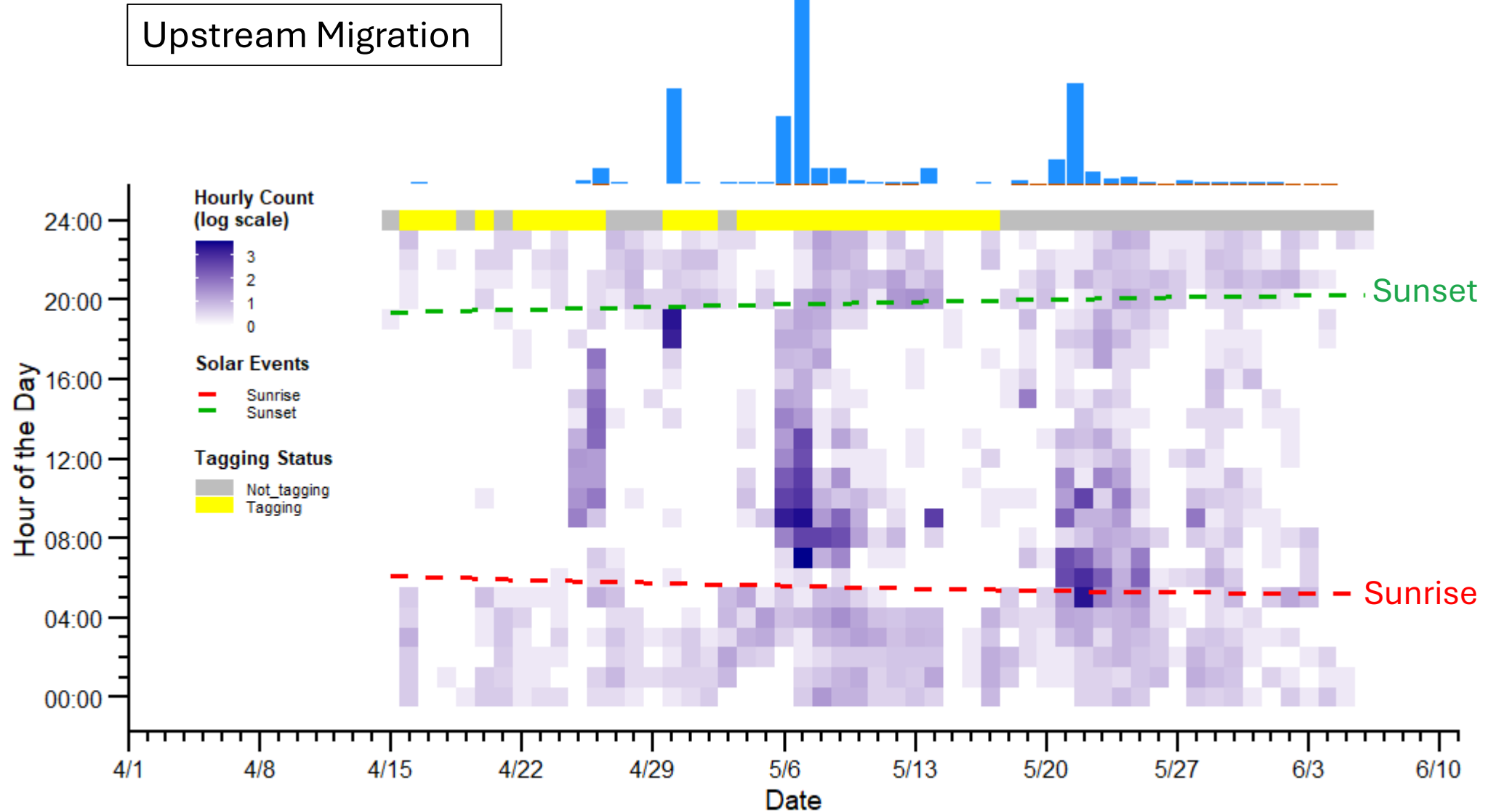
DISCount by Perez et al., 2023



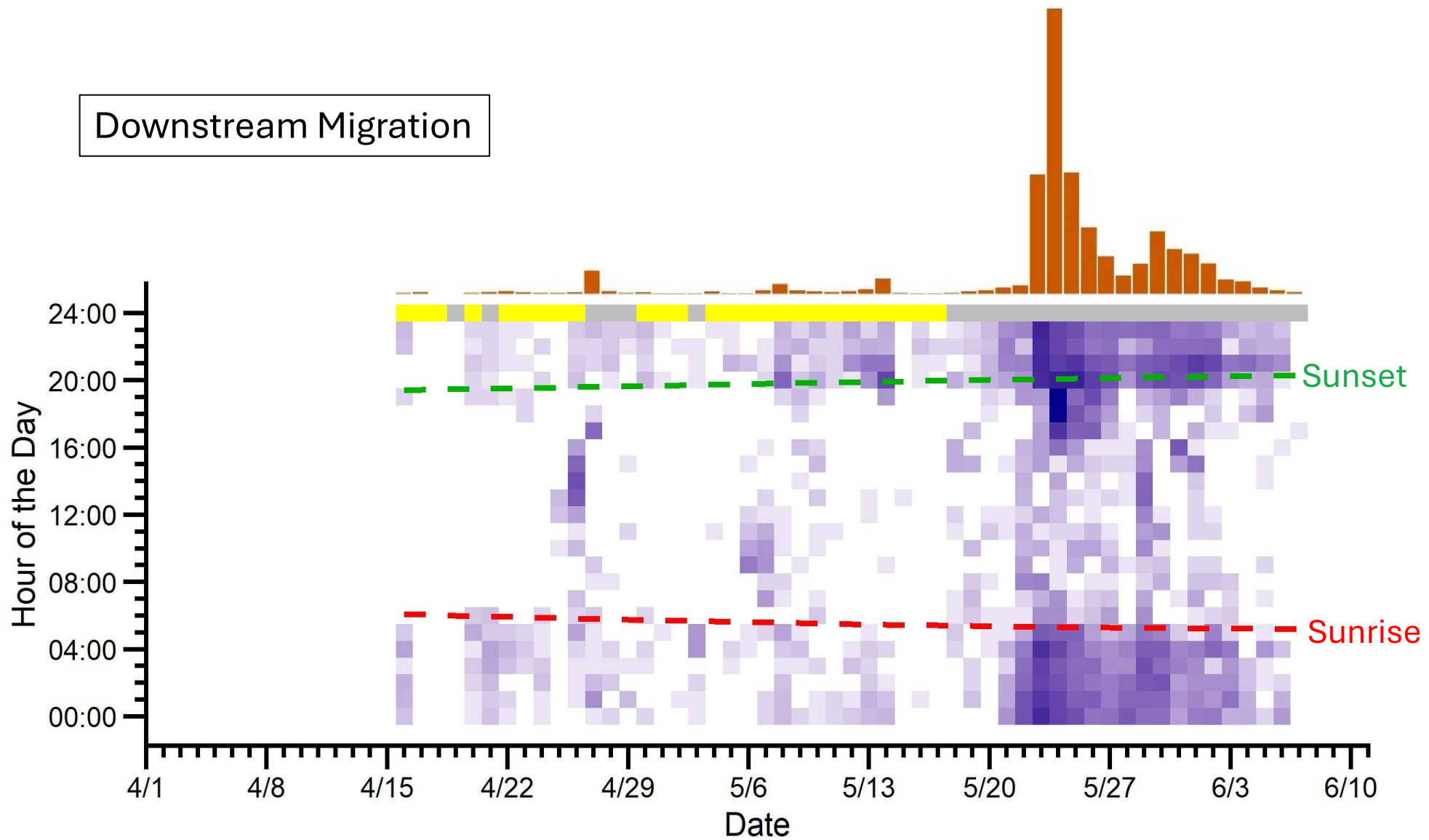
Daily Counts - 2024 Coonamessett River

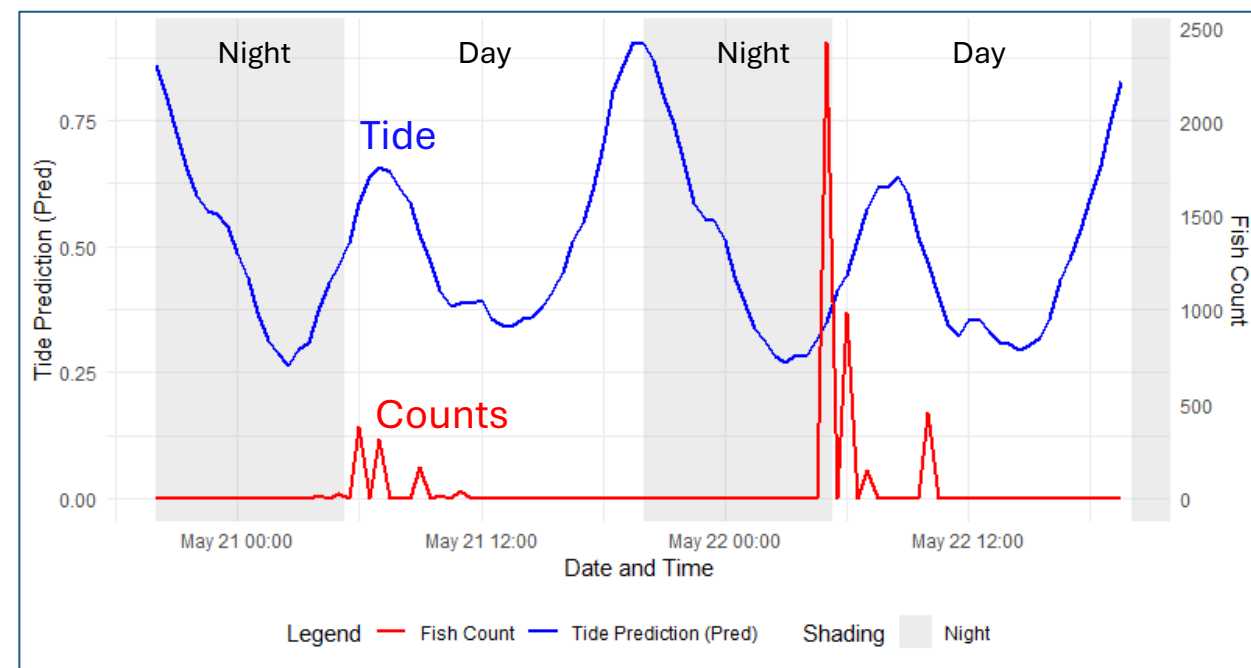
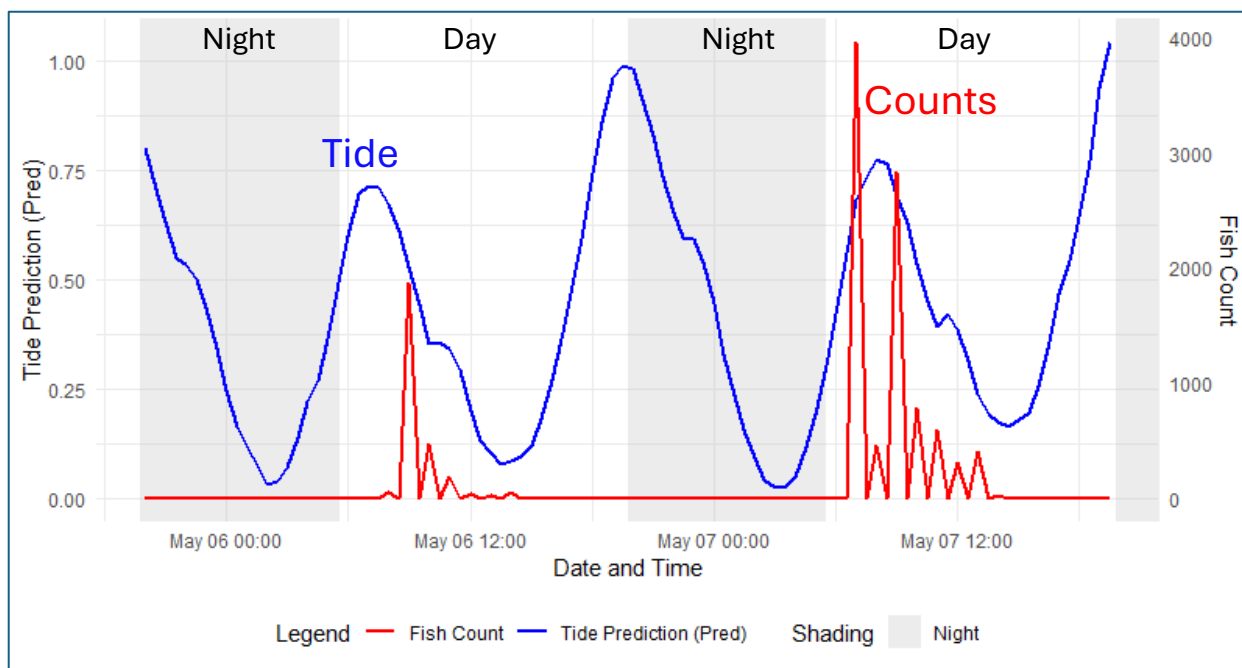
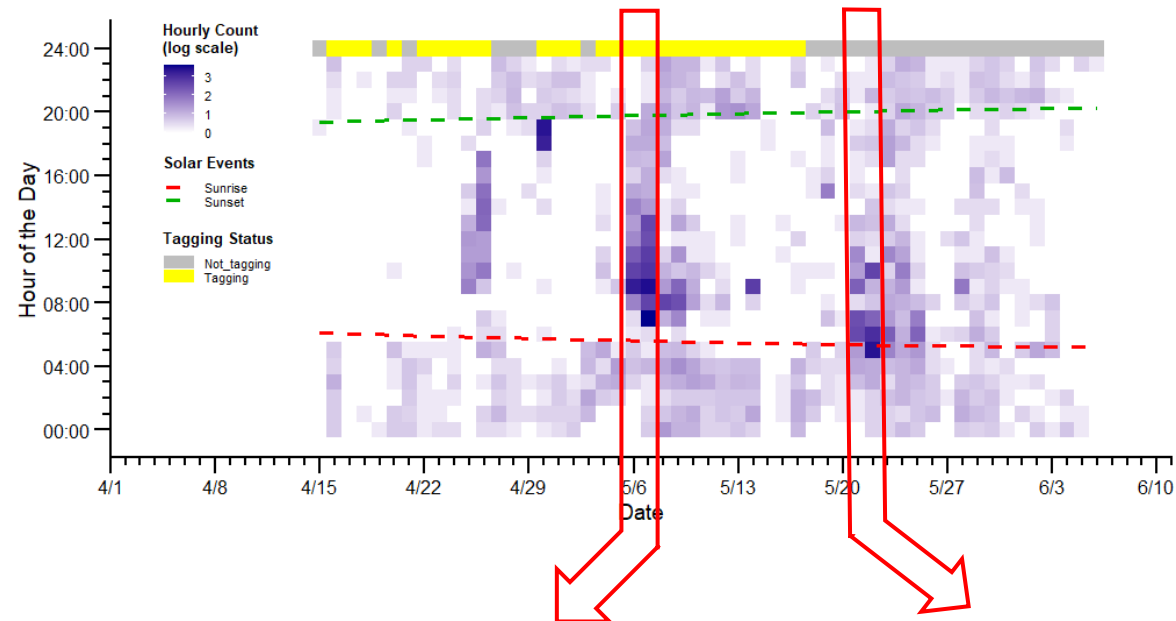


Hourly Counts - 2024 Coonamessett River

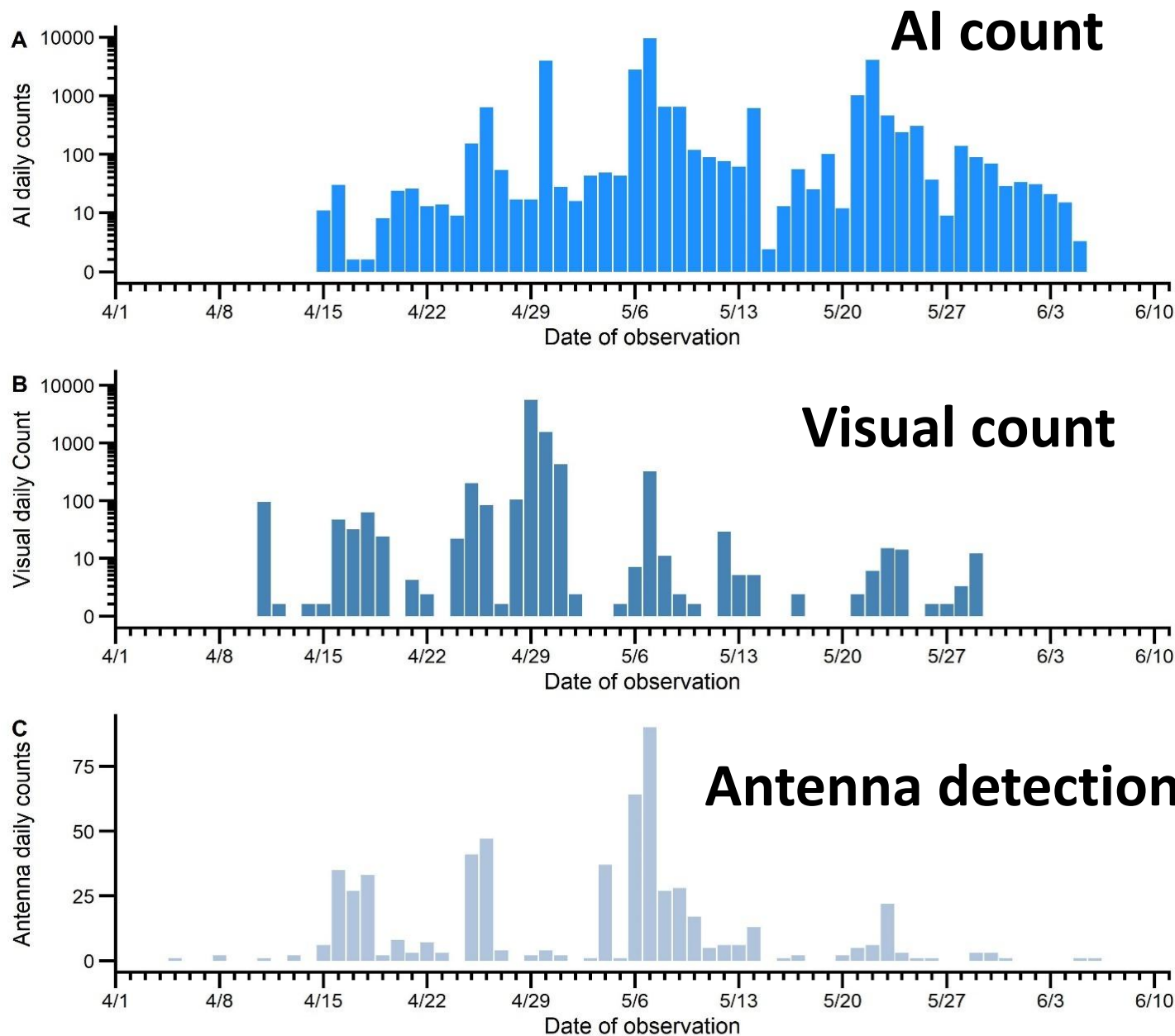


Hourly Counts - 2024 Coonamessett River

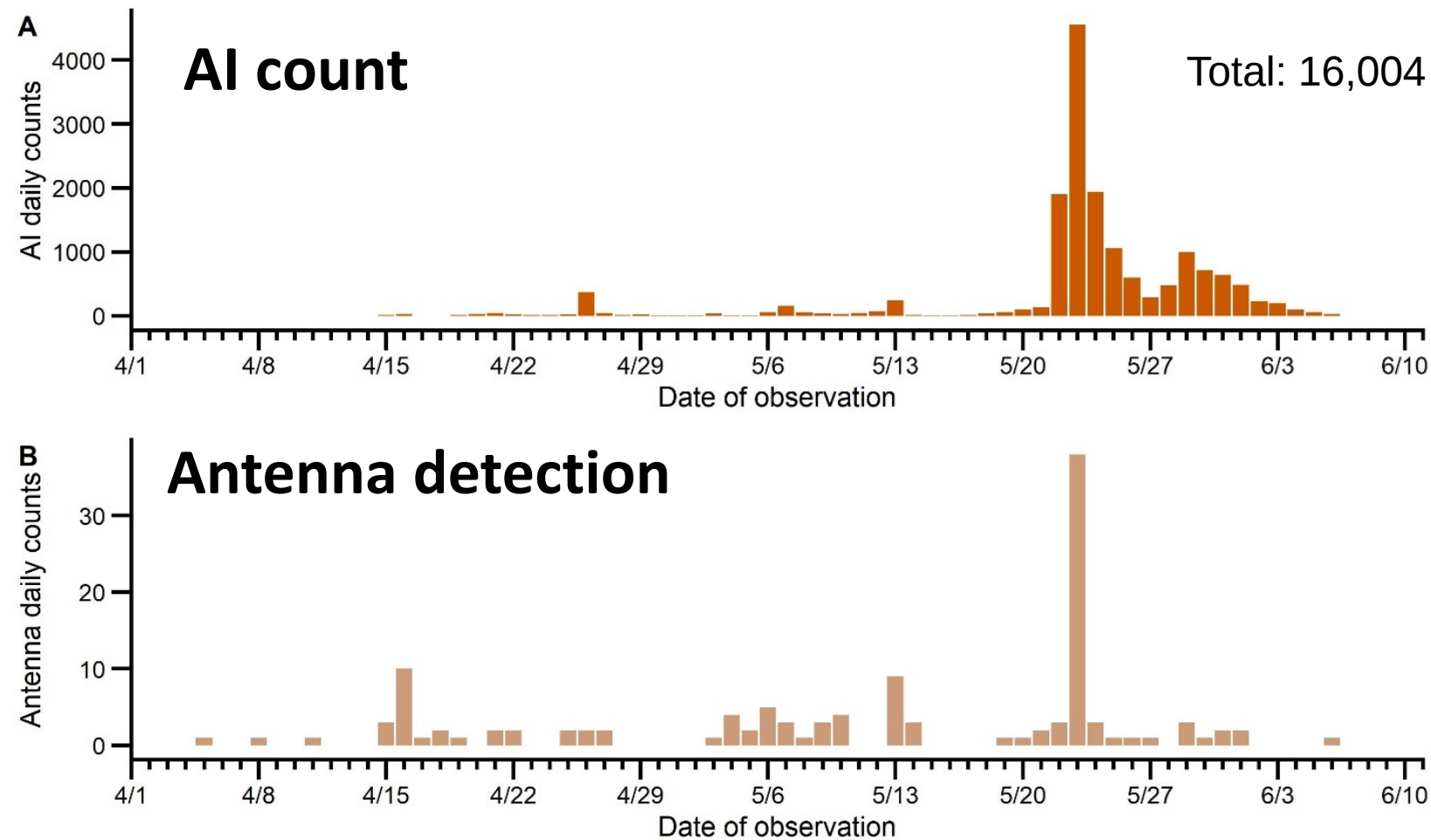




Compare AI, visual and Antenna Counts

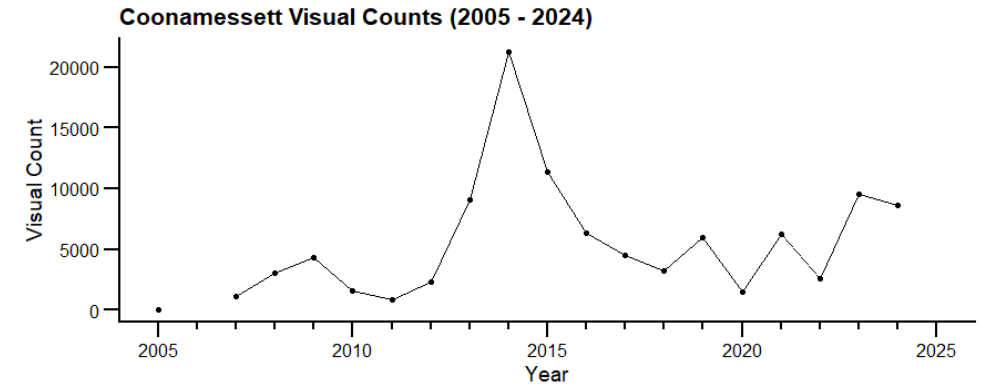


Count of Downstream Migration of River Herring



(New) Tasks for Citizen Scientist

- Visual counts
- Community engagement and awareness
- Qualitative observations
- Environmental monitoring beyond fish counting
- AI count results validation and verification
- Contributing to AI labeling
- Equipment camera setup maintenance and monitoring



Acknowledgements

Linda Deegan
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Chris Neill, Abigail Schill

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Austin Powell, Lydia Zuehsow

Eric Gonzalez, Ellie Lei, Frank Lie,
Vivia Trinh, Andy Zhang, Celinda Zhu

